DEVELOPMENT AND EVALUATION OF ALTERNATIVES
REGIONAL REPORT

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

Town of Guttenberg (NJ0108715)
North Bergen Municipal Utilities Authority (NJ0029084)

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

"Protecting Public Health and the Environment"

June 2019

SECTION A - INTRODUCTION AND BACKGROUND

A.0 SUMMARY OF CHANGES

This Report is for the Development and Evaluation of Alternatives Regional Report to be utilized by the North Bergen Municipal Utilities Authority ("NBMUA") Woodcliff Sewage Treatment Plant ("Woodcliff STP") Sewer Service Area, which includes a portion of the Township of North Bergen and the Town of Guttenberg. This Report describes the receiving water characterization, technology screening process, and the evaluation of CSO control alternatives for the NBMUA (discharging to the Woodcliff STP) and the Town of Guttenberg. This Report compiles the results of the two (2) individual Evaluation of Alternatives Reports for the Town of Guttenberg and the portion of the NBMUA discharging to the Woodcliff STP. In future versions, this section will include summaries of changes and when they were incorporated as appropriate.

A.1 TITLE OF PLAN AND APPROVAL

Title: Development and Evaluation of Alternatives Regional Report

Preparer:

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

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

Passaic Valley Sewerage Commission:

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

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

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

NJPDES Number NJ0029084 (North Bergen - Woodcliff)

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 NJ0108715 (Guttenberg)

Approval of this submittal:

Permittee: ______________________________ 6/24/19
Frank Pestana — Date
Licensed Operator, Town of Guttenberg

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
Licensed Operator, Town of Guttenberg

A.2 DISTRIBUTION LIST

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Guttenberg:	Frank Pestana, Licensed Operator

New Jersey Department of Environmental Protection
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A.3 PROGRAM CONTACT INFORMATION

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A.5 INTRODUCTION

The North Bergen Municipal Utilities Authority ("NBMUA") provides wastewater collection and treatment to the Township of North Bergen and the Town of Guttenberg. The combined sewer system ("CSS") and sewerage facilities are owned by the municipalities; however, the NBMUA holds the New Jersey Pollutant Discharge Elimination System ("NJPDES") Permit for the Woodcliff Sewage Treatment Plant ("STP" or "Woodcliff STP") facilities.

The total area of the Township of North Bergen is approximately 3,346 acres including land and water. North Bergen topography is divided into two areas: the western and central area of the Township of North Bergen slopes towards the Hackensack River and the eastern area slopes towards the Hudson River. The western and central section of the Township is part of the Passaic Valley Sewerage Commission ("PVSC") Treatment District and discussed under the *PVSC Service Area System Characterization Report* dated June 2018 (Revised 3/28/19). The extent of the PVSC Treatment District is shown in **Figure A-1**, which includes the NBMUA western and central service area. The eastern area of North Bergen drains to the NBMUA Woodcliff STP drainage area, which is discussed further in this report.

The total area of the Town of Guttenberg is approximately 124 acres. The majority of the town is served by combined sewer system. The combined sewer collection system conveys flow to the Woodcliff STP for further treatment, and allows extreme wet weather flows discharging through combined sewer overflow ("CSO") outfalls located at the Hudson River.

The Woodcliff STP is operated by the NBMUA. It receives sewer flows from eastern portion of the Township of North Bergen and the Town of Guttenberg. The combined dry weather flows from these two (2) municipalities are slightly less than 3 MGD. The Woodcliff STP sewer system includes two CSO outfalls associated with the NBMUA and another CSO outfall associated with the Town of Guttenberg. Both NBMUA and Guttenberg CSO outfalls discharge into the Hudson River. The Woodcliff - Guttenberg Service Area is shown on **Figure A-2.**

A general flow schematic of the Woodcliff – Guttenberg Service Area is shown on **Figure A-3.**

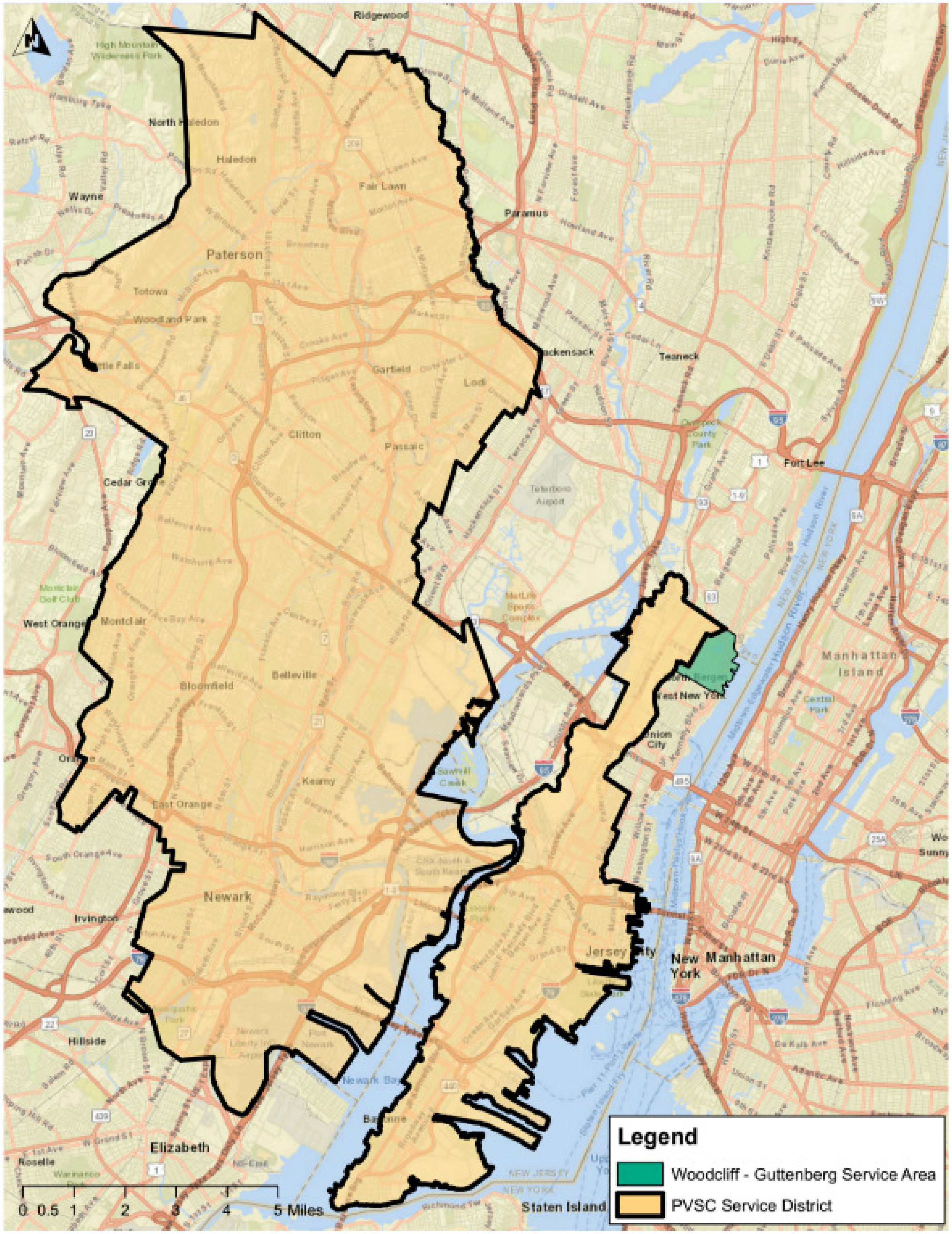

Figure A-1: The PVSC Treatment District and Woodcliff – Guttenberg Service Area

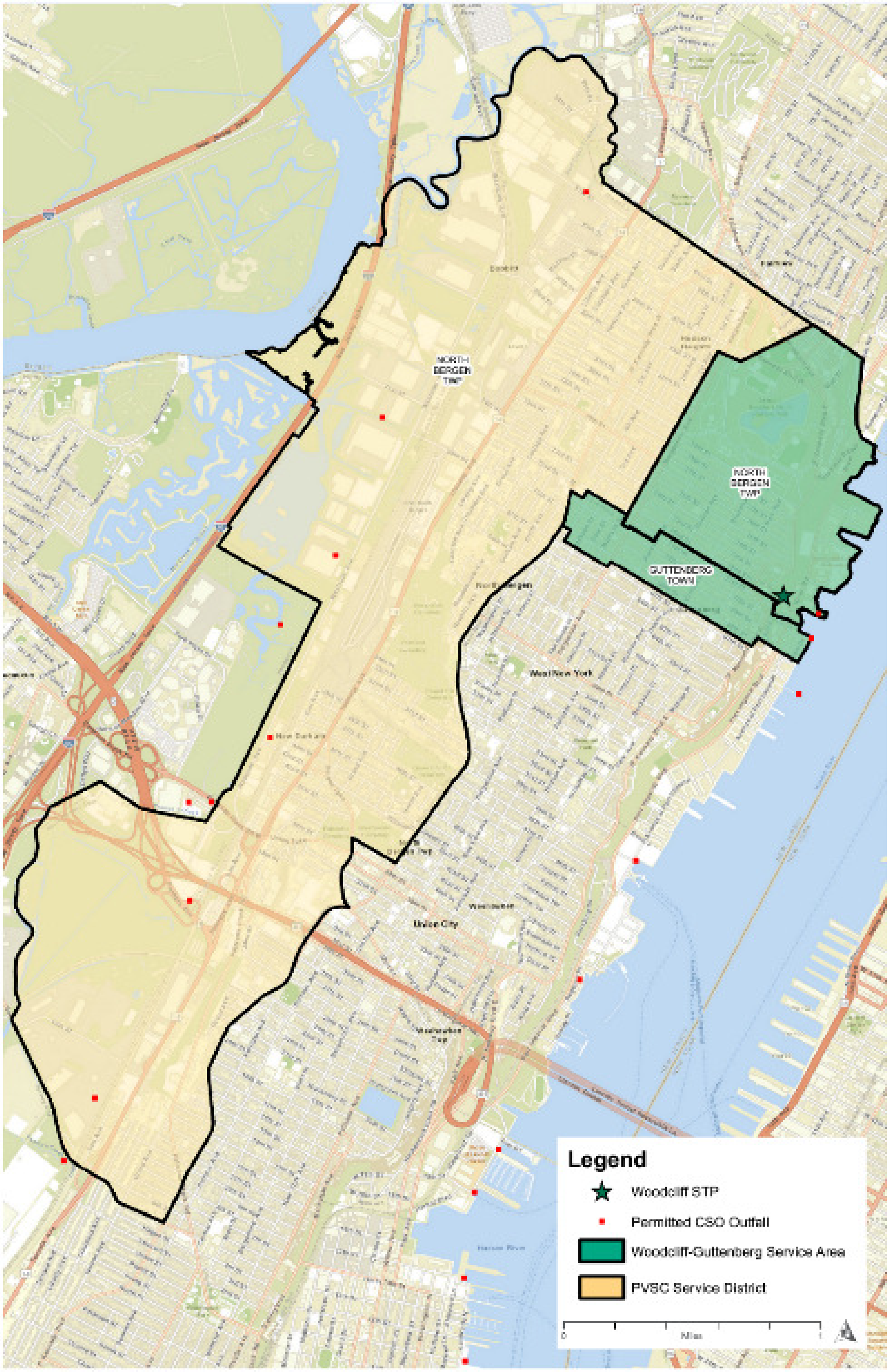

Figure A-2: The Woodcliff – Guttenberg Service Area

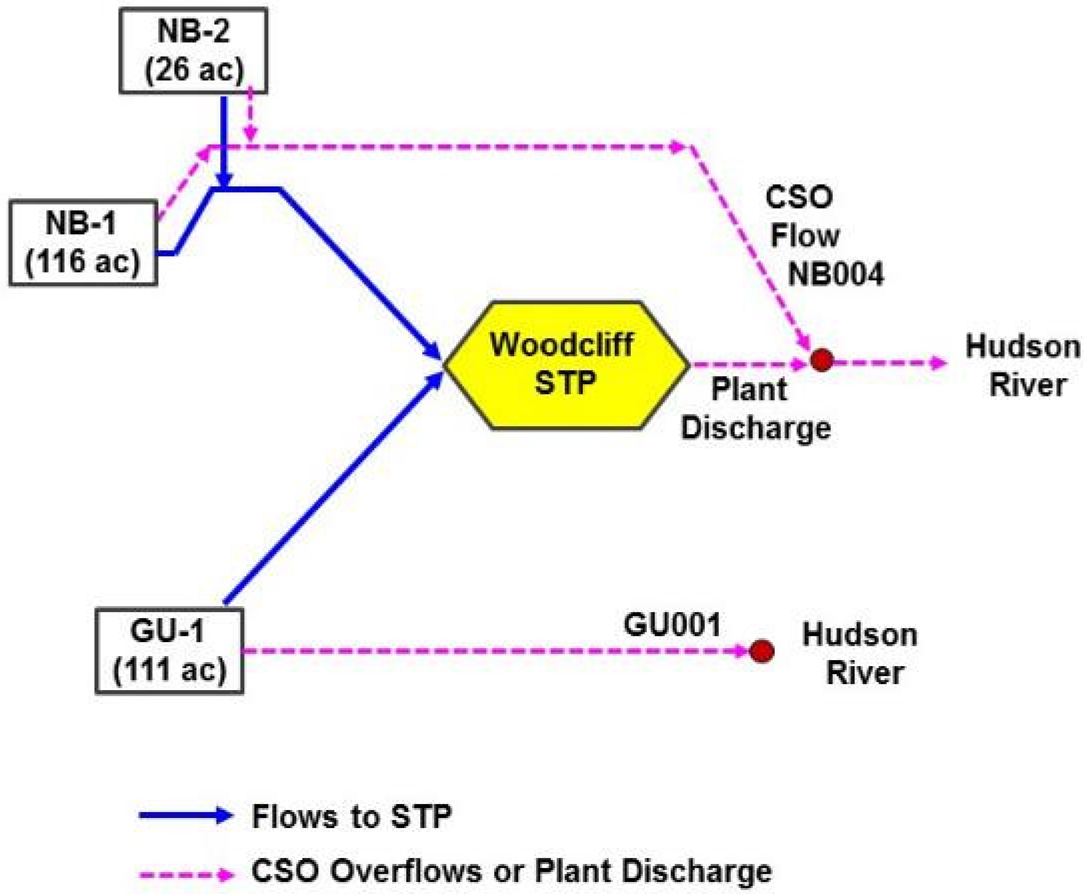

Figure A-3: Flow Schematic of the Woodcliff – Guttenberg Service Area

A.6 PURPOSE OF REPORT

Both of the NBMUA's (Woodcliff) NJPDES permit (Permit Number NJ0029084) and the Town of Guttenberg's NJPDES permit (Permit Number NJ0108723) outline the Long Term Control Plan ("LTCP") Submittal requirements for the Development and Evaluation of Alternatives 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 ("DEAR") shall be submitted by July 1, 2019.

To meet this requirement, the CSO Permittees developed their own individual Evaluation of Alternatives Report. This Development and Evaluation of Alternatives Regional Report ("Woodcliff Regional Alternatives Report") for the NBMUA Woodcliff STP Service Area compiles and summarizes the results of the two (2) individual DEARs for:

- Township of North Bergen (served by the Woodcliff STP)
- Town of Guttenberg

Both of the individual reports are included in their full version at the end of this Woodcliff Regional Alternatives Report as Appendices.

Section G.4 of both NJPDES permits outline the requirements of the Development Evaluation of Alternatives Report. The objective of the DEAR is to provide the NJDEP 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 New Jersey Administrative Code (N.J.A.C.) 7:9B, give the highest priority to controlling CSOs to sensitive areas, and address minimizing impacts from SIU discharges.*" Evaluation of Alternatives Reports for the NBMUA (Woodcliff) and the Town of Guttenberg have been developed to meet these permit requirements. This Woodcliff Regional Alternatives Report also evaluates, compares, and incorporates specific features of the local alternatives developed by the two (2) municipalities into the regional alternatives developed for the portion of the Township of North Bergen served by the Woodcliff STP.

A.7 CONTENTS OF THIS REPORT

This report provides an evaluation of a range of CSO control alternatives predicted to accomplish the requirements of the CWA. As required by the NJPDES Permit Section G.4.e, this report utilizes models to simulate the existing conditions and conditions as they are expected to exist after construction and operation of the chosen alternative(s). The report evaluates 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.

An overview of the organization and contents of this system characterization report are provided on **Table A-1.**

Table A-1: Woodcliff Regional 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	Receiving Waters	Describes the receiving waters for the CSO service area and the pollutant of concern (POC) for each water body.
C	Screening of CSO Control Technologies	Describes the technology screening process used to determine the CSO control technologies advanced for analysis in Section D. Also describes the selected approach.
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	

A.8 REGULATORY SETTING

A.8.1 Introduction

This document constitutes the *Development and Evaluation of Alternatives Regional Report* developed by the NBMUA for the portion of the Township of North Bergen within the Woodcliff sewershed and the Town of Guttenberg, as listed below in **Table A-2.**

Table A-2: Permittees Covered Under this Development and Alternatives Regional Report

Municipality	NJPDES #
North Bergen MUA (Woodcliff)	NJ0029084
Town of Guttenberg	NJ0108715

A.8.2 NJPDES Permit Requirements

Under Section 402 of the CWA, all point source discharges to the waters of the United States must be permitted. USEPA Region II has delegated permitting authority in New Jersey to the

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 NBMUA's (Woodcliff) and Town of Guttenberg's NJPDES Permits require the completion of an approvable DEAR, and 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 of both permits state 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 & Evaluation of CSO Control Alternatives Report are outlined in Section G.4 for both permits. These requirements are reproduced in **Table A-3**, along with the section of this Woodcliff Regional Alternatives Report in which those requirements are addressed.

Table A-3: Review of Requirements of the Development and Evaluation of Woodcliff Regional Alternatives Report

Permit Section	Permit Requirement	Woodcliff 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 Woodcliff 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
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

Permit Section	Permit Requirement	Woodcliff Regional Report Section
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
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.8.3 USEPA's CSO Control Policy

USEPA's CSO Control Policy (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 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 Policy establishes a framework for the coordination, planning, selection, and implementation of CSO controls required for permittee compliance with the CWA.

CSO Control 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 Control 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.8.3.1 Presumption Approach from USEPA's CSO Control Policy

Sub-section II.C.4.a of the USEPA's CSO Control 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 WQS."*

Under the Presumption Approach, CSO controls proposed in the LTCPU 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 Sub-section II.C.4.a of the CSO Control Policy as:

- *"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 WQS, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary."*

A.8.3.2 Demonstration Approach from USEPA's CSO Control Policy

Sub-section II.C.4.b of the USEPA's CSO Control 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 Control Policy:

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 proposed control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribution to their impairment. Where WQS 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 WQS or designated uses."*

A.8.4 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 Control 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.8.4.1 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.8.4.2 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 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.8.5 Comparison of the Two Approaches

Table A-4 summarizes the major differences between the Presumption Approach and the Demonstration Approach.

Table A-4: 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 overflow 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 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 Control Policy.

Certain tasks must be completed regardless if the Presumption or Demonstration Approach is used, such as system characterization, sewer and 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.8.6 NJPDES LTCP Permittees Approach and CSO Discharge Locations

Part IV, Section G.4.c of both NBMUA's (Woodcliff) NJPDES Permit (Permit Number NJ0029084) and the Town of Guttenberg's NJPDES Permit (Permit Number NJ0108723), 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 the NJDEP, 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 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.

Table A-5 summarizes the NJPDES, permittee name, CSO numbers, hydraulically connected group, and receiving water body.

Table A-5: Summary of CSO Discharge Locations

NJPDES	Permittee	CSO Number	Hydraulically Connected Group	Receiving Water Body
NJ0108715	Town of Guttenberg	001A		Hudson River
NJ0029084	North Bergen MUA – CSO Discharge to the Hudson	004A		Hudson River
NJ0029084	North Bergen MUA – Woodcliff STP	004A		Hudson River

A.9 EXISTING CONDITIONS

Section D.3.b.i of the NJDEP Permit for each Permittee required submittal of a System Characterization Work Plan to the NJDEP 6 months from the effective date of the permit. To meet this requirement a System Characterization and Landside Modeling Program Quality Assurance Project Plan ("QAPP") was submitted for the NBMUA ("Woodcliff") and the Town of Guttenberg to be executed and performed by the Passaic Valley Sewerage Commission ("PVSC"). 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 NJPDES Permits LTCP requirements, a System Characterization Report was submitted by July 1, 2018. This System Characterization Report has been developed to meet the permit requirements and incorporates the results of the QAPP for the System Characterization and Landside Modeling Program, the Baseline Monitoring and Modeling Plan program, and the System Characterization mapping of the combined and separate areas for the Woodcliff – Guttenberg Service Area. The System Characterization Report includes only the CSO municipalities that are hydraulically connected to the Woodcliff STP which are the Town of Guttenberg and NBMUA Woodcliff. Section G.1 of the permit outlines 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 the NBMUA 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.9.1 System Characterization Report Summary

The NBMUA (Woodcliff) and Guttenberg System Characterization Report documents that the NBMUA (Woodcliff) and the Town of Guttenberg 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 overflow events, and water quality issues associated with CSOs emanating from the systems.

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 program organization, key responsible individuals, problem definition, background, project description, summary and table of contents.
B	Regulatory Requirements	Describes regulatory requirements and context of the System Characterization Report.
C	Overview of Wastewater Facilities and Service Area	Characterizes the 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, 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 stream. 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 wastewater and water quality data collection, historic water quality data collection, the CSO and water quality monitoring program and related QAPP and wastewater 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 Service Area System Characterization Report for NBMUA (Woodcliff) and Town of Guttenberg provides a more comprehensive summary of the system characterization.

A.10 SENSITIVE AREAS

The United States Environmental Protection Agency's (USEPA) CSO Control Policy (Federal Register 59 [April 19, 1994]: 18688-18698) "expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas" (Section II.C.3). 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, only the portions of the Sensitive Areas Study Area (the "Study Area") includes the combined sewer service areas, including all receiving and adjacent downstream waters that may be potentially affected by CSOs from the various combined sewer service areas of the Woodcliff – Guttenberg Service Area. Affected waters include the Hudson River as well as its tributaries within the Study Area of this report.

A.10.1 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 issued last revised and submitted on March 29, 2019, and 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 water. The USEPA CSO Control Policy Guideline requires that highest priority is given to CSO's that discharge to sensitive areas.

B.1 RECEIVING WATERS OVERVIEW

The major receiving water body impacted from the Woodcliff – Guttenberg Service Area CSOs is the Lower Hudson River. The Lower Hudson River and its tributaries belong to the Hudson River drainage basin. 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 NJDEP has categorized all CSO receiving waters into Watershed Management Areas ("WMA") 1 through 20 and refers to these designations in the 303(d) list of impaired water. The Lower Hudson River is considered part of the NJDEP Watershed Management Area 05. The Woodcliff – Guttenberg Service Area CSO outfalls at the Hudson River is shown in **Figure B-1**.

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 Guttenberg Woodcliff Sewer District and expands from this service area to include receiving and adjacent downstream waters that may be potentially affected by CSOs from the various combined sewer service areas. The downstream confluence of the Hudson River is the Upper New York Harbor which is potentially affected by the Woodcliff – Guttenberg CSO Service Area discharges. The Hudson River is located within the Passaic, Hackensack, and New York Harbor Complex. **Table B-1** lists all of the CSO outfalls and the waterbodies into which they discharge.

Table B-1: CSO Outfalls and Their Receiving Waters

NJPDES	Permittee	CSO Number	Receiving Water Body
NJ0108715	Town of Guttenberg	GU001	Hudson River
NJ0029084	North Bergen MUA	BN004I	Hudson River

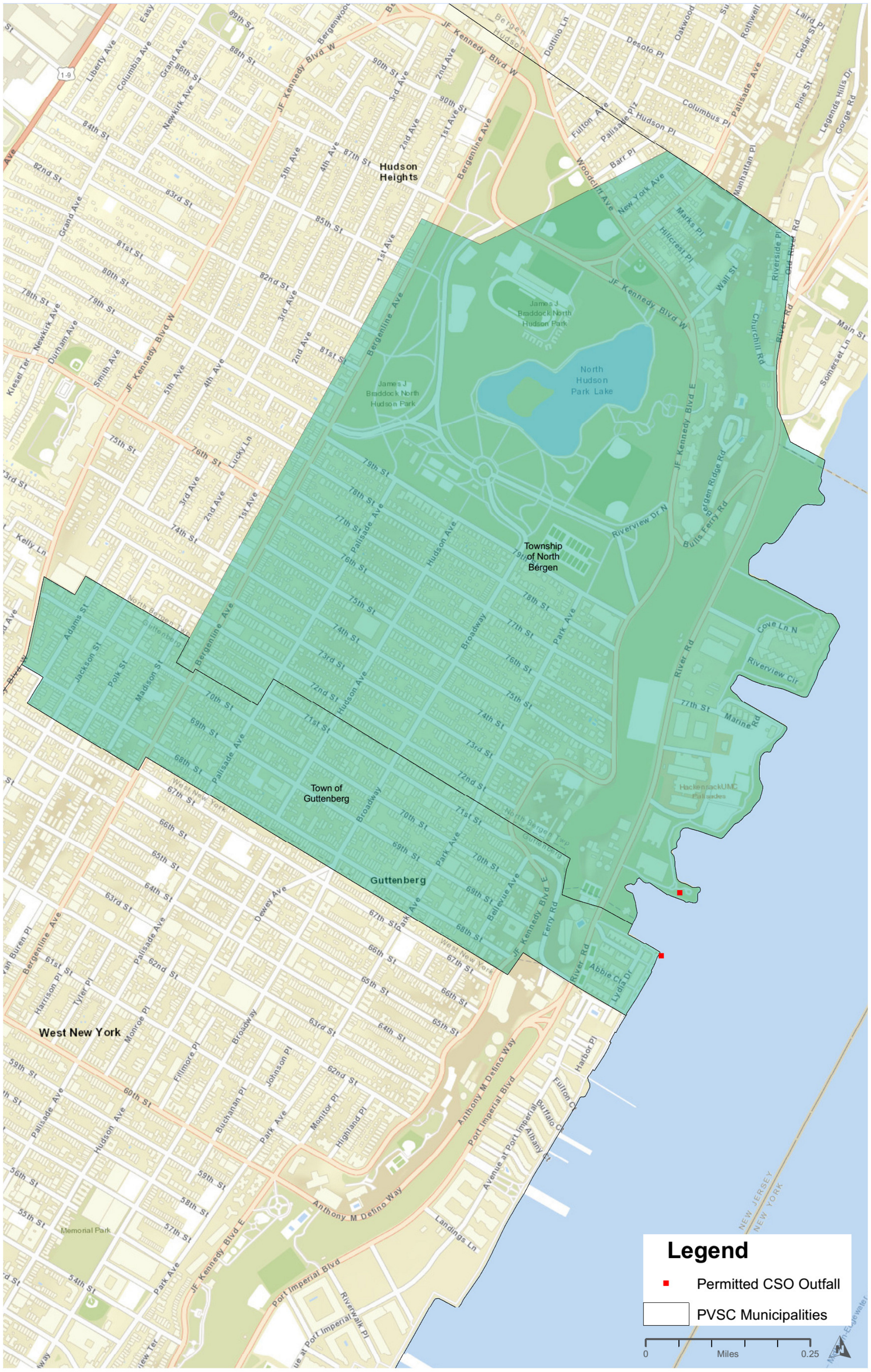

Figure B-1: Woodcliff - Guttenberg Service Area and Outfalls

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 the Woodcliff - Guttenberg Sewer District's receiving water. These three (3) POCs are parameters typically associated with CSO discharges. 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. The NJDEP determined POCs for the Upper New York Bay relative to the NBMUA (Woodcliff) and Town of Guttenberg CSO discharges are Fecal Coliform, Escherichia coli (E. coli, fresh water tributaries), and 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 federal Clean Water Act or "CWA" (33 USC § 1251 et seq.) requires each state to identify those waters for which effluent limitations are not stringent enough to attain applicable water quality standards; 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 water quality standards; and submit a list to USEPA of all impaired waters and their pollutant causes (i.e., the 303(d) List).

The NJDEP has established the 2014 New Jersey Integrated Water Quality Assessment Report. The primary source of information regarding causes of impairment, and the Total Maximum Daily Load (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 (CWA). 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	Component
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 are 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 the determination of 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.

The New Jersey Integrated Water Quality Monitoring and Assessment Report (303(d) list) is a catalog of the impaired waters throughout the state of New Jersey.

B.3.2 Interstate Environmental Commission (IEC) Water Quality Regulations

The Woodcliff-Guttenberg Service Area falls within the jurisdiction of the Interstate Environmental Commission ("IEC"). The IEC is a tristate air and water pollution control agency serving the states of New York, New Jersey, and Connecticut. The Commission and its area of jurisdiction were established in 1936 under a Tri-state compact, with the consent of Congress. The IEC establishes the receiving stream water quality standards to which NJPDES permittees are subject under the federal Clean Water Act[B-1] and the New Jersey Water Pollution Control Act.[B-2]

The IEC has specified two classes of waters:[B-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 sewered municipalities.

Class B Waters **–** IEC identified two sub-classes:

- **Class B-1** – the IEC water quality standards 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."

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

- **Class B-2** – the IEC water quality standards 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 water quality standard classification zones applicable to the Woodcliff STP combined sewered area are shown on **Figure B-2**.

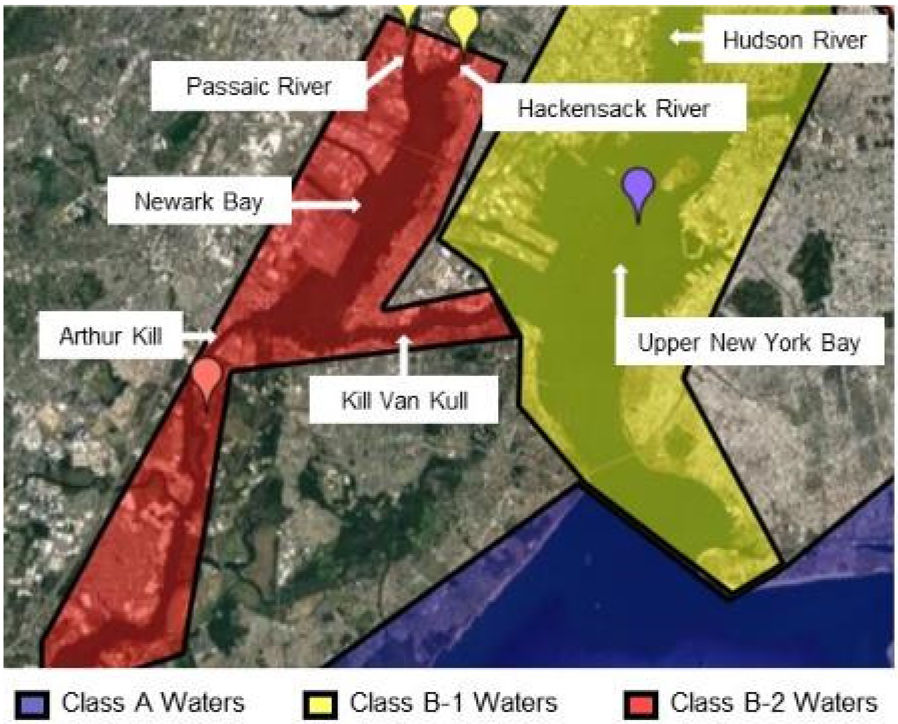

Figure B-2: Interstate Environmental Commission Water Quality Classifications

As shown in **Figure B-2**, the mouth of the Passaic River, the mouth of the Hackensack River, Newark Bay and the Kill Van Kull are classified as B-2 waters and the Upper Bay (including Hudson River) is classified as B-1. Water quality standards applicable to Class B-1 and Class B-2 waters relevant to CSO discharges are provided in **Table B-3** below. Class B-1 is applied for the Woodcliff – Guttenberg Service Area because its receiving waterbody Hudson River is classified as B-1.

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

Water Quality Parameter	Value
Dissolved Oxygen Class B-1	> 4 milligrams per liter
Dissolved Oxygen Class B-2	> 5 milligrams per liter
Dissolved Oxygen Classes B-1 & B-2	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.
Fecal Coliform (effluent discharges)	• 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.
General Requirements	
• 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.	
• 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.	
• 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.	

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 about the applicable water quality standards 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 (N.J.A.C.) Section 7:9B Surface Water Quality Standards lists the classifications, designated uses, and water quality criteria for the all New Jersey water bodies. The Hudson River is classified as SE2. Details about this classification code can be found in Section B.4.6.

B.4 HUDSON RIVER

B.4.1 Watershed Drainage Basin

The Troy Dam is the demarcation between the upper and lower Hudson River. The southernmost reach of lower Hudson River is bordered by the New York City boroughs of Manhattan, Brooklyn and Staten Island and the New Jersey municipalities of Jersey City and Bayonne. This portion of the lower Hudson River is a tidal estuary. Before reaching the Atlantic Ocean, the Hudson River flows into the northern end of the Upper New York Bay. The Upper New York Bay is a tidal bay and is located between New York City and Jersey City.

The Lower Hudson River is considered part of the NJDEP Watershed Management Area 05. See **Figure B-3** below for location of the CSO Outfalls in the Lower Hudson River.

B.4.2 Physical Characteristics

The portions of the Township of North Bergen and the Town of Guttenberg that discharge to the Woodcliff STP are heavily populated urban environments. The Town of Guttenberg and the East side of the Township of North Bergen are located at the top of the Hudson River Palisades and across the Hudson River from Manhattans Upper West side. Much of the land cover is impervious. One of the largest parks (green space) in the area, the James J. Braddock North Hudson County Park is 167 acres, and the streets that surround this park are Bergenline Avenue, Woodcliff Avenue, John F. Kennedy Boulevard, and 79th Street.

The Hudson River has a diverse array of habitat types including:

- Deep water
- Tidal wetlands
  - Fresh water marshes
  - Salt water marshes

The Hudson River estuary has one of the largest concentrations of freshwater wetlands in the Northeast. Even though the river can be considered brackish further south, 80 percent of the wetlands are outside the influence of the saltwater coming from the Atlantic Ocean. Currently, the river has about 7,000 acres of wetlands.

Figure B-3: The Hudson River

There is strong biological diversity, including intertidal vegetation like freshwater cattails and saltwater cordgrasses. Shallow coves and bays are often covered with submarine vegetation; shallower areas harbor diverse benthic fauna. Abundance of food varies over location and time, stemming from seasonal flows of nutrients. The Hudson River's large volume of suspended sediments reduces light penetration in the area's water column, which reduces phytoplankton photosynthesis and prevents sub-aquatic vegetation from growing beyond shallow depths.

B.4.3 Hydrodynamics

Hudson River is bordered by the New York City boroughs of Manhattan, Brooklyn and Staten Island and the New Jersey municipalities of Jersey City and Bayonne. The hydrodynamics within the river are complicated due to its interconnectedness with several waterbodies. It and is connected with the East River, Kill Van Kull, the Upper New York bay and the New York Bight (Atlantic Ocean). The channel of the Hudson as it passes through the Upper New York Bay is called the Anchorage Channel and is approximately 50 feet deep in the midpoint of the bay. The drainage area for the Hudson River is approximately 14,000 square miles, with 8,090 square miles in the non-tidally affected area above the Troy Dam near Green Island, NY. USGS gage 01358000 at Green Island, NY measures an average flow of approximately 14,500 cubic feet per second (cfs), with a maximum estimated flow of 215,000 cfs occurring on March 19, 1936. Additional freshwater is added from the drainage area below the dam.

The combination of freshwater flow from the Hudson River, saltwater flow from the Atlantic Ocean, and tidal exchange can create a two layer flow with freshwater at the surface leaving the Upper New York Bay to the south, and saltwater flow at the bottom entering the bay through the deep channel. The salt front (100 milligrams per liter of chloride) ranges from below Hastings-on-Hudson to New Hamburg during most years, but can move as far north as Poughkeepsie during periods of drought.

