CSO Presentation

Objective - explain what a combined sewer system is, discuss the effects and present alternatives solutions. The idea is to engage community stakeholders in the analysis process at an early stage. Your input will help us, the JCMUA, communicate with our board members and other decision makers and to ensure that we all have a clear understanding of the choices before us.

Slide 3: CSS Breakdown

As you may know, Jersey City operates on a combined sewer system. (CSS)

What does this mean?

A CSS is designed to collect rainwater run-off and waste water in the same sewer line. During dry weather, the system carries the wastewater to the treatment plant. During heavy rainfalls however, the sewer line cannot handle the combined volume of water sometimes causing an overflow into our waterways. This is called a combined sewer overflow or CSO.

Slide 4: CSO Locations

You can see here, Jersey City has 21 overflow discharge locations.

- Penhorn Creek - 1
- Hackensack River, Newark Bay - 11
- Hudson River -9

Each discharge point is equipped with netting facilities.

Slide 5: Netting Facilities

Each net collects the solid waste that slips through catch basins. Depending on the location, nets can remove 3000 – 5000 lbs of waste.

Slide 6: Netting Facilities

Nets are removed and replaced every 2 months or after a heavy rainfall. The old nets are then transported to a landfill.

Slide 7: Sewer Pipes and Materials

The sewer system is made up of 230 miles of pipe. 90% of the pipes are 88 – 131 years old.

Slide 8: Sewer Maps

As you can see, the first map shows the various materials our pipes are made of ranging from brick to clay. The 2nd map shows the year each pipe was installed. Most pipes were installed in the early 1900s.

Slide 9: Sewer Replacement

We began to rehabilitate and replace sewer lines in 2016, where necessary. As we continue to rehabilitate the combined sewer system, alternative solutions for the CSO discharges need to be developed in order for us to move forward.

Slide 10: Alternatives

The Alternatives being considered are broken into 4 categories.

- Source Controls
- Collection System Controls
- Treatment Technologies
- Storage Technologies

Slide 11: Source Controls – Green Infrastructure

Green Infrastructure stores, absorbs and uses rain water runoff.

Positives:

- Low Cost
- Reduce Flooding

Negatives:

- Maintenance Concerns
- Site-Specific: Green infrastructure practices to be incorporated into site design should be selected based on an evaluation of individual site characteristics and needs.

Examples:

- Green Roof
- Bioswale
- Rain Garden

Slide 12: How does it work?

Rainwater runoff enters the bioswale through the inlet. The stones slow the water flow and prevent erosion. The water moves through the vegetative channel as it slowly infiltrates into the ground. The plants used adapt to the soil assisting with evaporation and transpiration.

Slide 13: Collection System Controls

The next alternative category is collection system controls.

Slide 14: Collection System Controls

Sewer Separation: Separates the combined, single pipe system into separate sewers for sanitary and storm water flows.

Positives:

- Improve Water Quality
- Reduce or eliminate untreated sanitary discharge
- Reduce flooding in basements and streets

Negatives:

- High Cost
- Extensive Construction
- Internal Plumbing work

Infiltration/ Inflow Control

Infiltration and Inflow happen when groundwater and rainwater enter a sewer line through defects or leaks. It can be controlled by using cameras to monitor and inspect the sewer lines.

We have utilized this alternative and are in the process of rehabilitating the sewer lines that are broken as seen in the earlier slide.

Positives:

- Improve water quality
- Reduction of combined sewer volumes

Negatives:

- High Cost
- Possible disruption in sewer services
- Extensive Construction

Slide 15: Treatment Technologies

The next alternative category is Treatment Technologies.

Slide 16: Treatment Technologies

Screening: JCMUA's CSO facilities are currently equipped with netting facilities as seen in an earlier slide.

Disinfection Alternatives: Sodium Hypochlorite and Chlorine Dioxide are used for water purification

Positives:

- Easy to produce
- Equipment requires less space than other methods.
- The chlorine residual that remains in the wastewater effluent can prolong disinfection even after initial treatment and can be measured to evaluate the effectiveness.

Negatives:

- Limited use in the US
- Hazardous to transport
- Can produce potentially toxic byproducts
- Low dosages may not effectively inactivate some viruses, spores, and cysts.
- Chlorine reacts with certain types of organic matter in wastewater, creating hazardous compounds
- chlorine residual is toxic to aquatic life

Slide 17: Storage Technologies

The last alternative category is storage technologies

Slide 18: Storage Technologies

Two types of Storage

In Line – Near Surface Storage

Off Line – Basins or Concreate Tanks

Based on modeling, new in line storage is not realistic for the JCMUA system.

Off Line Service diverts the water to large tanks or deep tunnels.

Positives:

- Eliminates or reduces sewer back ups
- Improves the efficiency of existing treatment capacity
- Improves quality of treatment plant

Negatives:

- Lack of Real Estate available
- Difficulty managing flows to and from basin
- High Cost

Slide 19: Next Steps

Questions

Questionare

APPENDIX F

Development and Evaluation of Alternatives Report
Town of Kearny

Dated: July 1, 2019
Revised: November 21, 2019

NEW JERSEY DEPARTMENT
OF ENVIRONMENTAL PROTECTION

DEVELOPMENT AND EVALUATION OF ALTERNATIVES REPORT

FOR

TOWN OF KEARNY (NJPDES PERMIT No. NJ0111244)

July 1, 2019 (Revised: November 21, 2019)

Report Prepared by:

Neglia Engineering Associates
34 Park Avenue – P.O. Box 426
Lyndhurst, New Jersey 07071
Telephone: (201) 939-8805
Fax: (201) 939-0846

CERTIFICATE OF AUTHORIZATION (N.J.S.A. 45:8-56) 24GA27927000

with modeling support from:

HDR, Inc.
1 International Boulevard
10th Floor, Suite 1000
Mahwah, New Jersey 07495
Telephone: (201) 335-9414

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Report Disclaimer: The Town of Kearny has completed and participated in the production of this document as required by the Town's individual New Jersey Pollutant Discharge Elimination System (NJPDES) permit (NJPDES Permit No. NJ0111244). At this time, the Town of Kearny is not committing the current governing body of the Town, or future governing bodies, to the allocation of funds based on the costs presented in this report to complete projects related to the control of combined sewer overflows (CSOs).

SECTION A INTRODUCTION

A.1 BACKGROUND

The Town of Kearny, located in Hudson County, owns and operates a combined sewer system (CSS) which conveys all flow to the Passaic Valley Sewerage Commissioners (PVSC) wastewater treatment plant located in Newark, New Jersey. In 2015, Kearny was issued a revised New Jersey Pollutant Discharge Elimination System (NJPDES) permit, No. NJ0111244, Category CSM (Combined Sewer Management), with an effective date of July 1, 2015. Part IV Section D.3.b.vi of the NJPDES permit requires the Town to develop a Long Term Control Plan (LTCP) to reduce the number of Combined Sewer Overflows (CSOs) during wet weather events, to meet the goals set by the Clean Water Act as well as the National CSO Control Policy. The LTCP is required to be submitted to the NJDEP by June 1, 2020. As an interim step toward developing the LTCP, Kearny is required to prepare a Development and Evaluation of Alternatives Report, (Part IV Section D.3.b.v of the NJPDES permit) to investigate cost effective control strategies for reducing CSOs. The findings of this report will be incorporated into the LTCP, which, once approved, will become part of the Town's updated NJPDES permit.

A.2 EXISTING OUTFALLS

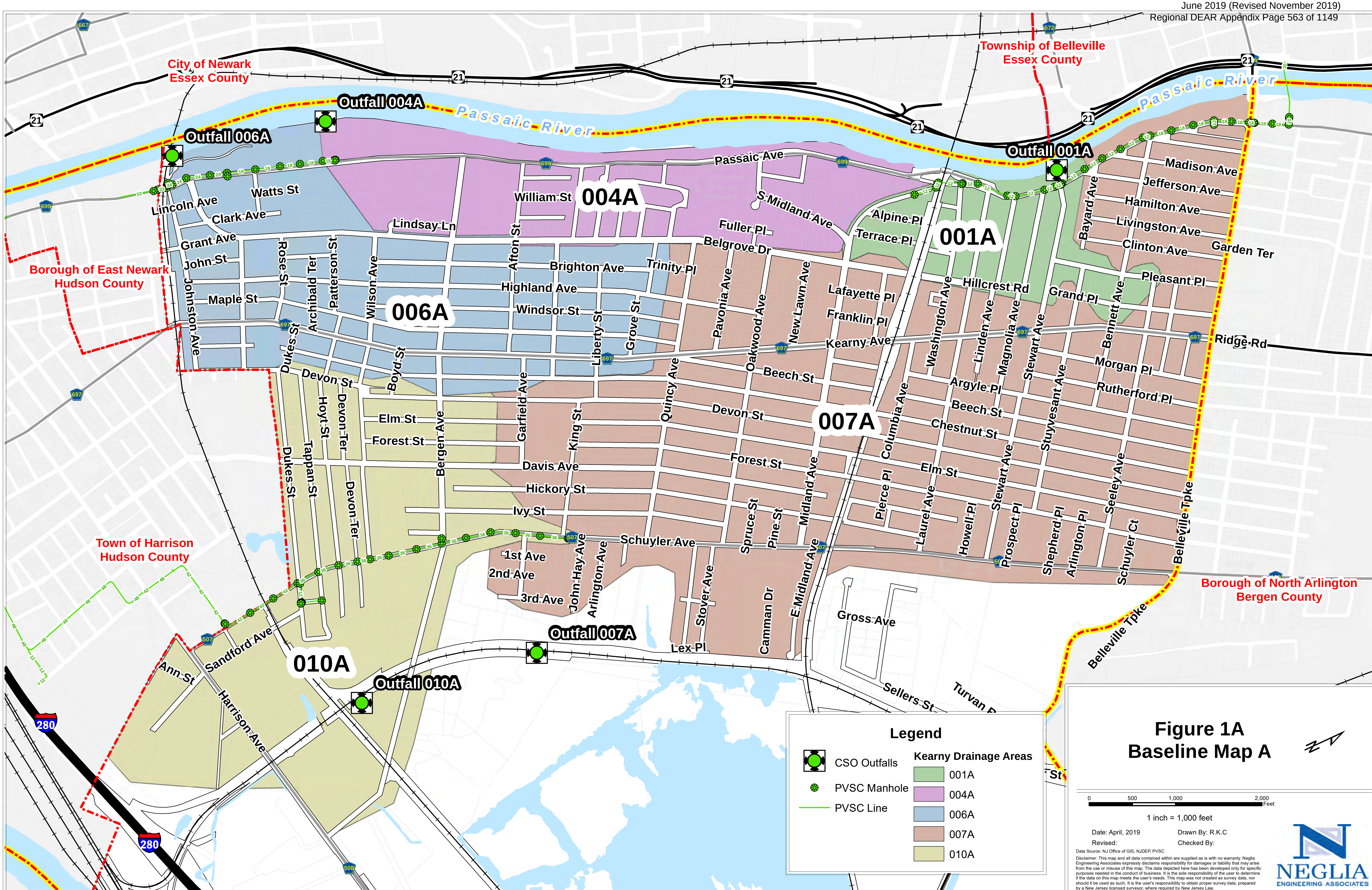
All sewage generated within the Town of Kearny is conveyed to the Passaic Valley Sewerage Commissioners (PVSC) wastewater treatment plant. During certain rainfall events, depending on the magnitude and duration of the event, flow in the conveyance system exceeds the sewer system's capacity, and excess flow is discharged to the adjacent surface water body, through its system of outfall regulator chambers. The Town of Kearny owns and operates five (5) wet weather outfalls, and associated regulator chambers, which are listed below. Refer also to the Town of Kearny Drainage Area Map, Figure 1A, and the individual location maps of the five outfalls, Figures 2A through 2E, shown on the following pages.

TABLE A-1 – EXISTING OUTFALLS		
OUTFALL NO.	LOCATION	RECEIVING STREAM
001A	Stewart Avenue	Passaic River
004A	Nairn Avenue	Passaic River
006A	Johnston Avenue	Passaic River
007A	Ivy Street	Frank's Creek (Tributary to Lower Passaic River)
010A	Dukes Street	Frank's Creek (Tributary to Lower Passaic River)

A.3 WATER QUALITY REQUIREMENTS

Of the five (5) CSO outfalls in Kearny, 001A, 004A, and 006A, discharge to the Passaic River on the western border of the Town. The remaining outfalls, 007A and 010A, discharge to the portion of the Lower Passaic River known as Frank's Creek, on the Town's eastern border. Both bodies of water are classified as SE-3 (C2) or Saline Estuary 3, Category 2. In accordance with N.J.A.C. 7:9B, Surface Water Quality Standards, Subsection 1.12, the designated uses for SE-3(C2) waters are as follows:

- Secondary Contact Recreation;
- Maintenance and Migration of Fish Population;
- Migration of Diadromous Fish;
- Maintenance of Wildlife; and


City of Newark
Essex County
Township of Belleville
Essex County
Borough of East Newark
Hudson County
Town of Harrison
Hudson County
Borough of North Arlington
Bergen County
Passaic River
Outfall 004A
Outfall 006A
Outfall 001A
Outfall 007A
Outfall 010A
004A
006A
001A
007A
010A
Passaic Ave
S Midland Ave
Kearny Ave
Schuyler Ave
Belleville Tpke
Ridge Rd
Bergen Ave
Harrison Ave
Sandford Ave
Devon St
Davis Ave
Legend
CSO Outfalls
PVSC Manhole
PVSC Line
Kearny Drainage Areas
001A
004A
006A
007A
010A
Figure 1A
Baseline Map A
0
500
1,000
2,000
Feet
1 inch = 1,000 feet
Date: April, 2019
Drawn By: R.K.C
Revised:
Checked By:
Data Source: NJ Office of GIS, NJDEP, PVSC
NEGLIA
ENGINEERING ASSOCIATES

CERTIFICATE OF AUTHORIZATION (N.J.S.A. 45:8-56) 24GA27927000

0 50 100 200 Feet

1 inch = 100 feet

N

Stewart Avenue CSO Outfall 001A
Town of Kearny
County of Hudson, New Jersey

Legend: CSO Outfalls; PVSC Manhole; PVSC Line; Parcels

NEGLIA ENGINEERING ASSOCIATES

Drawn By: R.K.C.	Checked By: J.R.	Project No: KEARMUN18.013	Sheet No: Figure 2A	Map References: NJ Office of GIS Nearmap Imagery (March 2019)
Designed By: R.K.C.	Page:			
Field Book No:	Date: April, 2019			

CERTIFICATE OF AUTHORIZATION (N.J.S.A. 45:8-56) 24GA27927000

0 100 200 400 Feet

1 inch = 200 feet

N

Nairn Avenue CSO Outfall 004A
Town of Kearny
County of Hudson, New Jersey

- CSO Outfalls
- PVSC Manhole
- PVSC Line
- Parcels

NEGLIA ENGINEERING ASSOCIATES

Drawn By: R.K.C.	Checked By: J.R.	Project No: KEARMUN18.013	Sheet No: Figure 2B	Map References: NJ Office of GIS Nearmap Imagery (March 2019)
Designed By: R.K.C.	Page:			
Field Book No:	Date: April, 2019			

CERTIFICATE OF AUTHORIZATION (N.J.S.A. 45:8-56) 24GA27927000

0 75 150 300 Feet

1 inch = 150 feet

N

Johnston Avenue CSO Outfall 006A
Town of Kearny
County of Hudson, New Jersey

CSO Outfalls
PVSC Manhole
PVSC Line
Parcels

NEGLIA ENGINEERING ASSOCIATES

Drawn By: R.K.C.	Checked By: J.R.	Project No: KEARMUN18.013	Sheet No: Figure 2C	Map References: NJ Office of GIS Nearmap Imagery (March 2019)
Designed By: R.K.C.	Page:			
Field Book No:	Date: April, 2019			

CERTIFICATE OF AUTHORIZATION (N.J.S.A. 45:8-56) 24GA27927000

0 100 200 400 Feet

1 inch = 200 feet

Ivy Street CSO Outfall 007A
Town of Kearny
County of Hudson, New Jersey

- CSO Outfalls
- PVSC Manhole
- PVSC Line
- Parcels

NEGLIA ENGINEERING ASSOCIATES

Drawn By: R.K.C.	Checked By: J.R.	Project No:	Sheet No:	Map References:
Designed By: R.K.C.	Page:	KEARMUN18.013	Figure 2D	NJ Office of GIS Nearmap Imagery (March 2019)
Field Book No:	Date: April, 2019			

CERTIFICATE OF AUTHORIZATION (N.J.S.A. 45:8-56) 24GA27927000

0 100 200 400 Feet

1 inch = 200 feet

Dukes Street CSO Outfall 010A
Town of Kearny
County of Hudson, New Jersey

- CSO Outfalls
- PVSC Manhole
- PVSC Line
- Parcels

NEGLIA ENGINEERING ASSOCIATES

Drawn By: R.K.C.	Checked By: J.R.	Project No: KEARMUN18.013	Sheet No: Figure 2E	Map References: NJ Office of GIS Nearmap Imagery (March 2019)
Designed By: R.K.C.	Page:			
Field Book No:	Date: April, 2019			

- Any other reasonable uses.

A.4 MODELING OF THE CSS SYSTEM

The Infoworks ICM hydraulic/hydrologic model was used to calculate the number of CSO events and CSO wastewater volumes, at each outfall, and Citywide, for a one year period. Citywide number of CSO events was calculated based on the hourly time series sum of individual outfall CSO events. A 24 hour inter event time (IET) was used to distinguish between CSO events. That is, if two separate outfalls experienced a discharge within 24 hours, that would be defined as one event. The model was calibrated using available data for the existing 2016/2017 conditions. "Typical year" 2004 rainfall and tides, and average evapotranspiration rates as indicated in the PVSC Technical Guidance Manual, were used with future estimated 2045 population to analyze future conditions and system responses. The Infoworks model was similarly used to calculate preliminary design parameters, such as storage tank volumes, tunnel volume, and design flows for treatment, at each outfall, and for the required 4, 8, 12, and 20 CSO events per year. Zero CSO events per year was not modeled. As will be seen later in the report under alternatives, zero CSO events per year is only considered in conjunction with total sewer separation on a Town wide basis.

A.4.1 Program Requirements

Alternatives considered in this evaluation must satisfy one of the following three (3) criteria:

- Reduction of the number of CSO events to an annual average of four (4) per year;
- 85% capture by volume of the combined sewage collected in the combined sewer system;
- during precipitation events on an annual average basis; and
- Capture of pollutants of concern equivalent to 85% capture.

As required by PVSC, the model looked at target scenarios of 0, 4, 8, 12 and 20 CSO events per year, with 4 CSOs per year being the required target goal, and the remaining scenarios used for cost comparison.

In accordance with NJDEP requirements, alternatives developed in this report are evaluated for the following scenarios:

- 0 CSO events per year (sewer separation only);
- 4 CSO events per year;
- 8 CSO events per year;
- 12 CSO events per year;
- 20 CSO events per year; and
- 85% capture by volume of the combined sewage collected in the combined sewer system during precipitation events on an annual average basis.

SECTION B FUTURE CONDITIONS

B.1 INTRODUCTION

This section presents the population projections used in the modeling effort for Kearny, along with planned projects and future wastewater flows.

B.2 PROJECTIONS FOR POPULATION GROWTH

The current population in Kearny is taken as 52,792. The projected 2045 population is estimated to be 57,415. This is based on the North Jersey Transportation Planning Authority (NJTPA) 2045 population projection and planned new development areas. Typical year 2004 rainfall and tides data, as well as average evapotranspiration rates were used to model future conditions.

B.3 PLANNED PROJECTS

Several residential development projects are planned in Kearny. These are shown on Figure 3, which illustrates the planned developments and their location within the Town.

B.4 PROJECTED FUTURE CSO FREQUENCIES AND VOLUMES

The model calculated the number of CSO events for each outfall, and volume in million gallons (MG). This was done for two distinct scenarios. The first, Scenario A, is based on current conditions.

B.4.1 Baseline A Scenario – Current Conditions

Based on existing conditions, with five CSO outfalls in operation, the model calculated the following number of CSO events and volumes for each outfall:

Table B-1 – CSO Frequency and Volume, Baseline A		
Outfall No.	CSO Event Count	Total Volume (MG)
001A	31	3.9
004A	42	12.4
006A	57	121.8
007A	34	90.0
010A	43	26.6
Entire Town	61	254.7

As seen above, the total annual number of CSO events is calculated to be 61. The volume of CSO discharges per year ranges from approximately 4 MG per year at outfall 001A (Stewart Avenue) to 122 MG per year at Outfall 006A at Johnston Street. Total CSO volume is approximately 255 MG.

B.4.2 Baseline B Scenario - Sewer Separation at Outfall 010A

The Town of Kearny has committed to achieving sewer separation for the sewers tributary to Outfall 010A, located in the vicinity of Dukes Street. At the time of this writing, plans and specifications are being finalized for the construction of the sewer separation project, along with an associated pumping station. When completed, the storm water and sanitary sewage in this sub catchment area will be

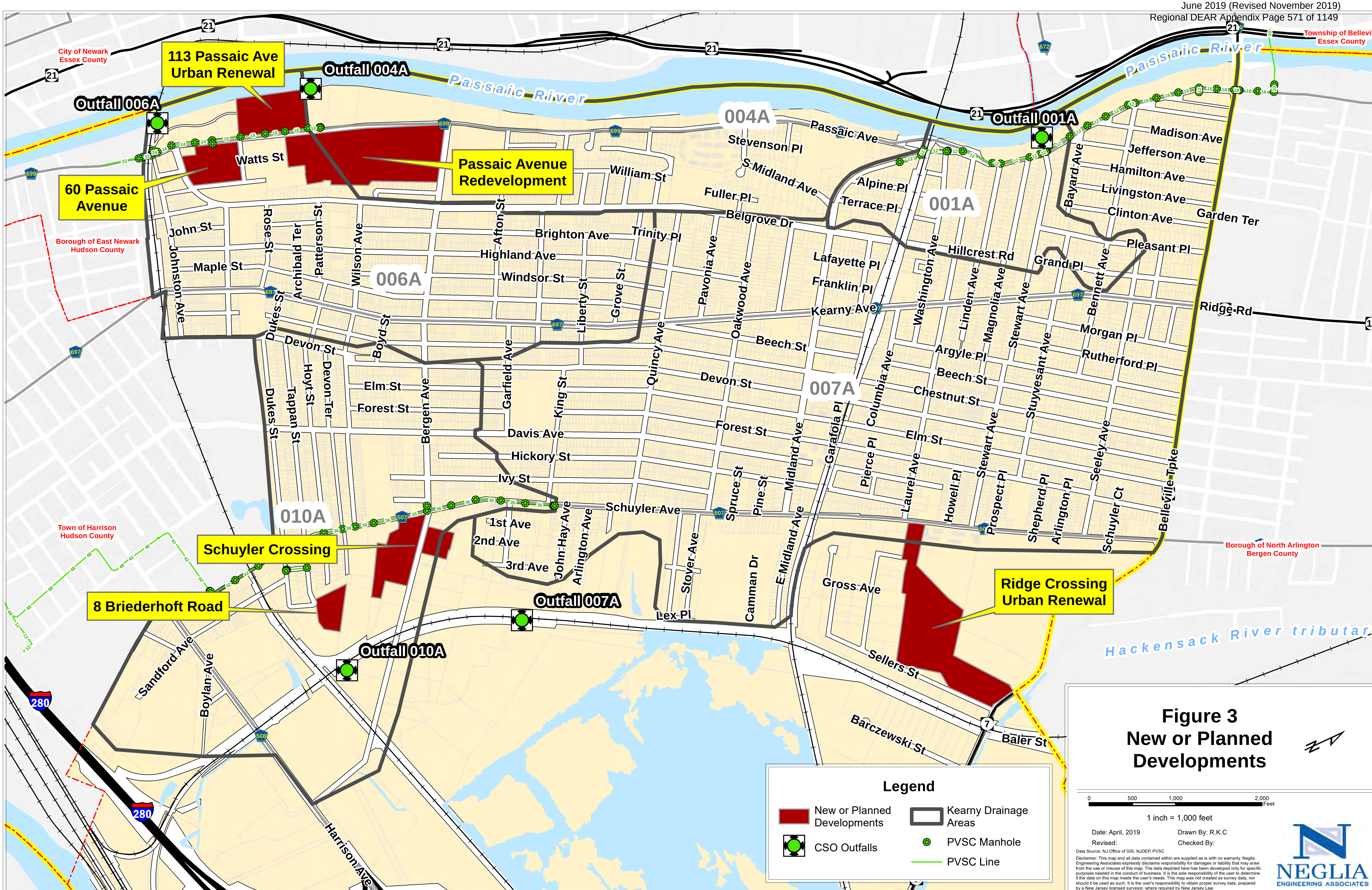


Figure 3
New or Planned Developments
113 Passaic Ave Urban Renewal
Passaic Avenue Redevelopment
60 Passaic Avenue
Schuyler Crossing
8 Briederhoft Road
Ridge Crossing Urban Renewal
Outfall 006A
Outfall 004A
Outfall 001A
Outfall 007A
Outfall 010A
004A
001A
006A
007A
010A
Passaic River
Hackensack River tributary
City of Newark
Essex County
Borough of East Newark
Hudson County
Town of Harrison
Hudson County
Township of Belleville
Essex County
Borough of North Arlington
Bergen County
Legend
New or Planned Developments
Kearny Drainage Areas
CSO Outfalls
PVSC Manhole
PVSC Line
0
500
1,000
2,000
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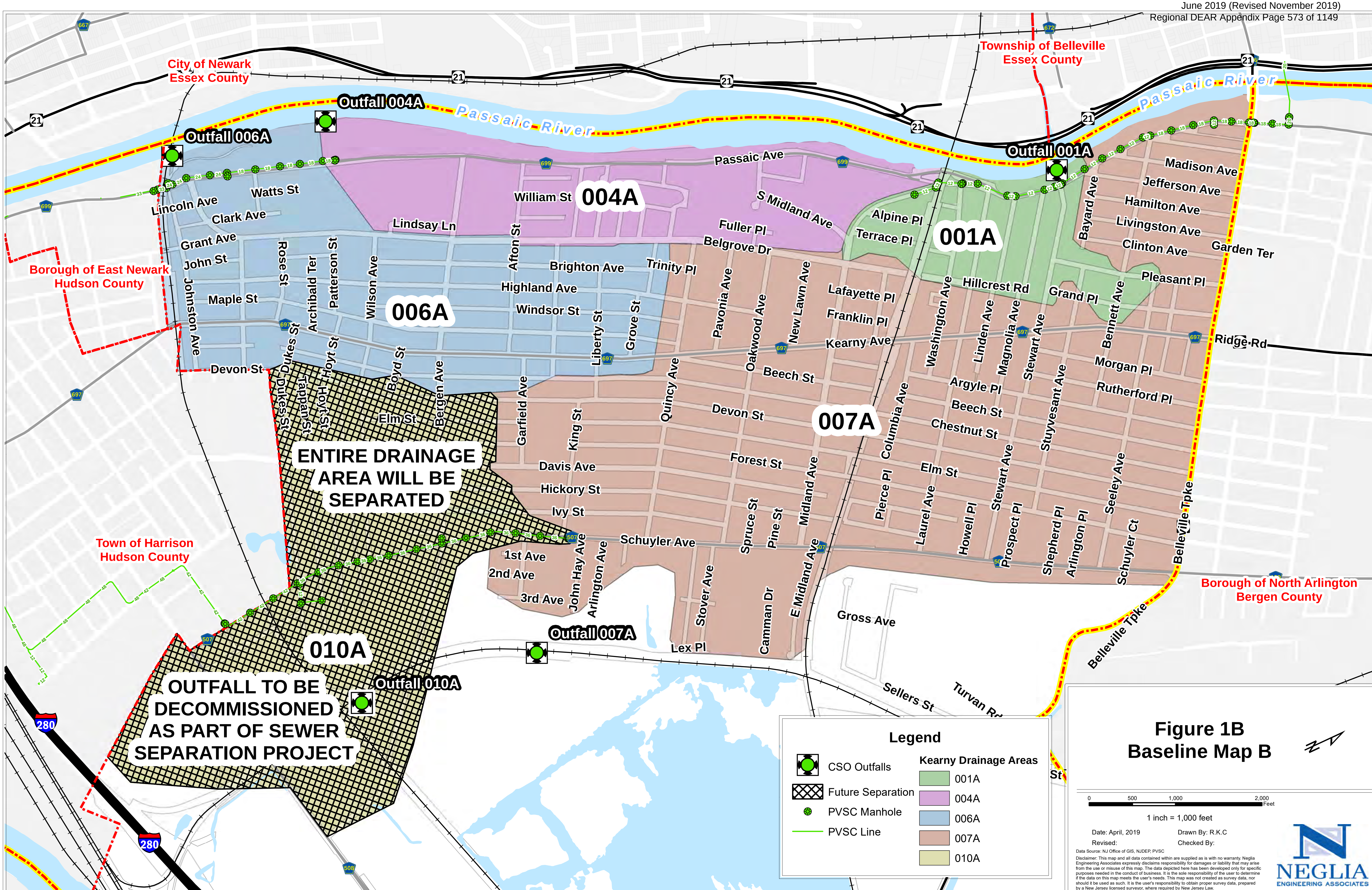
1 inch = 1,000 feet
Date: April, 2019
Drawn By: R.K.C
Revised:
Checked By:
NEGLIA
ENGINEERING ASSOCIATES

conveyed by separate storm and sanitary sewers. Thus, there will be zero CSO events at Outfall 010A upon completion of the project. This scenario was modeled as Baseline B. All alternatives developed in this report are based on Baseline B – i.e. zero CSO events from Outfall 010A. This is shown on Figure 1B.

Based on the upcoming elimination of CSO events at Outfall 010A, the model calculated the following number of CSO events, and volumes, at each outfall.

Table B-2 – CSO Frequency and Volume, Baseline B		
Outfall No.	**CSO Event Count**	**Total Volume (MG)**
001A	31	3.9
004A	42	12.4
006A	57	120.2
007A	32	83.8
010A	0	0.0
Town wide	61	220.3

As seen from the above, the total number of CSO events does not change as a result of sewer separation at Outfall 010A. However, the total volume of CSO discharges is reduced from 255 MG to 220 MG, a 13.5% decrease.


City of Newark
Essex County
Township of Belleville
Essex County
Borough of East Newark
Hudson County
Town of Harrison
Hudson County
Borough of North Arlington
Bergen County
Passaic River
Outfall 004A
Outfall 006A
Outfall 001A
Outfall 007A
Outfall 010A
004A
006A
001A
007A
010A
ENTIRE DRAINAGE AREA WILL BE SEPARATED
OUTFALL TO BE DECOMMISSIONED AS PART OF SEWER SEPARATION PROJECT
Legend
CSO Outfalls
Future Separation
PVSC Manhole
PVSC Line
Kearny Drainage Areas
001A
004A
006A
007A
010A
Figure 1B
Baseline Map B
0
500
1,000
2,000
Feet
1 inch = 1,000 feet
Date: April, 2019
Drawn By: R.K.C
Revised:
Checked By:
NEGLIA
ENGINEERING ASSOCIATES

SECTION C SCREENING OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

A wide range of CSO control technologies were considered for application in the Town of Kearny combined sewer system ("CSS"). The Town of Kearny systematically evaluated various control alternatives using technology categories. The technologies are grouped into the following categories:

- Source Control (Including Green Infrastructure);
- Base Flow Reduction;
- Sewer System Optimization;
- Inline Storage;
- Offline Storage;
- Wastewater Treatment Plant (WWTP) Expansion or Storage at the Plant;
- Sewer Separation; and
- Treatment of CSO Discharge.

The above technologies are described in further detail below and a summary assessment is provided in Table C-7.

C.2 SOURCE CONTROL

As a means of controlling stormwater runoff volumes and pollutants at the source, management technologies can be applied where the subject stormwater runoff and pollutants tend to accumulate. Applicable source technologies are categorized and described below:

C.2.1 Stormwater Management

- Street / Parking Lot Storage (Catch Basin Control): This includes storage of stormwater runoff on streets and/or parking lots to reduce the peak flow during wet weather events. This would be achieved by restricting the occurrence of CSOs and permitting controlled flooding within the streets and parking lots. However, the storage of combined sewage within streets and parking lots would create a public health hazard, would generate considerable public opposition and could potentially create hazardous flooding and freezing problems. It is also noted that this alternative would result in minimal bacteria and volume reduction, which are considered pollutants of concern. Therefore, this alternative has been eliminated from any further consideration.

- Catch Basin Modifications for Floatable Controls: The major objective of catch basin modifications for floatable controls is to capture and restrict the conveyance of floatables to the combined sewer system. This is generally achieved by retrofitting existing catch basins with curb pieces containing openings that do not allow for floatables of certain sizes (greater than 2 inches) to pass through to the combined sewer system. Furthermore, the Town of Kearny ensures that all new catch basin construction, including on private property, contain grates and curb openings that are effective at controlling floatables. While, this is not an effective measure of achieving bacteria and volume reduction associated with CSOs, it is effective at reducing the quantity of floatables that are captured within the combined sewer system. Therefore, the Town of Kearny continues to retrofit existing catch basins with Type N-Eco curb pieces, which typically have narrow, 1-1/2 inch wide openings, during roadway rehabilitation projects to ensure that floatables are less likely to enter. Furthermore, the Department of Public Works is vigilant about cleaning catch basins on a regular basis (including after significant rainfall events) and clearing the same of all debris. This alternative is considered to be implemented to a satisfactory level.

- Catch Basin Modifications for Leaching: A leaching catch basin is a modified catch basin that is fabricated of barrel and riser sections and permits the infiltration of stormwater runoff into the ground. Furthermore, a leaching catch basin would include an overflow pipe to ensure that excess stormwater runoff that does not infiltrate into the ground is conveyed to the combined sewer system and does not back up, which would result in localized flooding. This application could be utilized on existing street catch basins or can be constructed within new private developments. However, in order to achieve any bacteria or CSO volume reduction, this alternative would need to be implemented on a widespread scale. In addition, the effectiveness of leaching catch basins is contingent upon the permeability of the soil within the Town. Due to its minimal impact on CSO volume and bacteria reduction, as well as the uncertainty of soil permeability rates, this technology is eliminated from further consideration.

C.2.2 Public Education and Outreach

Public education and outreach programs are intended to notify the public of the CSO problem and to provide guidance on measures that community members can undertake to reduce CSO volume and associated bacteria. Generally, public education and outreach programs have minimal impacts on the volume, frequency or duration of CSO overflows. However, these programs tend to be effective at improving the CSO quality by promoting the reduction of floatable debris within the combined sewer system. Public education and outreach is inclusive of the following:

- Water Conservation: Effective water conservation programs would urge the public to reduce water consumption and thereby mitigate the volume of wastewater generated. The inherent benefit would be to reduce dry weather flow in the combined sewer system to create additional storage volume during wet weather events. Water conservation generally has no impact with respect to bacteria reduction and minimal impact on the overall CSO volume reduction. This is discussed further in Section C.4 where a 10% reduction in base flow was modeled and produced a minimal impact in CSO volume. Furthermore, it is noted that the Town does not own the water system. In light of the above factors, and understanding that the precise impact of water conservation on CSO volume and frequency cannot be accurately quantified, this alternative is eliminated from consideration with respect to the LTCP. However, the Town will consider water conservation programs moving forward as a means of general good stewardship, conservation of resources, etc.
- Catch Basin Stenciling: Effective catch basin stenciling includes installation of street pavement markings notifying the general public that waste flow (i.e. floatables) passing through the catch basins may ultimately discharge to a waterbody. While catch basin stenciling would have no impact on bacteria and volume reduction associated with CSOs, it may result in a reduction of floatables encountered within the combined sewer system, which would be beneficial to the overall longevity of the Town's CSO netting facilities at the outfalls. Furthermore, this is an alternative that could be implemented via public volunteers and serves as a significant opportunity to educate the public about CSOs. While the Town will consider reaching out to local volunteer groups to implement stenciling, this item is eliminated from further consideration with respect to the LTCP.
- Community Cleanup Programs: Similar to catch basin stenciling, as described above, community cleanup programs provide an opportunity for the public to engage and may result

in a reduction of floatables entering the combined sewer system. The Town has implemented a community cleanup program.

- Public Outreach Programs: The Town of Kearny has an independent public participation citizens group, Kearny AWAKE (Association of Water, Agriculture and Kearny's Environment), that was formed to provide input of the LTCP process and to educate the public on the CSO issues, along with general environmental issues associated with Kearny. Kearny AWAKE includes a Council member who serves as a liaison and provides updates at Town Council meetings. The Town's Consulting Engineer (NEA) has met with Kearny AWAKE to provide updates on the LTCP progress and to receive input on the same. The Consulting Engineer will continue to meet with Kearny AWAKE and will seek public input accordingly. It is also recommended that the Town engage Kearny AWAKE to participate in water conservation promotion, catch basin stenciling, and community cleanup efforts, as described above. It is noted that two (2) members of Kearny AWAKE participate in the PVSC Group Supplemental CSO Team. Public outreach technologies will be considered in conjunction with other control technologies.
- Fat, Oils and Grease Program: During the site plan review process (i.e. for applications appearing before the Zoning and Planning Boards) in Kearny, certain developments that will produce fats, oils and greases are required to provide grease traps to ensure that the aforementioned substances are not conveyed to the combined sewer system. This alternative has been implemented to a satisfactory level.
- Garbage Disposal Restriction: The Town of Kearny has weekly garbage and recycling collections. Information related to the same is provide on the Town's website. This alternative has been implemented to a satisfactory level.
- Pet Waste Management: The Town of Kearny regularly uses the Town website to notify the public of the requirements established within the Town's Pet Waste Ordinance and will continue to do so. This alternative has been implemented to a satisfactory level.
- Lawn and Garden Maintenance: The Town of Kearny regularly uses the Town website to notify the public of the guidelines for lawn and garden maintenance provided by the United States Environmental Protection Agency (USEPA). This alternative has been implemented to a satisfactory level.
- Hazardous Waste Collection: The Town of Kearny does not currently provide Hazardous Waste collection. However, the Town's website does include guidance as it relates to paint and battery guidance. Hazardous waste dumping is currently illegal in Kearny.

C.2.3 Ordinance Enforcement

The objective of ordinance enforcement as it relates to the occurrence of CSOs is to enact ordinances that may reduce the volume and/or bacteria loading of CSOs. Potential ordinance enforcements alternatives that have been considered for evaluation are further described below:

- Construction Site Erosion & Sediment Control: The Town of Kearny requires that new developments comply with the Standards for Soil Erosion and Sediment Control. The requirements of the same are enforced during the Planning / Zoning Board review process as well as on-site inspections conducted during construction. This alternative is satisfactorily implemented.

- Illegal Dumping Control: The Town of Kearny has ordinances that regulate procedures for disposal of waste and materials. These ordinances outline violations and penalties related to illegal dumping activities. These ordinances, along with the associated violations and penalties, are generally enforced by the Town of Kearny Department of Public Works and Police Department. This control measure has been satisfactorily implemented.
- Pet Waste Control: The Town of Kearny has ordinances that require proper disposal of pet waste. These ordinances contain violations and penalties for pet owners who fail to comply with the same. These ordinances, along with the associated violations and penalties, are generally enforced by the Town of Kearny Department of Public Works and Police Department. This control measure has been satisfactorily implemented.
- Litter Control: The Town of Kearny has an ordinance which requires property owners and/or tenants to keep properties, as well as the sidewalk, curbs and alleyways abutting the properties, free of litter. This ordinance is generally enforced by the Town of Kearny Department of Public Works and Police Department. This control measure has been satisfactorily implemented.
- Illicit Connection Control: The Town of Kearny has an illicit connection ordinance related to connections of domestic sewage, non-contact cooling water, process waste water, or other industrial waste (other than stormwater) to the separate municipal stormwater conveyance system. Overall, illicit connection control is difficult to monitor and is more applicable to separated sewer systems. Due to these factors, this control measure is eliminated from further consideration.

C.2.4 Good Housekeeping

Effective housekeeping is inclusive of practices put in place by the Town to reduce the volume of solids and pollutant loading within the combined sewer system. Overall, the goal of good housekeeping practices is to maximize the storage volume within the conveyance system while ensuring that potential pollutants are treated at the source.

- Street Sweeping/Flushing: The Town of Kearny conducts street sweeping operations on a weekly basis Monday through Thursday. Street signs indicating the hours when parking is prohibited are posted along the sweeping routes. Street sweeping has been implemented to a satisfactory level.

  The intent of combined sewer flushing is to re-suspend settled sewage solids and transmit the same to the wastewater treatment plant during dry weather to prevent stormwater runoff collected during a storm event from flushing these solids to a receiving water body. Overall, the process includes introducing a controlled volume of water over a short duration at key points in the conveyance system. This is done using external water from a tank truck by gravity or pressurized feed or using internal water detained manually or automatically. While the Town of Kearny sometimes uses sewer flushing to alleviate flooding areas, it is generally understood that sewer flushing is more beneficial when applied to flat collection systems. Generally, pipes within the combined system are sufficiently pitched to achieve ample conveyance. Therefore, it is not expected that combined sewer flushing will result in a reduction of CSO volume/events or a reduction in the pollutant loading. Due to the limited benefits of this alternative, it will not be further evaluated.

- Leaf Collection: The Town of Kearny Department of Public Works conducts planned curbside collection of leaves placed within biodegradable bags. The Town does not permit piling of leaves within the street. Leaf collection has been implemented to a satisfactory level.
- Recycling Program: The Town of Kearny has weekly recycling collections. A recycling program has been implemented to a satisfactory level.
- Storage/Loading/Unloading Areas: The Town of Kearny has requirements for storage and loading/unloading areas, as stipulated within the zoning ordinance and site plan review ordinances. These requirements provide the ratio of storage and loading/unloading areas based on the overall size of the proposed development. The requirements are enforced during the Planning/Zoning Board review process. While there are limited benefits to the overall CSO issue that are obtained via the provision of designated storage and loading/unloading areas, the Town of Kearny has implemented this alternative to a satisfactory level.
- Industrial Spill Control: The PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1. This item has been implemented to a satisfactory level.

C.2.5 Green Infrastructure

C.2.5.1 Introduction / Definition of Green Infrastructure

Green Infrastructure (GI) refers to a category of measures that can be used to capture storm water before it enters the sewer system, and conveys that flow into the ground via infiltration, or to the atmosphere via evapotranspiration. GI measures will reduce the quantity of storm flow entering into Kearny's combined sewers, and thereby will play a contributing role in reducing the overall volume of CSOs and the number of CSO events. The 2015 NJPDES permit for the Town of Kearny (and all the PVSC CSS permitees) stipulates that GI measures must be included as a component of the Long Term Control Plan (LTCP), to achieve CSO reduction.

The NJDEP has defined Green Infrastructure as follows:

"Green Infrastructure means methods of stormwater management that reduce wet weather/stormwater volume, flow, or changes the characteristics of the flow into combined or separate sanitary or storm sewers, or surface waters, by allowing the stormwater to infiltrate, to be treated by vegetation or by soils; or to be stored for reuse. Green infrastructure includes, but is not limited to, pervious paving, bioretention basins, vegetated swales, and cisterns".

C.2.5.2 Types of GI Measures

The GI measures considered in the PVSC Public Participation Process Report for Kearny include the following:

- Rain Gardens;
- Tree Pits;
- Harvesting of Rain Water; and
- Porous Pavements.

For detailed descriptions of Green Infrastructure measures, the reader is referred to the 2018 Technical Guidance Manual (TGM) and other NJDEP source material. However, brief descriptions are included below.

- Rain Gardens – consist of a shallow depressed area, with native plants and vegetation, to collect storm water runoff. The collected runoff infiltrates into the ground, or is lost to evaporation, or is transpired by the vegetation. Loading rates are typically 5 to 1 or less; for example, 1 acre of rain garden is needed to capture runoff from a 5 acre area. Porous soil is also needed for the system to perform as intended. Rain gardens have been used in New Jersey and across the country and are considered viable for use in Kearny's LTCP and are therefore retained for further consideration. Rain gardens were included in the modeling effort and costs for rain gardens are included in Tables D-4 and D-5.
- Right-of-Way Bioswales – similar to a rain garden, except that is is constructed along the curb, specifically designed to intercept street runoff, and is deeper than a rain garden, typically 4-1/2 feet deep. R.O.W. bioswales are considered viable for use in Kearny's LTCP and are retained for further consideration. R.O.W. bioswales were included in the modeling effort, and costs for bioswales are included in Tables D-4 and D-5.
- Enhanced Tree Pits – this measure uses an underground system of underdrains, crushed stone and porous soil, designed to infiltrate runoff. Where multiple tree pits are installed, it may be feasible to install permeable pavement between the tree pits. Enhanced tree pits may be feasible for some areas of Kearny and are retained for further consideration in the LTCP.
- Green Roofs – consist of a vegetative layer with porous soil and an underdrain system, all constructed on top of a building roof. The system only collects storm water falling on the roof, and the existing roof may require costly modifications to accept the Green Roof. Green roofs were included in the modeling effort and costs are shown in Tables D-4 and D-5. As seen in Tables D-4 and D-5, green roofs are the most costly of all the GI measures investigated. Therefore, green roofs are eliminated from further consideration.
- Porous Pavements – this measure includes porous asphalt, porous concrete, and porous interlocking concrete pavers (PICP). A stone layer beneath the pavement stores the collected storm water, before it infiltrates into the ground. Of all the types of porous pavements, porous asphalt may have the most potential for use in Kearny, particularly in parking areas. This is shown later in this section, where specific sites in Kearny are evaluated. Porous asphalt lacks the fines included in standard pavement, allowing water to migrate through it. Porous asphalt, porous concrete and porous CICP were modeled, and costs are presented in Tables D-4 and D-5. Porous asphalt is less sturdy than standard pavement, and is not suitable for high traffic areas. In general, porous pavements may be viable for some areas in Kearny, and are retained for further consideration in the LTCP, in conjunction with other technologies.
- Blue Roofs – these are roof systems which are designed to store storm water. Blue roofs can have the potential for leaks, and can be costly. Blue roofs have been installed in New York City. Due to the nature of the properties in Kearny, and proposed new developments, blue roofs are eliminated from further consideration.
- Rainwater Harvesting – for some of the sites investigated in Kearny, discussed below, harvesting of rainwater in cisterns was a measure suggested in the PPP Plan. Harvesting in cisterns is simple, and low maintenance, but may have little overall impact on Town wide CSO frequency and volume. Harvesting may be considered in conjunction with other Green Infrastructure measures.
- Planter Boxes – like rain gardens and right of way bioswales, planter boxes are another means of bioretention. Suitable locations in Kearny for large planter boxes may be limited. However, this control measure will be retained for further consideration in conjunction with other technologies.

