Appendix D

Development and Evaluation of Alternatives Regional Report
and
NJDEP approval letter dated January 17, 2020

State of New Jersey

PHIL MURPHY
Governor

SHEILA OLIVER
Lt. Governor

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Via E-mail
January 17, 2020

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Re: Approval of Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report
Passaic Valley Sewerage Commissioners, NJPDES Permit No. NJ0021016
Bayonne City Municipal Utilities Authority, NJPDES Permit No. NJ0109240
Borough of East Newark, NJPDES Permit No. NJ0117846
Town of Harrison, NJPDES Permit No. NJ0108871
Jersey City Municipal Utilities Authority, NJPDES Permit No. NJ0108723
Town of Kearny, NJPDES Permit No. NJ0111244
City of Newark, NJPDES Permit No. NJ0108758
North Bergen Municipal Utilities Authority, NJPDES Permit No. NJ0108898
City of Paterson, NJPDES Permit No. NJ0108880

Dear Permittees:

Thank you for your most recent submission dated November 22, 2019 which serves to update your July 1, 2019 submission entitled "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" as submitted to the New Jersey Department of Environmental Protection (the Department or NJDEP). The regional report and subsequent revision were submitted in a timely manner and were prepared in response to Part IV.D.3.v of the above referenced NJPDES permit as part of the development of the Long-Term Control Plan (LTCP) submittal requirements where the next deliverable is due on June 1, 2020.

The "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report" includes individual reports developed by PVSC and each of its 8 member combined sewer municipalities as Appendices. This subject letter serves to provide a response to the Regional Report where approval of this report serves to fulfill Part IV.D.3.b.v. Separate comment letters specific to Appendices A through I have been provided under separate cover.

The overall objective of the Development and Evaluation of Alternatives Report is to develop and evaluate a range of CSO control alternatives that meet the requirements of the Federal CSO Control Policy Section II.C.4, N.J.A.C. 7:14A-11, Appendix C, and the USEPA Combined Sewer Overflows Guidance for Long-Term Control Plan (EPA 832-B-95-002). Such evaluation shall include a range of CSO control alternatives for eliminating, reducing, or treating CSO discharge events. This subject report builds on other previously submitted LTCP reports referenced in Part IV.D.3.b of the NJPDES permit, which includes an approved hydrologic, hydraulic and water quality model and other information in the June 2018 "System Characterization Report" (approved by the Department on April 12, 2019); the June 2018 "Public Participation Process Report" (approved by the Department on March 29, 2019); the June 30, 2018 "NJCSO Group Compliance Monitoring Program Report" (approved by the Department on March 1, 2019; and the June 2018 "Identification of Sensitive Areas Report" (approved by the Department on April 8, 2019).

The Department provided technical comments on your Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report on September 25, 2019. In response to that letter, the Department received a revised regional report on November 22, 2019. Based on a review of the revised information, the Department has determined that **all technical comments have been fully addressed** but would like to comment on certain aspects of that submission:

Comment 1

The issue of percent capture and hydraulically connected system are discussed in Comment 1 and Comment 2 of the Department's September 25, 2019 letter on the "Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report." The following is stated with respect to percent capture within Section C.1.1 (Water Quality and CSO Control Goals) of the regional report, which includes additional text and an equation as compared to the original submission (additions shown with underline where the equation is also an addition):

> "…**Table C-8** presents the baseline existing wet weather percent captures for the PVSC system in the PVSC Interceptor Communities and HCFM communities. In reference to percent capture in this section of the report and the following sections, the equation used to calculate CSO capture for PVSC over a representative time frame is as follows:

$$\text{Percent capture} = 100 \times \frac{\text{Sum of volume delivered to acceptable treatment}}{\text{Sum of inflow volumes to the CSS [sanitary + runoff]}}$$

For the percent capture calculation, the wet weather period starts when the accumulated rainfall depth is greater than 0.1 inch and ends 12 hours after precipitation stops. The flow volume within this period is counted as wet weather flow.

This information has been updated as a result of refinements to the H&H model since the submittal of the System Characterization Report and will continue to change as the model is refined. No significant changes from the System Characterization Report have resulted from the updated model, and JCMUA's information has been added to the HCFM communities.

Table C-8: Typical Year % Capture

	PVSC Interceptor Communities	Hudson County Force Main Communities
Total Wet Weather Volume (MG)	12,495	6,411
Total CSO Volume (MG)	2,042	2,222
% Capture	83.7%	65.3%
Additional Capture Volume (MG) for 85% Capture	168	1,260

"

While the Department is approving the Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report, the Department reserves the right to comment on the issue of percent capture, resultant percent capture calculations and the definition of hydraulically connected system as part of the LTCP process. In addition, the Department reserves the right to require a breakdown of percent capture results by subcatchment in order to approve any percent capture calculation as well as a clear explanation of the hydraulically connected systems.

Comment 2

In the response to NJDEP Comment 7 (HCFM Capacity, PVSC Acceptance of Additional Flows) it is stated that the current capacity of the PVSC main interceptor (that runs through Newark) is estimated to be roughly between 360 and 380 MGD; the current flow rate of the HCFM is 117 MGD; and the current maximum pump rate of the HCFM is 134 MGD.

The majority of combined sewer municipalities within the PVSC sewer district express interest in storage as a CSO control alternative where these tanks would be dewatered directly after a rainfall event. The report further describes a range of dewatering times such as a certain number of days or a certain rate. Given that these municipalities send their combined flow to PVSC, coordination will be needed in order to ensure that the HCFM and PVSC main interceptor have sufficient capacity to accept these stored flows and that the PVSC WWTF can handle such flows.

If storage is selected as a CSO control alternative, provide a detailed discussion on any such coordination as well as the ability of the conveyance systems and WWTF to accept these stored flows as part of the LTCP submission.

Comment 3

In your response to NJDEP Comment 9 (Cost Performance) it is stated that updates to the cost analysis have been included your revised report. As noted in the Department's September 25, 2019 letter, the Department is not commenting on any cost analysis at this time and will defer its comments until the LTCP submission.

In sum, conditional on the above issues being further discussed within the LTCP, the Department has determined that the Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewer Systems – Regional Report is hereby approved and that this permit condition is now satisfied.

The Department looks forward to submission of the Selection and Implementation of the LTCP as due on June 1, 2020. Please let us know if you have any questions regarding submission of that report.

Thank you for your continued cooperation.

Sincerely,

Susan Rosenwinkel

Susan Rosenwinkel
Bureau Chief
Bureau of Surface Water Permitting

C: via email Dwayne Kobesky, Bureau of Surface Water Permitting
Marzooq Alebus, Bureau of Surface Water Permitting
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Johnathan Lakhicharran, Bureau of Surface Water Permitting
Adam Sarafan, Bureau of Surface Water Permitting

DEVELOPMENT AND EVALUATION OF ALTERNATIVES FOR LONG TERM CONTROL PLANNING FOR COMBINED SEWER SYSTEMS - REGIONAL REPORT

Submitted on behalf of the following participating Permittees
By the Passaic Valley Sewerage Commission:

Passaic Valley Sewerage Commission (NJ 0021016)
City of Bayonne (NJ0109240)
Borough of East Newark (NJ0117846)
Town of Harrison (NJ0108871)
Jersey City Municipal Utilities Authority (JCMUA) (NJ0108723)
Town of Kearny (NJ0111244)
City of Newark (NJ0108758)
North Bergen Municipal Utilities Authority (NBMUA) (NJ0108898)
City of Paterson (NJ0108880)

Passaic Valley Sewerage Commission
Essex County
600 Wilson Avenue
Newark, New Jersey

"Protecting Public Health and the Environment"

June 2019
Revised 11/22/19

SECTION A - INTRODUCTION AND BACKGROUND

A.0 SUMMARY OF CHANGES

This is the Regional Report for the Development and Evaluation of Alternatives for Long Term Control Planning for Combined Sewers to be utilized by the Passaic Valley Sewerage Commission ("**PVSC**"), later referred to as "this Report," and the entities who own and operate combined sewer collection systems within the PVSC Treatment District. This Report describes the receiving water characterization including water quality results, technology screening process, and the evaluation of combined sewer overflow ("CSO") control alternatives for the PVSC Treatment District. This Report compiles the results of the nine (9) individual Development and Evaluation of Alternatives Reports for the PVSC Treatment District. The history of this document and changes made to it are summarized below:In future versions, this section will include summaries of changes and when they were incorporated as appropriate.

- June 28, 2019: Submitted Development and Evaluation of Alternatives Regional Report in fulfillment of the LTCP Permit requirement.
- Revised November 22, 2019: Modified the Development and Evaluation of Alternatives Regional Report to address comments made by NJDEP in a series of letters dated September 25, 2019. Copies of the September 25, 2019 letters are included in Appendix K of this document. The June 28, 2019 submitted Development and Evaluation of Alternatives Regional Report was 99 pages with 918 pages of Appendices included separately. This version includes updates that resulted in a total of 125 pages in the report including the cover, and 1149 pages of Appendices. Table of Contents and page number updates are not reflected with redline-strikeout in this document. The following pages in this document have been changed to address NJDEP comments, with changes shown in redline-strikeout throughout the document:
  1. **Regional Evaluation of Alternatives Report**
     a) NJDEP Comment 1 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.
     b) NJDEP Comment 2 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
     Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Forebay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to

the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Forebay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF.

c) NJDEP Comment 3 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

d) NJDEP Comment 4 (STP Expansion) – Acknowledged. All instances of referencing bypassing as "expansion" has been replaced with "bypass." Section C.6 header has been changed to "Sewage Treatment Plant Expansion, Storage, or Bypass at the Plant."

e) NJDEP Comment 5 (Public Participation) – Section D.1.5 has been modified and new Appendix K - Public Comments, has been added.

f) NJDEP Comment 6 (Tunnel Discrepancies) – Appendix A contains evaluation of alternatives for the regulators owned and operated by PVSC. The alternatives presented include only these PVSC-owned regulators. The number and municipal locations of PVSC-owned regulators can be found in Table D-1 in Section D.2.3 of the PVSC Service Area System Characterization Report. The NJ440 Tunnel was not included in Appendix A as there are no PVSC-owned regulators in its service area.
In Section D.2.9 of Appendix B, Bayonne, North Bergen, and Jersey City (HCFM Communities) determined through a separate regional deep tunnel analysis from PVSC that the costs of this alternative exceeded the feasible costs of other alternatives, and no further evaluation was given. In addition, their dewatering limitation of 45.4 MGD, as indicated in their hydraulic model, would only feasibly achieve up to the 20 and 12 maximum overflows per year levels of control. The stored volumes cannot be dewatered in a timely manner to achieve the 8, 4, or 0 maximum overflows per year levels of control.
The storage tunnel evaluations in Section D.2.2 in this report relating to Regional Alternatives 2 and 4 provide a theoretical evaluation of the Paterson Citywide, McCarter Highway, and NJ440 tunnels for all levels of control to provide an all-encompassing evaluation of alternatives for the PVSC system. The NJ440 Tunnel is not the same as the regional deep tunnel evaluated by the HCFM communities, but the dewatering limitations will require an upgrade to the HCFM to achieve the more stringent levels of control. Please see modified Section D.2.2 for added language to clarify these discrepancies.

g) NJDEP Comment 7 (HCFM Capacity, PVSC Acceptance of Additional Flows) – In addition to increasing the flow through the HCFM and adding a new, parallel interceptor, Regional Alternatives 2, 3, and 4 evaluating adding wet weather flow capacity through a WRRF bypass. This would allow PVSC to accept these stored flows as proposed. A major limitation is at the higher levels of control (up to 0, 4, and 8 overflow events per year) for the HCFM communities due to the tunnel dewatering flow restrictions in the current force main, as noted in Section D.2.9 of Appendix B. The HCFM has a current flow rate of 117 MGD, as noted on page 415 in Appendix B of the PVSC Service Area System Characterization Report. Should a force main expansion occur beyond the proposed pump upgrades to the current system, the maximum 146 MGD flow rate can potentially increase. These flows would have to be re-evaluated by the PVSC WRRF, as the additional capacity available from the bypass needs to be allocated based on its member communities' needs. This is in addition to any alternatives to convey more flow to the plant from the interceptor-side communities, such as a parallel interceptor. The current capacity of the PVSC main interceptor that runs through Newark is estimated to be roughly 360-380 MGD based on the June 7, 2016 Technical Memorandum regarding the main interceptor completed by HDR. This capacity is consistent with the 1972 Manganaro Martin and Lincoln study of the main interceptor estimating flow to be between 350-370 MGD in Newark near the WRRF. Any changes to this value will be presented in the Selection and Implementation of Alternatives Report due June 1, 2020. No changes required.

h) NJDEP Comment 8 (Alternatives Descriptions) – See modified Section D.2.3 for the change from PVSC Alternative 5a to the correct description of Alternative 6.a.1, and modified D.2.4 for the change from PVSC Alternative 6 to the correct description of Alternative 7.a, respectively.

i) NJDEP Comment 9 (Cost Performance) – Acknowledged. Updates to the cost opinions have been included in Section D.2 and in Appendices A through I. These cost opinions and any further updates will be included in the Selection and Implementation of Alternatives Report.

2. PVSC Evaluation of Alternatives Report

a) NJDEP Comment 1 (Water Conservation Measures) – Section B.4 of Appendix A has been updated to reflect this comment. Historical data indicates that even as population has increased within the PVSC WRRF service area, the influent flow has decreased. From 1990-2015 population in Bergen, Essex, Hudson, Passaic, and Union counties, which comprise all 48 municipalities connected to the WRRF, has increased, while the average daily flow at the WRRF has decreased. A graph showing the inverse relationship is included as Figure B-1 in Appendix A. The data suggests that per capita water usage is decreasing at a rate that more than offsets the increase in population. Based on this historical precedent, it is assumed that flows will remain constant despite the projected 20% increase in population.

b) NJDEP Comment 2 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.

c) NJDEP Comment 3 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.

Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Forebay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Forebay just before the Primary Clarifiers."

The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation, and modified Section D.1.6 in Appendix A for further discussion of segmentation of the PVSC-serviced communities.

d) NJDEP Comment 4 (GI Measures) – 1) This ratio range of 1 gallon of CSO reduction per 1.4 to 2 gallons of runoff treated by GI, is not assumed but is calculated by the GI model. The language in this section has been revised for clarity. See modified Section C.2.1 of Appendix A; 2) These impervious surface targets are for general land cover and no possible specific locations were considered for GI opportunities in the PVSC sewer district area. As PVSC does not own property outside of the WRRF, it is difficult for PVSC to determine which areas would be the most appropriate to use for each permittee; 3) The volume referenced were derived from the model output.
e) NJDEP Comment 5 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible, we will consider protective measures outlined by the NJDEP. No changes required.
f) NJDEP Comment 6 (WRRF Expansion) – All references of the WRRF bypass as an expansion have been corrected. See modified Appendix A.
g) NJDEP Comment 7 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.
h) NJDEP Comment 8 (HCFM Capacity) – The current max capacity of the HCFM with no improvements is based on the current maximum pump rates available, 134 MGD. This is stated in the model integration presentation slides for the Jersey City model in the PVSC Service Area System Characterization Report. The current maximum capacity of the HCFM with new pumps is 146 MGD. Construction of a parallel force main is required to achieve 185 and 235 MGD capacities of the HCFM. This information has been included in Section D.2 of Appendix A.

i) NJDEP Comment 9 (CSO Volume Capture in HCFM) – Section D.2.6 of Appendix A has been revised for clarity. The slight increase in CSO volume captured under this alternative, despite a lower HCFM capacity relative to Alternative 5 is attributed to the hydraulic capacity at the WRRF and measuring performance by focusing on outfalls equipped with PVSC-owned and operated regulators as described under Section D.1.5 in Appendix A. Increasing the HCFM capacity to 146 MGD instead of 235 MGD as under Alternative 5, results in less capacity to capture CSO at outfalls hydraulically linked to the HCFM, but creates additional capacity at the WRRF for influent from the Main Interceptor. Because outfalls inthe Hudson County Force Main service area are not connected to PVSC-owned and operated regulators, the additional CSO capture by expanding the HCFM is not reflected in the performance results, which are constrained to PVSC-owned and operated regulators.

j) NJDEP Comment 10 (Storage Tank Locations) – Sections C.5.1.1 & C.5.2.1 of Appendix A have been revised to reflect these comments. All proposed storage tank configurations were given footprint areas in properties that have the potential to can some number of stated design volumes for storage.Certain tank configurations are not capable of meeting the target control levels (e.g. A proposed tank listed for the 0 OF configuration is constructible within the area footprint up to a certain size, but may not have sufficient area large enough to provide enough storage volume to meet the 0 OF control level.) These tanks are denoted in Table C-8 in Appendix A with an asterisk. All stored flow will be sent to the PVSC WRRF with no conveyance limitations. All proposed tanks are capable of being constructed above ground. Existing land usage and ownership information for the proposed tank locations have been identified, although no consideration has been given to any above ground amenities, because PVSC does not own any of the land.

k) NJDEP Comment 11 (Storage Tank Discrepancies) – There are a total of 11 storage tanks. Figures D-2, D-15, and D-15a in Appendix A have been corrected to call out the 11 storage tanks.

l) NJDEP Comment 12 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

3. Evaluation of Alternatives Report for City of Bayonne

a) NJDEP Comment 1 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.

b) NJDEP Comment 2 (Approach and Percent Capture) – An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation. Appendix B - Section D.1.5 has been modified.

c) NJDEP Comment 3 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.

Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Forebay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Forebay just before the Primary Clarifiers."

The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.

d) NJDEP Comment 4 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

e) NJDEP Comment 5 (GI Acreage Values) – As described in Section D.2.2 of Appendix B, the acreage associated with the two GI control levels evaluated are 50 acres and 100 acres of existing impervious surface. The two levels of control for GI were selected because they represent the range of what was initially targeted (10% of impervious areas) and found to be achievable (5% of impervious surfaces) in New York City, and that this range is consistent with anecdotal evidence from other communities. The actual number and location of GI projects will be determined during final Selection of Alternatives. GI cannot alone attain the CSO-control goals required, and the CSO control that can be achieved with GI is not cost effective versus other controls.

Siting considerations are discussed in Section D.1.1 of Appendix B, notably that Bayonne will seek "available City-owned sites, as those have minimal impact on sensitive stakeholders and lower potential to be controversial," and that even on City-owned sites, related issues include "buffer for roadways, accessibility, and potential conflicts with existing utilities." GI projects are particularly difficult for the municipality to site and maintain on private property, as noted in Table C-1 (pages 21-22) of Appendix B. Due to the dearth of available open space distributed across all CSO catchments, widespread GI projects would most likely need to be in the form of street side planter boxes set within the street right-of-way.

f) NJDEP Comment 6 (Storage Tanks) – Bayonne acknowledges that increased conveyance of wet-weather flows to the PVSC treatment plant is necessary to achieve some of the Presumptive Approach metrics, such as achieving fewer than

20 CSO events per typical year. However, Bayonne would like to point out that this is only an option if NJDEP approves an increase in PVSC's wet-weather flow rate, and if PVSC in turn increases its peak flow-rate agreement with Bayonne. Bayonne is beholden to these actions prior to being able to realistically consider this option.

Furthermore, the consolidated storage-tank sites shown on Figure D-2 (page 43) were evaluated for land ownership, and City-owned and vacant sites were considered to be more available than other sites. In addition, non-contaminated sites were also considered to be more desirable than contaminated sites. A final determination of site suitability will be performed in the Selection and Implementation of Alternatives phase.

Storage tanks that can fill by gravity are preferred over storage alternatives that require pumping to fill. As a result, the storage tanks will be subsurface. Subsurface-tank amenities, such as parks or other beneficial use, will be considered, and Bayonne has already discussed this possibility in meetings with the public such as members of the Bayonne Water Guardians.

No analysis has been given to adding treatment facilities to the storage tank alternatives. As discussed in the Appendix B, end-of-pipe treatment alternatives were found to be substantially more cost-effective in achieving the targets than the storage-tank alternatives.

g) NJDEP Comment 7 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

h) NJDEP Comment 8 (PAA Disinfection) – Past studies have demonstrated that properly sized PAA disinfection systems can achieve a 3-log reduction (99.9% kill rate) with regard to bacteria (Bayonne MUA 2017, PeroxyChem 2016, WERF 2005). We are assuming that a 3-log reduction (99.9% kill rate) will be sufficient for planning purposes. Final design of disinfection facilities will consider more site specific testing information (e.g., jar testing) to help develop suitable capacities, disinfectant dosing, and effect of pretreatment for solids removal to achieve the target kill rate. The intention is to meet applicable water quality standards with respect to the identified pollutants of concern by understanding the additional chemical requirements necessary for treating the CSOs.

Cost developed for satellite treatment included pretreatment (removal of suspended solids) such as a Flex Filter system. Pretreatment adds to site requirements and significantly increases costs, so treatability tests to determine how much, if any, pretreatment is necessary for PAA disinfection.

i) NJDEP Comment 9 (Water Quality) – Modified Appendix B - Sections D.3.3.1, D.1.5, D.2.10, and Bayonne has removed every related statement regarding receiving water quality. Should the Demonstration approach be selected at a later date, the issue will be revisited.

j) NJDEP Comment 10 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.

As a result of this coordination, the HCFM communities have established that the existing capacity of the 72" diameter Hudson County Force Main is 146 MGD. This means that the HCFM is physically capable of conveying more flow toward PVSC than it currently conveys. Multiple scenarios assuming various increases from each of the four HCFM communities were considered. Without knowledge of whether or not NJDEP would permit PVSC to increase wet-weather flows such that the full 146 MGD capacity of the HCFM could be used, the HCFM communities have not developed an agreement for a particular allotment of the unknown additional capacity. However, indications are that a mutually agreeable allotment can be achieved. No changes required.

4. Evaluation of Alternatives Report for Borough of East Newark

a) NJDEP Comment 1 (BASF Property) – Meetings will be held with East Newark and BASF in the future. Plans for the property are still evolving for this private property. The property is currently inactive and was supposed to be remediated and redeveloped for ecological use. Now there is a plan to redevelop it as a 616 residential unit complex. If this is done, East Newark may require that the redevelopment be separately sewered.

   The location for the storage tank alternative has not been determined other than to say that it will be along the waterfront of East Newark. See modified Section B.3 in Appendix C.

b) NJDEP Comment 2 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.

Communities were instructed that the HGL in the main interceptor should not be increased beyond existing conditions and the alternatives evaluated in their respective DEARs should reflect this. See modified Sections C.4 and C.6 in Appendix C.

c) NJDEP Comment 3 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.
d) NJDEP Comment 4 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.
e) NJDEP Comment 5 (Hydraulic Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Forebay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Forebay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.
f) NJDEP Comment 6 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.
g) NJDEP Comment 7 (GI Acreage Values) – The BASF property is 14 acres. For the Partial SS + 5% GI alternative we modeled 11.4 acres with sewer separation and 2.6 acres with GI. For the Partial SS + 10% GI we modeled 8.8 acres with sewer separation and 5.2 acres with GI. Sewer separation eliminates CSO while GI only eliminates CSO up to 1 inch of rain.
See Section C.2.1 in Appendix C for further GI opportunities in East Newark. The Rutgers study employed pervious pavement at most locations and stormwater planters and tree pits along the waterfront. They did not consider the BASF property for GI.

h) NJDEP Comment 8 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

i) NJDEP Comment 9 (PAA Disinfection) – Past studies have demonstrated that properly sized PAA disinfection systems can achieve a 3-log reduction (99.9% kill rate) with regard to bacteria (Bayonne MUA 2017, PeroxyChem 2016, WERF 2005). We are assuming that a 3-log reduction (99.9% kill rate) will be sufficient for planning purposes. Final design of disinfection facilities will consider more site specific testing information (e.g., jar testing) to help develop suitable capacities, disinfectant dosing, and effect of pretreatment for solids removal to achieve the target kill rate. The intention is to meet applicable water quality standards with respect to the identified pollutants of concern by understanding the additional chemical requirements necessary for treating the CSOs.
Cost developed for satellite treatment included pretreatment (removal of suspended solids) such as a Flex Filter system. Pretreatment adds to site requirements and significantly increases costs, so treatability tests to determine how much, if any, pretreatment is necessary for PAA disinfection.

5. Evaluation of Alternatives Report for Town of Harrison

a) NJDEP Comment 1 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.

b) NJDEP Comment 2 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.

c) NJDEP Comment 3 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Forebay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Forebay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.

d) NJDEP Comment 4 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

e) NJDEP Comment 5 (GI Acreage Values) – The representative GI units were modeled in InfoWorks using the InfoWorks SUDS (sustainable urban drainage systems) module as described in the last paragraph of Section D.2.7.2 in Appendix D. The reductions listed in Appendix D - Tables 61-66 were generated from the model output, and comparing the model output to the baseline conditions. No revisions made to the report.

f) NJDEP Comment 6 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.
Communities were instructed that the HGL in the main interceptor should not be increased beyond existing conditions and the alternatives evaluated in their respective DEARs should reflect this. PVSC provided guidance and coordinated the overall capacity of the interceptor system and plant capacity for purposes of alternatives development. Elements of the guidance provided are included in Section D and Appendix J. No changes required.

g) NJDEP Comment 7 (Storage Tank Sizing and Locations) – The required point storage sizes are summarized in Appendix D Tables 24-28 for individual sites and Appendix D Tables 31-35 for consolidated tanks. Figures 32-35 in Appendix D depict the layout of point storage tanks at the individual outfall for the 4 overflows level of control and Figures 38 and 39 in Appendix D depict the consolidated storage tank for 4 overflows.
Discussion of the nature of above and below grade facilities and site usage following the installation of the tanks is included in Appendix D Sections D.2.1.5 and D.2.2.5, including consideration given to parks where applicable. Regarding PVSC's acceptance of the dewatering flow, refer to response to Comment 6. No revisions made to report.

h) NJDEP Comment 8 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

i) NJDEP Comment 9 (Alternatives Approach) – Appendix D Section D.3 references that a mix of alternatives may be applied to formulate the LTCP. Apart from incorporating Green Infrastructure, which would not have a meaningful impact on the size of required facilities, there is little reason to mix alternatives such as storage and treatment at individual outfalls. The analysis does provide the building blocks to consider different approaches to each outfall, for example storage at some outfalls and treatment at others. However, to consider all the potential combinations would create an unreasonable number of alternatives. No revisions made to report.

6. **Evaluation of Alternatives Report for Jersey City Municipal Utilities Authority**

a) NJDEP Comment 1 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

b) NJDEP Comment 2 (Approach and Percent Capture) - An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation. Appendix E - Section D.1.5 has been modified.

c) NJDEP Comment 3 (Hydraulically connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Forebay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Forebay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.

d) NJDEP Comment 4 (GI Acreage Values) – The borings were plotted in GIS and shape files were drawn with the assistance of a rock geology map that encompass areas which have groupings of favorable borings with depth to rock and ground water in excess of ten feet.

To discover the effectiveness of GI per square foot a 100% GI scenario was performed, which assigned a depression storage of 1 inch and actual evaporation across the entire city during the 2004 typical year. Once inch of depression storage was chosen based on the goal of effective GI stated by NYDEP in the 2016 Green Infrastructure Performance Metrics Report is "...to manage the equivalent of stormwater generated by one inch of precipitation...". By using this run, we were able to determine an average volumetric retention per square foot in Jersey City. The percent capture increases from the baseline condition are as follows:

- Control of 7% of the impervious are increases the percent capture by 1% (170 MG wet weather overflow volume reduction) from the baseline percent capture of 72.4%
- Control of 10% of the impervious area increases the percent capture by 1.4% (201 MG wet weather overflow volume reduction) from the baseline percent capture.
- Control of 100% of the impervious area increases the percent capture by 7.6% from the baseline percent capture (904 MG wet weather overflow volume reduction)

The quote can be found in the first paragraph of the executive summary in the 2016 Green Infrastructure Performance Metrics Report which can be found here: http://www.nyc.gov/html/dep/pdf/green_infrastructure/gi-performance-metrics-report-2016.pdf

See modified Sections D.1.1.3 and D.1.5.3 in Appendix E.

e) NJDEP Comment 5 (PVSC Acceptance of Additional Flows) – The JCMUA met with representatives of PVSC, Bayonne, and North Bergen on March 8, 2019 to coordinate efforts for Hudson County. During this meeting, the following was discussed: ARCADIS presented slides for model simulations demonstrating that an 85% capture cannot be achieved due to flow restrictions in the interceptor. A profile of the JCMUA interceptor if the pumps were set to extremely high flows shows that the interceptor becomes the hydraulic flow choke off the JCMUA. See Appendix C of Appendix E for this JCMUA interceptor profile.

The findings of the Greeley and Hansen/CDM team were discussed, where two main points were stated: 1) If Hudson County could achieve an overflow reduction of 59% then an overall percent capture for the PVSC Interceptor Communities and HCFM communities would be 85%. 2) PVSC could accept a maximum pumped flow of 235 MGD from the HCFM communities.

PVSC requested Arcadis to run an alternative simulation with the JCMUA pumping 235 MGD to test the maximum flow to the POTW scenario. This was completed by ARCADIS, and the performance results are shown on Table D.1-2 of Appendix E. In this table, this alternative along would only be able to achieve a percent capture of 80% with a percent reduction of only 28.5% for Jersey City. This could not reach the desired percent capture of 85% and could not achieve the needed 59% overflow reduction. The JCMUA did not want to proceed with construction of a new and larger force main that could not meet either of the desired criteria but would still require additional grey infrastructure (i.e. - Tanks or Tunnels) to meet the presumptive approach criteria.

A second regional coordination meeting was conducted on March 20, 2019 with the consultants for the JCMUA, Bayonne, and North Bergen to discuss regional alternatives. The single regional alternative that all parties agreed to consider was a regional tunnel within Hudson County. The analysis was completed by Bayonne's Consultant, HDR, and is reported in Appendix B on the last paragraph of D.2.9 entitled, "Regional Deep Tunnel". The Regional DEAR also looked at a regional tunnel for the area and explored the tunnel options further by adding levels of control determined to be infeasible by HDR according to the dewatering limitation in the hydraulic model. The JCMUA and their consultant have reviewed these results found no reason to doubt the findings presented.

Another regional coordination effort started during a PVSC District meeting where Arcadis was requested to provide calculations to determine the maximum allowable flow to the HCFM. Arcadis did this based upon the criteria that a force main under such continuous, or only frequent, use such as HCFM, must be operated at no higher than a velocity of 8 ft./s in order to avoid significant scour and other damage to it. Based on this flow velocity criteria and the sizes of the 3 force mains, 2 in Jersey City with the third being the HCFM where all the flow converges into one flow, it was concluded the following were the maximum allowable flows in these force mains:

146.2 MGD for the 6 foot diameter HCFM

82.2 MGD for the 4.5 foot diameter force main from the East Side Pump Station (ESPS)

36.5 MGD for 3 foot diameter Force main (WSPS)

The velocity criteria of 8 fps is also supported by the following reference: "The Second Edition of Pumping Station Design, Editor in Chief, Robert L. Sanks, page 801, Section 25-12, Force Main Design, Paragraphs on 'Size'".

These calculations and other documentation in regard to coordination between Hudson County and PVSC representatives are now attached to Appendix E under "Appendix C - Regional Coordination".

f) NJDEP Commetn 6 (Storage Tanks) – Preliminary grouped tanks have a depth range for 4 overflows to 20 overflows to keep the diameter of the tank (and land use) from significant changes, and can be seen in Table D.1-3 of Appendix E. The feasible land area availability has been taken in consideration at the selected sites. Several factors were taken into consideration for selection of sites for storage tanks and new gravity sewers to connect existing outfalls. The preliminary locations for the nine grouped storage tanks are shown in Figure D.1-5 of Appendix E. Appendix E - Section D.1.1.6 has been modified to provide more explanation on the considerations given for storage.

g) NJDEP Comment 7 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added. Language detailing public meetings has been added to Appendix E in Section

D.1.4, and references of public participation correspondences added to Appendix E in its Appendix D.

h) NJDEP Comment 8 (Water Quality) – Modified Appendix E - Section D.3.2, JCMUA has removed every related statement regarding receiving water quality. Should the Demonstration approach be selected at a later date, the issue will be revisited.
i) NJDEP Comment 9 (Alternatives Approach) – A mixed approach has been considered for the 85% Capture alternative but not the 4, 8, 12, 20 overflow Scenarios. The current mixed approach with GI, Infiltration Inflow removal and Bates Street Sewer Separation, and grouped tanks for the 85% Capture alternative has shown that the infrastructure size (grouped tanks in this case) is slightly affected with the combination of the other source control technologies, therefore the combined approaches for the 4, 8, 12, 20 OF Scenarios would have similar sizes of infrastructure as singular approaches provide. No changes required.
j) NJDEP Comment 10 (Cost Performance) - Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

7. Evaluation of Alternatives Report for Town of Kearny

a) NJDEP Comment 1 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.
b) NJDEP Comment 2 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Fore bay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Fore bay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.
c) NJDEP Comment 3 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long

term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

d) NJDEP Comment 4 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.

e) NJDEP Comment 5 (GI Acreage Values) – As is described within Section D.3.1 of Appendix F, the referenced acreage values are based upon existing impervious coverage within the Town of Kearny, which accounts for approximately 715 acres (this value is based upon aerial analysis). As such, Appendix F considers green infrastructure alternatives that control stormwater runoff from 35.7 acres (5%) and 71.5 acres (10%) of the overall impervious coverage areas. No changes required.

f) NJDEP Comment 6 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.

   Communities were instructed that the HGL in the main interceptor should not be increased beyond existing conditions and the alternatives evaluated in their respective DEARs should reflect this. No changes required.

g) NJDEP Comment 7 (Storage Tanks) – At this time, the Town of Kearny does not consider storage tanks to be a viable alternative due to issues related to siting. However, should storage tanks be reconsidered for further evaluation, the issues presented within this comment will be addressed. No changes required.

h) NJDEP Comment 8 (PAA Disinfection) – Past studies have demonstrated that properly sized PAA disinfection systems can achieve a 3-log reduction (99.9% kill rate) with regard to bacteria (Bayonne MUA 2017, PeroxyChem 2016, WERF 2005). We are assuming that a 3-log reduction (99.9% kill rate) will be sufficient for planning purposes. Final design of disinfection facilities will consider more site specific testing information (e.g., jar testing) to help develop suitable capacities, disinfectant dosing, and effect of pretreatment for solids removal to achieve the target kill rate. The intention is to meet applicable water quality standards with respect to the identified pollutants of concern by understanding the additional chemical requirements necessary for treating the CSOs.

   Cost developed for satellite treatment included pretreatment (removal of suspended solids) such as a Flex Filter system. Pretreatment adds to site

requirements and significantly increases costs, so treatability tests to determine how much, if any, pretreatment is necessary for PAA disinfection.
Regarding pretreatment for solids removal, the previously submitted Development and Evaluation of Alternatives Report included several references to inclusion of pretreatment as follows: Section C8.3 pages 27 and 28, Section C8.7.2, page 33 (bottom paragraph), Figure 6 (following page 34), and Cost Table D-7 on pages 48-49 in which Alternatives 3C, 4C, 5C and 6C are titled "Partial SS – PAA – Flex Filter" in Appendix F. The costs for those alternatives include the cost of a Flex Filter pretreatment system.

i) NJDEP Comment 9 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

8. Evaluation of Alternatives Report for City of Newark

a) NJDEP Comment 1 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.

b) NJDEP Comment 2 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.

c) NJDEP Comment 3 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Fore bay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Fore bay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.

d) NJDEP Comment 4 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

e) NJDEP Comment 5 (Approach and Percent Capture) – As described in Section D.2.2 of Appendix G, the acreage associated with the three GI control levels evaluated are for the Rutgers Scenario at 11.7 acres, the 5% scenario at 228 acres, and for the 10% scenario at 455 acres. For the Rutgers scenario, the managed area for each site was given and then the acreage was summed.
For the 5% and 10% scenarios, it was assumed that 5% or 10% of the impervious area in each model sub catchment was managed by GI. These levels of control were selected because they represent the range of what was initially targeted (10% of impervious areas) and found to be achievable (5% of impervious surfaces) in New York City, and that this range is consistent with anecdotal evidence from other communities. The actual number and location of GI projects will be determined during final Selection and Implementation of Alternatives Report. GI cannot alone attain the CSO-control goals required, and the level of CSO control that can be achieved with GI is not cost effective compared to other controls. Siting considerations are discussed in Section D.1.1 in Appendix G, Newark will seek "available City-owned sites, as those have minimal impact on sensitive stakeholders and lower potential to be controversial," and that even on City-owned sites, related issues include "buffer for roadways, accessibility, and potential conflicts with existing utilities." GI projects are particularly difficult for the municipality to site and maintain on private property, and widespread GI projects would most likely include "street side planter boxes" set within the street right-of-way and other ROW measures.
f) NJDEP Comment 6 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.
Communities were instructed that the HGL in the main interceptor should not be increased beyond existing conditions and the alternatives evaluated in their respective DEARs should reflect this. PVSC was amenable to this alternative as long as the operational parameters can be met. As this alternative is further evaluated, Newark will continue to work with PVSC so that the goal of Alternative 1b is achievable within the plant operating parameters. No changes required. No changes required.
g) NJDEP Comment 7 (Storage Tanks) – Given the scope of the DEAR, specific sites for storage tanks or combinations of storage was not considered at this time.

In the Selection and Implementation of Alternatives Report due June 1, 2020, any storage alternatives selected for advancement will consider storage location and siting. The inclusion of amenities such as parks or GI will be considered at that time as well. Through the public involvement initiative, Newark will gather information on potential sites for such facilities for the public.

Conveyance of stored flow was considered as per PVSC guidance is discussed in section D.2.3 of Appendix G: "Total draining/pump back time from the storage facilities was also factored in when sizing the facilities. Storage facilities would not start draining during wet weather or before the system returns to normal flow conditions after the rain events. Also, the total draining rate from all storage facilities in the Newark drainage area was set not to be greater than 75% of the total average dry weather flow. Given these operating conditions the total storage volume, approximate number of days to dewater, volume captured and percent CSO reduction is summarized in Table D.2-5."

h) NJDEP Comment 8 (Extraneous Flow Investigations) - "Extraneous Flow Investigations" (Arcadis, July 2018) report details alternative for eliminating extraneous flows at selected locations in the City by pumping and conveying to new stormwater outfalls. A summary of this report has been included in the modified Section D.2.4 of Appendix G provide further clarification. The Selection and Implementation of Alternatives Report will provide additional details in the I/I source, reduction and elimination.

i) NJDEP Comment 9 (Jabez Interceptor) – The "Selection and Implementation of Alternatives" report due June 1, 2020 will be amended to provide some detail on the Jabez interceptor and affected outfalls. The report will further investigate I/I issues associated with the Jabez Interceptor. Figure D.2.-9 has been revised to clarify the location of the Jabez Interceptor and its proximity to upstream regulators in the Newark Interceptor.

j) NJDEP Comment 10 (PAA Disinfection) – Past studies have demonstrated that properly sized PAA disinfection systems can achieve a 3-log reduction (99.9% kill rate) with regard to bacteria (Bayonne MUA 2017, PeroxyChem 2016, WERF 2005). We are assuming that a 3-log reduction (99.9% kill rate) will be sufficient for planning purposes. Final design of disinfection facilities will consider more site specific testing information (e.g., jar testing) to help develop suitable capacities, disinfectant dosing, and effect of pretreatment for solids removal to achieve the target kill rate. The intention is to meet applicable water quality standards with respect to the identified pollutants of concern by understanding the additional chemical requirements necessary for treating the CSOs.

Cost developed for satellite treatment included pretreatment (removal of suspended solids) such as a Flex Filter system. Pretreatment adds to site requirements and significantly increases costs, so treatability tests to determine how much, if any, pretreatment is necessary for PAA disinfection.

k) NJDEP Comment 11 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

l) NJDEP Comment 12 (Water Quality) – Acknowledged. Newark removed the statement from the Section D.3.2 in Appendix G. Should the Demonstration approach be selected at a later date; the issue will be revisited.

9. Evaluation of Alternatives Report for North Bergen Municipal Utilities Authority

a) NJDEP Comment 1 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.

b) NJDEP Comment 2 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.

c) NJDEP Comment 3 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.
Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Fore bay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Fore bay just before the Primary Clarifiers."
The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.

d) NJDEP Comment 4 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.

As a result of this coordination, the HCFM communities have established that the existing capacity of the 72" diameter Hudson County Force Main is 146 MGD. This means that the HCFM is physically capable of conveying more flow toward PVSC than it currently conveys. Multiple scenarios assuming various increases from each of the four HCFM communities were considered. Without knowledge of whether or not NJDEP would permit PVSC to increase wet-weather flows such that the full 146 MGD capacity of the HCFM could be used, the HCFM communities have not developed an agreement for a particular allotment of the unknown additional capacity. However, indications are that a mutually agreeable allotment can be achieved. No changes required.

e) NJDEP Comment 5 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of a long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

f) NJDEP Comment 6 (GI Acreage Values) – GI eliminates the CSO that occurs up to 1 inch of rain. Anything in excess of 1 inch generates CSO. We will elaborate on GI opportunities in North Bergen. The Rutgers study employed a variety of GI practices on municipal property, and possible locations for GI opportunities in the CSS area can be found in the modified Section C.2.1 of Appendix H.

g) NJDEP Comment 7 (Storage Tanks) – Two tanks 125 ft by 125 ft by 25 ft deep tank (2.9 MG each) would be large enough to contain all regulator overflows to 8 overflows per year except for NB003. For NB003 a tank this size would reduce overflows to 20 per year. While sites have not been selected yet there are undeveloped areas near the regulators that might be available and a portion of the Central Pump Sation could be redeveloped as a storage tank.

h) NJDEP Comment 8 (PAA Disinfection) – Past studies have demonstrated that properly sized PAA disinfection systems can achieve a 3-log reduction (99.9% kill rate) with regard to bacteria (Bayonne MUA 2017, PeroxyChem 2016, WERF 2005). We are assuming that a 3-log reduction (99.9% kill rate) will be sufficient for planning purposes. Final design of disinfection facilities will consider more site specific testing information (e.g., jar testing) to help develop suitable capacities, disinfectant dosing, and effect of pretreatment for solids removal to achieve the target kill rate. The intention is to meet applicable water quality standards with respect to the identified pollutants of concern by understanding the additional chemical requirements necessary for treating the CSOs.
Cost developed for satellite treatment included pretreatment (removal of suspended solids) such as a Flex Filter system. Pretreatment adds to site requirements and significantly increases costs, so treatability tests to determine how much, if any, pretreatment is necessary for PAA disinfection.

i) NJDEP Comment 9 (Cost Performance) - Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

j) NJDEP Comment 10 (Alternatives Approach) – Combined alternatives will be considered in the Selection and Implementation of Alternatives report with a strategy of maximizing the use of the least expensive alternative (Flex Filter with PAA disinfection) with some GI. The final solution may be to use the Flex Filter with PAA disinfection and storage tanks to accomplish an 85% CSO reduction with Flex Filter and PAA for flows above 85%.

10. Evaluation of Alternatives Report for City of Paterson

a) NJDEP Comment 1 (Outfalls and Regulators) – Added Table A-1 in Appendix I A which lists all active/inactive outfalls, and associated regulators. Ongoing improvement projects towards outfall elimination, consolidation, and sewer relief construction and sewer separation have been logged by the City of Paterson within quarterly NJPDES CSO Permit progress reports. These quarterly reports can be found in the newly added Appendix I within Appendix I (Paterson DEAR).

b) NJDEP Comment 2 (Public Participation) – Section D.1.5 of the Regional Report has been modified and new Appendix K - Public Comments, has been added.

c) NJDEP Comment 3 (Approach and Percent Capture) – Acknowledged. An approach (Demonstrative or Presumptive) will be selected in the Selection and Implementation of Alternatives Report due June 1, 2020. See modified Section C.1.1 for percent capture equation.

d) NJDEP Comment 4 (Hydraulically Connected System) – Although some regional alternatives for all permittees have been considered, the "gravity flow" permittees that send their flow via the PVSC gravity interceptor (i.e. Newark, East Newark, Kearny, Harrison, and Paterson) and the Hudson County Force Main (HCFM) permittees that send their flow via the force main (North Bergen, Jersey City, and Bayonne) do not hydraulically influence the other. The HCFM permittees are hydraulically segmented from the "gravity flow" permittees because the HCFM connects directly upstream of PVSC's Primary Tank where screw pumps prevent backflow from occurring into the interceptor communities' system.

   Section C.1 of the PVSC Service Area System Characterization Report states, "The Main and South Side Interceptor's direct flow to the Headworks that includes a channelized Fore bay that divides flow between six (6) grit channels. Wastewater is screened and degritted and moved through an effluent channel to the Influent Pumping Station. Flow is then lifted by six (6) Archimedes screw pumps to Primary Clarifiers. The Hudson County flow, which includes flow from the cities of Jersey City, Bayonne, North Bergen and South Kearny, enters the plant downstream of the Fore bay just before the Primary Clarifiers."

   The physical features as described support the distinction of two larger, segmented areas forming PVSC's larger hydraulically connected system through the WRRF. See modified Section C.1.1 for percent capture equation.

e) NJDEP Comment 5 (Resiliency) – Acknowledged and we agree that the 2004 Typical Year considers local changes to the climate based on a review of long term precipitation data set. The designs for CSO reductions will consider resiliency requirements and where not possible we will consider protective measures outlined by the NJDEP. No changes required.

f) NJDEP Comment 6 (GI Acreage Values) – The acreages described in the 'top-down' approach were derived by calculating the total impervious areas in each of the land uses within the combined sewer drainage area in the City, and setting aside 2.5% to be treated by GI. These areas, and the reductions in overflow events observed in Paterson's Alternative 3, were used to quantify reductions in CSO volume and frequency, which can be attributed to GI. An ordinance on no-net-increase to impervious cover for any new development or alterations has existed for over 15 years. As such, the most promising GI opportunity is likely within the transportation corridors, with the costs, operation and maintenance responsibilities shared with the federal, state, county and city government entities.

g) Earlier evaluations performed during GI screening showed that a 3% managed impervious acreage with GI resulted in approximately 4% in CSO volume reductions, translating to approximately 14 MG (million gallons) per year. However, this evaluation did not show any meaningful reduction in CSO frequency at 3% GI. A separate evaluation for the recommended implementation rate of 2.5% GI was not performed, but an equivalency rate can be used to estimate CSO volume reductions towards getting credit for this recommended rate. No changes made.

h) NJDEP Comment 7 (Storage Tanks) – The potential storage tanks would all likely be subsurface. When these sites were proposed to the City, consideration was given to the current surface use of the site, and whether that use could be maintained after construction of the storage tank. In general, Paterson agreed that no long-term negative impact to the existing use of these sites would occur. The stored tank flow would be sent to PVSC using pumps that would be activated after a wet weather event. The capacity of each pump was set to dewater the storage tanks in two days, to avoid increasing flows beyond the dry weather flow limitation set by PVSC. Therefore, it was assumed that PVSC could accept the stored tank flow. Further discussion relating to this comment, as well as a summary table designed to supplement Appendices E and F, have been added to Section D.1.2 of the Appendix I.

~~a)~~i) NJDEP Comment 8 (PVSC Acceptance of Additional Flows) – PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City, and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.

Communities were instructed that the HGL in the main interceptor should not be increased beyond existing conditions and the alternatives evaluated in their respective DEARs should reflect this. No changes required.

j) NJDEP Comment 9 (Cost Performance) – Acknowledged. Updates to the cost have been included in Section D and in Appendices A through I. These costs and any further updates will be included in the Selection and Implementation of Alternatives Report.

A.1 TITLE OF PLAN AND APPROVAL

Title: Development and Evaluation of Alternatives Regional Report

Preparer:

Project Officer: Michael J. Hope, P.E., Greeley and Hansen LLC — Date: 6/25/19

QA Officer: Timothy J. Dupuis, P.E., CDM Smith — Date: 6/25/2019

Passaic Valley Sewerage Commission:

PVSC Program Manager: Bridget McKenna, Chief Operating Officer, PVSC — Date: 06/25/2019

PVSC QA Officer: Marques Eley — Marques Eley, Senior Engineer, PVSC — Date: 6/25/2019

New Jersey Department of Environmental Protection

DEP Permits: Joseph Mannick, CSO Coordinator — Date

DEP QA: Marc Ferko, Office of Quality Assurance — Date

Development and Evaluation of Alternatives Regional Report

Submitted by
Passaic Valley Sewerage Commission:

NJPDES Number NJ0021016 (Passaic Valley Sewerage Commission)

Approval of this submittal:

Permittee: ______________________________ 06/25/2019
Bridget McKenna — Date
Chief Operating Officer, Passaic Valley Sewage Commission

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________________ 06/25/2019
Bridget McKenna — Date
Chief Operating Officer, Passaic Valley Sewage Commission

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0109240 (Bayonne City)

Approval of this submittal:

Permittee: ______________________________ 6.25.19
Timothy Boyle Date
Superintendent, City of Bayonne Department of Public Works

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________________ 6.25.19
Timothy Boyle Date
Superintendent, City of Bayonne Department of Public Works

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0117486 (East Newark)

Approval of this submittal:

Permittee: ______________________ 6/24/19
Frank Pestana
Licensed Operator, Borough of East Newark
Date

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________ 6/24/19
Frank Pestana
Licensed Operator, Borough of East Newark
Date

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0108871 (Harrison)

Approval of this submittal:

Permittee: ______________________________ 6/25/19
Rocco Russomano — Date
Town Engineer, Town of Harrison

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________________ 6/25/19.
Rocco Russomano — Date
Town Engineer, Town of Harrison

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission on behalf of the NJ CSO Group

NJPDES Number NJ0108723 (Jersey City MUA)

Approval of Report:

Permittee: 6/26/19

Rich Haytas
Senior Engineer, Jersey City MUA
Date

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperation performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: 6/26/19

Rich Haytas
Senior Engineer, Jersey City MUA
Date

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0111244 (Kearny)

Approval of this submittal:

Permittee: ______________________ 9/25/19

Robert J. Smith Date
Town Administrator, Town of Kearny

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________ 9/25/19

Robert J. Smith, Date
Town Administrator, Town of Kearny

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

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0108758 (Newark)

Approval of this submittal:

Permittee: ______________________________ 6-25-19
Ras J. Baraka
Mayor, City of Newark
Date

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________________ 6-25-19
Ras J. Baraka
Mayor, City of Newark
Date

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0108988 (North Bergen Municipal Utilities Authority)

Approval of this submittal:

Permittee: ______________________________ 6/24/19

Frank Pestana — Date
Executive Director, North Bergen Municipal Utilities Authority

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________________ 6/24/19

Frank Pestana — Date
Executive Director, North Bergen Municipal Utilities Authority

Development and Evaluation of Alternatives Regional Report

Submitted on behalf of the following participating Permittee by Passaic Valley Sewerage Commission:

NJPDES Number NJ0108880 (Paterson)

Approval of this submittal:

Permittee: ______________________________ 6/28/19
William Rodriguez — Date
Director of Public Works, City of Paterson

NJPDES Certification:

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision; or (b) as part of a cooperative performed by members of the NJ CSO group effort in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Permittee: ______________________________ 6/28/19
William Rodriguez — Date
Director of Public Works, City of Paterson

A.2 DISTRIBUTION LIST

<u>Passaic Valley Sewerage Commission</u>
Bridget McKenna, Chief Operating Officer
Patricia Lopes, Director of Process Control Engineering and Regulatory Compliance
Marques Eley, PE, Senior Engineer

Participating Permittees:

Bayonne:	Timothy Boyle, Superintendent of Public Works
East Newark:	Frank Pestana, Licensed Operator
Harrison:	Rocco Russomano, Town Engineer
Jersey City:	Rich Haytas, Senior Engineer
Kearny:	Robert J. Smith, Town Administrator
Newark:	Ras J. Baraka, Mayor of Newark
North Bergen:	Frank Pestana, Executive Director
Paterson:	Manny Ojeda, Director of Public Works

<u>New Jersey Department of Environmental Protection</u>
Dwayne Kobesky, Surface Water Permitting
Joseph Mannick, Surface Water Permitting
Marc Ferko, Office of Quality Assurance

A.3 PROGRAM CONTACT INFORMATION

Contact information for those parties involved in the System Characterization Report is as follows:

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Paterson, NJ 07505

Frank Pestana
Licensed Operator
East Newark Borough
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Newark, NJ 07029

A.4 TABLE OF CONTENTS

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Appendices

A.5 INTRODUCTION

The Passaic Valley Sewerage Commission ("PVSC") provides wastewater treatment service to 48 municipalities within Bergen, Hudson, Essex, Union and Passaic counties in the Passaic Valley Treatment District located in Northeast New Jersey. In total, PVSC services approximately 1.5 million people, 198 significant industrial users and 5,000 commercial customers. The PVSC Treatment District covers approximately 150 square miles from Newark Bay to regions of the Passaic River Basin upstream of the Great Falls in Paterson. PVSC's main interceptor sewer begins at Prospect Street in Paterson and generally follows the alignment of the Passaic River to the PVSC Water Resource Recovery Facility ("WRRF") in the City of Newark. The WRRF receives flow from three sources: the Main Interceptor Sewer, the South Side Interceptor, and the Hudson County Force Main ("HCFM").

PVSC does not own or operate any of the combined sewer overflow ("CSO") outfalls but has assumed a lead role in coordinating the Development and Evaluation of Alternatives Regional Report on behalf of the permittees within the PVSC Treatment District. However, each of the individual CSO Permittees have performed an analysis and prepared their own Development of Evaluation of Alternatives Reports, which have been included as Appendices A through I of this Report. The extent of the PVSC Treatment District and the combined sewer areas within the study area are illustrated in **Figure A-1**.

Eight (8) of the municipalities within the PVSC Treatment District have combined sewer systems ("CSSs") and have received authorization to discharge under their respective New Jersey Pollutant Discharge Elimination System ("NJPDES") Permits for Combined Sewer Management. The eight (8) PVSC CSO Permittees are listed below:

- City of Paterson
- City of Newark
- Town of Kearny
- Town of Harrison
- Borough of East Newark
- City of Bayonne (Bayonne Municipal Utilities Authority was dissolved in 2016 and the City of Bayonne now own its CSS)
- Jersey City Municipal Utilities Authority ("JCMUA")
- North Bergen Municipal Utilities Authority ("NBMUA")

A general schematic of the PVSC sewer system is included in **Figure A-2**.

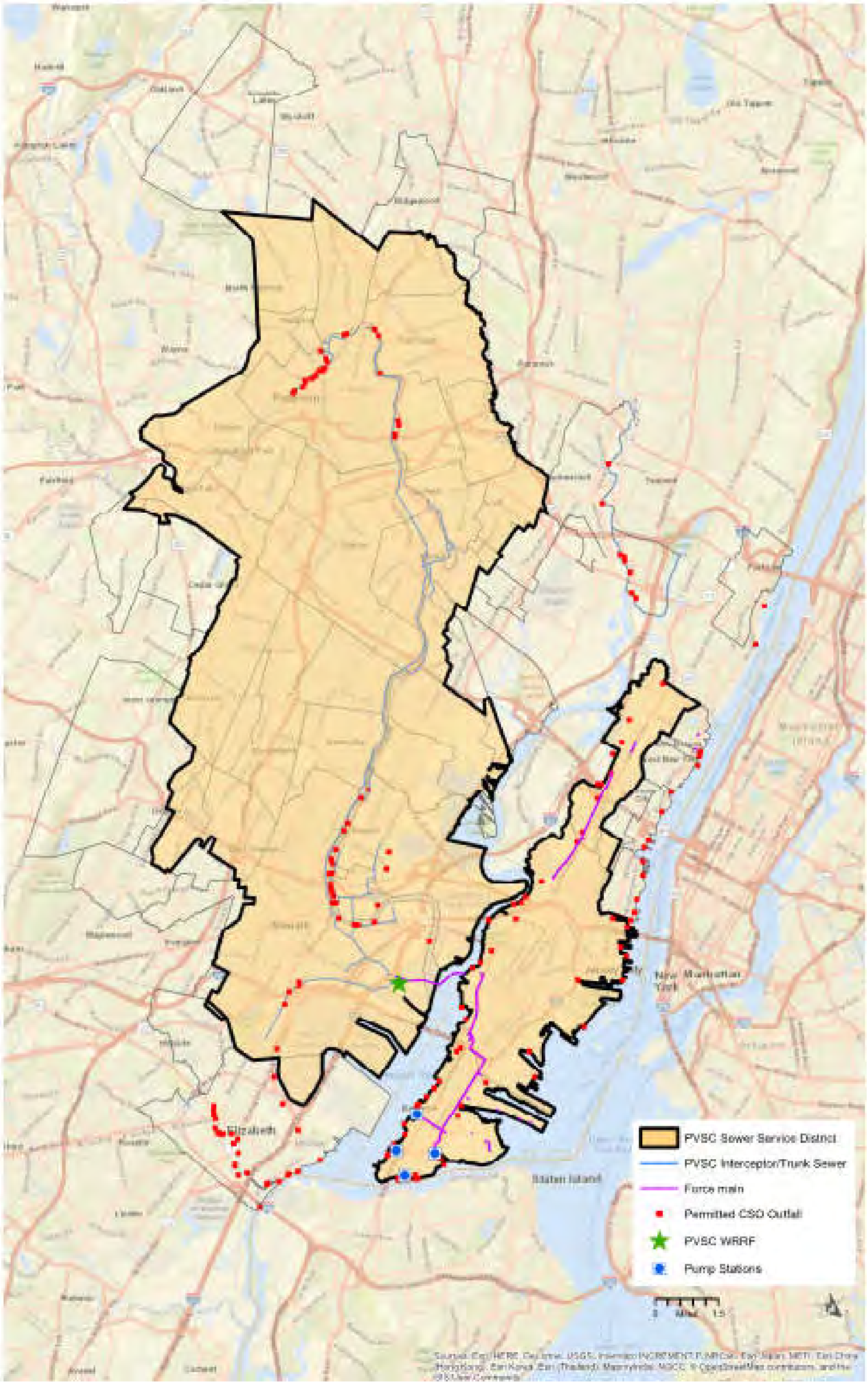

Figure A-1: The PVSC Treatment District

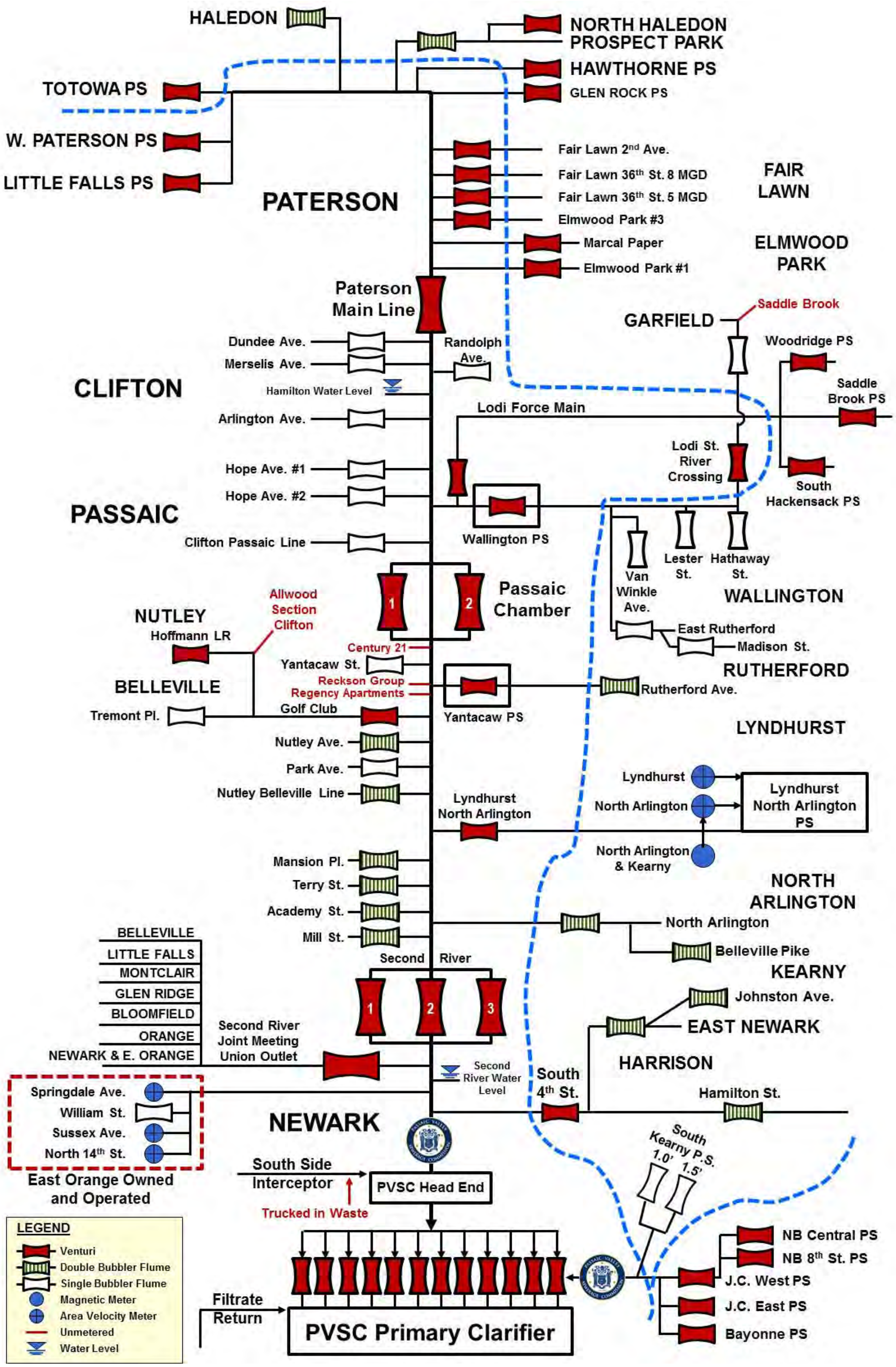

Figure A-2: The PVSC Sewer System Schematic

A.6 PURPOSE OF REPORT

The NJDPES Permit for each of the Permittees outlines the Long Term Control Plan (the "LTCP") Submittal requirements in Part IV (entitled Specific Requirement: Narrative), Section D.3. Subsection D.3.b.v states:

> *Step 2 - Development and Evaluation of Alternatives for the LTCP - In accordance with Sections G.2. through G.5. and G.9., the permittee shall submit an approvable Development and Evaluation of Alternatives Report: within 48 months from the effective date of the permit (EDP).*

In accordance with the NJPDES Permits' LTCP requirements, a Development and Evaluation of Alternatives Report shall be submitted by July 1, 2019.

To meet this requirement, of the CSO Permittees and PVSC developed their own individual Development and Evaluation of Alternatives Report. This *Development and Evaluation of Alternatives Regional Report* (the "Regional Alternatives Report") compiles and summarizes the results of the nine (9) individual Development and Evaluation of Alternatives Reports for the PVSC Treatment District, which includes PVSC's Report and the Development and Evaluation of Alternatives Reports developed by the CSO Permittees listed in Subsection A.5.

All nine (9) of the individual reports are included in their full version at the end of this Regional Alternatives Report as Appendices.

Section G.4 of the NJDPES Permit for each of the Permittees outlines the requirements of the Development and Evaluation of Alternatives Report. The objective of this Regional Alternatives Report is to enable the Permittees to evaluate the alternatives of CSO controls that will meet the water quality-based requirements of the Federal Water Pollution Control Act of 1972 (the "Clean Water Act" or the "CWA"), will be protective of the existing designated uses of the receiving waters, give priority to controlling CSOs to sensitive areas and address minimizing impacts from significant indirect user ("SIU") discharges. The Regional Alternatives Report also evaluates, compares, and incorporates the specific local alternatives developed by the eight (8) municipalities to the regional alternatives developed by PVSC as part of this Report.

A.7 REGULATORY SETTING

A.7.1 Introduction

This document constitutes the Regional Alternatives Report developed by PVSC and the municipalities and municipal authorities served by PVSC that are listed below in **Table A-1.**

Table A-1: Permittees Covered Under this Development and Regional Alternatives Report

Municipality	NJPDES #
PVSC	NJ0021016
Borough of East Newark	NJ0117846
Town of Harrison	NJ0108871
Town of Kearny	NJ0111244
City of Newark	NJ0108758
City of Paterson	NJ0108880
City of Bayonne	NJ0209240
North Bergen MUA	NJ0108898
Jersey City MUA	NJ0108723

A.7.2 NJPDES Permit Requirements

Under Section 402 of the CWA, all point source discharges to the waters of the United States must be permitted. The United States Environmental Protection Agency ("USEPA") Region II has delegated permitting authority in New Jersey to the New Jersey Department of Environmental Protection ("NJDEP"). The permits are reissued on a nominal five-year cycle. All twenty-one (21) New Jersey municipalities and municipal authorities with CSSs were issued new permits in 2015 that set forth the requirement for the completion of a Development and Evaluation of CSO Control Alternatives Report by July 1, 2019.

Part IV, Section D.3.b.v of the NJDPES Permit for each of the Permittees requires the completion of an approvable Development and Evaluation of Alternatives Report, to be prepared in accordance with Part IV, Sections G.2 through G.5 and G.9 of the permit. Those sections are listed below for reference:

- Section G.2 Public Participation Process
- Section G.3 Consideration of Sensitive Areas
- Section G.4 Evaluation of Alternatives
- Section G.5 Cost/Performance Considerations
- Section G.9 Compliance Monitoring Program (CMP)

Section G.4 states that the Evaluation of Alternatives must also comply with the requirements of Subsection D.3.a and Section G.10, recited below:

- Subsection D.3.a (under) Long Term Control Plan Submittal Requirements

  "The Department encourages a single LTCP to be developed and submitted on behalf of all of the permittees in a hydraulically connected sewer system."

- Section G.10 Permittee's LTCP Responsibilities

  "Where multiple permittees own/operate different portions of a hydraulically connected CSS, the permittee is required to work cooperatively with all other permittees to ensure the LTCPs are consistent. The LTCP documents must be based on the same data, characterization, models, engineering and cost studies, and other information, where appropriate. Each permittee is required to prepare the necessary information for the portion of the hydraulically connected system that the permittee owns/operates and provide this information to the other permittees within the hydraulically connected system in a timely manner for LTCP submission.

The specific requirements for the Development and Evaluation of CSO Control Alternatives Report are outlined in Section G.4. These requirements are reproduced in **Table A-2**, along with the section of this Regional Alternatives Report in which those requirements are addressed.

Table A-2: Review of Requirements of the Development and Evaluation of Regional Alternatives Report

Permit Section	Permit Requirement	Regional Report Section
Part IV G.4.a	"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 CWA using either the Presumption Approach or the Demonstration Approach (as described in Sections G.4.f.and G.4.g)."	**Section C:** Description of CSO Control Technologies
Part IV G.4.b	"The permittee shall submit, as per Section D.3.b.v, the Evaluation of Alternatives Report that will enable the permittee, in consultation with the Department, the public, owners and/or operators of the entire collection system that conveys flows to the treatment works, to select the alternatives to ensure the CSO controls will meet the water quality-based requirements of the CWA, will be protective of the existing and designated uses in accordance with N.J.A.C. 7:9B, give the highest priority to controlling CSOs to sensitive areas, and address minimizing impacts from SIU discharges."	Entire Regional Alternatives Report
Part IV G.4.c G.4.f G.4.g	"The permittee shall select either Demonstration or Presumption Approach for each group of hydraulically connected CSOs and identify each CSO group and its individual discharge locations."	**Section A:** Introduction and Background

Permit Section	Permit Requirement	Regional Report Section
Part IV G.4.d	"The Evaluation of Alternatives Report shall include a list of control alternative(s) evaluated for each CSO."	**Section D:** Summary of Alternatives Analysis
Part IV G.4.e	"The permittee shall evaluate a range of CSO control alternatives predicted to accomplish the requirements of the CWA. In its evaluation of each potential CSO control alternative, the permittee shall use an NJDEP approved hydrologic, hydraulic and water quality models. The permittee shall utilize the models to simulate the existing conditions and conditions as they are expected to exist after construction and operation of the chosen alternative(s). The permittee shall evaluate the practical and technical feasibility of the proposed CSO control alternative(s), and water quality benefits of constructing and implementing various remedial controls and combination of such controls and activities"	**Section C:** Description of CSO Control Technologies
Part IV G.4.e.i	The permittee shall evaluate the practical and technical feasibility of, Green infrastructure"	**Section C:** Description of CSO Control Technologies
Part IV G.4.e.ii	The permittee shall evaluate the practical and technical feasibility of, Increased storage capacity in the collection system"	**Section C:** Description of CSO Control Technologies
Part IV G.4.e.iii	"The permittee shall evaluate the practical and technical feasibility of, STP expansion and/or storage at the plant (an evaluation of the capacity of the unit processes must be conducted at the STP resulting in a determination of whether there is any additional treatment and conveyance capacity within the STP). Based upon this information, the permittee shall determine (modeling may be used) the amount of CSO discharge reduction that would be achieved by utilizing this additional treatment capacity while maintaining compliance with all permit limits"	**Section C:** Description of CSO Control Technologies
Part IV G.4.e.iv	"The permittee shall evaluate the practical and technical feasibility of, I/I reduction to meet the definition of non-excessive infiltration and non-excessive inflow as defined in N.J.A.C. 7:14A-1.2 in the entire collection system that conveys flows to the treatment works to free up storage capacity or conveyance in the sewer system and/or treatment capacity at the STP, and feasibility of implementing in the entire system or portions thereof"	**Section C:** Description of CSO Control Technologies
Part IV G.4.e.v	"The permittee shall evaluate the practical and technical feasibility of, Sewer separation"	**Section C:** Description of CSO Control Technologies

Permit Section	Permit Requirement	Regional Report Section
Part IV G.4.e.vi	"The permittee shall evaluate the practical and technical feasibility of, Treatment of the CSO discharge"	**Section C:** Description of CSO Control Technologies
Part IV G.4.e.vii	"The permittee shall evaluate the practical and technical feasibility of, CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7"	**Section C:** Description of CSO Control Technologies

A.7.3 USEPA's CSO Policy

USEPA's CSO Policy (the "CSO Policy") was issued in April of 1994 (59 FR 18688 - 18698) to elaborate on the 1989 National CSO Control Strategy and to expedite compliance with the requirements of the CWA. The CSO Policy provided guidance to municipal permittees with CSOs, to the state agencies issuing National Pollution Discharge Elimination permits (e.g., NJDEP and NJPDES permits) and to state and interstate water quality standards ("WQS"), authorities (e.g., the Interstate Environmental Commission). The CSO Policy establishes a framework for the coordination, planning, selection, and implementation of CSO controls required for permittee compliance with the CWA.

The CSO Policy Section II.C.4 – Evaluation of Alternatives states:

> *"EPA expects the long-term CSO control plan to consider a reasonable range of alternatives. The plan should, for example, evaluate controls that would be necessary to achieve zero overflow events per year, an average of one to three, four to seven, and eight to twelve overflow events per year. Alternatively, the long-term plan could evaluate controls that achieve 100% capture, 90% capture, 85% capture, 80% capture, and 75% capture for treatment. The long-term control plan should also consider expansion of POTW secondary and primary capacity in the CSO abatement alternative analysis. The analysis of alternatives should be sufficient to make a reasonable assessment of cost and performance as described in Section II.C.5. Because the final long-term CSO control plan will become the basis for NPDES permit limits and requirements, the selected controls should be sufficient to meet CWA requirements."*

The CSO Policy also states that "In addition to considering sensitive areas, the long-term control plan should adopt either the Presumption Approach or the Demonstration Approach.

A.7.3.1 Presumption Approach from USEPA's CSO Policy

Subsection II.C.4.a of the USEPA's CSO Policy (Presumption Approach) states that:

> *"A program that meets any of the criteria listed below would be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the permitting authority 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...These criteria are provided because*

data and modeling of wet weather events often do not give a clear picture of the level of CSO controls necessary to protect [water quality standards].”

Under the Presumption Approach, CSO controls proposed in the LTCP are presumed to protect water quality in the receiving water bodies if the CSS achieves any of the following three (3) criteria:

i. *“No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year. For the purpose of this criterion, an overflow event is one or more overflows from a CSS as the result of a precipitation event that does not receive the minimum treatment specified below; or*

ii. *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 system-wide annual average basis; or*

iii. *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 the paragraph ii above.”*

“Minimum treatment,” as noted in Item “i” above, is defined in Subsection II.C.4.a of the CSO Control Policy, which indicates that “combined sewer flows remaining after implementation of the nine minimum controls and within the criteria specified at II.C.4.a.i. or ii, should receive a minimum of:

- *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, where necessary.”*

Combined sewer flows are the flows that are remaining in the combined sewer system and are conveyed to the publicly owned treatment works for treatment and discharge.

A.7.3.2 Demonstration Approach from USEPA’s CSO Policy

Subsection II.C.4.b of the USEPA’s CSO Policy (Demonstration Approach) states that:

“A permittee may demonstrate that a selected control program, though not meeting the criteria specified in II.C.4.a. above is adequate to meet the water quality-based requirements of the CWA.”

Under the Demonstration Approach, the municipality would be required to successfully demonstrate compliance with each of the following criteria from the CSO Policy:

I. *"The planned control program is adequate to meet [water quality standards] and protect designated uses, unless [water quality standards] or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs;*

II. *The CSO discharges remaining after implementation of the proposed control program will not preclude the attainment of [water quality standards] or the receiving waters' designated uses or contribution to their impairment. Where [water quality standards] are not met in part because of natural background conditions or pollution sources other than CSO discharges, a total maximum daily load, including a waste load allocation and a load allocation or other means should be used to apportion pollutant loads;*

III. *The planned control program will provide the maximum pollution reduction benefits reasonably attainable; and*

IV. *The planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are determined to be necessary to meet [water quality standards] or designated uses."*

A.7.4 USEPA's Guidance for Long-Term Control Plan Requirements

The USEPA's CSO Guidance for Long-Term Control Plan (or "CSO Guidance Document") states that the Demonstration Approach and the Presumption Approach are the two general approaches to attainment of WQS, and that these two approaches provide municipalities with targets for CSO controls that achieve compliance with the CWA, particularly the protection of designated uses.

Section 1.3 of the CSO Guidance Document states:

> *"Permittees should develop long-term control plans (LTCPs) for controlling CSOs. A permittee may use one of two approaches: 1) demonstrate that its plan is adequate to meet the water quality-based requirements of the CWA ("demonstration approach"), or 2) implement a minimum level of treatment (e.g., primary clarification of at least 85 percent of the collected combined sewage flows) that is presumed to meet the water quality-based requirements of the CWA, unless data indicate otherwise ("presumption approach")."*

Section 2.6.2.1 states that:

> *"Under the [CSO Policy], a municipality should develop an LTCP that adopts either the demonstration or the presumption approach to attainment of WQS. The demonstration approach is based on adequately demonstrating that the selected CSOs will provide for the attainment of WQS, including designated uses in the receiving water. The presumption approach does not explicitly call for analysis of receiving water impacts.*

> *The presumption approach usually involves at least screening-level models of receiving water impacts, however, because the approach will not apply if the NPDES permitting authority determines that the LTCP will not result in attainment of CWA requirements."*

A.7.4.1 Presumption Approach from USEPA's CSO Guidance for LTCP

For the Presumption Approach, Section 3.2.1 of the USEPA's CSO Guidance Document states that:

> *"If the data collected by a community do not provide "...a clear picture of the level of CSO controls necessary to protect WQS", the presumption approach may be considered. Use of the presumption approach is contingent, however, on the municipality presenting sufficient data to the NPDES permitting authority to allow the agency to make a reasonable judgment that WQS will probably be met with a control plan that meets one of the three presumption criteria."*

Furthermore, the CSO Guidance Document states:

> *"Use of the presumption approach does not release municipalities from the overall requirement that WQS be attained. If data collected during system characterization suggest that use of the presumption approach cannot be reasonably expected to result in attainment of WQS, the municipality should be required to use the demonstration approach instead. Furthermore, if implementation of the presumption approach does not result in attainment of WQS, additional controls beyond those already implemented might be required."*

A.7.4.2 Demonstration Approach from USEPA's CSO Guidance for LTCP

For the Demonstration Approach, Section 3.2.1 of the USEPA's CSO Guidance Document states that:

> *"Generally, if sufficient data are available to demonstrate that the proposed plan would result in an appropriate level of CSO control, then the demonstration approach will be selected. The demonstration approach is particularly appropriate where attainment of WQS cannot be achieved through CSO control alone, due to the impacts of non-CSO sources of pollution. In such cases, an appropriate level of CSO control cannot be dictated directly by existing WQS but must be defined based on water quality data, system performance modeling, and economic factors."*

The Demonstration Approach is consistent with the total maximum daily load ("TMDL") development approach and may be used in the TMDL process where the WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs. Section 3.2.1.1 of the CSO Guidance Document states:

> *"The demonstration approach encourages the development of total maximum daily loads and/or the use of a watershed approach throughout the LTCP process. In conducting the existing baseline water quality assessments as part of the system characterization, for*

example, the specific pollutants causing nonattainment of WQS, including existing or designated uses, would be identified, and then the sources of these pollutants could be identified and loads apportioned and quantified."

A.7.5 Comparison of the Two Approaches

Table A-3 summarizes the major differences between the Presumption Approach and the Demonstration Approach.

Table A-3: Comparison of the Presumption Approach and Demonstration Approach

Item	Presumption Approach	Demonstration Approach
Criteria	• Meet one of three criteria and compliance is **presumed**: 1) No more than an average of 4-6 *CSO* events per year; 2) 85% capture (by volume) 3) Elimination or removal of the mass of pollutants, identified as causing water quality impairment.	• Number of CSO events, flow or pollutant loading limited by a proposed CSO system Waste Load Allocation which will not preclude the attainment of Water Quality Standards (WQS). • Relies on data collection and model simulation to **demonstrate** that the proposed LTCP results in meeting the current WQS and designated uses.
Monitoring Data Collection	• Flow metering of the collection system and/or water quality sampling of CSOs.	• Flow metering of the collection system and water quality sampling of CSOs and receiving water bodies.
Modeling	• Combined sewer system (CSS) hydrologic and hydraulic (H&H) model.	• CSS H&H Model and Receiving Water Quality Model(s).
Pollutant Sources Evaluated	• Only CSOs.	• The contributing pollutant sources in the watershed including urban stormwater, agricultural (if any), wildlife, etc.

The Demonstration Approach takes a holistic watershed based approach to understand the pollutant sources and their relative contributions, so that appropriate level of controls can be cost-effectively applied to each pollutant source instead of focusing on just the CSOs. The Demonstration Approach can help to understand where the current CSO program is in terms of meeting the WQS and demonstrate the impact of future WQS changes on the CSO controls. Under the Demonstration Approach, the permittee must document that their CSO control program is adequate to meet the water quality-based requirements of the CWA.

Use of the Presumption Approach for a particular water body is allowed when approved by the NJDEP that the specific presumption(s) to be used in a particular water body are reasonable pursuant to Section II.C.4.a of the CSO Policy.

Certain tasks must be completed regardless if the Presumption or Demonstration Approach is used, such as system characterization, sewer and Geographic Information System (GIS) mapping, and the evaluation of alternatives. However, it is to be noted that the study phase for the Demonstration Approach also requires water quality sampling and water quality modeling of the receiving waters. These tasks have been previously completed and the Reports and/or submittals that document the findings of each of these tasks have been submitted to the NJDEP in accordance with the NJPDES Permits.

A.7.6 NJPDES LTCP Permittees Approach and CSO Discharge Locations

Part IV, Section G.4.c of each Permittee's NJDPES Permit states:

> *"The permittee shall select either Demonstration or Presumption Approach for each group of hydraulically connected CSOs and identify each CSO group and its individual discharge locations."*

As discussed with NJDEP a specific approach (either the Presumption Approach or the Demonstration Approach) is not being selected at this time for the purposes of this Regional Alternatives Report. Rather, various CSO technologies to provide varying levels of control (i.e., 0, 4, 8, 12, and 20 CSO events per year, and 85% CSO volume capture) have been evaluated for effectiveness. The designation of the hydraulically connected groups and the approach (either Presumption or Demonstration) will be selected when identifying the selected controls for implementation and will be presented in the subsequent Selection and Implementation of Alternatives Report in the Final LTCP.

Table A-4 summarizes the NJPDES, permittee name, CSO numbers, and receiving water body.

Table A-4: Summary of CSO Discharge Locations

NJPDES	Permittee	CSO Number	Receiving Water Body
NJ0109240	Bayonne	001A	Kill Van Kull
NJ0109240	Bayonne	002A	Kill Van Kull
NJ0109240	Bayonne	003A	Kill Van Kull
NJ0109240	Bayonne	004A	Kill Van Kull
NJ0109240	Bayonne	006A	Upper NY Bay
NJ0109240	Bayonne	007A	Upper NY Bay
NJ0109240	Bayonne	008A	Kill Van Kull
NJ0109240	Bayonne	009A	Kill Van Kull
NJ0109240	Bayonne	010A	Kill Van Kull
NJ0109240	Bayonne	011A	Newark Bay
NJ0109240	Bayonne	012A	Newark Bay
NJ0109240	Bayonne	013A	Newark Bay
NJ0109240	Bayonne	014A	Newark Bay
NJ0109240	Bayonne	015A	Newark Bay
NJ0109240	Bayonne	016A	Newark Bay

NJPDES	Permittee	CSO Number	Receiving Water Body
NJ0109240	Bayonne	017A	Newark Bay
NJ0109240	Bayonne	018A	Newark Bay
NJ0109240	Bayonne	019A	Newark Bay
NJ0109240	Bayonne	020A	Newark Bay
NJ0109240	Bayonne	021A	Upper NY Bay
NJ0109240	Bayonne	022A	Newark Bay
NJ0109240	Bayonne	024A	Kill Van Kull
NJ0109240	Bayonne	026A	Newark Bay
NJ0109240	Bayonne	028A	Newark Bay
NJ0109240	Bayonne	029A	Newark Bay
NJ0109240	Bayonne	030A	Newark Bay
NJ0109240	Bayonne	034A	Newark Bay
NJ0109240	Bayonne	037A	Kill Van Kull
NJ0117846	East Newark	001A	Passaic River
NJ0108871	Harrison	001A	Passaic River
NJ0108871	Harrison	002A	Passaic River
NJ0108871	Harrison	003A	Passaic River
NJ0108871	Harrison	005A	Passaic River
NJ0108871	Harrison	006A	Passaic River
NJ0108871	Harrison	007A	Passaic River
NJ0111244	Kearny	001A	Passaic River
NJ0111244	Kearny	004A	Passaic River
NJ0111244	Kearny	006A	Passaic River
NJ0111244	Kearny	007A	Frank's Creek
NJ0111244	Kearny	010A	Frank's Creek
NJ0108758	Newark	002A	Passaic River
NJ0108758	Newark	003A	Passaic River
NJ0108758	Newark	004A	Passaic River
NJ0108758	Newark	005A	Passaic River
NJ0108758	Newark	008A	Passaic River
NJ0108758	Newark	009A	Passaic River
NJ0108758	Newark	010A	Passaic River
NJ0108758	Newark	014A	Passaic River
NJ0108758	Newark	015A	Passaic River
NJ0108758	Newark	016A	Passaic River
NJ0108758	Newark	017A	Passaic River
NJ0108758	Newark	018A	Passaic River
NJ0108758	Newark	022A	Passaic River

NJPDES	Permittee	CSO Number	Receiving Water Body
NJ0108758	Newark	023A	Peripheral Ditch / Elizabeth Channel
NJ0108758	Newark	025A	Peripheral Ditch / Elizabeth Channel
NJ0108758	Newark	026A	Queen Ditch
NJ0108758	Newark	027A/029A	Peripheral Ditch / Elizabeth Channel
NJ0108758	Newark	030A	Peripheral Ditch / Elizabeth Channel
NJ0108898	North Bergen MUA	003A	Bellmans Creek
NJ0108898	North Bergen MUA	005A	Cromakill Creek
NJ0108898	North Bergen MUA	006A	Cromakill Creek
NJ0108898	North Bergen MUA	007A	Cromakill Creek
NJ0108898	North Bergen MUA	008A	Cromakill Creek
NJ0108898	North Bergen MUA	009A	Cromakill Creek
NJ0108898	North Bergen MUA	010A	Cromakill Creek
NJ0108898	North Bergen MUA	011A	Cromakill Creek
NJ0108898	North Bergen MUA	014A	Cromakill Creek
NJ0108880	Paterson	001A	Passaic River
NJ0108880	Paterson	003A	Passaic River
NJ0108880	Paterson	005A	Passaic River
NJ0108880	Paterson	006A	Passaic River
NJ0108880	Paterson	007A	Passaic River
NJ0108880	Paterson	010A	Passaic River
NJ0108880	Paterson	013A	Passaic River
NJ0108880	Paterson	014A	Passaic River
NJ0108880	Paterson	015A	Passaic River
NJ0108880	Paterson	016A	Passaic River
NJ0108880	Paterson	017A	Passaic River
NJ0108880	Paterson	021A	Passaic River
NJ0108880	Paterson	022A	Passaic River
NJ0108880	Paterson	023A	Passaic River
NJ0108880	Paterson	024A	Passaic River
NJ0108880	Paterson	025A	Passaic River
NJ0108880	Paterson	026A	Passaic River
NJ0108880	Paterson	027A	Passaic River
NJ0108880	Paterson	029A	Passaic River
NJ0108880	Paterson	030A	Passaic River

NJPDES	Permittee	CSO Number	Receiving Water Body
NJ0108880	Paterson	031A	Passaic River
NJ0108880	Paterson	032A	Passaic River
NJ0108880	Paterson	033A	Passaic River

A.8 EXISTING CONDITIONS

Section D.3.b.i of the NJPDES Permit for each Permittee required submittal of a System Characterization Work Plan to the NJDEP 6 months (January 1, 2016) from the EDP. To meet this requirement, the CSO Permittees and PVSC submitted two System Characterization and Landside Modeling Program Quality Assurance Project Plans ("QAPPs") to be executed and performed by PVSC. See **Table A-5** for each municipality and associated QAPP.

Table A-5: Municipality and Associated QAPP Submissions

Municipalities and Permittees	QAPP Submission
PVSC; Borough of East Newark; Town of Harrison; Town of Kearny; City of Newark; City of Paterson; City of Bayonne; North Bergen MUA	PVSC QAPP Part 1
Jersey City MUA	PVSC QAPP Part 2

NOTE: NBMUA (Woodcliff) and Guttenberg was included under a separate QAPP.

The System Characterization and Landside Modeling Program includes the rainfall monitoring, wastewater sampling, collections system monitoring, modeling and other work necessary to characterize the CSO discharges from the participating municipalities and for development of a collections system model for the purposes of evaluating CSO control alternatives and developing a CSO LTCP.

In accordance with the Permits' LTCP requirements, two System Characterization Reports were submitted by July 1, 2018. The PVSC Treatment District System Characterization Report was developed on behalf of the following seven of the eight CSO Permittees in the PVSC Treatment District.

- Paterson
- Newark
- Kearny
- Harrison
- East Newark

- Bayonne
- North Bergen MUA

The Jersey City MUA System Characterization Report was submitted as a separate report

Each of the System Characterization Reports were developed to meet the permit requirements and incorporate the results of the QAPPs for the System Characterization and Landside Modeling Program, a summary of the Baseline Monitoring and Modeling Plan program, and the System Characterization mapping of the combined and separate sewer areas within the PVSC Treatment District. Details of the Baseline Compliance Monitoring Program were submitted under separate reports.

Section G.1 of the NJPDES Permits outline the requirements of the System Characterization Monitoring and Modeling of the Combined Sewer system study that will provide a comprehensive characterization of the CSS.

The objective of the System Characterization Report is to provide NJDEP, PVSC, and the Permittees with a comprehensive and empirical understanding of the physical nature and hydraulic performance of their respective sewerage systems for use in optimizing the performance of the current systems and in the development of CSO control alternatives.

A.8.1 System Characterization Report Summary

The PVSC Treatment District System Characterization Report provides a comprehensive characterization of the CSS developed through records review, monitoring, modeling establishing the existing baseline conditions to evaluate the efficacy of the CSO technology based controls and determine the baseline conditions upon which the LTCP will be based.

PVSC and the municipal permittees have developed a thorough understanding of their respective sewerage systems, the systems' responses to precipitation events of varying duration and intensity, the characteristics of system overflows, and water quality issues associated with CSOs emanating from the systems and is presented in this report.

An overview of the organization and contents of the System Characterization Report are provided on **Table A-6.**

Table A-6: System Characterization Report Contents and Organization

Section		Topics Covered
A	Introduction and Background	Documents the problem definition, background, project description, summary and table of contents.
B	Regulatory Requirements	Describes the scope, purpose and regulatory context of the System Characterization Report.
C	Overview of Wastewater Facilities and Service Area	Characterizes the service area comprising the PVSC combined sewer municipalities that are the subject of this system characterization report and current wastewater treatment facilities within the service area.
D	Characteristics of the Combined Sewer System	Characterizes the municipal collection sewers, sewer mains, interceptors and appurtenances such as pump stations, existing CSO control facilities, regulator structures, and CSO outfalls.
E	Collection of Precipitation and Sewer Flow Monitoring	Documents the precipitation and flow monitoring programs, data analyses, integration of wastewater treatment plant operational data, data validation and QA/QC and presents the results of the analyses.
F	Characteristics of the Receiving Waters	Describes the watersheds, physical characteristics, and hydrodynamics of the receiving streams. Also describes the designated uses and current water quality compliance (e.g., 303(d) listings) and achievement of designated use status.
G	Collection of Water Quality Data	Documents the regulatory requirements for water quality data collection, historic water quality data collection, the water quality monitoring program and related QAPP and receiving water quality results.
H	Typical Hydrologic Period	Documents the requirements for and selection of the typical year and summarizes the hydrologic characteristics of the typical year.
I	Hydrologic and Hydraulic Modeling	Documents the development and scope of the H&H model used in this system characterization and to be used in the development of CSO control alternatives. The documentation includes model inputs, sensitivity analyses, model calibration and validation and modeling results.
J	References	
K	Abbreviations	

The latest revision of the PVSC Treatment District System Characterization Report provides a more comprehensive summary of the system characterization.

A.9 SENSITIVE AREAS

Pursuant to USEPA's CSO Policy, a permittee's LTCP must, "give the highest priority to controlling overflows to sensitive areas." (Federal Register 59 [April 19, 1994]: 18688-18698.) The purpose of the Sensitive Areas Report is to document the State and Federal Agencies that were researched, and other means utilized in order to identify the location of potential sensitive areas as they may relate to the development of the CSO LTCP. This will allow the Permittees to develop a plan that incorporates consideration of these areas as physically possible and economically achievable.

The Permittees are in the process of developing a LTCP which follows the framework established by the USEPA. PVSC prepared the Sensitive Areas Report on behalf of the Permittees to identify all sensitive areas impacted by CSOs within the Study Area, which includes the receiving surface waters as well as the adjacent waters.

For the purposes of this report, the Sensitive Areas Study Area (the "Study Area") includes the combined sewer service areas, all receiving and adjacent downstream waters that may be potentially affected by CSOs, and the various combined sewer service areas of the PVSC Treatment District will be considered. Affected waters include the Passaic River, Hackensack River, Newark Bay, Hudson River, Kill Van Kull, Arthur Kill, Upper New York Bay, as well as their tributaries within the Study Area of this report.

A.9.1 Sensitive Areas Report Summary

A comprehensive review to identify sensitive areas within the project area was completed. Results from this review can be found in the Identification of Sensitive Areas Report last revised and submitted on March 29, 2019, with the associated comments and communications filed with NJDEP.

SECTION B - RECEIVING WATERS CHARACTERIZATION

Characteristics of the receiving waters include description of the receiving waters designated use, shoreline characteristics, identification of the waters on the impaired waters of NJ and a summary of the sensitive areas within the receiving waters. USEPA's CSO Policy requires that highest priority is given to CSOs that discharge to sensitive areas.

B.1 RECEIVING WATERS OVERVIEW

Major receiving waters impacted from the PVSC Treatment District combined sewer overflows include the Passaic River, Hackensack River, Newark Bay, and the Upper New York Bay. Waterbodies connected to these four (4) receiving waters include the Hudson River, Kill Van Kull, Raritan River and Raritan Bay, as well as their tributaries. The NJDEP has categorized these receiving waters into Watershed Management Areas (WMA) 1 through 20 and refers to these designations in the 303(d) list of impaired waters.

B.1.1 CSO Receiving Waters

CSO receiving waters are water bodies that either a CSO discharges into or receive flow from tributaries with CSOs. The receiving waters include the combined sewer service area of the PVSC Treatment District and expands from this service area to include all receiving and adjacent downstream waters that may be potentially affected by CSOs from the various combined sewer service areas of the NJ CSO Group. Receiving waters to which CSOs in PVSC's Treatment District discharge directly or indirectly include the Passaic River, Hudson River, Newark Bay, Upper New York Bay, Hackensack River, Kill Van Kull, as well as their tributaries. All of the CSO outfalls and the waterbodies into which they discharge are listed in the System Characterization Report.

B.1.2 Summary of Impacted Drainage Basins

The receiving waters and their tributaries belong to drainage basins that are impacted by CSO discharges. Drainage basins, or watersheds, are areas that are separated by drainage divides and within a watershed, all surface water drains to a single outlet such as a river. The impacted watersheds within PVSC Treatment District are listed in **Table B-1**. The watersheds are also shown with the QAPP Part 1 and Part 2 areas from the "System Characterization and Landside Modeling Program Quality Assurance Project Plan (QAPP)," which have been previously approved by NJDEP areas and are further shown in **Figure B-1**.

Table B-1: Watersheds Affected by CSO Discharges

Watershed Name	Area (sq. mi)
Hudson River	5
Passaic River Lower (Saddle to Pompton)	46
Hackensack River (below and including Hirschfeld Brook)	19
Passaic River Lower (Newark Bay to Saddle)	52
Elizabeth River	2
Newark Bay / Kill Van Kull / Upper NY Bay	25

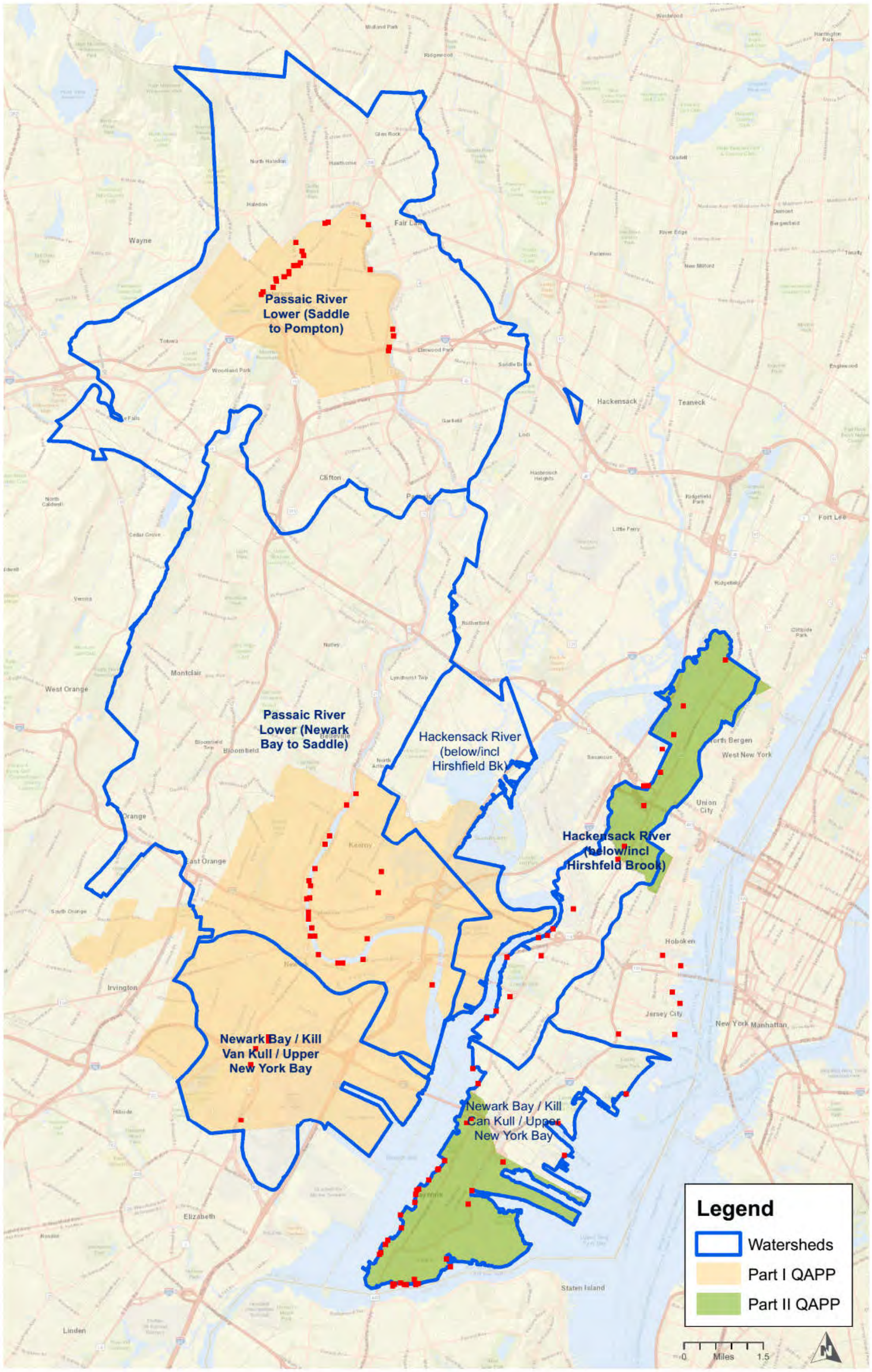

Figure B-1: PVSC Treatment District Watersheds

B.2 POLLUTANTS OF CONCERN IN THE RECEIVING WATERS

B.2.1 Summary of the Identified POCs for Each Receiving Water

Three (3) pollutants of concern ("POCs") were determined to apply to each of PVSC Treatment District's four (4) direct receiving waters. These three (3) POCs are parameters typically associated with CSO discharges, although they may also be associated with sources other than CSOs. The concentrations of these identified POCs in the receiving waters have been further investigated through the receiving water quality monitoring and modeling, subsequently described in the System Characterization Report and in the NJCSO Group Compliance Monitoring Program Report, which were previously submitted to the NJDEP. The NJDEP determined POCs for each of the receiving waters relative to the PVSC Treatment District are listed below:

- Passaic River
  - Fecal Coliform
  - Escherichia coli (E. coli) (fresh water)
  - Enterococcus
- Newark Bay
  - Fecal Coliform
  - E. coli (freshwater tributaries)
  - Enterococcus
- Upper New York Bay
  - Fecal Coliform
  - E. coli (freshwater tributaries)
  - Enterococcus
- Hackensack River
  - Fecal Coliform
  - E. coli (fresh water)
  - Enterococcus

B.3 APPLICABLE WATER QUALITY STANDARDS

B.3.1 NJ Integrated Water Quality Monitoring and Assessment Report (303(d) list)

Section 303(d) of the Clean Water Act requires each state to identify those waters for which effluent limitations are not stringent enough to attain applicable WQS; establish a priority ranking for such waters based on extent of water quality impairment and designated use non-support; establish a total maximum daily load ("TMDL") for each pollutant causing water quality impairment, based on their priority ranking, at a level necessary to attain applicable WQS; and submit a list to USEPA of all impaired waters and their pollutant causes (i.e., the 303(d) List).

NJDEP has established the 2014 New Jersey Integrated Water Quality Assessment Report. The primary source of information regarding causes of impairment, and the TMDL status of the water bodies (if any) is the 2014 New Jersey Integrated Water Quality Assessment Report, which satisfies New Jersey's requirement of both Section 303(d) and 305(b) of the Clean Water Act. The NJDEP Website explains the categories as shown in **Table B-2.**

Table B-2: Components of New Jersey's Integrated List of Water (Integrated List)

Sublist	Component
Sublist 1	An assessment unit is fully supporting all applicable designated uses and no uses are threatened. (The Department does not include the fish consumption use for determining placement on this sublist.)
Sublist 2	The assessment unit is fully supporting the designated use but is not supporting all applicable designated use(s).
Sublist 3	Insufficient data and information are available to determine if the designated use is fully supported.
Sublist 4	One or more designated uses are not supported or are threatened but TMDL development is not required because of one of the following reasons:
Sublist 4A	A TMDL has been completed for the parameter causing designated use non-support.
Sublist 4B	Other enforceable pollutant control measures are reasonably expected to result in fully supporting the designated use in the near future.
Sublist 4C	Non-support of the designated use is caused by something other than a pollutant.
Sublist 5	One or more designated uses are not supported or are threatened by a pollutant(s) that requires development of a TMDL.
Sublist 5A	Arsenic does not attain standards, but concentration is below those demonstrated to be from naturally occurring conditions.
Sublist 5L	Designated use impairment is caused by a "legacy" pollutant that is no longer actively discharged by a point source.
Sublist 5R	Water quality impairment is not effectively addressed by a TMDL, such as nonpoint source pollution that will be controlled under an approved watershed restoration plan or 319(h) Watershed Based Plan.

The Sublist 5 list constitutes the Section 303(d) list that the USEPA will approve or disapprove under the CWA. For the purposes of determining pollutants of concern, Sublists 4A and 5 are the relevant categories as they indicate the need for a TMDL in the receiving water body and the limiting of additional loadings for those parameters.

B.3.2 Interstate Environmental Commission Requirements

With the exception of the City of Paterson, the municipalities and authorities covered by this Regional Alternatives Report fall within the jurisdiction of the Interstate Environmental Commission (the "IEC"). The IEC is a tri-state air and water pollution control agency serving New York, New Jersey, and Connecticut. The IEC and its area of jurisdiction was established in 1936 pursuant to an interstate compact, with the consent of Congress. The IEC establishes the receiving stream WQS to which NJPDES permittees are subject under the federal Clean Water Act[1] and the New Jersey Water Pollution Control Act.[2]

The IEC has specified two (2) classes of waters:[3]

Class A Waters - Class A waters are suitable for all forms of primary and secondary contact recreation and for fish propagation, including shellfish harvesting in designated areas. There are no Class A waters within the receiving waters of the PVSC combined sewer municipalities.

Class B Waters – IEC identified two (2) sub-classes:

- **Class B-1** – the IEC WQS specify that Class B-1 waters remain "Suitable for fishing and secondary contact recreation. They shall be suitable for the growth and maintenance of fish life and other forms of marine life naturally occurring therein but may not be suitable for fish propagation."
- **Class B-2** – the IEC WQS specify that Class B-2 waters remain: "Suitable for passage of anadromous fish and for the maintenance of fish life in a manner consistent with the criteria established by the general regulations."

The IEC WQS classification zones applicable to the PVSC combined sewer municipalities are shown on **Figure B-2**.

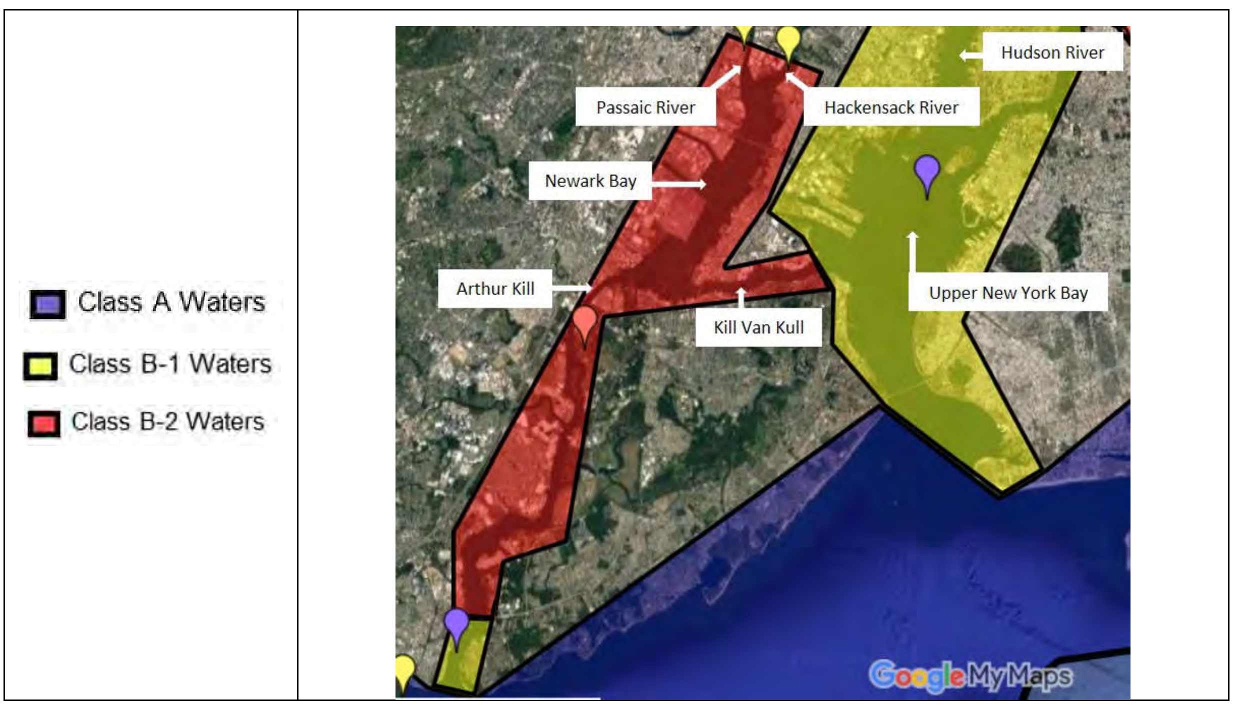

Figure B-2: Interstate Environmental Commission Water Quality Classifications

1 33 U.S.C. Chapter 26
2 N.J.S.A 58:10A-1 et seq.
3 Source: IEC website: http://www.iec-nynjct.org/wq.regulations.htm

As shown on **Figure B-2**, the mouth of the Passaic River, the mouth of the Hackensack River, Newark Bay, Kill Van Kull, and Arthur Kill are classified as B-2 waters and the Upper Bay (Hudson River) is classified as B-1. WQS applicable to Class B-1 and Class B-2 waters relevant to CSO discharges are provided in **Table B-3** below.

Table B-3: IEC Water Quality Standards for IEC Class B Waters

<table>
<tr><th>Water Quality Parameter</th><th>Value</th></tr>
<tr><td>Dissolved Oxygen Class B-1</td><td>$\geq$ 4 milligrams per liter</td></tr>
<tr><td>Dissolved Oxygen Class B-2</td><td>$\geq$ 5 milligrams per liter</td></tr>
<tr><td>Dissolved Oxygen Classes B-1 & B-2</td><td>Further, all sewage or other polluting matter discharged or permitted to flow into waters of the District shall first have been so treated as to effect a reduction in the oxygen demand of the effluent sufficient to maintain the applicable dissolved oxygen requirement in the waters of the District and also maintain the dissolved oxygen content in the general vicinity of the point of discharge of the sewage or other polluting matter into those waters, at a depth of about five (5) feet below the surface.</td></tr>
<tr><td>Fecal Coliform (effluent discharges)</td><td>• 200 per 100 ml on a 30 consecutive day geometric average;
• 400 per 100 ml on a 7 consecutive day geometric average;
• 800 per 100 ml on a 6 consecutive hour geometric average; and
• no sample may contain more than 2400 per 100 ml.</td></tr>
<tr><td colspan="2">General Requirements</td></tr>
<tr><td colspan="2">• All waters of the Interstate Environmental District (whether of Class A, Class B, or any subclass thereof) shall be of such quality and condition that they will be free from floating solids, settleable solids, oil, grease, sludge deposits, color or turbidity to the extent that none of the foregoing shall be noticeable in the water or deposited along the shore or on aquatic substrata in quantities detrimental to the natural biota; nor shall any of the foregoing be present in quantities that would render the waters in question unsuitable for use in accordance with their respective classifications.</td></tr>
<tr><td colspan="2">• No toxic or deleterious substances shall be present, either alone or in combination with other substances, in such concentrations as to be detrimental to fish or inhibit their natural migration or that will be offensive to humans or which would produce offensive tastes or odors or be unhealthful in biota used for human consumption.</td></tr>
<tr><td colspan="2">• No sewage or other polluting matters shall be discharged, permitted to flow into, be placed in, or permitted to fall or move into the waters of the District, except in conformity with these regulations.</td></tr>
</table>

The IEC website states:

> *"An effluent discharge which does not satisfy the requirements of the Commission shall not be considered to be in violation thereof if caused by temporary excess flows due to storm water conveyed to treatment plants through combined sewer systems, provided that the discharger is operating the facility with reasonable care, maintenance, and efficiency and has acted and continues to act with due diligence and speed to correct the condition resulting from the storm water flow.*

Unless there has been rainfall in greater than trace amounts or significant melting of frozen precipitation during the immediately preceding 24 hours, no discharges to the waters of the Interstate Environmental District shall occur from combined sewer regulating devices."

Additional information relating to the applicable WQS and the current use attainment status of the receiving waters is provided in the System Characterization Report.

B.3.3 New Jersey Administrative Code

New Jersey Administrative Code ("NJAC") Section 7:9B (Surface Water Quality Standards) lists the classifications, designated uses, and water quality criteria for all New Jersey water bodies. The classification and WQS for the CSO receiving waters within the PVSC CSO Sewer District are shown in **Table B-4** below.