B.4.4 Shoreline Characteristics

The Hudson River shoreline at the Township of North Bergen (Woodcliff) and the Town of Guttenberg is densely residential. High-rise apartment buildings and housing developments line the shoreline. The New Jersey Palisades rise up between the waterfront developments on the shoreline and the dense urban neighborhoods above.

Much of the Hudson River shoreline has been bulkheaded for industrial development including shipping and ferry terminals, residential use and park and recreational use. Several islands are located in the Upper New York Bay including Governors Island, Liberty Island, Ellis Island, and Robbins Reef. A small portion of the shoreline in is riprap and natural shoreline.

B.4.5 NJ Integrated Water Quality Monitoring and Assessment Report (303(d) list)

The Hudson River is listed on the 303 (d) list as being impaired for the following pollutants:

- Benzo(a)pyrene (“PAHs”)
- Cause Unknown
- Chlordane in Fish Tissue

- DDT and its metabolites in Fish Tissue
- Dieldrin
- Dioxin (including 2, 3, 7, 8-TCDD)
- Hexachlorobenzene
- Mercury in Fish Tissue
- PCB in Fish Tissue

B.4.6 Designated Critical Uses and Specific Water Quality Criteria from NJ Code

The portion of the Hudson River and saline portions of New Jersey tributaries from the confluence with the Harlem River, New York to a north-south line connecting Constable Hook (Bayonne) to St. George (Staten Island, New York) is listed by the N.J.A.C. Section 7:9B Surface Water Quality Standards as SE2. SE2 refers to a saline estuarine water body, its designated uses, indicator bacteria and their criteria are shown in **Table B-4** below.

Table B-4: NJ Administrative Code Regarding the Newark Bay

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

The N.J.A.C. Classifications of PVSC Treatment District Waterbodies are illustrated in **Figure B-4**.

B.4.7 Designated Zone and Water Quality Regulations from the IEC

The IEC classifies the Hudson River as Class B-1. For more information regarding the IEC standards for Class B-1 and B-2 water bodies, see Section B.3.2.

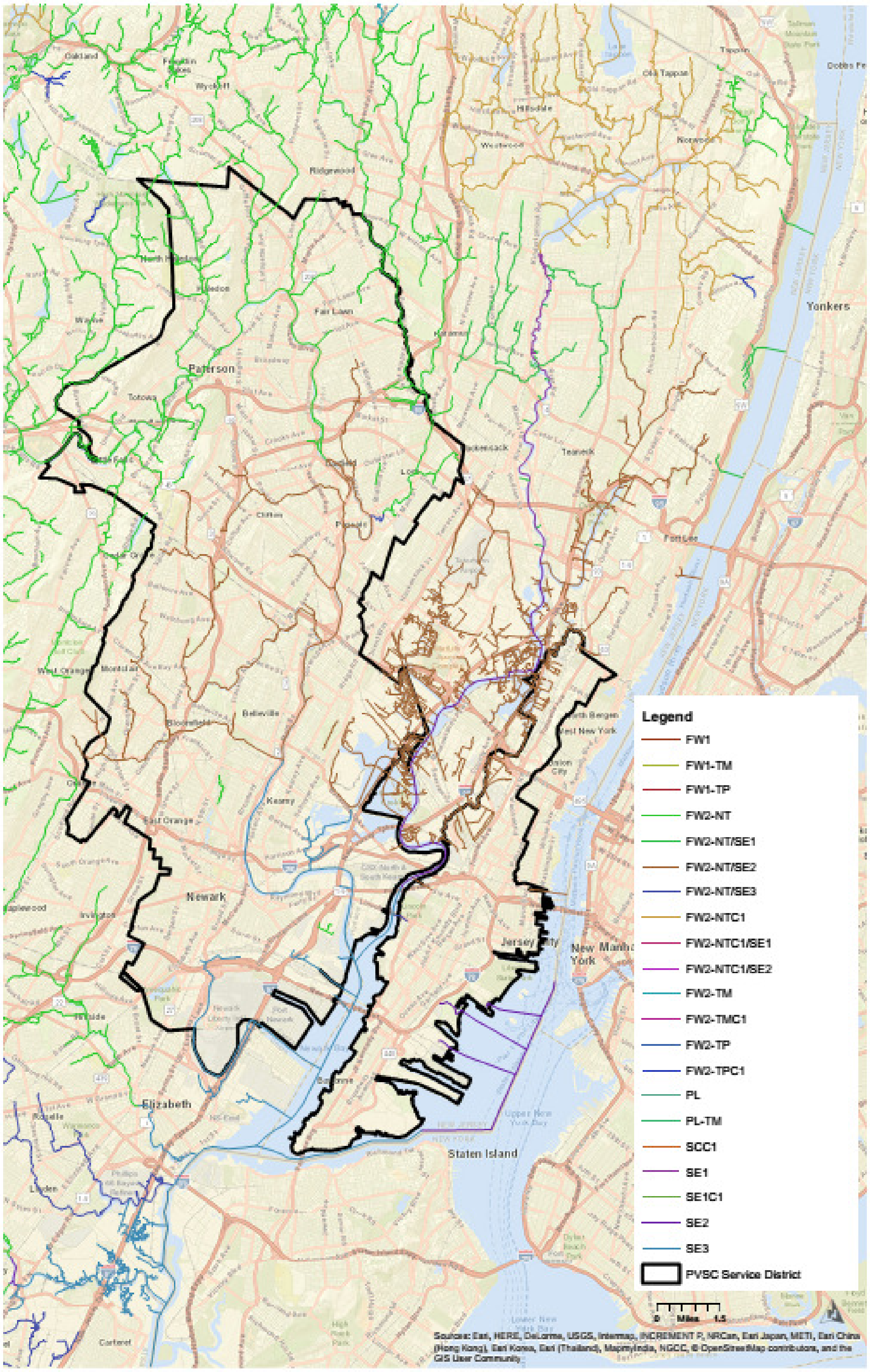

Figure B-4: N.J.A.C. Classifications of PVSC Treatment District Waterbodies

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 #
North Bergen MUA (Woodcliff)	NJ0029084
Town of Guttenberg	NJ0108715

In order to determine the appropriate combined sewer overflow control technologies, a review of 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 EPA'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 ("POC") and CSO control goals in order to achieve compliance with the CWA. The control technologies were screened based on the following POCs 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

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.

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 and final 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.

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

- **Source Controls:** Green infrastructure; 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-2, **Table C-3** and **Table C-4**, 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 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 Evaluation of Alternatives Reports.

C.2 SOURCE CONTROL

The EPA 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 measureable 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 is 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 Passaic Valley Sewerage Commission (PVSC) and North Bergen Municipal Utilities Authority (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/.

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 acceptance 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.

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 has 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 ("TMDLs"). 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

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 EPA 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 memorandum 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 Woodcliff sewershed 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 Woodcliff sewershed publically-owned property.

C.2.5.1 Green Roofs

Green roofs have bioretention media that collect runoff to promote evapotranspiration and achieve water quality standards 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**.

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.

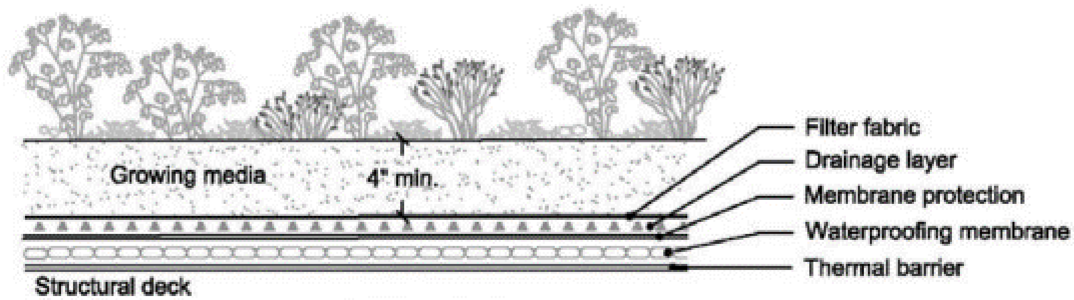

Figure C-1: Example Green Roof Section

Many rooftop retrofits are required for this GI technology to have measureable impact. Most of the buildings in the CSS are privately owned. Implementing this technology on a scale that would have a measureable 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 measureable 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 overflow events.

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.

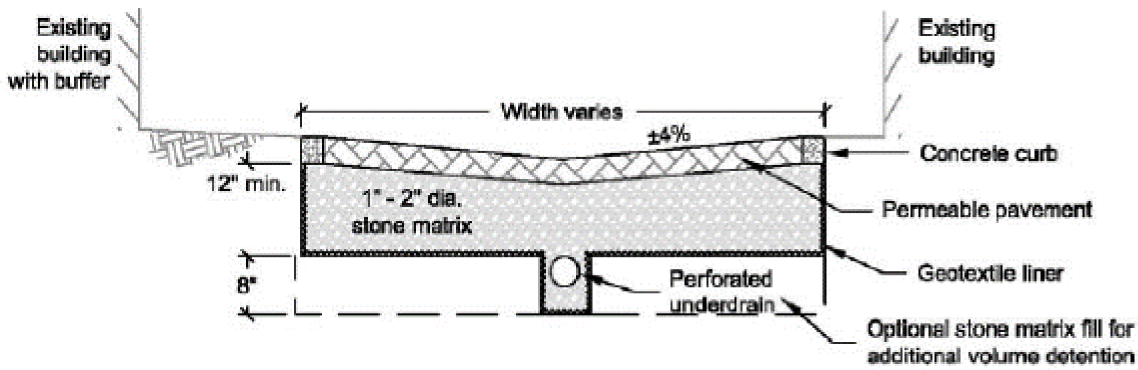

Figure C-3: Example Permeable Pavement Design near Existing Buildings

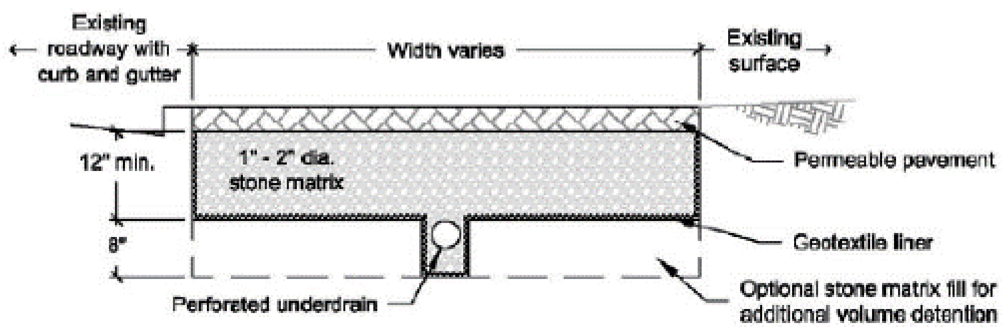

Figure C-4: Example Permeable Pavement Design near Existing Roadway and Surface

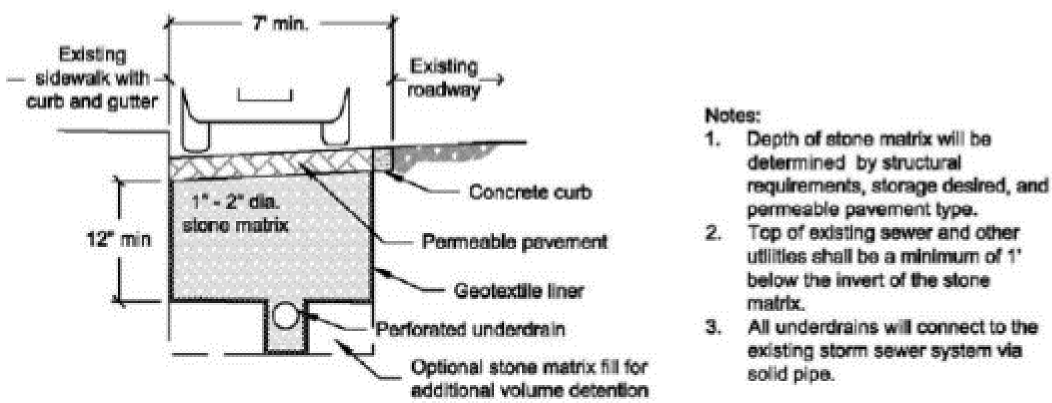

Figure C-5: Example Permeable Pavement Design near Existing Roadway and Sidewalk

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 Bumpout 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.

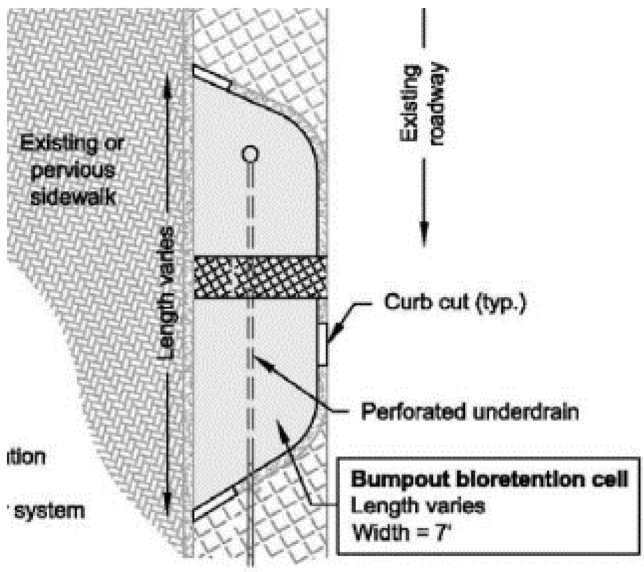

Figure C-6: Example Planter Bumpout Section

There are two (2) primary sizes of planter boxes for use based on the drainage pattern in developed areas: sidewalk planter boxes and bumpout planter boxes. Sidewalk planter boxes may also be more specifically referred to as a Tree Well Best Management Practice (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. Bumpout 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**.

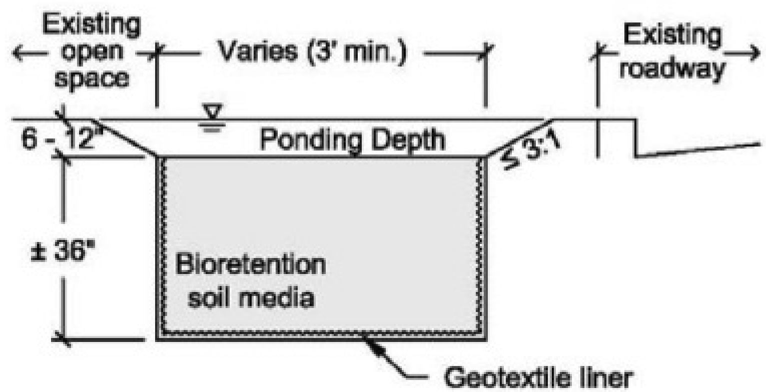

Figure C-7: Example Bioswale Design

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**.

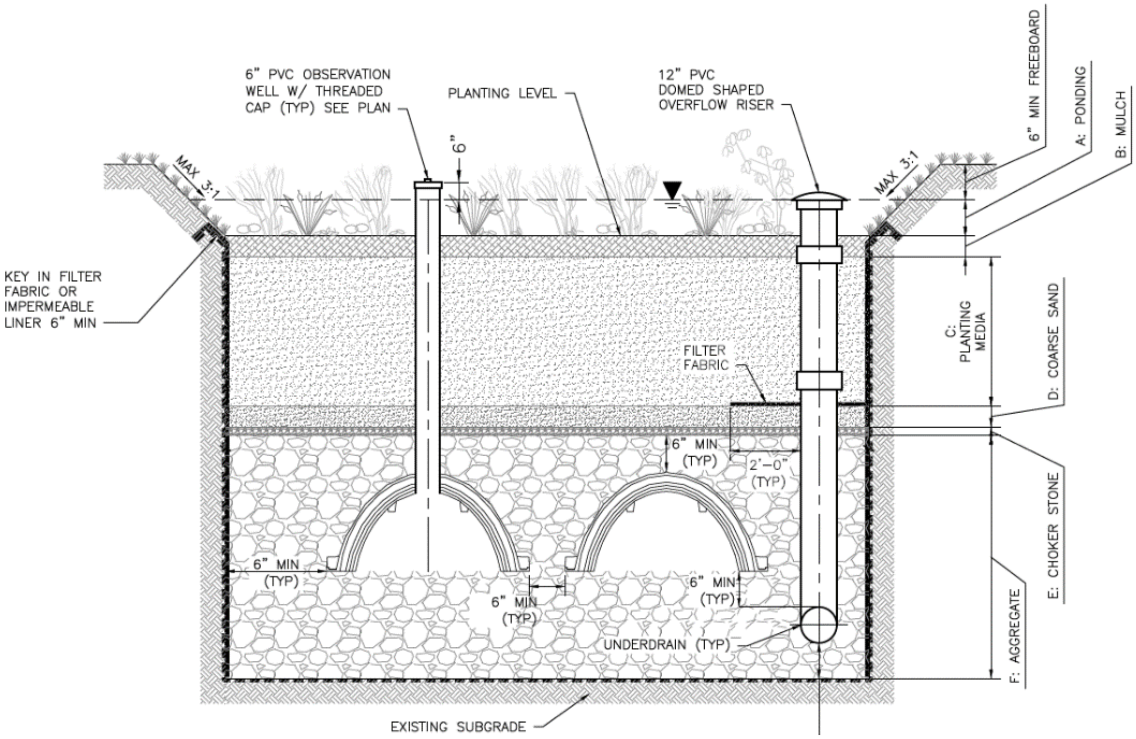

Figure C-8: Example Free-Form Rain Garden Design

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 operation and maintenance (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 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 the volume and frequency of CSO events 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 the frequency and volume of CSO events. 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 Hydrologic and Hydraulic (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 operate systems controls to maximize the storage capacity of the CSS and limit overflow 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 control, 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 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 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 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.

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 the quantity and frequency of CSO 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 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.

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 WRTP. 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 STP EXPANSION 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.

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 an overflow 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 overflow events 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 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 - 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). 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 two (2) municipalities for screening of the control technologies are presented in this Section. **Table C-2** presents the source control technologies, **Table C-3** presents the collection system technologies and **Table C-4** presents the storage and treatment technologies. Screening tables filled out by each municipality are presented in the individual Evaluation of Alternatives Reports in **Appendix A** and **Appendix B**.

Table C-2: 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		

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.	Yes		
	Illegal Dumping Control	Low	None	▪ Water quality improvements ▪ Aesthetic benefits	Enforcement of current law requires large number of code enforcement personnel; recycling sites maintained. Local ordinances already in place can be used as needed to address illegal dumping complaints.	Yes		
	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		
	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 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		

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.	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.	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	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	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.	Yes		

Table C-3: 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-4: 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-WRTP	Additional Treatment Capacity	High	High	▪ Water quality improvements ▪ Reduced surface flooding	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					
				▪ Reduced basement sewage 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 Township of North Bergen (within the Woodcliff sewershed) and the Town of Guttenberg, the approaches selected to perform the evaluations, and the factors used to evaluate each of the alternatives. Wastewater flows from both areas are conveyed to the Woodcliff STP which is operated by the NBMUA. The Town of Guttenberg and NBMUA, when discussed in conjunction, will be referred to as permittees. As part of this evaluation, four (4) alternatives were developed each for the Township of North Bergen and for the Town of Guttenberg.

For the Township of North Bergen, each of the alternatives presented is a combination of controls to manage CSOs in the Woodcliff service area. The CSO control technologies were evaluated for varying levels of control, including up to 0, 4, 8, 12, and 20 overflow events per year. For the Town of Guttenberg, the alternatives presented are standalone CSO control technologies with the associated capture volume and number of overflow events expected after implementation.

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 Environmental Protection Agency's (EPA) National CSO Policy and the N.J.A.C., a reasonable range of CSO control alternatives must be evaluated to meet the water quality-based requirements of the Clean Water Act (CWA).

NBMUA provides for much of the regional collection, conveyance, and all of the treatment of sewage in the sewershed. NBMUA's preliminary alternatives focus on CSO bacteria reduction and volume reduction.

Development of Alternatives

The preliminary alternatives were developed using the overflow control technologies identified as feasible for implementation by the *Development and Evaluation of Alternatives Report for the Township of North Bergen (Woodcliff)* and *the Town of Guttenberg Development and Evaluation of Alternatives Report*. Control technologies used for alternatives include storage tanks, Peracetic Acid (PAA) disinfection, upgrades to the Woodcliff Sewage Treatment Plant, inflow and infiltration (I/I) reduction, separation of the Galaxy Towers sewage system, and green infrastructure. The resulting alternatives for the two municipalities in the Woodcliff STP sewershed are listed in **Table D-1** below.

Table D-1: Woodcliff STP Sewershed Alternatives

NBMUA Woodcliff		
Alternative	Description	Overflow Events per Year
No. 1	Complete sewer separation	$\leq 0, \leq 4, \leq 8, \leq 12, \leq 20$
No. 2	Storage Tanks	$\leq 0, \leq 4, \leq 8, \leq 12, \leq 20$
No. 3	PAA Disinfection	$\leq 0, \leq 4, \leq 8, \leq 12, \leq 20$
No. 4	Green Infrastructure Cover	-
Town of Guttenberg		
Alternative	Description	
No. 1	Reduction of Infiltration/Inflow	
No. 2	Expansion of Woodcliff Treatment Plant[1]	
No. 3	Galaxy Tower - Storm and Sanitary sewer separation	
No. 4	Green Infrastructure – Green roofs, planter boxes, rain barrels	

[1]Ongoing efforts include upgrades to the Woodcliff STP, I/I reduction, and separation of the Galaxy Towers sewage system.

Evaluation factors for the analysis of alternatives are discussed below. Factors include siting, institutional issues, concerns regarding implementation, public acceptance, 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. The siting is discussed in individual reports in **Appendix A** and **Appendix B**. Space is at a premium in the Town of Guttenberg, as it is the most densely populated municipality in the United States. With very few large lots, undeveloped lots, and public land not dedicated to municipal buildings or urban parks, large-scale projects such as tanks or treatment plants rely heavily on the Township of North Bergen, with the Town of Guttenberg favoring decentralized, small projects.

D.1.3 Institutional Issues

The Township of North Bergen is a densely developed urban municipality with poverty levels at or above the state average. It is crucial that CSO control measures that are technically feasible for the NBMUA Woodcliff are also financially feasible. Context on the institutional issues, as well as the further discussion of institutional issues can be found in the individual report in **Appendix A**.

The Town of Guttenberg does not have its own sewer department, so operation of the sewer System is contracted to the NBMUA. The evaluation of alternatives should consider non-technical and low-maintenance installations in Guttenberg that could be fulfilled by the Town of Guttenberg Department of Public Works. Operator-intensive alternatives are problematic and would require either the establishment of a Sewer Department or an amended agreement between the Town of Guttenberg and NBMUA. In addition to the lack of available space in Guttenberg, point storage such as tanks requires flow- and cost-sharing agreements between the municipalities as they do not own the plant. These institutional issues are discussed further in the individual report in **Appendix B**.

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.1.3 and D.1.5 for specific discussions about public acceptance 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 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** and in the individual reports in **Appendix A** and **Appendix B**.

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, obtaining public input has been and will continue to be solicited throughout the development of the Long Term Control Plan.

The NBMUA and the Town of Guttenberg have continuously requested 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, 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 green infrastructure as a part of the CSO controls. This evaluation of alternatives has considered green infrastructure and is discussed further within this Report.

Any potential public acceptance concerns deemed applicable to an alternative are further discussed in the appropriate alternative subsection found in Section D.2 and in the individual reports in **Appendix A** and **Appendix B**.

D.1.6 Performance Considerations

CSO control alternatives were generally evaluated using several measures, ranging from cost and performance to ancillary benefits and qualitative criteria. The alternative must also be able to perform well under intermittent and variable flow conditions. The NBMUA Woodcliff analysis considered a comprehensive set of reasonable alternatives with ranges of CSO control goals for volume of overflow events or pathogen reduction with the ability to beneficially integrate with the hydraulically connected communities. The analysis for the Town of Guttenberg used the reduction of the number and volume of overflow events as the primary criteria for evaluation.

The performance considerations are discussed further in the individual reports in **Appendix A** and **Appendix B**.

D.1.7 Cost

Cost is another significant evaluation factor in determining the feasibility of each alternative. Costs for each alternative described include capital costs and contingencies as described in each of the individual reports in Appendix A and Appendix B.

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

This section summarizes the alternatives for the Town of Guttenberg and the NBMUA Woodcliff. The permittees detailed the overflow captures and costs for each alternative evaluated in their individual reports, which are included in the following appendices:

- Appendix A: Evaluation of Alternatives Report for North Bergen MUA (Woodcliff)
- Appendix B: Evaluation of Alternatives Report for the Town of Guttenberg

The only preliminary solution to that is common to both of the permittees is an anticipated upgrade to the Woodcliff STP to expand capacity by adding a 2 MGD wet weather bypass that is blended with the plant effluent prior to discharge.

D.2.1 NORTH BERGEN MUNICIPAL UTILITY AUTHORITY CONTROLS

This section summarizes the five (5) alternatives that were determined through coordination facilitated by PVSC.

D.2.1.1 Tank Storage

The conceptual evaluation of the storage tank for CSO reduction was performed. It is assumed that the storage tank would be located near the existing wastewater treatment plant or outfall and it would be below the ground. Only one storage tank is needed in the Woodcliff sewershed. The required storage and the annual overflow volume associated with the target number of CSO events per year are provided in **Table D-2** below.

Table D-2: Performance for Tank Storage

Target No. of CSO Events per Year	Require Storage (MG)	Overflow Volume (MG)	Volume Reduction [1]	Overflow Frequencies	Frequency Reduction [2]
≤ 0	1.8	0	100%	0	100%
≤ 4	0.9	1.7	87%	4	87%
≤ 8	0.7	2.5	81%	6	80%
≤ 12	0.5	4.2	68%	8	73%
≤ 20	0.2	8.8	33%	17	43%

[1] The baseline annual CSO volume (MG) is 13.2 MG (assuming that the Woodcliff STP will undergo an upgrade).
[2] The baseline annual CSO frequency is 30.

D.2.1.2 PAA Disinfection

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. The peak flow rate and the partially treated overflow volumes associated with the target number of CSO events per year are provided in **Table D-3** below.

Table D-3: Performance for PAA Disinfection

Target No. of CSO Events per Year	CSO Peak Flow Rates (MGD)	Partially Treated Overflow Volumes (MG)
≤ 0	34.7	0.0
≤ 4	18.7	1.4
≤ 8	10.3	4.0
≤ 12	9.3	4.3
≤ 20	4.9	8.0

D.2.1.3 STP Upgrade

The Woodcliff STP is operated by NBMUA and treats wastewater from the northeast section of the Township of North Bergen and the Town of Guttenberg. It has a rated capacity of 2.91 MGD with a wet weather capacity of 8 MGD. The plant is being upgraded to replace the secondary Lamella clarifiers with a membrane filtration system. The new membrane system will be sized to a dry weather flow of 3.46 MGD with a wet weather flow of 8 MGD. In addition to this, the plant will also have a 2 MGD wet weather bypass for a total plant capacity of 10 MGD. The capacity, average annual overflow events volumes and annual CSO event frequencies associated with the Woodcliff STP upgrades are provided in **Table D-4** below.

Table D-4: Impact of the Woodcliff STP Upgrades on CSOs

Attributes	Existing Conditions	Upgraded Conditions
Capacity (MGD)	8	10
Average Annual Overflow Event Volume (MG)	14.3	13.2
Annual CSO Events	30	30
Volume Reduction Per CSO Event (MG)		1.1
Percentage of Volume Reduction		8%

D.2.1.4 Green Infrastructure

Green Infrastructure can be used as a complementary CSO control technology in combination with other alternatives. This alternative targets management of 1" of stormwater runoff generated from 10% of the impervious surfaces in the NBMUA Woodcliff sewershed. The average annual overflow event volume, the CSO volume reduction and the CSO frequency associated with the green infrastructure alternative are provided in **Table D-5**.

Table D-5: Performance of Green Infrastructure

Attributes	Baseline	Management of 1" of Runoff from 10% of Impermeable Surfaces
Average Annual Overflow Event Volume (MG)	13.2	12.6
Overflow Event Frequencies	30	29
Volume Reduction Per CSO Event (MG)		0.6
Percentage of Volume Reduction		5%

D.2.1.5 Sewer Separation

Sewer separation is a process that typically involves the construction of new storm sewers to convey stormwater directly to the receiving water, leaving the existing combined sewers combined sewers to convey sanitary sewage and any remaining stormwater inputs. Sewer separation at the Township of North Bergen was previously found to represent the most expensive CSO control alternative. Also, there is a potential that future Municipal Separate Storm Sewer (MS4) permits may require treatment of the separated stormwater prior to discharge in the future. Despite these facts, sewer separation is a primary technology that would completely eliminate CSOs.

D.2.1.6 Summary of Cost Opinions - NBMUA

<u>Storage Tanks</u>

Storage tank capital costs are based on the latest available guidance for permittees. O&M costs for tanks are based on operational costs at $235,000 and maintenance costs at 3% of the construction cost. The capital costs, the O&M costs, the present-value (PV) of life-cycle, and the probable total project cost (PTPC) associated with Tank Storage are in **Table D-6**. The methods for ascertaining these values are provided in **Appendix A**.

Table D-6: CSO Control Alternatives Costs Summary

CSO Event Target/yr	Alternative ID	Raw Capital Cost ($M)	PTPC Capital Cost ($M)	20-yr O&M Cost as PV ($M)	Raw 20-yr Life Cycle Cost as PV ($M)	PTPC 20-yr Life Cycle Cost as PV ($M)
0	Alt_2A_0_Tank	$ 10.8	$ 26.9	$ 8.5	$ 19.2	$ 35.4
0	Alt_2B_0_PAA_FlexFilter	$ 9.5	$ 23.8	$ 2.0	$ 11.5	$ 25.8
0	Alt_2C_0_SewerSeparation	N/A	$ 47.0	$ 14.3	N/A	$ 61.3
4	Alt_3A_4_Tank	$ 7.1	$ 17.7	$ 6.8	$ 13.9	$ 24.5
4	Alt_3C_4_PAA_FlexFilter	$ 5.5	$ 13.7	$ 1.3	$ 6.8	$ 15.0
8	Alt_4A_8_Tank	$ 6.2	$ 15.5	$ 6.4	$ 12.6	$ 21.9
8	Alt_4C_8_PAA_FlexFilter	$ 3.4	$ 8.4	$ 0.9	$ 4.2	$ 9.3
12	Alt_5A_12_Tank	$ 4.5	$ 11.2	$ 5.6	$ 10.1	$ 16.8
12	Alt_5C_12_PAA_FlexFilter	$ 3.2	$ 7.9	$ 0.8	$ 4.0	$ 8.7
20	Alt_6A_20_Tank	$ 2.2	$ 5.6	$ 4.6	$ 6.9	$ 10.2
20	Alt_6C_20_PAA_FlexFilter	$ 1.9	$ 4.9	$ 0.6	$ 2.5	$ 5.5

<u>PAA Disinfection</u>
PAA Disinfection capital and O&M costs are based on the latest available guidance for permittees. The capital costs, the O&M costs, the present-value of life-cycle, and the probable total project cost associated with Tank Storage are in **Table D-6**. The methods for ascertaining these values are provided in **Appendix A**.

<u>Sewage Treatment Plant Upgrade</u>
The Woodcliff STP upgrades have a PV cost of $11,600,000 based on a capital cost of $5,800,000 and an additional $5,800,000 of O&M costs over a 20 year period. The calculations are explained further in **Appendix A**.

<u>Green Infrastructure</u>
The maximum PTPC 20 year Life Cycle PV cost for managing 1” of runoff generated by 5% of the impermeable surfaces in the Township of North Bergen portion of the Woodcliff STP service area with pervious concrete was estimated to be $7,643,000.

The maximum PTPC 20 year Life Cycle PV cost for managing 1” of runoff generated by 10% of the impermeable surfaces in the Township of North Bergen portion of the Woodcliff STP service area with pervious concrete was estimated to be $15,286,000.

Although a variety of green infrastructure technologies may suit this purpose, the option of using green roofs was eliminated because of the high cost and low implementation feasibility in a densely populated area. The cost of installing pervious concrete was the next most expensive option of the green infrastructure type, and thus was selected. The calculations are explained further in **Appendix A**.

Sewer Separation
The regulator drainage area is about 141 acres tributary to outfall NB004. Capital costs for complete sewer separation of this area is $47,021,808. This is based on a 2006 cost of $235,233 per acre normalized to 2018 cost of $333,488 per acre. 20 year O&M costs as PV are estimated at $14,300,000. The calculations are explained further in **Appendix A.**

Most Cost Effective Alternative
The most cost effective alternative is high rate filtration with PAA disinfection. This is the lowest costing alternative for all treatment options. To determine effectiveness of PAA without the FlexFilter or any other form of primary treatment (filtration), the potential need for primary treatment or performance of a pilot study may be included in subsequent discussions of this alternative.

D.2.2 TOWN OF GUTTENBERG CONTROLS

This section summarizes the four (4) preliminary alternatives proposed by the Town of Guttenberg for CSO management per the LTCP. Model results for baseline (i.e. existing) conditions for the typical year (2004) are shown in **Table D-7**.

- Alternative 1 – Reduction of Infiltration/Inflow
- Alternative 2 – Expansion of Woodcliff Treatment Plant
- Alternative 3A – Galaxy Tower (Storm sewer separation)
- Alternative 3B – Galaxy Tower (Sanitary sewer separation)
- Alternative 4A – Green Infrastructure (Green Roofs)
- Alternative 4B – Green Infrastructure (Planter Boxes)
- Alternative 4C – Green Infrastructure (Rain Barrels)

The preliminary alternatives selected by the Town of Guttenberg do not include wet weather capture volumes and cost for each overflow event condition (i.e. up to 0, 4, 8, 12, 20, and 85%) outside of the Woodcliff Treatment Plant Expansion and complete adoption of rain barrels by all homeowners. However, of the 4 alternatives shortlisted, none of the alternatives meet the 20 overflow event condition. Details of the screened alternatives are located in **Appendix B**.

Because none of the alternatives noted above were able to reduce the number of overflow events to 20 or less, consideration was given to separating the existing storm and sanitary flows in various portions of the Town Guttenberg. However, costs and significant technical challenges such as existing utilities in the ROWs make sewer separation difficult to implement in a cost effective way. As a result, sewer separation was not included as a proposed alternative for CSO Controls in the Town of Guttenberg.

Table D-7: Baseline Model Results for the Town of Guttenberg

Baseline Model	Wet Weather Capture	Number of Overflow Events
	78%	70

D.2.2.1 Infiltration Inflow (I/I) Reduction

There are ongoing efforts to address the I/I in the Town of Guttenberg collection system, which is currently estimated at approximately 480,000 gallons per day, roughly split between the main sewer lines and sewer connection laterals. The Town of Guttenberg does not believe that it is feasible to administer the responsibility for lateral repairs on property owners, although the Town will notify the property owners if excessive I/I is seen during the course of routine and ongoing video inspection.

For the purpose of this analysis, it is assumed that the I/I originating in the Town-owned lines will be reduced by approximately 25% (100,000 gallons per day). Several lines have already been designated (through an Administrative Consent Order with the EPA) for I/I mitigation; it is anticipated that this work will be done within the next five years. Additional area will be identified through upcoming CCTV inspection and will be incorporated into a Capital Improvement Plan going forward. By itself, I/I reduction has a minor impact on CSO performance, increasing capture to 79%, and reducing the number of overflow events to 61/year as shown in **Table D-8**.