C.2.5.3 Public Participation Process Report

In June 2018 PVSC submitted its Public Participation Process (PPP) Report to the NJDEP, on behalf of all of its CSS permittees. The Public Participation Process Report included a discussion of Green Infrastructure measures that could potentially be implemented within each municipality in the Study Area. For Kearny, a total of thirteen (13) Green Infrastructure sites were identified, with recommendations for implementing GI measures presented for each site. These sites, and the recommendations made in the Public Participation Process Report, are now discussed. Also discussed is NEA's field investigations to confirm the PPP findings.

Refer to Figure 4, Map of Green Infrastructure Sites, which illustrates the potential GI sites within the Town of Kearny, as per the PPP Report. Also shown are two additional sites which were suggested by a local citizens' group known as Kearny AWAKE.

C.2.5.4 Field Investigation

In January 2019, Neglia Engineering Associates (NEA) conducted its own field investigation, to evaluate and confirm the feasibility of GI measures at each of the sites listed in the PPP Report. Each listed site was visually inspected, photos were taken, to confirm the most up to date site conditions.

C.2.5.5 Site Evaluation

The thirteen (13) sites identified for Kearny in the Public Participation Process Report are as follows:

- Dowd Playground – 10 Devon Terrace;
- First Presbyterian Church – 663 Kearny Avenue;
- Girl Scout Building – 635 Kearny Avenue;
- Gunnel Oval – 520 Schuyler Avenue;
- Kearny Branch Public Library – 759 Kearny Avenue;
- Department of Public Works (DPW) Garage – 357 Bergen Avenue;
- Fire Department Engine 1 – 47 Davis Avenue;
- Main Public Library – 318 Kearny Avenue;
- Public Health Center – 645 Kearny Avenue;
- Riverside Park – 925 Passaic Avenue;
- Town Hall – 402 Kearny Avenue;
- Public Parking Lot – 101 Kearny Avenue; and
- Roosevelt School – 733 Kearny Avenue.

Of the above sites, those located on public lands owned by the Town of Kearny are the most desirable, in terms of availability, access and obtaining approval for use. Those sites not owned by the Town of Kearny are eliminated from consideration. These include the First Presbyterian Church and the Roosevelt School.

In addition, the Dowd Playground is located on Devon Terrace, which is on a steep slope. Due to the steepness of the slope, GI measures may prove to be ineffective, as surface runoff would likely predominate, rather than infiltration. Therefore the Dowd Playground site is not considered a desirable site.

Gunnel Oval is a large recreational area which is now undergoing improvements. Additional site features such as Green Infrastructure measures are not included in the current construction. Since much of the area consists of ballfields, the site is not considered amenable to GI measures such as rain gardens, bioswales, etc.

The remaining nine (9) sites are discussed as follows:

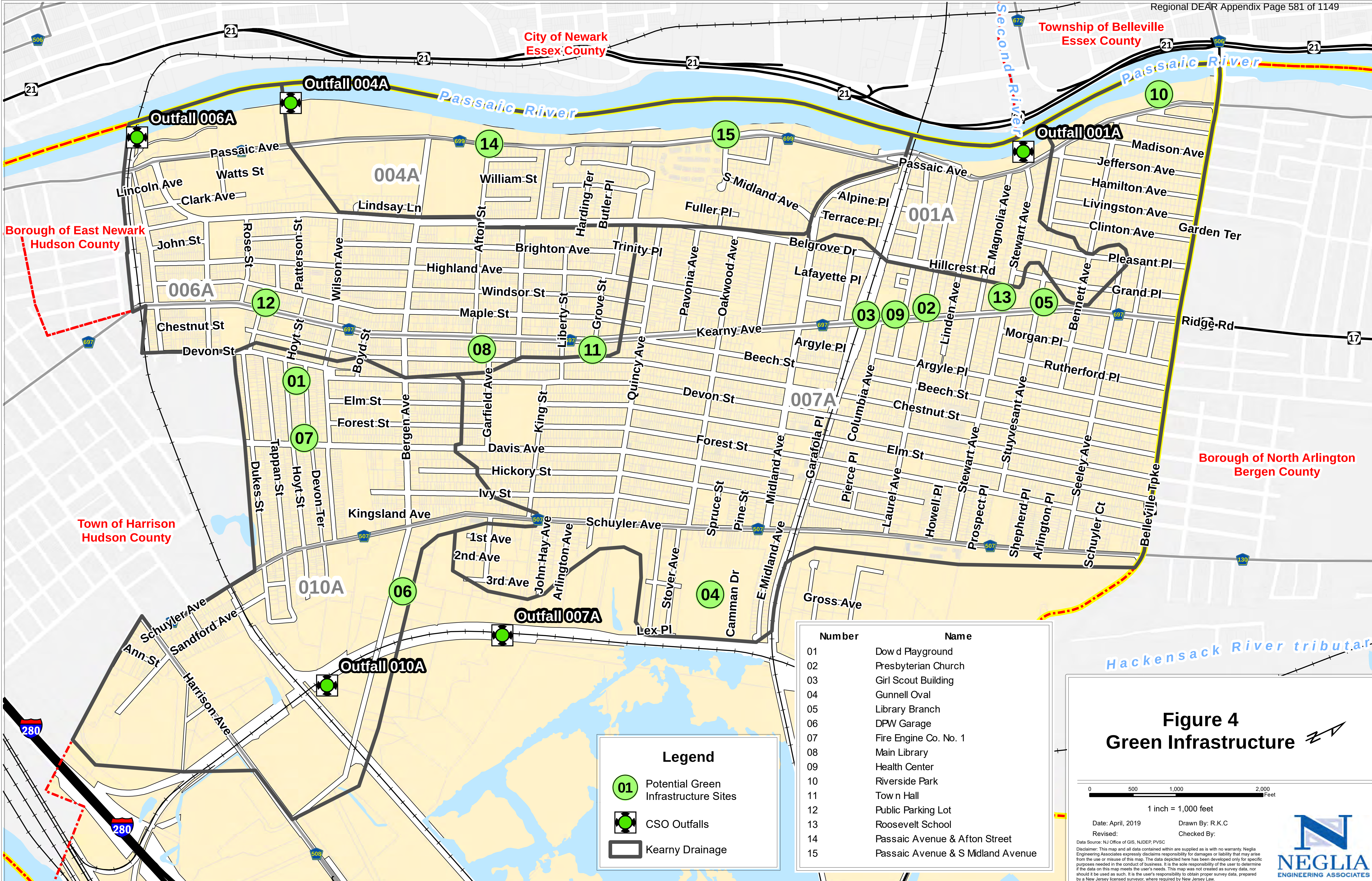


Figure 4
Green Infrastructure

0 500 1,000 2,000 Feet

1 inch = 1,000 feet

Date: April, 2019 Drawn By: R.K.C
Revised: Checked By:

Data Source: NJ Office of GIS, NJDEP, PVSC

Disclaimer: This map and all data contained within are supplied as is with no warranty. Neglia Engineering Associates expressly disclaims responsibility for damages or liability that may arise from the use or misuse of this map. The data depicted here has been developed only for specific purposes needed in the conduct of business. It is the sole responsibility of the user to determine if the data on this map meets the user's needs. This map was not created as survey data, nor should it be used as such. It is the user's responsibility to obtain proper survey data, prepared by a New Jersey licensed surveyor, where required by New Jersey Law.

NEGLIA ENGINEERING ASSOCIATES

Legend

- 01 Potential Green Infrastructure Sites
- CSO Outfalls
- Kearny Drainage

Number	Name
01	Dowd Playground
02	Presbyterian Church
03	Girl Scout Building
04	Gunnell Oval
05	Library Branch
06	DPW Garage
07	Fire Engine Co. No. 1
08	Main Library
09	Health Center
10	Riverside Park
11	Town Hall
12	Public Parking Lot
13	Roosevelt School
14	Passaic Avenue & Afton Street
15	Passaic Avenue & S Midland Avenue

- <u>Girl Scout Building (Site No. 3):</u> The Girl Scout Building, located at 635 Kearny Avenue, has a paved parking area on the south side of the building, which could be repaved with porous pavement, to capture and infiltrate storm water. Roof runoff, which currently discharges to the municipal conveyance system, could instead be captured in a cistern, and used onsite for lawn watering. The cistern would be located near the garage at the southeast corner of the building. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of the existing soil for GI implementation. See photographs No. 1 and 2.

Photo No. 1 – Grassed area in front of Girl Scout Building

Photo No. 2 - Parking Area and Garage at Girl Scout Building

- Kearny Public Health Center (Site No. 9): The Public Health Center is located at 645 Kearney Avenue, adjacent to the Girl Scout Building. The two buildings are separated by a driveway. There are two grassed areas in front of the building on either side of a paved walkway. Rain gardens could be installed in each of these grassed areas to capture, treat and infiltrate roof runoff. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of the existing soil for GI implementation. See photograph No. 3.

Photo No. 3 – Health Center Building

- Kearny Branch Public Library (Site No. 5): The Kearny Branch Public Library is located at 759 Kearny Avenue at the corner of Stuyvesant Avenue. The side of the building facing Stuyvesant Avenue has a large lawn area. This area has the potential for rain garden installation to capture, treat and infiltrate roof runoff. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of the existing soil for GI implementation. See Photograph No. 4.

Photo No. 4 - Branch Public Library Side Lawn Area Facing Stuyvesant Avenue

- Kearny Main Public Library (Site No. 8): The Kearny Main Public Library is located at 318 Kearny Avenue, at the corner of Garfield Avenue. A grassed area at the northwest corner of the lot could be the site of a rain garden to capture, treat and infiltrate roof runoff. Additional roof runoff could be collected in a cistern near the garage. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the existing soil's suitability for GI implementation. See Photograph No. 5 below.

Photo No. 5 – Kearny Main Library Side Lawn Area

- Kearny Town Hall (Site No. 11): The Town Hall is located at 402 Kearny Avenue. There is a paved parking lot in the back of the building facing out to Chestnut Street. This area could be repaved with porous pavement. At the front of the building, trees with tree pits could be planted in the sidewalk. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of the existing soils for GI implementation. See Photograph No. 6.

Photo No. 6 – Kearny Town Hall Rear Parking Lot

- Public Parking Lot (Site No. 12): The Town of Kearny owns and maintains a public parking lot located on Kearny Avenue near the intersection with Dukes Street and in the vicinity of the municipal boundary with the Town of Harrison. Within the parking lot is a concrete island with plantings. A rain garden at this location might be more effective in capturing, treating, and infiltrating parking lot runoff. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of the existing soils or GI implementation. See Photograph No. 7.

Photo No. 7 – Traffic Island in Public Parking Lot on Kearny Avenue and Dukes Street

- Department of Public Works (DPW) Garage (Site No. 6): The DPW Garage is located at 357 Bergen Avenue near the abandoned railroad tracks. The PPP Report identified this site as amenable to collection of storm water via cisterns, which would be located at a building corner for collection and on-site use. Additionally the parking area could be repaved with porous pavement. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of existing soils for GI implementation.

- Fire Department Engine No. 1 (Site No. 7): Fire Department Engine No. 1, located at 47 Davis Avenue, was identified in the PPP Report as potentially suitable for collection and storage of rain runoff via on-site cisterns. Additionally the parking area could be repaved with porous pavement. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of existing soils for GI implementation.

- Riverside Park (Site No. 10): Riverside Park is located at the northwest corner of the Town. The PPP Report recommended porous pavement be installed in the parking area, and a rain garden within the park. The park offers a lot of potential for implementing GI measures as it provides a large, non-paved area. NEA concurs that this site is feasible for implementing GI. As stated in the Public Participation Process Report, further soil testing is needed to determine the suitability of existing soils for GI implementation.

- Additional Green Infrastructure Sites: In February 2019, a meeting was held between NEA and the Kearny AWAKE Group. NEA discussed the overall LTCP process as it relates to Kearny and sought feedback on the same. Kearny AWAKE concern with the inclusion of Green Infrastructure in the LTCP noted two particular areas which have been prone to flooding during and after rainstorms. One such area is located along Passaic Avenue near Afton Street, while the second is located along Passaic Avenue near South Midland Street. These are shown as Site Numbers 14 and 15 on Figure 4. Kearny AWAKE suggested the use of bioswales and eddy basins to help mitigate flooding in those areas.

C.3 COMBINED SEWER SEPARATION

Sewer separation includes the construction of new storm water conveyance pipes which direct storm flow to outfalls at receiving water bodies, while separate sanitary sewers direct sewage flows to the WWTP, thereby eliminating CSO outfalls.

Two levels of sewer separation have been evaluated. The first is total sewer separation for the entire Town of Kearny. The second is partial sewer separation in Drainage Area 010 only. Drainage Area 010 is approximately 93 acres. Sewers have previously been separated in portions of this area, covering approximately 50 acres. For purposes of this study, partial sewer separation refers to separating the sewers in the remaining 43 acres, such that all of Area 010 has separate sewers, and zero CSO events will occur in this drainage area. Refer to Figures 1A and 1B. The Town is committed to achieving complete separation of sewers in all of Drainage Area 010. A project is currently in design and will go into construction in the near future, which will achieve this goal. The development and evaluation of alternatives includes two different baselines, labelled as Baseline A and Baseline B. Baseline A refers to the current infrastructure, including all five drainage areas, while Baseline B accounts for sewer separation in Drainage Area 010, with that area removed from the analysis. All Alternatives shown and evaluated in Section D are based on Baseline B, (i.e. they include sewer separation in Area 010).

- Roof Leader Disconnection: Disconnecting roof leaders and area drains from the storm sewers would need to be coupled with other Green Infrastructure measures, in order to provide an outlet for the discharge of this flow. This measure also requires cooperation from home and business owners. This control measure is eliminated from further consideration.
- Sump Pump Disconnection: This control measure is similar to roof leader disconnection as discussed above. With limited outlets for discharging to pervious areas, sump pump disconnection would need to be combined with other Green Infrastructure measures. This measure also requires cooperation from home and business owners. This control measure is eliminated from further consideration.

C.4 REDUCTION IN BASE FLOW

Reduction in base flow, i.e. dry weather flow, can be achieved through measures such as water conservation or Infiltration/Inflow (I/I) reduction. For separated sanitary sewer systems, I/I reduction has the potential to improve the performance of the sanitary conveyance system by removing storm flow which comes from roof drains, sump pumps, etc, thus alleviating sanitary sewer overflows (SSOs), and excessive flows coming to the wastewater treatment plant. For combined systems, I/I reduction is expected to have little impact on the number and volume of CSOs, as the majority of the CSO volume is not coming through leaks in the sewer piping, but from sanitary flow and precipitation. It was noted in Section C.2 that water conservation will have minimal impact on CSO volume and frequency. Both water conservation and I/I reduction have no impact on pathogen removal.

A 10 percent reduction in base flow was modeled. This reduction is based on a combination of water conservation and I/I reduction. The quantitative impacts resulting from this modeling effort are shown in Tables C-1 and C-2, shown previously in Section C.2.5. A 10 percent reduction in base flow resulted in a 1.6 percent reduction in overall Town wide CSO frequency, and a 1.4 percent reduction in overall Town wide CSO volume.

Based on the above analysis, base flow reduction is eliminated from further consideration.

C.5 COMBINED SEWER OPTIMIZATION

Sewer System Optimization refers to increasing storage and conveyance capacity in the sewers. This can be done via several measures, including additional sewer construction, regulator modifications, outfall consolidation/relocation or real time control.

C.5.1 Additional Sewer Construction

Constructing additional sewers to increase capacity would be costly. In addition, all residential and commercial areas within the Town are served by the municipal sewer system. Therefore, any new sewer construction in Kearny would be part of a sewer separation project. Sewer separation is discussed elsewhere in this report.

C.5.2 Regulator Modifications

Regulator modifications can include adding baffles for floatables capture, or raising the weirs in the chamber to keep more flow in the collection system. Raising the overflow weir in each Regulator Chamber by 6 inches was modeled. The results are tabulated in Tables C-1 and C-2 shown previously in Section C.2.5.

As Tables C-1 and C-2 illustrate, there was a negligible reduction in CSO frequency and volume resulting from this control measure. The model predicted zero percent reduction in Town wide CSO frequency, and 1.2 percent reduction in Town wide CSO volume. In addition, Outfalls 007 and 010 are located in low lying areas which experience flooding on a regular basis. Outfalls 004 and 006 are located in areas where the sewers have a history of surcharging. Thus raising the weirs in the regulators would only serve to intensify an existing problem in Kearny. Based on all of the above factors, increasing storage capacity in the sewers by raising the weirs in the regulator chambers is not considered feasible for Kearny and is eliminated from further consideration.

C.5.3 Outfall Consolidation/Relocation

Consolidation of outfalls reduces the number of discharge locations, thereby reducing O&M requirements and costs. It is also favorable from a regulatory standpoint. In Kearny, there is the potential to consolidate Outfalls 004A (Nairn Avenue) and 006A (Johnston Avenue) due to their close proximity to each other and the relative topography at these locations. Refer to the Town Drainage Area Map, Figure 1A. A single storage or treatment facility to serve both of those outfalls may be feasible. This will be investigated in further detail in the preparation of the 2020 Selection and Implementation Plan document.

C.5.4 Real Time Control

Automating the collection system with flow metering and feedback systems is not considered feasible for Kearny and is not considered for further evaluation. Further, such measures would need to be addressed with PVSC, the entity which owns the interceptor and the regulator chambers.

C.6 STORAGE

C.6.1 Inline Storage (CSO Tunnel)

Inline storage would consist of a single, large diameter tunnel extending from one end of Town to the other. The tunnel would have a single discharge outfall. The overflows from the other existing CSO outfalls KE 001, 004, 006 and 007 in Kearny would be piped to the tunnel. The tunnel would be approximately 10,000 feet in length and has been modeled based on 4, 8, 12, and 20 CSOs per year. A preliminary tunnel route is shown in Figure 5. Tunnel volumes for the target scenarios are shown below in Table C-1. Costs are presented in Section D.

Storage tunnel solutions considered in this evaluation include an analysis to optimize the size of one centralized storage tunnel necessary to achieve each CSO frequency target of 4, 8, 12, and 20 per year. This analysis assumes that the overflows from outfalls KE001, KE004, KE006, and KE007 will be directed to the centralized, deep storage tunnel. The tunnel is assumed to be 10,000 feet long, with varying diameters to achieve the required storage volume. The deep tunnel will store the CSOs generated during wet-weather events and would pump back to PVSC for treatment following the event or when there is available capacity in the system to treat the stored volumes. Required tunnel volumes for each of the target scenarios are shown below in Table C-3. Tunnel costs are included in Table D-3 in Section D. The tunnel option is retained for further consideration in the LTCP.

Table C-1 – Tunnel Storage (sized to fully capture all CSO for all but number of storms per year indicated)				
Outfall No.	Tunnel Volume for 4 CSO events/year (MG)	Tunnel Volume for 8 CSO events/year (MG)	Tunnel Volume for 12 CSO events/year (MG)	Tunnel Volume for 20 CSO events/year (MG)
Total	11.52	10.28	6.47	4.28

C.6.2 Offline Storage (Tanks)

Storage-tank solutions considered in this evaluation included an analysis to optimize the size of storage tanks at each outfall necessary to achieve each CSO-frequency target (4, 8, 12 and 20 per year). CSO is stored in the underground tanks during wet weather events and pumped back to the PVSC treatment plant when there is available capacity in the system. The storage tank would hold the flow for a maximum of three (3) days and then discharge the volume at a rate not to exceed 1.75 times the average dry weather flow when the PVSC treatment plant has the capacity to accept the flow. This analysis assumes that storage tanks will be constructed at locations upstream of the existing outfalls. Specific tank locations have not been identified in this report.

Storage Volumes were computed, for each target scenario, and for each outfall. These are shown below in Table C-2. Costs were estimated, based on the criteria of 4, 8, 12, and 20 CSO events per year. Costs for offline storage tanks are included in the Cost Summary Table in Section D. Offline storage tanks are retained for further consideration in the LTCP.

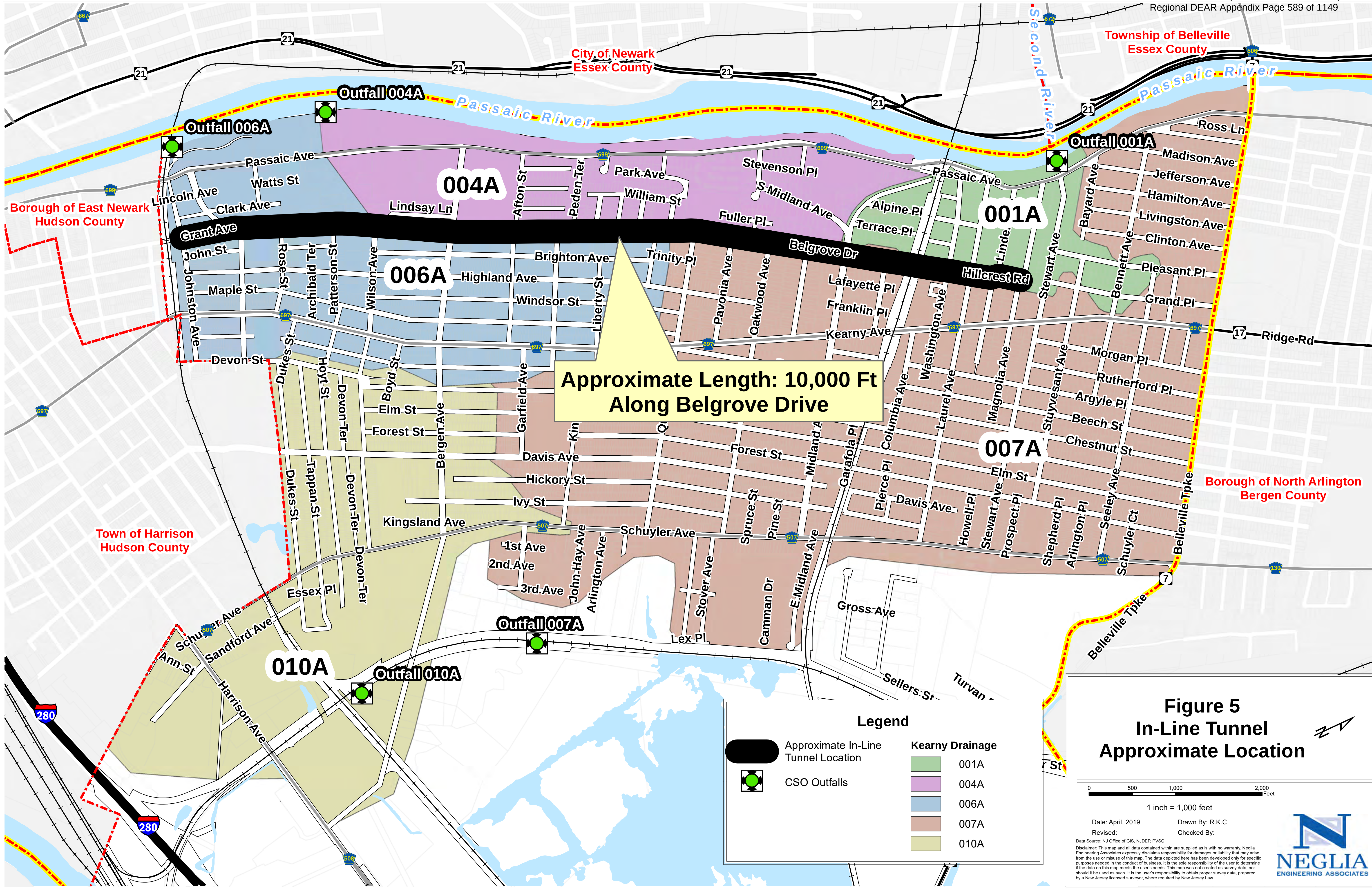


Figure 5
In-Line Tunnel
Approximate Location
Approximate Length: 10,000 Ft
Along Belgrove Drive
Legend
Approximate In-Line Tunnel Location
CSO Outfalls
Kearny Drainage
001A
004A
006A
007A
010A
Outfall 004A
Outfall 006A
Outfall 001A
Outfall 007A
Outfall 010A
004A
006A
001A
007A
010A
Passaic River
Second River
City of Newark
Essex County
Township of Belleville
Essex County
Borough of East Newark
Hudson County
Borough of North Arlington
Bergen County
Town of Harrison
Hudson County
Grant Ave
Belgrove Dr
Hillcrest Rd
Passaic Ave
Kearny Ave
Ridge Rd
Schuyler Ave
Belleville Tpke
Harrison Ave
Devon St
1 inch = 1,000 feet
0 500 1,000 2,000 Feet
Date: April, 2019
Drawn By: R.K.C
Revised:
Checked By:
NEGLIA
ENGINEERING ASSOCIATES

Table C-2 – Tank Storage (sized to fully capture all CSO for all but number of storms per year indicated)				
Outfall No.	**Tank Volume for 4 CSO events/year (MG)**	**Tank Volume for 8 CSO events/year (MG)**	**Tank Volume for 12 CSO events/year (MG)**	**Tank Volume for 20 CSO events/year (MG)**
KE001	0.25	0.25	0.19	0.15
KE004	0.67	0.51	0.42	0.31
KE006	6.19	5.78	3.94	2.75
KE007	5.01	3.88	2.39	1.38
Total	**12.12**	**10.42**	**6.94**	**4.59**

C.6.3 Industrial Discharge Detention

This would involve storage at the individual industrial users' facilities. PVSC has an Industrial Pretreatment Program (IPP). Therefore this control measure would be addressed by PVSC under its IPP program.

C.7 STP EXPANSION AND SECONDARY BYPASS

PVSC owns and operates the wastewater treatment plant which treats the flow from Kearny. Any modifications to the PVSC treatment plant to mitigate CSO volume and frequency, or any increased treatment capacity, will be addressed by PVSC and its consultants. NEA awaits the results of PVSC's analysis to provide feedback on this issue.

Wet weather blending, which involves bypassing of the secondary treatment process at the PVSC treatment plant, is a measure that is subject to NJDEP approval and, as with capacity expansion discussed in the previous paragraph, is a matter to be addressed by PVSC and its consultants. NEA awaits the results of PVSC's analysis to provide feedback on this issue.

C.8 TREATMENT OF CSO DISCHARGE

C.8.1 Introduction

This section of the report provides a brief discussion of various treatment technologies which are generally considered to be viable for use at CSO outfalls to reduce the pollutant load on the receiving water. Additional details regarding each of the technologies can be found in the earlier sections in the main body of this report. Some of the technologies discussed herein are viable for further consideration and others will be eliminated. Reasons for elimination of a particular technology from further consideration include, but are not limited to: 1) they do not help to meet the water quality goals of the Long Term Control Plan (LTCP); 2) they require a large amount of land which is not available at the CSO outfall sites; 3) they require a significant degree of operator attention due to their complexity, which is not practical at remote, unmanned CSO outfall sites; or 4) they are better suited to continuous flow, as is found at a wastewater treatment plant, then to the intermittent flow experienced at a CSO outfall.

For purposes of the LTCP, the pollutants of concern are bacteria (pathogens). Treatment technologies are discussed in terms of how effective they are in reducing or eliminating these pollutants.

Treatment technologies which have been used to treat CSOs generally consist of three (3) main categories – 1) screening; 2) pretreatment; and 3) disinfection. These broad categories can be further broken down into the subcategories shown below. Certain treatment technologies were identified and discussed in the updated (2015) Technical Guidance Manual (TGM) but were eliminated from further consideration, and therefore are not evaluated in this report. The technologies which were eliminated from consideration in the TGM are as follows:

Screening:
- Band and Belt Screens; and
- Drum Screens.

Pretreatment:
- Fuzzy Filters

Disinfectants:
- Chlorine Dioxide; and
- Ozone.

The following technologies are discussed below:

Screening:
- Mechanical Bar Screens;
- Fine Screens; and
- Netting Chambers.

Pretreatment:
- Vortex swirl separators;
- Ballasted Flocculation;
- Compressible Media Filtration (FlexFilters);
- Disinfection;
- Sodium Hypochlorite;
- Peracetic Acid (PAA); and
- Ultraviolet (UV) Radiation.

C.8.2 Vortex Swirl Separators

Vortex Swirl Separators have been used in CSO pretreatment applications to remove solids and floatables, but not pathogens. The circular motion of the liquid, shown by the arrows in the figure below, produces separation of solids from the liquid stream. The solids settle to the bottom and are discharged to the interceptor system. A more detailed discussion of this technology is given in the Front End of this report. One particular system that has been used in CSO treatment is the Storm King, manufactured by Hydro International. An illustration of the Storm King unit is shown below. Other similar systems are also available.

This system has no moving parts. Suspended solids removal is reported to be in the range of 35% to 50% and BOD removal is 15% to 25%. Performance of these units generally drops off as the hydraulic loading rate increases. The range of hydraulic loading rate is 7 to 44 gallons per minute per square foot of tank area (gpm/sf).

Use of a vortex separator by itself will only remove solids and floatables but not the pollutants of concern such as pathogens. A vortex separator would only be effective if it were used as a solids removal system prior to disinfection. Also, space for the system is limited and deep excavation may be required for installation depending on the elevation of the existing incoming sewers.

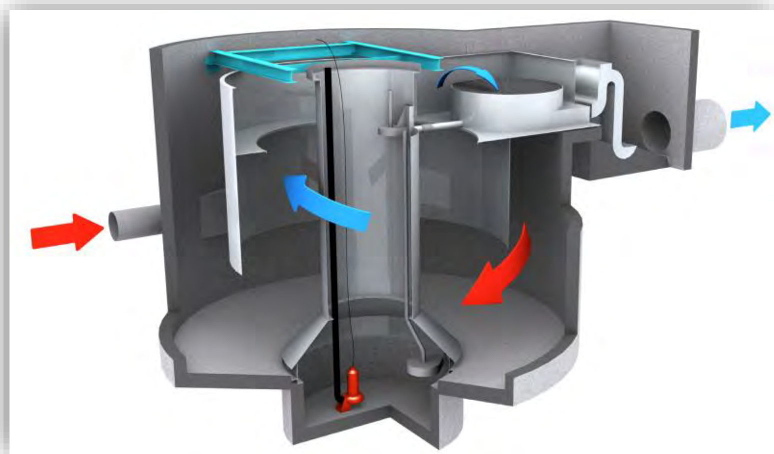


Photo No. 8 – Storm King Vortex Separator

Vortex Swirl Separators are an effective means of solids/liquid separation. However, this technology would be useful only as a pretreatment step prior to disinfection. ~~Kearny currently has Netting Chambers at each CSO outfall site to achieve solids removal. Therefore, vortex separators are eliminated from further consideration.~~

C.8.3 Screening

- <u>Mechanical Bar Screens:</u> Mechanical Bar Screens are used at both wastewater treatment plants and at CSO pump stations and outfalls. Mechanical Bar Screens are effective for removing large, visible solids, such as rags and floatables from the waste stream, but do not remove significant amounts of BOD, TSS, bacteria, fecal coliforms, or other pollutants. Mechanical screens are generally used at the headworks of wastewater treatment plants to protect downstream plant equipment from damage or clogging. While several types of Mechanical Bar Screens are available, the Climber Screen and the Multi-Rake screen are most commonly used. A Climber Screen uses a mechanically driven rake to remove solids which are trapped on an inclined bar rack. Captured screenings are dumped into a container. In larger installations, where multiple screens are used, a conveyor belt can be used to transport the screenings removed from several bar screens to the container. The screenings container is periodically emptied into a truck which transports the screenings offsite for disposal. While mechanical screens have sometimes been installed outdoors, it is preferable to install the screen inside a building, especially in colder climates, to prevent the equipment, and the captured screenings, from freezing. When mechanical screens are installed outdoors in cold climates, electrical heat tracing with insulation is used for freeze protection.

  The screenings which are dumped into the container contain significant amounts of liquid. This liquid increases the screenings' weight and volume, which in turn adds to the disposal cost. In many installations, a separate screenings washer/compactor is used, which compresses the liquid from the screenings, and results in a dryer product which is less costly to dispose of. The liquid removed by the compactor typically drains back into the sewage channel. Like the bar screen, the compactor is heat traced and insulated when installed outdoors.

For a CSO installation, which has intermittent flow, a level probe would be used to sense flow in the overflow pipe from the regulator and this probe would signal the rake motor to energize. As flow subsides and the level drops, the rake would then be directed to deenergize.

A multi-rake screen operates in a similar manner to a Climber Screen. However, as the name implies, instead of a single rake, a series of rakes, spaced a few feet apart, continually clean the bar rack so that there is less material buildup on the bar rack.

Typical Climber Screen installations and a multi-rake installation are illustrated in the following three photographs.

Photo No. 9 – Single Climber Screen

Photo No. 10 – Multiple Climber Screen Installation

Photo No. 11 – Multi-Rake Mechanical Screen

Use of a mechanical screen at a CSO outfall has certain advantages and disadvantages as follows:

- The Mechanical Screen removes large solids but does not remove pathogens, which are the pollutant of concern, and therefore would only be effective in meeting water quality goals as a pretreatment step prior to disinfection;
- Space for a new channel for the screen and bypass channel may be limited;
- The level of screenings collected in the container must be observed, such that when it is full, a truck is called on to dispose of the screenings. This requires operator attention;
- Access for a disposal truck to pull up to the screen may be limited;
- If not installed in a building, the screenings can be a source of odors to nearby residents;
- The screen depends on power for its operation. Power may not be available at many CSO sites. It can be costly to have the utility provide a new electrical service for the installation; and
- Mechanical screens operate automatically and intermittently, both of which are favorable conditions for CSO applications.

Solids capture at each CSO outfall in Kearny is currently achieved by the existing netting chambers. If additional solids removal is needed, it will be accomplished via FlexFilter or other solids removal systems. This is discussed later in this section, under Disinfection. Based on the above factors, mechanical screens are eliminated from further consideration.

- Fine Screens: The fine screen which has most commonly been used in CSO applications is the ROMAG screen manufactured by WesTech. The screen includes a bar rack with smaller spacing than the mechanical screens previously discussed. Spacing between screen bars is in the range of 0.16 inches to 0.47 inches. The ROMAG screen would be installed either in an existing regulator chamber or, more likely, in a new regulator chamber, as it is doubtful the existing regulator chambers can accommodate the new screen. Unlike the Climber or Multi Rake Screen, the fine screen does not remove solids from the waste stream; rather, it separates the screenings from the discharge and keeps solids in the waste stream, which ultimately flows to the treatment plant. The following figure illustrates a ROMAG fine screen arrangement.

Photo No. 12 – ROMAG Fine Screen

Fine screens, like mechanical screens, function intermittently to handle the varying and unpredictable nature of flows at a CSO outfall. A level controller would sense the flow when a storm event occurs and energize the rake accordingly. During dry periods, the rake can be energized via a timer.

Fine Screens have many of the same advantages and disadvantages as mechanical screens. Fine screens remove solids and floatables but not organics and pathogens. Fine screens would require major modification of the regulator chambers or construction of new regulator chambers. Fine screens would only be useful as a pretreatment step prior to disinfection. Solids capture at each CSO outfall in Kearny is currently achieved by the existing netting chambers. If additional solids removal is needed, it will be accomplished via FlexFilter or other solids removal systems. This is discussed later in this section, under Disinfection. Based on the above factors, fine screens are eliminated from further consideration.

C.8.4 Netting Chambers

Netting Chambers provide another means of solids removal. All of the CSO outfalls in Kearny are equipped with Netting Chambers. Netting Chambers are effective in removing solids from the waste stream up to ½- inch in size but require operator attention to periodically (approximately monthly) replace the nets. The Town of Kearny DPW maintains the nets, and will continue to do so. The Netting Chambers will remain in service, and therefore are a component of the LTCP. It is not known at this time if additional solids removal will be required as part of the LTCP. This is discussed later in this section.

The Netting Chamber at the Ivy Street Outfall (KE007) is shown below. This is the largest of the Netting Chamber installations in Kearny. Seen in the following photograph are the upper (overflow) nets at this facility.

Photo No. 13 – Netting Chamber at Ivy Street Outfall

C.8.5 Containment Booms

Containment booms can be used to control floatables. These are difficult to maintain, and require personnel and equipment to collect the floatables contained by the boom. The booms can also create unsightly conditions for nearby residents when the floatables become trapped. Containment booms are eliminated from further consideration.

C.8.6 Baffles

Baffles are another means of containing floatables. Baffles are typically installed inside a regulator chamber to trap floatables and permit flows to pass to the receiving water body. The regulator chambers in Kearny are owned by PVSC, who would have to approve any modifications to its regulators. Also, it is not known if the regulator chambers can accommodate installation of a baffle or if such installation would hinder access for maintenance. Baffles would increase head loss and thereby increase the hydraulic grade line (HGL) in the collection system. Furthermore, baffles trap floatables but do not address pathogen removal. Based on the above factors, baffles are eliminated from further consideration.

C.8.7 Disinfection

Disinfection of wastewater is the destruction of pathogens – such as fecal coliforms, E. coli, and Enterococci. Disinfection can be accomplished via chemical addition or radiation. Three methods of disinfection are discussed in this report, as follows:

- Chlorination/Dechlorination;
- Addition of Peracetic Acid (PAA); and
- Ultraviolet (UV) Radiation.

C.8.7.1 Chlorination / Dechlorination

Chlorination is the destruction of pathogens via addition of chlorine compounds. While several chlorine based compounds have been used for water and wastewater disinfection, the most commonly used chemical is liquid sodium hypochlorite. Other chlorine based compounds have been used for disinfection, including chlorine dioxide and calcium hypochlorite. However, these were eliminated from consideration in the PVSC 2015 Technical Guidance Manual (TGM) as not being practical or feasible for CSO treatment and are therefore not discussed further.

Liquid sodium hypochlorite (NaOCl) is sometimes referred to as chlorine bleach. The typical concentration used is 12% to 15%. NaOCl has proven effective for disinfecting wastewater and is safer than chlorine gas. However, it is highly corrosive, and requires the use of non-corrosive metals or non-metallic materials such as PVC for piping and valves conveying this chemical. The chief drawback to any form of chlorination is the disinfection byproduct, or chlorine residual that results, which is toxic to aquatic life. For this reason, the NJDEP requires that chlorination of wastewater be followed by a dechlorination process, to remove the chlorine residual prior to discharging to surface waters. This is accomplished by adding a sulfur based compound to the chlorinated effluent. The most commonly used dechlorination chemical is liquid sodium bisulfite.

Both sodium hypochlorite and sodium bisulfite are stored in non-metallic tanks, most commonly fiberglass or polyethylene. A 5,000 gallon vertical storage tank, the type that would be used to store hypochlorite or bisulfite, and a chemical metering pump are shown in the following photographs.

Photo No. 14 – Chemical Storage Tank

Photo No. 15 – Chemical Metering Pump

At the CSO outfalls, a chemical feed system would consist of a hypochlorite storage tank, metering pumps, piping and controls, located inside a small building. The tank would need a containment curb around it to contain a spill. A separate storage tank and containment curb, metering pumps, piping and controls are needed for sodium bisulfite addition. A contact basin with a flash mixer is needed to provide a minimum of 3 minutes contact time for the hypochlorite to react with the incoming flow. Sodium bisulfite would be added at the effluent end of the contact tank for dechlorination.

Chlorination is effective in destroying pathogens. However, there are several drawbacks with chlorination at CSO outfalls.

- Dechlorination is required to destroy the chlorine residual prior to discharge.
- Periodic chemical deliveries are needed.

- Sodium hypochlorite has a limited shelf life, so that limited storage can be provided, and frequent chemical deliveries are required.
- Sodium hypochlorite is highly corrosive and safety precautions are needed in the handling of the chemical. Careful selection of pipe materials is necessary, due to the corrosive nature of hypochlorite.

Disinfection with Sodium Hypochlorite will destroy pathogens, which are the primary pollutant of concern. However, chlorination produces a chlorine residual, which is a toxic disinfection byproduct that must be removed. Therefore chlorination must be followed by dechlorination, typically using sodium bisulfite. Thus, additional tankage, pumps, piping and controls are needed for the two separate chemical systems. Sodium hypochlorite has a limited shelf life, only 30 to 60 days, and considering the intermittent nature of CSOs, where long dry periods are possible, this makes hypochlorite impractical, as frequent replenishment of the chemical would be needed. For the above reasons, disinfection with sodium hypochlorite is eliminated from further consideration.

C.8.7.2 Disinfection with Peracetic Acid (PAA)

As discussed earlier, disinfection with sodium hypochlorite leaves a toxic byproduct which must be eliminated via dechlorination.

In recent years, another chemical, peracetic acid (PAA) has been found to be an effective wastewater disinfectant which leaves no toxic residual, yet effectively kills pathogens in wastewater. Peracetic acid is a mixture of hydrogen peroxide, acetic acid and water. It is a clear, colorless liquid with a pH of 2. Solutions of 12%, 15% and 22% are commercially available. PAA has been used as a wastewater disinfectant in Europe and is starting to gain popularity in the U.S. wastewater industry. Various pilot studies and full scale trials have been conducted with PAA with favorable results. These are discussed below.

- <u>Pilot Study at Bayonne MUA:</u> A demonstration project took place at the Bayonne MUA's Oak Street Pump Station, between 2014 and 2016 to demonstrate the effectiveness of various types of solids removal technologies, and disinfection technologies, to treat combined wastewater from CSOs. Included in this project was testing of PAA to evaluate its effectiveness as a wastewater disinfectant. A pilot scale disinfection system was set up on site. For most of the test runs, flows ranged from 50 to 100 gpm. Applied dosage was generally in the range of 1 to 3 ppm. Contact time was in the range of 3 to 6 minutes. The pilot setup is shown on the photograph provided on the following page.

Photo No. 16 – Bayonne MUA Pilot Testing of Peracetic Acid

The study found that PAA proved to be effective in destroying pathogens. A relationship was seen between PAA dosage and influent Chemical Oxygen Demand (COD). When PAA was applied at a dosage of 0.01 mg/L per mg/L of influent COD, a 3 log reduction (99.9%) in fecal coliforms was achieved, with slightly higher effectiveness for E. coli and slightly lower for Enterococci. Influent COD was generally in the range of 250 to 420 mg/L. Increasing the dosage to 0.015 mg/L PAA per mg/L COD achieved a 4 log reduction. Further increase of PAA dosage had limited effect on pathogen reduction. It was concluded that, for satellite facilities, PAA had many desirable characteristics, as follows:

- effective in destroying pathogens;
- six to twelve months shelf life;
- effective with contact times as low as three to six minutes;
- no toxic byproducts; and
- no need for additional processes, such as dechlorination.

▪ Frankfort, Kentucky WWTP: The Frankfort, Kentucky wastewater treatment plant, having a capacity of 9.9 mgd, selected PAA as a temporary disinfectant while the plant's ozone disinfection system was being upgraded. It was found that:

- A 12% solution of PAA was effective at controlling fecal coliforms and E. coli at a dose of 0.7 ppm;
- Effluent treated with PAA passed acute toxicity tests for Ceriodaphnia dubia;
- Residual PAA in the effluent was less than 1 ppm; and
- Treatment costs with PAA were competitive with disinfection with sodium hypochlorite and sodium bisulfite.

The Frankfort, Kentucky plant continues to use PAA as a full scale backup to its ozone disinfection system.

▪ Steubenville, Ohio WWTP: A one-month trial took place at the Steubenville, Ohio wastewater treatment plant. During that period, plant flow was in the range of 5 to 8 mgd. PAA dosage was 1.5 ppm or less. Residual averaged 0.4 ppm, and never exceeded 1 ppm. Pathogen control was within the plant's permit limits for the length of the trial.

From the case studies discussed above, it is concluded that PAA is a viable disinfection chemical and will be considered further in the Development and Evaluation of Alternatives.

PAA Addition was analyzed for all the Kearny Outfalls, based on a peak flow required for dosing to fully treat all but the number of storms per year indicated. Table C-3 below shows the peak design flow for each of the target frequencies, at each outfall. These flows would be used for sizing the chemical feed pumps required for dosing at the peak flow. Table C-4 below indicates the theoretical maximum chemical usage on an annual basis, at each outfall, assuming complete disinfection for all CSO events. This information would be used for computing storage volumes needed. Computation of pump sizes and storage volumes is beyond the scope of this report, but would be addressed in the 2020 LTCP.

Table C-3 – PAA Treatment (sized based on peak-flow required for dosing to fully treat all but number of storms per year indicated)				
Outfall No.	**Peak Flow for 4 CSO events/year (MGD)**	**Peak Flow for 8 CSO events/year (MGD)**	**Peak Flow for 12 CSO events/year (MGD)**	**Peak Flow for 20 CSO events/year (MGD)**
KE001	12.6	7.5	7.5	3.7
KE004	3.9	3.8	3.7	3.5
KE006	138.3	100.9	64.2	53.9
KE007	75.7	42.2	42.2	29.3

Table C-4 – Maximum Annual Quantity of Chemical Usage				
Outfall No.	**Baseline Total Annual CSO Volume (MG)**	**Annual Amount of PAA needed with dose of 2 mg/L (gal PAA)**	**Annual Amount of PAA needed with dose of 7 mg/L (gal PAA)**	**Annual Amount of PAA needed with dose of 10 mg/L (gal PAA)**
KE001	3.9	46	159	227
KE004	12.4	146	509	727
KE006	121.8	1,430	5,004	7,149
KE007	90.0	1,057	3,697	5,281
Total	**228.1**	**2,679**	**9,369**	**13,384**

Disinfection with Peracetic Acid will destroy pathogens, which are the primary pollutant of concern. In order to achieve the desired frequency targets, disinfection facilities are sized based upon the maximum CSO discharge rate for each event to *fully treat* all but 20, 12, 8, and 4 CSO discharges per year. During CSO events that are not fully treated, disinfection continues but full treatment is achieved only during times that CSO discharges are less than the design-maximum discharge rate. Where full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens, or a 3-log kill. This analysis assumes that PAA disinfection will be implemented at locations between the existing regulators and the existing outfalls.

PAA has a much longer shelf life than hypochlorite, up to one year, which makes it better suited for storage at a CSO site, which is unmanned and remote, than hypochlorite. Further, PAA does not leave a toxic byproduct, and so no additional chemical treatment is required. Although PAA has not been used widely in the U.S., there have been several pilot studies and full scale trials, which have demonstrated that PAA effectively destroys pathogens in wastewater including E. coli, fecal coliforms and Enterococci. PAA has been used in Europe for wastewater disinfection.

From the above, disinfection with PAA is retained for further consideration in the LTCP. PAA treatment costs shown herein include the cost of pretreatment (solids removal) using the FlexFilter system. However, if pretreatment is not necessary, cost savings of approximately 30% to 50%, on both a capital and present value basis would be realized. In addition, the required facility footprint would be smaller. For these reasons, if PAA disinfection is selected, Kearny will conduct treatability tests to determine if pretreatment is required.

