Appendix L

Selection and Implementation of Alternatives Report for City of Newark

Selection and Implementation of Alternatives Report

City of Newark

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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 New Jersey Pollutant Discharge Elimination System (NJPDES) Permit No. NJ0108758. All combined sewer flows from Newark are conveyed to the PVSC wastewater treatment plant through PVSC's main 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.

This report describes the selected alternatives from the Development and Evaluation of Alternatives Report (DEAR) for The City of Newark. PVSC NJDEP Permit Part IV.G Section 10 requires that permittee is “responsible for submitting an LTCP that addresses all nine elements in Part IV.G”. The nine elements are listed below:

1. Characterization Monitoring and Modeling of the Combined Sewer System
2. Public Participation Process
3. Consideration of Sensitive Area
4. Evaluation of Alternatives
5. Cost/Performance Considerations
6. Operational Plan
7. Maximizing Treatment at the existing plant
8. Implementation Schedule
9. Compliance Monitoring Program

Elements 1, 2, 3, and 9 above are addressed in the Regional SIAR. Each of the NJDEP approved reports for elements 1, 2, and 3 are included in the appendices of the regional report. Regional Report will also discuss the typical year selection and include the NJDEP approved Typical Hydrologic Period Report.

SECTION B - Screening of CSO Control Technologies

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 the Development and Evaluation of CSO Alternatives Report (June, 2019). The CSO-control technologies evaluated were grouped into the following categories:

- Source Control - Including Green Infrastructure and Conservation
- 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, effectiveness and cost. The objective of the alternatives analysis was 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 Development and Evaluation of CSO Alternatives Report.

B.1 Green Infrastructure and Conservation

Green Infrastructure (GI) 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. However, the required CSO capture/reductions typically cannot attained from GI alone. Some GI technologies 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.

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

Water conservation can reduce water consumption and 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.

B.2 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 Combined Sewer System (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.

B.3 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.

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.

Adjusting the weir elevation, length or orifice/gate size at specific regulators within the combined sewer system can increase “in-line” storage in upstream pipes or convey more flow to the PVSC Plant.

B.4 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. Storage technologies include linear storage (pipeline and tunnel) and point storage (tanks). Storage within the existing pipe network (inline storage) can be utilized to retain excess wet weather flows. The advantage of pipeline storage is the small construction area as compared to the construction area required for point or tank 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. Prior studies (2008, HDR) 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. 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.

B.5 STP Expansion

Expansion of the PVSC WWTP capacity during wet weather (primary-bypass) 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. Modifications to the treatment plant that would result in CSO volume and frequency reduction, or any increased treatment capacity, was addressed by PVSC and its consultants. Expansion of plant capacity and regulator modification to deliver more of Newark's CSO flow to the plant is a viable option for CSO control in Newark.

B.6 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. Limited sewer separation has been considered as a viable option.

B.7 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.

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. PAA disinfection technology was considered as an alternative for evaluation in the Newark DEAR and other communities. However after further discussion with NJDEP, PVSC and their consultants regarding the use of PAA and other disinfectant technologies, satellite treatment by disinfection became less desirable and cost effective than offline storage. Challenges such as permitting, pretreatment, chemical storage, staffing and sampling requirements, and cost caused CSO communities to reconsider disinfection. For these reasons disinfection with PAA is no longer a preferred alternative.

SECTION C - Evaluation of Alternatives

C.1 Introduction

The Development and Evaluation of Alternatives Report (DEAR) for The City of Newark evaluated several alternative for CSO control. 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 used in this evaluation are described in more detail below.

C.1.1 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

C.1.2 Capture of Combined Sewage for Treatment

The US EPA CSO Control Policy also defines an alternative 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 water bodies to meet water-quality standards. During the development and evaluation of alternatives, PVSC indicated (2019, G&H) that for Newark, a 7% reduction of CSO volume (that is, a CSO discharge reduction of no less than 93 MG) is required to achieve the 85% capture target. For the selection of alternative. Percent CSO capture was calculated and used and the performance metric.

C.1.3 Selected Performance Metric

For hydrology connected communities in the PVSC system the selected performance metric is 85% capture. Selected alternatives, either individual or regional will meet or exceed this measure achieving CSO discharge reduction and water quality goals.

C.2 Development and Evaluation of Alternatives

The CSO-control alternatives evaluated in the DEAR included 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 C-1 lists the alternative IDs and descriptions of the controls. All alternatives were 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. These 23 alternatives are discussed in detail in the Newark DEAR.

Table C-1. Control Alternatives Evaluated in Newark DEAR

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)

The Newark DEAR evaluation considered several factors to gauge the technical feasibility and applicability for CSO controls in Newark. In general, the alternatives evaluation factors included but not limited to receiving water quality standards and uses, 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.
- Financial capabilities

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 was based on multiple considerations including public input, water quality benefits and designated use, costs and other aspects. The preliminary selected alternative would 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 along with PVSC and other communities further develop the LTCP in cooperation with PVSC and hydraulically connected communities.

The evaluation and screening of control alternatives 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; other alternatives cannot alone achieve the frequency or percent capture targets. Overall, PAA disinfection with pretreatment generally achieves the frequency targets at lower cost than offline storage tanks.

As described in the Newark DEAR the selected metric 85% volume-capture; corresponds to a reduction in untreated CSO volume of approximately 7% from Baseline. The pollutant-capture metric corresponds to a pathogen load equivalent to a 7% reduction in CSO volume. In Newark, this capture target can be achieved by a wider selection of CSO-control alternatives than the CSO-frequency targets.

Table C-2 presents the example plan alternatives included in the DEAR to achieve different metrics, including the selected 85 percent capture metric, along with the associated number of untreated CSO events and volumes, Probable Total Project Cost (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 were provided to meet the 85 percent capture metric (i.e., a seven 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%) 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%, 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. Other combinations of alternatives are possible to achieve the selected performance metric of 85% capture, additional storage tanks and/or disinfection would almost certainly be required to achieve higher capture and lower frequency targets. Limited sewer separation may also be considered if it aligns with other city infrastructure projects such as road improvements, flooding abatement, or I/I reduction. These recommended alternatives will served as a base/minimum level of control for the final selected CSO control plan in Newark. The selected alterative will include the recommend 85% capture scenario as well as conservation measures and Green Infrastructure.

Table C-2. DEAR 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)
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%	562	584
For 4 CSO-Events/yr					
Disinfection[1]	4	49	96%	992	1,060
Storage Tanks	4	102	92%	1,088	1,119

(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 of DEAR for additional options.

SECTION D - Selection of Recommended LTCP

D.1 Introduction

The section of alternatives for the Newark LTCP is an iterative and collaborative process between the City, PVSC, neighboring and hydraulically connected communities and the public.

D.2 LTCP Selection Process

According to Newark's New Jersey Pollutant Discharge Elimination System (NJPDES) permit which has been issued in accordance with N.J.A.C. 7:14A. The permittee shall evaluate a reasonable range of CSO control alternatives, in accordance with D.3.a and G.10, that will meet the water quality-based requirements of the clean water act (CWA) using either the Presumption Approach or the Demonstration Approach.

The selected approach Newark and other PVSC communities selected for alternative evaluation is the "Presumption" Approach. The "Presumption" Approach, in accordance with N.J.A.C 7:14A-11 Appendix C provides:

A program that meets **any** of the criteria listed below will be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the Department determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas.

Combined sewer flows remaining after implementation of the nine minimum controls and within the criteria specified in Section G.4.f.i. and ii of the SPDES permit, shall receive minimum treatment in accordance with the items below:

- Primary clarification (removal of floatables and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification),
- Solids and floatables disposal, and
- Disinfection of effluent, if necessary, to meet water quality standards, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals/by-products (e.g. chlorine produced oxidants), where necessary.

The permittee must demonstrate any of the following three criteria below:

1) No more than an average of four overflow events (see below) per year from a hydraulically connected system as the result of a precipitation event that does not receive the minimum treatment specified below. The Department may allow up to two additional overflow events per year. For the purpose of this criterion, an ‘event' is:
   a) In a hydraulically connected system that contains only one CSO outfall, multiple periods of overflow are considered one overflow event if the time between periods of overflow is no more than 24 hours.
   b) In a hydraulically connected system that contains more than one CSO outfall, multiple periods of overflow from one or more outfalls are considered one overflow event if the time between periods of overflow is no more than 24 hours without a discharge from any outfall.
2) The elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS during precipitation events on a hydraulically connected system-wide annual average basis.
3) The elimination or removal of no less than the mass of the pollutants, identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort, for the volumes that would be eliminated or captured for treatment under Section G.4.f.ii.

D.3 Selection of Alternatives

D.3.1 Description

The Newark DEAR looked at several alternatives in order to achieve the goals of the LTCP. After submittal of the Regional Report and all the community DEARs, PVSC discussions with NJDEP and NJCSO Group meetings the presumptive approach and an 85% capture goal came into focus and an achievable cost effective approach.

In parallel to the individual community efforts PVSC further developed a regional alternative and is discussed in the regional approach section of the SIAR. This regional alternative includes plant expansion to secondary bypass and adding a parallel interceptor in Newark which will increase the conveyance capacity of the current main interceptor to deliver more flow to the expanded plant.

PVSC provided updated hydraulic models for baseline and plant secondary bypass conditions for the communities to use in the SIAR analysis. Maximum pumping capacities of the PVSC main pumps and force main community pumps in the model for the 400 MGD baseline and the 720 MGD secondary bypass are summarized in Table D-1. Additionally, the PVSC model represented the operation of the Newark gates in both the baseline and secondary bypass scenarios using Real Time Control (RTC) model functions, as listed in Table D-2. The PVSC baseline and secondary bypass models are used as the base scenarios for its SIAR alternative analysis.

Table D-1 Summary of Maximum Pumping Capacities for Baseline and Secondary Bypass Conditions in the PVSC model

Communities	PVSC Baseline 400 MGD Operating Capacity	PVSC Secondary Bypass 720 MGD Operating Capacity	
	Maximum Pump Capacity [MGD]	Maximum Pump Capacity [MGD]	Difference from Baseline [MGD]
Force main Communities			
Bayonne	17.5	32.0	14.5
South Kearny	17.5	17.5	0
Jersey City East	60.0	60.0	0
Jersey City West	45.4	45.4	0
Total	**140.4**	**154.9**	**14.5**
Main Interceptor			
Dry Pump	280	485	205
Wet Pump	40	140	100
Total	**320**	**625**	**305**

Table D-2 Summary RTC Rules for Baseline and Secondary Bypass Conditions in the PVSC model

Model Condition	Newark Gates	RTC Control Rule
PVSC 400 MGD Baseline	Clay St Gate	Close gate if plant south clarifier storage level >= 94.6ft
	Other Gates	Close gate when total plant Q (including FM)>=350MGD
PVSC 720 MGD Secondary Bypass	Clay St	Close gate if plant south clarifier storage level >= 94.6ft
	Other Gates	Close gate when total plant Q (including FM)>=715MGD

Remaining Overflows

As previously discussed in section C, a "Baseline" condition is established for evaluating the selection of the alternatives for Newark in consistent with the PVSC specifications. The Baseline condition uses 2004 Newark Airport rainfall as the "typical-year" hydrologic condition, and the 2050 population for the build year sanitary flow condition. Table D-3 tabulates the model predicted Newark CSOs volume and frequency by outfalls for this Baseline condition. The total annual Newark CSO is 1319MG, a CSO capture of 77% out of estimated 5728 MG wet weather flows.

Table D-3. Summary of Newark CSOs in Baseline

Outfall	Baseline	
	Volume (MG)	Frequency
NE002	93.7	42
NE003	0.0	0
NE004	1.4	16
NE005	26.4	41
NE008	99.1	44
NE009	173.9	39
NE010	173.9	39
NE014	195.7	45
NE015	91.1	42
NE016	57.4	39
NE017	116.7	39
NE018	78.7	45
NE022	46.6	47
NE023	27.9	31
NE025	73.9	17
NE027	17.5	17
NE030	11.8	19
NE026	33.2	19
Total Newark CSO Volume	**1319.0**	

D.3.2 Ability to Meet Water Quality Standards

Newark CSO outfalls discharge to primarily two water bodies. Table D-4 summarizes the Newark CSO outfalls their receiving water bodies and applicable water quality standards as shown Figure D-1.

Table D-4. Newark Outfall Water Quality Standards

Outfall/Regulator	Population	
	Water Body	WQ Standard
Verona(002)	Lower Passaic River	SE3
Delavan/Herbert(002,003,004, 005)		
Fourth Ave (008)		
Clay St (009/010)		
Rector/Saybrook(014)		
City Dock (015)		
Jackson(016)		
Polk(017)		
Freeman(018)		
Roanoke(022)		
Adams(023)	Newark Bay via Peripheral Ditch	
Peddie(25)		
Queen(026)		
Waverly(027/029)		
Wheeler(030)		

The Newark portion of the Lower Passaic River and Newark Bay are both saline waters. Saline waters are classified as saline estuarine (SE) or saline coastal (SC). SE waters are further classified as SE1, SE2, and SE3 waters based on their ability to support recreation, shellfish harvesting and warm water fish species. Newark's receiving waters are SE3. In all SE3 waters the designated uses are:

1. Secondary contact recreation;
2. Maintenance and migration of fish populations;
3. Migration of diadromous fish;
4. Maintenance of wildlife; and
5. Any other reasonable uses.

For the pollutant of concern, pathogens, the criteria for fecal coliform is that levels shall not exceed a geometric mean of 1500/100ml.

Figure D-2 and Figure D-3 show the location of water quality sampling station in the Lower Passaic River and Newark Bay respectively. HDR Engineers developed a three dimensional (3D) Hydrodynamic Water Quality Model to evaluate existing conditions, compliance, and water quality projections under proposed LTCP alternatives.