D.2.2.2 STP Upgrade

The planned upgrades to the Woodcliff STP are discussed in detail in Section D.2.1.3. This report assumes that the Town of Guttenberg's share of the expanded treatment capacity is based upon the current dry weather flow split where 58% of the Woodcliff STP capacity is allocated to the Township of North Bergen and 42% is allocated to the Town of Guttenberg. The projected share of flow to be allocated to the Town of Guttenberg (4.2 MGD) for wet weather events is a significant increase over the current value of approximately 1.8 MGD. **Table D-8** shows the plant expansion results in a major improvement to system performance, increasing capture to 92% (meeting the target of 85%), and reducing the number of overflow events to 31/year.

D.2.2.3 Separation of the Galaxy Towers' Sewage System

The Galaxy Towers development is located near the Woodcliff STP, below a bluff that separates the majority of the Town of Guttenberg from the Hudson. The Town's CSO line runs through the Galaxy property; and storm water from the 5-acre complex is collected and pumped into the CSO line downstream of the regulator. The Galaxy Towers existing connection to the collection system does not impact the number of CSO events in the system, it can increase the volume of discharge. The details of the Galaxy Towers' connection to the collection system, as well as further discussion regarding the separation of the Galaxy Towers flow, can be found in **Appendix B**.

Design is currently under way to remove the Galaxy Towers' storm flow from the CSO line and discharge the stormwater flow, via gravity, to the County-owned storm system nearby; the Galaxy Towers' storm flow would discharge through a stormwater-only discharge approximately 500 feet upriver. The impact of stormwater separation at the Galaxy Towers was not modeled as flow data from the 50-story condominium complex was unavailable; therefore separation of the stormwater was treated as having no impact on the performance of the CSO although it could help resolve some localized flooding issues in the area. The sanitary flow separation will have a minor impact on CSO performance, increasing capture to 80%, and reducing the number of overflow events to 53 per year.

D.2.2.4 Green Infrastructure

The Town of Guttenberg is considering rezoning areas to encourage high-density development. These new developments could be encouraged to integrate a green roof system into their designs. It is estimated that runoff from approximately 10% of the rezoned area (6 acres) would be captured by green roof systems. Further discussion regarding the potential for green infrastructure in the Town of Guttenberg can be found in **Appendix B**.

Planter boxes and rain barrels were also considered for storm runoff capture. Although the planter boxes will not make a significant impact on CSO system performance because the areas where they can be placed are limited, they may have a positive impact on public acceptance of the overall LTCP.

Rain barrels were found to meet the performance criteria of 85% capture of typical wet weather flow; however, the modeled performance of the rain barrels is predicated upon 100% of homeowners installing the units. In reality, far fewer units would likely be installed, since many homeowners would refuse the units, and the Town is not likely to pass an ordinance mandating their use. As a result, performance of this alternative would be significantly less than modeled.

D.2.2.5 Summary of Cost Opinions – Town of Guttenberg

A summary of the alternative costs, wet weather flow capture, and project status can be found in **Table D-8**. The development of costs presented in this summary are further detailed in **Appendix B**.

<u>Alternative 1 – Reduction of Infiltration/Inflow</u>
The estimated capital cost for the already designated work is $1,500,000. The repairs, pipelining and cleaning are expected to be completed by the year 2024.

<u>Alternative 2 – Expansion of Woodcliff Treatment Plant</u>
The Town of Guttenberg's share of the expansion cost of the treatment capacity is based upon the current dry weather flow split where 58% of the Woodcliff STP capacity is allocated to the Township of North Bergen and 42% is allocated to the Town of Guttenberg. Total cost for the Woodcliff STP expansion is set to cost $20,000,000 of which 20% ($4,000,000) will be used for wet weather management.

<u>Alternative 3 – Galaxy Tower (storm sewer and sanitary sewer separation)</u>
Design is currently under way to remove the Galaxy storm flow from the CSO line and discharge it via gravity to the County-owned storm system. There is an estimated capital cost of $160,000 for this construction. The sanitary sewer separation is to be completed in the near future according to the Town of Guttenberg. This construction has an estimated capital cost of $540,000.

Table D-8: Summary of Cost, Capture, and Status of Alternatives for the Town of Guttenberg

Alt #	Alternative	Wet Weather Capture (%)	Number of Overflow Events	Useful Life (years)	Capital Cost ($)	Annual O&M Costs ($)	Annualized Cost ($)	Status (If Applicable)	Notes/Comments
1	Reduction of Infiltration/Inflow	79%	61	50	$1,500,000	$2,800	$58,360	Work is ongoing as part of a five-year plan through 2024	Overall I/I in the Town of Guttenberg system is currently estimated at approximately 480,000 GPD, Control to reduce I/I by 25% (100 GPD)
2	Expansion of Woodcliff Treatment Plant	92%	31	50	$1,680,000	$3,112	$65,342	Upgrade in process	Flow for the Town of Guttenberg will increase from 1.8 MG to 4.2 MG. The Town of Guttenberg pays for 42% of the expansion cost
3	Separation of Galaxy Towers Flow	80%	53	50	$700,000	$1,111	$23,336	Work is anticipated to be completed in 2019 for stormwater separation. Sanitary sewer improvements to be completed in the near future.	Flow data from Galaxy Tower is unavailable. No modeling was done. Town assumed zero impact on overflow capture for stormwater separation. The existing line would need to be replaced with a larger main to incorporate approximately 0.25 MGD of sanitary flow.
4A	Green Infrastructure - Green Roofs	N/A	N/A	20	N/A	N/A	N/A		No cost for now. No capture reduction because of limited acreage. Transfer supposed cost to developers and provide tax incentives.
4B	Green Infrastructure - Planter Boxes	N/A	N/A	20	$415,000	$1,750	$29,004		No benefit to CSO Capture. May impact public acceptance of the overall LTCP.
4C	Green Infrastructure - Rain Barrels	90%	66	10	$370,000	$2,141	$44,965		Cost and capture based on 100% public participation. This will include the 1,200 buildings in the Town of Guttenberg. But a more realistic participation percentage is 10%

<u>Alternative 4 – Green Infrastructure</u>
The estimated cost for installing green roofs is unknown at this time - since the green roofs would be installed on private property, the construction costs would be borne by the developers, not the Town of Guttenberg. Rather, costs to the Town would be in the form of tax credits and/or rebates that would be provided to the high-density apartment developers to incentivize the integration of green roofs. An approach to incentivize green roofs will be identified upon finalizing the LTCP, the cost of green roofs to the Town will then be able to be estimated.

The estimated capital cost for the installation of 250 planter boxes is approximately $415,000, and the annual replacement of vegetation is included in the annual cost.

There are approximately 1,200 buildings in the Town; the actual number of barrels would depend on how many property owners are receptive to the program. But assuming 100% participation (though unlikely), the estimated construction cost for the installation of 1,200 rain barrels is approximately $370,000. Additionally, the estimated administrative cost to implement a successful rain barrel program is approximately $12,000-15,000.

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. This Section provides an overview of the evaluation factors and regulatory compliance requirements applicable to the evaluation of the alternatives stated in this report.

D.3.1 Evaluation Factors

The evaluation factors comprise of cost and non-cost factors deemed important for alternatives analysis. Evaluated factors such as cost and performance (level of CSO control), are summarized in Sections D.2.1.6 and D.2.2.5. Non-cost factors as discussed in Section D.1. Additional factors, such as public factors, water quality, Public health, and environmental impacts, operational impacts, and implementation concerns, will be taken into account in the next step when an alternative is being selected.

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. The analysis was performed for several levels of CSO controls: the reduction of CSS overflow event frequencies to maximums of 0, 4, 8, 12, and 20 events per year. A summary of cost opinions vs performance, detailed in Sections D.2.1.6 and D.2.2.5, was performed to assist in the evaluation of CSO controls.

D.3.3 Selection of Preliminary Alternatives

As discussed above, the selection of the regional alternative will be determined after this Woodcliff 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 Selection and Implementation of Alternatives Report in the Final LTCP, due on June 1, 2020.

SECTION E - REFERENCES

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SECTION F - ABBREVIATIONS

BMP: Best Management Practice
BOD: Biochemical Oxygen Demand
CSO: Combined Sewer Overflow
CSS: Combined Sewer System
CWA: Clean Water Act
DWF: Dry Weather Flow
EPA: United States Environmental Protection Agency
ESI: Environmental Sensitivity Index
GI: Green Infrastructure
GIS: Geographic Information System
GPD: Gallons Per Day
HDD: Horizontal Directional Drilling
H&H: Hydrologic and Hydraulic
LTCP: Long Term Control Plan
MG: Million Gallons
MGD: Million Gallons Per Day
NBMUA: North Bergen Municipal Utilities Authority
NJPDES New Jersey Pollutant Discharge Elimination System
NMC: Nine Minimum Controls
O&M: Operations and Maintenance
PAA: Peracetic Acid
PCBs: Polychlorinated Biphenyls
PTPC: Probable Total Project Cost
PV: Present Value
QAPP: Quality Assurance Project Plan
RTC: Real Time Control
SSS: Separate Sewer System
STP: Sewage Treatment Plant
TSS: Total Suspended Solids
USEPA: United States Environmental Protection Agency
UV: Ultraviolet
WRRF: Water Resources Recovery Facility
WRTP: Wastewater Reclamation Treatment Plant

APPENDIX A

Development and Evaluation of Alternatives Report
North Bergen MUA - Woodcliff

Dated: June 2019

(NO TEXT THIS PAGE)

Development and Evaluation of Alternatives Report

Township of North Bergen MUA-Woodcliff

June 2019

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Executive Summary

Section A Introduction

This report is the evaluation of CSO control alternatives for the North Bergen MUA-Woodcliff where flows are conveyed to the Woodcliff Sewage Treatment Plant.

The Township of North Bergen is a densely populated town in Hudson County, New Jersey. The northeast section discharges wastewater to the Woodcliff Sewage Treatment Plant. Plant effluent and CSO is discharged to the Hudson River. The drainage area for the Woodcliff plant is about 180 acres. Approximately 141 acres are serviced by the combined sewer system and 39 acres are serviced by separated sewer system. Only one CSO outfall discharges CSO to the Hudson River under NJPDES Permit No. NJ0029084 for Regulator NB004.

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, or July 1, 2019. To meet this regulatory requirement, the Woodcliff Sewage Treatment Plant in the Township of North Bergen prepared this report for the development and evaluation of CSO control measures. Various alternatives are being considered for the North Bergen-Woodcliff Wastewater Treatment Plant's LTCP including source control technologies, storage technologies, and treatment technologies.

Section B Future Conditions

B.1 Introduction

The Woodcliff Sewage Treatment Plant treats wastewater from the northeast section of the Township of North Bergen and Guttenberg. It has a rated capacity of 2.91 MGD with a wet weather capacity of 8 MGD. The plant is being upgraded to replace the secondary Lamella clarifiers with a membrane filtration system. The new membrane system will be sized to a dry weather flow of 3.46 MGD with a wet weather flow of 8 MGD. In addition to this, the plant will also have a 2 MGD wet weather bypass for a total plant capacity of 10 MGD. This provides the plant with an additional 2 MGD for treating CSOs from the Township of North Bergen and Guttenberg as an interim measure. The Township of North Bergen would like to make this interim measure a condition of the LTCP. As will be discussed later in this report, this capacity has been assumed to be a baseline CSO control.

The cost of the upgrade is approximately $20M. Fifty percent of the cost is associated with expanded and improved treatment of CSOs. Membranes will provided a higher degree of treatment of CSO and the bypass will increase the plant's wet weather capacity by 2 MGD.

B.2 Projections for Population Growth

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.

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

B.3 Planned Projects

Several development projects are in the planning stages in the Township of North Bergen that could contribute flow to the Woodcliff Sewage Treatment Plant. These projects will be summarized in the 2020 Selection and Implementation of Alternatives Report.

B.4 Projected Future Wastewater Flows

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

Section C Screening of CSO Control Technologies

C.1 Introduction

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

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

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

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

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

C.2 Source Control

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

As presented in Table C-1 (see Section C.9), source-control technologies can involve Stormwater Management, Public Education, Ordinance Enforcement, Good Housekeeping, and Green Infrastructure (GI). In the NJPDES permit, NJDEP recommends evaluation of the practical and technical feasibility of GI options as part of the alternatives development process. The Woodcliff Sewage Treatment Plant 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 (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 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 the Township of North Bergen's Woodcliff Sewage Treatment Plant drainage area, 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, North Bergen"* prepared by Rutgers University, identified a number of possible locations for GI opportunities in the City. 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 stormwater, "inflow" refers to *illicit* entry of flow from streams, tidal sources, or catch basins and similar structures in supposedly "separated" areas that are connected to the CSS.

Infiltration problems typically reflect a general overall deterioration of the sewer system and can be difficult to isolate and identify. Achieving significant reductions of infiltration can also be difficult and expensive. Infiltration control in Woodcliff Sewage Treatment Plant's

CSS is not a cost-effective method of CSO control for achieving the required CSO reductions.

C.4 Sewer System Optimization

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

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

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

Outfall Consolidation/Relocation: Combining and relocating outfalls can minimize the number of CSO control facilities and aid in their siting. This type of measure helps eliminate CSO discharges to sensitive areas or move discharge points to less sensitive areas. The measures may also lower operational requirements and reduce monitoring efforts. The solution generally involves routing overflows using new piping to a new discharge point. Outfall consolidation works best when the outfalls are in close proximity to each other, requiring limited modifications to the conveyance. The techniques can be effective in reducing high frequency, low volume CSOs. However, the Woodcliff Sewage Treatment Plant only has one CSO along a 2,500 foot stretch of the Hudson 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. 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 North Bergen-Woodcliff.

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

The Woodcliff Sewage Treatment Plant treats wastewater from the northeast section of the Township of North Bergen and Guttenberg. It has a rated capacity of 2.91 MGD with a wet weather capacity of 8 MGD. The plant is being upgraded to replace the secondary Lamella clarifiers with a membrane filtration system. The new membrane system will be sized to a dry weather flow of 3.46 MGD with a wet weather flow of 8 MGD. In addition to this, the plant will also have a 2 MGD wet weather bypass for a total plant capacity of 10 MGD. This provides the plant with an additional 2 MGD for treating CSO from the Township of North Bergen and Guttenberg as an interim measure. The Township of North Bergen would like to make this interim measure a condition of the LTCP. As will be discussed later in this report, this capacity has been assumed to be a baseline CSO control.

C.7 Sewer Separation

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

C.8 Treatment of CSO Discharges

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

- High – Technologies that will have a significant impact (≥ 65%) on this CSO control goal and are among the best technologies available to achieve that goal. Therefore, they may be considered for further evaluation.
- Medium – Technologies that are effective at achieving the CSO control goal (35-65%), but are not considered among the most effective technologies to achieve that goal.
- Low – Technologies that will have a minor impact (≤ 35%) on this CSO control goal. Therefore, they will need other positive attributes to be considered for further evaluation.

- None – Technology that will have zero or negative effect on the CSO control goals.

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

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

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

Table C-1. CSO Control Technology Screening Results

Township of North Bergen								
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Source Control Technologies								
Stormwater Management	Street/Parking Lot Storage (Catch Basin Control)	Low	Low	- 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	Yes
	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	No	Yes
	Catch Basin Modification (Leaching)	Low	Low	- Reduced surface flooding potential - Water quality improvements	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No	No	Yes
Public Education and Outreach	Water Conservation	None	Low	- Reduced surface flooding potential - Align with goals for a sustainable community	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume, but would have little impact on peak flows.	Yes	No	Yes
	Catch Basin Stenciling	None	None	- Align with goals for a sustainable community	Inexpensive; easy to implement; public education. Is only as effective as the public's acceptance and understanding of the message. Public outreach programs would have a more effective result.	Yes	Yes	Yes
	Community Cleanup Programs	None	None	- Water quality improvements - Align with goals for a sustainable community	Inexpensive; sense of community ownership; educational BMP; aesthetic enhancement. Community cleanups are inexpensive and build ownership in the city.	Yes	Yes	Yes
	Public Outreach Programs	Low	None	- Align with goals for a sustainable community	Public education program is ongoing. Permittee should continue its public education program as control measures demonstrate implementation of the NMC.	Yes	Yes	Yes
	FOG Program	Low	None	- Water quality improvements - Improves collection system efficiency	Requires communication with business owners; Permitee may not have enforcement authority. Reduces buildup and maintains flow capacity. Only as effective as business owner cooperation.	Yes	No	Yes
	Garbage Disposal Restriction	Low	None	- Water quality improvements	Permitee may not be responsible for Garbage Disposal. This requires an increased allocation of resources for enforcement while providing very little reduction to wet weather CSO events.	Yes	No	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	No	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	No	Yes
	Hazardous Waste Collection	Low	None	- Water quality improvements	The N.J.A.C prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	Yes

Table C-1. CSO Control Technology Screening Results

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

Table C-1. CSO Control Technology Screening Results

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

Table C-1. CSO Control Technology Screening Results

Township of North Bergen								
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
	Free-Form Rain Gardens	Low	Medium	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community	Site specific; good BMP; minimal vegetation & mulch O&M requirements with regular overflow and underdrain cleaning; effective at containing, infiltrating and evapotranspirating diverted runoff. Rain Gardens are flexible and can be modified to fit into the previous areas. Underground infiltration beds or detention tanks can be utilized to increase storage.	Yes	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	Yes	Yes
	Advanced System Inspection & Maintenance	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	No	No
	Combined Sewer Flushing	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	No	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	Yes	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	No	Yes
	Sump Pump Disconnection	Low	Low	- Reduced basement sewage flooding	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The Cities are densely populated and disconnected sump pumps have limited options for discharge to pervious space. Disconnection may be coupled with other GI technologies but is not considered an effective standalone option.	Yes	No	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	No	Yes
Combined Sewer Optimization	Additional Conveyance	High	High	- Water quality improvements - Reduced basement sewage flooding	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	No	No

Table C-1. CSO Control Technology Screening Results

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
Township of North Bergen								
	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. Permittees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	No	Yes
	Outfall Consolidation/ Relocation	High	High	- Water quality improvements - Passive and active recreational improvements	Lower operational requirements; may reduce permitting/monitoring; can be used in conjunction with storage & treatment technologies. Combining and relocating outfalls may lower operating costs and CSO flows. It can also direct flow away from specific areas.	Yes	No	Yes
	Real Time Control	High	High	- Water quality improvements - Reduced basement sewage flooding	Requires periodic inspection of flow elements; highly automated system; increased potential for sewer backups. RTC is only effective if additional storage capacity is present in the system.	Yes	No	Yes
Storage and Treatment Technologies								
Linear Storage	Pipeline	High	High	- Water quality improvements - Reduced surface flooding potential - Local jobs	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	No	Yes
Linear Storage	Tunnel	High	High	- Water quality improvements - Reduced surface flooding potential	Requires small area at ground level relative to storage basins; disruptive at shaft locations; increased O&M burden.	No	No	Yes
Point Storage	Tank (Above or Below Ground)	High	High	- Water quality improvements - Reduced basement sewage flooding	Storage tanks typically require pumps to return wet weather flow to the system which will require additional O&M; disruptive to affected areas during construction. Several CSO outfalls have space available for tank storage. There may be existing tanks in abandoned commercial and industrial areas to be converted to hold stormwater. Tanks are an effective technology to reduce wet weather CSO's.	No	No	Yes
Point Storage	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
Treatment-CSO Facility	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	Yes
Treatment-CSO Facility	Netting	None	None	- Water quality improvements	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	Yes
Treatment-CSO Facility	Contaminant Booms	None	None	- Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	No
Treatment-CSO Facility	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	Yes

Table C-1. CSO Control Technology Screening Results

Township of North Bergen									
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation
		Bacteria Reduction	Volume Reduction					
	Disinfection & Satellite Treatment	High	None	- Water quality improvements - Reduced basement sewage flooding	Requires additional flow stabilizing measures; requires additional resources for maintenance; requires additional system analysis. Disinfection is an effective control to reduce bacteria and BOD in CSO's.	Yes	No	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.	Yes	No	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	No	No
Treatment-WRTP	Additional Treatment Capacity	High	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	May require additional space; increased O&M burden.	No	No	Yes
	Wet Weather Blending	Low	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	No	Yes
Treatment-Industrial	Industrial Pretreatment Program	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Requires cooperation with Industrial User's; more resources devoted to enforcement; depends on IU's to maintain treatment standards. May require Permits.	Yes	No	Yes

Section D Alternative Analysis

D.1 Development and Evaluation of Alternatives

D.1.1 Siting

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

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

D.1.2 Institutional Issues

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

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

D.1.3 Implementability

In addition to the cost, performance, 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. North Bergen-Woodcliff has waterfront land on the Hudson River which includes a waterfront park.

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 the sensitive area study report for the Township of North Bergen. The Hudson River is a habitat for Atlantic and Shortnose Sturgeon. The sturgeon populations in the Hudson River have been successfully recovering since the species have been listed as endangered, and the coinciding improvements in water quality since the 1970s have had a positive impact. The current level of CSO discharge is not preventing the recovery of a healthy adult sturgeon population for either species. Therefore, CSO discharges to sensitive areas is not an issue for this alternatives evaluation.

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

Reliability: Reliability of CSO control alternatives is a significant technical issue. The operating history of existing similar installations can help 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, PVSC and the Township of North Bergen itself have continued raising public awareness of the LTCP development through ongoing public participation activities, as stressed in the NJPDES permit, and EPA policy and related guidance for the LTCP.

PVSC has held several quarterly regional supplemental CSO team public meetings over the course of the LTCP development effort. Local meetings were held in conjunction with 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 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 Township of North Bergen has not received any comments on any of the draft LTCP submittals provided to the supplemental CSO team members for review and feedback. It is anticipated that the Township of North Bergen will present the results of alternatives evaluation in one additional regional supplemental CSO team public meeting to discuss and address public comments in the NJDEP submittal as it would be necessary.

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 an overview of various control alternatives developed for the Township of North Bergen. The preliminary alternatives with detailed evaluations are:

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

D.2.1 Controls

1) Inflow/Infiltration (I&I) Reduction

The reduction of inflow and infiltration (I&I) was evaluated as one of the source control solutions. Two scenarios were evaluated --10% and 50% of I/I reduction. Model results in Table D-1 show that for the 10% I&I reduction, only a marginal amount of annual average overflow volume (AAOV) was reduced per year, overflow frequencies did not change. For the 50% I/I reduction, about 6% CSO volume was reduced and number of CSO events was reduced once. It appears that this alternative has positive impact on CSO volume reduction because the hydraulic capacity of the system is freed up to some extent. However, the benefit of this control is minimal in terms of CSO volume and 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
NB004	13.2	30	13.0	30	2%	12.4	29	6%

Note: AAOV -- Annual Average Overflow Volume

2) Regulator Modifications

Regulators limit the amount of flows to the Hudson County force main and divert excess flow to the outfalls during wet weather events. Modification of the regulator, such as increasing the weir length or height, will retain flows back in the system. By raising the existing overflow weirs elevation 6 inches, the annual overflow volume was decreased from 13.2 MG to 10.8 MG per year, about 18% reduction and overflow frequencies decreased from 30 to 28. Table D-2 summarizes CSO volume and number of overflows for this alternative. It is noted that HGL downstream of regulators was increased maximum of 3.6 feet comparing with the baseline. However, no overflows from manholes were found. It indicates that there is a moderate capacity available for storage. This alternative could be considered further.

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

Regulator Modifications					
	Baseline		Increase Weir Height by 6 Inches		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction
NB004	13.2	30	10.8	28	18%

3) Green Infrastructure

GI can be used as a complementary CSO control technology in combination with other alternatives. This alternative was evaluated alone to find out if GI 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 stormwater runoff generated from 5% and 10% of impervious surfaces. On the Woodcliff side, the impervious area is about 100 acres. Table D-3 shows the CSO volume and frequency before and after the implementation of GI comparing with baseline. If 5% of impervious area (about 5 acres) was controlled by GI, we would expect 2% CSO volume reduction, and 5% CSO volume reduction with 10% of impervious area controlled with GI. Overflow events were barely eliminated for both scenarios. Because of the relatively small impact achievable with GI, HDR decided to evaluate all alternatives conservatively, without GI, with the assumption that any additional impact of GI, however minor, would be considered in the development of the final selected alternatives.

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

Green Infrastructure								
	Baseline		5% GI			10% GI		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction	AAOV (MG)	CSO Event	Volume Reduction
NB004	13.2	30	12.9	30	2%	12.6	29	5%

4) Treatment Plant Improvement

The Woodcliff Sewage Treatment Plant treats wastewater from the northeast section of the Township of North Bergen and Guttenberg. It has a rated capacity of 2.91 MGD with a wet weather capacity of 8 MGD. The plant is being upgraded to replace the secondary Lamella clarifiers with a membrane filtration system. The new membrane system will be sized to a dry weather flow of 3.46 MGD with a wet weather flow of 8 MGD. In addition to this, the plant will also have a 2 MGD wet weather bypass for a total plant capacity of 10 MGD. This provides the plant with an additional 2 MGD for treating CSO's from the Township of North Bergen and Guttenberg as an interim measure. Table D-4 summarizes the CSO reductions associated with the increase in flow capacity of the plant. While the upgrade will not reduce the number of CSO events, it will reduce the volume of CSO by 8%. The Township of North Bergen would like to make this interim measure a condition of the LTCP. As will be discussed later in this report, this capacity has been assumed to be a baseline CSO control.

Table D-4. Overflow Volumes and Frequencies with Treatment Plant Improvement

Woodcliff Treatment Plant Improvement					
	8 MGD		10 MGD		
Outfalls	AAOV (MG)	CSO Event	AAOV (MG)	CSO Event	Volume Reduction
NB004	14.3	30	13.2	30	8%

5) Storage Tank

The conceptual evaluation of the storage tank for CSO reduction was performed. It is assumed that the storage tank would be located near the existing wastewater treatment plant or outfall and it would be below the ground. Only one storage tank is needed in Woodcliff. CSO is stored in tank during wet weather events. The stored CSO is pumped back to the interceptor for conveyance to the PVSC treatment plant during dry weather and when 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 0 CSO control target. Overflows from the tank are the same as those listed in the January 7, 2019 Tech Memo "top 20 storm table" for each target. Table D-5 shows the size of tank required at each CSO frequency target. Table D-6 summarizes the CSO volume not captured and retained in the tanks at each frequency target. Table D-7 summarizes the overflow frequencies at each outfall. Storage tank alternative is considered as a primary solution for the CSO frequency control because other alternatives cannot reach the overflow events control target.

Table D-5. Storage Tank Size (MG)

CSO Event Target/yr	NB004
0	1.8
4	0.9
8	0.7
12	0.5
20	0.2

Table D-6. Overflow Volumes (MG) with Storage Tank Alternative

CSO Event Target/yr	NB004	Volume Reduction
Baseline	13.2	
0	0.0	**100%**
4	1.7	**87%**
8	2.5	**81%**
12	4.2	**68%**
20	8.8	**33%**

Table D-7. Overflow Frequencies with Storage Tank Alternative

CSO Event Target/yr	NB004	Frequency Reduction
Baseline	30	
0	0	**100%**
4	4	**87%**
8	6	**80%**
12	8	**73%**
20	17	**43%**

6) Treatment - PAA Disinfection

Disinfection of combined sewer overflows is another option in North Bergen-Woodcliff. Disinfection by Peracetic Acid (PAA) serves as the basis in the evaluation. 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 event per year, the 5th largest storm in the typical year will be fullydisinfected. CSO will be fully treated for flows below the design flow and partially treated for flows above the design flow. Full treatment is achieved only during times that flow rates of CSO discharges are less than the design peak flow. When full treatment is achieved, disinfection is assumed to remove 99.9% of pathogens (a “3-log kill.”). This preliminary disinfection alternative assumes that PAA disinfection will be implemented at location between the existing regulator and the existing outfall. Table D-8 presents the peak flow rates at each CSO control target and Table D-9 summarized the partially treated overflow volumes at each CSO control target.

Table D-8. CSO Peak Flow Rates (MGD) at Each Control Target

CSO Event Target/yr	NB004
0	34.7
4	18.7
8	10.3
12	9.3
20	4.9

Table D-9. Partially Treated Overflow Volumes (MG) at Each Control Target

CSO Event Target/yr	NB004	Volume Reduction
Baseline	13.2	
0	0.0	100%
4	1.4	89%
8	4.0	70%
12	4.3	67%
20	8.0	39%

D.2.2 Summary of Cost Opinions

Cost analysis was performed for potential alternatives including sewer separation, storage tank, PAA disinfection with FlexFilter, and GI in North Bergen-Woodcliff. Assumptions used to estimate capital and O&M costs are described as followings.

1. Sewer Separation Costs
    a. The combined sewer area is about 141 acres tributary to outfall NB004. Capital costs for complete sewer separation of this area is $47,021,842. This is based on a normalized cost of $235,233 per acre (2006, HMM). To convert to 2018 costs, a ratio of 10817:7630 was applied herein, based on the Engineering News Record (ENR) Construction Cost Index (CCI) values for 2018 and 2006, respectively and are in Table D-10.
    b. O&M costs are estimated based on 2% of the capital cost (2019c, G&H) and are in 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)

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.

i. 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.

ii. 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.

iii. Freight was estimated at a lump sum of $20,000.

iv. Sales tax was estimates at 8%

v. Permits were estimated at $20,000

vi. Start up, performance testing, operator training and O&M manual were estimated at $50,000

vii. 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.

viii. Engineering, administration and legal fees were estimated at 10%

ix. A contingency of 10% is included for the remaining equipment items and non-component costs.

Table D-10. CSO Control Alternatives Costs Summary

CSO Event Target/yr	Alternative ID	Raw Capital Cost ($M)	PTPC Capital Cost ($M)	20-Yr O&M Cost as PV ($M)	Raw 20-Yr Life Cycle Cost as PV($M)	PTPC 20-Yr Life Cycle Cost as PV($M)
0	Alt_2A_0_Tank	$ 10.8	$ 26.9	$ 8.5	$ 19.2	$ 35.4
0	Alt_2B_0_PAA_FlexFilter	$ 9.5	$ 23.8	$ 2.0	$ 11.5	$ 25.8
0	Alt_2C_0_Sewer Separation	N/A	$ 47.0	$ 14.3	N/A	$ 61.3
4	Alt_3A_4_Tank	$ 7.1	$ 17.7	$ 6.8	$ 13.9	$ 24.5
4	Alt_3C_4_PAA_FlexFilter	$ 5.5	$ 13.7	$ 1.3	$ 6.8	$ 15.0
8	Alt_4A_8_Tank	$ 6.2	$ 15.5	$ 6.4	$ 12.6	$ 21.9
8	Alt_4C_8_PAA_FlexFilter	$ 3.4	$ 8.4	$ 0.9	$ 4.2	$ 9.3
12	Alt_5A_12_Tank	$ 4.5	$ 11.2	$ 5.6	$ 10.1	$ 16.8
12	Alt_5C_12_PAA_FlexFilter	$ 3.2	$ 7.9	$ 0.8	$ 4.0	$ 8.7
20	Alt_6A_20_Tank	$ 2.2	$ 5.6	$ 4.6	$ 6.9	$ 10.2
20	Alt_6C_20_PAA_FlexFilter	$ 1.9	$ 4.9	$ 0.6	$ 2.5	$ 5.5

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 Table D-11 and Table D-12. Table D-11 shows the capital costs, O&M costs, and raw total 20-yr present value cost 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 reduced and $M/Impervious acre controlled.

Table D-11. Costs Summary for Green Infrastructure with Control of 5% and 10% Impervious Surfaces

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% (~5 acres)	Rain Garden	$ 1.2	$ 3.8	$ 0.6	$ 1.8	$ 4.4
	Right-of-Way Bioswale	$ 1.9	$ 6.2	$ 0.6	$ 2.5	$ 6.8
	Green Roof	$ 5.9	$ 30.2	$ 0.6	$ 6.5	$ 30.8
	Porous Asphalt	$ 3.2	$ 6.7	$ 0.1	$ 3.3	$ 6.8
	Pervious concrete	$ 3.8	$ 7.5	$ 0.1	$ 3.9	$ 7.6
	Permeable Interlocking Concrete Pavers	$ 1.6	$ 4.6	$ 0.1	$ 1.7	$ 4.7
10% (~10 acres)	Rain Garden	$ 2.4	$ 7.5	$ 1.2	$ 3.6	$ 8.8
	Right-of-Way Bioswale	$ 3.7	$ 12.4	$ 1.2	$ 4.9	$ 13.6
	Green Roof	$ 11.9	$ 60.4	$ 1.2	$ 13.1	$ 61.6
	Porous Asphalt	$ 6.4	$ 13.5	$ 0.2	$ 6.6	$ 13.7
	Pervious concrete	$ 7.5	$ 15.1	$ 0.2	$ 7.7	$ 15.3
	Permeable Interlocking Concrete Pavers	$ 3.2	$ 9.2	$ 0.2	$ 3.4	$ 9.3

Table D-12. Normalized Green Infrastructure Cost Ranges

	Green Infrastructure Type	Min $M/MG CSO Reduced	Max $M/MG CSO Reduced	Min $M/Impervious Acre Controlled	Max $M/Impervious Acre Controlled
Raw Cost	Rain Garden	$ 3.6	$ 7.0	$ 0.2	$ 0.4
	Right-of-Way Bioswale	$ 4.5	$ 10.3	$ 0.3	$ 0.6
	Green Roof	$ 9.9	$ 42.3	$ 0.6	$ 2.6
	Porous Asphalt	$ 4.6	$ 9.3	$ 0.3	$ 0.6
	Pervious concrete	$ 5.3	$ 10.4	$ 0.3	$ 0.6
	Permeable Interlocking Concrete Pavers	$ 2.5	$ 6.4	$ 0.1	$ 0.4
Probable Total Project Cost	Rain Garden	$ 6.0	$ 14.6	$ 0.4	$ 0.9
	Right-of-Way Bioswale	$ 8.2	$ 22.6	$ 0.5	$ 1.4
	Green Roof	$ 21.8	$ 102.7	$ 1.3	$ 6.2
	Porous Asphalt	$ 11.0	$ 22.8	$ 0.7	$ 1.4
	Pervious concrete	$ 12.9	$ 25.5	$ 0.8	$ 1.5
	Permeable Interlocking Concrete Pavers	$ 5.7	$ 15.6	$ 0.3	$ 0.9

The cost of upgrading the wastewater treatment plant with membranes and a bypass is $20M. Approximately 50% of the cost is associated with expanding and improving treatment of CSO which translates to $10M. The flow split between the Township of North Bergen and Guttenberg is 58% and 42% respectively; therefore, the capital cost for the Township of North Bergen's share of the upgrade is $5.8M. The O&M costs associated with CSO operations was estimated at 5% of the capital costs or $0.29M per year. Over 20 years the O&M cost would be $5.8M so the present value would be:

$5.8M capital + $5.8 M 20 years of O&M = $11.6M PV

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 at the Woodcliff Sewage Treatment Plant. Some of the evaluation factors have already been outlined in Sections D.1.1 through D.1.5. In general, the alternatives evaluation factors include, 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 NJPDES) requirements.

D.3.2 Regulatory Compliance

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

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

D.3.3 Selection of Preliminary Alternatives

The evaluation and screening of a range of control alternatives described above resulted in a trend toward the use of storage tank and disinfection technologies as the preliminary solutions based on the effectiveness of CSO volume and frequency control. Apparently, the most cost effective control measure is PAA disinfection with FlexFilter. The PAA process may be pilot tested before a final selection of the alternative is made. We may test PAA alone and with filtration. The impact of filtration on the PAA dosage and the cost of the PAA dosage compared to the lifecycle cost of a filtration system, likely a FlexFilter system, will be determined. The FlexFIlter system has been selected as a representative suspended solids removal technology. The final selection of a technology will be made based on the need for suspended solids removal. Although GI has limited impact on the CSO volume and frequency reductions, it can be used for its complimentary community benefits combined with storage or disinfection to reach CSO frequency control target. These evaluations of alternatives will serve as a base for the consideration and development of a final selected CSO control plan in North Bergen-Woodcliff. An example of the cost range of alternatives is shown in Table D-13.