Table B-4: The NJ Administrative Code Classifications of PVSC Treatment District CSO Receiving Waters

Waterbody	Reach	Classification
Passaic River	Paterson - Outlet of Osborn Pond to Dundee Lake dam	FW2-NT
	Little Falls - Dundee Lake dam to confluence with Second River	FW2-NT/SE2
	Newark (@ Second River)	SE3
Hackensack River	Kearny Point	SE3
Hudson River	Englewood Cliffs	SE2
Kill Van Kull	Kill Van Kull	SE3
Newark Bay	Newark Bay	SE3

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 ml)
FW2-NT (Fresh Water Non Trout)	1. Maintenance, migration and propagation of the natural and established biota; 2. Primary contact recreation; 3. Industrial and agricultural water supply; 4. Public potable water supply after conventional filtration treatment (a series of processes including filtration, flocculation, coagulation, and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents) and disinfection; and	E. Coli	126 GM, 235 SSM

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 ml)
	5. Any other reasonable uses.		
SE2 (Saline Water)	1. Maintenance, migration and propagation of the natural and established biota; 2. Migration of diadromous fish; 3. Maintenance of wildlife; 4. Secondary contact recreation; and 5. Any other reasonable uses.	Fecal Coliform	770 GM
SE3 (Saline Water)	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.	Fecal Coliform	1500 GM

* *"The geometric mean (GM) shall be calculated using a minimum of five (5) samples collected over a thirty-day period"*

A map showing the administrative classifications for all of the waterbodies is found below as **Figure B-3.**

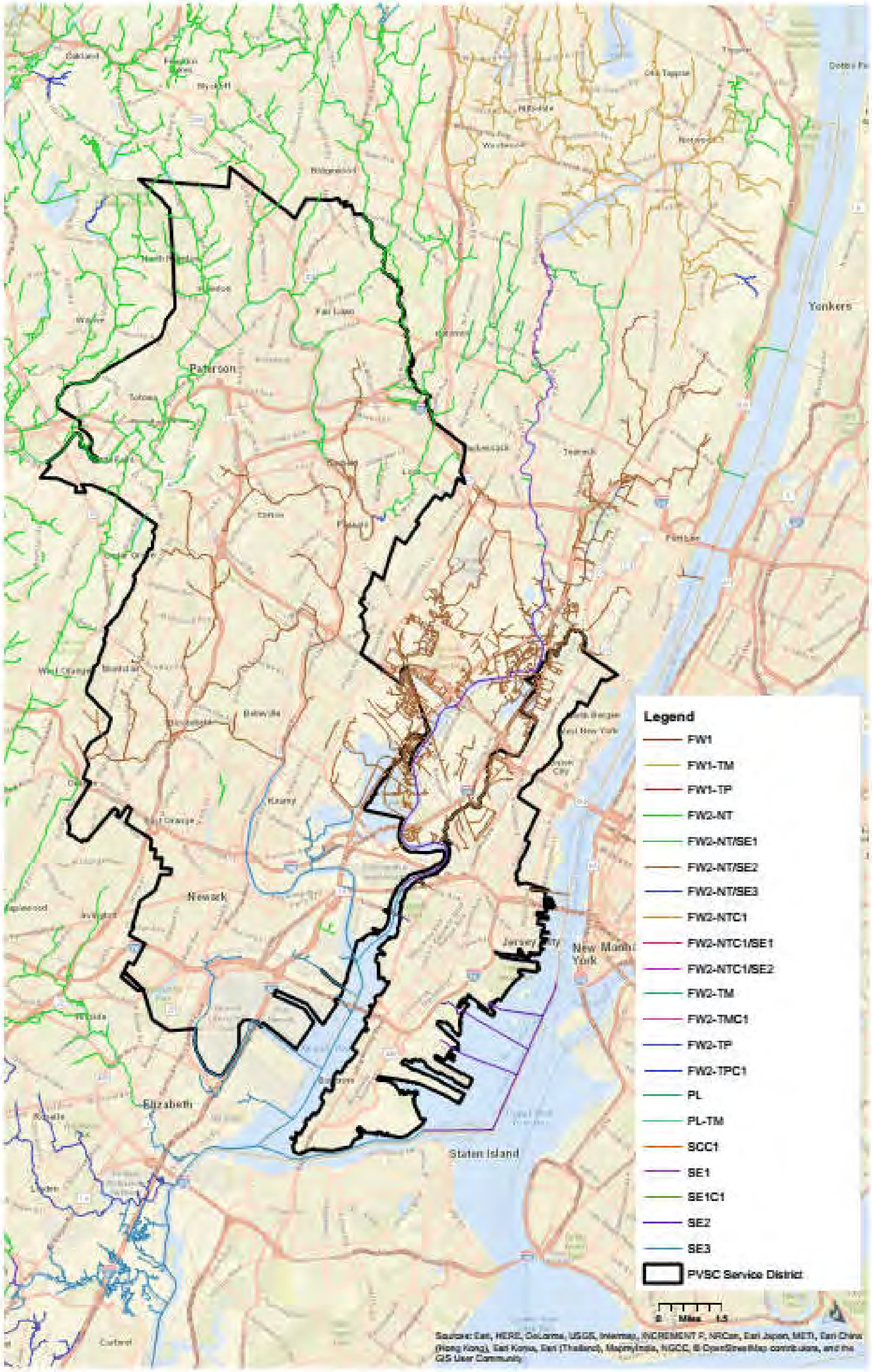

Figure B-3: Administrative Classifications of PVSC Treatment District Waterbodies

SECTION C - DESCRIPTION OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

This section of the report focuses on the technology screening process and the evaluation of CSO control alternatives as per the requirements of the NJPDES Permit for the following Municipalities shown in **Table C-1**.

Table C-1: NJPDES Permit Numbers

Municipality	NJPDES #
PVSC	NJ0021016
Borough of East Newark	NJ0117846
Town of Harrison	NJ0108871
Town of Kearny	NJ0111244
City of Newark	NJ0108758
City of Paterson	NJ0108880
City of Bayonne	NJ0209240
North Bergen MUA	NJ0108898
Jersey City MUA	NJ0108723

In order to determine the appropriate combined sewer overflow control technologies, a review of Combined Sewer Overflow (CSO) technologies was completed to determine those technologies that have the greatest potential to meet the requirements of the NJPDES Permit. This screening of technologies is consistent with the requirements of the CSOs Control Policy Section II.C.4 and the USEPA's "Guidance for Long Term Control Plan." The Alternatives Evaluation shall consist of:

- Technology Screening Process
- Evaluation of Specific CSO Control Alternatives

This screening of technologies does not consider cost or the cost effectiveness and is only meant to exclude those CSO control technologies not technically or physically appropriate for the PVSC Treatment District. The screening of CSO control technologies has also been presented to the public at a PVSC Regional Supplemental CSO Team Meeting. Public input received on the screening of CSO control technologies has been reviewed and considered in this evaluation. The results of this screening have brought several CSO control technologies forward for consideration in the development of the LTCP. These control technologies are further discussed in Section D of this report.

C.1.1 Water Quality and CSO Control Goals

With respect to water quality, control technologies are screened for their effectiveness at addressing pollutants of concern and CSO control goals in order to achieve compliance with the

CWA. The control technologies were screened based on the following pollutants of concern and CSO control goals.

- Reducing the count of fecal coliform colonies
- Reducing the count of Enterococcus colonies
- Reducing the count of Escherichia coli colonies
- CSO discharge volume reduction

The above-listed bacteria have been identified as POC applicable to each of PVSC Treatment District's four receiving waters. **Table C-2** through **Table C-7** contain the maximum concentrations, based on the NJAC Section 7:9B Surface Water Quality Standards, for the POC within the Passaic River, Newark Bay, Upper New York Bay, Kill Van Kull, Hudson River, and Hackensack River. The geometric mean (GM) shall be calculated using a minimum of five samples collected over a thirty-day period.

Table C-2: NJ Administrative Code Regarding the Passaic River

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 mL)
FW2	Primary Contact	E. coli	126 GM, 235 SSM
SE2	Secondary Contact	Fecal Coliform	770 GM
SE3	Secondary Contact	Fecal Coliform	1500 GM

Table C-3: NJ Administrative Code regarding the Newark Bay

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 mL)
SE3	Secondary Contact	Fecal Coliform	1500 GM

Table C-4: NJ Administrative Code regarding the Upper New York Bay

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 mL)
SE2	Secondary Contact	Fecal Coliform	770 GM

Table C-5: NJ Administrative Code regarding the Kill Van Kull

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 mL)
SE3	Secondary Contact	Fecal Coliform	1500 GM

Table C-6: NJ Administrative Code regarding the Hudson River

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 mL)
SE2	Secondary Contact	Fecal Coliform	770 GM

Table C-7: NJ Administrative Code regarding the Hackensack River

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100 mL)
SE1	Primary Contact	Enterococci	35 GM, 104 SSM
SE2	Secondary Contact	Fecal Coliform	770 GM
SE3	Secondary Contact	Fecal Coliform	1500 GM

The reduction in CSO discharge indirectly addresses the POC found in combined sewer overflows. **Table C-8** presents the baseline existing wet weather percent captured for the PVSC system in the PVSC Interceptor Communities and HCFM communities. In reference to percent capture in this section of the report and the following sections, the equation used to calculate CSO capture for PVSC over a representative time frame is as follows:

$$\text{Percent capture} = 100 \times \frac{\text{Sum of volume delivered to acceptable treatment}}{\text{Sum of inflow volumes to the CSS [sanitary + runoff]}}$$

For the percent capture calculation, the wet weather period starts when the accumulated rainfall depth is greater than 0.1 inch and ends 12 hours after precipitation stops. The flow volume within this period is counted as wet weather flow.

This information has been updated as a result of refinements to the H&H model since the submittal of the System Characterization Report and will continue to change as the model is refined. No significant changes from the System Characterization Report have resulted from the updated model, and JCMUA's information has been added to the HCFM communities.

Table C-8: Typical Year % Capture

	PVSC Interceptor Communities	Hudson County Force Main Communities
Total Wet Weather Volume (MG)	12,495	6,411
Total CSO Volume (MG)	2,042	2,222
% Capture	83.7%	65.3%
Additional Capture Volume (MG) for 85% Capture	168	1,260

The CSO goals mentioned above serve as an initial roadmap to narrow down the best control technologies for utilization during the alternative analysis. **Section 0** describes the evaluation methodology used for the screening of CSO Control Technologies.

C.1.2 Evaluation Methodology Used for this Study

The CSO control technologies evaluated in this section have been assigned a value based on their effectiveness at reaching primary CSO control goals. Descriptions of the goal effectiveness categories are detailed below:

- High: The CSO control technology will have a significant impact on this CSO control goal and is among the best technologies available to achieve that goal. These technologies may be considered for further evaluation for this reason.
- Medium: This technology is effective at achieving the CSO control goal but is not considered among the most effective technologies to achieve that goal.
- Low: This technology will have a minor impact on this CSO control goal. These technologies will need other positive attributes to be considered for further evaluation.
- None: The CSO control technology will have zero or negative effect on the CSO control goals.

Additionally, the positive impacts that each of the technologies may have on the community beyond achieving the primary goals described above were evaluated.

CSO control technologies will be recommended for further evaluation by each Permittee based on multiple factors. The first factor will be the goal-effectiveness value that generally quantifies the impact a technology will have towards achieving a water quality goal. These goal-effectiveness values are described above. In addition to the goal-effectiveness, identification of the potential community benefits the technology may bring when applied will also be considered. Another factor is whether or not the NJPDES Permit requires investigation of a technology. The permit identifies certain technologies that must be evaluated. The final factor in determining whether a technology will be evaluated as an alternative is the current or future implementation and operation of that technology. If the technology is currently in place, will be implemented, or is mandated by the Nine Minimum Controls, then an evaluation is unnecessary.

Potential CSO control technologies generally fall into the following broad categories:

- **Source Controls:** Green infrastructure ("GI"); public and private infiltration and inflow ("I/I") reduction and removal; sewer separation; and best management practices ("BMPs")/Nine Minimum Controls, including floatables control
- **Collection System Controls:** Gravity sewers; pump stations; hydraulic relief structures; in-line storage; outfall relocation/consolidation; and regulator/diversion structure modification
- **Storage Technologies:** Above and below ground tanks; and tunnels
- **Treatment Technologies:** Screening and disinfection; vortex separation; retention/treatment basins; high rate clarification; and satellite sewage treatment

Table C-9, **Table C-10**, and **Table C-11**, located in Section C.9 Screening of Control Technologies, group technologies based on the broad categories mentioned above and contain a brief description of the implementation and operation factors for each technology. A CSO technology that is highly effective in one or all evaluation factors will likely be recommended for further investigation. A CSO technology that does not reach a "medium" effectiveness in meeting CSO control goals will likely not be recommended for further evaluation.

The "Community Benefits" column in each of the three tables listed above provides a brief list of benefits that the technologies could bring to the community. This list was developed using general knowledge about each of the technologies, the New Jersey DEP Division of Water Quality's report entitled "Evaluating Green Infrastructure: A Combined Sewer Overflow Control Alternative for Long Term Control Plans," and the New Jersey Green Infrastructure Municipal Toolkit website (https://gitoolkit.njfuture.org/). The following discussion is structured to closely follow the order of CSO technologies listed in the NJPDES Permit. A summary of technologies recommended for further investigation for each permittee is provided in their respective Development and Evaluation of Alternatives Reports.

C.2 SOURCE CONTROL

USEPA defines source controls as those that impact the quality or quantity of runoff entering the combined sewer system. Source control measures can reduce volumes, peak flows, or pollutant discharges that may decrease the need for more capital-intensive technologies downstream in the CSS. However, source controls typically require a high level of effort to implement on a scale that can achieve a measurable impact. Source controls discussed in the following section will include both quantity control and quality control measures.

C.2.1 Stormwater Management

Stormwater management controls consist of measures designed to capture, treat, or delay stormwater prior to entering the CSS.

C.2.1.1 Street/Parking Lot Storage (Catch Basin Control)

Street and parking lot storage can be accomplished by modifying catch basins to restrict the rate of stormwater runoff that enters the CSS. A portion of the stormwater runoff that would otherwise immediately enter the CSS is allowed to pond on streets or parking lots for a period of time before entering the CSS. This control measure can be very effective at reducing peak flows during wet weather events, when most CSOs occur. However, this practice typically faces strong public opposition and can lead to hazardous road conditions if not managed properly (e.g., hydroplaning, ice formation during winter months, etc.).

C.2.1.2 Catch Basin Modification (Floatables Control)

Catch basin modifications consist of various devices that prevent floatables from entering the CSS. Inlet grates can reduce the amount of street litter and debris that enters the catch basin. Other modifications such as hoods, submerged outlets and vortex valves alter the outlet pipe hydraulics and keep floatables from exiting the catch basin and continuing downstream. These devices also provide a water seal for containing sewer gas. The success of a catch basin modification program is dependent on having catch basins with sumps deep enough to install hood-type devices. A potential disadvantage of catch basin outlet modifications and other insert-type devices is the fact that retained materials could clog the outlet if cleaning is not performed regularly.

C.2.1.3 Catch Basin Modifications (Leaching)

Catch basin modifications for leaching consist of catch basin base and riser sections that permit infiltration of stormwater into the ground. Leaching catch basins are generally installed in a geotextile and crushed stone lined excavation. Leaching catch basin installations are limited to highly permeable soils and should not be installed in series with other drainage structures. Leaching catch basins can be installed with or without an outflow pipe. Basins without an outflow can overflow into streets and parking lots and then freeze under excessive storm events or if soils decrease permeability over time. These control measures function much like an infiltration basin without an emergency overflow pipe. In order to avoid this adverse feature, an outflow pipe should be necessary in all leaching modified catch basins unless there is minimal flow to the basin, and a low overflow damage risk to the surrounding area.

C.2.2 Public Outreach Program

Public education and outreach are a non-structural control measure aimed at limiting the negative effects of certain human behavior on the CSS. Promoting certain human actions and discouraging others can impact the quality and quantity of water discharged to the CSS. A collaboration of entities who own and operate combined sewer systems within the PVSC Treatment District and the NBMUA services areas have established the Clean Waterways, Healthy Neighborhoods initiative. The initiative aims to foster public awareness by keeping the public informed of the efforts being taken to reduce the water quality impact of CSOs on the receiving waters in the area. Additional information is available on the following website: https://www.njcleanwaterways.com/.

PVSC's webpage (www.nj.gov/pvsc) provides numerous informational postings related to the CSO LTCP, such as information regarding CSO construction-related activities for each of the permittees within the PVSC Sewerage District. There is also a link to the NJ CSO Group's CSO Notification System. Notices for public meetings, plant tour request forms, as well as the history of and descriptions of PVSC's infrastructure are posted on the website. PVSC also advertises volunteering opportunities and educational outreach programs for kids K-12 on their website. Additionally, the NBMUA webpage (www.nbmua.com) provides a number of postings of information for the public related to the NBMUA-Woodcliff and Town of Guttenberg LTCP. The website includes information on the CSO construction-related activities, a link to the NJ CSO Group's CSO Notification System, as well as notices for public meetings.

A LTCP Facebook and Twitter social media plan was developed to enhance electronic outreach about the LTCP. The PVSC Facebook page provides relevant information about their services and ways that communities can learn more about getting involved with the agency. The page is open for comments and questions, which are answered by PVSC personnel. This allows the agency to showcase transparency and signals a real commitment to public input. Additionally, a Clean Waterways, Healthy Neighborhoods LTCP Facebook page was also developed. The LTCP Facebook page is branded with the Clean Waterways, Healthy Neighborhoods logo. It is updated on a regular basis to keep it fresh and informative, and serves to promote relevant LTCP information, including upcoming events and meetings, project visuals, Supplemental CSO Team and relevant municipal information, and other related news and articles. Both the PVSC Facebook page and the LTCP Facebook page are open to public feedback and comment. The

PVSC Facebook page is accessible through the PVSC website and the LTCP Facebook page is accessible through the Clean Waterways, Healthy Neighborhoods website.

As with the Clean Waterways, Healthy Neighborhoods Facebook page, the Twitter page is branded with the Clean Waterways, Healthy Neighborhoods logo and is updated on a regular basis to keep it fresh and informative. The Twitter feed serves to promote relevant LTCP information, including upcoming events and meetings, project visuals, Supplemental CSO Team and relevant municipal information, and other related news and articles. The LTCP Twitter page is also open to public feedback and comment.

The NJ CSO Group was originally formed to work cooperatively to fulfill the requirements of the last CSO General Permit. The group was recently expanded to include more permittees that discharge to the tidally connected waterbodies in the NY/NJ Harbor Estuary. The NJ CSO Group has created a CSO Notification System (njcso.hdrgateway.com/). This system provides up-to-date information regarding where CSO discharges may or may not be occurring.

Additional information on the Public Outreach Program can be found in the Public Participation Process Report, dated June 2018 and last revised January 25, 2019.

C.2.2.1 Water Conservation

Water conservation in CSS areas can reduce the volume of direct discharges to the system. Water conservation measures include the installation of low-flow fixtures, education to reduce water waste, leak detection and correction, and other programs. Although this measure has the potential to decrease CSS flows, it has very little impact on peak flows, which cause most CSOs.

C.2.2.2 Catch Basin Stenciling

Stenciling consists of marking catch basins with symbols and text such as, "Drains to the River" or "Only Rain Down the Storm Drain". This measure can help increase public awareness of the sewer system and discourage the public from dumping trash into the CSS, which can cause blockages and lead to CSOs. Catch basin stenciling is only as effective as the public's understanding and input of the program. Catch basin inlet grates have the equivalent effect while not relying on public cooperation.

C.2.2.3 Community Cleanup Program

Community cleanup programs are an inexpensive and effective way to reduce floatables entering the CSS and provide educational benefits to the community. Cleanup activities can be organized by local businesses, non-profit organizations, and student chapters at all levels. It is a great way to raise the sense of community spirit and environmental awareness.

C.2.2.4 Public Outreach (Public Meetings)

As part of the public outreach program to help raise citizens' awareness of water quality and other environmental issues, Public Meetings are held to educate citizens about CSS's and encourage people to do their part to reduce the grease, toxic chemicals, and floatables from entering local waterways. This is currently accomplished through Supplemental CSO Team Meetings (public meetings). Information presented in meetings is available as handouts.

C.2.2.5 FOG Program

Fats, oils and grease ("FOG") are not water soluble and will buildup and clog sewer and drainage pipes, resulting in messy, costly sanitary sewer overflows. These overflows are bad for commercial and retail businesses, the environment, and public health. FOG programs often consist of food service establishment inspection, installation of Grease Removal Devices ("GRDs") and development of a preferred pumper program for proper maintenance of GRDs. However, FOG programs have little effect on the amount of bacteria in the collection system and do not provide any flow reductions. PVSC currently has a robust FOG program that permits and inspects all commercial cooking establishments in the State to ensure grease traps are installed and maintained.

C.2.2.6 Garbage Disposal Restrictions

Garbage disposals provide a convenient means for residences and businesses to dispose of food waste. However, the use of garbage disposals increases the amount of food scrap entering the sewer system and is known to cause blockages and decrease the flow capacity in the CSS. Restricting garbage disposal usage has the potential to decrease the number of blockages that occur each year. Garbage disposal restrictions require an increased allocation of resources for enforcement and can face considerable public resistance. Furthermore, this practice does very little to reduce wet weather CSO events or decrease bacteria loads.

C.2.2.7 Pet Waste Management

When pet waste is not properly disposed of, it can be carried away by stormwater runoff and washed into storm drains or nearby streams. Since storm drains do not always connect to treatment facilities, untreated animal feces often end up in waterways, causing significant water pollution. An effective pet waste management program can help increase public awareness and encourage proper waste disposal. This is a low cost, long term program that has the potential to reduce bacteria loads to both the CSS and directly to local streams.

C.2.2.8 Lawn and Garden Maintenance

Failure to apply chemical treatments to lawns or gardens per USEPA guidelines may lead to ineffective treatment and contamination of the waterways through runoff or groundwater. A public outreach program that explains the guidelines and the reasons they exist may help reduce waterway contamination. This information is currently available to the public on the following USEPA website: https://www.epa.gov/safepestcontrol/lawn-and-garden. Runoff that contains chemical treatments can contribute to decreased water quality downstream of the CSS in the receiving waters.

C.2.2.9 Hazardous Waste Collection

Improperly disposed hazardous waste can find its way into stormwater runoff and into storm drains and waterways. Hazardous waste that ends up in waterways does not necessarily end up in a treatment facility and can cause significant surface water pollution. To prevent this, household hazardous waste collection events can be scheduled a few times every year to allow the community to properly dispose of any hazardous waste.

C.2.3 Ordinance Enforcement

C.2.3.1 Construction Site Erosion and Sediment Control

Construction site erosion and sediment control involves management practices aimed at controlling the transport of sediment and silt by stormwater from disturbed land. Erosion and sediment control have the potential to reduce sediment loads to both the CSS and directly to streams and can help reduce sewer cleanout Operation and Maintenance ("O&M") costs. The N.J.S.A. 4:24-39, NJ Soil Erosion and Sediment Control Act, requires all construction activities greater than 5,000 square feet to complete an application for certification of an erosion and sediment control plan for activities during construction.

C.2.3.2 Illegal Dumping Control

Illegal dumping is the disposal of trash or garbage by dumping, burying, scattering, or unloading trash in an unauthorized place, such as public or private property, streets or alleys, or directly into the CSS. When it occurs, illegal dumping contributes a considerable amount of floatables to stormwater runoff, as well as a moderate amount of bacteria, settleable solids, and other pollutants. Enforcement of illegal dumping regulations is being led by State Park Police & Conservation Officers and the NJDEP Department of Compliance & Enforcement.

C.2.3.3 Pet Waste Control

As described in the previous section, pet waste can be a significant contributor of bacteria to stormwater. Public education and outreach programs can help raise public awareness and reduce the level of improper waste disposal. Additional gains can be made through enforcement of the pet waste ordinances, which can be an effective tool in achieving public compliance. Significant resources would need to be devoted to enforcement to achieve similar improvements to Pet Waste Management, which requires very few resources to implement.

C.2.3.4 Litter Control

Litter consists of waste products that have been disposed of improperly in an inappropriate area. Litter is easily washed into the collection system during wet weather events, which increases the amount of floatables in the system. Strict enforcement of the litter control ordinances can help to curb violations and decrease the amount of floatables that make their way into the CSS. Similar to Pet Waste Control, public outreach and education is a more effective use of resources to achieve similar water quality improvements.

C.2.3.5 Illicit Connection Control

An illicit discharge is any discharge to the municipal separate storm sewer system (MS4) that is not composed entirely of storm water, except for discharges allowed under a NPDES permit or waters used for firefighting operations. Illicit connections can contribute polluted water, solids, and trash to the stormwater system, where it is eventually discharged to the environment without receiving proper treatment. These connections can be reduced through the implementation of an illicit discharge detection and elimination ("IDDE") program. Although this measure does not directly target the CSS, it can have significant impacts on local water quality that can help to address Total Maximum Daily Loads. Illicit connection control is not particularly effective at achieving any of the primary goals of the LTCP.

C.2.4 Good Housekeeping

C.2.4.1 Street Sweeping/Flushing

Municipal street cleaning enhances the aesthetic appearance of streets by periodically removing the surface accumulation of litter, debris, dust and dirt, which prevents these pollutants from entering storm or combined sewers. Common methods of street cleaning are manual, mechanical and vacuum sweepers, and street flushing. However, the total public area accessible to street sweepers is limited, and generally does not include sidewalks, traffic islands, and congested street parking areas. Although street sweeping/flushing can reduce the concentration of floatables and pollutants in storm runoff that originate from the street, the measure has minimal impact on bacteria or CSO volume reduction.

C.2.4.2 Leaf Collection

Leaf collection is an important part of stormwater management because it not only keeps leaves out of the stormwater system to maintain its maximum flow capacity, but also benefits water quality by reducing nutrients such as phosphorous and nitrogen that can originate from the decomposition of leaves. In most municipalities, this long term stormwater management measure is scheduled based on seasonal patterns and is an effective tool to maintain capacity in both the separate storm sewer and the CSS.

C.2.4.3 Recycling Programs

Recycling programs provide a means for the public to properly dispose of items that may otherwise end up entering the CSS, such as motor oil, anti-freeze, pesticides, animal waste, fertilizers, chemicals, and litter. These programs are usually effective in reducing floatables and toxins.

C.2.4.4 Storage/Loading/Unloading Areas

Industrial and commercial users would be required to designate and use specific areas for loading and unloading operations. This would concentrate the potential for loading and unloading related waste to a few locations on site, making it easier to manage waste. The effectiveness of this technology is limited to the number of industrial users upstream of CSO regulators. If there are no industrial users in the CSS, then this is technology is not applicable.

C.2.4.5 Industrial Spill Control

Industrial users would be required to utilize spill control technologies like containment berms and absorbent booms to mitigate the risk of contaminants entering the waterway or collection system. Similar to Storage/Loading/Unloading Areas, the effectiveness of this technology is limited to the number of industrial users upstream of CSO regulators.

C.2.5 Green Infrastructure

GI is a source control that uses natural processes such as infiltration, evapotranspiration, filtration, storage, and controlled release to reduce the stormwater volume, peak flows, or pollutant loads entering the sewer system or surface waters. A wide range of GI technologies are currently in use throughout the country and include pervious paving, bioretention basins, vegetated swales, green roofs, blue roofs, and rainwater harvesting. These technologies can be used alone in a scalable manner, or in conjunction with gray infrastructure to reduce the size and cost of gray infrastructure.

GI's benefits extend beyond reducing the flow of water into CSSs during wet weather events. By mimicking a more naturalized system, GI can deliver a broad range of ecosystem services or benefits to people, some of which include: improvements to community livability (aesthetics and property values), human health, air quality, water quality, groundwater recharge, wildlife habitats and connectivity, reduced heat island effects, reduced energy use, increased green jobs, and more recreational opportunities (USEPA, 2014). As described in Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control (USEPA, 2014), the USEPA requires that any incorporation of GI into a LTCP include analysis in two areas:

1. Community and political support for GI
2. Realistic potential for GI implementation

PVSC and the Permittees will assess the public support for GI and other CSO control alternatives through the implementation of the LTCP Public Participation Plan. This includes hosting quarterly public meetings with the Clean Waterways, Healthy Neighborhoods Supplemental CSO Team, participating in the meetings of various local groups, attending public events, meeting with municipal representatives, and soliciting public input through the Clean Waterways, Healthy Neighborhoods website and social media platforms. The realistic potential for the implementation will first be screened within this report and refined further in the alternatives evaluation.

There are a wide range of potential GI technologies currently in use throughout the country, and many of these include numerous design variations incorporated into a variety of documents and design manuals. The intent of this section is to summarize important aspects of the relevant practices, rather than to provide a comprehensive catalog or detailed design documents.

In addition, there are watershed-scale GI options that are not appropriate for **PVSC Treatment District** due to highly urbanized nature of the CSS area or improper resources to maintain the technology. These include land conservation efforts and creation, preservation, or restoration of riparian buffers, flood plains, wetlands, open space, and forests. These GI options should be encouraged when land use can easily be converted for this intention with minimal upkeep, but this report will not consider these technologies to reduce runoff volume and bacterial loading. With the above considerations in mind, feasible and appropriate GI technologies were evaluated for implementation in buildings, impervious areas, and pervious areas in **PVSC Treatment District** publicly-owned property.

C.2.5.1 Green Roofs

Green roofs have bioretention media that collect runoff to promote evapotranspiration and achieve WQS through soil media filtration. They are typically shallow in depth (4-8") based on the ability of the building to support the weight of the media, plantings, and captured rainfall. Green roofs may be built in layers on a roof or installed as cells in crates. An example green roof section can be found in **Figure C-1**.

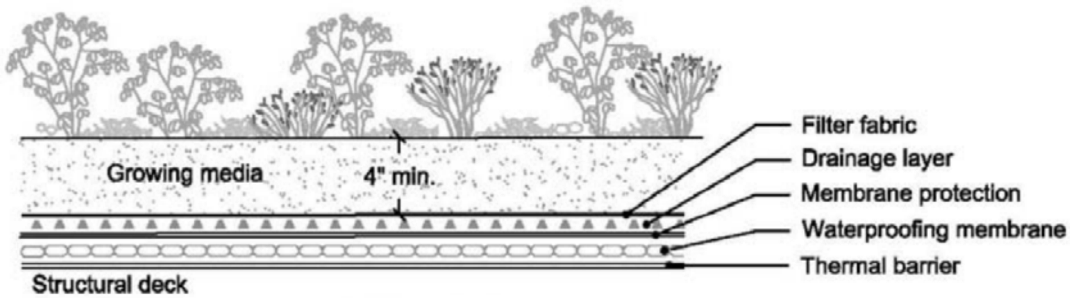

Figure C-1: Example Green Roof Section

Green roofs are recommended for use on buildings with flat roofs (recommended 1-2% slope) that have the structural capacity to support the weight of the media, plantings, and water. Structural improvements to an existing building to support the additional weight associated with a green roof are not typically recommended; therefore, this technology is more feasible on new construction. Green roofs can be installed in a section or across an entire roof. An overflow system is typically installed. The vegetation may require irrigation during the first 1-2 years to establish growth. Recommended maintenance for green roofs includes semi-annual maintenance of vegetation.

Many rooftop retrofits are required for this GI technology to have measurable impact. Most of the buildings in the CSS are privately owned. Implementing this technology on a scale that would have a measurable impact would require retrofits on private property.

C.2.5.2 Blue Roofs

Blue roofs collect runoff to promote evaporation (they do not have plantings) through detention. They are typically shallow in depth (4-8") based on the ability of the building to support the weight of the media and captured rainfall. Blue roofs may be built in layers on a roof or installed as cells in crates. Unlike green roofs, a blue roof may not provide any water quality benefits, unless filters or storage media are used specifically for this purpose. The water detained from blue roofs may be used on-site instead of being released with the appropriate modifications.

Blue roofs are recommended for use on buildings with flat roofs (recommended 1-2% slope) that have the structural capacity to support the weight of the media and water. Structural improvements to an existing building to support the additional weight associated with a blue roof are not typically recommended; therefore, this option is more feasible on new construction. Blue roofs can be installed in a section or across an entire roof. An overflow system is typically installed to direct the detained water off of the roof. Recommended maintenance for blue roofs includes semi-annual maintenance for clearing of debris.

Similar to green roofs, blue roofs would require implementation on private property to have a measurable impact.

C.2.5.3 Rainwater Harvesting

Rainwater harvesting is the collection and storage of rainfall from buildings to delay or eliminate runoff. The reduction in runoff volume varies based on the size of the rain barrel or cistern storage unit, and the reuse of the stored rainfall. A few typical reuse options are irrigation and vehicle washing. Indoor reuse options, such as toilet flushing and heating and cooling, may be possible if coordinated with building policies.

Rainwater harvesting is applicable to all types of buildings with gutters and downspouts but may be reserved for buildings where green or blue roofs are not appropriate (roof slopes greater than 2%). Storage units may be sized and installed for each downspout or for the building as a whole. Rain barrels, such as those in **Figure C-2**, are typically used for residential installations and larger cisterns are typically used for non-residential applications. They are typically placed at grade but can be buried below grade if a pumping system for water reuse is provided. An overflow system is typically installed. Recommended maintenance for rainwater harvesting includes semi-annual maintenance for clearing of debris in the piping or storage unit.

Figure C-2: Example Rain Barrels

Similar to green and blue roofs, this technology is limited by the number of available roofs, most of which are private. Private residential uses of cisterns are much less common than on private commercial properties but are encouraged to help reduce combined sewer overflows.

C.2.5.4 Permeable Paving

Permeable pavements promote runoff infiltration and rely on a permeable substrate (engineered soils) to store runoff and remove pollutants. There are different types of permeable pavements, most commonly constructed with asphalt, concrete, or pavers. Permeable asphalt and concrete are similar to traditional mixes except that the amount of fine aggregates is reduced or eliminated. Permeable pavers are individual paver units laid together to create a paved surface. The depth of the permeable substrate, anywhere from 3-10 feet, will have the largest impact on runoff volume reduction. Substrate design may incorporate stormwater retention chambers to increase storage volume. Underdrains may be necessary depending on the local soil types, depth of substrate, and groundwater elevation.

Permeable pavements are recommended for low traffic and low speed traffic areas such as sidewalks, parking lanes, parking lots, driveways, and alleys**. Figure C-3**, **Figure C-4**, and **Figure C-5** show slightly different permeable pavement details for each of these surfaces. Recommended maintenance for permeable pavement includes semi-annual inspection and vacuuming. Preventative maintenance is also necessary to minimize the introduction of soil and other fine particles that could clog the pavement pores.

This GI technology can be very effective when implemented in parking lots, parking lanes, and narrow sidewalks where planter boxes cannot be implemented.

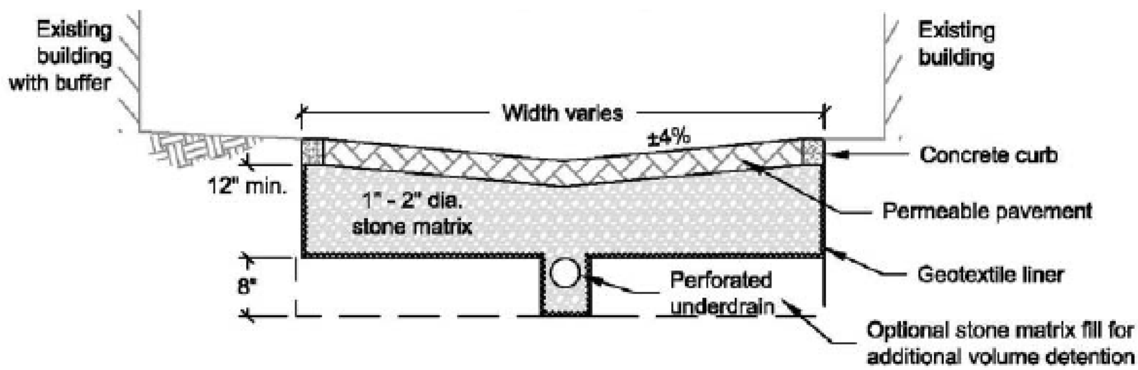

Figure C-3: Example Permeable Pavement Design near Existing Buildings

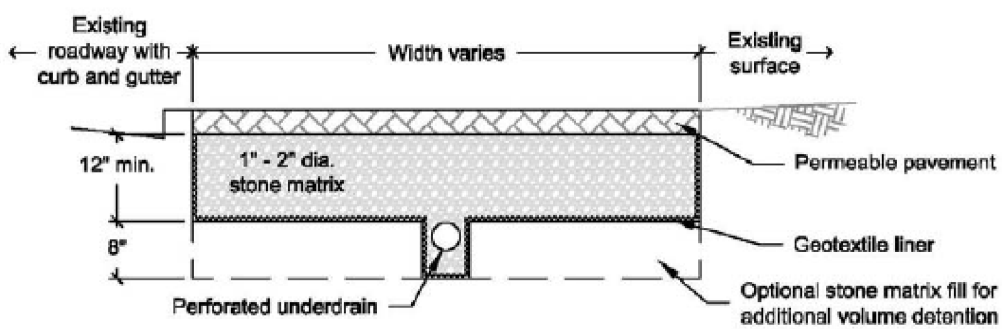

Figure C-4: Example Permeable Pavement Design near Existing Roadway and Surface

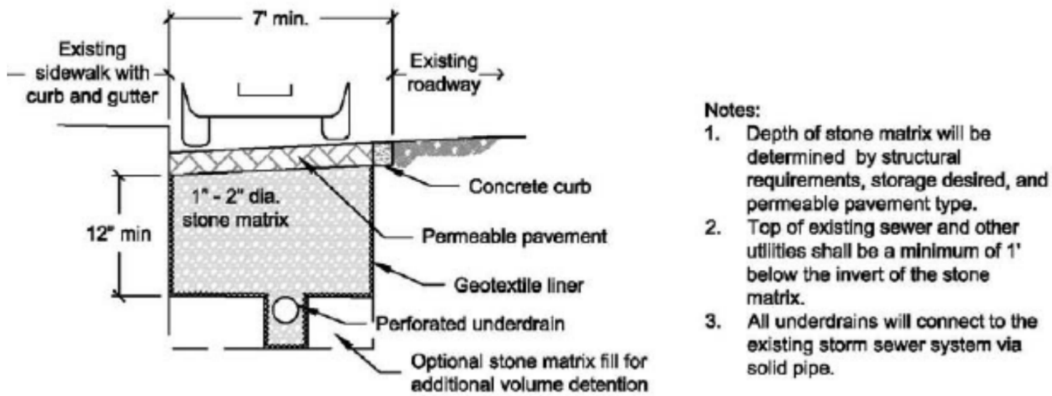

Figure C-5: Example Permeable Pavement Design near Existing Roadway and Sidewalk

C.2.5.5 Planter Boxes

Planter boxes are bioretention cells that collect runoff and promote runoff infiltration. These walled units are similar to free-form rain gardens as vegetated depressions (12-24") that rely on ponding and a permeable substrate (engineered soils) to store runoff and remove pollutants. The depth of the permeable substrate, anywhere from 3-10 feet, will have the largest impact on runoff volume reduction. An Example Planter Bump out Section can be found in **Figure C-6**. Substrate design may incorporate stormwater retention chambers to increase storage volume. Properly designed planter boxes limit ponding to 3-6 hours after a storm. Ponding overflow pipes and/or underdrains may be necessary depending on the local soil types, depth of substrate, and groundwater elevation. The vegetation promotes evapotranspiration to reduce the volume of the stored runoff.

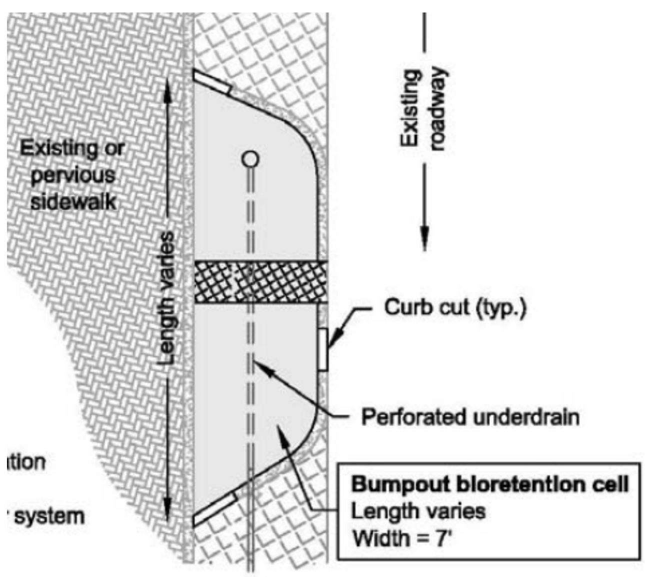

Figure C-6: Example Planter Bumpout Section

There are two (2) primary sizes of planter boxes for use based on the drainage pattern in developed areas: sidewalk planter boxes and bump out planter boxes. Sidewalk planter boxes may also be more specifically referred to as a Tree Well BMP, a Tree Well with Soil Panels, a Continuous Planting Strip, Mid-Sidewalk BMP, or a Back of Sidewalk BMP. Sidewalk planter boxes are depressed below the elevation of the existing sidewalk. Bump out planter boxes are larger units that extend from the sidewalk curb into an area of a parking lane. An example of this design can be found in **Figure C-6**. Curb cuts into planter boxes allow roadway runoff to enter the cells and overflow to street inlets once the maximum ponding depth has been reached. Planter boxes are recommended for use in regularly spaced intervals in the downstream drainage path in areas of impervious cover.

Recommended maintenance for planter boxes includes semi-annual inspections and improvements to vegetation and mulch, and annual inspection of overflow pipes and underdrains, if applicable. Inspection after a large storm is also recommended. If there is evidence of ponding after 48 hours, mulch replacement or overflow pipe cleaning may be necessary.

Planter boxes are well suited for highly developed areas where space allows. They can be installed block by-block to contain, infiltrate, and evapotranspirate stormwater runoff.

C.2.5.6 Bioswales

Bioswales are vegetated channels that reduce runoff velocity and promote runoff infiltration. These are linear channels with shallow depressions (6-12”) that incorporate vegetation and a permeable substrate (engineered soils). As a channel, runoff not infiltrated does not pond, but flows through the swale and is conveyed elsewhere. The channels, especially those with slopes greater than 6%, may incorporate check dams to assist in reducing runoff velocity and promote infiltration and pollutant removal. A design example for a bioswale is found in **Figure C-7**.

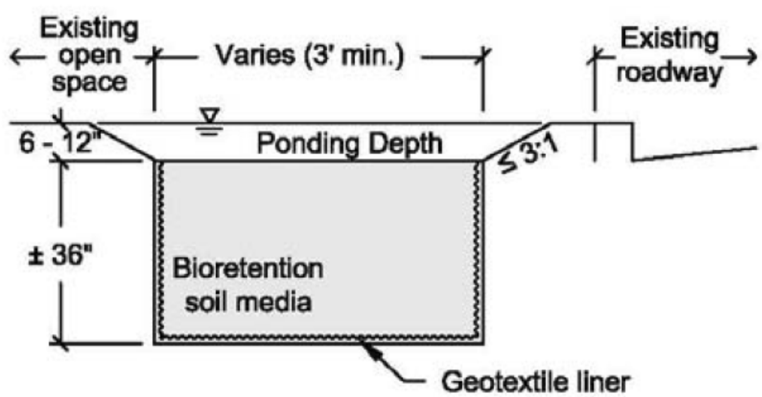

Figure C-7: Example Bioswale Design

Bioswales are recommended for use in parks and areas of natural cover since they primarily reduce runoff velocity and have a low volume reduction per square foot. Due to their linear nature, bioswales may also be effective in the buffer between open space areas and impervious areas with high volumes of runoff such as roads and parking lots. Recommended maintenance for bioswales includes semi-annual inspections and improvements to vegetation and mulch.

This technology incorporates both stormwater treatment and stormwater conveyance. While not as flexible as planter boxes, there may be locations in within the community where a bioswale could be effective.

C.2.5.7 Free-Form Rain Gardens

Rain gardens are bioretention basins that collect runoff and promote runoff infiltration. These are vegetated depressions (12-24") that rely on ponding and a permeable substrate (engineered soils) to store runoff and remove pollutants. The size and shape of rain gardens can be tailored to site-specific needs, but the depth of the permeable substrate (anywhere from 3-10 feet) will have the largest impact on runoff volume reduction. Substrate design may incorporate stormwater retention chambers to increase storage volume. Properly designed rain gardens limit ponding to 3-6 hours after a storm. Ponding overflow pipes and/or underdrains may be necessary depending on the local soil types, depth of substrate, and groundwater elevation. The vegetation promotes evapotranspiration to reduce the volume of the stored runoff, and infiltration helps improve water quality. An example of a free-form rain garden design is found in **Figure C-8**.

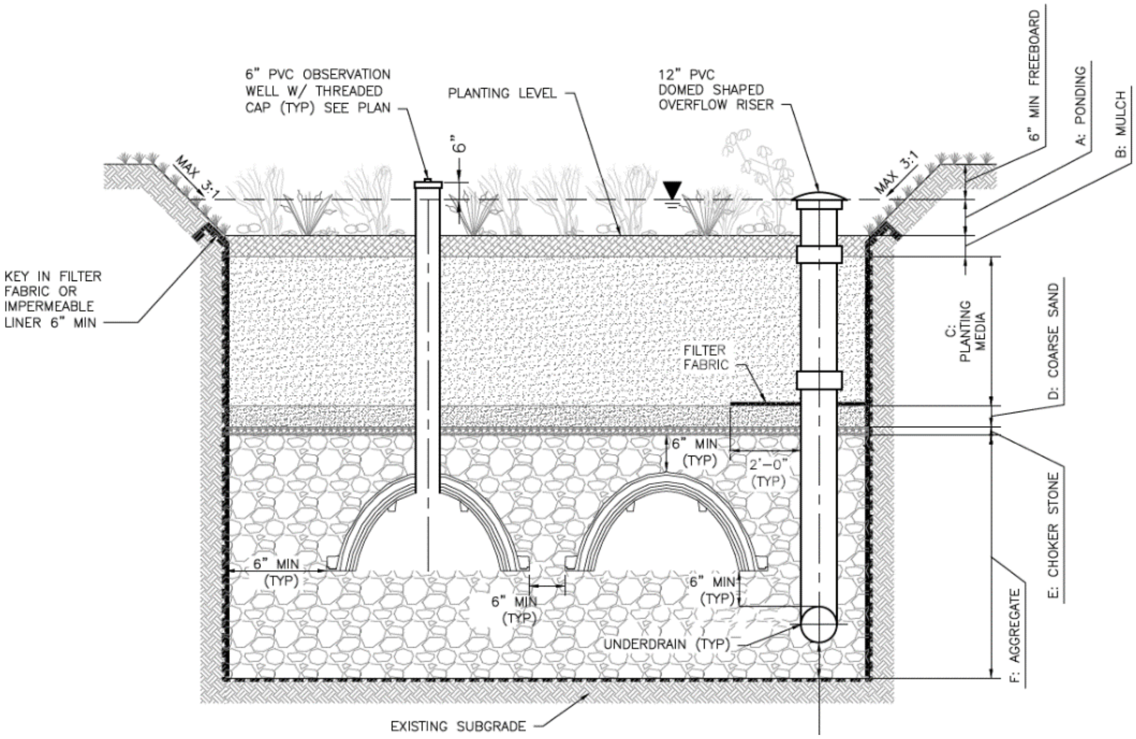

Figure C-8: Example Free-Form Rain Garden Design

Rain gardens are recommended for use in low points in parks and areas of natural cover so they can blend in seamlessly with a grassed buffer and enhance the vegetation without appearing to be a stormwater control mechanism. Locations near the transition from pervious to impervious cover can provide runoff reduction for nearby impervious areas.

Recommended maintenance for rain gardens includes semi-annual inspections and improvements to vegetation and mulch and annual inspection of overflow pipes and underdrains, if applicable. Annual inspection after a large storm is also recommended. If evidence of ponding exists after 48 hours, mulch and/or soil replacement or overflow pipe cleaning may be necessary. Rain gardens are very effective at capturing and treating stormwater and have versatile footprints that make them advantageous for use in highly developed urban environments.

C.3 INFILTRATION AND INFLOW CONTROL

Infiltration and inflow control falls under the USEPA category collection system controls. Collection system controls are defined as measures that reduce CSO volume and frequency by removing or diverting stormwater runoff to maximize the capacity of the collection system. Collection system controls have the potential to reduce the volume of CSO events.

C.3.1 Infiltration Inflow (I/I) Reduction

Excessive infiltration and inflow can consume the hydraulic capacity of a collection system and increase overall operations and maintenance costs. Inflow comes from sources such as roof drains, manhole covers, cross connections from storm sewers, catch basins, and surface runoff. Within a CSS, surface drainage is the primary source of inflow. Infiltration comes from groundwater that seeps in through leaking pipe joints, cracked pipes, manholes, and other similar sources. The flow from infiltration tends to be constant, but at a lower volume than that of inflow.

Identifying I/I sources is labor intensive and requires specialized equipment. Significant I/I reductions can also be difficult and expensive to achieve. However, the benefit of a good I/I control program is that it can save money by extending the life of the system, reducing the need for expansion, and lowering treatment costs. I/I reduction for combined sewers provides limited gains, since water tends to find another way into the system. However, I/I reductions in sanitary sewers can have significant impacts on increasing the available capacity in the downstream CSS.

C.3.2 Advanced System Inspection and Maintenance

System inspection and maintenance programs can provide valuable knowledge about the condition of the CSS infrastructure, which is beneficial for planning, inspection, and maintenance activities. This can help ensure design flow capacity is consistently available to prevent CSO events. This technology offers relatively minor advances towards meeting the primary and secondary goals of the LTCP.

C.3.3 Combined Sewer Flushing

This type of O&M practice re-suspends solids that have settled in the CSS and flushes them downstream. This practice consists of introducing a controlled volume of water over a short duration at key points in the collection system using external water from a tank truck, pressurized feed, or by detaining the CSS flow for a period, and then releasing it. Overall, this practice helps reduce the amount of settled solids that are resuspended and discharged during significant wet weather events. This measure is most effective when applied to flat collection systems since solids are more likely to become deposited on flat grades.

C.3.4 Catch Basin Cleaning

Catch basin cleaning reduces the transport of solids and floatables to the CSS by regularly removing accumulated catch basin deposits. Methods to clean catch basins include manual, bucket, and vacuum removal. Catch basin cleaning can be effective in reducing floatables in combined sewer; however, it is not effective at bacteria reduction or volume reduction, nor is it particularly effective at biochemical oxygen demand ("BOD") reduction.

C.4 SEWER SYSTEM OPTIMIZATION

Sewer system optimization involves collection system controls and modifications that affect CSO flows and loads once the runoff has entered the collection system. Options for system optimization include measures that maximize the volume of flow stored in the collection system or maximize the capacity of the system to convey flow to the treatment plant. Sewer system optimization techniques have no impact on water quality but do have the potential to reduce the volume of CSO events.

C.4.1 Increased Storage Capacity in the Collection System

Options for increased storage capacity rely on maximizing the volume of flow stored in the collection system or increasing the conveyance capacity of the system. Maximizing the use of the existing system involves ongoing maintenance and inspection of the collection system and can include minor modifications/repairs to existing structures to increase the volume of flow retained in the system. Increasing conveyance capacity is typically achieved by providing additional conveyance pipes or upsizing the existing conveyance system to handle a greater capacity.

C.4.1.1 Additional Conveyance

Conveyance is a technology that transports the combined sewage out of a particular area to a location where the flow can be stored, treated, or discharged where direct public contact with the water is less likely. Conveyance is accomplished by providing additional conveyance pipes or upsizing the existing conveyance pipe to a greater capacity. This practice can effectively reduce overflow volume and frequency in the affected areas. Large conveyance projects can be expensive and may require a lengthy permitting process.

C.4.1.2 Regulator Modifications

A CSO regulator can be uniquely configured to control combined sewer overflow frequency and volume. The existing regulators may be modified based on site-specific conditions. Regulator modifications can include adjusting gate control logic, increasing conveyance between the regulators and interceptor through pipe or regulator modifications, or increasing the overflow weir height. This technology is especially effective for CSO outfalls with high overflow frequency and low overflow volume, because the additional volume held back in the system is small and less likely to have negative impacts on upstream conditions.

C.4.1.3 Outfall Consolidation/Relocation

Consolidation of one or multiple outfalls can help eliminate CSO discharges in sensitive areas. Outfall consolidation may require modification or relocation of an outfall, the installation of additional conveyance to accommodate new flow configurations and may also require additional permitting with government agencies. This practice typically lowers O&M requirements for the CSS by limiting the number of outfall structures that need to be monitored. Outfall consolidation works best in areas where outfalls are located in close proximity to each other and require limited additional conveyance. Similar to regulator modifications, outfall consolidation is especially effective at reducing high frequency, low volume CSOs. This practice typically doesn't add a significant amount of extra capacity to the CSS (depending on the amount of conveyance pipe associated with the consolidation project), so its impact on infrequent, large volume CSO events can be limited. The H&H model can determine the level of impact that outfall consolidation will have in terms of reducing the number of CSO events.

C.4.1.4 Real Time Control

Real Time Control ("RTC") is a highly automated system in which sewer level and flow data are measured at key points in the sewer system and used to provide system control to maximize the storage capacity of the CSS and limit CSO events. The collected data is typically transferred to a control device where program logic is used to operate gates, pump stations, inflatable dams and other control components. Local dynamic controls are used to control regulators to prevent flooding and system wide dynamic controls are used to implement control objectives, such as maximizing flow to the treatment plant or transferring flows from one portion of the CSS to another to fully utilize the system. Predicative control, which incorporates use of weather forecast data, is an optional feature, but it should be noted that it is complex and requires sophisticated operational capabilities. Additionally, it is important to note that RTC involves the installation of numerous mechanical controls, which require upkeep and maintenance, and can only reduce CSO volumes where in-system storage capacity is available.

C.5 STORAGE

The objective of storage is to reduce overflows by capturing and storing wet weather flows, greater than CSS conveyance/treatment plant capacity, for controlled release back into the system once treatment and conveyance capacity have been restored. A storage facility can attenuate peak flows in the CSS and provide a relatively constant flow into the treatment plant after peak events. Storage technologies do not prevent water from entering the CSS or treat bacterial loads in CSO discharge but are effective at reducing or eliminating CSO events. Storage technologies typically have high construction and O&M costs compared to other CSO control technologies but are a reliable means of achieving CSO control goals.

C.5.1 Linear Storage

Linear storage is provided by underground storage facilities that are sized to detain peak flows during wet weather events for controlled release back into the system after the event. In-line linear storage (storage in series with the CSS) can be provided by over-sizing the existing interceptors for conveyance, as described in the previous section, whereas off-line linear storage (storage parallel to the CSS) can be provided by installing new facilities such as tunnels and pipelines.

C.5.1.1 Pipelines

Large diameter parallel pipelines or conduits can provide significant storage in addition to the ability to convey flow. Pipelines are typically constructed between an overflow point and a pump station or treatment facility. The pipelines include discharge controls to allow flow to be stored within the pipeline during wet weather events, and slowly released by gravity following the event. The pipelines' conveyance to the desired endpoint depends on the additional capacity necessary to handle the increased flow and is developed concurrently with the pipeline. A force main pipeline constructed from a pump station relies heavily on the increased flow capacity as the storage benefits are negligible. Pipelines have the advantage of requiring less area for construction compared to point storage. If trenchless technologies can be utilized, such as horizontal directional drilling (HDD), land requirements can be reduced even further.

A disadvantage of pipelines is that a larger volume is typically required to accommodate combined sewer storage needs. The installation of large diameter pipelines is typically less cost effective than tunneling, and the installation of smaller diameter pipes typically requires a significant length in order to provide adequate storage. Additionally, the installation of pipelines is very disruptive, typically requiring open trenches and the temporary closure of public streets.

C.5.1.2 Tunnels

Tunnels provide large storage volumes, while maintaining the ability to convey flow. Tunnel excavation is accomplished completely underground, and therefore results in minimal surface disruption and requires little right-of-way, outside of drop shafts and conveyance piping to the drop shafts. Overall costs for tunnels can be high, but their cost per million gallons of storage can be fairly reasonable compared to other storage technologies, depending on local geology. Tunnels are typically used in congested urban areas where available land is scarce and connections to most, if not all, of the CSO regulators can be made.

C.5.2 Point Storage

Point storage can be provided by above-ground or underground storage facilities such as tanks and equalization basins. These off-line facilities are placed at specific points in the system to detain peak flows for controlled return back to the system, reducing CSO discharge volume and bacterial loading.

C.5.2.1 Tanks

This technology reduces overflow quantity and frequency by storing all or a portion of diverted wet weather combined flows in off-line storage tanks. Stored flows are returned to the interceptor for conveyance to the treatment plant once system capacity becomes available. Storage tanks are generally fed by gravity and the stored flow is typically pumped back to the interceptor after the storm. The benefit of off-line storage tanks is that they are well suited for early action projects at critical CSO outfalls. Storage tanks capture the most concentrated first flush portion wet weather peak flow and help to reduce the downstream capacity needs for conveyance and treatment.

A disadvantage of off-line storage tanks is that they typically require large land area for installation, which may not be available in congested urban areas. Additionally, if the existing sewers are deep, then the storage tank must also be deep, which results in additional construction costs. Operation and maintenance costs can also be high, especially if the application includes provisions for partial treatment and discharge, rather than simple storage and bleed-back to the sewer. Depending on the application, odor problems may also be an issue. However, storage tanks can be a very effective means of CSO control.

C.5.2.2 Industrial Discharge Detention

This technology would require industrial users to build and maintain storage basins to hold industrial discharge during wet weather events and subsequently release it back to the CSS. This would limit the peak wet weather flow to the WRRF. The effectiveness of this technology is limited to the number of industrial users upstream of CSO regulators. If there are no industrial users in the CSS, then this is technology is not applicable.

C.6 SEWAGE TREATMENT PLANT EXPANSION, ~~OR~~ STORAGE AND BYPASS AT THE PLANT

C.6.1 Additional Treatment Capacity

CSOs can potentially be reduced by increasing the treatment capacity of plant. Other technologies can make use of this increased treatment capacity by providing more flow to the plant instead of CSO outfalls.

C.6.2 Wet Weather Blending

Blending is the practice of allowing portions of the wet weather peak flow to bypass certain treatment facilities at the plant. In blending, wet weather flows are typically routed through primary treatment, allowed to bypass secondary and tertiary treatment, and then recombined with effluent from all processes prior to disinfection and discharge to the environment. This practice may require increasing the capacity of primary treatment and disinfection facilities, but doesn't require the upsizing of secondary treatment facilities, which can be the more costly components. Other technologies can make use of the increased wet weather peak flow capacity by providing more flow to the plant instead of CSO outfalls.

C.7 SEWER SEPARATION

C.7.1 Roof Leader Disconnection

Roof leaders may directly be connected to the CSS. Roof leaders can be disconnected in order to divert stormwater elsewhere and/or to delay its entry into the CSS. Depending on the neighborhood, roof leaders may be run to dry well, vegetation bed, lawn, storm sewer, or street. This technology typically has limited benefits in dense urban areas due to the lack of pervious areas available to divert flow for infiltration. Unfortunately, the most feasible roof leader disconnection scheme in these areas is usually diversion to the street. In this case, disconnection can lead to nuisance street flooding and is only able to briefly delay the water from entering the CSS through catch basins. Roof leader disconnection is typically much more effective in areas with separate sewers where the roof leader was previously connected to a sanitary sewer, since the diverted rainwater does not have a direct path back into the system. Roof leader disconnection can be effective for both sanitary and storm sewers; however, the effect of this measure is highly contingent upon the extent of roof leaders in the system, site specific conditions, and the ability to find an adequate location to divert stormwater flow from the roof leader.

C.7.2 Sump Pump Disconnection

Buildings with basements below the ground water table sometimes are kept dry by using dewatering pumps. In many cases, these pumps discharge to the CSS or sanitary sewers. Sump pump disconnection diverts this pumped groundwater flow to a location other than these sewers. Sump pump disconnection programs are typically more effective in separate sewer areas and are subject to the same limitations as roof leader disconnection programs (extent, site conditions, diversion options, etc.). There are many limitations to the effectiveness of this approach in terms of the resources, impact on the public and difficulties implementing.

C.7.3 Combined Sewer Separation

Sewer separation is the conversion of a CSS into a system of separate storm sewers and sanitary sewers. This can be accomplished by installing a new sanitary sewer and using the existing combined sewer as a storm sewer or vice versa. This practice can be very expensive, disruptive to the public, and difficult to implement, especially in downtown areas or other densely developed urban environments. It typically requires closure of public streets for construction while the new pipes are installed, and the sewer is separated.

C.8 TREATMENT OF CSO DISCHARGE

Treatment technologies are intended to reduce the pollutant loads to receiving waters by treating wet weather flows prior to discharging to the environment. Specific technologies can address different pollutant constituents, such as settleable solids, floatables, or bacteria.

C.8.1 Treatment – CSO Facility

C.8.1.1 Vortex Separators

Vortex separation is a process that removes floatables and settleable solids from a wastewater stream by directing influent flow tangentially into a cylindrical tank, thereby creating a vortex. The vortex action causes settleable solids to move toward the center of the tank where they are concentrated with a fraction of the influent flow and directed to the underflow at the bottom of the tank. The underflow is then conveyed downstream to the treatment plant. The remaining influent flow travels under a baffle plate, which traps any floatables, and then over a circular baffle located in the center of the tank. It is then discharged to receiving waters or conveyed to storage or treatment devices for further processing. This technology does not address CSO volume or bacteria reduction and would only help meet water quality and CSO control goals only if used in combination with other technologies.

C.8.1.2 Screens and Trash Racks

Screens and trash racks consist of a series of vertical and horizontal bars or wires that trap floatables while allowing water to pass through the openings between the bars or wires. They can be installed at select points within a CSS to capture floatables and prevent their discharge during CSO events. Due to limited hydraulic capacity, screens are most suitable for small outfalls. Trash racks or static screens can be located on top of an overflow weir or near the outfall. These devices are inexpensive but usually incur high maintenance costs due to their tendency to become clogged. Frequent cleaning (after every storm) is usually required to prevent clogging, which can cause serious flooding and sewer backups.

Mechanical screens can remove floatables and some solids without frequent manual cleaning. This can be a significant advantage when compared to the maintenance requirements and the potential for flooding caused by a clogged static screen. However, most mechanical screens (climber screens, cog screens, or rake screens) require structural modifications to the outfall chamber to house and protect the screens. If weir-mounted mechanical screens are used instead, they require much less headroom and can be retrofitted into an existing overflow chamber with little to no structural modifications.

As this technology does not address CSO volume or bacteria reduction, it would do little to meet water quality and CSO control goals.

C.8.1.3 Netting

Netting systems involve mesh nets that are attached to a CSO outfall to capture floatable material as the CSO discharges into the receiving water. The nets are nylon mesh bags that can be concealed inside the CSO outfall until an overflow occurs. The advantage of this technology is that it captures floatables inexpensively and can provide a base level of control at some CSO sites. However, the operation and maintenance requirements are high, and it has some negative aesthetic impacts associated with the visibility of collected trash in the waterbody. This technology is strictly for floatables control and will not address water quality and CSO control goals alone.

C.8.1.4 Containment Booms

A containment boom is a temporary floating barrier used to contain floatables entering into the waterway from a CSO outfall. Containment booms are used to reduce the spread of floatables and reduce the level of effort for post-storm cleanup. These devices are very simple to install but can be difficult to maintain. Also, there are some negative aesthetic impacts associated with visibility of collected trash in a waterbody. This technology is strictly for floatables control and will not address water quality and CSO control goals alone.

C.8.1.5 Baffles

Baffles are simple floatables control devices that are typically installed at flow regulators within the CSS. They consist of vertical steel plates or concrete beams that extend from the top of the sewer to just below the top of the regulating weir. During a CSO event, floatables are retained by the baffles while water passes under the baffles, over the regulator, and into the receiving water body. When the flow recedes below the bottom of the baffle, floatable material is carried downstream to the treatment plant. Baffles are easy to install and require little maintenance but do require proper hydraulic configuration. This technology is strictly for floatables control and will not address water quality and CSO control goals alone.

C.8.1.6 Disinfection and Satellite Treatment

This technology consists of disinfecting and treating sewer overflows at a local facility near the CSO outfall. Disinfection is very effective at reducing bacteria through inactivation but provides only limited opportunities for volume reduction. Disinfection alone cannot provide reductions in total suspended solids ("TSS"), floatables, and nutrient loads unless other processes (e.g., screening, high-rate clarification, etc.) are provided upstream of the disinfection facility. The combination of these other processes with disinfection can provide a satellite location that helps reduce pollutants of concern.

Disinfection of wet weather flow is more challenging to design and control than traditional disinfection at a treatment plant, because of the complex characteristics of the flow. Intermittent occurrences and highly variable flowrates make it more challenging to regulate the addition of disinfectant. One way to address the variable flow issue is to provide flow retention facilities that provide for disinfectant contact time and capture through storage of the first flush of TSS, floatables and nutrients.

Wet weather flows can vary widely in temperature, suspended solids concentrations, and bacterial composition. Therefore, pilot studies are usually needed to characterize the range of conditions that exist for a particular area and the design criteria that need to be considered. Experience has shown that the long contact time required for conventional wastewater treatment is not appropriate for the treatment of wet weather flows. Disinfection can be achieved by providing an increased disinfection dosage and intense mixing to ensure disinfectant contact with the maximum number of microorganisms.

Although chlorination is the most common method for wastewater disinfection, various disinfection technologies are available, both with and without chlorine compounds. In addition to disinfection effectiveness, many factors should be considered when selecting a disinfectant, including potential toxic effects to the environment, regulations for residuals, safety precautions, and ease of operation and maintenance. Ultraviolet ("UV") light and Peracetic acid (PAA) are two (2) alternatives to chlorine compounds for wet weather disinfection.

- Ultraviolet Light - The main advantages of UV include its ability to quickly respond to flow variation and the absence of a disinfectant residual, among others. The size of the UV system mainly depends on the UV transmittance (i.e., the ability of wastewater to transmit UV light) and TSS concentrations in the wastewater. One of the challenges for UV disinfection is determining how to manage the disinfection of effluent during a power outage. In addition, UV typically has higher capital cost compared to chlorine disinfection systems.
- Peracetic Acid ("PAA") - The main advantage of PAA over sodium hypochlorite (chlorine) is its long "shelf life" without product deterioration. Due to the intermittent nature of CSO flows, stored sodium hypochlorite may degrade over time if not used. However, PAA systems generally have higher operating costs than chlorine systems

C.8.1.7 High Rate Physical/Chemical Treatment (ActiFlo®)

High rate physical/chemical processes, such as Veolia's Actiflo® or Infilco-Degremont's DENSADEG®, are treatment facilities that require a much smaller footprint than conventional processes. These two (2) competing products have very similar applications but have processes that differ from each other considerably. For brevity, only one of these processes (Actiflo®) is described in detail below.

Fundamentally, the Actiflo® process is very similar to conventional coagulation, flocculation, and sedimentation water treatment technology. Both processes use coagulant for suspended solid destabilization and flocculent aid (polymer) for the aggregation of suspended materials. The primary difference between Actiflo® and conventional processes is the addition of microsand for the formation of high-density flocs that have a higher-density nucleus and thus settle more rapidly.

Clarified water exits the process by flowing over a weir in the settling tank. The sand and sludge mixture that remains is collected at the bottom of the settling tank and pumped to a hydrocyclone which separates the sludge from the microsand. Sludge is discharged out of the top of the hydrocyclone while the sand is recycled back into the Actiflo® process for further use. This process requires upstream screening to ensure that particles larger than 3 to 6 mm do not clog the hydrocyclone.

Actiflo® performance varies, but in general removal rates of 80 - 95% for TSS and 30 - 60% for BOD are typical. Phosphorous and nitrogen are also removable with this process, although the removal efficiencies are dependent on the solubility of these compounds present in the wastewater. Phosphorous removal is typically between 60 – 90%, and nitrogen removal is typically between 15 – 35%. Removal efficiencies are also dependent on start-up time. Typically, the Actiflo® process takes about 15 minutes before optimum removal rates are achieved.

The LTCP primary goals are bacteria reduction and CSO volume reduction. While high rate physical/chemical treatment reduces bacteria somewhat, its principal purpose is TSS reduction. Disinfection would be required downstream for bacteria inactivation.

Furthermore, while technologies such as Actiflo® or DENSADEG® reduce the footprint of conventional treatment, they still require a significant amount of available space for implementation.

C.8.1.8 High Rate Physical Treatment (Fuzzy Filters)

The Fuzzy Filter® by Schreiber or the WesTech WWETCO FlexFilter™ is an innovative filtration technology that used a compressible filter media that allows for a much smaller footprint than conventional filtration (footprint reductions of nearly 90%). Both technologies use a synthetic fiber media, as opposed to granular media such as sand, which can handle increased flux rates (up to 30 – 40 gpm/sf). Additionally, the process uses compressed air scour with influent flow for filter backwashing which eliminates the need for storage tanks. The filter removes up to 80% of influent particles up to 4 microns in diameter. Overall, this is a relatively low maintenance process, which requires periodic lubrication and detergent addition for media washing.

This technology is designed for TSS reduction and does not address the primary goals of the LTCP (bacteria reduction and overflow volume reduction). Since downstream disinfection would be required for bacteria inactivation, this technology provides little benefit compared to disinfection alone. Additionally, although this technology decreases the footprint of conventional filtration, it still requires a substantial footprint for implementation.

C.9 SCREENING OF CONTROL TECHNOLOGIES

Templates of the screening tables used by the nine (9) municipalities for screening of the control technologies are presented in this Section. **Table C-9** presents the source control technologies, **Table C-10** presents the collection system technologies, and Table C-11 presents the storage and treatment technologies. Screening tables with the last two columns filled out by each municipality are presented in the individual Development and Evaluation of Alternatives Reports in **Appendix A** – **Appendix I**.

Table C-9: Source Control Technologies Screening Table

Source Control Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	▪ Reduced surface flooding	Flow restrictions to the CSS can cause flooding in lots, yards and buildings; potential for freezing in lots; low operational cost. Effective at reducing peak flows during wet weather events but can cause dangerous conditions for the public if pedestrian areas freeze during flooding.	No		
	Catch Basin Modification (for Floatables Control)	Low	None	▪ Water quality improvements ▪ Reduced surface flooding	Requires periodic catch basin cleaning; requires suitable catch basin configuration; potential for street flooding and increased maintenance efforts. Reduces debris and floatables that can cause operational problems with the mechanical regulators.	No		
	Catch Basin Modification (Leaching)	Low	Low	▪ Water quality improvements ▪ Reduced surface flooding	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No		
Public Education and Outreach	Water Conservation	None	Low	▪ Reduced surface flooding ▪ Align with goals for a sustainable community	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume but would have little impact on peak flows.	Yes		
	Catch Basin Stenciling	None	None	▪ Align with goals for a sustainable community	Inexpensive; easy to implement; public education. Is only as effective as the public's input and understanding of the message. Public outreach programs would have a more effective result.	Yes		
	Community Cleanup Programs	None	None	▪ Water quality improvements ▪ Align with goals for a sustainable community	Inexpensive; sense of community ownership; educational BMP; aesthetic enhancement. Community cleanups are inexpensive and build ownership in the city.	Yes		
	Public Outreach Programs	Low	None	▪ Align with goals for a sustainable community	Public education program is ongoing. Permittee should continue its public education program as control measures demonstrate implementation of the NMC.	Yes		
	FOG Program	Low	None	▪ Water quality improvements ▪ Improves collection system efficiency	Requires communication with business owners; Permittee may not have enforcement authority. Reduces buildup and maintains flow capacity. Only as effective as business owner cooperation.	Yes		
	Garbage Disposal Restriction	Low	None	▪ Water quality improvements	Permittee may not be responsible for Garbage Disposal. This requires an increased allocation of resources for enforcement while providing very little reduction to wet weather CSO events.	Yes		
	Pet Waste Management	Medium	None	▪ Water quality improvements	Low cost of implementation and little to no maintenance. This is a low-cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes		
	Lawn and Garden Maintenance	Low	Low	▪ Water quality improvements	Requires communication with business and homeowners. Guidelines are already established per USEPA. Educating the public on proper lawn and garden treatment protocols developed by USEPA will reduce waterway contamination. Since this information is already available to the public it is unlikely to have a significant effect on improving water quality.	Yes		
	Hazardous Waste Collection	Low	None	▪ Water quality improvements	The N.J.A.C. prohibits the discharge of hazardous waste to the collection system.	Yes		
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	▪ Water quality improvements	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if	Yes		

Source Control Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
					Permittee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.			
	Illegal Dumping Control	Low	None	▪ Water quality improvements ▪ Aesthetic benefits	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes		
	Pet Waste Control	Medium	None	▪ Water quality improvements ▪ Reduced surface flooding	Requires resources to enforce pet waste ordinances. Public education and outreach are a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes		
	Litter Control	None	None	▪ Property value uplift ▪ Water quality improvements ▪ Reduced surface flooding	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach are a more efficient use of resources.	Yes		
	Illicit Connection Control	Low	Low	▪ Water quality improvements ▪ Align with goals for sustainable community	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes		
Good Housekeeping	Street Sweeping/Flushing	Low	None	▪ Reduced surface flooding	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes		
	Leaf Collection	Low	None	▪ Reduced surface flooding ▪ Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes		
	Recycling Programs	None	None	▪ Align with goals for sustainable community	Most Cities have an ongoing recycling program.	Yes		
	Storage/Loading/Unloading Areas	None	None	▪ Water quality improvements	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes		
	Industrial Spill Control	Low	None	▪ Protect surface waters ▪ Protect public health	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes		
Green Infrastructure Buildings	Green Roofs	None	Medium	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ Local jobs ▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes		
	Blue Roofs	None	Medium	▪ Reduced heat island effect ▪ Property value uplift ▪ Local jobs ▪ Reduced surface flooding	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes		

Source Control Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Green Infrastructure Buildings				▪ Reduced basement sewage flooding ▪ Align with goals for a sustainable community				
	Rainwater Harvesting	None	Medium	▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Align with goals for a sustainable community ▪ Water saving	Simple to install and operate; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes		
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ Water quality improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Align with goals for a sustainable community	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas and can utilize underground infiltration beds or detention tanks to increase storage.	Yes		
	Planter Boxes	Low	Medium	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspiring runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes		
Green Infrastructure Pervious Areas	Bioswales	Low	Low	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ Local jobs ▪ Passive and active recreational improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes		

Source Control Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
				▪ Community aesthetic improvements ▪ Reduced crime ▪ Align with goals for a sustainable community ▪ Increased pedestrian safety through curb retrofits				
	Free-Form Rain Gardens	Low	Medium	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ Passive and active recreational improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Community aesthetic improvements ▪ Reduced crime ▪ Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspiring diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes		

Table C-10: Collection System Technologies Screening Table

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

Table C-11: Storage and Treatment Technologies Screening Table

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

Storage and Treatment Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
				flooding				
	Wet Weather Blending	Low	High	▪ Water quality improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes		
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	▪ Water quality improvements ▪ Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes		

SECTION D - SUMMARY OF ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

This section describes the development of preliminary CSO control alternatives applicable to the permittees in the PVSC Treatment District, the approaches selected to perform the evaluations, and the factors used to evaluate each of the alternatives. This section also factors cost into each alternative analysis. As part of this evaluation, four alternatives were developed and evaluated regionally and are incorporated in this Regional Alternatives Report, as per requirement of the PVSC NJPDES Permit No. NJ0021016 (hereon referred to as "the Permit") Combined Sewer Management (CSM) Part IV.D.1.c.

D.1.1 Alternatives Evaluation Approach

This section of the report discusses the regulatory requirements and guidelines used to develop the alternatives evaluation criteria and approach. In accordance with the NJPDES Permit and as defined by the USEPA's National CSO Policy and the New Jersey Administrative Code , a reasonable range of CSO control alternatives must be evaluated to meet the water quality-based requirements of the CWA. For the purpose of the evaluation of alternatives, various CSO control technologies were evaluated for varying levels of control, including 0, 4, 8, 12, and 20 CSO events per year, as well as 85% capture by volume.

Development of Alternatives

The preliminary alternatives were developed using the overflow control technologies identified as feasible for implementation by the permittees in each of their Development and Evaluation of Alternatives Reports, and as required as part of the Permit in Part IV.G.4.e. Control technologies used for alternatives include: GI, regulator modifications, storage tanks, tunnels, baseflow reduction, water conservation, increased wastewater conveyance to PVSC for treatment, maximizing pump station and force main capacities, parallel interceptor, bypass line, satellite treatment, and sewer separation. A range of alternatives was developed to evaluate each of the screened and preselected technologies, both individually and in combination with other technologies simultaneously. The resulting alternatives are listed in **Table D-1** below.

Table D-1: Regional Alternatives

Alternative	Description
No. 1	Most cost-effective alternatives for each permittee
No. 2	Regional Tunnel
No. 3	Newark Regulator Modifications and Rehabilitation + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)
No. 4	Newark Regulator Modifications and Rehabilitation + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels

Evaluation factors for the analysis of alternatives are discussed below. Factors include siting, institutional issues, implementability concerns, public input, performance considerations, and cost.

D.1.2 Siting

Identifying an appropriate site for the alternatives is an important consideration when determining the feasibility of the alternative. Siting is unique to each permittee and is discussed in individual reports in **Appendix B** through **Appendix I**.

D.1.3 Institutional Issues

PVSC does not own any of the CSO outfalls in the CSS. The outfalls are owned by the City of Paterson, City of Newark, Township of Kearny, Town of Harrison, Borough of East Newark, City of Bayonne, Jersey City MUA, and North Bergen MUA, who have received authorization to discharge under their respective NJPDES Permits for Combined Sewer Management.

As a result, and in the continued effort to cooperate with each of the Permittees to develop a collaborative LTCP, the ultimate selection of the controls for implementation will continue to be coordinated with the Permittees within PVSC Treatment District. These various factors that must be considered and coordinated with the various Permittees will occur prior to the completion of the subsequent Selection and Implementation of Alternatives Report in the Final LTCP.

D.1.4 Implementability

Implementation refers to considerations beyond cost and performance that influence the selection of a CSO control technology; these issues are often intertwined with political and institutional considerations. See **Section D.1.3** and **Section D.1.5**. for specific discussions of public input and institutional issues. The purview of this subsection is limited to scheduling, phasing, and constructability concerns for each of the overflow control technologies considered in the alternatives.

The CSO Policy provides that *"schedules for implementation of the CSO controls may be phased based on the relative importance of adverse impacts upon WQS and designated uses, priority projects identified in the long-term plan, and on a permittee's financial capability. Given the cost of CSO control facilities, municipalities might determine that projects can be implemented in smaller parts over a period of time are more affordable than a single, large one-time project. Phased implementation also allows time for evaluating completed portions of the overall project and the opportunity to modify later parts of the project due to unanticipated changes in conditions. The initial stages of phased projects often can be implemented sooner than a single, more massive project, bringing more immediate relief to a CSO problem."*

Constructability concerns were initially discussed in the screening of CSO control technologies portion of this report, which can be found in **Section C**. Additional implementation concerns applicable to an alternative are discussed further in the appropriate alternative subsection found within **Section D.2**. Concerns regarding the scheduling and phasing of alternatives will be considered prior to the completion of the Final Regional LTCP Report.

D.1.5 Public Input

As a majority of the alternatives discussed within this report will directly impact the public, both during construction and operation, public input has been and will continue to be solicited throughout the development of the LTCP.

PVSC has continuously solicited public input for the various CSO control technologies through the implementation of the LTCP Public Participation Plan ("PPP"). The implementation of the LTCP PPP is an ongoing process that includes hosting quarterly public meetings with the Clean Waterways, Healthy Neighborhoods Supplemental CSO Team, participating in the meetings of various local groups, participating as an active member of the PVSC Treatment District Communities GI Programs, including Newark DIG, Paterson SMART, Bayonne Water Guardians, Harrison TIDE, and Kearny AWAKE and partnering with Rutgers University in a GI municipal outreach program, attending public events, meeting with municipal representatives, and soliciting public input through the Clean Waterways, Healthy Neighborhoods website and social media platforms.

Public input will be one of the various factors considered when ultimately selecting the controls for implementation. For instance, the public has expressed interest in GI as a part of the CSO controls. This evaluation of alternatives has considered GI and is discussed further within this Report.

As of the date of this Report, 13 Supplemental CSO Team Meetings have been held with members of the public as shown in **Table D-2**.

The evaluation of alternatives being considered were presented to the public at many of these meetings and comments were requested from the public. In addition to the Supplemental CSO Team Meetings, various other public meetings have been held. For instance, the evaluation of alternatives was presented at the Town of Kearny Council Meeting on June 13, 2018 and the PVSC Commissioners' Meeting on May 16, 2019.

Additionally, a draft copy of this Report was distributed to the Supplemental CSO Team and other members of the public for review and comment. As a result, written comments from the public have been received from public interest groups and members of the Supplemental CSO Team. These comments have been grouped into general topics with a common response provided for all comments in the topic. The collection of comments, the commenters, and the grouped responses are found in **Appendix K.**

Table D-2: Dates and Locations of Supplemental CSO Team Public Meetings

Meeting Number	Date	Location	City
1	October 5, 2016	Harrison Elks Lodge	Harrison
2	January 10, 2017	Bayonne Public Library	Bayonne
3	April 11, 2017	The Hamilton Club at Passaic County Community College	Paterson
4	July 11, 2017	Newark City Hall	Newark
5	October 16, 2017	PVSC WRRF	Newark
6	January 9, 2018	North Bergen Municipal Building	North Bergen
7	April 17, 2018	Jersey City Council Chambers	Jersey City
8	July 31, 2018	Town of Kearny Council Chambers	Kearny
9	October 16, 2018	PVSC WRRF	Newark
10	January 22, 2019	Senior Citizens Center	East Newark
11	March 7, 2019	North Jersey Transportation Planning Authority Conference Room	Newark
12	May 28, 2019	Washington School	Bayonne
13	July 31, 2019	Ironbound Early Learning Center	Newark

D.1.6 Performance Considerations

The primary evaluation criteria for the evaluation of alternatives is the performance of an alternative at meeting the water quality and CSO control goals detailed in **Section C.1.1**. All four (4) regional alternatives evaluated increasing the volume capture of CSOs throughout the collection system to no less than 85% by volume. In addition, Alternative 1, Alternative 2, and Alternative 4 also evaluated the feasibility of reducing number of CSO events to a maximum of 0, 4, 8, 12, and 20 occurrences per year in the hydraulically connected system. In order to compare the effectiveness of reducing the number of CSO events to the selected target of a minimum of 85% CSO volume captured, the equivalent CSO volume captured by the number of CSO events has been calculated.

D.1.7 Cost

Cost is a significant evaluation factor in determining the feasibility of each alternative. The Costs for Regional Alternative 1 include capital costs and contingencies as described in each of the individual reports in **Appendix B** through **Appendix I**.

The opinions of probable construction cost used for the Regional Alternatives 2 through 4 are considered Level 5 estimates, as designated by Association for the Advancement of Cost Engineering ("AACE") Recommended Practice No. 18R-97. The accuracy range for Class 5 estimates is generally within a range of fifty percent less (-50%) to one-hundred percent more

(+100%) than the actual cost. To develop the present worth values of Alternatives, the primary components of the Alternative Opinion of Probable Construction Cost Methodology is:

- Identify appropriate alternative cost line items;
- Generate initial capital cost curves; and
- Generate operation and maintenance (O&M) costs along with contingency and other cost factor percentages to calculate life cycle costs

The first two items have been developed previously through the PVSC LTCP Technical Guidance Manual (PVSC TGM), which can be found in **Appendix J**. Any additional information used to supplement the cost line items or cost curves used comes from the following:

- Completed project construction cost data
- RS Means
- Manufacturer's cost data
- Environmental Protection Agency ("EPA") project cost data and cost curves
- Anderson, Indiana CSO Long Term Control Plan: Basis for Cost Opinion

Unless a specific control technology cost was gathered from another estimate or quote, typical markups from the initial capital costs include the following list, where applicable, due to the heavily urbanized area where PVSC operates:

- Pipe Installation – Heavy Utilities Contingency (65%)
- Tank/Storage Conduit – Heavy Utilities Contingency (65%)
- Pump Station – Difficult Installation Contingency (65%)
- WRRF Upgrade – Difficult Modification Contingency (65%)
- Sewer Separation – Heavy Utilities Contingency (65%)
- Overhead and Profit (15%)
- Bonds and Insurance (3%)
- Mobilization/Demobilization (5%)

These costs are combined for a construction cost subtotal. This subtotal then has the following additional markups applied to get a Total Cost (referred to as the Capital Cost):

- Engineering (25%)
- Permitting (3%)

The following O&M costs are applied to the Capital Cost, where applicable:

- Continuous Operating Post (1 COP = $470,000/yr.)
- Tank/Structure Maintenance (3% of Construction Cost)
- Tunnel Maintenance (2% of Construction Cost)
- Pipe Transmission Maintenance (2% of Pipe Construction Costs

To combine O&M and capital costs for each control technology, present worth calculations have to be completed. For this, a discount rate (i) of 2.75% is used (taken from the Rate for Federal

Water Projects, Natural Resources Conservation Service ("NRCS") Economics, Department of the Interior) with a life span (n) of 20 years. The following equation is then utilized to calculate the present worth factor to convert from annual O&M costs to present worth:

$$(P/A, i\%, n) = ((1+i)^n - 1) / ((i(1+i)^n)$$

The result of the equation is then multiplied by the annual O&M costs and then added to the construction costs to obtain the total life cycle cost. Salvage value is considered to be $0, as it is assumed no resale value will result from the control technologies utilized. Life cycle costs for each alternative are provided in Subsection D.2.

The life cycle cost for each level of control for an alternative was then divided by the applicable volume of capture to determine a cost per gallon ($/gal). These costs provide an additional method to compare alternatives.

D.2 CONTROL PROGRAM ALTERNATIVES

This section summarizes the four regional alternatives that were determined through coordination facilitated by PVSC. Alternative 1, which is summarized in **Section D.2.1**, was determined based on an analysis that each permittee performed to determine the most cost-effective alternative to meet each of the yearly CSO event frequencies used for the analysis (0, 4, 8, 12, and 20). The permittees detailed the CSO captures and costs for each alternative evaluated in their individual reports, which are included in the following appendices:

- Appendix B: City of Bayonne
- Appendix C: Borough of East Newark
- Appendix D: Town of Harrison
- Appendix E: Jersey City MUA
- Appendix F: Town of Kearny
- Appendix G: City of Newark
- Appendix H: North Bergen MUA
- Appendix I: City of Paterson

Using the data provided by the permittees, Alternative 1 was determined by combining the most cost-effective alternatives for each permittee to meet the yearly CSO event frequencies and 85% capture scenario. Alternative 2, which is summarized in **Section D.2.2**, was created as a regional approach to improve capture and treatment using regional tunnels to meet the yearly CSO frequencies and 85% capture scenario. **Section D.2.3** describes Alternative 3, which evaluates a combination of Newark Regulator Modifications and Rehabilitation + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Hudson County Force Main Pump Expansion (146 MGD HCFM) to meet the 85% capture scenario. Finally, Alternative 4, which is a combination of Newark Regulator Modifications and Rehabilitation + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Hudson County Force Main Pump Expansion (146 MGD HCFM) + Tunnels, was evaluated to meet the yearly CSO frequencies and 85% capture scenario, as summarized in **Section D.2.4**.

D.2.1 Regional Alternative 1

Regional Alternative 1 incorporates the most cost-effective alternative for each permittee to meet the yearly CSO frequencies and 85% capture. Each permittee evaluated a variety of alternatives as discussed in **Section D.1.1**. **Table D-3** and **Table D-4** summarize the anticipated life cycle costs and the CSO volume capture, respectively, for the lowest cost alternative for each yearly CSO frequency and the 85% capture scenario for each permittee.

Table D-3: Regional Alternative 1 – Life Cycle Cost vs. # CSO/CSO Capture

CSO Events	Regional Alternative 1 – Life Cycle Costs ($M)								
	Permittees								Total Life Cycle Cost ($M)
	BA	EN	HA	JC	KEA	NE	NB	PAT	
0	828.1	44.6	78.2	5,824.4	747.7	1,485.6	137.9	637.0	~~9,784~~ 9,783
≤4	549.0	34.0	58.6	~~857.26~~ 883.5	262.4	~~1,019.8~~ 1,060.3	113.5	363.0	~~3,258~~ 3,324
≤8	365.4	23.7	57.8	~~794.1~~ 796.8	212.6	665.6	92.8	234.0	~~2,446~~ 2,449
≤12	351.9	19.3	46.7	~~719.5~~ 720.0	188.7	577.5	83.9	203.0	2,191
≤20	220.2	16.2	41.1	546.6	170.3	321.0	67.0	172.0	1,554
85%	180.9	12.8	5.8	~~515.3~~ 525.3	100.6	5.8	62.9	~~77.3~~ 78.0	~~961~~ 972

Key: BA: Bayonne; EN: East Newark; HA: Harrison Town; JC: Jersey City; KEA: Kearny Town, NE: Newark; NB: North Bergen; PAT: Patterson

Table D-4: Regional Alternative 1 – CSO Volume Captured vs. # CSO/CSO Capture

CSO Events	Regional Alternative 1 – CSO Volume Captured (MG)							
	Permittees							
	BA	EN	HA	JC	KEA	NE	NB	PAT
0	748	17.2	61.5	1,557	254.7	1,313	274	353
≤4	720	16.7	57.7	~~1,473~~ 1,442	~~228.7~~ 243.7	~~1,211~~ 1264.1	263	~~311~~ 312
≤8	666	~~14.1~~ 14.3	57.5	~~1,449~~ 1,420	~~169.7~~ 220.7	~~886~~ 1142.1	242	~~268~~ 271
≤12	657	~~12.9~~ 14.3	51.8	1,405	~~143.7~~ 207.7	~~700~~ 1079.1	217	~~232~~ 234
≤20	542	~~10.3~~ 12.5	48.1	~~1,181~~ 1,120	~~109.7~~ 191.7	~~457~~ 817.1	175	~~156~~ 162
85%	~~441~~ 439	6.4	18.8	~~985~~ 1008	34.4	114	~~155~~ 159	~~109~~ 70

Key: BA: Bayonne; EN: East Newark; HA: Harrison Town; JC: Jersey City; KEA: Kearny Town, NE: Newark; NB: North Bergen; PAT: Patterson

As described in each permittee's individual report, various alternatives were evaluated alone and in combination with each other. Alternatives were found to have varying applicability, effectiveness, and cost, with some alternatives being more effective in combination with others. The following summarizes the alternatives found to be the most cost effective or the most capable of achieving major performance objectives, either alone or in combination with other alternatives:

- City of Bayonne: Sewer separation, PAA disinfection with potential solids treatment, offline storage with increased conveyance of wet-weather flows to PVSC for treatment, and GI.
- Borough of East Newark: 5% conversion of impervious area to GI, partial sewer separation followed by storage tanks or high rate filtration with PAA disinfection.
- Town of Harrison: consolidated tanks storage, 2.5% conversion of impervious area to GI
- Jersey City MUA: a combination of inflow/infiltration removal, partial sewer separation, green infrastructure, and grouped storage tanks
- Town of Kearny: complete sewer separation, partial sewer separation, high rate filtration with PAA disinfection
- City of Newark: PAA disinfection with pretreatment (level of pretreatment based on treatability studies), gate delay and disinfection at NE022
- North Bergen MUA: high rate filtration with PAA disinfection
- City of Paterson: Partial Sewer Separation, GI, PAA disinfection with potential primary treatment based on pilot project results, storage tanks and tunnels

It is noted that as the LTCP continues to develop, the models used for each permittee may be updated as well. Based on the model updates and feedback from NJDEP, the list of alternatives above, and hence, the life cycle costs and CSO volume discharged presented in **Table D-3** and **Table D-4**, may change for any or all permittees.

As expected, regardless of the alternative that each permittee listed above, the life cycle costs and CSO volumes captured are anticipated to be the highest when meeting the 0 CSO events per year scenario, and the costs and volume captured decreases as the number of CSO events per year increases. The difference in magnitude of costs stems mainly from the anticipated CSO volume captured (MG) for each permittee. For example, based on the analysis performed for Jersey City MUA, which has the highest life cycle costs for all scenarios, 1,557 MG of CSO volume is anticipated to be captured for the 0 CSO events per year scenario. In contrast, East Newark, which has significantly lower life cycle costs, is anticipated to only capture 17.2 MG of CSO volume for the 0 CSO events per year scenario.

In terms of the 85% capture scenario, the life cycle costs and CSO volumes captured are generally lower than for all of the CSO events per year scenarios. This is because even capturing all but 20 CSO events per year would capture more than 85% volume. In addition, the 85% capture scenario can be attained in many cases with projects associated with the largest outfalls rather than all outfalls.

The total life cycle costs are the summed life cycle costs for all of the alternatives used for each level of control and are also presented in **Table D-3** and discussed in more detail in **Section**

D.1.7 above. Overall, the costs to meet the 0 CSO events per year scenario are significantly higher than the costs to meet the 4, 8, 12, and 20 CSO Events per year scenarios.

D.2.2 Regional Alternative 2

Regional Alternative 2 includes infrastructure that can serve the region: three regional tunnels. PVSC's Evaluation of Alternatives Report (**Appendix A**) provided the basis for two of the tunnels, with an additional tunnel (NJ440) and cost-effective alternatives identified in Regional Alternative 1 to serve the HCFM communities. Regional Alternative 2 was evaluated to meet each of the yearly CSO event frequencies and for 85% CSO volume capture for the PVSC interceptor communities and the west side of the HCFM Communities. The regional tunnels would include the Paterson Citywide Tunnel, McCarter Highway Tunnel, and the NJ440 Tunnel, as shown in **Figure D-1** below. It is noted dedicated surface level piping leading to the drop shafts and microtunneling to connect the drop shafts to McCarter Highway Tunnel will be needed in Harrison, East Newark, and Kearny. Alternative technologies identified by Jersey City and Bayonne in Regional Alternative 1 will be evaluated for the 12 CSO outfalls not connected to the NJ440 Tunnel. These technologies will be complimentary toward the NJ440 Tunnel so that every CSO outfall in the PVSC service area will meet the proposed levels of control.

The total life cycle costs, CSO volume discharged and captured, and life cycle cost efficiency (cost/MG of CSO captured) were estimated to meet each yearly CSO frequency and the 85% capture scenario, as summarized in **Table D-5**.

Table D-5: Regional Alternative 2 – Summary of Life Cycle Cost, CSO Volume Discharged and Captured, and Life Cycle Cost Efficiency

CSO Events	Total Life Cycle Cost ($M)	Total CSO Volume Discharged (MG)	Total CSO Volume Captured (MG)	Life Cycle Cost Efficiency ($/gal)
0	~~$2,928~~ $6,003	~~641~~ 0	~~3,623~~ 4,264	~~$0.81~~ $1.41
≤4	~~$1,907~~ $2,453	~~1,077~~ 536	~~3,187~~ 3,728	~~$0.60~~ $0.66
≤8	~~$1,722~~ $2,203	~~1,318~~ 885	~~2,946~~ 3,379	~~$0.58~~ $0.65
≤12	~~$1,583~~ $2,006	~~1,721~~ 1,332	~~2,543~~ 2,932	~~$0.62~~ $0.68
≤20	~~$1,212~~ $1,502	~~2,769~~ 2,623	~~1,495~~ 1,641	~~$0.81~~ $0.92
85%	~~$1,051~~ $1,052	2,838	1,426	$0.74

The NJ440 Tunnel varies from the regional deep tunnel considered by the HCFM communities where the two overlap coverage in North Bergen, Jersey City, and Bayonne. The deep regional tunnel allows up to 12 overflows per year, citing flow restrictions in the HCFM preventing the dewatering rate necessary to achieve more stringent levels of control. The NJ440 Tunnel plans to evaluation indicates that it could potentially meet all proposed levels of control for the CSO outfalls within its catchment area.

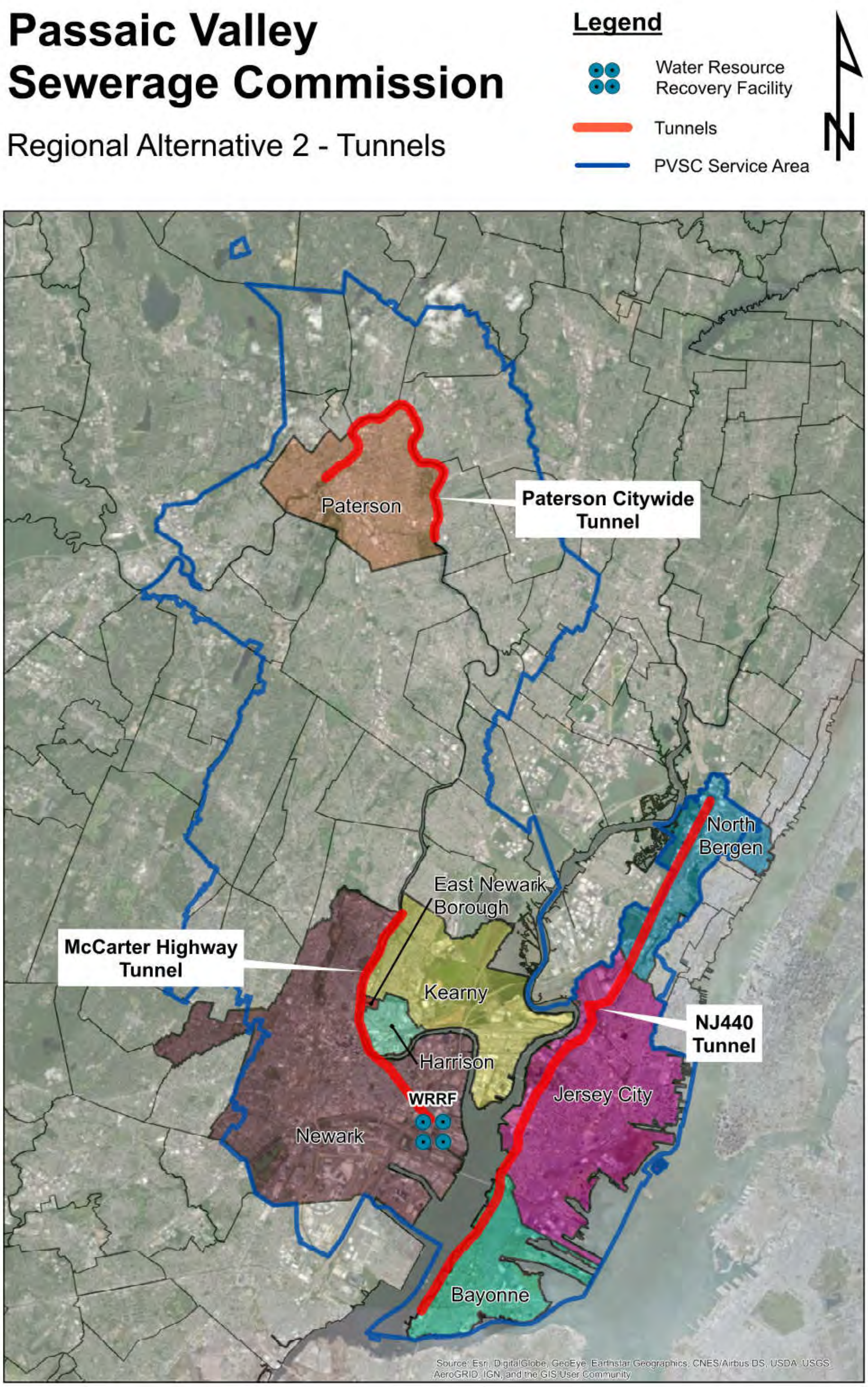

Figure D-1: Map of Regional Tunnels Locations NJ440

Further investigation into expanding NJ440 Tunnel dewatering flow or increasing the size of the tunnel could be considered based on the prior work performed by the HCFM communities.

Although the overflow volume discharged for the 85% capture scenario is similar to the 20 CSO events per year scenario, the life cycle costs are lower. This is because for the 0, 4, 8, 12, and 20 CSO events per year scenarios, all three tunnels are required to control all regulators, whereas the 85% capture scenario only requires the McCarter Highway Tunnel sized for the 4 CSO events per year scenario.

There is a significant difference between the life cycle costs for the two alternatives for the 0 CSO events per year scenario, due to the high capital costs required for system wide sewer separation, which was the lowest cost alternative evaluated for the 0 CSO events per year scenario.

D.2.3 Regional Alternative 3

Regional Alternative 3 is the same as Alternative ~~5a~~ 6.a.1 that was evaluated by PVSC (See **Appendix A**) and includes Newark Regular Modifications & Rehabilitation + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Hudson County Force Main Pump Expansion (146 MGD HCFM). This alternative aims to reduce CSO frequency by increasing storage and flow capacities using multiple CSO control technologies. **Figure D-2** depicts the components of Regional Alternative 3.

This section provides a brief summary of each technology for this alternative and further details regarding the technologies are included in **Appendix A**.

The first technology for this alternative is Newark Regulator Modifications & Rehabilitation. Within the PVSC CSS, there are 11 PVSC-owned and operated CSO regulators where regulator modifications may have a positive effect on reducing CSO frequency and increase storage capacity in the collection system. The 11 PVSC-owned and operated CSO regulators have existing gates to shut off flow entering the PVSC Main Interceptor. The current peak flow capacity at the WRRF is 400 MGD. When the combined wet weather inflow of the PVSC Main Interceptor, South Side Interceptor, and the HCFM gets closer to this peak capacity, the regulator gates close and CSOs occur.

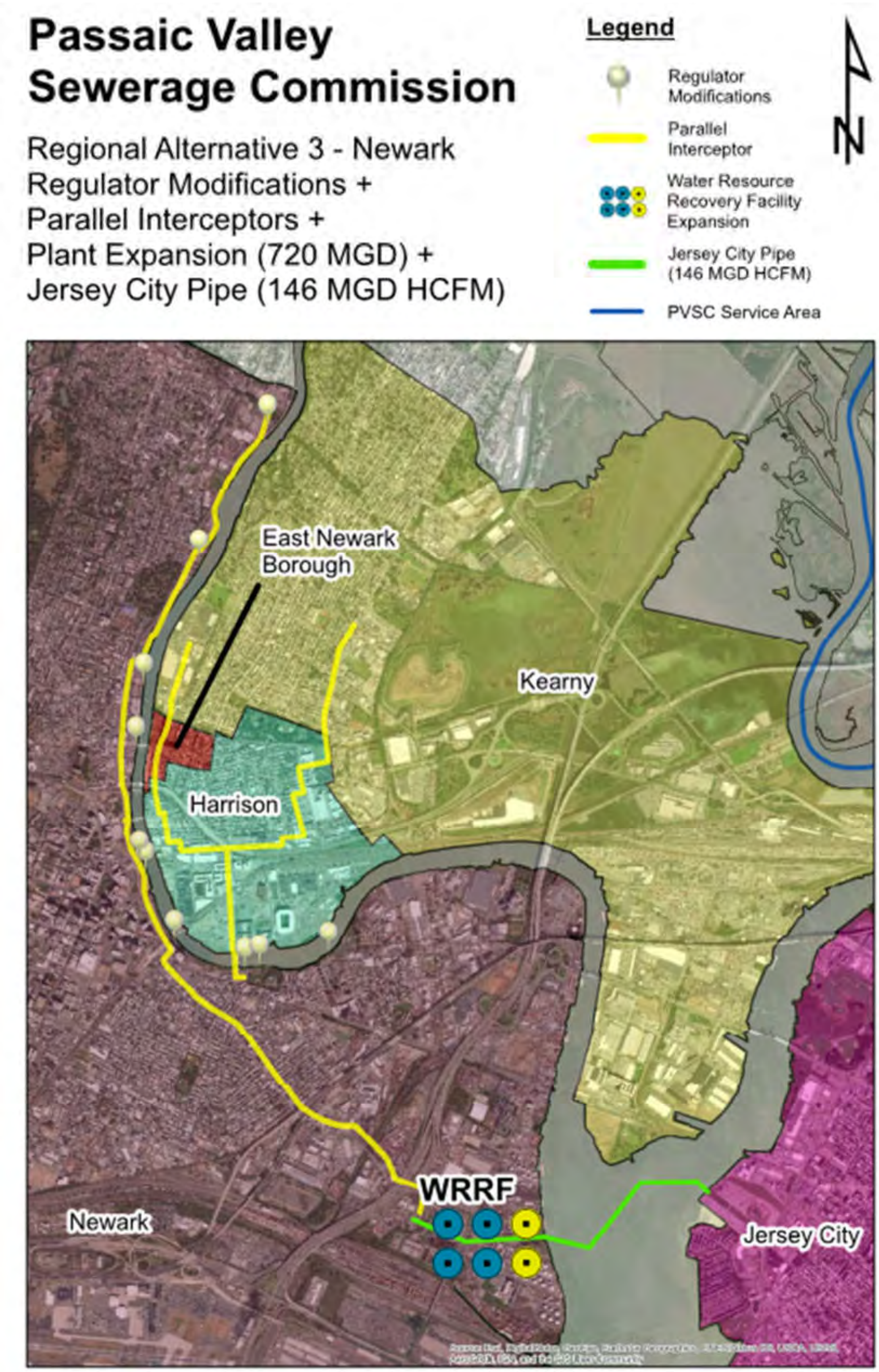

Figure D-2: Regional Alternative 3

It is possible to adjust the regulator gate shutoff timing to maximize flow into the PVSC Main Interceptor and WRRF. Updating the gate shutoff based on the results of the PVSC CSS model during the typical year and WRRF inflow rate can reduce both CSO occurrence and volume. The control technology itself does not require any additional capital investments or upkeep from what is currently in place. However, the effectiveness of this control technology would be increased with the addition of any technologies that increase flow capacity such as a parallel interceptor, secondary treatment expansion, or secondary flow bypass. In addition to the regulator modifications, a parallel interceptor would run from the WRRF to outfall regulator NE002. Regulator flows or upstream flows would be redirected to this new interceptor to reduce overflow and make use of an expanded 720 MGD treatment capacity at the WRRF. Finally, the HCFM, which receives flow from the cities of Jersey City, Bayonne, North Bergen, and South Kearny, would be maximized to 146 MGD.

Regional Alternative 3 was evaluated to meet the 85% CSO volume capture scenario only because the level of controls cannot be adjusted for the individual technologies. The total life cycle costs, CSO volume discharged and captured, and life cycle cost efficiency (cost/MG of CSO captured) estimated to meet the 85% capture scenario were as follows:

- Total life cycle costs: $465 M
- Total CSO Volume Discharged (MG): 2,884 MG
- Total CSO Volume Captured (MG): 1,380 MG
- Life Cycle Cost Efficiency: $0.34/gal

D.2.4 Regional Alternative 4

Regional Alternative 4 is the same as Alternative 7.a~~6~~ that was evaluated by PVSC, with the addition of the NJ440 Tunnel and other alternative technologies for the remaining CSO outfalls in the HCFM communities. This alternative combines all technologies used in Regional Alternative 2 and Regional Alternative 3. Regional Alternative 4 was evaluated to meet each of the yearly CSO event frequencies and for 85% CSO volume capture. This alternative aims to reduce CSO frequency by increasing storage and flow capacities using multiple CSO control technologies. **Figure D-3** depicts the components of Regional Alternative 4. Further details regarding the technologies for this alternative are included in **Appendix A**.

The total life cycle costs, CSO volume discharged, and life cycle cost efficiency (cost/MG of CSO captured) were estimated to meet each yearly CSO event frequency and the 85% capture scenario, as summarized in **Table D-6**.

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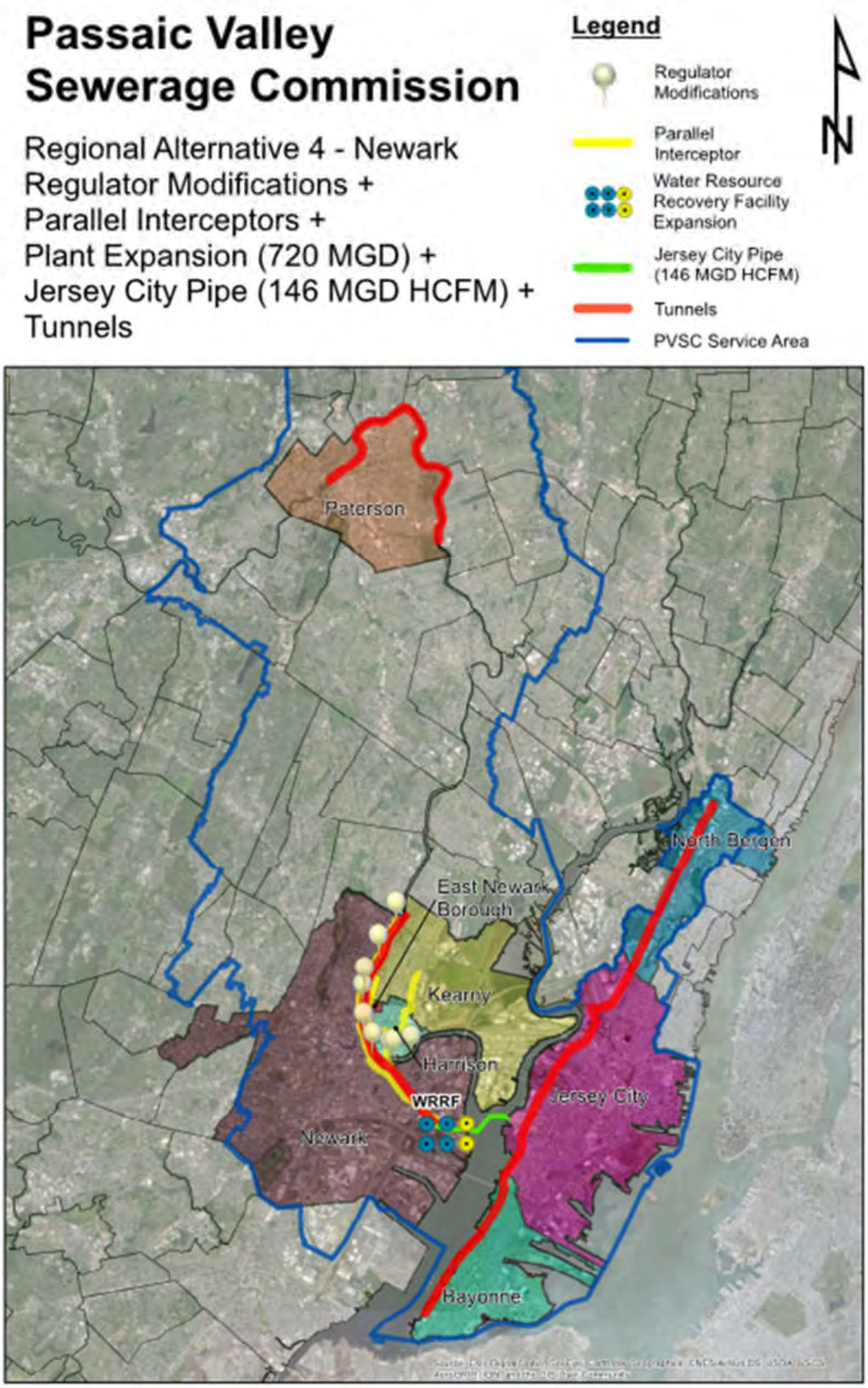

Figure D-3: Regional Alternative 4

Table D-6: Regional Alternative 4 – Summary of Life Cycle Cost, CSO Volume Discharged and Captured, and Life Cycle Cost Efficiency

CSO Events	Total Life Cycle Cost ($M)	Total CSO Volume Discharged (MG)	Total CSO Volume Captured (MG)	Life Cycle Cost Efficiency ($/gal)
0	~~$2,924~~ $5,995	~~579~~ 0	~~3,685~~ 4,264	~~$0.79~~ $1.41
≤4	~~$2,149~~ $2,695	~~878~~ 400	~~3,386~~ 3,864	~~$0.63~~ $0.70
≤8	~~$1,910~~ $2,380	~~1,208~~ 806	~~3,056~~ 3,458	~~$0.63~~ $0.69
≤12	~~$1,667~~ $2,090	~~1,530~~ 1,195	~~2,734~~ 3,069	~~$0.61~~ $0.68
≤20	~~$1,402~~ $1,692	~~2,055~~ 1,942	~~2,209~~ 2,322	~~$0.63~~ $0.73
85%	$465	2,884	1,380	$0.34

Similar to Regional Alternative 1 and Regional Alternative 2, the life cycle costs are anticipated to be highest when meeting the 0 CSO events per year scenario, and the decrease as the number of CSO events per year increases. The opposite trend is observed for overflow volume discharged, where the least volume is discharged for the 0 CSO events per year scenario and the volumes increase as the number of CSO events per year increases. The 85% capture scenario values are the same for Regional Alternative 3 and Regional Alternative 4 because the regional tunnels will not be needed for the 85% scenario.