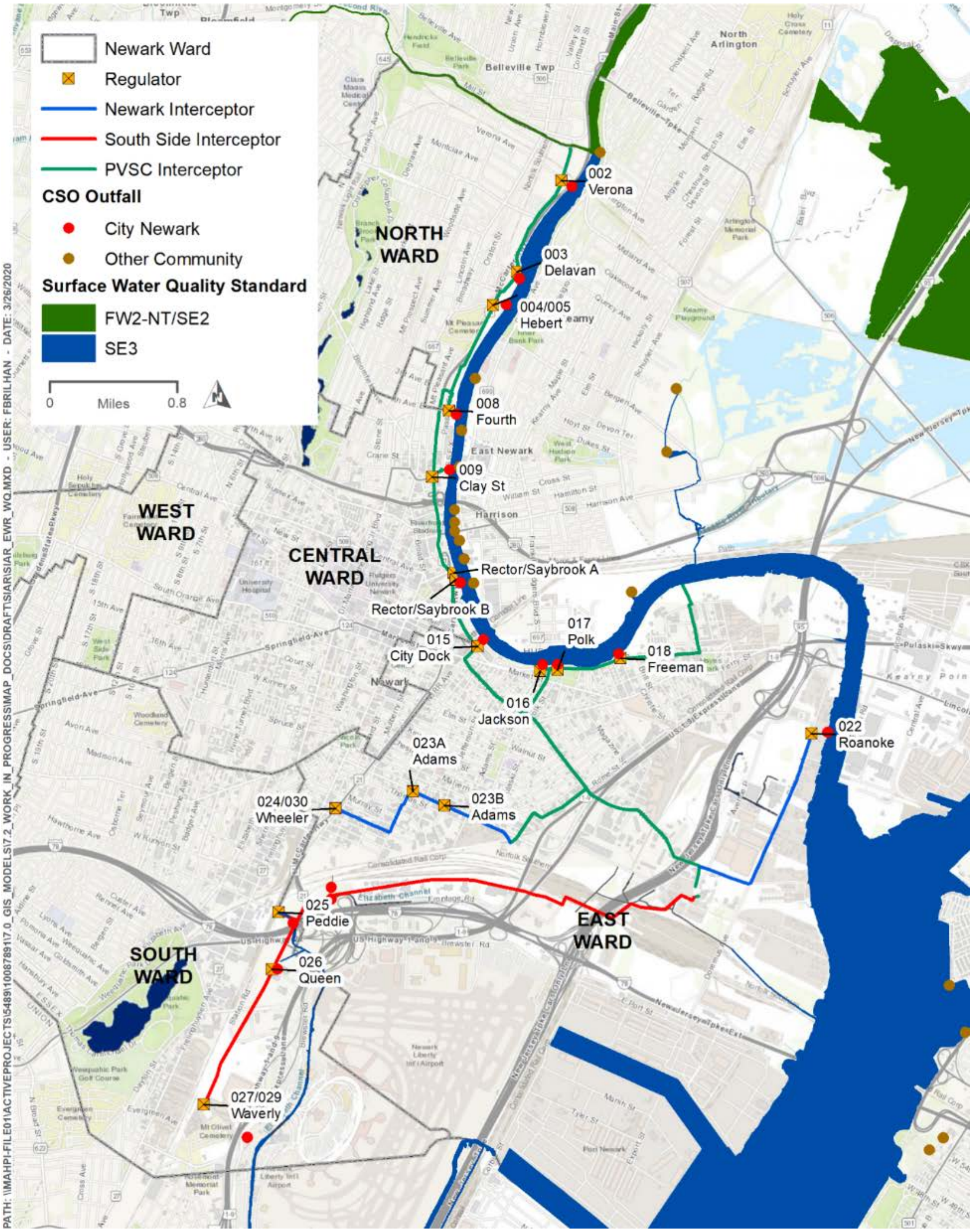


Figure D-1. Newark Water Quality Standards

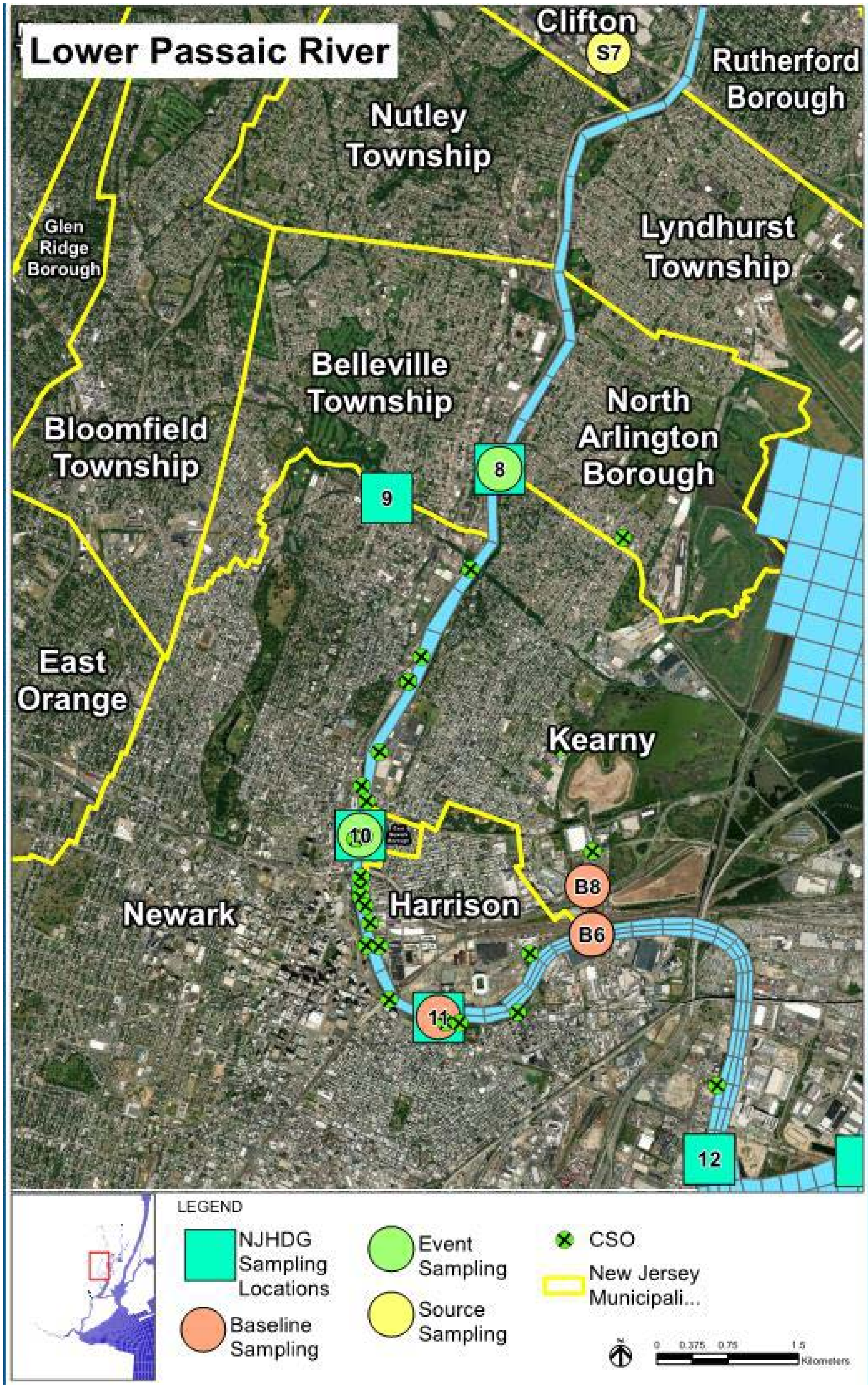


Figure D-2. Lower Passaic River Water Quality Sampling Stations

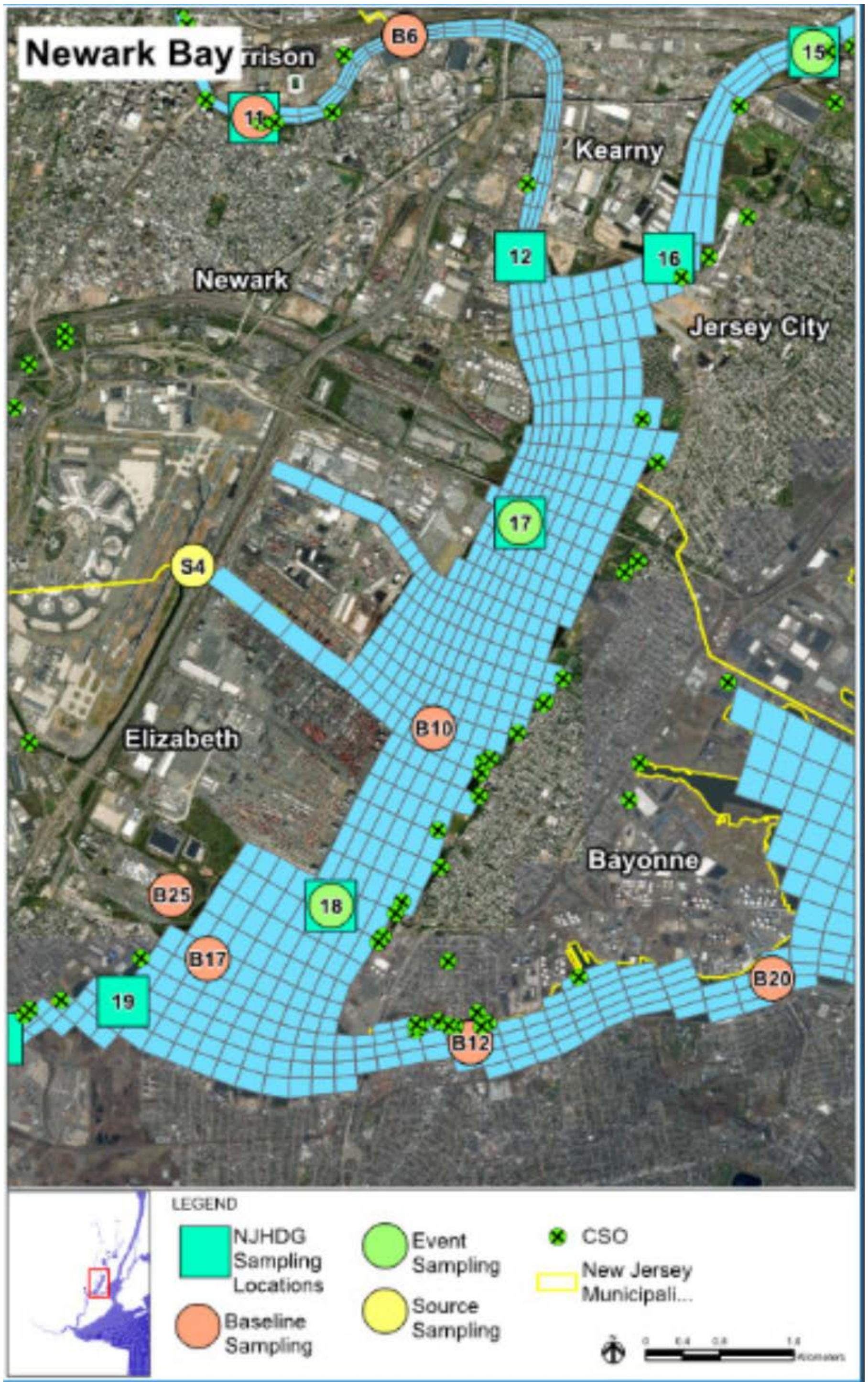


Figure D-3. Newark Bay Water Quality Sampling Stations

Water quality modeling results showed that under baseline existing conditions the Lower Passaic River and Newark Bay to which Newark's CSO discharge, all stations in Newark's receiving waters attained the SE3 water quality standard 100% of the time (Table D-5). One station outside of Newark (Station 8) and in Class FW2-SE2 waters achieved water quality standards 99.4% of the time based on values at the surface. It should be noted that the water quality standards for Class FW2-SE2 waters are more stringent than SE3 as shown below.

- FW2: E. coli levels shall not exceed a geometric mean of 126/100 ml or a single sample maximum of 235/100 ml.
- SE2:Fecal coliform levels shall not exceed a geometric mean of 770/100 ml. (SE2)

Table D-5. Modeled Baseline Water Quality Attainment

Receiving Water	Station	Classification	30 Day Rolling Geometric Mean	
			Depth Averaged	Surface
Lower Passaic River	8	FW2-SE2	100%	99.4%
	10	SE3	100%	100%
	11	SE3	100%	100%
	B8	SE3	100%	100%
	B6	SE3	100%	100%
	12	SE3	100%	100%
Newark Bay	17	SE3	100%	100%
	B10	SE3	100%	100%
	18	SE3	100%	100%
	B17	SE3	100%	100%
	19	SE3	100%	100%

The water quality modeling showed that under existing conditions Newark's receiving waters already meet water quality standards. Furthermore, the modeling study showed that CSOs do not preclude the attainment of water quality standards in Newark's receiving waters.

The selection of the presumptive approach with 85% capture will achieve the current water quality goals and provide additional improvement in water quality in Newark's receiving waters. This improvement will provide atheistic, environmental and quality of life benefits to Newark and it residents.

D.3.3 Non-Monetary Factors

Selection of the Newark LTCP alternative was driven by monetary and non-monetary factors. Some of the non-monetary factors include:

- Public Participation
- Ease of application/ development

- Community benefits (GI, as an example), and potential Social and environmental impacts.
- Minimizing disruptions
- Capability to beneficially integrate with hydraulically connected communities and the constraints involved.
- Risk and potential safety hazards to operators and public.
- LTCP Regulatory (EPA and NJSPDES) requirements.

Throughout the LTCP process it was clear that the public desired a plan that would include green infrastructure. The use of green infrastructure provides the community with several benefits including increased green space, reduction in heat island effect and the potential for green jobs. The City of Newark has launched a local hiring initiative aimed at assisting 2,020 local residents with gaining full-time positions at family-sustaining wages. The City of Newark in collaboration with the Newark Workforce Development Board is launching a training program to increase the skills of residents to prepare them for a wider range of positions with salaries that meet the family-sustaining threshold. GI is rising as a high demand position as cities in the area continue their efforts to address the local impacts of runoff. The program will increase the GI workforce by 25% in the City of Newark over a 2-year period, building the capacity of job seekers and local contractors to meet the demands for skilled GI labor to support renewable energy infrastructure and build sustainable urban drainage systems.

Other measures like water conservation are relatively inexpensive and also provide ancillary benefits such us a reduction in water use and reduced water bills.

D.3.4 Cost Opinion

Capital costs for the storage tanks are based on the latest available guidance from the cost curve in the PVSC memo – Updated Guidance on Costing for LTCP CSO Planning. Capital costs also include the cost of land acquisition near the selected outfalls. An average cost per acre was determined based on land value of surrounding commercial/vacant, public, and vacant parcels, as shown Table D-6. Tank footprints were then assumed based on a 20-foot tank depth, and multiplied by the average land cost per acre to determine the land acquisition cost for each tank. The estimated land acquisition cost was then added to the capital cost of the tanks.

Table D-6. Land Acquisition Cost Per Acre and Associated Estimated Tank Footprint

Outfall	Land Cost ($/acre)	Estimated Tank Footprint (acre)	Estimated Land Acquisition Cost ($)
NE009/NE010	$ 1,424,046	2.6	$3,702,520
NE014	$ 3,814,884	1.2	$4,577,861
NE022	$ 682,077	1	$682,077

O&M costs are also based on the latest information from the memo, Updated Guidance on Costing for LTCP CSO Planning.

Present worth calculations assume a discount rate of 2.75% with a life span of 20 years. Based on this information a present worth factor was calculated and is applied to the annual O&M cost which is then added to the construction cost to obtain the total lifecycle cost. Salvage value is considered to be $0 because it is assumed that no resale value will result from the control technologies utilized.

D.3.5 Selection of Recommended Alternative

The municipal long term alternatives for The City of Newark is summarized in Table D-7. The selected alternative is comprised of two parts. The first part is the baseline alternative under a presumptive approach to achieve 85% percent capture. This part includes three CSO storage tanks at outfalls NR009/010, NE014 and NE022 and operational modifications to regulators with automated controls as described in Section 2.2.1 of the Newark DEAR. A subsequent alternative is also evaluated with implementation of secondary bypass at the PVSC plant in addition on top of the 85% capture alternative described above. The second part of the long term alternative considered additional measures including Green infrastructure applies on up to 5% impervious areas, modification of the regulators along the South Side Interceptor and Water conservation.

Modeling analysis using the most updated PVSC collection system InfoWorks 9.0 were conducted to evaluate the 85% alternative. The model estimated a total typical year 2004 Newark CSO reduction of 572 MG from the baseline condition of 1319 MG when the 85% alternative with modified PVSC regulator operation is assumed, achieving 87.0% CSO capture as shown Table D-7. The Newark CSO reduction is 1086 MG with PVSC upgrade to secondary bypass and associated regulator operation assumed, reaching 95.9% of the Newark CSO capture rate.

CSO reduction of the additional measures are 61 MG, 4.8 MG and 36 MG annually for GI, South Site Interceptor regulator modifications (Peddie Street Only) and water conservation, respectively. Detailed discussions on these alternatives are provided in section D4.

Table D-7. Ctiy of Newark LTCP Alternatives

Selected Alternatives	% Reduction / %Capture(1)	Volume Captured	CSO Event Reduction	Cost Million $
Newark Alt 1b to achieve 85% Capture				
1. 17 MG Storage at NE0009/010 2. 7.8 MG Storage at NE014 3. 3.78 MG Storage at NE022 4. Modified PVSC Regulator Operation Assumed	43.4%Reduction /87.0% Capture	572MG	0-46	358.3
1. 17 MG Storage at NE0009/010 2. 7.8 MG Storage at NE014 3. 3.78 MG Storage at NE022 4. PVSC Secondary bypass and modified PVSC Regulator Operation Assumed	82.3%Reduction /95.9% Capture	1086MG	0-46	358.3
Addition LTCP Measures for additional CSO Reduction				
Green infrastructure (up to 5% impervious area managed)	4.6% Reduction /0.7% Capture	61 MG	0-4	90.3
Regulator modification on south-side regulator (Peddie St NE-025)	0.36% Reduction /0.08% Capture	4.8MG	0-4	0.4
Water Conservation	2.7%Reduction /0.02% Capture	36 MG	Reduction in approximately 2 events	1.5

Notes:

(1) CSO percent capture is calculated with the assumption that wet-weather period starts after the initial 0.1" rainfall and it includes the trailing 12hrs beginning 0.1" prior to the end of rainfall.

D.4 Description of Recommended LTCP

D.4.1 Storage Alternative For 85% Capture

CSO control through storage technology is to construct off-line storage tanks near the CSO outfalls. Instead of being discharged to receiving waters, CSOs during wet weather are diverted to the facility for storage until the storm event passes. The stored overflows are subsequently pumped back to the collection system during dry weather and conveyed to the PVSC plant for treatment. Only excess CSOs that exceed the storage facility capacity will be discharged. Sizing of the storage tanks are therefore based on the targeted overflow volume and frequency reductions previously analyzed during DEAR on 2004 typical year conditions, in addition to consideration of the capital and O&M cost of the storage facilities.

In this alternative to achieve 85% CSO capture, CSO storages are proposed at three of the Newark outfalls, NE009/010, NE014 and NE012. Figure D-4 shows the approximate locations of three proposed CSO storages at capture. CSO Storages for NE009/010 and NE014 are sized to capture their CSO volume to reach the goal of 12 OF/year, and the storage for NE022 is sized to reach the goal of 4 OF/year. This is consistent with the PVSC recommended alternative 1b (Alt1b) in the regional alternative analysis. Table D-8 lists the individual storage volumes and estimated cost breakdowns. The cost estimation are based on assumptions descripted in the PVSC April 10th technical memorandum on Updated Guidance on Costing for LTCP CSO Planning. The following equations are used for estimate of the cost according to the guidance. The capital cost in Table D-8 also includes the cost of land acquisition for the CSO storage sites, and O&M cost included the present-worth factor.

- Capital Cost (CC):
  Storage Tank Capital Cost in $M = 18.155*(Storage Volume in MG^0.826) + Land Cost
- O&M Cost:
  Storage Tank O&M Cost in $M = 0.0688*(Storage Volume in MG^0.4387)
- Life Cycle Cost (LCC):
  LCC=CC+O&M×15.227(Present-worth Factor assuming a discount rate of 2.75% for 20-year planning)

The storage alternatives were evaluated in two plant operation conditions:

1) The Baseline condition with modified Newark regulator gate operations
2) The Secondary Bypass condition with plant capacity upgrade and associated Newark regulator gate operations.

Both of the above scenarios are with the assumption that flows from other combined municipalities (Paterson, East Newark, Kearny and Harrison) and from force main served municipalities (Bayonne, Jersey City and North Bergen) are the same as the baseline conditions.

In the baseline condition the total PVSC plant capacity is at 400 MGD. The 10 Newark automated gates shown in Figure D-5 are set to close when the total plant flow reaches and exceeds 350 MGD, except for the gate at Clay Street (NE-009/010) which is set to close when the water level at the plant south clarifier reaches and exceeds 94.6ft (PVSC datum). When the regulator gates are closed, flows to the regulators are backed up to release CSOs to the outfalls that passes the weirs. 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 simulate operations of a structure, a sluice gate in this case.

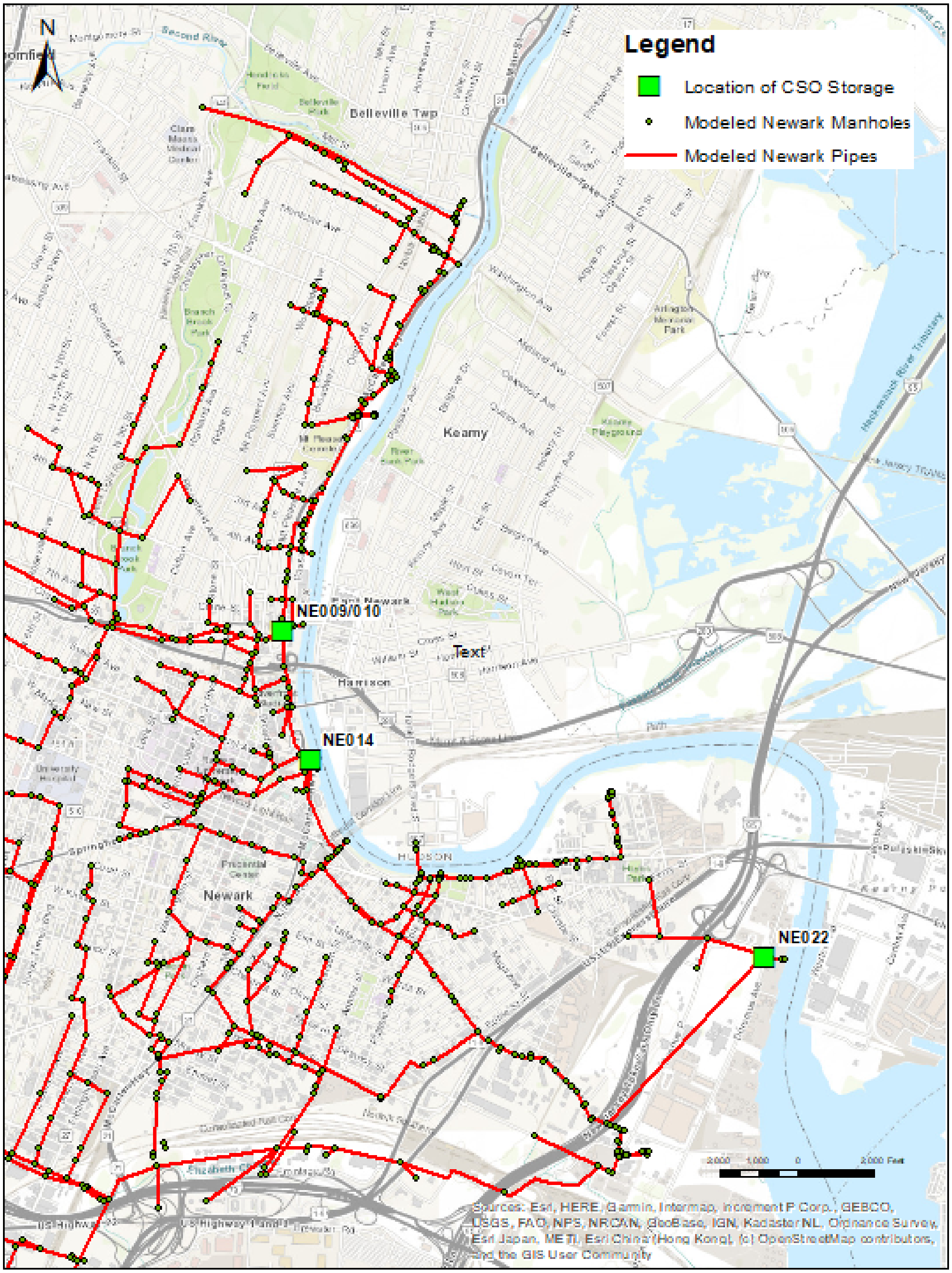


Figure D-4. Location of Proposed CSO Storage for 85% Capture.

Figure D-5. Newark Regulators with Automated Controls and South Side Interceptor Regulators

Table D-8. Ctiy of Newark LTCP Alternatives Costs

Outfall	Cost of CSO Storage					
	Tank Volume (MG)	Land ($M)	CC ($M)	20 Yr O&M ($M)	LCC ($M)	$M / MG
NE009/NE010	16.92	3.70	191.48	3.62	195.11	11.53
NE014	7.80	4.58	103.63	2.58	106.21	13.62
NE022	3.78	0.68	55.13	1.88	57.01	15.08
Total	**28.50**	**8.96**	**350.25**	**8.08**	**358.33**	**12.57**

The modified regulator gate operation for baseline condition assumes delayed gate closings till plant flow reaches 375MGD, 25MGD higher than the original control point of 350MGD, except for Clay Street, where operation is assumed to remain the same. The increase of the control flows shortens the time of CSO discharge and therefore increases the amount of the flow reaching the collection system. The modification of the gate operations do not add additional cost, but need to be monitored to ensure the interceptor system will not be stressed.

In the Secondary Bypass condition, the plant is assumed to be upgraded from a total of 400MGD capacity to 720 MGD. The Newark gates are assumed to operate at a threshold flow of 715MGD corresponding to the increase of the plant capacity to 720MGD based on the secondary bypass condition model.

Table D-9 tabulates the Newark CSO volume and frequency for the two plant operation conditions in comparison to baseline condition. The reductions from baseline at each outfall are also illustrated in Figure D-6 and Figure D-7. With regulator gate operation control flow modified from 350MGD in baseline to 375MGD, total Newark CSOs reduced from 1319 MG to 1245MG. This is a CSO reduction of 74MG (6%), increasing Newark CSO capture from 77.0% to 78.3%. The model also predicted that when the plant is expanded to secondary bypass, with the operation of the Newark gate closings only when total plant flow reaches 715MGD, Newark CSO is reduced by 758MG (57%) to 561MG. The Newark CSO capture increases to 90.2%, exceeded the 85% goal without additional measures.

It should be noted that in this scenario, flows from other contributing municipalities to the plant are assumed to remain the same level as in baseline condition. When the plant expansion is accompanied by flow increases from other hydraulically connected municipalities, Newark CSO reduction could reduce correspondingly. A sensitivity analysis was in fact conducted, using inflows from other municipalities that represents regional Alt3b CSO control from Bayonne and Alt1b CSO control measures from Alt1b from other force main (Jersey city and North Bergen) and combined areas (Paterson, East Newark, Kearny and Harrison). The increase of the total Newark CSOs is only 1.5MG, from 561.4MG to 562.9MG, although the increase of flows from the main interceptor is about 726MG and from force main is about 836 MG.

The reasons that the increase of Newark overflow is so small are because: 1) the automatic gate operation control plant flow is 715MGD in the plant bypass expansion scenario. During 2004 typical year condition, there's only one event that reached this flow level and caused the gates to operate. The gates have remained open for all other wet events and did not throttle flow in the bypass pass condition runs either with Baseline inflow or with Alt1b/3b inflows from other municipalities. 2) Because the Alt1b/3b control measures are mostly from using storage facilities to store CSOs and wait till the end or after the event to pump them back to the interceptor, the peak wet weather flows did not change to impact the operation of the Newark gates. Therefore, the resulting overflows in Newark has not changed. This situation could be different, however, if the CSO control measures from other municipalities causes increases of peak flows. Newark overflow could also be affected if the control flows are low than the currently assumed 715MGD from the plant bypass expansion scenarios assumed in the regional analysis, or during a wet year with higher rainfall and peak flows than typical year 2004.