Table D-13. CSO Control Costs Range

CSO Event Target/yr	Maximum PV Cost ($M)			Minimum PV Cost ($M)		
	Tank Storage	GI of 5% of Impervious Surface	Total Cost	PAA Disinfection with Flex Filter	GI of 5% of Impervious Surface	Total Cost
0	$ 35.4	$ 7.6	$ 43.0	$ 25.8	$ 7.6	$ 33.4
4	$ 24.5	$ 7.6	$ 32.1	$ 15.0	$ 7.6	$ 22.6
8	$ 21.9	$ 7.6	$ 29.5	$ 9.3	$ 7.6	$ 16.9
12	$ 16.8	$ 7.6	$ 24.5	$ 8.7	$ 7.6	$ 16.4
20	$ 10.2	$ 7.6	$ 17.9	$ 5.5	$ 7.6	$ 13.1

APPENDIX B

Development and Evaluation of Alternatives Report
Town of Guttenberg

Dated: June 2019

TOWN OF GUTTENBERG
NJPDES CSO PERMIT NO. NJ0108715

DEVELOPMENT AND EVALUATION OF ALTERNATIVES REPORT

PREPARED FOR

TOWN OF GUTTENBRG
6808 PARK AVENUE
GUTTENBERG, NJ 07093

PREPARED BY

REMINGTON & VERNICK ENGINEERS
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201-624-2137

JUNE 2019

RVE PROJECT NO.: 0903T022

REMINGTON & VERNICK ENGINEERS

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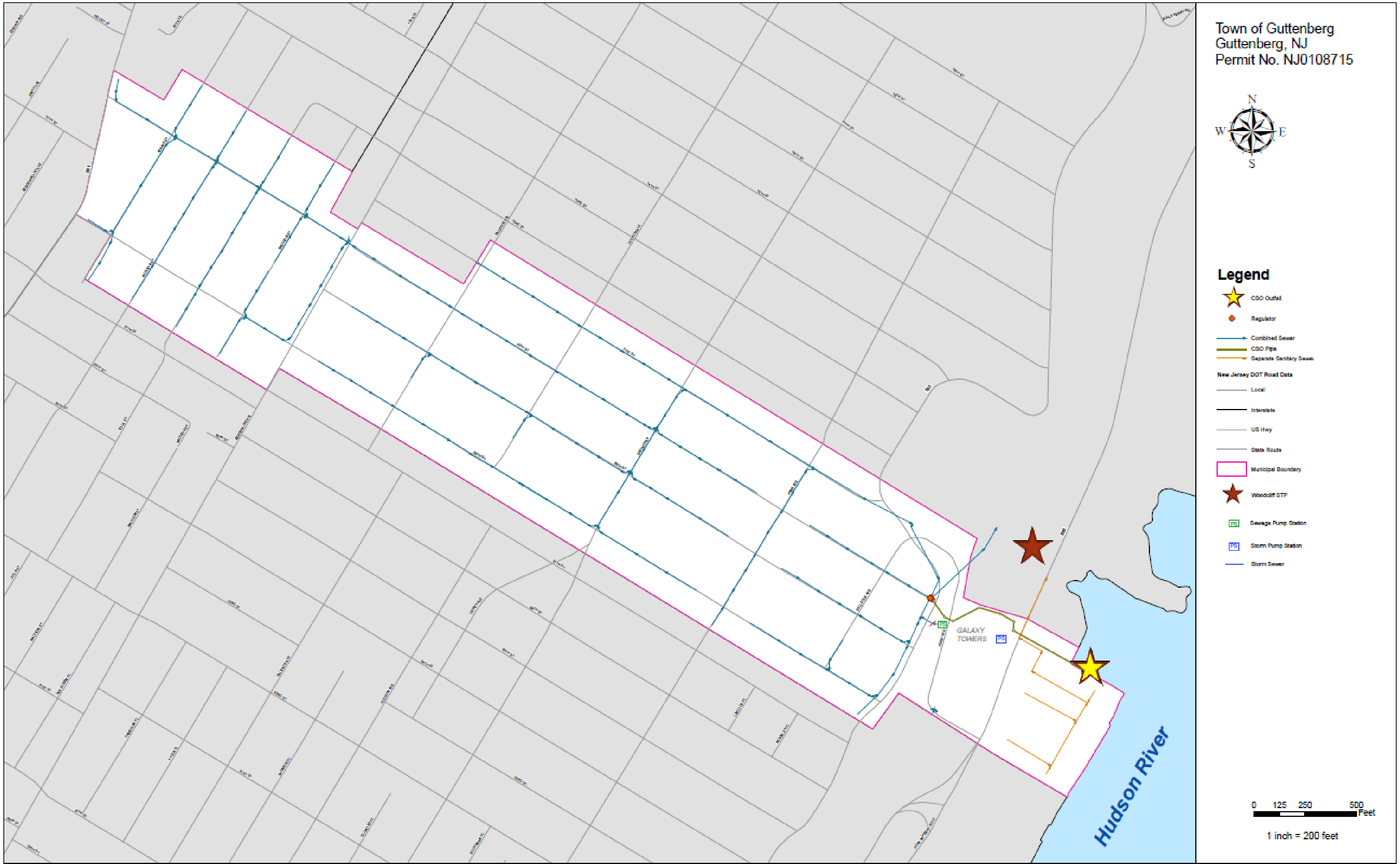
SECTION A INTRODUCTION

The Town of Guttenberg is located in Hudson County, New Jersey. It is bounded by The Township of North Bergen to the north and west, the Town of West New York to the south, and the Hudson River and New York City to the east. The Town has a population of approximately 11,700; with total area of approximately 124 acres, it is the most densely populated municipality in the United States.

The majority of the town (approximately 111 acres) is served by combined sewer system (see Figure A-1 for a system map). The combined sewer collection system conveys flow to the Woodcliff STP (owned by the North Bergen Municipal Utilities Authority, or NBMUA) for further treatment, and allows extreme wet weather flows discharging through a single combined sewer overflow (CSO) outfall located at the Hudson River. There is a small (approximately 13 acres) portion of the Town (to the east beneath the Palisades bluffs) that has separated sewers, with sanitary sewage flowing directly to the Woodcliff STP, and collected stormwater flow discharging into the river via Hudson County lines. Some separated storm water flow (from the Galaxy Towers residential high-rise) is pumped into the CSO line downstream of the regulator; a project is currently underway to relocate this flow to the County system, reducing discharge volume from the CSO during wet weather discharge.

The Town's combined flow to the Woodcliff plant is controlled by a single regulator chamber (known as Regulator G-1) located at the intersection of 71st Street and JFK Boulevard East. The regulator is currently set to allow wet weather flow of up to 1.8 MGD before bypassing flow to the CSO line. However, other factors at the STP (usually dependent on the intensity and duration of a precipitation event) can cause flow from Guttenberg to be throttled or suspended entirely, resulting in an overflow event at less than 1.8 MGD flow.

Guttenberg's combined sewer system operates under New Jersey Pollution Discharge Elimination System (NJPDES) Permit No. NJ0108715 (last renewed in 2015) allowing one combined sewer regulator to overflow to the Hudson River. Despite the fact that Guttenberg discharges no flow to the Passaic Valley Sewerage Commission (PVSC) treatment facility, it is considered part of the PVSC Group due to its relationship with the NBMUA (flow from the western portion of North Bergen is tributary to the PVSC system). As such, this Report has been prepared and formatted in accordance with PVSC guidance.



REMINGTON & VERNICK ENGINEERS

TOWN OF GUTTENBERG
CSO EVALUATION ALTERNATIVES REPORT
FIGURE A-1: GUTTENBERG SEWER SYSTEM

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SECTION B FUTURE CONDITIONS

B.1 INTRODUCTION

As an established urbanized community, Guttenberg is almost entirely built out, with nearly every lot developed to a significant extent. Very little capacity is available for organic population growth, with the exception of potential zoning changes to increase density

B.2 PROJECTIONS FOR POPULATION GROWTH

According to the North Jersey Transportation Planning Authority (NJTPA), the Town has a projected 2045 population of 12,000, an increase of only 2.5% over the current population of approximately 11,700.

B.3 PLANNED ZONING CHANGES

In September 2018, in accordance with the most recent Master Plan Reexamination Report for the Town, Guttenberg proposed the creation of a new high-rise (9-15 stories) residential zone (known as R-5) for certain areas of the Town now zoned for mid-rise (4-8 stories) residential use (known as R-4). The areas impacted by the proposed change are noted in Table B-1 below and shown on Figure B-1.

Table B-1 Proposed High-Rise Residential Areas

Area	Number of Lots Impacted	Affected Area (acres)
West of JFK Boulevard East (68th Street to 71st Street)	17	2.4
East of Kennedy Boulevard (west of Adams Street)	50	3.75
TOTAL	67	6.15

Because the proposed change also encourages lot consolidation, the anticipated impact of the zoning change will be less than would be expected by the number of lots impacted. The proposed up-zoning is expected to increase the Town's population by less than 1,000 residents.

B.4 PROJECTED FUTURE WASTEWATER FLOWS

The current dry weather sewage flow for the Town of Guttenberg is approximately 1.1 MGD which, at the current population of 11,700, results in an average per capita flow of 94 gpcd. Assuming that the currently proposed zoning change is adopted, the projected future sewage flow would be less than 0.100 MGD, or an increase of approximately 9% over current flows. Given the fact that wet weather combined flows are multiple times larger than the dry weather flows, and the fact that the development is vertical, with no increase in impervious surface, the projected increase in population is not anticipated to result in a significant impact to the number or volume of combined overflow events in the system.

SECTION C SCREENING OF CSO CONTROL TECHNOLOGIES

C.1 INTRODUCTION

As part of a standardized methodology for screening various CSO control technologies, PVSC and their consultants developed a list of various alternatives for all permittees to review. The purpose of the screening process is to eliminate those alternatives that are patently infeasible for a permittee and develop a small list of potential actions for further study (e.g., modeling). The list of potential controls is presented as Tables C-1 through C-3 at the end of this section, and a brief description of each is presented in the main body of this Report. The remainder of this Section discusses the applicability of the various options to the Guttenberg system, and the selection of options to be studied further in Section D.

C.2 SOURCE CONTROL

As noted in the main body of this Report, source control can be an effective way to reduce flows and bacterial loading to the combined sewer system, without costly “gray” construction projects. The several different categories of source control are discussed in the sections below and screened for their applicability and potential impacts on the Town of Guttenberg.

C.2.1 Stormwater Management

The Town of Guttenberg maintains approximately 175 storm water catch basins within its municipal boundaries (Hudson County maintains several other basins located on County roads). The basins are regularly inspected and cleaned (see Section C.2.4 below). The catch basins could potentially be modified to provide either floatables control or volume reduction (via leaching); however, these modifications carry a high price tag (for the replacement or modification of so many basins) and are expected to provide little to no reduction in bacteriological or volume loading.

The Town does encourage new, multifamily developments (typically “tear-down” projects replacing existing structures, due to the lack of undeveloped land in Town) to provide some level of storm water detention; however, these developments are privately owned and funded, and therefore not under the control of the Town. As a result, the alternatives in this section of the matrix will not be considered for inclusion as part of Guttenberg’s LTCP.

C.2.2 Public Outreach and Education

The Town currently pursues several forms of public outreach and education to increase awareness of storm water management. The Town’s water purveyor (Suez Water NJ) maintains a water conservation program through both bill stuffers and online material; the material is available in several languages. The Town provides for periodic hazardous waste collection events, in order to help keep these materials out of the sewer system; it also strongly encourages the immediate collection and bagging of pet waste, to keep it out of the catch basins and reduce the bacteriological loading on the system during wet weather.

Given the current level of outreach, it is unlikely that these methods could be increased to the extent that they result in a significant reduction in either bacterial or volume loading on the system. Other potential programs, such as stressing proper lawn and garden maintenance, are not likely to have much impact in a highly urbanized environment such as Guttenberg. Therefore, the alternatives in this section of the matrix were not considered for further study.

C.2.3 Ordinance Enforcement

The Town of Guttenberg has several ordinances that, while not directly related to storm water management, have beneficial impacts on bacterial loading. A pet waste pickup (i.e., "pooper scooper") ordinance keeps a significant amount of fecal matter out of the storm drains; anti-littering and illegal dumping ordinances also help improve runoff quality with regard to sediments and floatables, if not bacterial loading.

These ordinances do not impact the quantity of storm water flow to the sewer system. The one type of ordinance that does, an illegal connection ban, is not possible in a combined sewer system. There are no new general ordinances that would be anticipated to generate significant amounts of bacterial or volume reduction (except for possibly green infrastructure ordinances, which are discussed in subsequent sections); therefore, this type of control was not considered further in this Study.

C.2.4 Good Housekeeping

Guttenberg, through the Department of Public Works (DPW), performs several types of activities that help reduce sediment loading and floatables in the combined system. The Town runs a regular program of street sweeping to keep gutters clean, and contracts with outside vendors for regular recycling pickup, and for a leaf collection program in the fall (given the urbanized nature of the Town, the leaf collection program is not very large). As with some of the ordinances discussed in the previous section, these programs are primarily aesthetic in nature and do not have a significant impact on either bacterial or volume reduction in the system; therefore, this type of control was not considered further in this Study.

C.2.5 Green Infrastructure - Buildings

The majority of existing properties in Guttenberg are made up of either low- to mid-density residential or small business commercial buildings (the main exception being the Galaxy Towers high-rise development), privately owned. While it may be technically feasible to retrofit some of these building with green (or blue) roof technologies, the relatively large cost to the homeowners and the small roof areas of individual properties make this an unlikely approach for the Town to consider.

However, as discussed in Section B.3, the Town is currently considering some zoning changes, aimed at increasing the number of high-rise units in certain areas of the municipality (with a total area of approximately 6 acres). Specifically, the new zone (to be identified as "R-5") would encourage the consolidation of lots and the construction of new high-density (9-15 stories) developments. This presents an opportunity to pursue green roof technologies, for the following reasons:

- The green technologies can be designed integrally into the structures, reducing the incremental costs of the features; and
- The larger number of people residing in such development allows a wider base over which to spread costs, lowering the per-capita cost of the features.

Because the units will be privately-owned, it is unlikely that the Town would be able to mandate the inclusion of green roof technologies. However, their use could be encouraged by incentives (such as tax credits or rebates) to the developers. The cost to the Town in this case would not be a direct construction cost, but rather would be measured as a loss of tax income due to the credits and/or rebates. It is estimated that a total of 5-10% of the newly-zoned area could potentially be converted to green roofs.

In addition, the possibility exists for the incentive program to be structured for the retrofit of the Galaxy Towers complex; however, the potential barriers of implementation at Galaxy would be greater than those for new construction, including:

- Structural improvements to support the additional weight of the green features;
- Relocation of existing rooftop equipment, including HVAC systems; and
- Loss of usable space for other purposes.

Structured properly, a program incentivizing green roof technologies can provide a benefit to the Town in reducing flows to the combined sewer system. Therefore, this technology was designated for further consideration in this Study.

C.2.6 Green Infrastructure – Pervious and Impervious Areas

The Town of Guttenberg is nearly entirely covered with impermeable pavement (either asphalt or concrete). Insufficient areas of pervious surface are present in Town to make the use of green technologies such as bioswales or rain gardens feasible.

The use of permeable pavements would require the removal and replacement of existing surfaces (at significant cost), and would create maintenance problems going forward, as the pavement clogs in the future. In addition, permeable pavements are best suited for low-traffic areas such as parking lots, alleys and lanes; very few of these features exist in Guttenberg.

The use of planter boxes was considered; in a densely populated area such as Guttenberg, the loss of usable sidewalk area for pedestrians is considered to be a significant drawback. There may be some small areas in the Town where these boxes may be useful (such as commercial zones with wider sidewalks); their use will be considered by the Town as a part of this Study, but the limited availability of such land makes it unlikely that the boxes will make up a significant part of the Town's LTCP.

C.2.6 Green Infrastructure – Other

Another green infrastructure practice identified in this screening analysis is the use of rainwater harvesting (e.g., rain barrels, or cisterns). Rainwater harvesting is a simple, fairly inexpensive technology that can be used at individual buildings to capture, detain, and reuse runoff from rooftops. The units can be configured to either completely retain water, or to temporarily detain and slowly release water after the precipitation ends. There are approximately 1,200 buildings in Guttenberg that could potentially be fitted with rain barrels.

As with green roofs, these units would be installed on private property, with limited Town control over their use. However, the units could be directly purchased by the Town and given to homeowners and businesses, increasing the likelihood of adoption (this could be further increased via a mandatory use ordinance).

Given the potential impacts to volume reduction, and a relatively reasonable cost, rain barrels were designated for further consideration in this Study.

C.3 COLLECTION SYSTEM TECHNOLOGIES

This section focuses on potential improvements to the Town's combined collection system, with the goal of reducing peak flows to the regulator chamber and reducing the number of overflow events and/or the volume discharged in those events.

C.3.1 Operation and Maintenance Strategies

Similar to the Good Housekeeping practices of the previous section, these are activities the Town can perform to ensure the collection system is operating at peak efficiency, without new construction work. Of the four alternatives screened, three were rejected for further study.

Combined system flushing does not reduce the volume of overflow events, which is the primary concern for the Town. In addition, Guttenberg does not own its water system (Suez Water NJ), so use of the system as a source of flushing water can be prohibitively expensive.

Advanced system inspection and maintenance can provide valuable information regarding the condition and performance (both present and future) of the collection system; however, it does not have a direct impact on the goals of the LTCP and requires the commitment of additional resources and demands on a DPW that is already stretched thin by their many responsibilities. The program is worth reviewing for potential future implementation; however, for the purpose of this report, will not be considered further.

The DPW currently contracts with an outside vendor for catch basin cleaning services. Approximately 33% of the basins are cleaned and inspected each year; additional basins may be included if complaints are received from the public. The cleaning can reduce floatables and prevent localized backup, it has no impact on flow reduction, and minimal impact on bacterial loading. As such, it does not appear to be advantageous to increase the number or frequency of cleanings at this time, and it will not be considered further in this study.

C3.1.1 Infiltration and Inflow Control

The remaining alternative in this category is infiltration and inflow (I/I) reduction. I/I can add significant amounts of flow to the system, reducing its capacity to handle wet weather flows and potentially increasing the number and volume of CSO events. Reducing the amount of I/I is a common goal of nearly all sewer utilities.

I/I reduction was identified as a promising alternative for further study. For purposes of this report, it was assumed that only the main sewer lines will be inspected, and approximately 100,000 gpd will be eliminated. This figure can be revised later based upon the results of the Town-wide video survey.

C.3.2 Sewer System Optimization

Once the flow has entered the collection and conveyance system, this group of alternatives aims to ensure that the system is operating in such a way as to convey the most possible flow to the Woodcliff STP, instead of overflowing the weir at the regulator. Several alternatives were screened in this process (as described below); none were selected for further study.

Additional conveyance capacity in the system does not improve CSO performance in the absence of downstream improvements at the regulator and the treatment plant; while those are considered in the screening process and may be referred for further study, they do not depend on the increase of conveyance capacity.

Regulator modifications can potentially be made to maximize the flow to the Woodcliff STP. The regulator is periodically inspected by NBMUA and necessary modifications are made (most recently in July 2018). This process will continue in the future; however, it is unlikely that any improvements can be made to the process that would significantly improve on the current procedures, so this alternative will not be considered further.

With a single regulator and CSO outfall for the Town, outfall consolidation is not possible. With such a small riverfront (approximately 600 feet), there is nowhere that the outfall could be relocated. Therefore, both of these alternatives were dismissed.

C.3.3 Linear Storage (Increased Capacity in the Collection System)

Linear storage is designed to detain flow within the collection system (via the use of large pipes or culverts) and release it in a controlled manner after the precipitation event, when the treatment plant is able to receive and treat it. Control of the flow can be made either by gravity (weirs and orifices) or pumping systems.

Installation of the storage facilities is expensive; however, the amount of peak flow reduction may be such that the costs become worthwhile as part of the final LTCP. Therefore, linear storage was designated for further consideration in this Study.

C.3.4 Combined Sewer Separation

The ideal solution to the elimination of CSO event is, of course, the separation of storm and sanitary sewers. The sheer cost of constructing an entirely parallel system makes complete separation infeasible in almost every instance; even a small system like Guttenberg has over 20,000 linear feet (LF) of pipe that would need to be constructed. In addition, there may be areas in the Town where the locations of other utility lines prevent the installation of new sanitary sewer; requiring utility relocation which adds even more to the cost. Finally, the cost of modifying each building in Town to separate sanitary and storm discharge could be even greater than the cost of the new sanitary system itself.

Even if complete separation is nearly impossible, there may be some particular locations, or sections of the combined system, where storm and/or sanitary flow may be able to be separated from the main system, reducing the volume of wet weather flows through the regulator and potentially decreasing the number of overflow events. Several such locations were identified in the course of this analysis:

- Galaxy Towers Storm Flow
- Galaxy Towers Sanitary Flow
- New High-Rise Storm Flow
- Partial System Separation

Each of these scenarios will be discussed further in Section D of this Report.

C.4 STORAGE AND TREATMENT TECHNOLOGIES

The final group of potential alternatives addresses the system after the regulator and are aimed at reducing or preventing flow out of the CSO or providing sufficient treatment to reduce the microbiological load of the discharge.

C.4.1 Point Storage (Tanks)

This option would consist of the installation of a large storage tank to detain flow, that would otherwise be discharged through the CSO line, and later release it to the Woodcliff STP when flows are lower following the precipitation event. Because the Town does not own or operate the plant, this option cannot be implemented unilaterally by Guttenberg. Should the NBMUA decide to construct such a tank themselves, discussions would be held between the municipalities regarding flow- and cost-sharing agreements; however, the option will not be considered further in this study.

C4.2 Treatment of CSO Discharge

Given the fact that this technology does not reduce the number or the volume of overflow events in the system, and the fact that the receiving water already meets targets for bacteriological contamination, this technology does not provide a significant benefit to the system and will not be considered for further evaluation.

C4.3 STP Expansion or Storage at the Treatment Facility

Because Guttenberg does not own or operate their own treatment works facility, they cannot unilaterally implement any expansion or storage options at the Woodcliff STP for their flow. At this time, the NBMUA does not have any plans for combined sewer storage at the facility.

However, NBMUA is currently pursuing an expansion of the hydraulic capacity of their treatment plant, to which Guttenberg normally discharges. The plant expansion is designed to increase the hydraulic capacity of the plant from 8 to 10 MGD. Of the new capacity, the share available to Guttenberg is expected to be approximately 3.8-4.2 MGD, which is a significant increase over the existing 1.8 MGD setting at the regulator.

Because of the large increase in capacity, this is considered to be one of the most promising alternatives to reducing overflow events and volumes in the Guttenberg system. As such, it was one of the alternatives selected for further study.

C.4.4 Treatment of Industrial Dischargers

Guttenberg does not have any Significant Industrial Users (SIU's)within its system; therefore, an industrial pretreatment program is not applicable to the Town's LTCP.

C.5 SCREENING OF CONTROL TECHNOLOGIES

The attached Tables C-1 through C-3 present a summary of the alternative control methods considered during the screening process. Those alternatives selected for additional study are highlighted, and will be addressed in detail in Section D.

TABLE C-1										
Source Control Technologies										
Technology Group	**Practice**	**Primary Goals**		**Community Benefit**	**Implementation & Operation Factors**	**Consider Combining w/ Other Technologies**	**Being Implemented**	**Recommendation for Alternatives Evaluation**	**Control Considered for Cost Analysis**
		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	No
	Catch Basin Modification (for Floatables Control)	Low	None	- Water quality improvements - Reduced surface flooding potential	Requires periodic catch basin cleaning; requires suitable catch basin configuration; potential for street flooding and increased maintenance efforts. Reduces debris and floatables that can cause operational problems with the mechanical regulators.	No	No	No	No
	Catch Basin Modification (Leaching)	Low	Low	- Reduced surface flooding potential - Water quality improvements	Can be installed in new developments or used as replacements for existing catch basins. Require similar maintenance as traditional catch basins. Leaching catch basins have minor effects on the primary CSO control goals.	No	No	No	No
Public Education and Outreach	Water Conservation	None	Low	- Reduced surface flooding potential - Align with goals for a sustainable community	Water purveyor is responsible for the water system and all related programs in the respective City. However, water conservation is a common topic for public education programs. Water conservation can reduce CSO discharge volume, but would have little impact on peak flows.	Yes	Yes	No	No
	Catch Basin Stenciling	None	None	- Align with goals for a sustainable community	Inexpensive; easy to implement; public education. Is only as effective as the public's acceptance and understanding of the message. Public outreach programs would have a more effective result.	Yes	No	No	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	No	No	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	No	No	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.	Yes	No	No	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.	Yes	No	No	No
	Pet Waste Management	Medium	None	- Water quality improvements	Low cost of implementation and little to no maintenance. This is a low cost technology that can significantly reduce bacteria loading in wet weather CSO's.	Yes	Yes	No	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.	Yes	No	No	No
	Hazardous Waste Collection	Low	None	- Water quality improvements	The N.J.A.C. prohibits the discharge of hazardous waste to the collection system.	Yes	Yes	No	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	No	No	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	No	No	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	No	No	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	No	No	No
	Illicit Connection Control	Low	Low	- Water quality improvements - Align with goals for a sustainable community	Site specific; more applicable to separate sanitary system; new storm sewers may be required; interaction with homeowners required. The primary goal of the LTCP is to meet the NJPDES Permit requirements relative to POCs. Illicit connection control is not particularly effective at any of these goals and is not recommended for further evaluation unless separate sewers are in place.	Yes	No	No	No

TABLE C-1 (cont'd)										
Source Control Technologies										
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		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	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	No	No	No
	Recycling Programs	None	None	- Align with goals for a sustainable community	Most Cities have an ongoing recycling program.	Yes	Yes	No	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	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	No	No	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.	Yes	No	Yes	Yes
	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	No
	Rainwater Harvesting	None	Medium	- Reduced surface flooding - Reduced basement sewage flooding - Align with goals for a sustainable community - Water Saving	Simple to install and operate; low operational resource demand; will require the Permittees or private owners to implement; requires regular cleaning of gutters & pipes. Portions of the Cities have densely populated areas, but this technology is limited to capturing rooftop drainage. Capture is limited to available storage, which can vary on rainwater use. Can be difficult to require on private properties.	Yes	No	Yes	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	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	Yes
Green Infrastructure Pervious Areas	Bioswales	Low	Low	- Improved air quality - Reduced carbon emissions - Reduced heat island effect - Property value uplift - Local jobs - Passive and active recreational improvements - Reduced surface flooding - Reduced basement sewage flooding - Community aesthetic improvements - Reduced crime - Align with goals for a sustainable community - Increased pedestrian safety through curb retrofits	Site specific; good BMP; minimal vegetation & mulch O&M requirements; not as flexible or infiltrate as much stormwater as planter boxes. Technology requires open space and is primarily a surface conveyance technology with additional storage & infiltration benefits. Can be modified with check dams to slow water flow. Limited open space in most Cities means land can be utilized in more effective ways with the existing infrastructure.	Yes	No	No	No
	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	No

TABLE C-2

Collection System Technologies

Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		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	Yes	Yes	Yes
	Advanced System Inspection & Maintenance	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires additional resources towards regular inspection and maintenance work. Inspection and maintenance programs can provide detailed information about the condition and future performance of infrastructure. Offers relatively small advances towards goals of the LTCP.	Yes	No	No	No
	Combined Sewer Flushing	Low	Low	- Water quality improvements - Reduced basement sewage flooding	Requires inspection after every flush; no changes to the existing conveyance system needed; requires flushing water source. Ongoing: CSO Operational Plan; maximizes existing collection system; reduces first flush effect.	Yes	No	No	No
	Catch Basin Cleaning	Low	None	- Water quality improvements - Reduced surface flooding	Labor intensive; requires specialized equipment. Catch Basin Cleaning reduces litter and floatables but will have no effect on flow and little effect on bacteria and BOD levels.	Yes	Yes	No	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	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	No
	Combined Sewer Separation	High	High	- Water quality improvements - Reduced basement sewage flooding - Reduced surface flooding	Very disruptive to affected areas; requires homeowner participation; sewer asset renewal achieved at the same time; labor intensive.	No	No	Yes	Yes
Combined Sewer Optimization	Additional Conveyance	High	High	- Water quality improvements - Reduced basement sewage flooding	Additional conveyance can be costly and would require additional maintenance to keep new structures and pipelines operating.	No	No	No	No
	Regulator Modifications	Medium	Medium	- Water quality improvements	Relatively easy to implement with existing regulators; mechanical controls requires O&M. May increase risk of upstream flooding. Permitees have an ongoing O&M program and system wide replacement program for CSO regulators and tide gates.	Yes	Yes	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.	Yes	No	No	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.	Yes	No	No	No

TABLE C-3										
Storage and Treatment Technologies										
Technology Group	Practice	Primary Goals		Community Benefit	Implementation & Operation Factors	Consider Combining w/ Other Technologies	Being Implemented	Recommendation for Alternatives Evaluation	Control Considered for Cost Analysis
		Bacteria Reduction	Volume Reduction						
Linear Storage	Pipeline	High	High	- Water quality improvements - Reduced surface flooding potential - Local jobs	Can only be implemented if in-line storage potential exists in the system; increased potential for basement flooding if not properly designed; maximizes use of existing facilities. Pipe storage for a CSS typically requires large diameter pipes to have a significant effect on reducing CSOs. This typically requires large open trenches and temporary closure of streets to install.	No	No	Yes	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	No	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	No	No	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	No	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	No
	Screens and Trash Racks	None	None	- Water quality improvements	Prone to clogging; requires manual maintenance; requires suitable physical configuration; increased O&M burden. Screens and trash racks will only address floatables.	Yes	No	No	No
	Netting	None	None	- Water quality improvements	Easy to implement; labor intensive; potential negative aesthetic impact; requires additional resources for inspection and maintenance. Netting will only address floatables.	Yes	Yes	Yes	No
	Contaminant Booms	None	None	- Water quality improvements	Difficult to maintain requiring additional resources. Contaminant booms will only address floatables.	Yes	No	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	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	No	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.	Yes	No	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	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	Yes	Yes	Yes
	Wet Weather Blending	Low	High	- Water quality improvements - Reduced surface flooding - Reduced basement sewage flooding	Requires upgrading the capacity of influent pumping, primary treatment and disinfection processes; increased O&M burden. Wet weather blending does not address bacteria reduction, as it is a secondary treatment bypass for the POTW. Permittee must demonstrate there are no feasible alternatives to the diversion for this to be implemented.	Yes	Yes	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	No	No	No

SECTION D ALTERNATIVES ANALYSIS

D.1 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

As discussed in Section C of this Report, the following technologies were identified for further analysis:

- I/I Reduction
- Expansion of the Woodcliff Sewage Treatment Plant
- Separation of Galaxy Towers Flow (Storm and Sanitary)
- Separation of New High-Rise Storm Flow
- Pipeline Storage (Pumped)
- Partial System Separation
- Green Infrastructure
  - Green Roofs
  - Planter Boxes
  - Rain Barrels

Several criteria will be utilized in evaluating these options, which are discussed in further detail below.

D.1.1 Siting

In a municipality as small and as densely populated as Guttenberg, space is at a premium. There are very few large lots (except for the Galaxy Towers property, very few undeveloped lots (those that are not currently occupied are small residentially-zoned lots), and what public land there is, is primarily municipal buildings or urban parks. As a result, this analysis is severely constrained by the physical space needed for an alternative. These circumstances favor small projects, which are deconcentrated and able to be tied into existing building or infrastructure, and away from large-scale projects like tanks and treatment plants.

D.1.2 Institutional Issues

The Town of Guttenberg does not have its own Sewer Department – operation of the sewer system is contracted to the NBMUA. Therefore, the analysis would favor non-technical and low-maintenance installations. Operator-intensive alternatives (such as treatment or pump stations) are problematic and would require either the establishment of a Sewer Department (which is highly unlikely) or an amended (and significantly more costly) agreement between the Town and the MUA.

D.1.3 Public Acceptance

Many of the alternatives to be evaluated will directly impact the public (both during and after construction); therefore, it is vital to determine if the work has the support of the populace. For example, several of the Green Infrastructure alternatives will end up being installed on private property, meaning the maintenance will be the responsibility of the property owner (even if the capital cost is covered by the Town. This will likely reduce public acceptance, even though GI is broadly supported, and result in lower takeup of the program. For public installations, public impact is likely to be limited to construction-phase disruption.

D.1.4 Cost

As with any public project, cost is a significant factor in determining the feasibility of the various alternative. Costs were developed for each of the alternatives noted above, using industry-standard sources and institutional experience in recent bid results. Construction costs were then annualized based on the expected useful life of the facility(ies). In addition to the capital cost of the project, estimated annual O&M costs were developed using guidance from PVSC and their consultants (so that all permittees used the same basis). These were added to the annualized capital cost to determine a standardized cost for all alternatives that could then be compared.

D.1.5 Performance Considerations

Of course, the primary criteria for evaluation of alternatives is how well the technology performs at reducing the number or volume of overflow events. This evaluation of alternatives utilized computer models which provided theoretical outputs for different control strategies that could be implemented for the City of Guttenberg. Infoworks ICM version 9.0 was used to create computer models for different alternatives and combinations that can be used for long term control strategies. The basis for the Guttenberg computer model was provided by Greeley and Hansen. The model was used for their Service Area System Characterization Report for NBMUA Woodcliff and Guttenberg (WCGB) dated June 2018. Elements of the computer model are as follows:

- The year 2004 was used as the typical hydrologic year for the CSO LTCP.
- The model contains 28 total nodes, 1 regulator, 1 sluice gate, 1 weir, 1 outfall, and 26 links
- The model contains 5 subcatchments

The following changes were made to the original model from Greeley and Hansen:

- Added a GIS street map layer
- Changed the population to represent current conditions
- Added a subcatchment (GU_GT) to represent sanitary flow from Galaxy Towers
- Added a subcatchment (GU_StormGT) to represent storm flow from Galaxy Towers
- Modified the sluice gate in order to represent a max flow of approximately 1.8 MGD being sent to NBMUA as a baseline condition
- Changed wastewater flow to 82 gallons per person per day
- Overflows and 85% capture calculations were performed using the discharge flow from the Guttenberg regulator. Discharge flow from the Guttenberg outfall includes an existing separated storm water flow from Galaxy Towers.

Sewer data was collected from prior reports and GIS to develop and update the system inventory. Most of the pipe characteristics, including upstream and downstream nodes, dimension, shape, number of barrels, and flap gate information, were found or estimated from prior studies, record drawings, design drawings and sewer gravity main GIS shapefiles. If sewer main information was not available, sewer length was estimated in GIS geometry measurement. Manhole information, including invert and rim elevations, were found or estimated from record drawings, design drawings, and existing collection system models.

D.2 PRELIMINARY CONTROL PROGRAM ALTERNATIVES

With regard to the evaluation criteria set forth in Section D.1, the preliminary alternatives for Guttenberg's LTCP are detailed below.

The model was run for baseline (i.e., existing) conditions for the typical year (2004). Model results show a wet weather capture of 78% (the target capture is a minimum of 85%), with 70 overflow events for the year. Performance discussions for each of the alternatives will be in comparison to the baseline numbers.

D.2.1 Infiltration / Inflow Reduction

The Town of Guttenberg periodically inspects its sewers via closed circuit television (CCTV). The last significant video inspection work was in 2015; the Town is planning a full video survey in 2019/20. The inspections will identify sources of I/I into the system; the Town can then contract for spot repairs or line replacement to repair the leak. Individual laterals can also be a source of I/I in the system; however, the laterals in Guttenberg are owned in their entirety by the homeowners and as such pose challenges both to inspect and repair.

Overall I/I in the Guttenberg system is currently estimated at approximately 480,000 gallons per day, roughly split between the main sewer lines and sewer connection laterals. The Town has no real ability to force property owners to repair laterals, although they will notify the property owners if excessive I/I is seen during the course of video inspection.