A typical schematic diagram, which illustrates the configuration of a PAA storage and feed system at the CSO outfalls, is shown in Figure 6.

C.8.7.3 UV Radiation

Ultraviolet radiation is an alternative to chlorination that is used at thousands of wastewater treatment plants across the country. UV light bulbs, mounted on stainless steel racks, and housed in quartz sleeves, send UV radiation at a particular wavelength of 254 nm through the wastewater which destroys the reproductive capabilities (DNA) of the bacteria, thus killing the population of pathogens. UV radiation eliminates the need for chemical deliveries, and the dangers of chemical handling, and also eliminates the need for storage tanks and pumps.

UV lamps are installed in an open channel, in which wastewater flows past the lamps, making contact with the radiation. The lamp racks are installed adjacent to each other, in the direction of flow, across the width of the channel, so none of the flow escapes the lamps. A rack may contain 4, 6, or 8 lamps. A typical horizontal lamp rack containing 4 lamps is shown in the following photograph.

Photo No. 17 – Horizontal UV Lamp Rack Assembly

The group of lamp racks spanning the width of the channel is known as a bank. A UV channel may have one bank of lamps, or two or more banks in series. If more than one bank of lamps is installed in a channel, one bank would be energized all of the time, while a second bank might be activated when the flow increases. At wastewater treatment plants, it is common to have two parallel channels, for redundancy and reliability. However, some installations consist of only a single channel. The channel may be concrete, or for smaller installations, prefabricated stainless steel channels can be supplied by the manufacturer. At wastewater plants that previously used chlorine for disinfection, the chlorine contact tanks can be converted to UV channels.

UV lamp assemblies can also be supplied with vertical lamps, as shown in the photograph provided on the following page.

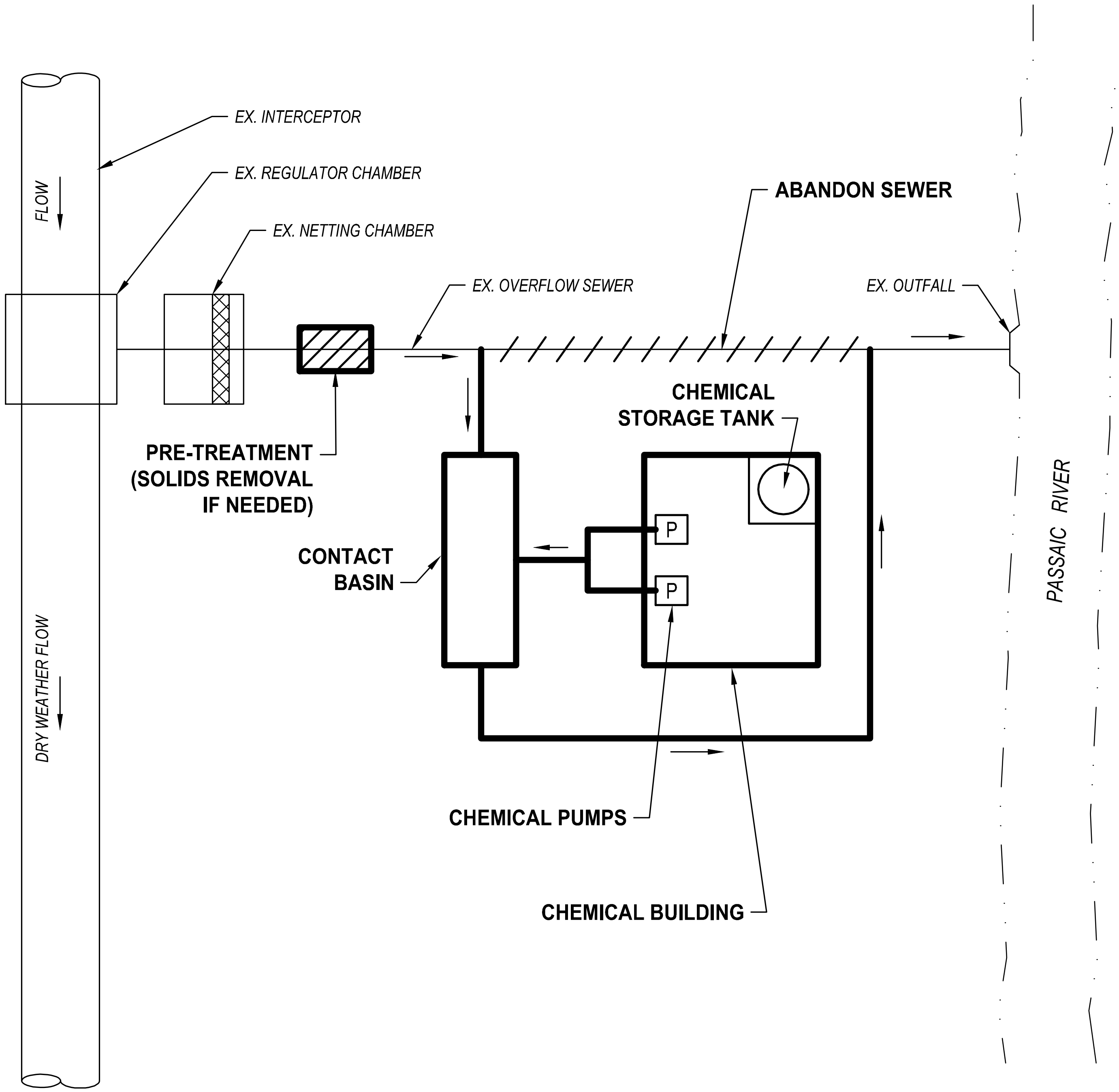


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FIGURE 6 SCHEMATIC: TYP. PAA ADDITION

KEARNY CSO LTCP

TOWN OF KEARNY

HUDSON COUNTY NEW JERSEY

DRAWN BY: M.E.W.	CHECKED BY:	PROJECT NO.: KEARMUN18.013	SHEET NO.: FIG-6
DESIGNED BY: J.R.	SCALE: N.T.S.		
FIELD BOOK NO.:	PAGE:		DATE: JUNE 6, 2019

Photo No. 16 – Verrtical UV Lamp Assemblies

UV controls and alarms include loss of power, individual bulb failure, and loss of lamp intensity. In some systems, the lamp intensity can vary with the incoming flowrate. The lamp rack assemblies can be removed from the wastewater channel for maintenance such as cleaning or replacing a lamp. UV lamps are designed to last approximately one year before needing replacement. Lamps can be cleaned by lifting them out of the channel and submerging them in a chemical cleaning tank. Systems are also available with self-cleaning lamps, in which a mechanical wiper moves across the lamp at preset, timed intervals.

There are several drawbacks to using UV for disinfection at CSO outfalls:

- Due to the variable nature and unpredictability of CSO volumes, it is difficult to properly size a UV system for a CSO application;
- UV systems require more power than chemical feed systems. Availability of power at remote CSO outfall sites is a potential problem. With loss of power, there will be no disinfection;
- UV lamps are designed to be energized and submerged at all times, to avoid building up excessive heat. Thus in dry periods, wastewater must remain in the UV channel to keep the lamps submerged. This could result in septic conditions, and odors; and
- In the 2007 Cost and Performance Report, UV was found to be the least cost effective means of disinfection, of all the methods investigated.

UV disinfection is a proven, effective means of destroying pathogens in wastewater. However, UV disinfection is better suited to use at a wastewater treatment plant where there is continuous flow, and operator attention. During dry periods, the wastewater must remain in the channels to protect the UV bulbs. This could be a source of objectionable odors to the surrounding community. A potential reduction in effectiveness of the UV bulbs can result, after prolonged periods of non -usage. In past studies, UV was found not to be a cost effective means of pathogen removal for CSO treatment. From the above, UV disinfection is eliminated from further consideration.

C.8.8 Ballasted Flocculation

Ballasted flocculation, also referred to as High Rate Clarification, combines chemical coagulation, high rate mixing, flocculation and settling, in a series of tanks, to remove suspended solid particles from the waste stream. The solids collected at the bottom of the clarifier, are pumped back to the flocculation zone, as ballast, to enhance settling. Polymer is also added to enhance settling. The system can take on a higher hydraulic loading rate, and has a smaller footprint, than a conventional clarifier. The overall system is designed to bring smaller solid particles together to form larger, heavier solids, which settle to the bottom of the clarifier more readily, thereby achieving solids/liquid separation.

The following Figure illustrates the DensaDeg Process, manufactured by Infilco Degremont (now owned by Suez). The Figure shows the different zones which comprise the process, i.e. the rapid mix/coagulation zone, the flocculation zone, etc.

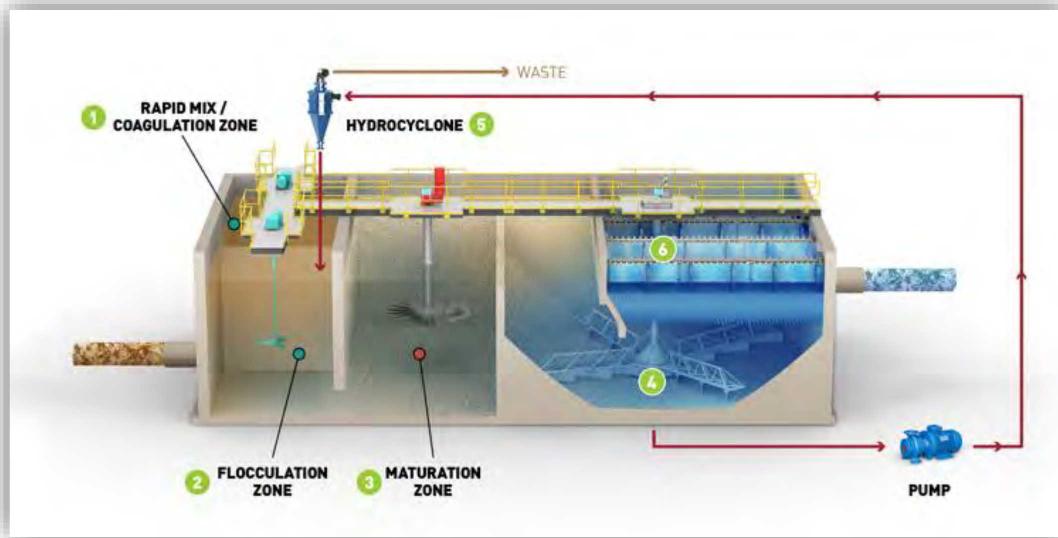

Photo No. 17 – Densa-Deg Ballasted Flocculation System Process

Another system which is commercially available is the ACTIFLO system manufactured by Veolia Water Technologies. The ACTIFLO system uses sand, rather than recycled sludge, as the ballast material to enhance settling.

Refer to the Front End of this report for a more detailed discussion of the Ballasted Flocculation process.

Ballasted Flocculation, or High Rate Clarification, combines chemical mixing, coagulation, flocculation and high rate settling with either sand or recirculated sludge used for ballast to enhance settling, plus polymer addition. This process is complex, requires a high degree of operator attention and therefore is better suited for use at a wastewater treatment plant where there is continuous flow, and onsite operators. Ballasted flocculation does not remove pathogens. It also requires significant space for the required tankage. Based on the above, ballasted flocculation is eliminated from further consideration.

C.8.9 Compressible Media Filters

Compressible Media Filters are another means of removing suspended solids and particulates from the incoming wastewater. Unlike conventional filters which use sand and gravel, or plastic media, the filter media is a synthetic, soft, compressible material.

There are two compressible media filters commercially available. These are the Fuzzy Filter manufactured by Schreiber, Inc. and the FlexFilter manufactured by WesTech. The fuzzy filter was eliminated from consideration in the Technical Guidance Manual and is therefore not discussed further. The FlexFilter is effective in removing solids, but not pathogens. Thus the FlexFilter would be useful only as a pretreatment step prior to disinfection.

Compressible Media Filters are a means of removing settleable solids, but they do not remove pathogens. Due to the existence of the Netting Chambers at the outfall sites, filtration is not needed, and compressible media filters are eliminated from further consideration.

C. 9 SCREENING OF CONTROL TECHNOLOGIES

In the above sections, the various control technologies are discussed, and either retained for further consideration or eliminated. Reasons given for eliminating a control technology from consideration include: 1) they do not help to meet the water quality goals of the LTCP; 2) they do not significantly impact the computed CSO volumes and frequencies; 3)they require a large amount of land which is not available at the CSO outfall sites; 4) they require a significant degree of operator attention, due to their complexity, which is not practical at remote, unmanned CSO outfall sites; and 5) they are better suited to continuous flow, such as is found at a wastewater treatment plant, then to the intermittent flow experienced at a CSO outfall.

The screening of alternatives is summarized in the matrix table which follows. The format of this report is in line with the matrix, to the extent practicable. However, certain items in the matrix are not applicable to Kearny. This report focuses primarily on the matrix items that are feasible and/or under consideration for the LTCP.

In summary, the control technologies which remain under consideration are as follows:

- Sewer Separation;
- Inline Storage (Tunnel);
- Offline Storage (Tanks);
- Netting Chambers;
- Disinfection With PAA; and
- Green Infrastructure.

The above technologies will be discussed further in Section D, Development and Evaluation of Alternatives.

Source Control Technologies								
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	- Reduced surface flooding potential	Flow restrictions to the CSS can cause flooding in lots, yards and buildings; potential for freezing in lots; low operational cost. Effective at reducing peak flows during wet weather events but can cause dangerous conditions for the public if pedestrian areas freeze during flooding.	No	No	No
	Catch Basin Modification (for Floatables Control)	Low	None	- Water quality improvements - Reduced surface flooding potential	Requires periodic catch basin cleaning; requires suitable catch basin configuration; potential for street flooding and increased maintenance efforts. Reduces debris and floatables that can cause operational problems with the mechanical regulators.	No	Yes	Yes
	Catch Basin Modification (Leaching)	Low	Low	- Reduced surface flooding potential - Water quality improvements	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No	No	Yes
Public Education and Outreach	Water Conservation	None	Low	- Reduced surface flooding potential - Align with goals for a sustainable community	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume, but would have little impact on peak flows.	Yes	No	No
	Catch Basin Stenciling	None	None	- Align with goals for a sustainable community	Inexpensive; easy to implement; public education. Is only as effective as the public's acceptance and understanding of the message. Public outreach programs would have a more effective result.	Yes	No	Yes
	Community Cleanup Programs	None	None	- Water quality improvements - Align with goals for a sustainable community	Inexpensive; sense of community ownership; educational BMP; aesthetic enhancement. Community cleanups are inexpensive and build ownership in the city.	Yes	Yes	Yes
	Public Outreach Programs	Low	None	- Align with goals for a sustainable community	Public education program is ongoing. Permittee should continue its public education program as control measures demonstrate implementation of the NMC.	Yes	Yes	Yes
	FOG Program	Low	None	- Water quality improvements - Improves collection system efficiency	Requires communication with business owners; Permittee may not have enforcement authority. Reduces buildup and maintains flow capacity. Only as effective as business owner cooperation.	Yes	Yes	Yes
	Garbage Disposal Restriction	Low	None	- Water quality improvements	Permittee may not be responsible for Garbage Disposal. This requires an increased allocation of resources for enforcement while providing very little reduction to wet weather CSO events.	Yes	Yes	Yes
	Pet Waste Management	Medium	None	- Water quality improvements	Low cost of implementation and little to no maintenance. This is a low cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes	Yes	Yes
	Lawn and Garden Maintenance	Low	Low	- Water quality improvements	Requires communication with business and homeowners. Guidelines are already established per USEPA. Educating the public on proper lawn and garden treatment protocols developed by USEPA will reduce waterway contamination. Since this information is already available to the public it is unlikely to have a significant effect on improving water quality.	Yes	Yes	Yes
	Hazardous Waste Collection	Low	None	- Water quality improvements	The N.J.A.C. prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	Yes
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	- Cost-effective water quality improvements	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if Permittee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.	Yes	Yes	Yes
	Illegal Dumping Control	Low	None	- Water quality improvements - Aesthetic benefits	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes	Yes	Yes
	Pet Waste Control	Medium	None	- Water quality improvements - Reduced surface flooding	Requires resources to enforce pet waste ordinances. Public education and outreach is a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes	Yes	Yes
	Litter Control	None	None	- Property value uplift - Water quality improvements - Reduced surface flooding	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach is a more efficient use of resources.	Yes	Yes	Yes
	Illicit Connection Control	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	Yes	No
Good Housekeeping	Street Sweeping/Flushing	Low	None	- Reduced surface flooding potential	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	Yes
	Leaf Collection	Low	None	- Reduced surface flooding potential - Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	Yes
	Recycling Programs	None	None	- Align with goals for a sustainable community	Most Cities have an ongoing recycling program.	Yes	Yes	Yes
	Storage/Loading/Unloading Areas	None	None	- Water quality improvements	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	Yes	Yes
	Industrial Spill Control	Low	None	- Protect surface waters - Protect public health	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	Yes

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Green Infrastructure Buildings	Green Roofs	None	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	No
	Blue Roofs	None	Medium	- Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	No
	Rainwater Harvesting	None	Medium	- Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community - Water Saving	Simple to install and operate; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	No	Yes
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Cost-effective water quality improvements - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	No	Yes
	Planter Boxes	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Green Infrastructure Pervious Areas	Bioswales	Low	Low	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community - Increased pedestrian safety through curb retrofits	Site specific; good BMP; minimal vegetation & mulch O&M requirements ; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	No	Yes
	Free-Form Rain Gardens	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes

Collection System Technologies								
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Operation and Maintenance	I/I Reduction	Low	Medium	- Water quality improvements - Reduced basement sewage flooding	Requires labor intensive work; changes to the conveyance system require temporary pumping measures; repairs on private property required by homeowners. Reduces the volume of flow and frequency; Provides additional capacity for future growth; House laterals account for 1/2 the sewer system length and significant sources of I/I in the sanitary sewer.	Yes	No	No
	Advanced System Inspection & Maintenance	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	Yes	Yes
	Combined Sewer Flushing	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	No	No
	Catch Basin Cleaning	Low	None	- Water quality improvements - Reduced surface flooding	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	No	Yes
Combined Sewer Separation	Roof Leader Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; Includes area drains and roof leaders; new storm sewers may be required; requires home and business owner participation. The Cities are densely populated and disconnected roof leaders have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	Yes	No
	Sump Pump Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The Cities are densely populated and disconnected sump pumps have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	No
	Combined Sewer Separation	High	High	- Water quality improvements - Reduced basement sewage flooding - Reduced surface flooding	Very disruptive to affected areas; requires homeowner participation; sewer asset renewal achieved at the same time; labor intensive.	No	No	Yes
Combined Sewer Optimization	Additional Conveyance	High	High	- Water quality improvements - Reduced basement sewage flooding	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	No	No
	Regulator Modifications	Medium	Medium	- Water quality improvements	Relatively easy to implement with existing regulators; mechanical controls requires O&M. May increase risk of upstream flooding. Permitees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	No	No
	Outfall Consolidation/Relocation	High	High	- Water quality improvements - Passive and active recreational improvements	Lower operational requirements; may reduce permitting/monitoring; can be used in conjunction with storage & treatment technologies. Combining and relocating outfalls may lower operating costs and CSO flows. It can also direct flow away from specific areas.	Yes	No	Yes
	Real Time Control	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires periodic inspection of flow elements; highly automated system; increased potential for sewer backups. RTC is only effective if additional storage capacity is present in the system.	Yes	No	No

Storage and Treatment Technologies									
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Linear Storage	Pipeline	High	High	- Water quality improvements - Reduced surface flooding potential - Local jobs	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities.Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	No	Yes
	Tunnel	High	High	- Water quality improvements - Reduced surface flooding potential	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	No	Yes
Point Storage	Tank (Above or Below Ground)	High	High	- Water quality improvements - Reduced basement sewage flooding	Storage tanks typically require pumps to return wet weather flow to the system which will require additional O&M; disruptive to affected areas during construction. Several CSO outfalls have space available for tank storage. There may be existing tanks in abandoned commercial and industrial areas to be converted to hold stormwater. Tanks are an effective technology to reduce wet weather CSO's.	No	No	Yes
	Industrial Discharge Detention	Low	Low	- Water quality improvements	Requires cooperation with industrial users; more resources devoted to enforcement; depends on IUs to maintain storage basins. IUs hold stormwater or combined sewage until wet weather flows subside; there may be commercial or industrial users upstream of CSO regulators.	Yes	No	No
Treatment-CSO Facility	Vortex Separators	None	None	- Water quality improvements	Space required; challenging controls for intermittent and highly variable wet weather flows. Vortex separators would remove floatables and suspended solids when installed. It does not address volume, bacteria or BOD.	Yes	No	No
	Screens and Trash Racks	None	None	- Water quality improvements	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	No	No
	Netting	None	None	- Water quality improvements	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	Yes
	Contaminant Booms	None	None	- Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	No
	Baffles	None	None	- Water quality improvements	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	Yes	No	No
	Disinfection & Satellite Treatment	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	Yes
	High Rate Physical/Chemical Treatment (High Rate Clarification Process - ActiFlo)	None	None	- Water quality improvements	Challenging controls for intermittent and highly variable wet weather flows; smaller footprint than conventional methods. This technology primarily focuses on TSS & BOD removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
	High Rate Physical (Fuzzy Filters)	None	None	- Water quality improvements	Relatively low O&M requirements; smaller footprint than traditional filtration methods. This technology primarily focuses on TSS removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
Treatment-WRTP	Additional Treatment Capacity	High	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	May require additional space; increased O&M burden.	No	No	This alternative is being further evaluated by PVSC as part of the Development and Evaluation of Alternatives Report preparation
	Wet Weather Blending	Low	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	This alternative is being further evaluated by PVSC as part of the Development and Evaluation of Alternatives Report preparation
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	No

SECTION D ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

This section of the report presents the development and evaluation of alternatives, which are based on the screening of technologies presented earlier, in Section C.

To reiterate from Section C.9, the control technologies which remain under consideration are as follows:

- Sewer Separation;
- Inline Storage (Tunnel);
- Offline Storage (Tanks);
- Netting Chambers;
- Disinfection With PAA; and
- Green Infrastructure.

D1.1 CSO Outfalls and Locations

As stated earlier in the report, the Town of Kearny owns and operates five (5) CSO discharge outfalls with their associated regulator chambers. These are listed below in Table D-1. Refer also to the Town Drainage Area Map, Figure 1A.

TABLE D-1 – EXISTING OUTFALLS		
OUTFALL NO.	LOCATION	RECEIVING STREAM
001A	Stewart Avenue	Passaic River
004A	Nairn Avenue	Passaic River
006A	Johnston Avenue	Passaic River
007A	Ivy Street	Frank's Creek (Tributary to Lower Passaic River)
010A	Dukes Street	Frank's Creek (Tributary to Lower Passaic River)

(Note – Outfall No. KE 001 corresponds to No. 001A in the Town's NJPDES permit, etc.)

As discussed in Section C, CSO Outfall 010A (Dukes Street) will be eliminated in the near future. Therefore, the development and evaluation of alternatives considers only the remaining four CSO outfalls listed above, i.e. 001, 004, 006, and 007.

This corresponds to Baseline B in this analysis. All alternatives evaluated are based on Baseline B (i.e. zero CSO events in Drainage Area 010).

Siting and other general issues are now discussed, followed by a listing and discussion of the alternatives under consideration, and summary cost tables which include capital, O&M, and overall present value costs for each of the alternatives.

D.1.2 Siting

D.1.2.1 General

Siting issues at each outfall location include available land area, proximity to residences, land use in adjacent parcels, subsurface conditions, access for operations and maintenance (O&M) (including personnel, vehicles, and chemical deliveries), as well as topography, aesthetics, and impacts to the surrounding area. For example, construction of an underground, offline storage vault requires a large area to be excavated. However, once constructed, the land at the surface is available for various uses – i.e. park, parking lot, etc. Sewer separation would involve a larger area of town, or possibly multiple areas, with excavations in numerous streets and subsequent disturbances to large numbers of residents and/or businesses. A treatment system, if constructed, would be located at an existing outfall, which is remote from residences, but would be nearer to a water body and, as such, environmental factors must be considered, such as flood hazard elevation, wetlands, minimizing impacts to the water body during construction, etc. A treatment system would also involve chemical deliveries, screenings and sludge disposal. Therefore truck access is needed, which may be difficult to provide at some sites.

The above describes general siting issues. Below, the four Kearny outfall sites are discussed; including specific site concerns and accompanying photographs.

D.1.2.2 Kearny Outfall Sites

Outfall 001A (Stewart Avenue): this site is within a park area off Passaic Avenue, at the northwest corner of Kearny, near its border with North Arlington. The site currently consists of a below ground netting chamber and valve vault. Surrounding properties consist of primarily residential users. As seen in the following photograph, numerous trees exist near the existing structures. Thus potential issues of concern are noise, odors, and disturbance to the park area. This park is not listed on the Green Acres Program Open Space Database and, therefore, is not believed to be within the jurisdiction of NJDEP or associated programs.

Photo No. 18 – Outfall Site KE 001 – Stewart Avenue

Outfall 004A (Nairn Avenue): At this site, the regulator chamber is located within the Passaic Avenue tight-of-way. Nairn Avenue is currently a paper street that has been developed with a parking lot area associated with a commercial development. The area surrounding the regulator chamber has been developed, commercially. Therefore any construction at this site would pose a significant disturbance to adjacent business owners. A residential development is currently under construction on Passaic Avenue, across the street from the regulator. Therefore, noise, truck traffic associated with chemical deliveries, and temporary disturbance during construction are issues of concern. Refer to the photographs Numbers 18 and 19 below.

Photo No. 19 – Commercial Development in the Vicinity if the Nairn Avenue Outfall

Photo No. 20 – Residential Development in the Vicinity if the Nairn Avenue Outfall

<u>Outfall 006A (Johnston Avenue):</u> this site is located near Passaic Avenue, at the southwest corner of the Town, where it borders East Newark. The site is located near an abandoned railroad bridge. Access for personnel and vehicles is limited. A stairway provides the only means of direct access to the outfall. There is a large open lot at street level, which is planned to be developed. Once this lot is developed, it may further hinder access to the outfall area. Construction at this outfall site will be difficult. The highest CSO volumes are generated within this drainage area. There is potential for consolidating Outfall 006A with Outfall 004A due to their proximity and existing topography.

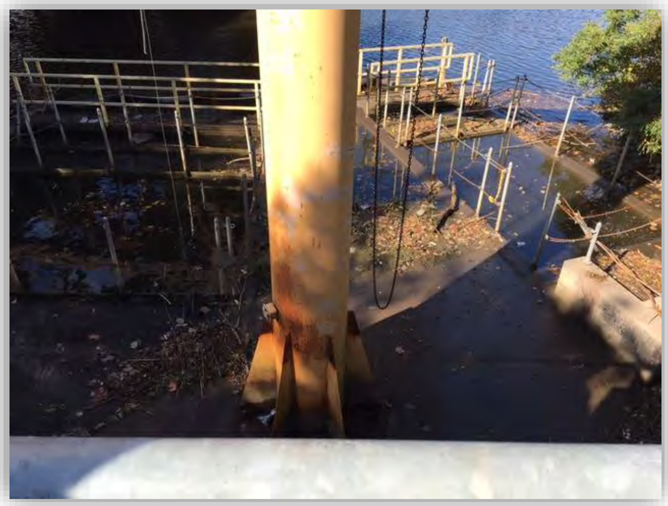

Photo No. 21 – Johnston Avenue Outfall During a Hide-Tide Period

<u>Outfall 007A (Ivy Street):</u> This outfall site is in a low lying residential/commercial area which is prone to flooding. It is surrounded by commercial businesses including a lumber yard, and is surrounded on all sides by existing structures, making access for vehicles difficult. This outfall site is characterized by a large netting chamber, with two rows of nets, and by a long channel going out to the Lower Passaic River. See the two (2) following photographs. There is virtually no space available for construction of any improvements on this site.

Photo No. 22 – Ivy Street Netting Chamber

Photo No. 23 – Ivy Street Outfall Channel

D.1.3 Institutional Issues

Institutional issues may be jurisdictional, regulatory or associated with land acquisition. For example, a potential site for a storage tank or treatment system might be restricted by Green Acres, which could be a significant obstacle to implementing the project (see D.1.4, Implementability). Town acceptance may be a concern, if Town residents or the Town Administration does not want to construct a storage or treatment facility at a particular site. NJDEP approval can also be an obstacle, if construction of a CSO storage or treatment facility is adjacent to wetlands, or in a flood hazard area, or otherwise environmentally sensitive area. The need for easements can also be an obstacle, if a property owner refuses to grant an easement or the cost of the land is prohibitive.

D.1.4 Implementability

Implementability refers to a number of contributing factors such as constructability, obtaining approvals on the local, State, County or Federal level as required, cost effectiveness, and public acceptance which is discussed below. Any of the above listed factors can become an obstacle to implementing a CSO control project.

D.1.5 Public Acceptance

Public acceptance (or resistance) will vary based on the nature of the project. For example, a Town-wide sewer separation project may be met with a high degree of public resistance due to the extent of the disturbance and the number of residents affected. A project at a remote outfall site might see less public resistance but might raise concerns among environmentally concerned citizens. Proposing a below grade storage tank beneath what appears to be an empty parcel might require cooperation from the Town and/or local developer, as the parcel might be planned for development. Public acceptance is also tied to public participation. Public involvement in the overall planning process, through public meetings, is an important step for gaining the public's acceptance. Kearny, through its Engineer, Neglia Engineering Associates, has held public meetings with the Town residents to discuss the CSO project. NEA has met with the Kearny AWAKE (Association of Water, Agriculture, and Kearny's Environment) group, a local citizen's environmental group, to discuss the CSO LTCP project. Kearny

AWAKE has provided NEA with valuable input regarding Green Infrastructure implementation, and specific areas in Town that are of concern.

D.1.6 Performance Considerations

Performance considerations are related to the ability of a proposed project to meet certain established goals. A treatment technology that only removes solids but does not remove pathogens, which are a pollutant of concern, would not satisfy the program water quality goals. Furthermore, a treatment technology which has a high degree of complexity and requires a high degree of operator attention has to be correctly located to facilitate maintenance and access. Use of a new technology that is untested or unproven, or supplied by a manufacturer with a limited number of full scale installations, would raise concerns over performance.

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

The alternatives considered in this evaluation include the following elements:

- Complete Sewer Separation – this refers to separating the sewers throughout the entire Town of Kearny;
- Partial Sewer Separation – separation of sewers within Drainage Area 010 only. Sewers were previously separated in portions of this drainage area. Sewers in the remaining portions of the drainage area will be separated. Since the Town of Kearny has committed to separation of sewers in Drainage Area 010, this measure is shown as Baseline B, and is a component common to all alternatives;
- Inline Storage via CSO Tunnel (one tunnel to serve the entire Town);
- Offline Storage via Below Grade Tanks, at Each Outfall;
- Disinfection With Peracetic Acid (PAA) at Each Outfall; and
- Green Infrastructure – at various locations throughout Kearny, and Included in all alternatives.

In addition, the alternatives cover all the various levels of control (i.e. 0, 4, 8, 12, and 20 CSO events per year, and the 85% capture goal). The Baseline A and Baseline B are also shown for comparison in order to show the impact of each alternative. The following alternatives are evaluated:

Scenarios Evaluated:

Table D-2 presents the conditions evaluated for this study. The first grouping of alternatives (Group 1) achieve the targeted annual CSO frequencies, and are presented in increasing order (zero, 4, 8, 12, and 20) of untreated discharges per year. Only Alternative 2A, complete Town wide sewer separation considers zero CSO events per year. The second grouping presents other alternatives that cannot alone achieve the targeted annual CSO frequencies. Costs for the "Group 2" alternatives are presented in Tables D-6 and D-7. The alternative identifiers shown in the first column are used to identify each alternative in subsequent tables.

Table D-2 – Listing of Evaluated Scenarios/Alternatives

Evaluated Scenario	Description
Baseline A (Existing Infrastructure)	Existing infrastructure with 2045 population and typical year meteorology (rainfall, evapotranspiration, tide levels)
Baseline B (KE010 Separation)	Baseline A plus separation of the combined sewers draining to outfall KE010 (Kearny has committed to completing sewer separation in this catchment)
Group 1 Alternatives	**Description**
Alt_2A_0_SewerSeparation	Baseline B with complete sewer separation to completely eliminate CSOs

Group 1 Alternatives (cont'd)	Description (cont'd)
Alt_3A_4_PartialSS-Tank	Baseline B with tank storage to control system-wide overflow to 4 events per year
Alt_3B_4_PartialSS-Tunnel	Baseline B with tunnel storage to control system-wide overflow to 4 events per year
Alt_3C_4_PartialSS-PAA	Baseline B with PAA disinfection fully treating all but 4 events annually
Alt_4A_8_PartialSS-Tank	Baseline B with tank storage to control system-wide overflow to 8 events per year
Alt_4B_8_PartialSS-Tunnel	Baseline B with tunnel storage to control system-wide overflow to 8 events per year
Alt_4C_8_PartialSS-PAA	Baseline B with PAA disinfection fully treating all but 8 events annually
Alt_5A_12_PartialSS-Tank	Baseline B with tank storage to control system-wide overflow to 12 events per year
Alt_5B_12_PartialSS-Tunnel	Baseline B with tunnel storage to control system-wide overflow to 12 events per year
Alt_5C_12_PartialSS-PAA	Baseline B with PAA disinfection fully treating all but 12 events annually
Alt_6A_20_PartialSS-Tank	Baseline B with tank storage to control system-wide overflow to 20 events per year
Alt_6B_20_PartialSS-Tunnel	Baseline B with tunnel storage to control system-wide overflow to 20 events per year
Alt_6C_20_PartialSS-PAA	Baseline B with PAA disinfection fully treating all but 20 events annually
Group 2 Alternatives	**Description**
Green Infrastructure	Baseline B with GI to control runoff from 5% of impervious surfaces and 10% of impervious surfaces
In-Line Storage	Baseline B with regulator weir raised to increase "in-line storage"
Base-flow Reduction (Water Conservation/ I/I Reduction)	Baseline B with a 10% reduction in base flow as resulting from water conservation and/or reduction of inflow and infiltration

D.3 REDUCTION OF CSO VOLUME AND FREQUENCY

The above control measures will reduce the number of CSO events experienced annually, at each CSO outfall, and the volume of the overflows. Table D-3 presents the frequency of overflows expected to occur annually at each outfall for each alternative listed above, and the percent reduction from the Baseline B. Table D-4 presents the volume in million gallons (MG) at each outfall for each alternative and the percent reduction from Baseline B.

Table D-3 –Annual Untreated Overflow Frequency by Outfall

Scenario	KE001	KE004	KE006	KE007	KE010	Total	%Reduction from	
							Baseline A	Baseline B
Baseline A (Existing Infrastructure)	31	42	57	34	43	61	N/A	N/A
Baseline B (KE010 Separation)	31	42	57	32	0	61	0.0%	N/A
Alt_2A_0_SewerSeparation	0	0	0	0	0	0	100.0%	100.0%
Alt_3A_4_PartialSS-Tank	4	3	2	4	0	4	93.4%	93.4%
Alt_3B_4_PartialSS-Tunnel	*	*	*	*	*	4	93.4%	93.4%
Alt_3C_4_PartialSS-PAA	**	**	**	**	**	4	93.4%	93.4%

Scenario (cont'd)	KE001 (cont'd)	KE004 (cont'd)	KE006 (cont'd)	KE007 (cont'd)	KE010 (cont'd)	Total (cont'd)	%Reduction from	
							Baseline A (cont'd)	Baseline B (cont'd)
Alt_4A_8_PartialSS-Tank	4	7	5	8	0	8	86.9%	86.9%
Alt_4B_8_PartialSS-Tunnel	*	*	*	*	*	8	86.9%	86.9%
Alt_4C_8_PartialSS-PAA	**	**	**	**	**	8	86.9%	86.9%
Alt_5A_12_PartialSS-Tank	7	10	11	11	0	11	82.0%	82.0%
Alt_5B_12_PartialSS-Tunnel	*	*	*	*	*	11	82.0%	82.0%
Alt_5C_12_PartialSS-PAA	**	**	**	**	**	12	80.0%	80.0%
Alt_6A_20_PartialSS-Tank	9	15	18	18	0	20	67.2%	67.2%
Alt_6B_20_PartialSS-Tunnel	*	*	*	*	*	20	67.2%	67.2%
Alt_6C_20_PartialSS-PAA	**	**	**	**	**	20	67.2%	67.2%

(1) The Baseline B alternative achieves the 85% capture target for PVSC interceptor communities.
(2) %Reduction indicates *frequency reduction* as a percentage from Baseline.
(3) Total and %Reduction values indicate *town-wide* values. Outfalls do not necessarily overflow during the same storms, so the town-wide values do not necessarily equal the highest-frequency outfall.
(4) Overflow frequency does not change from Baseline for disinfection alternatives, but the number of *untreated overflow events* drops to 4, 8, 12, and 20 per year (percent reductions shown).
(5) Partial SS refers to complete separation of the KE010 drainage area.
(6) In this context, a CSO event occurs if the CSO flow rate at any outfall exceeds the design flow rate for 3-log pathogen removal.
(*) Indicates tunnel storage solutions which were modeled as having one outfall to determine citywide overflow volume and frequency.
(**) Disinfection is assessed on a town-wide basis, not by individual outfalls.

Table D-4 – Annual Untreated Overflow Volume (MG) by Outfall

Scenario	KE001	KE004	KE006	KE007	KE010	Total	%Reduction from	
							Baseline A	Baseline B
Baseline A (Existing Infrastructure)	3.9	12.4	121.8	90.0	26.6	254.7	N/A	N/A
Baseline B (KE010 Separation)	3.9	12.4	120.2	83.8	0.0	220.3	13.5%	N/A
Alt_2A_0_SewerSeparation	0.0	0.0	0.0	0.0	0.0	0.0	100.0%	86.5%
Alt_3A_4_PartialSS-Tank	0.4	1.2	8.8	12.3	0.0	22.6	91.1%	77.6%
Alt_3B_4_PartialSS-Tunnel	*	*	*	*	*	25.9	89.8%	76.3%
Alt_3C_4_PartialSS-PAA	**	**	**	**	**	11.0	95.7%	95.0%
Alt_4A_8_PartialSS-Tank	0.4	2.1	11.3	18.9	0.0	32.6	87.2%	73.7%
Alt_4B_8_PartialSS-Tunnel	*	*	*	*	*	34.0	86.7%	73.1%
Alt_4C_8_PartialSS-PAA	**	**	**	**	**	34.0	86.7%	84.6%
Alt_5A_12_PartialSS-Tank	0.8	2.9	26.9	34.7	0.0	65.3	74.3%	60.8%
Alt_5B_12_PartialSS-Tunnel	*	*	*	*	*	70.3	72.4%	58.9%
Alt_5C_12_PartialSS-PAA	**	**	**	**	**	47.0	81.5%	78.7%
Alt_6A_20_PartialSS-Tank	1.11	4.5	44.4	48.9	0.0	98.9	61.2%	47.6%
Alt_6B_20_PartialSS-Tunnel	*	*	*	*	*	100.8	60.4%	46.9%
Alt_6C_20_PartialSS-PAA	**	**	**	**	**	63.0	75.3%	71.4%

(1) The Baseline B alternative achieves the 85% capture target for PVSC interceptor communities.
(2) % Reduction indicates *frequency reduction* as a percentage from Baseline.
(3) Total and % Reduction values indicate *town-wide* values. Outfalls do not necessarily overflow during the same storms, so the town-wide values do not necessarily equal the highest-frequency outfall.
(4) Overflow volume does not change from Baseline for disinfection alternatives, but the *untreated overflow volume* drops for the 4, 8, 12, and 20 per year scenarios (percent reductions shown).
(5) Partial SS refers to complete separation of the KE010 drainage area.
(6) In this context, "Untreated CSO Volume" is defined as the sum of discharged volumes during any 5-minute period that exceed the design flow rate for 3-log pathogen removal.
(*) Indicates tunnel storage solutions which were modeled as having one outfall to determine citywide overflow volume and frequency.
(**)Disinfection is assessed on a town-wide basis, not by individual outfalls.

D.3.1 Quantifying Impacts of GI Through Hydraulic Modeling

Green Infrastructure was modeled, using the Infoworks model, to quantify the impacts of implementing GI measures on CSO volume and frequency. The methodology is based on capturing the first inch of rainfall over an area equal to 5% or 10% of the Town's impervious area. Costs associated with GI are presented in Section D.

In order to evaluate the potential impact of widespread implementation of Green Infrastructure, analyses were performed to quantify the reduction from Baseline of CSO frequency and volume resulting from two different GI-implementation levels. The first level of GI implementation involves elimination of runoff from the first inch of rainfall falling on 10% of the impervious surfaces in Kearny, and the second involves elimination of runoff from the first inch of rainfall on 5% of the impervious surfaces. These two control levels represent what was initially targeted, and more recently found to be reasonably achievable, respectively, given efforts to successfully site and install GI projects in New York City.

Impervious surfaces (including rooftops, streets, sidewalks, parking lots) in Kearny cover approximately 715 acres. When 5% of the impervious area (or about 35.7 acres) are controlled with GI, CSO volumes decrease by about 5 MG (1.9%), and CSO event counts did not decrease at all. When 10% of the impervious area (or about 71.5 acres) are controlled with GI, CSO volumes decrease by about 10 MG (3.9%), and CSO event counts decreased by 2 (3.3%). The quantitative impacts of GI on Town wide CSO frequency and volume, are shown in Tables D-5 and D-6 below. Tables D-5 and D-6 also quantify the impacts of other measures such as base flow reduction and regulator modifications.

Table D-5 – Overflow Frequency by Outfall

Group 2 Alternatives	KE001	KE004	KE006	KE007	KE010	Total	% Reduction from	
							Baseline A	Baseline B
Baseline A (Existing Infrastructure)	31	42	57	34	43	61	N/A	N/A
Baseline B (KE010 Separation)	31	42	57	32	0	61	0.0%	N/A
Baseline B + GI for 5% of Impervious Surfaces	29	42	57	32	0	61	0.0%	0.0%
Baseline B + GI for 10% of Impervious Surfaces	29	42	56	32	0	59	3.3%	3.3%

Group 2 Alternatives (cont'd)	KE001 (cont'd)	KE004 (cont'd)	KE006 (cont'd)	KE007 (cont'd)	KE010 (cont'd)	Total (cont'd)	% Reduction from	
							Baseline A (cont'd)	Baseline B (cont'd)
Baseline B + 6'' Weir Elevation	29	31	57	32	0	61	0.0%	0.0%
Baseline B + 10% Base-Flow Reduction	30	42	56	32	0	60	1.6%	1.6%

(1) % reduction indicates f*requency reduction* as a percentage from Baseline.
(2) Total and % reduction values indicate *city-wide* values. Outfalls do not necessarily overflow during the same storms, so the Town-wide values do not necessarily equal the highest-frequency outfall.
(3) Complete separation of the KE010 drainage area is assumed for all group 2 alternatives.
(4) Baseline A and Baseline B are defined in Section B.

Table D-6 – Annual Overflow Volume (MG) by Outfall

Group 2 Alternative	KE001	KE004	KE006	KE007	KE010	Total	%Reduction from	
							Baseline A	Baseline B
Baseline A (Existing Infrastructure)	3.9	12.4	121.8	90.0	26.6	254.7	N/A	N/A
Baseline B (KE010 Separation)	3.9	12.4	120.2	83.8	0.0	220.3	13.5%	N/A
Baseline B + GI for 5% of Impervious Surfaces	3.7	11.9	117.1	82.7	0.0	215.4	15.4%	1.9%
Baseline B + GI for 10% of Impervious Surfaces	3.6	11.5	113.9	81.4	0.0	210.3	17.4%	3.9%
Baseline B + 6'' Weir Elevation	3.7	10.8	121.1	81.6	0.0	217.3	14.7%	1.2%
Baseline B + 10% Base-Flow Reduction	3.8	12.3	118.5	81.9	0.0	216.6	15.0%	1.4%

(1) % reduction indicates *volume reduction* as a percentage from Baseline.
(2) Total and % reduction values indicate *city-wide* values.
(3) Complete separation of the KE010 drainage area is assumed for all Group 2 alternatives.
(4) Baseline A and Baseline B are defined in Section B.

Despite the marginal quantitative impacts of GI on CSO frequency and volume, there are numerous benefits to implementing GI. Such benefits include aesthetics, and gaining public and regulatory acceptance. GI measures, regardless of overall impact on CSO's will be included in the final LTCP.

Because of the relatively small impact achievable with GI, all alternatives were evaluated conservatively, without GI, with the assumption that any additional impact of GI, however minor, would be considered in the development of the final selected alternatives.

The capital, O&M, and overall Present Value costs of implementing GI measures, in accordance with the analysis described above, are presented in Section D.5.

D.4 EVALUATION OF COSTS

D.4.1 Capital Costs

Capital costs for storage and treatment are taken from the cost curves presented in the current Technical Guidance Manual (TGM). Based on experience with past projects, the capital costs obtained from the TGM cost curves are multiplied by a factor of 2.5 to account for contractor's installation, electrical, piping, and indirect costs. Costs for sewer separation are taken from the 2007 Cost and

Performance Data and updated using the ENR Construction Cost Index (CCI). Capital costs presented in this report are based on an ENR CCI of 10817. The updated capital cost of sewer separation is multiplied by a factor of 1.5 to account for the ancillary costs not already included in the 2007 cost estimates.

D.4.2 Operation and Maintenance (O&M) Costs

Annual operation and maintenance (O&M) Costs are computed in accordance with the most recent methodology developed by Greeley and Hansen as follows: one continuous operating post (COP) is equivalent to three 8-hour shifts, 365 days per year, at a labor rate of $53.60 per hour, therefore one COP is computed as follows: $53.60/hr x 8 x 3 x 365 = $470,000 per year.

For a CSO tunnel, the operations cost is 1.0 x $470,000 per year. For storage tanks, the operations cost is 0.5 x $470,000 or $235,000 per year.

Maintenance costs are computed as a percentage of the construction cost. For tunnels, the percentage of capital cost is 2%. For storage tanks, the percentage of capital cost is 3%.

O&M costs are converted to present value (PV) costs, based on a 20-year life and an assumed interest rate of 2.75%.

D.4.3 Present Value (Life Cycle) Costs

Capital and O&M costs are added together to compute probable total project cost (PTPC) for a 20-year life cycle as shown in Table D-7.

D.4.4 Cost of Alternatives

From the totality of the previously discussed factor of the Evaluation of Costs, the capital, O&M and overall present value (PV) costs are shown in Table D-7. These costs do not include the estimated costs for implementing GI measures. GI costs are shown in Tables D-8 and D-9 and must be added to the costs shown in Table D-7.