Furthermore, the CSO storage proposed in Alt1b alternative are applied to the two plant operation conditions to evaluate the additional CSO capture. Table D-10 shows the CSO volume and frequency comparison of all Newark outfalls under the 1) baseline, 2) Storage alternative on baseline with modified gate operation, and 3) Storage alternative on plant secondary bypass upgrade. Total Newark CSO volume is reduced from 1319MG in baseline condition to 747MG (by 43%) when the proposed storages are applied to baseline with modified gate operation, and to 234MG (by 82%) when they are applied to updated plant to secondary bypass. CSO at NE009/010 is reduced from 348MG to 64MG (by 82%), 39 OF/yr to 7 OF/yr, at NE014 from 196MG to 18 MG (by 91%), 45 OF/yr to 8OF/yr as the storage targeted to 12 OF/yr is applied to baseline. The CSOs at NE014 are fully captured when the same size storages are applied to the plant upgrade scenario. At NE009/010, CSO is reduced to 2.8MG and 3OF/year. Because the sizing of the tanks are based on CSO capture from the baseline condition, the tanks could be further downsized to reduce the cost if they are to be used with plant upgrade, which alone, already provides additional CSO reduction. At outfall NE022, when the storage targeted to 4 OF/yr is applied to baseline, CSO is reduced from 47MG to 2.5MG (by 95%) in volume and 47 OF/yr to 1 OF/yr in discharge frequency. For secondary upgrade bypass, CSO at NE022 is reduced to 1.5MG (by 97%) and 1OF/yr.

Figure D-8 and Figure D-9 illustrate the percent reduction of CSO volume and frequency at each Newark outfalls for the storage alternative on baseline and second bypass plant upgrade conditions.

Table D-9. Newark Annual CSO Summary for Plant Operational Conditions

Outfall	1) Baseline		2) Baseline with Modified Newark Gate Operations		3) Plant Upgrade to Secondary Bypass with Associated Newark Gate Operations	
	Volume (MG)	Frequency	Volume (MG)	Frequency	Volume (MG)	Frequency
NE002	93.7	42	82.4	36	5.1	12
NE003	0.0	0	0.0	0	0.0	0
NE004	1.4	16	1.3	13	0.1	1
NE005	26.4	41	21.7	35	0.1	1
NE008	99.1	44	88.5	40	33.9	34
NE009	173.9	39	180.9	39	119.1	39
NE010	173.9	39	180.9	39	119.1	39
NE014	195.7	45	172.5	45	51.3	41
NE015	91.1	42	77.2	36	0.9	5
NE016	57.4	39	51.4	33	14.1	21
NE017	116.7	39	104.0	33	35.1	26
NE018	78.7	45	69.8	44	16.6	37
NE022	46.6	47	46.8	46	44.2	47
NE023	27.9	31	28.9	31	20.8	31
NE025	73.9	17	74.8	18	60.3	16
NE027	17.5	17	17.8	17	11.8	17
NE030	11.8	19	11.8	19	10.6	18
NE026	33.2	19	34.4	19	18.3	17
Total Newark CSO Volume	**1319.0**		**1244.9**		**561.4**	

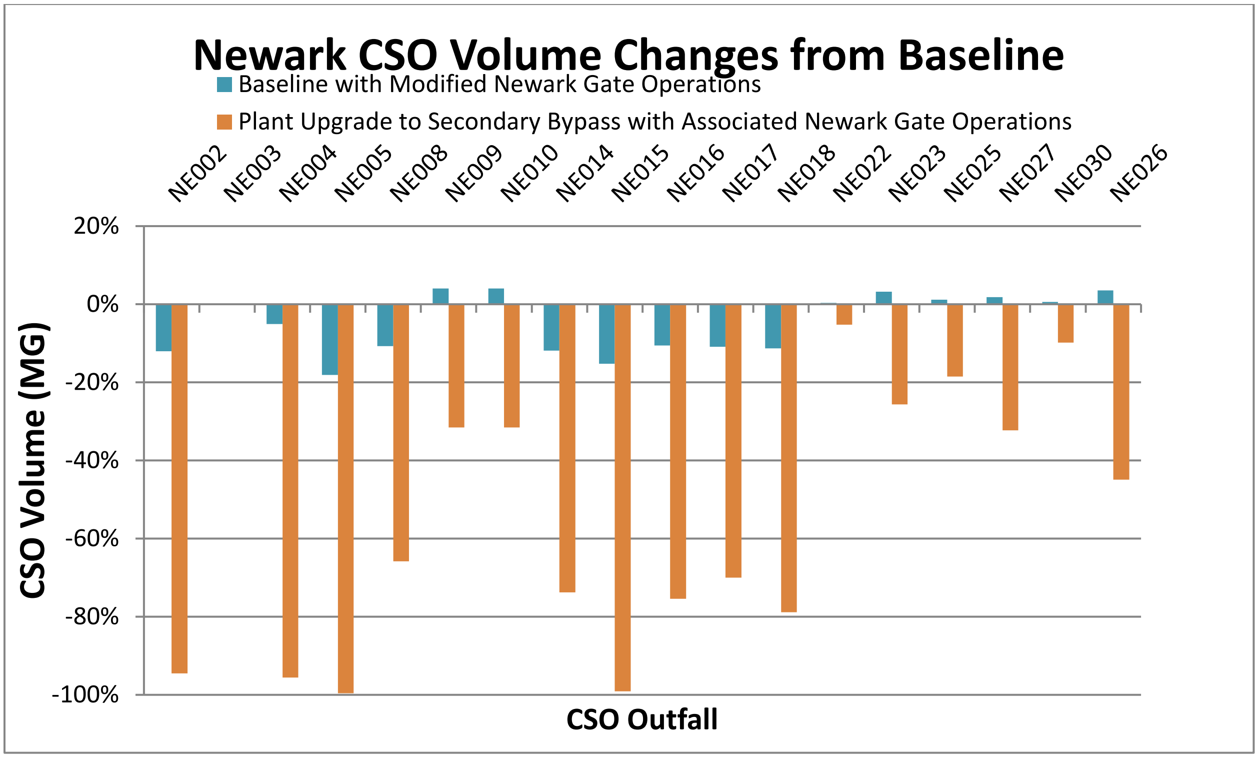


Figure D-6. CSO Volume Reductions at Newark Outfalls for Plant Operation Conditions

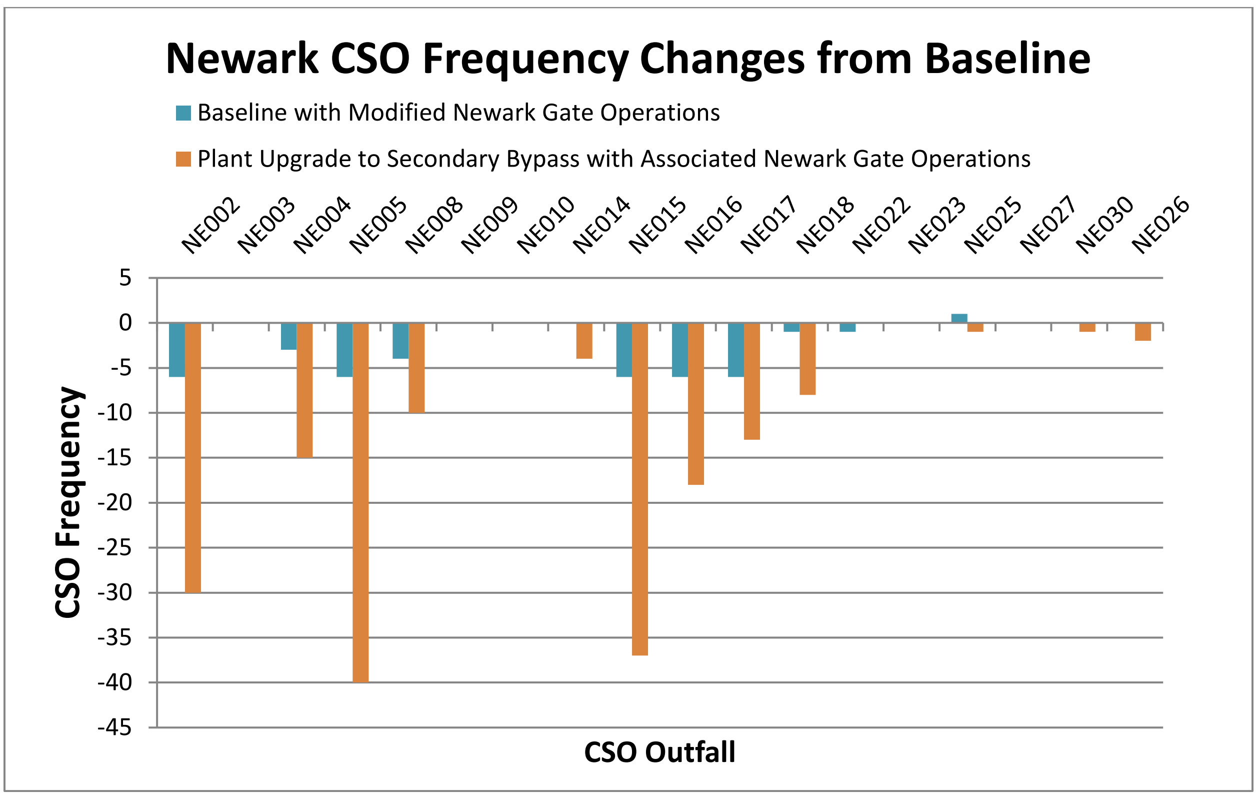


Figure D-7. CSO Frequency Reductions at Newark Outfalls for Plant Operation Conditions

Table D-10. Newark Annual CSO Summary for Storage Alternatives

Outfall	1) Baseline		2) Baseline with Storage for 85% Capture		3) Secondary Bypass with Storage	
	Volume (MG)	Frequency	Volume (MG)	Frequency	Volume (MG)	Frequency
NE002	93.7	42	81.9	35	5.3	12
NE003	0.0	0	0.0	0	0.0	0
NE004	1.4	16	1.3	14	0.1	1
NE005	26.4	41	21.7	35	0.1	1
NE008	99.1	44	88.3	40	34.0	34
NE009	173.9	39	32.2	7	1.4	3
NE010	173.9	39	32.2	7	1.4	3
NE014	195.7	45	18.0	8	0.0	0
NE015	91.1	42	76.9	36	1.0	5
NE016	57.4	39	51.4	33	14.4	21
NE017	116.7	39	103.9	33	35.5	26
NE018	78.7	45	69.5	43	16.8	37
NE022	46.6	47	2.5	1	1.5	1
NE023	27.9	31	28.7	31	20.9	31
NE025	73.9	17	74.5	18	60.4	16
NE027	17.5	17	17.7	17	11.9	17
NE030	11.8	19	11.8	19	10.6	18
NE026	33.2	19	34.1	19	18.4	17
Total Newark CSO Volume	**1319.0**		**746.6**		**233.5**	

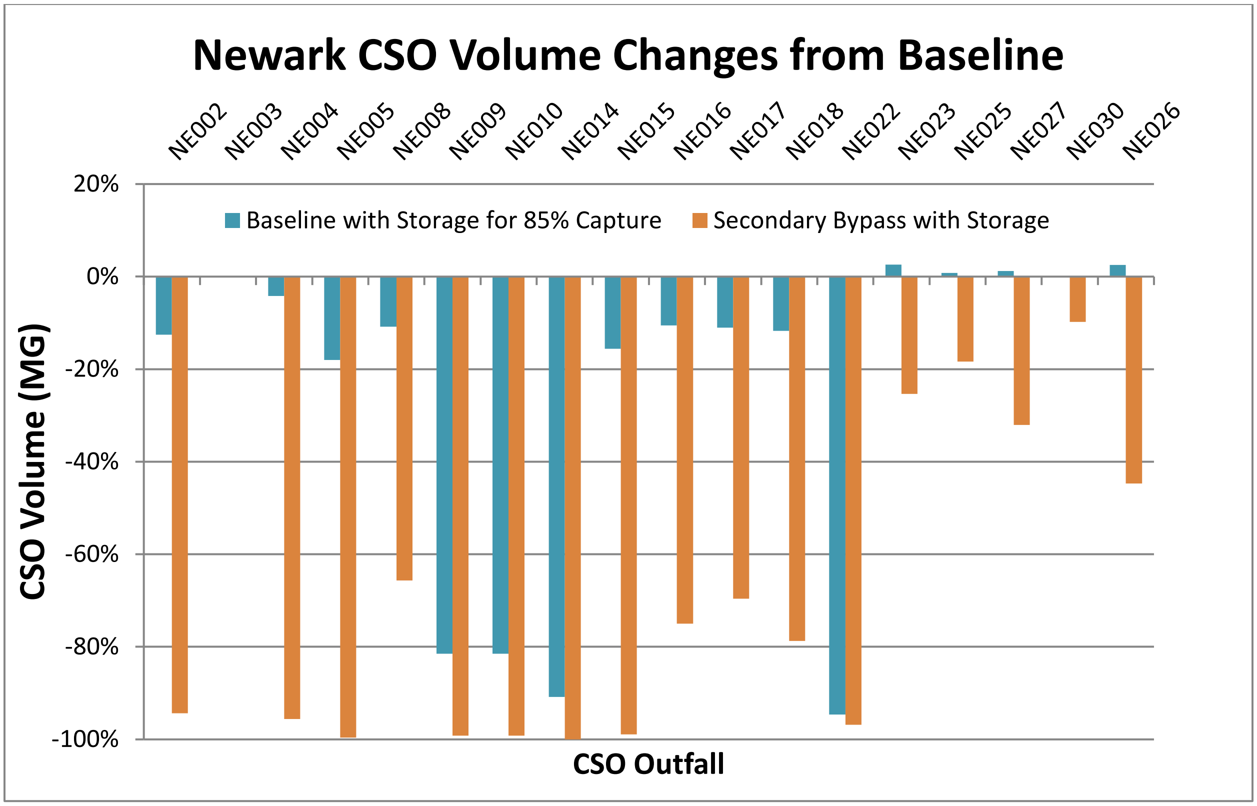


Figure D-8. CSO Volume Reduction at Newark Outfalls for Storage Alternatives

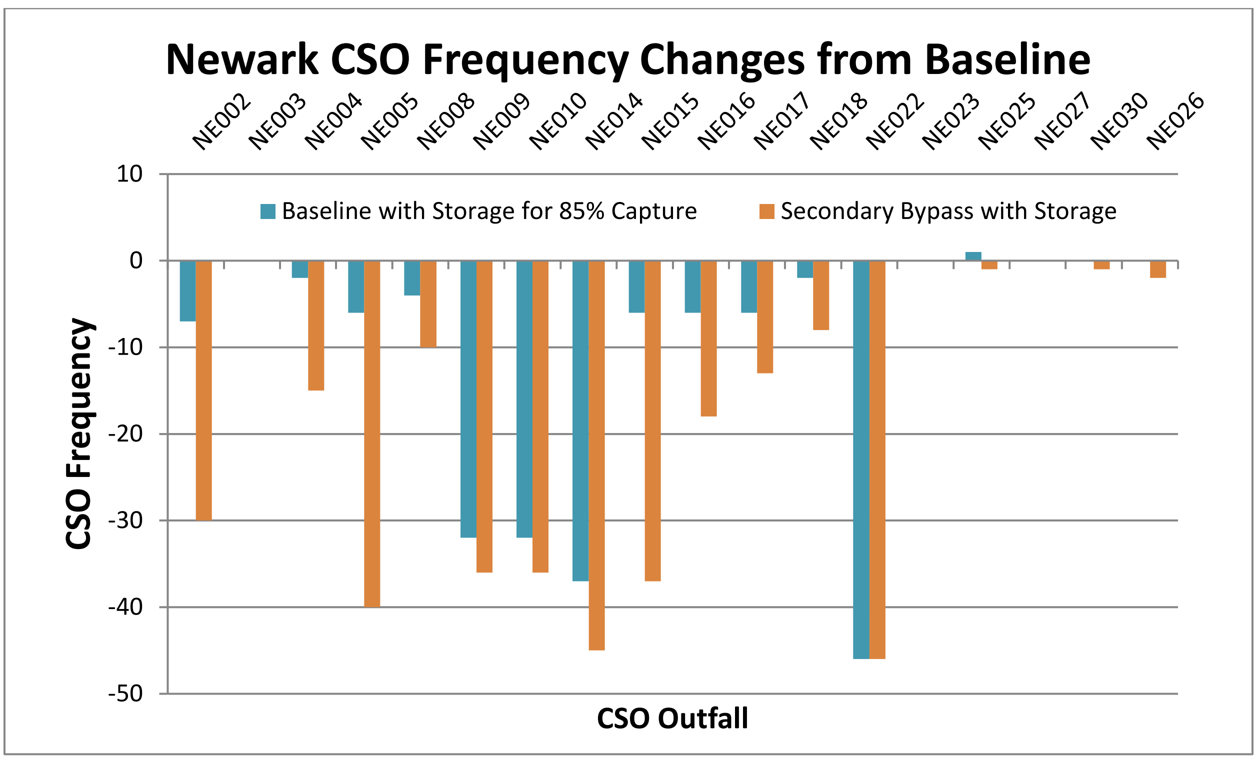


Figure D-9. CSO Frequency Reduction at Newark Outfalls for Storage Alternatives

D.4.2 Green infrastructure (5% Impervious Area Managed)

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 evapotranspiration. 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 was evaluated in the Newark DEAR in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control. The DEAR looked at three levels of control and estimated costs for three levels of control.

The first level involved the implementation of GI features and locations identified in a study by Rutgers. The second level involved 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.

GI provides a modest amount of CSO reduction but also delivers ancillary benefits to the community. In order to further the development of GI opportunities in the City of Newark an analysis of relevant spatial data was done to determine the area suitable to be managed with GI specific to each CSO outfall. The Rutgers Cooperative Extension Water Resources Program developed a GI Guidance Manual (http://water.rutgers.edu/Green_Infrastructure_Guidance_Manual/2015-03-31_Manual.compressed.pdf). This manual provides guidance for communities and design professionals for identifying opportunities, designing, implementing, and maintaining green infrastructure throughout urban and suburban areas of New Jersey.

The manual outlines GI design process steps as:

1. Assess existing stormwater issues
2. Identify site opportunities
3. Evaluate green infrastructure feasibility
4. Design green infrastructure practice

When recommending sites for GI community members can use the following check list from the guidance manual to help identify potential sites for GI in their community:

1. **GENERAL OBSERVATIONS**
    a. What is the source of stormwater runoff and where does it flow? Is there a noticeable source or deposit of sediment?
    b. What is the direction and relative slope of the site and/or street?
    c. Where on the site are impervious areas and estimate area in square feet (i.e., rooftops, parking lots, sidewalks)? For streetscapes, what is the building setback and/or sidewalk width?
    d. Do paved areas appear to be in poor condition (cracks, settling, vegetation growth, etc.) or do they appear newly paved or reconstructed?
    e. Does stormwater runoff from impervious areas flow directly to the sewer system (such as roof runoff directed into a storm drain)?
    f. Are there opportunities to redirect and disconnect runoff (downspouts, grassed areas, tree pits, and curb extensions)?
    g. How many stormwater catch basins are visible? Note general condition, i.e., clogged, functioning, shallow (<3ft), or deep (>3ft)?
    h. Is there evidence of ponding water at the site or flooding in streets or intersections?
    i. Are there mature trees/vegetation at the site? What types of plants would be appropriate at the site (sun or shade tolerant, height or site line restrictions)?
    j. Where are utilities on the site or in the right of way that could conflict with construction (sewer pipes, utility poles, water, gas, etc.)?
    k. Does pedestrian safety need to be addressed? Will parking or bus stops be impacted by construction?
2. **GI TYPE SPECIFIC OBSERVATIONS**
    a. Rain Gardens
        i. Are there visible, exterior downspouts on any buildings?
        ii. Are there unpaved areas suitable for landscaping?
        iii. Is the site subject to ponding or flooding?
    b. Rainwater Harvesting
        i. Are there nearby buildings with visible exterior downspouts?
        ii. Is there a community garden nearby or other use for collected rainwater?
    c. Tree Pits, Trenches, And Streetscape Strategies
        i. Does stormwater flow across sidewalks or along the curb?
        ii. Are there existing trees, landscaping or tree pits near the street?
        iii. Can water be directed from the street/curb into adjacent areas?
    d. Porous Pavement
        i. Are there large areas of pavement on the site and are any paved areas not heavily used (i.e., fire lane, overflow)?
        ii. Are existing impervious areas in poor condition and in need of replacement?
    e. Curb Extensions And Stormwater Planters
        i. Is this a heavily used pedestrian crossing? Are there pedestrian crosswalks that would be safer if shortened?
        ii. Is the intersection or street at a location where stormwater can be collected before it enters a storm drain?

A desk top analysis was conducted analyzing geospatial data including Newark sewer system data, Newark property parcel data, State of New Jersey impermeable areas data for Essex County and State of New Jersey elevation (slope) data, a geospatial data set representing parcels and public right of way areas preliminarily suitable for installation of Green Infrastructure solutions in each of the Newark's CSO outfall areas.

The following steps were taken in conducting the analysis:

1. Newark parcels that satisfy criteria of eligibility for GI siting within the CSO outfall areas;
    a. Public ownership,
    b. Vacant,
    c. Identification of parcel by the Rutgers Study.
2. Polygons representing one-block roadway and sidewalk areas within the CSO outfall areas and selected parcel data were combined to form a data set of potentially eligible sites.
3. Elevation was data to calculate average slopes, screening out of sites with average slope greater than 10% and with total area less than 0.1 acre, to produce a final potential site data set.
4. The final potential data set was then combined with Essex County impervious area data to calculate the total area within each CSO outfall drainage area that is both within an eligible site and is classified as impervious (other than buildings).

A preliminary investigation and analysis of soils and depth to bedrock was undertaken, but it was found that available public data in these categories was at an insufficiently detailed scale to support their use in site identification. It is expected that geophysical investigations will be needed at potential sites.