D.2.5 Summary of Cost Opinions

Cost opinions were determined for each of the four (4) regional alternatives. The most advantageous alternative is one that reduces the volume or frequency of CSO discharges for the lowest cost.

Permittees will select alternatives that provide the most benefits for the lowest costs. Afterward, further discussion between the Permittees and NJDEP will be conducted to arrive at a satisfactory conclusion for both parties and NJDEP approval.

D.3 SELECTION OF ALTERNATIVES

This section of the report describes the strategy that will be used for the final evaluation of CSO control alternatives for the permittees within the PVSC Treatment District. The selected alternative will meet each permittee's Permit requirements and will be considered feasible for application in conjunction with alternatives developed by the other CSO permittees within the hydraulically connected system, as per requirement by the Permits. The evaluation factors will be finalized, and the selection of the regional alternative will be determined after this Regional Alternatives Report is submitted, pending approval from the NJDEP of the alternatives to be evaluated. The selection of the CSO control alternatives and the corresponding implementation schedule will be provided in the subsequent Selection and Implementation of Alternatives Report in the Final LTCP.

D.3.1 Evaluation Factors

The evaluation factors comprise of cost and non-cost factors deemed important for alternatives analysis. Two of the factors, cost and performance (level of CSO control), are summarized in **Section D.1**. Additional factors, such as public factors, water quality, public health, and environmental impacts, operational impacts, and implementation concerns, may be accounted for while still considering cost and performance.

The criteria, weighting, and ranking method (quantitative or qualitative) will be discussed and determined through collaboration with the permittees.

D.3.2 Regulatory Compliance

Alternatives analyzed within this report includes those required by the NJPDES Permit requirements noted in Section G.4.e for each permittee.

D.3.3 Selection of Regional Alternative

As discussed above, the selection of the regional alternative will be determined after this Regional Alternatives Report is submitted and discussion with NJDEP and the Permittees takes place. The evaluation and selected regional alternative will be presented in the Final Regional LTCP (Selection and Implementation of Alternatives Report), due for submission by June 1, 2020.

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SECTION F - ABBREVIATIONS

AACE: Association for the Advancement of Cost Engineering
BA: Bayonne
BMP: Best Management Practices
BOD: Biochemical Oxygen Demand
CMP: Compliance Monitoring Program
CSO: Combined Sewer Overflow
CSS: Combined Sewer System
CWA: Clean Water Act
EDP: Effective Date of the Permit
EN: East Newark
EPA: Environmental Protection Agency
FOG: Fats, Oils, and Grease
FW2-NT: Fresh Water Non Trout
GI: Green Infrastructure
GIS: Geographic Information System
GM: Geometric Mean
GRDs: Grease Removal Devices
HA: Harrison Town
HCFM: Hudson County Force Main
HDD: Horizontal Directional Drilling
H&H: Hydrologic and Hydraulic
IDDE: Illicit Discharge Detection and Elimination
IEC: Interstate Environmental Commission
I/I: Inflow and Infiltration
JC: Jersey City
JCMUA: Jersey City Municipal Utilities Authority
KEA: Kearny Town
LTCP: Long Term Control Plan
MGD: Million Gallons Per Day
MUA: Municipal Utilities Authority
NJAC: New Jersey Administrative Code
NB: North Bergen
NBMUA: North Bergen Municipal Utilities Authority
NE: Newark
NJDEP: New Jersey Department of Environmental Protection
NJPDES: New Jersey Pollutant Discharge Elimination System
NRCS: Natural Resources Conservation Service
O&M: Operation and Maintenance
PAA: Peracetic Acid
PAT: Paterson
POC: Pollutants of Concern
POTW: Publicly Owned Treatment Works
PPP: Public Participation Plan
PVSC: Passaic Valley Sewerage Commission

QAPP: Quality Assurance Project Plan
RTC: Real Time Control
SE2 or SE3: Saline Water
SIU: Significant Indirect User
STP: Sewage Treatment Plant
TGM: Technical Guidance Manual
TMDL: Total Maximum Daily Load
TSS: Total Suspended Solids
USEPA: United States Environmental Protection Agency
UV: Ultraviolet
WMA: Watershed Management Areas
WQS: Water Quality Standards
WRRF: Water Resource Recovery Facility

APPENDIX A

Development and Evaluation of Alternatives Report
Passaic Valley Sewerage Commission

Dated: June 2019
Revised: November 2019

DEVELOPMENT AND EVALUATION OF ALTERNATIVES REPORT

Passaic Valley Sewerage Commission (NJ 0021016)

Passaic Valley Sewerage Commission
Essex County
600 Wilson Avenue
Newark, New Jersey

"Protecting Public Health and the Environment"

June 2019
Revised 11/22/19

SECTION A - INTRODUCTION AND BACKGROUND

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A.2 BACKGROUND

The Passaic Valley Sewerage Commission ("PVSC") provides wastewater treatment service to 48 municipalities within Bergen, Hudson, Essex, Passaic, and Union counties in the Passaic Valley Service District located in Northeast New Jersey. In total PVSC services approximately 1.5 million people, 198 significant industrial users and 5,000 commercial customers. PVSC's Treatment District covers approximately 150 square miles from Newark Bay to regions of the Passaic River Basin upstream of the Great Falls in Paterson.

The PVSC Water Resources Recovery Facility ("WRRF") receives flow from three sources: the Main Interceptor Sewer, the South Side Interceptor, and the Hudson County Force Main ("HCFM"). The Main Interceptor begins at Prospect Street in Paterson and generally follows the alignment of the Passaic River to the PVSC WRRF in the City of Newark. The South Side Interceptor is located entirely within the City of Newark. The Hudson County Force Main receives flow from the cities of Jersey City, Bayonne, North Bergen, and South Kearny.

PVSC does not own or operate any of the combined sewer overflow ("CSO") outfalls within the PVSC Treatment District. The extent of the PVSC Treatment District and the combined sewer areas within the study area are illustrated in **Figure A-1**.

Eight of the municipalities within the PVSC District have combined sewer systems ("CSSs") and have received authorization to discharge under their respective New Jersey Pollutant Discharge Elimination System ("NJPDES) Permits for Combined Sewer Management. The eight PVSC CSO Permittees are:

- City of Paterson
- City of Newark
- Town of Kearny
- Harrison Town
- Borough of East Newark
- City of Bayonne (Bayonne Municipal Utilities Authority was dissolved in 2016 and the City of Bayonne now owns its CSS)
- Jersey City Municipal Utilities Authority ("JCMUA")
- Township of North Bergen Municipal Utilities Authority ("NCMUA")

A general schematic of the PVSC sewer system is included in **Figure A-2**.

The Township of North Bergen has two combined sewer areas that are owned and operated by the NBMUA under two separate NJPDES permits: NBMUA and NBMUA (Woodcliff). The Woodcliff Sewage Treatment Plant (STP) service area is separate from the PVSC Treatment District. Any mention in this report of the infrastructure owned and operated (in part or in full) by NBMUA (Woodcliff) is only included where it is necessary in order to properly characterize the NBMUA system.

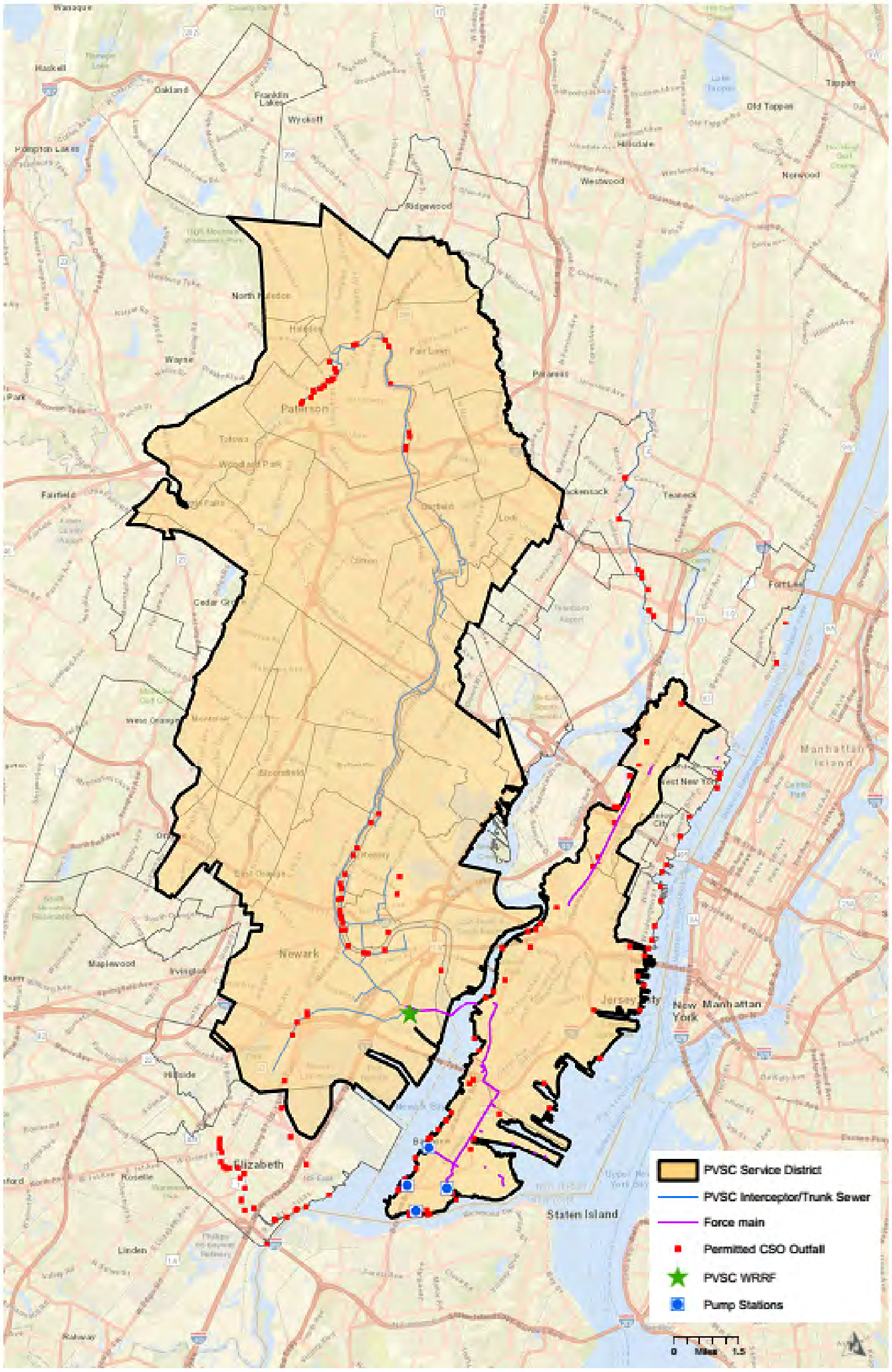


Figure A-1: PVSC Treatment District

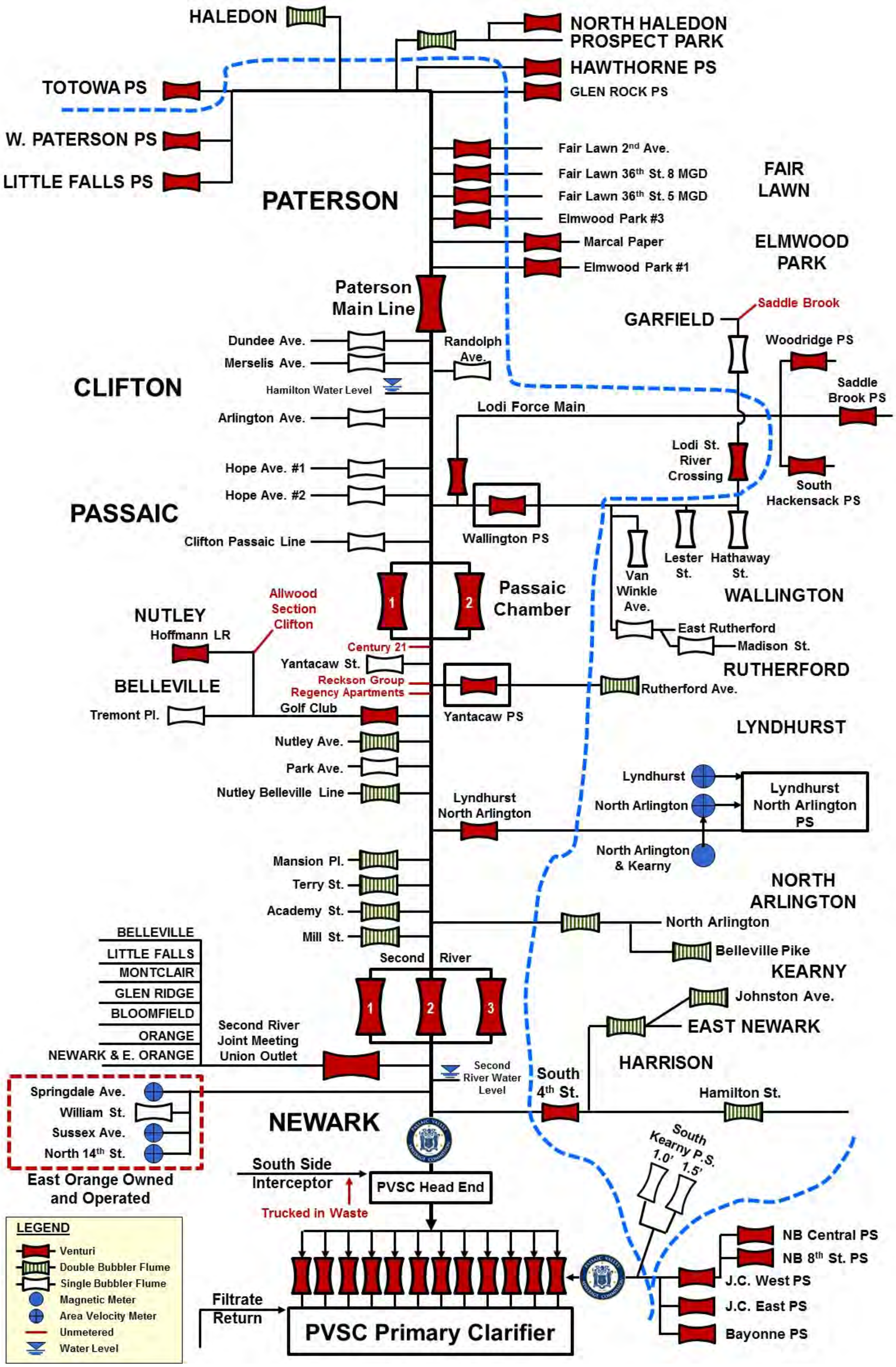


Figure A-2: The PVSC Sewer System Schematic

A.3 PURPOSE OF REPORT

In accordance with the PVSC NJPDES Permit's LTCP requirements, a Development and Evaluation of Alternatives Report ("DEAR") shall be submitted by July 1, 2019.

Part IV Section G.4 of the PVSC NJPDES Permit Number NJ0021016 outlines the requirements of the EAR. The objective of the EAR is to provide the NJDEP, PVSC, and the municipalities with a comprehensive evaluation of CSO control alternatives "*that will enable the permittee, in consultation with the Department, the public, owners and/or operators of the entire collection system that conveys flows to the treatment works, to select the alternatives to ensure the CSO controls will meet the water quality-based requirements of the Clean Water Act (CWA), will be protective of the existing and designated uses in accordance with N.J.A.C. 7:9B, give the highest priority to controlling CSOs to sensitive areas, and address minimizing impacts from SIU discharges.*"

This report constitutes the PVSC EAR, and has been developed to meet the above-cited permit requirements.

A.4 CONTENTS OF THIS REPORT

This EAR provides an evaluation of a range of CSO control alternatives predicted to accomplish the requirements of the Federal Water Pollution Control Act of 1972 (the "Clean Water Act" or "CWA"). As required by the NJPDES Permit Section G.4.e, this EAR utilizes models to simulate the existing conditions and the expected conditions after the construction and operation of the chosen alternative(s). The EAR evaluates the practical and technical feasibility of the proposed CSO control alternative(s), with the goal of achieving the water quality based requirements of the CWA through the construction and implementation of various remedial controls and the combination of such controls and activities.

An overview of the organization and contents of this EAR is provided in **Table A-1.**

Table A-1: Evaluation of Alternatives Report Contents and Organization

Section		Topics Covered
A	Introduction and Background	Documents the problem definition, background, project description, summary and table of contents.
B	Future Conditions	Describes the anticipated future conditions of the PVSC Treatment District across municipalities. Future conditions include project populations, projected flow rates, and planned projects.
C	Screening of CSO Control Technologies	Describes the technology screening process used to determine the CSO control technologies advanced for analysis in Section D.
D	Alternatives Analysis	Describes the process used to develop alternatives from the technologies advanced from Section C, the evaluation criteria, and performance and cost of each alternative.
E	References	
F	Abbreviations	

SECTION B - FUTURE CONDITIONS

B.1 INTRODUCTION

Section G.4.e of the NJDPES permit requires that "*the permittee shall utilize the models to simulate the existing conditions and conditions as they are expected to exist after construction and operation of the chosen alternative(s).*" The construction and operation schedule for the chosen alternative(s) will be established as part of the Final LTCP, which is to be submitted by June 1st, 2020. For the EAR, the PVSC Treatment District Permittees decided to evaluate future conditions for the year 2045.

This section of the EAR focuses on the expected future conditions of the PVSC Treatment District.

B.2 PROJECTIONS FOR POPULATION GROWTH

PVSC currently provides wastewater treatment services to approximately 1.5 million people, 198 significant industrial users, and 5,000 commercial customers in 48 municipalities. The eight municipalities served by combined sewers are developing their own population growth projections as part of their municipality specific reports.

Projected population growth information utilizes the North Jersey Transportation Planning Authority (NJTPA) final forecasts approved by the NJTPA Board on November 13, 2017. Based on data from PVSC, the current population served is approximately 1.5 million people. According to NJTPA's forecasts, population in this area is expected to grow roughly 20% by 2045.

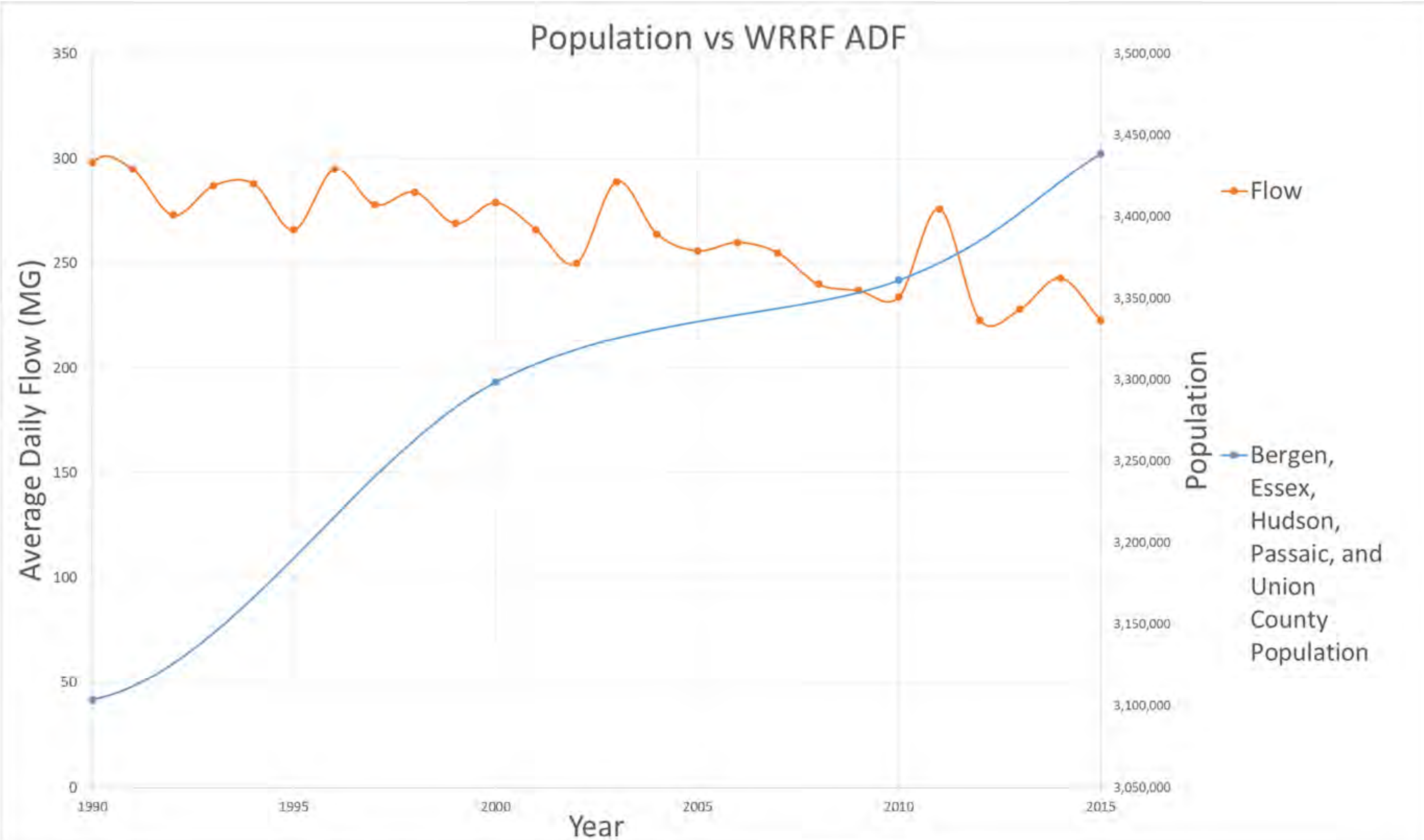
B.3 PLANNED PROJECTS

PVSC has not currently committed to any projects that would alter the PVSC Treatment District's existing conveyance or treatment capacity. However, PVSC is currently undergoing an interceptor inspection and rehabilitation project.

B.4 PROJECTED FUTURE WASTEWATER FLOWS

Despite increases in population within the PVSC Treatment District from approximately 1.4 million in 2011 (2011 Annual Report) to approximately 1.5 million in 2018, dry weather flows to the PVSC WRRF have declined over the previous decade. Water conservation measures, such as low flow fixtures and a decrease in the number of industrial users within the service area are believed to be significant reasons for this reduction. Historical data since 1990 shows that the average daily flow at the PVSC WRRF continues to decline despite an increase in population in the service area. **Figure B-1** plots the combined population of the serviced counties against the average daily flow at the PVSC WRRF from 1990-2015. Population data is based on the United States Census Bureau 2010 Housing and Population Report for 1990, 2000, and 2010 and the NJPTA forecast for 2015. Average daily flow is provided on a monthly average. Based on these trends, it is conservatively assumed that -wastewater flows used for existing and future conditions are the same for the purpose of this study. Based on the continued application of water conservation measures, PVSC expects this trend to continue; however, there is uncertainty in whether the flows to the PVSC WRRF are going to increase proportional to population growth.

Figure B-1: PVSC WWRF ADF vs Population (1990-2015)



SECTION C - SCREENING OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

This section of the EAR focuses on the CSO technology screening process as per the requirements of the NJPDES Permit No. NJ0021016 issued to PVSC. PVSC reviewed various CSO technologies in order to determine which ones have the greatest potential to meet the requirements of the NJPDES Permit. This screening of technologies is consistent with the requirements of the CSOs Control Policy Section II.C.4 and the United States Environmental Protection Agency's (USEPA) "Guidance for Long Term Control Plan." The Alternatives Evaluation shall consist of:

- Technology Screening Process
- Evaluation of Specific CSO Control Alternatives

It is important to note that this discussion only considers technologies applicable to PVSC-owned infrastructure. Additionally, this screening of technologies does not consider cost or cost effectiveness, and is only meant to exclude those CSO control technologies not technically or physically appropriate for PVSC application. A more detailed discussion of the technologies deemed appropriate for PVSC application is included within each respective subsection.

The results of this screening have advanced several CSO control technologies forward for consideration in the development of alternatives for the LTCP. Further evaluation of these control technologies as LTCP alternatives is discussed in Section D – Alternative Analysis of this EAR.

C.1.1 Water Quality and CSO Control Goals

With respect to water quality, control technologies are screened for their effectiveness at addressing pollutants of concern (POC) and CSO control goals in order to achieve compliance with the CWA. The control technologies were screened based on the following POC and CSO control goals.

- Reducing the count of fecal coliform colonies
- Reducing the count of Enterococcus colonies
- Reducing the count of Escherichia coli colonies
- CSO discharge volume reduction

C.1.2 Evaluation Methodology Used for this Study

Each CSO control technology evaluated in this section has been assigned a value based on its effectiveness at reaching primary CSO control goals. The categories used to describe goal effectiveness are as follows:

- High: The CSO control technology will have a significant impact on CSO control goals and is among the best technologies available to achieve those goals. This technology may be considered for further evaluation for this reason.
- Medium: The CSO control technology is effective at achieving CSO control goals, but is not considered among the most effective technologies to achieve those goals. This technology may or may not be considered for further evaluation.

- Low: The CSO control technology will have a minor impact on CSO control goals – POC reduction and CSO discharge volume reduction. This technology will need other positive attributes to be considered for further evaluation.
- None: The CSO control technology will have no impact or a negative impact on the CSO control goals. This technology will not likely be considered for further evaluation.

Additionally, the positive impacts that each of the technologies will have on the community beyond achieving the primary goals described above were evaluated. The community benefits were identified using as a reference the New Jersey DEP Division of Water Quality's report entitled "Evaluating Green Infrastructure: A Combined Sewer Overflow Control Alternative for Long Term Control Plans," and the New Jersey Green Infrastructure Municipal Toolkit website. Community benefits identified include aesthetic improvements, improvements to water quality, reduction of flooding potential, and alignment with sustainable community principles, among others.

CSO control technologies will be recommended for further evaluation based on multiple factors. The first factor will be the goal-effectiveness value that generally quantifies the impact a technology will have towards achieving a water quality goal. These goal-effectiveness values are described above. The second factor is whether or not the NJPDES Permit requires further investigation of a technology. The permit identifies certain technologies that must be evaluated further. The third factor in determining whether a technology will be evaluated further is the current or future implementation and operation of that technology. If the technology is currently in place, will be implemented, or is mandated by the Nine Minimum Controls, then an evaluation is unnecessary. The fourth and final factor is the feasibility of implementation, particularly in terms of land/infrastructure ownership. The community benefits identified for each technology also play an important role in determining whether implementation of the technology will be beneficial and recommended to be moved forward for further analysis.

A CSO technology that is highly effective in one or all evaluation factors will likely be recommended for further investigation. A CSO technology that does not reach a "medium" effectiveness for water quality goals will likely not be recommended for further evaluation. This screening methodology was presented to the public at the October 2018 PVSC Regional Supplemental CSO Meeting. Input was requested from the public and considered in this evaluation.

C.1.3 Further Evaluation as a CSO Control Technology

The CSO technologies recommended for further evaluation and deemed feasible for PVSC implementation contain additional discussion within Subsections C.2 to C.8 regarding CSO technology feasibility, implementation, and design. The additional analysis typically utilizes the following control levels to determine technology effectiveness: up to 0, 4, 8, 12, and 20 overflow events per year, and 85% CSO volume capture. This discussion only analyzes the individual CSO control technology effectiveness and does not consider cost or cost effectiveness.

Tables located in Subsection C.9 contain a brief description of the implementation and operation factors for a wide range of CSO technologies and summarize the results of the screening process for each CSO control technology described in Subsections C.2 through C.8. The summary tables in Section C.9 indicate which CSO technologies are recommended to move forward for the Evaluation of Alternatives, discussed in Section D of this EAR.

C.2 SOURCE CONTROL

The USEPA defines source controls as those that impact the quality or quantity of runoff entering the CSS. Source control measures can reduce volumes, peak flows, or pollutant discharges that may decrease the need for more capital-intensive technologies downstream in the CSS. However, source controls typically require a high level of effort to implement on a scale that can achieve a measureable impact. As PVSC does not own or operate the CSS or maintain significant ownership of property outside the WRRF, it has limited ability to implement source control technologies.

C.2.1 Green Infrastructure

Green infrastructure ("GI") is a source control that uses natural processes such as infiltration, evapotranspiration, filtration, storage, and controlled release to reduce the stormwater volume, peak flows, or pollutant loads entering the sewer system or surface waters. A wide range of GI technologies are currently in use throughout the country and include pervious paving, bioretention basins, vegetated swales, green roofs, blue roofs, and rainwater harvesting. These technologies can be used alone in a scalable manner, or in conjunction with gray infrastructure to reduce the size and cost of gray infrastructure.

GI's benefits extend beyond reducing the flow of water into CSSs during wet weather events. By mimicking a more naturalized system, GI can deliver a broad range of ecosystem services or benefits to people, some of which include: improvements to community livability (aesthetics and property values), human health, air quality, water quality, groundwater recharge, wildlife habitats and connectivity, reduced heat island effects, reduced energy use, increased green jobs, and more recreational opportunities (USEPA, 2014). As described in Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control (USEPA, 2014), the USEPA requires that any incorporation of GI into a LTCP include analysis in two areas:

1. Community and political support for GI
2. Realistic potential for GI implementation

PVSC assessed public support for GI and other CSO control alternatives through the implementation of the LTCP Public Participation Plan ("PPP"). The implementation of the LTCP PPP is an ongoing process that includes hosting quarterly public meetings with the Clean Waterways Healthy Neighborhoods Supplemental CSO Team, participating in the meetings of various local groups, attending public events, meeting with municipal representatives, and soliciting public input through the Clean Waterways Healthy Neighborhoods website and social media platforms. PVSC is also an active member of the PVSC Treatment District Communities GI Programs: Newark DIG, Jersey City START, Paterson SMART, Bayonne Water Guardians, Harrison Tide, and Kearny AWAKE. In addition, PVSC has partnered with Rutgers Cooperative Extension (RCE) Water Resources Program to pilot a Green Infrastructure Municipal Outreach and Technical Assistance Program to aid the 48 municipalities within the PVSC Treatment District on managing runoff and non-point source pollution using GI. This program is structured to support Rutgers' participation across the GI groups mentioned above. More information about this program can be found at http://water.rutgers.edu/PVSC/PVSC.html.

While discussing the realistic potential for the implementation of GI within the PVSC system, it is important to note that PVSC is not a regulating authority for building design and does not maintain significant ownership of property outside the WRRF. The actual implementation of GI within the PVSC Treatment District would be the responsibility of the municipalities within the service area. This provides a challenge in regard to the implementation of GI technologies and needs to be taken into consideration when evaluating GI opportunities for PVSC implementation.

With the above considerations in mind, GI shall be considered a feasible technology for PVSC implementation at a screening level only and will be carried forward for further evaluation as required by Section G.4.e.i of the NJPDES Permit. The analysis performed for the evaluation of alternatives assumes uniform application of GI at various implementation levels across the service area. Further analysis of GI, as it applies to CSO control alternatives, is discussed in SECTION D - Alternatives Analysis of this EAR.

To understand how the PVSC sewer system performance will respond to implementation of GI, it was necessary to utilize the hydrologic and hydraulic model to represent stormwater management practices. For this assessment, a bioretention type of stormwater management practice was assumed. The model represents the hydraulic and hydrologic processes in a bioretention feature, like storage, slow release, evapotranspiration, and infiltration.

The amount of bioretention was derived from the gross impervious surface area of the collection system which is approximately 14,000 acres. Facility size was evaluated at three implementation levels of 2.5%, 5%, and 10% of the total impervious area. These impervious surface targets are for general land cover and no possible specific locations were considered for GI opportunities in the PVSC district area. As PVSC does not own property outside of the WRRF, it is not practical for PVSC to determine which areas would be the most appropriate to use for each permittee. Facility volume is defined based on 1 inch of runoff from the contributing impervious area (2.5%, 5%, or 10%) for each sub-catchment. The GI facility then infiltrates and/or releases back to the CSS, with a targeted 48 hour drain down time. Any runoff from pervious and non-directly connected impervious area is routed to the CSS.

GI was evaluated by conveying runoff from directly connected impervious areas to simulated stormwater management facilities. **Table C-1** summarizes GI contributing area, CSO reduction and overflow event performance at the various levels of GI implementation in the PVSC system with 400 MGD WRRF capacity. Screening level modeling results indicated that for 1.4 to 2 gallons of runoff treated by GI, one (1) gallon of CSO reduction can be achieved depending on the hydraulic conditions in the system.- These ratios were calculated based on the model results by dividing the modeled "GI Treated Volume" by the "Annual Overflow Volume Reduction". The results are listed in the last row, "GI Treated Vol/CSO Vol reduction", of **Table C-1**.

Overflow event frequency is less sensitive to GI in general as shown by the small changes in the average annual overflow.

Table C-1: GI Performance Results

	Impervious Cover Controlled (% of impervious area)		
	2.5%	5%	10%
Impervious Area Controlled (acres)	330	660	1,320
GI Treated Volume (MG)	175	350	686
Annual Overflow Volume Reduction (MG)	116	223	421
Annual Overflow Percent Reduction	6%	11%	21%
Annual Overflow Events (Maximum/Average of 54 CSO locations)	73/33.4	73/32.5	72/30
GI Treated Vol/CSO Vol reduction	1.5	1.5	1.6

C.3 INFILTRATION AND INFLOW CONTROL

Infiltration and inflow control falls under the USEPA category collection system controls. Collection system controls are defined as measures that reduce CSO volume and frequency by removing or diverting stormwater runoff to maximize the capacity of the collection system. Collection system controls have the potential to reduce the volume of CSO events. PVSC does not own or operate the CSS and therefore has limited influence over infiltration and inflow control.

C.3.1 Infiltration/Inflow (I/I) Reduction

Excessive infiltration and inflow ("I/I") can consume the hydraulic capacity of a collection system and increase overall operations and maintenance costs. Inflow comes from sources such as roof drains, manhole covers, cross connections from storm sewers, catch basins, and surface runoff. Within a CSS, surface drainage is the primary source of inflow. Infiltration comes from groundwater that seeps in through leaking pipe joints, cracked pipes, manholes, and other similar sources. The flow from infiltration tends to be constant, but at a lower volume than that of inflow.

Section G.4.e.iv of the NJPDES Permit requires consideration of I/I reduction as a CSO control technology. As PVSC does not own or operate the CSS, PVSC has limited influence over I/I reduction. I/I reduction is not considered an applicable technology for PVSC implementation and will not be carried forward for further evaluation as a CSO control alternative.

PVSC has, however, sent letters to all separate sanitary municipalities within the PVSC Treatment District and has held meetings with several of those municipalities in order to request that the municipalities implement an I/I reduction program. To date, no municipalities have agreed to implement an I/I reduction program; however, it has been analyzed by several municipalities in the Regional DEAR. Documentation regarding this correspondence has been included in the Public Participation Plan Report, dated June 2018 and last revised January 25, 2019.

C.4 SEWER SYSTEM OPTIMIZATION

Sewer system optimization involves collection system controls and modifications that affect CSO flows and loads once the runoff has entered the collection system. Options for system optimization include measures that maximize the volume of flow stored in the collection system or maximize the capacity of the system to convey flow to the treatment plant. Sewer system optimization techniques have no impact on water quality, but do have the potential to reduce the volume of CSO events.

C.4.1 Increased Storage Capacity in the Collection System

Options for increased storage capacity rely on maximizing the volume of flow stored in the collection system or increasing the conveyance capacity of the system. Maximizing the use of the existing system involves ongoing maintenance and inspection of the collection system, and can include minor modifications/repairs to existing structures to increase the volume of flow retained in the system. Increasing conveyance capacity is typically achieved by providing additional conveyance pipes or upsizing the existing conveyance system to handle a greater capacity.

Increased storage capacity in the collection system is considered a feasible technology and will be carried forward for further evaluation as required by Section G.4.e.ii of the NJPDES Permit. Further discussion of this technology and its applicability as it relates to PVSC-owned and operated infrastructure is continued below.

C.4.1.1 Additional Conveyance

Conveyance is a technology that transports the combined sewage out of a particular area to a location where the flow can be stored, treated, or discharged where direct public contact with the water is less likely. Conveyance is accomplished by providing additional conveyance pipes or upsizing the existing conveyance pipe to a greater capacity. This practice can effectively reduce overflow event volume and frequency in the affected areas. Large conveyance projects can be expensive and may require a lengthy permitting process. This technology is considered feasible and will be further evaluated as an option to increase the storage capacity of the collection system. Further discussion of this technology and its applicability to PVSC implementation is found below.

Increased conveyance provides additional transmission capacity to bring combined sewer flows to the WRRF. Increased conveyance can be accomplished by paralleling existing interceptors with new pipes or replacing and upsizing existing interceptor with new, larger pipes. Parallel interceptors are located adjacent to or near the existing interceptor, paralleling the path of the interceptor with periodic connections to the existing interceptor or trunk sewer diversions directing combined sewer flow to the parallel interceptor. Interceptor replacement would involve excavation and removal of the existing interceptor and replacing it with a larger pipe. To understand how the PVSC sewer system performance will respond to implementation increased conveyance it was necessary to utilize the hydrologic and hydraulic model to represent various iterations of this potential technique. Two scenarios were evaluated:

1. The Newark relief scenario entails a parallel interceptor from the WRRF to outfall regulator NE002. Regulator flows are redirected to this new interceptor to reduce

overflow events to about 20 overflows per year and make use of an expanded 720 MGD treatment capacity at the WRRF. A figure showing the location of the potential Newark relief scenario is presented in **Figure C-1**.

2. The Newark and local relief scenario includes the parallel interceptor from Scenario 1 through Newark (to NE002) with upsized branch interceptors to collect additional flow from East Newark, Kearny, and Harrison local interceptors. Regulator flows are redirected to this new interceptor to reduce the overflow events to about 20 overflow events per year and make use of the expanded 720 MGD treatment capacity at the WRRF. A figure showing the location of the potential Newark, East Newark, Kearny, and Harrison relief scenario is presented in **Figure C-2**.

Table C-2 summarizes the parallel interceptor scenarios evaluated and the associated CSO capture and overflow event performance. System wide annual overflow events for each scenario includes two numbers: "Maximum system wide annual overflow event" is the number of events for the outfall that overflows most frequently within the entire system; the "Average of 115 CSO outfalls" is the summation of event count of all the outfalls divided by total number of outfalls in the system. Screening level modeling results indicate CSO reduction is more effective with the Newark relief scenario, in terms of CSO reduction per parallel/replaced interceptor conveyance length with a reduction of 32% from the baseline (1,423 MG). The Newark and Local relief scenario reduces CSO frequency at more locations and the overall system-wide overflow average in comparison to the Newark relief scenario. However, the additional conveyance only led to less than 200 MG in CSO volume reduction from the Newark only relief scenario.

Table C-2: Increased Conveyance CSO Reduction Performance Summary

	Increased Conveyance Scenario	
OF/yr.	Newark	Newark and Local
Number of Outfalls Controlled	13	26
Parallel Interceptor Length (ft.)	29,296	29,226
Interceptor Replacement Length (ft.)	0	27,796
Weir Adjustments	6	14
Annual Overflow Volume Reduction (MG)	1,069	1,268
Annual Overflow Percent Reduction	52%	62%
Annual Overflow Events (Maximum/Average of 54 CSO outfalls)	70/25.9	52/20.0

Further analysis of additional conveyance, as it applies to CSO control alternatives, is discussed in Section D - Alternatives Analysis of this EAR.

C.4.1.2 Regulator Modifications

A CSO regulator can be uniquely configured to control combined sewer overflow event frequency and volume. The existing regulators may be modified based on site-specific conditions. Regulator modifications can include adjusting gate control logic, increasing conveyance between the regulators and interceptor through pipe or regulator modifications, or increasing the overflow weir height. This technology is especially effective for CSO outfalls with high overflow event frequency and low overflow volume, because the additional volume held back in the system is small and less likely to have negative impacts on upstream conditions.

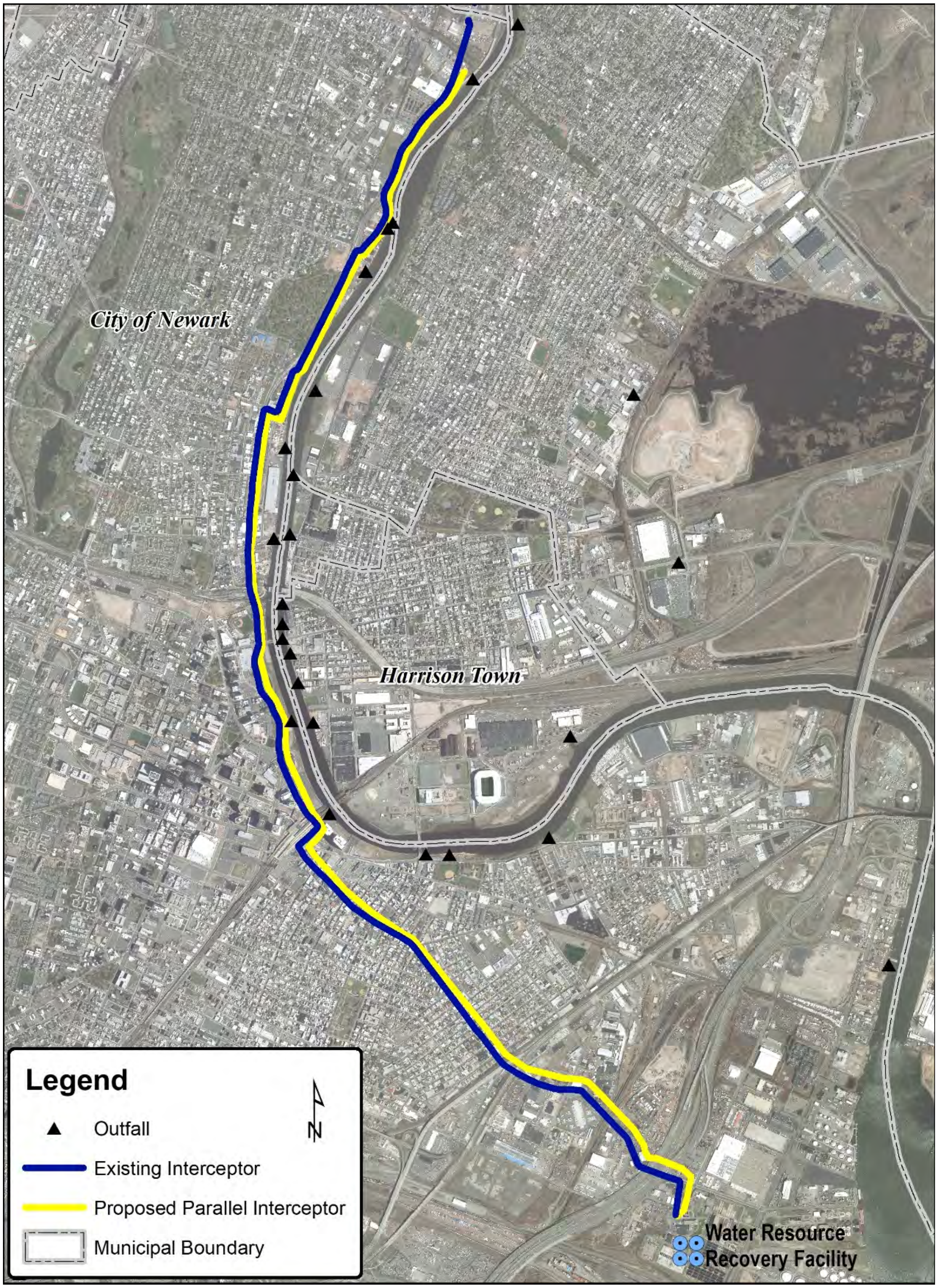


Figure C-1: Parallel Interceptor – Newark Relief Scenario

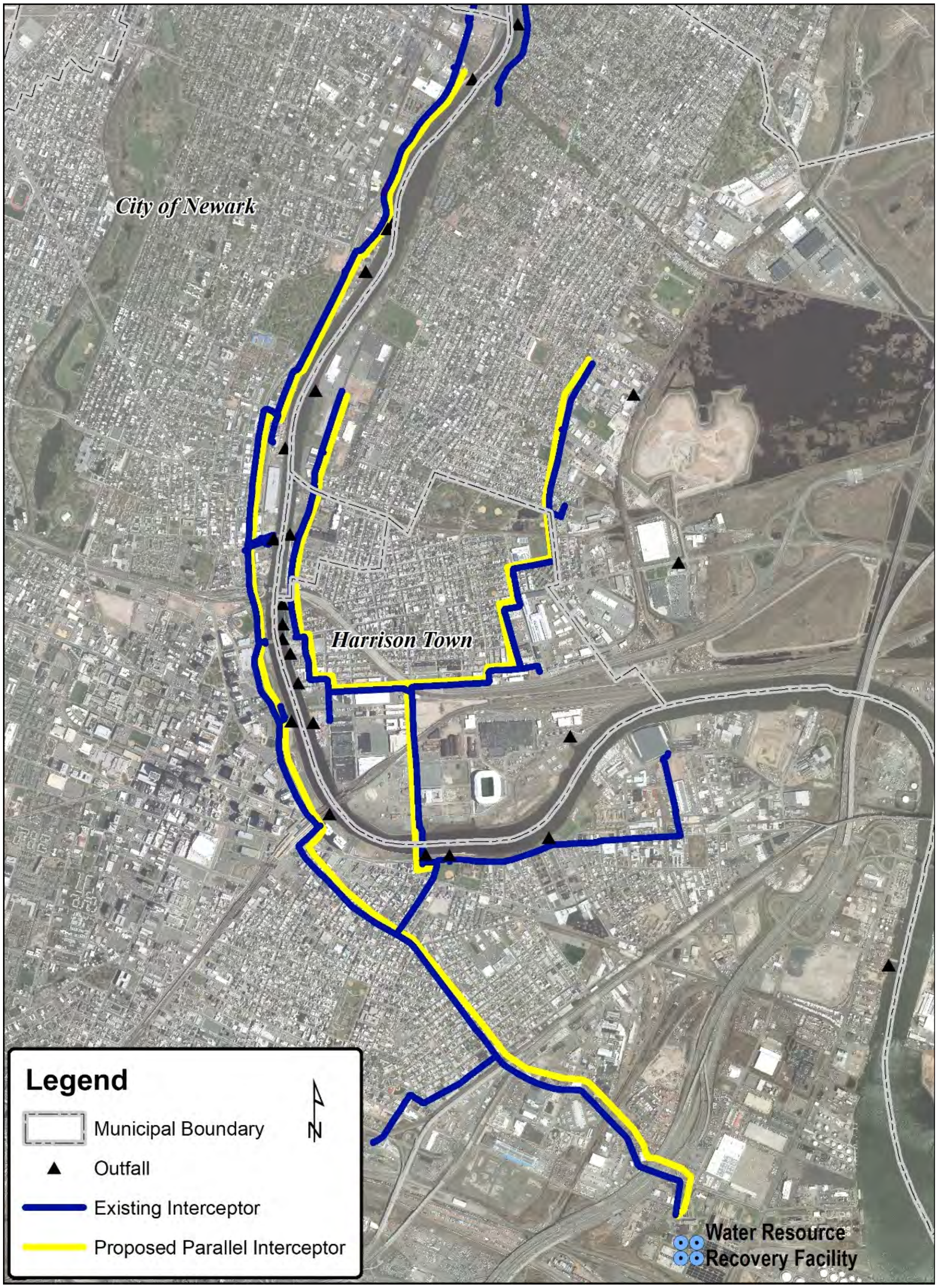


Figure C-2: Parallel Interceptor – Newark and Local Relief Scenario

Potential upstream and downstream effects were considered in the analysis of this CSO control technology. Further analysis of regulator modifications, in reference to CSO control alternatives, is discussed in Section D - Alternatives Analysis of this EAR.

C.5 STORAGE

The objective of storage is to reduce the volume and frequency of overflow events by capturing and storing wet weather flows, greater than CSS conveyance/treatment plant capacity, for controlled release back into the system once treatment and conveyance capacity have been restored. A storage facility can attenuate peak flows in the CSS and provide a relatively constant flow into the treatment plant after peak events. Storage technologies do not prevent water from entering the CSS or treat bacterial loads in CSO discharge, but are effective at reducing or eliminating CSO events. Storage technologies typically have high construction and Operation and Maintenance ("O&M") costs compared to other CSO control technologies, but are a reliable means of achieving CSO control goals. This section of the EAR will examine the feasibility of linear storage (tunnels) and point storage (tanks) for increased storage capacity in the PVSC CSS.

C.5.1 Linear Storage

Linear storage is provided by underground storage facilities that are sized to detain peak flows during wet weather events for controlled release back into the system after the event. In-line linear storage (storage in series with the CSS) can be provided by over-sizing interceptors for conveyance, as described in Subsection C.4.1.1 Additional Conveyance, whereas off-line linear storage (storage parallel to the CSS) can be provided by installing new facilities such as tunnels and pipelines.

Linear storage is considered a feasible technology and will be carried forward for further evaluation. Further discussion of this technology and its applicability as it relates to PVSC implementation is below.

C.5.1.1 Tunnels

Tunnels provide large storage volumes, while maintaining the ability to convey flow. Tunnel excavation is accomplished completely underground, and therefore results in minimal surface disruption and requires little right-of-way, outside of drop shafts and conveyance piping to the drop shafts. Overall costs for tunnels can be high, but their cost per million gallons of storage is fairly reasonable compared to other storage technologies, depending on local geology. Tunnels are typically used in congested urban areas where available land is scarce and connections to most, if not all, of the CSO regulators can be made.

As mentioned previously, storage tunnels (linear storage) is considered a feasible technology and will be carried forward for further evaluation. Additional discussion of this technology and its applicability to PVSC application is found below.

Two storage tunnels are proposed for evaluation in the PVSC Treatment District. One tunnel, the Paterson Citywide Tunnel, is located underneath the Passaic River in the City of Paterson and accommodates overflows from all 20 PVSC-owned regulators and 3 Paterson-owned regulators in the City of Paterson. The second tunnel, the McCarter Highway Tunnel, is located underneath the Passaic River and adjacent to Harrison, Kearny, Newark, and East Newark. This tunnel receives overflows from 23 PVSC-owned regulators in the aforementioned locales, as well as 7 regulators owned by the municipalities. The lists of regulators serviced by the Paterson Citywide and McCarter Highway Tunnel are included as **Table C-3** and **Table C-4**, respectively.

The general path of both tunnels was designed to follow the path of the Passaic River and extend to each of the PVSC-owned regulators listed in **Table C-3** and **Table C-4.** The total length of the Paterson Citywide Tunnel is approximately 6.4 miles and 45.3 miles for the McCarter Highway Tunnel.

Table C-3: Assigned Regulators to Paterson Citywide Tunnel

	Assigned Regulators	Regulator Street Name
Paterson Citywide Tunnel	Paterson 001	Curtis Place
	Paterson 003	West Broadway
	Paterson 005	Bridge Street
	Paterson 006	Montgomery Street
	Paterson 007	Straight Street
	Paterson 010	Warren Street
	Paterson 013	East Eleventh Street
	Paterson 014	Fourth Avenue
	Paterson 015	S.U.M Park Regulator
	Paterson 016	Northwest Street
	Paterson 017	Arch Street
	Paterson 021	Bergen Street
	Paterson 022	Short Street
	Paterson 023	Second Avenue
	Paterson 024	Third Avenue
	Paterson 025	East Thirty Third Avenue
	Paterson 026	20th Avenue
	Paterson 027	Market Street
	Paterson 028	Stewart Avenue
	Paterson 029	-
	Paterson 030	-
	Paterson 031	-
	Paterson 032	Loop Road

Table C-4: Assigned Regulators to McCarter Highway Tunnel

	Assigned Regulators	Regulator Street Name
McCarter Highway Tunnel	Kearny 001	Stewart Avenue
	Kearny 004	Nairn Avenue
	Kearny 006	Johnston Avenue
	Kearny 007	Duke Street
	Kearny 010	Ivy Street
	East Newark 001	Central Avenue
	Harrison 001	Hamilton Street
	Harrison 002	Cleveland Street
	Harrison 003	Harrison Street
	Harrison 005	Bergen Street
	Harrison 006	Middlesex Street
	Harrison 007	Worthington Avenue
	Newark 002	Verona Avenue
	Newark 003	Delvan Avenue
	Newark 004 Newark 005	Herbert Place
	Newark 008	Fourth Avenue
	Newark 009 Newark 010	Clay Street
	Newark 014	Saybrook Place
	Newark 014	Rector Street
	Newark 015	City Dock
	Newark 016	Jackson Street
	Newark 017	Polk Street
	Newark 018	Freeman Street
	Newark 022	Roanoke
	Newark 023	Adams
	Newark 025	Peddie Street
	Newark 027	Waverly
	Newark 030	Wheeler

The required storage volume for tunnels at each control level was determined as the sum of the overflow volume of the corresponding outfall(s) for each incorporated regulator at the specified control level. Based on this volume and the proposed length of the tunnel, tunnel storage volume was selected. Half foot increments were used to calculate the tunnel volume approximately equal to the required capacity. Approximate tunnel lengths, sizes, and storage capacities for stand-alone Paterson Citywide Tunnel and McCarter Highway Tunnel alternatives are summarized in **Table C-5** and **Table C-6**, respectively. Given an assumed depth of 100', it is anticipated that the proposed areas can sustain the necessary volume needed for storage infrastructure at all levels of control. Tunnels combined with other CSO control technologies will retain the same length, but possess smaller diameters as other control technologies will reduce the required storage capacity.

Table C-5: Paterson Citywide Tunnel Dimensions

OF/yr.	Tunnel Length (ft.)	Tunnel Ø (ft.)	Storage Capacity (MG)
0	33,528	15.5	47.57
4	33,528	10.5	21.72
8	33,528	9	15.96
12	33,528	7.5	11.08
20	33,528	5.5	5.96

Table C-6: McCarter Highway Tunnel Dimensions

OF/yr.	Tunnel Length (ft.)	Tunnel Ø (ft.)	Storage Capacity (MG)
0	28,140	34	191.14
4	28,140	21	72.92
8	28,140	19.5	62.87
12	28,140	17.5	50.64
20	28,140	13	27.94
85%	28,140	7	8.10

Tunnels were also evaluated to achieve 85% capture within the system. To achieve higher cost efficiency, the analysis only evaluated the implementation of one large tunnel (i.e. the McCarter Highway tunnel) rather than construction of two smaller tunnels (i.e. the Paterson Citywide and McCarter Tunnel). Analysis of the 85% capture control level was performed with the McCarter Highway tunnel due to its shorter length and higher outfall count. The applicable tunnel length, size, and storage capacity for 85% capture is noted above in **Table C-6**. For alternatives combining tunnels with other control technologies (i.e. Alternatives 6, 7, 8, 12, 13, 14, and 15), no tunnels were included in analysis of the 85% capture condition, as the other technologies were able to achieve 85% capture without utilization of tunnels. Both the McCarter Highway and Paterson Citywide tunnels were utilized for analysis of the maximum of 0, 4, 8, 12, and 20 overflow events conditions for all combined tunnel alternatives.

The tunnel design assumes a depth of 100 ft. to avoid all potential utility conflicts. Construction of each tunnel is assumed to require Tunnel Boring Machines (TBMs) for soft-ground conditions. To convey overflow from the regulators to the tunnel, off-line drop shafts are required. Drop shafts receive overflow from nearby regulators, and then discharge to the tunnel. All connections will be micro tunneled pipelines. Pipelines are sized for peak flow conditions. Any storage in the pipelines is considered negligible and not included in the overall storage calculation. Stored overflow is pumped back into the combined sanitary system, and to the WRRF, after the end of wet weather events via submersible pumps. One dewatering pump station is to serve each tunnel.

Tunnels are large scale construction projects that require extensive time, specialized equipment, and high costs. At the anticipated scale, a custom made TBM will be required for each tunnel. No benefits from tunnels will be received until construction is complete, which can take several years from commencement of design. Although TBMs are a form of trenchless construction, some surface level impact is unavoidable from drop shafts, entry points, and construction points.

Further analysis of storage tunnels, in reference to CSO control alternatives, is discussed in Section D Alternative Analysis of this EAR.

C.5.2 Point Storage

Point storage can be provided by above-ground or underground storage facilities such as tanks and equalization basins. These off-line facilities are placed at specific points in the system to detain peak flows for controlled return back to the system, reducing CSO discharge volume and bacterial loading.

Point storage is considered a feasible technology and will be carried forward for further evaluation. Further discussion of this technology and its applicability as it relates to PVSC-owned and operated infrastructure is below.

C.5.2.1 Tanks

This technology reduces the quantity and frequency of overflow events by storing all or a portion of diverted wet weather combined flows in off-line storage tanks. Stored flows are returned to the interceptor for conveyance to the treatment plant once system capacity becomes available. Storage tanks are generally fed by gravity and the stored flow is typically pumped back to the interceptor after the storm. The benefit of off-line storage tanks is that they are well-suited for early action projects at critical CSO outfalls. Storage tanks capture the most concentrated first flush portion of wet weather peak flow and help to reduce the downstream capacity needs for conveyance and treatment.

A disadvantage of off-line storage tanks is that they typically require large land area for installation, which may not be available in congested urban areas. Off-line storage tanks typically have higher costs per volume captured compared to other technologies. Additionally, if the existing sewers are deep, then the storage tank must also be deep, which results in additional construction costs. Operation and maintenance costs can also be high, especially if the application includes provisions for partial treatment and discharge, rather than simple storage and bleed-back to the sewer. Depending on the application, odor problems may also be an issue. However, storage tanks can be a very effective means of CSO control. As such, storage tanks are considered a feasible option for PVSC and will be further evaluated in this EAR.

As mentioned previously, storage tanks (point storage) is considered a feasible technology and will be carried forward for further evaluation. Additional discussion of this technology and its applicability to PVSC-owned and operated infrastructure is found below.

This CSO control technology is only being evaluated as a feasible technology to PVSC-owned and operated regulators. Given that PVSC does not own any property to facilitate the location of new storage tanks throughout the system, PVSC examined potential storage tank locations using available parcel information. The focus was on public property, vacant lots, and vacant parcels classified as industrial. Potential locations were first identified by reviewing GIS and Google Earth imagery for large land expanses in the vicinity of each PVSC-owned regulator.

The estimated available surface area of each location was then compared to the space required to accommodate a storage tank with adequate capacity to meet the control levels (up to 0, 4, 8, 12, and 20 overflows events per year) for its assigned regulator(s). Locations that could not meet this condition were removed from further consideration. Locations that directly conflicted with the existing interceptor were also removed from consideration. Note that further reference to these control standards during the discussion of tanks will only apply to the targeted outfalls (receiving flow from PVSC-owned and operated regulators) and not all outfalls within the system. For this reason, use of stand-alone tanks (i.e. Alternative No. 2) cannot achieve the 0, 4, 8, 12, and 20 levels of control system wide and therefore were not compared against the other alternatives at these control levels in Section D Alternative Analysis of this EAR. Performance results are included for reference only.

The analysis of this CSO control technology resulted in 11 reinforced concrete tanks throughout Paterson, Newark, Harrison, and Kearny. Each tank is assigned to handle the overflow from one or two PVSC-owned regulators. The offline storage tanks will store overflow from select regulators with controlled releases into the existing interceptor after the end of a wet weather event, at which time the WRRF will have capacity to handle all stored flow. ~~.~~It was assumed that each storage tank is fed by gravity and all ~~the~~ stored flow is pumped back to the interceptor, and ultimately, the WRRF, after the storm. No conveyance limitations to the WRRF are anticipated.

Tank sizing was calculated assuming a side water depth of 15 or 22 feet and rectangular dimensions. Where the tank size required to meet a certain control level (up to 0, 4, 8, 12, and 20 overflow events per year) exceeds the available space, the tank for that specific control level is classified as “not constructible” and the maximum sized constructible tank is analyzed. For example, if the required tank at a maximum of 8 overflow events per year is deemed too large for the available space, but the required tank at a control level at a maximum of 12 overflow events per year is constructible, the 12 overflow events per year tank will be carried forward throughout the analysis. These areas that are not large enough to sustain the needed volume of storage volume at a particular level of control are denoted with an asterisk in **Table C-8.**~~.~~

Storage tanks were also evaluated to achieve 85% capture within the system. Although the storage tanks are designed to reach 85% capture system wide, only PVSC-owned and operated regulators were analyzed in this analysis.

Regulators applicable to storage tank evaluation are included in **Table C-7**. The list of proposed tanks and~~, and~~ their corresponding regulators is included as Table C-8. The table indicates the design storage capacity at the control level for a stand-alone tank alternative. Tanks combined with other CSO control technologies will have smaller capacities as other control technologies will reduce the overall required tank storage volume.
ce the overall required tank storage volume.

Table C-7: Regulators Applicable to Storage Tank Analysis

Storage Tanks	Assigned Regulators	Tank Location	~~Regulator Street Name~~Parcel Description	Parcel Ownership
Tank No. 1	Paterson 001	NW Corner of W. Broadway & Memorail Dr.	Vacant Lot (Grass and Pavement)	Commercial
Tank No. 2	Paterson 003	NE Corner of W. Broadway and Memorial Dr.	~~West Broadway~~Private Parking Lot	Commercial
Tank No. 3	Paterson 006 Paterson 007	N. of Lawrence St. & S. of Montgomery St	~~Montgomery Street Straight Street~~Dog Park	Unknown Owner
Tank No. 4	Paterson 025	Median between McLean Blvd & East 33rd St	Grass Median~~East Thirty Third Avenue~~	Unknown Owner
Tank No. 5	Newark 002	Verona Ave. & McCarter Hwy	Parking Lot ~~Verona Avenue~~	Private
Tank No. 6	Newark 004 Newark 005	E. of McCarter Hwy	~~Herbert Place~~Vacant Paved Lot	City of Newark
Tank No. 7	Newark 009 Newark 010	NW Corner of Passaic Street & Clark Street	~~Clay Street~~Vacant Grass Lot	Unknown Owner
Tank No. 8	Newark 016 Newark 017	N. of Raymond Blvd. & W. of Jackson St.	Landscaped Grass and Trail at Joseph G. ~~Jackson Street Polk Street~~Minish Passaic River Waterfront Park	State of NJ
Tank No. 9	Newark 018	Located near intersection of Raymond Blvd. & Freeman St.	Parking Lot at Essex County Riverfront Park~~Freeman Street~~	Essex County
Tank No. 10	Kearny 004	SW Corner of Marshall St. & Passaic Ave.	~~Nairn Avenue~~Vacant Grass Lot	S&A Realty
Tank No. 11	Harrison 005 Harrison 006	E. of S. 1st Street near Railroad Ave.	~~Bergen Street Middlesex Street~~Gravel Trailer Parking Lot	Unknown Owner

Table C-8: Storage Tank Analysis – Corresponding Regulators & Storage Capacity

Storage Tanks	Assigned Regulators	Storage Capacity (MG)					
		0 OF/YR	4 OF/YR	8 OF/YR	12 OF/YR	20 OF/YR	85% Capture[2]
Tank No. 1	Paterson 001	1.28*	1.28	0.58	0.36	0.16	N/A
Tank No. 2	Paterson 003	0.35	0.17	0.10	No OF[1]	No OF[1]	N/A
Tank No. 3	Paterson 006 Paterson 007	5.04*	5.04	4.46	3.33	1.75	3.5
Tank No. 4	Paterson 025	1.71*	1.71*	1.71*	1.71*	1.71	N/A
Tank No. 5	Newark 002	4.90*	4.90	4.08	3.34	1.48	3.5
Tank No. 6	Newark 004 Newark 005	2.88	1.51	1.25	0.92	0.43	N/A
Tank No. 7	Newark 009 Newark 010	4.34*	4.34*	4.34*	4.34*	4.34	N/A
Tank No. 8	Newark 016 Newark 017	5.04*	5.04*	5.04*	5.04*	5.04	N/A
Tank No. 9	Newark 018	1.41*	1.41*	1.41*	1.41*	1.41	N/A
Tank No. 10	Kearny 004	1.60	0.66	0.53	0.40	0.22	N/A
Tank No. 11	Harrison 005 Harrison 006	4.41	2.07	1.44	1.07	0.37	3.5

1) No overflows occur at this control level.
2) Analysis performed to reach 85% capture.
* Site cannot sustain the needed dimensions/volume of storage infrastructure to achieve the target level of control for its assigned regulators

Tanks pose potential conflicts with the current landowners of the proposed tank locations, the community, and private utilities. Ideally, the proposed tank locations should be multi-use (e.g. parking lots) to facilitate community acceptance. -At this time, no specific multi-use applications have been identified for the tank locations, as PVSC has not initiated negotiation with the property owners.

However, Tank Nos. 2, 3, 5, 8, 9, and 11 are located at sites with discernible above ground usage (i.e. parking lots and park space). These tanks should be installed below ground to preserve the existing facilities. The remaining tank locations have no discernable above ground usage, and can accommodate either above or below ground tank installation.

Further analysis of storage tanks in reference to CSO control alternatives is discussed in Section D Alternative Analysis of this EAR.

C.6 WRRF EXPANSION, BYPASS, AND/OR STORAGE AT THE PLANT

C.6.1 Additional Treatment Capacity

CSOs can potentially be reduced by increasing the treatment capacity of plant. Other technologies can make use of this increased treatment capacity by providing more flow to the plant instead of CSO outfalls.

The consideration of WRRF capacity expansion and/or storage at the plant as a CSO control technology is required by Section G.4.e.ii of the NJPDES Permit in order to determine the volume of CSO discharge reduction that could "*be achieved by utilizing the additional treatment capacity while maintaining compliance with all permit limits.*" This option was evaluated by

PVSC in the Passaic Valley Sewerage Commission, New Jersey - WWTP No Feasible Alternatives (NFA) Analysis. The analysis evaluated several alternatives to expand the plant's treatment capacity and concluded that none of the alternatives evaluated, except adding a secondary bypass, would reliably achieve treatment capacity of up to 720 MGD. A copy of this EAR is found in **Appendix A**. Therefore, WRRF expansion (other than the bypass defined below) and/or storage at the plant will not be carried forward for further evaluation as a CSO control alternative.

C.6.2 Wet Weather Blending (Bypass of Secondary Treatment)

Blending is the practice of allowing portions of the wet weather peak flow to bypass certain treatment facilities at the WRRF. In blending, wet weather flows are typically routed through primary treatment, allowed to bypass secondary and tertiary treatment, and then recombined with effluent from all processes prior to disinfection and discharge to the environment. This practice may require increasing the capacity of primary treatment and disinfection facilities, but does not require the upsizing of secondary treatment facilities, which can be the more costly components.

The consideration of a CSO related bypass of the secondary treatment portion of the STP is required by Section G.4.e.vii of the NJPDES Permit in accordance with N.J.A.C. 7:14A-11.12 Appendix C, II C.7. This was evaluated in the Passaic Valley Sewerage Commission, New Jersey - WWTP No Feasible Alternatives (NFA) Analysis. A copy of this report is found in **Appendix A**.

The results of the NFA Analysis Report indicate that bypass of secondary treatment is the only feasible way to expand plant capacity. A CSO-related bypass of the secondary treatment portion of the WRRF that will expand plant capacity up to 720 MGD will be carried forward for further evaluation as a CSO control alternative. Further analysis of this technology in reference to CSO control alternatives is discussed in Section D - Alternatives Analysis of this EAR.

C.7 SEWER SEPARATION

Sewer separation is the conversion of a CSS into a system of separate storm sewers and sanitary sewers. This can be accomplished by installing a new sanitary sewer and using the existing combined sewer as a storm sewer or vice versa. This practice can be very expensive, disruptive to the public, and difficult to implement, especially in downtown areas or other densely developed urban environments. It typically requires closure of public streets for construction while the new pipes are installed and the sewer is separated.

The consideration of sewer separation as a CSO control technology is required by Section G.4.e.v of the NJPDES Permit. As PVSC does not own or operate the CSS, sewer separation is not considered a feasible technology for PVSC implementation and will not be carried forward for further evaluation as a CSO control alternative for PVSC.

C.8 TREATMENT OF CSO DISCHARGE

Treatment technologies are intended to reduce the pollutant loads to receiving waters by treating wet weather flows prior to discharging to the environment. Specific technologies can address different pollutant constituents, such as settleable solids, floatables, or bacteria.

The consideration for treatment of CSO discharge as a CSO control technology is required by Section G.4.e.vi of the NJPDES Permit. As PVSC does not own or operate any of the CSS, including combined sewer outfalls, treatment of CSO discharge is not considered a feasible technology and will not be carried forward for further evaluation as a CSO control alternative.

C.9 SCREENING OF CONTROL TECHNOLOGIES

Table C-9 through **Table C-11** provide a summary of the comprehensive screening of CSO control technologies process. The CSO control technologies summarized in this section present assigned values based on their effectiveness at reaching primary CSO control goals. Descriptions of the goal effectiveness categories and the evaluation methodology are located in Subsection C.1.2 Evaluation Methodology Used for this Study.

Table C-9 through **Table C-11** contain a brief description of the implementation and operation factors for the different CSO technologies and provide a summary of those CSO control technologies moving forward in alternatives evaluation in Section D.

Table C-9: Source Control Technologies

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

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

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

Source Control Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
				▪ Local jobs ▪ Passive and active recreational improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Community aesthetic improvements ▪ Reduced crime ▪ Align with goals for a sustainable community ▪ Increased pedestrian safety through curb retrofits	flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.			
	Free-Form Rain Gardens	Low	Medium	▪ Improved air quality ▪ Reduced carbon emissions ▪ Reduced heat island effect ▪ Property value uplift ▪ Passive and active recreational improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding ▪ Community aesthetic improvements ▪ Reduced crime ▪ Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspiring diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	No	Yes	Yes

Table C-10: Collection System Technologies

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

Table C-11: Storage and Treatment Technologies

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

Storage and Treatment Technologies								
Technology Group	Practice	Primary Goals		Community Benefits	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Treatment-WRTP	Additional Treatment Capacity	High	High	▪ Water quality improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding	May require additional space; increased O&M burden.	No	No	No
	Wet Weather Blending	Low	High	▪ Water quality improvements ▪ Reduced surface flooding ▪ Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	No	Yes	Yes
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	▪ Water quality improvements ▪ Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	Yes	No

SECTION D - ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

This section describes the development of CSO control alternatives applicable to the Passaic Valley Sewerage Commission (PVSC). Control alternatives were developed using the CSO control technologies identified for further analysis in Section C. These control technologies are listed below.

- GI
- Regulator Modifications
- Additional Conveyance (Parallel Interceptor)
- Linear Storage (Storage Tunnel)
- Point Storage (Storage Tanks)
- WRRF ~~Expansion~~ Bypass ~~(Bypass~~ of Secondary Treatment~~)~~

The alternatives evaluation approach and criteria utilized for evaluation are detailed in Subsections D.1.1 through D.1.7.

The PVSC NJPDES Permit No. NJ0021016 issued to PVSC and the permits associated with each of eight (8) CSO Permittees include requirements for PVSC and the CSO Permittees to cooperatively develop a CSO LTCP. To facilitate the CSO LTCP development, PVSC is evaluating alternatives that are appropriate for PVSC implementation on behalf of the owner municipalities; that is, alternatives that can be implemented for PVSC-owned infrastructure and/or implemented for CSO outfalls (that are owned by other Permittees) but are associated with PVSC-owned and operated regulators. The alternatives deemed appropriate for PVSC implementation may be incorporated into the separate Regional Evaluation of Alternatives Report for application in combination with alternatives developed by the other CSO Permittees.

D.1.1 Alternatives Evaluation Approach

This section of the EAR discusses the regulatory requirements and guidelines used to develop the alternatives evaluation criteria and approach. In accordance with the NJPDES Permit and as defined by the USEPA's National CSO Policy and the New Jersey Administrative Code , a reasonable range of CSO control alternatives must be evaluated to meet the water quality-based requirements of the CWA. The National CSO Policy indicates that the long term control plan should adopt either the Presumption Approach or the Demonstration Approach when evaluating and, ultimately selecting, the controls to meet the CWA requirements.

In accordance with Appendix C to N.J.A.C. 7:14A-11, the Presumption Approach allows NJPDES compliance to be met if a program meets any of the criteria specified therein, which is presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA. This is provided, however, that 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.

In line with Subsection II.C.4.a of the USEPA's CSO Control Policy (Presumption Approach), the N.J.A.C. 7:14A-11 Appendix C states:

> "*A program that meets any of the criteria listed below would 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…"*

Under the Presumption Approach and in accordance with the National CSO Policy, N.J.A.C. 7:14A-11 Appendix C and Part IV Section G.4.f of the NJPDES Permit, CSO controls proposed in the LTCP are presumed to protect water quality in the receiving water bodies if the CSS System achieves any of the following three (3) criteria:

i. *"No more than an average of four overflow events per year from a hydraulically connected system as a result of a precipitation event that does not receive 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:*

- *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.*
- *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.*

ii. *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 system-wide annual average basis.*

iii. *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."*

Combined sewer flows remaining after implementation of the nine minimum controls (NMCs) required by the Permit, and within the criteria specified in PVSC's Permit Section G.4.f.i. and ii. shall receive the following minimum treatment, in line with Subsection II.C.4.a of the CSO Control Policy and as defined in Part IV Section G.4.f of the NJPDES Permit:

- *"Primary Clarification (Removal of floatables and settable 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 WQS, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals/by-products (e.g. chlorine produced oxidants), where necessary."*

The Demonstration Approach, in accordance with N.J.A.C. 7:14A-11 Appendix C provides: A Permittee may demonstrate that a selected control program, though not meeting the criteria specified under Presumption Approach above, is adequate to meet the water quality-based requirements of the CWA. Under the Demonstration approach, in line with the USEPA's CSO Control Policy, Part IV Section G.4.f of the NJPDES Permit the NJPDES Permit states that for a successful demonstration, *"The permittee must demonstrate each of the following below:*

i. *"The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs.*

ii. *The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment.*

iii. *The planned control program will provide the maximum pollution reduction benefits reasonably attainable.*

iv. *The planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses.*

For the purposes of this EAR, a specific approach (either the Presumption Approach or the Demonstration Approach) is not being selected at this time. Rather, various CSO technologies to provide varying levels of control (i.e. up to 0, 4, 8, 12, and 20 overflow events per year, and 85% CSO volume capture) have been evaluated for effectiveness. The Alternatives Evaluation Approach (either Presumption or Demonstration) will be selected when identifying the selected controls for implementation and will be presented in the subsequent Selection and Implementation of Alternatives Report in the Final LTCP.

The PVSC provides for the regional collection, conveyance, and treatment of sewage throughout the sewershed. PVSC does not own or operate any outfalls or any portion of the CSS of the municipalities it serves within the regional collection system. Therefore, PVSC's alternatives focus on increasing the volume capture and/or reducing the frequency of overflow events of CSOs throughout the collection system to varying levels of control, exclusively by analyzing alternatives designed for only those CSO outfalls associated with PVSC-owned and operated regulators as discussed above.

The alternatives were developed using the overflow control technologies identified as feasible for implementation by PVSC in Section C of this DEAR, and as required as part of the NJPDES Permit in Part IV.G.4.e. Control technologies used for alternatives include the following: GI, PVSC-owned regulator modifications (Newark Regulators), parallel interceptor, storage tanks, tunnels, and ~~expansion~~ bypass of secondary plant treatment ~~capacity~~ (~~via bypass~~ as discussed in Section C). A range of alternatives were developed to evaluate each of the screened and preselected technologies, both individually and in combination with other technologies. The resulting alternatives are presented in Subsection D.2.

Evaluation factors for the analysis of alternatives are discussed below. Factors include siting, institutional issues, implementability concerns, public input, performance considerations, and cost.

D.1.2 Siting

PVSC does not maintain significant ownership of property across the different municipalities it serves throughout the sewer system. Therefore, the implementation of a majority of CSO alternatives will require easements or land acquisitions. To be specific, the implementation of any of the overflow control technologies that make up each CSO alternative, with the exception of regulator modifications (as those modifications take place inside the regulator structure), will require easements or land acquisitions.

PVSC's lack of significant property ownership was considered during the CSO technology screening and evaluation process. Detailed discussion of potential siting issues for CSO control technologies can be found in Section C. For the purpose of this evaluation of alternatives, PVSC factored in land acquisition costs for those alternatives where it was deemed appropriate.

D.1.3 Institutional Issues

PVSC does not own any of the CSO outfalls in the CSS. The outfalls are owned by the City of Paterson, City of Newark, Town of Kearny, Town of Harrison, Borough of East Newark, City of Bayonne, Jersey City MUA, and North Bergen MUA, who have received authorization to discharge under their respective NJPDES permits.

As a result, and in the continued effort to cooperate with each of the Permittees to develop a collaborative LTCP, the ultimate selection of the controls for implementation will continue to be coordinated with the Permittees within the PVSC Treatment District. These various factors that must be considered and coordinated with the various Permittees will occur prior to the completion of the subsequent Selection and Implementation of Alternatives Report in the Final LTCP.

D.1.4 Implementability

Implementation refers to considerations beyond cost and performance that influence the selection of a CSO control technology; these issues are often intertwined with political and institutional considerations. See Subsections D.1.2 and D.1.4. for specific discussions of public input and institutional issues. The purview of this subsection is limited to scheduling, phasing, and constructability concerns for each of the overflow control technologies considered in the alternatives.

The CSO Control Policy provides that *"schedules for implementation of the CSO controls may be phased based on the relative importance of adverse impacts upon WQS and designated uses, priority projects identified in the long-term plan, and on a permittee's financial capability. Given* *the cost of CSO control facilities, municipalities might determine that projects can be implemented in smaller parts over a period of time are more affordable than a single, large one-time project. Phased implementation also allows time for evaluating completed portions of the overall project and the opportunity to modify later parts of the project due to unanticipated changes in conditions. The initial stages of phased projects often can be implemented sooner than a single, more massive project, bringing more immediate relief to a CSO problem."*

Constructability concerns were initially discussed in the screening of each of the CSO control technologies portion of this EAR, which can be found in Section C. Any additional implementation concerns applicable to an alternative are discussed further in the appropriate alternative subsection found within Section D.2. Concerns regarding the scheduling and phasing of alternatives will be considered prior to the completion of the Final Regional LTCP Report.

D.1.5 Public Input

As a majority of the alternatives discussed within this EAR will directly impact the public, both during construction and operation, public input has been and will continue to be solicited throughout the development of the LTCP.

PVSC has continuously requested public input for the various CSO control technologies through the implementation of the LTCP Public Participation Plan. The implementation of the LTCP PPP is an ongoing process that includes hosting quarterly public meetings with the Clean Waterways Healthy Neighborhoods Supplemental CSO Team, participating in the meetings of various local groups, participating as an active member of the PVSC Treatment District Communities GI Programs, including Newark DIG, Jersey City START, Paterson SMART, Bayonne Water Guardians, Harrison Tide, and Kearny AWAKE and partnering with Rutgers University in a GI municipal outreach program, which supports Rutgers' participation in the GI groups mentioned above, attending public events, meeting with municipal representatives, and soliciting public input through the Clean Waterways Healthy Neighborhoods website and social media platforms. Questions from the public have been collected and addressed via a joint response from the eight PSVC CSO communities. This joint response is included in Appendix K of the Regional DEAR.

Public input will be one of the various factors considered when ultimately selecting the controls for implementation. For instance, the public has expressed interest in GI as a part of the CSO controls. This evaluation of alternatives has considered GI and is discussed further within this EAR.

D.1.6 Performance Considerations

Although one of the factors considered for the ultimate selection of the alternatives is based on the performance of an alternative at meeting the water quality and CSO control goals detailed in Subsection C.1.1, it is important to note that while PVSC provides for the regional collection, conveyance, and treatment of sewage throughout the sewershed, it does not own or operate any outfalls or any portion of the CSS of the municipalities it serves within the regional collection system (as previously stated in Section D.1). Therefore, PVSC's alternatives focus is on increasing the volume capture of CSOs throughout the collection system (i.e. the PVSC Main Iinterceptor communities) to no less than 85% by volume by analyzing alternatives designed only for CSO outfalls associated with PVSC-owned and operated regulators.

In addition to targeting the minimum 85% CSO volume capture stated above, PVSC also evaluated the feasibility of reducing the number of overflow events for each CSO outfall associated with a PVSC regulator to a maximum of 0, 4, 8, 12, and 20 overflow events per year in the hydraulically connected system. In order to compare the effectiveness of reducing the number of CSO events to the selected target of a minimum of 85% CSO volume captured, the equivalent CSO volume captured to the number of CSO events were calculated for each alternative and are presented with the performance results for each alternative in Section D.2. System % Volume Capture for each alternative is calculated using the baseline value of 12,495 MG of wet weather volume in the PVSC Main Iinterceptor communities.

CSO volume for outfalls connected to the HCFM were not included in this analysis. The HCFM is not hydraulically linked to the Main Interceptor at any point except at the PVSC WRRF. The HCFM connects just upstream from PVSC's primary storage tank, where screw pumps prevent backflow from occurring into the interceptor. As a result, CSO control technologies targeting one of the segmented hydraulic communities (i.e. the Main Interceptor or HCFM) will have no direct impact on the other. Only CSO control technologies targeting the PVSC WRRF (i.e. increasing the hydraulic capacity) will impact both of the segmented communities. Alternatives evaluating the performance across both segmented communities are included in the Regional DEAR.

All PVSC alternatives, except for those that only utilize tank and tunnel storage CSO control technologies, were modeled in InfoWorks ICM using the typical rainfall year to evaluate the technical feasibility of achieving each of the CSO target goals described above. Tank and tunnel storage requirements were calculated in Microsoft Excel spreadsheets after model runs were complete. Model results for each alternative are found in Subsection D.2.

Some alternatives such as the parallel interceptor are not capable of modification to meet a specified level of control for all regulators due to their location or applicability. In the case of the parallel interceptor, only regulators tied directly into the technology will see significant reductions in their discharge from its construction. As these alternatives cannot reduce discharge volumes for every regulator to the requirements for each level of control (i.e. up to 0, 4. 8, 12, and 20 overflow events per year), the wet weather flow capture percentages and discharge volumes should be used with cost as the methods of comparison between all alternatives.

D.1.7 Cost

In addition to siting, institutional issues, implementability concerns, public input, and performance considerations, cost is another significant evaluation factor in determining the feasibility of each alternative. The opinions of probable construction cost used for the alternatives are considered Level 5 estimates, as designated by the Association for the Advancement of Cost Engineering (AACE) Recommended Practice No. 18R-97. The accuracy range for Class 5 estimates is generally within a range of fifty percent less (-50%) to one-hundred percent more (+100%) than the actual cost. To develop the present worth values of

Alternatives, the primary components of the Alternative Opinion of Probable Construction Cost Methodology is:

- Identify appropriate alternative cost line items;
- Generate initial capital cost curves; and
- Generate operation and maintenance (O&M) costs along with contingency and other cost factor percentages to calculate life cycle costs

The first two items in the bullet list above were developed previously through the PVSC LTCP Technical Guidance Manual (PVSC TGM), which can be found as an Appendix to the Regional EAR. Any additional information used to supplement the cost line items or cost curves used comes from the following:

- Completed project construction cost data
- RS Means
- Manufacturer's cost data
- EPA project cost data and cost curves
- Anderson, Indiana CSO Long Term Control Plan: Basis for Cost Estimate

Unless a specific control technology cost was gathered from another estimate or quote, typical markups from the initial capital costs include the following, where applicable, due to the heavily urbanized area where PVSC operates:

- Pipe Installation - Heavy Utilities Contingency (65%)
- Tank/Storage Conduit - Heavy Utilities Contingency (65%)
- Pump Station - Difficult Installation Contingency (65%)
- WWTP Upgrade - Difficult Modification Contingency (65%)
- Sewer Separation - Heavy Utilities Contingency (65%)
- Overhead and Profit (15%)
- Bonds and Insurance (3%)
- Mobilization/Demobilization (5%)

These costs are combined for a construction cost subtotal. This subtotal then has the following additional markups applied to get a Total Cost (referred to as the Capital Cost):

- Engineering (25%)
- Permitting (3%)

The following O&M costs are applied to the Capital Cost, where applicable:

- Continuous Operating Post, COP (1 COP = $470,000/yr.)
- Tank/Structure Maintenance (3% of Construction Cost)

- Tunnel Maintenance (2% of Construction Cost)
- Pipe Transmission Maintenance (2% of Pipe Construction Costs)

To combine O&M and capital costs for each control technology, present worth calculations were completed. For this, a discount rate (*i*) of 2.75% was used (taken from the Rate for Federal Water Projects, NRCS Economics, Department of the Interior) with a life span (*n*) of 20 years. The following equation was then utilized to calculate the present worth factor to convert from annual O&M costs to present worth:

$$(P/A, i\%, n) = ((1+i)^n -1) / ((i(1+i)^n)$$

The result of the equation was multiplied by the annual O&M costs and then added to the capital cost to obtain the total life cycle cost. Salvage value was considered to be $0, as it is assumed no resale value will result from the control technologies utilized. Life cycle costs for each alternative are provided in Subsection D.2. Simplified life cycle costs calculations for the 0 overflow event condition for Alternative 1 are provided below as an example:

<u>Example</u>:
Based on a discount rate (i) of 2.75%, 20 year life span (n), and given capital cost of $1,209,000 and yearly O&M cost of $24,5000,000 the life cycle calculation is as follows:

Step 1: Calculate the Present Worth Factor

$$(P/A, 2.75\%, 20) = ((1+0.0275)^{20} -1) / ((0.0275(1+0.0275)^{20})$$
$$(P/A, 2.75\%, 20) = 15.23$$

Step 2: Multiply the Present Worth Factor by the yearly O&M cost.

$24,500,000 x 15.23 = $373,135,000

Step 3: Add the Present Worth O&M Cost to the Capital Cost

LCC = $1,209,000,000 + $373,135,000 = $1,582,135,000

The life cycle cost for each level of control for an alternative was then divided by the applicable volume of capture to determine a cost per million gallon ($M / MG). These costs provide an additional method to compare alternatives at the same level of control (e.g. the up to 0, 4, 8, 12, 20 overflow events conditions).

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

As previously stated in Subsection D.1, a PVSC alternative is defined as a control alternative comprising one or more CSO control technologies identified as feasible for implementation by PVSC in Section C of this DEAR. The PVSC alternatives are in themselves only building blocks for a PVSC-Municipality series of combined Alternatives that are addressed in the Regional DEAR. After undergoing the screening process, select control technologies were carried forward for more detailed analysis. This additional analysis includes evaluating the performance of each alternative's ability to achieve the targeted levels of CSO control performance by utilizing H&H models in order to analyze the combining of various control technologies. For example, exploring different sizes of the HCFM can provide more alternatives for conveying flow to the WRRF. The current peak flow rate through the HCFM is 134 MGD, and the maximum hydraulic capacity of the existing HCFM is 146 MGD. Expanding the HCFM capacity to 185 and 235 MGD will require construction of new large diameter piping to convey flow. Cost opinions were also completed for each alternative for comparison.

This section presents the PVSC alternative analysis results for each alternative. A list of the resulting alternatives is presented in **Table D-1** below.

Subsections D.2.1 through D.2.27 provide alternative analysis results. Subsection D.2.28 provides a summary of the cost opinion.

Table D-1 PVSC Alternatives

Alternative	Description
No. 1	Tunnels
No. 2	Storage Tanks
No. 3	Newark Regulator Modifications
No. 4a	GI (2.5%)
No. 4b	GI (5%)
No. 4c	GI (10%)
No. 5	Newark Regulator Modifications + Plant Expansion Bypass (720 MGD) + JC Pipe (235 MGD HCFM)
No. 5.a	Newark Regulator Modifications + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 6.a	Newark Regulator Modifications + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant Expansion Bypass (720 MGD) + JC Pipe (185 MGD HCFM)
No. 6.a.1	Newark Regulator Modifications + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 6.b	Newark Regulator Modifications + Parallel Interceptor (Newark only) + Plant Expansion Bypass (720 MGD) + JC Pipe (185 MGD HCFM)
No. 6.b.1	Newark Regulator Modifications + Parallel Interceptor (Newark only) + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 7	Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels
No. 7.a	Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels
No. 8	Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels + Storage Tanks
No. 8.a	Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels + Storage Tanks
No. 9	Newark Regulator Modifications + Tunnels + Storage Tanks
No. 10	Tunnels + Storage Tanks
No. 11	5% GI + Newark Regulator Modifications
No. 12	5% GI + Newark Regulator Modifications + Plant Expansion Bypass (720 MGD) + JC Pipe (235 MGD HCFM)
No. 12.a	5% GI + Newark Regulator Modifications + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 13	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (185 MGD HCFM)
No. 13.a	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM)
No. 14	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels
No. 14.a	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels

Alternative	Description
No. 15	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + JC Pipe (185 MGD HCFM) + Tunnels + Storage Tanks
No. 15.a	5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + JC Pipe (146 MGD HCFM) + Tunnels + Storage Tanks
No. 16	5% GI + Newark Regulator Modifications + Tunnels + Storage Tanks
No. 17	5% GI + Tunnels + Storage Tanks

D.2.1 Alternative 1 - Tunnels

This alternative examines the usage of tunnel storage as described in Subsection C.5.1.1. This evaluation only applies to CSO outfalls associated with PVSC-owned and operated regulators.

Alternative 1 analyzed the effectiveness of two storage tunnels in the PVSC Treatment District as detailed in Subsection C.5.1.1. The proposed tunnel locations are shown in **Figure D-1.**

The two tunnels were evaluated at the following control levels to determine technology effectiveness: 0, 4, 8, 12, and 20 overflow events per year. Tunnel sizing was also evaluated to achieve 85% CSO volume capture within the system. As detailed in Subsection C.5.1.1, the 85% capture analysis evaluated the implementation of only the McCarter Highway tunnel rather than construction of two smaller tunnels.

Table D-2 displays the total volume captured at each CSO control level and the associated cost of each measure for Alternative 1. The estimated cost for Alternative 1 was determined as detailed in Subsection D.1.7.

Table D-2: Alternative 1 Performance and Cost

Overflow Events per Year	Volume Captured (MG)	System % Capture	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	100	$1.2B	$1.6B	$0.77
≤ 4	1,771	97.8	$838	$1B	$0.59
≤ 8	1,638	96.8	$743	$934	$0.57
≤ 12	1,389	94.8	$680	$856	$0.62
≤ 20	785	89.9	$512	$648	$0.83
85%*	192	85.2	$243	$308	$1.60

*Target percent capture

D.2.2 Alternative 2 - Tanks

This alternative examines the usage of the storage tanks as described under Subsection C.5.2.1. This evaluation only applies to PVSC-owned and operated regulators.

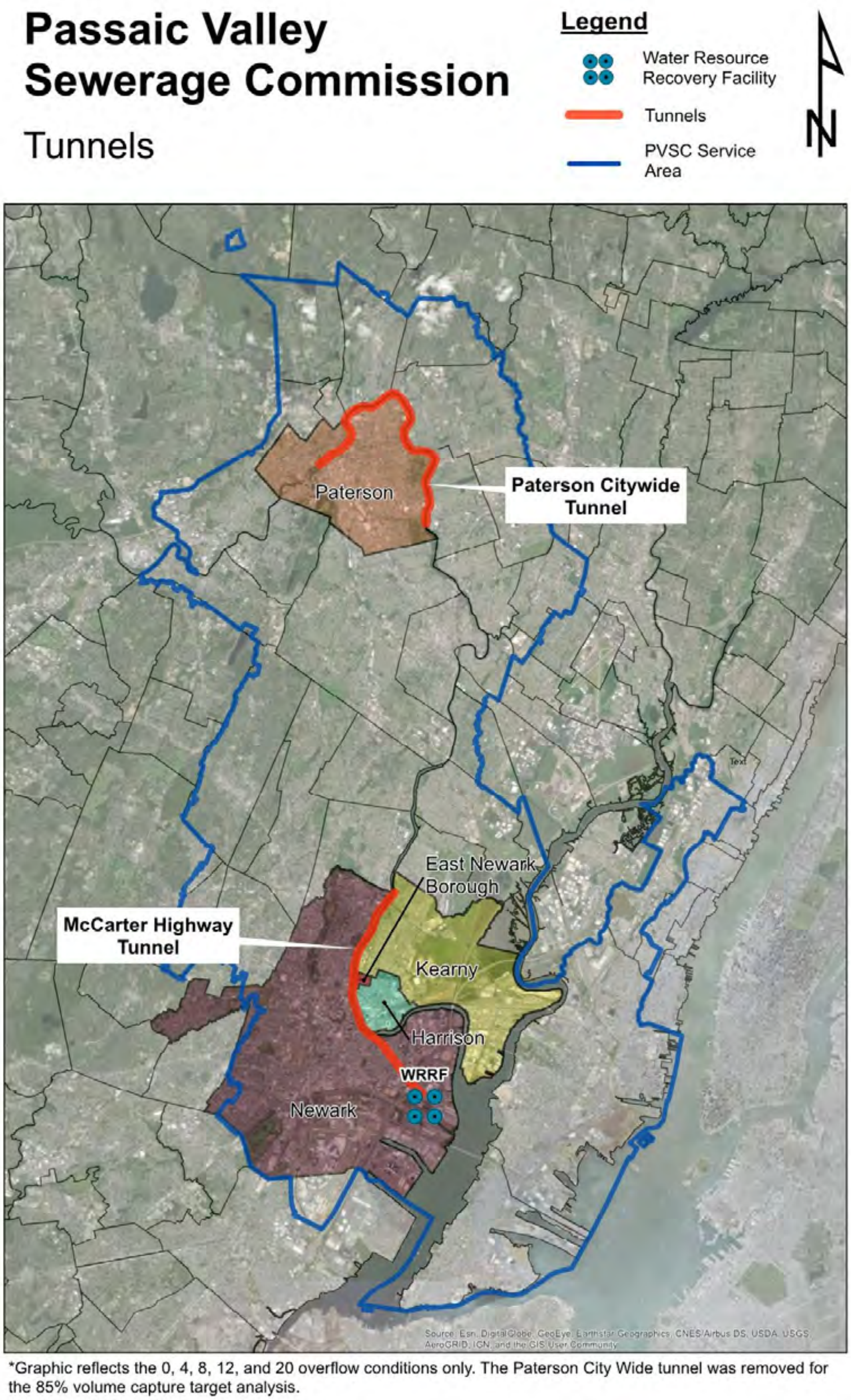


Figure D-1: Alternative 1 - Tunnels

Alternative 2 analyzed the effectiveness of storage tanks throughout the PVSC system as applicable to PVSC regulators. This resulted in 11 reinforced concrete storage tanks throughout Paterson, Newark, Harrison, and Kearny. The proposed storage tanks locations are shown in **Figure D-2** and **Table D-3**, below, provides a summary of the tank locations and associated outfalls.

Table D-3: Alternative 2 – Tank Locations and Associated Outfalls

Outfall(s) in Tank	Proposed Tank Location(s)	Parcel Information
PT001	NW Corner of W. Broadway & Memorial Dr.	Vacant Lot (Grass and Pavement)~~Commercial~~
PT003	NE Corner of W. Broadway and Memorial Dr.	Private Parking Lot~~Private Parking Lot~~
PT006, PT007	N. of Lawrence St. & S. of Montgomery St	Dog Park~~Dog Park - Unknown Owner~~
PT025	Median between McLean Blvd & East 33rd St	Grass Median~~Unknown Owner~~
	Burger King parking lot	Parking Lot ~~Private Parking Lot~~
NE002	Verona Ave. & McCarter Hwy	Vacant Paved Lot~~Public Property~~
	Verona Ave. & McCarter Hwy	Vacant Grass Lot~~Private Parking Lot~~
NE004, NE005	E. of McCarter Hwy	Landscaped Grass and Trail at Joseph G. Minish Passaic River Waterfront Park~~Vacant Land - City of Newark (Public)~~
NE009, NE010	NW Corner of Passaic Street & Clark Street	Parking Lot at Essex County Riverfront Park~~Unknown Owner~~
	SE Corner of Passaic Street & Clark Street	Vacant Grass Lot~~Unknown Owner~~
NE016 & NE017	N. of Raymond Blvd. & W. of Jackson St.	Gravel Trailer Parking Lot ~~Owner - State of NJ~~
NE018	Located near intersection of Raymond Blvd. & Freeman St.	Vacant Lot (Grass and Pavement)~~Parking Lot and Grass Area Behind Parking Lot~~
KE004	SW Corner of Marshall St. & Passaic Ave.	Private Parking Lot~~Vacant Lot - Owned by S&A Realty~~
HR005, HR006	E. of S. 1st Street near Railroad Ave.	Dog Park~~Vacant Lot - Unknown Owner~~

Each tank is assigned to accommodate the overflow from one or two PVSC-owned regulators. The storage tanks at each location were evaluated at the following control levels to determine technology effectiveness: maximum of 0, 4, 8, 12, and 20 overflow events per year. Storage tank sizing was also evaluated to achieve 85% CSO volume capture within the system. The analysis of this CSO control technology is detailed Subsection C.5.2.1.

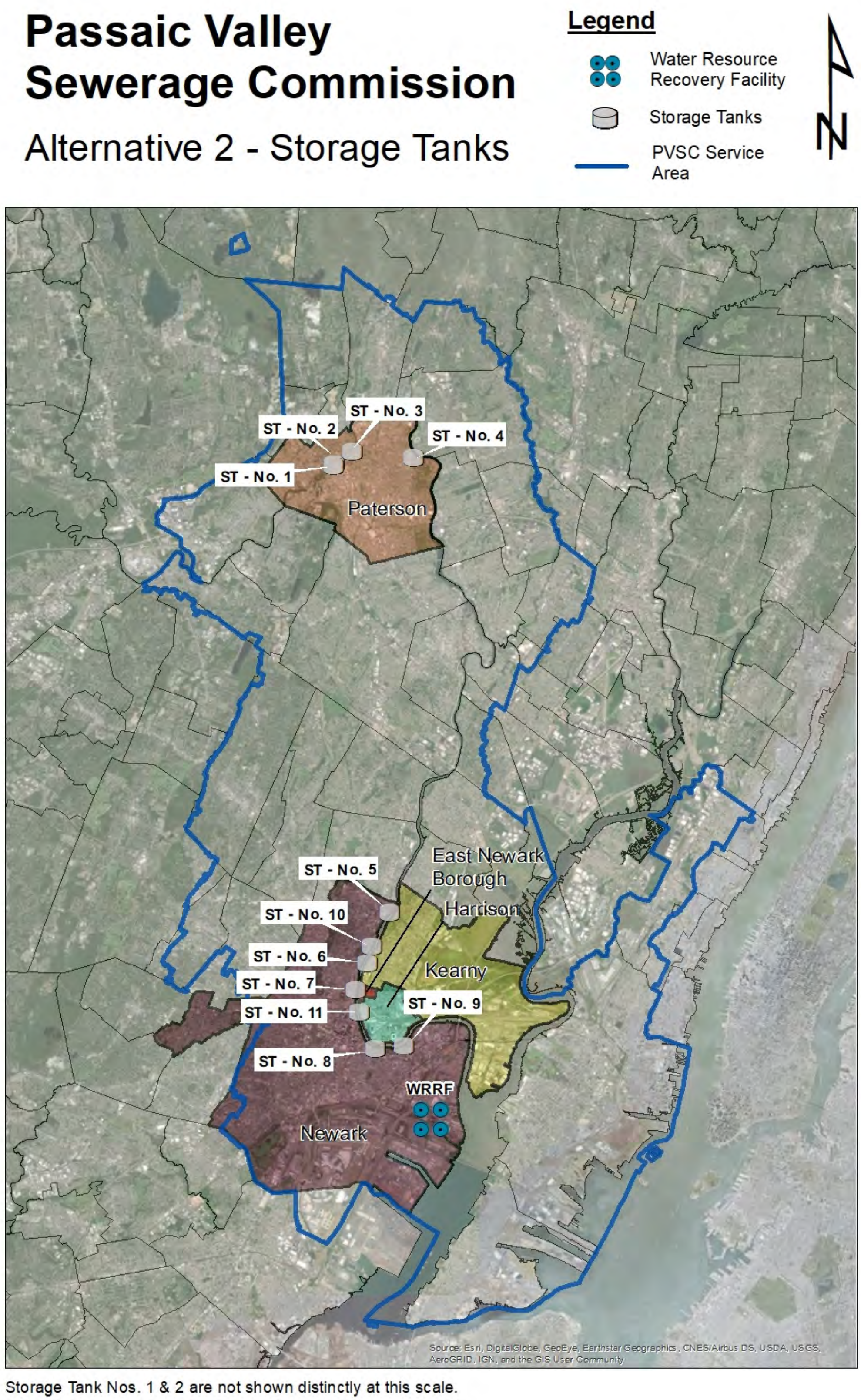


Figure D-2: Alternative 2 – Storage Tanks

Table D-4 details the storage tank capacity, total volume captured within the system, cost per CSO control level, and the associated cost per CSO overflow volume captured for Alternative 2. The estimated cost for Alternative 2 was determined in Subsection D.1.7.

Table D-4: Alternative 2 Performance and Cost

Overflow Events per Year*	Volume Captured (MG)	System % Capture	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	512	87.8	$548	$548	$1.07
≤ 4	505	87.8	$499	$499	$0.99
≤ 8	485	87.5	$470	$470	$0.97
≤ 12	453	87.3	$420	$420	$0.93
≤ 20	342	86.4	$354	$354	$1.03
85%**	163	85.0	$159	$159	$0.98

*Overflow events achieved at specific outfalls as explained in Subsection C.5.2.1.
**Target percent capture

D.2.3 Alternative 3 - Newark Regulator Modifications

This alternative examines the use of regulator modifications as described in Subsection C.4.1.2. This evaluation only applies to PVSC-owned and operated regulators and evaluates a target of 85% CSO volume capture.

Alternative 3 analyzed the effectiveness of regulator modifications, as described in Subsection C.4.1.2, throughout the PVSC Treatment District. As previously mentioned, regulator modifications are only deemed appropriate to PVSC-owned regulators in the City of Newark. **Figure D-3** presents an overview of the regulators applicable to Alternative 3.

Regulators alone provide minimal CSO reduction relative to other alternatives. The projected performance of this alternative is presented in **Table D-5**. Construction costs are not applicable to Alternative 3 as regulator modifications only require adjustments to the regulator gate shutoff timing as described in Subsection C.4.1.2.

Table D-5: Alternative 3 Performance

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
299	1,743	14.6%	86.1%	$0.40	$0.40	$0.0013

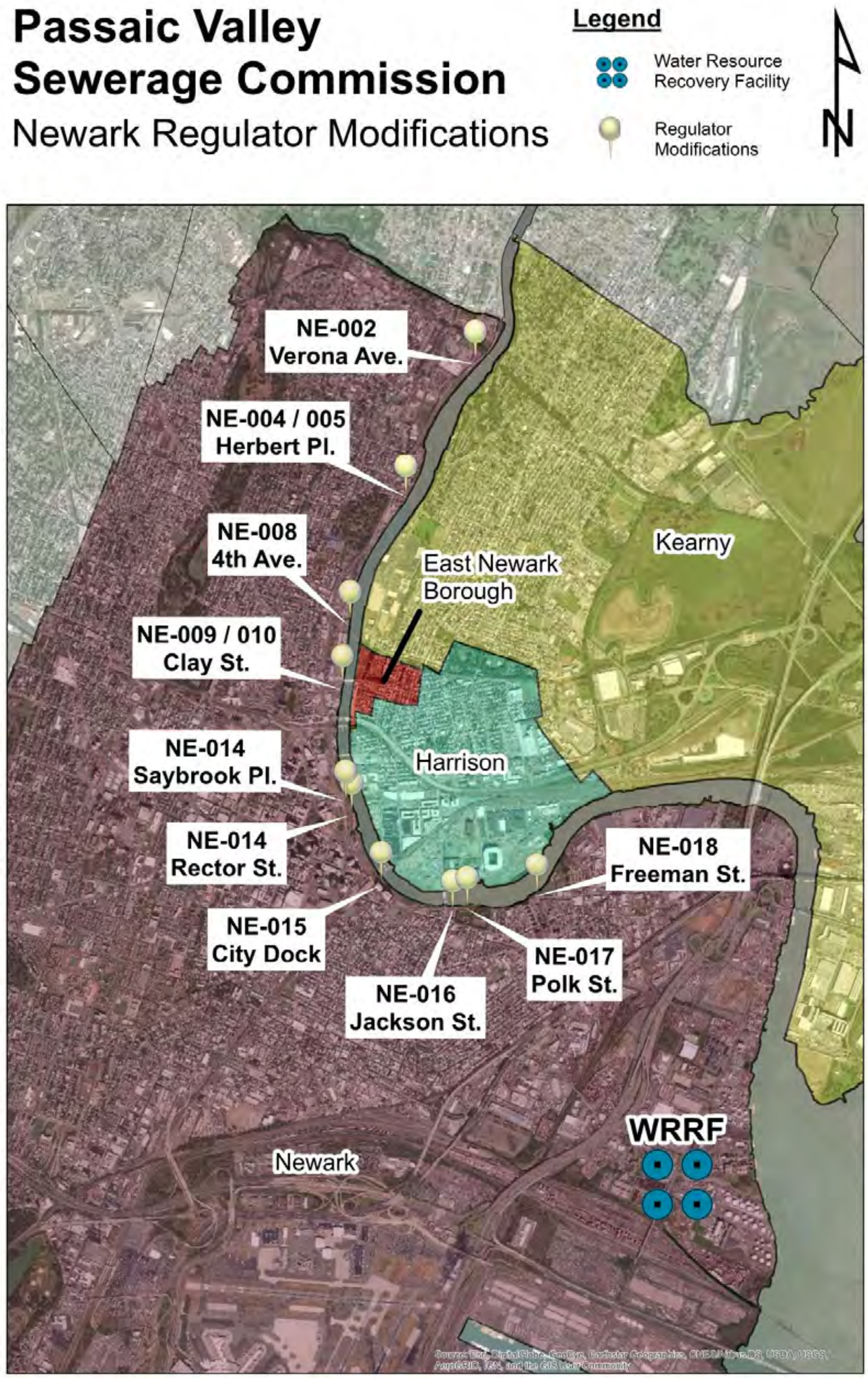


Figure D-3: Alternative 3 – Newark Regulator Modifications

D.2.4 Alternative 4 – GI (4a. 2.5%, 4b. 5%, 4c. 10%)

The application of GI as described under Subsection C.2.1 is considered in Alternative 4. As previously discussed, the gross impervious area of the PVSC collection system is approximately 14,000 acres. Alternative 4 considers three levels of GI implementation to be applied to the entire PVSC Treatment District. These levels are 2.5%, 5%, and 10% of the total impervious area to be managed by GI. The analysis has a target of 85% CSO volume capture. **Figure D-4** depicts the PVSC Treatment District area to which GI is proposed to be applied at the various percentages. Results utilizing the hydrologic and hydraulic model are shown below in **Table D-6**.

Table D-6: Alternative 4 Performance and Cost

Alternative (% GI)	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
4a. 2.5% GI	116	1,926	5.7%	84.2%	$85.3	$112	$1.52
4b. 5% GI	223	1,819	10.9%	85.1%	$171	$224	$1.24
4c. 10% GI	421	1,621	20.6%	86.7%	$341	$449	$1.17

D.2.5 Alternative 5 – Newark Regulator Modifications + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (235 MGD HCFM)

This alternative combines the use of regulator modifications as described in Subsection C.4.1.2, ~~with expansion of~~increasing the PVSC WRRF's plant capacity by bypassing secondary treatment and providing wet weather blending as described in Subsection C.6.2. This evaluation considers inflow from the HCFM at 235 MGD, which ~~is under review by the JCMUA to determine its feasibility~~will increase flow to the WRRF from communities not discharging to the interceptor. This will reduce the available capacity of the WRRF ~~has~~ to treat additional flow from the interceptor ~~inflow~~. A target performance of 85% CSO volume captured was used to model this alternative. A list of the CSO controls comprising this alternative is presented below.