Table D-7 – Total Capital Cost, PTCP Capital Cost, Total 20-yr O&M Cost, and PTPC(1) as 20-yr Present Value of Alternatives to Achieve 0, 4, 8, 12 and 20 CSOs per Year

Annual CSO Count	Alternative ID	Capital Cost ($M)	PTPC Capital Cost ($M)	20-Year O&M Cost ($M)	PTPC 20-Year PV Cost ($M)
61	Baseline B (KE010 Separation)	$30.86	$77.15	$23.49	$100.64
0	Alt_2A_0_SewerSeparation	$414.36	$621.54	$126.19	$747.74
4	Alt_3A_4_PartialSS-Tank	$82.58	$206.45	$61.44	$267.90
4	Alt_3B_4_PartialSS-Tunnel	$107.51	$268.77	$53.99	$322.76
4	Alt_3C_4_PartialSS-PAA-FlexFilter	$90.85	$227.13	$35.27	$262.40
8	Alt_4A_8_PartialSS-Tank	$77.04	$192.60	$58.90	$251.49
8	Alt_4B_8_PartialSS-Tunnel	$104.50	$261.25	$53.08	$314.32
8	Alt_4C_8_PartialSS-PAA-FlexFilter	$72.24	$180.60	$32.03	$212.63
12	Alt_5A_12_PartialSS-Tank	$66.41	$166.03	$54.05	$220.08
12	Alt_5B_12_PartialSS-Tunnel	$93.96	$234.90	$49.87	$284.77
12	Alt_5C_12_PartialSS-PAA-FlexFilter	$63.29	$158.23	$30.46	$188.70

Annual CSO Count (cont'd)	Alternative ID (cont'd)	Capital Cost ($M) (cont'd)	PTPC Capital Cost ($M) (cont'd)	20-Year O&M Cost ($M) (cont'd)	PTPC 20-Year PV Cost ($M) (cont'd)
20	Alt_6A_20_PartialSS-Tank	$59.04	$147.60	$50.68	$198.27
20	Alt_6B_20_PartialSS-Tunnel	$86.83	$217.08	$47.70	$264.78
20	Alt_6C_20_PartialSS-PAA-FlexFilter	$56.45	$141.13	$29.20	$170.32

(1) PTPC (Probable Total Project Costs) reflect a 2.5 escalation factor on capital costs, to account for installation, non-component cost, and indirect costs as described in the Assumptions. For complete sewer separation only, PTPC represents an escalation factor of 1.5 on capital costs to account for ancillary costs not already accounted for in the 2007 cost estimates.
(2) Capital and O&M costs for each alternative include the cost of separating the KE010 drainage area.
(3) The Baseline B alternative achieves the 85% capture goal for PVSC interceptor communities.
(4) Costs shown in Table D-7 do not include costs for Green Infrastructure, which are shown in Tables D-8 and D-9.

D.5 GREEN INFRASTRUCTURE

Capital and O&M costs for GI measures were taken from the recent 2018 G&H Technical Guidance Manual (TGM) and the NJDEP 2018 guidance document. As widespread implementation of GI could involve a variety of GI technologies depending on specific site conditions, a range of costs is provided in the GI cost table. Table D-8 shows the capital costs, O&M costs, and raw total 20-year present value cost for each GI technology for implementation at 5% and 10% of impervious surfaces. Capital costs were multiplied by 2.5 to calculate the probable total project cost (PTPC) of implementing each technology. The PTPC accounts for installation, non-component (electrical, piping, etc.) and indirect costs (freight, permits, etc.) for all storage and disinfection alternatives. An explanation of how the capital cost factor of 2.5 was calculated is shown in the "Assumptions" section. Table D-9 shows the raw and PTPC cost range of green infrastructure reported as $M/MG CSO controlled and $M/impervious acre controlled.

Table D-8 – Capital, 20-Year O&M, and Life-Cycle PV Cost Ranges For Green Infrastructure to Control 5 and 10% of Impervious Cover

Controlled(1) Portion of Impervious Area	Green Infrastructure Technology	Min. Raw(2) Capital Cost ($M)	Max. Raw(2) Capital Cost ($M)	20-Year O&M as PV Cost ($M)	Min. Raw(2) 20-Yr Life-Cycle as PV ($M)	Max. Raw(2) 20-Yr Life-Cycle as PV ($M)
5% (35.7 ac)	Rain Garden	$3.43	$10.90	$4.35	$7.79	$15.26
	Right-of-Way Bioswale	$5.36	$17.87	$4.35	$9.72	$22.23
	Green Roof	$17.16	$87.22	$4.35	$21.51	$91.57
	Porous Asphalt(3)	$9.29	$19.48	$0.68	$9.97	$20.16
	Pervious concrete(3)	$10.90	$21.81	$0.68	$11.58	$22.49
	PICP(3)	$4.65	$13.23	$0.68	$5.33	$13.91
10% (71.5 ac)	Rain Garden	$6.86	$21.81	$8.71	$15.57	$30.51
	Right-of-Way Bioswale	$10.72	$35.75	$8.71	$19.43	$44.46
	Green Roof	$34.32	$174.44	$8.71	$43.03	$183.15
	Porous Asphalt(3)	$18.59	$38.96	$1.36	$23.17	$44.97
	Pervious concrete(3)	$21.81	$43.61	$1.36	$23.17	$44.97
	PICP(3)	$9.29	$26.45	$1.36	$10.65	$27.81

Controlled[1] Portion of Impervious Area	Green Infrastructure Technology	Min. PTPC[4] Capital Cost ($M)	Max. PTPC[4] Capital Cost ($M)	20-Year O&M as PV Cost ($M)	Min PTPC[4] 20-Yr Life-Cycle as PV ($M)	Max PTPC[4] 20-Yr Life-Cycle as PV ($M)
5% (35.7 ac)	Rain Garden	$8.58	$27.26	$4.35	$12.93	$31.61
	Right-of-Way Bioswale	$13.40	$44.68	$4.35	$17.76	$49.04
	Green Roof	$42.90	$218.05	$4.35	$47.25	$222.41
	Porous Asphalt[3]	$23.23	$48.70	$0.68	$23.92	$49.38
	Pervious concrete[3]	$27.26	$54.51	$0.68	$27.94	$55.19
	PICP[3]	$11.62	$33.07	$0.68	$12.30	$33.75
10% (71.5 ac)	Rain Garden	$17.16	$54.51	$8.71	$25.87	$63.22
	Right-of-Way Bioswale	$26.81	$89.37	$8.71	$35.52	$98.07
	Green Roof	$85.79	$436.10	$8.71	$94.50	$444.81
	Porous Asphalt[3]	$46.47	$97.41	$1.36	$55.87	$110.39
	Pervious concrete[3]	$54.51	$109.03	$1.36	$55.87	$110.39
	PICP[3]	$23.23	$66.13	$1.36	$24.60	$67.49

(1) Control eliminates runoff from first inch of rain on controlled portion of impervious area.
(2) Costs based on information provided to NJ CSO Group by PVSC, G&H, except as otherwise noted.
(3) O&M costs for porous asphalt, pervious concrete, and PICP based on information from NJDEP (2018, NJDEP).
(4) PTPC capital costs based on application of an escalation factor of 2.5 times the raw capital cost.
(5) Overall minimum cost is shaded in blue. Overall maximum cost is shaded in red.

Table D-9 – Normalized Green Infrastructure Cost[1] Ranges

Cost Type	Green Infrastructure Technology	Min. 20-Yr Life Cycle Cost as PV, ($M/MG CSO Controlled)	Max. 20-Yr Life Cycle Cost as PV, ($M/MG CSO Controlled)	Min. 20-Yr Life Cycle Cost as PV, ($M/Acre Controlled)	Max. 20-Yr Life Cycle Cost as PV, ($M/Acre Controlled)
Raw Cost[2]	Rain Garden	$1.60	$3.13	$0.22	$0.43
	Right-of-Way Bioswale	$1.99	$4.56	$0.27	$0.62
	Green Roof	$4.41	$18.77	$0.60	$2.57
	Porous Asphalt[3]	$2.04	$4.13	$0.28	$0.56
	Pervious concrete[3]	$2.37	$4.61	$0.32	$0.63
	PICP[3]	$1.09	$2.85	$0.15	$0.39
Probable Total Project Cost[4]	Rain Garden	$2.65	$6.48	$0.36	$0.89
	Right-of-Way Bioswale	$3.64	$10.05	$0.50	$1.37
	Green Roof	$9.69	$45.59	$1.32	$6.23
	Porous Asphalt[3]	$4.90	$10.12	$0.67	$1.38
	Pervious concrete[3]	$5.73	$11.31	$0.78	$1.55
	PICP[3]	$2.52	$6.92	$0.34	$0.95

(1) Costs to eliminate runoff from the first inch of rain from targeted impervious area.
(2) Raw costs based on latest available capital, O&M, and PV (2018, G&H, 2019, G&H) except as noted.

(3) O&M costs for porous asphalt, pervious concrete, and PICP based on information gathered by NJDEP (2018, NJDEP)
(4) PTPC (Probable Total Project Costs) reflect a 2.5 escalation factor on capital costs, to account for installation, non-component cost, and indirect costs as described in Assumption #6.
(5) Costs for each GI technology do not reflect the cost of separating the KE010 drainage area.
(6) Costs in Table D-9 are not included in the costs shown in Table D-7.

Assumptions:

- Sewer Separation Costs
  - Capital costs for complete sewer separation of all combined-sewer drainage areas were modified from prior analyses (2007, HMM) that cited a normalized cost of $235,233 per acre (2006, HMM). To convert to 2018 costs, a ratio of 10817:7630 was applied herein, based on the Engineering News Record (ENR) Construction Cost Index (CCI) values for 2018 and 2006, respectively.
  - O&M costs are assumed to be 2% of the capital cost.
- Treatment Costs
  - Capital and O&M costs for PAA disinfection are based on the latest available guidance for permittees.
- Storage Tank Costs
  - Capital costs for tank-storage solutions are based on the latest available guidance for permittees.
  - O&M costs for tanks are based on operational costs at 0.5*$470,000 and maintenance costs at 3% of the construction cost, in accordance with the latest available guidance for permittees.
- Storage Tunnel Costs
  - Capital costs for tunnel-storage solutions are based on the latest available guidance for permittees.
  - O&M costs for tunnels are based on operational costs at 1.0*$470,000 and maintenance costs at 2% of construction cost, in accordance with the latest available guidance for permittees.
  - The ground type for tunnel cost calculations is assumed to be of the type “unknown”.
  - Construction cost of drop shafts is not included in the cost estimate for tunnel-storage solutions. The construction cost of the tunnel only without the drop shaft is more expensive than the capital cost of tanks therefore the cost of drop shafts were not calculated.
- Green Infrastructure Costs
  - Capital costs for various GI solutions are based on the latest available guidance for permittees.
  - O&M costs for Bioretention GI solutions were provided as $8,000 per managed acre.
  - O&M costs for Porous Pavement GI solutions were assumed to be $1,250 per managed acre.
- Additional Cost Factors
  - Present-value (PV) of life-cycle costs based on a 20-year period and an interest rate of 2.75% in accordance with the latest available guidance for permittees.
  - Based on experience on other similar projects, HDR developed “total probable project costs” using a factor of 2.5 to account for installation costs, non-component costs (electrical, piping, etc.), and indirect costs (freight, permits, etc.) for separation, storage and disinfection. A breakdown of how this factor was calculated is shown below.
    - Installation was estimated at 20% of equipment costs based on historic data experienced by HDR and industry standards for typical plants of similar size and complexity.

- Non-component costs including: electrical (10%), piping (10%), instrumentation and controls ($15,000), and civil site work (25%) were estimated based on factors or percentages of equipment costs. These factors account for standard installation commodities, accessories, steal supports and standard testing support.
- Freight was estimated at a lump sum of $20,000.
- Sales tax was estimates at 8%
- Permits were estimated at $20,000
- Start up, performance testing, operator training and O&M manual were estimated at $50,000
- Contract overhead and profit includes 29% for the following:
- Part time – Project management support, project controls, procurement, quality and safety support.
- Full time – Site construction manager (CM), site administration, standard CM travel pack.
- Engineering, administration and legal fees were estimated at 10%
- A contingency of 10% is included for the remaining equipment items and non-component costs.

- Wastewater Pumping Rate Limits
  - Dewatering of CSO-storage facilities (tanks or tunnels) must be done within 3 days to avoid septic conditions.
  - Dewatering from CSO-storage facilities (tanks or tunnels) cannot cause the total flow rate to exceed 1.75x the total average dry weather flow.

D.6 DISCUSSION OF COSTS

As can be seen from Table D-4 above, the lowest cost alternatives are Alternatives 6C, 5C, 4C, and 3C, all of which are based on Partial Sewer Separation in Area 010 (Baseline B), Plus Disinfection With PAA, for 20, 12, 8, and 4 CSO events per year, respectively. The PV costs for these four alternatives are very close, within 5 percent of each other. The required target frequency is 4 CSO events per year. Alternative 2A, total sewer separation throughout the entire Town, is by far the most costly alternative. In general, the alternatives are ranked from lowest to highest cost as follows:

- Partial Sewer Separation Plus Disinfection
- Partial Sewer Separation Plus Storage Tank
- Partial Sewer Separation Plus CSO Tunnel
- Complete Sewer Separation – Entire Town

APPENDIX G

Development and Evaluation of Alternatives Report
City of Newark

Dated: June 21, 2019
Revised: November 2019

Development and Evaluation of CSO Alternatives Report

City of Newark

November 12, 2019

Prepared by
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SECTION A INTRODUCTION

The City of Newark is a densely populated City in Essex County, New Jersey and the most populous city in the state of New Jersey with a total area covering approximately 26 square miles. Newark is one of the oldest cities in the United States. Its location at the mouth of the Passaic River (where it flows into Newark Bay) has made the city's waterfront an integral part of the Port of New York and New Jersey. The City's combined sewer system is permitted under NJPDES Permit No. NJ0108758**.** All combined sewer flows from Newark are conveyed to the PVSC wastewater treatment plant through PVSC's interceptor and Newark's South Side interceptor.

Consistent with the 1994 USEPA CSO Control Policy, the NJPDES permit requires implementation of CSO controls through development of a Long-Term Control Plan (LTCP). The permit includes requirements to cooperatively develop the LTCP with PVSC and its hydraulically connected CSO permittees. Each permittee is required to develop all necessary information for the portions of the system they own.

Section D.3.b.v of the NJPDES permit indicates that, as part of the LTCP requirements, a Development and Evaluation of CSO Control Alternatives report be submitted to the NJDEP within 48 months from the effective date (July 1, 2015) of the permit. The City of Newark prepared this report to meet this regulatory requirement. The report includes evaluations of various CSO-control alternatives, including source control technologies, storage technologies, and treatment technologies.

SECTION B FUTURE CONDITIONS

B.1 INTRODUCTION

Establishing baseline condition is an important step in the CSO LTCP alternatives analysis. The Baseline condition is used to compare the effectiveness of different CSO-control alternatives and to estimate the magnitude of the CSO volume and frequency reductions. The baseline condition uses a 25- to 35-year planning horizon for implementation of the CSO LTCP. The projection of dry-weather sanitary flows to that future time (see Section B.4) is based on the population projections described in Section B.2.

B.2 PROJECTIONS FOR POPULATION GROWTH

For the purposes of CSO LTCP future projections, this analysis estimated City of Newark population for year 2050 using available data from the US Census[1], the NJ Department of Labor and Workforce Development (NJDLWD)[2], and the New Jersey Transportation Planning Authority (NJTPA)[3]. Table B.2-1 summarizes population estimates for the State of New Jersey, Essex County, and Newark (US Census and NJTPA). Year 2050 populations were estimated using two methods: linear regression and average annual growth. US Census data shows the annual average growth as 0.43% for the State and 0.54% for

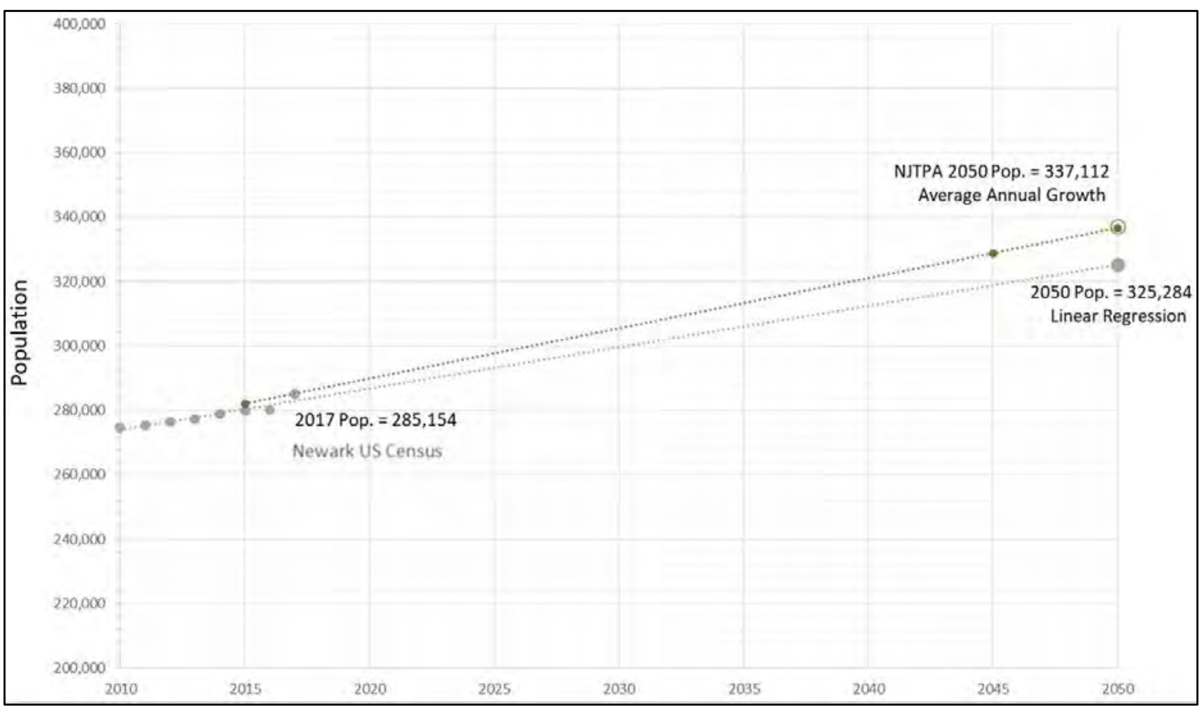
[1] https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk
[2] https://www.nj.gov/labor/lpa/dmograph/lfproj/lfproj_index.html
[3] https://www.njtpa.org/getattachment/Data-Maps/Demographics/Forecasts/Plan-2045-Forecasts.pdf.aspx

Newark. NJDLWD data shows an annual average growth rate of 0.30% for Essex County. NJTPA data shows annual average growth rate of 0.50% for Newark. Based upon discussions with PVSC and other communities, NJTPA data (0.50% annual average growth rate) was used to estimate the 2050 Newark population of 337,112. Figure B.2-1 graphically presents the US Census and NJTPA estimates for Newark.

Table B-1. Population Estimates

Year	Population				Growth (%)				Annual Growth (%/yr)			
	New Jersey (US Census)	Essex County (NJDLWD)	Newark (US Census)	Newark (NJTPA)	New Jersey (US Census)	Essex County (NJDLWD)	Newark (US Census)	Newark (NJTPA)	New Jersey (US Census)	Essex County (NJDLWD)	Newark (US Census)	Newark (NJTPA)
2010	8,791,894	783,969	274,674									
2011			275,512				0.31%				0.31%	
2012			276,478				0.35%				0.35%	
2013			277,357				0.32%				0.32%	
2014	8,938,200	795,700	278,750		1.7%	1.5%	0.50%		0.42%	0.37%	0.50%	
2015			279,793	282,102			0.37%				0.37%	
2016			280,139				0.12%				0.12%	
2017			285,154				1.79%				1.79%	
2019	9,132,700	808,300			2.2%	1.6%			0.44%	0.32%		
2024	9,338,000	819,100			2.2%	1.3%			0.45%	0.27%		
2029	9,530,900	829,800			2.1%	1.3%			0.41%	0.26%		
2034	9,733,400	840,100			2.1%	1.2%			0.42%	0.25%		
2045				328,809				20.0%				0.50%
Average Annual Growth									0.43%	0.3%	0.54%	0.50%
2050	Regression								Annual Growth (%)			
	10,359,628	878,406	325,284	336,594					10,424,837	885,177	336,726	337,112

Figure B.2-1. Newark 2050 Population Estimate



Since there are some areas outside of Newark in adjacent communities (East Orange, South Elizabeth) that flow into the Newark system populations for those areas were estimated using the Essex County average annual growth rate of 0.3%. Table B.2-2 summarizes the populations for each outfall/regulator and adjacent community used in the Newark portion of the InfoWorks model.

Table B-2. Newark InfoWorks Model Populations

Outfall/Regulator/Community	Population	
	Existing	Projected 2050
Verona (002)	4,572	5,203
Delavan/Herbert (002,004,005)	5,494	6,252
Fourth Ave (008)	7,701	8,764
Clay St (009/010)	80,893	92,060
Rector/Saybrook (014)	23,635	26,898
City Dock (015)	6,386	7,268
Jackson (016)	3,582	4,076
Polk (017)	8,387	9,545
Freeman (018)	5,320	6,054
Roanoke (022)	2,572	2,927
Adams (023)	10,541	11,996
Peddie (25)	64,179	73,039
Queen (026)	19,174	21,821
Waverly (027/029)	9,151	10,414
Wheeler (030)	27,559	31,364
Interceptor	17,073	19,430
Total Newark	**296,219**	**337,112**
East Orange	29,284	32,520
South Elizabeth	16,188	17,977
Total Adjacent Communities	**45,472**	**50,497**
Total Newark Model	**341,691**	**387,609**

B.3 PLANNED PROJECTS

No LTCP projects are planned at this time.

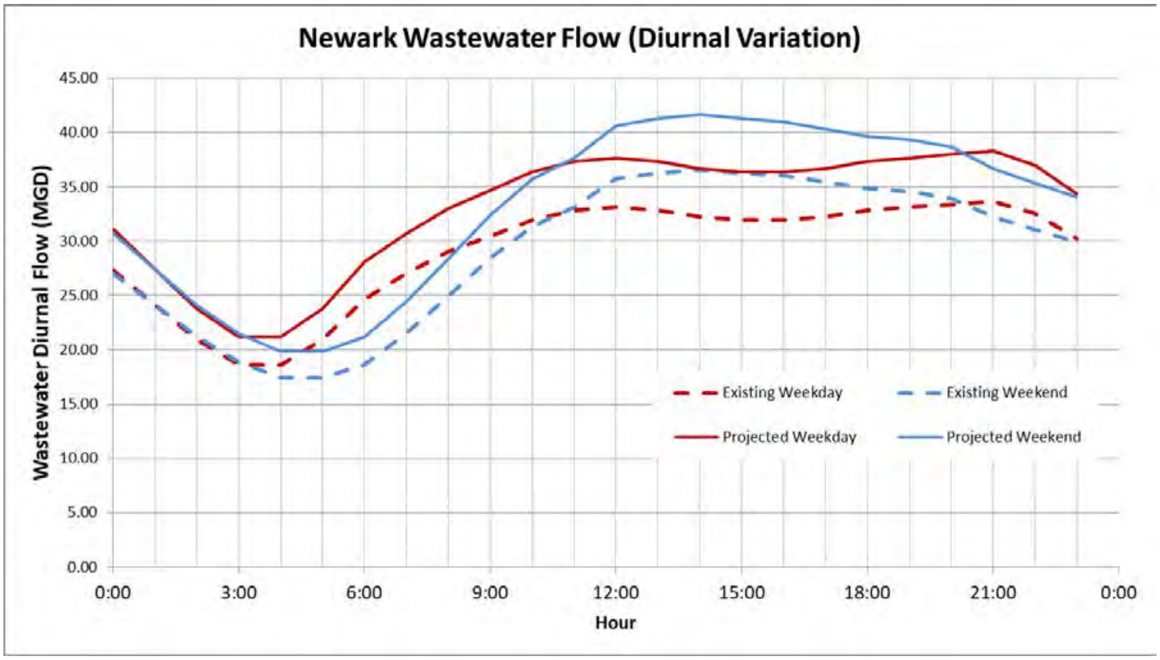
B.4 PROJECTED FUTURE WASTEWATER FLOWS

Model estimates of dry-weather (sanitary) wastewater flow are based on population and per-capita flow rates (98 gallons per capita per day). Table B.4-1 summarizes the existing and projected (year 2050) average wastewater flow for Newark and for each regulator/outfall/community contributing to the Newark system. A daily diurnal pattern for weekdays and weekends is applied to estimate the hourly flows, as summarized on Figure B.4-1.

Table B-3. Newark Average Dry-Weather Wastewater Flows

Outfall/Regulator	Wastewater Flow (MGD)	
	Existing	Projected 2050
Verona (002)	0.45	0.51
Delavan/Herbert (002,004,005)	0.54	0.61
Fourth Ave (008)	0.75	0.86
Clay St (009/010)	7.93	9.02
Rector/Saybrook (014)	2.32	2.64
City Dock (015)	0.63	0.71
Jackson (016)	0.35	0.40
Polk (017)	0.82	0.94
Freeman (018)	0.52	0.59
Roanoke (022)	0.25	0.29
Adams (023)	1.03	1.18
Peddie (25)	6.29	7.16
Queen (026)	1.88	2.14
Waverly (027/029)	0.90	1.02
Wheeler (030)	2.70	3.07
Interceptor	1.67	1.90
Total Newark	**29.03**	**33.04**
East Orange	2.87	3.19
South Elizabeth	1.59	1.76
Total Adjacent Communities	**4.46**	**4.95**
Total Newark Model	**33.49**	**37.99**

Figure B.4-1. Newark Wastewater Flows



SECTION C SCREENING OF CSO-CONTROL TECHNOLOGIES

C.1 INTRODUCTION

A variety of CSO-control technologies were considered as a part of a screening process to identify the options that would be most applicable for Newark. Options identified during this screening process were evaluated for effectiveness and cost, as described in Section D. The CSO-control technologies are grouped into the following categories:

- Source Control (Including Green Infrastructure)
- Inflow and Infiltration (I/I) Control
- Sewer-System Optimization
- In-line and Offline Storage
- Wastewater Treatment Plant (WWTP) Expansion or Storage at the Plant
- Sewer Separation
- Treatment of CSO Discharge

Screening was performed at a high level to consider the general capabilities of the CSO-control technologies. The following sections present a description of the technologies that were deemed viable for further evaluation (as described in Section D). Section C.9 presents a summary of the screening process and an overview of the technologies considered.

C.2 SOURCE CONTROL

Source-control technologies reduce stormwater runoff volume and/or pollutants upon entering the collection system. Many source-control technologies do not require significant structural improvements and can have lower capital costs. However, these technologies can be labor intensive and can have high operation and maintenance (O&M) costs.

Applicable source-control technologies include: Stormwater Management, Public Education, Ordinance Enforcement, Good Housekeeping, and Green Infrastructure (GI). The NJPDES permit recommends evaluation of the feasibility of GI technologies as a part of the evaluation of alternatives. GI was identified as a viable source control measure in Newark because of its ability to provide ancillary environmental and public benefits.

C.2.1 Green Infrastructure

Green Infrastructure technologies are used to capture stormwater before it enters the sewer system. Captured stormwater is typically infiltrated into the ground or conveyed to the atmosphere via evapotranspiration. Implementing GI technologies in Newark has the potential to reduce the volume of stormwater that enters the combined sewer system, thereby reducing the overall volume and frequency of CSO events. Some GI technologies also offer environmental, social, and economic benefits to the community, such as decreasing localized flooding, improving air quality, creating job opportunities, and providing needed green spaces for aesthetic purposes. However, GI does not generally provide the same level of volume or bacteria reduction as gray solutions.

GI technologies can be applied alone or in conjunction with other types of CSO control technologies. To provide significant system-wide CSO control, widespread implementation is typically needed, especially in highly urbanized environments such as Newark.

A previous study, *"Green Infrastructure Feasibility Study, Newark,"* prepared by Rutgers University, identified several possible locations throughout Newark where GI technologies could be implemented. Evaluation of potential GI opportunities will be further refined in the next steps of the alternative evaluation.

C.3 INFILTRATION AND INFLOW CONTROL

Excessive infiltration and inflow (I/I) into the combined sewer system can consume hydraulic capacity, both within the system and at the treatment facility. "Infiltration" refers to the intrusion of ground water into the collection system through defective pipe joints, cracked or broken pipes, manholes, footing drains, and other similar sources. In the context of CSS, which is designed to accept stormwater, "inflow" refers to entry of flow from streams, tidal sources, or catch basins and similar structures in supposedly "separated" areas that are connected to the CSS.

Controlling inflow to the CSS can reduce the volume and frequency of overflow and can provide additional capacity for growth in the future. The primary source of inflow is surface runoff. Unless existing storm drains are in place, a diversion of inflow sources to separate storm drains is not usually cost effective. All outfalls in the existing CSS are equipped with tide gates to prevent tidal flows from getting into the CSS. However, there are two significant sources of extraneous flow identified to Newark's CSS system, one from Branch Brook Lake, another the lake in Weequahic Park. Therefore, the alternative of controlling the inflows from the two sources are further evaluated and described in Section D.2.4.

C.4 SEWER SYSTEM OPTIMIZATION

By maximizing volume of flow stored in the collection system or maximizing the use of existing system capacity to convey flow to the treatment plant, sewer system optimization reduces CSO volume and frequency. Sewer system optimization technologies include improving conveyance, implementing regulator modifications, consolidation or relocation of outfalls, and applying real-time controls to minimize CSO frequency/volume or the number/cost of control facilities.

Conveyance: Improving conveyance of combined sewage through the sewer system to the treatment facility can reduce the number and volume of CSOs. Removing bottlenecks and redirecting overflows from more sensitive areas to areas where impacts are less significant are some of the ways that conveyance can be improved. Improving or adding conveyance in the existing system can be achieved by modifying the flow control and adding additional capacity to existing sewers and interceptors. Major conveyance improvements can create significant disruption in urban environments. Taking into account PVSC's plan to increase the capacity of the treatment plant, conveyance will be further reviewed and evaluated.

Outfall Consolidation/Relocation:

Regulator Modifications: Adjusting the weir elevation or length at specific regulators within the combined sewer system can increase "in-line" storage in upstream pipes. This type of modification will also maximize flow to the interceptor and treatment facility. Regulator modifications will be looked at for further evaluation.

Real Time Control (RTC): RTC provides integrated control for regulators, outfall gates, and pump station operations based on anticipated conditions, with feedback loops for control adjustments based on actual conditions within the system. RTC typically involves an automated monitoring and control system that operates control devices (such as gates or pump stations) to maximize the storage capacity of the CSS to limit overflows.

In the Newark CSO system, ten regulators are equipped with automatically controlled sluice gates that are controlled by PVSC based on inflow at the plant or water level at the storage clarifier. These gates are closed during a wet weather event to limit flows to the interceptor and PVSC Plant. Alternative control of RTC of the Newark gates are further evaluated and described in Section D.2.1.

C.5 STORAGE

Storage technologies allow excess wet weather flow to be stored for future treatment at the WWTP. Storage can be effective in reducing the peak flow entering the combined sewer system and provide a more constant flow into the treatment plant once the storm has ended. Storage technologies are reliable for CSO control, however construction and O&M costs can be high. Storage technologies include linear storage (pipeline and tunnel) and point storage (tanks).

Pipeline Storage: Storage within the existing pipe network can be utilized to retain excess wet weather flows. If storage capacity is not available within the existing pipe network, new larger size pipes can be constructed in place of, or parallel to the existing combined sewers. The advantage of pipeline storage is the small construction area as compared to the construction area required for point storage. However, significant lengths of piping could be required to provide adequate storage if a small diameter pipe is used. Pipelines typically require large open trenches and temporary closure of streets to install, which could create significant public disturbances.

If the utilization of available storage volume already existing within the CSS can be maximized, the use of pipeline storage can be a cost-effective method for reducing combined sewer overflows. However, this is not feasible in Newark based on a prior study (2008, HDR). This study concluded that the available sewer storage capacity for in-line storage was limited and would not help to significantly reduce the number of overflows to attain the performance objectives. Although it is possible to construct oversized conduits and increase in-line storage, the highly urbanized land use and existing underground facilities would make this expensive and disruptive.

Considering the limited opportunities discussed above, in-line storage using pipelines is not recommended and is removed from further consideration.

Tunnel Storage: Storage in deep tunnels involves the capture and storage of excess wet weather flows in a tunnel and the subsequent pumping out of this stored volume when the conveyance and treatment capacities become available. Flows are sent to the tunnel through drop shafts, and pumping stations are required for dewatering at the downstream end. Large diameter tunnels provide more storage volume than pipelines and cause minimal disturbance to the ground surface, which can be very beneficial to urban areas.

Tank Storage: Tank storage are usually installed at or near the CSO outfall or pump station to consolidate flows conveyed within the collection system from upstream locations. This type of technology is relatively simple and can reduce the frequency and volume of overflows effectively. Storage tanks are underground and store the CSO during wet weather events until there is available capacity in the system and the flow can be pumped back to the PVSC treatment plant. Tanks can capture the first flush portion of wet weather peak flow that is the most concentrated. For these reasons, storage tanks have been considered a viable option for Newark and were further evaluated.

C.6 STP EXPANSION OR STORAGE AT THE PLANT

Expansion of the WWTP can help reduce or eliminate CSOs by allowing each municipality to send more flow to the plant. PVSC owns and operates the wastewater treatment plant that receives and treats flows from Newark. Any modifications to the treatment plant that would result in CSO volume and frequency reduction, or any increased treatment capacity, will be addressed by PVSC and its consultants.

C.7 SEWER SEPARATION

Combined sewer overflows can be eliminated or reduced through the implementation of complete or partial sewer separation. This process involves the removal of stormwater connections from the CSS and the construction of new storm sewers to convey storm runoff directly to the receiving water, leaving the combined sewers to convey sanitary sewage. The existing CSO outfalls can be repurposed into stormwater outfalls, however this will require modification to the existing infrastructure such as manholes, regulators, and outfalls. Sewer separation is often highly disruptive to the neighborhood, especially in highly populated urban environments. Also, there is a potential in the future that Municipal Separate Storm Sewer (MS4) permits may require treatment of separated stormwater prior to discharge. Sewer separation has been considered as a viable option and will be further evaluated in Newark.

C.8 TREATMENT OF CSO DISCHARGE

Disinfection is used to destroy pathogenic microorganisms in CSO discharges. It is very effective at reducing pathogen concentrations but provides no volume reduction. Disinfection can either be conducted at centralized storage facilities or locally at satellite facilities near the outfalls. However, CSO disinfection can be challenging due to the inherent nature of CSO characteristics, such as intermittent occurrence and high variability of flow and pathogen concentrations. Therefore, the full range of possible flow conditions should be considered during the design.

Both chemical disinfection and Ultraviolet (UV) disinfection have been widely used in sewage treatment plants following conventional primary and secondary treatment. For CSO-treatment applications, UV disinfection is not effective due to the characteristics of variable flow and effluent quality. Many chemicals are available for chemical disinfection. Some of the more common technologies include gaseous chlorine, liquid sodium hypochlorite, chlorine dioxide, and ozone. For disinfection of CSOs, liquid sodium hypochlorite is the most common, although its apparent toxicity to aquatic life is a concern and for this reason, dechlorination is required.

The U.S. EPA approved peracetic acid (PAA) as a primary disinfectant for wastewater in 2007. A growing number of wastewater treatment plants in the United States have adopted PAA as a primary disinfectant. Several case studies applying PAA for CSO treatment have been undertaken in the US, including a demonstration study (2017, HMM) conducted in Bayonne. These studies have shown that PAA is an effective agent that requires a comparatively short contact time to achieve the desired level of disinfection, without residual toxicity. The main advantages of PAA over sodium hypochlorite include a longer "shelf life" without product deterioration, the strong relationship between higher dose and higher disinfection level, and the lack disinfection byproducts and associated toxicity, all of which are important for satellite CSO disinfection facilities subject to intermittent and highly variable flows. In addition, the relatively small footprint of PAA-disinfection facilities should allow it to be implemented upstream of each CSO outfall, at a location between the existing regulator and the existing netting facility. The need for pretreatment (suspended solids removal) prior to disinfection is unclear, as there is some evidence that pretreatment may not be required to achieve necessary disinfection levels, but the costs associated with pretreatment can be quite large. In fact, the cost of a PAA disinfection facility without pretreatment could be as little as 10% of the cost of a facility with pretreatment. If Newark selects PAA disinfection, the City may conduct treatability studies to determine if pretreatment is necessary.

Therefore, PAA disinfection technology is to be considered as an alternative for evaluation.

C.9 SCREENING OF CONTROL TECHNOLOGIES

Screening of available CSO-control technologies was conducted based upon several factors, including predicted effectiveness at reaching the primary goals of reducing untreated discharges and bacteria loads, implementation and operational factors, and whether to consider combining the technology with other technologies, if the technology is currently implemented, and finally if the technology can be recommended for the alternatives evaluation. In regard to the primary CSO control goal for bacteria reduction and volume reduction, the technologies were categorized as follows:

- **High** – The CSO-control technology will have a significant impact (≥ 65%) on reaching CSO-control goals and is considered generally feasible.
- **Medium** – This CSO-control technology is reasonably effective (35-65%) for reaching CSO-control goals, but may need to be combined with other technologies.
- **Low** – This technology will have a minor impact (≤ 35%) for reaching CSO-control goals. These technologies will need other positive attributes to be considered for further evaluation.
- **None** – The CSO control technology will have zero or negative effect on reaching CSO-control goals.

Table C-1. CSO Source Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	- Reduced surface flooding potential	Flow restrictions to the CSS can cause flooding in lots, yards and buildings; potential for freezing in lots; low operational cost. Effective at reducing peak flows during wet weather events but can cause dangerous conditions for the public if pedestrian areas freeze during flooding.	No	Yes	No
	Catch Basin Modification (for Floatables Control)	Low	None	- Water quality improvements - Reduced surface flooding potential	Requires periodic catch basin cleaning; requires suitable catch basin configuration; potential for street flooding and increased maintenance efforts. Reduces debris and floatables that can cause operational problems with the mechanical regulators.	No	Yes	No
	Catch Basin Modification (Leaching)	Low	Low	- Reduced surface flooding potential - Water quality improvements	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No	No	No
Public Education and Outreach	Water Conservation	None	Low	- Reduced surface flooding potential - Align with goals for a sustainable community	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume, but would have little impact on peak flows.	Yes	Yes	Yes
	Catch Basin Stenciling	None	None	- Align with goals for a sustainable community	Inexpensive; easy to implement; public education. Is only as effective as the public's acceptance and understanding of the message. Public outreach programs would have a more effective result.	Yes	Yes	No
	Community Cleanup Programs	None	None	- Water quality improvements - Align with goals for a sustainable community	Inexpensive; sense of community ownership; educational BMP; aesthetic enhancement. Community cleanups are inexpensive and build ownership in the city.	Yes	Yes	No
	Public Outreach Programs	Low	None	- Align with goals for a sustainable community	Public education program is ongoing. Permittee should continue its public education program as control measures demonstrate implementation of the NMC.	Yes	Yes	No
	FOG Program	Low	None	- Water quality improvements - Improves collection system efficiency	Requires communication with business owners; Permitee may not have enforcement authority. Reduces buildup and maintains flow capacity. Only as effective as business owner cooperation.	Yes	No	No
	Garbage Disposal Restriction	Low	None	- Water quality improvements	Permitee may not be responsible for Garbage Disposal. This requires an increased allocation of resources for enforcement while providing very little reduction to wet weather CSO events.	Yes	No	No
	Pet Waste Management	Medium	None	- Water quality improvements	Low cost of implementation and little to no maintenance. This is a low cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes	Yes	Yes
	Lawn and Garden Maintenance	Low	Low	- Water quality improvements	Requires communication with business and homeowners. Guidelines are already established per USEPA. Educating the public on proper lawn and garden treatment protocols developed by USEPA will reduce waterway contamination. Since this information is already available to the public it is unlikely to have a significant effect on improving water quality.	Yes	Yes	No
	Hazardous Waste Collection	Low	None	- Water quality improvements	The N.J.A.C prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	No

Table C-1. CSO Source Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	- Cost-effective water quality improvements	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if Permitee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.	Yes	Yes	No
	Illegal Dumping Control	Low	None	- Water quality improvements - Aesthetic benefits	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes	Yes	No
	Pet Waste Control	Medium	None	- Water quality improvements - Reduced surface flooding	Requires resources to enforce pet waste ordinances. Public education and outreach is a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes	Yes	Yes
	Litter Control	None	None	- Property value uplift - Water quality improvements - Reduced surface flooding	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach is a more efficient use of resources.	Yes	Yes	No
	Illicit Connection Control	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	Yes	Yes
Good Housekeeping	Street Sweeping/Flushing	Low	None	- Reduced surface flooding potential	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	No
	Leaf Collection	Low	None	- Reduced surface flooding potential - Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	No
	Recycling Programs	None	None	- Align with goals for a sustainable community	Most Cities have an ongoing recycling program.	Yes	Yes	No
	Storage/Loading/ Unloading Areas	None	None	- Water quality improvements	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	Yes	No
	Industrial Spill Control	Low	None	- Protect surface waters - Protect public health	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	No
Green Infrastructure Buildings	Green Roofs	None	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permitee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	Yes	Yes

Table C-1. CSO Source Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
	Blue Roofs	None	Medium	- Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permitees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	Yes
	Rainwater Harvesting	None	Medium	- Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community - Water Saving	Simple to install and operate; low operational resource demand; will require the Permitees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	Yes	Yes
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Cost-effective water quality improvements - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	Yes	Yes
	Planter Boxes	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	Yes	Yes
Green Infrastructure Pervious Areas	Bioswales	Low	Low	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community - Increased pedestrian safety through curb retrofits	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	Yes	Yes

Table C-1. CSO Source Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
	Free-Form Rain Gardens	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	Yes	yes
Operation and Maintenance	I/I Reduction	Low	Medium	- Water quality improvements - Reduced basement sewage flooding	Requires labor intensive work; changes to the conveyance system require temporary pumping measures; repairs on private property required by homeowners. Reduces the volume of flow and frequency; Provides additional capacity for future growth; House laterals account for 1/2 the sewer system length and significant sources of I/I in the sanitary sewer.	Yes	No	Yes
	Advanced System Inspection & Maintenance	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	No	No
	Combined Sewer Flushing	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	Yes	No
	Catch Basin Cleaning	Low	None	- Water quality improvements - Reduced surface flooding	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	Yes	No
Combined Sewer Separation	Roof Leader Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; Includes area drains and roof leaders; new storm sewers may be required; requires home and business owner participation. The Cities are densely populated and disconnected roof leaders have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	Yes	Yes
	Sump Pump Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The Cities are densely populated and disconnected sump pumps have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	No
	Combined Sewer Separation	High	High	- Water quality improvements - Reduced basement sewage flooding - Reduced surface flooding	Very disruptive to affected areas; requires homeowner participation; sewer asset renewal achieved at the same time; labor intensive.	No	No	Yes
Combined Sewer Optimization	Additional Conveyance	High	High	- Water quality improvements - Reduced basement sewage flooding	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	No	Yes

Table C-1. CSO Source Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
	Regulator Modifications	Medium	Medium	- Water quality improvements	Relatively easy to implement with existing regulators; mechanical controls requires O&M. May increase risk of upstream flooding. Permitees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	No	Yes
	Outfall Consolidation/ Relocation	High	High	- Water quality improvements - Passive and active recreational improvements	Lower operational requirements; may reduce permitting/monitoring; can be used in conjunction with storage & treatment technologies. Combining and relocating outfalls may lower operating costs and CSO flows. It can also direct flow away from specific areas.	Yes	No	Yes
	Real Time Control	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires periodic inspection of flow elements; highly automated system; increased potential for sewer backups. RTC is only effective if additional storage capacity is present in the system.	Yes	no	Yes
Linear Storage	Pipeline	High	High	- Water quality improvements - Reduced surface flooding potential - Local jobs	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	No	Yes
	Tunnel	High	High	- Water quality improvements - Reduced surface flooding potential	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	No	Yes
Point Storage	Tank (Above or Below Ground)	High	High	- Water quality improvements - Reduced basement sewage flooding	Storage tanks typically require pumps to return wet weather flow to the system which will require additional O&M; disruptive to affected areas during construction. Several CSO outfalls have space available for tank storage. There may be existing tanks in abandoned commercial and industrial areas to be converted to hold stormwater. Tanks are an effective technology to reduce wet weather CSO's.	No	No	Yes
	Industrial Discharge Detention	Low	Low	- Water quality improvements	Requires cooperation with industrial users; more resources devoted to enforcement; depends on IUs to maintain storage basins. IUs hold stormwater or combined sewage until wet weather flows subside; there may be commercial or industrial users upstream of CSO regulators.	Yes	No	No
Treatment-CSO Facility	Vortex Separators	None	None	- Water quality improvements	Space required; challenging controls for intermittent and highly variable wet weather flows. Vortex separators would remove floatables and suspended solids when installed. It does not address volume, bacteria or BOD.	Yes	No	No
	Screens and Trash Racks	None	None	- Water quality improvements	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	Yes	No
	Netting	None	None	- Water quality improvements	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	No
	Contaminant Booms	None	None	- Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	Yes	No
	Baffles	None	None	- Water quality improvements	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	Yes	No	No

Table C-1. CSO Source Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
	Disinfection & Satellite Treatment	High	None	- Water quality improvements - Reduced basement sewage flooding	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	Yes
	High Rate Physical/Chemical Treatment (High Rate Clarification Process - ActiFlo)	None	None	- Water quality improvements	Challenging controls for intermittent and highly variable wet weather flows; smaller footprint than conventional methods. This technology primarily focuses on TSS & BOD removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
	High Rate Physical (Fuzzy Filters)	None	None	- Water quality improvements	Relatively low O&M requirements; smaller footprint than traditional filtration methods. This technology primarily focuses on TSS removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
Treatment-WRTP	Additional Treatment Capacity	High	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	May require additional space; increased O&M burden.	No	No	Yes
	Wet Weather Blending	Low	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	Yes
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	No

SECTION D ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

The objective of the alternatives analysis is to develop solutions to control CSOs to achieve a range of CSO-control goals as necessary to inform future selection of control measures—individually and/or in combinations—for the CSO LTCP. Alternatives that could individually achieve the CSO-control objectives were developed based on a broad range of considerations including technical merit, implementation potential and operations aspects, social impacts, public acceptance, and costs, as outlined in the forthcoming sections of this report.