Table D-11 shows the total, target (5% impervious area) potentially managed and estimated GI manageable areas for the Newark CSO drainage areas. Relative percentages of managed areas are shown in Figure D-10.

Table D-11. Estimation of CSO outfall Impervious and GI Manageable Area (Acres)

CSO Area	Total Imp. Area	5% of Total Imp.	Total Potentially Managed Area	Target Managed Area					Managed Area Bio-retention
				Publicly Owned	Road	Side walk	Vacant	Grand Total	
NE_002	306.5	15.3	105.7	3.4	7.8	3.7	0.7	15.5	12.2
NE_004/5	183.9	9.2	59.3	0.3	5.3	2.9	0.2	8.7	8.4
NE_008	203.3	10.2	65.8	1.0	6.0	2.4	0.2	9.7	8.7
NE_009-10	1,234.0	61.7	448.8	15.7	35.9	10.9	3.4	66.0	50.2
NE_014	266.4	13.3	103.0	5.8	7.0	1.9	0.4	15.1	9.3
NE_015	240.8	12.0	70.1	1.1	7.2	1.7	0.3	10.3	9.2
NE_016	73.8	3.7	21.1	0.2	2.5	0.3	0.2	3.1	2.9
NE_017	202.2	10.1	53.8	0.9	6.0	0.5	0.5	7.9	7.0
NE_018	130.3	6.5	43.1	2.4	3.5	0.4	0.1	6.3	3.9
NE_022	126.5	6.3	26.5	0.2	1.5	0.4	1.8	3.9	3.7
NE_023	181.8	9.1	46.8	0.6	5.6	0.5	0.2	6.9	6.3
NE_025	1,393.8	69.7	535.4	16.0	45.3	13.5	3.9	78.7	62.7
NE_026	213.5	10.7	51.8	0.2	5.2	1.0	1.1	7.6	7.4
NE_027	218.7	10.9	42.7	2.0	3.2	0.6	0.5	6.3	4.3
NE_030	337.6	16.9	136.3	3.5	11.4	3.7	1.4	20.0	16.5
Grand Total	5,313.0	**265.6**	1,928.7	53.3	153.4	44.3	15.0	**266.0**	**212.7**

Total impervious area in the Newark CSO drainage area is estimated to be 5,313 acres for an estimated goal of managing 5% of the impervious area approximately 266 impervious acres would need to be managed. The GIS analysis showed that approximately 1,929 acres are potentially suitable for management with GI.

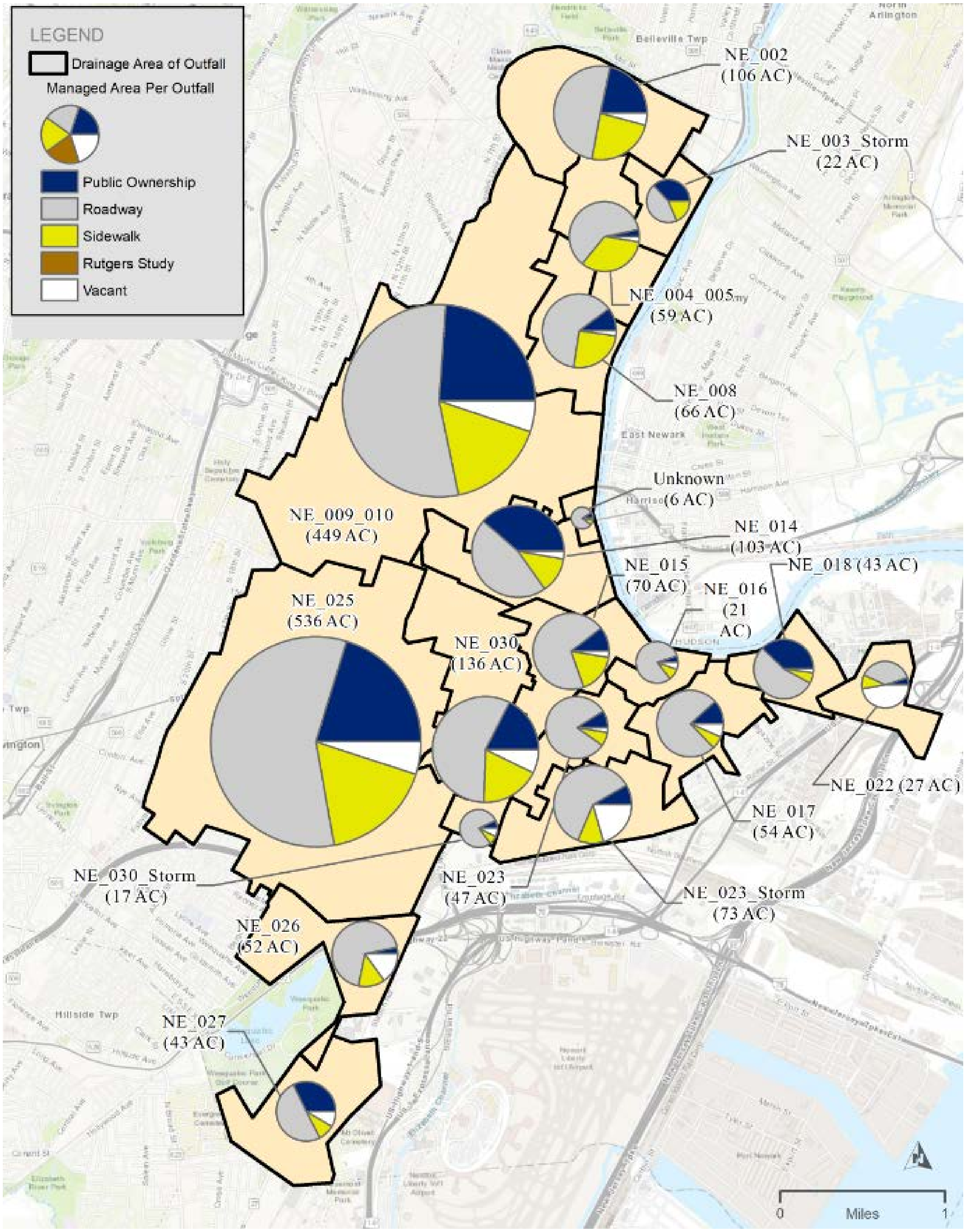


Figure D-10. Newark CSO Potentially Managed Impervious Area Relative Percentages

The targeted managed areas for the 5% goal are also shown and the estimated acreages for publicly owned, road, sidewalk, and vacant land summarized. For this analysis bio-retention GI was assumed and applied to roads, sidewalks and vacant land. This would yield approximately 213 managed acres.

Cost estimates for this level of control by GI for each outfall is shown inTable D-12. Estimated Managed Area and Costs by CSO Outfall Calculations are based on PVSC updated GI cost guidance for bio-retention systems; bio-retention systems include rain garden, roadway and right-of-way bioswales. The goal of GI implementation for the Long-Term Control Plan is to reduce storm water runoff generated from 5% of impervious area with respect to each CSO outfall. Areas targeted for GI locations are public-owned parcels including parking lots, vacant areas, roadways and sidewalks. The impervious covers of vacant areas, roadways and sidewalks could be managed by bioretention systems such as rain gardens and right-of-way bioswales. As per the PVSC cost standardization memo, a standard unit price of $390,000 per acre of impervious cover managed with green infrastructure is recommended assuming bioretention systems will be installed. An O&M cost of $2,250 per year per acre of impervious cover managed by green infrastructure with bioretention systems is used. Table D-10 shows the capital costs, O&M costs and total costs by outfalls and four example GI sites follow Table D-10.

Table D-12. Estimated Managed Area and Costs by CSO Outfall

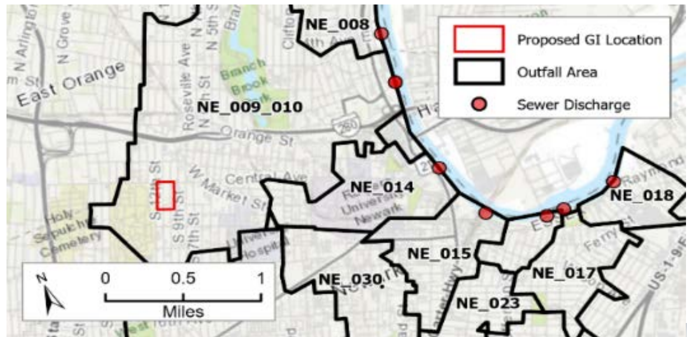
Outfall	Managed Area (acres)	Capital Costs (M$)	O&M Costs (M$)	Total Costs (M$)
NE-002	12.17	4.74	0.46	5.20
NE_004/005	8.42	3.28	0.30	3.58
NE_008	8.67	3.38	0.30	3.68
NE_009/010	50.22	19.58	1.67	21.25
NE_014	9.29	3.62	0.30	3.92
NE_015	9.21	3.59	0.30	3.89
NE_016	2.94	1.15	0.15	1.30
NE_017	6.98	2.72	0.30	3.02
NE_018	3.95	1.54	0.15	1.69
NE_022	3.69	1.44	0.15	1.59
NE_023	6.27	2.45	0.15	2.60
NE_025	62.72	24.46	2.13	26.59
NE_026	7.37	2.87	0.30	3.17
NE_027	4.26	1.66	0.15	1.81
NE_030	16.52	6.44	0.61	7.05
Total	212.67	82.94	7.31	90.25

Example GI Locations

Right-of-Way Bioswale Example: South 11th Street

Type of GI: Right-of-Way Bioswale
Type of Property: Public Right of Way
Owner: City of Newark
Location: South 11th Street between 11th Avenue and Central Avenue
Cadastral: Right of Way
Description of Site: Roadway
Type of Managed Area: Street and Sidewalk
Maximum Size of Managed Area: 1.4 Acres

Estimated Cost of Installation:
Capital Cost: 0.55 ($M)
Annual O&M Cost: 0.003 ($M)
20-Yr Life Cycle Cost: 0.59 ($M)



Rain Garden Example: 154-56 and 158 Avon Avenue

Type of GI: Rain Garden
Type of Property: Vacant, Private Ownership

Owners: 152 Jelliff Ave Corp and Best Provision Co.

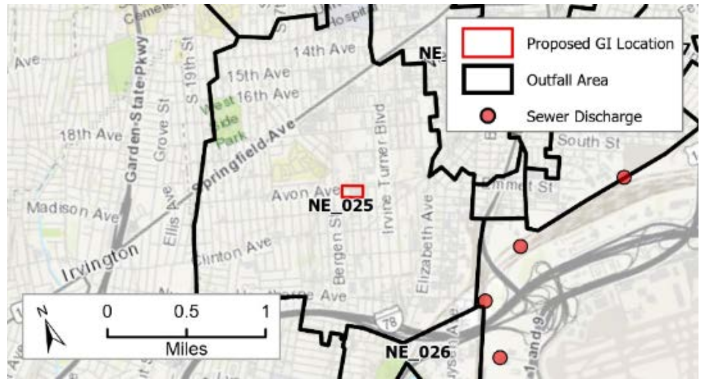
Locations: 154-56 Avon Avenue and 158 Avon Avenue

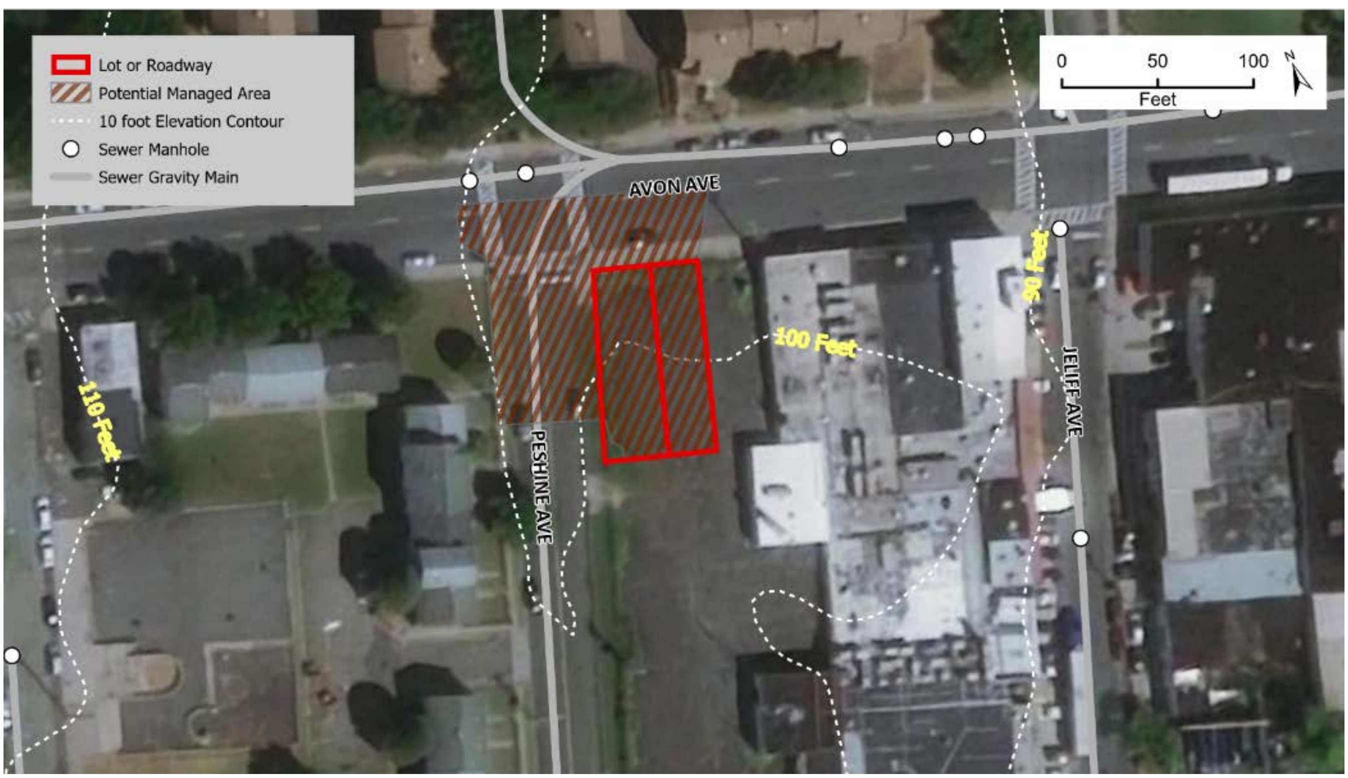
Cadastral: Block 2662, Lots 3 and 2

Description of Site: Vacant

Type of Managed Area: Street, Sidewalk and Vacant Lot

Maximum Size of Managed Area: 0.3 Acres
Estimated Cost of Installation:
Capital Cost: 0.12 ($M)
Annual O&M Cost: 0.001 ($M)
20-Yr Life Cycle Cost: 0.13 ($M)



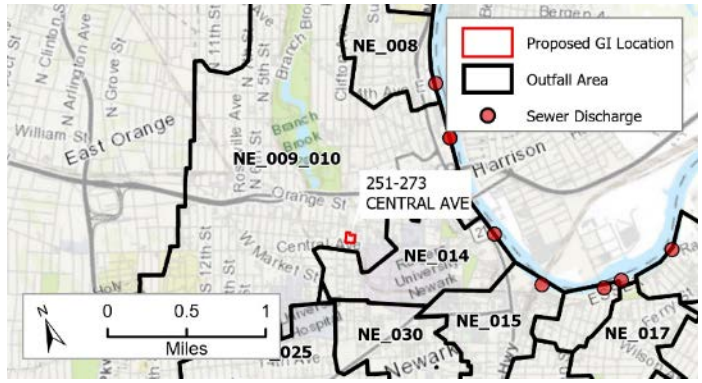


Rain Garden Example: 251-273 Central Avenue

Type of GI: Porous Asphalt
Type of Property: Public Ownership
Owner: ESSEX COUNTY IMPROVEMENT AUTHORITY
Location: 251-273 CENTRAL AVE
Cadastral: Block 2837, Lot 1
Description of Site: ADMINISTRATIVE BLDG.
Type of Managed Area: Parking Lot

Maximum Size of Managed Area: 1.15 Acres

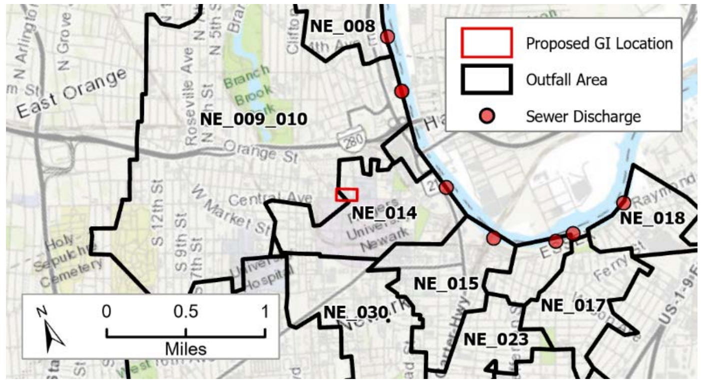
Estimated Cost of Installation:
Capital Cost: 0.45 ($M)
Annual O&M Cost: 0.003 ($M)
20-Yr Life Cycle Cost: 0.49 ($M)



Rain Garden Example: 251-273 Central Avenue

Type of GI: Rain Garden
Type of Property: Public Ownership
Owner: City of Newark
Location: CENTRAL AVE and SUSSEX AVE
Cadastral: Right of Way
Description of Site: Park.
Type of Managed Area: Streets and Park
Approximate Size of Managed Area: 1.0 Acres

Estimated Cost of Installation:
Capital Cost: 0.196 ($M)
Annual O&M Cost: 0.003 ($M)
20-Yr Life Cycle Cost: 0.242 ($M)



The model simulation of GI predicted an additional Newark CSO reduction of 61MG when applied to the 213 acre managed areas on the 85% with storage (Alt1b) alternative. Table D-13 shows the distribution of the CSO discharges in Baseline, the 85% with storage alternative, and GI application scenarios. Figure D-11 and Figure D-12 show the percent CSO volume and frequency reductions at each outfalls for GI application in comparison to the baseline and 85% storage alternative. The model predicted an increase of CSO percent capture in Newark from 87.0% to 87.7%, and a reduction of an additional 61MG over storage alone. The 61MG reduction is 4.6% of the CSO in Baseline and 8.1% of the CSO of the 85% storage (Alt1b) alternative.