- Newark Regular Modifications
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (235 MGD HCFM)

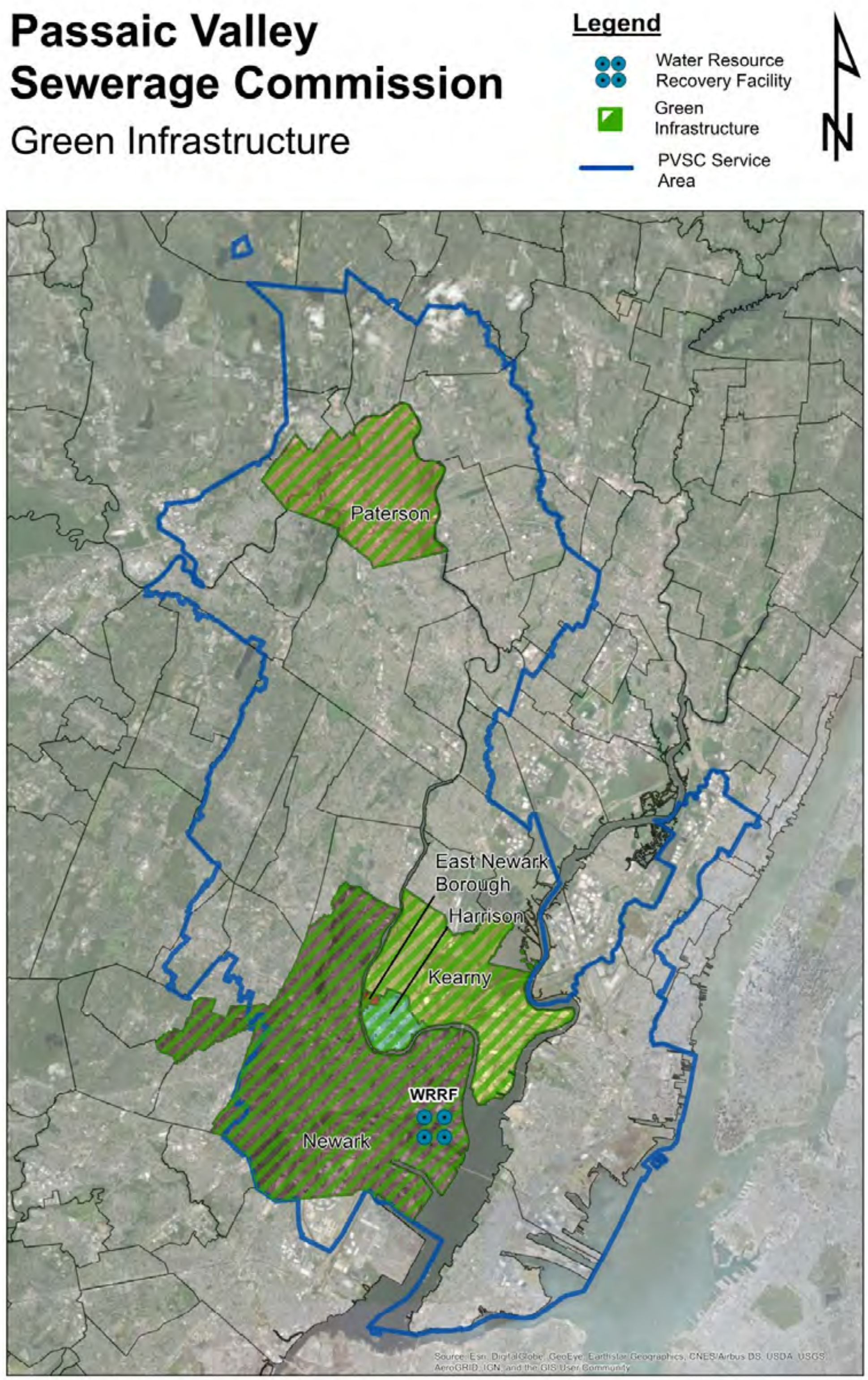


Figure D-4: Alternative 4 - Green Infrastructure

Figure D-5 depicts the CSO control technologies comprising Alternative 5. Performance and cost results are presented in **Table D-7.** Plant ~~expansion~~ bypass costs associated with this alternative ~~are only related to~~include the cost of the secondary treatment bypass.

Table D-7: Alternative 5 Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
603	1439	29.5%	88.5%	$133M	$138M	$0.23

D.2.6 Alternative 5.a – Newark Regulator Modifications + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)

This alternative combines the use of regulator modifications as described in Subsection C.4.1.2, ~~with expansion of~~increasing the PVSC WRRF's plant capacity by bypassing secondary treatment and providing wet weather blending as described in Subsection C.6.2. This evaluation considers inflow from the HCFM at 146 MGD, ~~which is under review by the JCMUA to determine its feasibility~~the maximum flow capacity available in the existing force main. A target performance of 85% CSO volume captured was used to model this alternative. A list of the CSO controls comprising this alternative is presented below.

- Newark Regular Modifications
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)

Figure D-6 depicts the CSO control technologies comprising Alternative 5.a. Performance and cost results are presented in **Table D-8**. Plant ~~expansion~~ bypass costs associated with this alternative ~~are only related to~~include the cost of the secondary treatment bypass. This alternative captures 618 MG of combined sewage at PVSC-owned and operated regulators, which exceeds the 603 MG of combined sewage captured by Alternative 5 despite its larger HCFM capacity.

The slight increase in combined sewage volume captured under this alternative, despite a lower HCFM capacity relative to Alternative 5, is attributed to the hydraulic capacity at the WRRF and measuring performance by focusing on outfalls equipped with PVSC-owned and operated regulators as described under Section D.1.5. Increasing the HCFM capacity to 146 MGD instead of 235 MGD as under Alternative 5, results in less capacity to capture combined sewage at outfalls hydraulically linked to the HCFM, but creates additional capacity at the WRRF for influent from the Main Interceptor. Because outfalls linked to the HCFM are not equipped with PVSC-owned and operated regulators, the additional ~~CSO~~combined sewage capture by expanding the HCFM is not reflected in the performance results, which are constrained to PVSC-owned and operated regulators.

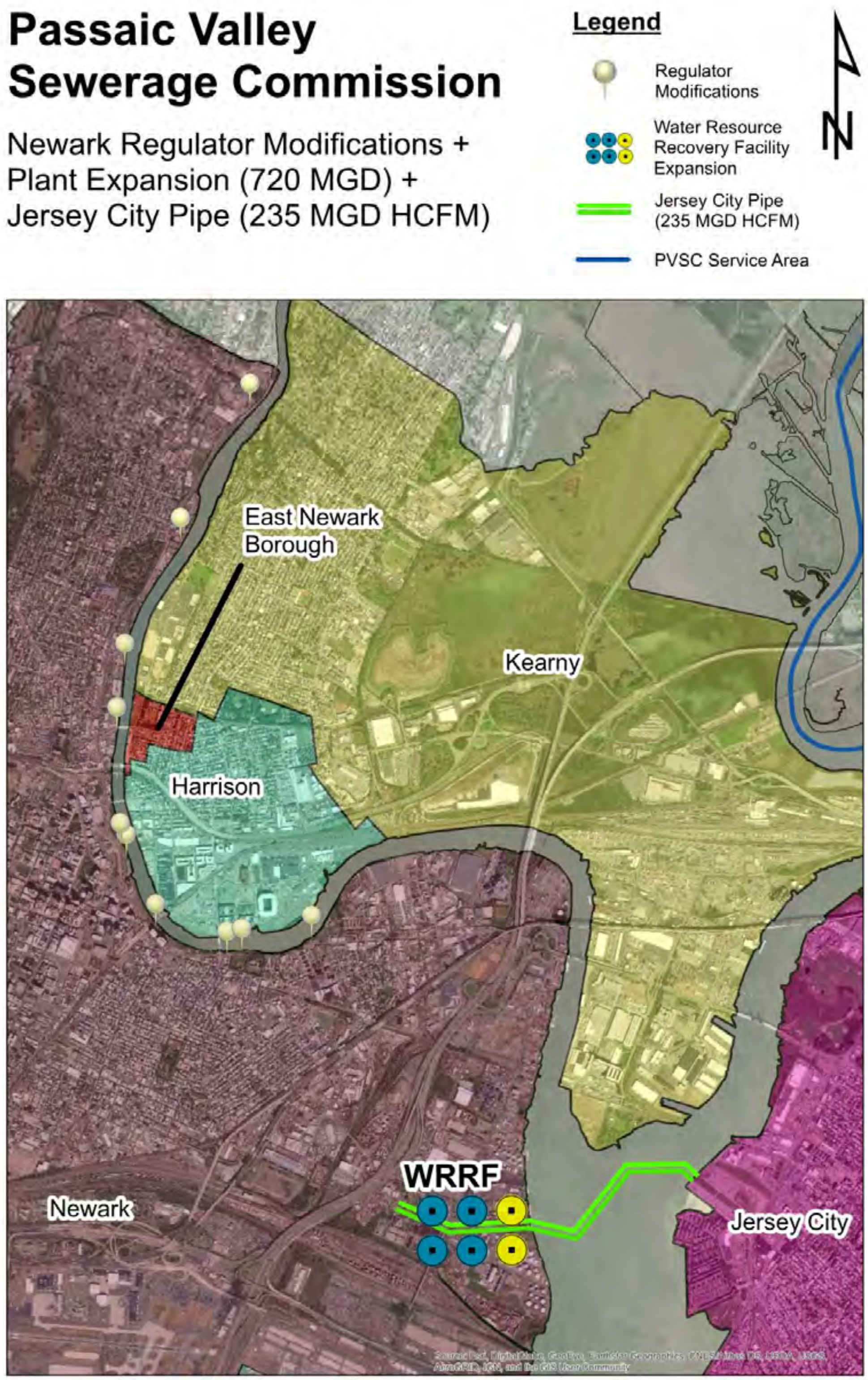


Figure D-5: Alternative 5

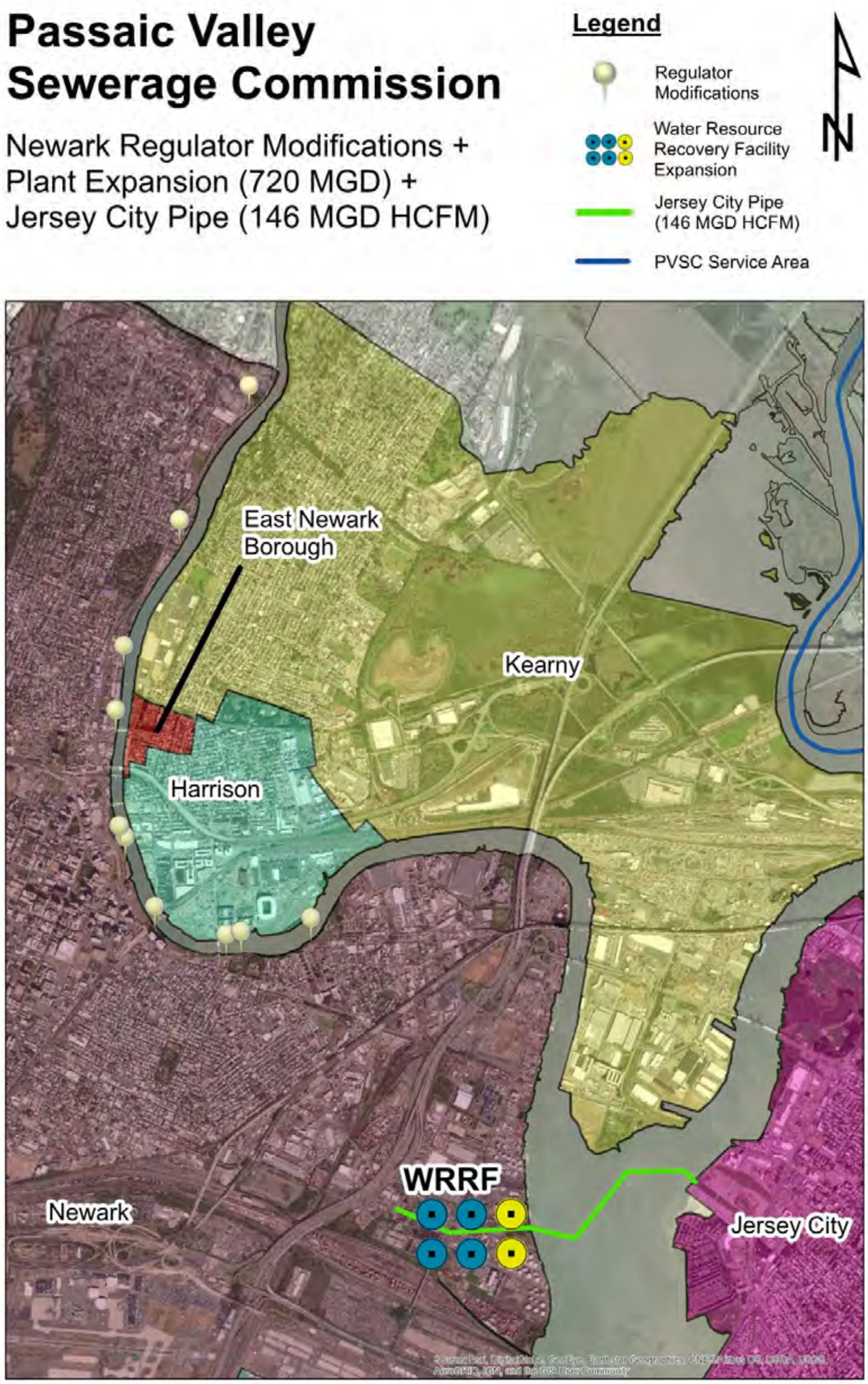


Figure D-6: Alternative 5.a

Table D-8: Alternative 5a Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
618	1424	30.3%	88.6%	$34M	$38M	$0.06

D.2.7 Alternative 6.a – Newark Regulator Modifications + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM)

This alternative combines several CSO control technologies applicable for PVSC implementation as described in Section C, including:

- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)

Figure D-7 depicts the CSO control technologies comprising Alternative 6.a. This evaluation considers inflow from the HCFM at 185 MGD, which will increase flow to the WRRF from communities not discharging to the interceptor. This will reduce the available capacity ~~of~~that the WRRF has to treat the interceptor inflow. A target of 85% CSO volume capture was used to analyze this Alternative. Performance and cost results are presented in **Table D-9**. Costs associated with this alternative are only related to the cost of the secondary treatment bypass and parallel interceptor.

Table D-9: Alternative 6.a Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
1,247	795	61.1%	93.6%	$560	$565	$0.45

D.2.8 Alternative 6.a.1 – Newark Regulator Modifications + Parallel Interceptor (Newark, Kearny, Harrison, East Newark) + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)

This alternative combines several CSO control technologies applicable for PVSC implementation as described in Section C, including:

- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)

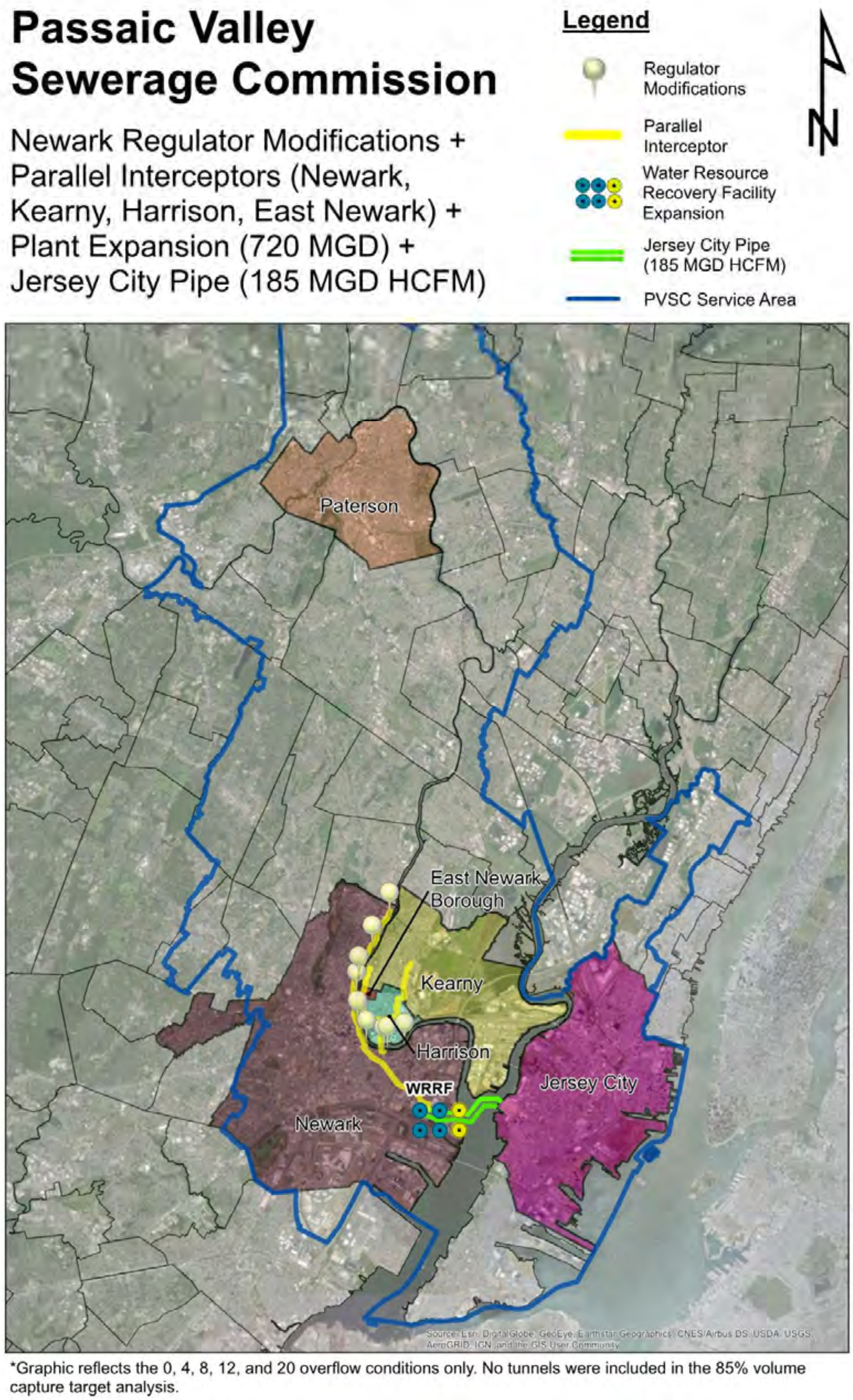


Figure D-7: Alternative 6.a

Figure D-8 depicts the CSO control technologies comprising Alternative 6.a.1. A target of 85% CSO volume capture was used to analyze this Alternative. Performance and cost results are presented in **Table D-10**. Costs associated with this alternative are only related to the cost of the secondary treatment bypass and parallel interceptor.

Table D-10: Alternative 6.a.1 Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
1282	760	62.8%	93.9%	$460	$465	$0.36

D.2.9 Alternative 6.b – Newark Regulator Modifications + Parallel Interceptor (Newark) + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM)

This alternative combines several CSO control technologies applicable for PVSC implementation as described in Section C, including:

- Newark Regular Modifications
- Parallel Interceptor (Newark as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)

Figure D-9 depicts the CSO control technologies comprising Alternative 6.b. A target of 85% CSO volume capture was used to analyze this Alternative. Performance and cost results are presented in **Table D-11**. Costs associated with this alternative are only related to the cost of the secondary treatment bypass and parallel interceptor.

Table D-11: Alternative 6.b. Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
1,045	997	51.2	92.0	560	565	$0.54

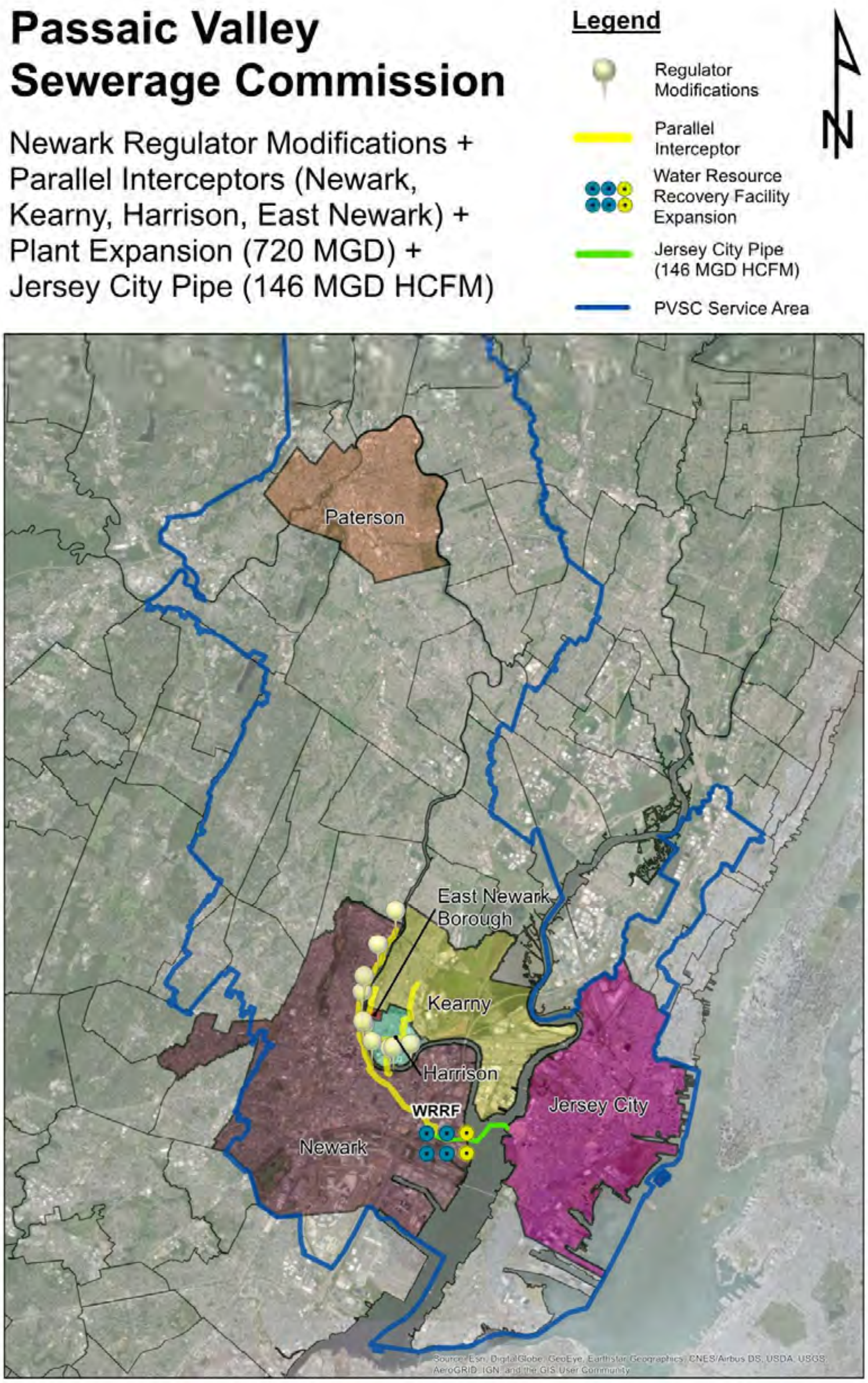


Figure D-8: Alternative 6.a.1

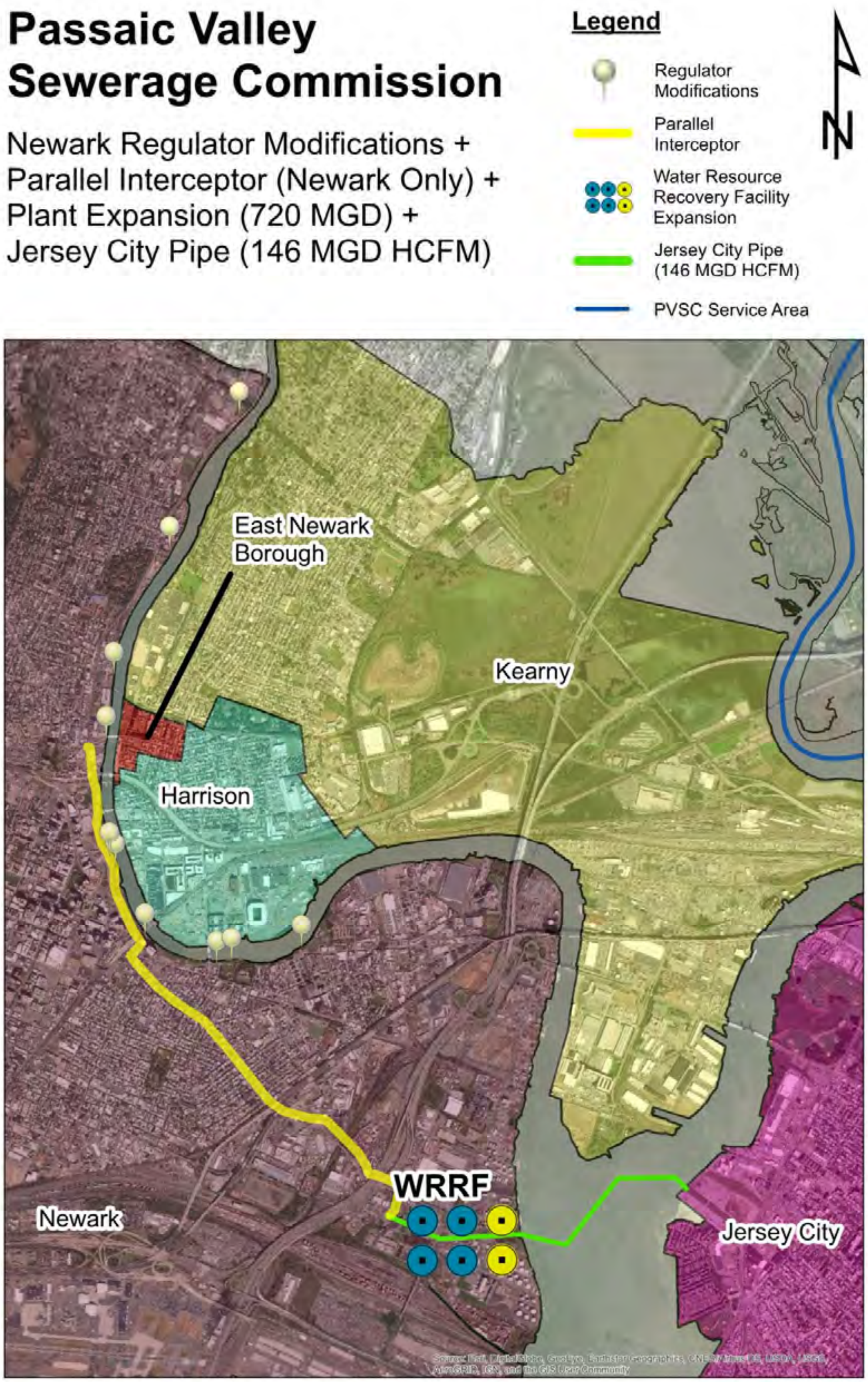


Figure D-9: Alternative 6.b

D.2.10 6.b.1 – Newark Regulator Modifications + Parallel Interceptor (Newark) + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)

This alternative combines several CSO control technologies applicable for PVSC implementation as described in Section C, including:

- Newark Regular Modifications
- Parallel Interceptor (Newark as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)

Figure D-10 depicts the CSO control technologies comprising Alternative 6.b.1. A target of 85% CSO volume capture was used to analyze this Alternative. Performance and cost results are presented in **Table D-12**. Costs associated with this alternative are only related to the cost of the secondary treatment bypass and parallel interceptor.

Table D-12: Alternative 6.b.1 Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
1068	974	52.3%	92.2%	$460	$465	$0.44

D.2.11 Alternative 7 – Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM) + Tunnels

This alternative builds upon Alternative 6 described above, by adding the Paterson citywide and McCarter Highway tunnels as described in Section C. This alternative, depicted in **Figure D-11** comprises the following CSO controls:

- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)
- Tunnel Storage

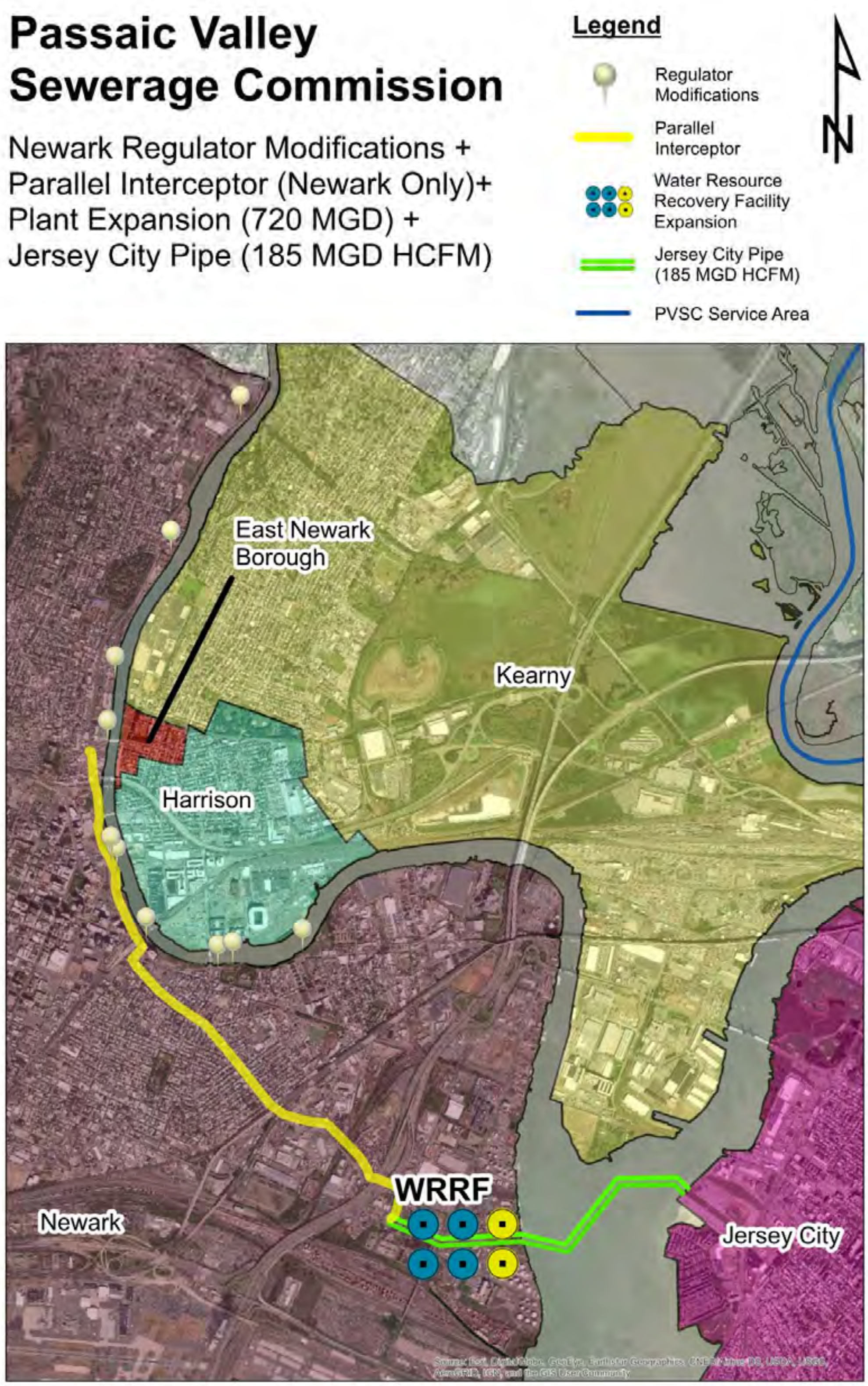
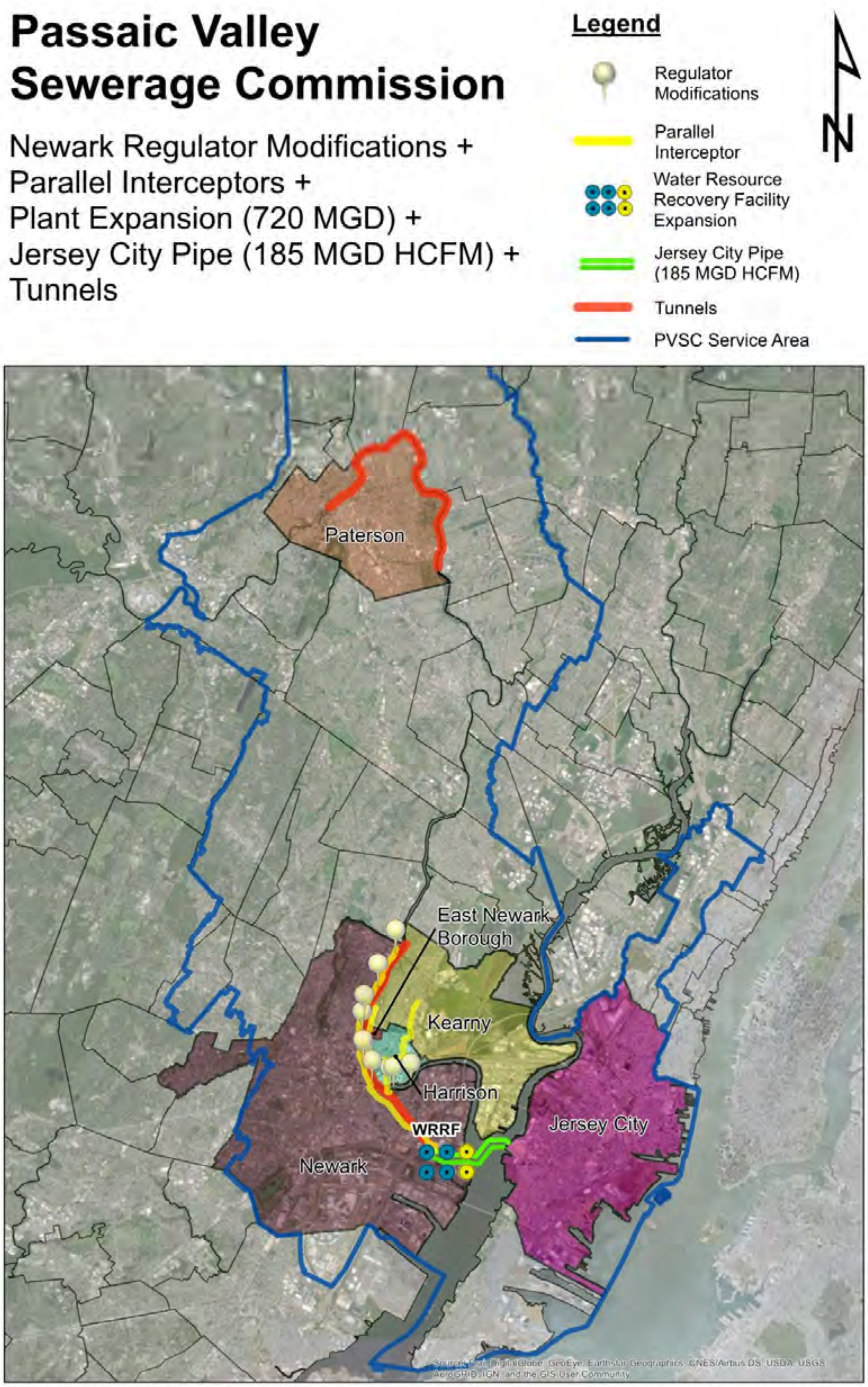


Figure D-10: Alternative 6.b.1



*Graphic reflects the 0, 4, 8, 12, and 20 overflow events only. No tunnels were included in the 85% volume capture target analysis.

Figure D-11: Alternative 7

Use of the tunnels as part of this alternative allowed for evaluation of the target overflow events in addition to the 85% percent capture target model for the remaining control technologies. Performance and cost results are presented in **Table D-13**.

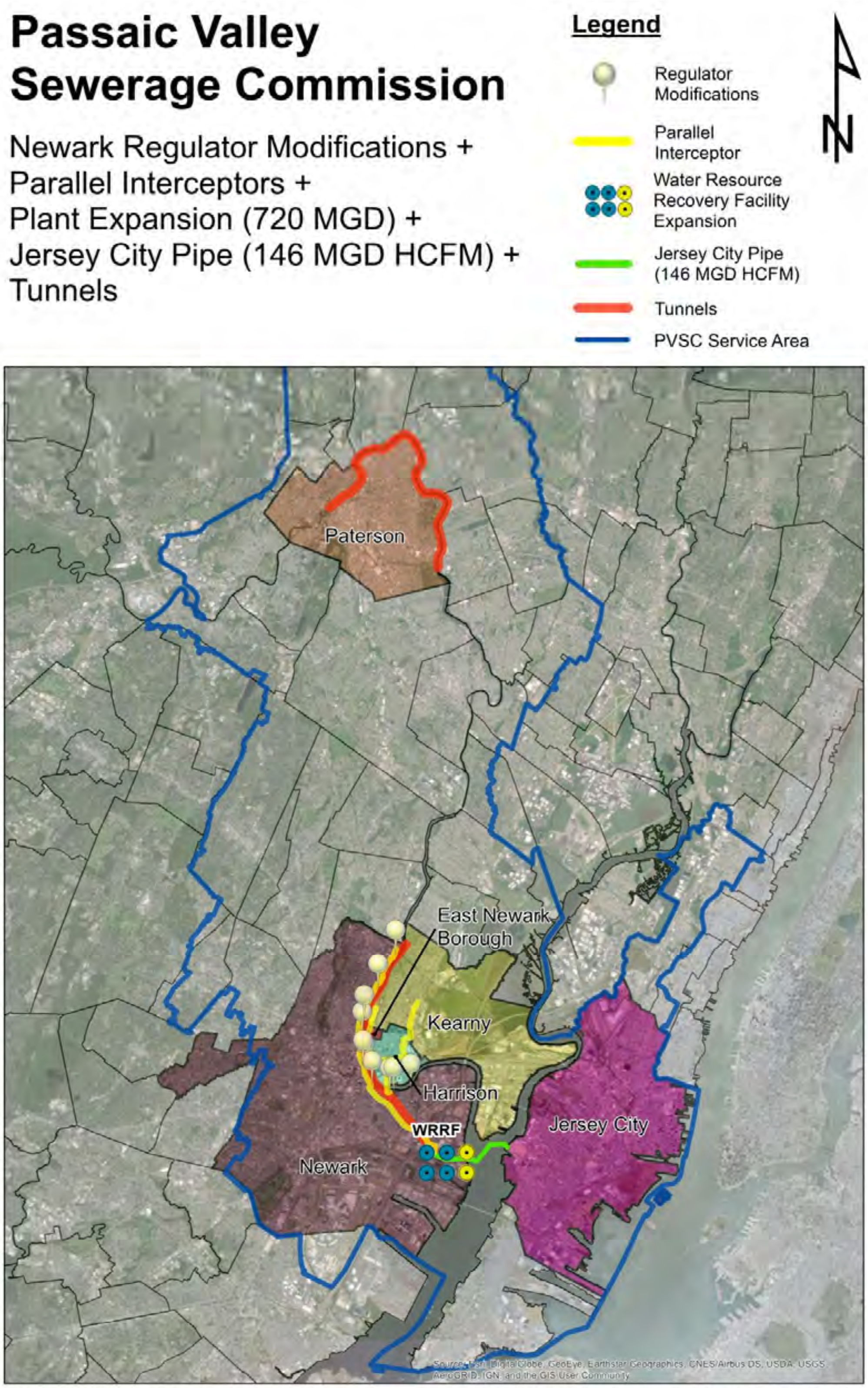
Table D-13: Alternative 7 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.4B	$1.7B	$0.83
≤ 4	1,880	162	92.1%	98.7%	$1.2B	$1.4B	$0.75
≤ 8	1,664	378	81.5%	97.0%	$1B	$1.2B	$0.74
≤ 12	1,482	560	72.6%	95.5%	$938	$1B	$0.71
≤ 20	1,382	660	67.7%	94.7%	$827	$910	$0.66
85%	1,247	795	61.1%	93.6%	$560	$565	$0.45

D.2.12 Alternative 7.a – Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels

This alternative builds upon Alternative 6 described above, by adding the Paterson citywide and McCarter Highway tunnels as described in Section C. This alternative, depicted in **Figure D-12** , comprises the following CSO controls:

- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)
- Tunnel Storage



*Graphic reflects the 0, 4, 8, 12, and 20 overflow events only. No tunnels were included in the 85% volume capture target analysis.

Figure D-12: Alternative 7.a

Use of the tunnels as part of this alternative allowed for evaluation of the target overflow events in addition to the 85% percent capture target model for the remaining control technologies. Performance and cost results are presented in **Table D-14**.

Table D-14: Alternative 7.a Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.3B	$1.6B	$0.77
≤ 4	1,907	136	93.4%	98.9%	$1.1B	$1.3B	$0.68
≤ 8	1,679	363	82.2%	97.1%	$980	$1.1B	$0.67
≤ 12	1,516	526	74.3%	95.8%	$832	$940	$0.62
≤ 20	1,406	636	68.9%	94.9%	$750	$838	$0.60
85%	1,282	760	62.8%	93.9%	$460	$465	$0.38

D.2.13 Alternative 8 – Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM) + Tunnels + Storage Tanks

This alternative builds upon Alternative 7 described above, by adding the storage tanks as described in Section C. The alternative comprises the following CSO controls:

- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)
- Tunnel Storage
- Tank Storage

Figure D-2 and **Figure D-11** depict the CSO control technologies comprising this Alternative.

Use of the tunnels and tanks as part of this alternative allowed for evaluation of the target overflow events in addition to the 85% percent capture target model for the remaining control technologies. Performance and cost results are presented in **Table D-15**.

Table D-15: Alternative 8 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.6B	$2B	$0.97
≤ 4	1,939	104	94.9%	99.2%	$1.4B	$1.7B	$0.88
≤ 8	1,657	385	81.1%	96.9%	$1.3B	$1.5B	$0.88
≤ 12	1,492	550	73.1%	95.6%	$1B	$1.2B	$0.83
≤ 20	1,384	658	67.8%	94.7%	$928	$1B	$0.75
85%	1,247	795	61.1%	93.6%	$560	$565	$0.45

D.2.14 Alternative 8.a – Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels + Storage Tanks

This alternative builds upon Alternative 7.a described above, by adding the storage tanks as described in Section C. The alternative comprises the following CSO controls:

- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)
- Tunnel Storage
- Tank Storage

Figure D-2 and **Figure D-12Figure D-12** depict the CSO control technologies comprising this Alternative.

Use of the tunnels and tanks as part of this alternative allowed for evaluation of the target overflow events in addition to the 85% percent capture target model for the remaining control technologies. Performance and cost results are presented in **Table D-16**.

Table D-16: Alternative 8.a Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100.0%	100.0%	$1.6B	$1.9B	$ 0.96
≤ 4	1,925	117	94.3%	99.1%	$1.4B	$1.6B	$ 0.84
≤ 8	1,692	350	82.8%	97.2%	$1.2B	$1.4B	$ 0.81
≤ 12	1,516	526	74.3%	95.8%	$989	$1.1B	$ 0.76
≤ 20	1,400	642	68.6%	94.9%	$810	$912	$ 0.65
85%	1,282	760	62.8%	93.9%	$554	$580	$ 0.48

D.2.15 Alternative 9 – Newark Regulator Modifications + Tunnels + Storage Tanks

This alternative examines the combination of the following control technologies: Newark regulator modifications, storage tunnels and storage tanks. The analysis behind each control technology is detailed in Subsection C.4.1.2, Subsection C.5.1.1, and Subsection C.5.2.1 respectively. **Figure D-1**, **Figure D-2** and **Figure D-3** at the beginning of Section D display the components of Alternative 9 as it applies to the PVSC Treatment District.

Regulator modifications will promote more flow into the WRRF through the main interceptor, with overflows redirected to storage tanks and tunnels up to the appropriate level of control. Overflow from regulators connected to both storage tanks and tunnels are channeled to the storage tank with any excess flow passing into the tunnel. All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The projected performance of this alternative is listed below as **Table D-17**.

Table D-17: Alternative 9 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.5B	$1.95B	$0.96
≤ 4	1,743	300	85.3%	97.6%	$1.0B	$1.4B	$0.79
≤ 8	1,620	422	79.3%	96.6%	$965	$1.2B	$0.76
≤ 12	1,257	785	61.5%	93.7%	$846	$1.1B	$0.86
≤ 20	775	1,268	37.9%	89.9%	$611	$786	$1.01
85%	299	1,743	14.6%	86.1%	$0.40	$0.40	$0.0013

D.2.16 Alternative 10 – Tunnels + Storage Tanks

This alternative utilizes control technology as described under Subsection C.9.2.3 and depicted in **Figure D-1** and **Figure D-2.** Overflows are redirected to storage tanks and tunnels up to the appropriate level of control. Overflow from regulators connected to both storage tanks and tunnels are channeled to the storage tank with any excess flow passing into the tunnel. All outfalls corresponding with PVSC owned regulators are captured in this analysis. The projected performance of this alternative is listed below as **Table D-18.**

Table D-18: Alternative 10 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.6B	$2.2B	$1.00
≤ 4	1,798	244	88.1%	98.0%	$1.2B	$1.5B	$0.82
≤ 8	1,668	374	81.7%	97.0%	$1.0B	$1.3B	$0.79
≤ 12	1,443	599	70.7%	95.2%	$927	$1.2B	$0.82
≤ 20	787	1,256	38.5%	90.0%	$698	$897	$1.14
85%	163	1,897	8.0%	85.0%	$123	$159	$0.98

D.2.17 Alternative 11 – 5% GI + Newark Regulators Modifications

This alternative utilizes control technologies as described under Subsections C.9.1. and C.9.2.1. and depicted in **Figure D-3** and **Figure D-4**. The 5% GI is applied to the entire PVSC Treatment District as described in Alternative 4. The source control aspect of the GI allows the regulator gates to remain open for longer periods of time since there is less flow coming into the PVSC main interceptor. The projected performance of this alternative is listed below as **Table D-19**.

Table D-19: Alternative 11 Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
678	1,364	33.2%	89.1%	$171	$224	$0.33

D.2.18 Alternative 12 - 5% GI + Newark Regulator Modifications + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (235 MGD HCFM)

This alternative builds upon Alternative 5, adding 5% GI to the control technology as described under **Subsections C.9.1., C.9.2.1.** and **C.9.2.2** and depicted in **Figure D-4** and Figure D-5. Both the WRRF ~~expansion~~ bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications and an expanded force main diameter contributing flow from the HCFM communities. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regular Modifications
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (235 MGD HCFM)

Similar to Alternative 5, the flow capacity of the HCFM is under evaluation and may be eliminated if encountered to be not feasible. The projected performance of this alternative is listed below as **Table D-20**.

Table D-20: Alternative 12 Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
794	1,248	38.9%	90.0%	$304	$363	$0.46

D.2.19 Alternative 12.a - 5% GI + Newark Regulator Modifications + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)

This alternative builds upon Alternative 5.a, adding 5% GI to the control technology as described under **Subsections C.9.1., C.9.2.1.** and **C.9.2.2** and depicted in **Figure D-4** and **Figure D-6.** Both the WRRF ~~expansion~~ bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications and an expanded force main diameter contributing flow from the HCFM communities. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regular Modifications
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)

The projected performance of this alternative is listed below as **Table D-21**.

Table D-21: Altermative 12.a Performance and and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
801	1,241	39.2	90.1	$204	$262	$0.33

D.2.20 Alternative 13 – 5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM)

This alternative builds upon Alternative 6.a by adding 5% GI to the control technologies described under Subsections C.9.1., C.9.2.1. and C.9.2.2. and in **Figure D-4** and **Figure** D-7. Both the WRRF expansion bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications and an expanded force main diameter contributing flow from the HCFM communities. The CSO control technologies comprising this alternative are:

- 5% GI Coverage.
- Newark Regulator Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant Expansion Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)

The projected performance of this alternative is listed below as **Table D-22.**

Table D-22: Alternative 13 Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
1,349	693	66.1%	94.5%	$730	$790	$0.59

D.2.21 Alternative 13.a – 5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant Expansion Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)

This alternative builds upon Alternative 6.a.1 by adding 5% GI to the control technologies described under Subsections C.9.1., C.9.2.1. and C.9.2.2. and in **Figures D-4** and **D-8**. Both the WRRF expansion bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications and an expanded force main diameter contributing flow from the HCFM communities. The CSO control technologies comprising this alternative are:

- 5% GI Coverage.
- Newark Regulator Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant Expansion Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)

The projected performance of this alternative is listed below as **Table D-23**.

Table D-23: Alternative 13.a Performance and Cost

CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
1381	661	67.6%	94.7%	$630	$689	$0.50

D.2.22 Alternative 14 – 5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM) + Tunnels

This alternative builds upon Alternative 13 by adding tunnels. It utilizes control technology as described under Subsections C.9.1 and C.9.2., **Figure D-4** and **Figure D-11**. Both the WRRF ~~expansion~~ bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications, a parallel PVSC interceptor, and an expanded force main diameter contributing flow from the HCFM communities. Overflows are redirected to storage tunnels up to the appropriate level of control. All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)
- Tunnel Storage

The projected performance of this alternative is listed below as **Table D-24**.

Table D-24: Alternative 14 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.7B	$2.0B	$1.01
≤ 4	1,927	116	94.3%	99.1%	$1.4B	$1.7B	$0.86
≤ 8	1,683	294	85.6%	97.6%	$1.2B	$1.4B	$0.86
≤ 12	1,635	407	80.1%	96.7%	$1.0B	$1.2B	$0.74
≤ 20	1,520	522	74.4%	95.8%	$979	$1.1B	$0.73
85%	1,349	693	66.1%	94.5%	$730	$789	$0.59

D.2.23 Alternative 14.a – 5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels

This alternative builds upon Alternative 13 by adding tunnels. It utilizes control technology as described under Subsections C.9.1 and C.9.2., **Figure D-4** and **Figure D-12**. Both the WRRF ~~expansion~~ bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications, a parallel PVSC interceptor, and an expanded force main diameter contributing flow from the HCFM communities. Overflows are redirected to storage tunnels up to the appropriate level of control. All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)
- Tunnel Storage

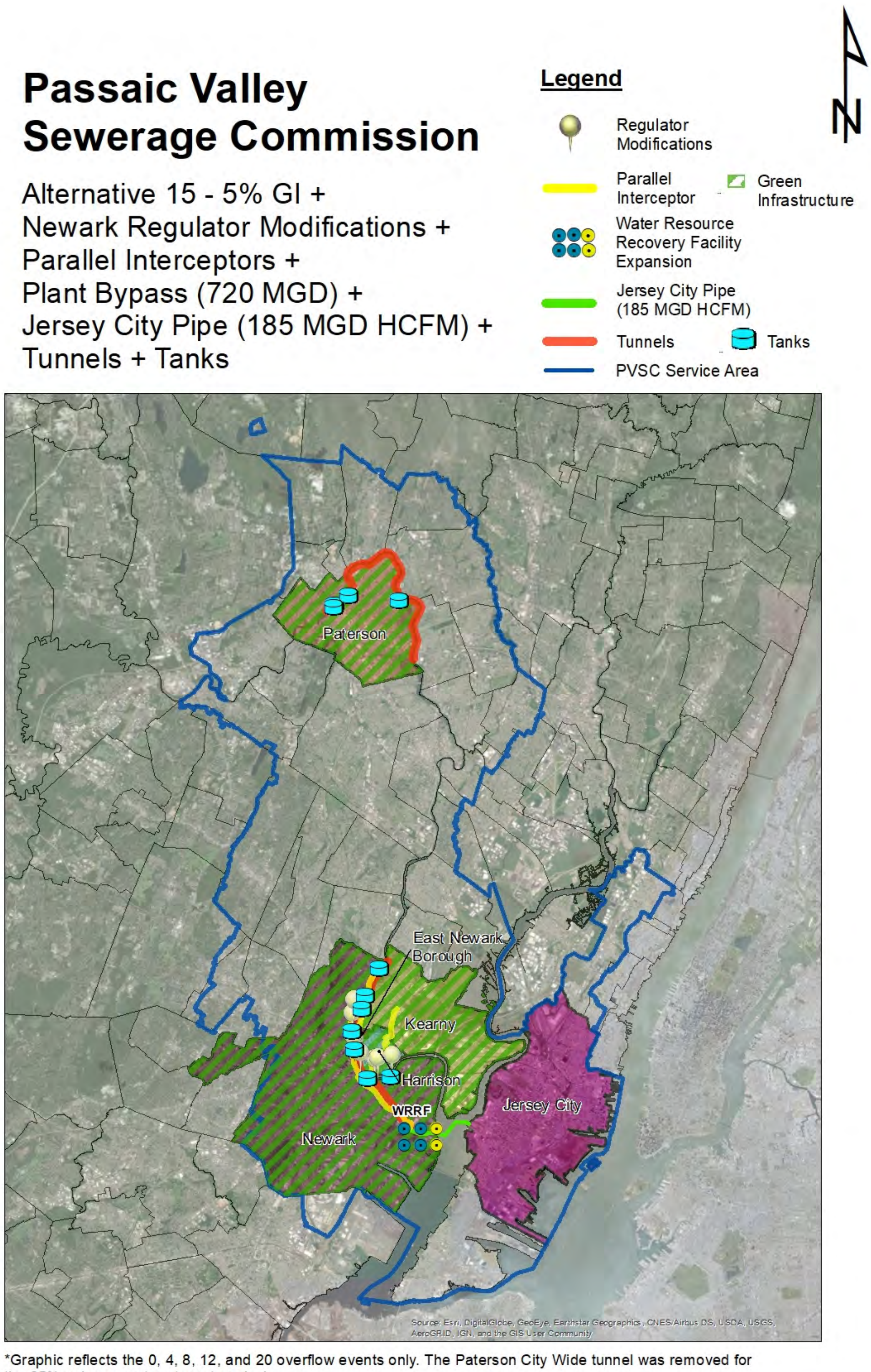
The projected performance of this alternative is listed below as **Table D-25**.

Table D-25: Alternative 14.a Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2042	0	100%	100%	$1.4B	$1.8B	$0.87
≤ 4	1902	140	93.1%	98.9%	$1.3B	$1.5B	$0.79
≤ 8	1719	323	84.2%	97.4%	$1.1B	$1.3B	$0.77
≤ 12	1574	468	77.1%	96.3%	$1.0B	$1.2B	$0.74
≤ 20	1488	554	72.8%	95.6%	$904	1.0B	$0.70
85%	1381	661	67.6%	94.7%	$631	$689	$0.50

D.2.24 Alternative 15 – 5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (185 MGD HCFM) + Tunnels + Storage Tanks

This alternative builds upon Alternative 14 by adding storage tanks. It utilizes control technology as described under Subsections C.9.1 and C.9.2. and in **Figure D-13** . Both the WRRF ~~expansion~~ bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications, a parallel PVSC interceptor, and an expanded force main diameter contributing flow from the HCFM communities. Overflows are redirected to storage tanks and tunnels up to the appropriate level of control. Overflow from regulators connected to both



*Graphic reflects the 0, 4, 8, 12, and 20 overflow events only. The Paterson City Wide tunnel was removed for the 85% volume capture target analysis.

Figure D-13: Alternative 15

storage tanks and tunnels are channeled to the storage tank with any excess flow passing into the tunnel.

All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (185 MGD HCFM)
- Tunnel Storage
- Tank Storage

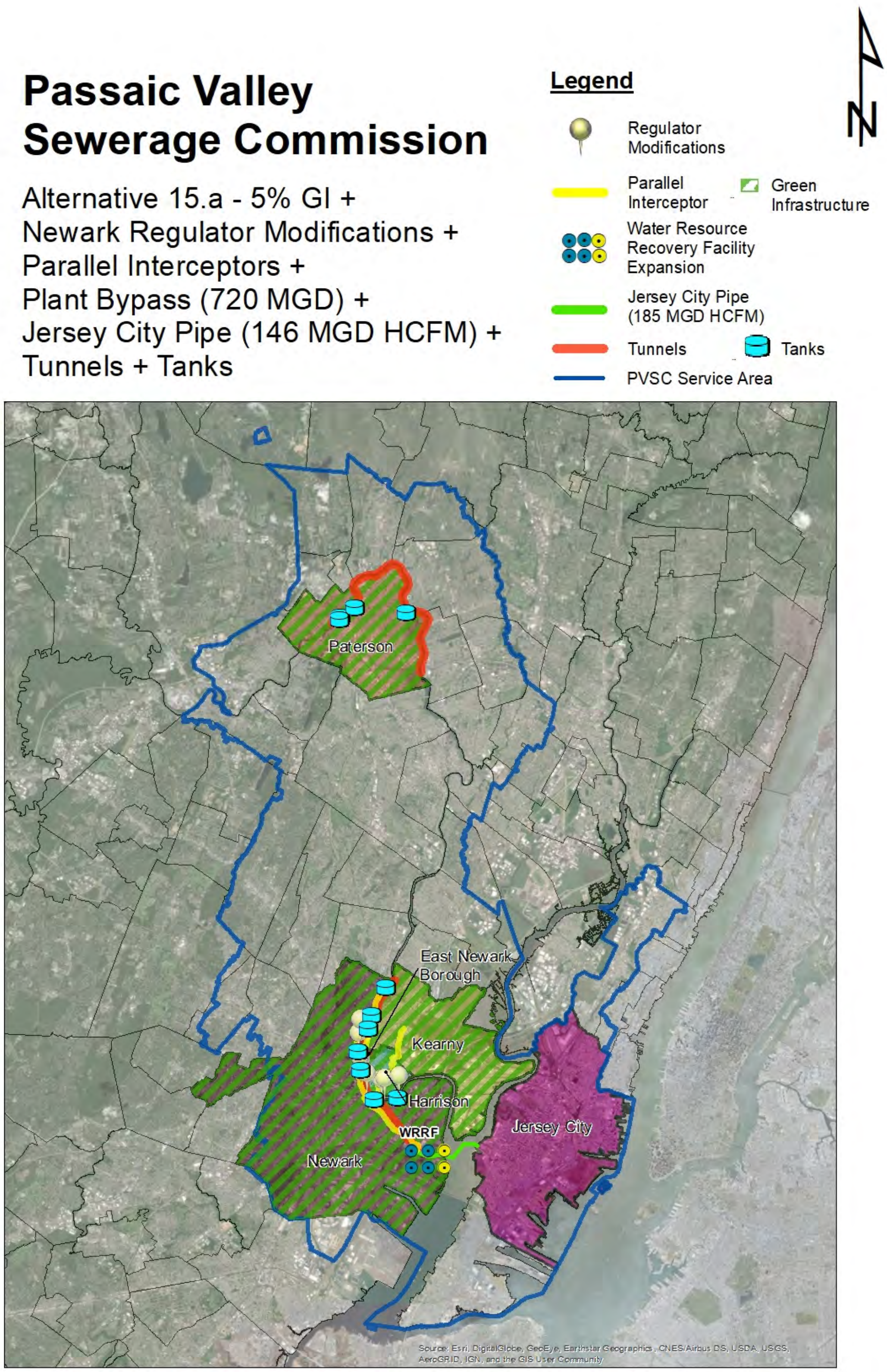
The projected performance of this alternative is listed below as **Table D-26**.

Table D-26: Alternative 15 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2042	0	100.0%	100.0%	$1.8B	$2.3B	$ 1.11
≤ 4	1858	184	91.0%	98.5%	$1.5B	$1.8B	$ 0.99
≤ 8	1695	347	83.0%	97.2%	$1.4B	$1.6B	$ 0.97
≤ 12	1532	510	75.0%	95.9%	$1.2B	$1.4B	$ 0.89
≤ 20	1453	589	71.1%	95.3%	$916	$1.0B	$ 0.72
85%	1349	693	66.1%	94.5%	$730	$789	$ 0.59

D.2.25 Alternative 15.a – 5% GI + Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels + Storage Tanks

This alternative builds upon Alternative 14.a by adding storage tanks. It utilizes control technology as described under Subsections C.9.1 and C.9.2. and in **Figure D-14**. Both the WRRF ~~expansion~~ bypass and 5% GI coverage provide additional flow capacity, which is utilized using the regulator modifications, a parallel PVSC interceptor, and an expanded force main diameter contributing flow from the HCFM communities. Overflows are redirected to storage tanks and tunnels up to the appropriate level of control. Overflow from regulators connected to both storage tanks and tunnels are channeled to the storage tank with any excess flow passing into the tunnel.



*Graphic reflects the 0, 4, 8, 12, and 20 overflow events only. The Paterson City Wide tunnel was removed for the 85% volume capture target analysis.

Figure D-14: Alternative 15.a

All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regular Modifications
- Parallel Interceptor (Newark and local relief scenario as defined in Section C.4.1.1)
- Plant ~~Expansion~~ Bypass (720 MGD)
- Jersey City Pipe (146 MGD HCFM)
- Tunnel Storage
- Tank Storage

The projected performance of this alternative is listed below as **Table D-27**.

Table D-27: Alternative 15.a Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2042	0	100.0%	100.0%	$1.7B	$2.2B	$1.06
≤ 4	1937	105	94.9%	99.2%	$1.5B	$1.8B	$0.94
≤ 8	1764	279	86.4%	97.8%	$1.3B	$1.6B	$0.90
≤ 12	1586	457	77.6%	96.3%	$1.1B	$1.3B	$0.82
≤ 20	1479	563	72.4%	95.5%	$916	$1.1B	$0.71
85%	1381	661	67.6%	94.7%	$630	$689M	$0.50

D.2.26 Alternative 16 – 5% GI + Newark Regulator Modifications + Tunnels + Storage Tanks

This alternative utilizes control technology as described under Subsections C.9.1, C.9.2.2 and C.9.2.3. and depicted in **Figure D-1** through **Figure D-4**. The source control aspect of the GI allows the regulator gates to remain open for longer periods of time since there is less flow coming into the PVSC main interceptor. Regulator Modifications will promote more flow into the WRRF through the main interceptor, with overflows redirected to storage tanks and tunnels up to the appropriate level of control. Overflow from regulators connected to both storage tanks and tunnels are channeled to the storage tank with any excess flow passing into the tunnel. All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Newark Regulator Modifications
- Tunnel Storage
- Tank Storage

The projected performance of this alternative is listed below as **Table D-28**.

Table D-28: Alternative 16 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.7B	$2.2B	$1.06
≤ 4	1,769	273	86.6%	97.8%	$1.2B	$1.5B	$0.86
≤ 8	1,608	434	78.7%	96.5%	$1.1B	$1.4B	$0.86
≤ 12	1,343	699	65.8%	94.4%	$945	$1.2B	$0.91
≤ 20	941	1,101	46.1%	91.2%	$681	$887	$0.94
85%	678	1,364	33.2%	89.1%	$171	$224	$0.33

D.2.27 Alternative 17 – 5% GI + Tunnels + Storage Tanks

This alternative utilizes control technology as described under Subsections C.9.1. and C.9.2.3. and depicted in **Figure D-1**, **Figure D-2** and **Figure D-4**. GI reduces incoming flow to the regulators. Overflows are redirected to storage tanks and tunnels up to the appropriate level of control. Overflow from regulators connected to both storage tanks and tunnels are channeled to the storage tank with any excess flow passing into the tunnel. All outfalls corresponding with PVSC-owned regulators are captured in this analysis. The CSO control technologies comprising this alternative are:

- 5% GI Coverage
- Tunnel Storage
- Tank Storage

The projected performance of this alternative is listed below as **Table D-29** .

Table D-29: Alternative 17 Performance and Cost

Overflow Events per Year	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	2,042	0	100%	100%	$1.7B	$2.2B	$1.09
≤ 4	2,030	12	99.4%	99.9%	$1.3B	$1.6B	$0.81
≤ 8	1,679	363	82.2%	97.1%	$1.2B	$1.5B	$0.88
≤ 12	1,477	565	72.0%	95.5%	$1.1B	$1.4B	$0.92
≤ 20	788	1,255	39.0%	90%	$813	$1.0B	$1.34
85%	181	1,861	9.0%	85.1%	$171	$224	$1.24

D.2.28 Summary of Cost Opinions

Table D-30 provides a summary of the most cost-effective alternative for each control level, factoring the cost of the alternative, the percent reduction in CSO overflow events, and the percent of CSO volume captured within the system.

D.3 PRELIMINARY SELECTION OF ALTERNATIVES

The NJPDES Permit requires the Permittees to submit a Selection and Implementation of Alternatives Report by June 1, 2020. As such, selection of alternatives will be performed as part of the next step in the implementation of the LTCP. This selection of alternatives will be performed as part of a regional solution, in combination with CSO control strategies formulated by the Permittees, discussed in the Regional Development and Evaluation of Alternatives Report. This Section provides an overview of the evaluation factors and regulatory compliance requirements applicable to the evaluation of the PVSC alternatives only.

D.3.1 Evaluation Factors

The factors discussed in the Section D.1 comprise cost and non-cost factors deemed important for the analysis of PVSC Alternatives. Evaluated factors such as cost and performance (level of CSO control), are summarized in Subsection D.2.28. These results, along with the PVSC alternatives that can potentially be implemented regionally in combination with CSO control alternatives proposed by other Permittees, will be coordinated with the Permittees for further assessment in the regional approach.

D.3.2 Regulatory Compliance

Alternatives analyzed within this EAR are required by the NJPDES Permit requirements noted in Section G.4.e. The analysis was performed for several levels of CSO controls: 85% wet weather capture and the reduction of CSS overflow events to a maximum of 0, 4, 8, 12, and 20 per year. PVSC performed a summary of cost opinions versus performance, detailed in Subsection D.2.28, to assist in the evaluation of CSO controls.

D.3.3 Selection of Preliminary Alternatives

As noted above, selection of alternatives will occur in the next phase of the LTCP development as a coordinated effort across Permittees. However, based on the analysis of this EAR, the following PVSC alternatives have been deemed applicable for consideration as components for the Regional Alternatives:

- Alternative 1: Tunnels
- Alternative 6.a.1: Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM)
- Alternative 7.a: Newark Regulator Modifications + Parallel Interceptor + Plant ~~Expansion~~ Bypass (720 MGD) + Jersey City Pipe (146 MGD HCFM) + Tunnels

The alternatives noted above are to be considered in conjunction with the alternatives developed by each individual CSO community. Further information about PVSC's participation in any regional alternatives for the PVSC Sewer District is discussed in the Regional Development and Evaluation of Alternatives Report.

Table D-30: Life-Cycle Cost Summary

Overflow Events per Year	Lowest Cost Alternative	CSO Volume Captured (MG)	Volume of Discharge (MG)	CSO % Reduction	System % Volume Captured	Capital Cost ($M)	Life Cycle Cost (LCC) ($M)	Cost ($M) per MG Captured
≤ 0	Alt 7a (RM + PI + PBE + HCFM 146 + T)	2,042	0	100%	100%	$1.3B	$1.6B	$0.77
≤ 4	Alt 1 (T)	1,771	271	86.7%	97.8%	$838	$1.0B	$0.59
≤ 8	Alt 1 (T)	1,638	404	80.2%	96.8%	$743	$934	$0.57
≤ 12	Alt 1 (T)	1,389	653	68.0%	94.8%	$680	$856	$0.62
≤ 20	Alt 7a (RM + PI + PBE + HCFM 146 + T)	1,406	636	68.9%	94.9%	$750	$838	$0.60

RM = Newark Regular Modifications
PI = Parallel Interceptor
PBE = Plant ExpansionBypass (720 MGD)
HCFM 146 = Hudson County Force Main (146 MGD HCFM)
T = Tunnel Storage

SECTION E - REFERENCES

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SECTION F - ABBREVIATIONS

BOD: Biochemical Oxygen Demand
BMP: Best Management Practice
CSO: Combined Sewer Overflow
CSS: Combined Sewer System
CWA: Clean Water Act
DWF: Dry Weather Flow
EAR: Evaluation of Alternatives Report
EPA: United States Environmental Protection Agency
ESI: Environmental Sensitivity Index
FOG: Fats, Oils, and Grease
GI: Green Infrastructure
GIS: Geographic Information System
HCFM: Hudson County Force Main
H&H: Hydrologic and Hydraulic
ICM: Integrated Catchment Modeling
LCC: Life Cycle Cost
LTCP: Long Term Control Plan
MGD: million gallons per day
NFA: No Feasible Analysis
NJPDES New Jersey Pollutant Discharge Elimination System
NJTPA: New Jersey Transportation Planning Authority
O&M: Operation and Maintenance
PCBs: polychlorinated biphenyls
POC: Pollutants of Concern
PPP: Public Participation Plan
QAPP: Quality Assurance Project Plan
RM: Regulator Modifications
RTC: Real Time Control
SSS: Separate Sewer System
STP: Sewage Treatment Plant
TGM: Technical Guidance Manual
TSS: Total Suspended Solids
USEPA: United States Environmental Protection Agency
WQS: Water Quality Standards
WRRF: Water Resources Recovery Facility

APPENDIX A

Passaic Valley Sewerage Commission
No Feasible Alternatives (NFA) Analysis Report

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Dated: February 2019

KLEINFELDER
Bright People. Right Solutions.

PASSAIC VALLEY SEWERAGE COMMISSION

NO FEASIBLE ALTERNATIVES ANALYSIS

REGULATORY SUPPORT DOCUMENT

PASSAIC VALLEY SEWERAGE COMMISSION
EST. 1902

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1.0 EXECUTIVE SUMMARY

This report addresses the regulatory aspects necessary to obtain approval for “blending.” Blending is the intentional bypass of the secondary treatment units at a publicly owned treatment works that receives combined wastewater flow, and the recombining of the wastewater with fully treated effluent prior to disinfection and discharge. A significant portion of the regulatory requirements that need to be met for blending are contained in the federal requirements for a “no feasible alternatives analysis.”

The Passaic Valley Sewerage Commission (PVSC) has evaluated the feasibility of blending in accordance with its NJPDES permit, the National CSO Policy (specific reference to Part II.C.7), Draft Guidance on Preparing a Utility Analysis, USEPA, July 2009 and the NJPDES regulations at N.J.A.C. 7:14A-11, Appendix C. As part of this evaluation, PVSC hired Hazen and Sawyer to perform a “no feasible alternatives” (NFA) analysis of the plant’s overall capacity, as well as individual unit capacities, during both dry- and wet-weather flow events. Hazen and Sawyer also conducted a detailed evaluation of alternatives to increase the secondary treatment capacity at PVSC as part of the NFA evaluation. Their report, entitled “Passaic Valley Sewerage Commission, New Jersey-WWTP No Feasible Alternatives (NFA) Analysis December 2018” (Hazen and Sawyer Report), is referenced throughout this report and provides the engineering evaluation and technical basis required for an NFA analysis.

This report, together with the Hazen and Sawyer Report, provide the technical, engineering and regulatory basis to support the use of blending to treat peak wet-weather flows at PVSC up to 720 million gallons per day (mgd), and reduce CSO discharges on an interim basis, prior to the LTCP implementation.

Based upon the estimated quantity and duration of blending events, PVSC estimates that on an annual basis, **1.4 billion additional gallons of combined wastewater flow can be treated at the wastewater treatment plant (WWTP) through blending, rather than being discharged through a CSO with no treatment.**

As described in the Hazen and Sawyer Report, blending would be accomplished by installing a passive weir system, or another equivalent control system, following the primary clarifies. When peak hourly flows following primary treatment reach 400 mgd, flows in excess of this amount would be routed around the secondary clarifiers by gravity, and then blended back with fully treated flow in the effluent channel receiving flows from the odd-numbered final clarifiers. In addition to installing the weir and related infrastructure in order to bypass flows around secondary treatment, PVSC is also proposing to reroute the recycle from the gravity thickener, decant tanks and thickening centrifuges to the primary clarifiers, in order to improve process stability, reduce dry weather TSS and CBOD concentrations and reduce the number of monthly percent removal exceedances.

Based upon the WWTP hydraulic and treatment capacity evaluation conducted by Hazen and Sawyer, PVSC is confident that 400 mgd of flow can reliably receive full treatment at the WWTP, and is therefore requesting approval to blend for peak wet-weather flows above 400 mgd, measured as peak hourly flow of primary treated effluent

PVSC understands that approval of blending at this time is an interim measure, and that NJDEP's approval of the PVSC final LTCP will govern future CSO operations at the WWTP.

2.0 INTRODUCTION

PVSC is a regional conveyance and treatment agency formed by the New Jersey Legislature in 1902. PVSC owns and operates a 330 million gallon per day (mgd) wastewater treatment plant (WWTP) located in Newark, New Jersey. The WWTP serves approximately 1.5 million people, 200 significant industrial users and 5,000 commercial users located throughout 48 municipalities in portions of Bergen, Essex, Hudson, Union and Passaic Counties.

Of the 48 municipalities served by PVSC, eight (8) own or operate combined sewers and/or combined sewer overflows (CSOs): City of Newark, City of Paterson, Jersey City, City of Bayonne, City of North Bergen, City of Harrison, City of Kearny and City of East Newark. While PVSC receives flow from combined sewer systems, PVSC does not, itself, own any CSOs.

In July 2015, the New Jersey Department of Environmental Protection (NJDEP) issued New Jersey Pollutant Discharge Elimination System (NJPDES) permits to the eight combined sewer municipalities noted above, and simultaneously renewed PVSC's NJPDES permit. In compliance with the U.S. Environmental Protection Agency (EPA) National Combined Sewer Overflow Control Policy, each of the nine NJPDES permits (PVSC and eight municipalities) requires that a Long-Term Control Plan (LTCP) be completed to evaluate the reduction and/or elimination of CSO discharges. As part of a cooperative effort, all nine permittees have agreed to submit a single LTCP to NJDEP, with PVSC being the lead agency in this effort.

As part of their LTCP development, PVSC's NJPDES permit, at Section G.4.e.vii, requires that PVSC explore *"CSO related bypass of the secondary treatment portion of the STP in accordance with N.J.A.C. 7:14A-11.12 Appendix C.II.C.7."* The "CSO related bypass of the secondary treatment portion of the STP" is commonly known as "blending." In general, blending refers to the process where wastewater at the WWTP passes through the headworks and is subject to removal of grit, screenings, and solids/floatables, followed by primary clarification. After the primary clarifiers, a portion of the flow is routed around the secondary treatment portion of the plant before being recombined or "blended" back with wastewater flow that has received secondary treatment. The blended flow is then disinfected and discharged, and must meet National Pollutant Discharge Elimination System (NPDES) permit effluent limitations at all times.

NJDEP issued a Response to Comments document in conjunction with PVSC's 2015 NJPDES permit renewal. This document provides further clarification for PVSC's bypass investigation requirement. Specifically, Response to Comments 95-100, states:

> *"Under Part IV.G.4.e.vii of the CSO Permit, as part of the LTCP, permittees are required to evaluate alternative wet-weather treatment protocols for reducing CSO events by maximizing the use of primary treatment capacity at the STP to meet the National CSO Policy's goal of making the greatest use of existing plant infrastructure. Specifically, permittees shall also evaluate the feasibility of using the plant's excessive primary treatment capacity with disinfection and dechlorination to increase the amount of primary treatment for flows that would otherwise be discharged through CSOs, while still meeting the STP's effluent limitations."*

While a full evaluation of the use of blending (often referred to as "bypassing" by EPA) on a long-term basis will be submitted as part of the PVSC final LTCP, PVSC has the potential ability to treat additional combined sewer flows during development and pending approval and implementation of the LTCP.

3.0 CURRENT TREATMENT PLANT OPERATIONS

PVSC is an activated sludge WWTP with a NJPDES permit flow value of 330 mgd. Wastewater enters the PVSC WWTP through two interceptors and one force main. The Main Interceptor begins in Paterson, and conveys flows from Paterson, East Newark, Kearny, Harrison, and parts of Newark. The Newark Southside Interceptor is owned and operated by the City of Newark, and conveys flows from the City of Newark. The Newark Southside Interceptor joins the Main Interceptor just upstream of the PVSC grit and screening facility. Finally, the Hudson County Force Main conveys flows from the Jersey City Municipal Utilities Authority (MUA), City of Bayonne and North Bergen MUA, and discharges to the after bay of the PVSC influent pumping station.

Major plant processes consist of grit and screenings removal, primary clarifiers, oxygen activated sludge reactors, final clarifiers, disinfection and discharge. A detailed description of the current plant treatment operations during both dry and wet-weather, as well as the process flow diagram, is contained in the Hazen and Sawyer Report as noted:

- Section 2.2 Current Plant Treatment Operations
- Section 2.3 Process Flow Diagram
- Section 2.4 Current Wet-weather Flow Process

PVSC has two permitted outfalls: DSN001A discharges to the Upper New York Bay, and DSN002A discharges to the Upper Newark Bay. In accordance with its NJPDES permit, treated wastewater flow is discharged through DSN002A only during wet-weather flow conditions when DSN001A has reached its hydraulic capacity.

4.0 REGULATORY REQUIREMENTS FOR BLENDING AND NO FEASIBLE ALTERNATIVE ANALYSIS

In accordance with the National CSO Policy Part II.C.7, the maximization of treatment at the existing publicly owned treatment works (POTW) may include the intentional bypass of flows around the secondary treatment units, followed by recombining the bypass flows with secondary treated flow, prior to disinfection and discharge. As per the National CSO Policy:

> *"Normally, it is the responsibility of the permittee to document, on a case-by-case basis, compliance with 40 CFR 122.41(m) in order to bypass flows legally. For*

some CSO-related permits, the study of feasible alternatives in the control plan may provide sufficient support for the permit record and for approval of a CSO-related bypass in the permit itself, and to define the specific parameters under which a bypass can legally occur."

A number of regulatory requirements govern blending (intentional bypassing) at POTWs that receive combined flows. PVSC is subject to, and must show compliance with, the following regulatory requirements:

a) EPA 1994 CSO Control Policy;
b) 40 CFR 122.41(m);
c) NJPDES regulations at N.J.A.C. 7:14A-11, Appendix C;
d) PVSC's individual NJPDES permit; and
e) PVSC's 2018 Administrative Order on Consent with EPA.

Items a) through d) above represent the federal and state rules, regulations, and policies that apply to all New Jersey CSO NJPDES permittees who seek approval to blend. The specific requirements contained therein are listed below as numbers 1 through 9. Item e) above, *PVSC's Administrative Order on Consent*, dated April 17, 2018, contains additional requirements which are listed at numbers 10 through 12 below.

These requirements are summarized as follows:

1. Provide justification for the cut-off point at which the flow will be diverted from the secondary treatment portion of the treatment plant;

2. Demonstrate that all wet-weather flows passing the headworks will receive at least primary treatment, solids and floatable removal, and disinfection;

3. Demonstrate that blending will meet the requirements of 40 CFR 122.41(m)(4) (anticipated bypass);

4. Demonstrate that secondary treatment units are properly operated and maintained;

5. Demonstrate that the secondary treatment units have been designed to meet secondary limits for flows greater than the peak dry-weather flow, plus an appropriate quantity of wet-weather flow;

6. Demonstrate that it is either technically or financially infeasible to provide secondary treatment for greater amounts of wet-weather flow;

7. Provide a benefit-cost analysis demonstrating that the conveyance of wet-weather flow to the POTW for primary treatment is more beneficial than other CSO abatement alternatives that could feasibly be implemented prior to implementation of the approved LTCP;

8. Demonstrate that blending will not cause an exceedance of water quality standards;

9. Provide an analysis of adverse impacts resulting from the use of the blending line;

10. Demonstrate compliance with 33 U.S.C. 1342(q)(1), 40 CFR 122.41(m), and N.J.A.C. 7:14A-11.12, Appendix C, II.C.7;

11. Develop and submit to EPA (after consultation with NJDEP) standard operating procedures (SOPs) for interim bypassing; and

12. Address the requirement for PVSC to monitor and report chlorine residual, fecal coliform indicator, and estimated flow discharged for DSN002A which shall be included in the individual NJPDES permit modification issued by NJDEP.

Each of the twelve (12) regulatory requirements is addressed below.

4.1 Flow Diversion Cut-Off Point

Provide justification for the cut-off point at which the flow will be diverted from the secondary treatment portion of the treatment plant.

The Hazen and Sawyer Report contains a detailed engineering and hydraulic analysis of the design capacity (including annual average, maximum monthly, and peak hourly) for each of the PVSC treatment units and major unit pumps (see Hazen and Sawyer Report, Section 2.6, Table 2-2). Their evaluation includes consideration of the number of units present for each treatment stage, the number of units operating, individual unit capacities, pumping capacities at each stage of treatment, and treatment constraints such as solids retention time, pounds of biomass under aeration, and other factors that impact the design capacity of each unit.

A summary of the treatment capacity of the major portions of PVSC's process (from the Hazen and Sawyer Report Table 2-2) is shown in Table 1 below.

Table 1: PVSC Treatment Process Summary

Treatment Element	Units	Annual Average	Maximum Monthly	Peak Hourly
Rated Total Influent Pumping Capacity (dry-plus wet-weather pumping)	mgd	270	360	775
Rated Primary Clarifier Capacity	mgd	330	400	720
Rated Oxygenation Tank Capacity	mgd	330	400	720
Rated Final Clarifier Capacity	**mgd**	**400**	**400**	**400**
Rated Return Activated Sludge and Waste Activated Sludge Pumping Capacity	mgd	330	434	720
Disinfection	mgd	720	720	720
Rated Effluent Pumping Capacity	mgd	240	480	720

As shown in the above table, all major treatment units and pumps have a peak hourly wet-weather treatment capacity of at least 720 mgd, with exception of the secondary clarifiers, which have a peak hourly wet-weather treatment capacity of 400 mgd.

As described in the Hazen and Sawyer Report, Section 4.2.2.1.2, hydraulic modeling using Infoworks software indicates that a secondary bypass initiated at 400 mgd (peak hourly primary clarifier effluent) would allow PVSC to treat up to 720 mgd of blended flow and still meet NJPDES permit requirements (see percent removal discussion Section 3.8 of this report). Hazen and Sawyer Report Figures 4-8 "Secondary Bypass Site Layout" and Figure 4-9 "Secondary Bypass Process Flow Diagram" provide details of the flow process.

As described, a bypass line would be constructed from the primary effluent conduit and route primary treated flow around the oxygenation tanks and secondary clarifiers before recombining with secondary treated flow in the effluent channel receiving flow from the odd-numbered final clarifiers. All flows will receive disinfection prior to discharge.

The primary bypass would be initiated when peak hourly wet-weather flows reach and exceed 400 mgd in the primary clarifier effluent channel. A passive weir, or other equivalent control structure, would be constructed at the primary treated flow effluent channel, with a Parshall flume to allow flow measurement. This passive weir structure allows the primary bypass to be initiated when hydraulically indicated, without the concern of bypassing before necessary or after secondary treatment capacity is exceeded. PVSC will monitor the bypass, and for each blending occurrence record the date of bypass, duration of bypass, and other information that NJDEP may require.

4.2 Minimum Treatment for All Flows Passing the Headworks

Demonstrate that all wet-weather flows passing the headworks will receive at least primary treatment, solids and floatable removal, and disinfection.

As can be seen from the Hazen and Sawyer Report Figure 2-5 “PVSC Wet-weather Process Flow Diagram,” all flows, with the exception of the force main flows from Jersey City, Bayonne and South Kearny, enter the headworks of the facility, where they flow through a bar screen and grit removal chamber. Flows from Jersey City, Bayonne and South Kearny enter the WWTP downstream of the influent pumping stations, and have their own screening and grit removal at an upstream location. Therefore, all flows passing the headworks and the influent pumping station have received solids and floatable removal and will receive primary clarification and disinfection prior to discharge.

4.3 Federal Requirements for an Anticipated Bypass

Demonstrate that blending meets the requirements of 40 CFR 122.41(m)(4) (anticipated bypass).

The federal requirement for an anticipated bypass provides that the permitting authority may approve an anticipated bypass if:

- The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
- There were no feasible alternatives to the bypass; and
- The permittee submits notices as required.

As contained in the National CSO Policy Section II.C.7:

> *"For the purposes of applying this regulation to CSO permittees, 'severe property damage' could include situations where flows above a certain level wash out the POTW's secondary treatment system."*

In the case of the PVSC WWTP, the Hazen and Sawyer Report clearly demonstrates that the maximum treatment capacity of the secondary clarifiers is 400 mgd peak wet-weather flow. Flow in excess of the capacity of these units will result in the secondary clarifier solids being washed out, leading to permit non-compliance and a challenging and time-consuming process to bring the secondary system back on-line again.

As presented throughout the Hazen and Sawyer Report, as well as this report, no feasible alternatives to the bypass are available on an interim basis, prior to implementation of the approved LTCP. Please see additional discussion of this under Section 3.7 of this report.

Notification of the bypass will be provided as required by NJDEP in the PVSC NJPDES permit.

4.4 Secondary Treatment Units

Demonstrate that secondary treatment units are properly operated and maintained.

Proper operation and maintenance of the secondary treatment system is required in order to meet the plant's permit limits, in particular carbonaceous biochemical oxygen demand (CBOD) and total suspended solids (TSS) limitations. PVSC has an ongoing maintenance program and detailed operating procedures to ensure that the treatment units are properly operated and maintained.

4.5 Secondary Treatment Limits

Demonstrate that secondary treatment units have been designed to meet secondary limits for flows greater than the peak dry-weather flow, plus an appropriate quantity of wet-weather flow.

As detailed in the Hazen and Sawyer Report, Section 3.1.1 (Plant Influent Flow), a flow analysis was conducted for PVSC's historical daily average influent flow from 2014 through 2017. The 50th percentile daily average flow for this period is 218 mgd. For the purposes of this NFA analysis, Hazen and Sawyer has defined peak dry-weather flow as >285 mgd. This number corresponds to the 90th percentile flow for that period. Therefore, the secondary treatment units, at 400 mgd treatment capacity, are designed to treat flows greater than peak dry-weather flow, plus an appropriate quantity of wet-weather flow.

4.6 Evaluation of Additional Secondary Treatment

Demonstrate that it is either technically or financially infeasible to provide secondary treatment for greater amounts of wet-weather flow

PVSC has conducted a detailed and exhaustive analysis of possible alternatives to provide additional secondary treatment at the WWTP. Evaluations in the Hazen and Sawyer Report include both operational modifications to the facility (Section 4.2.1) and infrastructure modifications (Section 4.2.2). Alternatives evaluated include:

a) Operational Modifications
- Chemically Enhanced Primary Treatment (CEPT) – the addition of chemicals to enhance primary settling through coagulation, flocculation and sedimentation.

b) Infrastructure Modifications
- Secondary Bypass – routes primary effluent around secondary clarifiers to effectively utilize primary clarifiers capacity; flow is disinfected prior to discharge.
- Step-Feed – reduces solids loadings to the final clarifiers. In order to achieve this, a new return activated sludge (RAS) distribution box would be constructed to distribute RAS to specific portions of the 12 oxygenation tanks.
- BioActiflo – installation of additional treatment units, equivalent to secondary treatment. The BioActiflo process, theoretically, would be online during periods of

peak wet-weather flow. This BioActiflo self-contained treatment unit consists of a coagulation tank where raw wastewater is received, followed by an injection tank where ballasted floc formation begins. The wastewater flow would then enter a "maturation tank" where additional floc formation continues and settling occurs. Clarified wastewater is discharged into the next stage of treatment at the WWTP.

- RAS storage – similar to Step-Feed, whereby active biomass inventory is protected from washout.
- Rerouting Recycle Streams – exploration of rerouting recycle streams from the gravity thickeners, decant tanks and thickening centrifuges to the primary clarifiers.
- Structural Modifications – exploration of rebuilding the final clarifier complex to create three independent squircle clarifiers with modern equipment, from each of the existing, rectangular clarifiers.
- Construction of additional secondary clarifiers – Hazen and Sawyer Report Section 4.2.2.9 explores the feasibility of additional structures and the constraints present on the site and off-site.

Each of the above alternatives were evaluated in detail in the Hazen and Sawyer Report. As concluded in that report, these alternatives are either technically or economically not feasible for PVSC to implement on an interim basis, prior to final approval and implementation of their LTCP.

4.7 Benefit-Cost Analysis

Provide a benefit-cost analysis demonstrating that the conveyance of wet-weather flow to the POTW for primary treatment is more beneficial than other CSO abatement alternatives that could feasibly be implemented prior to approval of the LTCP.

A NFA analysis for the use of the blending line on a long-term basis (as could be considered in a LTCP) would typically include an evaluation of CSO control alternatives such as WWTP expansion and/or storage at the plant, off-site storage, sewer separation, infiltration/inflow reduction, CSO treatment and green infrastructure. Conversely, a NFA analysis to address utilization of the blending line on an interim basis (preceding implementation of the approved LTCP) need only consider alternatives that could feasibly be completed and operational prior to LTCP approval and implementation.

The current NJPDES permit for the PVSC WWTP requires submittal of the final LTCP to NJDEP by July 2020. Allowing six months for NJDEP review, the LTCP could be approved as early as January 2021.

The following typical timeline is estimated for implementing a CSO control alternative which would not require land purchase nor extensive local or NJDEP approvals, and does not involve contaminated sites or environmentally sensitive areas:

- Evaluation of options, public participation 1.5 years
- Design, permitting 1.5 years
- Bidding, award 2 months
- Construction 1.5 years

Based on the above, it is expected that implementing a relatively small scale and simple CSO control alternative (prior to LTCP approval) other than blending would take a minimum of 4.5 years, which would result in implementation sometime in 2023, well beyond the estimated January 2021 date for LTCP implementation. Therefore, blending is the only feasible interim CSO control alternative.

In addition to exceeding the LTCP implementation timeline, there are other factors associated with the CSO control alternatives that need to be considered for this interim NFA evaluation prior to the LTCP submittal in July 2020 and estimated approval date of January 2021, including the following:

- As discussed in the Hazen and Sawyer Report Section 4.2.2.9.1, there is insufficient space available at the WWTP site to expand the plant to increase the secondary plant capacity or to provide additional temporary storage of the combined sewer flow. The minimal land space shown on the property footprint is already dedicated to the construction of a new Oxygen Production Plant and standby power generation facility. Therefore, these alternatives are not considered feasible.

- Siting new facilities for off-site storage (storage tanks, drop shafts or deep tunnels) or CSO treatment would be difficult given the densely populated collection service area and lack of open space or other undeveloped sites, as well as public opposition to these types of facilities. In addition, adjacent property is unavailable for any new infrastructure, due to pending litigation regarding the Passaic superfund cleanup.

- Separation of sanitary and storm sewers or lining of sewers to reduce infiltration would cause significant disruptions to residents and traffic patterns.
- Costs for implementing a CSO control alternative that could treat, store or reduce CSOs by a similar volume as the blending option (320 mgd of additional flow) would cost many millions of dollars. Costs for the blending option are minimal.
- While this report evaluates the use of blending on an interim basis (prior to completion of approved CSO control strategies), we are also providing estimated costs associated with other CSO control alternatives, as a baseline comparison. In compliance with the PVSC NJPDES permit, an in-depth and specific "Evaluation of Alternatives Report" will be submitted on, or prior to, July 1, 2019. The following analysis is preliminary in nature, and the final "Evaluation of Alternatives Report" shall be used by PVSC when evaluating the feasibility of CSO control alternatives in the final LTCP.

Kleinfelder has conducted a literature search to estimate industry standard costs associated with various CSO control strategies. These costs were then utilized to estimate site-specific expenditures for PVSC based upon population, service area, and engineering features. Please note that since these costs are submitted with little to no detailed design data, actual costs could be significantly higher or lower than the estimates provided.

In determining industry standard costs, Kleinfelder utilized the following sources:

- Manual: Combined Sewer Overflow Control (EPA, September 1993). (CSO Control Manual)
- Cost Estimating Manual – Combined Sewer Overflow Storage and Treatment (EPA, December 1976).
- Combined Sewer Overflow Long Term Control Plan Update, Basis for Cost Estimates, City of Elkhart, Department of Public Works (Greeley and Hansen, August 2007). (Elkhart Study)

- CSS Long Term Control Plan Update, Basis for Cost Opinions, City of Alexandria, Department of Transportation and Environmental Quality (Greeley and Hansen, October 2015). (Alexandria Study)

Sewer Separation

The Elkhart Study conducted an extensive survey of sewer separation costs across the country. This study analyzed the cost of sewer separation as a function of CSO drainage area. Table 2 from the Elkhart Study details this information, and is reproduced as Table 2 of this report below.

Table 2: Sewer Separation Construction Cost Data

City	CSO Drainage Area(acres)	Estimated Construction Cost (ENR=7,200)	Unit Construction Cost($/acre, ENR=7,200)	Type of Data
Elkhart, IN	148	$6,973,132	$47,151	Bid
Alexandria, VA	885	$34,480,254	$38,961	Estimate
Chicago, IL	240,000	$20,338,519,925	$84,744	Estimate
San Francisco, CA	24,995	$11,015,462,445	$440,707	Estimate
Peoria, IL	61.3	$3,286,770	$53,618	Estimate
Richmond, VA	11,000	$2,570,494,780	$233,681	Estimate
Minneapolis, MN	4,000	$93,145,711	$23,286	Estimate
Columbus, OH	22	$1,099,356	$49,971	Bid
S. Dorchester Bay, Boston, MA	786	$103,237,422	$131,345	Bid
Stony Brook, Boston, MA	608	$54,396,399	$89,468	Estimate
Cambridge, Boston, MA	250	$78,959,737	$315,839	Estimate
Garden City, MI	1,180	$37,555,639	$31,827	Bid
Livonia, MI	103	$1,353,735	$13,143	Bid
Plymouth Township, MI	138	$1,178,180	$8,538	Bid
Wayne, MI	288	$8,353,119	$29,004	Bid
Westland, MI	409	$10,737,342	$26,253	Bid
Bloomfield Hills, MI	86	$2,065,842	$24,021	Bid
Lansing, MI	6,900	$262,088,934	$37,984	Estimate/Bid[1]
Liberty Drive, Mishawaka, IN	59.6	$3,416,725	$57,328	Estimate
CSO 002 & 003, Mishawaka, IN	771	$48,016,057	$62,278	Estimate
South Bend Stormwater Management Master Plan[2]				
Combined Sewer Area 26	56	$1,386,777	$24,764	Estimate
North Area – Eastbank Project	165	$8,588,610	$52,052	Estimate
Eastside Project	30	$2,027,244	$67,575	Estimate
Downtown Project	62	$3,780,187	$60,971	Estimate
Combined Sewer Area 3 – Washington Street Project	39	$1,437,247	$36,852	Estimate
Master Plan Subtotal	*352*	*$17,220,064*	*$48,921*	*Estimate*

Based on the information presented in this table, the City of Elkhart determined that sewer separation costs of $50,000 per acre can be assumed, based on 2007 costs at an ENR construction cost index of 7,200. Based on the October 2017 ENR construction cost index being

10,817, the corresponding sewer separation costs in current dollars are $75,000 per acre. In order to apply this standard to PVSC, the sewer service area for the WWTP must first be determined. The "Service Area System Characterization Report," dated June 2018, prepared by Greeley and Hansen and CDM Smith, shows in Table C-1 (page 43) that the combined sewer contribution area totals 22,099 acres.

Utilizing the above current estimate of $75,000 per acre, **the estimated cost to separate combined sewer contributory to PVSC would be approximately $1.66 billion**, as shown below:

22,099 acres x $75,000 per acre = $1.66 billion dollars (rounded)

This cost does not take into consideration other potential costs related to stream crossings, regulator modifications, etc., which would also add to the overcall costs for this option. Further, there are significant community-wide quality-of-life issues that would be created by such an undertaking, such as extended and widespread street closures, emergency vehicle delays, increased emissions from heavy machinery, and others local disruptions. Finally, it is possible that certain parts of the sewer service area would simply not have the space available in the street to accommodate separate sewers, making this option impossible in some areas, regardless of cost.

<u>Storage Basins</u>

The use of off-line storage can be successful in areas where sufficient land is available for the construction of such facilities. Concerns such as odor, public health and safety, and aesthetics also dictate the location of a storage facility. In the case of PVSC, site constraints at the treatment facility itself, as well as limited suitable land areas available, make the use of storage basins at best challenging and more likely infeasible.

The proposed blending of wastewater at the PVSC facility will allow up 320 mgd of additional wet-weather flows to be treated. Because high flows could persist for 24 hours, and it is possible that a second storm could occur before the storage basin can be emptied. It is preliminarily estimated that a 640-million-gallon storage basin would need to be constructed to hold a minimum of two days' storage of excess flows. This would allow sufficient time for the PVSC facility to return to normal operating levels (up to 48 hours) before accepting the stored flows for treatment.

Therefore, for the purpose of this cost estimate, a storage basin of 640 million gallons was assumed.

The Alexandria Study referenced a cost curve for retention basins that was utilized in the EPA's CSO Control Manual, as given by the following equation:

$$\textit{CSO Retention Basin Construction Cost} = aV^{b}$$

Where
V = the storage volume in millions of gallons; and
a and *b* are constants which are unique to each line fit.

In the Alexandria Study, Greeley and Hansen used the data in Table 3 below to determine the values of *a* and *b.* After converting all costs to 2014 costs, and solving for the a and b variables, the Alexandria Study determined the construction cost curve for CSO retention basin to be:

$$\textit{CSO Retention Basin Construction Cost} = 6.9671V^{0.7811}$$

This curve, in 2014 dollars, is reproduced from the study on page 18 of this report. As it shows, a storage facility of 100 million gallons will have a construction cost in excess of approximately $254 million dollars (2014 dollars). Land costs will be additional, and based upon an internet search of available vacant land at the time of this report, costs may range from $0.5 million to $2.5 million, depending on the location.

Site-specific storage tank costs can vary widely, as also identified in the Alexandria Study, and ranged from $14.58 million for the 3.6-million-gallon Webber basin in Saginaw, MI, to $23.5 million for a 4.5-million-gallon basin in Acacia Park, MI.

The Alexandria Study also concluded that costs may range considerably based on the type and location of the storage system. This study provided an example of a 0.7-million-gallon underground, custom built storage tank located in Mariposa, San Francisco, with an estimated cost of $14.69 million.

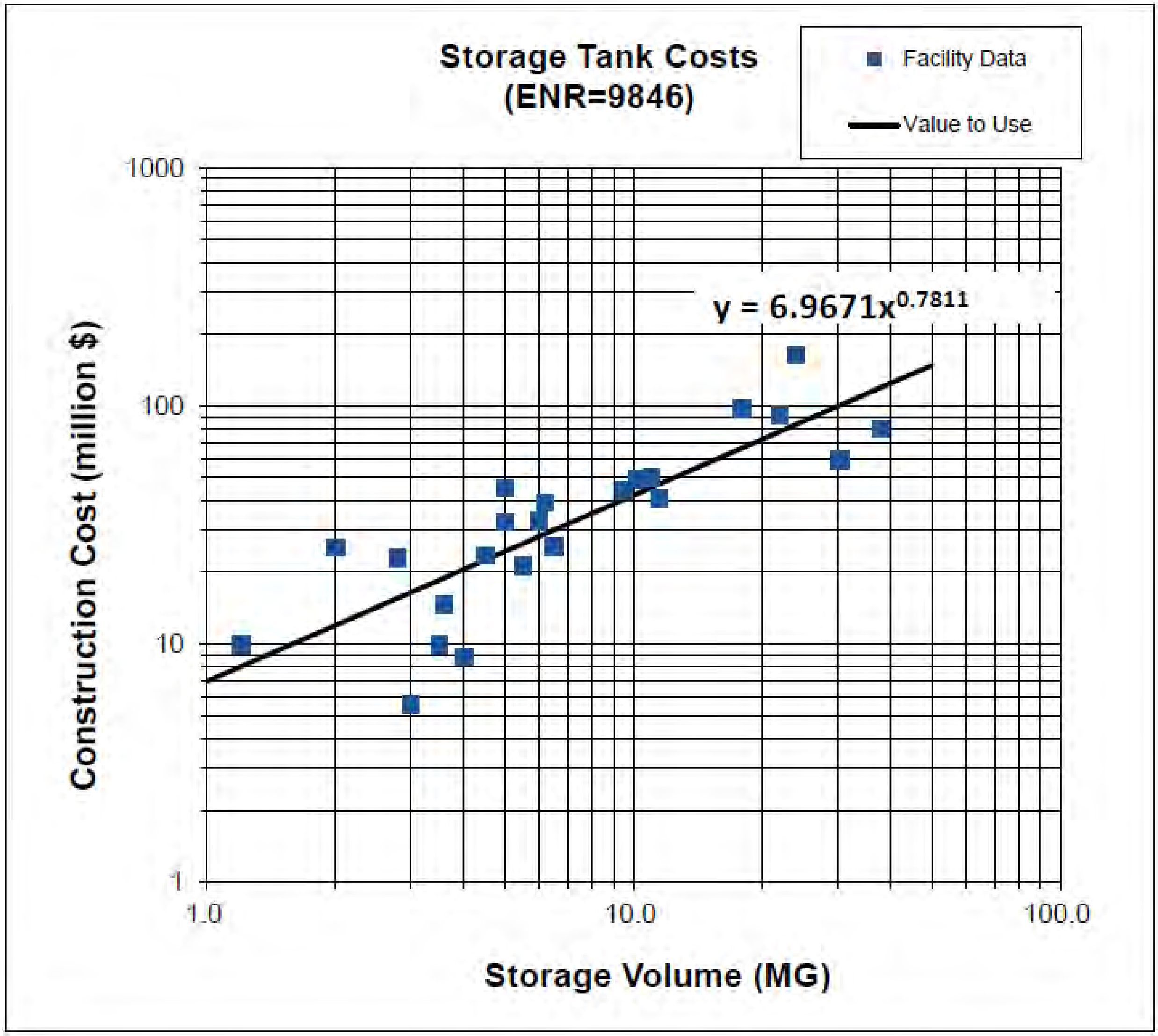
Table 3: Costs of Retention Basins for Selected Municipalities

Facility	Storage Volume (MG)	Escalated Construction Cost ($ in millions)	Escalated Unit Cost[1] ($M/MG)
Fitzhugh, Saginaw, MI	1.2	$9.90	$8.25
Seven Mile, Detroit	2.0	$25.35	$12.68
Salt/Frazer, Saginaw, MI	2.8	$22.86	$8.16
Seneca WWTP, MD	3.0	$5.58	$1.86
Chattanooga, TN	3.5	$9.88	$2.82
Webber, Saginaw, MI	3.6	$14.58	$4.05
Acacia Park, MI	4.5	$23.50	$5.22
Narragansett Bay, RI	5.0	$45.03	$9.01
Emerson, Saginaw, MI	5.0	$32.57	$6.51
Birmingham, MI	5.5	$21.30	$3.87
WSSC-Rock Creek	6.0	$32.68	$5.45
Sunnydale, SF, CA	6.2	$39.28	$6.34
14th St., Saginaw, MI	6.5	$25.68	$3.95
Weiss Street, Saginaw, MI	9.5	$44.24	$4.66
Bloomfield Village, MI	10.2	$48.85	$4.79
Edmund, Oakland, CA	11.0	$49.94	$4.54
Yosemite, SF, CA	11.5	$40.88	$3.55
Tournament Club, Detroit	22.0	$91.31	$4.15

Utilizing the EPA-derived cost curve equation (as modified by Greeley and Hansen) in the Alexandria Study, a suitably sized retention basin for PVSC of 640 million gallons yields a **CSO retention basin cost estimate of $1.1 billion dollars (rounded).**

Further, these costs do not include the cost of pumping stations (if needed to pump flow back to the plant), conveyance pipes, regulator modifications, maintenance, sludge removal and/or storage, and land.

Figure 1: Storage Tank Volume vs. 2014 Construction Costs



Deep Tunnels

Deep tunnels are alternatives to storage tanks and basins for temporary storage of combined sewage. Assuming a suitable location could be found in the sewer service area, for a deep tunnel to store 640 million gallons of combined sewage flow (two days' wet-weather), the length of a required tunnel, at proposed tunnel diameters of 10 feet and 20 feet, can be determined using the following formula:

*Length of Tunnel = Volume in cubic feet ÷ (π * (radius)* ^{2}*)*

Using the above formula for PVSC for a storage tunnel of 640 million gallons:

- A tunnel of 10 feet in diameter will need to be 1,089,327 linear feet (206 miles).
- A tunnel of 20 feet in diameter will need to be 272,331 linear feet (51 miles).

The infeasibility of constructing a 50-mile tunnel aside, we have researched various tunnel costs as utilized in other areas of the country. As contained in the Alexandria Study:

- The DC Water First Street Tunnel, with a finished diameter of 19.5 feet, has an estimated construction cost (2014 dollars) of $14,297 per linear foot, which in 2017 dollars would be $15,730 per linear foot.

The cost for PVSC of a similar sized tunnel (20-foot diameter) can be calculated as:

272,331 linear feet x $15,730 per linear foot = $4.3 billion dollars (rounded)

- The DC Water Westerly Tunnel, with a finished diameter of 10 feet, has an estimated construction cost of $8,954 per linear foot (2014 dollars), which in 2017 dollars would be $9,850 per linear foot.

The cost for PVSC of a similar sized tunnel (10-foot diameter) can be calculated as:

1,089,327 linear feet x $9,850 per linear foot = $10.7 billion dollars (rounded)

Summary of Costs

The above construction cost estimates are summarized in Table 4 below.

Table 4: Construction Cost Estimates Summary

Alternative	Estimated Construction Cost
Sewer Separation	$1.66B
Conventional Storage	$1.10B
Deep Tunnel	$4.30B
Blending Line	$14.5M - $22.3M[1]

[1] See Hazen and Sawyer Report, Appendix A

In consideration of the above, the use of blending, at an approximate construction cost of between \$14.5M-\$22.3M is the most cost-effective, feasible alternative for handling additional CSO flows on an interim basis prior to implementation of the approved LTCP.

4.8 Water Quality Standards

Demonstrate that blending will not cause an exceedance of water quality standards.

As detailed throughout the Hazen and Sawyer Report, the proposed blending scenario (blending flows above 400 mgd, to a maximum of 720 mgd) has been extensively analyzed and modeled, demonstrating that all NJPDES permit effluent limitation conditions will be met at all times, including during times of blending (see discussion of percent removal below). Since the effluent limits in the PVSC NJPDES permit are based upon meeting water quality standards at all times, compliance with those limits, even during times of blending, will ensure that water quality will be met.

The Hazen and Sawyer Report has evaluated compliance with all NJPDES permit effluent limitations, and their findings are in the following sections of their report:

- TSS, CBOD and ammonia projected compliance – Section 4.2.2.1.2; Table 4-9
- Metals projected compliance (total cyanide, nickel, zinc, lead, copper, and mercury) – Section 4.2.2.1.2; Table 4-10
- Fecal Coliform – Section 4.2.2.1.2

As further discussed in the Hazen and Sawyer Report, the PVSC WWTP is expected to meet all effluent limitations and conditions of its NJPDES permit at all times, including during blending, providing that a wet-weather exception for TSS and BOD percent removal is authorized.

Hazen and Sawyer projected blending conditions during 2014, 2015, 2016, and 2017 storm events. As discussed in the Hazen and Sawyer Report, occasional non-compliance for TSS percent removal is predicted during wet-weather events, when influent flows demonstrate exceptionally low TSS concentrations. This condition is not unusual for WWTPs that receive dilute influent flows during wet-weather, and has been recognized and addressed by EPA on many occasions. A review of recent permits issued in New York (which is under the jurisdiction of EPA Region II, as is New Jersey) shows a pattern of flexibility when addressing peak wet-weather flows. The following percent removal requirement is contained in numerous New York permits, including Oakwood Beach, Coney Island, Hunts Point, and Owl's Head:

> *"…effluent shall not exceed 15% and 15% of influent values for CBOD5 and TSS, respectively. During periods of wet-weather which causes plant flows over the permitted flow for a calendar day**, the CBOD and TSS influent and effluent results for that day shall not be used to calculate the 30-day arithmetic mean value concentration limitations.** All other effluent limitations remain in full effect."*

As part of its permit modification request for blending approval, PVSC will also request a waiver from TSS and CBOD percent removal during periods of wet-weather flow. If NJDEP were to approve a NJPDES permit modification for a wet-weather percent removal waiver, using similar language to that shown above, PVSC is confident that the WWTP will meet its TSS and CBOD percent removal NJPDES permit limitations at all times.

4.9 Adverse Impacts

Provide an analysis of adverse impacts resulting from the use of the blending line.

Use of the blending line will allow up to 320 mgd of additional wet-weather flow to receive partial treatment (screening and grease/floatables removal, primary clarification and disinfection) prior to discharge. Adverse impacts from use of the blending line are thus expected to be non-existent, since blending will allow this additional wet-weather flow to receive partial treatment and disinfection as opposed to direct discharge of raw sewage through CSOs with no treatment. Use of the blending line will have a positive impact on water quality.

4.10 Regulatory Compliance

Demonstrate compliance with 33 U.S.C 1342(q)(1), 40 CFR 122.41(m), and N.J.A.C. 7:14A-11, Appendix C, II.C.7.

Both this report and the Hazen and Sawyer Report have demonstrated compliance with these regulations as follows:

- 33 U.S.C 1342(q)(1): This section of the Federal Clean Water Act requires that any permit, order or decree issued after December 21, 2000, for a discharge from a municipal combined storm and sanitary sewer shall conform with the National CSO Policy. The applicable sections of the National CSO Policy are discussed throughout the current section (Section 3) of this report. All requirements of this policy can be met by PVSC during blending at the WWTP.

- 40 CFR 122.41(m): This section of the federal rules refers to provisions that must be met in order to allow a bypass. Conformance with this regulation is discussed in Section 3.3 of this report.
- N.J.A.C. 7:14A-11, Appendix C, II.C.7: These State of New Jersey regulations are equivalent to the National CSO Policy. The applicable sections of that policy are discussed throughout the current section (Section 3) of this report. All requirements of this policy can be met by PVSC during blending at the WWTP.

4.11 SOPs for Interim Bypassing

Develop and submit to EPA (after consultation with NJDEP) SOPs for interim bypassing.

A Draft SOP for Secondary Bypass Operating Procedure is attached to this report, as Attachment 1.

4.12 NJPDES Monitor and Report Requirement

Address the requirement for PVSC to monitor and report chlorine residual, fecal coliform indicator, and estimated flow discharged for DSN002A which shall be included in the individual NJPDES permit modification issued by NJDEP.

PVSC has no objection to monitoring and reporting for these parameters, as required by EPA. PVSC shall provide this data on their monthly discharge monitoring reports, or such other format as NJDEP requires. It is anticipated that PVSC will estimate flow volume discharged utilizing influent flow information, and flow as measured utilizing a Parshall flume to be constructed in the primary clarifier effluent channel. Chlorine residual and fecal coliform values are anticipated to be sampled and reported similarly to the manner in which PVSC samples and reports them for DSN001A.

5.0 FREQUENCY FOR UTILIZATION OF BLENDING

Blending would be implemented when the flows exceed 400 mgd as a peak hourly flow at the effluent channel of the primary clarifiers. As explained in the Hazen and Sawyer Report, Section

4.2.2.1.1 (page 4-29), "Bypass piping would be installed from the primary effluent channel, upstream of the location where sludge recycles are returned, to carry flow to the final clarifiers effluent channel, where it would mix with secondary effluent and flow to disinfection and discharge."

Diversion of flow would be accomplished through the construction of a weir, designed to bypass flows in excess of 400 mgd. Based upon WWTP records, PVSC estimates peak hourly flows at the primary effluent channel may exceed 400 mgd for an approximate duration of 335 hours/year. This is equivalent to approximately 14 days/year or 1.2 days per month. PVSC estimates that on an annual average basis, blending will provide treatment for 1.4 billion gallons of wastewater that would otherwise flow through CSOs into waterways without treatment.

6.0 EFFLUENT QUALITY DURING BLENDING

As discussed in Section 3 above, it is anticipated that blending could occur, on average, about 1.2 days per month, during wet-weather events when peak hourly flows at the primary clarifier effluent channel exceed 400 mgd. Effluent permit limits for the PVSC WWTP include limits based on daily, weekly and monthly averaging periods. See the Hazen and Sawyer Report, Section 4.2.2.1.3 for a detailed analysis on the expected effluent quality for blended flows up to 320 mgd (for a total plant maximum discharge of 720 mgd).

The Hazen and Sawyer findings are summarized in Table 5 below.