For the purpose of this analysis, it is assumed that the I/I originating in the Town-owned lines will be reduced by approximately 25%% (100,000 gpd). Several lines have already been designated (through an Administrative Consent Order with the EPA) for repair and/or lining; it is anticipated that this work will be done within the next five years. Additional area will be identified through upcoming CCTV inspection and will be incorporated into a Capital Improvement Plan going forward.

The estimated cost for the already designated work is approximately $1,500,000 as detailed in Table D-1. By itself, I/I reduction has a minor impact on CSO performance, increasing capture to 79%, and reducing the number of overflow events to 61/year.

D.2.2 Expansion of Woodcliff Treatment Plant

As discussed in Section C.4.3, the NBMUA is performing improvements at the Woodcliff STP, including the expansion of wet weather hydraulic capacity of from 8 MGD to 10 MGD. For details of the expansion, please refer to the NBMUA's Evaluation of Alternatives Report. For the purpose of this Report, it is sufficient to state that Guttenberg's share of the expanded treatment capacity is based upon the current dry weather flow split – 58% NBMUA, 42% Guttenberg. The projected share of flow to be allocated to Guttenberg (4.2 MGD) is a significant increase over the current value of approximately 1.8 MGD.

Per figures supplied by NBMUA (see Table D-2), the projected cost of the plant expansion is approximately $20 million, of which 20% ($4 million) is considered for expansion work. Costs for the work will be allocated according to the flow split; therefore, the cost to Guttenberg is anticipated to be approximately $1.68 million. The plant expansion results in a major improvement to system performance, increasing capture to 92% (meeting the target of 85%), and reducing the number of overflow events to 31/year.

REMINGTON & VERNICK ENGINEERS
ENGINEER'S ESTIMATE OF PROBABLE

Project Name:
Guttenberg CSO LTCP Alterntives Analysis
Project Number:
0903-T-022
Client:
Township of Guttenberg **4/25/2019**

Table D-1 - Infiltration and Inflow Reduction

Year	Description	Estimated Construction Cost
2019	Spot Repairs and Replacement: Adams Street, Bergeenline Avenue, 68th Street, 69th Street	$ 565,000.00
2020	Spot Repairs and Manhole Channel Repairs: Various Locations	$ 125,700.00
2021	Pipelining and Cleaning: Adams Street	$ 150,000.00
2022	Pipelining and Cleaning: Bergenline Avenue	$ 150,000.00
2023	Pipelining and Cleaning: 68th Street	$ 150,000.00
2024	Pipelining and Cleaning: 71st Street	$ 75,000.00
	Total Estimated Construction Cost:	**$ 1,215,700.00**
	Contingencies (5%):	**$ 60,785.00**
	Administrative Costs (3%):	**$ 36,471.00**
	Planning and Design:	**$ 63,825.00**
	Construction Management:	**$ 127,649.00**
	Total Estimated Project Cost:	**$ 1,504,430.00**

Source: USEPA Administrative Consent Order and Boswell Engineering Estimates, 2017; modified for 2019 work (bids received)

TABLE D-2 - EXPANSION OF WOODCLIFF STP

LP-5A BUDGET INFORMATION - NEW PROJECT

Name of Applicant: TOWN OF GUTTENBERG Project Number: S340652-14

COST CLASSIFICATION	a. Total Project Costs During Construction	b. Project Costs Not Allowable for Fund and Trust Financing	c. Allowable Costs Subtract Column b from Column a and enter below c=a-b
1. Administrative Expenses (3% of Line No. 4)	$468,315	$18,435	$449,880
2. Other Costs	$196,954	$0	$196,954
3. Engineering Fees	$1,870,000	$0	$1,870,000
4. Building Costs	$15,610,500	$614,500	$14,996,000
5. Contingencies (5% of line No. 4)	$780,525	$30,725	$749,800
6. Allowance for Planning and Design (see attached table)	$1,666,630	$36,870	$1,629,760
7. TOTAL PROJECT COSTS	**$20,592,924**	$700,530	**$19,892,394**

D.2.3 Separation of Galaxy Towers Flow (Storm and Sanitary)

The Galaxy Towers development is located on River Road, below the bluff separating the majority of Guttenberg from the Hudson. The Town's CSO line runs through the Galaxy property; storm water from the 5-acre complex is collected and pumped into the CSO line downstream of the regulator. Under low-intensity precipitation events, this is not considered an overflow event, even though flow discharges from the outfall, as this discharge is entirely storm flow (not combined). However, when the regulator is overflowing due to heavy precipitation (or throttling by the treatment plant), the volume of flow from Galaxy is considered part of the CSO event. Therefore, while the Galaxy storm flow does not impact the number of CSO events in the system, it can increase the volume of discharge.

Design is currently under way to remove the Galaxy storm flow from the CSO line and discharge it via gravity to the County-owned storm system in River Road; the Galaxy storm flow would discharge through a stormwater-only discharge approximately 500 feet upriver.

Sanitary flow from the Galaxy complex is currently pumped up the cliff to the regulator influent line, where it then flows either to the Woodcliff STP or the CSO line as circumstances dictate. Discussions have occurred between the Town of Guttenberg and Galaxy management regarding the potential of relocating the flow to a recently-constructed sanitary line in River Road, which serves the waterfront Bulls Ferry / Jacobs Ferry development and flows directly to the treatment plant. The existing line would need to be replaced with a larger main to incorporate the approximately 0.25 MGD of sanitary flow, but the project would remove the flow from the regulator chamber.

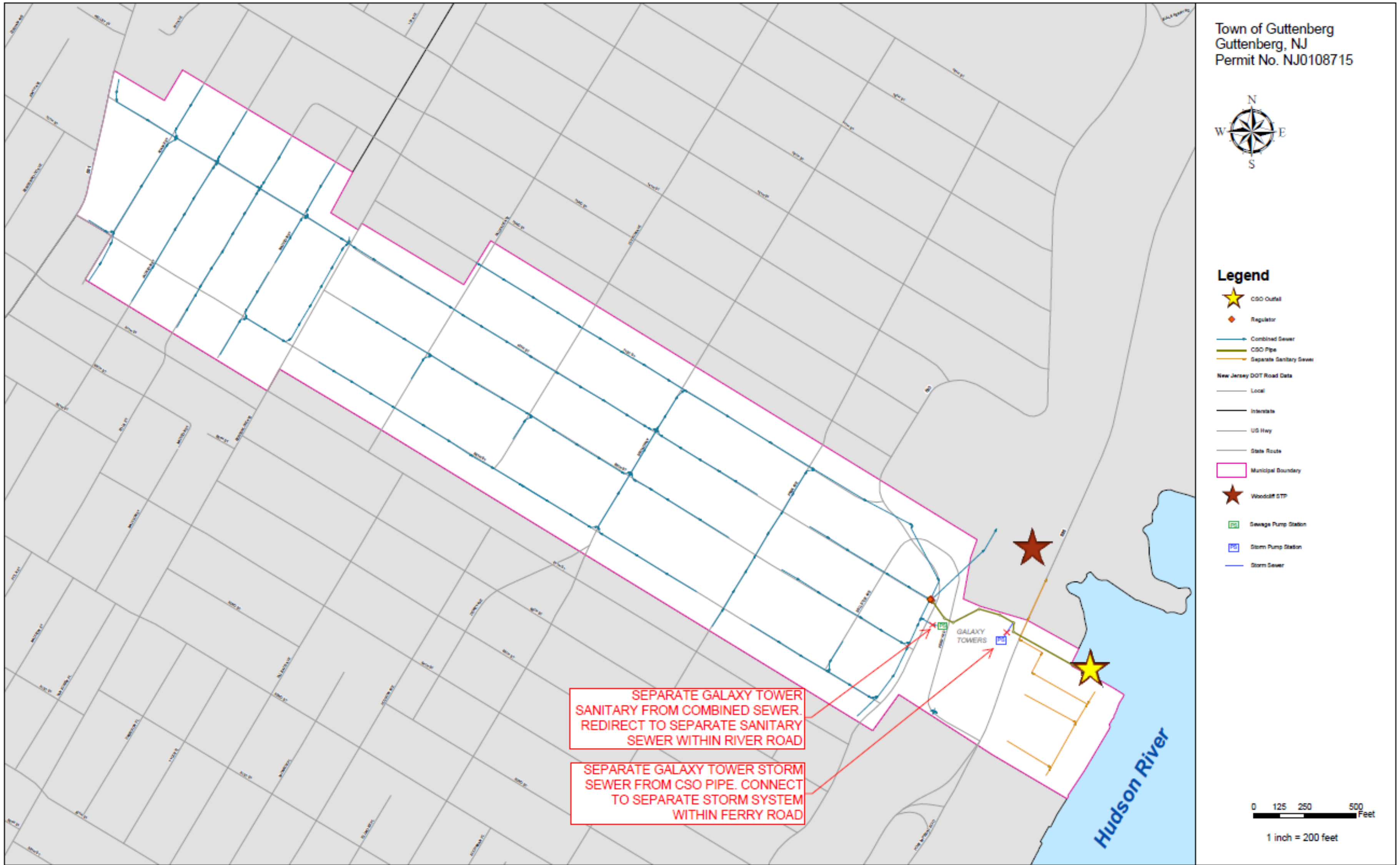
It is unclear what impact this would have on the CSO system. NBMUA has indicated that relocation of the Galaxy sanitary flow would reduce Guttenberg's Allocation at the plant by a similar amount. however, there may be some marginal impacts on the regulator operation.

The location for the Galaxy separation work is presented in Figure D-1. The estimated cost of storm separation is approximately $160,000 and sanitary separation is $540,000, as detailed in Tables D-3 and D-4, respectively, for a combined cost of $700,000. We were not able to accurately model the impact of the storm water separation, as the flow data from Galaxy was unavailable; therefore, separation of the storm water was treated as having no impact on the performance of the CSO (although it could help resolve some localized flooding issues at Galaxy). Sanitary flow separation has a modest impact on CSO performance, increasing capture to 80%, and reducing the number of overflow events to 53 per year.

D.2.4 Separation of New High-Rise Storm Flow

As discussed in Section B, the Town is rezoning two areas for the construction of new high-rise developments (see Figure D-2). These systems would be required to construct separate storm and sanitary piping on-site, only combining them at the point of connection to the municipal system. This way, if the municipal system is ever separated in the future, these developments could be easily converted to separate flow.

As part of this analysis, we looked at the potential to discharge storm flow separately; neither area appeared feasible. The larger area (approximately 4 acres) is located at the western edge of the Town, which topographically slopes west towards the Hackensack River. To discharge storm water, a line would have to be constructed through the Township of North Bergen and across Route 1-9, which would likely not be permitted by North Bergen. The other area of rezoning is at the top of



REMINGTON & VERNICK ENGINEERS

TOWN OF GUTTENBERG
CSO EVALUATION ALTERNATIVES REPORT
FIGURE D-1:GALAXY TOWER STORM AND SANITARY SEWER SEPARATION

ONE HARMON PLAZA, SUITE 210
SECAUCUS, N.J. 07094
(201) 624-2137, FAX (201) 624-2136
WEB SITE ADDRESS : WWW.RVE.COM

REMINGTON & VERNICK ENGINEERS
ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

PROJECT NAME:
Guttenberg CSO LTCP Alterntives Analysis
PROJECT NUMBER:
0903-T-022
CLIENT:
TOWN OF GUTTENBERG

Date: **4/25/2019**

Table D-3 - Relocation of Galaxy Towers' Storm Water Flow to County Line

Item No.	Description	Units	Bid Quantity	Plan Quantity	If & Where Directed	Est. Unit Price	Amount
1	Mobilization / Demobilization (<3% of Construction Cost)	LS	1	0	1	$3,500.00	$ 3,500.00
2	Test Pits	CY	0	5	5	$500.00	$ 2,500.00
3	Remove and Replace Existing Sewer With New 24" RCP Sewer, Complete, Inc. Excavation, Backfill and Testing	LF	100	0	100	$250.00	$ 25,000.00
4	Remove and Replace Existing Sewer With New 30" RCP Sewer, Complete, Inc. Excavation, Backfill and Testing	LF	42	0	42	$300.00	$ 12,600.00
5	Remove and Replace Existing Manholes, Complete, Inc. Excavation, Backfill and Testing	UN	1	0	1	$12,500.00	$ 12,500.00
6	Remove and Replace Existing Type "B" Inlets, Complete, Inc. Excavation, Backfill and Testing	UN	1	0	1	$12,500.00	$ 12,500.00
7	Modification of Existing Concrete Structures For Connection of New Sewer Pipe	LS	2	0	2	$5,000.00	$ 10,000.00
8	Pipe Bedding	CY	0	25	25	$30.00	$ 750.00
9	Select Fill (Bank Run Sand and Gravel)	CY	0	25	25	$6.50	$ 162.50
10	Cutting and Capping of Existing Pump Station Inlet and Discharge Lines	UN	2	0	2	$5,000.00	$ 10,000.00
11	6" Dense Grade Aggregate	CY	28	0	28	$35.00	$ 974.81
12	Hot Mix Asphalt 19M64 Base Course	TON	30	0	30	$120.00	$ 3,564.48
13	Hot Mix Asphalt 9.5M64 Surface Course	TON	10	0	10	$120.00	$ 1,190.54
14	Maintenance and Protection of Traffic	LS	1	0	1	$12,500.00	$ 12,500.00
15	Allowance for Uniformed Traffic Control Officers	ALL	1	0	1	$10,000.00	$ 10,000.00
	ESTIMATED PROJECT COST:						**$ 117,742.33**
						Contingencies (5%):	**$ 5,887.12**
						Administrative Costs (3%):	**$ 3,532.27**
						Planning and Design:	**$ 18,545.00**
						Construction Management:	**$ 12,363.00**
						Total Estimated Project Cost:	**$ 158,069.72**

REMINGTON & VERNICK ENGINEERS
ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

Project Name:
Guttenberg CSO LTCP Alterntives Analysis
Project Number:
0903-T-022
Client:
Township of Guttenberg **Date: 4/25/2019**

Table D-4 - Relocation of Galaxy Towers' Sanitary Sewer Downstream of Regulator

Item No.	Description	Units	Bid Quantity	Plan Quantity	If & Where Directed	Est. Unit Price	Amount
1	Mobilization / Demobilization (<3% of Construction Cost)	LS	1	1	0	$ 12,000.00	$ 12,000.00
2	8" Dia. PVC Sewer	LF	475	475	0	$ 80.00	$ 38,000.00
2a	Pipe Bedding	CY	73	73	0	$ 30.00	$ 2,190.00
2b	Filter Fabric	SY	459	459	0	$ 3.50	$ 1,606.50
2c	Backfill (I-13)	CY	470	470	0	$ 23.00	$ 10,810.00
3	Remove and Replace Existing 8" Dia. Sewer w/ 18" Dia. PVC Sewer, Complete, Inc. Excavation, Backfill and Testing	LF	215	215	0	$ 150.00	$ 32,250.00
3a	Pipe Bedding	CY	44	44	0	$ 30.00	$ 1,320.00
3b	Filter Fabric	SY	248	248	0	$ 3.50	$ 868.00
3c	Backfill (I-13)	CY	307	307	0	$ 23.00	$ 7,061.00
4	6" Dense Grade Aggregate	TON	78	78	0	$ 50.00	$ 3,900.00
5	Hot Mix Asphalt 19M64 Base Course	TON	97	97	0	$ 120.00	$ 11,640.00
6	Hot Mix Asphalt 9.5M64 Surface Course	TON	26	26	0	$ 120.00	$ 3,120.00
7	Excavation	CY	749	749	0	$ 75.00	$ 56,175.00
8	Cap and Redirect Galaxy Sanitary PS Influent Line	EA	1	1	0	$ 4,000.00	$ 4,000.00
9	4' Dia. Sanitary Manhole	EA	5	5	0	$ 5,500.00	$ 27,500.00
10	Connection of new 18" Dia. PVC Pipe to Ex. Manhole	EA	1	1	0	$ 5,000.00	$ 5,000.00
11	Test Pits	EA	0	0	5	$ 700.00	$ 3,500.00
12	Site Restoration	LS	1	1	0	$ 10,000.00	$ 10,000.00
13	Load, Haul, Dispose Excavated Material	CY	749	749	0	$ 150.00	$ 112,350.00
14	Utility Relocation Allowance	LS	1	1	0	$ 30,000.00	$ 30,000.00
15	Maintenance and Protection of Traffic	LS	1	1	0	$ 20,000.00	$ 20,000.00
16	Allowance for Uniformed Traffic Control Officers	LS	1	1	0	$ 10,000.00	$ 10,000.00
						Total Estimated Construction Cost:	**$ 403,290.50**
						Contingencies (5%):	**$ 20,164.53**
						Administrative Costs (3%):	**$ 12,098.72**
						Planning and Design:	**$ 63,519.00**
						Construction Management:	**$ 42,346.00**
						Total Estimated Project Cost:	**$ 541,418.74**

PROPOSED ZONING CHANGES
NEW R-5 HIGH RISE RESIDENTIAL

Source: Draft Town Master Plan

the bluff on the eastern side of the Town; however, this area is relatively small (approximately two acres) and would require either direct connection to the CSO pipe (putting it in the same situation as Galaxy Towers), or a new storm line would need to be constructed down the cliff to the County system (or a new outfall). Either option would be prohibitively expensive for the small number of people to be served. Therefore, this alternative will not be considered further in this study.

D.2.5 Pipeline Storage (Pumped)

The small size of the Guttenberg system and its topography mean that there are not many locations where new in-line storage pipe could be reasonably provided. Every street in the Town already contains existing sewer, and there is no available non-street area for location of pipe. Any storage options would have to be either:

- Deep-tunneled (at least 20' deep to be below the existing sewers) through the rock formation of the Palisades (this would be prohibitively expensive, and its construction would be unacceptably disruptive to the residents and businesses in the Town); or
- Replacing and upsizing existing sewer pipe within the system.

For the second option listed above, the system was reviewed, and three potential locations were identified for upsizing of pipe:

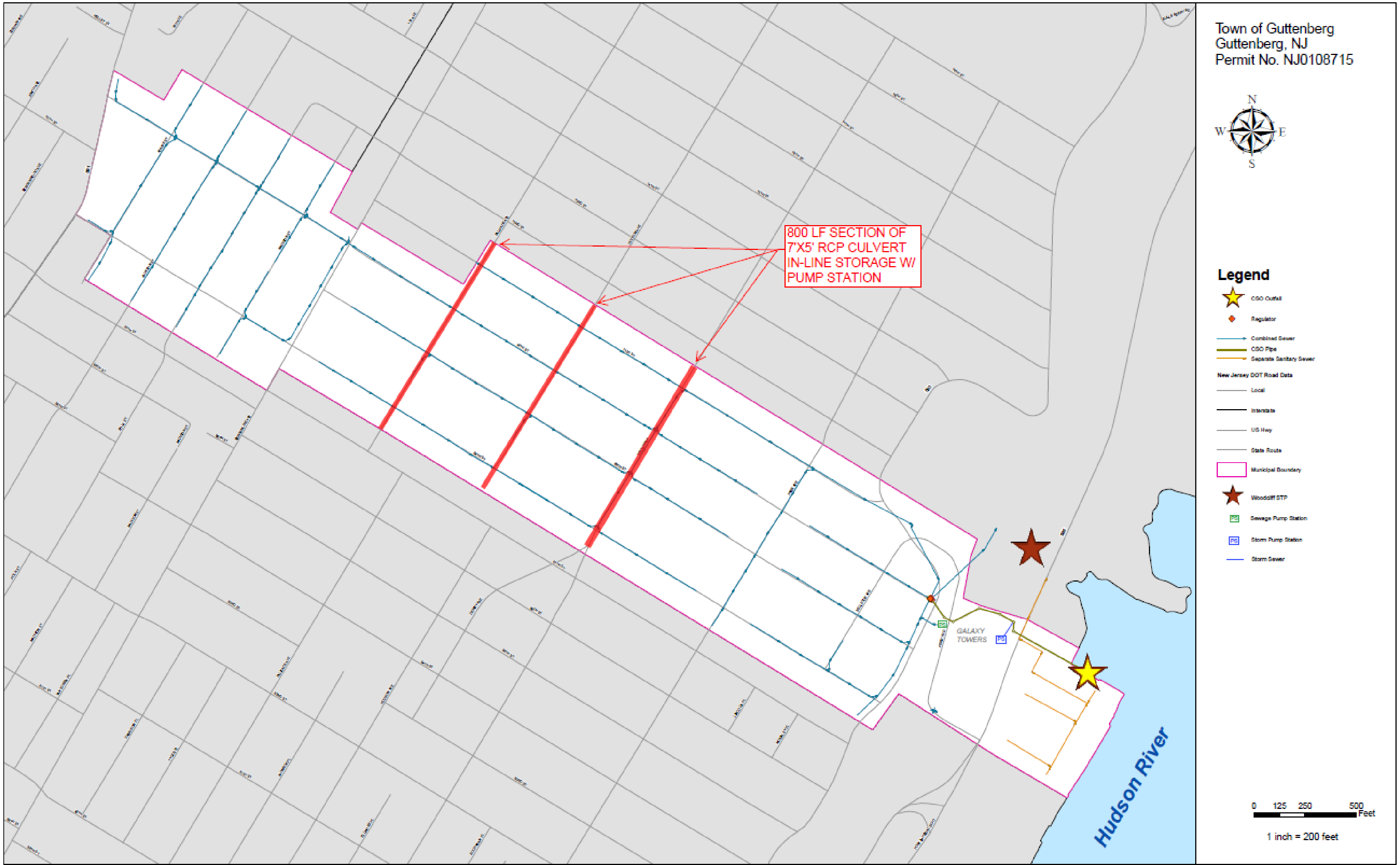
- Palisade Avenue, between 68th and 71st Streets
  - 800 LF of 5' x 7' box culvert, approximately 225,000 gallons
- Hudson Avenue, between 68th and 71st Streets
  - 800 LF of 5' x 7' box culvert, approximately 225,000 gallons
- Broadway, Avenue, between 68th and 71st Streets
  - 800 LF of 5' x 7' box culvert, approximately 225,000 gallons

Location of the storage pipelines are presented in Figure D-3. Total storage provided is approximately 675,000 gallons. The estimated cost for a pumped storage system at these locations is approximately $12 million, as detailed in Table D-5.

Because gravity storage would result (per the model) in significant sewer backups in the system, only pumped storage was considered in this alternative, with the storage pipe inverts being significantly below the surrounding system. This necessitates the construction of pump stations, which would have to be operated (even in dry weather) by the NBMUA, as Guttenberg DPW does not have the expertise for such operations. In addition, these stations would need to be located completely below grade within the public right-of-way, make access for maintenance and repairs difficult and disruptive to traffic and nearby residents. Therefore, this alternative will not be considered further in this study.

D.2.6 Green Infrastructure (Green Roofs)

As discussed in Section C.2.5, zoning changes in the Town of Guttenberg intend to increase the construction of high-density developments. These new high-density developments provide an opportunity to integrate the green roof systems into the design of the new buildings. This approach makes the installation of green roofs more feasible as retrofitting existing buildings with green roofs is prohibited by exorbitant costs to property owners. Furthermore, the high occupancy



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TOWN OF GUTTENBERG
CSO EVALUATION ALTERNATIVES REPORT
FIGURE D-3: IN-LINE STORAGE

ONE HARMON PLAZA, SUITE 210
SECAUCUS, N.J. 07094
(201) 624-2137, FAX (201) 624-2136
WEB SITE ADDRESS : WWW.RVE.COM

REMINGTON & VERNICK ENGINEERS
ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

Project Name:
Guttenberg CSO LTCP Alterntives Analysis
Project Number:
0903-T-022
Client:
Township of Guttenberg **Date:** **4/25/2019**

Table D-5 - Combined Sewer In-Line Storage

Item No.	Description	Units	Bid Quantity	Plan Quantity	If & Where Directed	Est. Unit Price	Amount
1	Mobilization / Demobilization (<3% of Construction Cost)	LS	1	0	1	$125,000.00	$ 125,000.00
2	Remove and Replace Existing Sewer With New 5' x 7' RCP Culvert, Complete, Inc. Excavation, Backfill and Testing	LF	2400	2400	0	$ 800.00	$ 1,920,000.00
2a	Pipe Bedding	CY	3289	3289	0	$ 30.00	$ 98,670.00
2b	Filter Fabric	SY	9600	9600	0	$ 3.50	$ 33,600.00
3	Pumping Station, Complete	EA	3	3	0	$ 400,000.00	$ 1,200,000.00
4	Dense Grade Aggregate	TON	16200	16200	0	$ 50.00	$ 810,000.00
5	Hot Mix Asphalt 19M64 Base Course	TON	1104	1104	0	$ 120.00	$ 132,480.00
6	Hot Mix Asphalt 9.5M64 Surface Course	TON	368	368	0	$ 120.00	$ 44,160.00
7	Excavation	CY	19200	19200	0	$ 75.00	$ 1,440,000.00
8	Connect Combined Sewer to New Storage Lines	EA	3	3	0	$ 20,000.00	$ 60,000.00
9	6' Dia. Sanitary Manhole	EA	6	6	0	$ 7,500.00	$ 45,000.00
10	Test Pits	EA	0	0	10	$ 700.00	$ 7,000.00
11	Site Restoration	LS	1	1	0	$ 50,000.00	$ 50,000.00
12	Environmental Testing Allow.	LS	1	1	0	$ 30,000.00	$ 30,000.00
13	Load, Haul, Dispose Excavated Material	CY	19200	19200	0	$ 150.00	$ 2,880,000.00
14	Utility Relocation Allow.	LS	1	1	0	$ 100,000.00	$ 100,000.00
15	Maintenance and Protection of Traffic	LS	1	1	0	$ 60,000.00	$ 60,000.00
16	Allowance for Uniformed Traffic Control Officers	LS	1	1	0	$ 40,000.00	$ 40,000.00

Total Estimated Construction Cost:	**$ 8,850,910.00**
Contingencies (5%):	**$ 442,545.50**
Administrative Costs (3%):	**$ 265,527.30**
Planning and Design:	**$ 1,394,019.00**
Construction Management:	**$ 929,346.00**
Total Estimated Project Cost:	**$ 11,882,347.80**

rates associated with high-density apartment buildings will spread the per capita cost of the green roof.

The zoning changes will affect approximately six (6) acres for the construction of new high-density (9-15 stories) developments; it is estimated that runoff from approximately 10% of the rezoned area would be captured by green roof systems. The locations of the rezoned areas for new high-density developments are presented in Figure D-4. Modeling indicates that an area this small would have minimal impact on CSO system performance, with the percent capture and number of overflows remaining essentially unchanged.

The estimated cost for installing green roofs is unknown at this time - since the green roofs would be installed on private property, the construction costs would be borne by the developers, not the Town of Guttenberg. Rather, costs to the Town would be in the form of tax credits and/or rebates that would be provided to the high-density apartment developers to incentivize the integration of green roofs. An approach to incentivize green roofs will be identified upon finalizing the LTCP, the cost of green roofs to the Town will then be able to be estimated.

D.2.7 Green Infrastructure (Planter Boxes)

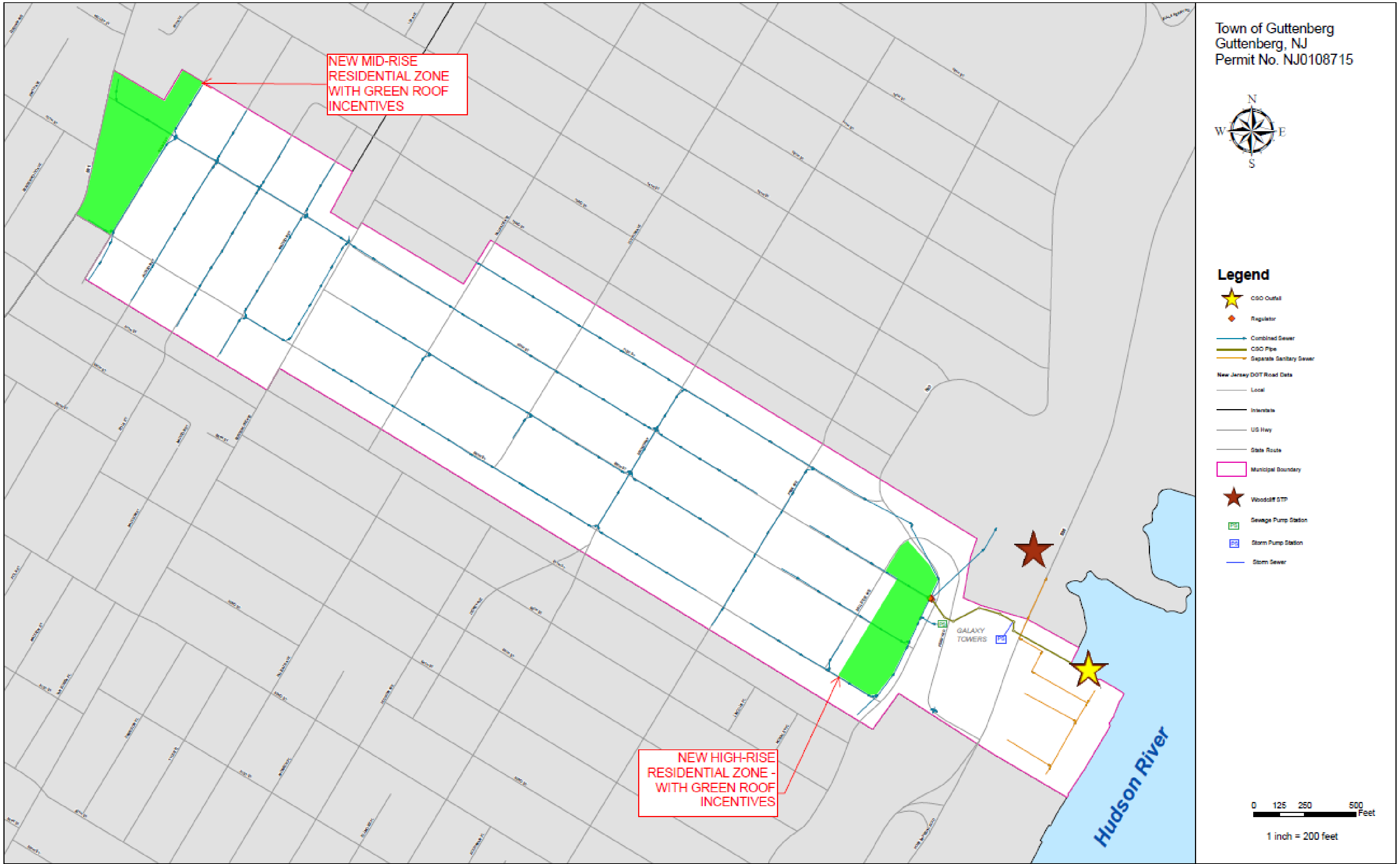
While bioswales and rain gardens were considered and rejected in Section C.2.6 of this Report due to open space and subsurface conditions, the use of planter boxes may be considered in certain areas to retain some rainwater, reducing flow into the combined sewer. Because the use of planter boxes requires the sacrifice of some sidewalk space that could otherwise be used for pedestrian movement, the boxes would likely be limited to the commercial areas of the Town, where wider sidewalks mean that space is available while maintaining pedestrian flow. The streets identified in these areas are Bergenline Avenue, Park Avenue and JFK Boulevard East. Because these areas are so limited, the overall impact of the planter boxes is likely to be minimal; however, the boxes can also contribute to the beautification of the streetscape and are popular with some residents and business patrons.

Downsides to planter boxes include increased maintenance, as the plantings would need to be replaced every year or two, and seasonal variations in effectiveness (i.e., in winter). In addition, the boxes may be used as trash receptacles by inconsiderate pedestrians; the boxes must be periodically cleaned to prevent this from happening.

Based upon initial field observation, a total of approximately 250 planter boxes (2’ x 4’) can be placed on the three identified streets, for a total area of approximately 2,000 sf. The estimated construction cost for the installation of 250 planter boxes is approximately $415,000, as detailed in Table D-6. As with the green roofs, this small area of capture would have minimal impact on CSO system performance, with the percent capture and number of overflows remaining essentially unchanged. However, adoption of the alternative may have some beneficial impact on public acceptance of the overall LTCP, as GI is popular with certain segments of the populace.

D.2.8 Green Infrastructure (Rain Barrels)

The installation of rainwater harvesting systems, such as rain barrels, provides an opportunity to capture, detain, and reuse stormwater runoff despite the lack of space for most green infrastructure practices. The rain barrels can be fitted at many of the private buildings (both residential and commercial) throughout the Town.



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TOWN OF GUTTENBERG
CSO EVALUATION ALTERNATIVES REPORT
FIGURE D-4: GREEN INFRASTRUCTURE - GREEN ROOFS

ONE HARMON PLAZA, SUITE 210
SECAUCUS, N.J. 07094
(201) 624-2137, FAX (201) 624-2136
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REMINGTON & VERNICK ENGINEERS
ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

Project Name:
Guttenberg CSO LTCP Alterntives Analysis
Project Number:
0903-T-022
Client:
Township of Guttenberg
Date: 4/25/2019

Table D-6 - Green Infrastructure - Planter Boxes

Item No.	Description	Units	Bid Quantity	Plan Quantity	If & Where Directed	Est. Unit Price	Amount
1	Mobilization / Demobilization (<3% of Construction Cost)	LS	1	1	0	$ 10,000.00	$ 10,000.00
2	6' x 2' Planter Boxes, Installed	EA	250	250	0	$ 1,250.00	$ 312,500.00
3	Maintenance and Protection of Traffic	LS	1	1	0	$ 7,500.00	$ 7,500.00
4	Allowance for Uniformed Traffic Control Officers	LS	1	1	0	$ 5,000.00	$ 5,000.00
						Total Estimated Construction Cost:	**$ 335,000.00**
						Contingencies (5%):	**$ 16,750.00**
						Administrative Costs (3%):	**$ 10,050.00**
						Planning and Design:	**$ 17,588.00**
						Construction Management:	**$ 35,175.00**
						Total Estimated Project Cost:	**$ 414,563.00**

Even though these rain barrels will be installed on private property, the Town would handle the costs of the materials and installation, then hand over ownership of the rain barrels to the private property owners who receive them. There are approximately 1,200 buildings in the Town; the actual number of barrels would depend on how many property owners are receptive to the rogram. Some properties may have more than one downspout that would be fitted with rain barrels; other owners may not wish to be part of the project at all.

The estimated construction cost for the installation of 1,200 rain barrels is approximately $370,000 (as shown in Table D-7); actual cost would be dependent on acceptance rate of property owners. If all homeowners were to utilize the barrels, it would have a significant impact on performance, raising capture to 90% (it would have a much more modest impact on the number of overflows, reducing the number to 66 events/year). However, it is extremely unlikely that takeup by homeowners would be this high; a rate of 10-15% acceptance seems more likely, with a concurrent reduction in performance.

Additionally, the Town would need to conduct community outreach and education regarding the rain barrels to increase public acceptance and participation of the rain barrel program. Based upon our experience with other municipalities, the estimated administrative cost to implement a successful rain barrel program is approximately $12,000-15,000.

D.2.9 Partial System Separation

Because none of the alternatives noted above were able to reduce the number of overflows to 20 or less, consideration was given to separating the existing storm and sanitary flows in various portions of Guttenberg. Separation was modeled on a "last-option" basis in the modeling; after the other feasible alternatives were activated in the model, the area to be separated was adjusted until the criteria was reached (number of overflow events).

A rough per-acre cost was developed for the separation (based on complete separation, see Table D-8); the per-acre cost was then multiplied by the required area of separation to estimate a cost for that particular option (see Figure D-5 for extents to be separated for each level of overflow control). Separation would start at the regulator chamber and proceed upstream as far as necessary to achieve the required acreage. Storm flow would be redirected to the existing CSO line downstream of the regulator; under most conditions, this would not be considered a CSO discharge, as it would contain no sanitary flow. Extreme storm events might still result in an overflow event; in those cases, the volume of the separated storm flow would be added to the combined overflow volume due to mixing.