Table D-13. Newark CSO Summary for GI Application Alternative 1b

Outfall	1)Baseline		2) Baseline with Storage for 85% Capture		3) Baseline with Storage for 85% Capture Plus 213 ac GI Application	
	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.
NE002	93.7	42	81.9	35	76.5	35
NE003	0.0	0	0.0	0	0.0	0
NE004	1.4	16	1.3	14	1.1	10
NE005	26.4	41	21.7	35	19.5	34
NE008	99.1	44	88.3	40	83.0	39
NE009	173.9	39	32.2	7	29.0	5
NE010	173.9	39	32.2	7	29.0	5
NE014	195.7	45	18.0	8	15.8	8
NE015	91.1	42	76.9	36	68.9	37
NE016	57.4	39	51.4	33	48.5	33
NE017	116.7	39	103.9	33	98.7	33
NE018	78.7	45	69.5	43	66.3	42
NE022	46.6	47	2.5	1	2.4	1
NE023	27.9	31	28.7	31	25.9	31
NE025	73.9	17	74.5	18	63.9	15
NE027	17.5	17	17.7	17	16.3	16
NE030	11.8	19	11.8	19	10.7	17
NE026	33.2	19	34.1	19	30.4	18
Total Newark CSO Volume	1319.0		746.6		685.8	

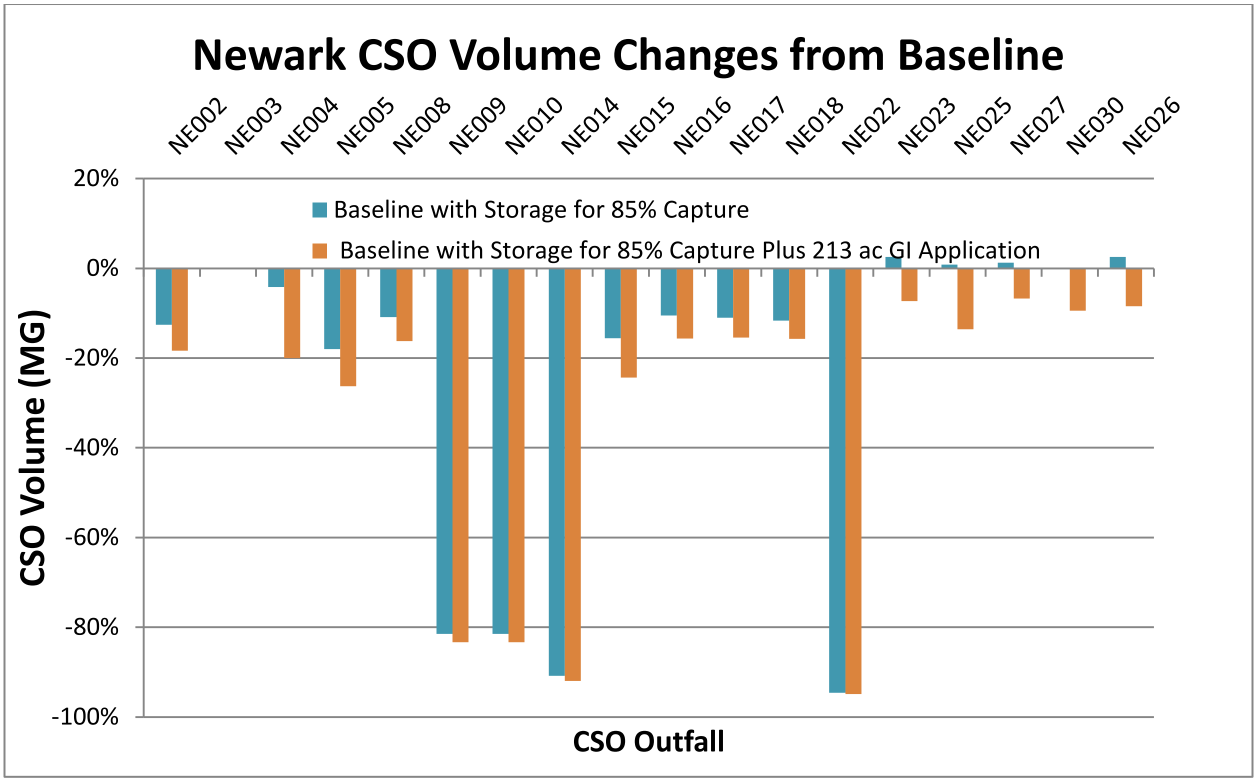


Figure D-11. CSO Volume Reduction at Newark Outfalls for Alt1b + GI Alternatives

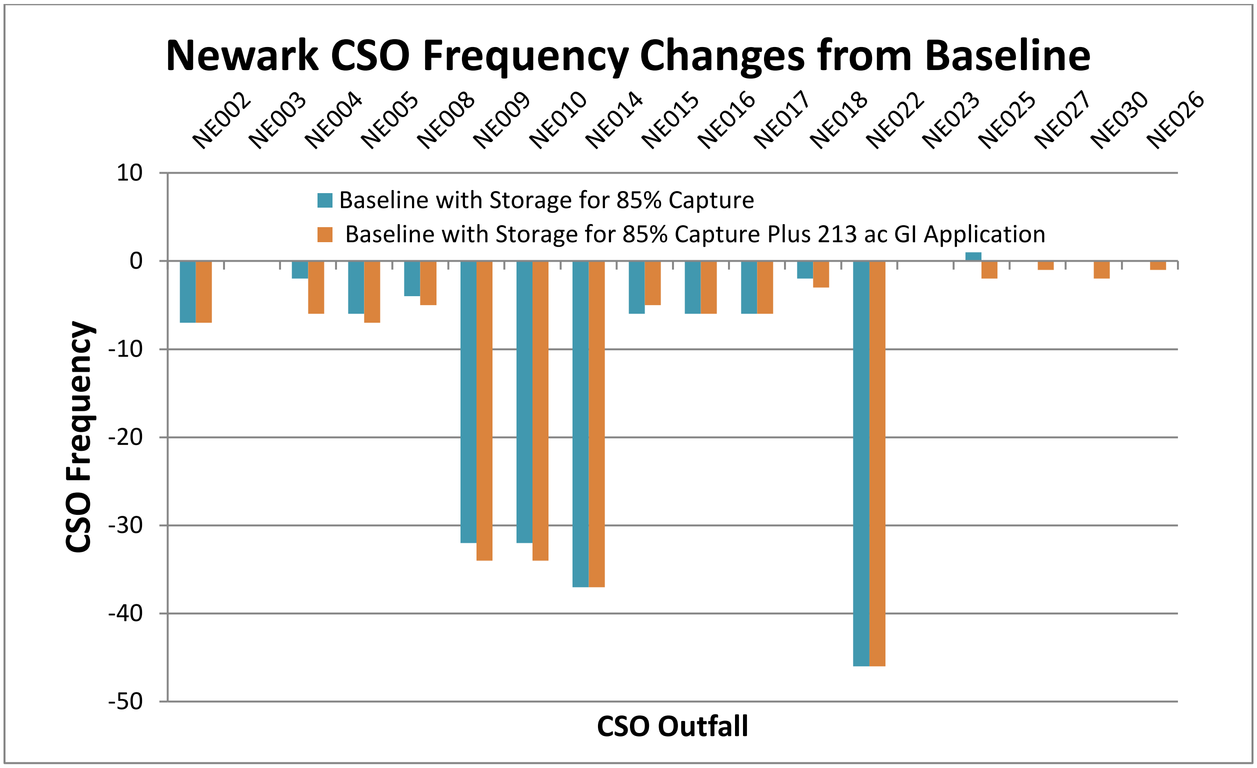


Figure D-12. CSO Frequency Reduction at Newark Outfalls for Alt1b + GI Alternatives

In addition evaluating the benefits of GI applications on Alt1b (Baseline with storage on 85% capture) scenario, model simulations were also conducted on the plant bypass expansion and Regional Alt3b (plant bypass with parallel interceptor) scenarios to see the benefit of GI application on different plant operational conditions. Table D-14 lists the CSO volumes and frequencies of these scenarios. GI application on secondary bypass expansion reduced total Newark CSO from 561.4MG to 518.5 MG by 43MG. This is a CSO reduction of 7.6% of the plant expansion scenario and 3.3% of the baseline. For the Regional Alt3b scenario, it is predicted that GI application will reduce Newark CSOs by 24MG (233.5MG to 209.5MG), a 10.3% reduction from the Alt3b scenario or an additional 1.8% from the baseline CSO of 1319MG. The Newark CSO capture for plant bypass with GI is 90.72% and for Regional Alt3b with GI is 96.24% in comparison to the with GI of 90.20%(plant by pass) and 95.92%(Alt3b).

In summary, the model predicted that GI application will reduce overall CSO discharges. The level of CSO reduction, however, varies with different plant operational conditions and the CSO discharges. Figure D-13 shows the CSO percent reduction for the GI scenarios in comparison to the plant condition that they were applied to. In modeling these scenarios for both the plant bypass scenario and the Regional Alt3b scenario, flows from the force main communities (Bayonne, Jersey City and North Bergen) and other CS communities (Paterson, Kearny, East Newark, Harrison) are represented with time series inflows assuming CSO controls for those communities are in place.

Table D-14. Newark CSO Summary for GI Application Plant Bypass and Regional Alternative

OUTFALL	Plant Bypass		Plant Bypass + GI		Regional Alt3b		Regional Alt3b + GI	
	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.
NE002	5.1	12	5	12	2.8	9	2.4	9
NE003	0.0	0	0	0	0.0	0	0.0	0
NE004	0.1	1	0	1	0.0	0	0.0	0
NE005	0.1	1	0	1	0.0	0	0.0	0
NE008	33.9	34	31	34	12.4	17	11.3	17
NE009	119.1	39	110	33	24.0	17	21.8	17
NE010	119.1	39	110	33	24.0	17	21.8	17
NE014	51.3	41	48	40	27.6	15	25.2	13
NE015	0.9	5	1	5	9.4	7	8.4	7
NE016	14.1	21	13	20	3.0	9	2.7	8
NE017	35.1	26	33	25	4.8	8	4.3	7
NE018	16.6	37	16	37	5.4	14	5.1	13
NE022	44.2	47	42	45	0.40	10	0.36	11
NE023	20.8	31	19	31	20.8	31	19.2	31
NE025	60.3	16	52	13	47.8	13	41.0	12
NE027	11.8	17	11	14	14.8	18	13.6	17
NE030	10.6	18	10	17	10.6	18	9.5	17
NE026	18.3	17	17	17	25.8	19	23.1	17
Total Newark CSO Volume	**561.4**		**518.5**		**233.5**		**209.5**	

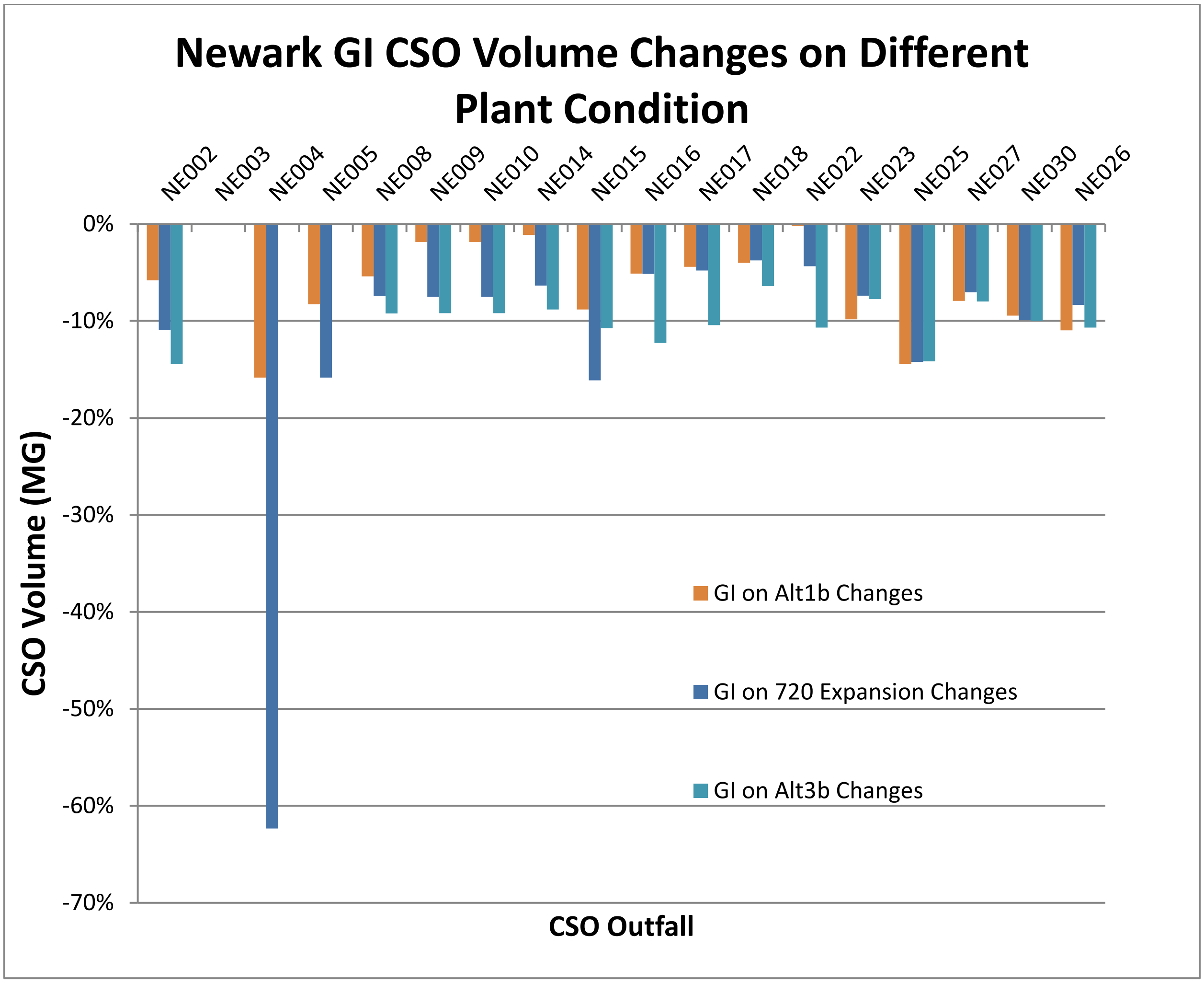


Figure D-13. CSO Volume Reduction at Newark Outfalls for GI Alternatives on Various Plant Operations

D.4.3 Green infrastructure (Tree Pits)

Tree pits are another form of Green Infrastructure that is often lower cost and easier to implement. The Newark Department of Public Works (DPW) conducted a survey of tree stumps in the city in order to plan for the replacement of dead trees. This provides an opportunity for the city to use green infrastructure to help manage CSO and storm water. By replacing dead trees with a tree box stormwater runoff can be retained and infiltrated rather than running off to a CSO or stormwater outfall. DPW surveyed a total of 734 tree stumps, 411 were in areas served by CSOs. Figure D-14 shows the locations of the surveyed tree stumps.

Rutgers Cooperative Extension Fact Sheet FS1209 describe the function, costs and operation of tree boxes. Tree boxes are a green infrastructure stormwater control measure that are designed to collect the first flush of stormwater and treat it prior to discharge into the storm sewer system or to the subsoil. The structure is typically a pre-manufactured concrete box which is installed in-ground, filled with soil media and planted with native, non-invasive tree or shrub. The tree box functions as a bioretention system, which is a GI stormwater control best management practice (BMP). In urban or areas such as Newark, tree boxes can fit within a small existing footprint and as retrofit projects such as the replacement of dead trees.

The utility of a tree box is the ability to be installed in dense urban areas as well as residential and suburban areas; regardless of land use tree boxes are designed to capture and treat small drainage areas. Tree boxes generally capture and treat stormwater runoff from small frequently-occurring storms but are not designed to capture runoff from large storms or extended periods of rainfall. Each tree box is designed to treat approximately 0.25 to 0.5 acre for this estimate a managed area per tree box of 0.33 acres was assumed. Estimated cost of individual tree boxes to manage 0.33 acres was assumed to be $12,000. Maintenance consists of annual removal/replacement of mulch, litter and pruning of trees. This can typically be conducted by DPW when trained by the manufacturers of the system. Performance efficiency is correlated with maintenance. The cost ranges from $100-$500 annually/tree box according to the Charles River Watershed Association (2008). The lower end of this range is indicative of maintenance performed by the owner, whereas the higher end is associated with proprietors of prefabricated systems maintenance plans (CRWA, 2008). An annual maintenance cost of $300/year was assumed.

Table D-15 summarizes the number of potential tree boxes in each CSO outfall drainage area, managed area and 20 yea life cycle costs. Approximately 137 acres can be managed at a cost of approximately 7 million dollars.

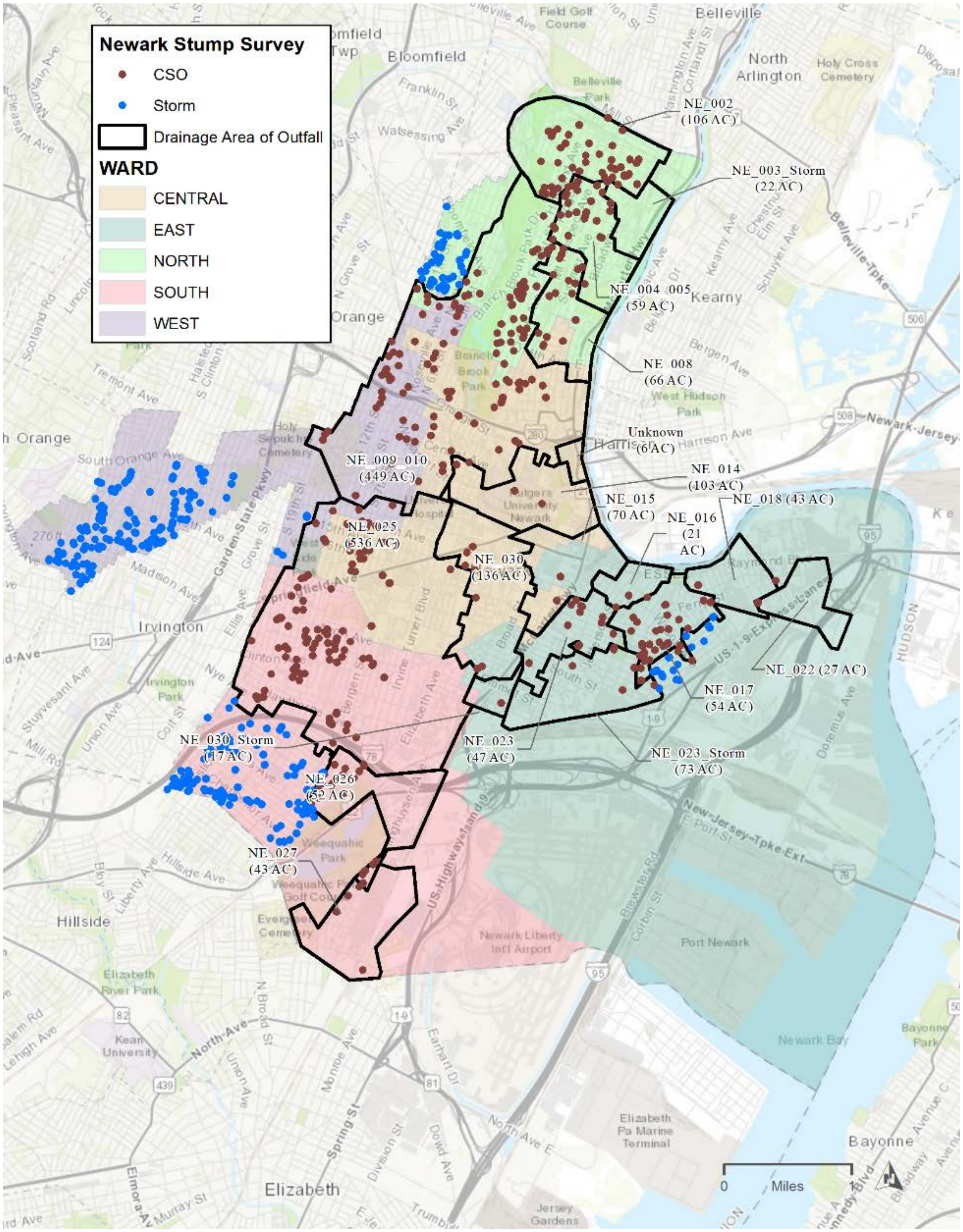


Figure D-14. Newark Tree Stump Survey Locations

Table D-15. Newark Tree Stump Survey Summary

Outfall	Trees to be Replaced (#)	Managed Area (Acres)	Capital Costs ($M)	Annual O&M Costs ($M)	20-Yr Life Cycle Costs ($M)
NE_002	45	15.00	0.56	0.014	0.77
NE_004_005	29	9.67	0.36	0.009	0.49
NE_008	19	6.33	0.24	0.006	0.32
NE_009_010	120	40.00	1.50	0.036	2.05
NE_014	3	1.00	0.04	0.001	0.05
NE_015	2	0.67	0.03	0.001	0.03
NE_016	2	0.67	0.03	0.001	0.03
NE_017	36	12.00	0.45	0.011	0.61
NE_018	2	0.67	0.03	0.001	0.03
NE_022	2	0.67	0.03	0.001	0.03
NE_023	12	4.00	0.15	0.004	0.20
NE_025	104	34.67	1.30	0.031	1.78
NE_026	24	8.00	0.30	0.007	0.41
NE_027	4	1.33	0.05	0.001	0.07
NE_030	7	2.33	0.09	0.002	0.12
Total	**411**	**137.00**	**5.14**	**0.123**	**7.01**

D.4.4 Regulator Modification on South-Side Regulator

CSO reductions can also be achieved by modification of regulators, adding additional capacities to the existing regulator structures so that the amount of flows that are passed through the regulators and conveyed to the treatment plant are increased. Regulator modification alternatives are evaluated for the three regulators that contribute flow to the South Side Interceptors (Figure D-1), namely Peddie Street (NE-025), Queens District (NE-026), and Waverly District (NE-027). The three regulators do not discharge CSO to the Passaic River, but to the Newark Airport peripheral ditch. Their annual CSO discharge total is 125MG on the 2004 typical year condition, 74MG (59%) of which is from the Peddie Street (NE-025) regulator.

The modeling analysis on increasing the capacities of these regulators are evaluated in two sets. The first is as a supplement to Alternative 1b (Alt1b) where storages at NE009/010, NE014 and NE022 are used to reduce CSOs and the second set as an addition to the regional Alternative 3b scenario (Alt3b), where sewer system conveyance capacity are being increased by adding a secondary interceptor that runs parallel to the existing main interceptor in the Newark section, with relief structures in Newark to divert additional flow to the parallel interceptor. In both the Alternative 1b and Alternative 3b scenarios, the plant capacity is assumed to be upgraded to 720 MGD (secondary bypass). In the Alt3b scenario, controlled flows from other combined municipalities (Paterson, Kearny, Harrison, and East Newark) and the Force Main municipalities (Bayonne, North Bergen and Jersey City) are represented as time-series inflows.

In both analyses, the plant capacity is assumed to be upgraded to receive additional wet weather flows from the communities, and making the maximization of the flows from Southside interceptor also possible. The plant upgrade alone reduces Newark CSO volume from 1319MG in baseline to 561MG, a reduction of 758MG (51.4%). On top of it, Alt1b storage scenarios increases the CSO reduction to 1088MG by 82.9% (231MG CSOs); and Alt3b reduces annual CSO volume in Newark further to 237MG without modification of South Side regulators, a reduction of 1082MG (82.0%). Regulator modification is most effective when there is available capacity at the plant and in the interceptor downstream of the modified regulators to receive the increase underflows. Six regulator modification alternatives are evaluated to estimate the additional CSO reductions and associated cost in addition to Alt1b and the regional Alt3b. They are:

1) Alternative 3b
    a. Increase the width of the Peddie Street regulator orifice to 1.25 times of its original width;
    b. Increase the width of the Peddie Street regulator orifice to 1.5 times of its original width;
    c. Increase the width of the Peddie Street regulator orifice to 2 times of its original width;
    d. Increase the width of the three South Side regulators orifices to 1.25 times of their original width; and
    e. Increase the width of the three South Side regulators orifices to 1.25 times of their original width.
2) Alternative 1b
    a. Increase the width of the Peddie Street regulator orifice to 2 times of its original width;

Alternative 3b is most suitable for regulator modification since it includes both a plant upgrade and parallel interceptor. Table D-16 summarizes the CSO discharges of the regulator modification scenarios at the three South Side Interceptor regulator outfalls and other Newark outfalls in comparison. Figure D-15 and Figure D-16 show the percent CSO volume and frequency changes at the three South Side Interceptor regulators; Figure D-17 shows the sum of CSO volume changes of the three regulators, other Newark regulator outfalls, and total CSO volume changes in Newark in comparison to Alternative 3b scenario without regulator modifications.