Table 5: Calculated Blended Effluent Quality

Parameter	NJPDES Permit Limit		Calculated Blended Flow Value at 720 mgd	
	Weekly (mg/L)	Monthly (mg/L)	Weekly (mg/L)	Monthly (mg/L)
TSS	45	30	23 - 39 (range)	19 - 25 (range)
CBOD	40	25	24 - 36 (range)	17 - 19 (range)
Ammonia	78,400[1]	53,700[2]	45,156 - 68,437 (range)[1]	29,043 - 50,177 (range)[2]
Fecal Coliforms	400	200	<400	<200
pH	6 - 9 (range)		6 - 9 (range)	
DO	>3		>3	
Parameter	**Daily max (kg/d)**	**Monthly average (kg/d)**	**Daily max (kg/d)**	
Total Cyanide	255	120	50	
Nickel	262	150	39	
Zinc	1037	562	402	
Lead	300	162	44	
Copper	350	187	122	
Mercury	n/a	2.5	2	

[1] measurement in kg/day daily maximum
[2] measurement in kd/day monthly average

7.0 CONCLUSION

In conformance with its NJPDES permit and the National CSO Policy, PVSC has evaluated the use of blending (intentional bypass of secondary treatment system) in order to treat additional peak wet-weather flows that would otherwise be discharged from a CSO with no treatment. PVSC has obtained the services of Hazen and Sawyer and Kleinfelder to prepare a no feasible alternatives analysis that includes a detailed regulatory analysis, engineering and hydraulic evaluation of the current overall plant capacity as well as individual unit capacities for dry- and wet-weather flows. In addition, Hazen and Sawyer evaluated a number of treatment options available to expand the secondary capacity at the WWTP. The Hazen and Sawyer findings are detailed in the report entitled: "Passaic Valley Sewerage Commission, New Jersey-WWTP No Feasible Alternatives (NFA) Analysis December 2018."

Based on their evaluation, the individual treatment processes at the WWTP have a maximum wet-weather treatment capacity of at least 720 mgd, with the exception of the secondary clarifiers, which have a treatment capacity of 400 mgd. Hazen and Sawyer evaluated numerous options to expand the secondary treatment capacity at the WWTP, including:

- CEPT
- Secondary Bypass
- Step-Feed
- BioActiflo
- RAS Storage
- Rerouting Recycle Streams
- Structural Modifications
- Construction of additional secondary clarifiers

The results of the Hazen and Sawyer evaluation concluded that secondary bypass (blending), in conjunction with rerouting certain wastestreams (recycle from the gravity thickener, centrate and decant) to the primary clarifiers is the most cost-effective solution for treating additional peak wet-weather flows at the WWTP. The Hazen and Sawyer Report, together with this report, provide the technical and regulatory basis to demonstrate, on an interim basis prior to submission, approval and implementation of their LTCP, that no feasible alternative to the use of blending to treat peak wet-weather flows exists for PVSC.

PVSC can fully treat a maximum of 400 mgd of peak wet-weather flow, and has the potential to treat an additional 320 mgd of wet-weather flow through blending. If provided with a percent removal waiver in its NJPDES permit (similar to New York facilities), PVSC can treat 720 mgd of peak wet-weather flow through blending, while continuing to meet NJPDES permit effluent limitations and conditions.

Through blending, PVSC estimates that **an additional 1.4 billion gallons of peak wet-weather flow as measured on an annual average basis can be treated at the facility**. These flows are currently discharged with no treatment through CSOs present in the member municipalities.

PVSC understands that approval of blending at this time is an interim measure, and that NJDEP's approval of the PVSC final LTCP will govern future CSO operations at the WWTP.

Attachment 1

DRAFT Secondary Bypass Operating Procedure

DRAFT Secondary Bypass Operating Procedure

During wet-weather events only, influent flow to the plant above 400 mgd may pass through preliminary treatment, primary treatment, and disinfection, thereby bypassing secondary treatment. A bypass is used to accept flows in the treatment plant above 400 mgd and up to 720 mgd while maintaining compliance with PVSC's NJPDES permit treatment requirements and preventing washout of biomass from the FCs. Secondary bypass operation is prohibited to be activated in dry weather.

- Based upon the design of the bypass structure, a passive bypass or equivalent will be initiated when instantaneous flows to the plant are above 400 mgd
- The passive bypass of flow will automatically end when instantaneous flows to the plant are below 400 mgd
- After plant flows fall below 400 mgd, send a "Notification of Bypass Use" email to …
- Flow measurement of bypass flow will be provided as part of bypass system

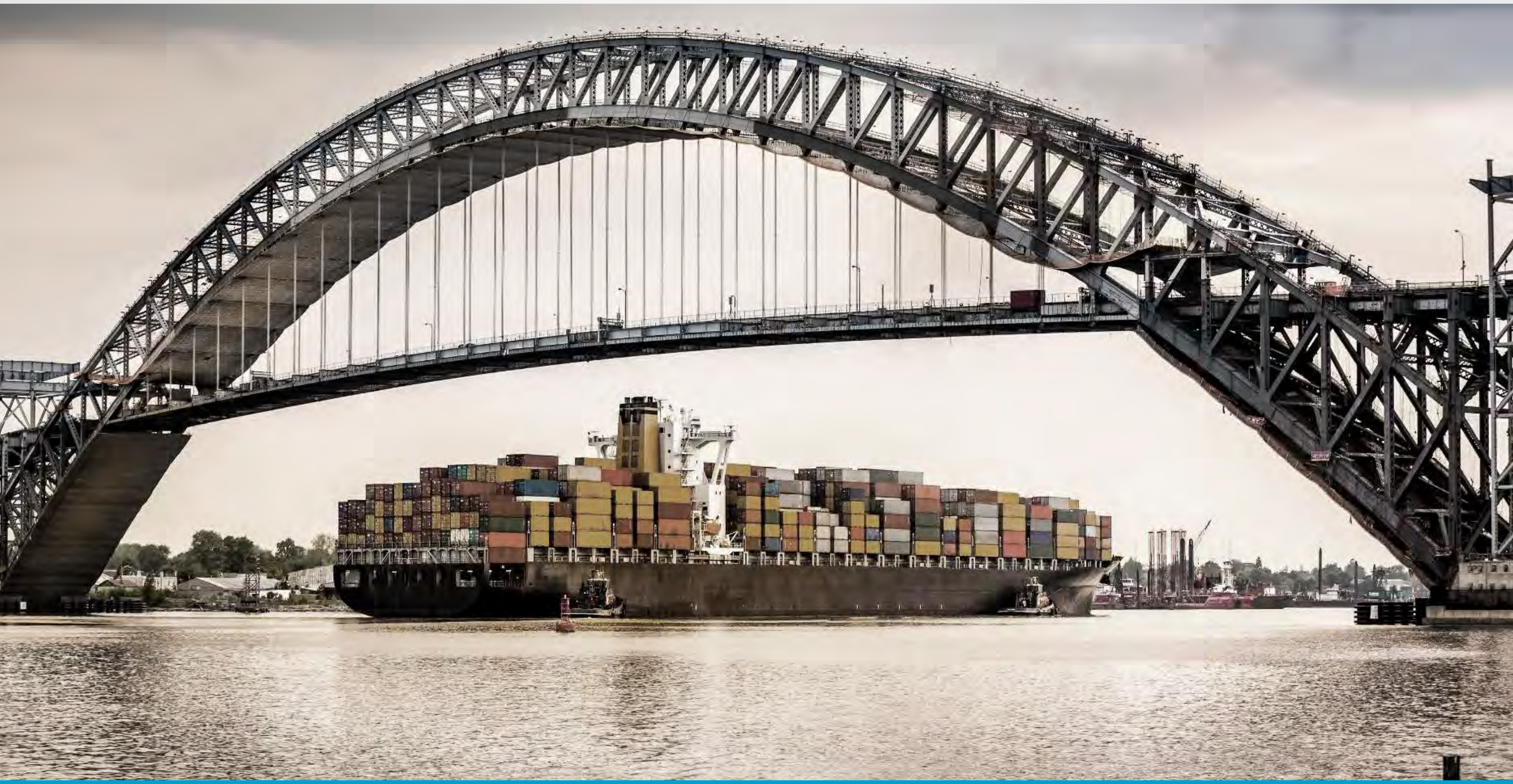
Note, this SOP is subject to change upon completion of design and construction

APPENDIX B

Development and Evaluation of Alternatives Report
City of Bayonne

Dated: June 2019
Revised: November 2019

PREPARED BY T&M ASSOCIATES
in collaboration with
HDR ENGINEERING, INC.



DEVELOPMENT & EVALUATION OF ALTERNATIVES

THE CITY OF BAYONNE | CSO LONG TERM CONTROL PLAN

Prepared on behalf of SUEZ

REVISED NOVEMBER 2019

JUNE 2019

TABLE OF CONTENTS

SECTION A – INTRODUCTION

A.1 INTRODUCTION

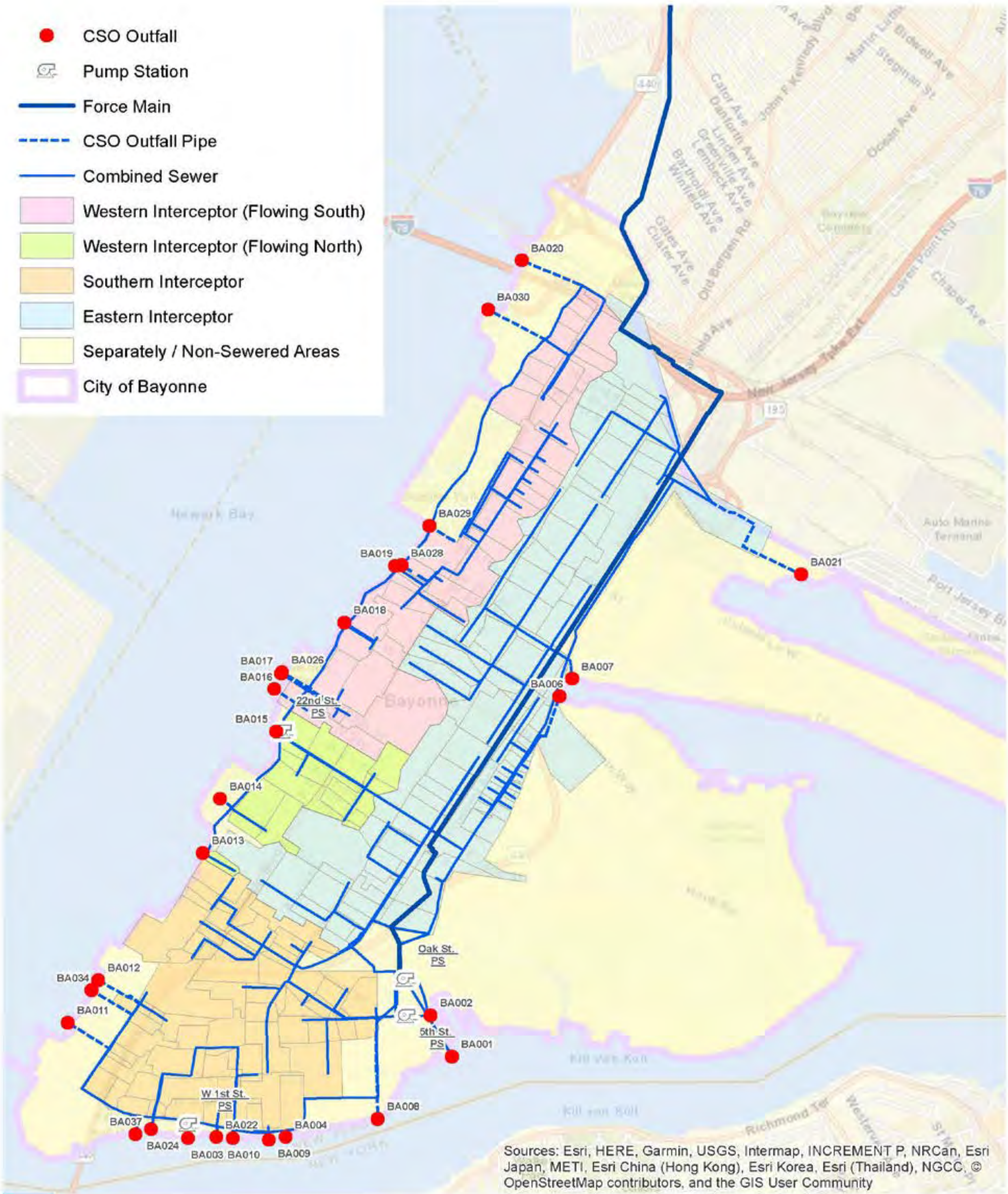
The City of Bayonne is a developed, urban community located in southern Hudson County across the Hudson River from New York City. The City encompasses an area of approximately five (5) square miles and is bordered by Jersey City to the north, Newark Bay to the west, the Kill Van Kull to the south, and the Upper New York Bay to the east. The City's combined sewer system (CSS), permitted under NJPDES Permit No. NJ0109240, is currently operated by SUEZ through a forty (40) year agreement established in December 2012 with United Water. While the City of Bayonne owns all the combined sewage collection, control and discharge facilities including pump stations, the City does not currently own any treatment facilities. Therefore, all combined sewer flows in the City that are conveyed to the Oak Street Pumping Station are transported to the Passaic Valley Sewer Commission (PVSC) wastewater treatment plant via a force main, parts of which the City wholly owns, and parts of which the City co-owns with the Jersey City Municipal Utility Authority (MUA) and the Kearny MUA. The flow from the force main enters directly into the primary treatment facility at the PVSC treatment plant in Newark, New Jersey. Under the City's existing service agreement with PVSC, wastewater flows from the City of Bayonne to the PVSC plant are restricted to an average daily flow of 11 MGD and a peak flow of 17.6 MGD. This, along with local and regional hydraulic constraints, limit the amount of flow that can be transported for treatment during the wet weather events, thus resulting in excess combined sewage being discharged into the receiving waters as Combined Sewer Overflows (CSOs). The City's CSS has twenty-eight (28) permitted outfalls through which CSOs may be discharged to receiving waters. Sixteen (16) of the outfalls discharge to Newark Bay, which is classified as Saline Estuary (SE3) waters; nine (9) outfalls discharge to the Kill Van Kull, which is also classified as Saline Estuary (SE3) waters; and three (3) outfalls discharge to Upper New York Bay (lower Hudson River), which is classified as Saline Estuary (SE2). These classifications of the receiving waters determine measures that are appropriate for the USEPA's long term CSO control goal. The Bayonne City's CSO outfalls and associated receiving waters are depicted in Figure A-1.

Through its CSO permit under the New Jersey Department of Environmental Protection (NJDEP), the City is required to cooperatively develop a CSO LTCP with PVSC and its hydraulically connected CSO permittees. Each permittee is required to develop all necessary information for the portion of the hydraulically connected system they own.

Section D.3.b.v of the City's NJPDES permit requires a "Development and Evaluation of CSO Control Alternatives report" to be submitted to the NJDEP within 48 months from the permit's effective date of July 1, 2015. To meet this requirement, the City has prepared this report describing the development and evaluation of CSO control measures. Evaluated alternatives are comprised of either a single CSO control measure, or a combination of control measures that will collectively address the water quality objectives for the waters receiving CSO discharges from the City of Bayonne. The report contains the following information:

- Future conditions for the LTCP Baseline (Section B)
- Screening of CSO Control Technologies (Section C)
- Alternative Analysis (Section D)

Figure A-1: Bayonne Outfall Location Map



SECTION B – FUTURE CONDITIONS

B.1 INTRODUCTION

Establishing future conditions analysis scenario is an important step in the LTCP process. Future conditions are used for baseline modeling to compare the effectiveness of CSO-control alternatives, and to predict whether proposed control alternatives would attain LTCP goals. A 25 to 30-year planning horizon is being assumed for implementation of the LTCP. To estimate the future sanitary sewage flow rates expected, this study considers available population projections and anticipated future development and redevelopment information as described in Section B.4.

B.2 PROJECTIONS FOR POPULATION GROWTH

The City of Bayonne is a densely developed urban municipality of 11.2 square miles in Hudson County, located just to the south of Jersey City on a peninsula between Newark Bay and the Hudson River. At one time, Bayonne was a major base of operations for Eastern Standard Oil (ESSO)/Exxon refineries. Indeed, ESSO/Exxon maintained operations in Bayonne from 1877 to approximately 1971. These operations peaked in 1936, and subsequently contracted as the result of economic factors and changes in the supply of crude oil. By approximately 1971, all operations ceased, and the refineries have since been removed.

Bayonne's historic population development is closely linked to the presence of ESSO/Exxon's refining operations. According to decennial census information of the US Census Bureau, the city's population grew significantly in the early part of the twentieth century and peaked with 88,979 residents at the time of the 1930 US Census. For much of the period since the 1930 US Census, however, the city's population contracted. By the time of the 1990 US Census, the city's population was just 61,444 residents, which represents a decline of 27,535 residents or 30.95 percent since the 1930 US Census.

Since the time of the 1990 US Census, there has been a slight rebound in the city's population. The US Census Bureau recorded a population of 63,024 residents in 2010, the most recent decennial census. Since then, the US Census Bureau estimates that the City's population has grown by about 4,162 to 67,186 residents in 2017.

Looking forward and given the fact that many redevelopments and new developments have been approved in Bayonne (see Section B.3), it is expected that the City's population will continue to grow. Tthe North Jersey Transportation Authority (NJTPA) has projected that Bayonne's 2045 population will increase to 70,939 residents.

B.3 PLANNED PROJECTS

The City has approved a number of commercial and residential developments, as presented in Table B-1. In total, these projects amount to over 4,500 new residential units. It is noted, however, that over the 5-year period from 2012 through 2016, the number of dwelling units *actually* created averaged only 68.8 annually.

TABLE B-1 CITY OF BAYONNE LIST OF PROPOSED DEVELOPMENTS

Application Number	Name	Street Number	Street Name	Hearing Date	Approved	Description	Total Residential Units
P-14-025	KAPLAN PROMENADE		AVENUE A AND WEST 1ST STREET	05.12.15	Y	MARINA CENTER, 250 CONDOS, 750 APARTMENTS, 60000 SQ FT OFFICE, 134,000 SQ FT RETAIL	1,000
P-18-008	19TH STREET REALTY LLC	197	AVENUE E	06.12.18	Y	10 STORY BUILDINGS WITH 125 UNITS AND 251 PARKING SPACES	125
P-18-008	19TH STREET REALTY LLC	197	AVENUE E	06.12.18	Y	10 STORY BUILDINGS WITH 125 UNITS AND 251 PARKING SPACES	
P-18-008	19TH STREET REALTY LLC	197	AVENUE E	06.12.18	Y	10 STORY BUILDINGS WITH 125 UNITS AND 251 PARKING SPACES	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	138
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-16-003	INGERMAN DEVELOPMENT		BROADWAY	03.08.16	Y	138 UNITS IN REDEVELOPMENT AREA	
P-17-019	VENCON DEVELOPERS	135	MEADOW STREET	12.12.17	Y	14 UNITS OVER PARKING	14
Z-18-016	VIVEK SINGH	234-236	AVENUE A			16 UNIT BOARDIGN HOUSE	16
P-15-019	26 NORTH STREET LLC	26	NORTH STREET	08.11.15	Y	170 RESIDENTIAL UNITS MIXED USE	170
P-16-046	PARKVIEW REALTY HOLDINGS		23RD AND 24TH AVENUE	01.04.17	Y	180 RESIDENTIAL UNITS AND 2900 SQ FT COMMERCIAL	180
P-16-046	PARKVIEW REALTY HOLDINGS		23RD AND 24TH AVENUE	01.04.17	Y	180 RESIDENTIAL UNITS AND 2900 SQ FT COMMERCIAL	
P-16-046	PARKVIEW REALTY HOLDINGS		23RD AND 24TH AVENUE	01.04.17	Y	180 RESIDENTIAL UNITS AND 2900 SQ FT COMMERCIAL	

(Table B-1 continued)

TABLE B-1 CITY OF BAYONNE LIST OF PROPOSED DEVELOPMENTS							
Application Number	Name	Street Number	Street Name	Hearing Date	Approved	Description	Total Residential Units
P-16-046	PARKVIEW REALTY HOLDINGS		23RD AND 24TH AVENUE	01.04.17	Y	180 RESIDENTIAL UNITS AND 2900 SQ FT COMMERCIAL	
P-16-046	PARKVIEW REALTY HOLDINGS		23RD AND 24TH AVENUE	01.04.17	Y	180 RESIDENTIAL UNITS AND 2900 SQ FT COMMERCIAL	
P-16-046	PARKVIEW REALTY HOLDINGS		23RD AND 24TH AVENUE	01.04.17	Y	180 RESIDENTIAL UNITS AND 2900 SQ FT COMMERCIAL	
P-16-025	BB BAYONNE LLC	138	AVENUE B	08.09.16	Y	24 UNITS, 24 PARKING SPACES	24
P-16-025	BB BAYONNE LLC	138	AVENUE B	08.09.16	Y	24 UNITS, 24 PARKING SPACES	
P-16-025	BB BAYONNE LLC	138	AVENUE B	08.09.16	Y	24 UNITS, 24 PARKING SPACES	
P-16-025	BB BAYONNE LLC	138	AVENUE B	08.09.16	Y	24 UNITS, 24 PARKING SPACES	
Z-17-030	128 JFK LLC	128	KENNEDY BLVD	03.19.18	Y	3 STORY 4 UNITS PARKING UNDER 4 SPACES	4
P-17-005	309 BROADWAY REALTY LLC	309	BROADWAY	06.13.17	Y	3 STORY 6 UNITS AND 6 PARKING SPACES	6
P-18-024	1031 BROADWAY LLC	1031	BROADWAY			3 STORY COMMERCIAL GROUND FLOOR AND 4 RESIDENTIAL	4
Z-17-009	258 BROADWAY LLC	258	BROADWAY	06.19.17	Y	3 STORY MIXED USE WITH 5 UNITS	5
P-18-023	673-675 AVENUE E	673-675	AVENUE E			3 STORY, 8 UNITS, 8 PARKING SPACES	8
P-16-042	FIRST DEVELOPERS LLC	295	BROADWAY	01.10.17	Y	4 UNITS OVER COMMERCIAL WITH 4 PARKING SPACES	4
P-16-037	JINCO INC	175	W 7TH STREET	12.13.16	Y	5 STORY 56 UNITS	56
P-18-010	BAYONNE REDEVELOPERS		HARBOR STATION	05.15.18		556 UNITS AND 835 PARKING SPACES	556
P-18-010	BAYONNE REDEVELOPERS		HARBOR STATION	05.15.18		556 UNITS AND 835 PARKING SPACES	
P-17-023	PIER VIEW LOFTS LLC AMENDED	676	AVENUE E	10.17.17	Y	AMENDED 5 STORY 71 UNITS	71
P-17-023	PIER VIEW LOFTS LLC AMENDED	676	AVENUE E	10.17.17	Y	AMENDED 5 STORY 71 UNITS	
P-16-013	230-250 AVENUE E LLC	230-250	AVENUE E	05.10.16	Y	AMENDED SITE PLAN (90 UNITS)	90
P-16-013	230-250 AVENUE E LLC	230-250	AVENUE E	05.10.16	Y	AMENDED SITE PLAN (90 UNITS)	

(Table B-1 continued)

TABLE B-1 CITY OF BAYONNE LIST OF PROPOSED DEVELOPMENTS							
Application Number	Name	Street Number	Street Name	Hearing Date	Approved	Description	Total Residential Units
P-16-013	230-250 AVENUE E LLC	230-250	AVENUE E	05.10.16	Y	AMENDED SITE PLAN (90 UNITS)	
P-16-013	230-250 AVENUE E LLC	230-250	AVENUE E	05.10.16	Y	AMENDED SITE PLAN (90 UNITS)	
P-18-020	KRE FLEET BAYONNE URBAN		HARBOR STATION	06.12.18	Y	AMENDED SITE PLAN (850 UNITS)	850
P-18-020	KRE FLEET BAYONNE URBAN		HARBOR STATION	06.12.18	Y	AMENDED SITE PLAN (850 UNITS)	
P-16-038	662 AVENUE C URBAN RENEWAL LLC	662	AVENUE C	09.13.16	Y	AMENDED SITE PLAN, 36 UNITS	36
P-18-001	ZM PROPERTIES LLC	31	W 8TH STREET			CONVERSION OF SECOND FLOOR TO RESIDENTIAL (2 UNITS)	2
Z-17-005	150-152 PROSPECT PARTNERS	150-152	PROSPECT AVENUE	04.17.17	Y	CONVERT FIRST FLOOR TO 2 UNITS	2
Z-17-005	150-152 PROSPECT PARTNERS	150-152	PROSPECT AVENUE	04.17.17	Y	CONVERT FIRST FLOOR TO 2 UNITS	
P-18-009	79-91 EAST 25 LLC	79-81	E 25TH STREET			CONVERT GROUND UNIT ONE 3 BEDROOM TO THREE 1 BEDROOM	4
P-15-023	PAULANTO DENTAL LLC	189	AVENUE E	12.08.15	Y	DENTAL OFFICE 18 UNITS	18
P-15-023	PAULANTO DENTAL LLC	189	AVENUE E	12.08.15	Y	DENTAL OFFICE 18 UNITS	
P-16-034	VIOLA MOORE	77	E 21ST STREET	11.10.16	Y	FIRE, REBUILD 6 FAMILY	6
Z-18-017	KFG REALTY LLC	502	BROADWAY			GROUND FLOOD COMMERCIAL AND 5 UNIT RESIDENTIAL IN 2ND STORY	5
P-16-032	RSB HOLDINGS LLC	424	AVENUE E	01.10.17	Y	GROUND FLOOR COMMERCIAL TO 2 RESIDENTIAL	2
P-17-015	49 COTTAGE STREET PARTNERS	49	COTTAGE STREET	09.00.17	Y	MINOR SUBDIVISION AND SITE PLAN 2 TWO FAMILY UNITS	4
P-18-022	JOHN AND MARYAN LLC	43-45	W 21ST STREET			MINOR SUBDIVISION TWO TWO FAMILY HOMES	
P-18-022	JOHN AND MARYAN LLC	43-45	W 21ST STREET			MINOR SUBDIVISION TWO TWO FAMILY HOMES	4
P-18-022	JOHN AND MARYAN LLC	43-45	W 21ST STREET			MINOR SUBDIVISION TWO TWO FAMILY HOMES	
P-18-021	JOHN AND MARYAN LLC	39-43	EVERGREEN			MINOR SUBDIVISION WITH 3 TWO FAMILY UNITS	6

(Table B-1 continued)

TABLE B-1 CITY OF BAYONNE LIST OF PROPOSED DEVELOPMENTS							
Application Number	Name	Street Number	Street Name	Hearing Date	Approved	Description	Total Residential Units
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	91
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-16-004	975 BROADWAY OWNER LLC	975	BROADWAY	04.06.16	Y	MULTI-FAMILY HIGH RISE (91 UNITS), GROUND FLOOR COMMERCIAL	
P-17-033	FAITHFUL HOME BAYONNE LLC	78-84	W 31ST STREET	01.09.18	Y	MINOR SUBDIVISION, 2 (2) FAMILY	4
Z-17-003	EXCEL AP LLC	36-38	E 22ND STREET	03.20.17	Y	MULTIFAMILY 20 UNITS	20
P-16-024	MADISON HILL PROPERTIES LLC	206	AVENUE E	06.27.16	Y	MULTISTORY MULTIFAMILY (70 UNITS)	70
P-16-024	MADISON HILL PROPERTIES LLC	206	AVENUE E	06.27.16	Y	MULTISTORY MULTIFAMILY (70 UNITS)	
P-17-002	FIRST DEVELOPERS LLC	439	AVENUE C	04.11.17	Y	OFFICE GROUND FLOOR 4 UNITS	4
Z-17-017	EOM 462 BROADWAY LLC	462	BROADWAY	08.21.17	Y	REHAB 10 NEW UNITS OVER RETAIL	10
Z-17-017	EOM 462 BROADWAY LLC	462	BROADWAY	08.21.17	Y	REHAB 10 NEW UNITS OVER RETAIL	
Z-17-017	EOM 462 BROADWAY LLC	462	BROADWAY	08.21.17	Y	REHAB 10 NEW UNITS OVER RETAIL	
Z-17-015	EOM 516 BROADWAY LLC	516	BROADWAY	08.21.17	Y	REHAB 8 UNITS	8

(Table B-1 continued)

TABLE B-1 CITY OF BAYONNE LIST OF PROPOSED DEVELOPMENTS							
Application Number	Name	Street Number	Street Name	Hearing Date	Approved	Description	Total Residential Units
Unknown-3	MAHALAXMI BAYONNE LLC		HARBOR STATION	07.11.17	Y	RESIDENTIAL (97 UNITS); GROUND FLOOR RETAIL	97
P-17-009	BAYONNE BAY DEVELOPERS					RESIDENTIAL (560 UNITS)	560
P-17-009	BAYONNE BAY DEVELOPERS					RESIDENTIAL (560 UNITS)	
P-17-009	BAYONNE BAY DEVELOPERS					RESIDENTIAL (560 UNITS)	
P-17-031	HUDSON PROPERTY HOLDINGS	43-43	W 49TH STREET	05.08.18	Y	SUBDIVISION, 4 LOTS, 2 FAMILY	8
P-17-031	HUDSON PROPERTY HOLDINGS	43-43	W 49TH STREET	05.08.18	Y	SUBDIVISION, 4 LOTS, 2 FAMILY	
P-17-031	HUDSON PROPERTY HOLDINGS	43-43	W 49TH STREET	05.08.18	Y	SUBDIVISION, 4 LOTS, 2 FAMILY	
P-17-031	HUDSON PROPERTY HOLDINGS	43-43	W 49TH STREET	05.08.18	Y	SUBDIVISION, 4 LOTS, 2 FAMILY	
Z-17-004	DINA SOBERAL	137	W 15TH STREET	03.20.17	Y	THREE FAMILY	3
Unknown-1	ST JOSEPHS PROPERTY	306	AVENUE E	05.08.18	Y	TWO SEVEN STORY RESIDENTIAL BUILDINGS (162 UNITS TOTAL)	162
Unknown-1	ST JOSEPHS PROPERTY	306	AVENUE E	05.08.18	Y	TWO SEVEN STORY RESIDENTIAL BUILDINGS (162 UNITS TOTAL)	
P-17-016	MYK BUILDERS, LLC	123	W 12TH STREET	10.10.17	N	TWO FAMILY MINIOR SUBDIVISION	4
P-17-001	536 BROADWAY PARTNERSHIP	536	BROADWAY	05.09.17	Y	VACANT LOTS. 4 UNITS OVER COMMERCIAL 3 STORY	4
P-16-044	NORTH STREET PROPERTIES LLC	105.5	NORTH STREET	01.10.17	Y	6 STORY WITH 68 UNITS	68
P-16-044	NORTH STREET PROPERTIES LLC	105.5	NORTH STREET	01.10.17	Y	6 STORY WITH 68 UNITS	
Z-18-003	PR BUILDERS LLC	82-84	E 31ST STREET	04.16.18	Y	6 UNIT APARTMENT	6
P-17-014	BAYONNE EQUITIES LLC	477	BROADWAY	07.11.17	Y	72 UNITS AND 7676 RETAIL	72
P-17-014	BAYONNE EQUITIES LLC	477	BROADWAY	07.11.17	Y	72 UNITS AND 7676 RETAIL	
Z-15-022	BAYONNE BLANKET 444 AVENUE C	444	AVENUE C	07.18.16	Y	8 TOTAL UNITS	8

(Table B-1 continued)

TABLE B-1 CITY OF BAYONNE LIST OF PROPOSED DEVELOPMENTS							
Application Number	Name	Street Number	Street Name	Hearing Date	Approved	Description	Total Residential Units
Z-15-022	BAYONNE BLANKET 444 AVENUE C	444	AVENUE C	07.18.16	Y	8 TOTAL UNITS	
Z-17-019	29 8TH STREET BAYONNE LLC	29	W 8TH STREET	09.18.17	Y	9 UNITS OVER COMMERCIAL	
Z-17-019	29 8TH STREET BAYONNE LLC	29	W 8TH STREET	09.18.17	Y	9 UNITS OVER COMMERCIAL	
Z-17-019	29 8TH STREET BAYONNE LLC	29	W 8TH STREET	09.18.17	Y	9 UNITS OVER COMMERCIAL	
Z-17-019	29 8TH STREET BAYONNE LLC	29	W 8TH STREET	09.18.17	Y	9 UNITS OVER COMMERCIAL	
Z-17-019	29 8TH STREET BAYONNE LLC	29	W 8TH STREET	09.18.17	Y	9 UNITS OVER COMMERCIAL	
Z-17-019	29 8TH STREET BAYONNE LLC	29	W 8TH STREET	09.18.17	Y	9 UNITS OVER COMMERCIAL	
						Total	**4,618**

B.4 PROJECTED FUTURE WASTEWATER FLOWS

The future baseline condition is intended to reflect the magnitude and geographic distribution of the anticipated sanitary sewage flow rates. To estimate the sanitary flow rates for the year 2045 planning horizon, the projected population increases (see Section B.2) are applied with existing per-capita sanitary flow rates, based on observed 2016/2017 measured flows and year 2017 population estimates. This calculation represents an increase in dry-weather, sanitary sewage flow of about 6.7% relative to the observed 2016/2017 dry-weather flows.

In order to properly account for where the increased sanitary flow will enter the City's CSS, this analysis adjusted the existing geographic distribution to account for the location, type, and size of known new and anticipated developments (per Section B.3). For new residential developments, this analysis assumed an average household size of 2.3 members (2010, USCB). For new commercial developments, this analysis applied typical wastewater flow rates provided in the NJDEP Division of Water Quality Water Pollution Control rules (N.J.A.C 7:14A-23.3). For modeling inputs, the flow from each commercial development was added in terms of an equivalent population, based on the per-capita flow rates, in the model subcatchment corresponding to the location of development.

This analysis assumed no change in existing infiltration rates affecting base wastewater flows for the future baseline condition, or equivalently, that any future increases in infiltration will be offset by future base-flow reduction efforts. Similarly, this analysis assumed no change in effective ground-surface imperviousness associated with new developments.

SECTION C – SCREENING OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

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

As part of the screening process, each CSO control technology was evaluated for its effectiveness to achieve the following goals: 1) achieving water quality standards and designated uses of the receiving waters, 2) reducing pollutant-of-concern discharges, 3) reducing CSO-discharge frequency, 4) reducing CSO-discharge volumes. Other considerations in the evaluation of CSO-control technologies included implementation requirements (land, neighborhood, noise, disruption) and operational factors.

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

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

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

C.2 SOURCE CONTROL

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

As presented in Table C-1 (see Section C.9), source control technologies can involve Stormwater Management, Public Education, Ordinance Enforcement, Good Housekeeping, and Green Infrastructure (GI). NJSPDES permit recommends evaluation of the practical and technical feasibility of GI options as part of the alternatives development process. The City of Bayonne has identified GI application as a viable source control measure that can provide ancillary environmental and public benefits.

C.2.1 Green Infrastructure

Green Infrastructure (GI) refers to a host of source control approaches that can reduce and treat rainfall runoff prior to its entry into the CSS. GI approaches typically intercept rainfall runoff with soil media and plants to eliminate or attenuate volumes and pollutants through absorption, infiltration, and evapo-transpiration. Many GI approaches can also deliver ancillary environmental, social, and economic benefits 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 however, generally does not provide the same level of volume or bacteria reduction as gray solutions.

GI can be used alone or in conjunction with other types of CSO 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 Bayonne, where they may not be as practical as traditional "gray infrastructure" approaches in providing reliable, stand-alone solutions. Nevertheless, GI approaches are being featured in CSO LTCP programs for a number of municipalities, including New York City and the City of Philadelphia. GI is being evaluated in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control.

A previous study, "*Green Infrastructure Feasibility Study, Bayonne,"* prepared by Rutgers University, identified possible locations for GI opportunities in the City. The realistic potentials of GI opportunities and approaches will be further refined in the alternative evaluation with the associated benefits and concerns in mind. The City's citizen education and support services will continue to promote localized GI on a homeowner scale as a program enhancement.

C.3 INFILTRATION AND INFLOW CONTROL

Infiltration and inflow in excessive amounts can increase operations and maintenance costs and consume hydraulic capacity, both in the collection system and at the treatment facility. "Infiltration" refers to the intrusion of ground water into the collection system through defective pipe joints, cracked or broken pipes, manholes, footing drains, and other similar sources. In the context of CSS, which is designed to accept stormwater, "inflow" refers to *illicit* entry of flow from streams, tidal sources, or catch basins and similar structures in supposedly "separated" areas that are connected to the CSS.

Infiltration problems are typically reflect a general overall deterioration of the sewer system and can be difficult to isolate and identify. Identification of infiltration sources is difficult and requires specialized equipment. Achieving significant reductions of infiltration can be difficult and expensive. A March 2007 study, *"CSO Long Term Control Plan Cost & Performance Analyis Report, Vol. 1"* by Hatch Mott MacDonald (2007, HMM), concluded that the level of infiltration in Bayonne's CSS is non-excessive under the N.J.A.C. 7:14A rules. Based on the results of that study and dry-weather flow measaurements in 2016/2017, infiltration in Bayonne is deemed non-excessive. Threfore, infiltration control will not be a cost-effective measure.

Inflow control can reduce the volume of infiltration flow and frequency and can provide additional capacity for future growth. Surface runoff is the primary source of inflow into a combined sewer system. It can enter the CSS through roof drains, manhole covers, cross connections from storm sewers, and catch basins. Genrally, a diversion of inflow sources to separate storm drains can be cost effective if the storm drains are already in place. Due to the fact that Bayonne's collection system is primarily a combined sewer system, any redirection of inflows associated with storm water is not possible without a significant investment. Inflow control in Bayonne's CSS would focus primarily on potential tidal inflows, as the separated catchments do not contribute stormwater to the CSS, and there are no known or suspected stream inflows to the CSS. Tidal inflows to the CSS can be identified via measurement of chlorides and controlled at reasonable cost by replacement or proper maintaince of flex valves and tide gates at the existing CSO control falilites. HMM 2007 study reported non-excessive inflows under the N.J.A.C. 7:14A rules. The report also concluded no evidence of tidal impact at the time of evaluation.

In light of the above discussion, Infiltration and Inflow control will not be considered further in the alternatives development. However, investigation and control of tidal inflow will be retained as a program enhancement to protect against future increases of CSO.

C.4 SEWER SYSTEM OPTIMIZATION

Sewer system optimization reduces CSO volume and frequency by maximizing the volume of flow stored in the collection system or maximizing the use of system capacity to convey flow to a treatment facility. Techniques used for sewer system optimization include improving conveyance, implementing regulator modifications, consolidating or relocating outfalls, and applying real-time controls to minimize CSO frequency/volume or the number/cost of control facilities.

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

Regulator Modifications: Existing regulator structures can sometimes be modified, based on site specific conditions, by adjusting weir elevations or length to take advantage of upstream "in-line" pipe storage, or by adjusting elevations of piping to maximize flow to the interceptor and treatment facility. Regulator modification will be included in the alternatives evaluation.

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

Real Time Control (RTC): RTC provides integrated control for regulators, outfall gates, and pump station operations based on anticipated conditions, with feedback loops for control adjustments based on actual conditions within the system. RTC typically involves an automated monitoring and control system that operates control devices (such as gates or pump stations) to maximize the storage capacity of the CSS and to limit overflows. This measure may involve installation of numerous mechanical and electrical control devices and require specialized operational capacities. RTC can only be effective in reducing CSO volumes where in-line storage capacity is available in the system, which generally exists in a CSS with relatively flat upstream slopes. According to a prior study (2007, HMM), there is not much in-line storage available in the Bayonne CSS due a relatively steep topography and high pipe slopes. As such, this measure has been identified as a complementary technology to be reviewed in combination with primary technologies in the alternatives evaluation process.

C.5 STORAGE

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

Pipeline Storage: Additional in-line storage to retain wet weather excess flows can be created by the construction of new larger size pipes in place of, or parallel to existing combined sewers. Pipeline has the advantage of requiring a smaller construction area than a point storage. However, it could take significant lengths of piping to provide adequate storage if a smaller diameter is used. Pipelines typically require large open trenches and temporary closure of streets to install, which could create significant public disruptions. One of the principles that govern storage with larger size pipes is to assure a minimum slope. According to a prior report (2007, HMM), in-line storage using large pipe sizes was investigated, but the option was rejected due to various factors including existing pipe inverts, slope requirements and utility congestions in the areas of considerations.

The use of pipeline storage is a cost-effective method for reducing combined sewer overflows if you can maximize the use of available storage volume already existing within the CSS. This is not feasible at Bayonne based on a prior study (2007, HMM). The study concluded that there was little, if any, available storage within the CSS because of pipe sizes and slope.

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

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

Tank Storage: The most prevalent form of offline storage of combined sewer flows is to install storage tanks at or near the CSO outfalls or pump stations so that the storage can consolidate flows conveyed within the collection system from upstream locations. This type of facility can be relatively simple in design and operation and can effectively reduce the frequency of overflows. Tanks can capture the most concentrated first flush portion of wet weather peak flow and help to reduce the capacity needs for conveyance and treatment. Additionally, storage tanks can be used for providing contact time for disinfecting the effluent during larger events, depending upon the application needs. Note that Bayonne can use its abandoned primary treatment tank of approximately 3.5 MG volume to store excess combined sewer flows. This tank, including additional storage tanks that will be needed as well, will be further evaluated as one of primary technologies for CSO control in Bayonne.

C.6 STP EXPANSION OR STORAGE AT THE PLANT

Expansion of a sewage treatment plant (STP) can help to reduce or eliminate CSOs by allowing more flows into the plant. The City of Bayonne transports combined sewer flows to the PVSC STP via a long force main, parts of which are jointly owned with the Jersey City MUA and the Kearny MUA. According to the City's current contract with PVSC, the maximum rate of combined sewer flow from Bayonne shall not exceed 17.6 MGD. As indicated in Section C.4, PVSC is considering modifications to their treatment facilities to be able to accept additional wet weather flows. While all dry weather flows from the City of Bayonne are conveyed to PVSC, local and regional hydraulic constraints can limit the amount of additional flow above the contracted amount that can be conveyed for treatment. Also, negotiations would have to be undertaken with the Jersey City MUA and Kearny MUA to construct joint facilities which would primarily be led by the parties' interests. Due to these facts, it would likely be less intricate and more cost effective if local storage (e.g tunnel, tank) is considered, rather than conveying the full peak flow of Bayonne to PVSC for treatment. Since Bayonne currently neither owns nor operates a wastewater treatment facility, STP expansion or modification for wet weather flow treatment or storage would not apply and subsequently it has been removed from further consideration.

C.7 SEWER SEPARATION

Wet weather peaks and consequently the risk of combined sewer overflows can be eliminated or reduced by complete or partial removal of stormwater connections from the CSS, a process called "sewer separation." This process typically involves the construction of new storm sewers to convey stormwater directly to the receiving water, leaving the existing combined sewers to convey sanitary sewage and any remaining stormwater inputs. During the sewer separation process, storm water inputs such as catch basin inlets, roof leaders, sump pumps, etc. must be redirected to the new storm sewers. On the other hand, if new separate sanitary sewers are installed, the existing sanitary laterals must be redirected to the new separate sanitary. This CSO control technique may also require modification to the other elements of the existing infrastructure such as manholes, regulators and outfalls. Sewer separation can be disruptive to the neighborhood, especially in a densely developed urban environment. Sewer separation at Bayonne was previously found to represent the most expensive CSO-control alternative (2007, HMM). Also, there is a potential that future Municipal Separate Storm Sewer (MS4) permits may require treatment of the separated storm stormwater prior to discharge in the future. Despite these facts, sewer separation is a primary technology that would completely eliminate CSOs. Therefore, the previous cost evaluation (2007, HMM) will be used for a comparison with the tunnel and tank storage options.

C.8 TREATMENT OF CSO DISCHARGE

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

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

The U.S. EPA approved peracetic acid (PAA) as a primary disinfectant for wastewater in 2007. A growing number of wastewater treatment plants in the United States have adopted PAA as a primary disinfectant. Several case studies applying PAA for CSO treatment have been undertaken in the US, including a demonstration study (HMM, 2017) 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. However, it is understood that the residual toxicity and PAA disinfection operations at CSO facilities is not fully known. The main advantages of PAA over sodium hypochlorite include a longer “shelf life” without product deterioration, which is 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.

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

C.9 SCREENING OF CONTROL TECHNOLOGIES

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

- **High** – Technologies that will have a significant (≥ 65%) impact on the CSO control goal and are among the best technologies available to achieve that goal. Therefore, they may be considered for further evaluation.
- **Medium** – Technologies that are somewhat effective at achieving the CSO-control goal (35-65%), but are not considered among the most effective technologies to achieve that goal.

- **Low** – Technologies that will have a minor impact (≤ 35%) on this CSO-control goal. Therefore, they will need other positive attributes to be considered for further evaluation.
- **None** –Technology that will have zero or negative effect on the CSO control goals.

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

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

As indicated in Section C-1, technologies not recommended due various reasons such as cost, maintenance, public acceptance, etc. are removed from consideration. The results of the CSO control technologies screening process are summarized in Table C-1 below. The columns at the right indicate the current status of each technology, whether or not the technology is suitable to be combined with others, and whether or not the technology is being evaluated further (in Section D).

Table C-1 CSO Control Technology Screening Results

CITY OF BAYONNE

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

(Table C-1 continued)

Table C-1 CSO Control Technology Screening Results

CITY OF BAYONNE

TECHNOLOGY GROUP	PRACTICE	PRIMARY GOALS		COMMUNITY BENEFIT	IMPLEMENTATION AND OPERATION FACTORS	CONSIDER COMBINING W/ OTHER TECHNOLOGIES	BEING IMPLEMENTED	RECOMMENDATION FOR ALTERNATIVES EVALUATION
		BACTERIA REDUCTION	VOLUME REDUCTION					
	Hazardous Waste Collection	Low	None	- Water quality improvements	The N.J.A.C. prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	No
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	- Cost-effective water quality improvements	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if Permittee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.	Yes	Yes	No
	Illegal Dumping Control	Low	None	- Water quality improvements - Aesthetic benefits	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes	Yes	No
	Pet Waste Control	Medium	None	- Water quality improvements - Reduced surface flooding	Requires resources to enforce pet waste ordinances. Public education and outreach is a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes	Yes	No
	Litter Control	None	None	- Property value uplift - Water quality improvements - Reduced surface flooding	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach is a more efficient use of resources.	Yes		
	Illicit Connection Control	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	Yes	No
Good Housekeeping	Street Sweeping/Flushing	Low	None	- Reduced surface flooding potential	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	No
	Leaf Collection	Low	None	- Reduced surface flooding potential - Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	No
	Recycling Programs	None	None	- Align with goals for a sustainable community	Most Cities have an ongoing recycling program.	Yes	Yes	No
	Storage/Loading/Unloading Areas	None	None	- Water quality improvements	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	No	No
	Industrial Spill Control	Low	None	- Protect surface waters - Protect public health	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	No

(Table C-1 continued)

Table C-1 CSO Control Technology Screening Results

CITY OF BAYONNE

TECHNOLOGY GROUP	PRACTICE	PRIMARY GOALS		COMMUNITY BENEFIT	IMPLEMENTATION AND OPERATION FACTORS	CONSIDER COMBINING W/ OTHER TECHNOLOGIES	BEING IMPLEMENTED	RECOMMENDATION FOR ALTERNATIVES EVALUATION
		BACTERIA REDUCTION	VOLUME REDUCTION					
Green Infrastructure Buildings	Green Roofs	None	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	No
	Blue Roofs	None	Medium	- Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	No
	Rainwater Harvesting	None	Medium	- Reduced surface flooding- Reduced basement sewage flooding- Align with goals for a sustainable community- Water Saving	Simple to install and operate; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	Yes	Yes
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Cost-effective water quality improvements - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	No	Yes
	Planter Boxes	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes

(Table C-1 continued)

Table C-1 CSO Control Technology Screening Results

CITY OF BAYONNE

TECHNOLOGY GROUP	PRACTICE	PRIMARY GOALS		COMMUNITY BENEFIT	IMPLEMENTATION AND OPERATION FACTORS	CONSIDER COMBINING W/ OTHER TECHNOLOGIES	BEING IMPLEMENTED	RECOMMENDATION FOR ALTERNATIVES EVALUATION
		BACTERIA REDUCTION	VOLUME REDUCTION					
Green Infrastructure Pervious Areas	Bioswales	Low	Low	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community - Increased pedestrian safety through curb retrofits	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	No	Yes
Green Infrastructure Pervious Areas	Free-Form Rain Gardens	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes
Collection System Technologies								
Operation and Maintenance	I/I Reduction	Low	Medium	- Water quality improvements - Reduced basement sewage flooding	Requires labor intensive work; changes to the conveyance system require temporary pumping measures; repairs on private property required by homeowners. Reduces the volume of flow and frequency; Provides additional capacity for future growth; House laterals account for 1/2 the sewer system length and significant sources of I/I in the sanitary sewer.	Yes	No	Yes (tidal inflows)
Operation and Maintenance	Advanced System Inspection & Maintenance	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	Yes	No
Operation and Maintenance	Combined Sewer Flushing	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	Yes	No

(Table C-1 continued)

Table C-1 CSO Control Technology Screening Results

CITY OF BAYONNE

TECHNOLOGY GROUP	PRACTICE	PRIMARY GOALS		COMMUNITY BENEFIT	IMPLEMENTATION AND OPERATION FACTORS	CONSIDER COMBINING W/ OTHER TECHNOLOGIES	BEING IMPLEMENTED	RECOMMENDATION FOR ALTERNATIVES EVALUATION
		BACTERIA REDUCTION	VOLUME REDUCTION					
	Catch Basin Cleaning	Low	None	- Water quality improvements - Reduced surface flooding	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	Yes	No
Combined Sewer Separation	Roof Leader Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; Includes area drains and roof leaders; new storm sewers may be required; requires home and business owner participation. The Cities are densely populated and disconnected roof leaders have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	No
	Sump Pump Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The Cities are densely populated and disconnected sump pumps have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	No
	Combined Sewer Separation	High	High	- Water quality improvements - Reduced basement sewage flooding - Reduced surface flooding	Very disruptive to affected areas; requires homeowner participation; sewer asset renewal achieved at the same time; labor intensive.	No	No	No
Combined Sewer Optimization	Additional Conveyance	High	High	- Water quality improvements - Reduced basement sewage flooding	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	No	Yes
	Regulator Modifications	Medium	Medium	- Water quality improvements	Relatively easy to implement with existing regulators; mechanical controls requires O&M. May increase risk of upstream flooding. Permitees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	No	Yes
	Outfall Consolidation/Relocation	High	High	- Water quality improvements - Passive and active recreational improvements	Lower operational requirements; may reduce permitting/monitoring; can be used in conjunction with storage & treatment technologies. Combining and relocating outfalls may lower operating costs and CSO flows. It can also direct flow away from specific areas.	Yes	Yes	Yes
	Real Time Control	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires periodic inspection of flow elements; highly automated system; increased potential for sewer backups. RTC is only effective if additional storage capacity is present in the system.	Yes	No	Yes
Storage & Treatment Technology								
Linear Storage	Pipeline	High	High	- Water quality improvements - Reduced surface flooding potential - Local jobs	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	No	No
	Tunnel	High	High	- Water quality improvements - Reduced surface flooding potential	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	No	Yes

(Table C-1 continued)

Table C-1 CSO Control Technology Screening Results

CITY OF BAYONNE

TECHNOLOGY GROUP	PRACTICE	PRIMARY GOALS		COMMUNITY BENEFIT	IMPLEMENTATION AND OPERATION FACTORS	CONSIDER COMBINING W/ OTHER TECHNOLOGIES	BEING IMPLEMENTED	RECOMMENDATION FOR ALTERNATIVES EVALUATION
		BACTERIA REDUCTION	VOLUME REDUCTION					
Point Storage	Tank (Above or Below Ground)	High	High	- Water quality improvements - Reduced basement sewage flooding	Storage tanks typically require pumps to return wet weather flow to the system which will require additional O&M; disruptive to affected areas during construction. Several CSO outfalls have space available for tank storage. There may be existing tanks in abandoned commercial and industrial areas to be converted to hold stormwater. Tanks are an effective technology to reduce wet weather CSO's.	No	No	Yes
	Industrial Discharge Detention	Low	Low	- Water quality improvements	Requires cooperation with industrial users; more resources devoted to enforcement; depends on IUs to maintain storage basins. IUs hold stormwater or combined sewage until wet weather flows subside; there may be commercial or industrial users upstream of CSO regulators.	Yes	No	No
Treatment-CSO Facility	Vortex Separators	None	None	- Water quality improvements	Space required; challenging controls for intermittent and highly variable wet weather flows. Vortex separators would remove floatables and suspended solids when installed. It does not address volume, bacteria or BOD.	Yes	No	No
	Screens and Trash Racks	None	None	- Water quality improvements	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	Yes	No
	Netting	None	None	- Water quality improvements	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	No
	Contaminant Booms	None	None	- Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	No
	Baffles	None	None	- Water quality improvements	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	Yes	No	No
	Disinfection & Satellite Treatment	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	Yes
	High Rate Physical/ Chemical Treatment (High Rate Clarification Process - ActiFlo)	None	None	- Water quality improvements	Challenging controls for intermittent and highly variable wet weather flows; smaller footprint than conventional methods. This technology primarily focuses on TSS & BOD removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
	High Rate Physical (Fuzzy Filters)	None	None	- Water quality improvements	Relatively low O&M requirements; smaller footprint than traditional filtration methods. This technology primarily focuses on TSS removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No
Treatment-WRTP	Additional Treatment Capacity	High	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	May require additional space; increased O&M burden.	No	No	No
	Wet Weather Blending	Low	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	No
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	No

SECTION D – ALTERNATIVE ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

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

D.1.1 Siting

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

Facilities siting in this evaluation is preliminary in nature and based on space requirements. Other considerations have in mind are a buffer for roadways and accessibility and potential conflicts with existing utilities, highways, and local streets.

D.1.2 Institutional Issues

Institutional constraints include matters related to political issues, public opinion, and other non-technical factors that could impact project approval. Institutional and political factors can influence CSO control projects because such projects are generally funded by taxpayers or sewer ratepayers. The general public must be convinced that the proposed project is cost-effective and for the public good, so that potential for the public rejection is minimized. This is important to support the fundraising needed for implementation of the project. The City has continued raising public awareness about the LTCP project through ongoing public participation activities, as stressed in the NJPDES permit, and US EPA policy and related guidance for the LTCP. It is to be noted that the City is a densely developed urban municipality with poverty levels well above the state average, and the City's 2012 contract with United Water (currently SUEZ) was primarily triggered by existing debt and the investment needs for the water and sewer systems. Therefore, it is acknowledged that negotiations among politicians, institutions, and other stakeholders and interested parties are necessary to ensure that CSO-control measures are technically, financially, and politically feasible for Bayonne. Budgetary constraints of the permittee and indirectly, constituent rate payers are not explicitly considered in this analysis. While certain alternatives may provide measurable benefit within other evaluation criteria, it may be the case that overall costs prove to be prohibitive to implement those alternatives.

D.1.3 Implementability

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

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

Consideration of alternatives achieving zero CSO discharge to sensitive areas is a requirement in the evaluation of the CSO-control alternatives. In collaboration with City, PVSC submitted an "*Identification of Sensitive Areas Report*" to NJDEP in June 2018. This report, which NJDEP accepted in a letter dated April 8, 2019, identified no sensitive areas within the City's receiving waters. As such, this alternatives evaluation does not consider achievement of zero CSO discharges to any of the City's receiving waters.

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

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

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

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

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

D.1.4 Public Acceptance

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

PVSC has held quarterly regional Supplemental CSO team public meetings over the course of the LTCP development effort. In addition, the City assembled a local supplemental CSO team to discuss the LTCP and Bayonne’s efforts under the NJPDES permit. These local meetings were held in conjunction with the PVSC’s regional Supplemental CSO team meetings. The details of the public participation process and the associated outreach program activities have been documented in the January 2019 revision of the Public Participation Process Report submitted to NJDEP.

Thus far, the regional Supplemental CSO team public meetings have continued being held and the supplemental CSO teams’ members have been encouraged to provide feedback on further LTCP development milestone deliverables, including the Development and Evaluation of Alternatives. In this regard, the City of Bayonne has encouraged public participation at their Alternative Evaluation Workshop held on December 11, 2018 where two members from the local supplemental CSO group, who are also involved with the Bayonne Water Guardians, attended the workshop conducted at the office of SUEZ, Bayonne. Further the City has presented its CSO alternatives evaluation approach in tandem with other permittees at the March 7, 2019 regional supplemental CSO pubic meeting (Session -11) held at the NJTPA's conference room. The majority of comments received thus far have been verbal comments, some of which are related to application of GI. To date, the City of Bayonne has not received any comments on any of the draft LTCP submittals provided to the supplemental CSO team members for review and feedback. It is anticipated that Bayonne will present the results of alternatives evaluation in one additional regional supplemental CSO team public meeting to discuss and address public comments in the NJDEP submittal, as it would be necessary.

D.1.5 Performance Considerations

CSO controls must, when implemented, provide the required performance results relative to the CSO control objectives. The ability of a candidate control alternative to achieve performance objectives is of primary importance to the evaluation process. The US EPA's CSO Policy requires CSO permittees to evaluate alternatives for a reasonable range of control to reduce or eliminate CSO discharges, with the ultimate goal that receiving waters attain applicable water-quality standards and support designated uses of the waterbodies that receive the CSO discharges. EPA describes two approaches toward that goal: a "Presumptive Approach" and a "Demonstration Approach." The Presumptive Approach focuses on reductions of CSO discharges, while the Demonstration Approach focuses on the water quality.

~~Bayonne's CSOs discharge to waterbodies that meet existing water quality standards. As such, CSO control in Bayonne is already in a state to potentially qualify for the "Demonstration Approach". Nevertheless, ~~T~~t~~his alternatives evaluation is analyzing performance metrics associated with "Presumptive Approach" reductions of CSO discharges. However, Bayonne may consider the "Demonstration Approach" during final Alternative Selection if analyses verify that water quality standards can be met effectively with different control levels than indicated under the Presumptive Approach.

D.1.5.1 Performance Metrics

Presumption Approach performance analyses consider if and how alternatives can achieve a range of CSO control goals, such as number of CSO events per year, capture of combined sewage, or reduction of pathogen discharges. The performance metrics for these goals are described in more detail below.

Frequency of CSO Events: The US EPA CSO Control Policy refers to the frequency of "CSO events" that occur in a typical hydrologic year as one performance metric. Specifically, this "CSO events" metric refers to the number of rainfall events that cause an overflow at one or more locations from the CSS, 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:

- Twenty (20) overflow events
- Twelve (12) overflow events

- Eight (8) overflow events
- Four (4) overflow events
- Zero (0) overflow events

Capture of Combined Sewage for Treatment: The US EPA CSO Control Policy defines another performance metric as the capture of combined sewage volumes for treatment. Expressed as a percentage of the total combined sewage generated during wet weather on an annual basis, this metric refers to the degree to which volumes of combined sewage are captured for treatment, versus overflow. US EPA indicates that attainment of 85 percent capture is typically sufficient for receiving waterbodies to meet water-quality standards. Accordingly, the performance objective associated with this metric is 85 percent volume capture of combined sewage.

~~PVSC (2019a, PVC) has~~ It was determined that Bayonne and the other Hudson County communities of North Bergen and Jersey City must reduce CSO volume by 59 percent (see Regional DEAR Section C.1.1) in order to achieve the 85% volume capture performance metric. For Bayonne, a 59 percent reduction equates to an allowable CSO discharge of 306 MG per year, down from the Baseline CSO discharge of 748 MG per year.

Removal of Pollutants of Concern: The US EPA CSO Control Policy defines the removal of pollutants as another performance metric for CSO control. US EPA indicates that removing pollutants of concern to the same degree as would be removed through 85 percent capture of combined sewage volume is typically sufficient for receiving waterbodies to meet water-quality standards. Accordingly, the performance objective associated with this metric is removal of pathogens to a level *equivalent to* the capture of 85 percent of the combined sewage volume noted above.

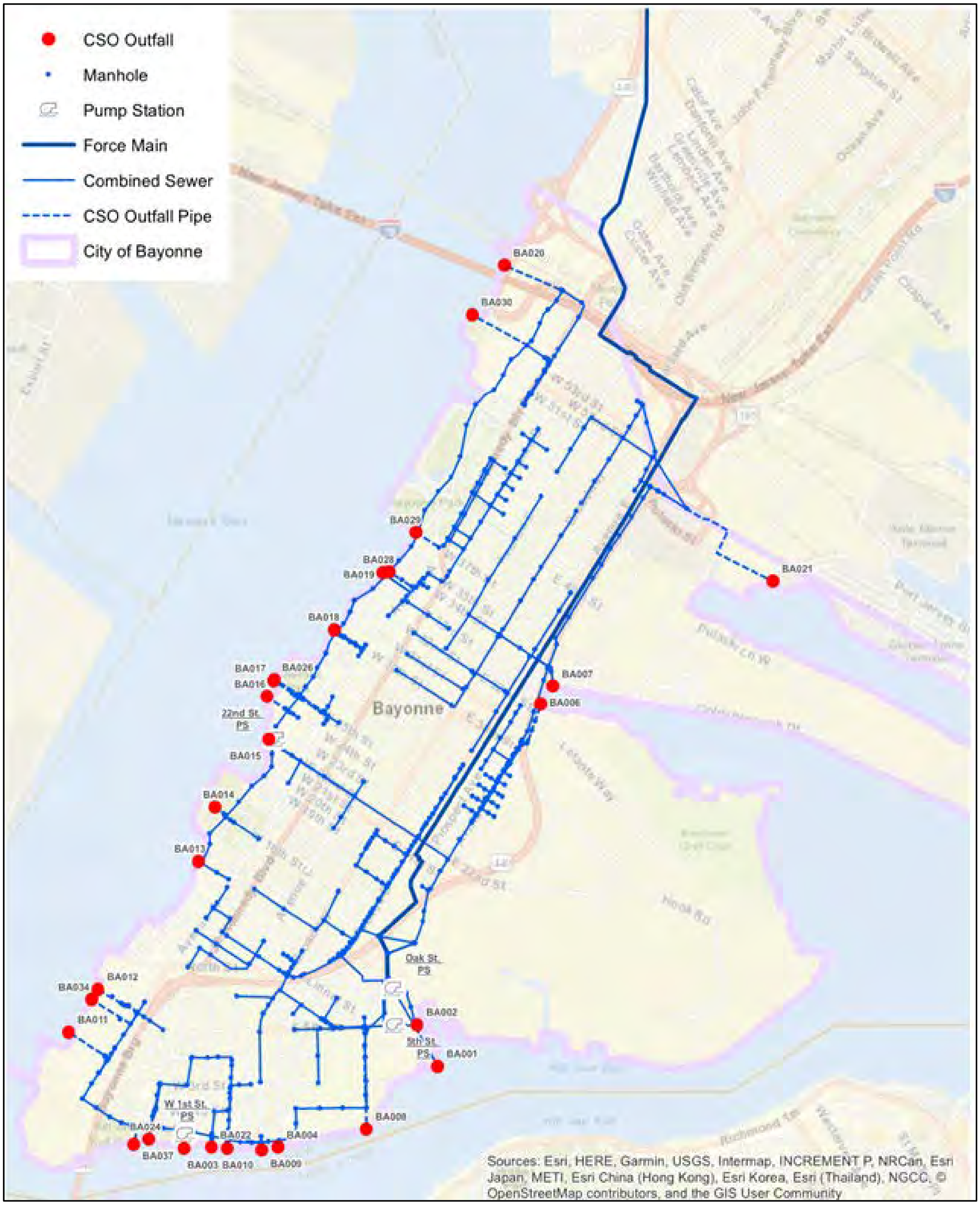
For Bayonne, a 59 percent reduction of pathogens would provide the equivalent reduction to a 59 percent reduction in untreated CSO volume, assuming that pathogen concentrations typically align with the event-mean concentration. This is a conservative assumption when implementing many CSO-control alternatives, such as storage, if the initial portion of an overflow event is fully captured and the later portion of the event bypasses the storage facility. Treatment alternatives can also implement chemical dosing based on “first flush” concentrations to ensure sufficient pathogen removal.

D.1.5.2 Assessment of Performance Metrics

A calibrated hydrologic/hydraulic (H&H) model of the CSS can be a powerful tool when evaluating and comparing the performance of proposed CSO-control alternatives. An H&H model simulates the expected performance of the CSS under hypothetical conditions, such as a design storm or with certain proposed CSO-control in place. A properly calibrated H&H model can determine each of the metrics listed above, as well as other relevant information, such as risk of flooding of basements or streets. The H&H model applied in this study is described in prior reports associated with the current study (2019, PVSC). Figure D-1 presents a map of the major sewer-system elements that comprise the Bayonne model.

For the purposes of evaluating performance of various alternatives, the model must employ certain conditions in all model simulations so that the results can be compared to each other. 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 (2018b, PVSC). Second, model simulations must reflect conditions during the 2045 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.

Figure D-1: Bayonne Combined Sewer System Model Elements



D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

Section C described the screening of CSO control technologies performed to identify measures for further evaluation. This section presents those evaluations for each of the following technologies identified in Section C:

- Water Conservation
- Green Infrastructure
- Additional Conveyance
- Sewer Separation (complete)
- Regulator Modifications (including Real Time Control)
- Outfall Consolidation / Relocation
- Storage (including in-line, off-line tanks, off-line tunnels, and a regional tunnel)
- Disinfection

D.2.1 Water Conservation

Water conservation can reduce sanitary flow in the collection system, thereby increasing the conveyance capacity available during wet weather. To evaluate the potential impact of water conservation in the City, analyses assume a 10% reduction of base (sanitary dry-weather) flows. As presented in Table D-1, modeling analyses indicate that such a reduction in base flows would reduce annual CSO volume by about 10 MG (1.3%) and would have no impact on the CSO-event count.

Due to the minimal impact of water conservation on CSO-event frequency and volume, this analysis focuses on other control technologies with more significant impacts.

Table D-1 | Impacts of Water Conservation for CSO Control Objectives

Outfall	CSO Event Frequency (CSO Events/yr)		CSO Volume (MG/yr)	
	Baseline	10% Water Conservation	Baseline	10% Water Conservation
BA001	52	51	380.0	373.3
BA002	10	10	12.0	12.0
BA003	24	24	6.9	6.8
BA004	4	4	0.2	0.2
BA006	38	37	12.3	12.2
BA007	32	32	55.7	55.3
BA008	18	18	5.9	5.8
BA009	25	24	3.1	3.1
BA010	31	31	15.3	15.2
BA011	32	32	5.1	5.1
BA012	37	37	11.5	11.5
BA013	17	17	0.5	0.5
BA014	32	32	13.2	13.2
BA015	46	46	45.4	45.0
BA016	32	31	5.7	5.6
BA017	54	54	51.9	51.1
BA018	45	45	13.7	13.6
BA019	31	31	34.9	34.6
BA020	30	30	9.6	9.5
BA021	42	41	53.0	52.6
BA022	0	0	0.0	0.0
BA024	7	7	0.4	0.4
BA026	8	8	1.3	1.3
BA028	1	1	0.0	0.0
BA029	24	24	7.4	7.4
BA030	14	14	1.6	1.5
BA034	7	7	0.2	0.2
BA037	8	8	1.1	1.1
Total	**60**	**60**	**748.0**	**738.1**
Reduction[1]		**0.0%**		**1.3%**

(1) Reduction indicates reduction of total as a percentage from Baseline.

D.2.2 Green Infrastructure

In order to evaluate the potential impact of widespread implementation of Green Infrastructure (GI), modeling analyses were applied to quantify the reduction from Baseline of CSO count and volume resulting from two different levels of GI-implementation. The first level of GI implementation involves elimination of runoff from the first inch of rainfall falling on 5% of the impervious surfaces in Bayonne, and the second involves elimination of runoff from the first inch of rainfall on 10% of the impervious surfaces. These two control levels represent what has been found to be reasonably achievable, and what was initially targeted, respectively, given efforts to successfully site and install GI projects in New York City. While these achievable levels are consistent with anecdotal reports from other municipalities, GI implementability can vary depending on site availability, specific site characteristics, and performance goals.

Impervious surfaces (including rooftops, streets, sidewalks, parking lots) in Bayonne cover approximately 1,000 acres. Table D-2 summarizes the results of modeling to determine the impacts of GI. Compared to Baseline, control of runoff from 5% of the impervious area (or ~50 acres) reduces CSO volumes by about 25 MG (~3.4%), and decreases the CSO-event count by 1 (<2%). Control of runoff from 10% of the impervious area (or ~100 acres) reduces CSO volumes by 50 MG (~6.7%), and decreases the CSO-event count by 1 (that is, no further decrease in CSO-event count from the 5% control level).

Because GI can achieve relatively small reductions of CSO frequency and volume that fall short of desired performance objectives on its own, GI is considered a “complementary” solution. Specific GI applications will be evaluated in combination with other alternatives during development of the final selected alternatives.

Table D-2 | Impact on CSO Discharges of GI to Control Runoff from First Inch of Rain on 5% and 10% of Impervious Area

Outfall	CSO Events (count/yr)			CSO Volume (MG/yr)		
	Baseline	GI for 5% of Impervious Area	GI for 10% of Impervious Area	Baseline	GI for 5% of Impervious Area	GI for 10% of Impervious Area
BA001	52	52	51	380.0	368.1	356.2
BA002	10	9	9	12.0	11.6	11.2
BA003	24	24	24	6.9	6.5	6.3
BA004	4	4	4	0.2	0.2	0.2
BA006	38	37	35	12.3	11.8	11.4
BA007	32	31	31	55.7	53.6	51.6
BA008	18	18	17	5.9	5.6	5.3
BA009	25	23	23	3.1	2.9	2.8
BA010	31	31	31	15.3	14.8	14.2
BA011	32	32	32	5.1	4.9	4.7
BA012	37	36	34	11.5	11.1	10.7
BA013	17	15	14	0.5	0.5	0.4
BA014	32	32	32	13.2	12.8	12.4
BA015	46	45	44	45.4	43.8	42.2
BA016	32	31	30	5.7	5.4	5.3
BA017	54	53	53	51.9	50.3	48.6
BA018	45	44	44	13.7	13.2	12.7
BA019	31	31	31	34.9	33.6	32.3
BA020	30	29	28	9.6	9.2	8.8
BA021	42	41	38	53.0	51.4	49.7
BA022	0	0	0	0.0	0.0	0.0
BA024	7	7	7	0.4	0.4	0.4
BA026	8	8	7	1.3	1.2	1.1
BA028	1	1	1	0.0	0.0	0.0
BA029	24	23	23	7.4	7.0	6.7
BA030	14	14	14	1.6	1.5	1.4
BA034	7	7	5	0.2	0.2	0.2
BA037	8	8	8	1.1	1.1	1.1
Total	**60**	**59**	**59**	**748.0**	**722.8**	**697.8**
Reduction[1]		**1.7%**	**1.7%**		**3.4%**	**6.7%**

(1) Reduction indicates reduction of total as a percentage from Baseline.

D.2.3 Additional Conveyance of Wastewater

Increasing the conveyance of wastewater to the STP can reduce overflows from the CSS. The City is currently under agreement (1986, PVSC) to limit the peak wastewater flow rate that it can send to PVSC for treatment to 17.6 MGD from the Oak Street Pump Station. Although the nominal capacity of the Oak Street Pump Station is 40 MGD, analyses indicate that undersized portions of about 7 miles of the City's force main limit its hydraulic capacity.

This analysis evaluated the impact of two increased conveyance levels on CSO discharges.. Conveying 20 MGD represents the maximum possible flow rate through Bayonne's existing force main in order to maintain velocities of less than 10 feet per second, irrespective of capacities further downstream to PVSC's facilities. Conveying 40 MGD represents the maximum possible flow rate if all undersized segments of the force main (including about 4,400 feet of 24-inch diameter pipe and about 1,600 feet of 30-inch diameter pipe) were upsized to 36 inches to match the rest of the force main.

As shown in Tables D-3 and D-4, results of the modeling analyses indicate that increasing the peak conveyance rate to 20 MGD, the impact on the frequency and volume of CSO events would be minor. Increasing the peak conveyance rate to 40 MGD would reduce CSO volumes by over 30%, but would not reduce CSOevent frequencies, which are driven by outfalls that are independent of hydraulics at the Oak Street Pump Station.

Table D-3 | Impact of Increased Conveyance Capacity on CSO-Event Frequency

CSO Outfall	CSO-Event Frequency (count/yr) by Outfall for Conveyance Scenarios		
	Baseline Conveyance[1] (17.6 MGD)	Increased Conveyance[1] (20 MGD)	Increased Conveyance[1] (40 MGD)
BA001	52	50	34
BA002	10	10	9
BA003	24	24	22
BA004	4	4	3
BA006	38	36	34
BA007	32	32	32
BA008	18	18	12
BA009	25	24	24
BA010	31	31	27
BA011	32	32	32
BA012	37	37	37
BA013	17	17	17
BA014	32	32	32
BA015	46	46	46
BA016	32	32	31
BA017	54	54	54
BA018	45	45	45
BA019	31	31	31
BA020	30	30	30
BA021	42	41	42
BA022	0	0	0
BA024	7	7	7
BA026	8	8	8
BA028	1	1	1
BA029	24	24	24
BA030	14	14	14
BA034	7	7	7
BA037	8	8	8
Total[2]	**60**	**60**	**60**
Reduction[3]		**0%**	**0%**

(1) Conveyance capacity refers to maximum flow diversion to PVSC from Oak Street Pump Station.
(2) Total represents City-wide value. Individual outfalls may not discharge during the same CSO events, so City-wide count does not necessarily equal maximum count of individual outfalls.
(3) Reduction indicates reduction of total as a percentage from Baseline.

Table D-4 | Impact of Increased Conveyance Capacity on CSO Volume

CSO Outfall	CSO Volume (MG/yr) by Outfall for Conveyance Scenarios		
	Baseline Conveyance[1] (17.6 MGD)	Increased Conveyance[1] (20 MGD)	Increased Conveyance[1] (40 MGD)
BA001	380.0	348.3	170.2
BA002	12.0	11.9	10.6
BA003	6.9	6.7	5.4
BA004	0.2	0.2	0.1
BA006	12.3	11.9	9.2
BA007	55.7	55.0	50.6
BA008	5.9	5.3	2.6
BA009	3.1	3.0	2.7
BA010	15.3	14.9	11.5
BA011	5.1	5.1	5.0
BA012	11.5	11.5	11.5
BA013	0.5	0.5	0.5
BA014	13.2	13.2	13.2
BA015	45.4	45.4	45.4
BA016	5.7	5.7	5.7
BA017	51.9	51.9	51.9
BA018	13.7	13.7	13.7
BA019	34.9	34.9	34.9
BA020	9.6	9.6	9.6
BA021	53.0	52.8	51.5
BA022	0.0	0.0	0.0
BA024	0.4	0.4	0.4
BA026	1.3	1.3	1.3
BA028	0.0	0.0	0.0
BA029	7.4	7.4	7.4
BA030	1.6	1.5	1.5
BA034	0.2	0.2	0.2
BA037	1.1	1.1	1.0
Total[2]	**748.0**	**713.7**	**517.8**
Reduction[3]		**4.6%**	**30.8%**

(1) Conveyance capacity refers to maximum flow diversion to PVSC from Oak Street Pump Station.
(2) Total indicates City-wide value.
(3) Reduction indicates total as a percentage from Baseline.

D.2.4 Sewer Separation

Sewer separation has been considered in the past as a means to eliminate the occurrence of CSO in the City. A prior study (2007, HMM) investigated how complete separation of the existing combined sewer might be best achieved. That study suggested complete separation could be achieved by installing new sanitary sewers connected to the existing interceptors, rerouting the appropriate private connections into the new sanitary sewers, and plugging regulator connections draining to the interceptor. The analysis assumed that private service laterals connect via collector sewers rather than directly to an interceptor, and that the interceptors have adequate conveyance capacity (reasonable, as they already transport all sanitary flows), and that all existing pipes are in satisfactory condition. Newly installed sanitary sewers would connect to existing interceptors to convey flows to the Oak Street Pump Station and then to PVSC's STP for treatment. Stormwater entering the former combined sewers would be conveyed via the former regulator structures (after disconnection from the interceptors) to discharge through existing outfalls to receiving water.

Complete separation of combined sewers would eliminate CSOs. However, to the extent that the existing CSS captures stormwater, separation would increase discharges of stormwater. Stormwater discharges from municipal separate stormwater sewers are subject to current and future MS4 permitting requirements.

D.2.5 Regulator Modifications

Regulator modifications were evaluated to assess the potential for utilizing in-line storage to reduce CSO discharges. For the purposes of this evaluation, the potential impact of raising weir-crest elevations by 6 inches at existing regulators. The idea behind low-cost action is that it could enable more of the volume in the pipes upstream of each regulator to store combined sewage within the system, rather than to allow that volume to overflow. However, H&H model results show raising regulator weirs did not change CSO-event counts and only slightly changed the CSO volume (~0.1%), primarily re-distributing CSO to other outfalls. More importantly, raising weirs increased water levels within the CSS, which in turn can increase the possibility of flooding basements or streets. Although adjustable weirs controlled via telemetered sensors and Real Time Control could be used to mitigate the risks of such flooding, the minor potential benefits do not warrant the additional expense and risk of such measures.

These results confirm the findings of prior studies (2007, HMM) that little if any in-line storage is available in the City's CSS, due to the pipe sizes and slopes (see Section C.5). Because of these findings, regulator modifications for in-line storage will not be evaluated further.

D.2.6 Outfall Consolidation/Relocation

Outfall consolidation/relocation can sometimes be applied to reduce the number of outfall locations, CSO events, and/or CSO discharges to certain areas. This analysis considers outfall consolidation/relocation in combination with other alternatives, such as off-line storage tanks and tunnels. Outfall consolidation/relocation is discussed as applicable in those sections, which follow.

D.2.7 Storage

Storage technologies prevent CSO discharges by detaining combined sewage until such time that available capacity for conveyance in the CSS and treatment at the PVSC STP. As such, storage technologies are evaluated based upon the performance objectives related to the volume and frequency of CSO discharges.

Two forms of storage technology are evaluated: in-line and off-line storage. In-line storage typically drains back passively as capacity in the CSS becomes available. Off-line storage typically requires pumping to dewater some or all of the stored volume back into the CSS when capacity becomes available.

In-Line Storage: The potential for in-line storage is described above under Regulator Modifications. Due to insufficient available storage capacity, in-line storage was not found to represent a viable CSO-control alternative in Bayonne.

Off-line Storage Tanks: Off-line storage tanks are typically constructed below grade to take advantage of gravity to fill the tanks rather than to rely on pumping, which would need to be sized to keep up with the highly variable inflows during wet weather; dewatering can be accomplished over longer periods of time up to three days, to avoid septic conditions (2019b, G&H) and therefore can involve lower-capacity pumps. Below-grade facilities can also have a reduced visible impact, and can provide opportunities for other above-grade uses, such as parking facilities or recreational fields.

In addition to the above-mentioned requirement that off-line storage facilities be dewatered within three days, dewatering cannot cause the City's total wastewater flow rate to exceed hydraulic or contracted limits. According to an existing agreement with PVSC, the City can send wastewater to PVSC's treatment facilities at a peak rate of no more than 17.6 MGD (1986, PVSC). Based on its diameter, the existing Bayonne force main is hydraulically limited to approximately 20 MGD (2018, HDR). Replacement of approximately 6,000 linear feet of the force main would be required to bring its entire length up to a consistent diameter of 36 inches, as necessary to hydraulically convey up to about 40 MGD. As described below, all of these conveyance rates are considered in the evaluation of off-line storage facilities.

The sizing of storage tank facilities to meet performance objectives is based upon continuous model simulations to account not only for the volume of CSO to be captured during each CSO event, but also whether or not stored volumes can be dewatered prior to the next CSO event in order to avoid tank overflow. Results of the modeling analyses provide tank-overflow frequency and volume for a given tank capacity.

Storage Tanks at Individual Outfalls: Table D-5 summarizes the results of an initial set of modeling analyses performed to determine tank sizes required to achieve each CSO-frequency target (20, 12, 8 and 4 per year) at each outfall, without regard to available capacity of the CSS for dewatering of any particular tank. However, modeling analyses indicate that, given the dewatering limitations described above, only the 20 CSO-event/yr performance objective can be met on a City-wide basis with the current pumping limitation of 17.6 MGD at the Oak Street Pump Station. Assuming that the hydraulically possible rate of 20 MGD at the Oak Street Pump Station would be allowed, the 12 CSO-Event/yr performance objective could also be met on a City-wide basis. More stringent performance objectives, such as the 8- and 4 CSO events/yr targets, would require a conveyance capacity of 40 MGD from the Oak Street pump station and its force main, with a possible need for capacity improvement within other portions of the collection system.

Table D-5 | Off-Line Storage Tank Sizes Required at Individual Outfalls to Achieve CSO-Frequency Goals

	Off-Line Storage Tank Volumes (MG) Required at Individual Outfalls to Achieve CSO-Event Goals, by Outfall[1]			
Outfall	**20 CSO Events/year**	**12 CSO Events/year**	**8 CSO Events/year**	**4 CSO Events/year**
BA001[2]	13.0	18.6	21.6	22.3
BA002	0.3	0.9	1.7	1.7
BA003	0.3	0.3	0.3	0.5
BA004	0.0	0.0	0.0	0.0
BA006	0.8	0.8	0.8	0.8
BA007	1.9	2.2	3.0	3.3
BA008	0.2	0.4	0.6	0.8
BA009	0.1	0.2	0.2	0.2
BA010	0.3	0.7	1.0	1.1
BA011	0.2	0.2	0.3	0.3
BA012	0.4	0.5	0.6	0.6
BA013	0.0	0.0	0.0	0.0
BA014	0.3	0.4	0.6	0.7
BA015	1.0	1.5	2.1	2.1
BA016	0.1	0.3	0.4	0.4
BA017	1.4	2.1	2.6	2.6
BA018	0.3	0.5	0.6	0.0
BA019	1.0	1.0	1.5	2.1
BA020	0.4	0.4	0.5	0.7
BA021	0.9	1.8	2.5	3.0
BA022	0.0	0.0	0.0	0.0
BA024	0.0	0.0	0.1	0.1
BA026	0.0	0.2	0.2	0.2
BA028	0.0	0.0	0.0	0.0
BA029	0.4	0.5	0.7	0.7
BA030	0.1	0.2	0.2	0.2
BA034	0.0	0.0	0.0	0.0
BA037	0.0	0.1	0.1	0.2
Total	**23.5**	**33.8**	**42.4**	**44.8**

(1) Zero values indicate performance metric is already being met.

(2) About 3.5 MG of existing tankage is available at the former Bayonne wastewater treatment plant at Oak Street.

D.2.8 Storage Tanks at Consolidated Locations

Recognizing the operational and financial benefits of consolidating nearby tanks to reduce the number of storage facilities, a preliminary analysis was performed to optimize the number and size of storage tanks necessary to achieve performance objectives. This optimization applied Optimatics™ software to the balance between the cost savings of having fewer tanks versus the additional cost of conveyance infrastructure required to transport wastewater from existing overflow locations to more distant tank locations. The results of the analyses indicate that consolidating off-line storage tanks to nine (9) sites, as shown in Figure D-2, represents an optimal number and location of storage facilities. Table D-6 shows which outfalls would be consolidated, the consolidated outfall name, and the name of the closest existing outfall to the consolidated outfall (as referenced in the H&H model). Preliminary tank storage volumes for each of the frequency targets (20, 12, 8, and 4 events per year) are presented in Table D-7 for the consolidated outfall locations. In the subsequent CSO count and overflow tabulations (Tables D-8 and D-9), results for the consolidated outfalls are shown for the closest existing outfall (reference Table D-6) for comparison to the Baseline model results. Due to the dewatering constraints previously stated, achieving fewer than 12 CSO events per year requires extensive upgrades of the force main to enable wastewater pumping flow rates, as described for the conveyance alternative.

Figure D-2: Consolidated Off-Line Storage Tank Locations

Table D-6 | Existing and Consolidated Outfalls for Storage Tank Alternatives

Consolidated Outfall Name	Nearest Existing Outfall	Consolidated Outfalls
F_ST_01	BA017	BA016, BA017, B018, BA019, BA026, BA028
F_ST_02	BA029	BA029, BA030
F_ST_03	BA020	BA020
F_ST_04	BA007	BA006, BA007
F_ST_05	BA015	BA013, BA014, BA015
F_ST_06	BA022	BA003, BA004, BA009, BA010, BA022, BA024, BA037
F_ST_07	BA011	BA011, BA012, BA034
F_ST_08	BA021	BA021
F_ST_09	BA001	BA001, BA002, BA008

Note : Refer to Figure D-2 for tank and outfall locations.

Table D-7 | Size of Consolidated Storage Tanks Required to Achieve Targeted CSO-Event Frequency

Outfall[1]	Consolidated Off-Line Storage Tank Volume (MG) Required to Achieve CSO-Event Frequency, by Location			
	20 CSO Events/year	12 CSO Events/year	8 CSO Events/year	4 CSO Events/year
ST_01	3.0	4.1	5.4	5.4
ST_02	0.4	1.1	1.0	1.9
ST_03	0.2	0.6	0.6	1.0
ST_04	6.8	7.4	10.2	10.8
ST_05	1.0	1.5	1.7	1.9
ST_06	1.5	1.6	2.3	2.7
ST_07	0.5	0.8	0.8	1.3
ST_08	1.2	2.1	2.1	3.3
ST_09	4.9	7.7	13.8	13.8
Existing Tank OSPS	3.5	3.5	3.5	3.5
Citywide Total	**22.8**	**30.5**	**41.5**	**45.6**

(1) Refer to Figure D-2 for tank and outfall locations.
(2) Approximately 3.5 MG of storage tankage is available at the former Bayonne wastewater treatment plant at Oak Street.

Table D-8 | Annual CSO-Event Frequency by Outfall for Consolidated Tank Storage Alternatives

CSO Outfall	CSO-Event Frequency (count/yr) by Outfall with Consolidated Storage Tanks to Achieve:				
	Baseline	20 CSO Events/yr[1]	12 CSO Events/yr[2]	8 CSO Events/yr[3]	4 CSO Events/yr[3]
BA001	52	14	7	1	1.0
BA002	10	*	*	*	*
BA003	24	*	*	*	*
BA004	4	*	*	*	*
BA006	38	*	*	*	*
BA007	32	12	12	2	1.0
BA008	18	*	*	*	*
BA009	25	*	*	*	*
BA010	31	*	*	*	*
BA011	32	10	4	4	0.0
BA012	37	*	*	*	*
BA013	17	*	*	*	*
BA014	32	*	*	*	*
BA015	46	17	9	5	2.0
BA016	32	*	*	*	*
BA017	54	11	10	4	4.0
BA018	45	*	*	*	*
BA019	31	*	*	*	*
BA020	30	9	2	1	0.0
BA021	42	10	5	5	2.0
BA022	0	13	10	2	2.0
BA024	7	*	*	*	*
BA026	8	*	*	*	*
BA028	1	*	*	*	*
BA029	24	9	4	3	1.0
BA030	14	*	*	*	*
BA034	7	*	*	*	*
BA037	8	*	*	*	*
Total[4]	**60**	**19**	**12**	**7**	**4**
Reduction[5]		**68%**	**80%**	**88%**	**93%**

(*) Indicates outfall consolidation per Table D-6.
(1) 20 CSO-events/yr can be achieved with existing 17.6 MGD peak flow at Oak Street PS.
(2) 12 CSO-events/yr can be achieved with upgrade to 20.0 MGD at Oak Street PS.
(3) 8 and 4 CSO-events/yr can be achieved with upgrade to 40.0 MGD at Oak Street PS.
(4) Total indicates City-wide values. Outfalls do not necessarily overflow during the same storms, so the city-wide values do not necessarily equal the highest frequency outfall.
(5) Reduction indicates CSO-event frequency reduction as a percentage from Baseline.

Table D-9 | Annual CSO Volume by Outfall for Consolidated Tank Storage Alternatives

CSO Outfall	CSO Volume (MG/yr) by Outfall with Consolidated Storage Tanks to Achieve:				
	Baseline	20 CSO Events/yr[1]	12 CSO Events/yr[2]	8 CSO Events/yr[3]	4 CSO Events/yr[3]
BA001	380.0	62.6	26.5	0.2	0.1
BA002	12.0	*	*	*	*
BA003	6.9	*	*	*	*
BA004	0.2	*	*	*	*
BA006	12.3	*	*	*	*
BA007	55.7	41.1	35.6	9.3	8.3
BA008	5.9	*	*	*	*
BA009	3.1	*	*	*	*
BA010	15.3	*	*	*	*
BA011	5.1	4.2	1.3	0.9	0.0
BA012	11.5	*	*	*	*
BA013	0.5	*	*	*	*
BA014	13.2	*	*	*	*
BA015	45.4	12.3	5.5	3.7	2.9
BA016	5.7	*	*	*	*
BA017	51.9	26.7	15.6	9.3	9.3
BA018	13.7	*	*	*	*
BA019	34.9	*	*	*	*
BA020	9.6	3.5	0.4	0.3	0.0
BA021	53.0	12.1	4.9	4.2	0.3
BA022	0.0	11.7	9.5	2.8	2.2
BA024	0.4	*	*	*	*
BA026	1.3	*	*	*	*
BA028	0.0	*	*	*	*
BA029	7.4	7.4	2.6	1.9	0.3
BA030	1.6	*	*	*	*
BA034	0.2	*	*	*	*
BA037	1.1	*	*	*	*
Total[3]	**748.0**	**181.7**	**101.9**	**32.7**	**23.4**
Reduction[4]		**75.7%**	**86.4%**	**95.6%**	**96.9%**

(*) Indicates outfall consolidation per Table D-6.
(1) 20 CSO-events/yr can be achieved with existing 17.6 MGD peak flow at Oak Street PS.
(2) 12 CSO-events/yr can be achieved with upgrade to 20.0 MGD at Oak Street PS.
(3) 8 and 4 CSO-events/yr can be achieved with upgrade to 40.0 MGD at Oak Street PS.
(4) Total indicates City-wide values.
(5) Reduction indicates CSO volume reduction as a percentage from Baseline.

D.2.9 Storage Tunnels

Off-Line Deep-Tunnel Storage: Like off-line storage tanks, deep tunnel storage facilities are also primarily below grade, but require vertical shafts to the surface for ventilation, filling, dewatering, and maintenance access. Deep tunnels also share the restrictions regarding dewatering time and flow rate as previously described for off-line storage tanks.

Deep Tunnel Configurations in Bayonne: Deep tunnels represent a form of "linear storage" and as such typically provide storage for overflows that would otherwise discharge from numerous outfalls. Because different outfalls can overflow at different times, tunnels can sometimes enable a tunnel to be sized with a somewhat smaller storage capacity than the sum of multiple tanks. However, as with off-line storage tanks, dewatering and wastewater-flow limitations preclude the feasibility of achieving fewer than 12 CSO events per year.

Three different deep-tunnel configurations were evaluated. Initially, a single tunnel aligned along the shoreline was assumed such that each existing outfall would deliver its overflow via its own drop shaft to the tunnel. This configuration represents a high-end cost due to the length of the tunnel as well as the maximum number of drop shafts. Then, a second configuration was developed, this time consolidating drop shafts to the same nine (9) locations determined for storage tanks. Finally, a third configuration was developed, again with the nine consolidated drop shafts, but this time using three independent tunnel segments rather than a single tunnel. Each of these configurations represents similar performance to the consolidated off-line tank scenario described above, but at a different cost, as described in Section D.2.9.

Regional Deep Tunnel: The City also cooperated with North Bergen and Jersey City, neighboring municipalities that also send flows through a shared force main, to consider the possibility of utilizing a regional off-line storage tunnel for CSO flows from North Bergen, the western side of Jersey City, and Bayonne. To intercept CSO discharges, an analysis considered a regional tunnel extending roughly 18 miles, from the northern end of North Bergen to the southern end of Bayonne, at a vertical depth of about 120 ft below ground. The regional tunnel would be dewatered to the Jersey City West Side Pump Station (JCWSPS), assuming the maximum rate that wastewater can be sent to PVSC's STP is 45.4 MGD (as indicated in the hydraulic model). With this dewatering limitation, tunnels are feasible to achieve the 20 and 12-CSOevent frequency performance objectives, but not the 8, 4, or 0-CSO-event frequency objectives (the stored volumes cannot be dewatered quickly enough). Because the costs of the feasible tunnel alternatives exceeded the costs of other feasible options that would not have the additional complication of sharing ownership, this alternative was not evaluated further.

D.2.10 Disinfection Technologies

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

As described in Section C.8, PAA disinfection offers significant potential advantages over other disinfection technologies. Due its relatively small space requirements, PAA disinfection facilities can be implemented upstream of each CSO outfall, at a location between the existing regulator and the existing netting facility. Recognizing the fact ~~that Bayonne already meets the water quality standards for pathogens and~~ that smaller space requirements and significant (~75%) cost savings could be realized if the disinfection facility is not provided with suspended solids removal. Therefore, Bayonne may consider disinfection wiothout solids removal.

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

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

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

Table D-10 summarizes the overall reduction in the number of CSO events and CSO volume, with PAA disinfection facilities sized so that all but 20, 12, 8, 4 and 0 CSO events are *fully treated* annually, and discharged volumes not fully treated during any 5-minute interval are considered *untreated*.

Table D-10 | Impacts of Disinfection for Range of CSO-Control Objectives

Disinfection Scenario	Untreated[1] CSO Events		Untreated[2] CSO Volume	
	Count	Reduction	(MG)	Reduction
Baseline	60	-	748	-
20 Untreated CSO Events	20	67%	206	72%
12 Untreated CSO Events	12	80%	91	88%
8 Untreated CSO Events	8	87%	82	89%
4 Untreated CSO Events	4	93%	28	96%
0 Untreated CSO Events	0	100%	0	100%

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

[2] In this context, "Untreated CSO Volume" is defined as the sum of discharged volumes during any 5-minute period that exceed the design flow rate for 3-log pathogen removal.

D.2.11 Summary of Cost Opinions

This Section presents cost opinions associated with each CSO-control alternative developed above. Where possible, costing information is referenced to most recent, common sources available to members of the NJ CSO Group. Costing procedures typically apply sizing information necessary to achieve the performance objectives (as described earlier in this Section for individual CSO-control alternatives), together with cost curves to develop capital and annual operation and maintenance (O&M) costs. Life-cycle costs accounting for the present value (PV) of capital and O&M costs for a 20-year period are then developed based on an interest rate of 2.75%, in accordance with the latest available guidance for permittees (~~2019a, G&H, 2019c, G&H~~ Regional DEAR Appendix J)

Life-cycle costs (again expressed as PV for a 20-year period at 2.75% interest) are also estimated herein based on "total probable project costs" (PTPCs) to account for additional costs associated with installation, non-component costs (electrical, piping, etc.), and indirect costs (freight, permits, etc.) that are not otherwise included. Based on experience with other, similar types of projects, we estimated PTPCs through application of a factor of 2.5 on capital costs, developed as an approximation of the following factors. Installation was estimated at 20% of equipment cost, based on experience and industry standards for typical facilities of similar size and complexity. Non-component costs were estimated based on factors or percentages of equipment costs, including electrical (10%), piping (10%), instrumentation and controls ($15,000), and civil site work (25%). These factors account for standard installation commodities, accessories, steal supports, and standard testing support. Freight was estimated at a lump sum of $20,000. Sales tax was estimated at 8%. Permits were estimated at $20,000. Start up, performance testing, operator training, and O&M manual were estimated at $50,000. Contract overhead and profit includes 29% for part-time staff (project management support, project controls, procurement, quality and safety support), full-time staff (site construction manager (CM), site administration, standard CM travel pack), engineering (administration and legal fees estimated at 10%), and contingency (10% for the remaining equipment items and con-component costs).

D.2.11.1 Water Conservation

No cost estimates were developed for water-conservation measures. Water conservation is assumed to be an ongoing measure in place through utilization of low water-use fixtures.

D.2.11.2 Green Infrastructure

Capital costs for various GI technologies are based on the latest available guidance for permittees (2018a, PVSC). O&M costs for Bioretention technologies are taken as $8,000 per managed acre (~~2019c, G&H~~ Regional DEAR Appendix J). O&M costs for Porous Pavement technologies are taken as $1,250 per managed acre (2018, NJDEP). Table D-11 presents a summary of the estimated capital, O&M, and 20-year life-cycle costs as present value for a variety of GI technologies, as implemented to eliminate runoff from the first inch of rainfall on 5% and 10% of impervious areas. Table D-12 summarizes the range of raw and PTPC life-cycle costs for various GI technologies to eliminate runoff from the first inch of rainfall on 5% and 10% of impervious areas.

Table D-11 | Capital, 20-Year O&M, and 20-Yr Life-Cycle PV Cost Ranges For Green Infrastructure to Control 5 and 10% of Impervious Cover

Controlled[1] Portion of Impervious Area	Green Infrastructure Technology	Min. Raw[2] Capital Cost ($M)	Max. Raw[2] Capital Cost ($M)	20-Year O&M as PV Cost ($M)	Min. Raw[2] 20-Yr Life-Cycle as PV ($M)	Max. Raw[2] 20-Yr Life-Cycle as PV ($M)
5% (~50 acres)	Rain Garden	4.80	15.25	6.09	10.89	21.34
	Right-of-Way Bioswale	7.50	25.00	6.09	13.59	31.09
	Green Roof	24.00	122.00	6.09	30.09	128.09
	Porous Asphalt(3)	13.00	27.25	0.95	13.95	28.20
	Pervious concrete(3)	15.25	30.50	0.95	16.20	31.45
	PICP(3)	6.50	18.50	0.95	7.45	19.45
10% (~100 acre)	Rain Garden	9.60	30.50	12.18	21.78	42.68
	Right-of-Way Bioswale	15.00	50.00	12.18	27.18	62.18
	Green Roof	48.00	244.00	12.18	60.18	256.18
	Porous Asphalt(3)	26.00	54.50	1.90	27.90	56.40
	Pervious concrete(3)	30.50	61.00	1.90	32.40	62.90
	PICP(3)	13.00	37.00	1.90	14.90	38.90
Controlled[1] Portion of Impervious Area	**Green Infrastructure Technology**	**Min. PTPC[4] Capital Cost (M)**	**Max. PTPC[4] Capital Cost (M)**	**20-Year O&M as PV Cost (M)**	**Min PTPC[4] 20-Yr Life-Cycle as PV (M)**	**Max PTPC[4] 20-Yr Life-Cycle as PV (M)**
5% (~50 acres)	Rain Garden	12.00	38.13	6.09	18.09	44.22
	Right-of-Way Bioswale	18.75	62.50	6.09	24.84	68.59
	Green Roof	60.00	305.00	6.09	66.09	311.09
	Porous Asphalt(3)	32.50	68.13	0.95	33.45	69.08
	Pervious concrete(3)	38.13	76.25	0.95	39.08	77.20
	PICP(3)	16.25	46.25	0.95	17.20	47.20
10% (~100 acre)	Rain Garden	24.00	76.25	12.18	36.18	88.43
	Right-of-Way Bioswale	37.50	125.00	12.18	49.68	137.18
	Green Roof	120.00	610.00	12.18	132.18	622.18
	Porous Asphalt(3)	65.00	136.25	1.90	66.90	138.15
	Pervious concrete(3)	76.25	152.50	1.90	78.15	154.40
	PICP(3)	32.50	92.50	1.90	34.40	94.40

(1) Control eliminates runoff from first inch of rain on targeted portion of impervious area.

(2) Raw capital costs based on latest available capital, O&M, and PV (2018a, PVSC; 2019a, G&H; 2019c, G&H Regional DEAR Appendix J) except as otherwise noted.

(3) O&M costs for porous asphalt, pervious concrete, and PICP based on information from NJDEP (2018, NJDEP).

(4) PTPC Life-Cycle costs reflect a 2.5 escalation factor on capital costs, to account for installation, non-component cost, and indirect costs as described at the beginning of Section D.2.11.

Table D-12 | Normalized Life-Cycle as PV Cost Ranges for GI Technologies

Cost Type	Green Infrastructure Technology	Min. 20-Yr Life-Cycle Cost as PV, ($M / MG CSO Controlled)	Max. 20-Yr Life-Cycle Cost as PV, ($M / MG CSO Controlled)	Min. 20-Yr Life-Cycle Cost as PV, ($M / Acre Controlled)	Max. 20-Yr Life-Cycle Cost as PV, ($M / Acre Controlled)
Raw Life-Cycle Cost(2)	Rain Garden	0.44	0.85	0.22	0.43
	Right-of-Way Bioswale	0.54	1.24	0.27	0.62
	Green Roof	1.20	5.12	0.60	2.56
	Porous Asphalt(3)	0.56	1.13	0.28	0.56
	Pervious concrete(3)	0.65	1.26	0.32	0.63
	PICP(3)	0.30	0.78	0.15	0.39
PTPC Life-Cycle Cost(4)	Rain Garden	0.72	1.77	0.36	0.88
	Right-of-Way Bioswale	0.99	2.74	0.50	1.37
	Green Roof	2.64	12.43	1.32	6.22
	Porous Asphalt(3)	1.34	2.76	0.67	1.38
	Pervious concrete(3)	1.56	3.08	0.78	1.54
	PICP(3)	0.69	1.89	0.34	0.94

(1) Costs to eliminate runoff from the first inch of rain from targeted impervious area.
(2) Raw Life-Cycle costs based on latest available capital, O&M, and PV (2018a, PVSC; ~~2019c, G&H~~ Regional DEAR Appendix J) except as noted.
(3) O&M costs for porous asphalt, pervious concrete, and PICP based on information from NJDEP (2018, NJDEP)
(4) PTPC Life-Cycle costs reflect a 2.5 escalation factor on capital costs, to account for installation, non-component cost, and indirect costs as described at the beginning of Section D.2.11.

D.2.11.3 Additional Conveyance

As described in Section D.2.3, the current maximum rate that Bayonne can transport wastewater to PVSC for treatment is 17.6 MGD, in accordance with an agreement between the City and PVSC (1984, PVSC). With minor upgrades to the Oak Street Pump Station, the existing peak flow could be increased to about 20 MGD. To enable the Oak Street Pump Station to be able to pump at its nominal rate of 40 MGD, more significant a capital investments would be required, including upsizing about 6,000 feet of force main (including 4,400 feet of 24-inch diameter pipe and about 1,600 feet of 30-inch diameter pipe) to make the entire force main a 36-inch diameter pipe. Table D-13 summarizes the costs associated with these conveyance capacity upgrades. As shown, the present value of the PTPC 20-year life-cycle cost to increase conveyance capacity to 40 MGD is approximately $22.3 million.

Table D-13 | Costs for Increasing Peak Wastewater Conveyance Rate to PVSC

Conveyance Scenario	Peak Flow (MGD)	Raw Capital Cost ($M)	PTPC Capital Cost ($M)	20-Yr O&M Cost as PV[1] ($M)	Raw 20-Yr Life-Cycle Cost as PV ($M)	PTPC 20-Yr Life-Cycle Cost as PV ($M)
Baseline	17.6	-	-	-	-	-
Minor Upgrades at Oak St. PS	20.0	0.50	1.25	0.15	0.65	1.40
Upgrades at Oak St PS and Upsize Force Main (6,000 ft, 36 in)	40.0	8.72	21.81	0.46	9.18	22.26

(1) O&M costs for pump upgrades estimated as 2% of capital costs.

D.2.11.4 Sewer Separation

A prior investigation (2007, HMM) established an estimated capital cost of $190,000 per acre for complete sewer separation in Bayonne. Adjusting that normalized cost according to the applicable Engineering News Record (ENR) Construction Cost Index (CCI) values for 2018 and 2006 (10817:7630), and applying the number of combined-sewer acres in the City yields a capital cost estimate of $459 million. Assuming associated annual O&M costs of 2% of the capital costs (~~2019c, G&H~~ Regional DEAR Appendix J), the 20-year O&M cost for sewer separation is $139.8 million. The raw life-cycle cost as PV is therefore $598.6 million, and the PTCP life-cycle cost as PV is $828.1 million (based on an escalation factor of 1.5 above the previously estimated capital cost).

D.2.11.5 Regulator Modifications

Regulator Modifications evaluated in this study involved raising weir crests by 6 inches. This type of modification is considered a low-cost retrofit. No cost estimate is developed herein.

D.2.11.6 Outfall Consolidation/Relocation

Outfall consolidation/relocation considered in this study involved construction of new sewer conduits sized to deliver wet-weather flows from existing regulators/outfalls to nine (9) locations. The capital cost for this work, developed based upon the latest guidance available to the NJ CSO Group (2018, PVSC), totaled $34.2 million.

D.2.11.7 Off-Line Storage Tanks

As previously described, conceptual off-line storage tank facilities have been developed for each of the twenty-eight (28) individual CSO outfalls and for nine (9) consolidated facilities. Capital costs for tank storage solutions are based on the latest available guidance for permittees (2018a, PVSC). Annual O&M costs for tanks are based on the latest available guidance for NJ CSO-Group permittees (~~2019c, G&H~~ Regional DEAR Appendix J).

Individual-Outfall Off-Line Storage Tanks: Costs for off-line storage tanks installed at individual outfalls are provided in Table D-14 (capital costs), Table D-15 (20-year O&M costs), and Table D-16 (20-yr life-cycle cost, as present value). In each table, a zero ($-) cost is shown where a facility is not needed to meet the performance objective. Table D-17 summarizes total costs for individual storage tanks.

Table D-14 | Capital Costs of Individual Storage Tanks Sized for 20 or 12 CSO Events Per Year, by Outfall

Outfall	Capital Cost ($M) of Individual Storage Tanks Sized to Achieve 20 and 12 CSO Events/Year			
	Raw Capital Cost		PTPC Capital Cost	
	20 CSO Events/yr[1]	12 CSO Events/yr[2]	20 CSO Events/yr[1]	12 CSO Events/yr[2]
BA001	43.06	59.00	107.66	147.51
BA002	3.15	7.62	7.88	19.06
BA003	2.77	2.95	6.91	7.39
BA004	-	-	-	-
BA006	6.68	6.68	16.70	16.70
BA007	11.08	11.81	27.71	29.52
BA008	2.56	3.55	6.39	8.87
BA009	1.73	2.17	4.33	5.41
BA010	3.11	6.01	7.77	15.04
BA011	2.37	2.64	5.92	6.60
BA012	3.64	4.32	9.09	10.80
BA013	1.17	1.25	2.92	3.11
BA014	2.97	3.83	7.43	9.58
BA015	7.80	9.93	19.51	24.83
BA016	1.87	3.07	4.68	7.67
BA017	9.70	11.49	24.25	28.73
BA018	2.99	4.29	7.46	10.73
BA019	8.47	8.47	21.19	21.19
BA020	3.91	3.91	9.78	9.78
BA021	7.22	10.77	18.05	26.93
BA022	-	-	-	-
BA024	-	1.21	-	3.04
BA026	1.07	2.22	2.67	5.56
BA028	-	-	-	-
BA029	3.47	4.67	8.67	11.68
BA030	1.44	2.19	3.61	5.47
BA034	-	1.12	-	2.80
BA037	-	1.45	-	3.63
Tank Cost	**132.22**	**176.64**	**330.55**	**441.61**
Pumping[2] Cost	**-**	**0.50**	**-**	**1.25**
Total Cost	**132.22**	**177.14**	**330.55**	**442.86**

(1) 20 CSO Events/yr scenario has 17.6 MGD at Oak Street PS.
(2) 12 CSO Events/yr scenario has 20.0 MGD at Oak Street PS requiring an additional capital cost at Oak St PS.
(3) Zero cost (-) indicates CSO-event frequency goal already met at that outfall.
(4) Capital costs reflect 2018 dollars per (2018a, PVSC).

Table D-15 | 20-Year O&M Costs of Individual Storage Tanks Sized for 20 or 12 CSO Events Per Year, by Outfall

Outfall	20-Year O&M Cost ($M) of Individual Storage Tanks Sized to Achieve 20 or 12 CSO Events/yr	
	20 CSO Events/yr[1]	12 CSO Events/yr[2]
BA001	23.80	31.26
BA002	5.14	7.23
BA003	4.96	5.05
BA004	-	-
BA006	6.79	6.79
BA007	8.85	9.19
BA008	4.86	5.32
BA009	4.47	4.68
BA010	5.12	6.48
BA011	4.77	4.90
BA012	5.36	5.68
BA013	4.21	4.25
BA014	5.05	5.46
BA015	7.31	8.31
BA016	4.54	5.10
BA017	8.20	9.04
BA018	5.06	5.67
BA019	7.63	7.63
BA020	5.49	5.49
BA021	7.04	8.70
BA022	-	-
BA024	-	4.23
BA026	4.16	4.70
BA028	-	-
BA029	5.29	5.85
BA030	4.34	4.69
BA034	-	4.19
BA037	-	4.34
Tank Cost	**142.43**	**174.20**
Pumping[2] Cost	**-**	**0.15**
Total Cost	**142.43**	**174.35**

(1) 20 CSO Events/yr scenario has 17.6 MGD at Oak Street PS.

(2) 12 CSO Events/yr scenario has 20.0 MGD at Oak Street PS requiring an additional O&M cost at Oak St PS.

(3) Zero cost (-) indicates CSO-event frequency goal already met at that outfall.

(4) 20-Year O&M as PV costs reflect 2018 dollars per (~~2019c, G&H~~ Regional DEAR Appendix J).

Table D-16 | 20-Yr Life-Cycle Cost as PV of Individual Storage Tanks Sized for 20 or 12 CSO Events, by Outfall

Outfall	Life-Cycle Costs as PV ($M) of Individual Storage Tanks Sized to Achieve 20 or 12 CSO Events/yr			
	Raw		PTPC	
	20 CSO Events/yr[1]	12 CSO Events/yr[2]	20 CSO Events/yr[1]	12 CSO Events/yr[2]
BA001	66.87	90.26	131.46	178.77
BA002	8.29	14.85	13.01	26.29
BA003	7.72	8.00	11.87	12.43
BA004	-	-	-	-
BA006	13.47	13.47	23.48	23.48
BA007	19.93	20.99	36.55	38.71
BA008	7.41	8.87	11.25	14.20
BA009	6.20	6.84	8.80	10.09
BA010	8.23	12.49	12.89	21.51
BA011	7.14	7.54	10.69	11.50
BA012	9.00	10.01	14.46	16.49
BA013	5.38	5.49	7.12	7.36
BA014	8.03	9.29	12.49	15.03
BA015	15.11	18.24	26.82	33.13
BA016	6.41	8.17	9.22	12.77
BA017	17.90	20.53	32.45	37.77
BA018	8.05	9.96	12.52	16.40
BA019	16.10	16.10	28.81	28.81
BA020	9.40	9.40	15.27	15.27
BA021	14.26	19.48	25.09	35.63
BA022	-	-	-	-
BA024	-	5.45	-	7.27
BA026	5.23	6.93	6.83	10.26
BA028	-	-	-	-
BA029	8.75	10.52	13.96	17.53
BA030	5.78	6.87	7.94	10.15
BA034	-	5.31	-	6.99
BA037	-	5.79	-	7.97
Tank Cost	**274.65**	**350.84**	**472.99**	**615.81**
Pumping[2] Cost	**-**	**0.65**	**-**	**1.40**
Total Cost	**274.65**	**351.49**	**472.99**	**617.21**

(1) 20 CSO Events/yr scenario has 17.6 MGD at Oak Street PS.