D.1.1 Siting

Siting is commonly a subject of most public debate on CSO-control projects. Therefore, one of the key considerations in assessing the overall feasibility of a CSO-control alternative is the identification of an appropriate site for proposed facilities. Newark is fully developed with not much available open space. Land availability can be an issue, as most of the controls are preferred to be located near CSO regulators and outfalls typically located near the waterfront, where the land is expensive and mostly developed in much of Newark. It is recognized that issues involving facility location, land acquisition, and easements in both public and private lands can lead to disagreements among various stakeholders. Therefore, this alternatives evaluation focuses on the use of available City-owned sites, as those have minimal impact on sensitive stakeholders and lower potential to be controversial. The environmental, political, socioeconomic and regulatory impacts of locating a facility at a designated site will need to be evaluated in detail during the facilities-planning and design phase.

Facilities siting in this evaluation assumes a suitable site can be located based on space requirements. As part of the selection of alternatives and facilities-planning and design phase, other considerations will include a buffer for roadways and access base and potential conflicts with existing utilities, highways, and local streets as well as stakeholder involvement.

D.1.2 Institutional Issues

Institutional constraints include matters related to political issues, public opinion, and other non-technical factors that could impact project approval. Institutional and political factors can influence CSO-control projects because such projects are generally funded by taxpayers or sewer ratepayers. The general public must be convinced that the proposed project is cost-effective and for the public good, so that potential for the public rejection is minimized. This is important to support the fundraising needed for implementation of the project. The City has continued raising public awareness about the LTCP project through ongoing public participation activities, as stressed in the NJPDES permit, and US EPA policy and related guidance for the LTCP. It should be noted that Newark is a densely developed urban municipality with a 27.8% of the population below the poverty line (1.5 times the rate of Essex County and more than double the State average). Therefore, it is acknowledged that negotiations among politicians, institutions, and other stakeholders and interested parties are necessary to ensure that CSO-control measures are technically, financially, and politically feasible.

Budgetary constraints of the permittee—and indirectly, constituent rate payers—are not explicitly considered in this analysis. While certain alternatives may provide measurable benefit within other evaluation criteria, it may be the case that overall costs prove to be prohibitive to implement those alternatives.

D.1.3 Implementability

In addition to the cost, performance and political and institutional aspects, several other factors can affect implementation of a potential alternative. The following are some of the key implementability issues that have been part of preliminary considerations in the alternatives evaluation, but they have not been reviewed or analyzed in depth. The considerations made in this evaluation are solely based on the available information obtained from various sources listed below.

Environmental Issues: These issues may be related to land conservation, use and acquisition; zoning changes, easement, traffic and site access, noise and vibration, floodplains and zoning, wetland buffer zones, utilities relocation and loss of services, and short term impacts water or air quality. Newark has extensive waterfront along the Passaic River and Newark Bay, while the primary use of the Passaic River is recreation with parks located along the river, Newark Bay is primarily a shipping and port area. Alternatives that fit with existing land uses and favor City property will receive a positive consideration under this evaluation. Any specific permits that would be required to implement a CSO-control alternative would be identified at the facility planning and design phase.

Consideration of alternatives achieving zero CSO discharge to sensitive areas is a requirement in the evaluation of the CSO-control alternatives. In collaboration with PVSC, the “Identification of Sensitive Areas Report” was submitted to NJDEP in June 2018. This report, which NJDEP accepted in a letter dated April 8, 2019, found no sensitive areas within Newark’s receiving waters. Therefore, the alternatives evaluation does not require achievement of zero CSO discharges to any of Newark’s receiving waters.

Constructability: This relates to the ease of construction. Constructability can be impacted by work site subsurface conditions. Adequate geologic data for the subsurface conditions is not currently available For Newark, so there is a large amount of uncertainty as to the rock and soil conditions. It is anticipated that alternatives with unsuitable soils, extensive rock or high groundwater requiring extensive dewatering or rerouting of drainage patterns may impose construction challenges. Alternatives involving complex designs and specialized construction would tend to drive up costs. Therefore, alternatives with few constructability issues will be preferred.

Reliability: Reliability of CSO-control alternatives is a significant technical issue. The operating history of existing similar installations can help predicting the reliability of a proposed solution. System components must function properly when required, particularly for CSO facilities that operate only on an intermittent basis. Alternatives that rely on simpler or less complex equipment and automation are inherently more reliable. Alternatives involving systems with unknown or poor track records will not be favored.

Ease of Operations: Operability issues involve both process and personnel related considerations. Alternatives involving equipment and system components that are relatively easy to operate and require reasonable operator assistance will be preferred. Unfavorable alternatives would involve highly specialized systems that require extensive training and staffing requirements.

Multiple-Use Considerations: Multiple-use CSO-control facilities can help to gain public and institutional acceptance. An alternative would be considered advantageous if it can serve another beneficial purpose while also mitigating CSOs. Examples include parking facilities over storage/treatment tanks, and recreational opportunities such as constructing bike paths over the routes of consolidation conduits or improving river access, which are possible enhancements that have been shown to provide additional public benefit.

Compatibility to Phased Construction: Given the cost of CSO-control facilities, alternatives that can be implemented in smaller parts can be more affordable than a single large project. Phasing can lessen the immediate financial impact on ratepayers with some immediate relief to CSO problems. Preferable alternatives will need to meet current needs but also will adapt to future conditions.

D.1.4 Public Acceptance

Community acceptance of a recommended solution is essential to its success. All permittees are required to involve the public, regulators, and other stakeholders throughout the LTCP development process. As such, the PVSC and the City of Newark has continued raising public awareness of the LTCP development through ongoing public participation activities, as stressed in the NJPDES permit, and EPA policy and related guidance for the LTCP.

PVSC has held quarterly regional Supplemental CSO team public meetings over the course of the LTCP development effort. In addition, the Newark assembled a local supplemental CSO team to discuss the LTCP and Newark’s efforts under the NJPDES permit. These local meetings were held in conjunction with the PVSC’s regional Supplemental CSO team meetings. The details of the public participation process and the associated outreach program activities have been documented in the Public Participation Process Report submitted to NJDEP.

D.1.5 Performance Considerations

CSO-control alternatives are generally evaluated using several measures, ranging from cost and performance to ancillary benefits and qualitative criteria, such as the ability to beneficially integrate the alternative with other hydraulically connected communities. Desirable alternatives achieve the goals of the LTCP in a cost-effective manner relative to other options, and are able to perform well under intermittent and variable-flow conditions. The US EPA’s CSO Policy requires CSO permittees to evaluate alternatives for a reasonable range of control to reduce or eliminate CSO discharges to ensure that water-quality standards are met. These evaluations can be performed with the assistance of a calibrated hydrologic/hydraulic model, as described in prior reports associated with the current study (2019, PVSC). For the purposes of evaluating and comparing performance of various alternatives, these models must employ certain conditions. First, model calculations must use the same “typical-year” hydrologic condition, defined as the rainfall recorded in 2004 at Newark Airport in Newark, New Jersey. Second, model calculations must reflect conditions during the 2050 build year, and therefore reflect anticipated demographic conditions (e.g., population, sanitary flow) at that time, as described previously in Section B. Together, these conditions are referred to as the “future baseline” or “Baseline” condition, in order to avoid confusion with model calculations performed for “existing” conditions.

Performance analyses consider a comprehensive set of reasonable alternatives with ranges of CSO-control goals, such as number of CSO events per year, capture of combined sewage, or pathogen reduction. The performance metrics for these goals are described in more detail below.

Frequency of CSO Events

The USEPA CSO Control Policy refers to the frequency of CSO events that occur in a typical hydrologic year as one performance metric. Specifically, this metric refers to the number of rainfall events that cause an overflow at one or more locations, and is separated in time by no fewer than 12 hours from any other CSO event. The performance objectives evaluated for this metric are defined as follows:

For the typical hydrologic year, up to:

- Zero (0) overflow events per year
- Four (4) overflow events per year
- Eight (8) overflow events per year
- Twelve (12) overflow events per year
- Twenty (20) overflow events per year

Capture of Combined Sewage for Treatment

The US EPA CSO Control Policy defines another performance metric as the capture of combined sewage volumes for treatment. Expressed as a percentage of the total combined sewage generated during wet weather on an annual basis, this metric refers to the degree to which volumes of combined sewage are captured for treatment, versus overflow. US EPA indicates that attainment of 85 percent capture is typically sufficient for receiving waterbodies to meet water-quality standards. PVSC has indicated (2019, G&H) that for Newark, a 7% reduction of CSO volume (that is, a CSO discharge of no more than 93 MG) is required to achieve the 85% capture target.

Removal of Pollutants of Concern

The US EPA CSO Control Policy defines the removal of pollutants as another performance metric for CSO control. US EPA indicates that removing pollutants of concern to the same degree as would be removed through 85 percent capture of combined sewage volume is typically sufficient for receiving water bodies to meet water-quality standards. Accordingly, the performance objective associated with this metric is removal of pathogens to a level *equivalent to* a 7% reduction in CSO volume (or a pathogens load equivalent to that associated with no more than 93 MG), as noted above.

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

The CSO-control alternatives evaluated in this analysis include regulator controls (Alt1), green infrastructure (Alt2), overflow tank storage (Alt3), inflow and infiltration reduction (Alt4), water conservation (Alt5) and peracetic acid (PAA) disinfection (Alt6). Table D.2-1 lists the alternative IDs and descriptions of the controls. All alternatives are evaluated compared to a "Baseline" condition that represents Newark's existing sewer infrastructure with Queens District regulator/outfall (026) reactivated, using typical year (2004) rainfall and 2050 populations/flows.

Table D-1. Preliminary Control Alternatives Evaluated

Alternative ID	Description
Baseline400MGD	Existing Condition with 2050 flows (population), Queens St regulator reactivated, PVSC at 400MGD
Alt1a Gate Open	Baseline with auto-gates non-operational i.e. always open
Alt1b Gate Delayed	Baseline with auto-gates operating at 110% of flow except for Clay St gate
Alt1c Weir 6in	Baseline with regulator weirs increased by 6 inches at regulators without auto-gates
Alt2c GI Rutgers	Baseline with aggregated GI in Rutgers University Study GI
Alt2b GI5	Baseline with 5% impervious converted to GI
Alt2a GI10	Baseline with 10% impervious converted to GI
Alt3 Storage 0 CSO	Baseline with storage at regulator/outfalls to control system-wide overflow to 0 events per year
Alt3a Storage 4 CSO	Baseline with storage at regulator/outfalls to control system-wide overflow to 4 events per year
Alt3b Storage 8 CSO	Baseline with storage at regulator/outfalls to control system-wide overflow to 8 events per year
Alt3c Storage 12 CSO	Baseline with storage at regulator/outfalls to control system-wide overflow to 12 events per year
Alt3d Storage 20 CSO	Baseline with storage at regulator/outfalls to control system-wide overflow to 20 events per year
Alt4 InflowPark	Baseline with inflows from lakes at two parks (Branch Brook Park Lake and Weequahic Lake) disconnected
Alt4a ParkII90	Baseline with Newark base infiltration reduced to 90% i.e. 10% I/I reduction
Alt4b ParkII75	Baseline with Newark base infiltration reduced to 75% i.e. 10% I/I reduction
Alt4c ParkII50	Baseline with Newark base infiltration reduced to 50% i.e. 10% I/I reduction
Alt5 WaterCon10	Baseline with waste water reduced by 10% (Excluding South Elizabeth and East Orange)
Alt6 Disinfection 0 CSO	Baseline with Disinfection Facility to treat all wet weather events (cost calculated not modeled)
Alt6a Disinfection 4 CSO	Baseline with Disinfection Facility to treat wet weather except for 4 events/yr (cost calculated not modeled)
Alt6b Disinfection 8 CSO	Baseline with Disinfection Facility to treat wet weather except for 8 events/yr (cost calculated not modeled)
Alt6c Disinfection 12 CSO	Baseline with Disinfection Facility to treat wet weather except for 12 events/yr (cost calculated not modeled)
Alt6d Disinfection 20 CSO	Baseline with Disinfection Facility to treat wet weather except for 20 events/yr (cost calculated not modeled)
Alt7 Sewer Separation	Baseline with Sewer Separation (cost calculated not modeled)

D.2.1 Alternative 1 – Regulator Modification/Flow Maximization

There are ten regulators (Table D.2-2) in the Newark CSO system that are equipped with automatically controlled sluice gates that can be closed during a wet-weather event to limit flows to the interceptor and PVSC Plant. These gates are controlled by PVSC at the plant.

Table D-2. Newark Regulators with Automated Controls

Newark Regulators with Automated Controls	
Verona (002)	Saybrook Place (014)
Herbert (004,005)	City Dock (015)
Fourth Ave (008)	Jackson(016)
Clay St (009/010)	Polk(017)
Rector St (014)	Freeman(018)

In the InfoWorks model, the operation of the gates are simulated through using a real time control (RTC) module that allows rules to be set to control operations (a gate, for example) based on conditions such as flow or level at designated points in the model network. The Newark regulator gates are operated based on model-calculated flows in the interceptor to the PVSC plant downstream of the junction of the main interceptor and the south side interceptor, and model-calculated water level in the stand-by primary clarifier.

In the Baseline condition model, all Newark regulator automated gates, except for Clay St, are set to close when the plant inflow reaches and exceeds 250 MGD. This causes flow to back up and overflow the regulator weir as CSO. When the model-calculated flow at the plant decreases below 250 MGD, the model RTC opens the gates, allowing flow from the regulators to enter the interceptor again. The Clay Street regulator gate RTC in the model is similar, but is controlled by the model-calculated water elevation in the stand-by primary clarifier (with a threshold of 96 feet above the PVSC datum). The model RTC sets the Clay Street regulator gate to open while the model-calculated water level in the stand-by primary clarifier is less than 96 feet (PVSC datum), and to close when model-calculated water level reaches or exceeds 96 feet (PVSC datum). The model RTC uses a gate speed of 0.07 feet per second or approximately 5 inches per minute during opening or closing.

For the regulator modification alternative, three model simulations were conducted. In Alt1a, the automated gates were left always open (i.e. no automated control). In Alt1b, the regulator control rules were modified to delay the operation of the gates. The interceptor flow operation threshold was increased by 10% to 275 MGD, so the gates remain open longer than in the Baseline condition; the operation of the Clay Street regulator was not changed and remained the same as in the Baseline condition. In Alt1c, the weir elevation of Newark regulators without automated gates was increased by 6 inches in order to delay overflow and send more flow to the interceptor.

The Alt1a simulation was a test to estimate the maximum flow that could be delivered to the interceptor. Model results predicted that is caused the hydraulic grade line (HGL) in the main interceptor to exceed guidelines set forth by PVSC, so no further analysis was conducted.

In Alt1b, where the interceptor flow operation threshold was increased by 10% to 275 MGD and Clay St regulator operation was left unchanged, model results indicate a 5.3% (69 MG) reduction in total CSO volume and a reduction in overflow frequency of 1 to 6 overflows per year, depending on the outfall.

For Alt1c, where weir elevations at regulators without automated gates were raised by 6 inches, model results show a reduction of only 0.7% (9.5 MG) of CSO volume and 1 to 6 fewer overflows per year, depending on outfall. Figure D.2-1 and Figure D.2-2 graphically present these reductions of CSO volume and frequency.

Figure D.2-1. Alt1a and Alt1b Annual CSO Volume Reductions

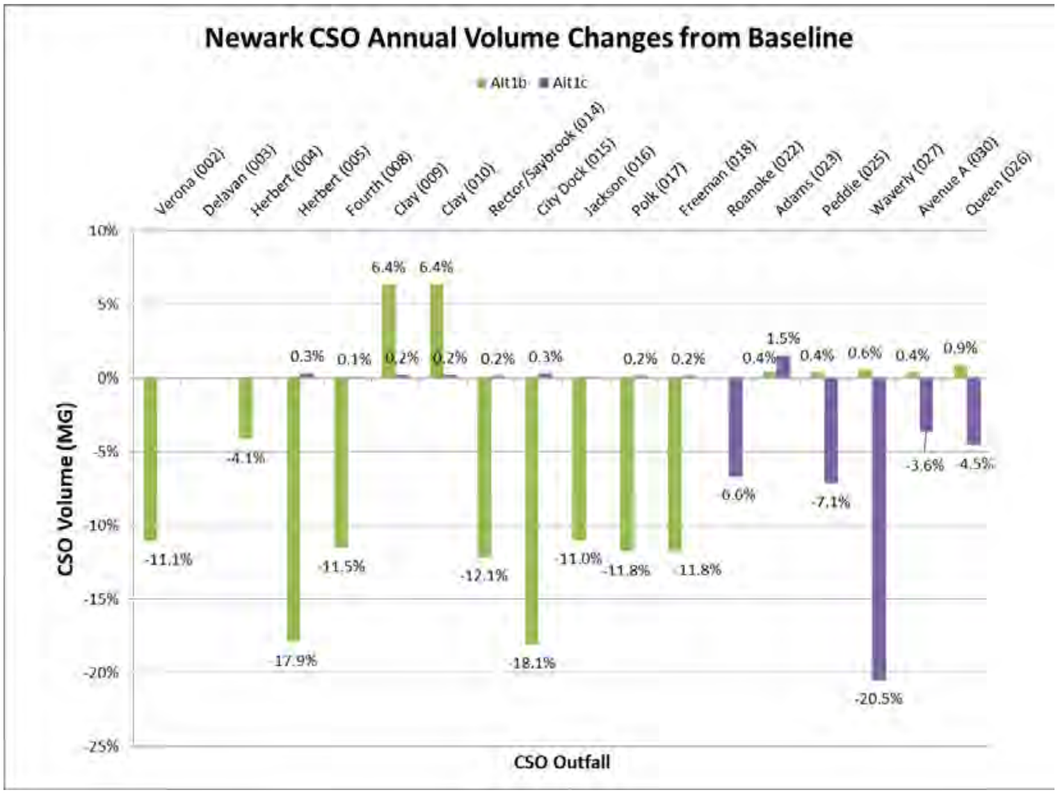


Figure D.2-2. Alt1a and Alt1b Annual CSO Frequency Reductions

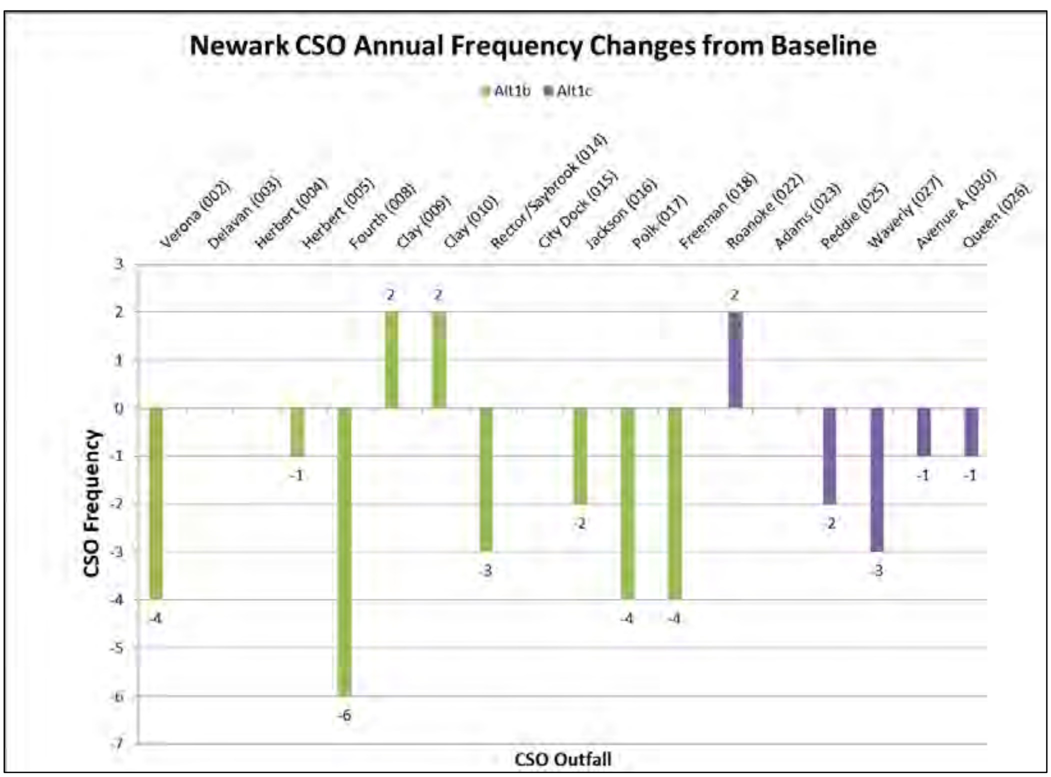


Figure D.2-3, Figure D.2-4, and Figure D.2-5 present the maximum HGLs calculated for the Baseline, Alt1b, and Alt1c scenarios, respectively. A review of the HGL for these scenarios shows that the increase in HGL along the Newark portion of the PVSC main interceptor is minimal. Table D.2-3 summarizes the HGL at three segments along the interceptor. Generally, the maximum increase in HGL in the Newark portion of the interceptor is approximately 0.10 ft. or 1.2 inches. At the location where the crown of the interceptor is closets to the ground (near Wallington, NJ) the maximum increase in HGL was also approximately 0.10 ft. or 1.2 inches.

Table D-3. Alternative 1 HGL Comparison

Model Link	Upstream Invert	HGL (ft. PVSC datum)			Change (ft.)	
		Baseline	Alt 1b	Alt 1c	Alt 1b	Alt 1c
MI-015.1	79.3	100.1	100.2	100.3	0.10	0.10
MI-018D.1	81.2	100.6	100.7	100.7	0.10	0.00
MI-035	86.1	105.1	105.2	105.2	0.10	0.00

Regulator modification by changing gate closure setting or increasing weir heights are both no cost/low cost alternatives. Because increasing weir heights provides a minimal reduction in total CSO discharge, it is eliminated from further consideration. However, delaying gate closure provides a modest amount of reduction at little to no cost, and should continue to be considered as a CSO-control alternative.

Figure D.2-3. PVSC Main Interceptor Baseline HGL (Newark Border to South Side Interceptor)

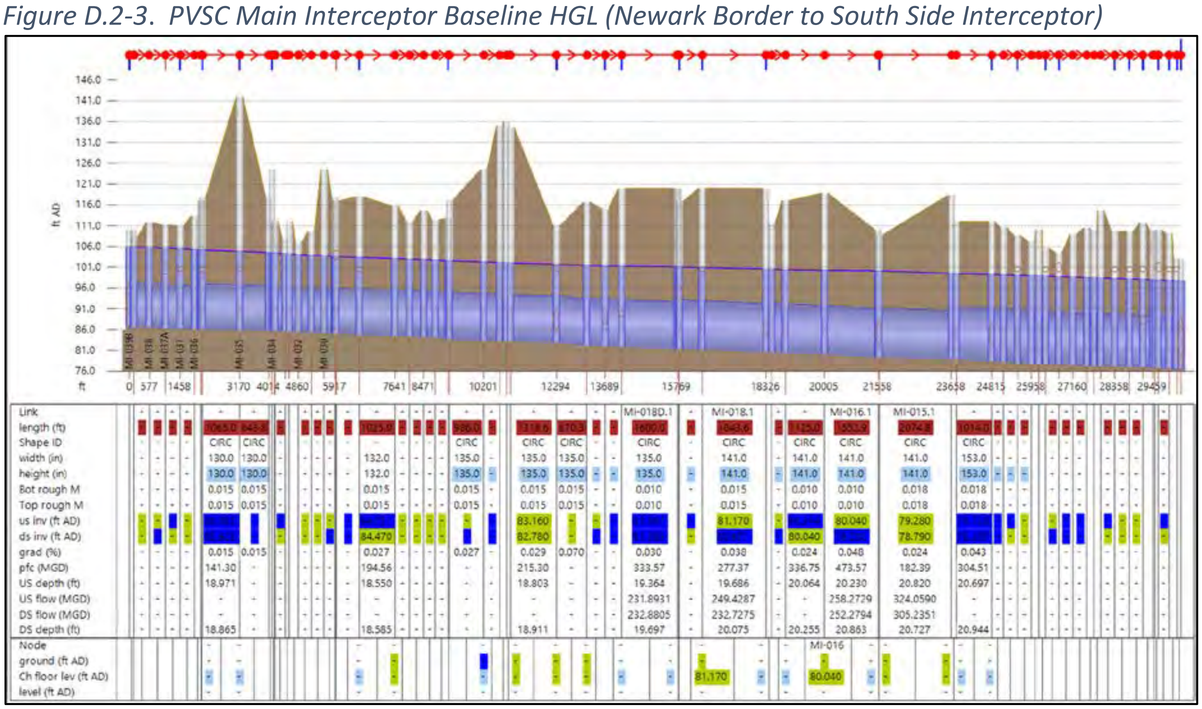


Figure D.2-4. PVSC Main Interceptor Alt1b HGL (Newark Border to South Side Interceptor)

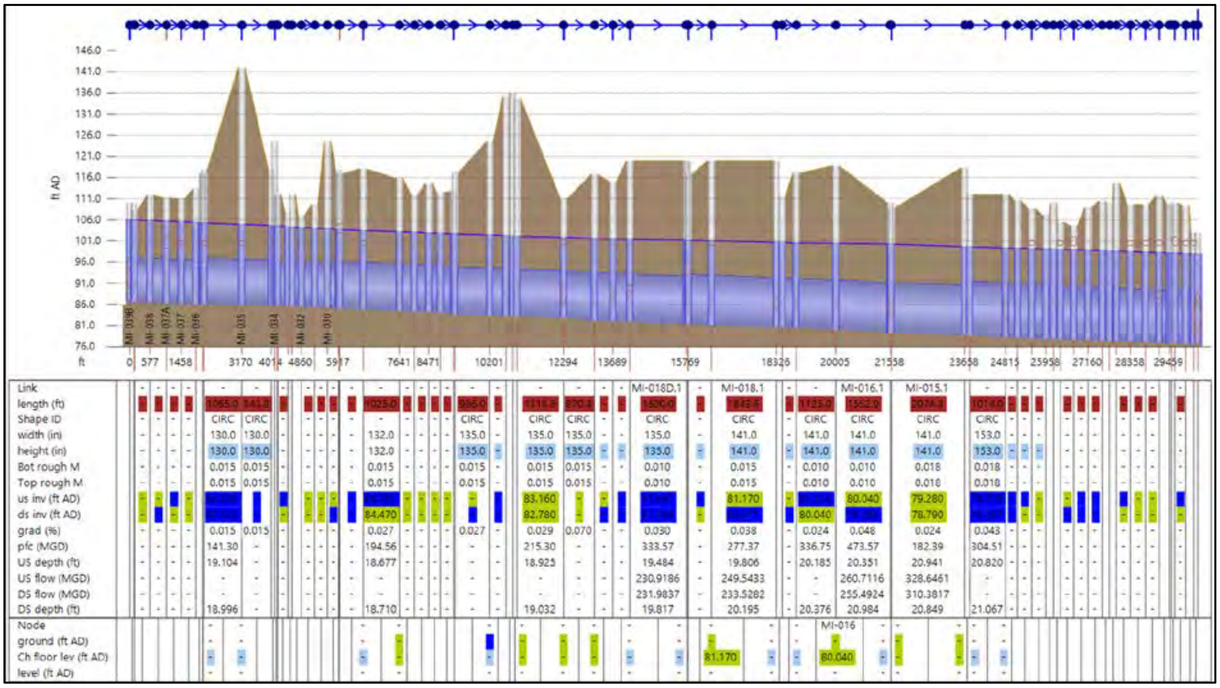
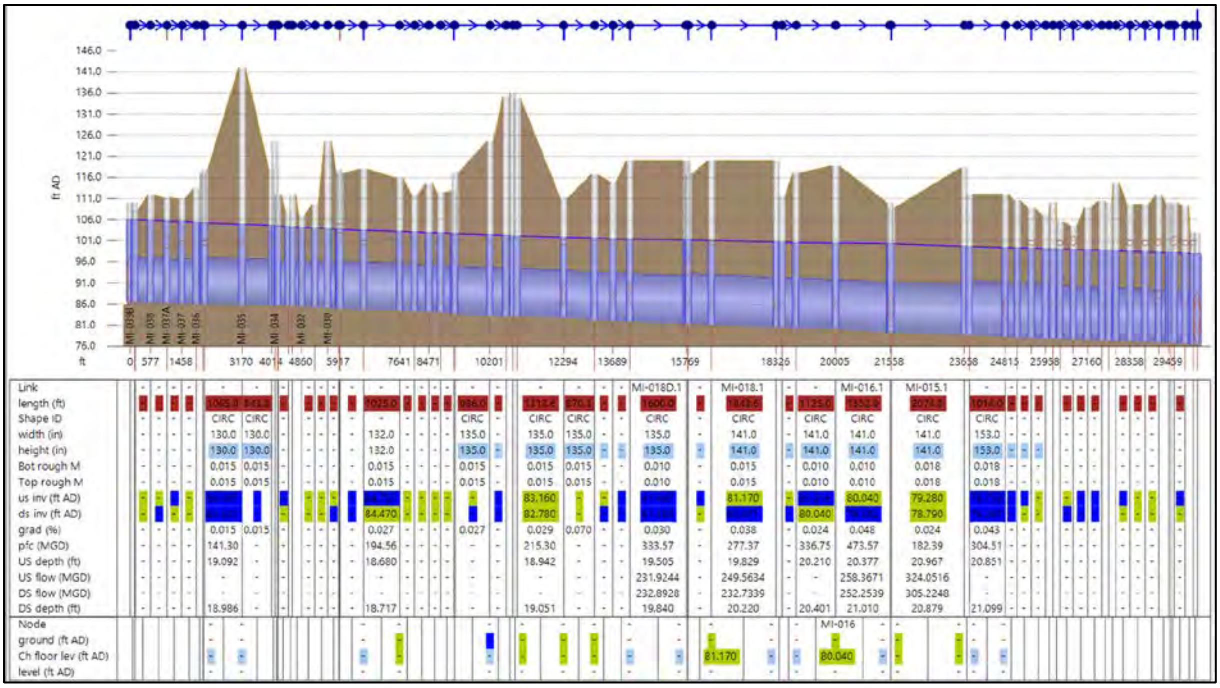


Figure D.2-5. PVSC Main Interceptor Alt1c HGL (Newark Border to South Side Interceptor)



D.2.2 Alternative 2 – Green Infrastructure (GI)

Green Infrastructure (GI) refers to a host of source-control approaches that can reduce and treat rainfall runoff prior to its entry into the combined sewer system (CSS). GI approaches typically intercept rainfall runoff with soil media and plants to eliminate or attenuate volumes and pollutants through absorption, infiltration, and evapo-transpiration. Many GI approaches can also deliver ancillary environmental, social, and economic benefits and amenities to the community, such as decreasing localized flooding, reducing the heat-island effect, improving air quality, creating job opportunities, and providing needed green spaces for aesthetic purposes. GI can be used alone or in conjunction with other types of CSO control alternatives. Due to their reliance on the physical and biological properties of soil media and plants, some GI approaches are susceptible to seasonally variable performance.

GI typically requires widespread implementation to provide significant system-wide CSO control, particularly in highly urbanized areas like The City of Newark. GI approaches are being featured in CSO LTCP programs for a number of municipalities, including New York City and the City of Philadelphia. GI is being evaluated in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control.

A previous study, "Impervious Cover Reductions Action Plan for Newark, Essex County NJ", prepared by Rutgers University and available at this link:–(http://water.rutgers.edu/Projects/SURDNA/RAP/), identified possible locations for GI opportunities in Newark. In order to evaluate the potential impact of widespread implementation of Green Infrastructure (GI), HDR performed analyses to quantify the reduction from Baseline of CSO count and volume resulting from three different GI-implementation levels. The first level (Alt2c) involves the implementation of GI features and locations identified in the Rutgers study. The second level (Alt2b) involves applying bio-detention modeling that detain and infiltrates runoff generated from 5% of the impervious surfaces in Newark, and the third level of GI implementation involves application on 10% of the impervious surfaces in Newark. These control levels represent what was initially targeted, and more recently found to be reasonably achievable, respectively, given efforts to successfully site and install GI projects in New York City.

Locations and types of the Rutgers GI features are shown in Figure D.2-6, managed areas for each GI opportunity in a particular subcatchment were summed and represented in the model as a single GI feature in each subactchment. For this alternative (Alt1c) 63 sites manage a total of 11.7 acres with GI. CSO volumes decrease by about 4 MG (~0.3%), and CSO event counts remain unchanged. When 5% (Alt1b) of the impervious area (or ~228 acres) are controlled with GI, CSO volumes decrease by about 97 MG (~7.4%), and CSO event counts decrease by 0-6 events depending on outfall. When 10% (Alt1a) of the impervious area (or ~455 acres) are controlled with GI, CSO volumes decrease by about 192 MG (14.6%), and CSO event counts decrease by 0-8 events depending on outfall. Figure D.2-7 and Figure D.2-8 show reductions in CSO volume and frequency for each outfall respectively.

GI provides a modest amount of CSO reduction but also delivers ancillary benefits to the community. All alternatives are analyzed on their own without GI, with the assumption that some level of GI (up to 10%) would be considered in the development of the final selected alternative.

Figure D.2-6. Rutgers GI Opportunities

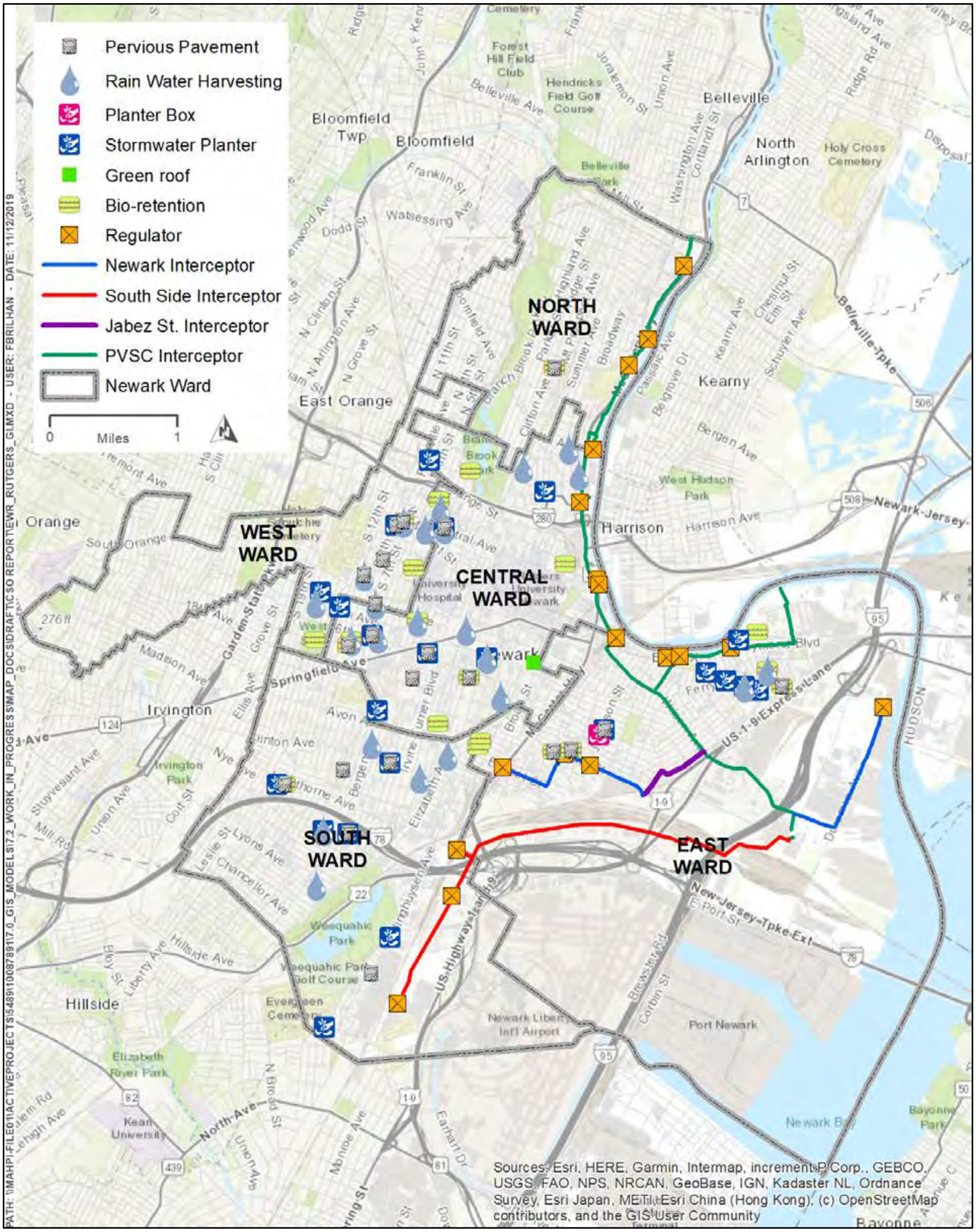


Figure D.2-7. Alt2a, Alt2b, and Alt2c Annual CSO Volume Reductions

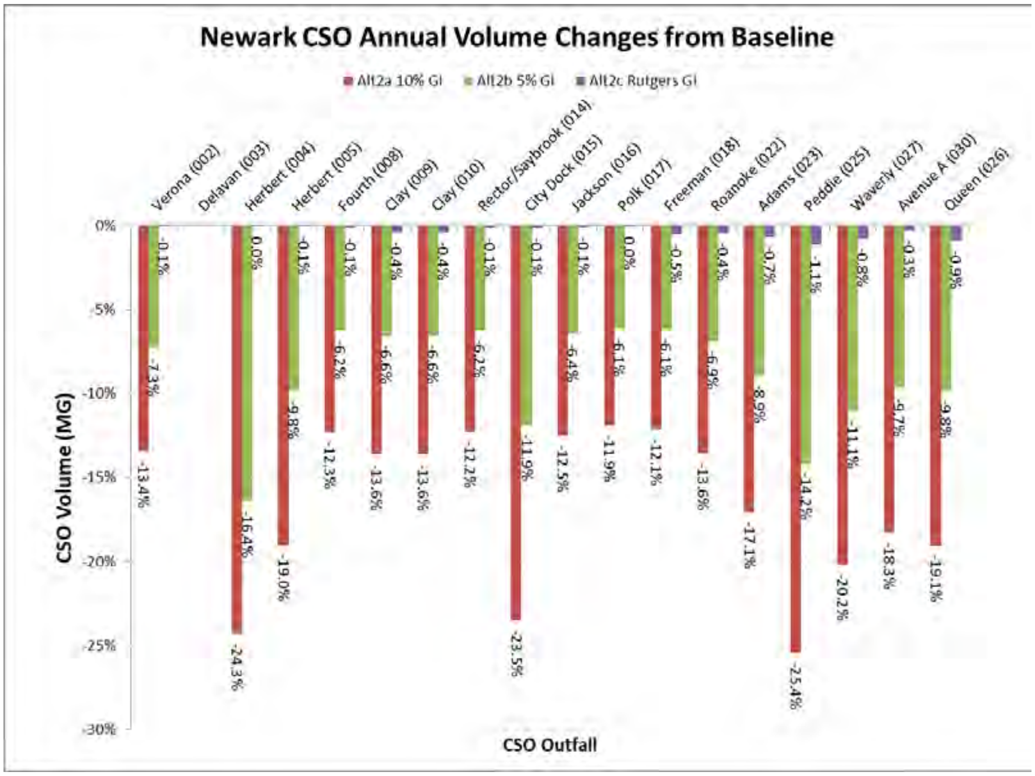
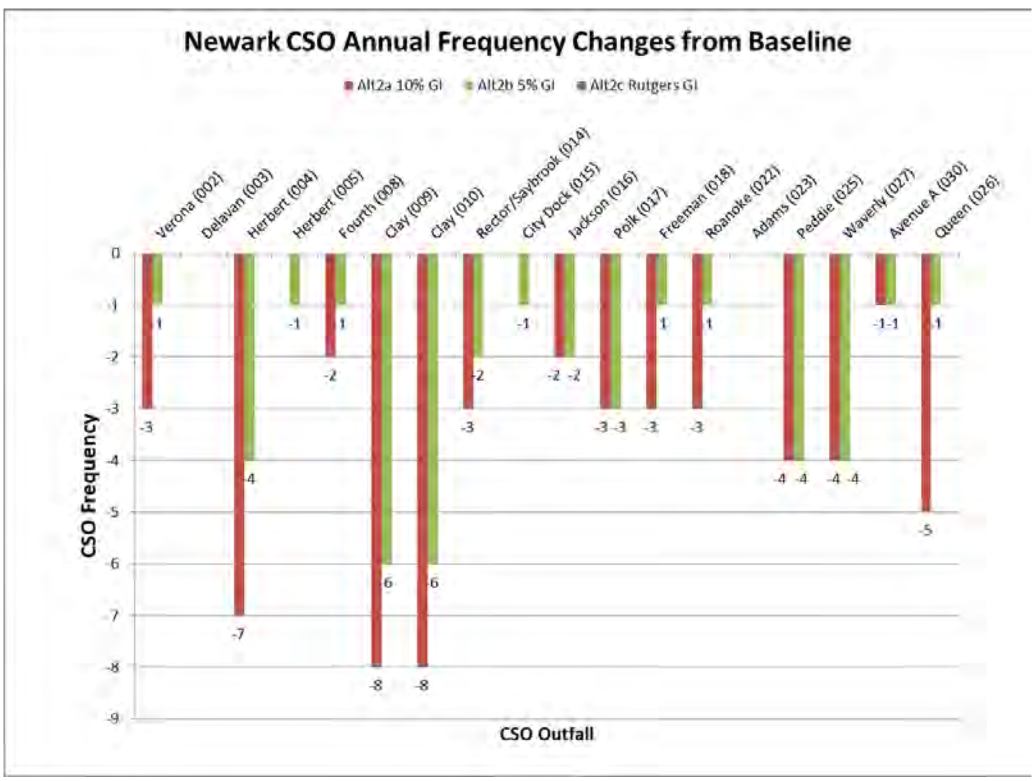


Figure D.2-8. Alt2a, Alt2b, and Alt2c Annual CSO Frequency Reductions



D.2.3 Alternative 3 – CSO Storage

In this alternative, CSO is diverted and stored in off-line storage tanks during and after storm events. During the subsequent dry-weather periods, stored overflow is pumped back to the PVSC plant for treatment. For this alternative, tanks were sized to reduce the number of CSO events per year to 4, 8, 12, and 20 (Alt3, Alt3a, Alt3b, Alt3c, and Alt3d, respectively); zero CSO events/yr was not feasible.

Achieving the targeted overflow frequencies across an inter-connected system requires that all outfalls within that system be fully controlled for all but the targeted events. This must be done on a system-wide basis, not just at individual outfalls. For example, to achieve a target of 4 overflow events per year, controlling the 5th largest event at "Outfall A" and the 5th largest event at "Outfall B" would achieve the target only if the top 4 events were the same at both outfalls. Otherwise, it may be necessary to control individual outfalls to lower frequencies to achieve the targeted frequency across the inter-connected system. The approach used here was to determine which events need to be fully controlled at each outfall in order to achieve the targeted overflow frequency is to rank the system-wide total event discharge volumes and require that only those top events for the targeted level of control be allowed to discharge at any individual outfall. The top-20 events, in terms of total system CSO volume for the PVSC main interceptor inter-connected system, are presented in Table D.2-4.

Table D-4. Top 20 Main Interceptor Inter-Connected System CSO Discharge Events

Rank	Event	Total CSO (MG)	Start	End	Duration (hh:mm)
1	49	262	9/28/2004 5:30	9/30/2004 13:45	8:15
2	46	154.4	9/8/2004 3:30	9/9/2004 22:00	18:30
3	48	129.4	9/18/2004 7:15	9/18/2004 15:15	8:00
4	36	115	7/18/2004 16:30	7/19/2004 2:00	9:30
5	56	106.9	11/28/2004 3:30	11/29/2004 0:15	20:45
6	35	101	7/12/2004 9:15	7/14/2004 23:30	14:15
7	32	98.1	6/25/2004 17:00	6/26/2004 6:15	13:15
8	37	94.4	7/23/2004 10:30	7/24/2004 4:15	17:45
9	6	89.9	2/6/2004 8:00	2/6/2004 23:45	15:45
10	23	87.6	5/12/2004 15:30	5/12/2004 21:45	6:15
11	38	78.9	7/27/2004 16:15	7/28/2004 8:45	16:30
12	15	78.5	4/12/2004 18:15	4/14/2004 21:00	2:45
13	44	59.7	8/21/2004 13:30	8/21/2004 18:30	5:00
14	17	59.5	4/26/2004 1:30	4/27/2004 6:00	4:30
15	34	57.7	7/5/2004 3:00	7/5/2004 16:45	13:45
16	43	57.2	8/14/2004 22:30	8/16/2004 12:30	14:00
17	52	44.4	11/4/2004 14:15	11/5/2004 17:30	3:15
18	57	44.3	12/1/2004 4:30	12/1/2004 15:15	10:45
19	24	38.7	5/15/2004 21:30	5/16/2004 9:00	11:30
20	22	38.6	5/10/2004 23:45	5/11/2004 5:45	6:00

An iterative approach was used to estimate the volume required for 0, 4, 8, 12, and 20 overflows. Offline storage was model as a diversion weir, storage, and an overflow to the existing outfall and pump back to the collection system. For this planning level analysis it was assumed that tanks can be located near the regulators or outfalls. Total draining/pump back time from the storage facilities was also factored in when sizing the facilities. Storage facilities would not start draining during wet weather or before the system returns to normal flow conditions after the rain events. Also, the total draining rate from all storage facilities in the Newark drainage area was set not to be greater than 75% of the total average dry weather flow. Given these operating conditions the total storage volume, approximate number of days to dewater, volume captured and percent CSO reduction is summarized in Table D.2-5.

Table D-5. Total CSO Storage Volumes and Reductions for 0, 4, 8, 12, and 20 Overflows

Alternative	CSO Event Frequency (count/yr)	Total Storage Volume (MG)	Approximate Days to Dewater	Volume Captured (MG)	% Volume Reduction
Alt3	0	188	5.1[1]	1,313	100%
Alt3a	4	85	2.3	1,211	92%
Alt3b	8	77	2.1	1,196	91%
Alt3c	12	58	1.6	1,112	85%
Alt3d	20	38	1.0	905	69%

(1) Not feasible – exceeds maximum allowable dewatering time of 3 days.

D.2.4 Alternative 4 – Inflow and Infiltration Reduction

In the evaluation of inflow and infiltration (I/I) reduction four model simulations were conducted. Alt4, Alt4a, Alt4b, and Alt4c. These alternatives simulated the reduction of I/I by the elimination of inflows to the sewer system from Branch Brook and Weequahic Park (Alt4), a 10% reduction in base infiltration (Alt4a), a 25% reduction in base infiltration (Alt4b), and a 50% reduction in base infiltration (Alt4c).