For the alternative where only the Peddie Street regulator is modified, the model predicts that CSO discharges at Peddie Street outfall decreases as the opening of its orifice increases for more flow to entire South Side Interceptor. The CSO reduction at Peddie Street CSO is 5.9MG for the 1.25 times scenario, 9.6MG for the 1.5 times scenario, and 13.6MG for the 2 times scenario. Due to the additional flow in the South Side Interceptor resulted from the modification of the Peddie Street regulator, the CSO discharges from the other two regulators, Queens District (NE-026) and Waverly District (NE-027) increase; other Newark regulators also show slight increase of CSO volumes. The reduction on Peddie Street exceeded the increases at other regulators, so the total CSO volume in Newark appears to decrease. The total reduction of CSO in Newark is 2.1, 2.7 and 3.5MG for the 1.25times, 1.5 times and 2 times increase scenarios, respectively.

For the alternatives where all three regulators are modified, the three regulators have shown similar behavior as the Peddie Street modification, i.e. CSO volume is reduced at Peddie Street, but increased at the other two regulators. Minor CSO increases are also shown in other Newark regulators. The net reduction of Newark CSOs are 2.4MG for the 1.25time scenario and 4.0MG for the 1.5 times scenario.

Comparing the alternatives where all three regulators are modified to the alternatives where only Peddie Street were modified, the modification of the two additional regulators provided an extra CSO reduction of 0.3MG for the 1.25 time scenario and 1.3 MG for the 1.5 times scenario. The cost of the regulator modification are shown in Table D-17. Overall, the Regulator Modification alternatives show reduction of the CSO at Newark outfalls increases along with the increase of the regulator sizes. Estimation for regulator modification cost were based on similar estimates HDR developed comparable modifications to regulators in the Tallman Island CSO system.

Similar to when regulator modification is applied to the Alt3 scenario, the modification of the regulator reduced overall Newark CSO discharges by 4.8MG in Alt1b with the plant upgrade scenario (Table D-18), as result of decreased CSO volume and events at Peddie Street, some flows are shifted to the other two regulators that contribute to South Side Interceptor. The model predicts no or very minimal changes on other Newark or Non-Newark related to modification of the Peddle Street regulator. Given increased capacity at the plant, or a parallel interceptor with increased plant capacity, regulator modification can be a low cost alternative for CSO reduction.

Table D-16. South Side Interceptor Regulator Modifications

Outfall	Alt3b with No Regulator Modification		Alt3b +Peddiex1.25		Alt3b +Peddiex1.5		Alt3b (Peddiex2 included)		Alt3b +SSRegx1.25		Alt3b+SSRegx1.5	
	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.	Vol. (MG)	Freq.
NE025 (Peddie St)	61.4	16	55.5	16	51.8	14	47.8	13	57.0	16	54.1	16
NE027 (Waverly District)	12.2	17	13.3	17	14.0	17	14.8	18	13.3	17	14.0	17
NE026 (Queens District)	19.2	17	21.6	18	23.5	19	25.8	19	19.4	17	19.8	17
	Vol. (MG)		Vol. (MG)	Diff (MG)	Vol. (MG)	Diff (MG)	Vol. (MG)	Diff (MG)	Vol. (MG)	Diff (MG)	Vol. (MG)	Diff (MG)
South Side Interceptor Regulator CSO	92.8		90.4	-2.4	89.3	-3.5	88.4	-4.4	89.6	-3.2	87.9	-4.9
Other Newark Regulator CSO	144.2		144.6	0.3	145.0	0.8	145.1	0.9	145.0	0.7	145.1	0.9
Total Newark CSO	237.0		235.0	-2.1	234.3	-2.7	233.5	-3.5	234.6	-2.4	233.0	-4.0

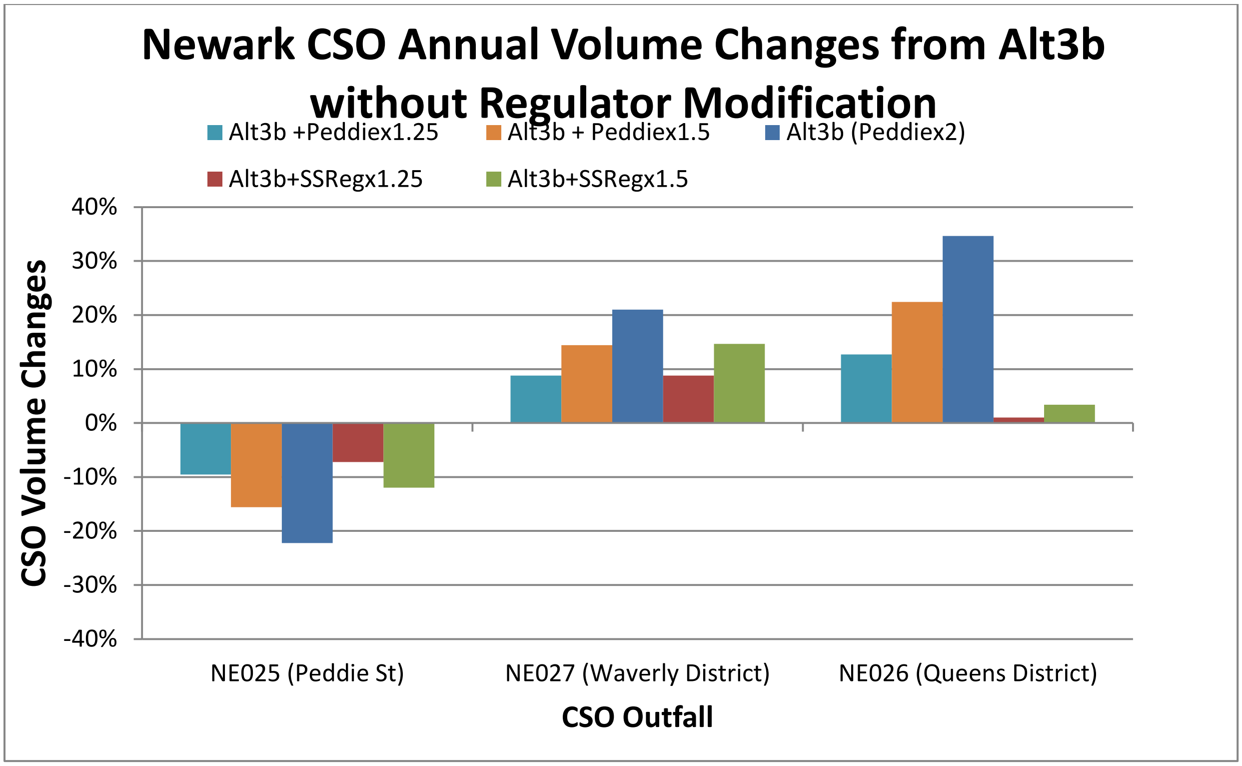


Figure D-15. Newark CSO Volume Reduction at South Side Interceptor Regulators for Regulator Modification Alternatives

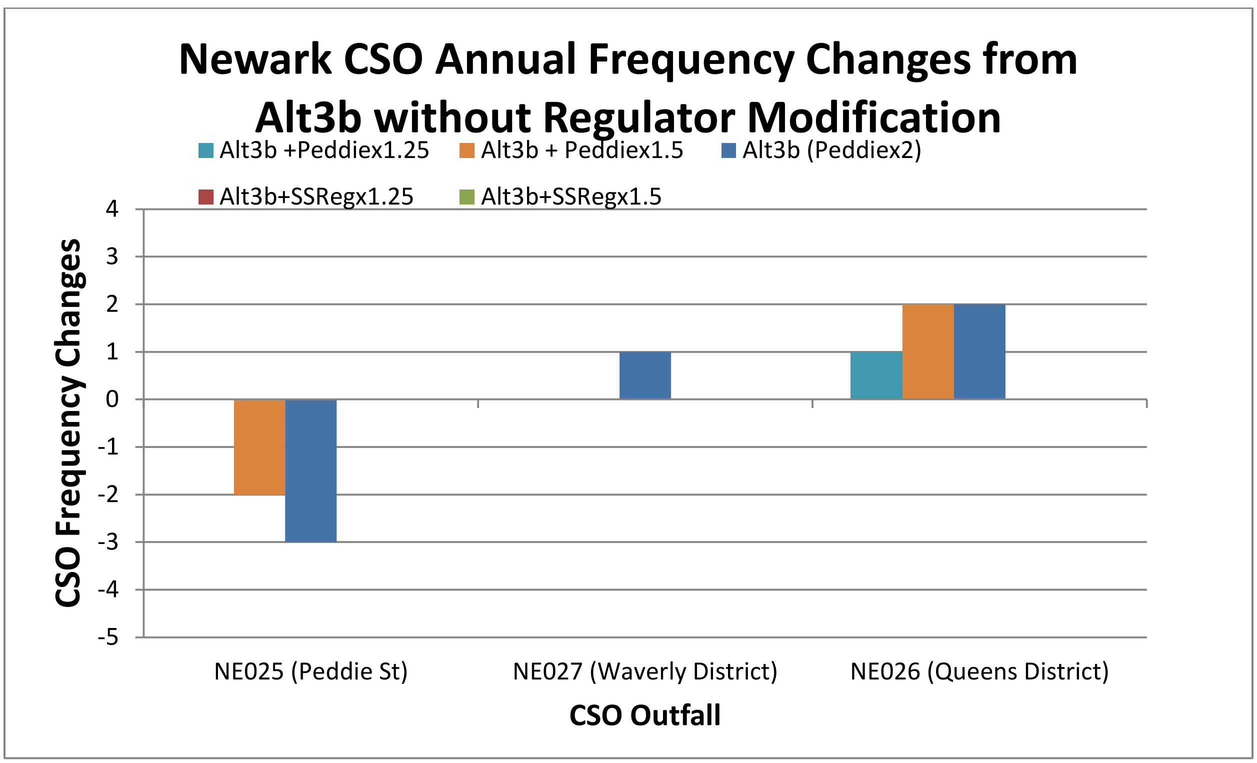


Figure D-16. Newark CSO Frequency Reduction at South Side Interceptor Regulators for Regulator Modification Alternatives

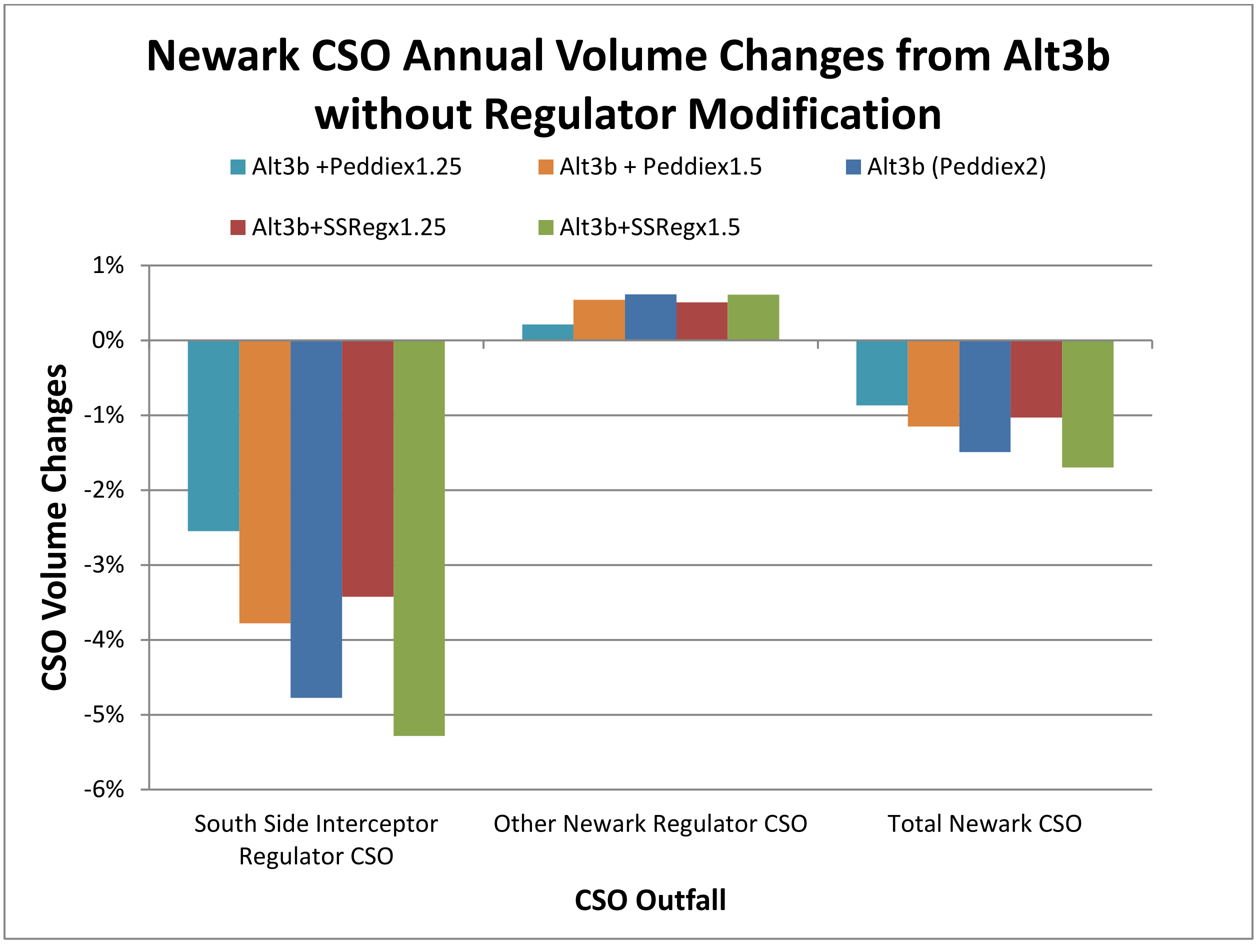


Figure D-17. Summary of CSO Volume Reduction for Regulator Modification Alternatives

Table D-17. Cost Estimation of South Side Interceptor Regulator Modification

Tallman Island Regulator	Cost
Regulator 10 (2010)	$100,000
Regulator 10A (2010)	$100,000
Regulator 13 (2010)	$350,000
Average Cost (2010, rounded to nearest thousand)	$183,000
Average Cost + Overhead, Profit, and General Conditions (2010)	$265,000
Estimated Newark Cost Per Regulator (2020, escalated 3.5% per year)	**$374,000**

Table D-18. Peddie Street Regulator Modification on Alt1b with Plant Upgrade

Outfall	Alt1b with 720 MGD Operating Capacity Secondary Bypass		Alt1b with 720 MGD Operating Capacity Secondary Bypass +Peddie x2	
	Vol. (MG)	Freq.	Vol.(MG)	Freq.
NE025 (Peddie St)	60.4	16	46.7	13
NE027 (Waverly District)	11.9	17	14.5	18
NE026 (Queens District)	18.4	17	24.8	19
	Vol. (MG)		Vol. (MG)	Diff (MG)
South Side Interceptor Regulator CSO	90.6		86.0	-4.6
Other Newark Regulator CSO	142.9		142.7	-0.2
Total Newark CSO	**233.5**		**228.7**	**-4.8**
Main Interceptor Non-Newark CSO	755.6		755.6	0.0

D.4.4 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. For example NYCDEP's Toilet Replacement Program invested $1.85 million to retrofit more than 13,200 toilets citywide in multi-family buildings. The total water savings of this effort is more than 620,000 gallons per day.

The Newark DEAR estimated that a 10% reduction in water use provided a modest decrease in CSO overflows, 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. For planning purposes the cost of a water conservation program for the City of Newark is $1.5 million.

SECTION E - Financial Capability

E.1 Introduction

This section of the Newark's Selection and Implementation of Alternatives Report (SIAR) quantifies the projected affordability impacts of Newark's proposed long term CSO controls for the Newark combined sewer system (CSS) and updates the 2019 preliminary Financial Capabilities Assessment (FCA) memo that was intended to guide the development and selection of long term controls. This section is excerpted from a memorandum prepared by the Passaic Valley Sewerage Commission (PVSC) which is incorporated as Appendix P of PVSC's SELECTION AND IMPLEMENTATION OF ALTERNATIVES FOR LONG TERM CONTROL PLANNING FOR COMBINED SEWER SYSTEMS - REGIONAL REPORT (Regional Report).

The Financial Capability assessment is a two-step process including *Affordability* which evaluates the impact of the CSO control program on the residential ratepayers and *Financial Capability* which examines a permittee's ability to finance the program. Affordability is measured in terms of the Residential Indicator (RI) which is the percentage of median household income spent on wastewater services. Total wastewater services exceeding 2.0% of the median household income are considered to impose a high burden by USEPA. The financial capability analysis uses metrics similar to the municipal bond rating agencies. The second step of the analysis assesses the City of Newark ability to finance the required CSO controls. The financial capability analysis uses metrics similar to the municipal bond rating agencies.

USEPA encourages the use of additional information and metrics to more accurately capture the impacts of the proposed CSO controls on the permittee and its residents. Therefore, this FCA includes information on the impacts of future costs among lower income residents and within the context of local costs of living.

Detailed discussion of the FCA for the PVSC service area and Permittees can be found in the Regional Report and a detailed analysis of the Newark's FCA can be found in the FCA Memorandum specifically written for Newark attached as part of Appendix P of the Regional Report.

E.2 Baseline Conditions (Without CSO Controls)

The estimated annual cost for wastewater services for a typical single-family residential user in Newark for 2019 is $340. This estimate is based on typical residential potable water usage of 4,500 gallons monthly. Based on the estimated Mean Household Income (MHI) of $35,600 the Residential Indicator was approximately 1.0% in 2019, or at the border of what the EPA guidance defines as a low burden. By definition the current residential indicator for one half of the households is greater than the 1.0%.

In Newark as of 2017, 28.3% of the population was living below the poverty line. The total Census households are broken out by income brackets on Table E-1 below, along with the respective current Residential Indicators by income bracket. The RI for each bracket was calculated from the mid-point income within the bracket. At the lowest income levels, the current RI is already between 2.7% and 6.8%.

Table E-1 Analysis of the Current Residential Indicator

Income Bracket	Households		Bracket Average Income	Bracket RI at Typical Cost per Household
	Number	Cumulative		
Less than $10,000	14,841	14,841	$5,000	6.80%
$10,000 to $14,999	7,790	22,631	$12,500	2.72%
$15,000 to $24,999	13,900	36,531	$20,000	1.70%
$25,000 to $34,999	11,283	47,814	$30,000	1.13%
$35,000 to $49,999	13,618	61,432	$42,500	0.80%
$50,000 to $74,999	14,743	76,175	$62,500	0.54%
$75,000 to $99,999	7,855	84,030	$87,500	0.39%
$100,000 to $149,999	7,600	91,630	$125,000	0.27%
$150,000 to $199,999	2,136	93,766	$175,000	0.19%
$200,000 or more	1,550	95,316	$200,000	0.17%

PVSC has developed a time-based model that calculates annual costs and revenue requirements based on assumed program costs, schedules and economic variables such as interest and inflation rates. The residential indicator is calculated for each year based upon the costs per typical residential users which changes annually based on the annual system revenue requirements.

The estimated inflationary impacts on wastewater costs per typical single family residential user without additional CSO control costs are shown on Table E-2. The costs are projected to the year 2031. The use of 2031 is based on the LTCP implementation schedule for Newark's Municipal Control Alternative in Section F of this SIAR report which targets the completion of capital improvements through 2030. The schedules in Section F show a 30 year plan, however all construction activities are slated to be completed within 20 years i.e. before 2040.

The regional alternative would result in lowered overall costs for the control of CSOs within the PVSC service area. Under this approach, both the costs of the regional facilities such as a relief interceptor and the resultant savings would be allocated amongst the PVSC municipalities with combined sewer systems. As the basis of this allocation remains under discussion as of the writing of this SIAR, the FCA focuses on implementation of the Municipal Control Alternative. Should the permittees come to agreement on the cost allocation for the Regional Control Plan, the FCA will be revisited to reassess the affordability and schedule for implementation of the LTCP.

Assuming inflation, the projected cost per typical single family residential user are projected to increase from $340 in 2019 to $476 in 2031.

Table E-2 Newark Projected Residential Indicator in 2041 Without CSO Controls

Metric	Baseline (2019 unless noted)	Cost per Typical Residential Wastewater User in 2041
RI	1.0%	1.2%
Annual $	$340	$476

E.3 Summary and Conclusion

E.3.1 Affordability

Newark has identified a long term CSO control strategy that will achieve 85% capture of wet weather flows during the typical year utilizing controls within and implemented by the City. PVSC and the PVSC combined sewered municipalities have also developed a potential regional control strategy that would result in lower overall capital costs. These controls are summarized on Table E-3.