(2) 12 CSO Events/yr scenario has 20.0 MGD at Oak Street PS requiring an additional cost at Oak St PS.

(3) Zero cost (-) indicates CSO-event frequency goal already met at that outfall.

(4) Life-Cycle cost includes capital and present value of O&M over 20-yr period at 2.75% interest ~~(2019a, G&H)~~.

Table D-17 | Summary of Costs for Individual Storage Tanks Sized for 20 and 12 CSO Events

Cost Type	Citywide Cost ($M) of Storage Tanks at Each Individual Outfall	
	20 CSO Events/yr[1]	12 CSO Events/yr[2]
Raw Capital Cost	132.22	177.14
PTPC Capital Cost	330.55	442.86
20-Yr O&M as PV	142.43	174.35
Raw 20-Yr Life Cycle as PV[3]	274.65	351.49
PTPC 20-Yr Life Cycle as PV[3]	472.99	617.21

(1) 20 CSO Events/yr scenario has 17.6 MGD at Oak Street PS.
(2) 12 CSO Events/yr scenario has 20.0 MGD at Oak Street PS requiring an additional cost at Oak St PS.
(3) Life-cycle costs include capital cost and PV of 20 years of O&M costs at 2.75% interest ~~(2019a, G&H).~~

Consolidated Off-Line Storage Tanks: As noted above, optimization analyses indicated that consolidating off-line storage tanks to nine (9) locations minimizes storage costs. Table D-18 summarizes the capital, O&M, and life-cycle costs for consolidated tanks (including $34.19 million for consolidating conveyance infrastructure, in addition to the tanks themselves) required to achieve the targeted CSO-event frequencies. As shown, the consolidated tank costs with the additional cost of consolidating conveyance infrastructure is less than tanks at individual outfalls without consolidating conveyance infrastructure to achieve the 20- and 12-CSO event frequencies. As a result, consolidated tank costs were also examined for the 8- and 4-CSO event frequencies. Due to dewatering time limitations, achieving these frequencies requires an increase of peak wasterwater conveyance capacity to 40 MGD; .

Table D-18 | Cost Summary of Consolidated Storage Tanks Sized for Targeted CSO Frequencies

Breakdown of Costs ($M)	20 CSO Events/yr[1]	12 CSO Events/yr[2]	8 CSO Events/yr[3]	4 CSO Events/yr[3]
Raw Capital Cost[4]	136.17	165.70	205.16	220.45
PTPC Capital Cost[5]	340.43	414.25	512.89	551.12
20-Year O&M as PV	84.33	98.06	112.97	120.12
Raw Life-Cycle Cost[6] as PV	220.50	263.76	318.12	340.57
PTPC Life-Cycle Cost[6] as PV	424.75	512.30	625.86	671.24

(1) 20 CSO Events/yr scenario has 17.6 MGD at Oak Street PS.
(2) 12 CSO Events/yr scenario includes costs to increase Oak Street PS peak capacity to 20.0 MGD .
(3) 8- and 4 CSO Events/yr scenarios include costs to increase peak conveyance capacity to 40.0 MGD.
(4) Capital costs include $34.19M for infrastructure to convey wastewater flows to the consolidated tank locations.
(5) PTPC includes escalation of capital costs to account for ancillary costs not otherwise included.
(6) Life-Cycle cost includes capital and present value of O&M over 20-yr period at 2.75% interest~~ (2019a, G&H)~~.

D.2.11.8 Storage Tunnels

Improved construction methods have made deep tunnel storage more competitive, considering the relatively low land requirements and ease of capacity expansion. Limitations of deep tunnels primarily include the need for specialized, high-lift pumping stations and the inability to provide any treatment of discharges in excess of the deep tunnel storage volume. For this analysis, costing conservatively assumes that the tunnel construction would be in soft ground, below the water table, and using an earth pressure balanced boring machine with a full gasketted concrete segmental liner erected immediately behind. Tunnel costing analyses are based upon the tunnel length, depth, and diameter needed to provide the sufficient volume, connectivity to overflows, and slopes for the application. Tunnel costs also depend upon the number and size of drop shafts required to deliver flow to the tunnel. Capital costs for tunnel storage solutions are based on the latest available guidance for permittees (2018a, PVSC). Annual O&M costs for tunnels are based on the latest available guidance for NJ CSO-Group permittees (~~2019c, G&H~~ Regional DEAR Appendix J).

As with the off-line tank storage facilities, the off-line tunnel facilities are also limited by restrictions regarding dewatering time and flow rates. Storing more than necessary to achieve 12 CSO-events/yr requires additional conveyance upgrades (see that section), so for price comparison to tanks, tunnel costs are herin computed for the 20 and 12-per-year metrics.

For this application, two tunnel configurations were developed for costing purposes. Both configurations assume that drop shafts would be located at the nine (9) sites previously identified as the optimum sites for storage facilities. The first configuration involves a single, 42,240-foot tunnel that connects all the drop shafts. To achieve 20 or 12 CSO events/yr, this tunnel requires a diameter of either 8.9-foot or 10.5-foot, respectively. The second configuration involves three tunnel segments, each connecting groups of drop shafts (referencing Figure D-2: ST03-ST05, ST07-ST09, and ST04-ST08). These segments are 14,520, 13,200, and 7,920 feet in length. To achieve 20 CSO events/yr, the three segments are diameters of 7.3, 9.5, and 13.1 feet. To achieve 12 CSO events/yr, the three segments are diameters of 9.3, 11.5, and 14.3 feet.

Table D-19 summarizes the costs associated with each of the tunnel configurations as required to achieve the 20 and 12 CSO-event/yr performance objectives. As shown, the three-segment tunnel proved to be less expensive than the single-segment tunnel; however, consolidated storage tanks were more cost effective than tunnels to achieve the same performance objectives. As a result, costs of tunnels were not evaluated for the 8- or 4-CSO event frequency targets.

Table D-19 | Capital, O&M, Raw Life-Cycle as PV, and PTPC Life-Cycle as PV Costs for Tunnels to Achieve 20 or 12 CSO Events Per Year

Breakdown of Costs		Costs ($M) for Tunnel Sized to Achieve 20 or 12 CSO Events/yr	
		20 CSO Events/yr	12 CSO Events/yr
Single Segment Tunnel	Raw Capital Cost	298	323
	PTPC Capital Cost	746	807
	20-Year O&M as PV	88	95
	Raw Life-Cycle as PV	386	418
	PTPC Life-Cycle as PV	833	902
Three Segment Tunnel	Raw Capital Cost	256	281
	PTPC Capital Cost	641	704
	20-Year O&M as PV	75	82
	Raw Life-Cycle as PV	331	364
	PTPC Life-Cycle as PV	716	786

D.2.11.9 Regional Deep Tunnel

The cost of a regional tunnel serving the Hudson County communities of North Bergen, Jersey City, and Bayonne was also evaluated to determine if such an option could provide a cost-effective alternative to other options. As described below, even without including all anticipated elements of a regional tunnel, its costs clearly exceed the costs of other, similar alternatives (e.g., off-line storage tanks). Nevertheless, the following summarizes costs associated with elements of the regional deep tunnel.

A deep tunnel capable of storing combined sewage from all of North Bergen, all of Bayonne, and the western side of Jersey City was assumed to be 18.5 miles long (97,680 linear feet) and 118 feet deep. It runs from the northern end of North Bergen, through Jersey City, and wraps around Bayonne to include all outfalls. Bayonne drop-shaft costs were estimated for each of the consolidated facility locations based on the associated peak flow rates to storage.

Table D-20 presents the capital, O&M, raw life-cycle (as PV), and PTPC life-cycle (as PV) costs for the regional tunnel storage alternative to achieve the feasible performance objectives of 20 and 12 CSO events per year. Costs include nine (9) drop shafts in North Bergen, nine (9) drop shafts in Bayonne, and thirteen (13) drop shafts in Jersey City. The cost of consolidation to the nine (9) drop shaft locations in Bayonne is also included in the cost estimate. To compare the relative cost of a regional tunnel to the cost of storage tanks serving the municipalities involved (Bayonne, North Bergen, and Jersey City), Table D-21 shows the raw life-cycle cost as present value required to achieve each of the feasible CSO-event frequencies (20 and 12 CSO events per year). As shown, the cost of the regional tunnel is more expensive than the cost of storage tanks serving the three municipalities.

Table D-20 | Capital, O&M, and Life-Cycle Costs of Regional Tunnel for CSO-Frequency Objectives

Breakdown of Costs	Costs ($M) for Regional Tunnel for Targeted CSO Frequency Goals[1]			
	20 CSO Events/yr	12 CSO Events/yr	8 CSO Events/yr	4 CSO Events/yr
Raw Capital Cost	610	654	701	754
PTPC Capital Cost	1,525	1,635	1,752	1,884
20-Year O&M as PV	183	196	216	226
Raw Life-Cycle as PV	793	850	917	980
PTPC Life-Cycle as PV	1,708	1,831	1,968	2,111

(1) Offline storage is feasible to achieve 20 or 12 CSO events per year; fewer CSO events cannot be accommodated without significant changes to hydraulic capacity of the force mains and other infrastructure necessary to deliver and treat the wastewater at the PVSC STP. These costs do not include estimates for increased conveyance.

Table D-21 | Comparison of Raw Life-Cycle Costs for Storage Tanks and Regional Tunnel Required to Achieve 20 and 12 CSO Events Per Year

Raw Life-Cycle Cost ($M) of Storage Tanks and Regional Storage Tunnel as Required to Achieve 20 and 12 CSO Events/yr[1]				
Municipality	20 CSO Events/Year		12 CSO Events/Year	
	Tanks	Regional Tunnel	Tanks	Regional Tunnel
Bayonne	207	NA	250	NA
North Bergen	82	NA	103	NA
Jersey City	212	NA	298	NA
Total	**502**	**793**	**651**	**850**

(1) Offline storage is feasible to achieve 20 or 12 CSO events per year; fewer CSO events cannot be accommodated without significant changes to hydraulic capacity of the force mains and other infrastructure necessary to deliver and treat the wastewater at the PVSC STP.

D.2.11.10 PAA Disinfection

Using the latest available guidance for NJ CSO group permittees (2018a, PVSC), capital and O&M costs were estimated for peracetic acid (PAA) disinfection facilities at individual outfalls to achieve CSO-performance objects (20, 12, 8, and 4 CSO events per year), with pretreatment (suspended solids removal) using FlexFilter.

For each outfall, Table D-22 provides information on the capital costs; Table D-23 provides 20-year O&M costs as PV; Table D-24 provides the raw 20-year life-cycle cost as PV; and Table D-25 provides the PTPC 20-year life-cycle cost as PV. In cases where a particular performance objective is met without the need for a facility, a cost of zero is indicated. As shown, the PTPC life-cycle cost as PV ranged from $220 million for 20 untreated overflows per year, to $549 million for 4 untreated overflows per year. These costs include a FlexFilter pretreatment system at each outfall, but a significant cost reduction of 75 percent or more could be anticipated without such pretreatment, and for that reason, Bayonne intends considering disinfection without suspended solids removal.

Table D-22 | Capital Cost for PAA Disinfection Facilities Required to Achieve Frequency Performance Objectives

Outfall	Capital Cost ($M) for PAA Disinfection Facilities at Individual Outfalls, Sized to Achieve CSO-Frequency Targets			
	20 CSO[1] Events/yr	12 CSO[1] Events/yr	8 CSO[1] Events/yr	4 CSO[1] Events/yr
BA001	20.97	25.60	26.18	27.89
BA002	-	3.79	3.80	13.04
BA003	2.23	2.23	2.23	2.23
BA004	-	-	-	1.34
BA006	2.15	3.55	3.89	6.41
BA007	7.36	15.46	15.63	25.27
BA008	1.15	3.70	3.70	6.69
BA009	1.90	3.01	3.01	4.94
BA010	2.61	3.23	3.23	4.40
BA011	2.55	3.36	3.36	3.38
BA012	4.07	5.31	5.32	7.80
BA013	1.00	1.31	1.31	1.55
BA014	2.00	3.41	3.41	5.45
BA015	4.90	8.29	8.38	12.20
BA016	1.41	1.78	1.91	2.02
BA017	5.90	9.47	9.47	10.24
BA018	3.31	4.21	4.30	6.37
BA019	4.73	6.88	7.87	10.08
BA020	2.59	3.89	4.70	6.43
BA021	5.63	11.08	11.08	18.84
BA022	-	-	-	-
BA024	-	-	-	1.37
BA026	-	-	1.58	6.84
BA028	-	-	-	-
BA029	2.40	5.39	5.42	7.94
BA030	1.44	3.03	3.15	6.20
BA034	-	-	-	1.09
BA037	-	1.15	1.15	2.15
Total	**80.30**	**129.16**	**134.10**	**202.18**

(1) In this context, a “CSO” event is a wet-weather event during which peak flow exceeds the design maximum for full disinfection.

Table D-23 | 20-Year O&M Cost for Individual PAA Disinfection Facilities Required to Achieve Frequency Performance Objectives

Outfall	20-Year O&M Cost as PV ($M) for PAA Disinfection Sized to Achieve Frequency Performance Objectives, by Outfall			
	20 CSO[1] Events/yr	12 CSO[1] Events/yr	8 CSO[1] Events/yr	4 CSO[1] Events/yr
BA001	4.10	4.91	5.00	5.29
BA002	-	0.93	0.93	2.68
BA003	0.64	0.64	0.64	0.64
BA004	-	-	-	0.48
BA006	0.62	0.89	0.95	1.43
BA007	1.61	3.12	3.15	4.85
BA008	0.44	0.92	0.92	1.48
BA009	0.58	0.79	0.79	1.15
BA010	0.71	0.83	0.83	1.05
BA011	0.70	0.85	0.85	0.85
BA012	0.99	1.22	1.22	1.69
BA013	0.42	0.47	0.47	0.51
BA014	0.60	0.86	0.86	1.25
BA015	1.14	1.79	1.80	2.52
BA016	0.49	0.56	0.58	0.60
BA017	1.33	2.01	2.01	2.15
BA018	0.84	1.01	1.03	1.42
BA019	1.11	1.52	1.71	2.12
BA020	0.71	0.95	1.11	1.44
BA021	1.28	2.31	2.31	3.73
BA022	-	-	-	-
BA024	-	-	-	0.48
BA026	-	-	0.52	1.51
BA028	-	-	-	-
BA029	0.67	1.24	1.24	1.72
BA030	0.49	0.79	0.81	1.39
BA034	-	-	-	0.43
BA037	-	0.44	0.44	0.62
Total	**19.48**	**29.04**	**30.18**	**43.51**

(1) In this context, a "CSO" event is a wet-weather event during which peak flow exceeds the design maximum for full disinfection.

Table D-24 | Raw Life-Cycle Costs for Individual PAA Disinfection Facilities Required to Achieve Frequency Performance Objectives

Outfall	Raw Life-Cycle Cost as PV ($M) for PAA Disinfection Sized to Achieve Frequency Performance Objectives, by Outfall			
	20 CSO[1] Events/yr	12 CSO[1] Events/yr	8 CSO[1] Events/yr	4 CSO[1] Events/yr
BA001	25.08	30.51	31.19	33.19
BA002	-	4.72	4.73	15.72
BA003	2.87	2.87	2.87	2.87
BA004	-	-	-	1.81
BA006	2.77	4.44	4.84	7.85
BA007	8.97	18.57	18.78	30.12
BA008	1.59	4.62	4.62	8.18
BA009	2.48	3.80	3.80	6.10
BA010	3.32	4.06	4.06	5.45
BA011	3.25	4.21	4.21	4.23
BA012	5.06	6.53	6.55	9.49
BA013	1.42	1.78	1.78	2.07
BA014	2.60	4.27	4.27	6.70
BA015	6.04	10.08	10.18	14.72
BA016	1.90	2.33	2.48	2.62
BA017	7.24	11.48	11.48	12.39
BA018	4.15	5.23	5.33	7.79
BA019	5.84	8.40	9.58	12.21
BA020	3.30	4.84	5.81	7.87
BA021	6.91	13.39	13.39	22.57
BA022	-	-	-	-
BA024	-	-	-	1.85
BA026	-	-	2.10	8.35
BA028	-	-	-	-
BA029	3.07	6.62	6.66	9.66
BA030	1.93	3.82	3.96	7.59
BA034	-	-	-	1.52
BA037	-	1.59	1.59	2.78
Total	**99.78**	**158.20**	**164.28**	**245.68**

(1) In this context, a "CSO" event is a wet-weather event during which peak flow exceeds the design maximum for full disinfection.

Table D-25 | PTPC Life-Cycle Costs as PV for Individual PAA Disinfection Facilities Required to Achieve Frequency Performance Objectives

Outfall	PTPC Life-Cycle Cost as PV ($M) for PAA Disinfection Sized to Achieve Frequency Performance Objectives, by Outfall			
	20 CSO[1] Events/yr	12 CSO[1] Events/yr	8 CSO[1] Events/yr	4 CSO[1] Events/yr
BA001	56.53	68.91	70.47	75.03
BA002	-	10.41	10.43	35.29
BA003	6.22	6.22	6.22	6.22
BA004	-	-	-	3.82
BA006	6.00	9.78	10.67	17.47
BA007	20.00	41.76	42.23	68.02
BA008	3.31	10.17	10.17	18.21
BA009	5.33	8.31	8.31	13.51
BA010	7.24	8.91	8.91	12.05
BA011	7.08	9.25	9.25	9.30
BA012	11.17	14.50	14.53	21.19
BA013	2.93	3.75	3.75	4.40
BA014	5.59	9.39	9.39	14.88
BA015	13.38	22.52	22.75	33.02
BA016	4.01	5.00	5.34	5.65
BA017	16.09	25.69	25.69	27.75
BA018	9.12	11.55	11.77	17.34
BA019	12.94	18.71	21.38	27.33
BA020	7.19	10.68	12.86	17.52
BA021	15.36	30.02	30.02	50.83
BA022	-	-	-	-
BA024	-	-	-	3.90
BA026	-	-	4.47	18.60
BA028	-	-	-	-
BA029	6.66	14.70	14.80	21.58
BA030	4.08	8.37	8.69	16.89
BA034	-	-	-	3.15
BA037	-	3.31	3.31	6.01
Total	**220.23**	**351.93**	**365.43**	**548.95**

(1) In this context, a "CSO" event is a wet-weather event during which peak flow exceeds the design maximum for full disinfection.

D.3 PRELIMINARY SELECTION OF ALTERNATIVES

This evaluation of alternatives served primarily to quantify the sizing and/or extent of implementation necessary for CSO-control alternatives to achieve certain metrics, or to determine the reasonable extent to which CSO-control alternatives are capable of reducing CSO discharges. This evaluation also developed the costs associated for CSO-control alternatives. These analyses provide the basis for developing an alternative that balances performance, cost, and other factors in a way that is suitable for the community.

D.3.1 Evaluation Factors

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

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

D.3.2 Regulatory Compliance

The alternatives evaluation included in the report was prepared in compliance with the LTCP regulatory (US 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 an LTCP as required by the State and Federal regulations. The selection of the preliminary alternatives is based on multiple considerations including public input, water quality benefits and designated use, costs and other aspects as outlined in Section D.1.1 through D.1.5 and D.3.1. The preliminary alternatives will result in full attainment of the existing pathogen water quality criteria providing the maximum bacterial reduction reasonably attainable. The remaining CSO discharges will not preclude the attainment of the water quality standards for bacteria or the designated uses of the receiving waters.

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

D.3.3 Selection of Preliminary Alternatives

As described in the preceding sections, the evaluations performed herein have identified which CSO-control alternatives can achieve major performance objectives on their own, which CSO-control alternatives can provide complementary improvements when used in combination with other alternatives, which alternatives are being retained for consideration but provide minor improvements or have significant disadvantages. The following presents a summary of these findings.

D.3.3.1 Primary Alternatives

Alternatives that are capable of achieving the major performance objectives are herein designated primary CSO-control alternatives. These alternatives are:

1. PAA Disinfection
2. Sewer Separation
3. Offline Storage Tanks
4. Offline Storage Tunnels

PAA Disinfection: PAA disinfection is capable of achieving the full range of CSO-control objectives in terms of frequency of uncontrolled discharges and discharge of pollutants of concern. PAA disinfection is also a cost-effective alternative that does not require a large footprint, particularly if pretreatment (suspended solids removal) is not provided. For that reason, Bayonne may consider disinfection without pretreatment. ~~As noted above, Bayonne's receiving waters already meet applicable water-quality standards and designated uses, including pathogen levels. Disinfection of CSO discharges would provide significant reductions of pathogens, which have been identified as the pollutant of concern.~~

Sewer Separation: Sewer separation is capable of eliminating CSOs or, when partial sewer separation were applied, the full range of CSO-control objectives, in terms of frequency of discharges and discharged CSO volumes and pollutants of concern. However, sewer separation is extremely expensive and disruptive to communities, and actually increases discharges of untreated stormwater, which is itself the subject of MS4 permits and potential future treatment requirements. As such, sewer separation is not a desirable CSO-control alternative.

Off-Line Storage Tanks: Storage tanks are capable of achieving significant advancement toward CSO-control objectives in terms frequency of uncontrolled discharges and discharge of CSO volumes and pollutants of concern. However, the costs associated with storage tanks are much higher than with PAA disinfection, even when combined with cost-saving outfall consolidation. Moreover, restrictions on dewatering times (stored volumes must be dewatered to treatment within three days following a storm) and wastewater flow rates in and downstream of the CSS (both in terms of hydraulic limitations and contractual limitations with PVSC) preclude the feasibility of off-line storage tanks alone to reduce CSO-event frequencies to fewer than 12 per year (which itself assumes that the current contractual limitation of 17.6 MGD peak flow can be relaxed to a hydraulically feasible 20.0 MGD peak flow). For storage tanks to achieve 8, 4 or 0 uncontrolled discharges per year, a combination of other primary controls (such as disinfection or partial separation), or extensive implementation of combinations of secondary controls (such as conveyance, water conservation, outfall consolidation, and green infrastructure) would be necessary. Such combinations are not desirable, as they add complexity to the control program.

Off-Line Storage Tunnels: Storage tunnels offer similar performance characteristics as storage tanks (as described above), but are more expensive. Although tunnels can provide an alternative to tanks when site availability and costs are an issue, tunnels are not otherwise as desirable as tanks as a CSO-control alternative.

D.3.3.2 Secondary Alternatives

Alternatives that are not capable of achieving the major performance objectives are herein designated secondary CSO-control alternatives. These alternatives are:

1. Water Conservation
2. Additional Conveyance
3. Outfall Consolidation/Relocation
4. Green Infrastructure

Water Conservation: Water conservation is essentially a “best practice” that will continue to help keep in check the impacts of other trends, but does not provide much benefit with respect to CSO control. Analyses show that water conservation measures resulting in 10% lower sanitary flow rates would reduce CSO volumes by about 1.3%. Water conservation is an ongoing measure in place through utilization of low water use fixtures.

Additional Conveyance: Additional conveyance is a necessary complement to the primary CSO controls involving storage (i.e., storage tunnels and storage tanks) to achieve CSO-frequency goals of fewer than 20 per year. The cost associated with additional conveyance is dependent upon the degree of additional conveyance needed. As such, the specific amount of conveyance needed will depend upon the final selected alternative, as well as the ability of PVSC to treat higher wastewater flows. By itself, increasing the conveyance from the Oak Street Pump Station to 20 MGD (from 17.6 MGD) would decrease CSO volumes by about

4.6%. Greater conveyance would require capital investment to upsize segments of the Bayonne force main and downstream infrastructure including treatment capacity at PVSC.

Outfall Consolidation/Relocation: Outfall consolidation/relocation can be used to mitigate the costs of primary controls such as PAA disinfection and storage tanks. The cost associated with outfall consolidation is dependent upon the degree of consolidation needed to minimize the cost or utilize acceptable sites for the final selected alternative.

Green Infrastructure: Green infrastructure can achieve limited progress toward the CSO-control objectives when implemented at typically successful levels. Control of the first inch of runoff from 10% of impervious areas across the CSS reduces CSO volume by less than 7%, so substantial control through GI technologies is unlikely on a widespread basis. However, implementation of specific GI applications will be considered as part of final alternative selection.

D.3.3.3 Ineffective/Problematic Alternatives

Alternatives that do not have much potential to improve CSO control and that may be problematic are not going to be considered unless no other options are available. These alternatives are:

1. Regulator Modifications for in-line storage
2. Real Time Control (RTC) for in-line storage

Regulator Modifications: Regulator modifications for in-line storage appear to risk flooding yet offer very limited benefits for City's CSO control. As such, this CSOcontrol alternative will not be considered unless other alternatives are not applicable or other controls proposed for the site involve changes to the infrastructure that could change the flooding risks involved.

Real Time Control: Similar to regulator modification, real time control options to enhance in-line storage are not desirable due to the potential risks for flooding and the limited benefits of implementation. This option will not be considered unless other alternatives are not applicable or other controls proposed for the site involve changes to the infrastructure that could change the flooding risks involved.

D.3.3.4 Example Plan Alternatives

To achieve the full range of the *CSO-frequency* objectives described in Section D.1.5.1, two different plans are offered here as examples. The first example plan is PAA Disinfection at each outfall, and the second example plan is Consolidated Storage Tanks with Additional Conveyance. Table D-26 presents a side-by-side summary of the efficacy and life-cycle costs of these two control alternatives. As shown, the life-cycle costs of PAA Disinfection (with FlexFilter pretreatment) are a fraction of the cost of Consolidated Tanks with Additional Conveyance to achieve similar CSO-control metrics. In addition, the Consolidated Tanks with Additional Conveyance alternative may require infrastructure improvements outside of Bayonne (such as the conduits to the PVSC STP, as well as at the STP itself), which are wholly or partly outside of Bayonne's jurisdiction.

Table D-26 | Example Plan Alternatives for CSO-Frequency Targets

Control Alternative	Untreated CSO Events (count/yr)	Untreated CSO Volume (MG/yr)	Untreated CSO Volume Reduction (%)	20-Yr Life-Cycle Cost, Raw as PV ($M)	20-Yr Life-Cycle Cost, PTPC as PV ($M)
Baseline	60	748	-	-	-
PAA Disinfection with FlexFilter Pretreatment	20	206	72%	99.78	220.23
	12	91	88%	158.20	351.93
	8	82	89%	164.28	365.43
	4	28	96%	245.68	548.95
Consolidated Tanks with Additional Conveyance	20	182	76%	220.50	424.75
	12	102	86%	272.28	533.17
	8	59	92%	308.94	603.59
	4	92	94%	331.39	648.98

(1) An "Untreated CSO Event" is a wet-weather event with at least one overflow that does not receive full treatment.
(2) Baseline and "Consolidated Tanks with Additional Conveyance for 20 Events/yr" require peak conveyance capacity of 17.6 MGD at Oak Street PS.
(3) "Consolidated Tanks with Conveyance for 12 Events/yr" require peak conveyance capacity of 20.0 MGD at Oak Street PS.
(4) "Consolidated Tanks with Conveyance for 8 and 4 Events/yr" require peak conveyance capacity of 40.0 MGD at Oak Street PS and include the cost of upsizing the force main to 36''.

To achieve the 85 percent capture of CSO volume, or the equivalent capture of CSO pollutant of concern (as described in Section D.1.5.1), a number of plans are offered here as examples. As noted previously, to meet the 85 percent capture target for Bayonne, a 59 percent reduction in untreated CSO (that is, no more than 306 MG of untreated CSO) must be achieved.

Focusing first on volume capture (and noting that, of all evaluated alternatives, only offline storage can achieve 59 percent reduction of CSO volume) three different plans are presented below, one for each of the three conveyance levels evaluated (17.6, 20.0, and 40.0 MGD, as described herein). Each plan involves implementation of three storage tanks: one near outfall BA-015, one near BA-017, and one near BA-001/002. In each plan, the tanks at BA-015 and

BA-017 are 2.5 MG, while the tank at BA-001/002 is sized at 17 MG, 15 MG, or 6.5 MG, for each of the three conveyance levels, respectively. Table D-27 presents a side-by-side summary of the efficacy and life-cycle costs for these three control alternatives. Slight differences in the expected untreated CSO volume all provide the requred reduction of CSO volume, but for significantly different life-cycle costs. The most cost-effective option here has a life-cycle cost (20-year PTPC as PV) of $181M, less expensive than the $220M PAA Disinfection (with FlexFilter Pretreatment) alternative (Table D-26), but also less effective in terms of resulting number or untreated events and untreated CSO volume.

Table D-27 | Example Plan Alternatives for CSO Volume/Pollutant Capture Targets

Control Alternative	Untreated[1] CSO Events (count/yr)	Untreated[1] CSO Volume (MG/yr)	Untreated[1] CSO Volume Reduction (%)	20-Yr Life-Cycle Cost, Raw as PV ($M)	20-Yr Life-Cycle Cost, PTPC as PV ($M)
Baseline	60	748	-	-	-
17.6 MGD 2.5 MG BA015 2.5 MG BA017 17 MG BA001/2	48	298	60%	128.31	248.21
20.0 MGD[2] 2.5 MG BA015 2.5 MG BA017 15 MG BA001/2	48	300	60%	120.52	232.54
40.0 MGD[3] 2.5 MG BA015 2.5 MG BA017 6.5 MG BA001/2	48	309	59%	93.18	180.88

(1) An “Untreated CSO Event” is a wet-weather event with at least one overflow, “Untreated CSO Volume” determined for each 5-minute period exceeding the design capacity of the disinfection facility.
(2) Option provides peak conveyance capacity of 20.0 MGD at Oak Street PS.
(3) Option provides peak conveyance capacity of 40.0 MGD at Oak Street PS and through the force main.

References

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Acronyms

$M	Million Dollars
CCI	Construction Cost Index
COP	Continuous Operating Post
CSO	Combined Sewer Overflow
ENR	Engineering News-Record
GI	Green Infrastructure
H&H	Hydrologic and Hydraulic (Model)
ILS	In-Line Storage
LTCP	Long Term Control Plan
MG	Million Gallons
MGD	Million Gallons per Day
MS4	Municipal Separately Sewered Stormwater System
MUA	Municipal Utility Authority
NJDEP	New Jersey Department of Environmental Protection
NJSPDES	New Jersey State Pollutant Discharge Elimination System
NMC	Nine Minimum Controls (for CSO Control, per USEPA)
O&M	Operation and Maintenance
OSPS	Oak Street Pump Station
PAA	Peracetic Acid (disinfection agent)
PICP	Permeable Interlocking Concrete Pavers
PV	Present Value (Cost)
PVSC	Passaic Valley Sewerage Commission
TGM	Technical Guidance Manual
USEPA	United State Environmental Protection Agency
UV	Ultraviolet (disinfection agent)

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APPENDIX C

Development and Evaluation of Alternatives Report
Borough of East Newark

Dated: June 2019
Revised: November 2019

Development and Evaluation of Alternatives Report

Borough of East Newark

~~April~~ June 2019

Revised November 2019

Contents

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Executive Summary

Section A Introduction

The Borough of East Newark is a densely populated town in Hudson County, New Jersey. The town comprises an area of approximately 0.1 square miles and is boarded by the Town of Kearny in the north and Harrison in the south. It is located by the Passaic River and has one CSO outfall discharging CSO to the Passaic River. All combined sewer flows from Borough of East Newark will be conveyed to the PVSC wastewater treatment plant through PVSC interceptor. The Borough's combined sewer system is permitted under NJPDES Permit No. NJ0117846

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

Section D.3.b.v of the NJPDES permit indicates that, as part of the LTCP requirements, a Development and Evaluation of CSO Control Alternatives Report be submitted to the NJDEP within 48 months from the effective date (July 1, 2015) of the permit. To meet this regulatory requirement, the Borough of East Newark prepared this report for the development and evaluation of CSO control measures. Various alternatives evaluated for the Borough of East Newark CSO LTCP including source control technologies, collection system technologies, storage and treatment technologies.

Section B Future Conditions

B.1 Introduction

Establishing baseline condition is an important step in the CSO LTCP alternatives analysis. Baseline condition is used to compare the effectiveness of different CSO control alternatives and to estimate the magnitude of the CSO volume and frequency reductions. A 25 to 35 year planning horizon is being assumed for implementation of the CSO LTCP. The projection of sanitary flows is based on the population as described in Section B.4.

B.2 Projections for Population Growth

The Borough of East Newark's population was 2,406 counted in the 2010 United States Census. Based on the North Jersey Transportation Authority (NJTPA) report, the 2045 population is projected to be 2,993.

B.3 Planned Projects

One planned project in the Borough of East Newark is the remediation of the BASF property which was the site of a former Clark Thread Mill. Plans for the property are still evolving for this private property but it is likely that i~~I~~t will be ~~remediated~~ redeveloped ~~to~~ as an ecological site with minimal domestic waste or as a residential site which will be separately sewered. Details on the site redevelopment will be developed during late 2019. For now we are assuming that storm water and wastewater will be separately sewered. This will reduce the CSO drainage area by 14 acres and create a new storm water discharge.

B.4 Projected Future Wastewater Flows

The future baseline condition is intended to reflect the magnitude and geographic distribution of the anticipated sanitary sewage flow rates. To estimate the sanitary flow rates for the year 2045 planning horizon, the projected population increases (see Section B.2) are applied with existing per-capita sanitary flow rates, based on observed 2016/2017 measured flows and year 2017 population estimates. This calculation represents an increase in sanitary sewage flow of about 7.5% relative to the observed 2016/2017 dry weather flows. This analysis assumed no change in existing infiltration rates affecting base wastewater flows for the future baseline condition.

Section C Screening of CSO Control Technologies

C.1 Introduction

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

As part of the screening process, each CSO control technology was evaluated for its effectiveness to achieve the following goals: 1) achieving water quality standards and designated uses of the receiving waters, 2) reducing pollutant-of-concern discharges, 3) reducing CSO-discharge frequency, and 4) reducing CSO-discharge volumes. Other considerations in the evaluation of CSO control technologies included implementation requirements (land, neighborhood, noise, disruption) and operational factors.

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

- Primary Technology – High potential of meeting water-quality and CSO control goals;

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

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

C.2 Source Control

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

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

C.2.1 Green Infrastructure

Green Infrastructure refers to a host of source-control approaches that can reduce and treat rainfall runoff prior to its entry into the CSS. GI approaches typically intercept rainfall runoff with soil media and plants to eliminate or attenuate volumes and pollutants through absorption, infiltration, and evapo-transpiration. Many GI approaches can also deliver ancillary environmental, social, and economic benefits 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 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 Bayonne, where they may not be as practical as traditional "gray infrastructure" approaches in providing reliable, stand-alone solutions. Nevertheless, GI approaches are being featured in CSO LTCP programs for a number of municipalities, including New York City and the City of Philadelphia. GI is being evaluated in conjunction with other primary alternatives that are necessary to achieve the volume and bacteria reduction primary goals for CSO control. GI will be considered based on absorbing a 1 inch rainfall. Anything in excess of 1 inch generates CSO.

A previous study, "Green Infrastructure Feasibility Study, East Newark," prepared by Rutgers University, identified possible locations for GI opportunities in the City which included:

- East Newark Recreation Center
- East Newark Public Schools
- East Newark Borough Hall
- East Newark Playground and Soccer Field
- St Anthony Roman Catholic Church Pastoral Center
- John Street One-Way
- No Parking Zones
- Passaic Ave Streetscape
- Municipal Parking Lots (6)
- Municipal Street Tree Pit Planting

GI treatment methods include:

- Curb Cut Stormwater Planters
- Rainwater Harvesting
- Permeable Pavers, Porous Asphalt, Pervious Concrete
- Curbside Stormwater Planters

. The realistic potentials of GI approaches will be further refined in the alternative evaluation with the associated benefits and concerns in mind. The City's citizen education and support services will also continue to promote localized GI on a homeowner scale as a program enhancement.

C.3 Infiltration and Inflow Control

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

Infiltration problems typically reflect a general overall deterioration of the sewer system and can be difficult to isolate and identify. Achieving significant reductions of infiltration can also be difficult and expensive. Infiltration in the Borough of East Newark is not a cost-effective method of CSO control.

Inflow control in the Borough of East Newark's CSS would focus primarily on potential tidal inflows, as the separated catchments do not contribute storm water to the CSS, and there are no known or suspected stream inflows to the CSS. Tidal inflows to the CSS can be identified via measurement of chlorides and controlled at reasonable cost by replacement or proper maintenance of flex valves and tide gates at the existing CSO control facilities. The Borough of East Newark will investigate their outfall for tidal inflow to the CSS and make any repairs that are needed.

In summary, investigation and control of I/I via identification and control of tidal inflow will be retained as a program enhancement to protect against future increases of CSO.

C.4 Sewer System Optimization

Sewer system optimization reduces CSO volume and frequency by maximizing the volume of flow stored in the collection system or maximizing the use of system capacity to convey flow to a treatment facility. Techniques used for sewer system optimization include: implementing regulator modifications, improving conveyance, consolidating or relocating outfalls, and applying real-time controls to minimize CSO frequency/volume or the number/cost of control facilities.

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

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

PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. To date, there have not been discussions with PVSC to address the issue of conveying additional flow to the PVSC treatment plant. However, should this alternative be further considered as part of the Selection and Implementation of Alternatives Report, discussions with PVSC regarding the issues of conveyance capacity, acceptance, etc. will be conducted. In addition, three of the Hudson County Force Main communities (Bayonne, Jersey City and North Bergen) and PVSC have met on at least two occasions (March 8, 2019 and March 20, 2019) specifically to discuss increases in flow capacity and other regional solutions, with multiple follow-up exchanges.

Communities were instructed by PVSC that the HGL in the main interceptor should not be increased beyond existing conditions unless a flow increase is approved and allocated to the CSO permittees.

Outfall Consolidation/Relocation: Combining and relocating outfalls can minimize the number of CSO control facilities and aid in their siting. This type of measure helps eliminate CSO discharges to sensitive areas or move discharge points to less sensitive areas. The measures may also lower operational requirements and reduce monitoring efforts. The solution generally involves routing overflows using new piping to a new discharge point. Outfall consolidation works best when the outfalls are in close proximity to each other, requiring limited modifications to the conveyance. The techniques can be effective in reducing high frequency, low volume CSOs. However, the Borough of East Newark only has one CSO along a 2,000 foot stretch of the Passaic River: therefore, Outfall Consolidation/Relocation is unlikely.

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

C.5 Storage

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

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

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

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

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

Additionally, storage tanks can be used for providing contact time for disinfecting the effluent during larger events, depending upon the application needs. Storage tanks will be further evaluated as one of primary technologies for CSO control in the Borough of East Newark.

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

Expansion of a sewage treatment plant can help to reduce or eliminate CSOs by allowing more flows into the plant. The Borough of East Newark transports their combined sewer flows to the PVSC wastewater treatment facility via the main interceptor. As indicated in Section C.4, PVSC is considering modifications to their treatment facilities to be able to accept additional wet weather flows from their district permitees. While all dry weather flows from the Borough of East Newark are conveyed to PVSC, local and regional hydraulic constraints would limit the amount of additional flows above the contracted amount that can be conveyed for treatment. Also, negotiations would have to be undertaken with Kearny and Harrison to construct joint facilities which would primarily be led by the parties' interest. Due to these facts, it would likely be less intricate and more cost effective if local storage (e.g., tunnel, tank) is considered, rather than conveying the full peak flow of the Borough of East Newark to PVSC for treatment. Since the Borough of East Newark currently neither owns nor operates a wastewater treatment facility, STP expansion or modification for wet weather flow could only be done by PVSC. These discussions with PVSC will be held in late 2019.

As stated in Section C.4, PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. Communities were instructed by PVSC that the HGL in the main interceptor should not be increased beyond existing conditions unless a flow increase is approved and allocated to the CSO permittees.

C.7 Sewer Separation

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

C.8 Treatment of CSO Discharges

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

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

The U.S. EPA approved peracetic acid (PAA) as a primary disinfectant for wastewater in 2007. A growing number of wastewater treatment plants in the United States have adopted PAA as a primary disinfectant. Several case studies applying PAA for CSO treatment have been undertaken in the US, including a demonstration study (2017, HMM) conducted in Bayonne. These studies have shown that PAA is an effective agent that requires a comparatively short contact time to achieve the desired level of disinfection, without residual toxicity. The main advantages of PAA over sodium hypochlorite include a longer "shelf life" without product deterioration, the strong relationship between higher dose and higher disinfection level, and the lack disinfection byproducts and associated toxicity, all of which are important for satellite CSO disinfection facilities subject to intermittent and highly variable flows. In addition, the relatively small footprint of PAA-disinfection facilities should allow it to be implemented upstream of each CSO outfall, at a location between the existing regulator and the existing netting facility. It is understood that pilot testing may be required to demonstrate that satisfactory treatment can be achieved in this manner through adjustment of flow-paced dosing of PAA.

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

C.9 Screening of Control Technologies

The City has already implemented some low- to medium-level CSO control practices related to the nine minimum controls (NMCs). Screening of available CSO control technologies was therefore conducted to characterize the likely effectiveness of each control as:

- Measure already in place vs. measure not already in place;
- Measure alone will meet vs. partially meet vs not meet LTCP objectives; and
- Measure in combination with other technologies will meet vs. partially meet vs not meet LTCP objectives.

The technologies were categorized as follows with regard to the primary CSO control goals of bacteria reduction or volume reduction:

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

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

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

As indicated in Section C-1, technologies not recommended due to various reasons such as cost, maintenance, public acceptance, etc. are removed from consideration. The results of the CSO control technologies screening process are summarized in Table C-1 below. The columns at the right indicate the current status of each technology, whether or not the technology is suitable to be combined with others, and whether or not the technology is being evaluated further (in Section D).

Table C-1. CSO Control Technology Screening Results

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

Table C-1. CSO Control Technology Screening Results

Borough of East Newark								
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		Bacteria Reduction	Volume Reduction					
	Pet Waste Management	Medium	None	Low cost of implementation and little to no maintenance. This is a low cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes	No	Yes	No
	Lawn and Garden Maintenance	Low	Low	Requires communication with business and homeowners. Guidelines are already established per USEPA. Educating the public on proper lawn and garden treatment protocols developed by USEPA will reduce waterway contamination. Since this information is already available to the public it is unlikely to have a significant effect on improving water quality.	Yes	No	Yes	No
	Hazardous Waste Collection	Low	None	The N.J.A.C prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	Yes	No
Ordinance Enforcement	Construction Site Erosion & Sediment Control	None	None	In building code; reduces sediment and silt loads to waterways; reduces clogging of catch basins; little O&M required; contractor or owner pays for erosion control. A Soil Erosion & Sediment Control Plan Application or 14-day notification (if Permitee covered under permit-by-rule) will be required by NJDEP per the N.J.A.C.	Yes	Yes	Yes	No
	Illegal Dumping Control	Low	None	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes	Yes	Yes	No
	Pet Waste Control	Medium	None	Requires resources to enforce pet waste ordinances. Public education and outreach is a more efficient use of resources, but this may also provide an alternative to reducing bacterial loads.	Yes	No	Yes	No
	Litter Control	None	None	Aesthetic enhancement; labor intensive; City function. Litter control provides an aesthetic and water quality enhancement. It will require city resources to enforce. Public education and outreach is a more efficient use of resources.	Yes	No	Yes	No
	Illicit Connection Control	Low	Low	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	No	Yes	No
Good Housekeeping	Street Sweeping/Flushing	Low	None	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	Yes	No
	Leaf Collection	Low	None	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	Yes	No

Table C-1. CSO Control Technology Screening Results

Borough of East Newark								
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		Bacteria Reduction	Volume Reduction					
	Recycling Programs	None	None	Most Cities have an ongoing recycling program.	Yes	Yes	Yes	No
	Storage/Loading/Unloading Areas	None	None	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	No	Yes	No
	Industrial Spill Control	Low	None	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	Yes	No
Green Infrastructure Buildings	Green Roofs	None	Medium	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permitee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	Yes	Yes
Green Infrastructure Buildings	Blue Roofs	None	Medium	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permitees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	Yes	Yes
Green Infrastructure Buildings	Rainwater Harvesting	None	Medium	Simple to install and operate; low operational resource demand; will require the Permitees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	No	Yes	No
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	No	Yes	Yes
Green Infrastructure Impervious Areas	Planter Boxes	Low	Medium	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes	Yes

Table C-1. CSO Control Technology Screening Results

Borough of East Newark									
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		Bacteria Reduction	Volume Reduction					
Green Infrastructure Pervious Areas	Bioswales	Low	Low	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	No	Yes	Yes
	Free-Form Rain Gardens	Low	Medium	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	Yes	No
Collection System Technologies								
Operation and Maintenance	I/I Reduction	Low	Medium	Requires labor intensive work; changes to the conveyance system require temporary pumping measures; repairs on private property required by homeowners. Reduces the volume of flow and frequency; Provides additional capacity for future growth; House laterals account for 1/2 the sewer system length and significant sources of I/I in the sanitary sewer.	Yes	Yes	Yes	Yes
	Advanced System Inspection & Maintenance	Low	Low	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	No	No	No
	Combined Sewer Flushing	Low	Low	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	No	Yes	No
	Catch Basin Cleaning	Low	None	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	Yes	Yes	No
Combined Sewer Separation	Roof Leader Disconnection	Low	Low	Site specific; Includes area drains and roof leaders; new storm sewers may be required; requires home and business owner participation. The Cities are densely populated and disconnected roof leaders have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	Yes	No

Table C-1. CSO Control Technology Screening Results

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

Table C-1. CSO Control Technology Screening Results

Borough of East Newark								
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		Bacteria Reduction	Volume Reduction					
	Industrial Discharge Detention	Low	Low	Requires cooperation with industrial users; more resources devoted to enforcement; depends on IUs to maintain storage basins. IUs hold stormwater or combined sewage until wet weather flows subside; there may be commercial or industrial users upstream of CSO regulators.	Yes	No	No	No
Treatment-CSO Facility	Vortex Separators	None	None	Space required; challenging controls for intermittent and highly variable wet weather flows. Vortex separators would remove floatables and suspended solids when installed. It does not address volume, bacteria or BOD.	Yes	No	No	No
	Screens and Trash Racks	None	None	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	No	Yes	No
	Netting	None	None	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	Yes	No
	Contaminant Booms	None	None	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	No	No
	Baffles	None	None	Very low maintenance; easy to install; requires proper hydraulic configuration; long lifespan. Baffles will only address floatables.	Yes	No	Yes	No
	Disinfection & Satellite Treatment	High	None	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	Yes	Yes
	High Rate Physical/Chemical Treatment (High Rate Clarification Process - ActiFlo)	None	None	Challenging controls for intermittent and highly variable wet weather flows; smaller footprint than conventional methods. This technology primarily focuses on TSS & BOD removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	Yes	No
	High Rate Physical (Fuzzy Filters)	None	None	Relatively low O&M requirements; smaller footprint than traditional filtration methods. This technology primarily focuses on TSS removal, but does not help reduce the bacteria or CSO discharge volume.	Yes	No	No	No

Table C-1. CSO Control Technology Screening Results

Borough of East Newark								
Technology Group	Practice	Primary Goals		Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		Bacteria Reduction	Volume Reduction					
Treatment-WRTP	Additional Treatment Capacity	High	High	May require additional space; increased O&M burden.	No	No	Yes	No
	Wet Weather Blending	Low	High	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	Yes	No
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	Yes	No

Section D Alternative Analysis

D.1 Development and Evaluation of Alternatives

D.1.1 Siting

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

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

D.1.2 Institutional Issues

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

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

D.1.3 Implementability

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

Environmental Issues: These issues may be related to land conservation, use and acquisition, zoning changes, easement, traffic and site access, noise and vibration, floodplains and zoning, wetland buffer zones, utilities relocation and loss of services, and short term impacts water or air quality. The Borough of East Newark has waterfront land on the Passaic River which is used to a limited extent both commercially and for boating recreation. Alternatives that fit with existing land uses and favor City property will receive a positive consideration under this evaluation. Any specific permits that would be required to implement a CSO control alternative would be identified at the facility planning and design phase.

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

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

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

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

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

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

D.1.4 Public Acceptance

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

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

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

D.1.5 Performance Considerations

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

D.2 Preliminary Control Program Alternatives

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

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

D.2.1 Controls

1) Inflow/Infiltration (I&I) Reduction

The reduction of Inflow and infiltration (I&I) was evaluated as one of the source control solutions. Two scenarios were evaluated, 10% and 50% of I/I reduction. Model results in Table D-1 shows that for the 10% I&I control, only marginal amount of CSO volume was reduced per year, overflow frequencies were remain unchanged. For the 50% I/I reduction, about 0.3 MG CSO volume was reduced, however, number of overflow events was not eliminated. It is indicated that the benefit of this control is very minimum for the Borough of East Newark combined sewer area in terms of annual CSO volume and overflow frequencies. This control strategy will not be considered further.

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

I/I Reduction								
	Baseline		10% Reduction			50% Reduction		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction	AAOV (MG)	CSO Event	Volume Reduction
EN001	17.2	32	17.1	32	1%	16.9	32	2%

2) Regulator Modifications

In the Borough of East Newark, regulator R38 limits the amount of flow to the PVSC main interceptor and diverts excess flow to the outfall during wet weather events. Modification of the regulator, such as increasing the weir length or height will retain flows back in the system. By raising the existing overflow weir elevation 6 inches, the annual overflow volume was decreased from 17.2 MG to 15.7 MG per year, about 9% reduction. But overflow frequencies did not drop at all. Table D-2 is the summary of CSO volume and number of overflows for this alternative. It is noted that HGL downstream of the regulator in the main interceptor was increased by about 0.04 inches, which was less than 0.05 inches. It is uncertain if this alternative would cause street or basement flooding or not. More investigation would be needed if this alternative is considered.

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

Regulator Modifications					
	Baseline		Increase Weir Height by 6 Inches		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction
EN001	17.2	32	15.7	32	9%

3) Partial Sewer Separation

In the northwest part of the Borough of East Newark, there is a 14 acres former BASF Clark Thread Mill manufacturing site which has been shut down. This area could be separated from the combined sewer area and inflows produced from this manufacturing industry could be removed from the combined sewer. The implementation of sewer separation includes ~~the excavating of the existing infrastructure and~~ the construction of a new storm water pipe a new storm water outfall. Once it is separated, it will require a MS4 permit for the new storm water outfall.

From modeling results, the annual CSO volume was reduced from 17.2 MG to 12.6 MG, a 27% volume reduction per year, overflow frequencies were reduced from 32 to 31. Although CSO events did not have a significant decrease, this alternative will provide significant benefits for the CSO volume reduction and will be reflected in the reduced size of CSO storage facility as well as the costs. Table D-3 shows the results before and after sewer separation. Volume reductions with sewer separation and GI will be discussed in the subsequent section.

Table D-3. Overflow Volumes and Frequencies with Partial Sewer Separation Alternative

Partial Sewer Separation					
	Baseline		Partial SS		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction
EN001	17.2	32	12.6	31	27%

4) Green Infrastructure

GI can be used as a complementary CSO control technology in combination with other alternatives. This alternative was evaluated alone to find out if GI could have a significant impact on CSO volume and frequency reduction. Two different target levels of GI control were evaluated. One of them was to manage 1” of storm water runoff generated from 5% of impervious surfaces, another target level was to manage 1” of storm water runoff generated from 10% of impervious surfaces. In the Borough of East Newark, the combined sewer area is about 62 acres, the impervious surface make up about 84% of the total area, which is about 52 acres. Table D-4 shows the CSO volume and frequency before and after the implementation of GI within partial sewer separation area (BASF property). Sewer separation only reduces the CSO volume by 27% to 12.6 MG. Whe GI is added to sewer separation ~~T~~the CSO volume ~~was~~ is reduced ~~about~~to 28% with 5% GI control and ~~was reduced about~~ 30% with 10% GI. This says that GI will only reduce CSOs by 1 to 3%. ~~control comparing with the baseline condition~~. Only one CSO event was eliminated for both scenarios. Because of the relatively small impact achievable with GI, HDR decided to evaluate all alternatives conservatively, without GI, with the assumption that any additional impact of GI, however minor, would be considered in the development of the final selected alternatives.

Table D-4. Overflow Volumes and Frequencies with GI and Partial SS Alternatives

Green Infrastructure with Partial SS							
	Baseline		5% (2.6 acres)		10% (5.2 acres)		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	Volume Reduction	AAOV (MG)	CSO Event	Volume Reduction
EN001	17.2	32	12.3	28%	12.0	31	30%

5) Storage Tank

The conceptual evaluation of the storage tank for CSO reduction was performed. It is assumed that a storage tank would be located near the existing outfall and it would be below the ground. Only one storage tank is needed in the Borough of East Newark. CSO is stored in the tank during wet weather events. The stored CSO is pumped back to the interceptor for conveyance to the PVSC treatment plant during dry weather and when the system capacity is available. Five scenarios were analyzed to size the storage tank in order to achieve CSO frequencies of 0, 4, 8, 12, and 20 overflows per year. For example, in order to achieve 4 CSO events control target citywide per year, the sizing criteria for the storage tank is to capture the 5th biggest rainfall event during the typical year of 2004. Tank dewatering pump back rate is no more than 75% of the total average dry weather flows and the tank can be dewatered within 72 hours except for zero CSO control target. Overflows from the tank are the same as those listed in the January 7, 2019 Tech Memo "top 20 storm table" for each target. This alternative combined with partial sewer separation at the BASF Clark Thread Mill site described earlier and with 5% and 10% GI were analyzed. Table D-5 shows the size of the tank required at each CSO frequency target. Table D-6 summarizes the CSO volume not captured and retained in the tank at each frequency target, as well as how much volume is reduced when achieving the frequency targets. Table D-7 shows the comparison of CSO frequencies. Storage tank alternative is considered as a primary solution for the CSO frequency control because it is able to reach the overflow event control target. This alternative was assessed based on the partial sewer separation.

Table D-5. Storage Tank Size (MG)

CSO Event Target/yr	EN001
0	1.8
4	0.9
8	0.6
12	0.4
20	0.2

Table D-6. Overflow Volumes (MG) with Storage Tank, GI and Partial SS

	5% GI with Partial SS		10% GI with Partial SS	
CSO Event Target/yr	**EN001**	**Volume Reduction**	**EN001**	**Volume Reduction**
Baseline	17.2		17.2	
0	0.00	100%	0	100%
4	0.55	97%	0.53	97%
8	1.30	92%	1.44	92%
12	2.22	87%	2.39	86%
20	3.98	77%	4.21	76%

Table D-7. Overflow Frequencies with Storage Tank, GI and Partial SS

	5% GI with Partial SS		10% GI with Partial SS	
CSO Event Target/yr	**EN001**	**Frequency Reduction**	**EN001**	**Frequency Reduction**
Baseline	32		32	
0	0	100%	0	100%
4	4	88%	3	91%
8	5	84%	5	84%
12	9	72%	9	72%
20	17	47%	18	44%

6) Treatment - PAA Disinfection

Solids removal an an dDisinfection of combined sewer overflows is another option in the Borough of East Newark. The WWEDCO FlexFilter and dDisinfection by Peracetic Acid (PAA) serves as the basis in the evaluation. Total suspended solids and Pathogens pathogens represent the primary pollutant of concern for CSO discharges. Disinfection facilities are sized based on the maximum CSO discharge flow rate for each event to fully treat all but 4, 8, 12, and 20 CSO discharges per year. For the target of 4 CSO events per year, the 5th largest storm in the typical year will be captured and disinfected. For the storm events larger than the 5th event, CSO discharges will be partially treated, full treatment is achieved only during times that CSO discharges are less than the maximum discharge rate. Where full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens (a “3-log kill.”). This degree of performance would reduce an influent of 500,000 CFU/100 mL to 500 CFU/100 mL in the effluent at the design flow rate. Performance would improve at lower flow rates. This preliminary disinfection alternative assumes that PAA disinfection will be implemented at locations between the existing regulators and the existing outfalls. Similar to the storage tank control, this alternative was assessed based on partial sewer separation. Table D-8 presents the peak flow rates at each CSO control target and Table D-9 summarizes the volume of partially treated overflows at different control level.

The Flex Filter was included with PAA disinfection to provide the equivalent of primary treatment. The WWEDCO website describes the technology and its performance (http://www.westech-inc.com/en-usa/products/combined-sewer-overflow-cso-and-tertiary-treatment-wwetco-flexfilter). In the 2004 Report To Congress average CSO was reported to contain 215,000 CFU/100 mL and in PeroxyChem’s 2016 presentation titled Trends In Wastewater Disinfection Peracetic Acid (PAA), a Ct value (disinfectant dose in mg/L times the contact time in minutes) of 45 mg/L-min was reported to reduce Fecal Coliform in a secondary effluent to 200 CFU/100 mL. This Ct value is equivalent to a PAA dosage of 9 mg/L at a contact time of 5 minutes. This is an indication that PAA will disinfect CSO but testing is required to understand the site specific variables such as suspended solids concentration, PAA demand of the CSO and the Fecal

Coliform concentration of the CSO. If disinfection is selected we will test PAA disinfection with and without pretreatment for suspended solids removal. The purpose of conducting the PAA tests will be to understand the additional chemical requirements and costs for treating raw CSO.

Table D-8. CSO Peak Flow Rates (MGD) at Each Control Target

	5% GI with Partial SS	10% GI with Partial SS
CSO Event Target/yr	EN001	EN001
0	65.33	66.96
4	37.11	35.5
8	19.90	20.27
12	19.90	20.27
20	9.85	9.76

Table D-9. Partially Treated CSO Volumes (MG) at Each Control Target

	5% GI with Partial SS		10% GI with Partial SS	
CSO Event Target/yr	EN001	Volume Reduction	EN001	Volume Reduction
Baseline	17.2		17.2	
0	0.00	100%	0.00	100%
4	1.12	93%	1.39	92%
8	2.88	83%	3.00	83%
12	2.88	83%	3.00	83%
20	4.70	73%	4.86	72%

D.2.2 Summary of Cost Opinions

Cost analysis was performed for GI, storage tank, and PAA disinfection in the Borough of East Newark. Assumptions used to estimate capital and O&M costs are described as follows.

1. Sewer Separation Costs

   a. Capital cost for partial sewer separation is based on a normalized cost of $235,233 per acre (2006, HMM). To convert to 2018 costs, a ratio of 10817:7630 was applied herein, based on the Engineering News Record (ENR) Construction Cost Index (CCI) values for 2018 and 2006, respectively. Table D-10
   b. O&M costs are estimated based on 2% of the capital cost (2019c, G&H).Table D-10

2. Treatment Costs
   a. Capital and O&M costs for PAA disinfection are based on the latest available guidance for permittees (2018, G&H) and are in Table D-10.

3. Storage Tank Costs
   a. Capital costs for tank-storage solutions are based on the latest available guidance for permittees (2018, G&H) and are in Table D-10.
   b. O&M costs for tanks are based on operational costs at $235,000 and maintenance costs at 3% of the construction cost, in accordance with the latest available guidance for permittees (2019c, G&H) and are in Table D-10.

4. Green Infrastructure Costs
   a. Capital costs for various GI solutions are based on the latest available guidance for permittees (2018, G&H) and are in Table D-11.
   b. O&M costs for Bioretention GI solutions were provided as $8,000 per managed acre (2019c, G&H) and are in Table D-11.
   c. O&M costs for Porous Pavement GI solutions were assumed to be $1,250 per managed acre (2018, DEP) and are in Table D-11.

5. Additional Cost Factors
   a. Present-value (PV) of life-cycle costs based on a 20-year period and an interest rate of 2.75% in accordance with the latest available guidance for permittees (2019a, G&H).
   b. Based on experiences on other similar CSO LTCP projects, HDR applied a capital-cost factor of 2.5 to calculate the probable total project cost (PTPC) of implementing each technology. The PTPC accounts for installation, non-component (electrical, piping, etc.), and indirect costs (freight, permits, etc.) for all storage and disinfection. A breakdown of how this factor was calculated is shown below.
      - Installation was estimated at 20% of equipment costs based on historic data experienced by HDR and industry standards for typical plants of similar size and complexity.
      - Non-component costs including: electrical (10%), piping (10%), instrumentation and controls ($15,000), and civil site work (25%) were estimated based on factors or percentages of equipment costs. These factors account for standard installation

commodities, accessories, steal supports and standard testing support.

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

Table D-10. Total Capital Cost, Total 20-yr O&M Cost, Raw and PTPC as 20-yr Present Value

CSO Event Target/yr	Alternative ID	Raw Capital Cost($M)	PTPC Capital Cost ($M)	20-Yr O&M Cost as PV ($M)	Raw 20-Yr Life Cycle Cost as PV($M)	PTPC 20-Yr Life Cycle Cost as PV($M)
85% Capture	Alt_1A_PartialSS_5%GI_PAA	$ 1.9	$ 8.5	$ 1.9	$ 3.8	$ 10.5
0	Alt_2A_0_PartialSS_5%GI_Tank	$ 12.4	$ 34.8	$ 10.1	$ 21.0	$ 44.9
0	Alt_2B_0_PartialSS_5%GI_PAA	$ 2.4	$ 9.8	$ 3.9	$ 4.7	$ 13.7
0	Alt_2C_0_PartialSS_10%GI_Tank	$ 14.0	$ 37.9	$ 9.8	$ 22.6	$ 47.7
0	Alt_2D_0_PartialSS_10%GI_PAA	$ 4.0	$ 12.9	$ 3.6	$ 5.5	$ 16.6
4	Alt_3A_4_PartialSS_5%GI_Tank	$ 8.8	$ 25.8	$ 8.4	$ 15.7	$ 34.3
4	Alt_3B_4_PartialSS_5%GI_PAA	$ 2.3	$ 9.5	$ 3.0	$ 3.8	$ 12.5
4	Alt_3C_4_PartialSS_10%GI_Tank	$ 10.8	$ 30.0	$ 8.3	$ 18.0	$ 38.4
4	Alt_3D_4_PartialSS_10%GI_PAA	$ 3.9	$ 12.6	$ 2.7	$ 5.5	$ 15.3
8	Alt_4A_8_PartialSS_5%GI_Tank	$ 6.9	$ 21.2	$ 7.6	$ 13.0	$ 28.7
8	Alt_4B_8_PartialSS_5%GI_PAA	$ 2.1	$ 9.2	$ 2.5	$ 3.0	$ 11.7
8	Alt_4C_8_PartialSS_10%GI_Tank	$ 8.5	$ 24.3	$ 7.3	$ 14.7	$ 31.6
8	Alt_4D_8_PartialSS_10%GI_PAA	$ 3.7	$ 12.3	$ 2.5	$ 4.6	$ 14.5
12	Alt_5A_12_PartialSS_5%GI_Tank	$ 5.4	$ 17.4	$ 6.9	$ 10.8	$ 24.3
12	Alt_5B_12_PartialSS_5%GI_PAA	$ 2.1	$ 9.2	$ 2.5	$ 2.8	$ 11.7
12	Alt_5C_12_PartialSS_10%GI_Tank	$ 7.0	$ 20.6	$ 6.6	$ 12.5	$ 27.2
12	Alt_5D_12_PartialSS_10%GI_PAA	$ 3.7	$ 12.3	$ 2.2	$ 4.5	$ 14.5
20	Alt_6A_20_PartialSS_5%GI_Tank	$ 3.8	$ 13.4	$ 6.2	$ 8.5	$ 19.6
20	Alt_6B_20_PartialSS_5%GI_PAA	$ 2.0	$ 8.9	$ 2.2	$ 2.5	$ 11.1
20	Alt_6C_20_PartialSS_10%GI_Tank	$ 5.4	$ 16.5	$ 5.9	$ 10.1	$ 22.4
20	Alt_6D_20_PartialSS_10%GI_PAA	$ 3.6	$ 12.0	$ 1.9	$ 4.2	$ 13.9
	Partital SS +5% GI	$ 1.6	$ 7.8	$ 1.6	$ 1.6	$ 9.4
	Partital SS +5% GI	$ 3.2	$ 10.9	$ 1.3	$ 3.3	$ 12.2

Note:85% capture refers to capture in East Newark only.

Table D-11. Capital, O&M, and PTPC Ranges for Green Infrastructure to Control 5 and 10% of Impervious Cover

Target Level of GI Controll	GI Technology	Capital Cost Min PTPC ($M)	Capital Cost Max PTPC ($M)	20-Yr O&M Cost as PV ($M)	Min PTPC 20-Yr Life Cycle Cost as PV($M)	Max PTPC 20-Yr Life Cycle Cost as PV($M)
5% (~2.6 acres)	Rain Garden	$ 0.63	$ 2.00	$ 0.32	$ 0.95	$ 2.32
	Right-of-Way Bioswale	$ 0.98	$ 3.28	$ 0.32	$ 1.30	$ 3.59
	Green Roof	$ 3.14	$ 15.98	$ 0.32	$ 3.46	$ 16.30
	Porous Asphalt	$ 1.70	$ 3.57	$ 0.05	$ 1.75	$ 3.62
	Pervious concrete	$ 2.00	$ 4.00	$ 0.05	$ 2.05	$ 4.05
	PICP	$ 0.85	$ 2.42	$ 0.05	$ 0.90	$ 2.47
10% (~5.2 acres)	Rain Garden	$ 1.26	$ 4.00	$ 0.64	$ 1.90	$ 4.63
	Right-of-Way Bioswale	$ 1.96	$ 6.55	$ 0.64	$ 2.60	$ 7.19
	Green Roof	$ 6.29	$ 31.96	$ 0.64	$ 6.93	$ 32.60
	Porous Asphalt	$ 3.41	$ 7.14	$ 0.10	$ 3.51	$ 7.24
	Pervious concrete	$ 4.00	$ 7.99	$ 0.10	$ 4.10	$ 8.09
	PICP	$ 1.70	$ 4.85	$ 0.10	$ 1.80	$ 4.95

For the cost of GI, the latest guidance available to permittees (2018, G&H and 2019c, G&H) provides capital and O&M costs for a variety of GI technologies, O&M costs are available for porous-pavement technologies from the NJDEP (2018, NJDEP). As widespread implementation of GI could involve a variety of GI technologies depending on specific site conditions, a range of costs is provided in Tables D-11 and Table D-12. Table D-11 shows the capital costs, O&M costs, and PTPC for each GI technology for implementation at 5% and 10% of impervious surfaces. Table D-12 shows the raw and PTPC cost range of green infrastructure reported as $M/MG CSO controlled and $M/impervious acre controlled.

Table D-12. Normalized Green Infrastructure Cost Ranges

Cost Type	Green Infrastructure Type	Min $M/MG CSO Reduced	Max $M/MG CSO Reduced	Min $M/Impervious Acre Controlled	Max $M/Impervious Acre Controlled
Raw Cost	Rain Garden	$ 1.41	$ 2.75	$ 0.22	$ 0.43
	Right-of-Way Bioswale	$ 1.75	$ 4.01	$ 0.27	$ 0.62
	Green Roof	$ 3.88	$ 16.53	$ 0.60	$ 2.56
	Porous Asphalt	$ 1.80	$ 3.64	$ 0.28	$ 0.56
	Pervious concrete	$ 2.09	$ 4.06	$ 0.32	$ 0.63
	PICP	$ 0.96	$ 2.51	$ 0.15	$ 0.39
Probable Total Project Cost	Rain Garden	$ 2.33	$ 5.71	$ 0.36	$ 0.88
	Right-of-Way Bioswale	$ 3.21	$ 8.85	$ 0.50	$ 1.37
	Green Roof	$ 8.53	$ 40.14	$ 1.32	$ 6.22
	Porous Asphalt	$ 4.32	$ 8.91	$ 0.67	$ 1.38
	Pervious concrete	$ 5.04	$ 9.96	$ 0.78	$ 1.54
	PICP	$ 2.22	$ 6.09	$ 0.34	$ 0.94

D.3 Preliminary Selection of Alternatives

D.3.1 Evaluation Factors

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

- Performance capabilities and effectiveness under future (baseline) conditions

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

D.3.2 Regulatory Compliance

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

East Newark intends to select the approach (Demonstration vs Presumption) which will be presented in the "Selection and Implementation of Alternatives" report due June 1, 2020. At that time we will also make a determination with regard to our segmentation within the hydraulically connected system which includes the Hudson County Force Main and PVSC. The definition of hydraulically connected system allows us to segment a larger hydraulically connected system into a series of smaller inter-connected systems. If the Presumptive Approach is selected, a memorandum presenting and describing the percent capture equation will be presented by PVSC.

PVSC has coordinated extensively with member municipalities during the course of the CSO LTCP, with monthly or twice monthly meetings, including discussions regarding whether or not NJDEP might approve a higher wet-weather flow capacity for PVSC that would enable PVSC to increase the flow limitations. Without knowledge of whether or not NJDEP would permit PVSC to increase wet-weather flows East Newark has not developed an agreement for a particular allotment of the unknown additional capacity. However, indications are that a mutually agreeable allotment can be achieved.

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

D.3.3 Selection of Preliminary Alternatives

The evaluation and screening of the range of control alternatives described above resulted in a trend toward the use of storage or disinfection technologies as the preliminary solutions based on the effectiveness of CSO volume and frequency control. From the cost standpoint, apparently the most cost effective control measure is PAA disinfection. The potential add-on alternatives could provide positive benefits for the CSO volume reduction, however, they cannot achieve CSO overflows frequency control target of 0, 4, 8, 12 and 20 CSOs per year if the alternative was selected alone. Although green infrastructure has limited impact on the CSO volume and frequency reductions, it can be used as a complimentary control strategy for other benefits combined with storage tanks or disinfection. The separation of the BASF former Clark Thread Mill site is also identified as another effective complimentary solution in terms of CSO volume reduction and can be used with tank or disinfection to reach CSO frequency control target. These evaluations of alternatives will serve as a base for the consideration and development of final selected CSO control plan in East Newark. An example of the cost range of alternatives is shown in Table D-13.

Table D-13. PV Cost Range for CSO Control Alternatives

CSO Event Target/yr	Maximum PV Cost ($M)			Minimum PV Cost ($M)		
	Sewer Separation plus Tank	GI of 10% of Impervious Surface	Total Cost	Sewer Separation plus Disinfection	GI of 5% of Impervious Surface	Total Cost
4	$ 30.26	$ 8.09	$ 38.35	$ 8.45	$ 4.05	$ 12.50
8	$ 23.49	$ 8.09	$ 31.58	$ 7.61	$ 4.05	$ 11.66
12	$ 19.09	$ 8.09	$ 27.18	$ 7.61	$ 4.05	$ 11.66
20	$ 14.33	$ 8.09	$ 22.42	$ 7.02	$ 4.05	$ 11.07

APPENDIX D

Development and Evaluation of Alternatives Report
Town of Harrison

Dated: July 1, 2019
Revised: November 2019

MOTT MACDONALD

Town of Harrison
Combined Sewer Overflow
Long Term Control Plan

Development and Evaluation of Alternatives Report

NJDEP Submission July 1, 2019
Revised November 15, 2019

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Development and Evaluation of Alternatives Report

NJDEP Submission July 1, 2019
Revised November 15, 2019

Town of Harrison

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
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1	11/15/2019	J. Dening	P. Kocsik	J. Dening	Revised per NJDEP Comments

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Information class: Standard

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CERTIFICATIONS

Certification

Title: **Town of Harrison Development and Evaluation of Alternatives Report**

NJPDES Number NJ0108871

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information."

Permitee: ______________________________ 6/20/19

Rocco Russomano — Date

Town Engineer, Town of Harrison

Certification

Title: **Town of Harrison Development and Evaluation of Alternatives Report**

NJPDES Number NJ0108871

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information."

Permitee: John Dening 6/20/2019

John Dening, NJ P.E. #45517 Date

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ACRONYMS AND ABBREVIATIONS

BMP – Best Management Practices
BOD – Biochemical Oxygen Demand
CCI – Construction Cost Index
CSO – Combined Sewer Overflow
CSS – Combined Sewer Systems
CWA – Clean Water Act
DEFM – Demographic and Employment Forecast Model
DWF – Dry Weather Flow
ENR – Engineering News Record
FOG – Fats Oil and Grease
GI – Green Infrastructure
GP – General Permit
gpcpd – gallons per capita per day
HGA – Heyer, Gruel, & Associates
HSG – Hydrologic Soil Group
I/I – Infiltration/Inflow
IU – Industrial Users
KHN - Kearny-Harrison-Newark
LTCP – Long Term Control Plan
MHW – Mean High Water
N.J.A.C – New Jersey Administrative Code
NJDEP – New Jersey Department of Environmental Protection
NJPDES – New Jersey Pollutant Discharge Elimination System
NJTPA – North jersey Transportation Authority
NMC – Nine Minimum Controls
NOAA – National Oceanic and Atmospheric Administration
PAA – Peracetic Acid
PVSC – Passaic Valley Sewerage Commission
ROSI – Recreation and Open Space Inventory
RTC- Real Time Control
SIU – Significant Indirect Users
STP – Sewage Treatment Plant
TAZ – Traffic Analysis Zone
TBM – Tunnel Boring Machine
TGM – Technical Guidance Manual
TIDE – Transforming Infrastructure and Defending our Environment
TSS – Total Suspended Solids
USACE – United States Army Corps of Engineers
USCG – United States Coast Guard
USEPA – United States Environmental Protection Agency
USFWS – United Stated Fish and Wildlife Service
WQS – Water Quality Standards
WRRF – Water Resource Recovery Facility

EXECUTIVE SUMMARY

This Development and Evaluation of Alternatives Report has been prepared in partial fulfillment of the Town of Harrison's obligations under their individual Combined Sewer Management Permit, permit number NJ0108871, issued March 12, 2015, with an effective date of July 1, 2015 and minor revisions issued October 9, 2015. Specifically, this report addresses the requirements of Part IV.D.3.b.v, as per the details provided in Part IV.G.4. This report is being developed cooperatively with the Passaic Valley Sewerage Commission (PVSC) Combined Sewer Overflow (CSO) Group, and is attached to the PVSC Main Report. Accordingly, this report references the Main Report and incorporates and makes use of information in the Main Report without specifically duplicating that information. References are also made to prior reports submitted by the PVSC CSO Group on behalf of Harrison including:

- Combined Sewer System Characterization Report
- Public Participation Process Report
- Sensitive Areas Report
- Baseline Compliance Monitoring Program Report

These documents have all been approved by the New Jersey Department of Environmental Protection (NJDEP).

The PVSC CSO Group is also coordinating and reporting on the systemwide performance of alternatives, as a result, the reporting of certain results, for example systemwide percent capture, may be found in the Main Report. Results reported in this document have been coordinated with the PVSC NJ CSO Group to address systemwide levels of control. This is consistent with the permit requirement that the Long Term Control Plan's (LTCP) performance be evaluated for the hydraulically connected system; in the case of Harrison this would encompass the PVSC interceptor communities.

Permittee Background

The Town of Harrison is located in Hudson County immediately north and east of the City of Newark. It is bounded on the north by the Town of Kearny and the Borough of East Newark. The Passaic River separates the Town of Harrison from the City of Newark. Harrison has a population of 17,643 (2017 US Census Bureau estimate) and comprises an area of approximately 1.75 square miles.

Town's NJPDES permit currently includes 7 outfalls. Due to ongoing sewer separation projects, NJDEP will be issuing Harrison a minor modification NJPDES permit action to remove the Dey Street outfall 004A in the near future. Since outfall 004A was abandoned following 2015, it will be included in the baseline conditions and its removal incorporated in the 2050 future baseline.

Public Outreach

Public outreach and input are an important component of the LTCP progress, and the project team has endeavored to provide opportunities for public education and awareness, as well as to gain feedback on the CSO control alternatives. Efforts by the overall PVSC Group, of which Harrison is a part, are documented in the Main Report. This section only covers actives since the Public Participation Process report was submitted, and prior activities are documented in that report.

Below is a summary of activities specific to Harrison, undertaken since the approved Public Participation Process report:

- Harrison Tide
- PVSC CSO Group Supplemental CSO Team
- Town Caucus Meeting
- Additional Outreach Efforts

Sensitive Areas

The Permit calls for the Permittee to "give the highest priority to controlling CSOs to sensitive areas" as documented in the Sensitive Areas Report, and indicated by the NJDEP's April 8, 2019 approval letter, the Town of Harrison does not own any outfalls which discharge combined sewage to sensitive areas. Accordingly, the Harrison outfalls will be addressed uniformly with consideration to the overall reductions in systemwide volume and frequency of overflows.

Future Baseline Condition

The Permit requires the permittee to simulate "conditions as they are expected to exist after construction and operation of the chosen alternative(s)" (Part IV.G.4.e). The intent is to mitigate the risk, that foreseeable changes in the community and sewer system will reduce the effectiveness of the proposed LTCP facilities. To address this, an evaluation of anticipated changes to the Town's population and potential changes to sewer flows was undertaken. Discussions were also held with the Town to document planned changes to the sewer system, including sewer separations through redevelopment, specifically the planned separation of Outfall 005A. It has been assumed that the alternatives that are selected through the LTCP process will be constructed and implemented over a 30-year period. As such, the year 2050 has been selected as the future baseline condition. A comparison of the 2015 and 2050 baselines is provided below in Table 1.

Table 1: Summary of CSO performance for Future Baseline

Outfall	Baseline 2015 (Typical Year)			Baseline 2050 (Typical Year)			Change		
	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	25	1.5	59	-1	-0.5	-39
H-002A	35	3.2	162	25	2.2	78	-10	-1.0	-84
H-003A	32	13.1	155	33	12.8	107	1	-0.3	-48
H-004A	10	0.3	6	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	27	7.0	106	-1	-1.0	-16
H-007A	53	14.5	352	52	19.3	347	-1	4.8	-4
Total	--	61.5	--	--	42.8	--	--	-18.7	--

The PVSC CSO Group estimated that a 7% reduction in overflow volume by the interceptor communities would be required to achieve a systemwide 85% capture of wet weather flows as per the presumptive approach. The 30% reduction achieved between the 2015 baseline and 2050 future baseline exceeds this reduction goal. Thus, all alternatives evaluated would achieve the 85% capture level of control, through the separation of basin H-005.

Screening of CSO Technologies

The screening took place on several levels. In some cases, a general category of technologies was screened in or out based on its applicability to the Town of Harrison. In other instances, while the general category may be applicable, only certain specific sub-categories of the control are applicable to Harrison. If the general category is applicable and so are many sub-categories, the screening reduced the sub-categories to a reasonable number of representative sub-categories. This is allowable under Part IV G 4a, which calls for the Permitee to "evaluate a reasonable range of CSO control alternatives".

The screening was based on the requirement to "evaluate the practical and technical feasibility of the proposed CSO control alternative(s)" (Part IV G 4e) to determine if the alternative will proceed to a more detailed evaluation in Section D. The above requirement introduces three concepts that may be addressed for each technology:

- Evaluate
- Practical
- Technical Feasibility

Siting of CSO Facilities

Preliminary siting issues is listed in USEPA's Combined Sewer Overflow – Guidance for Long Term Control Plans (EPA 832-B-95-002 September 1995) as a screening mechanism and recommends the evaluation of the following:

- Availability of sufficient space for the facility on the site
- Distance of the site from CSO regulator(s) or outfall(s) that will be controlled
- Environmental, political, or institutional issues related to locating the facility on the site.

An analysis was undertaken to identify locations where storage or end-of-pipe treatment might be installed for CSO control. The following publicly available GIS information was utilized:

- Aerial photography
- Land Use / Land Cover
- Parcel data, including vacant land, land ownership, and property value information
- Open Space / Green Acres
- Soil Type
- Topography
- Known Contaminated Sites
- Brownfields

Potential sites were identified as were the constraints on each site. Some sites were eliminated from consideration due to their suitability for siting CSO control facilities.

Performance Objective

The magnitude of the facilities in terms of CSO volume managed is the primary driver of both its cost and effectiveness. Accordingly, a procedure was developed to achieve the desired control objectives, in this case limiting the overflows to 0, 4, 8, 12 or 20 during the Typical Year. Since the permit requires the levels of control to be established on the basis of the hydraulically connected system it is not adequate merely to achieve the desired number of overflows at each individual outfall, or within Harrison. Prior to the evaluation it was necessary to determine for the PVSC Interceptor system what storm events must be controlled for each level of control. Since the LTCP may incorporate volume-based controls (storage) as well as peak flow-based control (treatment) the same sets of storms were established for either control methodology at each outfall.

Control Programs

Seven control programs were developed, each is discussed in greater detail in SECTION D:

- Control Program 1 – Point Storage at Individual Outfalls
- Control Program 2 – Consolidated Tank Storage
- Control Program 3 – Tunnel Storage
- Control Program 4 – End-of-Pipe Treatment
- Control Program 5 – Consolidated End-of-Pipe Treatment
- Control Program 6 – Sewer Separation
- Control Program 7 – Green Stormwater Infrastructure

Evaluation

Each alternative was implemented in the approved InfoWorksICM 2050 baseline model and the modeled facilities scaled to achieve each of the performance objectives for the Typical Year rainfall. The exception was green infrastructure which was implemented to address 2.5%, 5%, 7.5%, 10% and 15% of the modeled directly connected impervious areas. 20-year net present work costs were generated for each alternative using capital costs and operations and maintenance costs. For comparison purposes each alternative was normalized by the cost to remove on gallon of CSO during the Typical Year. Results are summarized below in Table 2 through Table 4.

Table 2: 20-Year net present worth for all control plans

	NPW Summary - Overflows per Year ($M)				
Control Plan	0	4	8	12	20
1) Point Storage	$88	$63	$61	$48	$40
2) Consolidated Storage	$78	$59	$58	$47	$41
3) Tunnel	$160	$152	$146	$142	$139
4) Treatment (Individual Sites)	$174	$136	$134	$128	$96
5) Consolidated Treatment	$134	$103	$103	$96	$67
6) Sewer Separation	$181	NA	NA	NA	NA
	NPW Summary - % of Impervious Area Managed ($M)				
	2.50%	5%	7.50%	10%	15%
7) Green Infrastructure	$6	$12	$18	$23	$35

Table 3: Summary of CSO control program CSO volume reductions

	Volume Reduction per # of Overflows/Year (MG)				
Control Plan	0	4	8	12	20
1) Point Storage	42.8	38.3	38	32	26.2
2) Consolidated Storage	42.8	39	38.8	33	29.4
3) Tunnel	42.8	41.7	38.9	33.5	27.8
4) Treatment (Individual Sites)	42.8	42	42	41.5	36.1
5) Consolidated Treatment	42.8	42	42	41.4	35.9
6) Sewer Separation	42.8	NA	NA	NA	NA
	Volume Reduction for Impervious Area Managed (MG)				
	2.50%	5%	7.50%	10%	15%
7) Green Infrastructure	0.1	0.2	0.3	0.4	0.5

Table 4: Net present worth costs normalized by gallon of CSO reduction

	Cost per Gallon of CSO Volume Reduction ($/gal)				
Control Plan	0	4	8	12	20
1) Point Storage	$2.1	$1.7	$1.6	$1.5	$1.5
2) Consolidated Storage	$1.8	$1.5	$1.5	$1.4	$1.4
3) Tunnel	$3.7	$3.6	$3.8	$4.2	$5.0
4) Treatment (Individual Sites)	$4.1	$3.2	$3.2	$3.1	$2.6
5) Consolidated Treatment	$3.1	$2.4	$2.4	$2.3	$1.9
6) Sewer Separation	$4.2	NA	NA	NA	NA
	Volume Reduction for Impervious Area Managed (MG)				
	2.50%	5%	7.50%	10%	15%
7) Green Infrastructure	$58	$58	$58	$58	$70

Each alternative was ranked on and the results are summarized in Table 5:

- Cost
- CSO Reduction
- CSO Frequency Reduction
- Institutional Issues
- Implementability
- Public Acceptance

Table 5: Summary Rating of Control Programs

Control Program	Cost	CSO Volume Reduction	CSO Frequency Reduction	Institutional Issues	Implement-ability	Public Acceptance	Weighted Score
1) Point Storage	4	5	5	3	1	2	3.40
2) Consolidated Storage	4	5	5	4	3	3	4.00
3) Tunnel Storage	2	5	5	4	2	2	3.20
4) End of Pipe Treatment	2	5	5	2	1	1	2.60
5) Consolidated End of Pipe Treatment	3	5	5	2	3	2	3.30
6) Sewer Separation	1	5	5	3	2	2	2.80
7) GI - 10% of Impervious	1	1	1	5	4	5	2.65
Weighting	25%	15%	15%	15%	15%	15%	100%

Preliminary Alternatives

The decision to select alternatives will take place during the next phase of the permit from July 1, 2019 to June 1, 2020. The selected plan may include one of the Control Programs evaluated, it may consist of a combination of Control Programs or include items not discussed in this report. The selection will not be just the outcome of an engineering evaluation but may be influenced by the community's ability to afford the alternative, political considerations, environmental justice, public acceptance, the community's long-term planning and policy decision relating to potential future CSO permitting actions. While no decisions are being made at this time, the overall ratings in Table 5, indicate that in general options that include consolidation may be preferable to options that address each outfall individually and that storage options may be preferable to end of pipe treatment options.

SECTION A INTRODUCTION

This Development and Evaluation of Alternatives Report has been prepared in partial fulfillment of the Town of Harrison's (Harrison or the Town) obligations under their individual Combined Sewer Management Permit, permit number NJ0108871, issued March 12, 2015, with an effective date of July 1, 2015 and minor revisions issued October 9, 2015. Specifically, this report addresses the requirements of Part IV.D.3.b.v, as per the details provided in Part IV.G.4. Throughout the report reference is made to the specific permit requirements as each is addressed. This report is being developed cooperatively with the Passaic Valley Sewerage Commission (PVSC) Combined Sewer Overflow (CSO) Group, and is attached to the PVSC Main Report (Main Report). Accordingly, this report references the Main Report and incorporates and makes use of information in the Main Report without specifically duplicating that information. References are also made to prior reports submitted by the PVSC CSO Group on behalf of Harrison including:

- Combined Sewer System Characterization Report
- Public Participation Process Report
- Sensitive Areas Report
- Baseline Compliance Monitoring Program Report

These documents have all been approved by the New Jersey Department of Environmental Protection (NJDEP).

The PVSC CSO Group is also coordinating and reporting on the systemwide performance of alternatives, as a result, the reporting of certain results, for example systemwide percent capture, may be found in the Main Report. Results reported in this document have been coordinated with the PVSC NJ CSO Group to address systemwide levels of control. This is consistent with the permit requirement that the Long Term Control Plan's (LTCP) performance be evaluated for the hydraulically connected system; in the case of Harrison this would encompass the PVSC interceptor communities.

A.1 Regulatory Background

As a permittee of a hydraulically connected system, the Town of Harrison and PVSC are cooperating and collaborating on the development of a Long Term Control Plan (LTCP) for CSO control per the permit conditions. The Town and PVSC communicate regularly, sharing information, and exchanging hydraulic models and have undertaken integrated modeling of the hydraulically connected system to effectively develop and evaluate the alternatives presented in this report.

The long-term CSO control plan will evaluate controls that will ultimately result in compliance with the permit requirement to provide an adequate level of control to meet the water quality-based requirements of the Clean Water Act (CWA). The CWA requirements can be met using either the Presumption Approach or the Demonstration Approach in the evaluation of alternatives. Under the "Evaluation of Alternatives" (Part IV.G.4.c), the Permit calls for the Permittee to "select either the Demonstration or Presumption Approach", it is understood that this requirement applies to the Evaluation of Alternatives and, more specifically, the individual alternatives being evaluated. Accordingly, for the alternatives, evaluated the resulting frequencies of overflow will be reported along with the total volume of overflow. These values may then be used to determine the alternative's contribution to meeting the systemwide Demonstration Approach or Presumptive

Approach goals. The systemwide overflows and percent capture have been coordinated among the Permittees so that progress towards the Presumptive Approach can be reported using the results from the individual Permittee, in this case Harrison. Concurrently, the receiving water quality model has been run for vary levels of CSO control which will allow for the alternatives to be evaluated on a systemwide basis for their contribution towards the Demonstration Approach. The Town of Harrison will select the Demonstration or Presumption approach as it applies to the LTCP during the Selection and Implementation of Alternatives Report.

The “Presumption” Approach refers to a program that is presumed to meet Water Quality Standards (WQS) using the following criteria for combined sewer flows remaining after the minimum treatment of primary clarification, solids and floatables disposal, and disinfection of effluent, if necessary, as described in the National CSO Policy. The Presumption Approach requires the following:

- No more than an average of four overflow events per year occurs from a hydraulically connected system as the result of a precipitation event. The Department may allow up to two additional overflow events per year.
- Elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the Combined Sewer System (CSS) during precipitation events on a hydraulically connected system-wide annual average basis.
- Elimination or removal of no less than the mass of the pollutants identified as causing water quality impairment.

The “Demonstration” Approach refers to a program that uses a receiving water model to meet the water quality-based requirements of the Clean Water Act taking into consideration the following:

- The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions, or pollution sources other than CSOs.
- The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters’ designated uses or contribute to their impairment.
- The planned control program will provide the maximum pollution reduction benefits reasonably attainable.
- The planned control program is designed to allow cost effective expansion or cost-effective retrofitting, if additional controls are subsequently determined to be necessary to meet WQS or designated uses.

See the Main Report as prepared by PVSC for additional discussion on the selection of Presumption versus Demonstration Approaches.

It is understood that for purposes of the LTCP formulation, compliance with the above requirements is model based, by applying the approved Typical Year rainfall (2004 Newark Liberty International Airport gage) to the approved landside and receiving water models. Specifically, this report will make use of the InfoWorksICM model created as part of the Characterization Report. The model version has been fixed to InfoWorksICM 7.5 to be consistent with the modeling performed under the characterization.

A.1.1 Sensitive Areas

The Permit calls for the Permittee to "give the highest priority to controlling CSOs to sensitive areas" as documented in the Sensitive Areas Report, and indicated by the NJDEP's April 8, 2019 approval letter, the Town of Harrison does not own any outfalls which discharge combined sewage to sensitive areas. Accordingly, the Harrison outfalls will be addressed uniformly with consideration to the overall reductions in systemwide volume and frequency of overflows.

A.2 Permittee Background

Passaic Valley Sewerage Commission (PVSC) provides wastewater treatment service to 48 municipalities within Bergen, Hudson, Essex, Union and Passaic Counties in the Passaic Valley Service District located in northeast New Jersey. In total, PVSC services approximately 1.5 million people, 198 significant industrial users and 5,000 commercial customers. The PVSC District covers approximately 150 square miles from Newark Bay to regions of the Passaic River Basin upstream of the Great Falls in Paterson. PVSC's main interceptor sewer begins at Prospect Street in Paterson and generally follows the alignment of the Passaic River to the PVSC Water Resource Recovery Facility (WRRF) in the City of Newark. PVSC has assumed a lead role in the development of the System Characterization and Landside Modeling Program on behalf of these permittees.

Eight of the municipalities within the PVSC District have combined sewer systems (CSSs) and have received authorization to discharge under their respective New Jersey Pollutant Discharge Elimination System (NJPDES) Permits for Combined Sewer Management. The Town of Harrison is one of these CSO Permittees. The other permitees are:

- Newark City
- East Newark Borough
- Kearny Town
- Paterson City
- Jersey City
- Bayonne
- North Bergen MUA

The Town of Harrison is located in Hudson County immediately north and east of the City of Newark. It is bounded on the north by the Town of Kearny and the Borough of East Newark. The Passaic River separates the Town of Harrison from the City of Newark. Harrison has a population of 17,643 (2017 US Census Bureau estimate) and comprises an area of approximately 1.75 square miles.

A.3 Sewer System Description

The Town has approximately 770 acres contributing area to the PVSC system, of which 420 acres are combined system and 350 acres are serviced by separate sanitary and storm systems. The Town's NJPDES permit currently includes 7 outfalls. Due to ongoing sewer separation projects, NJDEP will be issuing Harrison a minor modification NJPDES permit action to remove the Dey Street outfall 004A in the near future. Since outfall 004A was abandoned following 2015, it will be included in the baseline conditions and its removal incorporated in the 2050 future baseline.

The outfalls are summarized below in Table 6:

Table 6: Summary of Harrison outfalls

SPDES #	CSO Number	Regulator Number	Receiving Water Body
NJ0108871	001A	H-001A (Hamilton Ave.)	Passaic River
NJ0108871	002A	H-002A (Cleveland Ave.)	Passaic River
NJ0108871	003A	H-003A (Harrison Ave.)	Passaic River
NJ0108871	004A (Eliminated)	H-004A (Dey Street)	Passaic River
NJ0108871	005A	H-005A (Middlesex St.)	Passaic River
NJ0108871	006A	H-006A (Bergen St.)	Passaic River
NJ0108871	007A	H-007A (Worthington Ave.)	Passaic River

The outfalls and CSO drainage basins are shown in the Figure 1 below. It is noted that, due to the locations of the outfalls, some of the CSO control alternatives may be grouped according to geography such that outfalls 001A, 002A, 003A, and 006A may be managed in one grouping, and outfall 007A located on the opposite side of the town will be addressed separately. It is noted that the drainage area to outfall 005A is proposed to become a separately sewered area. As such this CSO outfall will be decommissioned, as discussed in more detail later in this report.

In addition to the six CSO outfalls, the major facilities of the Town's sewer system include:

- Approximately 17 miles of combined sewer pipe with diameters generally ranging from 8 inches to 30”x45” inches.
- Six CSO Floatable Control Facilities owned and operated by the Town.
- Six active regulating chambers tributary to the PVSC interceptors, owned and operated by PVSC.

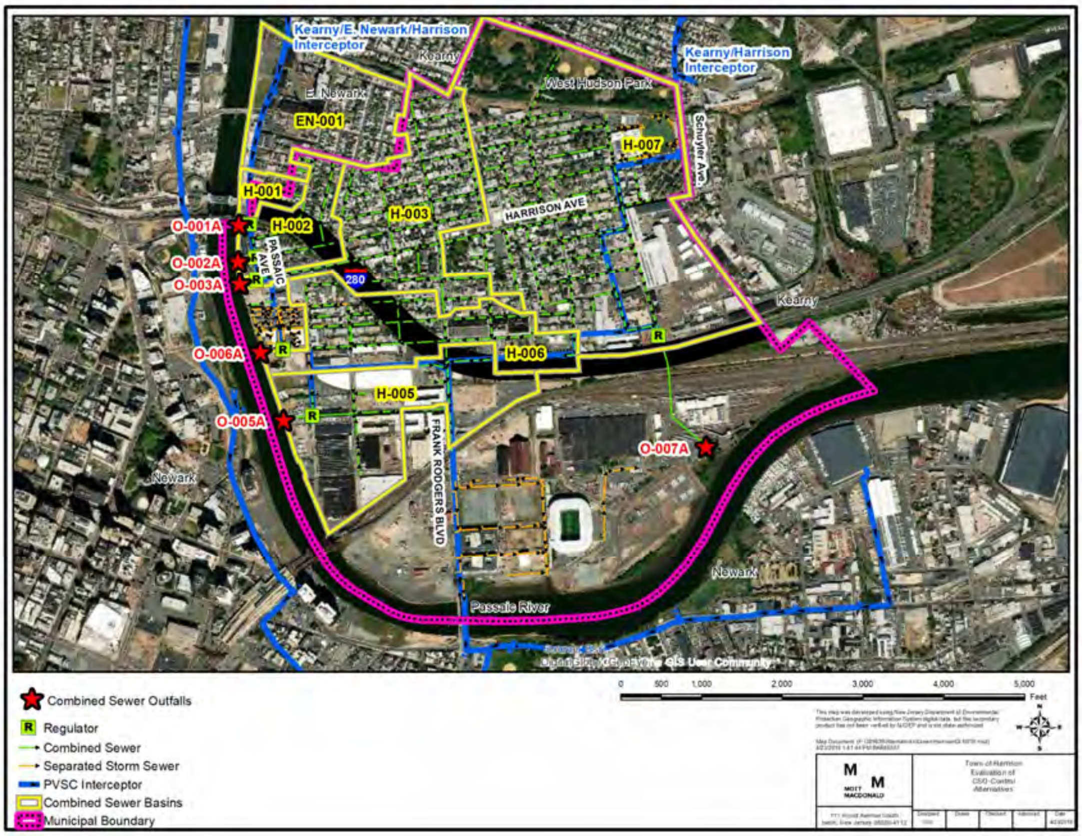

Figure 1: Location of CSO Outfalls and drainage basin delineations in Town of Harrison

There are two PVSC branch interceptors that pass through Harrison, as shown in Figure 1:

- Kearny-East Newark-Harrison Branch Interceptor
- Kearny-Harrison-Newark Branch Interceptor

The Kearny-East Newark-Harrison Branch Interceptor is approximately 8,948 feet long and extends from the Kearny-Harrison-Newark Branch Interceptor upstream of manhole KHN-5 on Frank E. Rogers Blvd. in Harrison, to the Nairn Street Regulator in Kearny. The Kearny-East Newark-Harrison Branch Interceptor generally follows Essex Street, First Street, Bergen Street, Dey Street, Passaic Avenue and Nairn Avenue. Flows are metered at two separate locations along the route, the East Newark Meter Chamber and the Johnston Avenue Meter Chamber.

The Kearny-Harrison-Newark (KHN) Branch Interceptor is approximately 15,355 feet long and extends from the Main Interceptor at the intersection of Ferry Street and Van Buren Street to north of King Street on Schuyler Avenue in Kearny. The Kearny-Harrison-Newark Branch Interceptor generally follows Van Buren Street and Raymond Boulevard in Newark, South Fourth Street, Essex Street, 7th Street, Bergen Street, Manor Avenue, Ann Street, Worthington Avenue, Kingsland Avenue in Harrison and Hamilton Avenue and Schuyler Avenue in Kearny.

All six of the CSO outfalls discharge in to the Passaic River. The portion of the Passaic River Basin which overlaps the PVSC service area is mainly in the lower basin. All 129 square miles of the Lower Passaic River Watershed are primarily urban/suburban. The section of the Lower Passaic River within the urban/suburban area has poor water quality conditions due to numerous point sources, significant nonpoint source contributions, and high sediment oxygen demands, (State of New Jersey, 2014). The Lower Passaic River Watershed's water quality conditions are affected by a number of hazardous waste sites and contamination issues that have resulted from a long history of industrialization (State of New Jersey, 2014).

NJAC Section 7:9B Surface Water Quality Standards classifies the Passaic River as SE3 in the Newark reach, extending from the confluence with Second River to the mouth. That reach includes the Town of Harrison, SE3 refers to saline estuarine water bodies, Table 7.

Table 7: Passaic River Designated Uses and Water Quality Standards

Classification	Designated Use(s)	Indicator Bacteria	Criteria (per 100mL)
SE3 (saline water)	1. Secondary contact recreation; 2. Maintenance and migration of fish populations; 3. Migration of diadromous fish; 4. Maintenance of wildlife; 5. Any other reasonable uses.	Fecal Coliform	1500 Geometric Mean (GM)

*Geometric mean calculated using a minimum of five samples collected over a thirty-day period.

A.4 System Characterization Report Summary

Rainfall and flow monitoring data were collected from April 2016 to August 2016. A temporary flow meter was installed in Harrison at the influent line of Regulator 006. It was determined that a rainfall depth of 0.2 inches would likely trigger overflows in Harrison.

Two areas within the Town of Harrison experience accumulations of grease from restaurant and store grease traps, these areas are addressed through regular maintenance and enforcement. Combined sewer system-induced flooding is not reported as an issue within the town.

The Town of Harrison was modelled as having a total imperviousness of 80% and effective (directly connected) imperviousness of 34%. The average subcatchment slope was modelled as 2.3% and subcatchment unit width of 64 ft/ac. The results of the system characterization are summarized in the Main Report.

The hydraulic and hydrologic model that was developed and calibrated for the PVSC system characterization was the main tool for analysis of CSO management alternatives for the Town of Harrison.

A.5 Public Outreach Summary

Public outreach and input are an important component of the LTCP progress, and the project team has endeavored to provide opportunities for public education and awareness, as well as to gain feedback on the CSO control alternatives. Below is a summary of activities specific to Harrison. Efforts by the overall PVSC Group, of which Harrison is a part, are documented in the Main Report. This section only covers actives since the Public Participation Process report was submitted, and prior activities are documented in that report.

A.5.1 Harrison TIDE

Much of the outreach took place through the monthly meetings of local community-based outreach groups, most notably Harrison TIDE ("Transforming Infrastructure and Defending our Environment"). While Harrison TIDE was not acting in an official capacity as a Supplemental CSO Team, several of its members are involved with CSOs and CSOs are almost always one of their meeting topics. Harrison TIDE has representation from municipal government, community, businesses, green infrastructure experts, academia, local utility authorities, and nonprofit groups. Engagement with these groups via Harrison TIDE is one of the main vehicles through which Harrison has addressed public outreach. Working closely with public officials, monthly meetings have been specifically geared toward addressing LTCP awareness and the development of long-term CSO controls. Stakeholders are encouraged to ask questions and provide input during and after these meetings. During the March 6, 2019 meeting, the Town directly engaged the public, through Harrison TIDE by presenting on the alternatives analysis. Representatives of the PVSC CSO Group also presented additional information on CSOs and the LTCP. The meeting was used to advertise the PVSC CSO Group Supplemental CSO Team meeting scheduled to meet the following night. The event included a free raffle to distribute five (5) rain barrels, including free delivery, to attendees.

A.5.2 PVSC CSO Group Supplemental CSO Team Meetings

Mott MacDonald prepared a presentation on the progress of the alternatives evaluation to present at the PVSC CSO Group Supplemental CSO Team meeting on March 7, 2019. To advertise the event the Town posted an announcement on the Town's website; see Figure 2. Copies of the event flier were distributed to the Town Council and posted in Town Hall and the public library. Ultimately, the meeting ran long, and the presentation was postponed to the May meeting. The May meeting took place on May 28th an updated presentation was made and extensive questions from the audience were addressed by the Town's consultant. Any members of the public that addended were able to hear an overview of the potential CSO control alternatives and presentations by the other communities. The presentation slides for Harrison were included in the meeting minutes for both the March and May meeting.

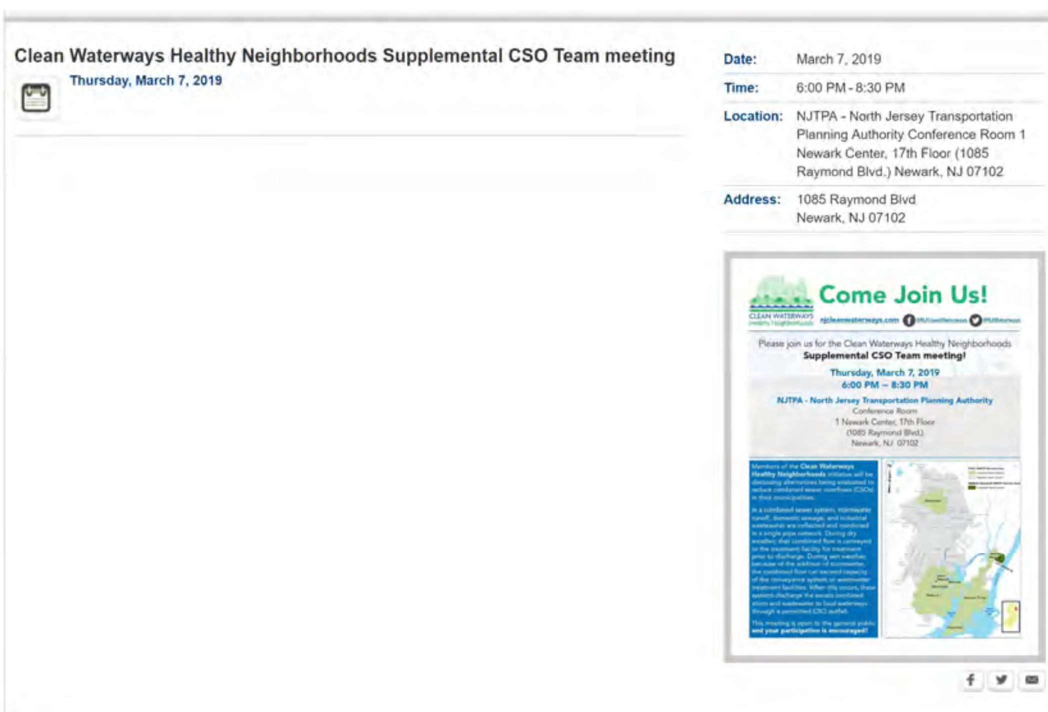

Figure 2: Supplemental CSO Team meeting announcement posted on Town Website

A.5.3 Town Caucus Meeting

To further advance the public involvement, a presentation was made at the Town's March 12, 2019 caucus meeting. The meeting included both town officials and members of the public. Mott MacDonald presented an overview of combined sewers, the regulatory history and prior work leading up to the current permit. The Town's obligations under the permit were reviewed and the current progress discussed. The anticipated work and overall project schedule were presented, and the Town informed attendees of the upcoming decisions they will be required to make. A representative of PVSC was present and stressed the importance of the project and the need to meet the permit's objectives and obligations.

A.5.4 Additional Outreach Efforts

In addition to the monthly meetings, many community groups have been circulating and posting information related to CSOs and the LTCP online through social media and organization websites to help spread awareness to local citizens. The Town of Harrison hosted the first PVSC Supplemental CSO Team meeting on October 5, 2016. They have also participated in various community events by presenting the public with information at a table or booth. For example, rain barrel workshops have been presented to Harrison TIDE and the community on April 13, 2018 and October 23, 2018.

SECTION B FUTURE CONDITIONS

B.1 INTRODUCTION

The Permit requires the permittee to simulate “conditions as they are expected to exist after construction and operation of the chosen alternative(s)” (Part IV.G.4.e). The intent is to mitigate the risk, that foreseeable changes in the community and sewer system will reduce the effectiveness of the proposed LTCP facilities. To address this, an evaluation of anticipated changes to the Town’s population and potential changes to sewer flows was undertaken. Discussions were also held with the Town to document planned changes to the sewer system. It has been assumed that the alternatives that are selected through the LTCP process will be constructed and implemented over a 30-year period. As such, the year 2050 has been selected as the future baseline condition.

It is acknowledged that sea levels have been rising and are expected to continue to rise over the life of the project and beyond; however, the rate of change is uncertain. To overflow, the water level in the combined sewer must exceed the tide elevation. The rate of discharge is also related to the relative elevation difference between the water level in the combined sewer and the receiving water. Thus, increased sea levels would tend to reduce the volume of combined sewage overflow. Existing tide levels were used to provide a conservative estimation of the alternatives’ performance.

There have been discussions of changes in rainfall patterns. Unfortunately, there are no reliable predictions that can be applied to create a Typical Year for planning purposes. It is noted that, through the development of the Typical Year, that for the top 10 contenders, there were years ranging from 1973 to 2014 with every decade in between represented, and initially the top two ranked years were from the 1980s. This seems to indicate that the rainfall pattern as they relate to Typical Year analysis have been relatively static. Accordingly, lacking a reasonable method for predicting future weather conditions, it is reasonable to assume the 2004 rainfall is suitable for use in the future baseline condition.

It is noted that there is a great deal of uncertainty in future projections and that, as the planning horizon increases, the uncertainty increases dramatically. This is evidenced below in cases where a variety of reputable sources produce differing projections. The goal was to select future conditions that would be a reasonable, yet conservative, estimate of likely future conditions. It is noted that actual future conditions could vary substantially due to demographic trends, economic conditions, changes in technology, climate impacts and a myriad of other influences beyond the control of the Permittee.

B.2 PROJECTIONS FOR POPULATION GROWTH

According to the Town of Harrison Master Plan adopted in 2007, the residential portion of the Town is substantially developed with very few areas that are undeveloped. It is anticipated that most of the future residential development will take place in or near the Waterfront Redevelopment Area located south of the I-280 corridor. Any proposed development north of the I-280 corridor will likely continue as it has in the past as subdivision and infill development, and such growth can reasonably be expected to be negligible, as further discussed in this section.

Several population projections were examined to select a reasonable projection for the future baseline. These are summarized below

B.2.1 U.S. Census Bureau

The United State Census Bureau is considered an authoritative source for population data. Data is available from the 1990, 2000 and 2010 censuses, as well as population estimates through 2017, see Table 8.

Table 8: US Census Population Data

Year	Population
1990	13,165
2000	14,337
2010	13,620
2011 (ACS estimated)	13,609 (ACS estimated)
2012 (ACS estimated)	13,683 (ACS estimated)
2013 (ACS estimated)	14,025 (ACS estimated)
2014 (ACS estimated)	14,436 (ACS estimated)
2015 (ACS estimated)	14,629 (ACS estimated)
2016 (ACS estimated)	15,007 (ACS estimated)
2017 (ACS estimated)	15,898 (ACS estimated) 17,643 US Census Estimate

Source: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

As can be seen from the data, from 1990 until 2012 the population was relatively static changing less than 4% (0.18% annually) and not exceed the peak reached in 2000 until 2014. Following 2012, the Town's population entered a period of rapid expansion increasing 16% (2.8% annually) between 2012 and 2017, coinciding with a period of redevelopment. It is also noted that estimates for the 2017 population, both sourced from the US Census website differ greatly. It is possible to extrapolate a population for 2050 using this data, but the estimates from the historic long-term trends (1990 to 2010) would produce a number that is likely too low. In contrast, using the short-term trends (2012-2017) would produce an unrealistically high estimate as this redevelopment rate cannot be sustained. The overall conclusion from the historic Census data, which pertains primarily to the combined area, is that the population outside of the redevelopment area has historically been static and it is reasonable to assume it will remain relatively static. Thus, for future baseline purposes all future growth can be assumed to take place in the redevelopment areas.

B.2.2 North Jersey Transportation Authority (NJTPA)

The NJTPA is a metropolitan planning organization with federal authorization. It is responsible for the 13 northern counties in New Jersey and is responsible for overseeing certain transportation related projects and studies. The NJTPA updates its regional forecasts for population, households and employment every four years.

In 2017, NJTPA completed the latest set of forecasts. Final forecasts were approved by the NJTPA Board on November 13, 2017 and extend to 2045. The NJTPA employs the Demographic and Employment Forecast Model (DEFM). According to their website:

> The DEFM uses regional and county level forecasts of employment, population and households produced from a regional econometric modeling effort and allocates these forecasts to a localized Traffic Analysis Zone (TAZ) level. It also aggregates the TAZ level information to the municipal level. The DEFM uses data elements that influence location behavior to perform this allocation analysis including:

- Current land use data (residential, commercial, industrial and vacant land);
- Composite zoning estimates for density;
- Highway and transit accessibility;
- Historical growth; and
- Known project developments.