Investigation of extraneous flows by others (https://waterandsewer.newarknj.gov/projects/investigate-extraneous-flows) identified two significant sources of extraneous flow. The formerly marshy area from which the First River originated is now Branch Brook Lake. The outflow from the lake appears to be directly tied into Newark's sewer system. In addition to the flow from Branch Brook Lake, the flow from the lake in Weequahic Park also appears to be directly tied into the City's sewer system, the flow from which is conveyed to the Passaic Valley Sewerage Commission's Wastewater Treatment Plant (Figure D.2-9).

To both increase available sewer capacity and reduce the amount of flow conveyed to PVSC for treatment, the City looked to identify sources of extraneous flow and evaluate the feasibility of removing these flows from the system. Extraneous flow, also known as inflow and infiltration, is generally defined as clean water (stormwater, groundwater, or directly connected sources) that gets into the sewer system. Groundwater enters the system through cracks, unsealed pipe joints and other sewer system defects. Most of Newark's sewer system is a combined sewer system, meaning sanitary flow and stormwater are carried in the same pipe during wet weather events. Priority was given to sources that are constantly discharging during dry and wet weather. Removal of large volume dry weather inflows will provide the most benefit to the City by reducing treatment costs and increasing wet weather capacity.

The ~~report~~ investigation concluded that outflows from the~~se~~ two lakes, are believed to be the largest sources of inflow in the City. As part of the study flow metering was conducted and the average flow from Branch Brook and Weequahic Park was 0.84 MGD and 1.31 MGD respectively. Removing extraneous flow from the City's combined sewer system complements the City's Long Term Control Plan strategy which calls for the elimination of extraneous flow. It offers the opportunity for cooperation with Essex County for water reuse, and potential cost sharing, as the two sources to be removed are both in County owned facilities. If the water can be reused in the County parks, the project may be considered for green infrastructure eligibility.

For alternative Alt4, the elimination of extraneous park flows CSO volumes decrease by about 31 MG (2.4%), and CSO event counts CSO event counts decrease by 0-2 events depending on outfall. For a 10% reduction in I/I (Alt4a), CSO volumes decrease by about 19 MG (1.4%), and CSO event counts decrease by 0-2 events depending on outfall. For a 25% reduction in (Alt4b) I/I, CSO volumes decrease by about 44 MG (3.4%), and CSO event counts decrease by 0-4 events depending on outfall. For a 50% reduction in (Alt4c) I/I, CSO volumes decrease by about 89 MG (6.7%), and CSO event counts decrease by 0-5 events depending on outfall. Figure D.2-10 and Figure D.2-11 show reductions in CSO volume and frequency for each outfall respectively.

The City of Newark has conducted sewer upgrade projects, including the lining of the brick sewers, and is expected to continue to upgrade the sewer system. This will control infiltration/inflow; however, these types of projects on their own will not attain the performance objectives in the General Permit.

The Jabez St Interceptor has also been identified and a potential source of uncontrolled stormwater flows. As part of the final alternative selection Newark will also investigate the removal or reduction of uncontrolled stormwater flows in the Jabez St Interceptor which conveys flows from the Adams and Wheeler regulators (Figure D.2-9) as well as the effect of and screenings wash water flows from floatables control facilities on CSO overflows and flows to the interceptor.

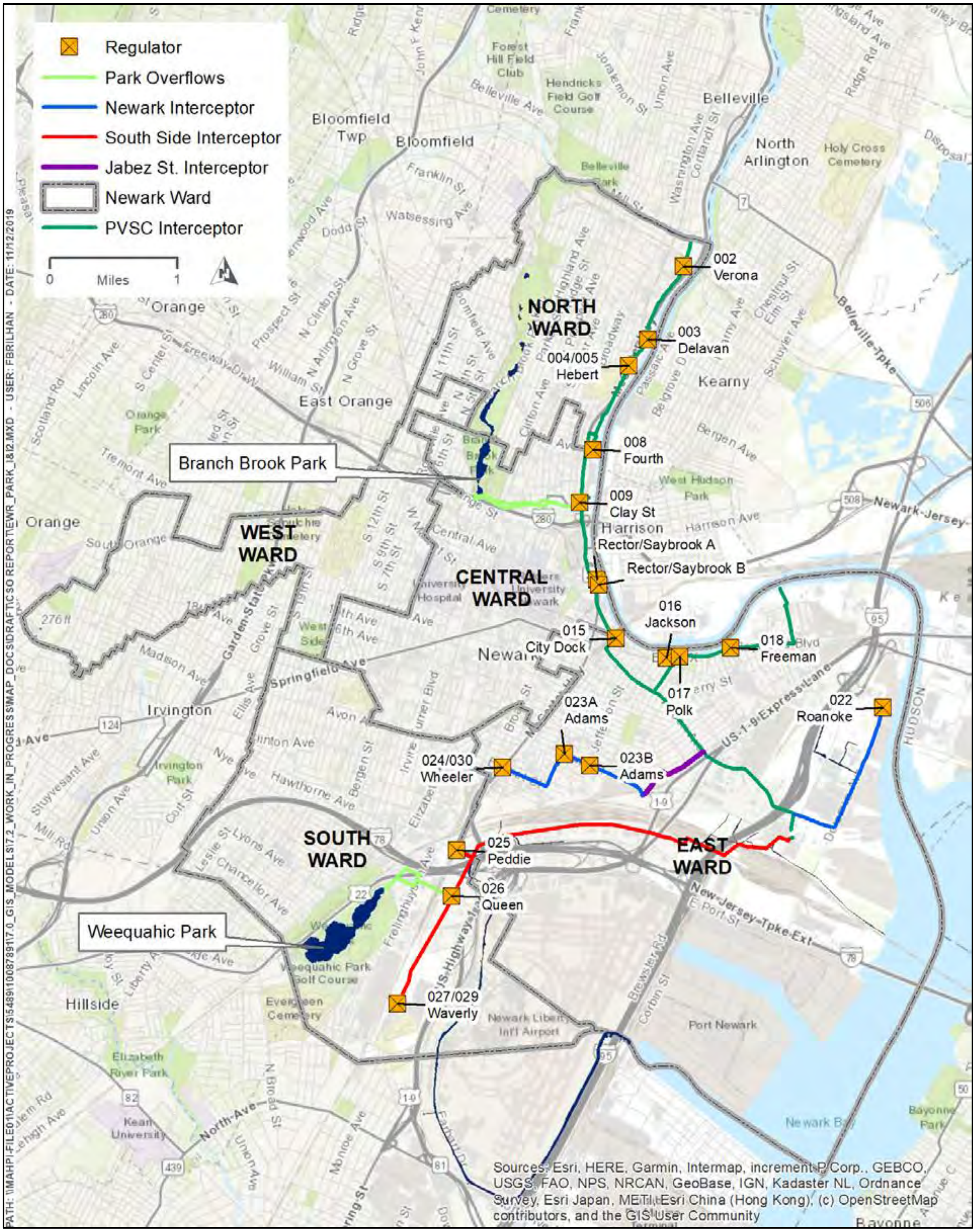


Figure D.2-9. Newark Extraneous Flow Investigations

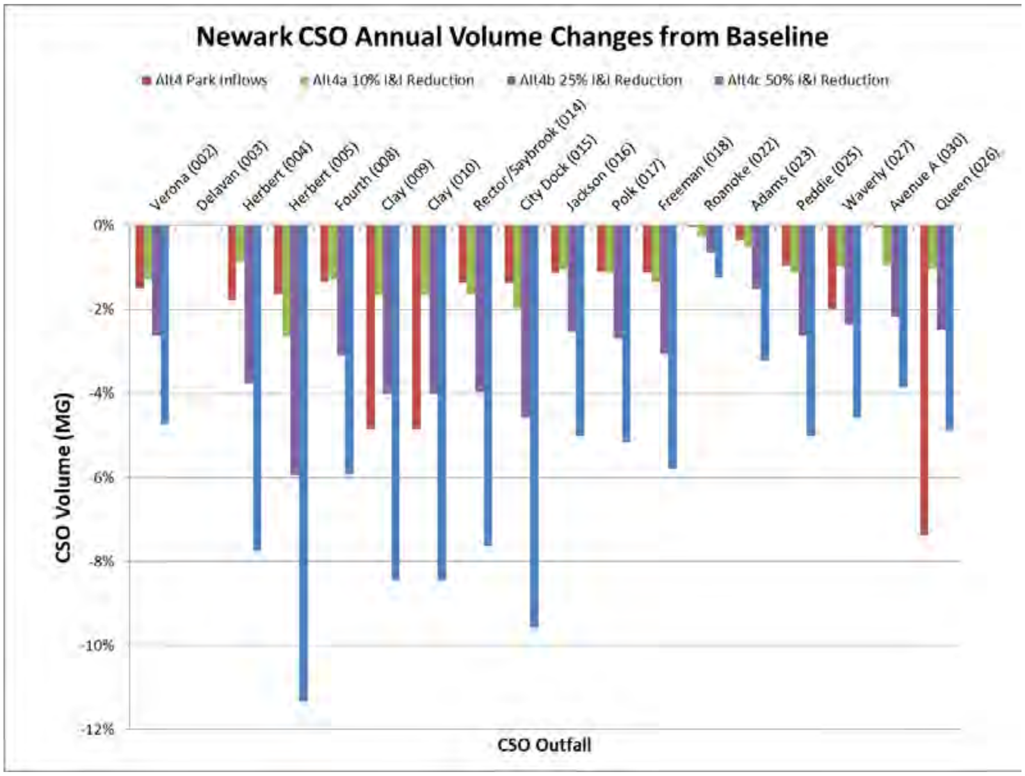


Figure D.2-10. Alt4, Alt4a, Alt4b, and Alt4c Annual CSO Volume Reductions

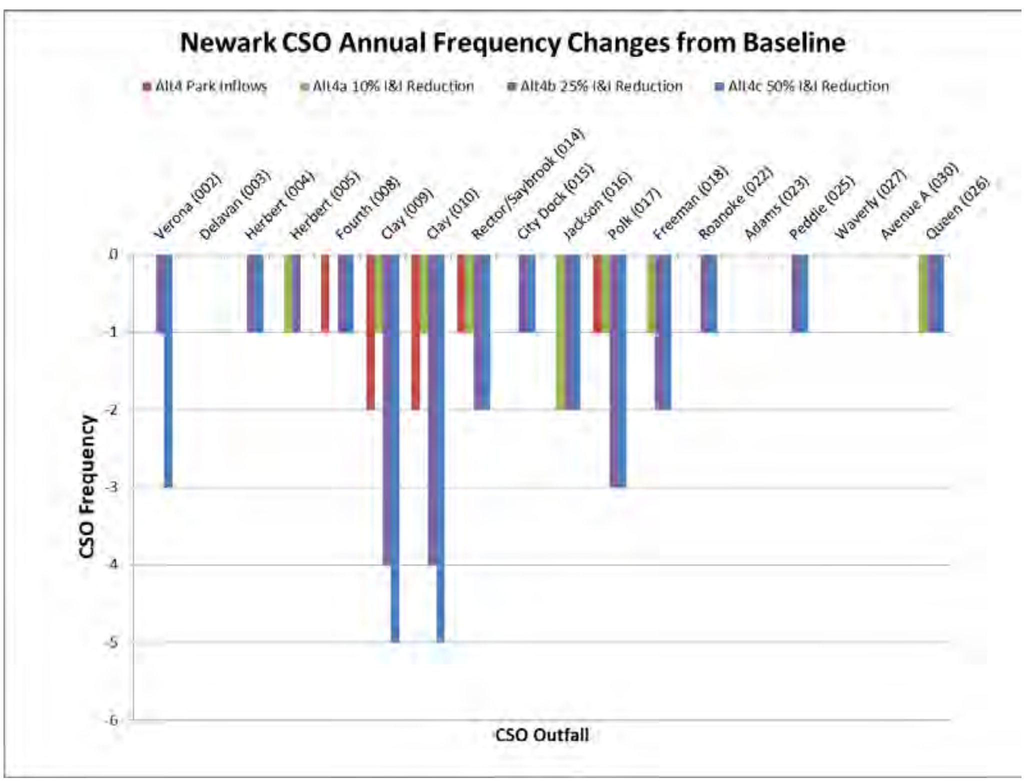


Figure D.2-11. Alt4, Alt4a, Alt4b, and Alt4c Annual CSO Frequency Reductions

D.2.5 Alternative 5 – Water Conservation

Reducing overall water consumption can provide some reduction in CSO discharge volume by providing additional wet-weather capacity in the collection system and helping to alleviate the stress on the existing wastewater treatment facilities. The CSO-reduction benefits provided through water conservation measures will be dependent upon the coincidence of wet-weather events and the highs and lows of daily water usage. Water-consumption reduction can be achieved through a variety of measures, including public outreach and education, distribution system leak detection and repair; water efficient landscaping; and water efficient plumbing fixtures (i.e., toilets and urinals, faucets, and showerheads). Implementing these measures can vary in cost for a municipality. Education and modification of building ordinance are low-cost options, while giveaways of low-flow fixtures, shower heads, and toilets would be a higher cost. Assuming that nearly all water use inside residences and commercial users will ultimately be disposed of in the sewer, outside water use, such as lawn watering and leaks in the distribution system will not be addressed in this analysis.

Significant amounts of water and energy can be wasted through use of non-water efficient faucets and showerheads. Even a brief five-minute shower can consume 15-35 gallons of water with a conventional showerhead with a flow rate of 3-7 gpm. Prior to 1980, typical faucets had a flow rate of 4 gpm. Faucets installed between 1980 and 1994 flowed at approximately 3 gpm. Federal guidelines in 1994 required that all lavatory and kitchen faucets and replacement aerators use no more than 2.5 gpm measured at normal water pressure (typically 80 pounds per square inch, psi). A similar limit was established for showerheads in 1994, which reduced the typical flow rate of a showerhead from 3-7 gpm to 2.5 gpm.

Another significant source of water to the sewer system is flushed toilets and urinals. Many plumbing fixtures still in use today were designed at a time when little concern was given to water conservation. Prior to 1950, typical toilets consumed 7-gallons-per-flush (gpf). Toilets installed between 1950 and 1994 consumed 4-5 gpf. Federal laws enacted in 1994 required that residential toilets use no more than 1.6 gpf. In 1997, similar limits were established for commercial toilets, and urinals were limited to 1.0 gpf.

Alternative 5 (Alt5) simulated water conservation by a 10% reduction in water use. A 10% reduction in water use provided a modest decrease in CSO overflows. For Alternative 5 (10% reduction in water use), model calculations indicate a modest reduction in CSO volumes of 2.7% (36 MG) for CSO volume and a reduction in overflow frequency of up to 2 per year, depending on the outfall.

D.2.6 Alternative 6 – Satellite Treatment

As NJDEP confirmed in meetings with the CSO Group, pathogens represent the pollutant of concern for CSO discharges. Accordingly, disinfection of CSO satisfies CSO-control objectives. For the purposes of this analysis, disinfection facilities are designed to remove 99.9 percent (“3-log reduction”) of pathogens for full treatment. Sizing of disinfection facilities is determined via selection of the design 5-minute peak CSO-flow rate, which affects contact time and dosage of the disinfection agent (2018, PVSC). Flow-paced dosing achieves disinfection while minimizing chemical dosage and costs.

As described in Section C.8, PAA disinfection offers significant potential advantages over other disinfection technologies. Due their relatively small space requirements, PAA disinfection facilities can, in many cases, be sited upstream of each CSO outfall, at a location between the existing regulator and the existing screening/netting facility or collocated at a screening/netting facility. The relatively long shelf life of PAA is also suitable for intermittent/infrequent use CSO sites. Costs for disinfection are also lower than many other CSO controls.

Recognizing that, without pretreatment, disinfection facilities would require smaller sites and would cost up to 90% less than with pretreatment, Newark may conducting treatability tests to determine whether or not satisfactory disinfection can be achieved without pretreatment.

Disinfection facilities can be sized to meet the CSO-control objectives described in Section D.1.5:

1. To achieve a certain level of service in terms of frequency, the peak CSO-flow rate is selected based upon the acceptable number of CSO events per year. For example, to achieve full treatment of *all CSO events* annually, each disinfection facility must be sized to handle its annual-peak CSO-flow rate; to achieve full treatment of *all but 4 CSO events* annually, the disinfection facilities in the CSS must be sized to so that no more than 4 CSO events involve *any number* of facilities achieving less than full treatment.
2. To achieve a pollutant-mass removal equivalent to 85 percent volume capture, disinfection would allow the same load of pathogens as would discharge with a reduction of approximately 59 percent from Baseline conditions (2019, G&H).

Note that the overall pollutant-mass reduction for the frequency objectives may be very high, considering that full disinfection is achieved at all times of overflow except during the brief periods when the peak CSO-flow rates are exceeded, and during those periods, disinfection still occurs, albeit at rates lower than 99.9 percent.

Table D.2-6 summarizes the overall reduction in the number of (untreated) CSO events assuming that PAA disinfection facilities are sized to allow no more than 20, 12, 8, 4 and 0 *fully treated* CSO events annually.

Table D-6. Impacts of Disinfection for Range of CSO-Control Objectives

	Untreated[1] CSO Events		Untreated[2] CSO Volume	
CSO-Control Scenario	Count/yr	Reduction	(MG/yr)	Reduction
Baseline	61	-	1,313	-
20 Untreated CSO Events	20	67%	496	62%
12 Untreated CSO Events	12	80%	234	82%
8 Untreated CSO Events	8	87%	171	87%
4 Untreated CSO Events	4	93%	49	96%
0 Untreated CSO Events	0	100%	0	100%

(1) In this context, a CSO event occurs if the CSO flow at any outfall exceeds the design rate for 3-log pathogen removal.

(2) In this context, "Untreated CSO Volume" is the sum of discharged volumes during any 5-minute period that exceed the design rate for 3-log pathogen removal at each CSO outfall.

D.2.7 Alternative 7 – Sewer Separation

Sewer separation is the conversion of a combined sewer collection system into separate stormwater and sanitary sewage systems. A cost calculation procedure was used that is based on estimated area-based costs by general land use type in Kansas City (KCWSD, 2006) adjusted up by 10% for Newark and corrected to 2018 dollars using and escalation factor 1.42 from Engineering News Record (ENR) construction cost index (CCI) (Table D.2-7).

Table D-7. City of Newark General Land Use Sewer Separation Cost/acre

General Land Use	2006 Cost/acre	2018 Cost/acre
Commercial	$95,000	$134,681
Downtown	$145,000	$205,565
Residential	$40,000	$56,708

Using these rates, the 2012 NJDEP land use data (Figure D.2-12) were translated into CSO separation costs by ward. The State's land use classifications were generalized into three categories; commercial, downtown and residential to fit the general land use types used in Kansas City's cost calculation procedure. Table D.2-8 shows the grouping of the State's land use classifications.

Table D-8. General Land Use and NJDEP Categories

General Category	NJDEP 2012 Land Use	
Commercial	Industrial	Other Urban Or Built-Up Land
	Industrial And Commercial Complexes	Railroads
	Major Roadway	Stadium, Theaters, Cultural Centers And Zoos
	Mixed Transportation Corridor Overlap Area	Transportation/Communication/Utilities
Downtown	Commercial/Services	Mixed Urban Or Built-Up Land
Residential	Altered Lands	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)
	Artificial Lakes	Old Field (< 25% Brush Covered)
	Athletic Fields (Schools)	Orchards/Vineyards/Nurseries/Horticultural Areas
	Bridge Over Water	Recreational Land
	Cemetery	Residential, High Density Or Multiple Dwelling
	Cropland And Pastureland	Residential, Rural, Single Unit
	Deciduous Brush/Shrubland	Residential, Single Unit, Medium Density
	Deciduous Forest (>50% Crown Closure)	Stormwater Basin
	Deciduous Forest (10-50% Crown Closure)	Tidal Rivers, Inland Bays, And Other Tidal Waters
	Mixed Deciduous/Coniferous Brush/Shrubland	Transitional Areas
	Mixed Forest (>50% Deciduous With >50% Crown Closure)	Upland Rights-Of-Way Undeveloped

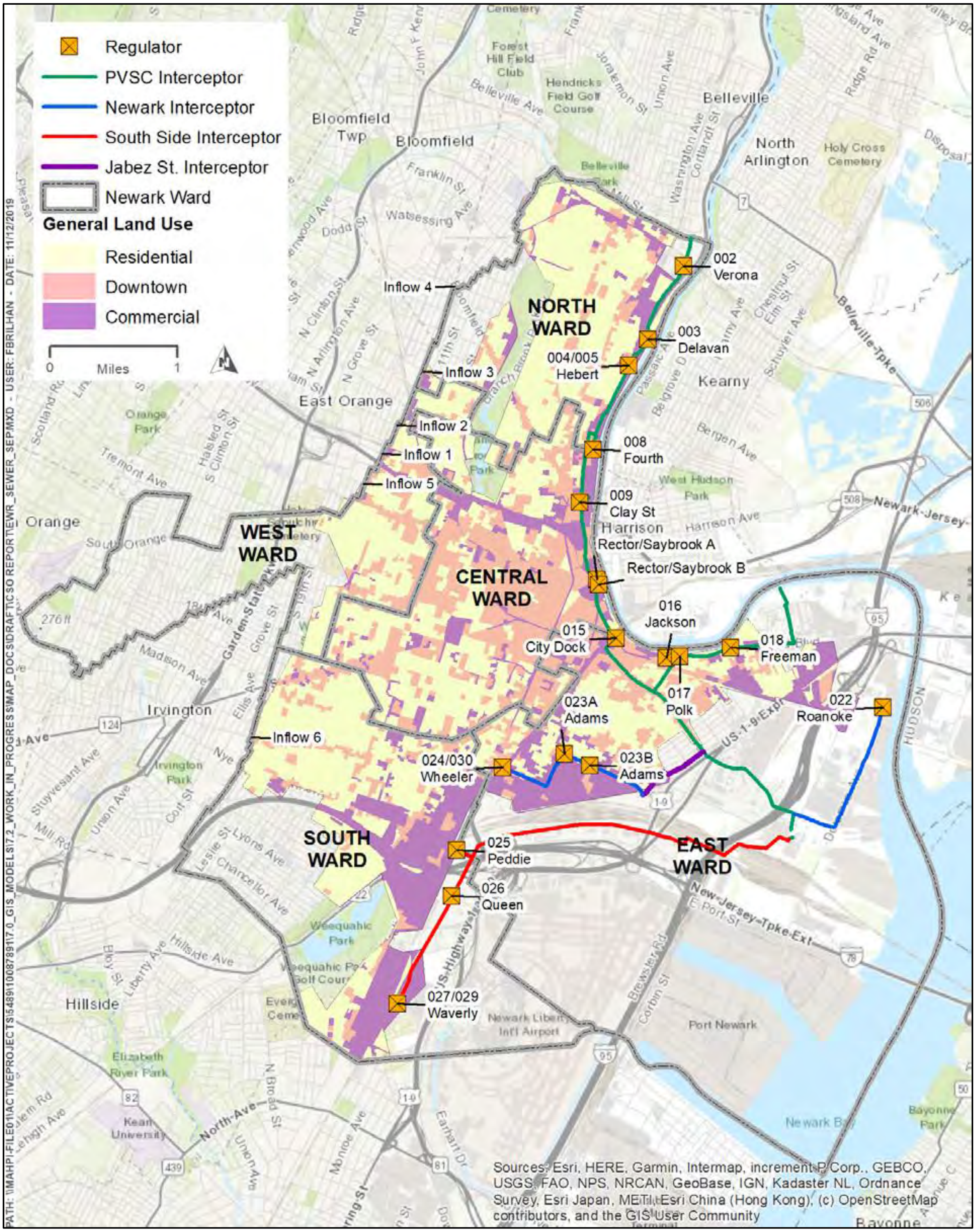
The resulting sewer separation land use areas by ward are shown in Table D.2-9. Costs are presented in Section D.2.8.

Table D-9. City of Newark Sewer Separation Land Use Area by Ward

Ward	Area (Acres)		
	Commercial	Downtown	Residential
Central	334	887	896
East	482	369	544
North	175	177	929
South	558	236	928
West	42	179	475
Total	**1591**	**1848**	**3772**

Sewer separation in certain areas of the combined sewer system may be practical as storm sewers can sometimes be isolated from combined sewers and stormwater flow can be re-routed through a new pipe into a nearby receiving water in limited areas. A sewer separation alternative may be investigated further if added benefits such as flood reduction or redevelopment in the areas warrants it.

Figure D.2-12. City of Newark General Land Use



D.2.8 Summary of Cost Opinions

The cost analysis was performed on GI scenarios, CSO storage, I/I reduction, satellite treatment (disinfection), and sewer separation. The raw capital cost of storage and treatment solutions were estimated based on the available cost curves and information provided in the NJ CSO Technical Guidance Manual (TGM, 2018) and Kansas City LTCP. A Probable Total Project Cost (PTPC) was estimated by applying a 2.5 escalation factor to the capital cost to account for installation cost and contingencies. Life-cycle costs are based on a 20-year period with an annual interest rate of 2.75% for present value (PV) estimation. The present value factor is 15.227. The operations and maintenance (O&M) cost estimation for each CSO-control category is discussed separately in the following sections.

Alternative 1 – Regulator Modification/Flow Maximization

Regulator Modification alternatives are considered low cost and were not explicitly calculated. Cost incurred for modifying regulator operation rules would only be the additional cost to the volume of flow delivered to the PVSC plant. Modification of regulators typically involve the installation of stop logs to raise weir heights and is also a low-cost option.

Alternative 2 – Green Infrastructure (GI)

Table D.2-10 is a summary of costs for various GI technology options for the three GI scenarios evaluated. Each GI technology was evaluated for the entire controlled areas in each scenario to see which control technology was most cost effective. Per direction given by PVSC, O&M costs of $8,000 per acre of controlled impervious area was used for rain gardens, bioswales, and green roofs, while O&M costs of $1,250 per controlled impervious acre was used for porous asphalt, pervious concrete or permeable pavers. Table D.2-11 summarizes the unit costs for each type of GI technology.

Table D-10. Cost Estimation for Green Infrastructure By Evaluated Alternative

Alternative ID	GI Type	Min. Raw Capital Cost ($M)	Max. Raw Capital Cost ($M)	20-Year O&M as PV Cost ($M)	Min. Raw 20-Yr Life-Cycle as PV ($M)	Max. Raw 20-Yr Life-Cycle as PV ($M)
Alt2a_10%GI GI application acre: 455.4	Rain Garden	43.7	138.9	55.5	99.2	194.4
	Right-of-Way Bioswale	68.3	227.7	55.5	123.8	283.2
	Green Roof	218.6	1,111.20	55.5	274.1	1,166.7
	Porous Asphalt	118.4	248.2	8.7	127.1	256.9
	Pervious concrete	138.9	277.8	8.7	147.6	286.5
	PICP(1)	59.2	168.5	8.7	67.9	177.2
Alt2a_5%GI GI application acre: 227.7	Rain Garden	21.9	69.4	27.7	49.6	97.2
	Right-of-Way Bioswale	34.2	113.9	27.7	61.9	141.6
	Green Roof	109.3	555.6	27.7	137.0	583.3
	Porous Asphalt	59.2	124.1	4.3	63.5	128.4
	Pervious concrete	69.4	138.9	4.3	73.8	143.2
	PICP(1)	29.6	84.2	4.3	33.9	88.6
Alt2a_RutgersGI GI application acre: 11.7	Rain Garden	1.1	3.6	1.4	2.5	5.0
	Right-of-Way Bioswale	1.8	5.9	1.4	3.2	7.3
	Green Roof	5.6	28.5	1.4	7.0	30.0
	Porous Asphalt	3	6.4	0.2	3.3	6.6
	Pervious concrete	3.6	7.1	0.2	3.8	7.4
	PICP	1.5	4.3	0.2	1.7	4.6

Alternative ID	GI Type	Min. PTPC (2) Capital Cost ($M)	Max. PTPC (2) Capital Cost ($M)	20-Year O&M as PV Cost ($M)	Min. PTPC(2) 20-Yr Life-Cycle as PV ($M)	Max. PTPC(2) 20-Yr Life-Cycle as PV ($M)
Alt2a_10%GI GI application acre: 455.4	Rain Garden	109.3	347.2	55.5	164.8	402.7
	Right-of-Way Bioswale	170.8	569.3	55.5	226.3	624.7
	Green Roof	546.5	2,777.9	55.5	602.0	2,833.4
	Porous Asphalt	296	620.5	8.7	304.7	629.2
	Pervious concrete	347.2	694.5	8.7	355.9	703.2
	PICP(1)	148	421.2	8.7	156.7	429.9
Alt2a_5%GI GI application acre: 227.7	Rain Garden	54.6	173.6	27.7	82.4	201.4
	Right-of-Way Bioswale	85.4	284.6	27.7	113.1	312.4
	Green Roof	273.2	1,389.0	27.7	301.0	1,416.7
	Porous Asphalt	148	310.2	4.3	152.3	314.6
	Pervious concrete	173.6	347.2	4.3	178.0	351.6
	PICP(1)	74	210.6	4.3	78.3	215.0
Alt2a_RutgersGI GI application acre: 11.7	Rain Garden	2.8	8.9	1.4	4.2	10.3
	Right-of-Way Bioswale	4.4	14.6	1.4	5.8	16.1
	Green Roof	14	71.4	1.4	15.5	72.8
	Porous Asphalt	7.6	15.9	0.2	7.8	16.2
	Pervious concrete	8.9	17.8	0.2	9.1	18.1
	PICP(1)	3.8	10.8	0.2	4.0	11.0

(1) PICP: Permeable Interlocking Concrete Pavers (2) PTPC: Probable Total Project Cost

Table D-11. Cost Estimation for Green Infrastructure Alternatives (cost/acre & cost/MG)

Green Infrastructure Type		Per Area Application ($M/Acre)		Per Overflow Reduction ($M/MG)	
		Minimum	Maximum	Minimum	Maximum
Raw Cost	Rain Garden	0.2	0.4	0.5	1.0
	Right-of-Way Bioswale	0.3	0.6	0.6	1.5
	Green Roof	0.6	2.6	1.4	6.0
	Porous Asphalt	0.3	0.6	0.7	1.3
	Pervious concrete	0.3	0.6	0.8	1.5
	PICP	0.1	0.4	0.4	0.9
PTPC	Rain Garden	0.4	0.9	0.9	2.1
	Right-of-Way Bioswale	0.5	1.4	1.2	3.2
	Green Roof	1.3	6.2	3.1	14.7
	Porous Asphalt	0.7	1.4	1.6	3.3
	Pervious concrete	0.8	1.5	1.8	3.6
	PICP	0.3	0.9	0.8	2.2

PICP: Permeable Interlocking Concrete Pavers
PTPC: Probable Total Project Cost

<u>Alternative 3 – CSO Storage</u>

Table D.2-12 summarizes capital cost, O&M cost, and life-cycle costs using storage alternatives for the targeted levels of control. The capital costs were estimated based on the size of the storage facility per the TGM 2018 manual, with an escalation factor of 2.5 to account for PTPC. The O&M cost estimation for storage tanks was based on data provided by PVSC. Maintenance is 3% of the capital cost, and operation cost is 0.5 of the estimated labor cost of $470,000 continuous operation post cost (COP).

Table D-12. Alternative 3 – Storage Costs

Alternative ID	Raw Capital Cost ($M)	20-year O&M Cost, PV ($M)	20-year Life Cycle Raw Cost, PV ($M)	20-year Life Cycle PTPC Cost, PV ($M)
Alt3 0 CSO Events	624.2	338.8	963.0	1899.4
Alt3a 4 CSO Events	326.7	202.9	529.7	1019.8
Alt3b 8 CSO Events	304.5	192.8	497.3	954.1
Alt3c 12 CSO Events	248.2	167.1	415.3	787.7
Alt3d 20 CSO Events	184.7	138.1	322.8	599.9

(1) PTPC costs include a 2.5 factor on raw capital costs

Alternative 4 – Inflow & Infiltration Reduction

The ARCADIS Extraneous Inflow report calculated cost for various alternative for removing the park inflows. In order to fairly compare the alternatives, their total annual costs were calculated over thirty years. It was assumed that the City would participate in the New Jersey Environmental Infrastructure Financing Program (Program) to fund the selected alternative. The Program's current funding package allows for 75% of the funds required to be borrowed at 0% interest, and the remaining 25% to be borrowed at AAA market rate. The Program allows principal forgiveness on certain types of projects, including combined sewer projects. Total annual costs for each alternative are presented in the Table D.2-13.

Table D-13. Total Annual Cost Comparison Inflow Removal at Parks

Alternative	"2018 Project Cost"	2018 Annual O&M Cost	Total Annual Cost (30 Years)
Weequahic - Meeker Avenue Alternative	$8,600,000	$67,000	$521,000
Weequahic - NJ Transit Alternative	$8,000,000	$67,000	$490,000
Weequahic - Hollywood Avenue Alternative	$11,100,000	$75,000	$662,000
Weequahic - Peddie Ditch Alternative	$6,900,000	$50,000	$413,000
Branch Brook - Branch Brook Park Road Alternative	$14,600,000	$50,000	$826,000
Branch Brook – Lake Avenue Alternative	$13,900,000	$42,000	$782,000

The preliminary recommended alternative for Weequahic Park was the Peddie Alternative, which has the lowest annual cost and has permitting requirements similar to other alternatives. The preliminary recommendation for Branch Brook was the Branch Brook Park Road Alternative, which involves one stakeholder, and the costs are roughly equivalent to those of the other alternatives. Both routes have similar permitting requirements.

Costs of special programs to remove base infiltration were not calculated herein because the costs of such programs are known to be high compared to the CSO-discharge reductions they can achieve. However, the City of Newark is constantly improving and replacing its sewer pipes, and this process helps to reduce infiltration over time.

As part of the final alternative selection Newark will investigate the removal or reduction of uncontrolled stormwater flows in the Jabez Interceptor and screenings wash water flows from floatables control facilities to the interceptor and develop costs for this alternative.

Alternative 5 – Water Conservation

As noted in Section D.2.5, costs to implement water-conservation measures are typically low. Costs for a water-conservation program were not developed herein.

Alternative 6 – Satellite Treatment

Table D.2-14 summarizes the capital cost, O&M cost, and 20-year life-cycle costs for each targeted level of control using peracetic acid (PAA) disinfection. An escalation factor of 2.5 was applied to the capital cost to account for installation cost and contingencies in the possible cost estimation.

These costs include pretreatment (removal of suspended solids) based on a FlexFilter system (but any similar system could be specified). Pretreatment adds to site requirements and significantly increases costs: without pretreatment, a cost reduction of up to 90 percent could be anticipated. For that reason, Newark may perform treatability tests to determine if pretreatment is necessary for PAA disinfection.

Although disinfection does not reduce the total volume or frequency of discharges, it does reduce the volume and frequency of *untreated* discharges. For this analysis, PAA-disinfection facilities were sized to fully treat all but 4, 8, 12, or 20 CSOs/year, based on the peak 5-minute overflow rate at each outfall. The number of untreated CSO events represent the number of CSO events during which the design peak flow rate through disinfection facilities is surpassed.

Table D-14. Satellite Treatment – Disinfection Costs

Alternative ID	Raw Capital Cost ($M)	20-year O&M Cost as PV ($M)	Raw 20-year Life Cycle Cost as PV ($M)	PTPC[1] 20-year Life Cycle Cost as PV ($M)
Alt6 Disinfection 0 CSO	558.3	89.5	647.8	1485.3
Alt6a Disinfection 4 CSO	396.8	68.3	465.1	1060.3
Alt6b Disinfection 8 CSO	247.6	46.5	294.2	665.6
Alt6c Disinfection 12 CSO	214.4	41.6	256.0	577.5
Alt6d Disinfection 20 CSO	118.7	24.3	143.0	321.0

(1) PTPC (Probable Total Project Costs) include an escalation factor of 2.5 on raw capital costs

Alternative 7 – Sewer Separation

Table D.2-15 presents sewer-separation costs by ward. Raw capital costs would be approximately $973 million. Sewer separation would also incur considerable social costs, as it is disruptive to businesses, emergency (such as fire, police, and ambulance) squads, residents and workers in areas affected by the sewer-separation activities. Further, NJDEP stormwater regulations for Tier A municipalities such as Newark would impose current and potential future Municipal Separate Storm Sewer System (MS4) permit requirements, such as outfall mapping, illicit discharge inspection, storm drain labeling, and possibly future discharge requirements.

Table D-15. City of Newark Sewer Separation Raw Capital Cost by Ward

Ward	Raw Capital Costs			
	Commercial	Downtown	Residential	Total
Central	$ 45,056,600	$ 119,656,300	$ 120,870,400	$ 285,583,300
East	$ 65,021,800	$ 49,778,100	$ 73,385,600	$ 188,185,500
North	$ 23,607,500	$ 23,877,300	$ 125,322,100	$ 172,806,900
South	$ 75,274,200	$ 31,836,400	$ 125,187,200	$ 232,297,800
West	$ 5,665,800	$ 24,147,100	$ 64,077,500	$ 93,890,400
Total	**$ 214,625,900**	**$ 249,295,200**	**$ 508,842,800**	**$ 972,763,900**

Table D-16. City of Newark Sewer Separation Cost Estimation

Raw Capital Cost ($M)	PTPC Capital Cost ($M)	20 -Year O&M Cost as PV ($M)	Raw 20-Yr Life-Cycle as PV ($M)	PTPC 20-Yr Life-Cycle as PV ($M)
$972.8	$1,459.1	$296.3	$1,269.1	$1,755.4

D.3 PRELIMINARY SELECTION OF ALTERNATIVES

D.3.1 Evaluation Factors

This preliminary evaluation considered several factors to gauge the technical feasibility and applicability for CSO controls in Newark. Some of the evaluation factors have already been outlined in Sections D.1.1 through D.1.5. In general, the alternatives evaluation factors included but not limited to receiving water quality standards and uses and LTCP goals, sewer system characteristics, wet weather flow characteristics, hydraulic and pollutant loading, climate, implementation requirements (land, neighborhood, noise, disruption), and maintenance requirements. Pathogen reduction in CSO discharges and the frequency and volume of untreated CSO discharges are accounted as the priorities for all alternatives along with their potential cost implications, and public acceptance and interests. The other significant factors considered in alternatives evaluation are:

- Performance capabilities and effectiveness under future (baseline) conditions.
- Applicability at a single CSO outfall or at grouped outfalls and capability to minimize number of new facilities required.
- Capability to beneficially integrate with hydraulically connected communities and the constraints involved.
- Community benefits (GI, as an example), and potential Social and environmental impacts.

- Risk and potential safety hazards to operators and public.
- LTCP Regulatory (EPA and NJSPDES) requirements.

D.3.2 Regulatory Compliance

The alternatives evaluation included in the report was prepared in compliance with the LTCP regulatory (EPA and NJSPDES) requirements and associated guidance documents. The analysis was conducted in cooperation with PVSC and the permittees within the PVSC Sewer District. The evaluation considered a wide range of BMPs and CSO control measures, including all specified in Part IV G.4.e of the NJPDES permit, to identify the preliminary alternatives that will provide the levels of CSO controls necessary to develop a LTCP as required by the State and Federal regulations. The selection of the preliminary alternatives is based on multiple considerations including public input, water quality benefits and designated use, costs and other aspects as outlined in Section D.1.1 through D.1.5 and D.3.1. ~~The preliminary alternatives will result in full attainment of the existing pathogen water quality criteria providing the maximum bacterial reduction reasonably attainable. The remaining CSO discharges will not preclude the attainment of the water quality standards for bacteria or the designated uses of the receiving waters.~~

Further refinement and modifications of the alternatives is expected as the City further develops the LTCP through selection of the compliance approach in cooperation with the PVSC and hydraulically connected communities.

D.3.3 Selection of Preliminary Alternatives

The evaluation and screening of the range of control alternatives described above indicated that offline storage tanks and disinfection technologies can provide the full range of CSO control with respect to both CSO-event frequency and capture metrics; the other alternatives cannot alone achieve the frequency targets. Overall, PAA disinfection with pretreatment generally achieves the frequency targets at lower cost than offline storage tanks.

As described in Section D.1.5, the 85% volume-capture metric corresponds to a reduction in untreated CSO volume of 7% from Baseline. The pollutant-capture metric corresponds to a pathogen load *equivalent* to a 7% reduction in CSO volume. In Newark, these capture targets can be achieved by a wider selection of CSO-control alternatives than the CSO-frequency targets.

Table D.3-1 presents a number of example plan alternatives to achieve different metrics, including 85 percent capture, 20 CSO-events/yr frequency, and 4 CSO-events/yr frequency, along with the associated number of untreated CSO events and volumes, PTPC capital costs, and 20-year Life-Cycle Costs (PTPC as PV). As shown, the lowest costs are associated with achieving the 85 percent capture metrics, and the highest costs are associated with achieving 4 CSO events/yr.

Three example alternatives are provided to meet the 85 percent capture metric (i.e., a 7 percent reduction of CSO volume or equivalent discharge of pathogens). The first example combines the operation of the control gates (for a reduction of about 5.3%, as shown in Alternative 1B) with PAA

Disinfection at an outfall without an automated regulator gate (NE022). The cost is estimated based on PAA disinfection at this one regulator only, and assuming the cost to change the operation of the gates is negligible, with no additional cost to treat additional flow at the plant. Another example alternative is PAA Disinfection of all discharges from a single (NE002) outfall, as required to achieve the equivalent of 7% CSO volume treatment. Finally, a third example alternative is implementation of Green Infrastructure to reduce CSO volumes by 7% (Alternative 2B, which involves application of GI on 5% of Newark's impervious areas); the full range of potential costs is shown based upon the least expensive (rain garden) and most expensive (green roof) GI technologies; the actual GI technologies that could be specified may vary from site to site as necessary based on site characteristics and other factors.

Two examples are also provided to achieve each of two CSO-event frequency targets: 20 and 4 CSO events per year. For simplicity, disinfection and offline storage tanks are shown for each. More complex combinations of alternatives are possible to achieve these metrics, although storage tanks and/or disinfection would almost certainly be required to achieve lower frequency targets. Limited sewer separation may also be considered if it aligns with other city infrastructure projects such as road improvements or flooding abatement. These evaluations of alternatives will serve as a base for the consideration and development of final selected CSO control plan in Newark.

Table D-17. Example Plan Alternatives for CSO Volume/Pollutant Capture Targets

Control Alternative	Untreated CSO Events (count/yr)	Untreated CSO Volume (MG/yr)	Untreated CSO Volume Reduction (%)	PTPC Capital Cost ($M)	20-Yr Life-Cycle Cost, PTPC as PV ($M)
Baseline	61	1,313	-	-	-
For 85% Capture					
Gate Delay + Disinfection[1] at NE022	50	1,199	9%	22.2	24.1
Disinfection[1] at NE002	61	1,215	7%	68.5	73.7
Green Infrastructure[2] Rain Garden Green Roof	57	1,216	7%	55 - 174 274 - 1,389	82 - 201 301 - 1,417
For 20 CSO-Events/yr					
Disinfection[1]	20	496	62%	297	321
Storage Tanks	20	408	69%	462	600
For 4 CSO-Events/yr					
Disinfection[1]	4	49	96%	992	1,060
Storage Tanks	4	102	92%	817	1,020

(1) Disinfection costs shown herein assume that pretreatment (for suspended solids removal) is included. Disinfection costs could be reduced by up to 90% without pretreatment.

(2) Green Infrastructure to control 5% of impervious areas, ranges for least expensive (rain garden) and most expensive (green roof) technologies. See Table D.2.10 for additional options.

APPENDIX H

Development and Evaluation of Alternatives Report
Township of North Bergen (MUA)

Dated: June 2019

Revised: November 2019

Development and Evaluation of Alternatives Report

Township of North Bergen (MUA)

~~April~~ June 2019

Revised November 2019

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Executive Summary

Section A Introduction

This report is the evaluation of CSO control alternatives for the North Bergen MUA central area where flows are conveyed to the PVSC treatment plant. A similar report will be provided for the drainage areas by the Hudson River side where flows are conveyed to the Woodcliff Sewage Treatment Plant.

The Township of North Bergen is a densely populated town in Hudson County, New Jersey. The west side of the township of North Bergen is tributary to the Hackensack River and the northeast section is situated on the Hudson River. The total area of the township is about 3,568 acres, in the central area approximately 1,414 acres is serviced by the combined sewer system. The Township of North Bergen has nine CSO outfalls in the central area discharging to the Hackensack River. All combined sewer flows from the central area will be conveyed to the PVSC treatment plant through Hudson County Force Main. The township's combined sewer system is permitted under NJPDES Permit No. NJ108898 for the PVSC side.

In consistency with the 1994 USEPA's CSO Control Policy, the NJPDES permit requires implementation of CSO controls through development of a Long-Term Control Plan (LTCP). The permit includes requirements to cooperatively develop the LTCP with PVSC and its hydraulically connected CSO permittees. Each permittee is required to develop all necessary information for the portion of the hydraulically connected system they own.

Section D.3.b.v of the NJPDES permit indicates that, as part of the LTCP requirements, a Development and Evaluation of CSO Control Alternatives report be submitted to the NJDEP within 48 months from the effective date (July 1, 2015) of the permit. To meet this regulatory requirement, the Township of North Bergen prepared this report for the development and evaluation of CSO control measures. Various alternatives evaluated for the Township of North Bergen LTCP including source control technologies, collection system technologies, and storage and treatment technologies. The final selection of alternatives will depend on the ability to comply with EPAs CSO Control Policy, the affordability of the program and the ability to meet water quality objectives. It is likely that more than one alternative will be selected.

Section B Future Conditions

B.1 Introduction

Establishing baseline condition is an important step in the CSO LTCP alternatives analysis. Baseline condition is used to compare the effectiveness of different CSO control alternatives and to estimate the magnitude of the CSO volume and frequency reductions.

A 25 to 35 year planning horizon is being assumed for implementation of the CSO LTCP. The projection of sanitary flows is based on the population as described in Section B.4.

B.2 Projections for Population Growth

The Township of North Bergen's population was 60,773 counted in the 2010 United States Census. Based on the North Jersey Transportation Authority (NJTPA) report, the 2045 population is projected to be 67,599.

B.3 Planned Projects

Several development projects are in the planning stages in the Township of North Bergen that could contribute flow to the CSOs in the Central pump station side of the town. These projects will be summarized in the 2020 Selection and Implementation of Alternatives Report.