Table E-3 Newark's Selected CSO Controls

Wet Weather Control Types	Estimated Costs (in millions)	
	Capital Costs	20 year O&M
Storage Tank at NE022, 4 OF/yr (MG)	$55.13	$1.88
Storage Tank at NE009 & NE010, 12 OF/yr (MG)	$191.48	$3.62
Storage Tank at NE014, 12 OF/yr (MG)	$103.63	$2.58
Water Conservation	$1.50	$0.00
Regulator Modifications on Main Interceptor	$0.00	$0.00
Green Infrastructure (ac)	$82.94	$7.31
Total	**$434.7**	**$15.4**

Implementation of the $434.7 million Newark Municipal Control Alternative through 2030 would result in projected annual costs per typical single family user of $515 (without inflation) works out to a 1.5% RI in 2031. Accounting for inflation, annual costs would grow to $723 with a residential indicator of 1.8% in 2031 (Table E-4).

Table E-4 Newark Projected Residential Indicator Upon Full Implementation of the Municipal CSO Control Alternative

Metric	Baseline (2019)	Cost per Typical Residential Wastewater User in 2041			
		No LTCP		Municipal Control Alternative	
		With Inflation	Without Inflation	With Inflation	Without Inflation
RI	1.0%	1.2%	1.0%	1.8%	1.2%
Annual $	$340	$476	$340	$723	$515

This analysis does not reflect the current and lingering financial impacts as a result of the COVID -19 pandemic and the FCA should be revisited upon memorializing the LTCP implementation schedule in the City of Newark's next NJPDES Permit.

E.3.2 Financial Capability Assessment

The second part of the financial capability assessment - calculation of the financial capability indicator for the permittee - includes six items that fall into three general categories of debt, socioeconomic, and financial management indicators. The six items are:

1. Bond rating
2. Total net debt as a percentage of full market real estate value
3. Unemployment rate
4. Median household income
5. Property tax revenues as a percentage of full market property value
6. Property tax revenue collection rate

Each item is given a score of three, two, or one, corresponding to ratings of strong, mid-range, or weak, according to EPA-suggested standards. The overall financial capability indicator is then derived by taking a simple average of the ratings. This value is then entered into the financial capability matrix to be compared with the residential indicator for an overall capability assessment.

As shown on Table E-5, the overall score for the financial indicators is 2.0 yielding an EPA Qualitative Score of "mid-range". This calculation is based on the use of six of the six indicators that are applicable to Newark.

Table E-5 Permittee Financial Capability Indicator Benchmarks

Indicator	Rating	Numeric Score
Bond Rating	Mid-Range	2
Overall Net Debt as a Percent of Full Market Property Value	Strong	3
Unemployment Rate	Weak	1
Median Household Income	Weak	1
Property Tax as a Percent of Full Market Property Value	Mid-Range	2
Property Tax Collection Rate	Strong	3
Total		12
Overall Indicator Score: (numeric score / number of applicable indicators)		2.0
EPA Qualitative Score		**Mid-Range**

The derivation of this score is presented in the detailed FCA memorandum presented in Appendix P of the PVSC Regional Report. As each of the financial indicators are generally based upon publicly available data from 2017 or earlier, this analysis does not reflect the current and lingering impacts of the COVID -19 pandemic and should be revisited upon memorializing the LTCP implementation schedule in the City's next NJPDES Permit.

E.3.3 Implementation Feasibility Implications

The 1997 EPA guidance indicates that ratepayers and permittees who are highly burdened future expenditures added to their current wastewater treatment, conveyance, and collection costs can be allowed 15 years to complete capital projects to handle CSOs. In extreme cases, the guidance suggested a 20-year compliance schedule might be negotiated. [1]

The affordability analysis detailed above has documented that the $434.7 million (current dollars) in capital expenditures under Newark's Municipal Control Alternative along with related operation and maintenance costs would result in a Residential Indicator of 1.8% in 2031.

Additional economic factors are presented in the Newark FCA Memorandum presented in Appendix P of the SELECTION AND IMPLEMENTATION OF ALTERNATIVES FOR LONG TERM CONTROL PLANNING FOR COMBINED SEWER SYSTEMS - REGIONAL REPORT enforcing the limits to the affordability of CSO controls and the City's financial capability.

While the affordability analysis detailed above has documented that the selected $434.7 million (current dollars) Municipal Control Alternative along with related operation and maintenance costs would result in a Residential Indicator of "medium impact" under EPA's criteria; the reality of the high poverty rates, low household incomes compared to the rest of New Jersey and nationally, and the high costs of living in Newark argue strongly that the EPA metric understates the impacts of the CSO control costs on the residents of the City. Newark is and is likely to remain financially distressed due to structural economic factors beyond its direct control and its ability to afford and finance future CSO control facilities is restricted. As evidenced by its New Jersey Municipal Revitalization Index score in the top 11th percentile, Newark's capacity for additional CSO controls, beyond those proposed in the SIAR, is limited.

E.3.4 Potential Impacts of the COVID-19 Pandemic in Affordability

The projections and conclusions concerning the affordability of the Municipal Control Alternative proposed in this SIAR and Newark's financial capability to finance the CSO control program are premised on the baseline financial conditions of Newark as well as the economic conditions in New Jersey and the United States generally at the time that work on this SIAR commenced. While the impacts of the pandemic on the long-term affordability of the CSO LTCP are obviously still unknown, it is reasonable to expect that there will be potentially significant impacts. There are several dimensions to these potential impacts, including reduced utility revenues and household incomes.

Given the current and likely continuing uncertainties as to the New Jersey and national economic conditions, Newark will be reticent to commit to long term capital expenditures for CSO controls without the incorporation of adaptive management provisions, including provisions to revise and reschedule the long term CSO controls proposed in this SIAR based on emergent economic conditions beyond the permittees' control. As detailed in Section F of Newark's SIAR, these provisions could include scheduling the implementation of specific CSO control measures to occur during the five year NJPDES

[1] Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development, EPA 832-B-97-004, Page 46.

permit cycles. A revised affordability assessment should be performed during review of the next NJPDES permit to identify controls that are financially feasible during that next permit period.

SECTION F - Recommended Long-Term Control Plan

F.1 Introduction

The development of alternatives process looked at several ways to achieve the goals of the LTCP. As described in Section D.3, presumptive approach with an 85% capture goal was selected as an achievable cost effective approach for long term control planning. PVSC hydraulically connected communities developed individual LTCP alternatives in this effort as individual municipal plans.

In parallel to the individual community efforts developing individual LTCP alternatives; PVSC further developed a regional alternative which is discussed in the regional approach section of the SIAR. This regional alternative includes plant expansion to secondary bypass and adding a parallel interceptor in Newark which will increase the conveyance capacity of the current main interceptor to deliver more flows to the expanded plant. Both options are presented in the SIAR and PVSC CSO Communities are evaluating the benefits, potential cost savings and funding alternative of the regional alternative.

F.2 Recommended LTCP

LTCP alternatives were developed to meet the presumptive approach and achieve 85% capture for Newark CSOs. Two potential sets of scenarios exist for the Newark individual LTCP. One when the PVSC plant capacity remains as is and one with the expanded plant capacity. The selected plan elements are:

- Modified Newark Gate Operation (only w.r.t. baseline condition, plant expansion includes Newark gate operation updates)
- Three CSO storage tanks
- GI up to 5% impervious area managed
- Water conservation
- Peddie Street Regulator Modification (Only applies when the PVSC plant is expanded)

For the two plant capacity scenarios, the recommended combination of CSO controls are:

- NO PLANT UPGRADE
  - *Modified Gate Operation*
  - *Three Storage tanks*
  - *GI up to 5% impervious area managed*
  - *Water Conservation*
- PLANT UPGRADE
  - *Option 1: Three Storage tanks, Peddie St. Regulator Modification, GI, Water Conservation*
  - *Option 2: Peddie St. Regulator Modification, GI, Water Conservation*

Table F-1 summarizes the Newark recommended plan options, their estimated CSO percent capture for Newark, and estimated total costs, except for water conservation, which is estimated to provide approximate 36MG additional CSO reduction (0.7% capture) with a cost of about 1.5M dollars.

Without the plant upgrade, it is predicted that CSO capture achieves the 85% target with the Newark gate operation modification and 28.5 MG storage addition (87% CSO capture). Adding GI and water conservation to the recommended LTCP municipality plan increases the CSO capture to around 88%.

For the scenario with PVSC plant upgrade to secondary bypass and storage, Newark CSO capture reaches 95.9%. When the parallel interceptor is included (regional Alt3b), the CSO capture is around 96%. From the perspective of Newark CSO reduction, the capture provided by the 28.5 MG storage tanks (Option1 on plant upgrade) is similar to the parallel interceptor in regional Alt3b (option2 on Alt3b). Either option increases CSO capture from 90% to about 96%. The estimated cost in Table F-1 are plant elements for Newark; cost associated with the regional plans such as plant upgrade or adding parallel interceptor, is not included in the estimation.

It is also noted that the regional plans for plant upgrade and interceptors assumed an updated Newark gate operation control flow of 715MGD at the PVSC plant. Newark CSO can be different when they are operated at different control flows.

Table F-1. Newark Recommended CSO LTCP Summary

Alternative	Plant Capacity	Alternative Description	CSO Percent Capture (%)	Cost for Newark (LCC in $M)
Municipal	Total 400 MGD	Modified Gate Operation	78.3%	$0.0
		Modified Gate Operation + Storage (28.5 MG at Three Outfalls)	87.0%	$358.3
		Modified Gate Operation + Storage + GI	87.7%	$448.6
		Modified Gate Operation + Storage + GI + Conservation	87.7%	$450.1
Regional	Total 720 MGD With secondary bypass	Plant Secondary Bypass + Storage	95.9%	$358.3
		Plant Secondary Bypass + Storage + Peddie St Regulator Modification	96.0%	$358.7
		Plant Secondary Bypass + Storage + Peddie St Regulator Modification +GI	96.3%	$449.0
		Plant Secondary Bypass + Storage + Peddie St Regulator Modification +GI + Conservation	96.3%	$450.5
		Regional Alt3b (Plant Secondary Bypass + Controlled Flow at Other Municipalities + Parallel Interceptor + Peddie St Regulator Modification Included)	95.9%	$0.4
		Regional Alt3b +GI	96.2%	$90.7
		Regional Alt3b +GI + Conservation	96.2%	$92.2

Notes:

1. The regional alternatives were evaluated with inflows from other municipalities, the capacities of FM and total plant were not modeled explicitly.

2. Newark's share of the cost for the regional alternative 3b was not included in the cost estimation as the cost sharing allocation is yet to be determined. It should be noted that under a regional alternative Newark would see cost saving as compared to a municipal only alternative

3. Water conservation has an estimated CSO reduction of 2.7% or capture of 0.02%. Percent capture adding conservation showed no change during round-off.

F.3 Implementation Cost opinion

For the Municipal LTCP alternative where the City of Newark needs to achieve 85% capture under a presumptive approach the estimated cost are presented in Table F-2. This shows the selected elements with two option for green infrastructure.

Table F-2 Implementation Cost Opinion

LTCP Element	Element Cost (LCC in $M)	CSO Percent Capture (%)	Cost for Newark (LCC in $M) Tree boxes	Cost for Newark (LCC in $M) Bio-retention and bioswales
Modified Gate Operation	$0.0	78.3%	$0.0	$0.0
Storage (28.5 MG at Three Outfalls)	$358.3	87.0%	$358.3	$358.3
Conservation	$1.5	87.0%	$359.8	$359.8
Green Infrastructure Tree Pits (137 acres managed)	$7.0	87.7%	$366.8	NA
Green Infrastructure 5% impervious area managed (213 acres managed)	$90.3	87.7%	NA	$450.1
Total			$366.8	$450.1

Notes:

1. Water conservation has an estimated CSO reduction of 2.7% or capture of 0.02%. Percent capture adding conservation showed no change during round-off.

Two options for the implementation of GI are included in the final cost opinion to show the range of costs when considering GI implantation using tree pits or rain gardens (bioretention/bioswales). Since the target GI build out of 5% of impervious area is not achieved by the lowest cost option (tree pits). The application of GI in the City od Newark will most probably be a combination of the two technologies. Given this the total cost for the Newark Municipal LTCP is between $366.8 million and $450.1 million.

F.4 Implementation Schedule

This section discusses the implementation schedule for the selected CSO LTCP. Newark assumes that the Post Construction Monitoring Program (PCMP) for the continued verification of compliance with the water quality standards will be coordinated through PVSC and the NJCSO Dischargers Group. As Newark's receiving waters already meet water quality standards, the PCMP will confirm continued compliance with standards and monitor changes any further improvements in water quality. In developing the implementation schedule, typical construction sequencing practices along with consideration of the FAC were used to identify a schedule that provides the greatest benefits to the region while maintaining affordability and a logical construction sequence to complete the recommended LTCP projects.

F.5 Bases for LTCP Development and Implementation Schedule

Table F-3 provides an overview of the implementation schedule by individual projects of the recommended LTC plan elements, and the plan elements were further broken down to phases. GI application, Newark gate operation modification, storage and water conservation will start after the LTCP plan is approved, while Peddie Street regulator modification will not be started till after the regional plan of plant secondary bypass, which provides additional conveyance capacity to deliver more south side flows to the plant.

For green infrastructure implementation, a four-phase approach is proposed to implement the 213 acre GI application. Each phase would spread in 5 years to accomplish the design (2 years), implementation (2 years) and post construction monitoring (1 year) of 25% (about 53 acres) of the targeted impervious areas; and each phase would start after the previous phase's design stage is completed, i.e. two years apart. The schedule included a 20-year O&M period after construction of each phase, extending the total schedule to 30 years after LTCP approval.

It is proposed that the water conservation program is to consist of four phases of 5-programs spreading out to a course of 20 years after the LTCP approval, with a quarter of the conservation target being achieved in each phase.

The CSO storage project will be also be conducted in three phases, constructing one outfall tank in each phase. It is estimated to complete each tank's design and build in 5 years, and have a two year post monitoring following it. Because the storage plan has the highest cost, the three phases are to start with 2 years apart. The smallest storage (3.8MG at NE-022) is proposed to be built first, followed by the medium sized storage (7.6MG at NE-014), and the largest storage (at NE-009/010) will be built subsequently to spread out the cost. Similarly to the GI, a 20-year O&M period after construction for each tank is included in this schedule.

The estimated annual cost were also listed in Table F-3 with the assumption that 15% of the capital total cost is for design and 85% is for construction. O&M cost is evenly distributed for 20 years after construction, including the first year or two after construction when post construction monitoring takes place. Figure F-1 illustrates the annual cost variations based on the proposed LTCP implementation schedule as well as these cost assumptions. Accumulative cost for each year is also graphed in this figure.

This schedule assumed the major plan elements will be completed by 10 years after the LTCP approval, except for water conservation program. It is predicted that the average annual cost is $43.7M dollars for the first 10 years, with the highest cost at about $ 92M on the 7th year.

The schedule and cost distribution to the alternative GI plan option of 137ac tree pit implementation (as discussed in section D.4.3) in lieu of the 5% impervious GI implementation are also provided in Table F-3 and Figure F-2. The total cost for tree pit GI option is $367.2M in comparison to the $450.5M for the 5% impervious area GI application.

Table F-3. Proposed Newark CSO LTCP Implementation Schedule

	Projects Phases	Estimated Project Cost ($M)	Years After LTCP Plan Approval																													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Regional	Plant Secondary Bypass - Regional Plan	0																														
	Parallel Interceptor and Relief - Regional Plan	0																														
Newark Recommended Plan	Modified Regulator Gate Operation - Municipal Plan	0																														
	Green Infrastructure (213 ac) - Municipal and Regional Plans	90.23																														
	GI Design Phase I (25%)	3.1																														
	GI Implementation Phase I (25%)	17.6																														
	GI Post Monitoring and Maintenance Phase I (25%)	1.8																														
	GI Design Phase II (50%)	3.1																														
	GI Implementation Phase II (50%)	17.6																														
	GI Post Monitoring and Maintenance Phase II (50%)	1.8																														
	GI Design Phase III (75%)	3.1																														
	GI Implementation Phase III (75%)	17.6																														
	GI Post Monitoring and Maintenance Phase III (75%)	1.8																														
	GI Design Phase IV (100%)	3.1																														
	GI Implementation Phase IV (100%)	17.8																														
	GI Post Monitoring and Maintenance Phase IV (100%)	1.8																														
	Peddie Street Regulator Modification - Regional Plan	0.4																														
	Regulator Inspection and Design	0.16																														
	Regulator Modification Construction	0.24																														
	CSO Storage - Municipal and Regional Plan	358.33																														
	CSO Storage Land Acquisition/Design (NE-022)	8.8																														
	CSO Storage Construction (NE-022)	46.3																														
	Post Montoring and Maintenance (NE-022)	1.9																														
	CSO Storage Land Acquisition/Design (NE-014)	19.4																														
	CSO Storage Construction (NE-014)	84.2																														
	Post Montoring and Maintenance (NE-014)	2.6																														
	CSO Storage Land Acquisition/Design (NE-009/010)	31.9																														
	CSO Storage Construction (NE-009/010)	159.6																														
	Post Montoring and Maintenance (NE-009/010)	3.6																														
	Water Conservation - Municipal and Regional Plans	1.5																														
	Phase I (25%)	0.375																														
	Phase II (50%)	0.375																														
	Phase III (75%)	0.375																														
	Phase IV (100%)	0.375																														
	Estimated Cost for Recommended Plan ($M)		6.05	6.05	35.40	35.40	69.96	54.31	92.00	63.51	63.74	9.65	0.84	0.84	0.84	0.84	0.84	1.00	1.08	0.84	0.84	0.84	0.77	0.77	0.77	0.77	0.68	0.58	0.49	0.36	0.27	0.09
	Estimated Accumulative Cost for Recommended Plan ($M)		6.0	12.1	47.5	82.9	152.9	207.2	299.2	362.7	426.4	436.1	436.9	437.8	438.6	439.4	440.3	441.3	442.4	443.2	444.1	444.9	445.7	446.4	447.2	448.0	448.6	449.2	449.7	450.1	450.4	450.5
GI Tree Pit Option	Green Infrastructure (137 ac Tree Pit) - Municipal and Regional Plans	7.0																														
	GI Design Phase I (25%)	0.2																														
	GI Implementation Phase I (25%)	1.1																														
	GI Post Monitoring and Maintenance Phase I (25%)	0.5																														
	GI Design Phase II (50%)	0.2																														
	GI Implementation Phase II (50%)	1.1																														
	GI Post Monitoring and Maintenance Phase II (50%)	0.5																														
	GI Design Phase III (75%)	0.2																														
	GI Implementation Phase III (75%)	1.1																														
	GI Post Monitoring and Maintenance Phase III (75%)	0.5																														
	GI Design Phase IV (100%)	0.2																														
	GI Implementation Phase IV (100%)	1.1																														
	GI Post Monitoring and Maintenance Phase IV (100%)	0.5																														
	Estimated Cost for Recommended Plan w/ Tree Pit GI Option ($M)		4.59	4.59	25.71	25.71	60.19	44.55	82.16	53.66	55.19	1.11	0.57	0.57	0.57	0.57	0.57	0.73	0.81	0.57	0.57	0.57	0.50	0.50	0.50	0.50	0.47	0.38	0.36	0.23	0.20	0.02
	Estimated Accumulative Cost for Recommended Plan ($M)		4.6	9.2	34.9	60.6	120.8	165.3	247.5	301.2	356.3	357.5	358.0	358.6	359.2	359.7	360.3	361.0	361.9	362.4	363.0	363.6	364.1	364.6	365.1	365.6	366.0	366.4	366.8	367.0	367.2	367.2

GI Design, Construction or Post Monitoring	GI O&M	Storage Design, Construction or Post	Storage O&M	Plant Secondary Bypass Expansion
Water Conservation Program	Gate Operation Modification	Regulator Modification Design or Construction	Regional Parallel Interceptor (Alt3b)	

*It is assumed that design is 15% of Capital Cost, construction is 85% of Capital Cost, O&M is 20 year after construction and O&M cost is equality distributed in the 20 years.

**Post monitoring schedule is estimated, but it is assumed its cost is part of the O&M cost and was not separately estimated.