The NJTPA forecasts strong growth in the population of Harrison, but as noted above, the NJTPA forecasts only extend to 2045 and fall short of the 2050 planning period. The forecast, which was extended to 2050 using the same annual growth projected in the report, is summarized in Table 9 below, extending the same annual growth through 2050:

Table 9: NJTPA population projections

County	Municipality Code	Municipality Name	2015 Population	2045 Population	Annualized % Population Change 2015-2045	2050 Population Extrapolation
Hudson	3401730210	Harrison town	15,157	30,165	2.3%	33,832

Source: https://www.njtpa.org/data-maps/demographics/forecasts.aspx

It can be seen from the above table that based on the historical growth rate, the NJTPA forecast produces an unrealistically high estimate for 2050, which is most like an indication that the 2.3% annual growth cannot be continuously sustained. Likely, redevelopment which is driving the overall population growth will reach a saturation point at which time the population growth would plateau. Thus, the average growth rate of 2.3% from 2015 through 2045 is driven by redevelopment earlier in the time period and would likely not persist beyond 2045. The NJTPA population projection does indicate a population growth in Harrison to 30,165 people in 2045, which can be used as a comparison to other population methods.

B.2.3 New Jersey Department of Labor

Population and labor force projections on a county-wide basis have been developed by the New Jersey Department of Labor extending to 2034. To obtain an estimated population for 2050, we assumed that Harrison will grow at the same rate as the county as a whole. Accordingly, since Harrison made up 2.1% of the county population in 2010, it would be expected to make up 2.1% of the county population in 2050. The projected county population was extrapolated to 2050, which yields the following estimates shown in Table 10.

Table 10: New Jersey Department of Labor population estimates for Hudson County

	Census	Projections to July 1				Projected for LTCP
County	4/1/2010	2019	2024	2029	2034	2050
Hudson	634,266	708,100	718,700	747,400	766,500	831,008
Harrison	13,620					17,451

It is noted that the Town of Harrison is currently undergoing rapid development, and this method yields a population in 2050 that is similar to some projections of the current estimated population. It is clear that the redevelopment and demographic trends of Harrison are not mirrored by the overall county. As such, projected trends in population growth at the county level are not suitable for projecting the population of Harrison and Department of Labor population estimates were not used for this analysis.

B.2.4 Heyer, Gruel & Associates (HGA) Community Planner Projections

Community planning firm HGA has produced a redevelopment map (Figure 3) and build out chart for the redevelopment areas in Harrison, as of 2016. This projection provides a rate of population growth as well as where in the Town that this growth will happen. HGA applied an estimated distribution of the dwelling unit sizes and anticipated impact to populations excerpted in Table 11. The estimated population growth for each unit constructed is 1.87. HGA noted that in reality, the total population may be less than the projection. This is because the current development trend in Harrison is to produce more studio/one-bedroom units than 2/3 bedroom units. The current estimate would be conservative from the perspective of future flows.

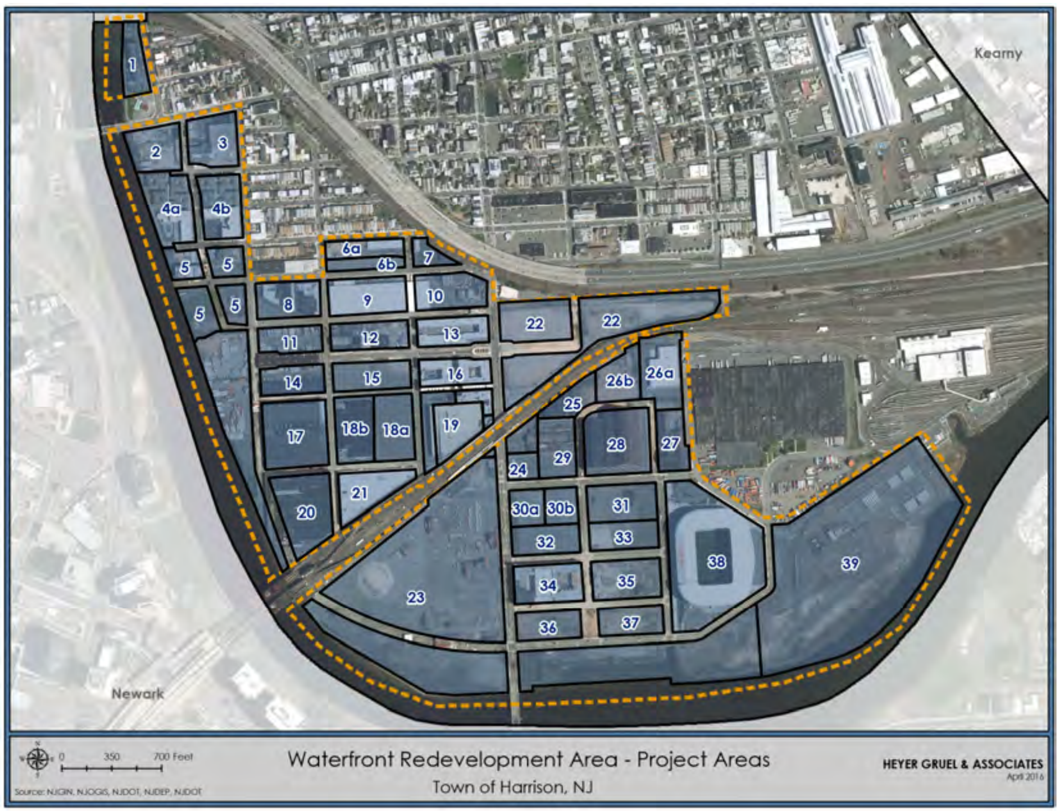

Figure 3: HGA redevelopment areas map

Table 11: Anticipated household size distribution.

Housing Type/Size	Total Persons per Unit (including school children)
Studio/1 BR (50%)	1.526
2BR (45%)	2.106
3BR (5%)	3.109
Weighted Average	1.87

Source: Multiplier source: "Who Lives in New Jersey Housing?" Table II-A-1 Total Persons, Prepared by David Listokin

In addition to the combined sewer basins, there are currently two separately sewered areas undergoing redevelopment, as follows:

- Separated Area North – upstream of former CSO outfall 004, extending from Warren Street to Bergen Street, from South 2nd Street to the Passaic River.
- Separated Area South – South of the PANYNJ railroad tracks extending across the town from east to west; and

The basins and separated areas are overlain on the redevelopment map in Figure 4.

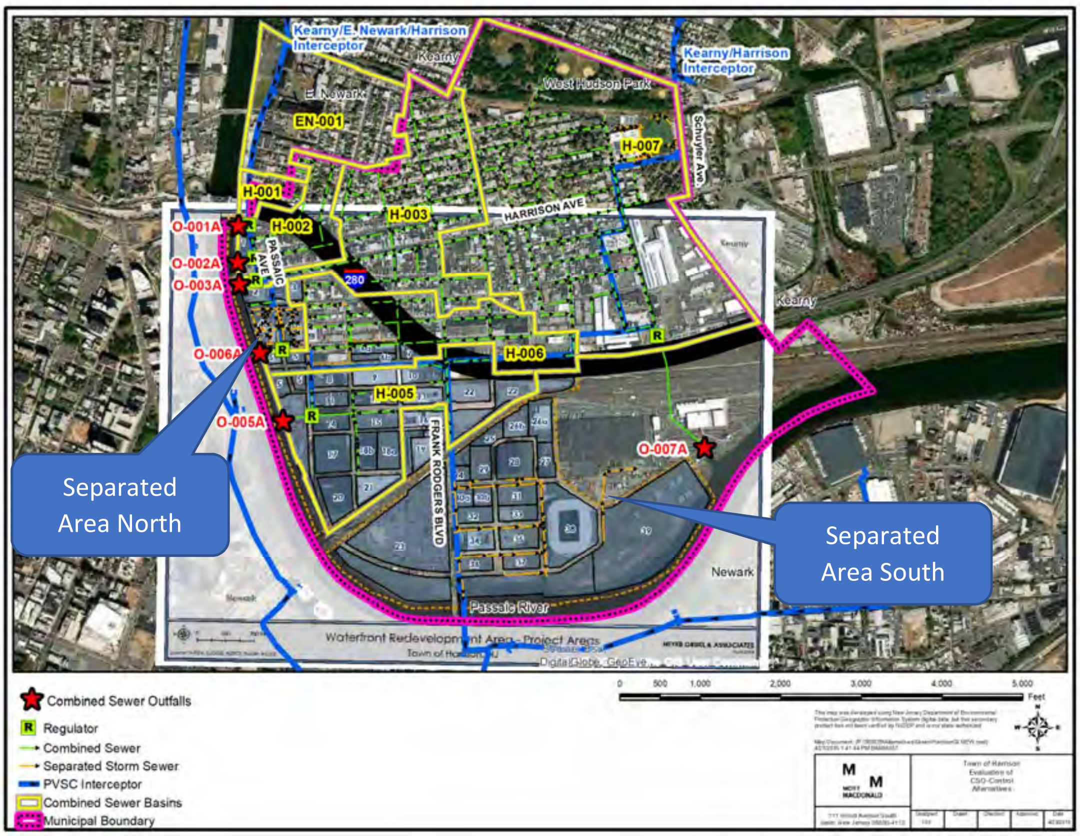

Figure 4: Drainage basins overlain on HGA redevelopment map.

The developments planned for these growth areas are described by basin in Table 12 below. The projected populations are distributed into the regulator and separate drainage areas to correspond with the modeled sub-catchments.

Table 12: Summary of redevelopment by basin

Project Area	Development Type	Residential Units per Basin							
		H-001	H-002	H-003	H-006	H-005	H-007	Separated North	Separated South
1	Hotel		-						
2	Residential							257	
3	Commercial							-	
4a	Residential (built prior to 2015 baseline)							0	
4b	Residential (built prior to 2015 baseline)							0	
5	Residential				276	276			
6a	Residential				104				
6b	Commercial				-				
7	Commercial				-				
8	Commercial					-			
9	Commercial					-			
10	Commercial					-			
11	Residential					231			
12	Residential					336			
13	Mixed Use/ Residential					329			
14	Residential					198			
15	Residential					396			
16	Mixed Use/ Residential					275			
17	Residential					528			
18a	Residential					270			
18b	Residential					350			
19	Mixed Use/ Residential					135			
20	Residential					473			
21	Residential					308			
22	Mixed Use/ Residential					640			
23	Commercial								-
24	Commercial								-
25	Commercial								-
26a	Commercial								-
26b	Commercial								-
27	Commercial								-
28	Commercial								-
29	Mixed Use/ Residential								100
30a	Commercial								-
30b	Mixed Use/ Residential								175
31	Mixed Use/ Residential								242
32	Mixed Use/ Residential								242
33	Mixed Use/ Residential								242
34	Residential								399
35	Residential								399
36	Residential								286
37	Residential								280
38	Stadium								-
39	PSE&G								-
N/A	Residential					345			
	Total Units per Basin	0	0	0	380	5090	0	257	2365

The rest of the town is already built out, as discussed when reviewing the Census data, as such, these areas will be the only additional population growth for the Town. The information from HGA included an expected distribution of housing unit sizes and associated residents per dwelling unit, resulting in a weighted average of 1.87 residents per dwelling unit. This was used to convert the number of units into additional population by basin as shown below in Table 13. This results in an estimated 15,101 new residents for a total 2050 population of 29,730 (2015 Census Estimate of 14,629 + 15,101 new residents).

Table 13: Planner's estimate of population growth by basin

Regulator/Drainage Area	New Dwelling Units	Additional Population
H-001	0	0
H-002	0	0
H-003	0	0
H-005	380	9,499
H-006	5090	709
H-007	0	0
Separated Area North	257	480
Separated Area South	2365	4,413
Total	8092	15,101

B.2.5 Population Summary

The HGA population projection was selected as the basis of the future baseline condition, as it incorporates more recent and Town-specific considerations in its estimates. It also provides detail on where in the Town this redevelopment will take place and is within 2% of the 2045 NJTPA population projection of 30,165 through 2045, as previously discussed.

B.3 PLANNED PROJECTS

B.3.1 Sewer Separation in Redevelopment Area

The H-005 drainage basin has been partially separated through prior redevelopment. The current redevelopment agreement calls for the separation to be completed during the next phase of redevelopment. Accordingly, the future conditions will incorporate the separation of the H-005 basin as shown in Figure 5.

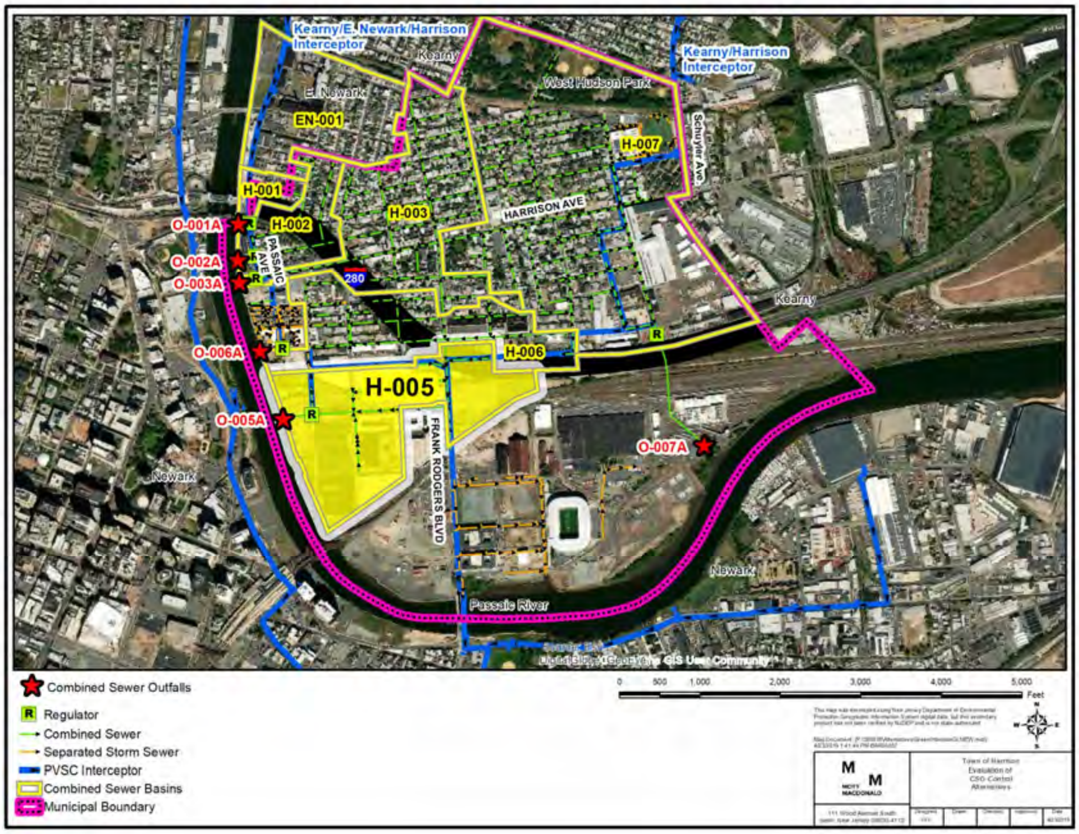

Figure 5: H-005 drainage area to be separated

B.3.2 Likely System Upgrades

A review of the hydraulic model noted that existing modeling shows insufficient capacity in certain pipes upstream of the regulators and certain outfalls. This may be due in part to limited detail in the upstream system omitting in line storage within the collection system. However, the available volume of inline storage does not appear adequate to attenuate the peak flows. It has been assumed that between the present time and the 2050, baseline projects will be undertaken to upgrade the existing conveyance system so that adequate capacity is provided for the typical year flows to be conveyed to the regulators and through the outfalls without causing surface flooding. Pipe segments in the model were enlarged or paralleled to provide adequate conveyance in the Future Baseline Model. This assumption is not based on specific planned projects, but rather to attempt to ensure that upgrades to the collection system will not invalidate the performance of the facilities being evaluated. The assumed upgrades will not impact the generation of runoff or wastewater flows but will impact the flow rate and, due to the shape and duration of the hydrograph, the resulting distribution of flow between the outfall and the interceptor.

B.4 PROJECTED FUTURE WASTEWATER FLOWS

To represent the future estimated population in the model as required, additional population was added to the various sub-catchments. The model assumes a flow of 98 gallons per capita per day (gpcpd) and was calibrated by adjusting the population to provide the required flow. To incorporate the projected population into the model, the current modeled average flow was divided by the current population to estimate a base sanitary flow per person. This per person flow was then multiplied by the projected future population to determine the projected future wastewater flow. This calculation is shown in Table 14 and Table 15 below:

Table 14: Future base sanitary flows (BSF)

	Existing BSF (MGD)	Population	BSF per Capita (GPD)	Projected BSF (MGD)
Existing (2015)	0.99	14,629	67.7	
Projected (2050)		29,730	67.7	2.01

Table 15: Future flows added to model

Regulator/Drainage Area	Additional Population	Additional BSF @67.7 gpcpd (mgd)	Equivalent Additional Population Added to Model @ 98 gpcpd
H-001	0	0	0
H-002	0	0	0
H-003	0	0	0
H-005	9,499	0.643	6,560
H-006	709	0.048	490
H-007	0	0	0
Separated Area North	480	0.032	330
Separated Area South	4,413	0.299	3,050
Total	15,101	1.025	10,430

The modeled populations were then updated by distributing the equivalent additional population as shown in Table 8 into the subcatchments where the redevelopment is planned. It is noted that this projected flow does not include any additional flow for commercial developments. This is because it is assumed that the original modeled flows were developed with commercial flows built into the calculation of per capita flows. As such, the projected BSF flow of 2.01 MGD, also includes commercial flow, as it is assumed the ratio of residents to commercial facilities remains the same, and thus the ratio of residential flows to commercial flows is preserved.

B.5 Modeling of Future Baseline Conditions

The projected Future Baseline conditions impact the combined sewer overflow volumes, with some factors serving to increase overflows and others to reduce overflows, see Table 16. The greatest reduction comes from the proposed separation of the H-005 drainage basin, and the greatest increase comes from the assumption that the existing drainage system will be upgraded to prevent flooding in the upstream collection system during the Typical Year. There are slight reductions in overflow volumes from Outfalls 001A, 002A and 003A which are associated with additional interceptor capacity created by the separation of Basins 004 and 005. Overall, there is a net reduction of 18.7 MG or 30% and one overflow event for the typical year.

Table 16: Summary of CSO performance for Future Baseline

Outfall	Baseline 2015 (Typical Year)			Baseline 2050 (Typical Year)			Change		
	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	25	1.5	59	-1	-0.5	-39
H-002A	35	3.2	162	25	2.2	78	-10	-1.0	-84
H-003A	32	13.1	155	33	12.8	107	1	-0.3	-48
H-004A	10	0.3	6	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	27	7.0	106	-1	-1.0	-16
H-007A	53	14.5	352	52	19.3	347	-1	4.8	-4
Total	--	61.5	--	--	42.8	--	--	-18.7	--

The PVSC CSO Group estimated that a 7% reduction in overflow volume by the interceptor communities would be required to achieve a systemwide 85% capture of wet weather flows as per the presumptive approach. The 30% reduction achieved between the 2015 baseline and 2050 future baseline exceeds this reduction goal. Thus, all alternatives evaluated would achieve the 85% capture level of control, through the separation of basin H-005.

SECTION C SCREENING OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

The evaluation of seven (7) CSO control alternatives is mandated in the Permit in Part IV G 4e. This list is not intended to be limiting, but rather sets general categories of control alternatives that must be considered. The list of control alternatives provided in the Permit is broad enough that most of the control alternatives explored in the subsequent sections fall within the list. The seven (7) control alternatives listed in the Permit, and the corresponding sections of this report in which they are addressed are:

1. Green infrastructure. – Section C.2.5
2. Increased storage capacity in the collection system. – Section C.5
3. Sewage Treatment Plant (STP) expansion and/or storage at the plant (an evaluation of the capacity of the unit processes must be conducted at the STP resulting in a determination of whether there is any additional treatment and conveyance capacity within the STP). Based upon this information, the permittee shall determine (modeling may be used) the amount of CSO discharge reduction that would be achieved by utilizing this additional treatment capacity while maintaining compliance with all permit limits. – Section C.5.2.2
4. If applicable, the evaluation of dry and wet weather flows that entering the combined sewer system from separately sewered municipalities, and in all cases Inflow/Infiltration (I/I) reduction in the entire collection system that conveys flows to the treatment works to free up storage capacity or conveyance in the sewer system to inform the evaluation of I/I reduction as an alternative in the LTCP. – Section C.3
5. Sewer separation. – Section C.7
6. Treatment of the CSO discharge. – Section C.8
7. CSO related bypass of the secondary treatment portion of the STP in accordance with New Jersey Administrative Code (N.J.A.C.) 7:14A-11.12 Appendix C, II C.7. – Addressed in the PVSC Development and Evaluation of Alterative Main Report.

The evaluation consists of two steps: a screening of alternatives at a high level, followed by a more detailed evaluation of the performance and costs of the alternatives that pass the screening, which is presented in SECTION D. The screening of alternatives is summarized in this section.

The screening took place on several levels. In some cases, a general category was screened in or out based on its applicability to the Town of Harrison. In other instances, while the general category may be applicable, only certain specific sub-categories of the control are applicable to Harrison. If the general category is applicable and so are many sub-categories, the screening reduced the sub-categories to a reasonable number of representative sub-categories. This is allowable under Part IV G 4a, which calls for the Permitee to “evaluate a reasonable range of CSO control alternatives”.

The screening will be based on the requirement to “evaluate the practical and technical feasibility of the proposed CSO control alternative(s)” (Part IV G 4e) to determine if the alternative will proceed to a more detailed evaluation in Section D. The above requirement introduces three concepts that may be addressed for each alternative.

- Evaluate – As per the requirements of Part IV G 4a and b the alternatives must contribute to the "water quality-based requirements". This means that, while an alternative may be beneficial as a matter of good practice, if the benefit cannot be quantified in terms of water-quality benefits, it cannot be evaluated. It also means that if an alternative does not meaningfully contribute to the reduction of CSO volume and frequency, it will not be considered for detailed devaluation, regardless of its other virtues. Many such practices are already in place as requirements under the Permit or the Town's MS4 permit. These practices would be considered part of the Baseline and their continuation part of the Future Baseline and would not be part of the LTCP.
- Practical – The facilities and measures ultimately implemented under the LTCP must be practical for the Town of Harrison to implement. For example, a residential neighborhood could not be displaced to make room for a storage or treatment facility, Nor could the Town's entire municipal budget be devoted to CSO controls. Accordingly, alternatives that clearly have excessive community/societal impacts or alternatives that provide marginal CSO controls at high costs will be removed from consideration.
- Technical feasibility – Technology is continually advancing and what is not technically feasible today may be in the future. However, there are no guarantees of such advancement. There are certain general limits, for example, maximum tunnel diameter and depth of open cut pipe installation, that will be observed for cost and safety reasons. Accordingly, technical feasibility is limited to the current state of the practice. Future advancements, should they occur, will need to be addressed in future permit iterations.

The screening will focus on applying the above criteria to the alternatives described in detail in Section C of the Main Report, to which this report is attached. This section will address only the screening a detailed description of what constitutes each alternative and general comments on its applicability and effectiveness for CSO reduction are included in the Main Report. The reader is referred to the Main Report for a detailed description of each alternative. A summary matrix or the screening alternatives is included in Section C.9.

C.2 SOURCE CONTROL

The United States Environmental Protection Agency (USEPA) defines source controls as those that impact the quality or quantity of runoff entering the combined sewer system. Source control measures can reduce volumes, peak flows, or pollutant discharges which in turn may decrease the need for more capital-intensive technologies downstream in the CSS. However, source controls typically require a high level of effort to implement on a scale that can achieve a measurable impact. Source controls are discussed in more detail in this section.

C.2.1 Stormwater Management

Stormwater management consists of measures designed to capture, treat, or delay stormwater prior to entering the CSS.

C.2.1.1 Street/Parking Lot Storage (Catch Basin Control)

Providing surface storage by intentionally ponding runoff in streets and parking lots risks property damage and potential injury and is not considered a practical component of a LTCP. Accordingly, street/parking lot storage will be removed from consideration.

C.2.1.2 Catch Basin Modification (Floatables Control)

In general, catch basins in Harrison are equipped with sumps and hoods and their benefit is already being realized. In addition, the regulators in Harrison are equipped with sand-catching chambers (see Figure 6), and outfalls are equipped with netting facilities, which already provide control of coarse solids and floatables.

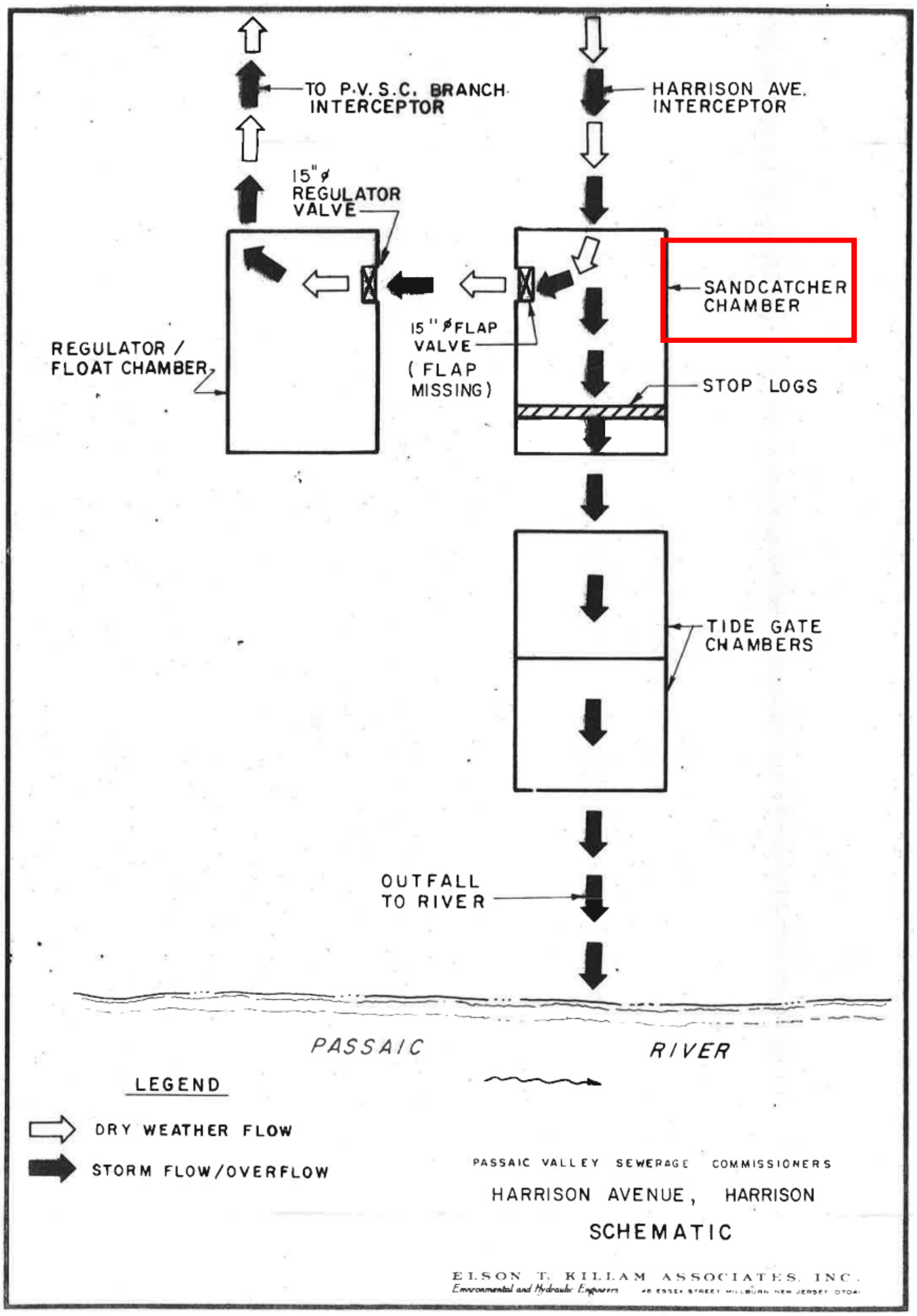

Figure 6: Representative outfall configuration in Harrison showing sand catcher

Catch basin modification to incorporate additional floatables controls would not provide a significant or quantifiable contribution to the LTCP and will be removed from consideration for the detailed alternatives evaluation.

C.2.1.3 Catch Basin Modifications (Leaching)

To function, leaching catch basins must be able to infiltrate the water collected in their sumps. This requires two things: soils capable of infiltration and separation from groundwater. Figure 7 below shows the USDA NRCS Web Soil Survey results for Harrison regarding soil infiltration potential. West Hudson Park at the north end of Harrison is classified as hydrologic soil group C with low to medium infiltration potential. The area where soil HSG was not determined (unrated) is primarily characterized as urban land. The soil has low permeability and very low available water storage. The runoff class is “very high” and depth to restrictive feature is 0 inches. Note that much of the Town is not rated but would be expected to be Hydrologic Soil Group (HSG) C soils as is typical of disturbed urban areas and consistent with adjacent rated soils. The depth to water table shown in Figure 8 is about 20 to 28 inches in areas where soils were rated. There are areas of deeper groundwater shown, but these are located in the unrated portions of the Town and it is uncertain, but likely, the groundwater is shallow and similar to the adjacent rated areas

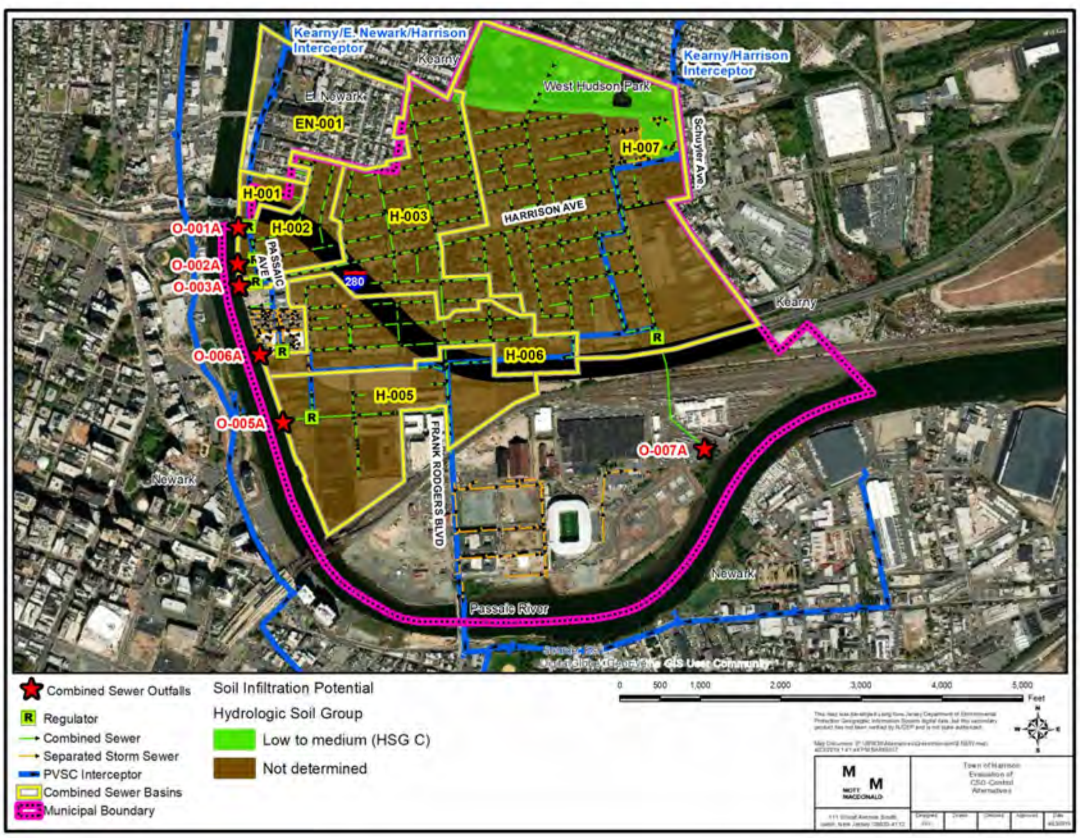

Figure 7: Harrison soils map

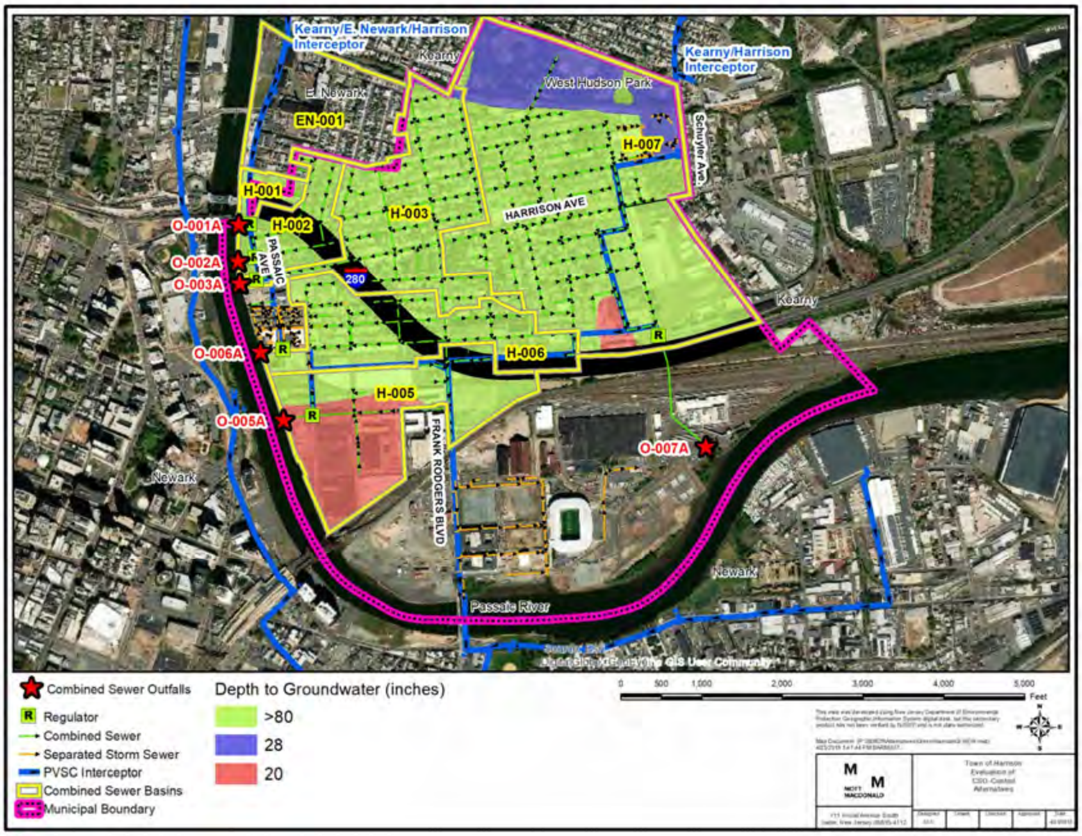

Figure 8: Harrison depth to groundwater map.

Leaching catch basins are not considered practical because they offer no filtering of the urban runoff prior to infiltrating below the catch basin. The 15-20 ratio of impervious area to infiltration area is recommended by the State's *Evaluating Green Infrastructure: A Combined Sewer Overflow Control Alternative for Long Term Control Plans.* The impervious area to infiltration area for a leaching inlet would greatly exceed this range for typical inlets and their use would not be practical. Further, based on the information from the soil survey, the majority of the Town of Harrison soils are low permeability with very low available water storage. Accordingly leaching catch basins will be removed from consideration for the alternatives evaluation.

C.2.2 Public Outreach Program

The current permit requires a robust public outreach program and it is anticipated that future permits will as well. In addition, many outreach programs are already in place and thus would be considered part of the future baseline condition. While public outreach programs are beneficial they are generally not evaluated as part of the LTCP. This does not mean the LTCP will not include public outreach, but rather that it is not a quantifiable component of the plan generally because these programs rely on human behavior which cannot be predicted. Nevertheless, the specific public outreach alternatives identified are summarized below for completeness.

It is anticipated that public outreach will continue under future iterations of the Permit and should be considered a key component of the LTCP. However, the impact of public outreach cannot be quantified, thus is removed from future consideration for the alternatives evaluation.

C.2.2.1 Water Conservation

The Town of Harrison enforces water conservation through the plumbing code. While water conservation has merits in reducing water demand and can reduce dry weather flows in the sewer system, it has minimal impact on peak wet weather flows. It does not change the total pollutant load but results in less flow with a higher concentration. It is also difficult to enforce long term, as residents can change plumbing fixtures and disable water conserving devices. Accordingly, while the Town should continue its current programs and code enforcement to conserve water, it is not practical to make it a component of the alternatives evaluation. The impact of water conservation measures will likely be apparent in changes to dry weather flow rates observed during future combined sewer system characterizations.

C.2.2.2 Catch-Basin Stenciling

Catch-basin stenciling is already required under the Town's MS4 permit, and the Town of Harrison is complying with the applicable requirements. Any benefits derived from stenciling would have been seen in the characterization and may be observed in future combined sewer system characterizations. The performance of stenciling is dependent on human behavior, i.e. the response of the observer to alter their actions due to the presence of the stenciling, which cannot be reliably enforced or predicted. Accordingly, catch-basin stenciling will be removed from future consideration for the alternatives evaluation.

C.2.2.3 Community Cleanup Programs

The Town of Harrison currently supports and hosts community cleanup efforts. Community cleanup programs are beneficial to the environment and the community but provide minimal benefits to combined sewers. Litter removed by the cleanup effort would likely be captured by the netting facilities and litter removal offers no meaningful reduction of pathogens. Community cleanup programs also rely on community involvement which cannot be guaranteed. Accordingly, community cleanup programs will be removed from future consideration for the alternatives evaluation.

C.2.2.4 Fats, Oil and Grease (FOG) Program

The Town of Harrison currently has a FOG program, and the effects of the program should be reflected in the baseline characterization. A FOG program requires communication with business owners and is only as effective as business owner cooperation and Town enforcement. It is anticipated that the FOG program will continue, but its impact to pathogens is minimal and unlikely to represent a change from current conditions. Accordingly, a FOG program will be removed from future consideration for the alternatives evaluation, since it is already in place.

C.2.2.5 Garbage Disposal Restriction

Restricting the use of garbage disposals provides minimal reductions in pollutant loads, particularly pathogens. While it may be possible to effectively restrict garbage disposals in commercial establishments, the vast majority of the combined sewer area in the Town of Harrison is residential thus enforcing a garbage disposal restriction would not be practical. Accordingly, garbage disposal restrictions will be removed from future consideration for the alternatives evaluation.

C.2.2.6 Pet Waste Management

The Town of Harrison currently enforces a pet waste management ordinance as required under its MS4 permit and as a matter of good practice. The impact of pet waste management should be reflected in the characterization. Accordingly, pet waste management will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.2.7 Lawn and Garden Maintenance

The combined sewer area within the Town of Harrison is highly impervious and most pervious areas are in residential backyards. While the Town encourages proper application of chemicals such as fertilizers, it is not practical to enforce control over these activities in a quantifiable way. Accordingly, lawn and garden maintenance will be removed from future consideration for the alternatives evaluation.

C.2.2.8 Hazardous Waste Collection

The Town of Harrison participates in a County hazardous waste collection program and anticipates continued participation in the program. The effects of the program should be reflected in the baseline characterization. Accordingly, hazardous waste collection will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.3 Ordinance Enforcement

C.2.3.1 Construction Site Erosion and Sediment Control

New Jersey's requirements for soil erosion and sediment control are enforced through the Hudson-Essex-Passaic Soil Conservation District and it is anticipated this enforcement will continue at its current level or with more stringent requirements in the future. Accordingly, construction site erosion and sediment control will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.3.2 Illegal Dumping Control

The Town of Harrison enforces ordinances to control illegal dumping and intends to continue doing so. Accordingly, illegal dumping control will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.3.3 Pet Waste Control

The Town of Harrison currently enforces a pet waste management ordinance as required under its MS4 permit and as a matter of good practice. The impact of pet waste management should be reflected in the characterization. Accordingly, pet waste management will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.3.4 Litter Control

The Town of Harrison currently enforces a litter control ordinance as required under its MS4 permit and as a matter of good practice. The impact of the litter control ordinance should be reflected in the characterization. Accordingly, litter control will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.3.5 Illicit Connection Control

The Town of Harrison currently controls illicit connections under its MS4 permit and as a matter of good practice. Illicit connection control is applicable only to separately sewered areas since combined sewers are intended to accept sanitary flows. Accordingly, illicit connection control will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.4 Good Housekeeping

C.2.4.1 Street Sweeping/Flushing

The Town of Harrison currently has a program to sweep streets and anticipates that program will continue as required under its MS4 permit. The impact of street sweeping is already reflected in the characterization and its continuation would be reflected in future baseline. Thus, there is no quantifiable additional impact of street sweeping. Accordingly, street sweeping will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.4.2 Leaf Collection

The Town of Harrison currently has a leaf collection program and anticipates that program will continue as required under its MS4 permit. The impact of leaf collection is already reflected in the characterization and its continuation would be reflected in future baseline. Thus, there is no quantifiable additional impact of leaf collection. Accordingly, leaf collection will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.4.3 Recycling Program

The Town of Harrison currently has a recycling program and anticipates the program will continue. The impact of recycling is already reflected in the characterization and its continuation would be reflected in future baseline. Thus, there is no quantifiable additional impact of a recycling program. Accordingly, recycling programs will be removed from future consideration for the alternatives evaluation since it is already in place.

C.2.4.4 Storage/Loading/Unloading Areas

Implementing and enforcing ordinances regarding storage/loading/unloading areas in Harrison is unlikely to produce a quantifiable benefit to the CSO program. The majority of the industrial areas are located in the separately sewered areas. There are some industrial areas in the Regulator 007 drainage area. These industries are regulated under industrial stormwater permits which require good housekeeping procedures to be followed. Containment is required for loading and unloading areas for hazardous materials. Any solids and floatables prevented from entering the combined sewer system would likely be captured by the existing netting facilities, minimizing any benefits from enforcing additional ordinances. Accordingly, storage/loading/unloading areas ordinances are removed from future consideration for the alternatives analysis.

C.2.4.5 Industrial Spill Control

Industrial users are required to provide containment for storage and loading/unloading areas for hazardous materials. Additional ordinances are unlikely to produce additional benefits beyond the current enforcement practices, and the benefits of such actions cannot be quantified in terms of reduction to CSO pollutant loadings. Accordingly, industrial spill control is removed from future consideration for the alternatives analysis.

C.2.5 Green Infrastructure

Green infrastructure is widely employed in combined sewer areas to reduce inflow volumes and/or peak flows and thus reduce combined sewer overflows. It is noted that the impacts of green infrastructure extend beyond CSO reduction. However, this evaluation is being conducted as an element of the development and evaluation of alternatives for compliance with the Permit. The permit requires "The permitee shall evaluate … the water quality benefits of constructing various remedial controls …" Therefore, the focus of this report shall be the impact of green infrastructure with respect to reductions in CSO volumes and frequencies, i.e. water quality benefits. It is acknowledged the green infrastructure has many other benefits that do not pertain to water quality benefits. These benefits in conjunction with public input may result in green infrastructure being implemented apart from the CSO LTCP or result in a decision to implement it at a greater cost than other alternatives. However, that decision must be made by the governing body, their constituents and other stakeholders.

The goal is to evaluate the optimal implementation level for green infrastructure as it is applicable to the LTCP. Too little could result in missed potential benefits, while overcommitting may result in higher costs and maintenance efforts than are not practical to accomplish the Town's obligations under the LTCP. Overcommitting may also result in a LTCP that cannot be accomplished because sufficient opportunities to install green infrastructure may not exist or may not be practical to utilize, resulting in the Town failing to meet its permit obligations. The following factors are considered in evaluating green infrastructure for applicability to the LTCP.

1. Green infrastructure must be sited, designed, constructed and maintained to provide a high level of confidence that it will continually perform as expected. The State has established guidelines for the design, implementation and maintenance of green infrastructure. Given that reliability will be required from the LTCP, it is reasonable to assume these standards would constitute the minimum requirements for green infrastructure implemented under the LTCP. To account for this, the evaluation and analysis was conducted using guidance from:

   - *NJ Stormwater Best Management Practices Manual*, NJDEP, April 2004 Revised September 2014, February 2016, September 2016, November 2016, September 2017 & November 2018.
   - *Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control,* U.S. Environmental Protection Agency, March 2014.

2. The green infrastructure must be under the control of the Town to ensure that it remains in place and that maintenance occurs. Practices evaluated will be sited on land owned by the Town including:

   - Schools
   - Libraries
   - Parks – at this time it is uncertain if the Green Acres program will allow for widescale use of parks for managing offsite stormwater, so parks will all be considered to manage only stormwater generated within the park.
   - Public buildings
   - The public town owned right-of-way

3. Publicly available data will be utilized. Given the planning level of this evaluation these sources of information may or may not be complete and will be subject to professional judgement and experience in their interpretation. Sources of data include:

   - Soil surveys
   - Aerial photography
   - Land use and land cover data sets
   - Property owner data sets
   - Site visits

The requirements for evaluating green infrastructure listed above are rigorous and can greatly increase the cost and limit the opportunities for green infrastructure. However, these requirements only apply to green infrastructure in the context of the LTCP and does not limit implementation of green infrastructure by the Town or other entities apart from the LTCP. Green infrastructure can be implemented which is not formally incorporated into the LTCP, and the benefits of such projects may manifest themselves in future iterations of the system characterization. It may also be possible to expand the implementation of green infrastructure through public-private cooperation with formal agreement to perpetuate and maintain the green infrastructure; however, the measurable success of such a program involves factors beyond the control of the town and factors that cannot be evaluated at this time. As such, opportunities for additional green infrastructure exist, but not necessarily within the scope of the LTCP.

It may be possible to incorporate green infrastructure to reduce the need for gray infrastructure. This evaluation is intended to evaluate different levels of green infrastructure that could be practically implemented under the criteria above for the LTCP.

There are a variety of green infrastructure practices that can be applied to combined sewer areas. Each practice has advantages and disadvantages, which impact its applicability and performance. Considering different levels of implementation as well as combinations of practices, the number of possible alternatives exceeds a reasonable number. As such, the most common urban application of green infrastructure, roadside bioswales, was selected as a representative practice for evaluation. Subsequent subsections explore in detail the applicability of various types of green infrastructure, and SECTION D will discuss how the reasonable extents of the practices were determined and how the overall implementation of green infrastructure was evaluated through the equivalent implementation of bioswales.

C.2.5.1 Green Roofs

Green roofs could be implemented in Harrison at the following locations:

- Existing Town owned roofs;
- Future Town buildings; or
- New buildings in redevelopment areas.

Green roofs are not considered suitable for roofs with greater than 20% slope, per the NJ Stormwater Best Management Practices (BMP) Manual Chapter 9.14, November 2018, thus will not be considered for residential areas, shown on Figure 9.

It is difficult to retrofit existing buildings with green roofs as it is unlikely that an existing building was designed to support the additional load. The process of certifying that an existing roof is structurally able to support the additional weight of a green roof is difficult and with an uncertain outcome. While the Town could investigate retrofit of existing Town-owned buildings, given the limited areas of existing Town-owned roofs (shown in Figure 10 below) and the associated technical challenges, it is not practical or prudent to evaluate retrofit of existing Town-owned buildings for green roofs in the context of the LTCP.

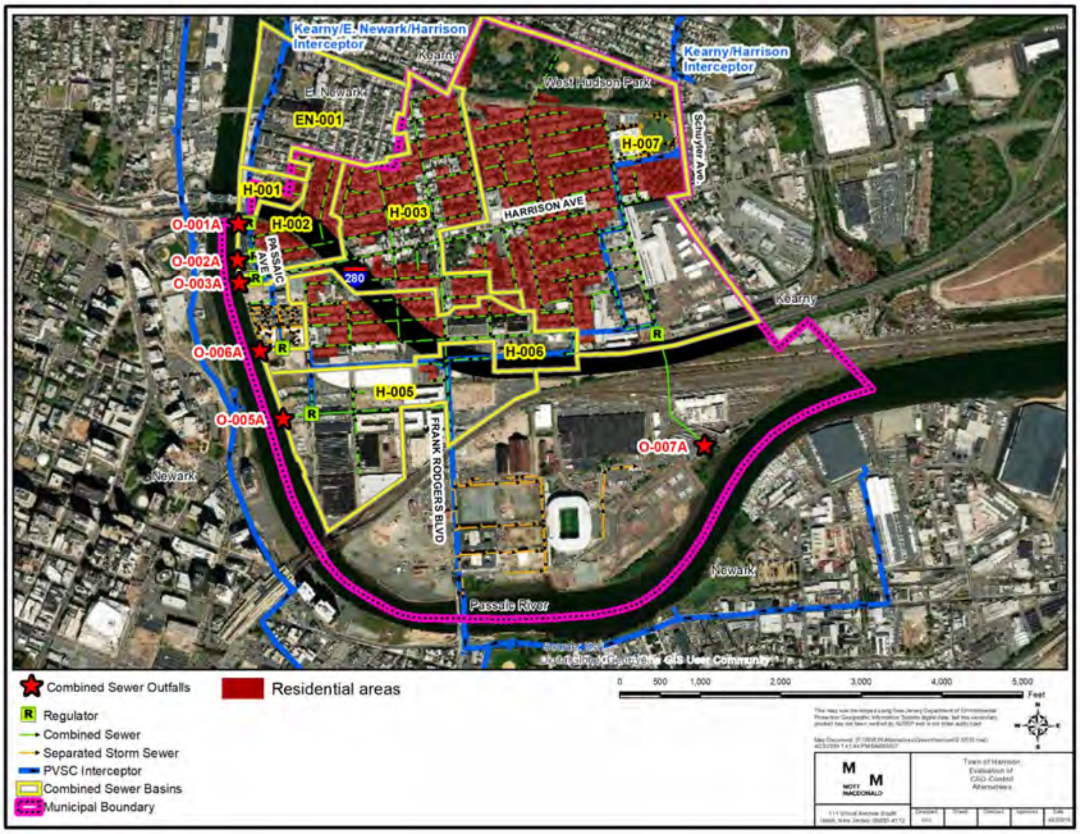

Figure 9: Residential areas within Harrison

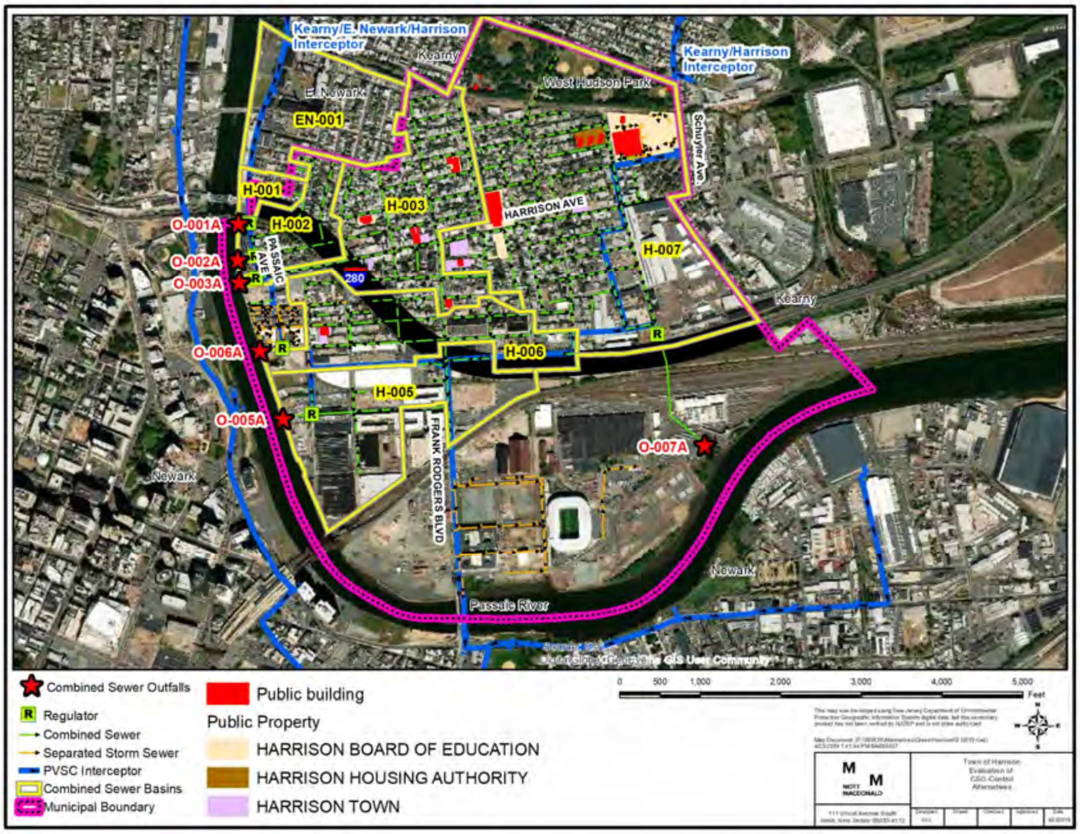

Figure 10: Publicly owned buildings in Harrison

The Town can investigate incorporating green roofs into future Town buildings that will be constructed. However, no new Town buildings are currently planned nor would any such building represent a meaningful proportion of the Town's impervious area; thus, their benefit cannot be quantified for the purposes of the LTCP.

The best opportunity for implementing green roofs would be through redevelopment requirements. However, the former industrial areas where redevelopment is planned are either separately sewered or planned to be separated, meaning green roofs would not have a benefit in terms of CSO reduction in these areas. Figure 4 overlays the future redevelopment areas with the CSO drainage basins. Note the vast majority of the redevelopment is in the separately sewered areas and basin 005 which will be separated. The remaining redevelopment in the combined area is already underway, leaving almost no opportunities to implement green roofs for the purpose of CSO reduction.

The Town of Harrison could encourage green roofs to realize the other benefits they provide, but they are not considered practical based on the technical constraints and anticipated redevelopment patterns in Harrison as a means of achieving reduction of CSOs. Accordingly, green roofs will not receive further consideration as part of the alternatives analysis.

C.2.5.2 Blue Roofs

Like green roofs, blue roofs could be implemented in Harrison at the following locations:

- Existing Town owned roofs;
- Future Town buildings; or

- New buildings in redevelopment areas.

Since blue roofs are not considered suitable for pitched roofs they will not be considered for residential areas, shown on Figure 9.

As noted in the previous subsection, it is difficult to retrofit existing buildings with blue roofs as it is unlikely that an existing building was designed to support the additional load. The process of certifying that an existing roof is structurally able to support the additional weight of a blue roof is difficult and with an uncertain outcome. While the Town could investigate retrofit of existing Town-owned buildings, given the limited areas of existing Town-owned roofs (see Figure 10) and the associated technical challenges, it is not practical or prudent to evaluate retrofit of existing Town-owned buildings for blue roofs in the context of the LTCP.

The Town can investigate incorporating blue roofs into future Town buildings that will be constructed. However, no new Town buildings are currently planned, nor would any such building represent a meaningful proportion of the Town's impervious area, thus their benefit cannot be quantified for the purposes of the LTCP.

The best opportunity for implementing blue roofs would be through redevelopment requirements. However, as described in the previous green roof sub-section, the former industrial areas are where redevelopment is planned (see Figure 4), these areas are separately sewer, meaning blue roof would not have a benefit in terms of CSO reduction in these areas. The Town of Harrison could decide to encourage blue roofs to realize the other benefits they provide, but as a means of achieving reduction of CSOs they are not considered practical based on the technical constraints and anticipated redevelopment patterns in Harrison. Accordingly, blue roofs will not receive further consideration as part of the alternatives analysis.

C.2.5.3 Rainwater Harvesting

To effectively implement rainwater harvesting as part of a LTCP, the facility must be under the jurisdiction of the Permittee, in this case the Town of Harrison. This is necessary to ensure the access and maintenance of the facility in perpetuity so that is can remain fully functional and deliver the required performance to allow Harrison to comply with its permit requirements. As such, rainwater harvesting tools such as rain barrels on residential properties have not been considered feasible, limiting the number of locations where harvesting can practically be installed as part of the LTCP. It is reiterated that this does not preclude promoting rainwater harvesting and encouraging residential rain barrel programs.

It may be possible to require rainwater harvesting through ordinances for redevelopment projects. However, the vast majority of the planned redevelopment is slated to take place in the separately sewered areas shown in Figure 4, thus would not have an impact on CSO volumes.

Rainwater harvesting tends to have minimal benefits to CSO reduction as the intent is to retain water for future use. Since it rains on average every three days, it is likely the rainwater harvesting storage tank would be full or partially full when the next rainfall occurs, relying on manual operation to empty the tank prior to rain, which would create an additional level of risk for the practice.

Accordingly, in the evaluation of this alternative, rainwater harvesting will not receive further consideration as part of the alternatives analysis.

C.2.5.4 Permeable Pavement

Suggested locations for permeable pavement include parking lots, parking lanes and sidewalks. These public areas are more suitable for permeable pavement because it is necessary to ensure the access and maintenance of the facility in perpetuity so that is can remain fully functional and deliver the required performance to allow Harrison to comply with its permit requirements.

Permeable pavement is typically recommended for low traffic areas; thus, it may be feasible to re-pave municipal parking areas with permeable pavement, specifically the parking stalls and not the travel lanes. This is a common approach and is reflected in Example 1 of Chapter 9.7 of the New Jersey Stormwater BMP Manual (updated November 2016). A loading ratio of 4:1 (ratio of impervious area to green practice area) will be used as recommended by Table 2-1 of the NJDEP's Evaluating Green Infrastructure: A Combined Sewer Overflow Control Alternative for Long Term Control Plans, January 2018.

The New Jersey Stormwater BMP Manual also requires 1 foot of separation from the seasonal high groundwater for non-infiltrating practices and 2 feet for infiltrating practices, a choker course and adequate volume to hold the runoff from the water quality storm (1.25" of rain which is approximately 1.0" of runoff from impervious surfaces with CN-98). It is also recommended to extend the reservoir course below the frost line. These requirements may push the permeable pavement box below the seasonal high groundwater, violating the groundwater separation requirement. Since groundwater levels are uncertain, but thought to be shallow, this may greatly limit locations where permeable pavement can be implemented and increases the uncertainty of the alternative's effectiveness.

Parking lanes within the Town offer a large area to implement permeable pavement. It is noted that there is a high demand for street parking in Harrison, and the temporary unavailability of parking associated with installation of the permeable pavement makes this approach less favorable. There are also numerous utilities in the parking lanes which could be very difficult to work around or relocate. However, there may be some potential to identify parking lanes where permeable pavement would be feasible.

Sidewalks offer a reasonable opportunity to install permeable pavement. Sidewalks in Harrison are generally narrow, so would offer a relatively small area to implement this practice. The sidewalks are generally at a higher elevation than the adjacent roadway and roof leaders are generally piped to the street so very little impervious area would be directed to sidewalks resulting in a low loading ratio and minimal effectiveness.

As such, permeable pavement will be considered for the stall areas of municipal parking areas and selected parking lanes, but a maximum of 10% of the available locations will be assumed to be viable because of the issues noted above. It is noted that this is just for evaluation purposes and the proposed analysis will report on the impacts of a wider range of green infrastructure implementation. If permeable pavement is found to be functionally, and economically effective additional investigations can be undertaken.

C.2.5.5 Planter Boxes

Planter boxes would be most applicable in commercial areas, where runoff from buildings could be directed to boxes placed in the sidewalk area. They would be considered feasible for locations where roof leaders are located outside the building. The public visibility may also help promote maintenance of these facilities. Planter boxes would not be considered applicable to residential areas, as they would most likely be located on private property and thus may not be regularly maintained. In general, the building frontage in residential areas is utilized for front doors and garage doors leaving little room for planters, even if placed perpendicular to the building. There may be limited locations in industrial areas within the combined sewer area, however, since planter boxes are unlikely to be maintained, other practices will be considered for industrial areas.

Figure 11 below shows a Google StreetView of a typical residential area, along Hamilton Street in the northeast area of Harrison. As illustrated the lot size and proximity of the frontage of the houses to the street does not leave for much area for installing planter boxes.

Figure 11: StreetView of a typical residential street in Harrison. Source: Google Earth StreetView

The industrial areas in Harrison do not offer much space for installation of planter boxes due to the wide roads and driveways, and narrow sidewalks. A representative StreetView is shown along Supor Boulevard in Figure 12 below, it shows minimal sidewalk area and extensive drop curbing for access to loading areas.

Figure 12: StreetView of a typical industrial street in Harrison. Source: Google Earth Street View

Planter boxes will thus not be considered any further in the alternatives analysis process.

C.2.5.6 Bioswales

Bioswales have been widely implemented in areas such as New York and Philadelphia but may have limitations in the narrow rights-of-way in Harrison. Nevertheless, they are easily modeled in InfoWorksICM and can be applied in a distributed fashion. They can also be used as a surrogate for modeling other green infrastructure practices. Accordingly, bioswales will be further evaluated in SECTION D.

C.2.5.7 Free-Form Rain Gardens

Rain gardens are functionally similar to bioswales but must be evaluated for suitability on a site-specific basis. They are a widely-used stormwater best management practice and are effective at containing, infiltrating and evapotranspirating diverted runoff. They also require minimal maintenance of vegetation & mulch requirements provided there is regular cleaning of inlets, overflows and underdrains. Sizing is flexible, and they can be modified to fit into site-specific areas. Underground infiltration beds or detention tanks can also be utilized to increase storage. There are limited locations for siting rain gardens within control of the Town. Figure 10 shows limited Town owned property of which only a small fraction is suitable for rain gardens. While parks offer opportunities for rain gardens, at this time they are only allowed to be used to treat onsite runoff. Since the parks are highly pervious, applying rain gardens within them will produce minimal benefits. The Town may elect to site rain gardens within available land and continue to promote them on private property apart from the CSO LTCP. Accordingly, since the opportunities and benefits of rain gardens are minimal, rain gardens will not be further evaluated in SECTION D.

C.3 INFILTRATION AND INFLOW CONTROL

C.3.1 Infiltration/Inflow (I/I) Reduction

Section G.4.e.iv. of the NJPDES Permit, “Evaluation of Alternatives”, states that non-excessive infiltration and non-excessive inflow (I/I reduction) should be investigated as a CSO control alternative for the entire collection system that conveys flows to the treatment works in order to free up storage capacity or conveyance in the sewer system and/or treatment capacity at the STP, as well as the feasibility of implementing I/I controls in the entire system or portions thereof. This section of the permit is currently being modified by the NJDEP to remove the reference to meeting “non-excessive” levels, which have been shown to be unattainable, and to limit the investigation of dry and wet weather flows from separate sewer municipalities tributary to combined sewer systems and I/I reduction, unless I/I reduction is proposed as a selected LTCP alternative. If selected as an alternative, the permittee would need to develop and submit a schedule and written agreements with the affected municipalities to revise rules, ordinances, and/or sewer use agreements to require the affected municipalities to: (1) operate and maintain their treatment works; (2) identify and reduce I/I; and (3) identify and eliminate interconnections and cross-connections in storm sewers.

Harrison has no separate sanitary sewer communities tributary to its combined sewer system. In addition, Harrison has no control over the other communities tributary to PVSC, so it is not feasible for the Town of Harrison to implement I/I controls across the entire system. It may be beneficial to incorporate I/I measures into other CSO measures that are being investigated.

C.3.2 Advanced Sewer Inspection and Maintenance

The Town of Harrison maintains its collection system regularly and is not aware of problem areas that could materially benefit from advanced inspection and maintenance. The proper maintenance of the system is reflected in the system baseline. While advances in the practice of sewer maintenance are expected, it is not appropriate to include them in the alternatives evaluation for Harrison. This does not preclude the adoption of such measures in the future, which, if implemented, would be reflected in future iterations of the system characterization.

C.3.3 Combined Sewer Flushing

The Town of Harrison currently maintains its collection system and performs sewer cleaning and flushing regularly and as needed. The Town is not aware of any areas that are subject to excessive sedimentation, which would reduce sewer capacity during rain events. The proper maintenance of the system is reflected in the baseline. Accordingly, additional combined sewer flushing is not appropriate for inclusion in the alternatives analysis.

C.3.4 Catch Basin Cleaning

The Town of Harrison has a program to clean its catch basins. Clogged catch basins are not known to be a problem within the Town. Proper maintenance of catch basins is reflected in the baseline modeling and is required under the Town's MS4 permit. Catch basin cleaning is unlikely to change the volume or quality of the combined sewer overflows. Accordingly, additional catch basin cleaning is not appropriate for inclusion in the alternatives analysis.

C.4 SEWER SYSTEM OPTIMIZATION

Sewer system optimization is being investigated through possible increased conveyance and storage capacity in the collection system. The Harrison system is currently operated to maximize inline storage and conveyance to the PVSC WRRF, thus available additional benefits are likely minimal; however, operation should be optimized where possible. Possible strategies which could be combined with pipeline alternatives include:

- Additional conveyance – Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.
- Regulator modifications – The CSO Regulators and tide gate chambers are owned and operated by PVSC. The Brown and Brown mechanical regulators were, for the most part removed in the PVSC transport system over a decade ago to maximize wet weather flows to the PVSC WRRF in Newark. While some regulators in Newark and Paterson were modified to sluice gates controlled at the WRRF, to the best of our knowledge the mechanical regulators in Harrison and other municipalities on the PVSC Branch Interceptors (Kearny and East Newark) were removed. The removal of the mechanical gates results in orifice control at each regulator and accordingly it is anticipated that no additional modifications are practical.
- Outfall consolidation / relocation – Based on previous reports outfall consolidation results in lower operational requirements; reduces permitting/monitoring; and is cost-effective when used in conjunction with storage & treatment technologies. Combining and relocating outfalls should also lower operating costs and reduction of CSO discharges. Consolidation can also be used to direct flow away from specific areas such as sensitive areas, which is not applicable to Harrison, since there are no sensitive areas
- Real time controls (RTC) are typically used in conjunction with inline storage to minimize the rate and volume of CSO discharges. The process will require periodic inspection of flow elements and a highly automated system to minimize operator errors, while

increasing potential for sewer backups. Since there is little or no additional storage capacity in the Harrison sewer system this control will not be considered any further in the alternative analysis.

C.4.1 Increased Capacity in the Collection System

Increased storage capacity can be achieved by either maximizing the volume of flow stored in the existing collection system, or by increasing the conveyance capacity of the overall system. Options are discussed as follows.

C.4.1.1 Additional Conveyance

As with most urban towns and cities, the rights-of-way within Harrison are relatively narrow and full of existing utilities and thus additional conveyance is not considered very practical for the Town of Harrison. Currently, the capacity-limiting facility in the PVSC transport system is the Kearny-East Newark-Harrison branch interceptor sewer that passes through Harrison and crosses the Passaic River by means of a siphon, and the capacity of the PVSC main interceptor sewer through Newark to the treatment plant. The hydraulic grade in the main interceptor is currently the hydraulic limitation to the siphon and branch interceptor. Thus, providing additional transport conveyance within Harrison will not be able to effectively move excess flows from the system without also increasing the capacity of the Main Interceptor.

One other option would be to construct a pumping station on the Harrison side of the River and to pump all flow by means of a dedicated force main directly to the PVSC headworks. This option however involves three municipalities (Kearny, East Newark, Harrison) and PVSC and thus cannot be completed by Harrison alone. Nevertheless, a review of the required facilities indicates that the treatment plant is approximately 18,000 feet from Harrison (see Figure 13). To provide CSO controls to manage the 4th largest overflow would require conveying a peak flow of approximately 250 MGD and a force main approximately 10' in diameter, which would cost an estimated $110,000,000 (2018 Technical Guidance Manual (TGM), Figure 3-6 $6,100/LF 10' tunnel <10,000 LF soft ground below the water table, assuming the Tunnel Boring Machine (TBM) will need to be relaunched several times), without considered diversion structures, consolidation piping and tunnel boring machine costs under the Passaic River. Even with a plant expansion, it is not anticipated that the PVSC plant could accept an additional 250 MGD.

Accordingly, additional conveyance will not be evaluated further. However, consolidation conduits may be necessary for other alternatives.

Figure 13: Conceptual conveyance conduit route from Harrison to PVSC

C.4.1.2 Regulator Modifications

Regulator modifications to increase flows to the interceptor/treatment plant are not considered feasible for the same reason that additional conveyance is not considered feasible. The hydraulic control on the system is the capacity of the existing interceptors, so modifying the regulators will not allow additional flow to be conveyed to the treatment plant and may adversely affect other communities on the interceptor. Accordingly, regulator modifications for additional conveyance will not be evaluated further except as part of another alternative.

Regulator modifications to increase storage within the existing collection system are also not considered feasible. Increasing storage within the existing system works best with large-diameter, gently sloping pipes. Calculations were performed to determine the volume of additional storage that could be realized by raising the existing weir, and it was found that the storage volume generated by modifying the weir elevation was marginal relative to the overall overflow volumes. This is described in more detail in Section C.5.

C.4.1.3 Outfall Consolidation/Relocation

Outfall consolidation/relocation is not being considered as an independent alternative. The Passaic River along Harrison is relatively consistent in terms of usage and water quality, with no identified sensitive areas, so there is no advantage to moving outfall discharges from one place to another. However, in conjunction with other alternatives, consolidation of outfalls may be practical. Accordingly, outfall consolidation/relocation will not be evaluated further except as part of another alternative.

C.4.1.4 Real Time Controls

Real time controls may be incorporated into other alternatives. There are no automated components in the existing system, so it is not practical to implement real time control, except as part of another alternative. Accordingly, real time controls will not be considered as an independent alternative.

C.5 STORAGE

Options for providing storage have been considered to reduce overflows by capturing and storing wet weather flows for controlled release back into the system once treatment and conveyance capacity have been restored.

C.5.1 Linear Storage

There are two forms of linear storage considered: pipelines and tunnels, described below.

C.5.1.1 Pipelines

Linear storage in a sewer can only be implemented if in-line storage potential exists in the system. If not done properly it can increase potential for basement flooding. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.

In-line storage within the existing sewers was investigated through the potential for additional storage generation by modifying the weirs, see Figure 14. Table 17 below summarizes the weir heights relative to the upstream pipe elevations.

It can be seen that at two of the locations, H-001A and H-006A, the top of weir elevation is above the pipe crown, as such, raising the weir would not provide any additional storage. Additional raising of the weirs at these locations to utilize potential storage within the collection system would not be prudent, as it could result in upstream backups. Analysis was completed at the other locations to identify the additional storage that would be generated in the system if the weir elevations were raised to the crown of the influent pipe. Again, raising the weir could result in upstream flooding, however, the impact could be minimized by installing bending weirs. The results of this analysis are provided as follows in Table 17.

Table 17: Regulator and Upstream Pipe Characteristics and available storage volume

Regulator #	Incoming Pipe			Overflow Weir	Is Weir at or above Pipe Crown?	Additional Volume if Weir is Raised to Crown (gal)
	DS Invert	Slope	Size	Crest		
H-001A (Hamilton Ave)	100.02	0.0144, 0.0091	18”	101.63	Yes	NA
H-002A (Cleveland Ave)	101.34	0.0058	15”, 20”	102.46	Yes	1,200
H-003A (Harrison Ave)	102.33	0.0036	30”x45”	104.05	No	10,600
H-005A (Middlesex St)	99.74	0.0008	24”	100.89	No	11,700
H-006A (Bergen St)	98.23	0.0078, 0.0039	24”	100.72	Yes	NA
H-007A (Worthington Ave)	101.36	0.0038	24”	102.53	No	4,300

Source Report Upon Overflow Analysis to PVSC Passaic River Overflow 1976, elevations in PVSC Datum.

Raising of the weirs would produce a total additional 0.028 MG of storage volume. This is not a significant volume and would also increase the risk of upstream flooding in the system, which is not desirable. Given the risk and the small potential benefit, raising weir is not feasible and will not receive further consideration in the alternatives analysis.

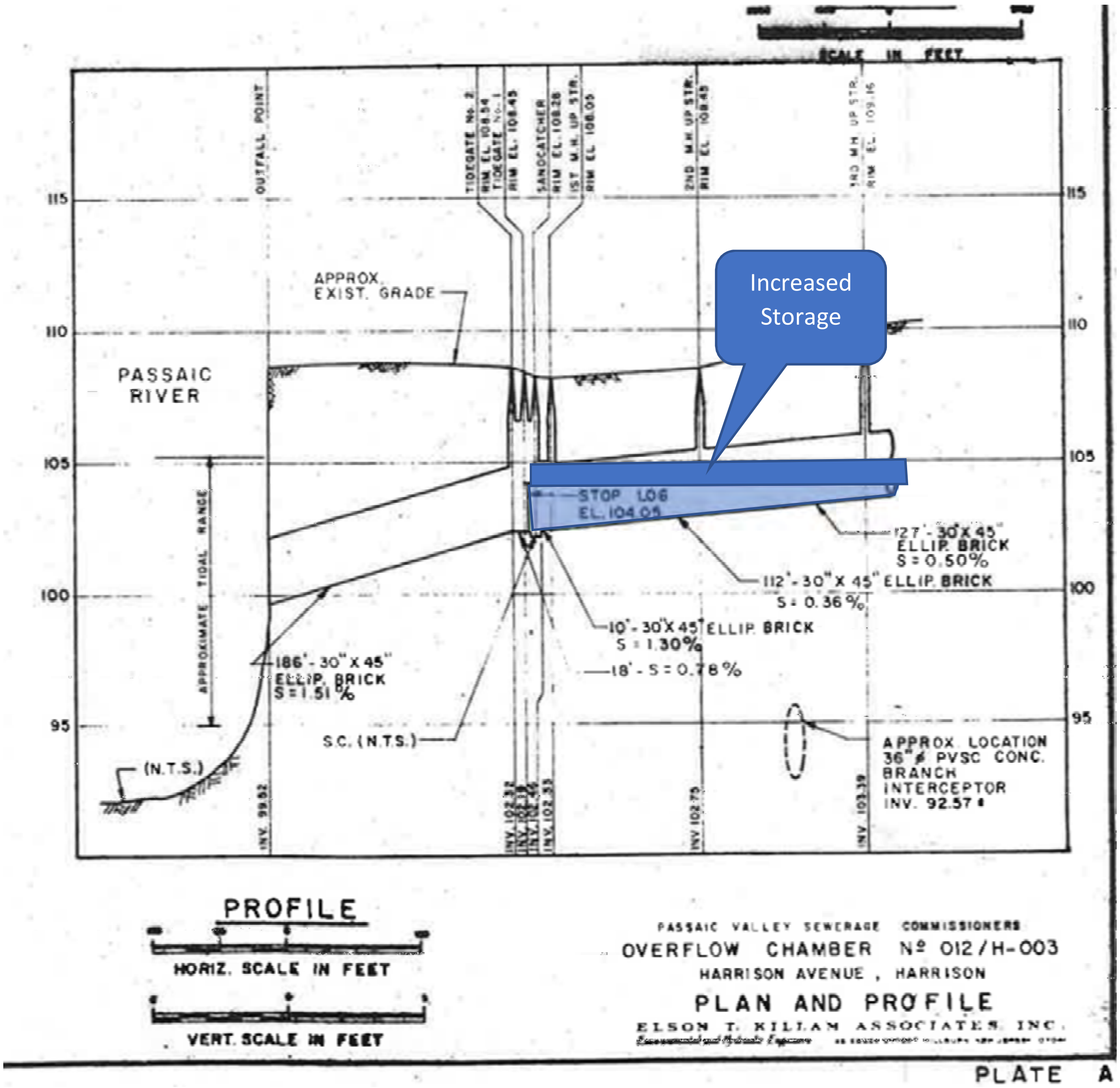

Figure 14: Example of additional storage created through weir raising.

C.5.1.2 Tunnels

The construction of new tunnels through the Town of Harrison was considered to provide storage in addition to what is available in the near surface pipelines.

Figure 15 below is a portion of the “Bedrock Geologic Map of the Elizabeth Quadrangle – Essex, Hudson and Union Counties, New Jersey” produced by the New Jersey Geological and Water Survey in 2015. It shows that the elevation of bedrock surface is between -100 and -250 feet. As such, it can be assumed that a tunnel would be constructed in soft ground, which is typically more expensive and difficult than rock tunneling, and greatly increases the risk of damage to surface structures through settlement.

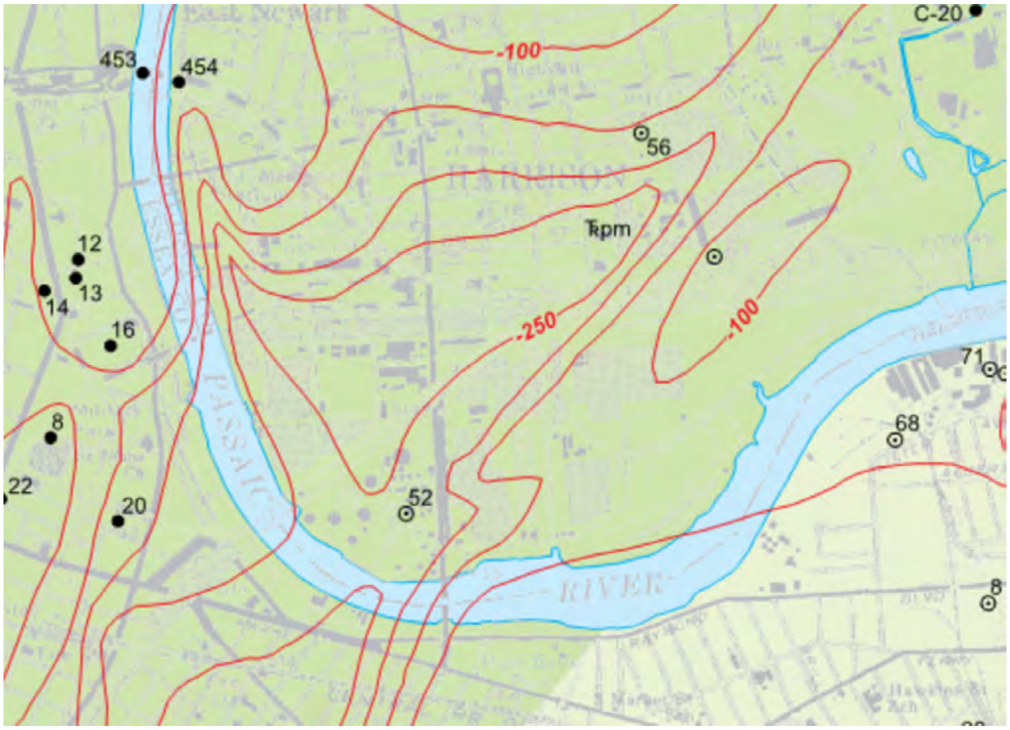

Figure 15: Depth to bedrock map of Harrison.

Excerpted from "Bedrock Geological Map of Elizabeth Quadrangle, Monteverde and Herman 2015

Due to the locations of the outfalls, it would be most practical to attempt to consolidate some or all of the flows from outfalls 001A, 002A, 003A, and 006A prior to the drop into the tunnel and to convey flows from outfall 007A to the tunnel separately. This assumes that 005A has been eliminated through sewer separation. Consolidation piping could be run under existing streets or along the waterfront beneath the partially completed river walk, however, existing bridge abutments may interfere with the route.

Siting a tunnel within Harrison is challenging given the large areas needed for mucking operations, mining shaft and recovery shaft. Potential alignments are limited due to the irregular street grid with likely routes running east to west, for example along Bergen Street.

A tunnel route along the waterfront would not be possible due to the many properties or easements that would need to be acquired. The structures along the waterfront, particularly the Water's Edge apartment complex on Dey Street, are located very close to the shoreline. As such, there is limited space to install a tunnel without compromising the stability of adjacent buildings. Likewise, a tunnel along the river would impact bridge piers.

While there are many challenges associated with constructing a tunnel in Harrison, because of the large storage volume provided with minimal permanent surface impacts and successful application of tunnels in other CSO communities, tunnels will be considered for evaluation in SECTION D.

C.5.2 Point Storage

Off-line storage facilities can be implemented above or below ground within the combined sewer system.

C.5.2.1 Tanks

While siting of storage tanks within a densely populated area such as Harrison can be challenging, there are some potential areas available, as well as options for consolidated storage. Storage tanks provide effective reduction of CSO volumes and provide full treatment by allowing the retained volume to be conveyed to the treatment plant. Operationally, they are simple, consisting of a small pumping station, odor control and tipping bucket flushing system. Their operations and maintenance are within the capabilities of most municipal department of public works.

Accordingly, storage tanks have been identified as a viable approach to detain peak flows along various points of the collection system. Possible tank sites and site analysis are described in SECTION D for future consideration in the alternatives evaluation.

C.5.2.2 Industrial Discharge Detention

Significant Indirect Users (SIU) are regulated under the industrial pre-treatment program administered by the receiving WRRF, in this case PVSC. PVSC is working with the industrial discharges to address detention. The reader is referred to the Main Report for additional details.

C.6 STP EXPANSION OR STORAGE AT THE PLANT

Expansion of the treatment plant and storage at the treatment plant are the responsibility of PVSC and have not been evaluated by Harrison. They are discussed in the Main report.

C.7 SEWER SEPARATION

C.7.1.1 Roof Leader Disconnection

Disconnection of area drains and roof leaders has been investigated, however the Town of Harrison is highly urbanized, thus there are limited opportunities for infiltration of storm flow from roof leaders discharging onto pervious areas; see Figure 11 and Figure 12. Most disconnected roof leaders would discharge onto small pervious areas in residential front lawns. These lawns do not provide the recommend minimum of 25 feet for flow to spread out and achieve sheet flow, prior to the flow reaching the street, thus there is little impact from infiltration. The volume of flow reaching the street and then the combined sewer system will be similar to the directly connected volume and the disconnection will provide minimal benefits regarding CSO reduction. Roof leader disconnection also requires coordination and buy-in from home and business owners, which may not be achievable systemwide. Disconnection may be coupled with other green infrastructure technologies but is not considered an effective standalone option and will not receive further consideration as an alternative to evaluate.

C.7.1.2 Sump Pump Disconnection

Disconnection of sump pumps is more applicable to separately sewered areas and would be a necessary component of sewer separation. It also requires coordination and buy-in from home and business owners, which may not be achievable system-wide. The Town of Harrison is highly urbanized thus there is limited opportunity for infiltration of sump pump flows as the discharge flows across pervious area. Without separate storm sewers the disconnected sump pump discharge would flow to the street, down the gutter into the inlet and into the combined sewer as it currently does. The Town has a sump pump disconnection program that requires sump pumps to be disconnected to issue a certificate of occupancy, but the number of sump pumps detected through this is relatively small, and reconnection of sump pumps cannot be enforced. Sump pump disconnection may be coupled with other green infrastructure technologies but is not considered an effective standalone option and will not receive further consideration as an alternative to evaluate.

C.7.1.3 Combined Sewer Separation

Sewer separation has been incorporated in parts of Harrison recently through redevelopment. Sewer separation has been completed along Dey Street, effectively decommissioning Outfall 004A as a combined sewer overflow outfall. The other area in Harrison currently being planned for sewer separation is a portion of the drainage area tributary to Outfall 005A. Figure 5 shows the area that will be separated.

Historically sewer separation has been found to have a very high cost, if implemented outside of large-scale redevelopment. Creating new stormwater outfalls also present unique water quality challenges, so separated sewers are not necessarily an effective long-term solution for improving water quality. This is because stormwater would also contribute to a decrease in water quality. Currently, sewer separation projects are subject to water quality requirements by the State when Department of Land Use Regulation permits are required. Draft rules formalizing and increasing the requirements on sewer separation projects were recently issued for public comment. It is anticipated that stormwater outfalls will be subject to additional regulations in the future that will eventually require progressively more stringent treatment prior to discharge. This may make separation infeasible in the future and makes current cost estimates highly uncertain.

In spite of its many challenges, sewer separation is essentially the only way to guarantee elimination of combined sewer overflow. For this reason and since sewer separation is being planned for parts of the Town of Harrison this alternative is maintained for future consideration in the alternatives evaluation.

C.8 TREATMENT OF CSO DISCHARGE

Treatment technologies can be effective in reducing the pollutant loads to receiving waters by treating wet weather flows prior to discharging to the environment. Satellite, end-of-pipe treatment has been used successfully in other places, and there is potential for installing end-of-pipe treatment in Harrison. End-of-pipe treatment is often operator intensive, with the permittee operating several small-scale wastewater treatment plants. It has also been indicated that providing primary treatment and disinfect through satellite end-of-pipe treatment may not be considered adequate in the future and additional facilities may be required under subsequent permits.

Possible end-of-pipe treatment sites are described in SECTION D for future consideration in the alternatives evaluation. The proposed treatment facilities will consist of pretreatment (screening), high-rate primary treatment and disinfection with interim pumping also required. To limit the alternatives, a representative set of technologies to provide the treatment train described will be selected. The subsequent sections will screen the extensive list of technologies, it is understood that the LTCP may not select the same exact set of technologies and that pilot testing will ultimately be required to select a technology for construction.

C.8.1 Course Solids and Floatables Removal

C.8.1.1 Vortex Separators

Vortex separators would be considered a pre-treatment technology to remove floatables and suspended solids, but do not address volume, bacteria or Biochemical Oxygen Demand (BOD) components of CSO flow. Vortex separators have been found to be effective at removing inorganic Total Suspended Solids (TSS), but limited in their removal of smaller and lighter particles. Improved performance has been achieved through chemical addition and the addition of large tanks to store the underflow. Vortex separators were not selected as the representative pretreatment technology.

C.8.1.2 Screens and Trash Racks

Depending on the opening size, screens and trash racks can capture a variety of particle sizes and protect downstream equipment. Generally, they only address floatables. They have an increased operational and maintenance requirement because they are prone to clogging and require regular maintenance. They have a relatively small footprint and the screenings can either be returned to the interceptor or handled separately without the need for a large tank. Accordingly, screens and trash racks will only be considered as ancillary elements to other CSO technologies.

C.8.1.3 Netting

Netting facilities are already in use in Harrison, as such they provide no additional future benefit and are not considered further in the evaluation of alternatives.

C.8.1.4 Containment Booms

Containment booms address floatables, however the Town already uses netting facilities for floatables. Booms are difficult to maintain. As such, containment booms provide no additional future benefit and are not considered further in the LTCP.

C.8.1.5 Baffles

Baffles address floatables, however the Town already uses netting facilities for floatables. As such baffles provide no additional future benefit and are not considered further in the LTCP.

C.8.2 Disinfection & Satellite Treatment

Disinfection is an effective control to reduce bacteria in CSO flow. As such, disinfection is considered further in the alternatives evaluation. It is noted that disinfection does not provide solids removal, as such solids removal to meet the regulatory requirements and to allow for proper disinfection, would be accomplished with a separate technology. While other disinfection technologies exist such as UV and chlorination, for evaluation purposes, peracetic acid (PAA) is considered as a disinfection approach. PAA is being considered as the representative technology because of its long shelf life, short required contact time and lack of residual byproducts which must be removed for other technologies such as chlorination.

C.8.3 High Rate Primary Clarification

C.8.3.1 High Rate Physical/Chemical Treatment (ActiFlo)

High rate treatment such as ActiFlo primarily focuses on TSS and BOD removal but does not address volume and bacteria components of CSO flow. While these systems have a smaller footprint than conventional methods, they are challenging to implement for locations with intermittent or highly variable wet weather flows. Given its effectiveness in removing pollutants and small footprint, ActiFlo is being considered as a representative technology for primary treatment.

C.8.3.2 High Rate Physical Treatment (Flex Filter)

High rate treatment such as the FlexFilter compressed media filter system and cloth media filters systems have a smaller footprint than traditional filtration methods and have relatively low operational and maintenance requirements. They primarily focus on TSS removal but do not address volume and bacteria components of CSO flow. As such, high rate treatment such as FlexFilter may be coupled with other technologies but is not considered an effective standalone option. The alternatives evaluation will only look at high rate physical/chemical treatment as representative technologies, but the final selection may include high rate physical treatment. Ultimately, any system installed will require pilot testing to ensure its effectiveness on the combined sewage produced in Harrison.

C.9 SCREENING OF CONTROL TECHNOLOGIES

The range of CSO control alternatives to be further evaluated in the next section is summarized in Table 18 through Table 20.

Table 18: Source Control Technologies Summary Screening Table

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

Table 18 (Continued)

Source Control Technologies									
Technology Group	Practice	Primary Goals		Potential Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Notes
		Bacteria Reduction	Volume Reduction						
Good Housekeeping	Street Sweeping/Flushing	Low	None	- Reduced surface flooding potential	Labor intensive; specialized equipment; doesn't address flow or bacteria; City function. Street sweeping and flushing primarily addresses floatables entering the CSS while offering an aesthetic improvement.	Yes	Yes	No	Already being implemented.
	Leaf Collection	Low	None	- Reduced surface flooding potential - Aesthetic benefits	Requires additional seasonal labor. Leaf collection maximizes flow capacity and removes nutrients from the collection system.	Yes	Yes	No	Already being implemented.
	Recycling Programs	None	None	- Align with goals for a sustainable community	Most Cities have an ongoing recycling program.	Yes	Yes	No	Already being implemented.
	Storage/Loading/Unloading Areas	None	None	- Water quality improvements	Requires industrial & commercial facilities designate and use specific areas for loading/unloading operations. There may be few major commercial or industrial users upstream of CSO regulators.	Yes	No	No	Minimal benefits.
	Industrial Spill Control	Low	None	- Protect surface waters - Protect public health	PVSC has established a pretreatment program for industrial users subject to the Federal Categorical Pretreatment Standards 40 CFR 403.1.	Yes	Yes	No	Already being implemented.
Green Infrastructure Buildings	Green Roofs	None	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittee or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof vegetation. Portions of Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	No	Not practical
	Blue Roofs	None	Medium	- Reduced heat island effect - Property value uplift - Local jobs - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Adds modest cost to new construction; not applicable to all retrofits; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes; upkeep of roof debris. Portions of the Cities have densely populated areas, but this technology is limited to rooftops. Can be difficult to require on private properties.	Yes	No	No	Not practical
	Rainwater Harvesting	None	Medium	- Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community - Water Saving	Simple to install and operate; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	No	No	Not feasible

Table 18 (Continued)

Source Control Technologies									
Technology Group	Practice	Primary Goals		Potential Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Notes
		Bacteria Reduction	Volume Reduction						
Green Infrastructure Impervious Areas	Permeable Pavements	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Cost-effective water quality improvements - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Not durable and clogs in winter; oil and grease will clog; significant O&M requirements with vacuuming and replacing deteriorated surfaces; can be very effective in parking lots, lanes and sidewalks. Maintenance requirements could be reduced if located in low-traffic areas, and can utilize underground infiltration beds or detention tanks to increase storage.	Yes	No	Yes	Proceed to evaluation
	Planter Boxes	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of runoff in developed areas. Flexible and can be implemented even on a small-scale to any high-priority drainage areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	No	Not Practical
Green Infrastructure Pervious Areas	Bioswales	Low	Low	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community - Increased pedestrian safety through curb retrofits	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	No	Yes	Proceed to evaluation
	Free-Form Rain Gardens	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltration and evapotranspiration of diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	No	No	Incorporated into evaluation as bioswales

Table 19: Collection System Technologies Summary Screening Table

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

Table 20: Storage and Treatment Technology Summary Screening Table

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

SECTION D ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

The alternatives have been evaluated according to the factors below, in order to provide information and insight on the feasibility of an alternative in addition to the cost and performance considerations. The text below addresses decision factors that are critical in the alternatives evaluation process and provide a necessary "reality check" on the overall implementability of CSO control alternatives. This is important as recommendation of an alternative that can be implemented in a model but that cannot ultimately be built could have serious implications for fulfillment of the LTCP objectives, which cannot be obtained from cost and performance numbers alone.

D.1.1 Siting

Preliminary siting issues is listed in USEPA's Combined Sewer Overflow – Guidance for Long Term Control Plans (EPA 832-B-95-002 September 1995) as a screening mechanism and recommends the evaluation of the following:

- Availability of sufficient space for the facility on the site
- Distance of the site from CSO regulator(s) or outfall(s) that will be controlled
- Environmental, political, or institutional issues related to locating the facility on the site.

An analysis was undertaken to identify locations where storage or end-of-pipe treatment might be installed for CSO control. The following publicly available GIS information was utilized:

- Aerial photography
- Land Use / Land Cover
- Parcel data, including vacant land, land ownership, and property value information
- Open Space / Green Acres
- Soil Type
- Topography
- Known Contaminated Sites
- Brownfields

This information was layered into GIS and analyzed to identify candidate sites for storage or end-of-pipe treatment. The first step of the analysis was to eliminate residential areas, transportation corridors and water bodies, as it was reasoned that these areas would not be suitable candidates for the extensive disturbance that would be required for a storage or end-of-pipe treatment facility. The overall land use of Harrison is shown in Figure 16, with residential, transportation corridors and water bodies subtracted out. The remaining shaded areas were evaluated for potential sites by visual inspection.

The remaining areas were analyzed based on aerial photography, with sites prioritized based on public ownership and vacant land, as well as potential underutilized sites such as parking areas or possible abandoned sites. It is noted that much is unknown at this time and use is made of existing data and reasonable interpretation and inferences where appropriate.

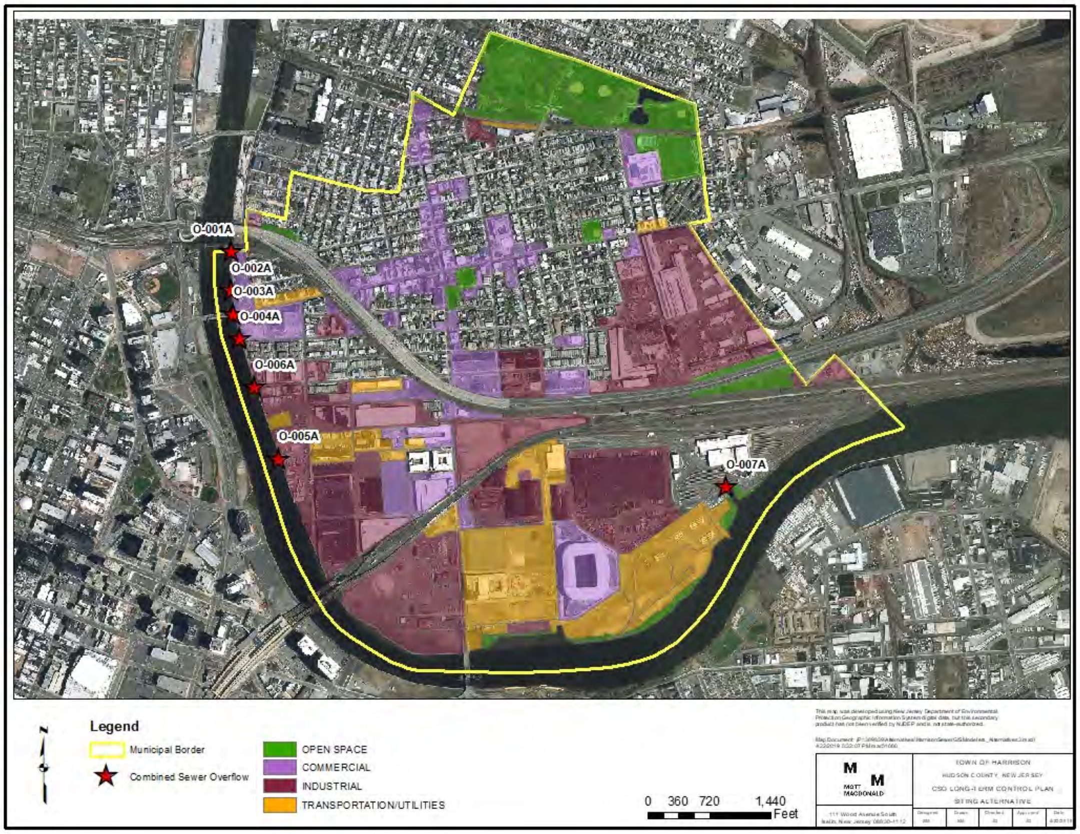

Figure 16: Town of Harrison Land Use Map, non-residential areas

The Table 21 below summarizes the characteristics that were considered at each site:

Table 21: Siting Criteria Table

Evaluation Factor	Favorable	Unfavorable
Land Cover	Open paved or grass areas, vacant land	Buildings / Structures
Land Use	Industrial, Commercial, Open Space	Green Acres, Residential, Transportation Corridors
Ownership	Publicly owned	Privately owned
Elevation Change	Small elevation change to outfall or regulator	Large elevation change to outfall or regulator
Proximity	Close to outfall or regulator	Far from outfall and regulator
Contamination	No known soil or groundwater contamination	Known contaminated site or brownfield site

The selected candidate sites described below are primarily underutilized commercial, industrial or open space areas, that may be known brownfields and are in close proximity to a combined sewer outfall.

Potential CSO facility sites are identified for each outfall as follows.

D.1.1.1 Outfall H-001A

Designated as Site 001A, Veteran's Plaza, located at Harrison Avenue and Frank E. Rodgers Boulevard South, was investigated as a possible site for Outfall HR001 (Figure 17). It is located about 0.5 miles from the outfall and is currently a publicly-owned open park space and a soccer field owned by the Town of Harrison. This site area is 1.4 acres, with 0.9 acres under the park and 0.5 acres under the soccer field. This site is not listed on the NJDEP Recreation and Open Space Inventory (ROSI) database, however, it may be considered a Green Acres property. The utilization of Green Acres for CSO control is still being addressed, and for this analysis it is assumed that only green infrastructure alternatives will be allowed on a Green Acres property. If it is considered a Green Acres site, additional permitting and land compensation will be required to disturb the site. Accordingly, other than for localized green infrastructure this site will not receive further consideration.

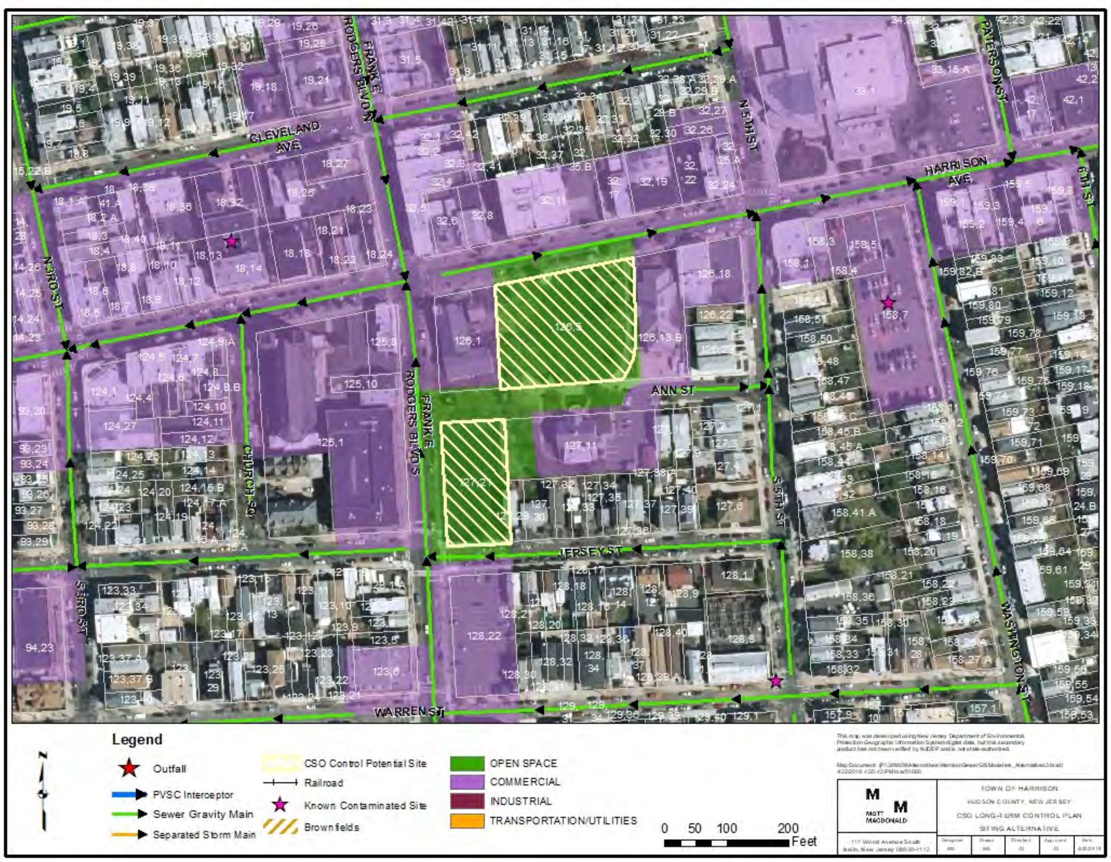

Figure 17: Site 001A Veterans Plaza

Designated at Site 001B, another possible location for HR 001, is under the northern parking lot of the Hampton Inn located at Hamilton Street and Passaic Avenue (Figure 18). This site is directly adjacent to HR 001 and has an area of approximately 0.4 acres. Aboveground facilities would need to be limited to reduce impacts to the hotel parking, aesthetics and operations. Because it is located on private property, an agreement with the owner or property acquisition will be required. Access is available from Passaic Avenue, and traffic will not be disturbed as the construction area can be contained within the parking area. It is also known to be a contaminated site. Due to its proximity to the Passaic River, a Waterfront Development permit and other permits would likely be required, depending on the nature of the proposed work.

Figure 18: Site 001B Hampton Inn Parking Lot - North

Although it is classified as a residential area, the area across the street from the Hampton Inn, designated at Site 001C, may also be considered, with an area of 0.3 acres (Figure 19). The narrow irregular shape of this property and proximity to the railroad track and retaining wall supporting the rail embankment would limit what could be constructed on this site. Because it is located on private property, an agreement with the owner or property acquisition will be required. Access is available from Passaic Avenue, and traffic will not be disturbed as the construction area can be contained within the parking area. Due to its proximity to the Passaic River, a Waterfront Development permit would likely not be required.

Figure 19: Site 001C Parking are in residential complex

D.1.1.2 Outfall H-002A

Designated as Site 002A, the southern end of the parking lot of the Hampton Inn located at Cleveland Avenue and Passaic Avenue is located directly adjacent to HR 002 and has an area of about 0.3 acres (Figure 20). Aboveground facilities would need to be limited to reduce impacts to the hotel parking, aesthetics and operations. Because it is located on private property, an agreement with the owner or property acquisition will be required. Access is available from Passaic Avenue, and traffic will not be disturbed as the construction area can be contained within the parking area. It is also known to be a contaminated site. Due to its proximity to the Passaic River, a Waterfront Development permit would likely be required.

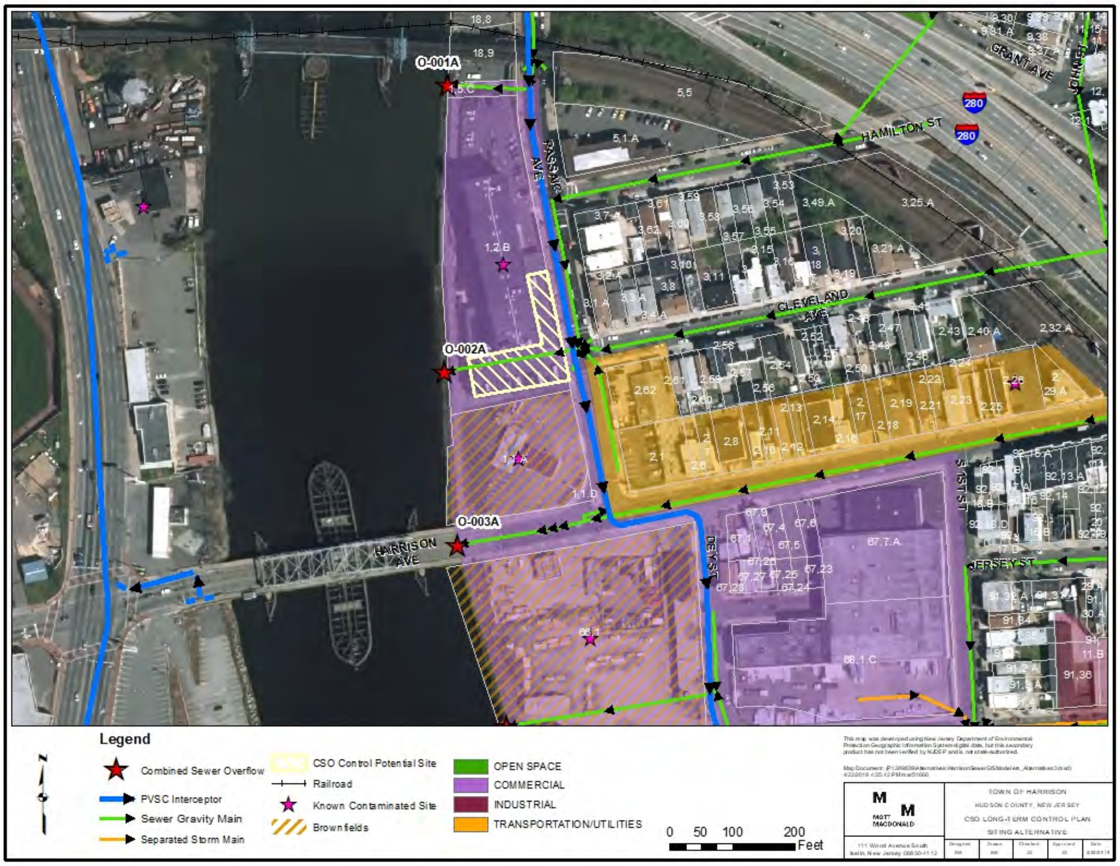

Figure 20: Site 002AHampton Inn Parking Lot - South

Designated as Site 002B/003A, the Speedway Gas Station at Harrison Avenue and Passaic Avenue site was considered, which has an area of about 0.3 acres (Figure 21). Because of its proximity to the Passaic River, a Waterfront Development permit would likely be required. The site is actively in use, likely has limited storage area underneath due to existing fuel storage tanks, and is also a brownfield (contaminated) site. At this phase of the project, only the grassed portion of this site is considered suitable for potential CSO facilities. Given its proximity to the Passaic River a Waterfront Development Permit and likely other permits will be required, depending on the nature of the facilities.

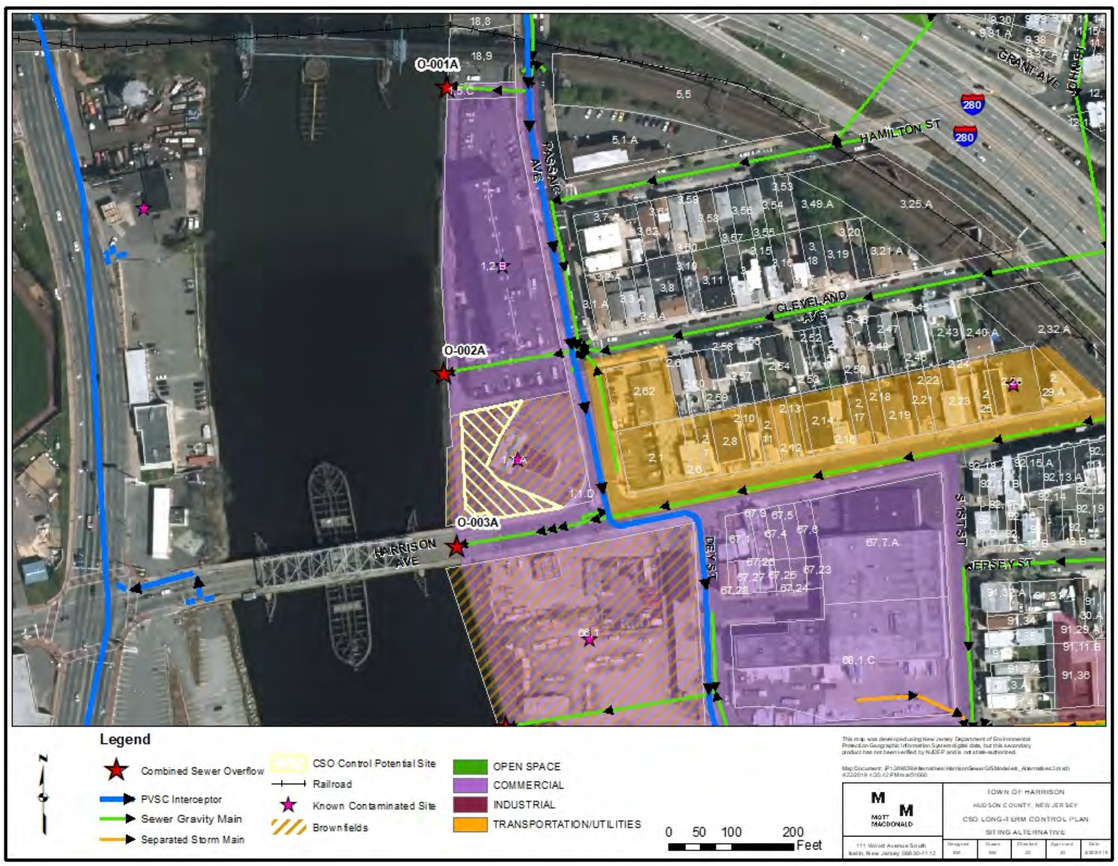

Figure 21: Site 002B/003A Speedway Gas Station

D.1.1.3 Outfall H-003A

Designated Site 003A, there was a 2.9 acre lumber yard / auto sales lot located adjacent to H-003 on Dey Street (Figure 22). It is being noted in this report because it appeared underutilized on the recent aerials. However, it has recently been redeveloped and is currently occupied by a new residential complex.