B.4 Projected Future Wastewater Flows

The future baseline condition is intended to reflect the magnitude and geographic distribution of the anticipated sanitary sewage flow rates. To estimate the sanitary flow rates for the year 2045 planning horizon, the projected population increases (see Section B.2) are applied with existing per-capita sanitary flow rates, based on observed 2016/2017 measured flows and year 2017 population estimates. This calculation represents an increase in sanitary sewage flow of about 8% relative to the observed 2016/2017 dry weather flows. This analysis assumed no change in existing infiltration rates affecting base wastewater flows for the future baseline condition.

Section C Screening of CSO Control Technologies

C.1 Introduction

A wide variety of CSO control alternatives were reviewed as part of the technology screening process to identify the options that have the greatest potential in the Woodcliff Sewage Treatment Plant to achieve the CSO control goals. Options identified during this screening process were subsequently evaluated for effectiveness and costs, as described in Section D.

As part of the screening process, each CSO control technology was evaluated for its effectiveness to achieve following goals: 1) Bacteria reduction and 2) Volume reduction. The other considerations included the ambient receiving water quality goals, the characteristics of the existing sewer system, the characteristics of the wet weather flow (peak flow rate, volume, frequency, and duration), hydraulic and pollutant loading, climate, implementation requirements (land, neighborhood, noise, disruption), and the operational factors.

CSO control technologies can be grouped generally as Source Control, Collection System Control, Storage or Treatment technologies. Technologies under each group were also reviewed with respect to their potential program-role categories as shown below. These categories provide an indication of how a given technology could fit into the overall LTCP program:

- Primary Technology – High potential of meeting water-quality and CSO control goals,
- Complementary Technology – Some potential to bring positive impacts, but may be limited in effectiveness,
- Program Enhancement Technology – Generally good practices, but likely to have limited impact on water-quality and CSO control goals,
- In place/In-progress Technology – Already implemented or included in near-term plans; and
- Not Recommended Technology – Removed from consideration for various reasons (cost, maintenance, public acceptance, constructability, etc.).

The assessment presented here involved high-level screening and was limited to the consideration of the general capabilities of CSO control technologies. The following sections present the technologies that were deemed viable in terms of effectiveness, cost, feasibility, and public acceptance. Section C.9 presents details of the screening process and lists technologies retained for further evaluation in the alternative analysis.

C.2 Source Control

Source control technologies reduce runoff volume and/or associated pollutants entering the collection system. Reductions of peak wet weather flows in the CSS can reduce CSOs directly. Reductions of runoff volumes and pollutant loads may decrease the need for more capital-intensive technologies downstream in the CSS. Some source-control techniques do not require significant structural improvements and thus can have attractive capital costs. However, some source-control measures can be labor intensive and, therefore, can have high operation and maintenance costs.

As presented in Table C-1 (see Section C.9), source-control technologies can involve Stormwater Management, Public Education, Ordinance Enforcement, Good Housekeeping, and Green Infrastructure (GI). In the NJSPDES permit, NJDEP recommends evaluation of the practical and technical feasibility of GI options as part of the alternatives development process. The Township of North Bergen has identified GI application as a viable source-control measure that can provide ancillary environmental and public benefits. Table C-1 identifies which controls are being implemented, which controls are being considered for evaluation, and which have been identified for costing.

C.2.1 Green Infrastructure

Green Infrastructure is an approach that can reduce and treat stormwater at its source while delivering environmental, social, and economic benefits to the community. It is known to be effective to increase the time of concentration of remaining runoff and reduce pollutant loads through absorption and filtration. In addition to effectively retaining and infiltrating rainfall, GI technologies can simultaneously help in decreasing localized flooding, reducing the heat island effect, improving air quality, job creation, and providing needed green spaces; although, it generally does not provide the same level of volume or bacteria reduction as gray solutions.

GI technologies are being used as a primary CSO control approach in other LTCP programs, including the City of Philadelphia and New York City. The technology can be used alone, or it can be used in conjunction with gray infrastructure to reduce the size and costs of gray infrastructure. GI technology is not practical as a stand-alone solution for a highly urbanized CSS area like the City of Bayonne. The technology however, will be considered for evaluation in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control. GI will be considered based on absorbing a 1 inch rainfall. Anything in excess of 1 inch generates CSO.

A previous study, "*Green Infrastructure Feasibility Study, North Bergen"* prepared by Rutgers University, identified possible locations for GI opportunities in the CSS area which included:

- North Bergen High School
- John F. Kennedy Elementary School
- Hudson County School of Technology Adult High School
- North Bergen Public Library
- North Bergen Municipal Building
- North Bergen Community Pool
- North Bergen Department of Public Works
- North Bergen Municipal Utilities Authority
- James J. Braddock Park
- North Bergen Parking Authority Street Parking Lots
- North Bergen Parking Authority Off-Street Street Parking Lots

GI treatment methods include:

- Rain Gardens
- Rainwater Harvesting
- Permeable Pavers, Porous Asphalt, Pervious Concrete
- Curbside Stormwater Planters

.-The ~~realistic~~ potentials of these opportunities will be further refined in the alternative evaluation with the associated benefits and concerns in mind.

C.3 Infiltration and Inflow Control

Excessive amounts of infiltration and inflow (I/I) can increase CSO through reduced CSS conveyance capacity, and can increase operations and maintenance costs associated with the CSS and treatment facilities. "Infiltration" refers to the intrusion of groundwater into the collection system through defective pipe joints, cracked or broken pipes, manholes, footing drains, and other similar sources. In the context of CSS, which is designed to accept stormwater, "inflow" refers to *illicit* entry of flow from streams, tidal sources, or catch basins and similar structures in supposedly "separated" areas that are connected to the CSS.

Infiltration problems typically reflect a general overall deterioration of the sewer system and can be difficult to isolate and identify. Achieving significant reductions of infiltration can also be difficult and expensive. Infiltration in Woodcliff Sewage Treatment plants CSS is not a cost-effective method of CSO control for achieving the required CSO reductions.

In light of the above discussion, only the presence and control of tidal inflow will be further considered for evaluation to verify the current status. This will be considered as a program enhancement and will not be considered further in the alternatives development.

C.4 Sewer System Optimization

Sewer system optimization reduces CSO volume and frequency by removing or diverting runoff, maximizing the volume of flow stored in the collection system, or maximizing the capacity of the system to convey flow to a treatment facility. Improved or additional conveyance, regulator modifications, outfall consolidation or relocation and real time controls are the techniques which can be utilized to maintain proper hydraulic conditions in the system, while minimizing the quantity and frequency of CSO discharges, as well as, the number of control facilities.

Regulator Modifications: Existing regulator structures can sometimes be modified, based on site specific conditions, by adjusting weir elevations or length to take advantage of upstream "in-line" pipe storage, or by adjusting elevations of piping to maximize flow to the interceptor and treatment facility. Caution should be practiced when modifying regulator operations to ensure that basement flooding or street flooding will not result. A field survey or review of sewer system design drawings should be done before modifying any regulators. Regulator modification will be included in the alternatives evaluation.

Conveyance: The transportation of combined sewage through the CSS to a treatment facility involves piping, diversion structures, and pump stations. CSOs and their impacts may be avoided by removing bottlenecks or redirecting overflows from more sensitive areas to areas where impacts are less significant. Improved or additional conveyance can be gained by modifying the flow control and adding additional capacities to existing sewers or force mains. Major conveyance improvements can be costly, require a cumbersome permitting process, and can generate public opposition when they involve significant disruption in urban environments. Considering PVSC's plan to consider accepting more flow at its treatment facility, conveyance is considered a primary technology that will be reviewed further for the development of CSO control alternatives.

Outfall Consolidation/Relocation: Combining and relocating outfalls can minimize the number of CSO control facilities and aid in their siting. This type of measure helps eliminate CSO discharges to sensitive areas or move discharge points to less sensitive areas. The measures may also lower operational requirements and reduce monitoring efforts. The solution generally involves routing overflows using new piping to a new discharge point. Outfall consolidation works best when the outfalls are in close proximity to each other, requiring limited modifications to the conveyance. The techniques can be effective in reducing high frequency, low volume CSOs.

Real Time Control (RTC): RTC provides integrated control for regulators, outfall gates, and pump-station operations based on anticipated conditions, with feedback loops for control adjustments based on actual conditions within the system. RTC typically involves an automated monitoring and control system that operates control devices (such as gates or pump stations) to maximize the storage capacity of the CSS and to limit overflows. This measure may involve installation of numerous mechanical and electrical control devices and require specialized operational capacities. RTC can only be effective in reducing CSO volumes where in-line storage capacity is available in the system, which generally exists in a CSS with relatively flat upstream slopes. This measure has been identified as a complementary technology to be reviewed in combination with primary storage technologies in the alternatives evaluation process

C.5 Storage

Storage technologies allow excess wet weather flows to be stored for subsequent conveyance to a treatment facility as required. The technology can attenuate peak flows in the CSS and provide a relatively constant flow into the treatment plant after the storm is over. Storage technologies are a reliable means for CSO control, but they have fairly high construction and O&M costs. Technologies in this group typically are linear storages (pipeline and tunnel) and point storages (tanks).

Pipeline Storage: Additional in-line storage to retain wet weather excess flows can be created by the construction of new larger size pipes in place of, or parallel to, existing combined sewers. Pipeline has the advantage of requiring a smaller construction area than point storage. However, it could take significant lengths of piping to provide adequate storage if a small diameter is used. Pipelines typically require large open trenches and temporary closure of streets to install, which could create significant public disruptions. One of the principles that govern storage with larger size pipes is to assure a minimum slope.

The use of pipeline storage is a cost-effective method for reducing combined sewer overflows if you can maximize the use of available storage volume already existing within the CSS. The technology will be evaluated further as a CSO control.

Tunnel Storage: This control alternative involves the capture and storage of wet weather excess flows in a tunnel and the subsequent pumping out of this stored volume when the conveyance and treatment capacities become available. The technology is used in CSO systems depending on the peak and volume of the wet weather flows needed to be captured. Flows are introduced into the tunnels through drop shafts and pumping facilities are usually required at the downstream ends for dewatering. Tunnels provide more storage volume than the pipeline method previously described. The ease of capacity expansion and its underground construction techniques allow for relatively minimal disturbance to the ground surface, which can be very beneficial in congested urban areas. Therefore, tunnels have been considered as one of the primary technologies for the alternative evaluation.

Tank Storage: The most prevalent form of offline storage of combined sewer flows is to install storage tanks at or near the CSO outfalls or pump stations so that the storage can consolidate flows conveyed within the collection system from upstream locations. This type of facility can be relatively simple in design and operation and can effectively reduce the frequency of overflows. Tanks can capture the most concentrated first flush portion of wet weather peak flow and help to reduce the capacity needs for conveyance and treatment. CSO Storage Tanks are generally below grade structures that allow them to fill by gravity and are dewatered over one to three days. Below grade structures can also be redeveloped as parks, parking lots and other public uses. If they are above grade, in most cases, they would require pumps that can handle short term (5 to 10 minute) peak flows. Also, above grade tanks offer no public benefits that below grade tanks do.

Additionally, storage tanks can be used for providing contact time for disinfecting the effluent during larger events, depending upon the application needs.

C.6 Sewage Treatment Plant (STP) Expansion or Storage

Expansion of a sewage treatment plant can help to reduce or eliminate CSOs by allowing more flows into the plant. The Township of North Bergen transports their combined sewer flows to the PVSC wastewater treatment facility via a force main, several miles long, jointly owned with the Jersey City MUA and the Kearny MUA. According to the Township of North Bergen's current contract with PVSC, the maximum rate of combined sewer flow from the Township of North Bergen shall not exceed 18 MGD. As indicated in Section C.4, PVSC is considering modifications to their treatment facilities to be able to accept additional wet weather flows from their district ~~permitees~~permittees. While all dry weather flows from the Township of North Bergen are conveyed to PVSC, local and regional hydraulic constraints would limit the amount of additional flows above the contracted amount that can be conveyed for treatment. Also, negotiations have been initiated with the Jersey City and Kearny MUAs to investigate joint facilities which would serve all three municipalities. Due to these facts, it would likely be less intricate and more cost effective if local storage (e.g., tunnel, tank) is considered, rather than conveying the full peak flow of the Township of North Bergen to PVSC for treatment. Since North Bergen currently neither owns nor operates a wastewater treatment facility that can receive the flows, STP expansion or modification for wet weather flow could only be done by PVSC. These discussions with PVSC will be held in late 2019.

C.7 Sewer Separation

Wet weather peak flows and, consequently, the risk of combined sewer overflows can be eliminated or reduced by complete or partial removal of stormwater connections from the CSS, a process called "sewer separation." This process typically involves the construction of new storm sewers to convey stormwater directly to the receiving water, leaving the existing combined sewers to convey sanitary sewage and any remaining stormwater inputs. During the sewer separation process, stormwater inputs such as catch basin inlets, roof leaders, sump pumps, etc. must be redirected to the new storm sewers. On the other hand, if new separate sanitary sewers are installed, the existing sanitary laterals must be redirected to the new separate sanitary. This CSO control technique may also require modification to the other elements of the existing infrastructure such as manholes, regulators, and outfalls. Sewer separation can be disruptive to the neighborhood, especially in a densely developed urban environment like the Township of North Bergen. Sewer separation at North Bergen was previously found to represent the most expensive CSO control alternative. Also, there is a potential that future Municipal Separate Storm Sewer (MS4) permits may require treatment of the separated stormwater prior to discharge in the future. Despite these facts, sewer separation is a primary technology that would completely eliminate CSOs. Therefore, the previous cost evaluation will be used for a comparison with the tunnel and tank storage options.

C.8 Treatment of CSO Discharges

Disinfection is used to destroy pathogenic microorganisms in CSO discharges. Suspended solids removal is also used for pretreatment if suspended solids are high. It is very effective at reducing pathogens through inactivation, but provides only limited to no opportunities for volume reduction. Disinfection can either be conducted at centralized storage facilities or locally at satellite facilities near the outfalls. However, disinfection of CSO is challenging because of its intermittent occurrence with high variability in flow and loading characteristics. Therefore, all possible conditions should be considered during the design.

Both chemical disinfection and Ultraviolet (UV) disinfection have been widely used with WWTPs following conventional primary and secondary treatment. UV disinfection has been ineffective for most satellite CSO treatment systems mainly because of the flow characteristics. Many chemicals are available for chemical disinfection. Some of the more common technologies include gaseous chlorine, liquid sodium hypochlorite, chlorine dioxide, and ozone. For disinfection of CSOs, liquid sodium hypochlorite is the most common, although its apparent toxicity to aquatic life is a concern and for this reason dechlorination is required.

The U.S. EPA approved peracetic acid (PAA) as a primary disinfectant for wastewater in 2007. Only a limited number of wastewater treatment plants in the United States have adopted PAA as a primary disinfectant, but its application is growing. Several case studies have been undertaken in the US including the pilot study for CSO treatment conducted by Bayonne. It has been reported that PAA is an effective agent which requires a comparatively shorter contact time to achieve the desired level of disinfection. The Bayonne pilot study, as well as other studies on PAA disinfection of wastewater, did not experience toxicity of residual PAA. However, it is still an issue which may be further verified in the near future. Also, there is currently no known application of PAA for CSO disinfection in the US. The main advantage of PAA over sodium hypochlorite is its long “shelf life” without product deterioration, which is important for satellite CSO disinfection facilities due to the intermittent nature of flows. PAA also does not require quenching of residual concentration that would exist in a CSO discharge.

Disinfection has been identified as a primary technology to consider in the alternatives evaluation.

C.9 Screening of Control Technologies

The Township of North Bergen has already implemented some low to medium level CSO control practices related to the nine minimum controls (NMCs). Screening of available CSO control technologies was therefore conducted based upon if a measure is already in place, or not in place but it will meet, partially meet or not meet the LTCP objectives in combination, or not in combination, with other technologies. In regard to the primary CSO control goal for bacteria reduction and volume reduction, the technologies were categorized as follows:

- High – Technologies that will have a significant impact (≥ 65%) on this CSO control goal and are among the best technologies available to achieve that goal. Therefore, they may be considered for further evaluation.
- Medium – Technologies that are effective at achieving the CSO control goal (35-65%), but are not considered among the most effective technologies to achieve that goal.
- Low – Technologies that will have a minor impact (≤ 35%) on this CSO control goal. Therefore, they will need other positive attributes to be considered for further evaluation.
- None – Technology that will have zero or negative effect on the CSO control goals.

The screening of each CSO control technology was then conducted with the following in mind:

- Predicted effectiveness at reaching the primary goals of bacteria and volume reduction;
- Implementation and operational factors, and whether to consider combining the technology with other technologies;
- If the technology is currently implemented, and
- If the technology can be recommended for the alternatives evaluation.

As indicated in Section C-1, technologies not recommended were removed from consideration for various reasons such as cost, maintenance, public acceptance, etc. The result of the CSO control technologies screening with "yes" or "no" answers are presented in Table C-1 below. The columns at the right indicate the current status of each technology, whether or not the technology is suitable to be combined with others, and whether or not the technology is being evaluated further (in Section D).

Table C-1. CSO Control Technology Screening Results

Township of North Bergen							
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction				
Source Control Technologies							
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	Flow restrictions to the CSS can cause flooding in lots, yards and buildings; potential for freezing in lots; low operational cost. Effective at reducing peak flows during wet weather events but can cause dangerous conditions for the public if pedestrian areas freeze during flooding.	No	No	Yes
	Catch Basin Modification (for Floatables Control)	Low	None	Requires periodic catch basin cleaning; requires suitable catch basin configuration; potential for street flooding and increased maintenance efforts. Reduces debris and floatables that can cause operational problems with the mechanical regulators.	No	No	Yes
	Catch Basin Modification (Leaching)	Low	Low	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No	No	Yes
Public Education and Outreach	Water Conservation	None	Low	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume, but would have little impact on peak flows.	Yes	No	Yes
	Catch Basin Stenciling	None	None	Inexpensive; easy to implement; public education. Is only as effective as the public's acceptance and understanding of the message. Public outreach programs would have a more effective result.	Yes	Yes	Yes
	Community Cleanup Programs	None	None	Inexpensive; sense of community ownership; educational BMP; aesthetic enhancement. Community cleanups are inexpensive and build ownership in the city.	Yes	Yes	Yes
	Public Outreach Programs	Low	None	Public education program is ongoing. Permittee should continue its public education program as control measures demonstrate implementation of the NMC.	Yes	Yes	Yes
	FOG Program	Low	None	Requires communication with business owners; ~~Permitee~~Permittee may not have enforcement authority. Reduces buildup and maintains flow capacity. Only as effective as business owner cooperation.	Yes	No	?
	Garbage Disposal Restriction	Low	None	~~Permitee~~Permittee may not be responsible for Garbage Disposal. This requires an increased allocation of resources for enforcement while providing very little reduction to wet weather CSO events.	Yes	No	?
	Pet Waste Management	Medium	None	Low cost of implementation and little to no maintenance. This is a low cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes	No	Yes
	Lawn and Garden Maintenance	Low	Low	Requires communication with business and homeowners. Guidelines are already established per USEPA. Educating the public on proper lawn and garden treatment protocols developed by USEPA will reduce waterway contamination. Since this information is already available to the public it is unlikely to have a significant effect on improving water quality.	Yes	No	Yes

Table C-1. CSO Control Technology Screening Results

Township of North Bergen							
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction				
	Hazardous Waste Collection	Low	None	The N.J.A.C prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	Yes
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if Permitee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.	Yes	Yes	Yes
	Illegal Dumping Control	Low	None	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes	Yes	Yes
	Pet Waste Control	Medium	None	Requires resources to enforce pet waste ordinances. Public education and outreach is a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes	No	Yes
	Litter Control	None	None	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach is a more efficient use of resources.	Yes	No	Yes
	Illicit Connection Control	Low	Low	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	No	Yes
Good Housekeeping	Street Sweeping/Flushing	Low	None	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	Yes
	Leaf Collection	Low	None	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	Yes
	Recycling Programs	None	None	Most Cities have an ongoing recycling program.	Yes	Yes	Yes
	Storage/Loading/Unloading Areas	None	None	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	No	Yes
	Industrial Spill Control	Low	None	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	Yes
Green Infrastructure Buildings	Green Roofs	None	Medium	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the ~~Permitee~~Permittee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	Yes
	Blue Roofs	None	Medium	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the ~~Permitees~~Permittees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	Yes

Table C-1. CSO Control Technology Screening Results

Township of North Bergen							
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction				
Green Infrastructure Impervious Areas	Rainwater Harvesting	None	Medium	Simple to install and operate; low operational resource demand; will require the ~~Permitees~~Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	No	Yes
	Permeable Pavements	Low	Medium	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	No	Yes
	Planter Boxes	Low	Medium	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes
Green Infrastructure Pervious Areas	Bioswales	Low	Low	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	No	Yes
	Free-Form Rain Gardens	Low	Medium	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes
Collection System Technologies							
Operation and Maintenance	I/I Reduction	Low	Medium	Requires labor intensive work; changes to the conveyance system require temporary pumping measures; repairs on private property required by homeowners. Reduces the volume of flow and frequency; Provides additional capacity for future growth; House laterals account for 1/2 the sewer system length and significant sources of I/I in the sanitary sewer.	Yes	Yes	Yes
	Advanced System Inspection & Maintenance	Low	Low	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	No	No
	Combined Sewer Flushing	Low	Low	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	No	Yes
	Catch Basin Cleaning	Low	None	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	Yes	Yes

Table C-1. CSO Control Technology Screening Results

Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
Township of North Bergen							
		Bacteria Reduction	Volume Reduction				
Combined Sewer Separation	Roof Leader Disconnection	Low	Low	Site specific; Includes area drains and roof leaders; new storm sewers may be required; requires home and business owner participation. The Cities are densely populated and disconnected roof leaders have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	Yes
	Sump Pump Disconnection	Low	Low	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The Cities are densely populated and disconnected sump pumps have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	Yes
	Combined Sewer Separation	High	High	Very disruptive to affected areas; requires homeowner participation; sewer asset renewal achieved at the same time; labor intensive.	No	No	Yes
Combined Sewer Optimization	Additional Conveyance	High	High	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	No	No
	Regulator Modifications	Medium	Medium	Relatively easy to implement with existing regulators; mechanical controls requires O&M. May increase risk of upstream flooding. ~~Permitees~~Permittees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	No	Yes
	Outfall Consolidation/Relocation	High	High	Lower operational requirements; may reduce permitting/monitoring; can be used in conjunction with storage & treatment technologies. Combining and relocating outfalls may lower operating costs and CSO flows. It can also direct flow away from specific areas.	Yes	No	Yes
	Real Time Control	High	High	Requires periodic inspection of flow elements; highly automated system; increased potential for sewer backups. RTC is only effective if additional storage capacity is present in the system.	Yes	No	Yes
Storage and Treatment Technologies							
Linear Storage	Pipeline	High	High	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	No	Yes
	Tunnel	High	High	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	No	Yes
Point Storage	Tank (Above or Below Ground)	High	High	Storage tanks typically require pumps to return wet weather flow to the system which will require additional O&M; disruptive to affected areas during construction. Several CSO outfalls have space available for tank storage. There may be existing tanks in abandoned commercial and industrial areas to be converted to hold stormwater. Tanks are an effective technology to reduce wet weather CSO's.	No	No	Yes

Table C-1. CSO Control Technology Screening Results

Township of North Bergen							
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction				
	Industrial Discharge Detention	Low	Low	Requires cooperation with industrial users; more resources devoted to enforcement; depends on IUs to maintain storage basins. IUs hold stormwater or combined sewage until wet weather flows subside; there may be commercial or industrial users upstream of CSO regulators.	Yes	No	No
Treatment-CSO Facility	Vortex Separators	None	None	Space required; challenging controls for intermittent and highly variable wet weather flows. Vortex separators would remove floatables and suspended solids when installed. It does not address volume, bacteria or BOD.	Yes	No	No
	Screens and Trash Racks	None	None	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	No	Yes
	Netting	None	None	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	Yes
	Contaminant Booms	None	None	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	No
	Baffles	None	None	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	Yes	No	Yes
	Disinfection & Satellite Treatment	High	None	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	No
	High Rate Physical/Chemical Treatment (High Rate Clarification Process - ActiFlo)	None	None	Challenging controls for intermittent and highly variable wet weather flows; smaller footprint than conventional methods. This technology primarily focuses on TSS & BOD removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	Yes
	High Rate Physical (Fuzzy Filters)	None	None	Relatively low O&M requirements; smaller footprint than traditional filtration methods. This technology primarily focuses on TSS removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
Treatment-WRTP	Additional Treatment Capacity	High	High	May require additional space; increased O&M burden.	No	No	Yes
	Wet Weather Blending	Low	High	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	Yes
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	Yes

Section D Alternative Analysis

D.1 Development and Evaluation of Alternatives

D.1.1 Siting

Siting is commonly a subject of most public debate on CSO control projects. Therefore, one of the key considerations in assessing the overall feasibility of a CSO control alternative is the identification of an appropriate site for new facilities. The Township of North Bergen is fully developed with not much available open space. Land availability can be an issue as most of the controls are preferred to be located near the waterfront, which is expensive and mostly developed in much of the city. It is recognized that issues involving facility location, land takings, and easements in both public and private lands can lead to disagreements among various stakeholders. Therefore, this alternatives evaluation focuses on the use of the city-owned available sites which have minimal impact on sensitive stakeholders to be less likely controversial. The environmental, political, socioeconomic, and regulatory impacts of locating a facility at a designated site will need to be evaluated in detail during the facilities planning and design phase.

Facilities siting in this evaluation is preliminary in nature and it is based on the space requirements. A buffer for roadways and access base, potential conflicts with above ground existing utilities at the site, highways, and local streets are also part of the preliminary facility siting considerations.

D.1.2 Institutional Issues

Institutional constraints include matters related to political issues, public opinion, and other non-technical factors that could impact project approval. Institutional and political factors can influence CSO control projects as most part of such project is generally funded by tax payers or sewer rate payers. The general public must be convinced that the proposed project is cost-effective and for the public good, so that possible public rejection is minimized. This is important to support the fundraising needed for implementation of the project. The Township of North Bergen has continued raising public awareness about the LTCP project through ongoing public participation activities with PVSC, as stressed in the NJPDES permit and EPA policy and related guidance for the LTCP. It is to be noted that the Township of North Bergen is a densely developed urban municipality with poverty levels at or above the state average. Therefore, it is acknowledged that negotiations amongst politicians, institutions, and other stakeholders and interested parties are necessary to ensure that CSO control measures that are technically feasible for the Township of North Bergen are also financially and politically feasible.

It is to be mentioned that budgetary constraints of the permittee and, indirectly, constituent rate payers are not explicitly considered in this analysis. It is recognized that while certain alternatives may provide measurable benefit within other evaluation criterion, it may be the case that overall costs prove to be prohibitive to implementation for those alternatives.

D.1.3 Implementability

In addition to the cost, performance, political, and institutional aspects, several other factors can affect implementation of a potential alternative. The following are some of the key implementability issues that have been part of preliminary considerations in the alternatives evaluation, but they have not been reviewed or analyzed in depth. The considerations made in this evaluation are solely based on the available information obtained from various sources.

Environmental Issues: These issues may be related to land conservation, use and acquisition; zoning changes, easement, traffic and site access, noise and vibration, floodplains and zoning, wetland buffer zones, utilities relocation and loss of services, and short term impacts water or air quality. Alternatives that fit with existing land uses and favor City property will receive a positive consideration under this evaluation. Any specific permits that would be required to implement a CSO control alternative would be identified at the facility planning and design phase.

Consideration for no CSO discharges to sensitive areas is a requirement in the evaluation of the CSO control alternatives. The NJDEP approved sensitive area study report identified no such area for the North Bergen CSO receiving waters. Therefore, CSO discharges to sensitive areas is not an issue for this alternatives evaluation.

Constructability: This relates to the ease of construction. Constructability can be impacted by work site subsurface conditions. Adequate geologic data for the subsurface conditions is not currently available at the Township of North Bergen, so there is a large amount of uncertainty as to the rock and soil conditions. It is anticipated that alternatives with unsuitable soils, extensive rock or high groundwater requiring extensive dewatering or rerouting of drainage patterns may impose construction challenges. Alternatives involving complex designs and specialized construction would tend to drive up costs. Therefore, alternatives with few constructability issues will be preferred.

Reliability: Reliability of CSO control alternatives is a significant technical issue. The operating history of existing similar installations can help predicting the reliability of a proposed solution. System components must function properly when required, particularly for CSO facilities that operate only on an intermittent basis. Alternatives that rely on simpler or less complex equipment and automation are inherently more reliable. Alternatives involving systems with unknown or poor track records will not be favored.

Ease of Operations: Operability issues involve both process and personnel related considerations. Alternatives involving equipment and system components that are relatively easy to operate and require reasonable operator assistance will be preferred. Unfavorable alternatives would involve highly specialized systems that require extensive training and staffing requirements.

Multiple Use Considerations: Multiple-use CSO control facilities can help to gain Public and institutional acceptance. An alternative would be considered advantageous if it can serve another beneficial purpose while also mitigating CSOs. Examples include parking facilities over storage/treatment tanks, and recreational opportunities such as constructing bike paths over the routes of consolidation conduits or improving river access, which are possible enhancements that have been shown to provide additional public benefit.

Compatibility to Phased Construction: Given the cost of CSO control facilities, alternatives that can be implemented in smaller parts can be more affordable than a single large project. Phasing can lessen the immediate financial impact on rate payers with some immediate reliefs to CSO problems. Preferable alternatives will need to meet current needs but also will adapt to future conditions.

D.1.4 Public Acceptance

Community acceptance of a recommended solution is essential to its success. All permittees are required to involve the public, regulators, and other stakeholders throughout the LTCP development process. As such, the PVSC and the Township of North Bergen itself have continued raising public awareness of the LTCP development through ongoing public participation activities, as stressed in the NJPDES permit, and EPA policy and related guidance for the LTCP.

PVSC has held several quarterly regional supplemental CSO team public meetings over the course of the LTCP development effort. Local meetings were held in conjunction with the PVSC's regional supplemental CSO team meetings. The details of the public participation process and the associated outreach program activities have been documented in the January 2019 revision of the Public Participation Process Report submitted to NJDEP.

Thus far, the regional Supplemental CSO team public meetings have continued being held and the supplemental CSO team members have been encouraged to provide feedback on further LTCP development milestone deliverables, including the Development and Evaluation of Alternatives. Further, the City has presented its CSO alternatives evaluation approach in tandem with other ~~permitees~~permittees at the March 7, 2019 regional supplemental CSO pubic meeting (Session 11) held at the NJTPA's conference room. The majority of comments received ~~thus far~~ have been verbal and written comments, some of which are related to application of GI. ~~To date, the Township of North Bergen has not received any comments on any of the draft LTCP submittals provided to the supplemental CSO team members for review and feedback.~~ It is anticipated that the Township of North Bergen will present the results of alternatives evaluation in one additional regional supplemental CSO team public meeting to discuss and address public comments in the NJDEP submittal as it would be necessary. North Bergen will also continue to communicate the LTCP process in future PVSC Public Participation meetings.

D.1.5 Performance Considerations

CSO control alternatives are generally evaluated using several measures, ranging from cost and performance to ancillary benefits and qualitative criteria. The EPA's CSO Policy requires CSO permittees to evaluate a reasonable range of control alternatives to reduce or eliminate CSO discharges to ensure that water quality standards are met. An alternative must include options to address all goals of the LTCP in a cost-effective manner relative to other options. The alternative must also be able to perform well under intermittent and variable flow conditions. A comprehensive set of reasonable alternatives with ranges of CSO control goals for percent capture or number of overflows or pathogen reduction with the ability to beneficially integrate with the hydraulically connected communities are among the considerations in this analysis.

D.2 Preliminary Control Program Alternatives

Section C described the CSO control technology screening performed to identify the preliminary CSO control measures. The screened control measures were further evaluated and described in the following sections. The following section presents overview of various control alternatives developed for the Township of North Bergen. The preliminary alternatives with detailed evaluations are:

- Inflow/infiltration reduction
- Regulator modifications
- Green infrastructure (GI)
- Storage tank
- Storage tunnel
- Treatment
- Sewer separation

D.2.1 Controls

1) Inflow/Infiltration (I&I) Reduction

The reduction of Inflow and Infiltration (I&I) was evaluated as one of the source control solutions. Two scenarios were evaluated -- 10% and 50% of I/I reduction. Model results in Table D-1 shows that for the 10% I&I reduction, only marginal amount of CSO volume was reduced per year, overflow frequencies were eliminated once. For the 50% I/I reduction, about 9.3 MG CSO volume was reduced and overflow was reduced two discharges. It appears that this alternative has positive impact on CSO volume reduction because the hydraulic capacity of system is freed up at some extent. However, the benefit of this control is very minimal for the combined sewer area in terms of annual CSO volume and overflow frequencies. This control strategy will not be considered further.

Table D-1. Overflow Volumes and Frequencies with I/I Reduction Alternative

I/I Reduction								
	Baseline		10% Reduction			50% Reduction		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction	AAOV (MG)	CSO Event	Volume Reduction
NB003	153.7	45	152.6	45	1%	148.3	45	4%
NB005	26.0	48	25.8	47	1%	25.2	46	3%
NB006	0.02	1	0.02	1	0%	0.02	1	0%
NB007	14.2	29	14.0	29	1%	13.2	29	6%
NB008	24.3	30	24.2	30	1%	23.7	30	3%
NB009	27.7	35	27.5	35	1%	26.7	34	4%
NB010	1.2	19	1.2	19	0%	1.2	19	1%
NB011	19.4	33	19.3	33	0%	19.0	33	2%
NB014	7.2	28	7.1	28	1%	7.0	27	2%
Total	**273.8**	**52**	**271.9**	**51**	**1%**	**264.5**	**50**	**3%**

2) Regulator Modifications

Regulators limit the amount of flows to the Hudson County force main and divert excess flow to the outfalls during wet weather events. Modification of regulator such as increasing the weir length or height will hold flows back in the system. By raising the existing overflow weirs elevation 6 inches, the annual overflow volume was decreased from 287 MG to 284.1 MG per year city wide, about 0.2% reduction but overflow frequencies did not drop at all. Table D-2 summarizes CSO volume and number of overflows for this alternative. It appears that the capacity of the system is not available for the additional storage. This alternative will not be considered further.

Table D-2. Overflow Volumes and Frequencies with Regulator Modifications Alternative

Regulator Modifications					
	Baseline		Increase Weir Height by 6 Inches		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction
NB003	153.7	45	153.9	45	0%
NB005	26.0	48	26.0	48	0%
NB006	0.0	1	0.0	1	-1%
NB007	14.2	29	14.7	29	-4%
NB008	24.3	30	22.4	29	8%
NB009	27.7	35	28.0	35	-1%
NB010	1.2	19	1.2	19	4%
NB011	19.4	33	19.4	33	0%
NB014	7.2	28	7.7	28	-8%
Total	**273.8**	**52**	**273.3**	**52**	**0.2%**

3) Green Infrastructure

GI can be used as a complementary CSO control technology in combination with other alternatives. This alternative was evaluated alone to find out if GI has a significant impact on CSO volume and frequency reduction. Two different target level of GI control were evaluated. One of them was to manage 1" of storm water runoff generated from 5% and 10% of impervious surfaces. On the PVSC side, the impervious area is about 994 acres. Table D-3 shows the CSO volume and frequency before and after the implementation of GI comparing with baseline. If 5% of impervious area (about 50 acres) was controlled by GI, we would expect a 3% CSO volume reduction, and a 6% CSO volume reduction with 10% of impervious area controlled with GI. Only three CSO events were eliminated for both scenarios. Because of the relatively small impact achievable with GI, HDR decided to evaluate all alternatives conservatively, without GI, with the assumption that any additional impact of GI, however minor, would be considered in the development of the final selected alternatives.

Table D-3. Overflow Volumes and Frequencies with GI Alternative

Green Infrastructure								
	Baseline		5%			10%		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction	AAOV (MG)	CSO Event	Volume Reduction
NB003	153.7	45	149.4	44	3%	145.0	44	6%
NB005	26.0	48	25.3	46	3%	24.5	46	6%
NB006	0.02	1	0.02	1	-5%	0.02	1	-4%
NB007	14.2	29	13.7	29	3%	13.2	29	7%
NB008	24.3	30	23.5	30	3%	22.8	30	6%
NB009	27.7	35	26.9	35	3%	26.0	33	6%
NB010	1.2	19	1.2	19	3%	1.2	19	6%
NB011	19.4	33	18.9	33	3%	18.3	33	6%
NB014	7.2	28	6.9	27	4%	6.7	27	7%
Total	**273.8**	**52**	**265.8**	**49**	**3%**	**257.7**	**49**	**6%**

4) Storage Tank

The conceptual evaluation of the storage tank for CSO reduction was performed. It is assumed that storage tanks are located near the existing outfalls and are below the ground. CSO is stored in tank during wet weather events. The stored CSO is pumped back to the interceptor for conveyance to the PVSC treatment plant during dry weather and when the system capacity is available. Five scenarios were analyzed to size the storage tank in order to achieve CSO frequency control target of 0, 4, 8, 12, and 20 overflows per year. For example, in order to achieve 4 CSO events control target citywide per year, the sizing criteria for the storage tank is to capture the 5^{th} biggest rainfall event during the typical year of 2004. Tank dewatering pump back rate is no more than 75% of the total average dry weather flows and tank can be dewatered within 72 hours except for 0 CSO control target. Overflows from the tank are the same as those listed in the January 7, 2019 Tech Memo "top 20 storm table" for each target.

Two tanks 125 ft by 125 ft by 25 ft deep tank (2.9 MG each) would be large enough to contain all regulator overflows to 8 overflows per year except for NB003. For NB003 a tank this size would reduce overflows to 20 per year. While sites have not been selected yet there are undeveloped areas near the regulators that might be available and a portion of the Central Pump Station could be redeveloped as a storage tank.

Table D-4 shows the size of tank required at each CSO frequency target. Table D-5 summarizes the CSO volume not captured and retained in the tanks at each frequency target. Table D-6 summarizes the overflow frequencies at each outfall. Storage tank alternative is considered as a primary solution for the CSO frequency control because other alternatives cannot reach the overflow events control target.

Table D-4. Storage Tank Size (MG)

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014	Total
0	19.4	3.0	0.0	2.0	3.7	3.7	0.2	3.0	1.2	**36.3**
4	7.4	1.4	0.0	0.8	1.4	1.5	0.1	1.3	0.3	**14.2**
8	7.0	1.1	0.0	0.7	1.1	1.2	0.1	0.8	0.3	**12.3**
12	4.9	0.8	0.0	0.4	0.8	0.8	0.1	0.6	0.2	**8.4**
20	3.0	0.5	0.0	0.3	0.4	0.5	0.0	0.4	0.1	**5.3**

Table D-5. Overflow Volumes (MG) with Storage Tank Alternative

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014	Total	Volume Reduction
Baseline	153.7	26.0	0.02	14.2	24.3	27.7	1.2	19.4	7.2	**273.8**	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**100%**
4	13.8	2.1	0.0	1.5	3.2	2.9	0.2	1.2	0.7	**25.6**	**91%**
8	14.9	3.2	0.0	2.0	5.4	4.8	0.2	3.4	0.9	**34.8**	**87%**
12	36.1	7.2	0.0	5.1	9.0	9.0	0.4	5.8	1.9	**74.4**	**73%**
20	64.6	11.7	0.0	7.5	14.6	14.0	0.9	8.8	2.4	**124.5**	**55%**

Table D-6. Overflow Frequencies with Storage Tank Alternative

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014	Total	Frequency Reduction
Baseline	45	48	1	29	30	35	19	33	28	**52**	
0	0	0	0	0	0	0	0	0	0	**0**	**100%**
4	3	2	0	2	3	3	4	2	2	**4**	**92%**
8	3	6	0	4	6	7	4	6	5	**7**	**87%**
12	11	12	0	11	11	11	7	11	11	**12**	**77%**
20	18	20	0	19	19	20	13	18	14	**20**	**62%**

5) Storage Tunnel

Storage tunnel solutions considered in this evaluation include an analysis to optimize the size of one centralized storage tunnel necessary to achieve each CSO frequency target (0, 4, 8, 12, and 20 per year). This analysis assumed that overflow from all outfalls will be directed to a centralized, deep storage tunnel. The length of tunnel is assumed to be 18,480 feet long, with varying diameter to achieve required storage volume. The deep tunnel will store CSO generated during wet weather events and pump back stored CSO to PVSC for treatment during dry weather and when the capacity of system is available. Same as storage tank option, the sizing criteria for the storage tunnel is to capture the 5th biggest rainfall event during the typical year of 2004 for achieving 4 CSO events per year. Tank dewatering pump back rate is no more than 75% of the total average dry weather flows and tank can be dewatered within 72 hours except for 0 CSO control target. Overflows from the tank are the same as those listed in the January 7, 2019 Tech Memo “top 20 storm table” for each target. Table D-7 shows the size of tunnel required at each CSO control target. Table D-8 and Table D-9 summarizes volume of CSO discharged from the tunnel and frequencies at each control target, respectively.

Table D-7. Storage Tunnel Size (MG)

CSO Event Target/yr	Tunnel
0	36.3
4	14.2
8	12.3
12	8.4
20	5.3

Table D-8. Overflow Volumes (MG) with Storage Tunnel Alternative

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014	Total	Volume Reduction
Baseline	153.7	26.0	0.02	14.2	24.3	27.7	1.2	19.4	7.2	273.8	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100%
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.3	89%
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.8	85%
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.9	70%
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	130.0	52%

Table D-9. Overflow Frequencies with Storage Tunnel Alternative

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014	Total	Frequency Reduction
Baseline	45	48	1	29	30	35	19	33	28	52	
0	0	0	0	0	0	0	0	0	0	0	100%
4	0	0	0	0	0	0	0	0	0	4	92%
8	0	0	0	0	0	0	0	0	0	8	85%
12	0	0	0	0	0	0	0	0	0	12	77%
20	0	0	0	0	0	0	0	0	0	20	62%

6) Treatment ~~-~~ – Solids Removal and PAA Disinfection

Solids removal and d~~D~~isinfection of combined sewer overflows is another option in the Township of North Bergen. The WWEDCO Flex Filter and d~~D~~isinfection by PAA serve~~s~~ as the basis in the evaluation. Total suspended and p~~P~~athogens represent the primary pollutant of concern for CSO discharges. Disinfection facilities are sized based on the maximum CSO discharge flow rate for each event to fully treat all but 4, 8, 12, and 20 CSO discharges per year. For the target of 4 CSO events per year, the 5th biggest storm in the typical year will be captured and disinfected. For the storm events bigger than the 5th event, CSO discharges will be partially treated, full treatment is achieved only during times that CSO discharges are less than the maximum discharge rate. Where full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens (a "3-log kill."). This degree of performance would reduce an influent of 500,000 CFU/100 mL to 500 CFU/100 mL in the effluent at the design flow rate. Performance would improve at lower flow rates. This preliminary disinfection alternative assumes that PAA disinfection will be implemented at locations between the existing regulators and the existing outfalls. Table D-10 presents the peak flow rate at each CSO control target, and Table D-11 summarizes the partially treated overflow volumes at each CSO control target.

The Flex Filter was included with PAA disinfection to provide the equivalent of primary treatment. The WWEDCO website describes the technology and its performance (http://www.westech-inc.com/en-usa/products/combined-sewer-overflow-cso-and-tertiary-treatment-wwetco-flexfilter). In the 2004 Report To Congress average CSO was reported to contain 215,000 CFU/100 mL and in PeroxyChem's 2016 presentation titled Trends In Wastewater Disinfection Peracetic Acid (http://www.cseao.org/images/2016-summer-conferences-presentations/trends-in-wastewater-chemical-feed.pdf), a Ct value (disinfectant dose in mg/L times the contact time in minutes) of 45 mg/L-min was reported to reduce Fecal Coliform in a secondary effluent to 200 CFU/100 mL. This Ct value is equivalent to a PAA dosage of 9 mg/L at a contact time of 5 minutes. This is an indication that PAA will disinfect CSO but testing is required to understand the site specific variables such as suspended solids concentration, PAA demand of the CSO and the Fecal Coliform concentration of the CSO. If disinfection is selected we will test PAA disinfection with and without pretreatment for suspended solids removal. The purpose of conducting the PAA tests will be to understand the additional chemical requirements and costs for treating raw CSO.

Table D-10. CSO Peak Flow Rates (MGD) at Each Control Target

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014
0	62.8	23.0	1.2	14.5	23.9	16.7	3.2	26.3	3.3
4	59.8	21.0	0.0	9.5	17.3	11.7	2.5	16.9	3.2
8	49.6	17.2	0.0	6.3	10.9	9.4	1.9	13.2	2.9
12	42.7	15.2	0.0	4.9	9.0	8.9	1.8	12.9	2.8
20	36.4	7.7	0.0	4.4	7.7	8.1	0.6	6.7	2.5

Table D-11. Partially Treated CSO Volumes (MG) at Each Control Target

CSO Event Target/yr	NB003	NB005	NB006	NB007	NB008	NB009	NB010	NB011	NB014	Total	Volume Reduction
Baseline	153.7	26.0	0.02	14.2	24.3	27.7	1.2	19.4	7.2	273.8	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100%
4	6.2	0.6	0.0	0.5	1.1	0.6	0.1	1.6	0.4	11.1	96%
8	15.4	2.9	0.0	1.9	3.6	2.6	0.2	3.9	1.3	31.9	88%
12	31.7	6.1	0.0	3.6	5.6	3.8	0.2	4.0	1.7	56.9	79%
20	53.8	9.9	0.0	5.0	8.3	8.5	1.1	9.7	2.6	99.0	64%

D.2.2 Summary of Cost Opinions

Cost analysis was performed for sewer separation, storage tank, storage tunnel, PAA disinfection, and GI in the Township of North Bergen. Assumptions used to estimate capital and O&M costs are described as followings.

1. Sewer Separation Costs
    a. Capital cost for complete sewer separation of this area is $ 467,779,955. This is based on a normalized cost of $235,233 per acre (2006, HMM). To convert to 2018 costs, a ratio of 10817:7630 was applied herein, based on the Engineering News Record (ENR) Construction Cost Index (CCI) values for 2018 and 2006, respectively. Table D-12
    b. O&M costs are estimated based on 2% of the capital cost (2019c, G&H). Table D-12
2. Treatment Costs
    a. Capital and O&M costs for PAA disinfection are based on the latest available guidance for permittees (2018, G&H) and are in Table D-12.