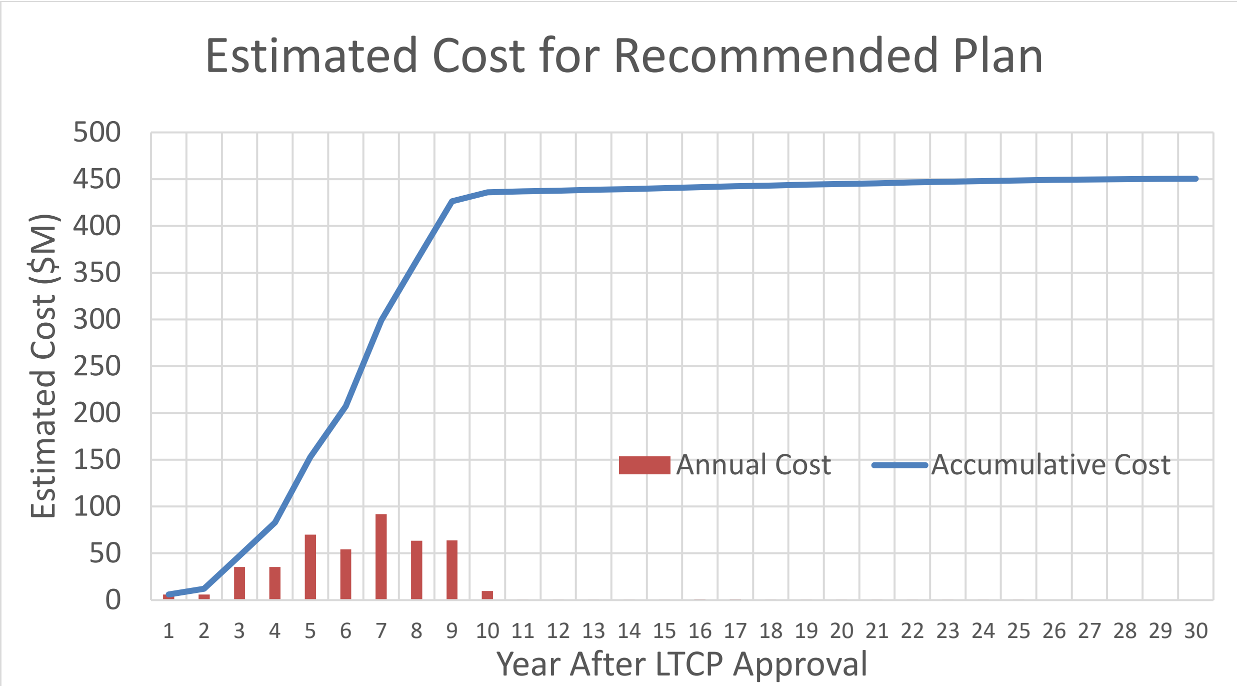


Figure F-1. Estimated Newark Cost with LTCP Implementation Schedule

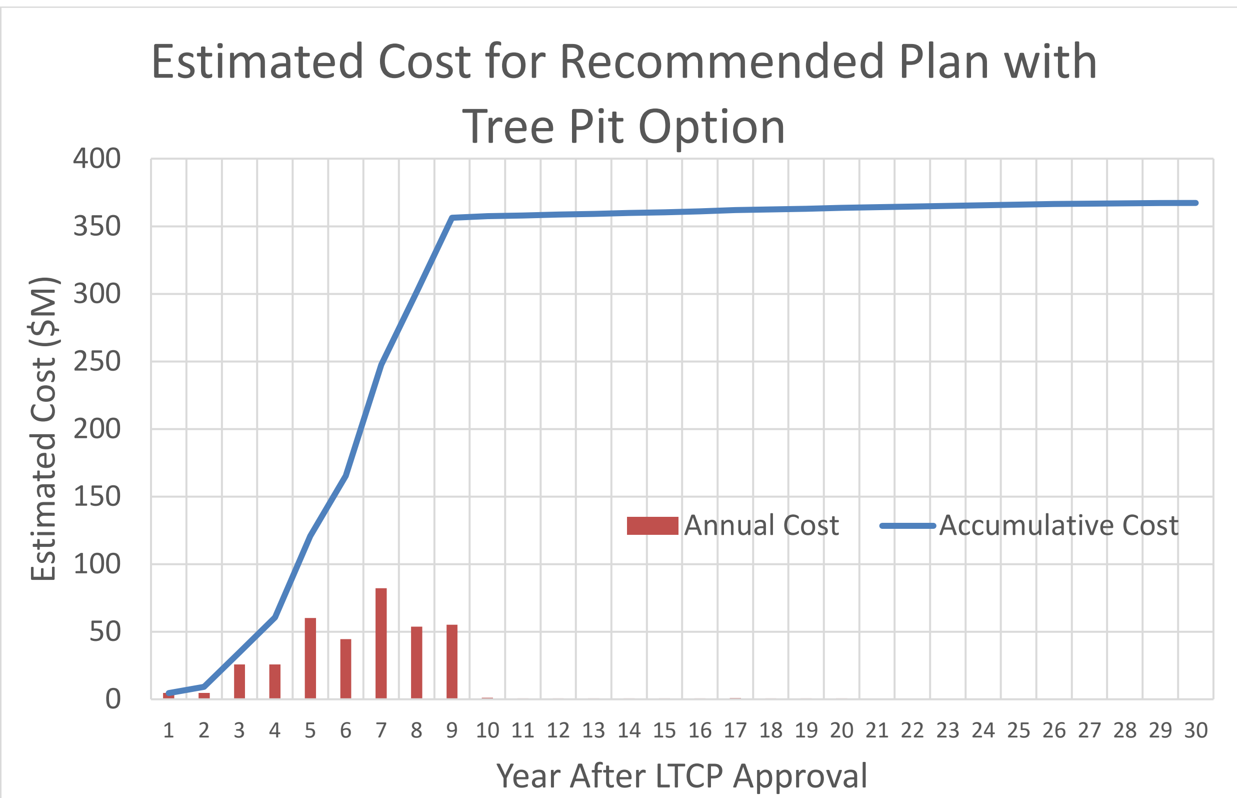


Figure F-2. Estimated Newark Cost (Tree Pit Option) with LTCP Implementation Schedule

F.6 CSO Reduction versus Time

The rate of CSO reduction versus time is also estimated based on the proposed LTCP implementation schedule as shown in Table F-4. The reduction calculation are categorized to 1) Municipal Plan, assuming baseline condition on PVSC plant operation and flows from other hydraulic connected municipalities including Paterson, Kearny, Harrison, East Newark, Bayonne, Jersey City and North Bergen; and 2) Regional plan, when PVSC plant is expanded to secondary bypass, and furthermore, according to the regional plant Alt3b, where a parallel interceptor is added to receive Newark regulator relief flows and the increased flows from other hydraulic connected municipalities under their Alt3b CSO reduction target. In Table F-4, CSO reduction of a plan phase is assumed to occur when its construction is completed in this estimation.

The annual CSO reduction is plotted in Figure F-3 for both the municipal plan and the regional plan. For the municipal plan, the highest CSO reductions will be achieved at the beginning when regulator gate operation modification is implemented, and subsequently when each storage tank is constructed. For the regional plan, the highest CSO reductions will be reached when the PVSC plant is upgraded to secondary bypass and then when the parallel interceptor plan is implemented. Figure F-4 and Figure F-5 illustrate the accumulative amount of CSO reduction and remaining discharge volume with time out of the original 1319 MG discharge from baseline prior to the plan implementation.

		Projects Phases	CSO Reduction (MG)	CSO Reduction for Years After LTCP Plan Approval																			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Newark Municipal Plan	Plan Elements	Modified Regulator Gate Operation	74.0	74																			
		Green Infrastructure (213 ac)	60.8																				
		GI Design Phase I (25%)	0.0	0	0																		
		GI Implementation Phase I (25%)	15.2			0	15.2																
		Post Monitoring and Maintenance Phase I (25%)	0.0					0															
		GI Design Phase II (50%)	0.0			0	0																
		GI Implementation Phase II (50%)	15.2					0	15.2														
		Post Monitoring and Maintenance Phase II (50%)	0.0							0													
		GI Design Phase III (75%)	0.0					0	0														
		GI Implementation Phase III (75%)	15.2							0	15.2												
		Post Monitoring and Maintenance Phase III (75%)	0.0									0											
		GI Design Phase IV (100%)	0.0							0	0												
		GI Implementation Phase IV (100%)	15.2									0	15.2										
		ost Monitoring and Maintenance Phase IV (100%)	0.0											0									
		CSO Storage	498.3																				
		CSO Storage Design (NE-022)	0.0	0	0																		
		CSO Storage Construction (NE-022)	44.3			0	0	44.3															
		Post Montoring and Maintenance (NE-022)	0.0						0	0													
		CSO Storage Design (NE-014)	0.0			0	0																
		CSO Storage Construction (NE-014)	154.5					0	0	154.5													
		Post Montoring and Maintenance (NE-014)	0.0								0	0											
		CSO Storage Design (NE-009/010)	0.0					0	0														
		CSO Storage Construction (NE-009/010)	299.5							0	0	299.5											
		Post Montoring and Maintenance (NE-009/010)	0.0										0	0									
		Water Conservation	36.0																				
		Phase I (25%)	9.0	1.8	1.8	1.8	1.8	1.8															
		Phase II (50%)	9.0						1.8	1.8	1.8	1.8	1.8										
		Phase III (75%)	9.0											1.8	1.8	1.8	1.8	1.8					
		Phase IV (100%)	9.0																1.8	1.8	1.8	1.8	1.8
	Estimated Yearly CSO Reduction (MG)			**75.8**	**1.8**	**1.8**	**17.0**	**46.1**	**17.0**	**156.3**	**17.0**	**301.3**	**17.0**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
	Estimated Accumulative CSO Reduction (MG)			**75.8**	**77.6**	**79.4**	**96.4**	**142.5**	**159.5**	**315.8**	**332.8**	**634.1**	**651.1**	**652.9**	**654.7**	**656.5**	**658.3**	**660.1**	**661.9**	**663.7**	**665.5**	**667.3**	**669.1**
	Estimated CSO Discharge (MG)		**1319.0**	**1243.2**	**1241.4**	**1239.6**	**1222.6**	**1176.5**	**1159.5**	**1003.2**	**986.2**	**684.9**	**667.9**	**666.1**	**664.3**	**662.5**	**660.7**	**658.9**	**657.1**	**655.3**	**653.5**	**651.7**	**649.9**
Regional Plan	Plan Elements	Plant Secondary Bypass	757.6	0	0	0	0	757.6															
		Parallel Interceptor and Relief (Alt3b)	324.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	324.3					
		Green Infrastructure (213 ac)	24.0																				
		GI Design Phase I (25%)	0.0	0	0																		
		GI Implementation Phase I (25%)	6.0			0	6																
		Post Monitoring and Maintenance Phase I (25%)	0.0					0															
		GI Design Phase II (50%)	0.0			0	0																
		GI Implementation Phase II (50%)	6.0					0	6														
		Post Monitoring and Maintenance Phase II (50%)	0.0							0													
		GI Design Phase III (75%)	0.0					0	0														
		GI Implementation Phase3 III (75%)	6.0							0	6												
		Post Monitoring and Maintenance Phase III (75%)	0.0									0											
		GI Design Phase IV (100%)	0.0							0	0												
		GI Implementation Phase IV (100%)	6.0									0	6										
		ost Monitoring and Maintenance Phase IV (100%)	0.0											0									
		Peddie Street Regulator Modification	3.5																				
		Regulator Inspection and Design	0.0																0				
		Regulator Modification Construction	3.5																	3.5			
		Water Conservation	36.0																				
		Phase I (25%)	9.0	1.8	1.8	1.8	1.8	1.8															
		Phase II (50%)	9.0						1.8	1.8	1.8	1.8	1.8										
		Phase III (75%)	9.0											1.8	1.8	1.8	1.8	1.8					
		Phase IV (100%)	9.0																1.8	1.8	1.8	1.8	1.8
	Estimated Yearly CSO Reduction (MG)			**1.8**	**1.8**	**1.8**	**7.8**	**759.4**	**7.8**	**1.8**	**7.8**	**1.8**	**7.8**	**1.8**	**1.8**	**1.8**	**1.8**	**326.1**	**1.8**	**5.3**	**1.8**	**1.8**	**1.8**
	Estimated Accumulative CSO Reduction (MG)			**1.8**	**3.6**	**5.4**	**13.2**	**772.6**	**780.4**	**782.2**	**790.0**	**791.8**	**799.6**	**801.4**	**803.2**	**805.0**	**806.8**	**1132.9**	**1134.7**	**1140.0**	**1141.8**	**1143.6**	**1145.4**
	Estimated CSO Discharge (MG)		**1319.0**	**1317.2**	**1315.4**	**1313.6**	**1305.8**	**546.4**	**538.6**	**536.8**	**529.0**	**527.2**	**519.4**	**517.6**	**515.8**	**514.0**	**512.2**	**186.1**	**184.3**	**179.0**	**177.2**	**175.4**	**173.6**

Legend
- GI Design, Construction or Post Monitoring
- GI O&M
- Storage Design, Construction or Post Monitoring
- Storage O&M
- Water Conservation Program
- Gate Operation Modification
- Regulator Modification Design or Construction
- Plant Secondary Bypass Expansion
- Regional Parallel Interceptor (Alt3b)

Table F-4. Estimated Newark CSO Changes with LTCP Implementation Schedule

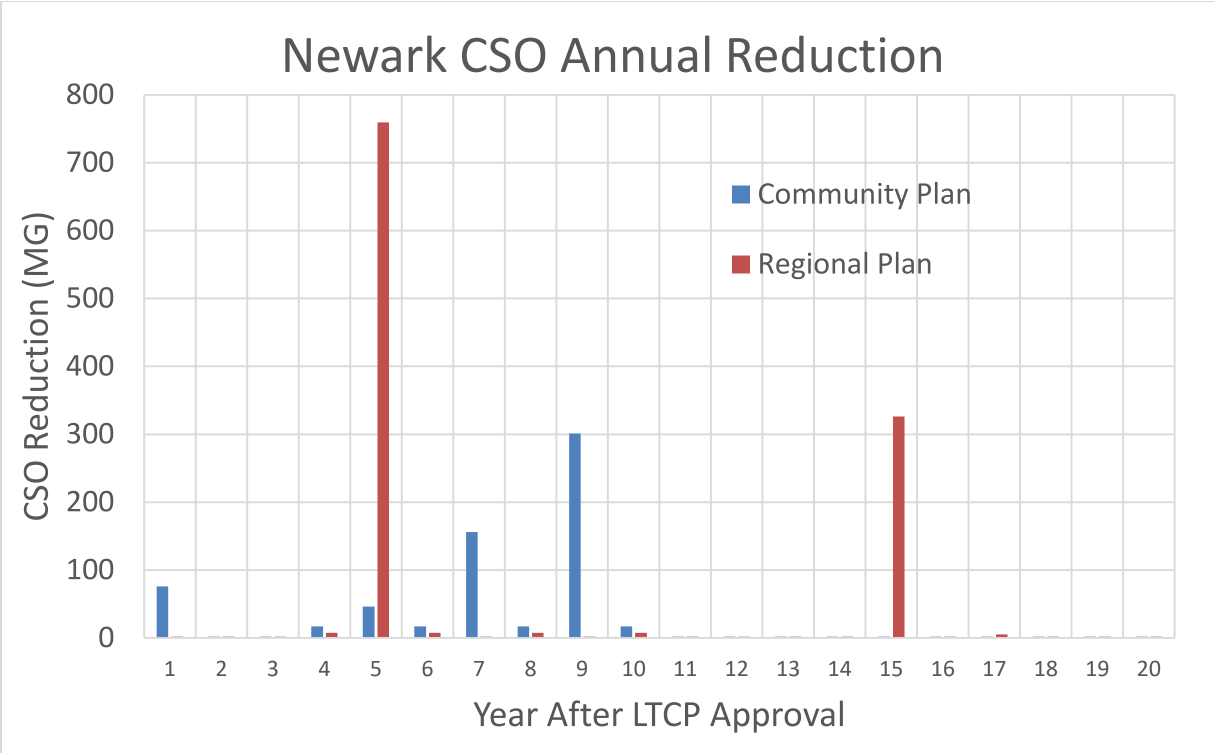


Figure F-3. Estimated Newark CSO Changes with LTCP Implementation Schedule

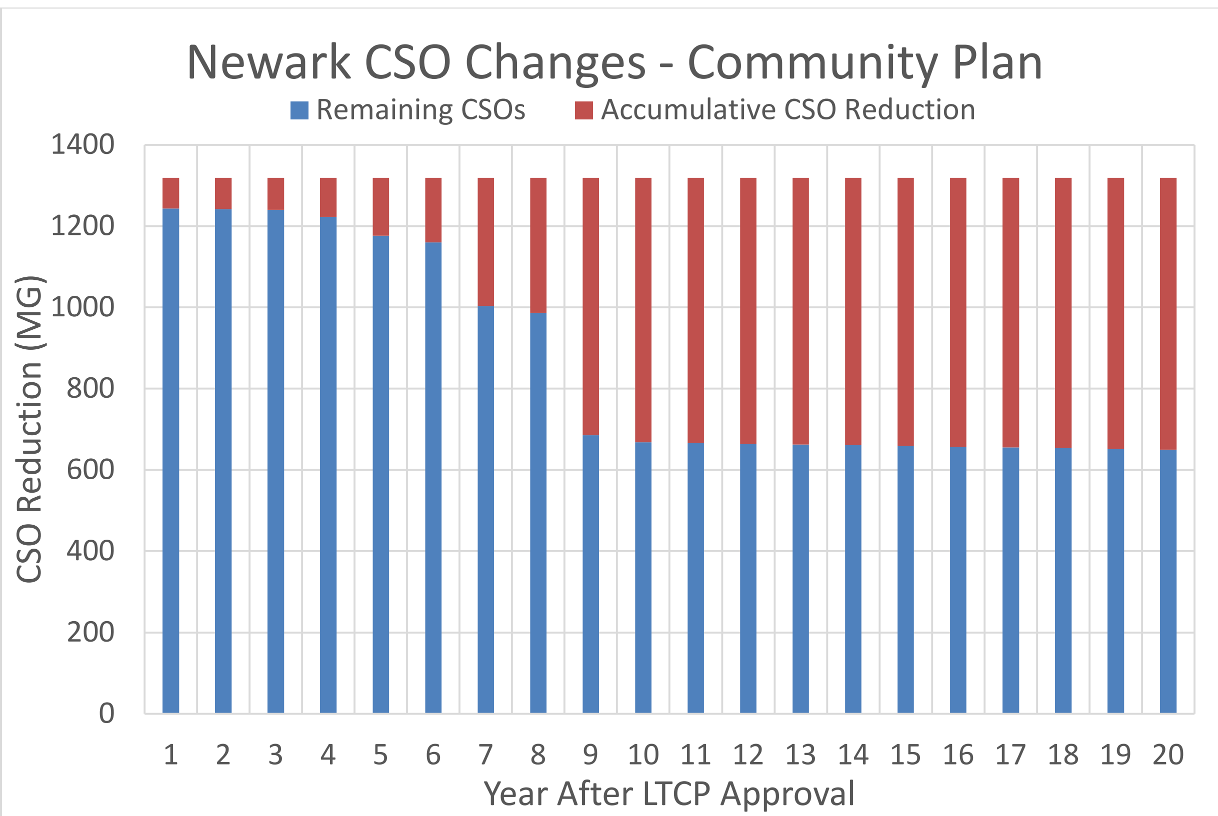


Figure F-4. Estimated Newark CSO Reduction for Municipal Plan

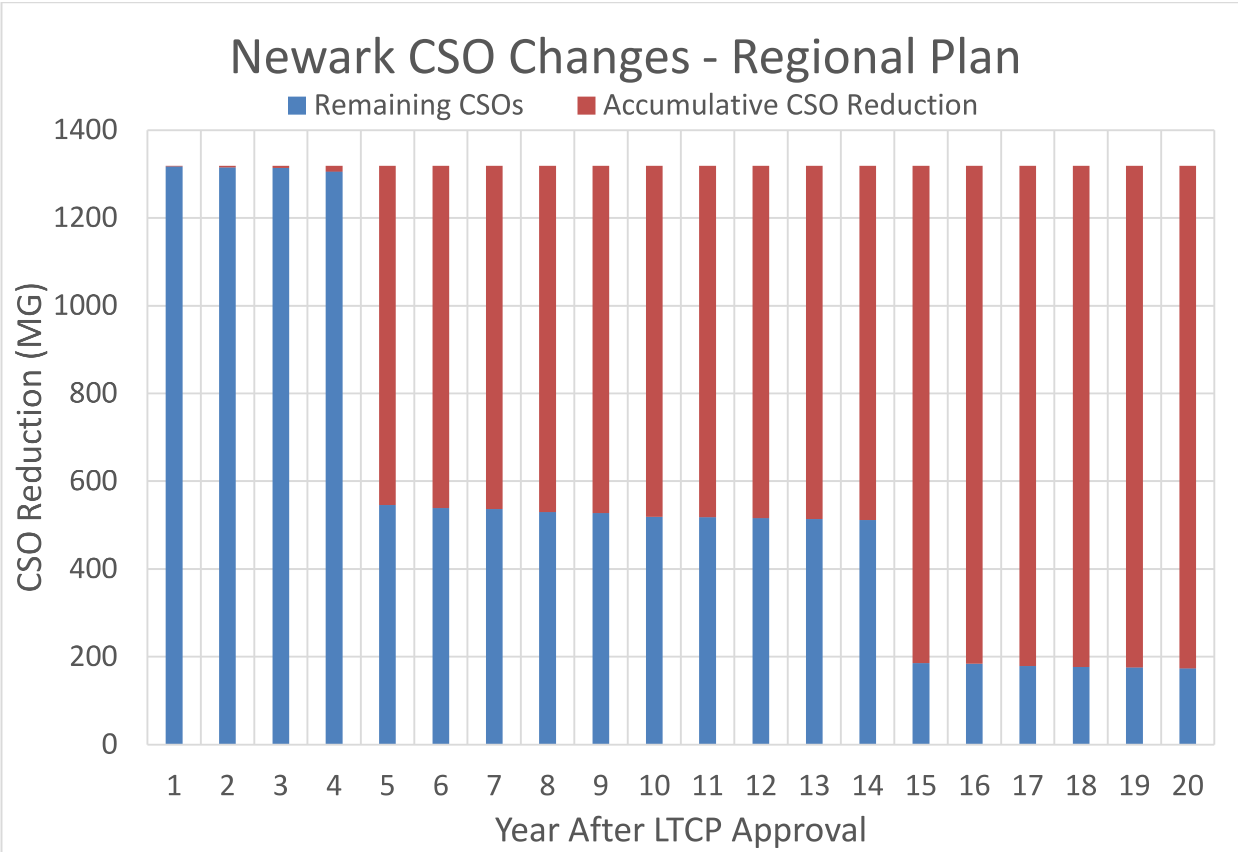


Figure F-5. Estimated Newark CSO Reduction for Regional Plan