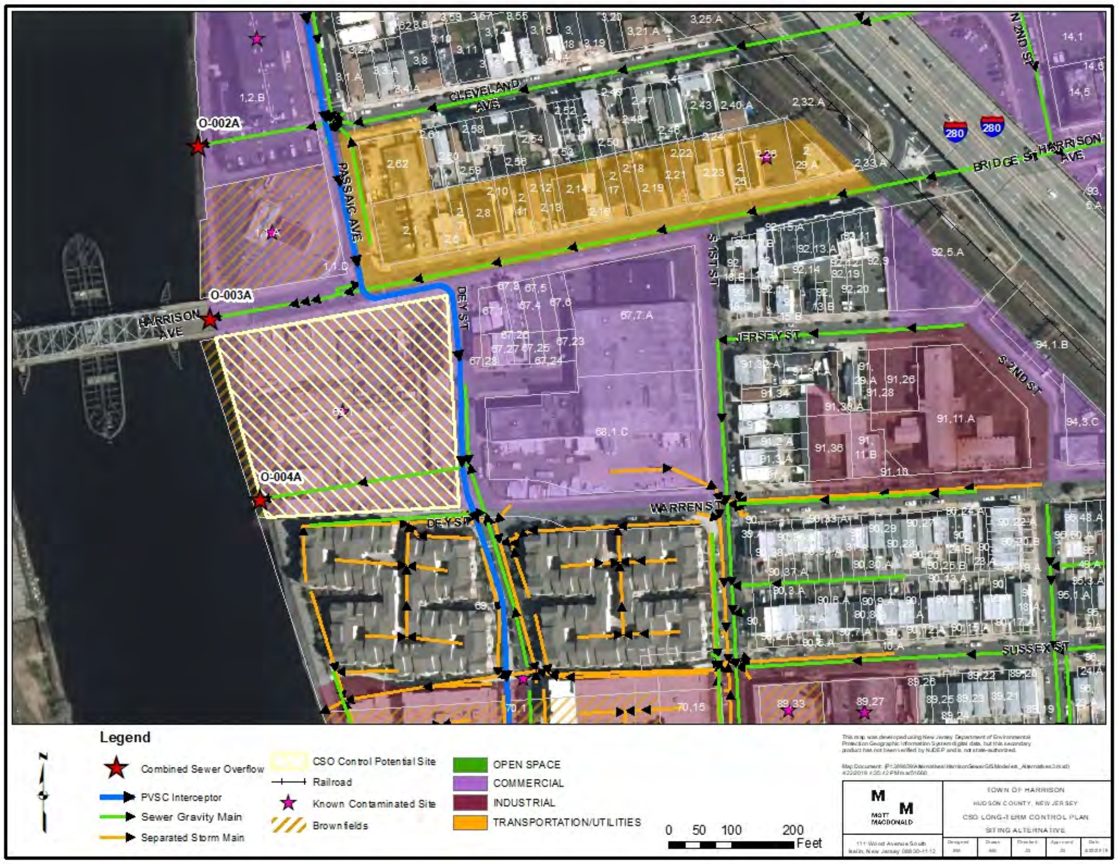

Figure 22: Site 003B Former Lumber/Auto Sales site, now residential complex

Designated as Site 003C, there is a parking lot of a commercial building located across the road at Harrison Avenue and Dey Street, which has an area of 0.3 acres (Figure 23). Given the configuration and size of the site, it would only be suitable for limited below ground facilities. Because it is located on private property owned by Estrella Development LLC, an agreement with the owner or property acquisition will be required. Access is available from Harrison Avenue, and traffic will not be disturbed as the construction area can be contained within the parking area.

Figure 23: Site 003C Commercial Site

D.1.1.4 Outfall H-006A

Designated as Site 006A, there is an underutilized parking area between HR 006 and HR 005 at South 1st Street and Railroad Avenue. The total area available is 0.97 acres (Figure 24). The site may be suitable for a consolidated CSO storage or treatment facility. Because part of it is located on private property, an agreement with the respective owners or property acquisition will be required. Access is available from South 1st Street, and traffic will not be disturbed as the construction area can be contained within the parking area. This site is slated for redevelopment and will not receive further consideration.

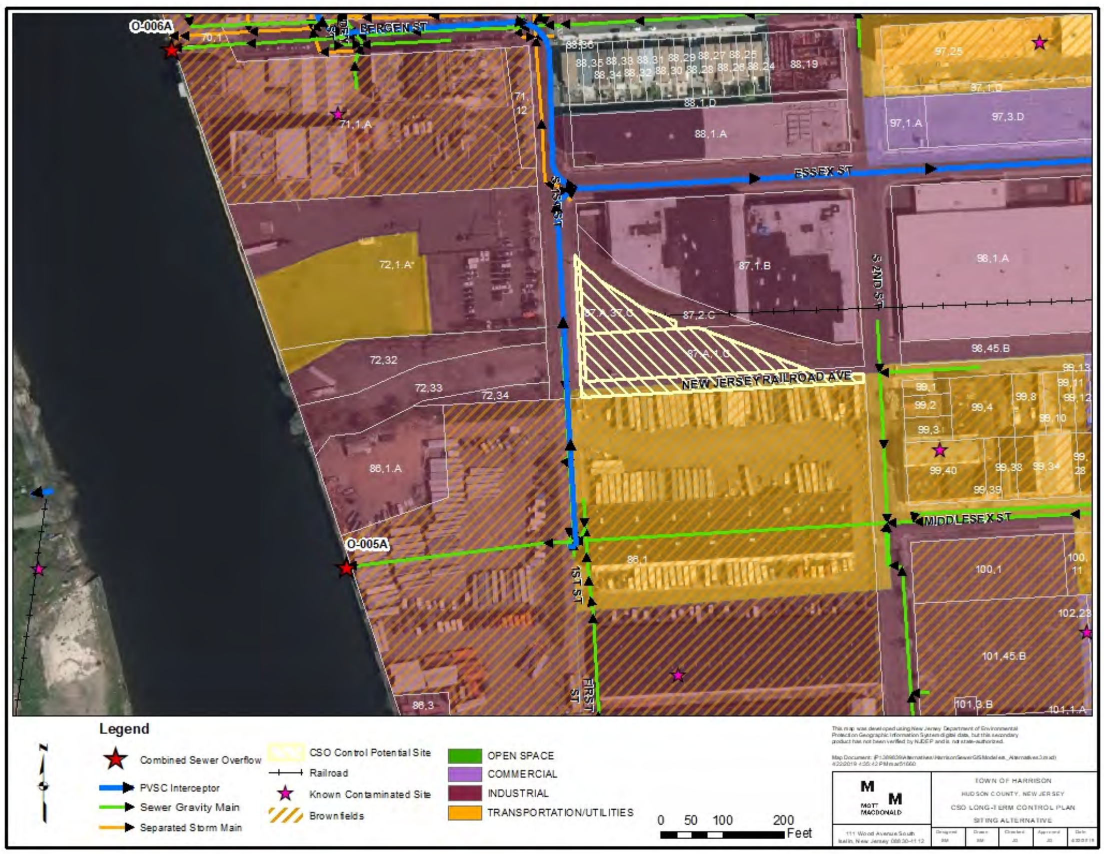

Figure 24: Site 006A Industrial Open Space/Parking

Designated as Site 006B, there are truck parking areas further south near 1st Street and New Jersey Railroad Avenue, which are brownfields with a total area of about 9.8 acres (Figure 25). The site is known to be contaminated. Discussions with Town of Harrison staff indicated that the site south of Railroad Avenue is planned for redevelopment as a park while the area north of Railroad Avenue is designated for residential redevelopment. This would limit the type of CSO facility that is implemented but would still be a viable location. Because part of it is located on private property owned by 760 First Street LLC and Hartz Mountain Industries Inc., an agreement with the respective owners or property acquisition will be required. Access is available issue from South 1st Street, and traffic will not be disturbed as the construction area can be contained within the parking area. Due to its proximity to the Passaic River, a Waterfront Development permit would likely be required. Given the known redevelopment plans this site will not be considered as available for CSO control facilities.

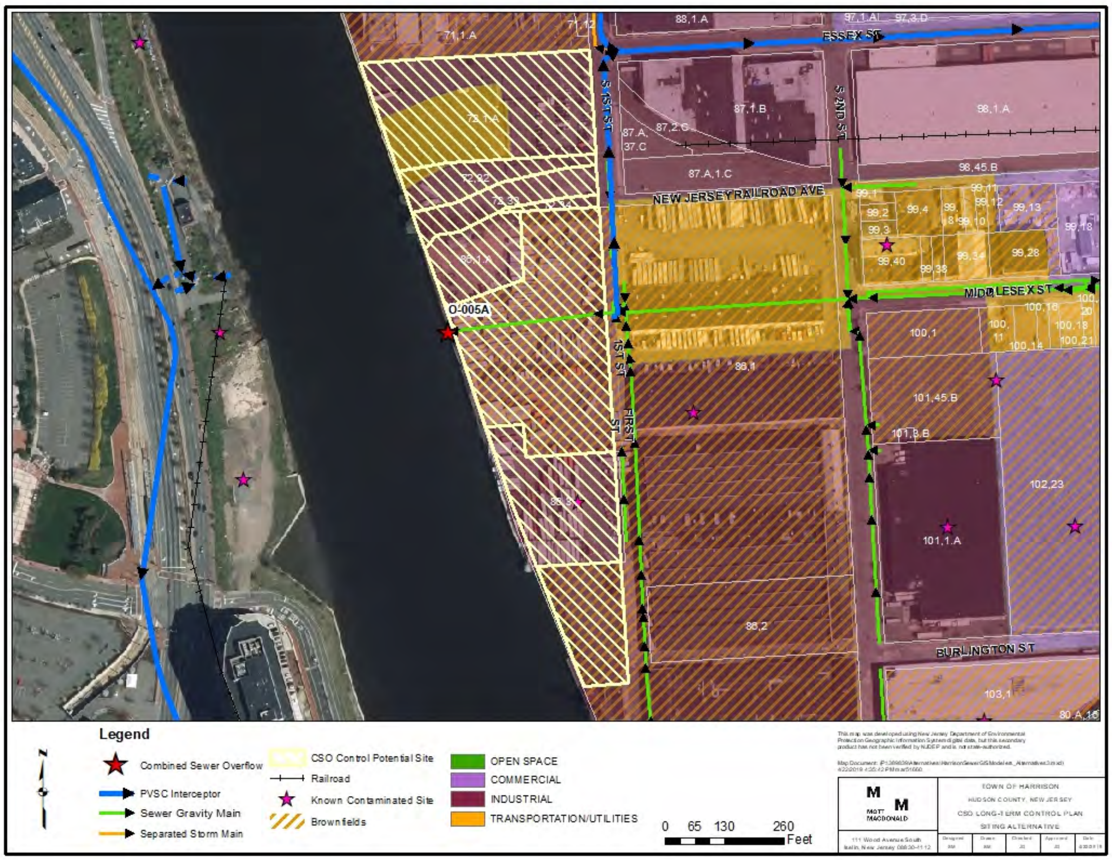

Figure 25: Site 006B Brownfield Parking Lots

D.1.1.5 Outfall H-007A

Designated as Site 007A there are two areas of unutilized space and parking adjacent to Outfall HR 007 with a combined area of 2.5 acres (0.8 acres to the northeast, 1.7 acres to the southwest) (Figure 26). In discussions with the Town of Harrison, it was determined that this location would not have a path for access to perform repairs or maintenance, thus would not be a viable candidate for a CSO facility.

Figure 26: Site 007A Parking Lot / Undeveloped Space

Designated 007B, there is also an open space area north of HR 007 between Highway 280 and the railroad track, which has an area of 2.8 acres (Figure 27). The site appears to be owned by Weldon Quarry as part of their overall facility which contains a concrete plant and stockpiles. Because part of it is located on private property, an agreement with the respective owners or property acquisition will be required. The portion of the site identified in Harrison does not appear to be utilized at this time. Traffic will not be disturbed as the construction area can be contained within the area, however because it is situated between a highway and rail line, access will be more challenging.

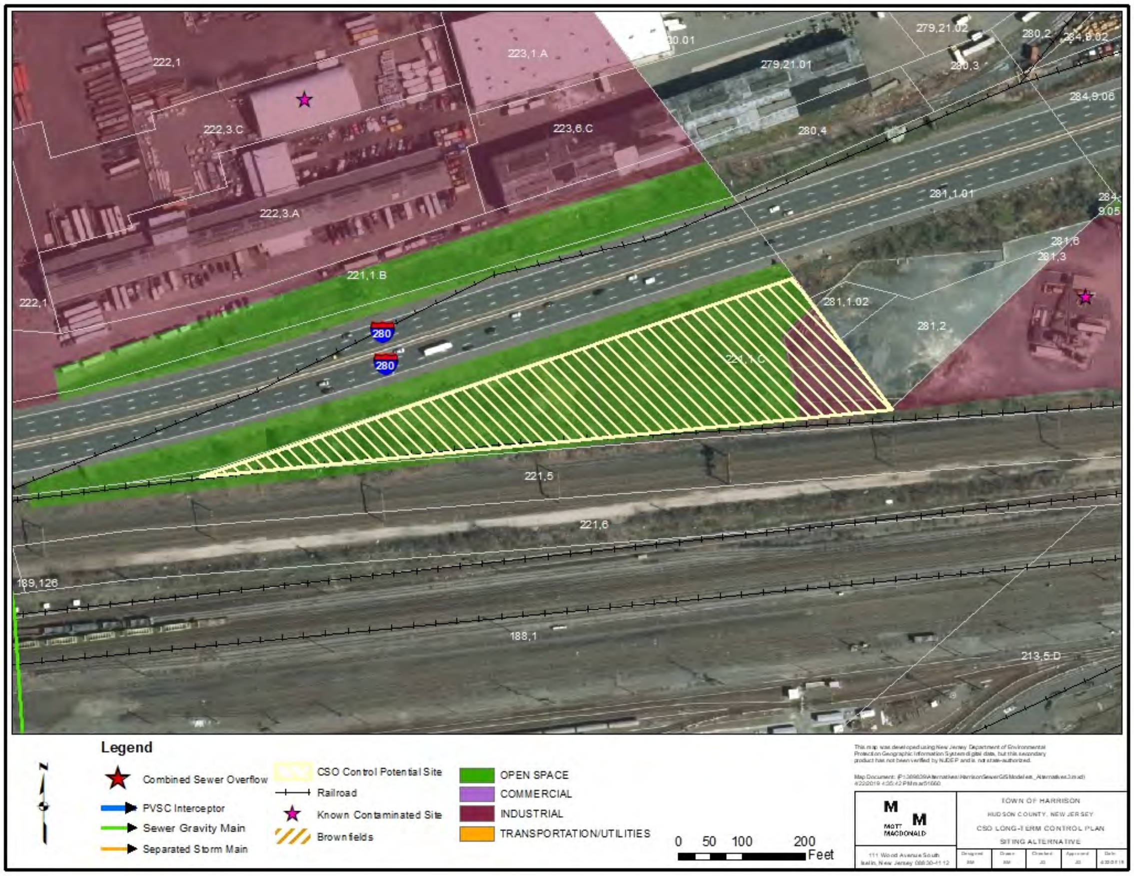

Figure 27: Site 007B Undeveloped Space beside rail and I-280

Designated as Site 007C, there is a large industrial area north of I-280 at the Supor Boulevard and Harrison Avenue which appears to be underutilized and could potentially be converted into storage (Figure 28). It is currently owned by J. Supor LLC, a trucking company, and the parcel has an area of 24.9 acres. Because it is located on private property, an agreement with the respective owners or property acquisition will be required. Access is available from Supor Boulevard, and traffic will not be disturbed as the construction area can be contained within the parking area. In discussion with the Town of Harrison it was determined that only 1.2 acres of open parking area at the southwest corner of the site (shown below) would be needed for a CSO facility.

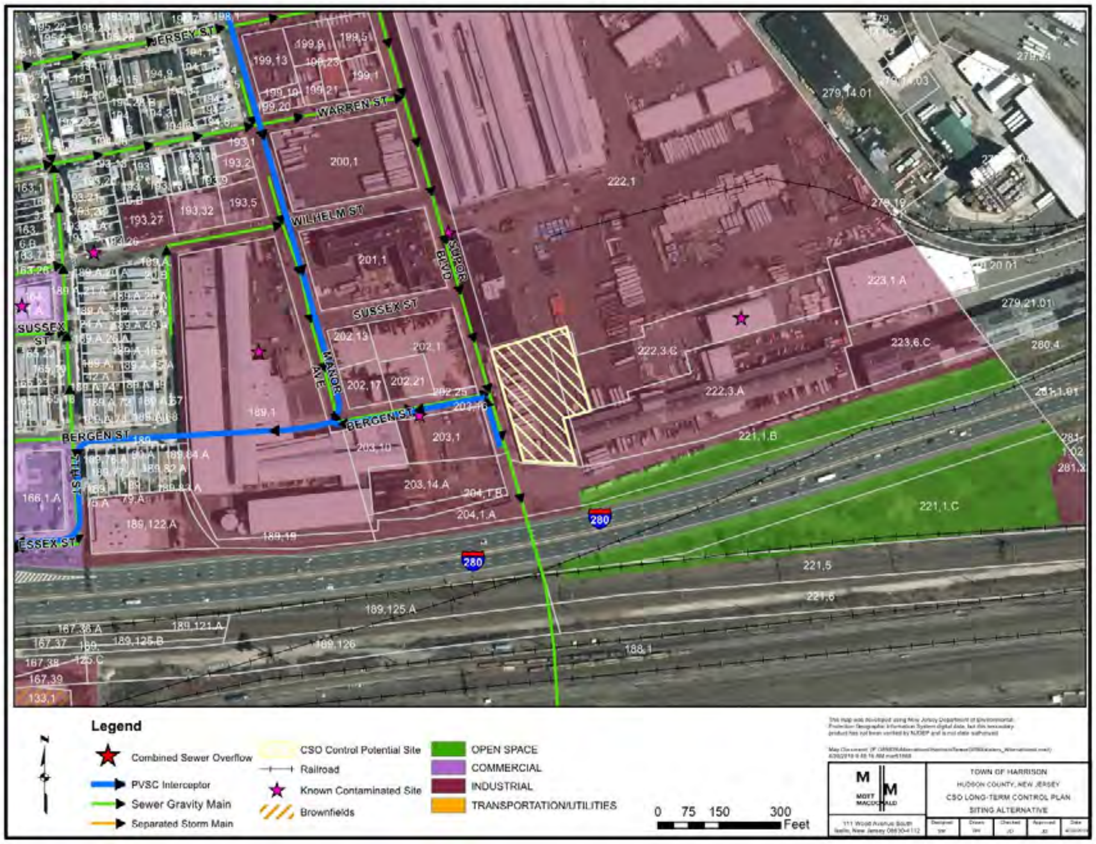

Figure 28: Site 007C Industrial Area North of I-280

Site 007D is a large industrial area directly west of Site 007C, located at Supor Boulevard and Sussex Street. The area appears to be underutilized and could potentially be converted into storage (Figure 29). It is currently owned by Campbell Foundry Co., a manufacturer of castings. The available area for a CSO facility is 1.45 acres. Because it is located on private property, an agreement with the respective owners or property acquisition will be required. Access is available from Supor Boulevard, and traffic will not be disturbed as the construction area can be contained within the open portion of the site.

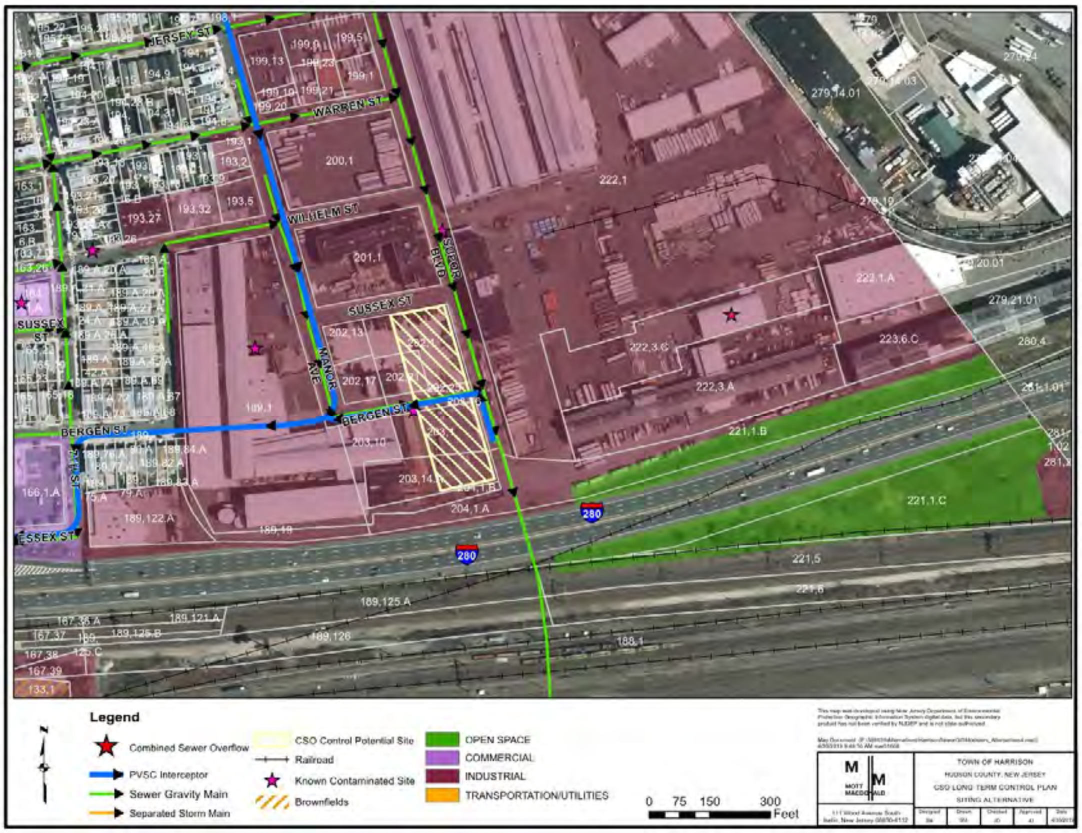

Figure 29: Site 007D Campbell Foundry Industrial Area

Table 22 below summarizes the potential sites moving forward, and considerations for each location:

Table 22: Summary of End-Of-Pipe Sites

Site ID	Area (ac)	General location	Dominant Land Use	Near known contamination?	In 100-yr flood zone?	In Waterfront Redevelopment Area?	Green Acres?
001B	0.393	Passaic Ave near Hamilton St	Commercial	Y	Y	Y	N
001C	0.318	Passaic Ave near Hamilton St	Residential	N	Y	N	N
002A	0.302	Passaic Ave near Cleveland St	Commercial	Y	Y	Y	N
002B/003A	0.298	Passaic Ave near Harrison Ave.	Commercial	Y	Y	Y	N
003C	0.318	Harrison Ave. and Dey St.	Commercial	N	N	N	N
006B	9.783	First St from Essex St. to Burlington St.	Industrial	Y	Y	Y	N
007B	2.771	Along I-280 across from Supor Blvd.	Greenspace	N	N	N	N
007C	1.198	Supor Blvd. near Sussex St.	Industrial	Y	N	N	N
007D	1.450	Supor Blvd. near Sussex St.	Industrial	Y	N	N	N

Note: Sites 001A, 003B, 006A and 007a were eliminated from consideration

D.1.2 Institutional Issues

Institutional issues refer to permitting requirements, likelihood of receiving permits, and timeline to receive permits, regulatory compliance in terms of water quality improvements, and ownership of the site (public vs. private). Regulatory considerations such as Green Acres, flood hazard area, wetlands, and threatened or endangered species are also evaluated, as well as zoning/planned development of the site by the municipality, and whether the site could be re-purposed for multiple-use (such as a parking facility over a storage tank). Institutional issues also refer to built-in limitations such as capacity in the PVSC interceptor and WRRF.

Permitting is a major Institutional Issue and is typically a major factor in a project's design schedule. The following is a list of anticipated major permits applicable to the alternatives being analyzed:

- Waterfront Development Permit – Construction will take place within the waterfront development area, which extends from inland from the mean high water (MHW) line a minimum of 100 feet and a maximum of 500 feet, with the development area being truncated at the first paved public road or surveyable property line beyond 100 feet from MHW. The portion of the project within the Waterfront Development Area would also need to comply with the applicable Flood Hazard Area requirements. Restrictions are much more stringent for in water work, including the Flood Hazard Area prohibitions regarding placement of fill in the floodway. Waterfront Development Permits are typically issued within 90-days from receipt of an approvable application (construction permits).
- Flood Hazard Area Permit – A flood hazard area permit will be required for work within the floodplain outside of the Waterfront Development Area. Since the floodplain in Harrison is tidal, much of the work will be eligible for permit-by-rule, however certain facilities may require individual permits. While most areas within Harrison are paved, there may be some small areas of riparian zone vegetation impacts. Flood Hazard Area Permits are 90-day construction permits, however, there are mechanisms which could delay the issuing of a permit beyond 90-days.
- Treatment Works Approval – Treatment Works Approval is required for modifications to the sanitary and combined sewer systems. There are regulatory thresholds for when a treatment works approval is required, however the activities associated with a LTCP would easily exceed those thresholds. Treatment Works Approval Permits are 90-day construction permits.
- Stormwater Management – While not specifically a permit, the State claims jurisdiction over major developments for projects that require Land Use permits. The Stormwater Rules (N.J.A.C. 7:8) primarily concern themselves with stormwater quantity, quality and recharge. Since Harrison is in a tidal flood hazard area, quantity of discharge from the municipal separate storm sewer system is not expected to be an issue. Recharge of groundwater, likewise, should not be an issue since Harrison is highly urbanized. The quality of discharge will be the largest challenge, primarily related to sewer separation projects. The NJDEP's current position is that sewer separation of an area containing more than one quarter acre of impervious area is a major development and must address the stormwater quality requirements for TSS removal. Proposed changes to the Stormwater Rules formalize the Department's policy surrounding sewer separation. They also

implement requirements to apply green stormwater infrastructure to meet the regulations for sewer separation. The proposed changes are not in effect yet, but may be finalized prior to the LTCP selection.

- Army Corps of Engineer Nationwide 404 Permit - The Army Corps of Engineers (USACE) regulates tidal waterways within New Jersey. The USACE does not regulate upland areas, as such, only disturbances below the MHW line would be regulated by USACE. Other agencies such as United States Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA) and United States Coast Guard (USCG) may concurrently review the permit application. A more detailed impact analysis such as an Essential Fish Habitat Assessment may be required as part of the USACE submission. USACE permits do not have a set review timeframe.
- Wetlands Permits – Any wetland habitats identified landward of the MHW would be regulated as freshwater wetlands. A wetland delineation and investigation would be accomplished based on the 1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands, which is the recognized wetland delineation manual for the State of New Jersey. Any proposed impacts to identified freshwater wetlands or transition areas would be subject to the rules applied under N.J.A.C. 7:7A. Freshwater Wetland Permits do not have a set review timeframe; however, if submitted concurrently with a Waterfront Development Permit and/or Flood Hazard Area Permit may be issued within 90-days.
- Tidelands – The State lays claim to all lands now of formerly flowed by the tide, the land is held in public trust. Projects making use of the land must either obtain a tidelands license (lease) or be granted (purchase) the riparian rights. All such grants and licenses must be approved by the Tideland committee in a process that takes several months, and in case of granting riparian rights, the appraised market value must be paid to the State. The State has tidelands claims inland along the banks of the Passaic River, possibly the result of prior installation of bulkheads and land fill, see Figure 30. It is not known if any of these areas have been granted in the past. This will need to be investigated following selection of the final implementation plan.

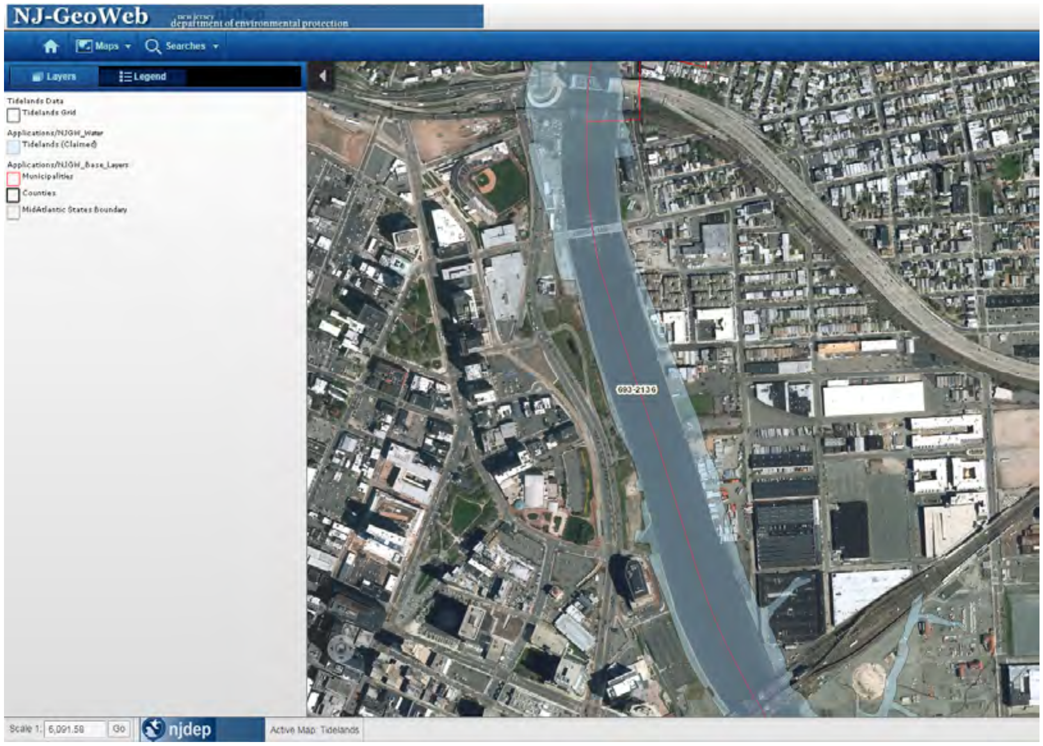

Figure 30: NJDEP Geo-Web showing Tidelands claims in Harrison

- Local Permits – Depending on the nature of the project there are a number of local permits that may be required. These may include zoning permits, construction permits, land use board approval, road opening permits, etc. It is assumed that since the LTCP will be conducted by the Town, they will assist in obtaining these approvals and that for certain approvals (i.e. land use board) only a courtesy review will be required. In general, local permits are not considered a major obstacle.

- Green Acres – Minimal areas appear to be impacted by Green Acres, however use of Green Acres land for CSO facilities of any sort is currently considered a diversion of use. This is a lengthy and costly process that should be avoided where possible. Accordingly, Green Acres sites will only be considered to address the stormwater within the Green Acres property through green infrastructure which is allowable under the current regulations. The State is investigating greater flexibility in the use of Green Acres property for CSO control facilities, possibly allowing them to accept offsite stormwater for treatment in green infrastructure.

- County and State Highway Permits – Approvals will be required for work impacting County and State roads. There are several County roads in Harrison which could be impacted by construction. There are no State highways through Harrison although it is transected by I-280, which is administered by the State DOT

- Railroad Occupancy – A number of industrial rail lines as well as tracks associated with the PATH and NJ Transit are located in Harrison. Agreements to acquire or occupy rail rights-of-way are difficult, expensive and time consuming to obtain.

D.1.3 Implementability

Implementability refers to considerations that could present challenges or prevent the construction of an alternative. This includes such factors as:

- Site access – If space is available, but it cannot be efficiently accessed, the cost to construct and maintain LTCP facilities could be prohibitive. This could be a consequence of geography or existing infrastructure.
- Ownership and ease of acquisition or easement – Ultimately, the Town is responsible for the operation and maintenance for LTCP facilities. Therefore, they must be able to acquire (purchase) the property the facilities are sited on, or obtain permanent easements that will allow for maintenance, as well as potential future upgrades.
- Land area available – CSO control facilities are large and often do not lend themselves to be distributed to sites remote from the CSO outfalls. While some challenges associated with land area can be overcome through diversion piping doing so may greatly increase the overall project cost.
- Environmental considerations – In addition to the permits required as discussed under institutional issues other factors such as soil type are relevant to some of the alternatives both for infiltration/dewatering, as well as for tunneling construction/excavation.
- Compatibility with existing infrastructure – This is also considered in terms of any existing structures or utilities that would need to be relocated or decommissioned. Relocation of utilities can greatly increase the cost of a specific project and may have a potential impact on the local community, as it often requires shutting down of the utility while it is being relocated.

D.1.4 Public Acceptance

Public acceptance refers to the degree to which community residents, businesses and institutions would be impacted or perceive the alternative to be favorable or unfavorable. This includes considerations such as:

- Construction disturbance – Construction brings a variety of unwelcome impacts to a community, such as traffic, dust, noise and vibration. These are unavoidable to some degree, but the construction methods selected can serve to reduce or augment these concerns. For example, an alternative that required pile driving produces much more noise and vibration than traditional excavation, or other potential methods for pile installation. The duration of the construction, and to a certain extent the methods should also be a considered.
- Visibility – Residents prefer solutions that are aesthetically pleasing and have an expectation that their community will be left looking as nice or better than it did prior to the project. There may also be concerns that the visual impact may reduce property values.
- Impact to community spaces – Public areas such as parks are seen as amenities, and if their functionality is diminished the public will object.
- Community character – Communities are generally built around common land uses, for example industrial areas are generally separate from residential areas. Accordingly,

opposition could be expected if an industrial looking CSO facility was sited in a residential area. Likewise, facilities that could be perceived as not good for business may not be accepted in a commercial area. Facilities that potentially produce noise or odor are also expected to create opposition.

- Traffic impacts – Traffic impacts may occur during construction and after construction. During construction, consideration must be given to the location and length of time of the impacts. Acceptance of impacts that may persist after construction would depend on the severity of the impact, both in terms of residents impacted and magnitude of inconvenience.
- Cultural resources – Sites of historic significance should be avoided. It is also possible that the historic significance of sites may be highly localized and not detected until the plan is well advanced.
- Environmental justice – In general, both in perception and in reality, project must avoid impacts are skewed towards those with lower socio-economic standing.
- Community resources – Projects that impact community resources are likely to receive higher levels of opposition. Community resources may include, schools, houses of worship, emergency services and community centers. This may include projects that directly impact community resources, such as taking part of the property or indirectly by impeding access to or function of such as key routes to hospitals or for emergency services.

Public acceptance can take many forms. In some areas residents and business may not be concerned and accept the construction, however, it is also possible for stronger levels of community opposition to occur. Opposition groups can be extremely vocal, active and well-funded. There is also the possibility that opposition groups can influence local election in favor of those that oppose the CSO LTCP or mount legal challenges. While public outreach such as the CSO Supplemental Team and public meetings can mitigate these challenges, it cannot altogether eliminate them as risks to the project.

D.1.5 Performance Considerations

There is no guarantee that a proposed technology will work until it is implemented. This uncertainty can be greatly mitigated through the selection of the technology. Some considerations are:

- Past performance – Is the technology well tested with a history of successful applications to CSO, with reliable data supporting its performance.
- Performance Flexibility – CSO flows are known for rapid changes in both quantity and quality, the technology selected must not only be able to accommodate the design conditions, but also the rapid changes that take place prior to reaching design conditions. CSOs can occur anytime of the year and under a variety of meteorological conditions and must function properly under all such conditions.
- Operational Flexibility – Most municipalities cannot afford highly specialized staff to operate and maintain facilities that are used intermittently. Thus, the technology must be simple to operate for available staff that must also fulfill other duties. Specialized skills should only be required infrequently and then under planned conditions.

- Reliability – While a technology may be successful, it must function consistently. CSO flows create harsh environments for equipment. Equipment typically functions under continual use, whereas CSOs are intermittent, which can lead to seizing between uses.

D.1.6 Basis of Cost

D.1.6.1 Background

The LTCP development process requires that the permittees each evaluate a variety of CSO control alternatives and submit an Evaluation of Alternatives Report. Part of this analysis is the evaluation of costs for each alternative at different CSO control levels. This chapter outlines the basis and assumptions upon which the cost estimates have been developed.

D.1.6.2 Cost Estimating Approach

Cost estimates for the CSO control alternatives have been developed as part of the LTCP process. The costs provided are meant to provide an order of magnitude estimate, referred to as Class 5 estimates with an accuracy of -50% to +100%, and generally include a 50% contingency to reflect the planning level. The estimates have been developed specifically for the configurations of the alternatives that have been described. It is noted that any modifications to these alternatives or their configurations may impact the cost. The information and costs presented in this report is for planning purposes only, and all assumptions and information must be verified in subsequent planning and design stages.

The costs are presented as follows:

- Capital cost – including equipment cost, installation, training, labor, electrical and water connections, structural platforms, land acquisition, design, administrative costs, construction management, etc.
    - Design costs were assumed to be 10% of the construction cost.
    - Construction Management Costs were assumed to be 10% of the construction costs.
    - Administrative/Legal costs were assumed to be 5% of the construction cost.
- Operations & Maintenance (O&M) – annual power, chemical dosing, labor, etc. Since a 20-year planning period has been selected, it does not include any larger-scale overhauls or replacements/repairs that would be completed of the life of the facility.
- Present worth – for a period of twenty years, with an interest rate of 2.75%, as described below.

Most costs are presented in terms of the level of CSO controls, however alternatives such as sewer separation are presented as a lump sum cost for reducing CSO events to zero per year.

In addition to itemized cost items, the costs are presented as dollars per gallon ($/gal) of CSO removed from the receiving water during the Typical Year, in order to provide a point for comparison between alternatives.

D.1.6.3 Present Worth Calculations

To be consistent with other permitees, ~~PVSC~~ guidance from the ~~January 8th memorandum and meeting on March 21, 2019~~TGM (See Main Report Appendix J) was used to develop present worth costs for all of the alternatives, to combine O&M and full capital costs for each control technology. A discount rate of 2.75% was used (Rate of Federal Water Projects, NRCS Economics, Department of the Interior) with a life span of 20 years. The following equation was then utilized to calculate the present worth factor to convert from annual O&M costs to present worth.

$$(P/A, i\%, n) = ((1+i)^n - 1)/((i(1+i)^n)$$

The above was multiplied by the annual O&M costs and added to the construction costs to obtain the total life cycle cost. For the given life cycle and interest rate the P/A factor is 15.227. Salvage value was assumed to be $0, as it is assumed no resale value will result from the Control Technologies utilized.

D.1.6.4 References

References used to prepare the cost estimates are based on various baseline years. For consistency, the costs presented have been escalated to 2019 dollars.

D.1.6.5 PVSC Updated Technical Guidance Manual (January 2018)

In 2004, the NJDEP issued a General Permit (GP) for combined sewer systems that, in part, required combined sewer system owners to initiate the CSO LTCP development process and undergo a Cost and Performance Analysis for Combined Sewer Overflow Point Operation. That analysis required the permittees to evaluate alternatives at each CSO point that would provide continuous disinfection prior to discharge. To assist their communities in performing the analysis, PVSC developed a Technical Guidance Manual that provides an overview of various screening, pretreatment, disinfection, and storage technologies along with guidance on costs. The original TGM was released in 2007.

The New Jersey Pollutant Discharge Elimination System (NJPDES) permits issued in 2015 requires the permittees to continue the CSO LTCP development process and perform a complete CSO control alternatives evaluation that will lead to a selected alternative and eventual implementation. While much of the information in the original TGM is still viable, a decade has passed since it was developed. To assist their permittees with the current permit, PVSC has updated the TGM to reflect new information, updated costs, and new permit requirements such as the evaluation of green infrastructure.

The TGM provides a methodology for developing planning level construction costs for various control alternatives, as well as a process for including contingencies, non-direct costs, overhead and profit and soft costs for legal, administrative and engineering services. The TGM was used to develop capital costs for end-of-pipe storage, end-of-pipe treatment, tunnels and green infrastructure.

- End-of-pipe (off-line) storage – estimated based on cost curves provided in the PVSC TGM. The cost curves were replicated and extrapolated to represent costs for the estimated flows at each outfall location. Costs were also developed to consolidate Outfalls 001A, 002A, 003A and 006A into a consolidated facility with Outfall 007A remaining as an individual facility. Costs were developed for the different control levels.
- Tunneling - estimated based on cost curves provided in the PVSC TGM. The cost curves were replicated and extrapolated to represent costs for the estimated tunnel diameter and length to consolidate all five outfalls anticipated to remain at the end of the project (2050 baseline).
- End-of-pipe treatment - estimated based on cost curves provided in the PVSC TGM. The cost curves were replicated and extrapolated to represent costs for the estimated flows at each outfall location. Costs were also developed to consolidate Outfalls 001A, 002A, 003A and 006A into a region facility with Outfall 007A remaining as an individual facility. Costs were developed for the different control levels.

- Green infrastructure – costs were developed for each of the control levels directing 2.5%, 5%, 7.5%, 10% and 15% of the directly connected impervious area within the combined sewer area to green stormwater infrastructure. It was assumed that property acquisition would not be required because all work would be completed in the public right-of-way. The capital cost was based on a unit cost for bioswales and permeable pavement which were provided in the TGM.

The TGM did not include cost information on sewer separation and in-pipe storage, as such, alternative resources were consulted to develop the cost estimate. Specific considerations and supplements from reference documents were used to fill in any gaps or assumptions from the TGM. These additional tools are described below.

D.1.6.6 PVSC ~~District CSO Permittee Meeting (March 21, 2019)~~Technical Guidance Manual Supplement

~~At a PVSC meeting on March 21, 2019, Greeley and Hansen presented~~A supplement to the TGM was added to include typical operational and maintenance (O&M) costs for green infrastructure, storage tanks, and tunnels. These are summarized in the table below

Table 23: Typical Operation and Maintenance Costs

	Item	Unit	Cost Basis (per year)
Operation	Pump Station*		
	Up to 100 MGD	COP	0.5 x $470K
	Over 100 MGD	COP	2.0 x $470K
	Storage	COP	0.5 x $470K
	Tunnels	COP	1.0 x $470K
Maintenance	Green Infrastructure	Per impervious acre managed	$8,000
	Pump Station	% of construction cost	2.0%
	Storage	% of construction cost	3.0%
	Tunnels	% of construction cost	2.0%
	Conveyance Pipelines/ Sewer Separation	% of construction cost	2.0%

*Pump station operation for tunnels included in tunnel operation. Only add pump station operation costs if standalone pump station.

The above estimate assumes labor cost as one operator on a 24-hour year-round basis at a cost of $53.60/hr. Assuming an eight-hour workday with three shifts per day year-round, the average cost of a Continuous Operating Post (COP) would be $470,000.

At this meeting, guidance for calculation of present worth cost as described above was also presented.

D.1.6.7 Technology-Specific Sources

For some of the CSO control alternatives, additional sources were consulted to develop a more detailed and comprehensive cost understanding. These are described as follows:

- Sewer separation – The approach for estimating the total projected conceptual cost of sewer separation was to derive unit costs (cost per linear foot of sewer) for a number of drainage areas, and then to apply these unit costs to the entire combined sewer system. First, drainage areas to each regulator were delineated and enumerated. Then, a proposed sanitary sewer system layout was developed for two representative regulator drainage areas. Sanitary sewers were proposed in all areas served by combined sewers. Manning's number, slope, and pipe size were considered in siting the new separate sanitary sewers. Treatment of stormwater runoff was included in the cost estimate by selecting the San-Sep solids removal technology from the TGM. It is noted that proposed rule amendments to the Stormwater Management Rules were issued by NJDEP. These amendments would require the use of green infrastructure for sewer separation projects to address the requirements of the rules for the areas within the public right-of-way. The final form of the rule amendments has not been issued, as such, their impact cannot be reasonably anticipated, and thus has not been incorporated into the cost estimate. The resulting sewer separation costs were found to be $295,000 per acre plus stormwater treatment costs.

D.1.6.8 Land Acquisition Costs

There is a great deal of uncertainty when estimating land acquisition costs, as the dramatic rise in prices leading up to 2008 and the subsequent drop in real estate values demonstrated. For planning purposes, it was assumed that commercial and residential properties could be acquired for $75 per square foot while industrial areas could be acquired for $50 per square foot. This approach provides a consistent basis of cost. The actual acquisition cost will depend on the owner's willingness to sell, with additional legal costs incurred if it is necessary to acquire the property through condemnation. The site history of contamination and future plans for development will also factor in the final price of acquisition. It was also assumed that rather than acquiring the estimated footprint of the CSO control facilities, acquisition of the entire area identified in the siting analysis would be required.

D.1.6.9 Cost Index

The costs were indexed to the Engineering News Record (ENR) Construction Cost Index (CCI) for January 2019 with a CCI of 11,205.

D.1.7 Performance Objectives – Systemwide Level of Control

The magnitude of the facilities in terms of CSO volume managed is the primary driver of both its cost and effectiveness. Accordingly, a procedure was developed to achieve the desired control objectives, in this case limiting the overflows to 0, 4, 8, 12 or 20 during the Typical Year. Since the permit requires the levels of control to be established on the basis of the hydraulically connected system, it is not adequate merely to achieve the desired number of overflows at each individual outfall, or within Harrison. Prior to the evaluation it was necessary to determine for the PVSC Interceptor system what storm events must be controlled for each level of control. Since the LTCP may incorporate volume-based controls (storage) as well as peak flow-based control (treatment), the same sets of storms were established for both control methods.

Each level of control has a corresponding list of storms which would not be fully captured or treated as a result of the control. For example, for a single outfall, to achieve 4 overflows, the fifth largest storm would need to be stored and ultimately sent to the WRRF for treatment. However, since sewersheds respond to precipitation differently due to sewer system characteristics such as land use, size, and shape, the four largest storms may also vary in storm characteristics (i.e. peak intensity) between watersheds. Accordingly, a system-wide list of storms was established by identifying the events that generate the greatest volume of overflow system-wide. The Typical Year storms ranked systemwide by overflow volume are listed in Figure 31, which identifies the allowable overflow events for each level of control. This same list is applied to peak flow controls to establish consistent levels of control regardless of which control technology or combination of control technologies is employed. It is noted that by imposing a system-wide level of control, the control required at each outfall may be significantly higher than if the outfall was considered individually. Thus, some outfalls may be limited to one, two or three overflows to achieve the systemwide goal of four overflows, to meet the objectives of the overall CSO LTCP.

	Rank	Event	Total CSO (MG)	Start	End
Top 4 Storm Events by Overflow	1	49	262.0	9/28/2004 5:30	9/30/2004 13:45
	2	46	154.4	9/8/2004 3:30	9/9/2004 22:00
	3	48	129.4	9/18/2004 7:15	9/18/2004 15:15
	4	36	115.0	7/18/2004 16:30	7/19/2004 2:00
Top 8 Storm Events by Overflow	5	56	106.9	11/28/2004 3:30	11/29/2004 0:15
	6	35	101.0	7/12/2004 9:15	7/14/2004 23:30
	7	32	98.1	6/25/2004 17:00	6/26/2004 6:15
	8	37	94.4	7/23/2004 10:30	7/24/2004 4:15
Top 12 Storm Events by Overflow	9	6	89.9	2/6/2004 8:00	2/6/2004 23:45
	10	23	87.6	5/12/2004 15:30	5/12/2004 21:45
	11	38	78.9	7/27/2004 16:15	7/28/2004 8:45
	12	15	78.5	4/12/2004 18:15	4/14/2004 21:00
Top 20 Storm Events by Overflow	13	44	59.7	8/21/2004 13:30	8/21/2004 18:30
	14	17	59.5	4/26/2004 1:30	4/27/2004 6:00
	15	34	57.7	7/5/2004 3:00	7/5/2004 16:45
	16	43	57.2	8/14/2004 22:30	8/16/2004 12:30
	17	52	44.4	11/4/2004 14:15	11/5/2004 17:30
	18	57	44.3	12/1/2004 4:30	12/1/2004 15:15
	19	24	38.7	5/15/2004 21:30	5/16/2004 9:00
	20	22	38.6	5/10/2004 23:45	5/11/2004 5:45

Figure 31: Ranking of top 20 overflow events in the Typical Year

Note: volumes may change in the future due to anticipated model refinements.

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

Following the screening process, the remaining technologies were assembled into control programs. Seven control programs were developed.

- Control Program 1 – Point Storage at Individual Outfalls
- Control Program 2 – Consolidated Tank Storage
- Control Program 3 – Tunnel Storage
- Control Program 4 – End-of-Pipe Treatment
- Control Program 5 – Consolidated End-of-Pipe Treatment
- Control Program 6 – Sewer Separation
- Control Program 7 – Green Stormwater Infrastructure

D.2.1 Control Program 1: Point Storage at Individual Outfalls

D.2.1.1 Control Program 1 Description

This control program consists of siting storage tanks at the end of each outfall. Each facility consists of:

- A diversion structure;
- An offline below grade tank equipped with a flushing system and odor control;
- Tank overflow to an outfall;
- Dewatering pumping station; and
- Discharge connection back to the interceptor.

Storage tanks were input into the model to identify any impacts to CSO reduction. The cumulative dewatering rate from the tanks was set to 1.2 MGD which is the maximum acceptable dewatering rate for Harrison, as per discussion with PVSC. PVSC requested that dewatering be delayed by 12 hours after the rain to allow flows in the interceptor to attenuate. This was achieved by tying the operation of the dewatering pump to the water level in the PVSC interceptor just upstream of the Passaic River crossing. As discussed, the performance levels have been coordinated with the overall PVSC hydraulically connected system. The system hydraulics were refined to prevent adverse impacts on the collection system upstream of the regulator. The regulator weir heights were not changed so that the system continues to maximize flow to the treatment plant. However, to allow for conveyance of peak runoff rates, the weirs may be lengthened.

The evaluation of practicality and feasibility draws on the siting analysis to identify locations for each facility and drives the consolidation of select facilities. Figure 32 through Figure 35 below depict conceptual site layouts sized to limit the Typical Year number of overflows to 4 events. Modeling was performed for the range of control alternatives 0, 4, 8, 12 and 20 overflows.

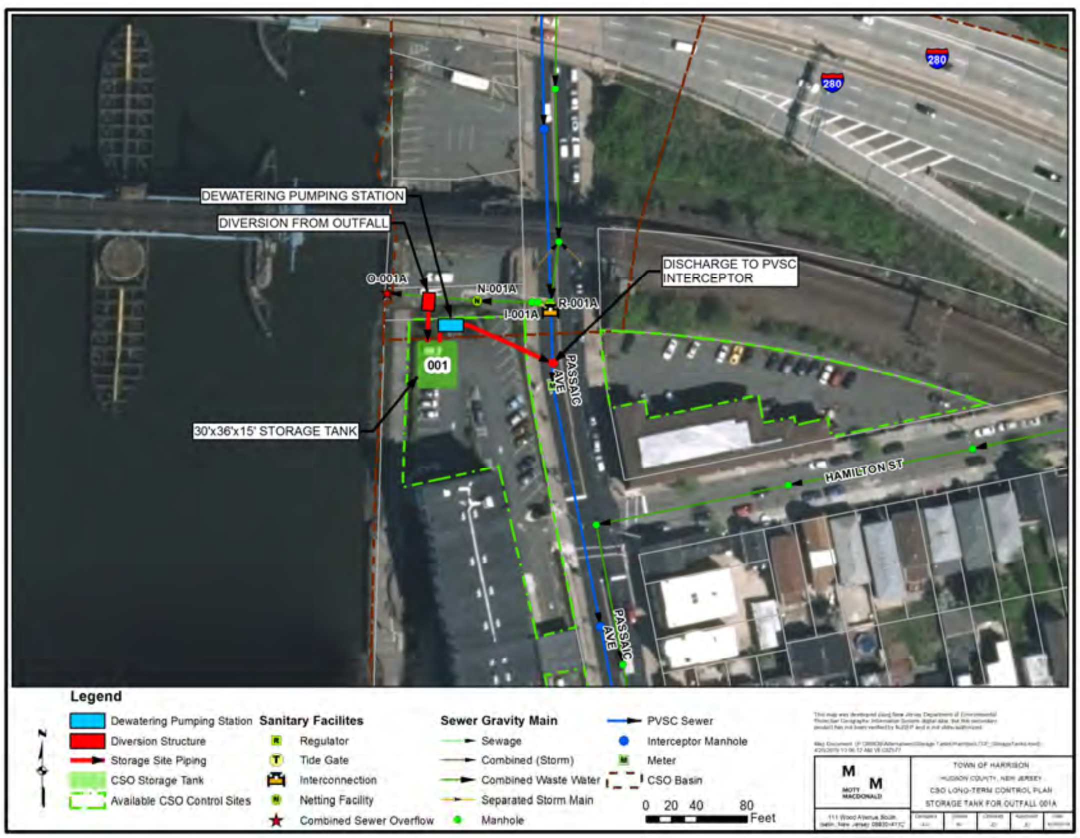

Figure 32: Point Storage - Outfall 001A (Site 001B)

Figure 33: Point Storage - Outfall 002A and 003A (Site 002A/003A)

Figure 34: Point Storage Outfall 006 (Site 006B)

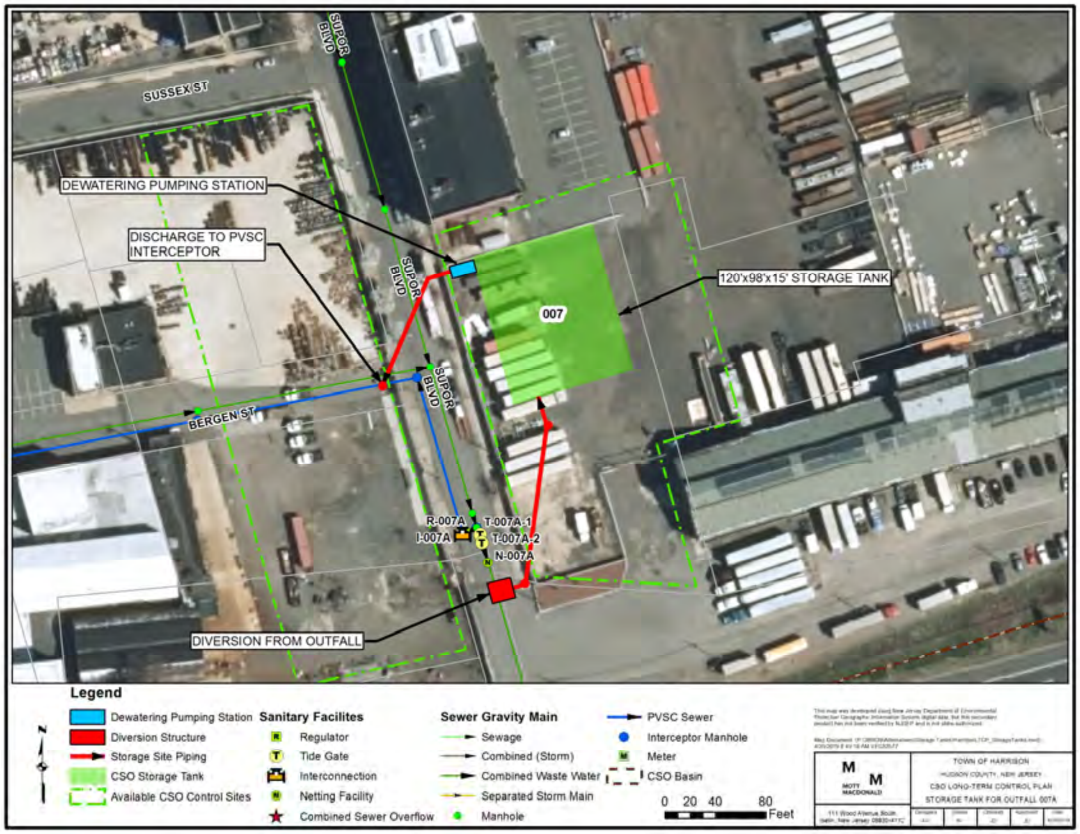

Figure 35: Point Storage - Outfall 007A (Site 007C)

D.2.1.2 Control Program 1 Analysis

The sizing of storage control facilities in the InfoWorks model for multiple outfalls is time consuming to model the facilities, computationally expensive to run test simulations, and requires the processing of massive amounts of data. Operationally, a storage tank captures overflows until it is full, once it is full, excess volumes are discharged as overflows. When the storm is over, the storage volume is dewatered back to the interceptor at a set flow rate. Thus, initially, the storage can be sized based on the Typical Year baseline overflow rates and a set of rules for dewatering. A spreadsheet analysis was used to perform this analysis and the resulting volume modeled in InfoWorks and refined to address hydraulic issues.

Time series data at a 15 min timestep for each overflow is available from the InfoWorksICM model. To this data a series of rules was applied to divert the overflows into a conceptual storage facility. The evaluation consisted of calculating the volume of overflow for each timestep, and provided there is room in the tank, the overflow is diverted to the storage facility. Once the storage facility is calculated to be full, remaining flows are tracked as overflows. The tank volume is tracked and once the volume is exceeded the tank is considered full and no additional volume is accepted.

The storage was assigned a dewatering rate such that the cumulative dewatering rate would not exceed 1.2 MGD as requested by PVSC. The dewatering was only applied to the storage if there was no overflow from the regulator for a minimum of 12 hours, to allow the interceptor hydrograph to recede and create available capacity in the interceptor. If the overflow resumed or a new overflow began, then dewatering ceased until there was a period of 12 hours with no overflow. As sample output can be seen below in Figure 36. Overflows beyond the tank volume were tracked and a list of storms identified as producing an overflow was generated. The list of remaining overflows generated was compared to the allowable list (Figure 31), and the storage volume increased until the remaining storms consisted only of those allowable on the systemwide basis.

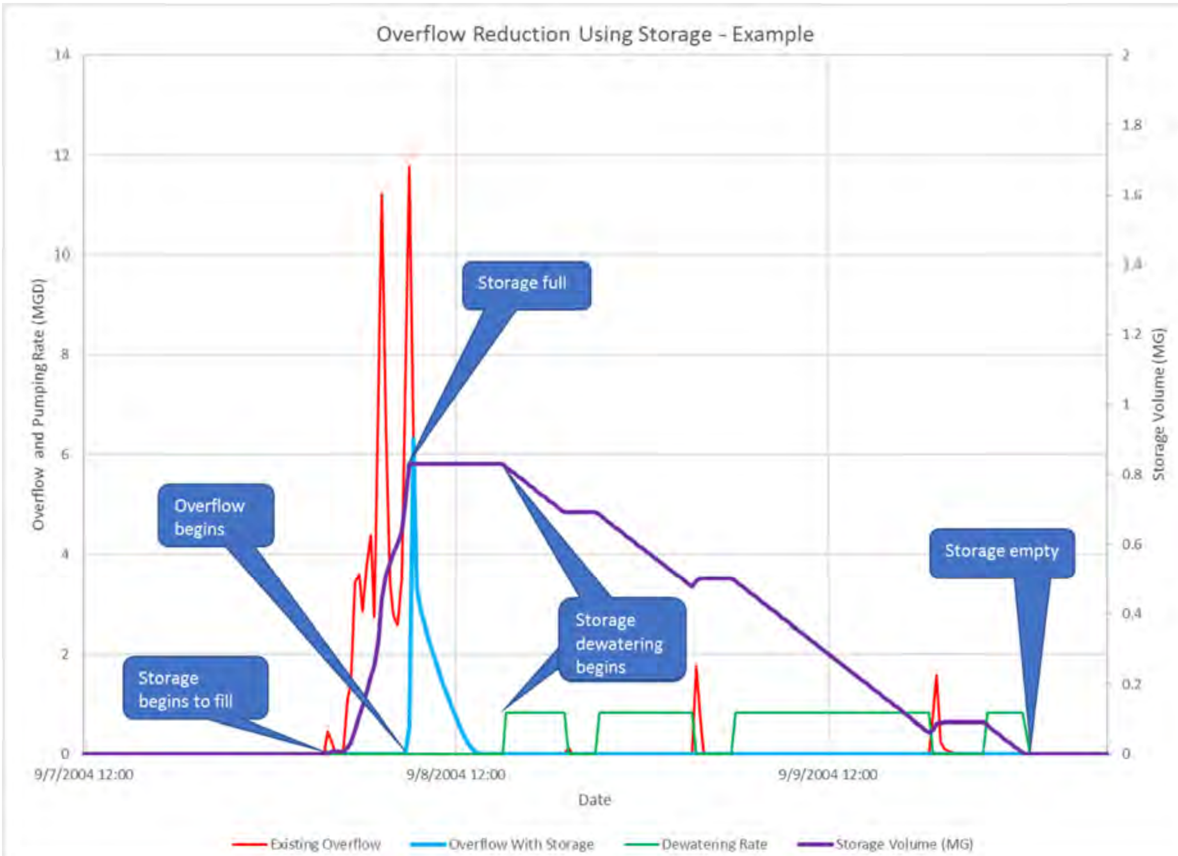

Figure 36: Example hydrograph of tank storage

The resulting tank volumes were then modeled in the 2050 baseline InfoWorks model. A typical model configuration is shown below in Figure 37.

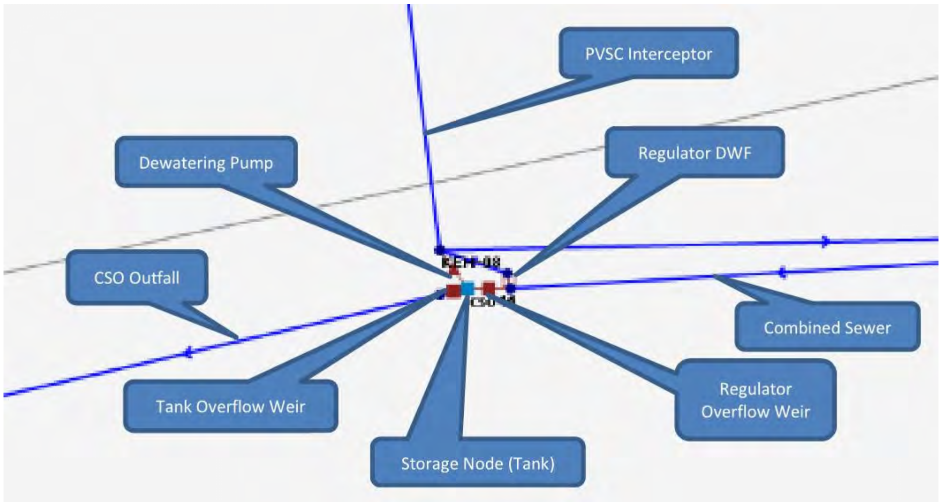

Figure 37: Point Storage - Sample Model Configuration

D.2.1.3 Control Program 1 Institutional Issues

The institutional issues surrounding Control Program 1 are typical of a large-scale construction project in an urban area. While located in an urban area, construction of the facilities associated with this control program will require environmental permits. Below is list of anticipated permits required:

- Waterfront Development Permit – required at Outfalls 001A, 002A, 003A and 006A
- Flood Hazard Area Permit – required at Outfalls 001A, 002A, 003A and 006A
- USACE Nationwide 404 Permit – required if existing outfall is not reused.
- Local Permits – all outfalls
- NJDEP Treatment Works Approval

The tank at outfall 006A is located on the site of a planned park. The tank must be installed prior to creation of the park at which time the site will become encumbered by Green Acres. It may also be possible to write the Green Acres agreement to allow for the tank to be installed after the park is constructed, but this may come with additional requirements and may not be attainable.

These permits are standard permits and while they must be obtained, they do not appear to have the potential to greatly extend the project schedule or add excessive risk to the project.

A reduction in storage volumes may be possible if a higher dewatering rate is allowed, due to the impact of back to back storms. The dewatering rate may be refined depending on alternatives implemented by other communities, particularly Kearny and East Newark.

D.2.1.4 Control Program 1 Implementability

Installation of storage tanks in urban areas can be challenging. The tanks have been sized assuming a 15-foot water storage depth. Since the intent is to fill them by gravity and the existing outfalls are approximately 8 feet below grade a total excavated depth of 25 feet is generally required. Excavating to this depth requires costly dewatering and support of the excavation, which is made more challenging by adjacent buildings which must be protected and monitored throughout construction. In addition, utilities in the area of construction must be relocated, protected, or supported. The tanks to be sited at outfalls 001A and 002A/003A are in proximity to existing buildings, whereas the tanks at 006A and 007A are further from buildings.

Control of groundwater will be a significant challenge, as noted previously, groundwater is thought likely to be shallow throughout the Town. With the exception of 007A all the tank sites are in close proximity to the Passaic River which creates additional risks.

There is little available information on the soil characteristics at the tank sites, however, given the depth to bedrock and proximity to the floodplain, soil conditions could be poor, and the tanks may need to be situated on piles. Piles may also be required to anchor the tanks, so they do not become buoyant in the event of a flood, or periods of high groundwater. Tidal flooding is a concern because high storm surge levels could produce inundation with little rainfall meaning the tank would be empty and prone to floatation.

The long-term costs to maintain and operate these facilities would place an ongoing burden on the Town's financial resources and workforce.

D.2.1.5 Control Program 1 Public Acceptance

The construction required for storage tanks is large and invasive making public acceptance of the project a concern. This is particularly true for Outfalls 001A and 002A/003A which are located in heavily trafficked areas and on private property. The tank on 006A is located on a parcel of land slated for redevelopment and the construction may be more acceptable in terms of public acceptance. The construction at 007A is in an industrial area and may raise fewer concerns from the public, however, there would be a significant impact on the property owner.

Once construction is completed, tanks are generally preferable from the standpoint of public acceptance since the majority of the facility is underground. Aboveground features will still be required such as electrical facilities, odor control, access points to pumps, flushing systems, and access ways to the tank for periodic maintenance. There may also be concerns with odors, particularly at 001A. 002A/003A and 006A which will be in commercial and residential areas. These locations may require significant odor control facilities on the surface. The land above the outfall 006A tank could be converted to a park to enhance acceptance, thus providing a public amenity and enhancing public acceptance.

D.2.1.6 Control Program 1 Performance Summary

The performances associated with Control Program 1 are summarized in Table 24 through Table 29, which provide project details for 0, 4, 8, 12 and 20 overflows per year respectively.

Table 24: Control Program 1 - Outfall Storage Tanks, Performance Summary – 0 Overflows

	Baseline 2015			Point Storage 0 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	0.40	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	0.40	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	1.6	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	1.5	0	0.0	0	-28	-8.0	-122
H-007A	53	14.5	352	2.2	0	0.0	0	-53	-14.5	-352
Total		61.5				0.0			-61.5	

Table 25: Control Program 1 - Outfall Storage Tanks, Performance Summary – 4 Overflows

Outfall	Baseline 2015			Point Storage 4 Overflows				Change		
	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	0.12	4	0.3	9	-22	-1.6	-89
H-002A	35	3.2	162	0.22	2	0.2	1	-33	-3.0	-161
H-003A	32	13.1	155	1.0	3	1.2	8	-29	-11.9	-147
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	0.8	3	0.9	7	-25	-7.1	-116
H-007A	53	14.5	352	1.3	3	1.9	9	-50	-12.5	-342
Total		61.5				4.5			-57.0	

Table 26: Control Program 1 - Outfall Storage Tanks, Performance Summary – 8 Overflows

Outfall	Baseline 2015			Point Storage 8 Overflows				Change		
	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	0.09	6	0.5	13	-20	-1.5	-85
H-002A	35	3.2	162	0.22	2	0.2	1	-33	-3.0	-161
H-003A	32	13.1	155	0.89	4	1.4	9	-28	-11.8	-147
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	0.80	3	0.9	7	-25	-7.1	-116
H-007A	53	14.5	352	1.3	3	2.0	9	-50	-12.5	-342
Total		61.5				4.9			-56.7	

Table 27: Control Program 1 - Outfall Storage Tanks, Performance Summary – 12 Overflows

Outfall	Baseline 2015			Point Storage 12 Overflows				Change		
	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	0.06	8	0.7	17	-18	-1.3	-81
H-002A	35	3.2	162	0.16	6	0.4	8	-29	-2.8	-154
H-003A	32	13.1	155	0.65	7	2.8	15	-25	-10.4	-140
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	0.48	6	2.1	14	-22	-5.9	-108
H-007A	53	14.5	352	0.76	8	4.9	20	-45	-9.5	-331
Total		61.5				10.9			-50.7	

Table 28: Control Program 1 - Outfall Storage Tanks, Performance Summary – 20 Overflows

Outfall	Baseline 2015			Point Storage 20 Overflows				Change		
	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	0.02	15	1.0	32	-11	-0.9	-66
H-002A	35	3.2	162	0.11	8	0.8	14	-27	-2.4	-148
H-003A	32	13.1	155	0.49	11	4.4	22	-21	-8.8	-133
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
H-006A	28	8.0	122	0.27	9	3.2	19	-19	-4.8	-103
H-007A	53	14.5	352	0.54	12	7.2	41	-41	-7.3	-311
Total		61.5				16.6			-44.9	

Table 29: Control Program 1 - Harrison Summary Overflow Reduction

	Baseline 2015 (MG)	Control Program 1 (MG)	% Reduction from 2015	Baseline 2050 (MG)*	% Reduction from 2050
0 Overflows	61.5	0.0	100%	42.8	100%
4 Overflows	61.5	4.5	93%	42.8	89%
8 Overflows	61.5	4.9	92%	42.8	89%
12 Overflows	61.5	10.9	82%	42.8	75%
20 Overflows	61.5	16.6	73%	42.8	61%

*Note 30.4% reduction in annual overflow volume due to planned project incorporated in 2050 baseline.

D.2.1.7 Control Program 1 Cost Summary

The Class 5 (+100%, -50%) cost estimate associated with Control Program 1 for each level of control are summarized in Table 30.

Table 30: Control Program 1 – Outfall Storage Tanks, Cost Summary

Control Program 1 - End of Pipe Storage (Individual Sites)					
	Overflows per Year				
	0	4	8	12	20
Capital Cost ($ Million)	$65.1	$46.5	$45.4	$35.7	$29.6
O&M Cost ($ Million)	$1.5	$1.1	$1.0	$0.8	$0.7
20-Yr Net Present Worth ($ Million)	$88.0	$63.2	$60.7	$47.9	$40.3

D.2.2 Control Program 2 - Consolidated Tank Storage

D.2.2.1 Control Program 2 Description

This will be the same as Control Program 1 except that consolidation piping will be run to consolidate the overflows from H-001A, 002A, 004A and 006A to the site of the future park, the existing outfalls will be abandoned, and a new outfall created. This control program offers some advantages over Control Program 1:

- The result will be only leave two active discharge outfalls; the consolidated outfall and outfall 007A. This will simplify future permitting and effectively eliminate three outfalls.
- This control program will result in fewer facilities for the town to maintain.
- It makes use of public rights-of-way and land that will be under the control of the town.
- The park can be sited over the tank with minimal surface disturbance after construction.

There are also some potential disadvantages:

- There will be more disturbance and interruptions to local streets as a result of the consolidation piping.
- There will be additional costs associated with the consolidation piping, which may be offset by fewer pumping stations and the greater efficiency of a larger tank.

Conceptual layouts of the consolidation piping and storage sized to limit the Typical Year number of overflows to 4 events for 4 overflows can be seen below in Figure 38 and Figure 39

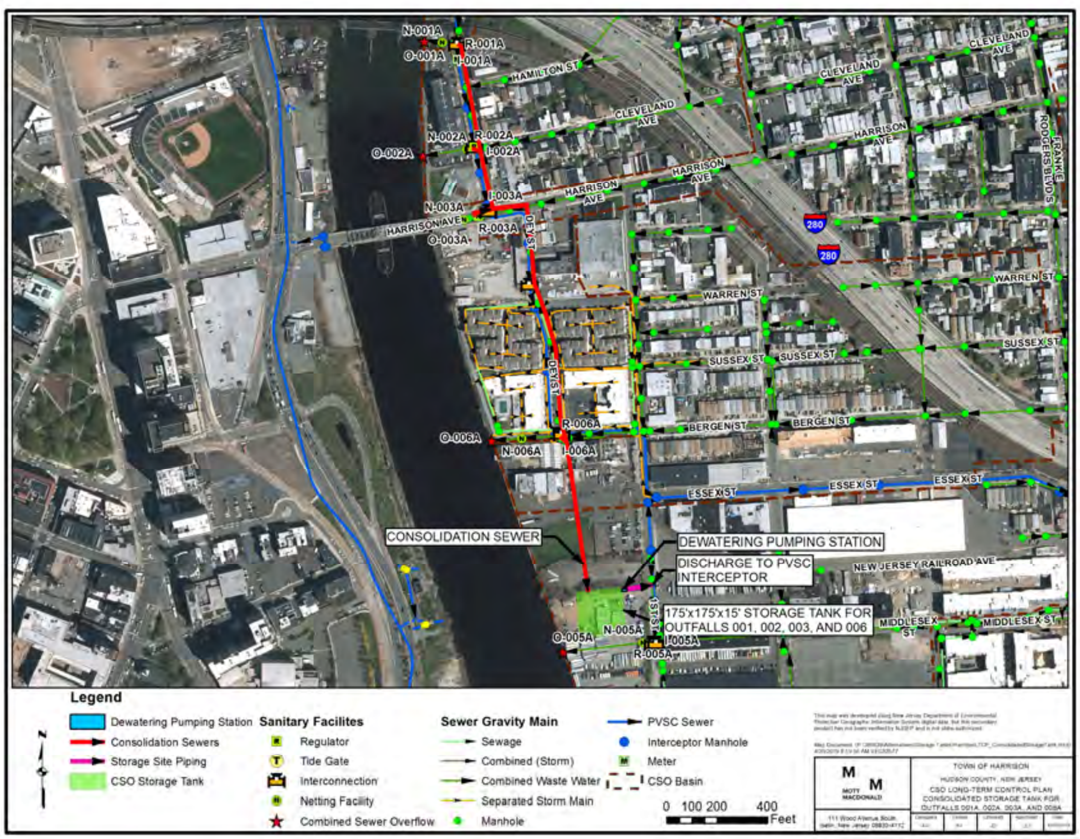

Figure 38: Consolidate Storage - Consolidation Piping

Figure 39: Consolidate Storage - Storage Tank

D.2.2.2 Control Program 2 Analysis

The consolidated tank was implemented in the 2050 baseline model by sizing pipes ranging from 3 feet to 6 feet in diameter to convey the modeled overflow from Outfalls 001A, 002A, 003A and 006A to the consolidated tank site. The consolidation piping capacity was evaluated for the Typical Year and it was sized such that there would be no adverse impacts (water surface increases) to the upstream system. The tank volume was initially estimated by adding the volumes of the individual tanks then this volume was refined. Pump controls in the model were tied to the interceptor levels in the same manner as the individual tanks to adhere to the requirement not to increase peak flows to the PVSC interceptors. The consolidated tank was modeled with an overflow weir and outfall equipped with a tide gate to allow the discharge excess flows without causing upstream flooding.

D.2.2.3 Control Program 2 Institutional Issues

The institutional issues surrounding Control Program 2 are typically similar for large scale construction projects in an urban area. While located in an urban area, construction of the facilities associated with this control program will require environmental permits. Below is list of anticipated permits required:

- Waterfront Development Permit
- Flood Hazard Area Permit
- USACE Nationwide 404 Permit – for consolidated outfall
- Local Permits

- NJDEP Treatment Works Approval

The consolidated tank at outfall 006A is located on the site of a planned park. The tank must be installed prior to creation of the park at which time the site will become encumbered by Green Acres. It may also be possible to write the Green Acres agreement to allow for the tank to be installed, but this may come with additional requirements. In addition, there could be significant public resistance to disturbing a newly established park and a general public feeling that the sequencing of the project showed a lack of fiscal responsibility, and poor municipal coordination oversight in planning and construction of these two projects.

These permits are standard permits and while they must be obtained, they do not appear to have the potential to greatly extend the project schedule or add excessive risk to the project.

D.2.2.4 Control Program 2 Implementability

Installation of storage tanks in urban areas can be challenging. The tanks have been sized assuming a 15-foot water storage depth. Since the intent is to fill them by gravity and the existing outfalls are approximately 8 feet below grade a total excavated depth of 25 feet is generally required. Excavating to this depth requires costly dewatering and excavation support, which is made more challenging by adjacent buildings which must be protected and monitored throughout construction and utilities which must be relocated, protected or supported. The consolidated tank at 006A and the tank at 007A are some distance from other buildings.

Installing the large diameter consolidation piping within the Harrison Street could be challenging. There are numerous other utilities in the street including and existing stormwater outfall that must be crossed and the Kearny-East Newark-Harrison Branch Interceptor which must be avoided.

Control of groundwater would be a significant challenge, as noted previously. Groundwater is thought to likely be shallow throughout the Town and the consolidated tank site is in close proximity to the Passaic River.

There is little available information on the soil characteristics at the tank sites, however, given the depth to bedrock and proximity to the floodplain, soil conditions may be poor, and the tanks may need to be situated on piles. Piles may also be required to anchor the tanks, so they do not float in the event of a flood. Likewise, piles may be required to support the consolidation piping.

The long-term costs to maintain and operate these facilities would place an ongoing burden on the Town’s financial resources and workforce.

D.2.2.5 Control Program 2 Public Acceptance

The construction required for storage tanks is large and invasive making public acceptance of the project a concern. The consolidated tank near 005A is located on a parcel of land slated for redevelopment and the construction may be more acceptable in terms of public acceptance. The construction at 007A is in an industrial area and may raise fewer concerns from the public, however, there would be a significant impact on the property owner.

Once construction is completed, tanks are generally preferable from the standpoint of public acceptance since the majority of the facility is underground. Aboveground features will still be required such as electrical facilities, odor control facilities and access points to pumps, flushing systems and the tank. There may be concerns with odors, at the consolidated tank which will be in a residential area. It is anticipated that the land above the consolidated tank will be converted to a park providing a public amenity and enhancing public acceptance, but this makes odor control more important.

D.2.2.6 Control Program 2 Performance Summary

The performances associated with Control Program 2 are summarized in Table 31 through Table 36, which provide project details for 0, 4, 8, 12 and 20 overflows per year respectively.

Table 31: Control Program 2 - Consolidated Storage Tanks, Performance Summary – 0 Overflows

	Baseline 2015			Consolidated Storage 0 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Consolidated H-006A	28	8.0	122	3.6	0	0.0	0	-28	-8.0	-122
H-007A	53	14.5	352	2.2	0	0.0	0	-53	-14.5	-352
Total		61.5				0.0			-61.5	

Table 32: Control Program 2 - Consolidated Storage Tanks, Performance Summary – 4 Overflows

	Baseline 2015			Consolidated Storage 4 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Consolidated H-006	28	8.0	122	2.1	3	1.7	47	-25	-6.2	-75
H-007	53	14.5	352	1.3	3	2.1	9	-50	-12.4	-342
Total		61.5				3.8			-57.7	

Table 33: Control Program 2 - Consolidated Storage Tanks, Performance Summary – 8 Overflows

	Baseline 2015			Consolidated Storage 8 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Consolidated H-006A	28	8.0	122	2.0	3	1.9	47	-25	-6.0	-75
H-007A	53	14.5	352	1.3	3	2.1	9	-50	-12.4	-342
Total		61.5				4.0			-57.5	

Table 34: Control Program 2 - Consolidated Storage Tanks, Performance Summary – 12 Overflows

	Baseline 2015			Consolidated Storage 12 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Consolidated H-006A	28	8.0	122	1.4	6	4.6	78	-22	-3.3	-44
H-007A	53	14.5	352	0.8	8	5.1	20	-45	-9.3	-331
Total		61.5				9.8			-51.8	

Table 35: Control Program 2 - Consolidated Storage Tanks, Performance Summary – 20 Overflows

	Baseline 2015			Consolidated Storage 20 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Storage Volume (MG)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Consolidated H-006A	28	8.0	122	0.89	9	7.3	98	-19	-0.7	-24
H-007A	53	14.5	352	0.66	11	6.1	24	-42	-8.4	-328
Total		61.5				13.4			-48.1	

Table 36: Control Program 2 - Harrison Summary Overflow Reduction

	Baseline 2015 (MG)	Control Program 2	% Reduction from 2015	Baseline 2050 (MG)*	% Reduction from 2050
0 Overflows	61.5	0.0	100%	42.8	100%
4 Overflows	61.5	3.8	94%	42.8	91%
8 Overflows	61.5	4.0	93%	42.8	91%
12 Overflows	61.5	9.8	84%	42.8	77%
20 Overflows	61.5	13.4	78%	42.8	69%

*Note 30.4% reduction in annual overflow volume due to planned project incorporated in 2050 baseline.

D.2.2.7 Control Program 2 Cost Summary

The Class 5 (+100%, -50%) cost estimates for Control Program 2 are summarized in Table 37.

Table 37: Control Program 2 – Consolidated Storage Tanks, Cost Summary

Control Program 2 - End of Pipe Storage (Consolidated Sites)					
	Overflows per Year				
	0	4	8	12	20
Capital Cost ($ Million)	$59.1	$44.6	$44.1	$35.9	$31.7
O&M Cost ($ Million)	$1.3	$0.9	$0.9	$0.7	$0.6
20-Yr Net Present Worth ($ Million)	$78.2	$58.6	$57.8	$46.7	$41.1

D.2.3 Control Program 3 Tunnel Storage

D.2.3.1 Control Program 3 Description

This Control Program calls for a tunnel to follow Bergen Street and for the consolidation of H-001A, 002A, 004A and 006A into the tunnel at one end and H-007A at the other. The tunnel will be dewatered into the interceptor and include an overflow to the river. The result will be only one outfall. The available route fixed the tunnel length at 3,900 feet. The tunnel system will consist of:

- Consolidation piping from Outfall 001A, 002A, 003A and 006A
- Diversion piping from Outfall 007A
- Control Gates
- Drop shafts at either end of the tunnel
- Tunnel, approximately 60 feet deep
- Deaeration chambers
- A tunnel dewatering pumping station
- Grit and screening facilities
- Force main connection back to the PVSC interceptor
- A tunnel overflow with tide gate

Conceptual layouts of the tunnel are shown in Figure 40 and Figure 41, sized to limit the Typical Year to 4 overflows which is a 12-foot diameter tunnel. It is noted that the layout and feasibility of tunnels is highly dependent on geotechnical information. The available soils information indicate that the tunnel will be in soft ground which increases both risk and expense.

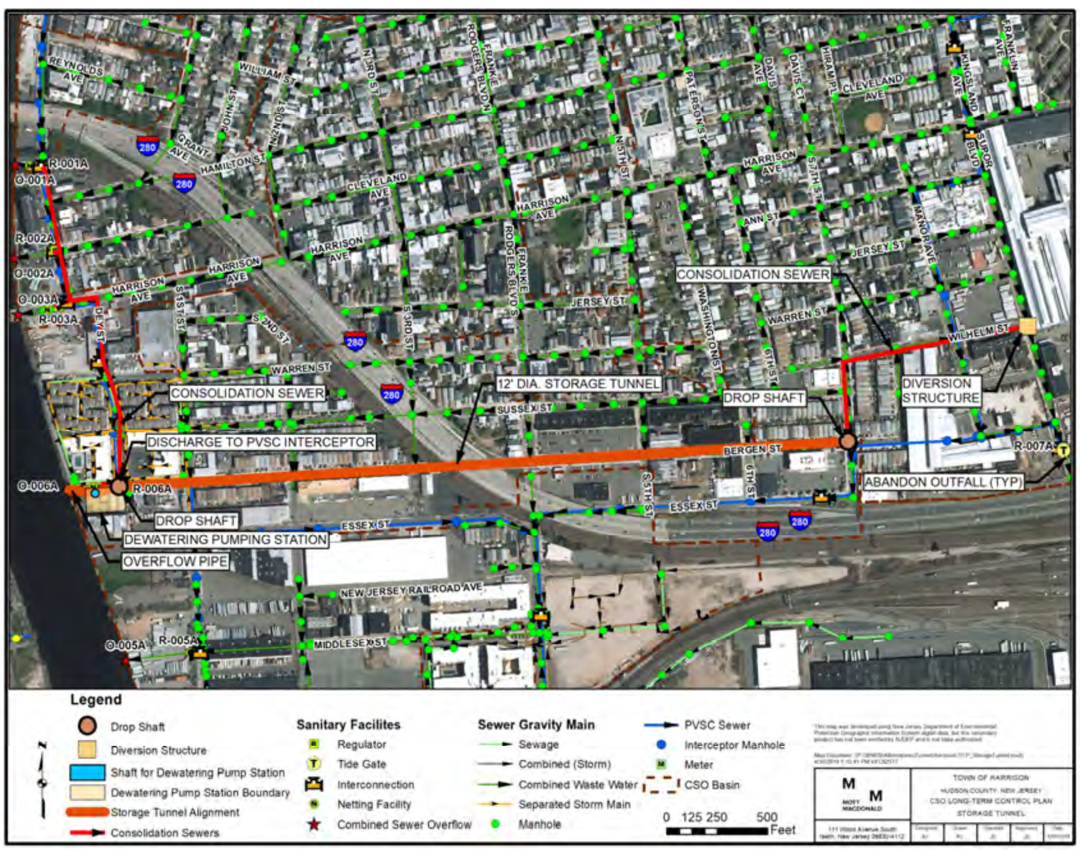

Figure 40: Tunnel Storage Conceptual Layout

Figure 41: Tunnel Storage Conceptual Dewatering Layout

D.2.3.2 Control Program 3 Analysis

Since there was no feasible route parallel to the Passaic River to collect Outfalls 001A, 002A, 003A and 006A with the tunnel, an east-west alignment along Bergen Street was selected. Outfalls 001A, 002A, 003A and 006A were consolidated through piping to the west end of the tunnel and Outfall 007A was diverted to the east end of the tunnel. The tunnel was input into the 2050 baseline InfoWorksICM model. Initial tunnel sizes were developed by adding the storage volumes from the consolidated tank storage and determining a tunnel diameter that would correspond to the required volume. Since InfoWorksICM dynamically tracks storage, the tunnel volumes could be modeled explicitly using conduits in the model, Figure 42.

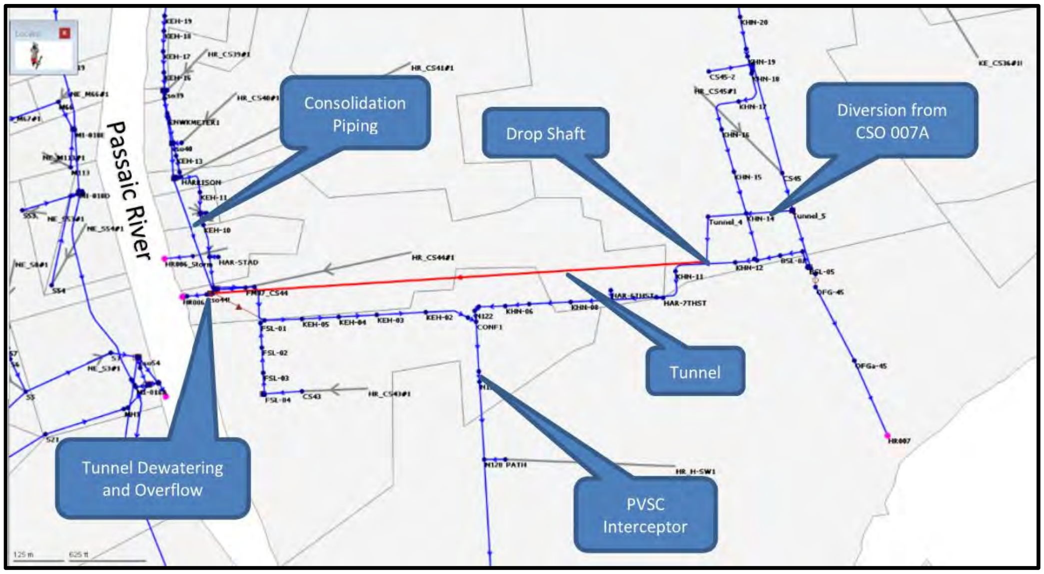

Figure 42: Tunnel - InfoWorksICM model configuration

D.2.3.3 Control Program 3 Institutional Issues

The institutional issues surrounding Control Program 3 are typical of a large-scale construction project in an urban area. While located in an urban area, construction of the facilities associated with this control program will require environmental permits. Below is list of anticipated permits required:

- Waterfront Development Permit
- Flood Hazard Area Permit
- USACE Nationwide 404 Permit
- Local Permits
- NJDEP Treatment Works Approval
- Permits and coordination with railroads and State DOT

These permits are standard permits and while they must be obtained, they do not appear to have the potential to greatly extend the project schedule or add excessive risk to the project.

D.2.3.4 Control Program 3 Implementability

Implementing a tunnel within the confines of a dense urban area is challenging. Mining and recovery shaft areas are required for this alternative to be feasible, and available area in Harrison for this purpose is minimal. This alternative also requires area to site a dewatering pumping station and a tunnel overflow, and available area in this highly urbanized town are limited. While it is possible to control the flow into the tunnel through the use of automated gates and level sensors, the tunnel must still be provided with a relief point.

Based on available geotechnical information, bedrock is very deep, thus the tunnel will need to be a soft ground tunnel. This will increase the costs and carries a greater risk of subsidence due to soil loss, potentially damaging nearby buildings and other surface infrastructure. The construction of de-aeration chambers at tunnel level is further complicated by the soft ground conditions.

Tunnels may also be subject to highly complex hydraulic transients. Typically, these are controlled by limiting the tunnel inflow and preventing the tunnel from filling completely and by providing a tunnel overflow structure to relieve the excess flow.

The long-term costs to maintain and operate these facilities would place an ongoing burden on the Town's financial resources and workforce, with the periodic requirement for highly specialized and trained personnel.

D.2.3.5 Control Program 3 Public Acceptance

The construction required for tunnels is large and invasive making public acceptance of the project a concern. The tunnel shaft site is located on a parcel of land slated for redevelopment and there may be concerns related to such heavy mechanical facilities in an area slated for residential development. The construction at 007A is in an industrial area and may raise fewer concerns from the public.

Following construction, tunnels are generally preferable from the stand point of public acceptance since the majority of the facility is underground. Aboveground features will still be required such as air release, electrical facilities, odor control facilities and access points to pumps.

D.2.3.6 Control Program 3 Performance Summary

The performance of Control Program 3 is summarized in Table 38 through Table 43 that provide data for 0, 4, 8, 12, and 20 overflows annually, the tunnel is 3,900 lf and the diameter varied from 8 to 16 feet depending on the level of control.

Table 38: Control Program 3 - Tunnel Storage, Performance Summary – 0 Overflows

	Baseline 2015			3,900 LF Tunnel Storage 0 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Tunnel Diameter (ft)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Tunnel H-006A	28	8.0	122	16	0	0.0	0	-28	-8.0	-122
H-007A	53	14.5	352	--	0	0.0	0	-53	-14.5	-352
Total		61.5				0.0			-61.5	

Table 39: Control Program 3 - Tunnel Storage, Performance Summary – 4 Overflows

	Baseline 2015			3,900 LF Tunnel Storage 4 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Tunnel Diameter (ft)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Tunnel H-006A	28	8.0	122	12	2	1.1	30	-26	-6.9	-92
H-007A	53	14.5	352	--	0	0.0	0	-53	-14.5	-352
Total		61.5				1.1			-60.4	

Table 40: Control Program 3 - Tunnel Storage, Performance Summary – 8 Overflows

	Baseline 2015			3,900 LF Tunnel Storage 8 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Tunnel Diameter (ft)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0.0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0.0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0.0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0.0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0.0	0.0	0	-34	-20.5	-229
Tunnel H-006A	28	8.0	122	12	3.0	3.9	60	-25	-4.1	-62
H-007A	53	14.5	352	--	0.0	0.0	0	-53	-14.5	-352
Total		61.5				3.9			-57.6	

Table 41: Control Program 3 - Tunnel Storage, Performance Summary – 12 Overflows

	Baseline 2015			3,900 LF Tunnel Storage 12 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Tunnel Diameter (ft)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Tunnel H-006A	28	8.0	122	10	6	9.4	86	-22	1.4	-36
H-007A	53	14.5	352	--	0	0.0	0	-53	-14.5	-352
Total		61.5				9.4			-52.2	

Table 42: Control Program 3 - Tunnel Storage, Performance Summary – 20 Overflows

	Baseline 2015			3,900 LF Tunnel Storage 20 Overflows				Change		
Outfall	# of Events	Volume (MG)	Duration (HR)	Tunnel Diameter (ft)	# of Events	Volume (MG)	Duration (HR)	# of Events	Volume (MG)	Duration (HR)
H-001A	26	1.9	97	--	0	0.0	0	-26	-1.9	-97
H-002A	35	3.2	162	--	0	0.0	0	-35	-3.2	-162
H-003A	32	13.1	155	--	0	0.0	0	-32	-13.1	-155
H-004A	10	0.3	6	--	0	0.0	0	-10	-0.3	-6
H-005A	34	20.5	229	--	0	0.0	0	-34	-20.5	-229
Tunnel H-006A	28	8.0	122	8	12	15.0	156	-16	7.0	34
H-007A	53	14.5	352	--	0	0.0	0	-53	-14.5	-352
Total		61.5				15.0			-46.5	

Table 43: Control Program 3 - Harrison Summary Overflow Reduction

	Baseline 2015 (MG)	Control Program 3	% Reduction from 2015	Baseline 2050 (MG)*	% Reduction from 2050
0 Overflows	61.5	0.0	100%	42.8	100%
4 Overflows	61.5	1.1	98%	42.8	97%
8 Overflows	61.5	3.9	94%	42.8	91%
12 Overflows	61.5	9.4	85%	42.8	78%
20 Overflows	61.5	15.0	76%	42.8	65%

*Note 30.4% reduction in annual overflow volume due to planned project incorporated in 2050 baseline.

D.2.3.7 Control Program 3 Cost Summary

The Class 5 (+100%, -50%) cost estimates for Control Program 3 are summarized in Table 44.

Table 44: Control Program 3 – Tunnel Storage, Cost Summary

Control Program 3 - Tunnels					
	Overflows per Year				
	0	4	8	12	20
Capital Cost ($ Million)	$124.1	$117.1	$112.6	$109.1	$106.6
O&M Cost ($ Million)	$2.4	$2.3	$2.2	$2.1	$2.1
20-Yr Net Present Worth ($ Million)	$160.4	$151.7	$146.1	$141.8	$138.7

The net present worth associated with tunnel storage are approximately twice the cost of consolidated storage tanks. Accordingly, tunnel storage will be eliminated from further consideration.

D.2.4 Control Program 4 End-of-Pipe Treatment

D.2.4.1 Control Program 4 Description

This control program consists of siting a treatment facility at the end of each outfall. According to the national CSO Policy, overflows that meet the minimum required treatment are no longer considered overflows. Thus, by providing a treatment train capable of providing disinfection and the accompanying solids removals, the number of overflows can be reduced by removing all overflows that discharge at flow rates less than the treatment provided.

For purposes of evaluation the following treatment train was established:

1. Divert flows downstream of the regulator, and if possible, downstream of the existing netting facility.
2. Provide fine screening (removal of solids >0.5 inch) of the flows to remove additional floatables and course particles.
3. Provide interim pumping to offset the head loss associated with the treatment processes.
4. Provide high rate primary treatment of the flows to remove solids in advance of disinfection. For evaluation purposes, ActiFlo was used as a representative technology given its widespread use.
5. Disinfect with peracetic acid, by providing a six-minute contact time.
6. The flow is then discharged through the existing outfall or possibly a modified outfall.

The evaluation of practicality and feasibility draws on the siting analysis to identify locations for each facility and drives the consolidation of select facilities. Modeling was performed for the range of control alternatives 0, 4, 8, 12 and 20 overflows. Figure 43 through Figure 47 below depict conceptual site layouts sized to limit the Typical Year number of overflows to 4 events.

At Outfall 001A while the facilities can be sighted in the parking areas, since they are above grade they would have a severe impact on the businesses and may require taking the residential property in its entirety.

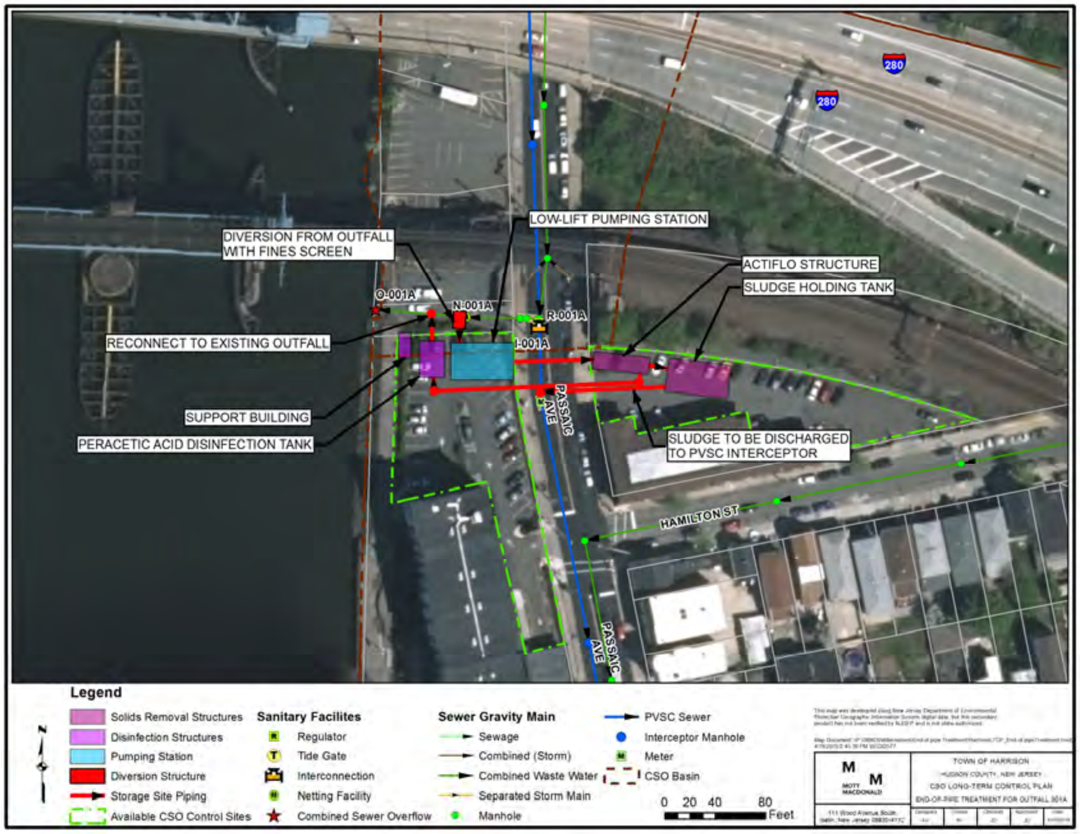

Figure 43: Point Treatment - Outfall 001A

At Outfall 002A it appears the treatment facilities could be sited within the available footprint, shown below.

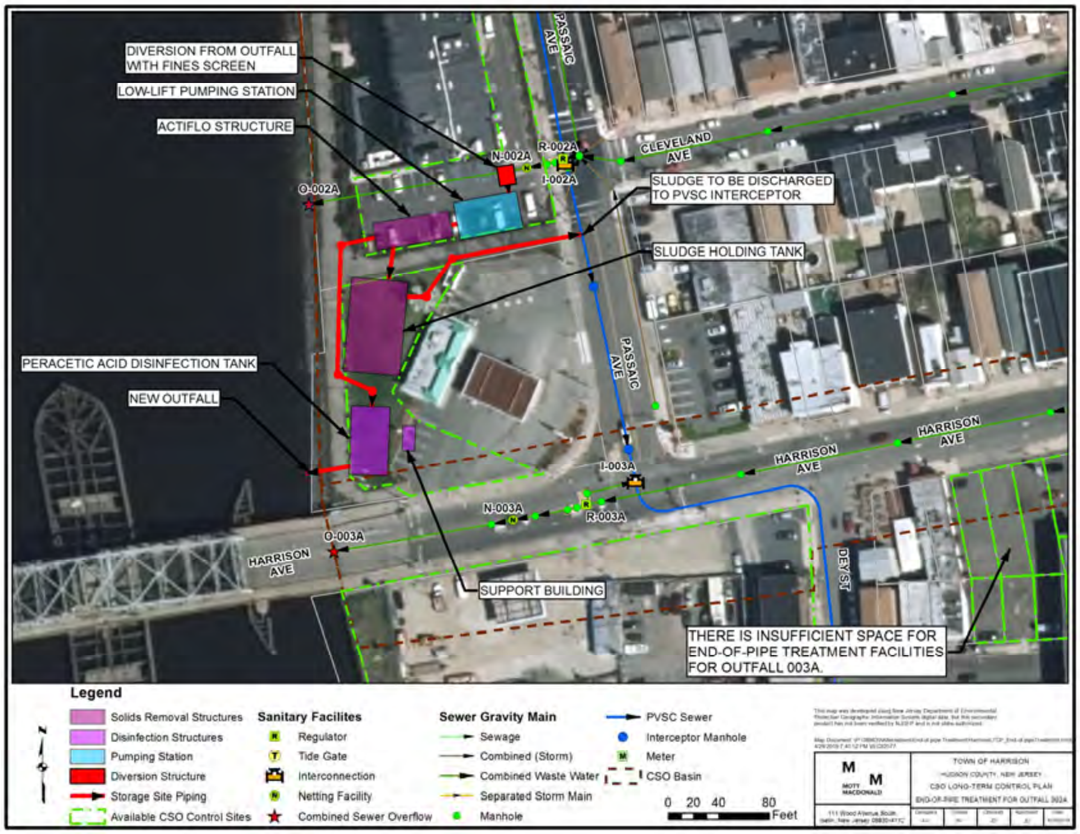

Figure 44: Point Treatment - Outfall 002A

It would not be feasible to place treatment facilities at Outfall 003A as there is no land available. Facilities for Outfall 003A could not be consolidated with Outfall 002A as there would be insufficient space.

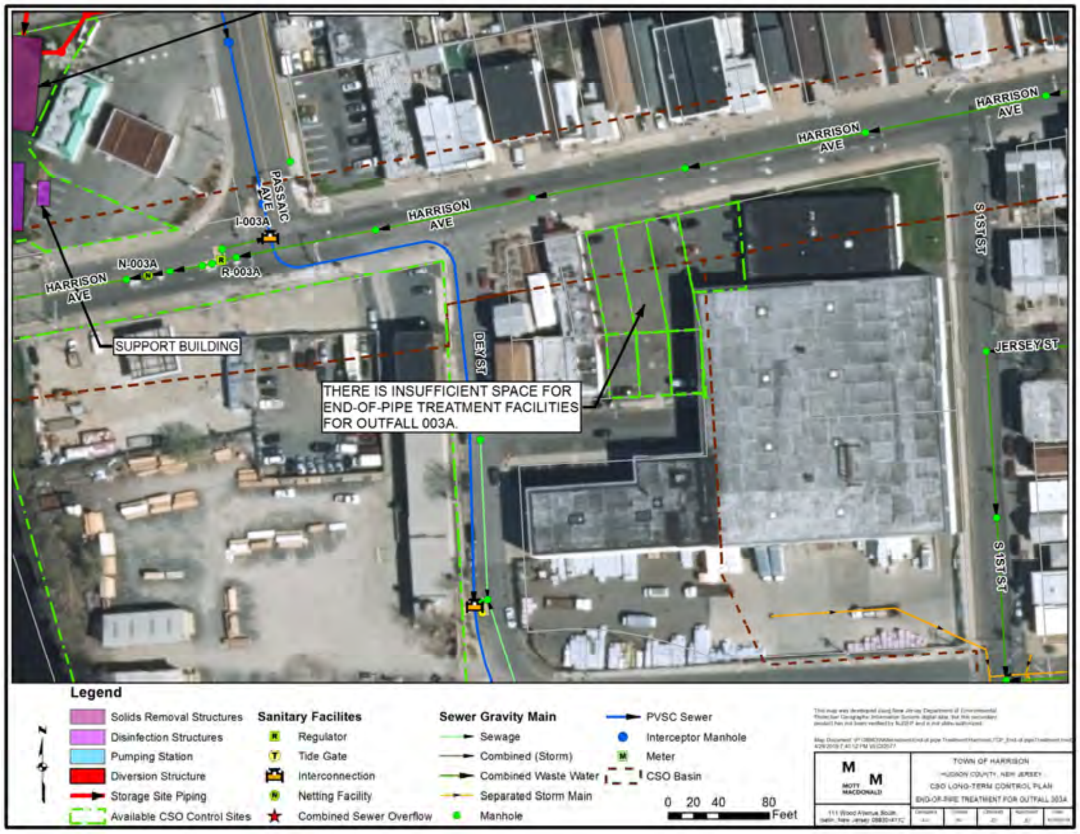

Figure 45: Point Treatment - Outfall 003A insufficient space

At Outfall 006A there appears to be sufficient space available, however the impact to the future park will be significant. A great deal of conveyance piping will be required to bring the flow from the 006A outfall to the available land. There could be some reduction in piping by creating a new outfall for the treated discharge or by relocating the existing outfall.

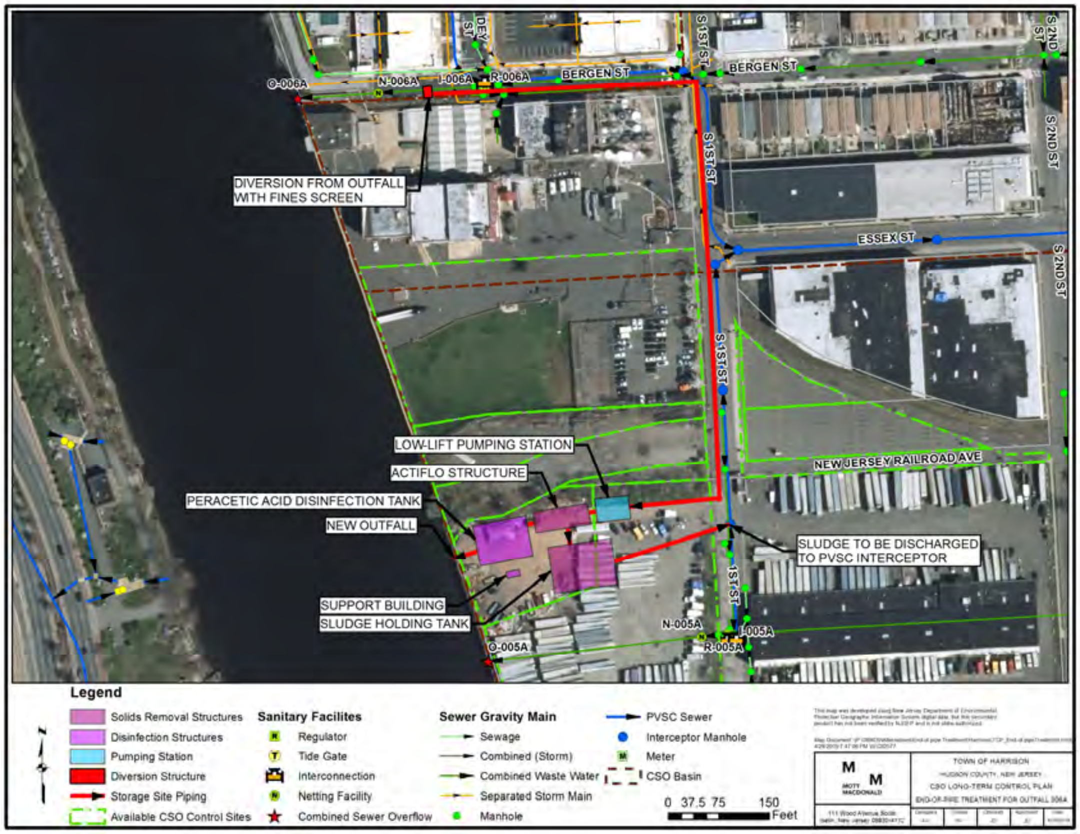

Figure 46: Point Treatment - Outfall 006A

At Outfall 007A there appears to be sufficient space available. However, there would be a substantial impact on the industrial facility as the space required for the treatment facilities is currently used and these operations would need to be relocated within the existing industrial complex.

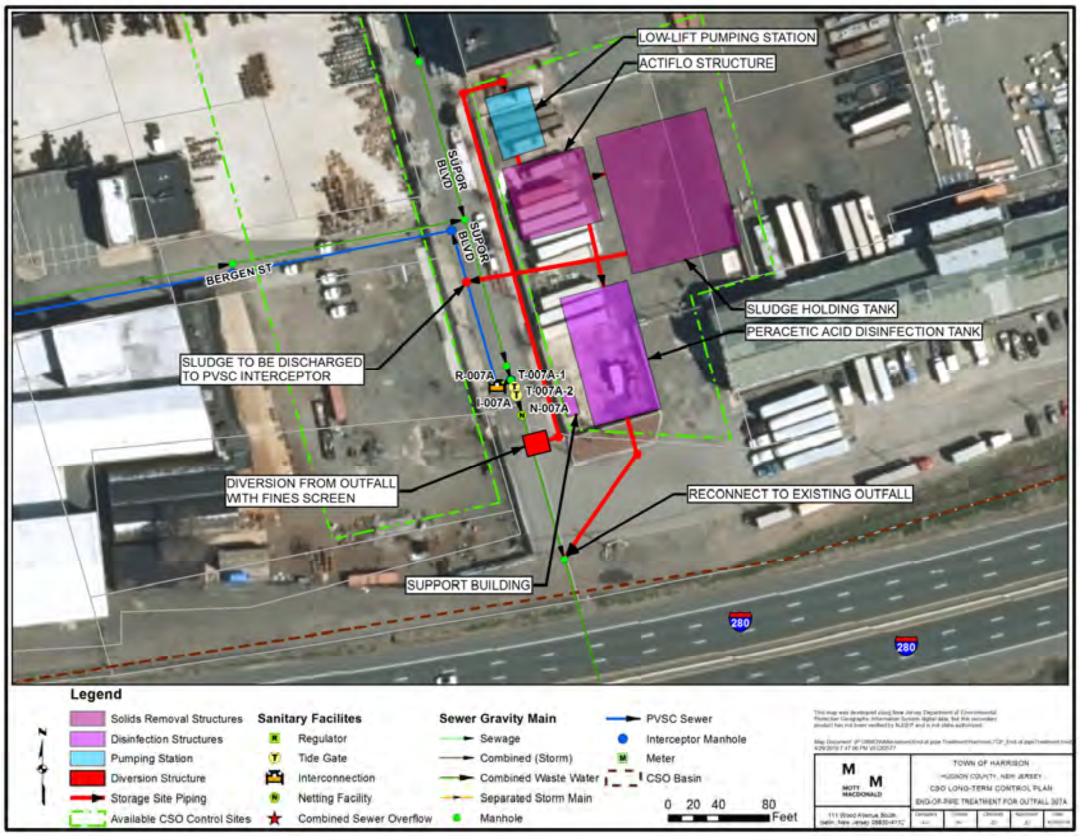

Figure 47: Point Treatment - Outfall 007A

D.2.4.2 Control Program 4 Analysis

The sizing for treatment facilities are often the same to achieve 4, 8 and 12 overflows, and sizing is difficult to combine with storage-based control programs. This is because peak flows are generally driven by the peak rainfall intensity coinciding with the time of concentration of the basin, whereas the total overflow volume is driven by the total rainfall event. As such, the sizing of the end of pipe treatment facilities are driven by a different set of storms than end of pipe storage facilities. To achieve a consistent level of control on the basis of peak flows requires a much higher level of control to be achieved through end of pipe treatment. This can be seen in the output in Table 45 through Table 49.

Based on the treatment sizing required for each site, end-of-pipe facilities were input into the InfoWorks ICM model. The evaluation consisted of peak flow rate of overflows diverted to the treatment facility, and the corresponding treatment. Once the treatment facility has exceeded the peak treatment rate, remaining flows are tracked as overflows. The treatment rate is tracked and once it is exceeded, no additional flow is diverted through the treatment facility.