In order to develop a cost for partial system separation, a full separation cost was developed ($35 million) and is presented in Table D-8 below. This results in a per-acre cost of approximately $325,000 / acre, which was then combined with the required separation area from the model to calculate a rough estimate of the partial system separation (Table D-9).

In addition to the immense costs, partial and complete separation of the combined sewer system presents significant technical challenges, as existing utilities in the ROW's leave little to no room for new separated lines, or would require massive utility relocation, driving the costs up even further. As a result, except for the Galaxy Towers (see Section D.2.3 above), sewer separation will not be considered further in this Study. The Town will, however, continue to look at separation as a very-long-term option, and continue to require new buildings to separate their internal systems so as to be compatible with any potential future separation projects.

REMINGTON & VERNICK ENGINEERS
ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

Project Name:
Guttenberg CSO LTCP Alterntives Analysis
Project Number:
0903-T-022
Client:
Township of Guttenberg

Date: **4/25/2019**

Table D-7 - Green Infrastructure - Rain Barrels

Item No.	Description	Units	Bid Quantity	Plan Quantity	If & Where Directed	Est. Unit Price	Amount
1	Mobilization / Demobilization (<3% of Construction Cost)	LS	1	1	0	$ 9,000.00	$ 9,000.00
2	Rain Barrels, Installed	EA	1200	1200	0	$ 225.00	$ 270,000.00
3	Maintenance and Protection of Traffic	LS	1	1	0	$ 12,500.00	$ 12,500.00
4	Allowance for Uniformed Traffic Control Officers	LS	1	1	0	$ 7,500.00	$ 7,500.00
						Total Estimated Construction Cost:	**$ 299,000.00**
						Contingencies (5%):	**$ 14,950.00**
						Administrative Costs (3%):	**$ 8,970.00**
						Planning and Design:	**$ 15,698.00**
						Construction Management:	**$ 31,395.00**
						Total Estimated Project Cost:	**$ 370,013.00**

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ENGINEER'S ESTIMATE OF PROBABLE CONSTRUCTION COST

Project Name:
Guttenberg CSO LTCP Alterntives Analysis
Project Number:
0903-T-022
Client:
Township of Guttenberg **Date:** **4/25/2019**

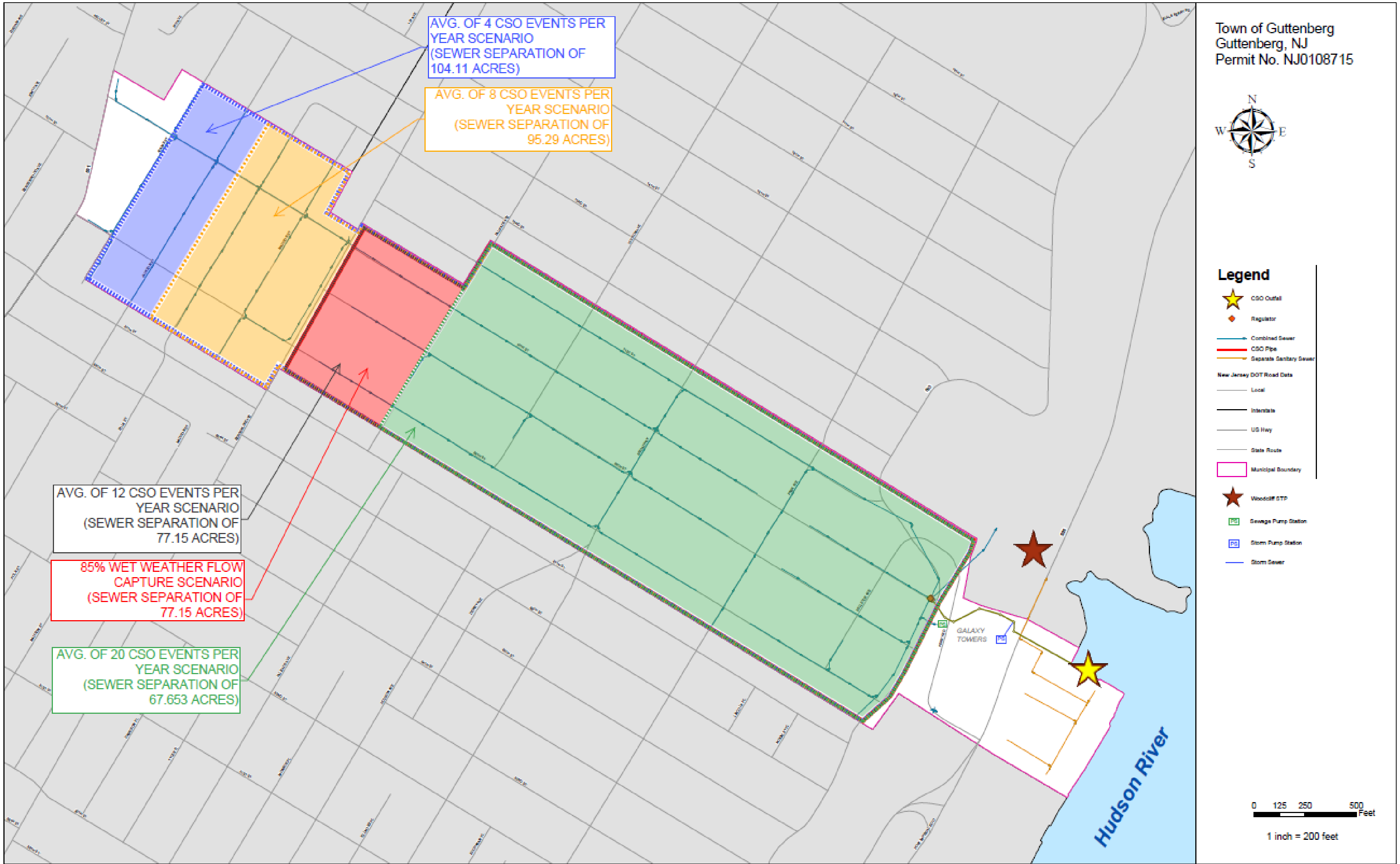
Table D-8: Separation of Combined Sewer System

Item No.	Description	Units	Bid Quantity	Plan Quantity	If & Where Directed	Est. Unit Price	Amount
1	Mobilization / Demobilization (<3% of Construction Cost)	LS	1	1	0	$ 850,000.00	$ 850,000.00
2	Install 8" Dia. PVC Sewer, Complete, Inc. Excavation, Backfill and Testing	LF	12335	12335	0	$ 125.00	$ 1,541,875.00
2a	Install 18" Dia. PVC Sewer, Complete, Inc. Excavation, Backfill and Testing	LF	1700	1700	0	$ 200.00	$ 340,000.00
2b	Pipe Bedding	CY	3191	3191	0	$ 30.00	$ 95,730.00
2c	Filter Fabric	SY	16447	16447	0	$ 3.50	$ 57,564.50
4	Dense Grade Aggregate	TON	19968	19968	0	$ 50.00	$ 998,400.00
5	Asphalt 19M64 Base Course	TON	1655	1655	0	$ 120.00	$ 198,600.00
6	Asphalt 9.5M64 Surface Course	TON	1064	1064	0	$ 120.00	$ 127,680.00
7	Excavation	CY	25698	25698	0	$ 75.00	$ 1,927,350.00
9	Install 4' Dia. Sanitary Manhole, Complete, Inc. Excavation, Backfill and Testing	EA	187	187	0	$ 9,000.00	$ 1,683,000.00
10	New Sewer Connections	EA	2500	2500	0	$ 5,000.00	$ 12,500,000.00
11	Test Pits	EA	0	0	100	$ 700.00	$ 70,000.00
12	Upgrade Sanitary Sewer Line to Woodcliff STP	LS	1	1	0	$ 500,000.00	$ 500,000.00
13	Modifications at Regulating Chamber	LS	1	1	0	$ 200,000.00	$ 200,000.00
14	Load, Haul, Dispose Excavated Material	CY	25698	25698	0	$ 150.00	$ 3,854,700.00
15	Utility Relocation Allow.	LS	1	1	0	$ 1,000,000.00	$ 1,000,000.00
16	Maintenance and Protection of Traffic	LS	1	1	0	$ 500,000.00	$ 250,000.00
17	Allowance for Uniformed Traffic Control Officers	LS	1	1	0	$ 500,000.00	$ 250,000.00
						Total Estimated Construction Cost:	**$ 26,194,899.50**
						Contingencies (5%):	**$ 1,309,744.98**
						Administrative Costs (3%):	**$ 785,846.99**
						Planning and Design:	**$ 4,125,697.00**
						Construction Management:	**$ 2,750,465.00**
						Total Estimated Project Cost:	**$ 35,166,653.46**

Assumptions:

1. Avergage sanitary sewer diameter is 8-inches, with larger (18") trunk lines.

2. Average depth to top of sanitary sewer pipe is 10 feet.



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TOWN OF GUTTENBERG
CSO EVALUATION ALTERNATIVES REPORT
FIGURE D-5:SEWER SEPARATION SCENARIOS

ONE HARMON PLAZA, SUITE 210
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Table D-9 Costs for Partial Sewer System Separation

Target No. of Events	Acres to be Separated	Cost
20	68	$22,100,000
12	77	$25,000,000
8	95	$30,900,000
4	104	$33,800,000
0	111	$35,000,000

D.2.10 Summary of Cost Opinions

Removing the three eliminated options (High Rise Separation, Pumped Storage, and Partial System Separation), the following cost estimated were developed for the remaining alternatives:

Table D-10 Summary of Costs

Alternative	Capital Cost	Useful Life (years)	Annualized Capital Cost [1]	Annual O&M [2]	Annualized Cost
Reduction of Infiltration / Inflow	$1,500,000	50	$55,560	$2,800	$58,360
Expansion of Woodcliff Treatment Plant	$1,680,000	50	$62,230	$3,112	$65,342
Separation of Galaxy Towers Flow	$600,000	50	$22,225	$1,111	$23,336
Green Infrastructure (Green Roofs)	unknown	20	N/A	N/A	N/A
Green Infrastructure (Planter Boxes)	$415,000	20	$27,254	$1,750 [3]	$29,004
Green Infrastructure (Rain Barrels)	$370,000	10	$42,824	$2,141	$44,965

Notes: [1] *Annualized cost at 2.75% over useful life*
[2] *O&M costs assumed based upon 5% of annualized capital cost*
[3] *Includes annual replacement of vegetation*

D.3 PRELIMINARY SELECTION OF ALTERNATIVES

D.3.1 Evaluation Factors

In reviewing the nine alternatives that were developed during the screening process, three of the options (High Rise Separation, Pumped Storage, and Partial System Separation) were eliminated from consideration based upon siting and/or institutional criteria. Of the remaining six, two ((Expansion of the Woodcliff Plant and Rain Barrels) were found to meet the performance criteria of 85% capture of typical wet weather flow; however, the modeled performance of the rain barrels is predicated upon 100% of homeowners installing the units. In reality, far fewer units would likely be installed, since many homeowners would refuse the units, and the Town is not likely to pass an ordinance mandating their use. As a result, performance of this alternative would be less than modeled.

The remaining “gray” infrastructure alternatives (Infiltration / Inflow Reduction and Separation of Galaxy Towers Flow) have a much smaller impact on system performance; however, the projects serve other purposes for the Town and are already in design or construction. The Galaxy storm work is anticipated to be completed in 2019, and the sanitary work in the near future. I/I work is ongoing as part of a five-year plan through 2024, with future work to be determined based upon ongoing video inspection work.

Green Infrastructure (Green Roofs and Planter Boxes), while popular with the general public (although possibly not by those parties directly impacted), are likely of too little area to significantly impact system performance. In addition, although the alternatives generally carry a smaller overall capital cost than some of the “gray” alternatives, their shorter lifespan raises their annualized costs to a much higher level. However, implementation of at least some GI may help in building public support for the overall LTCP program.

D.3.2 Regulatory Compliance

Depending on the alternative, various regulatory agencies have review and approval jurisdiction over the proposed control work. For example, the NJDEP’s Division of Water Quality must approve any changes to a sanitary or combined sewer system, through its Treatment Works Approval (TWA) Program. Work in public roadways is under the jurisdiction of the governmental entity which owns the road (State, County or Town), while the local Planning/Zoning Boards may have jurisdiction over above-grade improvements. Finally, if an alternative includes discharge into another system (for conveyance and/or treatment), the owner of that receiving system must approve the work.

In brief, the following is a list of the agencies having jurisdiction over each of the alternatives considered in this Section:

- *I/I Reduction* – No TWA is necessary, as the I/I work is repair and/or replacement only, no expansion or changes to the sewer system are involved. Local approval is required for work in Township roadways. Finally, the I/I work is being performed under an Administrative Consent Order between the Town of Guttenberg and the US Environmental Protection Agency (EPA), which sets the work schedule and requires regular updates on the progress of the work.
- *Expansion of the Woodcliff Sewage Treatment Plant* – A TWA is necessary for the plant upgradework, along with Courtesy approval by the Township of North Bergen Planning Board. In addition, the work is being financed by the New Jersey Infrastructure Bank (administered by NJDEP), which sets additional requirements on the design, bidding and construction of the project.
- *Separation of Galaxy Towers Flow (Storm and Sanitary)* – No NJDEP approvals are needed for the storm separation; however, County approval is required for work in River Road, as well as tie-in to the County storm water system. Sanitary work will require a TWA for extension and/or upgrading of lines, and County approval is required for work in River Road. Finally, NBMUA approval is required as the receiving system for the relocated flow.
- *Green Infrastructure* – NJDEP approval is not required for the various types of green infrastructure (green roofs, planter boxes, and rain barrels. Local approval may be required by the Planning and/or Zoning Boards for the installation of the features on public or private property. In addition, the mandating of green roofs in new high-rise zones will require changes to the Town Zoning ordinance, and potentially other ordinances by Council.

D.3.3 Selection of Preliminary Alternatives

Based upon the findings of this Development and Evaluation of Alternatives Report, the following six (6) alternatives have been selected for further study:

- I/I Reduction
- Expansion of the Woodcliff Sewage Treatment Plant
- Separation of Galaxy Towers Flow (Storm and Sanitary)
- Green Roofs
- Planter Boxes
- Rain Barrels

These alternatives will be refined and considered for selection in the final LTCP (Selection and Implementation of Alternatives Report), due for submission by June 1, 2020.

APPENDIX C

Procedures and Conditions Applicable to NJPDES-DSW Permits (N.J.A.C. 7:14A-11)

Dated: June 2019

SUBCHAPTER 11. PROCEDURES AND CONDITIONS APPLICABLE TO NJPDES-DSW Permits

7:14A-11.1 Purpose and scope

(a) This subchapter sets forth specific conditions and procedures which are applicable only to DSW permits. N.J.A.C. 7:14A-24 and 25 set forth additional specific conditions and procedures which are applicable to DSW or DGW permits for stormwater discharges.

(b) The DSW program requires permits for the discharge of pollutants into surface waters of the State from any point source, stormwater discharge associated with industrial activity or small construction activity, and nonpoint sources regulated under N.J.A.C. 7:14A-2.5(d) or 24.2(a)7ii..

7:14A-11.2 Establishing DSW permit conditions

(a) In addition to the conditions established under N.J.A.C. 7:14A-6.3, the Department shall include in DSW permits one or more conditions which meet the following requirements, as applicable:

1. Pollutants for which the permittee is required to report noncompliance with an effluent limitation in accordance with N.J.A.C. 7:14A-6.10(a)1 shall be identified and listed in the permit. This list shall include any toxic pollutant or hazardous substance or another appropriate indicator specifically identified as the method to control a toxic pollutant or hazardous substance;

2. In addition to the monitoring requirements contained in N.J.A.C. 7:14A-6.5, to assure compliance with permit limitations, a permittee shall be required to monitor:

   i. The mass, or other measurement specified in the permit, for each pollutant limited in the permit;

   ii. The volume of effluent discharged from each outfall;

   iii. Other measurements as appropriate, including pollutants in internal waste streams addressed at N.J.A.C. 7:14A-13.16(a), pollutants in intake water for net limitations addressed at N.J.A.C. 7:14A-13.4(k); parameters for noncontinuous discharges addressed at N.J.A.C. 7:14A-13.20; pollutants subject to notification requirements at N.J.A.C. 7:14A-11.3(a); and pollutants in sewage sludge, or other monitoring as specified in 40 C.F.R. 503 or as determined to be necessary on a case-by-case basis pursuant to section 405(d)(4) of the CWA; and

   iv. In accordance with the test procedures under 40 C.F.R. 136 for the analyses of pollutants having approved methods (unless other test procedures have been specified in the permit), or according to a test procedure specified in the permit for pollutants with no approved methods pursuant to N.J.A.C. 7:14A-6.5(a)2. If more than one method exists for analyzing a pollutant and the Department specifies a particular method in the permit, the Department shall provide the basis for selecting the particular method in the fact sheet for the draft permit in accordance with N.J.A.C. 7:14A-15.8;

3. For municipal separate storm sewer systems and for stormwater discharges associated with industrial activity or small construction activity that are not subject to an effluent limitation guideline that establishes monitoring requirements or numeric effluent limitations, monitoring requirements shall be established in accordance with N.J.A.C. 7:14A-24.9;

4. (Reserved)

5. For facilities that may operate at certain times as a means of transportation over water, the permit shall contain a condition that the discharge shall comply with any applicable regulations established for safe transportation, handling, carriage, and storage of pollutants as promulgated by the Secretary of the Department within which the Coast Guard is operating; and/or

6. Any conditions that the Secretary of the Army considers necessary to ensure that navigation and anchorage shall not be substantially impaired, in accordance with N.J.A.C. 7:14A-11.4.

7:14A-11.3 Additional requirements for all existing manufacturing, commercial, mining, silviculture, and research facilities

(a) The following condition, in addition to those set forth in N.J.A.C. 7:14A-11.2 and the general conditions applicable to all permits in N.J.A.C. 7:14A-6.2, applies to all DSW permits for the facilities specified below:

1. In addition to the reporting requirements under N.J.A.C. 7:14A-6.5 and 6.10, all existing manufacturing, commercial, mining, and silvicultural dischargers and research facilities shall notify the Department, in writing, as soon as they know or have reason to believe:

i. That any activity has occurred or will occur which would result in the discharge of any toxic pollutant which is not limited in the permit if such discharge will exceed the highest of the following notification levels:

(1) One hundred micrograms per liter (100 μg/L);

(2) Two hundred micrograms per liter (200 μg/L) for acrolein and acrylonitrile; five hundred micrograms per liter (500 μg/L) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/L) for antimony;

(3) Five times the maximum concentration value reported for the pollutant in the permit application in accordance with N.J.A.C. 7:14A-4.4(b); or

(4) The notification level established by the Department in accordance with N.J.A.C. 7:14A-6.2(b)2.

ii. With the exception of research facilities, that they have begun or expect to begin to use or manufacture as an intermediate or final product or by-product any toxic pollutant which was not reported in the permit application pursuant to N.J.A.C. 7:14A-4.3(a)19 or in the request for authorization under N.J.A.C. 7:14A-6.13(d), unless the general permit expressly refers to a "request for authorization" and does not require the request for authorization to include a listing of toxic pollutants.

7:14A-11.4 Permit denial or conditions requested by other governmental agencies

(a) If during the comment period for a draft DSW permit, the District Engineer of the Army Corps of Engineers advises the Department in writing that anchorage and navigation of any of the waters of the United States would be substantially impaired by the granting of a point source DSW permit, the permit shall be denied and the applicant so notified.

(b) If the District Engineer advises the Department that imposing specified conditions upon the permit is necessary to avoid any substantial impairment of anchorage or navigation, then the Department shall include the specified conditions in the permit.

(c) Review or appeal of a denial of a permit or of conditions specified by the District Engineer shall be made through the applicable procedures of the Corps of Engineers, and may not be made through the procedures provided in this chapter. If the conditions are stayed by a court of competent jurisdiction or by applicable procedures of the Corps of Engineers, those conditions shall be considered stayed in the DSW permit for the duration of that stay.

(d) If, during the comment period, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, or any other State or Federal Agency with jurisdiction over fish, wildlife, or public health advises the Department in writing that the imposition of specified conditions upon the permit is necessary to avoid substantial impairment of fish, shellfish, or wildlife resources, the Department shall include the specified conditions in the permit to the extent they are determined necessary to carry out provisions of 40 CFR 122.49 and the State and Federal Acts.

(e) In appropriate cases the Department may consult with one or more of the agencies referred to in this section or other agencies it deems appropriate before issuing a draft permit and may reflect such agencies' views in the statement of basis, the fact sheet, or the draft permit.

7:14A-11.5 (Reserved)

7:14A-11.6 Federal criteria and standards for DSW permits

(a) The following Federal criteria and standards apply to DSW permits:

1. The criteria and standards for the imposition of technology-based treatment requirements in DSW permits shall be as set forth in 40 C.F.R. 125, Subpart A;
2. The criteria for issuance of a permit to aquaculture projects shall be as set forth in 40 C.F.R. 125, Subpart B;
3. The criteria and standards for determining fundamentally different factors shall be as set forth in 40 C.F.R. 125, Subpart D;
4. The criteria and standards for determining alternative effluent limitations for the thermal component of a discharge shall be as set forth in 40 C.F.R. 125, Subpart H;
5. The criteria applicable to cooling water intake structures shall be as set forth in 40 C.F.R. 125, Subpart I, when the USEPA adopts these criteria;
6. (Reserved)
7. The criteria and standards for imposing conditions for the disposal of sewage sludge shall be as set forth in 40 C.F.R. 125, Subpart L; and
8. The criteria for ocean discharges shall be as set forth in 40 C.F.R. 125, Subpart M.

(b) Whenever the provisions elsewhere in this chapter are more stringent than the criteria and standards referenced in this section, the more stringent provisions elsewhere in this chapter shall apply.

7:14A-11.7 Variances and modifications under the State and Federal acts

(a) Any discharger may request a variance from effluent limitations by filing a request by the close of the public comment period established pursuant to N.J.A.C. 7:14A-15.10 as follows:

1. A variance under N.J.A.C. 7:9B-1.8 or 1.9 for achieving water quality based effluent limitations. An applicant shall follow the procedures in N.J.A.C. 7:9B-1.8 or 1.9.
2. A variance under Section 316(a) of the Federal Act for the thermal component of any discharge. A copy of the request submitted to USEPA pursuant to 40 C.F.R. 125, Subpart H, shall be submitted simultaneously to the Department as required under 40 C.F.R. 125. Such request shall be determined in accordance with N.J.A.C. 7:14A-11.11.

(b) A discharger which is not a POTW may request a variance from otherwise applicable effluent limitations under any of the following statutory or regulatory provisions within the time period specified in this subsection:

1. A request for a variance based on the presence of fundamentally different factors from those on which the effluent limitation guideline was based shall be submitted as follows:

    i. For a request for a variance from best practicable control technology currently available (BPT), by the close of the public comment period established under N.J.A.C. 7:14A-15.10.

ii. For a request for a variance from best available technology economically achievable (BAT) and/or best conventional pollutant control technology (BCT), by no later than 180 days after the date on which an effluent limitation guideline is published in the Federal Register for a request based on an effluent limitation guideline promulgated on or after February 4, 1987.

iii. Any request for a variance made under this paragraph shall explain how the requirements of 40 C.F.R. 125, Subpart D have been met.

2. A request for a variance from the BAT requirements of Section 301(b)(2)(F) of the Federal Act for non-conventional pollutants (ammonia; chlorine; color; iron; total phenols (4AAP) and any other pollutant which the Administrator lists under Section 301(g)(4) of the Federal Act) pursuant to Section 301(c) of the Federal Act because of the economic capability of the owner or operating entity, or pursuant to Section 301(g) of the Federal Act shall be submitted as follows:

i. For those requests for a variance from an effluent limitation based upon an effluent limitation guideline a requester shall submit:

(1) An initial request to the Regional Administrator and to the Department, stating the name of discharger, the permit number, the outfall number(s), the applicable effluent guideline, and whether the discharger is requesting a Section 301(c) or Section 301(g) modification or both. This request shall be filed not later than 270 days after promulgation of an applicable effluent limitation guideline for guidelines promulgated after December 27, 1977; and

(2) A complete request no later than the close of the public comment period established under N.J.A.C. 7:14A-15.10, demonstrating that the requirements of N.J.A.C. 7:14A-15.13 and the applicable requirements of 40 C.F.R. 125 have been met. Notwithstanding this provision, the complete request under section 301(g) shall be filed 180 days before the Department is required to make a final decision (unless the Department establishes a shorter or longer period).

ii. For those requests for a variance from effluent limitations not based on effluent limitation guidelines, the request need only comply with (b)2i(2) above, and need not be preceded by an initial request under (b)2i(1) above.

3. A request for a modification, under Section 302(b)(2) of the Federal Act, of water quality related effluent limitations developed by the USEPA under

Section 302(a) of the Federal Act shall be submitted by the close of the public comment period established under N.J.A.C. 7:14A-15.10 on the permit for which the modification is being sought.

4. A request for a modification of effluent limitations which are more stringent than the BAT based limitations established in accordance with N.J.A.C. 7:14A-13.4 shall be submitted by the close of the public comment period established under N.J.A.C. 7:14A-15.10 on the permit for which the modification is being sought. For a modification requested under this paragraph, the relief and procedures in N.J.A.C. 7:9B-1.8 or 1.9 shall apply.

(c) Notwithstanding the time period requirements in (a) and (b) above, the Department may send notification before a draft permit is issued under N.J.A.C. 7:14A-15.6 that the draft permit will likely contain limitations which are eligible for variances. In the notice, the Department may require as a condition of consideration of any potential variance request submission a request explaining how the requirements of 40 C.F.R. 125 applicable to the variance have been met and may require submission of such a request within a specified reasonable time after receipt of the notice. The notice may be sent before the permit application has been submitted. The draft or final permit may contain the alternative limitations which may become effective upon granting of the variance.

(d) A discharger who cannot file a complete request required under (a)1, (b)2i(2), 2ii or 4 above may request a one time extension. The extension may be granted or denied at the discretion of the Department. If the extension request is denied, the Department shall state the reason(s) for the denial. An extension shall be limited to:

1. Twelve months for a variance requested under (a)1 or (b)4; or

2. Six months for a variance requested under (b)2i(2) or 2ii.

7:14A-11.8 Decisions on variances

(a) The Department may grant or deny a request for a variance for the thermal component of a discharge under Section 316(a) of the Federal Act.

(b) The Department may deny, forward to the Regional Administrator with a written concurrence, or submit to USEPA without recommendation a completed request for:

1. A variance based on the economic capability of the applicant under Section 301(c) of the Federal Act; and

2. A variance based on water quality related effluent limitations under Section 302(b)(2) of the Federal Act.

(c) The Department may deny or forward to the Regional Administrator with a written concurrence a completed request for:

1. A variance based on the presence of "fundamentally different factors" from those on which an effluent limitation guideline was based; and

2. A variance based on certain water quality factors under section 301(g) of the Federal Act.

(d) The Department shall reopen or revoke and reissue a permit, after final action by the USEPA, for a variance from water quality based effluent limitations under N.J.A.C. 7:9B-1.8 or 1.9.

(e) If the USEPA approves the variance, the Department shall prepare a draft permit incorporating the variance. Any public notice of a draft permit for which a variance or modification has been approved or denied shall identify the applicable procedures for appealing that determination under 40 C.F.R. 124.64, or under N.J.A.C. 7:14A-17.2 if the variance was denied or partially denied by the Department.

7:14A-11.9 Procedures for variances

(a) A request for a variance filed under N.J.A.C. 7:14A-11.7 shall be processed as follows:

1. If, at the time that a request for a variance is submitted, the Department has received an application for issuance or renewal of a permit but has not yet prepared a draft permit, the Department may:

    i. Prepare a draft permit for public notice incorporating the Department's decision on the variance request; or

    ii. If the variance determination will cause significant delay in issuing the permit, separate the variance request from the permit application and process the permit application.

2. If, at the time that a request for a variance is submitted the Department has published public notice of the draft permit but has not issued a final permit decision, the Department may:

    i. Stay administrative proceedings concerning the draft permit and prepare a new draft permit incorporating the Department's decision on the variance request; or

    ii. If the variance determination will cause significant delay in issuing the permit, separate the variance request from the draft permit and issue the final permit decision.

3. If the final permit decision has been issued and a variance request has been separated from a draft permit pursuant to (a)1 or 2 above, the Department may subsequently prepare a new draft permit for public notice incorporating the Department's decision on the variance request.

(b) The Department may grant a stay of an effluent limitation(s) until a decision on a variance is made in accordance with the following:

1. For a request under Section 301(g), effluent limitations shall not be stayed unless:

    i. In the judgment of the Department, the stay or variance sought will not result in the discharge of pollutants in quantities which may be reasonably anticipated to pose an unacceptable risk to human health or the environment because of bioaccumulation, persistence in the environment, acute toxicity, chronic toxicity, or synergistic propensities;

ii. In the judgment of the Department, there is a substantial likelihood that the discharger will succeed on the merits of its appeal; and

iii. The discharger files a bond or appropriate security as deemed necessary by the Department to assure timely compliance with the requirements from which a variance is sought in the event that the appeal is unsuccessful.

2. For a request other than under Section 301(g), the requirements for requesting a stay in accordance with N.J.A.C. 7:14A-17.6 shall apply.

7:14A-11.10 Public notice of Section 316(A) request

(a) In addition to the information required under N.J.A.C. 7:14A-15.10(f), public notice of a DSW draft permit for a discharge where a request under section 316(a) of the Federal Act and Section 6 of the State Act has been filed under N.J.A.C. 7:14A-11.7(a)2 shall include:

1. A statement that the thermal component of the discharge is subject to effluent limitations under Sections 301 and 306 of the Federal Act and Section 6 of the State Act and a brief description, including a quantitative statement, of the thermal effluent limitations proposed under Sections 301 or 306 of the Federal Act and Section 6 of the State Act;

2. A statement that a Section 316(a) request has been filed and that alternative less stringent effluent limitations may be imposed on the thermal component of the discharge under Section 316(a) and a brief description, including a quantitative statement, of the alternative effluent limitations, if any, included in the request; and

3. If the applicant has filed an early screening request pursuant to 40 C.F.R. 125.72 for a Section 316(a) variance, a statement that the applicant has submitted such a request.

7:14A-11.11 Special procedures for decisions on thermal variances under Section 316(A)

(a) Except as provided in 40 C.F.R. 124.65, the only issues connected with issuance of a particular permit on which the Department will make a final decision before the final permit decision is issued under N.J.A.C. 7:14A-15.15 are whether alternative effluent limitations would be justified under Section 316(a) of the Federal Act and Section 6 of the State Act and whether cooling water intake structures will use the best available technology under Section 316(b) of the Federal Act. A permit applicant who seeks an early decision on these issues should request it and furnish supporting reasons with the permit application filed under N.J.A.C. 7:14A-4.2. The Department shall decide whether or not to make an early decision. If the Department makes an early decision, such a decision on issues under Section 6 of the State Act and Section 316(a) or (b) of the Federal

Act and the grant of the balance of the permit shall be considered issuance of a final permit decision under this chapter, subject to the requirements of public notice and comment and adjudicatory hearing requests of N.J.A.C. 7:14A-15 and 17.

(b) If the Department, on review of the administrative record, determines that the information necessary to decide issues under Section 6 of the State Act and Section 316(a) of the Federal Act is not likely to be available before the final permit decision, the Department may issue a permit under N.J.A.C. 7:14A-15.15 for a term up to five years. This permit shall require achievement of the effluent limitations initially proposed for the thermal component of the discharge no later than the date otherwise required by State or Federal law. However, the permit shall also afford the permittee an opportunity to file a demonstration under Section 316(a) of the Federal Act after conducting such studies as are required under 40 C.F.R. 125, Subpart H. A new discharger may not exceed the thermal effluent limitation which is initially proposed unless and until its State Act Section 6 and Federal Act Section 316(a) variance request is finally approved.

(c) Any proceeding held under (a) above shall be subject to public notice as required by N.J.A.C. 7:14A-15.10 and shall be conducted at a time allowing the permittee to take necessary measures to meet the final compliance date in the event its request for modification of thermal limits is denied.

(d) Whenever the Department defers the decision under Section 316(a) of the Federal Act and Section 6 of the State Act, any decision under Section 316(b) may be deferred.

7:14A-11.12 Discharges from combined sewer overflows

Permits issued for discharges from combined sewer overflows shall include applicable provisions of the Federal Combined Sewer Overflow (CSO) Policy (59 Federal Register 18688, published April 19, 1994) incorporated herein at Appendix C.

7:14A-11.13 NJPDES/DSW PCB Pollutant Minimization Plans for Major Facilities Discharging to PCB Impaired Waterbodies

(a) The following conditions apply to any major facility that discharges to a PCB impaired waterbody segment.

1. PCB-impaired waterbody segments are those listed on Sublist 5 of the New Jersey List of Water Quality Limited Waters (also known as the 303(d) List or as the Impaired Waterbodies List), as being impaired or threatened for one or more designated uses due to PCBs. The reference in this paragraph to the List of Water Quality Limited Waters includes all amendments, supplements, and updates thereto. The current list of Water Quality Limited Waters is included in the New Jersey Integrated Water Quality Monitoring and Assessment Report, which can be found on the Department's web site at http://www.state.nj.us/dep/wmm/sgwqt/wat/integratedlist/2004report.html.

2. Major facility is defined at N.J.A.C. 7:14A-1.2.

(b) Facilities subject to an adopted TMDL that establishes requirements for PCBs shall be subject to that TMDL. The adopted TMDL shall supercede the requirements of this section.

(c) Monitoring requirements shall be in accordance with N.J.A.C. 7:14A-14.4 and include the following:

1. The permittee shall analyze its effluent for the 209 PCB congeners.

2. Sanitary wastewater treatment plants and publicly owned treatment works shall perform three dry weather and three wet weather samples on the facility's main outfall by 24 months after the effective date of the modification or renewal of the facilities' permits under (e) below. Industrial facilities with discharges consisting of process wastewater, as defined at N.J.A.C. 7:14A-1.2, shall perform three dry weather samples by 24 months after the effective date of the modification or renewal of the facilities' permits under (e) below. Industrial facilities with commingled process wastewater and stormwater discharges shall perform three dry weather and three wet weather samples by 24 months after the effective date of the modification or renewal of the facilities' permits under (e) below.

    i. Dry weather sampling shall be conducted when less than 0.1 inches of rainfall has occurred within the previous 72 hours.

    ii. Wet weather conditions are defined as following the onset of a precipitation event of 0.1 inches or greater and an increase in wastewater flow, provided that no rainfall (defined as less than 0.1 inches) has occurred within the previous 72 hours. Sampling should start no sooner than two hours prior to the start of the rising hydrograph or no later than 30 minutes after the start of the rising hydrograph for the discharge.

    iii. Samples collected from continuous discharges during dry and wet weather flows will be taken as 24 hour time-weighted composite samples at a frequency not greater than one aliquot every hour for a nominal sample volume of two liters for both the sample and the field replicate. For short term wet weather discharges, the sample shall be taken using a grab sample.

3. Discharges consisting of non-contact cooling water only shall not be subject to this section.

4. All samples shall be collected at least 30 days after the previous sampling event.

5. All sampling shall be performed during periods which are representative of normal facility operations.

6. All testing shall be performed using Method 1668A, Revision A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS. EPA-821-R-00-002, December 1999, as supplemented or amended, and incorporated by reference herein.

(d) After submission of the PCB monitoring required under (c) above and under the facility's permit, the Department will determine whether each permittee must complete a PCB Pollutant Minimization Plan (PMP), and will notify each permittee of this decision in writing.