3. Storage Tank Costs
    a. Capital costs for tank storage solutions are based on the latest available guidance for permittees (2018, G&H) and are in Table D-12.
    b. O&M costs for tanks are based on operational costs at $235,000 and maintenance costs at 3% of the construction cost, in accordance with the latest available guidance for permittees (2019c, G&H) and are in Table D-12.
4. Storage Tunnel Costs
    a. Capital costs for tunnel storage solutions are based on the latest available guidance for permittees (2018, G&H) and are in Table D-12.
    b. O&M costs for tunnels are based on operational costs at $470,000 and maintenance costs at 2% of construction cost, in accordance with the latest available guidance for permittees (2019c, G&H) and are in Table D-12.
    c. The ground type for tunnel cost calculations is assumed to be of the type “unknown”.
    d. Construction cost of drop shafts is not included in the cost estimate for tunnel-storage solutions. The construction cost of the tunnel only without the drop shaft is more expensive than the capital cost of tanks therefore the cost of drop shafts were not calculated.
5. Green Infrastructure Costs
    a. Capital costs for various GI solutions are based on the latest available guidance for permittees (2018, G&H) and are in Table D-13.
    b. O&M costs for Bioretention GI solutions were provided as $8,000 per managed acre (2019c, G&H) and are in Table D-13.
    c. O&M costs for Porous Pavement GI solutions were assumed to be $1,250 per managed acre (2018, DEP) and are in Table D-13.
6. Additional Cost Factors
    a. Present-value (PV) of life-cycle costs based on a 20-year period and an interest rate of 2.75% in accordance with the latest available guidance for permittees (2019a, G&H).
    b. Based on experiences on other similar CSO LTCP projects, HDR applied a capital-cost factor of 2.5 to calculate the probable total project cost (PTPC) of implementing each technology. The PTPC accounts for installation, non-component (electrical, piping, etc.), and indirect costs (freight, permits, etc.) for all storage and disinfection. A breakdown of how this factor was calculated is shown below.
        - Installation was estimated at 20% of equipment costs based on historic data experienced by HDR and industry standards for typical plants of similar size and complexity.
        - Non-component costs including: electrical (10%), piping (10%), instrumentation and controls ($15,000), and civil site work (25%)

were estimated based on factors or percentages of equipment costs. These factors account for standard installation commodities, accessories, steal supports and standard testing support.

- Freight was estimated at a lump sum of $20,000.
- Sales tax was estimates at 8%
- Permits were estimated at $20,000
- Start up, performance testing, operator training and O&M manual were estimated at $50,000
- Contract overhead and profit includes 29% for the following:
    a. Part time – Project management support, project controls, procurement, quality and safety support.
    b. Full time – Site construction manager (CM), site administration, standard CM travel pack.
- Engineering, administration and legal fees were estimated at 10%
- A contingency of 10% is included for the remaining equipment items and non-component costs.

Table D-12. Alternatives Cost Summary

CSO Event Target/yr	Alternative ID	Raw Capital Cost ($M)	PTPC Capital Cost ($M)	20-Yr O&M Cost as PV ($M)	Raw 20-Yr Life Cycle Cost as PV($M)	PTPC 20-Yr Life Cycle Cost as PV($M)
85% Capture	Alt_1A_85% Capture_PAA_FlexFilter	$ 22.7	$ 56.8	$ 6.1	$ 28.8	$ 62.9
0	Alt_2A_0_Tank	$ 144.9	$ 362.3	$ 94.8	$ 239.7	$ 457.1
0	Alt_2B_0_Tunnel	$ 170.7	$ 426.8	$ 59.1	$ 229.9	$ 485.9
0	Alt_2C_0_PAA_FlexFilter	$ 50.6	$ 126.4	$ 11.5	$ 49.7	$ 137.9
0	Alt_2D_0_Sewer Separation	N/A	$ 471.6	$ 143.6	N/A	$ 615.2
4	Alt_3A_4_Tank	$ 76.6	$ 191.5	$ 63.6	$ 140.2	$ 255.1
4	Alt_3B_4_Tunnel	$ 123.6	$ 308.9	$ 44.8	$ 168.3	$ 353.7
4	Alt_3C_4_PAA_FlexFilter	$ 41.6	$ 103.9	$ 9.6	$ 51.2	$ 113.5
8	Alt_4A_8_Tank	$ 69.4	$ 173.4	$ 60.3	$ 129.7	$ 233.8
8	Alt_4B_8_Tunnel	$ 118.0	$ 295.0	$ 43.1	$ 161.1	$ 338.1
8	Alt_4C_8_PAA_FlexFilter	$ 33.8	$ 84.6	$ 8.1	$ 42.0	$ 92.8
12	Alt_5A_12_Tank	$ 51.3	$ 128.3	$ 52.1	$ 103.4	$ 180.4
12	Alt_5B_12_Tunnel	$ 105.5	$ 263.8	$ 39.3	$ 144.8	$ 303.1
12	Alt_5C_12_PAA_FlexFilter	$ 30.5	$ 76.3	$ 7.5	$ 38.1	$ 83.9
20	Alt_6A_20_Tank	$ 36.8	$ 92.0	$ 45.4	$ 82.2	$ 137.4
20	Alt_6B_20_Tunnel	$ 92.4	$ 231.0	$ 35.3	$ 127.7	$ 266.3
20	Alt_6C_20_PAA_FlexFilter	$ 24.3	$ 60.7	$ 6.4	$ 30.6	$ 67.0

Note: 85% CSO capture refers to capture in North Bergen only.

For the cost of GI, the latest guidance available to permittees (2018, G&H and 2019c, G&H) provides capital and O&M costs for a variety of GI technologies, O&M costs are available for porous-pavement technologies from the NJDEP (2018, NJDEP). As widespread implementation of GI could involve a variety of GI technologies depending on specific site conditions, a range of costs is provided in Tables D-13 and Table D-14. Table D-13 shows the capital costs, O&M costs, and PTPC 20-yr present value cost for each GI technology for implementation at 5% and 10% of impervious surfaces. Table D-14 shows the raw and PTPC cost range of green infrastructure reported as $M/MG CSO

Table D-13. Cost Summary for Green Infrastructure with Control 5 and 10% of Impervious Cover

Controlled % of Impervious Area	Green Infrastructure Type	Capital Cost Min PTPC ($M)	Capital Cost Max PTPC ($M)	20-Yr O&M Cost as PV ($M)	Min PTPC 20-Yr Life Cycle Cost as PV ($M)	Max PTPC 20-Yr Life Cycle Cost as PV ($M)
5% (~50 acres)	Rain Garden	$ 11.9	$ 37.9	$ 6.1	$ 18.0	$ 43.9
	Right-of-Way Bioswale	$ 18.6	$ 62.1	$ 6.1	$ 24.7	$ 68.2
	Green Roof	$ 59.6	$ 303.0	$ 6.1	$ 65.7	$ 309.1
	Porous Asphalt	$ 32.3	$ 67.7	$ 0.9	$ 33.2	$ 68.6
	Pervious concrete	$ 37.9	$ 75.8	$ 0.9	$ 38.8	$ 76.7
	Permeable Interlocking Concrete Pavers	$ 16.1	$ 46.0	$ 0.9	$ 17.1	$ 46.9
10% (~100 acres)	Rain Garden	$ 23.8	$ 75.8	$ 12.1	$ 36.0	$ 87.9
	Right-of-Way Bioswale	$ 37.3	$ 124.2	$ 12.1	$ 49.4	$ 136.3
	Green Roof	$ 119.2	$ 606.1	$ 12.1	$ 131.3	$ 618.2
	Porous Asphalt	$ 64.6	$ 135.4	$ 1.9	$ 66.5	$ 137.3
	Pervious concrete	$ 75.8	$ 151.5	$ 1.9	$ 77.7	$ 153.4
	Permeable Interlocking Concrete Pavers	$ 32.3	$ 91.9	$ 1.9	$ 34.2	$ 93.8

Table D-14. Normalized Green Infrastructure Cost Ranges

	Green Infrastructure Type	Min $M/MG CSO Reduced	Max $M/MG CSO Reduced	Min $M/Impervious Acre Controlled	Max $M/Impervious Acre Controlled
Raw Cost	Rain Garden	$ 1.4	$ 2.7	$ 0.2	$ 0.4
	Right-of-Way Bioswale	$ 1.7	$ 3.9	$ 0.3	$ 0.6
	Green Roof	$ 3.7	$ 16.0	$ 0.6	$ 2.5
	Porous Asphalt	$ 1.7	$ 3.5	$ 0.3	$ 0.6
	Pervious concrete	$ 2.0	$ 3.9	$ 0.3	$ 0.6
	Permeable Interlocking Concrete Pavers	$ 0.9	$ 2.4	$ 0.1	$ 0.4
Probable Total Project Cost	Rain Garden	$ 2.2	$ 5.5	$ 0.4	$ 0.9
	Right-of-Way Bioswale	$ 3.1	$ 8.5	$ 0.5	$ 1.4
	Green Roof	$ 8.2	$ 38.8	$ 1.3	$ 6.2
	Porous Asphalt	$ 4.2	$ 8.6	$ 0.7	$ 1.4
	Pervious concrete	$ 4.9	$ 9.6	$ 0.8	$ 1.5
	Permeable Interlocking Concrete Pavers	$ 2.1	$ 5.9	$ 0.3	$ 0.9

D.3 Preliminary Selection of Alternatives

D.3.1 Evaluation Factors

This preliminary evaluation considered several factors to gauge the technical feasibility and applicability for CSO controls in the Township of North Bergen in conjunction with the hydraulically connected communities. Some of the evaluation factors have already been outlined in Sections D.1.1 through D.1.5. In general, the alternatives evaluation factors included, but not limited to, receiving water quality standards and uses and LTCP goals, sewer system characteristics and optimization opportunities, wet weather flow characteristics, hydraulic and pollutant loading, climate, implementation requirements (land, neighborhood, noise, disruption), and maintenance requirements. Pathogen reduction in CSO discharges and the frequency and volume of untreated CSO discharges are accounted as the priorities for all alternatives along with their potential cost implications, and public acceptance and interests. The other significant factors considered in alternatives evaluation are:

- Performance capabilities and effectiveness under future (baseline) conditions.
- Applicability at a single CSO outfall or at grouped outfalls and capability to minimize number of new facilities required.
- Capability to beneficially integrate with hydraulically connected communities and the constraints involved.
- Community benefits (GI, as an example) and potential social and environmental impacts.
- Risk and potential safety hazards to operators and public.
- LTCP Regulatory (EPA and NJSPDES) requirements.

D.3.2 Regulatory Compliance

The alternatives evaluation included in the report was prepared in compliance with the LTCP regulatory (EPA and NJSPDES) requirements and associated guidance documents. The analysis was conducted in cooperation with PVSC and the ~~permitees~~permittees within the PVSC Sewer District. The evaluation considered a wide range of BMPs and CSO control measures, including all specified in Part IV G.4.e of the NJPDES permit, to identify the preliminary alternatives that will provide the levels of CSO controls necessary to develop a LTCP as required by the State and Federal regulations. The selection of the preliminary alternatives is based on multiple considerations including public input, water quality benefits and designated use, costs and other aspects as outlined in Section D.1.1 through D.1.5 and D.3.1. The preliminary alternatives will result in full attainment of the existing pathogen water quality criteria providing the maximum bacterial reduction reasonably attainable. The remaining CSO discharges will not preclude the attainment of the water quality standards for bacteria or the designated uses of the receiving waters.

North Bergen intends to select the approach (Demonstration vs Presumption) which will be presented in the "Selection and Implementation of Alternatives" report due June 1,

2020. At that time we will also make a determination with regard to our segmentation within the hydraulically connected system which includes the Hudson County Force Main and PVSC. The definition of hydraulically connected system allows us to segment a larger hydraulically connected system into a series of smaller inter-connected systems. If the Presumptive Approach is selected, a memorandum presenting and describing the percent capture equation will be presented by PVSC on behalf of the PVSC CSO Team.

PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges. As a result of this coordination, the HCFM communities have established that the existing capacity of the 72" diameter Hudson County Force Main is 146 MGD which will be verified by PVSC. This means that the HCFM is physically capable of conveying more flow toward PVSC than it currently conveys. Multiple scenarios assuming various increases from each of the four HCFM communities were considered. Without knowledge of whether or not NJDEP would permit PVSC to increase wet-weather flows such that the full 146 MGD capacity of the HCFM could be used, the HCFM communities have not developed an agreement for a particular allotment of the unknown additional capacity. However, indications are that a mutually agreeable allotment can be achieved.

Further refinement and modifications of the alternatives is expected as the City further develops the LTCP through selection of the compliance approach in cooperation with the PVSC and hydraulically connected communities.

D.3.3 Selection of Preliminary Alternatives

The evaluation and screening of a range of control alternatives described above resulted in a trend toward the use of storage tank, storage tunnel, or disinfection technologies as the preliminary solutions based on the effectiveness of CSO frequency control. From the cost standpoint, apparently the most cost effective control measure is PAA disinfection. It appears that the cost of disinfection is about 10-15% of the cost of storage tank. The potential add-on alternatives could provide positive benefits for the CSO volume reduction, however, they cannot achieve CSO overflows frequency control target of 0, 4, 8, 12, and 20 CSO events per year if the alternative was selected alone. Although GI has limited impact on the CSO volume and frequency reductions, it can be used as a complimentary control strategy for other benefits combined with storage tanks/tunnel or disinfection. These evaluations of alternatives will serve as a base for the consideration and development of final selected CSO control plan in the Township of North Bergen. An example of the cost range of alternatives is shown in Table D-15.

Table D-15. Summary of CSO Control Costs

CSO Event Target/yr	Maximum PV Cost ($M)			Minimum PV Cost ($M)		
	Tunnel Storage	GI of 5% of Impervious Surface	Total Cost	PAA Disinfection with Flex Filter	GI of 5% of Impervious Surface	Total Cost
0	$ 485.9	$ 76.7	$ 562.6	$ 137.9	$ 76.7	$ 214.6
4	$ 353.7	$ 76.7	$ 430.4	$ 113.5	$ 76.7	$ 190.2
8	$ 338.1	$ 76.7	$ 414.8	$ 92.8	$ 76.7	$ 169.5
12	$ 303.1	$ 76.7	$ 379.8	$ 83.9	$ 76.7	$ 160.6
20	$ 266.3	$ 76.7	$ 343.0	$ 67.0	$ 76.7	$ 143.7

APPENDIX I

Development and Evaluation of Alternatives Report
City of Paterson

Dated: July 1, 2019
Revised: November 18, 2019

City of Paterson
Combined Sewer System

Development and Evaluation of Alternatives Report

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Passaic County, New Jersey

and

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July 1, 2019

Last Revised:
November 18, 2019

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SECTION A INTRODUCTION

Description of the City

The City of Paterson (City) is an older urban community located within Passaic County, New Jersey. The City is bounded on the west by the Boroughs of West Paterson and Totowa, on the north by the Passaic River and the Boroughs of Haledon and Prospect Park, on the east by the Passaic River and the Boroughs of Elmwood Park and Fairlawn, and the south by the City of Clifton.

The City consists of approximately 5,290 acres, and the City's population in 2010 (according to the US Census Bureau) was 146,199 persons. Most of the housing in the City was constructed prior to 1940.

As stated above, the City encompasses approximately 8.26 square miles (5,290 acres). The City's land use is varied, consisting of residential, commercial and industrial areas. It is approximated that eight (8%) percent of the City is commercial, 19% is industrial, 65% is residential, and the remaining eight (8%) percent is considered open space. The main commercial area of the City is the downtown, an area roughly encompassed by Main Street and Memorial Drive and King Boulevard (Broadway) and Market Street. The major industrial areas of the City are along the Passaic River, with most of these industries lying along the northern boundary of the City. There are also additional industrial areas along the Interstate 80 corridor.

Description of the City's Combined Sewer System

The City of Paterson is the owner and operator of a combined sewer system (CSS) (a system where sewage and storm water are collected and flow within the same conduit) that provides sanitary and storm water conveyance throughout the City. As previously mentioned, the City consists of 5,290 acres, of which approximately 4,760 acres (90%) are serviced by a CSS (refer to Appendix A for maps of the City's CSS, with sub-areas and CSOs labeled).

During dry weather, sewage is conveyed through the City's CSS, into combined sewer overflow (CSO) control facilities (i.e.: regulator chambers) that are owned and operated by the Passaic Valley Sewerage Commissioners (PVSC). From the regulators, the sewage flows to the PVSC's interceptor, which ultimately conveys the sewage to the PVSC Water Pollution Control Facility (WPCF) in Newark for treatment.

During wet weather events, the combined flow in the CSS is too great for the PVSC interceptor to accommodate. Excess flow crests a weir within the PVSC regulators, and sewer overflows occur at discharge points at the Passaic River (refer to Figure 1).

Each of the City's original twenty-eight (28) overflow discharge pipes originate at PVSC regulators, and each of these overflow pipes discharges to the Passaic River. Over time, flow to four (4) of these overflow discharge points (CSO Areas 012, 018, 019 and 020) has been halted, either through the plugging or abandonment of the outfall pipe or the regulator. Another five (5) overflow points (CSO Areas 002, 004, 008, 009, and 011) were recently consolidated with others and/or abandoned as part of the City's Solids/Floatables program. Once this work was completed, only 19 of the City's original 28 overflow discharge points remained in service.

Over the years, the City has constructed relief sewer systems (consisting of weirs, internal overflow chambers (IOCs), and large diameter relief sewers) in order to provide hydraulic relief to the combined sewer system. The relief sewer systems were specifically designed to prevent surcharging of the combined sewer systems and alleviate street flooding. (The relief sewer systems are prevalent in CSO Areas 028, 029, 030 and 031). When it was convenient, storm water inlets along the route of the relief sewers were connected directly to the relief sewer; however, most of the inlets in upstream areas remained connected to the combined sewer system. It should be noted that the relief sewer systems were constructed to provide hydraulic relief and alleviate street flooding; they were not intended to function as separated storm sewer systems.

These new control facilities (weirs and IOCs) divert excess flow from the combined sewer system to the relief sewers, with the ultimate discharge of this excess flow being to the Passaic River. Overall, the relief sewer system contains 24 active internal control facilities, owned and operated by the City, which are tributary to four (4) combined sewer overflow discharge pipes.

Description of the Combined Sewer System Areas

As previously discussed, a majority of the sections within the City of Paterson are serviced by combined sewer systems that convey sanitary and storm water in the same conduit. During dry periods, sewage is transported through the City's collection system to a PVSC regulator chamber, to the PVSC interceptor and ultimately to the PVSC WPCF in Newark. However, the interceptor lines have limited hydraulic capacity, and during wet weather the excess combined flow is diverted at the regulator chambers to an outfall pipe which discharges to the Passaic River.

The following is a brief description of each of the City's CSO areas, as reported in the 2007 Schoor DePalma Cost and Performance Analysis Report. It is a discussion of the proposed improvements that have either been constructed or were proposed to be constructed in that Report within each area, in order for the City to comply with the Solids/Floatables Control requirements of its General Permit. Proposed improvements were published in design drawings by CMX, titled "City of Paterson CSO – Solids and Floatables Control Facilities Project," issued for bid on October 1, 2009.

CSO001 - Curtis Place

The Curtis Place PVSC Regulator is located approximately 100 feet west of the intersection of Curtis Place and Broadway. Outfall 001 is a 48" diameter pipe, approximately 30 feet long, which discharges at the southwest comer of the bridge that leads to the parking lot of the Salvation Army Building. It should be noted that the Curtis Place PVSC Regulator is one of the upstream starting points of the PVSC Interceptor (along with the S.U.M. Regulator).

The existing 48" outfall was brick and mortared plugged and partially removed. The overflow from PVSC Regulator 001 is now diverted into a new four (4) net netting chamber. The netting chamber is located two (2) feet downstream of the Regulator and in between the Regulator and the bridge that leads to the parking lot of the Salvation Army Building. The screened overflow discharges into a manmade drainage channel approximately ten (10") in width which flows for about sixty (60') feet until it flows into the Passaic River.

CSO002 - Mulberry Street

The Mulberry Street PVSC Regulator is located in a paved area between (currently abandoned) River Street and the Passaic River, approximately 250 feet southwest of the intersection of River Street and West Broadway. Outfall 002 is a 12” diameter pipe, approximately 20 feet long, which discharges to the north of the regulator, directly into the Passaic River.

This outfall is currently inactive and has been plugged since the implementation of controls proposed to address floatables/solids control.

CSO003 - West Broadway

The West Broadway PVSC Regulator is located within West Broadway, approximately forty (40’) feet northwest of the intersection of West Broadway and (currently abandoned) River Street. Outfall 003 is an 18” diameter pipe, approximately 40 feet long, which discharges to the Passaic River through the southeastern foundation wall of the County Bridge over the Passaic River that links the north and south sides of West Broadway.

An in-line netting chamber is proposed to be installed in order to capture solids and floatables of *W’* or greater diameter prior to their discharge to the river. Due to the location of the existing regulator and the outfall pipe (along the centerline of West Broadway), new piping will be installed to re-direct combined overflow to an in-line netting chamber located outside of the West Broadway right-of-way. The combined overflow is conveyed through the new diversion piping, through the netting chamber, discharging to the Passaic River.

With a design flow of six (6) MGD (9.28 cfs) the proposed netting chamber will house two (2) nets. The size of the netting chamber will be 23’ x 8’-8”. The chamber will be located within a vacant lot directly northeast of the regulator; this lot is currently being redeveloped, but accommodations have been made to provide space for the proposed netting chamber. The netting chamber will be placed approximately fifteen (15’) feet east of the existing roadway and approximately 25-30 feet from the bank of the Passaic River.

A new doghouse manhole will be installed along the existing outfall pipe approximately five (5’) feet downstream of the regulator to redirect the combined flow 90 degrees in an easterly direction to a new manhole located within the vacant lot. A pipe connection running ten (10’) feet will be made to connect this manhole to the proposed netting chamber. A pipe will exit from the opposite side of the netting chamber to connect to another proposed manhole. A check valve will be installed within this manhole to prevent backflow into the netting chamber. A new pipe running approximately thirty (30’) feet will exit this manhole and will run through a core-drilled hole in an existing headwall, thus directly discharging the combined flow into the Passaic River.

CSO004 - Bank Street

The Bank Street PVSC Regulator is located in an abandoned roadway approximately 250 feet northwest of the intersection of (currently abandoned) River Street and West Broadway. Mapping shows that Outfall 004 is approximately 150 feet long and is located approximately 240 feet downstream of Outfall 003, but this outfall is buried, and could not be located.

In the area of the PVSC regulator, Bank Street has essentially been abandoned due to realignment of the adjacent roadways. The sewer pipe leading to this regulator will be abandoned in place and filled with grout, and the regulator will also be abandoned in place. The outfall pipe and other influent and dry weather piping entering and exiting the regulator will also be brick and mortared sealed and abandoned in place.

Sewer separation is proposed in this CSO Area, which will connect the existing catch basins to an existing manhole that connects to the River Street storm sewer system. The proposed storm sewer pipe will be 12” ductile iron, approximately 70 feet in length. The previous connections from the catch basins to the regulator will be brick and mortar plugged.

As of the current LTCP, this sewer separation has been completed and CSO004 has been plugged.

CSO005 - Bridge Street

The Bridge Street PVSC Regulator is located approximately 50 feet northwest of the intersection of River and Bridge Streets. Outfall 005 is approximately twenty-five (25) feet long, and discharges to the Passaic River beneath the southeast foundation of the bridge that links the north and south sides of Bridge Street over the Passaic River.

A two (2) net netting chamber is proposed for CSO005. Overflow is being redirected from the existing PVSC Regulator 005 via 60” RCCP to the adjacent comer lot southwest of the regulator (similar to CSO007’s design). Overflow is then screened through a two (2) net in- line netting chamber. Screened flow then is discharged from a new headwall at the end of the netting chamber directly into the Passaic River. A 5’ x 4’ rectangular hydraulic flap valve is proposed at the outfall. The existing outfall pipe will be sealed and abandoned in place.

CSO006 - Montgomery Street

The Montgomery Street PVSC Regulator is located in a sidewalk area along the northwest edge of River Street at its intersection with Montgomery Street. There is no discharge pipe at Outfall 006; combined sewer discharge to the Passaic River occurs immediately northwest of the regulator.

A four (4) net netting chamber was installed at CSO006. The netting chamber was installed directly at the end of the PVSC Regulator where it discharged into the Passaic River. The screened overflow now discharges directly into the Passaic River like before, except now at the end of the netting chamber. Re-grading was done for the installation of the netting chamber, which is located with the Regulator in a gravel parking lot between River Street and the Passaic River.

CSO007 - Straight Street

The Straight Street PVSC Regulator is located approximately 30 feet northwest of the intersection of Straight Street and River Street. Outfall 007 passes through the southeastern foundation wall of the Straight Street Bridge, and discharges to the Passaic River.

CSO007 is currently under construction. Overflow is being redirected from the existing PVSC Regulator 007 via 60" RCCP to the adjacent comer lot southwest of the regulator. Overflow is then screened through a three (3) net in-line netting chamber. Screened flow then continues approximately fifteen (15) feet to a new outfall with tide flap, which is located on the bank of the Passaic River. The existing outfall pipe will be sealed and abandoned in place.

CSO008 - Franklin Street

The Franklin Street PVSC Regulator is located along the northwest edge of River Street at its intersection with Franklin Street. Outfall 008 is believed to be buried and inactive; its flow was consolidated with the outfall pipe from CSO007.

CSO009 - Keen Street

The Keen Street PVSC Regulator is located approximately 75 feet southwest of the intersection of Keen Street and River Street. Outfall 009 discharges to the Passaic River at the southwest terminus of Keen Street. The outfall pipe from CSO009 is inactive; it was consolidated with the outfall pipe from CSO010.

CSO010 - Warren Street

The Warren Street PVSC Regulator is located on Warren Street approximately 350 feet west of River Street in a truck loading driveway for Halal Meat. Outfall 010 is approximately 50 feet long, and discharges to the Passaic River behind Halal Meat.

A three (3) net netting chamber was installed approximately forty (40) feet downstream of the PVSC Regulator 010. The netting chamber is located on the bank of the Passaic River in between two buildings of Halal Meat and behind a fenced in walkway connecting the two buildings used to move animals to and from the buildings. Screened overflow is directly discharged into the Passaic River.

CSO011 - 6th Avenue

The 6th Avenue PVSC Regulator is located on 6th Avenue, approximately 70 feet west of Shady Street. Outfall 011 is 18" in diameter and runs west from the regulator along 6th Avenue approximately 55 feet through the easterly foundation wall of the 6th Avenue Bridge, where it discharges to the Passaic River. The land use within the 6th Avenue drainage area is primarily industrial.

It was determined that the Area of CSO011 was 100% separated. As such, the regulator outfall pipe, influent pipe and dry weather pipe were brick and mortared sealed and abandoned. The upstream manhole from the regulator located at the intersection of 6th Avenue and Shady Street will be removed, and a new junction chamber approximately 11'-8" x 6'-8" will be installed to allow sewage to flow directly to the PVSC interceptor.

CSO012 - 5th Street and 5th Avenue

The 5th Street and 5th Avenue PVSC Regulator is located at the intersection of 5th Street and 5th Avenue. Previous field studies determined that the sewer drainage basin leading to Regulator 012 is 100% separated, and Outfall 012 has been plugged.

CSO013 - East 11th Street

The East 11th Street PVSC Regulator is located in East 11th Street approximately 450 feet north of 5th Avenue. Outfall 013 discharges to the Passaic River at the north terminus of East 11th Street.

A three (3) net netting chamber was installed approximately thirty (30) feet downstream of the PVSC Regulator 013. The netting chamber is located in the middle of the roadway at the end of 11th Street (a dead end street). Screened overflow flows approximately twenty-five (25) feet via 48" RCP to the existing headwall, where it discharges into a wetland area which is also part of the Passaic River bank.

CSO014 - East 12th Street / 4th Avenue

The East 12th Street / 4th Avenue PVSC Regulator is located at the intersection of East 12th Street and 4th Avenue. Outfall 014 runs north from the regulator and discharges to the Passaic River at the bottom of a steep slope.

A two (2) net end-of-pipe netting chamber was installed at the bottom of a steep slope along the banks of the Passaic River where the previous outfall was located. The PVSC Regulator 014 is located at the top of the slope at the intersection of East 12th Street and 4th Avenue as mentioned above. A 24" RCP outfall pipe leaves the regulator and flows northwest down the slope for approximately forty (40) feet, then bends and flows perpendicular to the Passaic River where it flows into the netting chamber. A new concrete stairway from the regulator to the netting chamber was installed along with a gravel entrance driveway. Screened overflows discharge from the netting facility directly into the Passaic River.

CSO015 - S.U.M. Park

The S.U.M. Park PVSC Regulator is located approximately 200 feet southeast of the southeasterly comer of Hinchcliffe Stadium. Outfall 015 is a 36" diameter pipe, which is located along a steep slope. The outfall discharges to the Passaic River approximately 60 feet southeast of the regulator. It should be noted that the S.U.M. PVSC Regulator is one of the upstream starting points of the PVSC Interceptor (along with the Curtis Place Regulator).

An in-line netting chamber was constructed along the embankment near Outfall 015. Due to the steepness of the embankment, re-grading and structural fill was placed to provide a stable foundation for the netting chamber. Once a stable foundation was achieved, the concrete chamber was installed between the regulator and outfall point (over the existing pipe) in a "doghouse" fashion. The slope was re-graded, and an embankment/retaining wall was installed to secure the netting chamber in place and facilitate servicing. A tide gate was installed at the end of the existing outfall pipe to prevent backflow of flood waters into the netting chamber.

With a design flow of 22 MGD (34.04 cfs) the proposed netting chamber will house two (2) nets. The size of the netting chamber will be 23' x 8'-8". A ten (10) foot wide asphalt access driveway from the park's paved path to the netting facility will be installed in order to access the netting chamber for maintenance.

CSO016 - Northwest Street

The Northwest Street PVSC Regulator is located at the intersection of Broadway and Presidential Boulevard. Outfall 016 is approximately 20 feet long, and discharges to the Passaic River through the north foundation wall of the County Bridge that links the north and south sides of Broadway over the Passaic River.

A Romag (mechanical) screen and netting facility have been installed for the short-term control technology for CSO016. Existing PVSC Regulator 016 was modified to divert overflow via cast-in-place concrete box culvert to the new screening facility. The new screening facility is located at the corner of the park east of the Broadway Avenue Bridge. Overflow flows into the new screening facility where flow is diverted into two channels, each channel having a Romag screen and two nets. Screened flow is then discharged directly into the Passaic River. The existing outfall pipe was sealed and abandoned in place.

CSO017 - Arch Street

The Arch Street PVSC Regulator is located at the southeast end of Arch Street, approximately 200 feet southeast of Presidential Boulevard. Outfall 017 discharges to the Passaic River underneath the bridge connecting Arch and Bridge Streets.

Prior to the 2007 Schoor DePalma Report, field investigations at this site found that the tide gates within the regulator were forced shut with 2' x 4's, effectively plugging the outfall. The City had reported that there were no overflow issues related to this CSO Area at the time. Therefore, no further work was required at this CSO Area.

Subsequent to the 2007 Report, the Arch Street PVSC Regulator is in service and the overflow is treated with an end-of-pipe netting chamber. The forward flow not relieved by the PVSC regulating chamber then diverts to the CSO032 Hudson Street regulating chamber. Overflow is screened at CSO032 by end-of-pipe netting facilities, and forward flow crosses the river to the PVSC Main Line at Lawrence Street.

CSO018 - Jefferson Street

The Jefferson Street PVSC Regulator is located approximately 40 feet southeast of the intersection of Jefferson Street and Presidential Boulevard. Outfall 018 discharges to the Passaic River approximately 90 feet southeast of Presidential Boulevard. However, the outfall could not be located and is believed to be buried. It is understood that a masonry wall was installed within the regulator to block peak dry weather flows from discharging through the overflow pipe.

As the regulator is blocked, and no dry or wet weather flow can discharge to the Passaic River from this regulator, no further work is required at this CSO Area.

CSO019 - Stout Street

The Stout Street PVSC Regulator is located approximately 40 feet southeast of the intersection of Stout Street and Presidential Boulevard. Outfall 019 discharges to the Passaic River. However, the outfall could not be located and is believed to be buried. It is understood that a masonry wall was installed within the regulator to block peak dry weather flows from discharging through the overflow pipe.

As the regulator is blocked, and no dry or wet weather flow can discharge to the Passaic River from this regulator, no further work is required at this CSO Area.

CSO020 - North Straight Street

The North Straight Street PVSC Regulator is located approximately fifty (50') feet east of the intersection of North Straight Street and Main Street. Outfall 020 runs along the centerline of North Straight Street and discharges to the Passaic River underneath the bridge connecting North Straight Street and Straight Street. It is understood that a masonry wall was installed within the regulator to block peak dry weather flows from discharging through the overflow pipe.

As the regulator is blocked and no dry or wet weather flow can discharge to the Passaic River from this regulator, no further work is required at this CSO Area.

CSO021 - Bergen Street

The Bergen Street PVSC Regulator is located at the eastern terminus of Bergen Street. A short section of 32" x 49" box culvert exits the regulator and discharges to the Passaic River immediately east of the regulator.

The existing solids/floatables control technology for Outfall 021 is an end-of-pipe netting facility. Bergen Street will be extended approximately eighteen feet; a new headwall will be installed to support the street extension and new sidewalls will be installed to support the proposed netting chamber. New piping will be installed beneath the street extension to allow the combined flow to continue to the proposed netting facility. With a design flow of 8.0 MOD (12.38 cfs) the proposed end-of-pipe netting facility will house two (2) nets. Re-grading and placement of fill will be necessary for the street extension and netting facility. Riprap will be installed at the discharge points of both the netting facility and an existing storm line to prevent scouring along the channel bottom.

CSO022 - Short Street

The Short Street PVSC Regulator is located at the eastern terminus of Short Street. Outfall 022 runs approximately 20 feet to the east and discharges to the Passaic River.

A two (2) net netting chamber is proposed for CSO022. The proposed netting chamber is to be located at the end of the PVSC Regulator 022. A new retaining wall is proposed around the netting chamber with a 4' x 4' rectangular hydraulic flap valve. Screened flow then is discharged from a new headwall/retaining wall at the end of the netting chamber onto a new concrete pad then directly into the Passaic River.

CSO023 - 2nd Avenue

The 2nd Avenue PVSC Regulator is located along the eastern shoulder of McLean Boulevard (N.J.S.H. 20) at its intersection with 2nd Avenue. Outfall 023 is approximately 35 feet long and discharges to the Passaic River at a point approximately 220 feet east of the intersection of 2nd Avenue and 25th Street.

An in-line netting chamber is proposed to be installed at Outfall 023. A new access lane (complete with a new retaining wall and associated fill and pavement) will be constructed between the northbound shoulder of McLean Boulevard (N.J.S.H. 20) and the Passaic River in order to install the netting chamber. The access lane will provide safe access to the netting chamber, allowing maintenance trucks to stage off of N.J.S.H. 20 to service the facility. The unit will house two (2) nets. New outfall piping will also be installed to accommodate the orientation of the netting chamber as required to properly maintain the facility.

CSO024 - 3rd Avenue

The 3rd Avenue PVSC Regulator is located at the intersection of McLean Boulevard (N.J.S.H. 20) and 3rd Avenue. (The regulator lies underneath the southbound travel lanes of Route 20.) Outfall 024 is a 42” diameter pipe, approximately 70 feet long, which discharges to the Passaic River at a point approximately 100 feet east of the intersection of 3rd Avenue and McLean Boulevard.

An in-line netting chamber is proposed to be installed at Outfall 024. The proposed location of the chamber is within the shoulder of the northbound lanes of N.J.S.H. 20, and some minor re-grading will be necessary along the existing slope between N.J.S.H. 20 and the Passaic River. The unit will house two (2) nets that will service a design flow of 35.0 MGD (54.15 cfs). The concrete chamber housing the nets will have (approximate) dimensions of 23’ x 8’- 8”. The chamber will be installed in the “doghouse” fashion over the existing outfall pipe. The existing headwall will be replaced with a new headwall installed in the same location with a tide gate valve attached to prevent backflow into the netting chamber.

CSO025 - 10th Avenue and 33rd Street

The 10th Avenue and 33rd Street PVSC Regulator is located at the intersection of McLean Boulevard (N.J.S.H. 20) and 33rd Street. Outfall 025 runs along the centerline of 33rd Street for approximately 250 feet and discharges to the Passaic River through the southwest foundation wall of County Bridge #8.

A Romag (mechanical) screen and netting facility were installed to meet the short-term control technology requirements for CSO025. A new junction chamber was installed approximately one hundred and fifty (150) feet downstream of the PVSC Regulator 025. The proposed junction chamber will divert flow from existing 72” RCP outfall pipe to a new 84” PCCP. Overflow will then flow into the screening facility which is proposed to be located in existing parking lot adjacent to the east side of the bridge. Flow inside the facility is diverted into two channels, each channel having a Romag screen and two (2) nets. Screened flow then flows from the facility via a 10’ x 10’ box culvert to a new headwall/outfall. A coarse bar screen is proposed at the outlet of the headwall and flow is discharged directly into the Passaic River.

CSO026 - 20th Avenue

The 20th Avenue PVSC Regulator is located along the eastern edge of McLean Boulevard (N.J.S.H. 20) and its intersection with 20th Avenue. Outfall 026 is approximately 600 feet long and runs to the east along a warehouse complex access driveway, discharging to the Passaic River.

A two (2) net in-line netting chamber is proposed for the short-term control technology for CSO026. The netting chamber’s proposed location is approximately ten (10) feet downstream of the PVSC Regulator 026. It is proposed to cut out an appropriate section of the existing 43” x 56” brick outfall pipe, connecting the chamber and existing pipe with a concrete collar. A 24” tide flap valve is proposed at the outfall.

CSO027 - Market Street

The Market Street PVSC Regulator is located along the western edge of the Market Street exit ramp from McLean Boulevard (N.J.S.H. 20), approximately 240 feet northwest of the intersection of Interstate 80 and McLean Boulevard. Outfall 027 runs beneath Route 20 approximately 400 feet and discharges to the Passaic River through the west foundation wall of the bridge that connects Market Street (Elmwood Park) and McLean Boulevard (Paterson).

A Romag (mechanical) screen and netting facility is proposed for the short-term control technology for CSO027. Due to the existing PVSC Regulator 027 location, the existing regulator is proposed to be modified and a new regulator and screening facility installed upstream. A new junction chamber is proposed at the intersection of Vreeland Street and East 41st Street to divert flow from existing 84” RCP into a proposed 90” PCCP. The new 90” PCCP flows across East 41st Street to an existing parking lot on Market Street between East 41st and East 42nd Streets where the new regulator and screening facility is proposed to be located. Flow will then enter the new regulator which will divert dry weather flow to via new sanitary sewer to the proposed modified regulator which will discharge all flow into the PVSC interceptor. Overflow at the new regulator will enter the proposed screening facility located next to the new regulator. The screening facility will divert flow into two channels, each channel having a Romag screen and two (2) nets. Screened flow then flows from the facility via a 90” PCCP and ties back into the existing 90” RCP outfall pipe with a new junction chamber located approximately just south of the facility in the middle of Market Street. Screened flow then flows via the existing 90” RCP outfall pipe and discharges directly into the Passaic River. Sanitary lines downstream of the new facility and upstream of the existing regulator will be diverted from entering the outfall pipe and connected into the new sanitary sewer running from the new regulator to the existing regulator.

Subsequent to the baseline modeling work performed in October 2006 for the 2007 Schoor DePalma Report, it was believed that the knife gate at PVSC Regulator 027 was no longer being operated to limit system inflows during wet weather. As a result, overflows at this location drop from 56 annually to 52 (using 1988 JFK rainfall data), and annual CSO volume decreases substantially, dropping from approximately 341 MG annually to 31 MG. This required a major change to the Paterson hydraulic & hydrologic model received from PVSC, which did not reflect this system change when acquired for this LTCP. Furthermore, it has prompted Paterson to request that their baseline design year be set back to 2006, which more accurately represents the initiation of the City's improvements to their CSS. A complete summary of the Paterson model expansion and calibration is detailed later in Section A.

CSO028 - S.U.M. Park 2

Outfall 028 (also known as the S.U.M. Park 2 Overflow) discharges to the Passaic River approximately 250 feet southeast of Hinchcliffe Stadium and approximately 500 feet east of the Great Falls. The 90" to 116" relief sewer was constructed as a bypass for the Molly Ann Brook into which additional storm sewers were constructed and connected. To provide hydraulic relief to the combined sewer system, nine (9) City owned and operated internal overflow chambers (IOCs) were constructed between the combined sewer system and the Molly Ann Brook bypass.

As stated above, CSO Area 028 consists of nine (9) internal overflow chambers (IOC). It was determined that one (1) IOC has been plugged, and five (5) others did not record overflows during wet weather events. The five (5) IOCs will be plugged and abandoned in place, thus leaving three (3) functioning IOCs in this CSO Area. Static bar screens are proposed to be installed within the remaining three (3) roes (A I-3, A I-4, and A I-5). Each static bar screen will be constructed of 1" x 1/2" steel bars at 1/2" maximum spacing between bars. Additional support will be provided from 1/4" x 1/8" steel bars welded perpendicular to the screening bars at 10" center minimum. The bar screens will be angled (when possible) to facilitate manual servicing.

CSO029 - River Road (Loop Road)

Outfall 029 contains six (6) City owned and operated roes which discharge to this outfall. The overflow from Overflow Chamber EF-1 discharges to Outfall 029 just north of River Street; the overflow from Overflow Chambers EF-2 through EF-6 discharge to the outfall along Paterson Avenue between the intersections of Grand Street and Van Houten Street.

An in-line netting chamber is proposed to be installed at Outfall 029. This chamber is proposed to be installed downstream of the existing City owned IOC EF-1, in a cul-de-sac along (currently abandoned) River Road. The concrete chamber will be installed below grade with the access hatches at pavement level. The concrete chamber will house four (4) nets which will service a design flow of 50.0 MGD (77.36 cfs). The chamber will be sized 23' x 15'-8".

Currently dry weather flow enters the IOC and is diverted into a 15" VCP that flows to the PVSC interceptor. In order to make room for the netting chamber, this line will be rerouted. The existing line will still exit the IOC in the same location, but a new manhole will be installed approximately ten (10) feet downstream of the roe in order to reroute the flow through a proposed 18" PVC line. This line will run behind the netting chamber to another proposed manhole and will reconnect at an existing manhole. From this manhole the existing 15" VCP will be replaced with 18" PVC line to convey the flow to the PVSC interceptor.

Currently the wet weather flow that overflows the weir inside the IOC is conveyed through a 48" pipe directly into an existing 108" storm line. A new 48" DIP is proposed that will convey flow through the north wall of the existing IOC chamber into a new manhole. (The existing 48" pipe will be brick and mortared sealed.) The combined sewage will then flow into the proposed netting chamber. The wet weather flow will then exit the netting chamber; continuing through a 48" RCP line to a new outfall, where it will discharge into the Passaic River. A proposed tide gate valve will be installed directly on a new headwall to prevent backflow into the netting chamber.

Additional improvements at this site include a proposed storm line which will connect the existing storm water inlets along River Road and divert this flow into the new wet weather overflow line upstream of the netting chamber.

The remaining internal regulators making up the rest of CSO029 currently collect into a 120" RCP which then splits into two 108" RCPs and discharges to the Passaic River. The EF-1 regulator currently ties into one of the 108" RCP outfall pipes just upstream of the outfall point.

A Romag (mechanical) screen and netting facility are currently being constructed to meet the short-term requirements for CSO029. A new junction chamber is proposed approximately three hundred (300) feet upstream of the existing junction chamber which splits the 120" RCP into two (2) 108" RCP (exiting junction chamber located at the intersection of Memorial Drive and Bridge Street). The proposed junction chamber will divert flow from existing 120" RCP outfall pipe to a new 12' wide by 10' high box culvert. Overflow will then flow into the screening facility which is proposed to be located along the sidewalk of Memorial Drive just north of the intersection of Paterson Street within the existing comer lots. Flow inside the facility is diverted into two channels, each channel having a two (2) Romag screens and three (3) nets. Screened flow then flows from the facility via a 12' x 10' box culvert and ties back into the existing 120" RCP with a new junction chamber located approximately sixty (60) feet upstream of the existing junction mentioned above. Screened flow then flows via the existing two (2) 108" RCP outfall pipes and discharges directly into the Passaic River.

CSO030 - 19th Avenue

The 19th Avenue IOC is located at the intersection of 19th Avenue and Vreeland Street. Outfall 030 runs east along 19th Avenue and discharges to the Passaic River approximately 500 feet east of McLean Boulevard.

A Romag (mechanical) screen was installed to meet the short-term control requirements for CSO030. The screen facility is located at the end of Vreeland Avenue at the three-way intersection of Vreeland, 19th and East 36th Street. Flow will continue through an 84" RCP, and overflow will be screened and diverted out to existing 90" RCP outfall pipe, which continues down 19th Avenue and discharges directly into the Passaic River.

CSO031 - Route 20 Bypass

Outfall 031 discharges to the Passaic River underneath the entrance ramp to Interstate 80 from Route 20. The combined sewer overflows tributary to this outfall originates from nine (9) City owned and operated IOCs which are located within an 1800' radius from the E. 29th Street Bridge over Interstate 80.

CSO Area 031 consists of nine (9) IOCs (V 1-1, V 1-2, V 1-3, V 1-4, V 1-5, V 1-6, V 1-7, V 1-8, and V 1-9); all nine (9) of these IOCs are scheduled for the installation of static bar screens. Each static bar screen will be constructed of 1” x *W’* steel bars at Y2” maximum spacing between bars. Additional support will be provided from *Yi”* x 1/8” steel bars welded perpendicular to the screening bars at 10” center minimum. The bar screens will be angled (when possible) to facilitate manual servicing.

CSO032 - Hudson Street

The Hudson Street PVSC Regulator is located approximately thirty (30’) feet southeast of the intersection of Hudson Street and Presidential Boulevard. Outfall 032 runs approximately (20’) feet and discharges to the Passaic River.

The Hudson Street Regulator is located on a branch interceptor of the PVSC system and is used to regulate combined flows from areas upstream of the regulator in which other PVSC Regulators have been plugged (specifically Areas of CSO017, CSO018, CSO019 and CSO020).

A three (3) net end-of-pipe netting chamber is proposed for CSO032. A 48” x 48” flexible hydraulic flap valve on a new concrete headwall is proposed to be located approximately five (5’) feet downstream at the end of the PVSC Regulator 032. The netting chamber is proposed to be approximately five (5’) feet downstream of the new headwall. Screened flow then is discharged from the netting chamber directly into the Passaic River.

Table A-1, shown on the next page, summarizes the current status of each of the City’s outfall structures, regulators and internal overflow chambers (IOCs). Further, Appendix I contains summaries of CSO related work dating back to 2015. These summaries were prepared and submitted to the NJDEP on a quarterly basis, per requirements of the City’s NJPDES CSO Permit.