1. If the Department determines that a permittee is required to complete a PMP, the permittee shall prepare and submit the PMP by the date specified in the permit or as otherwise directed by the Department.
2. The PMP shall be developed to achieve maximum practical reduction in accordance with the PMP Technical Manual, which can be found on the Department's web site at www.state.nj.us/dep/dwq/techmans.
3. The permittee shall implement the PMP within 30 days after written notification from the Department that the PMP is complete.
4. If the Department determines that the permittee is required to perform a PMP, the permittee shall submit an annual report every 12 months from the implementation of the PMP. The annual report shall contain:
   i. Any revisions to the PMP as a result of ongoing work shall be reported in the Annual Report; and
   ii. at a minimum, a detailed discussion of the specific progress and actions taken by the permittee during the previous 12-month period that addresses reducing PCB loadings and implementation of the PMP.

(e) The Department will modify the permits of the major facilities identified in (a) above in accordance with the procedures at N.J.A.C. 7:14A-16. For any permit that is expired as of January 16, 2007, the requirements set forth in this section and N.J.A.C. 7:14A-14.4 will be incorporated into the permit at the next renewal of the permit.

APPENDIX A (Reserved)

APPENDIX B (Reserved)

APPENDIX C

FEDERAL POLICY ON COMBINED SEWER OVERFLOWS

Appendix C incorporates the Federal policy on combined sewer overflows published in the Federal Register on April 19, 1994.

ENVIRONMENTAL PROTECTION AGENCY

[FRL-4732-7]

Combined Sewer Overflow (CSO) Control Policy

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final policy.

SUMMARY: EPA has issued a national policy statement entitled ``Combined Sewer Overflow (CSO) Control Policy." This policy establishes a consistent national approach for controlling discharges from CSOs to the Nation's waters through the National Pollutant Discharge Elimination System (NPDES) permit program.

FOR FURTHER INFORMATION CONTACT: Jeffrey Lape, Office of Wastewater Enforcement and Compliance, MC-4201, U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460, (202) 260-7361.

SUPPLEMENTARY INFORMATION: The main purposes of the CSO Control Policy are to elaborate on the Environmental Protection Agency's (EPA's) National CSO Control Strategy published on September 8, 1989, at 54 FR 37370, and to expedite compliance with the requirements of the Clean Water Act (CWA). While implementation of the 1989 Strategy has resulted in progress toward controlling CSOs, significant public health and water quality risks remain.

This Policy provides guidance to permittees with CSOs, NPDES authorities and State water quality standards authorities on coordinating the planning, selection, and implementation of CSO controls that meet the requirements of the CWA and allow for public involvement during the decision-making process.

Contained in the Policy are provisions for developing appropriate, site-specific NPDES permit requirements for all combined sewer systems (CSS) that overflow as a result of wet weather events. For example, the Policy lays out two alternative approaches--the ``demonstration'' and the ``presumption'' approaches--that provide communities with targets for CSO controls that achieve compliance with the Act, particularly protection of water quality and designated uses. The Policy also includes enforcement initiatives to require the immediate elimination of overflows that occur during dry weather and to ensure that the remaining CWA requirements are complied with as soon as practicable.

The permitting provisions of the Policy were developed as a result of extensive input received from key stakeholders during a negotiated policy dialogue. The CSO stakeholders included representatives from States, environmental groups, municipal organizations and others. The negotiated dialogue was conducted during the Summer of 1992 by the Office of Water and the Office of Water's Management Advisory Group. The enforcement initiatives, including one which is underway to address CSOs during dry weather, were developed by EPA's Office of Water and Office of Enforcement.

EPA issued a Notice of Availability on the draft CSO Control Policy on January 19, 1993, (58 FR 4994) and requested comments on the draft Policy by March 22, 1993. Approximately forty-one sets of written comments were submitted by a variety of interest groups including cities and municipal groups, environmental groups, States, professional organizations and others. All comments were considered as EPA prepared the Final Policy. The public comments were largely supportive of the draft Policy. EPA received broad endorsement of and support for the key principles and provisions from most commenters. Thus, this final Policy does not include significant changes to the major provisions of the draft Policy, but rather, it includes clarification and better explanation of the elements of the Policy to address several of the questions that were raised in the comments. Persons wishing to obtain copies of the public comments or EPA's summary analysis of the comments may write or call the EPA contact person.

The CSO Policy represents a comprehensive national strategy to ensure that municipalities, permitting authorities, water quality standards authorities and the public engage in a comprehensive and coordinated planning effort to achieve cost effective CSO controls that ultimately meet appropriate health and environmental objectives. The Policy recognizes the site-specific nature of CSOs and their impacts and provides the necessary flexibility to tailor controls to local situations. Major elements of the Policy ensure that CSO controls are cost effective and meet the objectives and requirements of the CWA.

The major provisions of the Policy are as follows.

CSO permittees should immediately undertake a process to accurately characterize their CSS and CSO discharges, demonstrate implementation of minimum technology-based controls identified in the Policy, and develop long-term CSO control plans which evaluate alternatives for attaining compliance with the CWA, including compliance with water quality standards and protection of designated uses. Once the long-term CSO control plans are completed, permittees will be responsible to implement the plans' recommendations as soon as practicable.

State water quality standards authorities will be involved in the long-term CSO control planning effort as well. The water quality standards authorities will help ensure that development of the CSO permittees' long-term CSO control plans are coordinated with the review and possible revision of water quality standards on CSO-impacted waters.

NPDES authorities will issue/reissue or modify permits, as appropriate, to require compliance with the technology-based and water quality-based requirements of the CWA. After completion of the long- term CSO control plan, NPDES permits will be reissued or modified to incorporate the additional requirements specified in the Policy, such as performance standards for the selected controls based on average design conditions, a post-construction water quality assessment program, monitoring for compliance with water quality standards, and a reopener clause authorizing the NPDES authority to reopen and modify the permit if it is determined that the CSO controls fail to meet water quality standards or protect designated uses. NPDES authorities should commence enforcement actions against permittees that have CWA violations due to CSO discharges during dry weather. In addition, NPDES authorities should ensure the implementation of the minimum technology- based controls and incorporate a schedule into an appropriate enforceable mechanism, with appropriate milestone dates, to implement the required long-term CSO control plan. Schedules for implementation of the long-term CSO control plan may be phased based on the relative importance of adverse impacts upon water quality standards and designated uses, and on a permittee's financial capability.

EPA is developing extensive guidance to support the Policy and will announce the availability of the guidances and other outreach efforts through various means, as they become available. For example, EPA is preparing guidance on the nine minimum controls, characterization and monitoring of

CSOs, development of long-term CSO control plans, and financial capability.

Permittees will be expected to comply with any existing CSO-related requirements in NPDES permits, consent decrees or court orders unless revised to be consistent with this Policy.

The policy is organized as follows:

2. Enforcement for Compliance With Phase II Permits

D. Penalties

List of Subjects in 40 CFR Part 122

Water pollution control.

Authority: Clean Water Act, 33 U.S.C. 1251 et seq.

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Combined Sewer Overflow (CSO) Control Policy

I. Introduction

A. Purpose and Principles

The main purposes of this Policy are to elaborate on EPA's National Combined Sewer Overflow (CSO) Control Strategy published on September 8, 1989 at 54 FR 37370 (1989 Strategy) and to expedite compliance with the requirements of the Clean Water Act (CWA). While implementation of the 1989 Strategy has resulted in progress toward controlling CSOs, significant water quality risks remain.

A combined sewer system (CSS) is a wastewater collection system owned by a State or municipality (as defined by section 502(4) of the CWA) which conveys sanitary wastewaters (domestic, commercial and industrial wastewaters) and storm water through a single-pipe system to a Publicly Owned Treatment Works (POTW) Treatment Plant (as defined in 40 CFR 403.3(p)). A CSO is the discharge from a CSS at a point prior to the POTW Treatment Plant. CSOs are point sources subject to NPDES permit requirements including both technology-based and water quality-based requirements of the CWA. CSOs are not subject to secondary treatment requirements applicable to POTWs.

CSOs consist of mixtures of domestic sewage, industrial and commercial wastewaters, and storm water runoff. CSOs often contain high levels of suspended solids, pathogenic microorganisms, toxic pollutants, floatables, nutrients, oxygen-demanding organic compounds, oil and grease, and other pollutants. CSOs can cause exceedances of water quality standards (WQS). Such exceedances may pose risks to human health, threaten aquatic life and its habitat, and impair the use and enjoyment of the Nation's waterways.

This Policy is intended to provide guidance to permittees with CSOs, National Pollutant Discharge Elimination System (NPDES) permitting authorities, State water quality standards authorities and enforcement authorities. The purpose of the Policy is to coordinate the planning, selection, design and implementation of CSO management practices and controls to meet the requirements of the CWA and to involve the public fully during the decision making process.

This Policy reiterates the objectives of the 1989 Strategy:

1. To ensure that if CSOs occur, they are only as a result of wet weather;

2. To bring all wet weather CSO discharge points into compliance with the technology-based and water quality-based requirements of the CWA; and

3. To minimize water quality, aquatic biota, and human health impacts from CSOs.

This CSO Control Policy represents a comprehensive national strategy to ensure that municipalities, permitting authorities, water quality standards authorities and the public engage in a comprehensive and coordinated planning effort to achieve cost-effective CSO controls that ultimately meet appropriate health and environmental objectives and requirements. The Policy recognizes the site-specific nature of CSOs and their impacts and provides the necessary flexibility to tailor controls to local situations. Four key principles of the Policy ensure that CSO controls are cost-effective and meet the objectives of the CWA. The key principles are:

1. Providing clear levels of control that would be presumed to meet appropriate health and environmental objectives;

2. Providing sufficient flexibility to municipalities, especially financially disadvantaged communities, to consider the site-specific nature of CSOs and to determine the most cost-effective means of reducing pollutants and meeting CWA objectives and requirements;

3. Allowing a phased approach to implementation of CSO controls considering a community's financial capability; and

4. Review and revision, as appropriate, of water quality standards and their implementation procedures when developing CSO control plans to reflect the site-specific wet weather impacts of CSOs.

This Policy is being issued in support of EPA's regulations and policy initiatives. This Policy is Agency guidance only and does not establish or affect legal rights or obligations. It does not establish a binding norm and is not finally determinative of the issues addressed. Agency decisions in any particular case will be made by applying the law and regulations on the basis of specific facts when permits are issued. The Administration has recommended that the 1994 amendments to the CWA endorse this final Policy.

B. Application of Policy

The permitting provisions of this Policy apply to all CSSs that overflow as a result of storm water flow, including snow melt runoff (40 CFR 122.26(b)(13)). Discharges from CSSs during dry weather are prohibited by the CWA. Accordingly, the permitting provisions of this Policy do not apply to CSOs during dry weather. Dry weather flow is the flow in a combined sewer that results from domestic sewage, groundwater infiltration, commercial and industrial wastewaters, and any other non- precipitation related flows (e.g., tidal infiltration). In addition to the permitting provisions, the Enforcement and Compliance section of this Policy describes an enforcement initiative being developed for overflows that occur during dry weather.

Consistent with the 1989 Strategy, 30 States that submitted CSO permitting strategies have received EPA approval or, in the case of one State, conditional approval of its strategy. States and EPA Regional Offices should review these strategies and negotiate appropriate revisions to them to implement this Policy. Permitting authorities are encouraged to evaluate water pollution control needs on a watershed management basis and coordinate CSO control efforts with other point and nonpoint source control activities.

C. Effect on Current CSO Control Efforts

EPA recognizes that extensive work has been done by many Regions, States, and municipalities to abate CSOs. As such, portions of this Policy may already have been addressed by permittees' previous efforts to control CSOs. Therefore, portions of this Policy may not apply, as determined by the permitting authority on a case-by-case basis, under the following circumstances:

1. Any permittee that, on the date of publication of this final Policy, has completed or substantially completed construction of CSO control facilities that are designed to meet WQS and protect designated uses, and where it has been determined that WQS are being or will be attained, is not covered by the initial planning and construction provisions in this Policy; however, the operational plan and post-construction monitoring provisions continue to apply. If, after monitoring, it is determined that WQS are not being attained, the permittee should be required to submit

a revised CSO control plan that, once implemented, will attain WQS.

2. Any permittee that, on the date of publication of this final Policy, has substantially developed or is implementing a CSO control program pursuant to an existing permit or enforcement order, and such program is considered by the NPDES permitting authority to be adequate to meet WQS and protect designated uses and is reasonably equivalent to the treatment objectives of this Policy, should complete those facilities without further planning activities otherwise expected by this Policy. Such programs, however, should be reviewed and modified to be consistent with the sensitive area, financial capability, and post-construction monitoring provisions of this Policy.

3. Any permittee that has previously constructed CSO control facilities in an effort to comply with WQS but has failed to meet such applicable standards or to protect designated uses due to remaining CSOs may receive consideration for such efforts in future permits or enforceable orders for long-term CSO control planning, design and implementation.

In the case of any ongoing or substantially completed CSO control effort, the NPDES permit or other enforceable mechanism, as appropriate, should be revised to include all appropriate permit requirements consistent with Section IV.B. of this Policy.

D. Small System Considerations

The scope of the long-term CSO control plan, including the characterization, monitoring and modeling, and evaluation of alternatives portions of this Policy may be difficult for some small CSSs. At the discretion of the NPDES Authority, jurisdictions with populations under 75,000 may not need to complete each of the formal steps outlined in Section II.C. of this Policy, but should be required through their permits or other enforceable mechanisms to comply with the nine minimum controls (II.B), public participation (II.C.2), and sensitive areas (II.C.3) portions of this Policy. In addition, the permittee may propose to implement any of the criteria contained in this Policy for evaluation of alternatives described in II.C.4. Following approval of the proposed plan, such jurisdictions should construct the control projects and propose a monitoring program sufficient to determine whether WQS are attained and designated uses are protected.

In developing long-term CSO control plans based on the small system considerations discussed in the preceding paragraph, permittees are encouraged to discuss the scope of their long-term CSO control plan with the WQS authority and the NPDES authority. These discussions will ensure that the plan includes sufficient information to enable the permitting authority to identify the appropriate CSO controls.

E. Implementation Responsibilities

NPDES authorities (authorized States or EPA Regional Offices, as appropriate) are responsible for implementing this Policy. It is their responsibility to assure that CSO permittees develop long-term CSO control plans and that NPDES permits meet the requirements of the CWA. Further, they are responsible for coordinating the review of the long- term CSO control plan and the development of the permit with the WQS authority to determine if revisions to the WQS are appropriate. In addition, they should determine the appropriate vehicle (i.e., permit reissuance, information request under CWA section 308 or State equivalent or enforcement action) to ensure that compliance with the CWA is achieved as soon as practicable.

Permittees are responsible for documenting the implementation of the nine minimum controls and developing and implementing a long-term CSO control plan, as described in this Policy. EPA recognizes that financial considerations are a major factor affecting the implementation of CSO controls. For that reason, this Policy allows consideration of a permittee's financial capability in connection with the long-term CSO control planning effort, WQS review, and negotiation of enforceable schedules. However, each permittee is ultimately responsible for aggressively pursuing financial arrangements for the implementation of its long-term CSO control plan. As part of this effort, communities should apply to their State Revolving Fund program, or other assistance programs as appropriate, for financial assistance.

EPA and the States will undertake action to assure that all permittees with CSSs are subject to a consistent review in the permit development process, have permit requirements that achieve compliance with the CWA, and are subject to enforceable schedules that require the earliest practicable compliance date considering physical and financial feasibility.

F. Policy Development

This Policy devotes a separate section to each step involved in developing and implementing CSO controls. This is not to imply that each function occurs separately. Rather, the entire process surrounding CSO controls, community planning, WQS and permit development/revision, enforcement/compliance actions and public participation must be coordinated to control CSOs effectively.

Permittees and permitting authorities are encouraged to consider innovative and alternative approaches and technologies that achieve the objectives of this Policy and the CWA.

In developing this Policy, EPA has included information on what responsible parties are expected to accomplish. Subsequent documents will provide additional guidance on how the objectives of this Policy should be met. These documents will provide further guidance on: CSO permit writing, the nine minimum controls, long-term CSO control plans, financial capability, sewer system characterization and receiving water monitoring and modeling, and application of WQS to CSO-impacted waters. For most CSO control efforts however, sufficient detail has been included in this Policy to begin immediate implementation of its provisions.

II. EPA Objectives for Permittees

A. Overview

Permittees with CSSs that have CSOs should immediately undertake a process to accurately characterize their sewer systems, to demonstrate implementation of the nine minimum controls, and to develop a long-term CSO control plan.

B. Implementation of the Nine Minimum Controls

Permittees with CSOs should submit appropriate documentation demonstrating implementation of the nine minimum controls, including any proposed schedules for completing minor construction activities.

The nine minimum controls are:

1. Proper operation and regular maintenance programs for the sewer system and the CSOs;

2. Maximum use of the collection system for storage;

3. Review and modification of pretreatment requirements to assure CSO impacts are minimized;

4. Maximization of flow to the POTW for treatment;

5. Prohibition of CSOs during dry weather;

6. Control of solid and floatable materials in CSOs;

7. Pollution prevention;

8. Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts; and

9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

Selection and implementation of actual control measures should be based on site-specific considerations including the specific CSS's characteristics discussed under the sewer system characterization and monitoring portions of this Policy. Documentation of the nine minimum controls may include operation and maintenance plans, revised sewer use ordinances for industrial users, sewer system inspection reports, infiltration/inflow studies, pollution prevention programs, public notification plans, and facility plans for maximizing the capacities of the existing collection, storage and treatment systems, as well as contracts and schedules for minor construction programs for improving the existing system's operation. The permittee should also submit any information or data on the degree to which the nine minimum controls achieve compliance with water quality standards. These data and information should include results made available through monitoring and modeling activities done in conjunction with the development of the long-term CSO control plan described in this Policy.

This documentation should be submitted as soon as practicable, but no later than two years after the requirement to submit such documentation is included in an NPDES permit or other enforceable mechanism. Implementation of the nine minimum controls with appropriate documentation should be completed as soon as practicable but no later than January 1, 1997. These dates should be included in an appropriate enforceable mechanism.

Because the CWA requires immediate compliance with technology-based controls (section 301(b)), which on a Best Professional Judgment basis should include the nine minimum controls, a compliance schedule for implementing the nine minimum controls, if necessary, should be included in an appropriate enforceable mechanism.

C. Long-Term CSO Control Plan

Permittees with CSOs are responsible for developing and implementing long-term CSO control plans that will ultimately result in compliance with the requirements of the CWA. The long-term plans should consider the site-specific nature of CSOs and evaluate the cost effectiveness of a range of control options/strategies. The development of the long-term CSO control plan and its subsequent implementation should also be coordinated with the NPDES authority and the State authority responsible for reviewing and revising the State's WQS. The selected controls should be designed to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS, including existing and designated uses.

This policy identifies EPA's major objectives for the long-term CSO control plan. Permittees should develop and submit this long-term CSO control plan as soon as practicable, but generally within two years after the date of the NPDES permit provision, Section 308 information request, or enforcement action requiring the permittee to develop the plan. NPDES authorities may establish a longer timetable for completion of the long-term CSO control plan on a case-by-case basis to account for site-specific factors which may influence the complexity of the planning process. Once agreed upon, these dates should be included in an appropriate enforceable mechanism.

EPA expects each long-term CSO control plan to utilize appropriate information to address the following minimum elements. The Plan should also include both fixed-date project implementation schedules (which may be phased) and a financing plan to design and construct the project as soon as practicable. The minimum elements of the long-term CSO control plan are described below.

1. Characterization, Monitoring, and Modeling of the Combined Sewer System

In order to design a CSO control plan adequate to meet the requirements of the CWA, a permittee should have a thorough understanding of its sewer system, the response of the system to various precipitation events, the characteristics of the overflows, and the water quality impacts that result from CSOs. The permittee should adequately characterize through monitoring, modeling, and other means as appropriate, for a range of storm events, the response of its sewer system to wet weather events including the number, location and frequency of CSOs, volume, concentration and mass of pollutants discharged and the impacts of the CSOs on the receiving waters and their designated uses. The permittee may need to consider information on the contribution and importance of other pollution sources in order to develop a final plan designed to meet water quality standards. The purpose of the system characterization, monitoring and modeling program initially is to assist the permittee in developing appropriate measures to implement the nine minimum controls and, if necessary, to support development of the long-term CSO control plan. The monitoring and modeling data also will be used to evaluate the expected effectiveness of both the nine minimum controls and, if necessary, the long-term CSO controls, to meet WQS.

The major elements of a sewer system characterization are described below.

a. Rainfall Records--The permittee should examine the complete rainfall record for the geographic area of its existing CSS using sound statistical procedures and best available data. The permittee should evaluate flow variations in the receiving water body to correlate between CSOs and receiving water conditions.

b. Combined Sewer System Characterization--The permittee should evaluate the nature and extent of its sewer system through evaluation of available sewer system records, field inspections and other activities necessary to understand the number, location and frequency of overflows and their location relative to sensitive areas and to pollution sources in the collection system, such as indirect significant industrial users.

c. CSO Monitoring--The permittee should develop a comprehensive, representative monitoring program that measures the frequency, duration, flow rate, volume and pollutant concentration of CSO discharges and assesses the impact of the CSOs on the receiving waters. The monitoring program should include necessary CSO effluent and ambient in-stream monitoring and, where appropriate, other monitoring protocols such as biological assessment, toxicity testing and sediment sampling. Monitoring parameters should include, for example, oxygen demanding pollutants, nutrients, toxic pollutants, sediment contaminants, pathogens, bacteriological indicators (e.g., Enterococcus, E. Coli), and toxicity. A representative sample of overflow points can be selected that is sufficient to allow characterization of CSO discharges and their water quality impacts and to facilitate evaluation of control plan alternatives.

d. Modeling--Modeling of a sewer system is recognized as a valuable tool for predicting sewer system response to various wet weather events and assessing water quality impacts when evaluating different control strategies and alternatives. EPA supports the proper and effective use of models, where appropriate, in the evaluation of the nine minimum controls and the development of the long-term CSO control plan. It is also recognized that there are many models which may be used to do this. These models range from simple to complex. Having decided to use a model, the permittee should base its choice of a model on the characteristics of its sewer system, the number and location of overflow points, and the sensitivity of the receiving water body to the CSO discharges. Use of models should include appropriate calibration and verification with field measurements. The sophistication of the model should relate to the complexity of the system to be modeled and to the information needs associated with evaluation of CSO control options and water quality impacts. EPA believes that continuous simulation models, using historical rainfall data, may be the best way to model sewer systems, CSOs, and their impacts. Because of the iterative nature of modeling sewer systems, CSOs, and their impacts, monitoring and modeling efforts are complementary and should be coordinated.

2. Public Participation

In developing its long-term CSO control plan, the permittee will employ a public participation process that actively involves the affected public in the decision-making to select the long-term CSO controls. The affected public includes rate payers, industrial users of the sewer system, persons who reside downstream from the CSOs, persons who use and enjoy these downstream waters, and any other interested persons.

3. Consideration of Sensitive Areas

EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas. Sensitive areas, as determined by the NPDES authority in coordination with State and Federal agencies, as appropriate, include designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas, and shellfish beds. For such areas, the long-term CSO control plan should:

a. Prohibit new or significantly increased overflows;

b.

i. Eliminate or relocate overflows that discharge to sensitive areas wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment; or

ii. Where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, provide the level of treatment for remaining overflows deemed necessary to meet WQS for full protection of existing and designated uses. In any event, the level of control should not be less than those described in Evaluation of Alternatives below; and

c. Where elimination or relocation has been proven not to be physically possible and economically achievable, permitting authorities should require, for each subsequent permit term, a reassessment based on new or improved techniques to eliminate or relocate, or on changed circumstances that influence economic achievability.

4. Evaluation of Alternatives

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.

In addition to considering sensitive areas, the long-term CSO control plan should adopt one of the following approaches:

a. ``Presumption" Approach

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 described above. 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 WQS.

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 paragraph ii. above. 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 WQS, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary.

b. ``Demonstration'' Approach

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. To be a successful demonstration, the permittee should demonstrate each of the following:

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. Where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload 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 subsequently determined to be necessary to meet WQS or designated uses.

5. Cost/Performance Considerations

The permittee should develop appropriate cost/performance curves to demonstrate the relationships among a comprehensive set of reasonable control alternatives that correspond to the different ranges specified in Section II.C.4. This should include an analysis to determine where the increment of pollution reduction achieved in the receiving water diminishes compared to the increased costs. This analysis, often known as knee of the curve, should be among the considerations used to help guide selection of controls.

6. Operational Plan

After agreement between the permittee and NPDES authority on the necessary CSO controls to be implemented under the long-term CSO control plan, the permittee should revise the operation and maintenance program developed as part of the nine minimum controls to include the agreed-upon long-term CSO controls. The revised operation and maintenance program should maximize the removal of pollutants during and after each precipitation event using all available facilities within the collection and treatment system. For any flows in excess of the criteria specified at II.C.4.a.i., ii. or iii and not receiving the treatment specified in II.C.4.a, the operational plan should ensure that such flows receive treatment to the greatest extent practicable.

7. Maximizing Treatment at the Existing POTW Treatment Plant

In some communities, POTW treatment plants may have primary treatment capacity in excess of their secondary treatment capacity. One effective strategy to abate pollution resulting from CSOs is to maximize the delivery of flows during wet weather to the POTW treatment plant for treatment. Delivering these flows can have two significant water quality benefits: First, increased flows during wet weather to the POTW treatment plant may enable the permittee to eliminate or minimize overflows to sensitive areas; second, this would maximize the use of available POTW facilities for wet weather flows and would ensure that combined sewer flows receive at least primary treatment prior to discharge.

Under EPA regulations, the intentional diversion of waste streams from any portion of a treatment facility, including secondary treatment, is a bypass. EPA bypass regulations at 40 CFR 122.41(m) allow for a facility to bypass some or all the flow from its treatment process under specified limited circumstances. Under the regulation, the permittee must show that the bypass was unavoidable to prevent loss of life, personal injury or severe property damage, that there was no feasible alternative to the bypass and that the permittee submitted the required notices. In addition, the regulation provides that a bypass may be approved only after consideration of adverse effects.

Normally, it is the responsibility of the permittee to document, on a case-by-base 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. For approval of a CSO-related bypass, the long-term CSO control plan, at a minimum, should provide justification for the cut-off point at which the flow will be diverted from the secondary treatment portion of the treatment plant, and provide a benefit-cost analysis demonstrating that conveyance of wet weather flow to the POTW for primary treatment is more beneficial than other CSO abatement alternatives such as storage and pump back for secondary treatment, sewer separation, or satellite treatment. Such a permit must define under what specific wet weather conditions a CSO-related bypass is allowed and also specify what treatment or what monitoring, and effluent limitations and requirements apply to the bypass flow. The permit should also provide that approval for the CSO-related bypass will be reviewed and may be modified or terminated if there is a substantial increase in the volume or character of pollutants being introduced to the POTW. The CSO-related bypass provision in the permit should also make it clear that all wet weather flows passing the headworks of the POTW treatment plant will receive at least primary clarification and solids and floatables removal and disposal, and disinfection, where necessary, and any other treatment that can reasonably be provided.

Under this approach, EPA would allow a permit to authorize a CSO-related bypass of the secondary treatment portion of the POTW treatment plant for combined sewer flows in certain identified circumstances. This provision would apply only to those situations where the POTW would ordinarily meet the requirements of 40 CFR 122.41(m) as evaluated on a case-by-case basis. Therefore, there must be sufficient data in the administrative record (reflected in the permit fact sheet or statement of basis) supporting all the requirements in 40 CFR 122.41(m)(4) for approval of an anticipated bypass.

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. EPA further believes that the feasible alternatives requirement of the regulation can be met if the record shows that the secondary treatment system is properly operated and maintained, that the system has been designed to meet secondary limits for flows greater than the peak dry weather flow, plus an appropriate quantity of wet weather flow, and that it is either technically or financially infeasible to provide secondary treatment at the existing facilities for greater amounts of wet weather flow. The feasible alternative analysis should include, for example, consideration of enhanced primary treatment (e.g., chemical addition) and non-biological secondary treatment. Other bases supporting a finding of no feasible alternative may also be available on a case-by-case basis. As part of its consideration of possible adverse effects resulting from the bypass, the permitting authority should also ensure that the bypass will not cause exceedances of WQS.

This Policy does not address the appropriateness of approving anticipated bypasses through NPDES permits in advance outside the CSO context.

8. Implementation Schedule

The permittee should include all pertinent information in the long term control plan necessary to develop the construction and financing schedule for implementation of CSO controls. 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.

Construction phasing should consider:

a. Eliminating overflows that discharge to sensitive areas as the highest priority;

b. Use impairment;

c. The permittee's financial capability including consideration of such factors as:

i. Median household income;

ii. Total annual wastewater and CSO control costs per household as a percent of median household income;

iii. Overall net debt as a percent of full market property value;

iv. Property tax revenues as a percent of full market property value;

v. Property tax collection rate;

vi. Unemployment; and

vii. Bond rating;

d. Grant and loan availability;

e. Previous and current residential, commercial and industrial sewer user fees and rate structures; and

f. Other viable funding mechanisms and sources of financing.

9. Post-Construction Compliance Monitoring Program

The selected CSO controls should include a post-construction water quality monitoring program adequate to verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls. This water quality compliance monitoring program should include a plan to be approved by the NPDES authority that details the monitoring protocols to be followed, including the necessary effluent and ambient monitoring and, where appropriate, other monitoring protocols such as biological assessments, whole effluent toxicity testing, and sediment sampling.

III. Coordination With State Water Quality Standards

A. Overview

WQS are State adopted, or Federally promulgated rules which serve as the goals for the water body and the legal basis for the water quality-based NPDES permit requirements under the CWA. WQS consist of uses which States designate for their water bodies, criteria to protect the uses, an anti-degradation policy to protect the water quality improvements gained and other policies affecting the implementation of the standards. A primary objective of the long-term CSO control plan is to meet WQS, including the designated uses through reducing risks to human health and the environment by eliminating, relocating or controlling CSOs to the affected waters.

State WQS authorities, NPDES authorities, EPA regional offices, permittees, and the public should meet early and frequently throughout the long-term CSO control planning process. Development of the long-term plan should be coordinated with the review and appropriate revision of WQS and implementation procedures on CSO-impacted waters to ensure that the long-term controls will be sufficient to meet water quality standards. As part of these meetings, participants should agree on the data, information and analyses needed to support the development of the long-term CSO control plan and the review of applicable WQS, and implementation procedures, if appropriate. Agreements should be reached on the monitoring protocols and models that will be used to evaluate the water quality impacts of the overflows, to analyze the attainability of the WQS and to determine the water quality-based requirements for the permit. Many opportunities exist for permittees and States to share information as control programs are developed and as WQS are reviewed. Such information should assist States in determining the need for revisions to WQS and implementation procedures to better reflect the site-specific wet weather impacts of CSOs. Coordinating the development of the long-term CSO control plan and the review of the WQS and implementation procedures provides greater assurance that the long-term control plan selected and the limits and requirements included in the NPDES permit will be sufficient to meet WQS and to comply with sections 301(b)(1)(C) and 402(a)(2) of the CWA.

EPA encourages States and permittees jointly to sponsor workshops for the affected public in the development of the long-term CSO control plan and during the development of appropriate revisions to WQS for CSO-impacted waters. Workshops provide a forum for including the public in discussions of the implications of the proposed long-term CSO control plan on the water quality and uses for the receiving water.

B. Water Quality Standards Reviews

The CWA requires States to periodically, but at least once every three years, hold public hearings for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards. States must provide the public an opportunity to comment on any proposed revision to water quality standards and all revisions must be submitted to EPA for review and approval.

EPA regulations and guidance provide States with the flexibility to adapt their WQS, and implementation procedures to reflect site-specific conditions including those related to CSOs. For example, a State may adopt site-specific criteria for a particular pollutant if the State determines that the site-specific criteria fully protects the designated use (40 CFR 131.11). In addition, the regulations at 40 CFR 131.10(g), (h), and (j) specify when and how a designated use may be modified. A State may remove a designated use from its water quality standards only if the designated use is not an existing use. An existing use is a use actually attained in the water body on or after November 28, 1975. Furthermore, a State may not remove a designated use that will be attained by implementing the technology-based effluent limits required under sections 301(b) and 306 of the CWA and by implementing cost-effective and reasonable best management practices for nonpoint source controls. Thus, if a State has a reasonable basis to determine that the current designated use could be attained after implementation of the technology-based controls of the CWA, then the use could not be removed.

In determining whether a use is attainable and prior to removing a designated use, States must conduct and submit to EPA a use attainability analysis. A use attainability analysis is a structured scientific assessment of the factors affecting the use, including the physical, chemical, biological, and economic factors described in 40 CFR 131.10(g). As part of the analysis, States should evaluate whether the designated use could be attained if CSO controls were implemented. For example, States should examine if sediment loadings from CSOs could be reduced so as not to bury spawning beds, or if biochemical oxygen demanding material in the effluent or the toxicity of the effluent could be corrected so as to reduce the acute or chronic physiological stress on or bioaccumulation potential of aquatic organisms.

In reviewing the attainability of their WQS and the applicability of their WQS implementation procedures to CSO-impacted waters, States are encouraged to define more explicitly their recreational and aquatic life uses and then, if appropriate, modify the criteria accordingly to protect the designated uses.

Another option is for States to adopt partial uses by defining when primary contact recreation such as swimming does not exist, such as during certain seasons of the year in northern climates or during a particular type of storm event. In making such adjustments to their uses, States must ensure that downstream uses are protected, and that during other seasons or after the storm event has passed, the use is fully protected.

In addition to defining recreational uses with greater specificity, States are also encouraged to define the aquatic uses more precisely. Rather than ``aquatic life use protection,'' States should consider defining the type of fishery to be protected such as a cold water fishery (e.g., trout or salmon) or a warm weather fishery (e.g., bluegill or large mouth bass). Explicitly defining the type of fishery to be protected may assist the permittee in enlisting the support of citizens for a CSO control plan.

A water quality standard variance may be appropriate, in limited circumstances on CSO-impacted waters, where the State is uncertain as to whether a standard can be attained and time is needed for the

State to conduct additional analyses on the attainability of the standard. Variances are short-term modifications in water quality standards. Subject to EPA approval, States, with their own statutory authority, may grant a variance to a specific discharger for a specific pollutant. The justification for a variance is similar to that required for a permanent change in the standard, although the showings needed are less rigorous. Variances are also subject to public participation requirements of the water quality standards and permits programs and are reviewable generally every three years. A variance allows the CSO permit to be written to meet the ``modified'' water quality standard as analyses are conducted and as progress is made to improve water quality.

Justifications for variances are the same as those identified in 40 CFR 131.10(g) for modifications in uses. States must provide an opportunity for public review and comment on all variances. If States use the permit as the vehicle to grant the variance, notice of the permit must clearly state that the variance modifies the State's water quality standards. If the variance is approved, the State appends the variance to the State's standards and reviews the variance every three years.

IV. Expectations for Permitting Authorities

A. Overview

CSOs are point sources subject to NPDES permit requirements including both technology-based and water quality-based requirements of the CWA. CSOs are not subject to secondary treatment regulations applicable to publicly owned treatment works (Montgomery Environmental Coalition vs. Costle, 646 F.2d 568 (D.C. Cir. 1980)).

All permits for CSOs should require the nine minimum controls as a minimum best available technology economically achievable and best conventional technology (BAT/BCT) established on a best professional judgment (BPJ) basis by the permitting authority (40 CFR 125.3). Water quality-based requirements are to be established based on applicable water quality standards.

This policy establishes a uniform, nationally consistent approach to developing and issuing NPDES permits to permittees with CSOs. Permits for CSOs should be developed and issued expeditiously. A single, system-wide permit generally should be issued for all discharges, including CSOs, from a CSS operated by a single authority. When different parts of a single CSS are operated by more than one authority, permits issued to each authority should generally require joint preparation and implementation of the elements of this Policy and should specifically define the responsibilities and duties of each authority. Permittees should be required to coordinate system-wide implementation of the nine minimum controls and the development and implementation of the long-term CSO control plan.

The individual authorities are responsible for their own discharges and should cooperate with the permittee for the POTW receiving the flows from the CSS. When a CSO is permitted separately from the POTW, both permits should be cross-referenced for informational purposes.

EPA Regions and States should review the CSO permitting priorities established in the State CSO Permitting Strategies developed in response to the 1989 Strategy. Regions and States may elect to revise these previous priorities. In setting permitting priorities, Regions and States should not just focus on those permittees that have initiated monitoring programs. When setting priorities, Regions and States should consider, for example, the known or potential impact of CSOs on sensitive areas, and the extent of upstream industrial user discharges to the CSS.

During the permittee's development of the long-term CSO control plan, the permit writer should promote coordination between the permittee and State WQS authority in connection with possible WQS revisions. Once the permittee has completed development of the long-term CSO control plan and has coordinated with the permitting authority the selection of the controls necessary to meet the requirements of the CWA, the permitting authority should include in an appropriate enforceable mechanism, requirements for implementation of the long-term CSO control plan, including conditions for water quality monitoring and operation and maintenance.

B. NPDES Permit Requirements

Following are the major elements of NPDES permits to implement this Policy and ensure protection of water quality.

1. Phase I Permits--Requirements for Demonstration of Implementation of the Nine Minimum Controls and Development of the Long-Term CSO Control Plan

In the Phase I permit issued/modified to reflect this Policy, the NPDES authority should at least require permittees to:

a. Immediately implement BAT/BCT, which at a minimum includes the nine minimum controls, as determined on a BPJ basis by the permitting authority;

b. Develop and submit a report documenting the implementation of the nine minimum controls within two years of permit issuance/modification;

c. Comply with applicable WQS, no later than the date allowed under the State's WQS, expressed in the form of a narrative limitation; and

d. develop and submit, consistent with this Policy and based on a schedule in an appropriate enforceable mechanism, a long-term CSO control plan as soon as practicable, but generally within two years after the effective date of the permit issuance/ modification. However, permitting authorities may establish a longer timetable for completion of the long-term CSO control plan on a case-by-case basis to account for site-specific factors that may influence the complexity of the planning process.

The NPDES authority should include compliance dates on the fastest practicable schedule for each of the nine minimum controls in an appropriate enforceable mechanism issued in conjunction with the Phase I permit. The use of enforceable orders is necessary unless Congress amends the CWA. All orders should require compliance with the nine minimum controls no later than January 1, 1997.

2. Phase II Permits--Requirements for Implementation of a Long-Term CSO Control Plan

Once the permittee has completed development of the long-term CSO control plan and the selection of the controls necessary to meet CWA requirements has been coordinated with the permitting and WQS authorities, the permitting authority should include, in an appropriate enforceable mechanism, requirements for implementation of the long-term CSO control plan as soon as practicable. Where the permittee has selected controls based on the ``presumption'' approach described in Section II.C.4, the permitting authority must have determined that the presumption that such level of treatment will achieve water quality standards is reasonable in light of the data and analysis conducted under this Policy. The Phase II permit should contain:

a. Requirements to implement the technology-based controls including the nine minimum controls determined on a BPJ basis;

b. Narrative requirements which insure that the selected CSO controls are implemented, operated and maintained as described in the long-term CSO control plan;

c. Water quality-based effluent limits under 40 CFR 122.44(d)(1) and 122.44(k), requiring, at a minimum, compliance with, no later than the date allowed under the State's WQS, the numeric performance standards for the selected CSO controls, based on average design conditions specifying at least one of the following:

   i. A maximum number of overflow events per year for specified design conditions consistent with II.C.4.a.i; or

   ii. A minimum percentage capture of combined sewage by volume for treatment under specified design conditions consistent with II.C.4.a.ii; or

   iii. A minimum removal of the mass of pollutants discharged for specified design conditions consistent with II.C.4.a.iii; or

   iv. performance standards and requirements that are consistent with II.C.4.b. of the Policy.

d. A requirement to implement, with an established schedule, the approved post-construction water quality assessment program including requirements to monitor and collect sufficient information to demonstrate compliance with WQS and protection of designated uses as well as to determine the effectiveness of CSO controls.

e. A requirement to reassess overflows to sensitive areas in those cases where elimination or relocation of the overflows is not physically possible and economically achievable. The reassessment should be based on consideration of new or improved techniques to eliminate or relocate overflows or changed circumstances that influence economic achievability;

f. Conditions establishing requirements for maximizing the treatment of wet weather flows at the POTW treatment plant, as appropriate, consistent with Section II.C.7. of this Policy;

g. A reopener clause authorizing the NPDES authority to reopen and modify the permit upon determination that the

CSO controls fail to meet WQS or protect designated uses. Upon such determination, the NPDES authority should promptly notify the permittee and proceed to modify or reissue the permit. The permittee should be required to develop, submit and implement, as soon as practicable, a revised CSO control plan which contains additional controls to meet WQS and designated uses. If the initial CSO control plan was approved under the demonstration provision of Section II.C.4.b., the revised plan, at a minimum, should provide for controls that satisfy one of the criteria in Section II.C.4.a. unless the permittee demonstrates that the revised plan is clearly adequate to meet WQS at a lower cost and it is shown that the additional controls resulting from the criteria in Section II.C.4.a. will not result in a greater overall improvement in water quality.

Unless the permittee can comply with all of the requirements of the Phase II permit, the NPDES authority should include, in an enforceable mechanism, compliance dates on the fastest practicable schedule for those activities directly related to meeting the requirements of the CWA. For major permittees, the compliance schedule should be placed in a judicial order. Proper compliance with the schedule for implementing the controls recommended in the long-term CSO control plan constitutes compliance with the elements of this Policy concerning planning and implementation of a long term CSO remedy.

3. Phasing Considerations

Implementation of CSO controls may be phased based on the relative importance of and adverse impacts upon WQS and designated uses, as well as the permittee's financial capability and its previous efforts to control CSOs. The NPDES authority should evaluate the proposed implementation schedule and construction phasing discussed in Section II.C.8. of this Policy. The permit should require compliance with the controls proposed in the long-term CSO control plan no later than the applicable deadline(s) under the CWA or State law. If compliance with the Phase II permit is not possible, an enforceable schedule, consistent with the Enforcement and Compliance Section of this Policy, should be issued in conjunction with the Phase II permit which specifies the schedule and milestones for implementation of the long-term CSO control plan.

V. Enforcement and Compliance

A. Overview

It is important that permittees act immediately to take the necessary steps to comply with the CWA. The CSO enforcement effort will commence with an initiative to address CSOs that discharge during dry weather, followed by an enforcement effort in conjunction with permitting CSOs discussed earlier in this Policy. Success of the enforcement effort will depend in large part upon expeditious action by NPDES authorities in issuing enforceable permits that include requirements both for the nine minimum controls and for compliance with all other requirements of the CWA. Priority for enforcement actions should be set based on environmental impacts or sensitive areas affected by CSOs.

As a further inducement for permittees to cooperate with this process, EPA is prepared to exercise its enforcement discretion in determining whether or not to seek civil penalties for past CSO violations if permittees meet the objectives and schedules of this Policy and do not have CSOs during dry weather.

B. Enforcement of CSO Dry Weather Discharge Prohibition

EPA intends to commence immediately an enforcement initiative against CSO permittees which have CWA violations due to CSOs during dry weather. Discharges during dry weather have always been prohibited by the NPDES program. Such discharges can create serious public health and water quality problems. EPA will use its CWA Section 308 monitoring, reporting, and inspection authorities, together with NPDES State authorities, to locate these violations, and to determine their causes. Appropriate remedies and penalties will be sought for CSOs during dry weather. EPA will provide NPDES authorities more specific guidance on this enforcement initiative separately.

C. Enforcement of Wet Weather CSO Requirements

Under the CWA, EPA can use several enforcement options to address permittees with CSOs. Those options directly applicable to this Policy are section 308 Information Requests, section 309(a) Administrative Orders, section 309(g) Administrative Penalty Orders, section 309 (b) and (d) Civil Judicial Actions, and section 504 Emergency Powers. NPDES States should use comparable means.

NPDES authorities should set priorities for enforcement based on environmental impacts or sensitive areas affected by CSOs. Permittees that have voluntarily initiated monitoring and are progressing expeditiously toward appropriate CSO controls should be given due consideration for their efforts.

1. Enforcement for Compliance With Phase I Permits

Enforcement for compliance with Phase I permits will focus on requirements to implement at least the nine minimum controls, and develop the long-term CSO control plan leading to compliance with the requirements of the CWA. Where immediate compliance with the Phase I permit is infeasible, the NPDES authority should issue an enforceable schedule, in concert with the Phase I permit, requiring compliance with the CWA and imposing compliance schedules with dates for each of the nine minimum controls as soon as practicable. All enforcement authorities should require compliance with the nine minimum controls no later than January 1, 1997. Where the NPDES authority is issuing an order with a compliance schedule for the nine minimum controls, this order should also include a schedule for development of the long-term CSO control plan.

If a CSO permittee fails to meet the final compliance date of the schedule, the NPDES authority should initiate appropriate judicial action.

2. Enforcement for Compliance With Phase II Permits

The main focus for enforcing compliance with Phase II permits will be to incorporate the long-term CSO control plan through a civil judicial action, an administrative order, or other enforceable mechanism requiring compliance with the CWA and imposing a compliance schedule with appropriate milestone dates necessary to implement the plan.

In general, a judicial order is the appropriate mechanism for incorporating the above provisions for Phase II. Administrative orders, however, may be appropriate for permittees whose long-term control plans will take less than five years to complete, and for minors that have complied with the final date of the enforceable order for compliance with their Phase I permit. If necessary, any of the nine minimum controls that have not been implemented by this time should be included in the terms of the judicial order.

D. Penalties

EPA is prepared not to seek civil penalties for past CSO violations, if permittees have no discharges during dry weather and meet the objectives and schedules of this Policy. Notwithstanding this, where a permittee has other significant CWA violations for which EPA or the State is taking judicial action, penalties may be considered as part of that action for the following:

1. CSOs during dry weather;

   2. Violations of CSO-related requirements in NPDES permits; consent decrees or court orders which predate this policy; or

   3. Other CWA violations.

   EPA will not seek penalties for past CSO violations from permittees that fully comply with the Phase I permit or enforceable order requiring compliance with the Phase I permit. For permittees that fail to comply, EPA will exercise its enforcement discretion in determining whether to seek penalties for the time period for which the compliance schedule was violated. If the milestone dates of the enforceable schedule are not achieved and penalties are sought, penalties should be calculated from the last milestone date that was met.

   At the time of the judicial settlement imposing a compliance schedule implementing the Phase II permit requirements, EPA will not seek penalties for past CSO violations from permittees that fully comply with the enforceable order requiring compliance with the Phase I permit and if the terms of the judicial order are expeditiously agreed to on consent. However, stipulated penalties for violation of the judicial order generally should be included in the order, consistent with existing Agency policies. Additional guidance on stipulated penalties concerning long-term CSO controls and attainment of WQS will be issued.

Paperwork Reduction Act

The information collection requirements in this policy have been approved by the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 et seq and have been assigned OMB control number 2040-0170.

This collection of information has an estimated reporting burden averaging 578 hours per response and an estimated annual recordkeeping burden averaging 25 hours per recordkeeper. These estimates include time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Chief, Information Policy Branch; EPA; 401 M Street SW. (Mail Code 2136); Washington, DC 20460; and to the Office of Information and Regulatory Affairs, Office of Management and

Budget, Washington, DC 20503, marked ``Attention: Desk Officer for EPA."

APPENDIX D

PVSC Updated Technical Guidance Manual

By: Greeley and Hansen & CDM Smith

Dated: January 2019

Passaic Valley Sewerage Commissioners

CSO Long Term Control Plan

Updated Technical Guidance Manual

January 2018

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Section 1

Introduction

The combined sewer systems (CSS) in the State of New Jersey are owned by a mix of municipal governments and authorities that are responsible for the State's 210 permitted outfalls. These collection systems are serviced by nine publicly owned treatment works (POTW) wastewater treatment facilities. The New Jersey Department of Environmental Protection has issued NJPDES permits to each of the CSS owners and POTWs requiring that the nine hydraulically connected systems develop and submit a Long Term Control Plan (LTCP) for reducing the impact of combined sewer overflow (CSO) to their receiving waters.

The Passaic Valley Sewerage Commission (PVSC) is one of the nine permitted POTW facilities and is coordinating the LTCP for its eight combined sewer communities: Bayonne, East Newark, Harrison, Jersey City, Kearny, Newark, North Bergen, and Paterson. The North Bergen Municipal Utility Authority also operates one of the nine permitted POTW facilities with its Woodcliff Wastewater Treatment plant, which services parts of North Bergen and Guttenberg. While a separate LTCP will be developed for that system, PVSC and NBMUA have agreed that PVSC would coordinate that LTCP development process as well.

The LTCP development process requires that the permittees each evaluate a variety of CSO control alternatives and submit an Evaluation of Alternatives Report. Although the PVSC and NBMUA hydraulically connected communities will submit system-wide LTCPs, each permittee will be responsible for evaluating the alternatives within their community.

To assist in the communities in performing their alternatives evaluations, PVSC has updated this Technical Guidance Manual (TGM) that was originally developed in 2007.

1.1 Background

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 require 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.

1.2 Purpose of the Technical Guidance Manual

The Technical Guidance Manual is intended as a guidance document to assist the individual permittees in performing their LTCP alternatives evaluations. The information and costs provided throughout the document are for planning purposes only, and the individual permittees should verify all of the assumptions and information contained herein.

Section 2

Treatment Technology

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. To satisfy CSO treatment objectives, treatment technologies for each unit processes of screenings/ pretreatment/ disinfection alternatives have been evaluated, including the following:

- Screenings - mechanical bar screens, fine screens, band and belt screens, and drum screens.
- Pretreatment - vortex/swirl Separation (Storm King® Vortex Separator, HYDROVEX® Fluidsep Vortex Separator, and SANSEP Process), ballasted flocculation (ACTIFLO® Ballasted Flocculation Process and DensaDeg Ballasted Flocculation), and compressible media filtration (FlexFilter Process)
- Disinfection – chlorination, peracetic acid, ozonation, and, UV disinfection.

CSOs are intermittent in nature and are characterized by highly variable flow rates relative to base sewage flow. Bacterial and organic loadings from the collection system also vary greatly, both within and between storm events. The screenings/pretreatment/disinfection system must be able to handle variable pollutant loadings and large fluctuations in flow that can change drastically. Where treatment facilities are to be considered, provisions for the handling, treatment, and ultimate disposal of sludge and other treatment residuals shall also be included.

2.1 Treatment Technology Evaluation Criteria

In the evaluation of each treatment technology as included in subsequent sections, the following description outlines the process used to evaluate each technology:

1. **Description of Process**: includes a verbal and graphical description of the treatment process and pertinent components.
2. **Applicability**: evaluates the applicability of technology for CSO control. Equipment manufacturers/vendors have been contacted to gather information on installation list for CSO applications, technology evaluation and case study. If determined not applicable for CSO control, no further evaluation will be performed.
3. **Performance**: Each process has been evaluated on a preliminary basis for its performance under similar conditions to CSO, particularly where flow and loading rates varied significantly. Individual processes have a different ability to handle varying loading rates and still maintain a reasonably consistent removal rate, or disinfection rate. The inability to maintain a required level of performance over varying hydraulic loadings may eliminate the process, or require that limitations to its use be considered.

4. **Hydraulics**: The screenings/ pre-treatment/ disinfection alternatives will need to be physically located between the CSO control facility and the receiving waters. In many locations, there may be limited difference in elevation between the water surface level in the regulator and the receiving water level. This will be particularly true wherein the receiving water elevations are affected by tides. Head loss within an individual control process will vary from negligible to as much as 8 feet. The total head loss for a treatment train consisting of screenings, pre-treatment, and disinfection may be as much as 10 feet. For this reason, the evaluation will identify the need for intermediate pumping. Screw pumps, which are capable of efficiently handling large flows under low head conditions, can be utilized for this purpose.

5. **Generation of Waste Streams:** Most if not all screening and pretreatment processes produce waste streams that must be contained and disposed of; however, none of the disinfection processes produce appreciable waste streams. Waste streams for the screening processes consist of the storing and/or disposal of collected screening materials. For the pre-treatment process, the waste streams are more varied. The vortex units produce underflow containing the solids removed by the process, which can be as much as 10% of the design flow of the vortex unit. Ballasted flocculation units produce waste sludge as part of the process. In addition, there is a startup period (approximately 20 minutes) for the ballasted flocculation system during which time the process effluent is of poor quality, and filtration processes produce filter backwash water. When these processes are located at a WWTP or along an interceptor sewer with available capacity, the waste streams can be discharged and treated. However, in remote locations, such as those envisioned for CSO treatment facilities, there is typically no place to dispose of the waste stream. While the permittees that own and operate the CSO conveyance systems will be evaluating the feasibility of increasing wet weather flows to the WWTP, most interceptor sewers during wet weather events are currently at capacity or surcharged. As a result, ancillary tankage must be provided to store the volume of the waste stream produced until such time that it can either be introduced into the process, or discharged to the interceptor sewer for treatment at the WWTP. Where applicable, the need for ancillary tanks must be included in the evaluation of the process.

6. **Complexity**: This portion of the evaluation will identify the level of complexity of the process, whether it is capable of functioning unmanned in a remote setting, and the level of instrumentation that would be needed to operate the system during the overflow events.

7. **Limitations**: Different processes can have limitations on the hydraulic and pollutant loading conditions that it can operate within, which can include both lower and upper limits. Any such limitation must be considered when determining the configuration of unit sizes for that process as needed to handle the variable flow/pollutant loading conditions. Limitations for each process are discussed in subsequent sections and have been considered in development of the evaluation process.

8. **Construction Costs**: This portion of the evaluation will provide preliminary report level construction cost estimates, which includes budgetary equipment costs as provided by the manufacturer, installation costs, building costs, and contingency for design flow ranging from 10 MGD to 450 MGD.

9. **Operation and Maintenance Costs**: Information on the operation and routine maintenance requirements was obtained from each of the equipment manufacturers and included in this section. Annual operation costs have been prepared based on power requirements for operation of the equipment, the estimated cost of power, and the estimated annual hours of operation of the equipment. In addition, annual maintenance costs reflecting those recommended by the equipment manufacturer, as well as the manpower required for anticipated post-overflow event clean up and service has been included.

10. **Space Requirements**: Due to the proximity of the regulators to the receiving water body, in most cases it is unlikely that there will be sufficient existing open land available to construct the screenings/pre-treatment/disinfection facilities. Therefore, it will likely be necessary for the Permittee to purchase land. The evaluation of the respective process shall include an evaluation of the space needed for the process. This area is not limited to the process or tank area but includes a small buffer for roadways and access base.

In the process of preparing this TGM, technology users were contacted to gather information on their experience with using the technology for CSO treatment.

2.1.1 Bayonne Wet Weather Demonstration Project

The Bayonne Wet Weather Flow Treatment and Disinfection Demonstration Project (Bayonne MUA Pilot Study) was conducted over a two-year period at the Oak Street facility in Bayonne, NJ which receives the CSO from Bayonne City. The project was sponsored by the Bayonne Municipal Utilities Authority (BMUA), with grants and collaboration from New Jersey Department of Environmental Protection (NJDEP) and the United States Environmental Protection Agency (USEPA). The primary focus of the Bayonne MUA Pilot Study was to verify the performance of selected technologies to treat CSO discharges for solids removal and disinfection under field conditions as suitable for remote satellite locations.

The treatment technologies evaluated included high rate solids removal (i.e., vortex and plate settler units) and enhanced high rate solids treatment (i.e., a compressed media filter). Three types of disinfection units were also included, namely chemical disinfection (i.e., Peracetic acid, PAA), and ultraviolet (UV) disinfection (low and medium pressure units). The evaluation results of the pilot study are discussed in the corresponding sections of the TGM.

2.2 Screenings

Screening technologies can either represent minimal treatment of a CSO before disinfection or can be used to remove larger particles upstream of vortex/swirl separation, ballasted flocculation, or compressed media filtration before high rate disinfection processes. The screening technologies and their related clearances, reviewed for this Technical Guidance Manual, are as follows:

- Mechanical Bar Screens 0.25" to 2" (6-50 mm) bar spacing
- Fine Screens 0.125" to 0.5" (3-13 mm) bar spacing
- Band and Belt Screens 0.08" to 0.4" (2-10 mm) openings
- Drum screens 0.0004" (0.01 mm) openings

As indicated above, screening technology will remove large material or particles as small as 0.0004" from the waste stream. The choice of a particular screening technology is a function of the general purpose of the screen, and what additional treatment process or equipment lies downstream. Screens with smaller openings, such as belt and micro screens, typically require pretreatment with a mechanical bar screen to prevent damage from large objects. Screenings equipment which are not continuously cleaned, such as manually cleaned bar screens, were eliminated from this evaluation due to the potential for backup and surcharging of the collection system. In general, screening systems are very effective in removing floatable and visible solids, but do not remove a significant amount of TSS, fecal coliform, enterococci, BOD, COD, NH3, TKN, total phosphorous, and total nitrogen.

The following sections describe the types of screens and equipment, as well as its capability to remove the various pollutants of concern. At the end of the section a summary of performance, operation, and environmental impacts will be presented. Based upon this summary some of the screening technologies will be eliminated from further consideration.

2.2.1 Mechanical Bar Screens

Description of Equipment

The three most common types of mechanically cleaned bar screens are: (1) chain driven, (2) climber type rake, and (3) catenary. Chain driven mechanical raking systems consist of a series of bar rakes connected to chains on each side of the bar rack. During the cleaning cycle, the rakes travel continuously from the bottom to the top of the bar rack, removing material retained on the bars and discharging them at the top of the rack. A disadvantage of chain-driven systems is that the lower bearings and sprockets are submerged in the flow and are susceptible to blockage and damage from grit and other materials. Climber-type systems employ a single rake mechanism mounted on a gear driven rack and pinion system. The gear drive turns cog wheels that move along a pin rack mounted on each side of the bar rack. During the cleaning cycle, the rake mechanism travels up and down the bar rack to remove materials retained on the bars. Screenings are typically discharged from the bars at the top of the rack. This type of bar screen has no submerged bearings or sprockets and is less susceptible to blockages, damage and corrosion. Catenary systems also employ chain drive rake mechanisms, but all sprockets, bearings, and shafts are located above the flow level in the screen channel. This in turn reduces the potential for damage and corrosion and facilitates routine maintenance. During the cleaning cycle, the rakes travel continuously from the bottom to the top of the bar rack to remove materials retained on the bars. Screenings are typically discharged from the bars at the top of the rack. The cleaning rake is held against the bars by the weight of its chains, allowing the rake to be pulled over large objects that are lodged in the bars and that might otherwise jam the rake mechanism.

Bar screens will remove essentially 100% of all rigid objects of which the minimum dimension is more than the spacing between the bars. Removing screenings from CSOs essentially does not remove any dissolved solids, or nutrients such as TKN, total nitrogen and total phosphorous. Screenings removed from overflows can however contain some larger rigid materials that reflect a BOD loading. Solids, such as fecal material, can also be contained within screenings collected on the bar screen, however the velocity between the bars increases with increasing flow, thus this material can be broken up and pass through the bars. Therefore, it is difficult to quantify on a consistent basis any BOD loading, fecal coliform and enterococci count, and TSS concentrations removed by the screening technologies. Nevertheless, some removal estimates, as provided by the manufacturer, have been included within the analysis procedure for further consideration.

For the purposes of the Technical Guidance Manual, the mechanical bar screen evaluation is based on the use of Climber Screens® since these have been found to be more reliable and significantly lower in operation and maintenance requirements than others. Figure 2-1 shows photos of typical climber screens. The Technical Guidance Manual analysis is based on mechanical bar screens with a maximum velocity between the bars of 4.5 feet per second (fps) and a peak velocity of approach of 3.0 fps. These are the standard criteria for designing bar screens for use in wastewater treatment plants, where flow is continuous and the diurnal patterns more predictable. Since CSOs are intermittent, with widely varying flow rates, these standards are more likely to be violated for short periods of time. The mechanical bar screen selections are also based upon an anticipated head loss of less than one foot, a peak flow level of six feet under peak flow conditions, with an operating floor located twelve feet above the water surface. For CSO applications where heavy debris loadings are likely, the minimum bar spacing should be approximately 1 inch.

Figure 2-1 - Photos of Typical Climber Screens

(Source: Infilco Degremont, Inc.)

Applicability to The Project

Mechanical bar screens have proven to be a relatively simple and inexpensive means of removing floatables and visible solids. They are typically the screen of choice in treatment facilities, and are used at a many CSO treatment facilities. There have been hundreds of Climber Screens® installed in CSO applications across the US. A list is provided in Appendix A focused on Type IIS and IIIAS installations in NJ, NY, and PA since 2000.

Performance Under Similar Conditions

As stated above, mechanical bar screens are already installed in many CSO facilities and operate successfully to remove floatables and visible solids over the fluctuations in flow rates seen in CSOs. Slight removal of TSS, total phosphorous, and total nitrogen (typically 5%, 3%, and 2%, respectively) can be achieved with the solids removal.

Hydraulics

Hydraulic losses through bar screens are a function of approach velocity, and the velocity through the bars. The head loss across the bar screen increases as the bar screen becomes clogged, or blinded. Instrumentation provided with mechanically cleaned screens is typically configured to send a signal to the cleaning mechanism so the head loss across the screen is limited to 6 inches.

Generation of Waste Streams

As screenings are removed from the CSO flows they generate a waste stream for disposal. Studies have found that the average CSO screenings loads vary from approximately 0.5 to 11 cubic feet per million gallons, with peaking factors based upon hourly flows ranging from 2:1 to greater than 20:1. These screenings must be either transferred to the interceptor sewer for ultimate disposal at the WWTP, or removed and stored in a container for onsite removal at a convenient time. The collection of screenings can be performed using conveyors, screenings compactors, or pumps. Any enclosure around the screenings equipment should provide space for a container and odor control.

Complexity

Mechanical bar screens are able to function intermittently, at remote locations with a minimum level of instrumentation. A level detector is needed to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer can be utilized to periodically exercise the screen, so it is ready for use.

Limitations

When mechanical bar screens are installed in a WWTP, the flows vary within an anticipated range which is predetermined so the screens can be sized for the necessary peak flows, and redundant units can be provided. In CSO installations there are wide variations in flow rates that can pass through the screens, but the high flow rates are usually of short duration. Due to the intermittent nature of CSOs, it is not considered cost effective, nor necessary to provide redundancy. Nevertheless, providing multiple units in separate channels is a means of handling equipment out of service. The quickness with which CSO flows can increase however can lead to problems in getting units in other channels into operation quickly enough given the operating speeds of motor operated sluice gates. A review of the pollutant removal rates as reported by the manufacturer indicates that only about 5% of the TSS is removed by the screen. While screening of solids may be adequate for the lower treatment objects (50%, 85%, and 95% removals) where TSS levels are not as critical, the literature does not indicate that screening alone will remove adequate solids to provide for consistent and reliable disinfection at higher treatment objectives.

Construction Costs

Table 2-1 presents the preliminary planning level construction cost estimates of Climber Screens® for design flows ranging from 10 MGD to approximately 450 MGD. It includes equipment cost, installation cost, general contractor (GC) field general conditions, GC overhead & profit (OH&P), and contingency. This cost estimates assume that the Climber Screens® will be installed in existing CSO channels. If the existing CSO channel does not provide adequate channel width to maintain velocities below 3 fps, a new or modified chamber will be required at an additional cost. The installation cost is assumed at 50% of the equipment cost based on the complexity of the installation. Budgetary equipment pricing information for Climber Screens® was gathered from equipment manufacturer Suez, formerly Infilco Degremont, Inc. The estimated total construction costs for the Climber Screens® are plotted against flowrates from 10 MGD to approximately 450 MGD in Figure 2-2.

Climber Screens® pricing is primarily determined by channel size which is dictated by the flow and plant specific parameters or design. Therefore, the Type IIS is suitable for channels up to 7'-0" wide. Pricing provided by the manufacturer is based on assumed channel dimensions of 5'-0" wide by 10'-6" deep. A single unit of this model of Climber Screen® would be suitable for up to 50 MGD or larger depending on channel dimensions. The Type IIIAS is suitable-for channels 6'-6" to 12'-0" wide. The pricing provided by the manufacturer is accurate up to the 8'-0" wide and 10'-6" deep dimensions. For the large 450MGD flow, multiple units each designed for a peak flow of 112 MGD are recommended. Capacity can be adjusted based on channel dimensions, bar rack clear spacing, and number of units desired.

Operation and Maintenance

Costs associated with operation include the electrical cost for operating the motor(s) on the mechanical bar screens. Regular maintenance requires visits to the site after each storm to inspect the screens for damage, remove any large material in the channels, clean up any screenings on the floor or equipment, and general wash down of the area. Regular maintenance also includes routine lubrication and maintenance of the tracks, racks, drives, and gear boxes. It is important to keep the pin racks and carriage bearings greased and oiled. It is also important to inspect the bearings for excessive wear. The Type IIS and IIIAS carriage assemblies utilize self-greasing/oiling canisters which are easily replaced at the recommended intervals. The follower shaft bearings and carriage drive bearings are replaced utilizing access points built into the side frames (i.e. carriage does not need to be removed). It is recommended to perform periodic visual inspections to ensure proper operation, lubrication and bearing wear.

Estimated annual operation costs for the Climber Screen® are presented on Table 2-2 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-3.

Space Requirements

The space required for mechanical bar screens consists of the building and area on the exterior of the building for access to remove the screenings container.

Case Study

New York City utilized TypeIIIAS Climber Screens® at their Manhattan and Bronx Grit Chambers from 1986 until 2016. These chambers deliver combined sewage to the Wards Island WWTP, which has a total plant flow of approximately 500 MGD. After the first 6 years of using the Climber Screens®, the shaft bearings were beyond their useable life. Although initially designed for 5HP per motor based on the average weight of debris, it was later found that 7.5 HP was required to handle the harsher conditions imposed by the combined sewage.

Table 2-1 - Preliminary Construction Cost Estimates for Climber Screens

Flow Range	System	Width x Depth	Budgetary Equipment Price	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD to 50 MGD	(1) Type IIS	5’-0” x 10’-6”	$305,000	$152,500	$45,750	$45,750	$274,500	$823,500
50 MGD to 112 MGD	(1) Type IIIAS	8’-0” x 10’-6”	$465,000	$232,500	$69,750	$69,750	$418,500	$1,255,500
112 MGD to 224 MGD	(2) Type IIIAS	8’-0” x 10’-6”	$465,000	$232,500	$69,750	$69,750	$418,500	$1,255,500
224 MGD to 336 MGD	(3) Type IIIAS	8’-0” x 10’-6”	$1,900,000	$950,000	$285,000	$285,000	$1,710,000	$5,130,000
336 MGD to 448 MGD	(4) Type IIIAS	8’-0” x 10’-6”	$1,900,000	$950,000	$285,000	$285,000	$1,710,000	$5,130,000

Notes:
(1) Installation cost is assumed at 50% of the equipment cost.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-2 - Total Estimated Construction Cost of Climber Screens

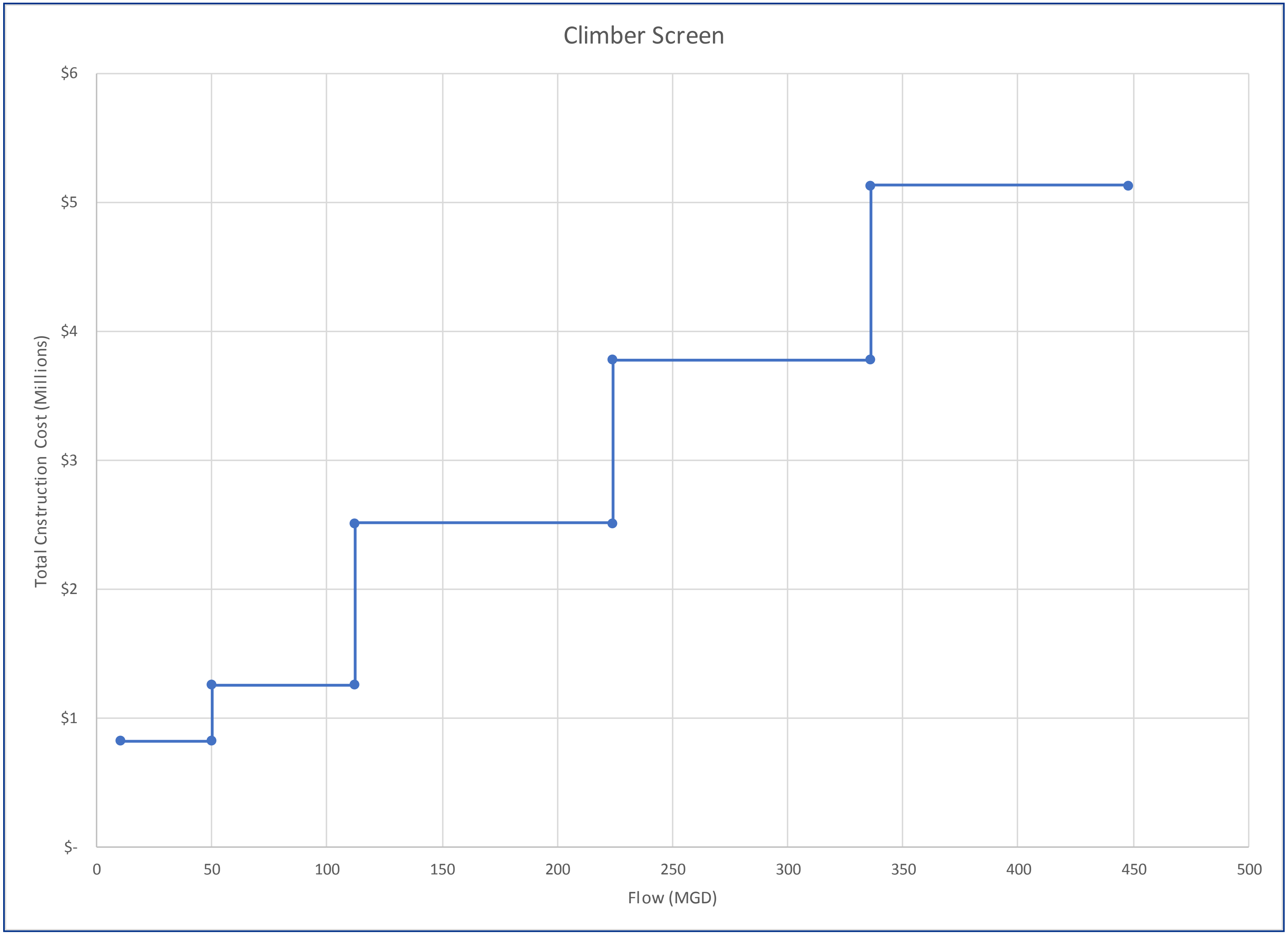


Table 2-2 - Annual Operation Costs of Climber Screens

Flow Range	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD to 50 MGD	(1) Type IIS	3	2	1,119	$157
50 MGD to 112 MGD	(1) Type IIIAS	5	4	1,864	$261
112 MGD to 224 MGD	(2) Type IIIAS	10	7	3,729	$522
224 MGD to 336 MGD	(3) Type IIIAS	15	11	5,593	$783
336 MGD to 448 MGD	(4) Type IIIAS	20	15	7,457	$1,044

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-3 - Annual Maintenance Labor Costs of Climber Screens

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)(2)
Monthly	Cam Tracks and Pin Racks	Grease and inspection	0.5	$900
Bi-annually	Automatic Lubricators	Grease	0.5	$150
Annually	Automatic Lubricators	Oil	0.5	$75
2-3 years	Carriage Drive Shaft Bearing	Replace	1	$75
3-5 years	Follower Shaft Bearing	Inspect - replace as necessary	2	$100
5 years	Gear Box	Change fluid	2	$60
After Each CSO Event	Screens	Inspection and cleanup	2	$30,000
Total Annual Maintenance Labor Cost				$31,360

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

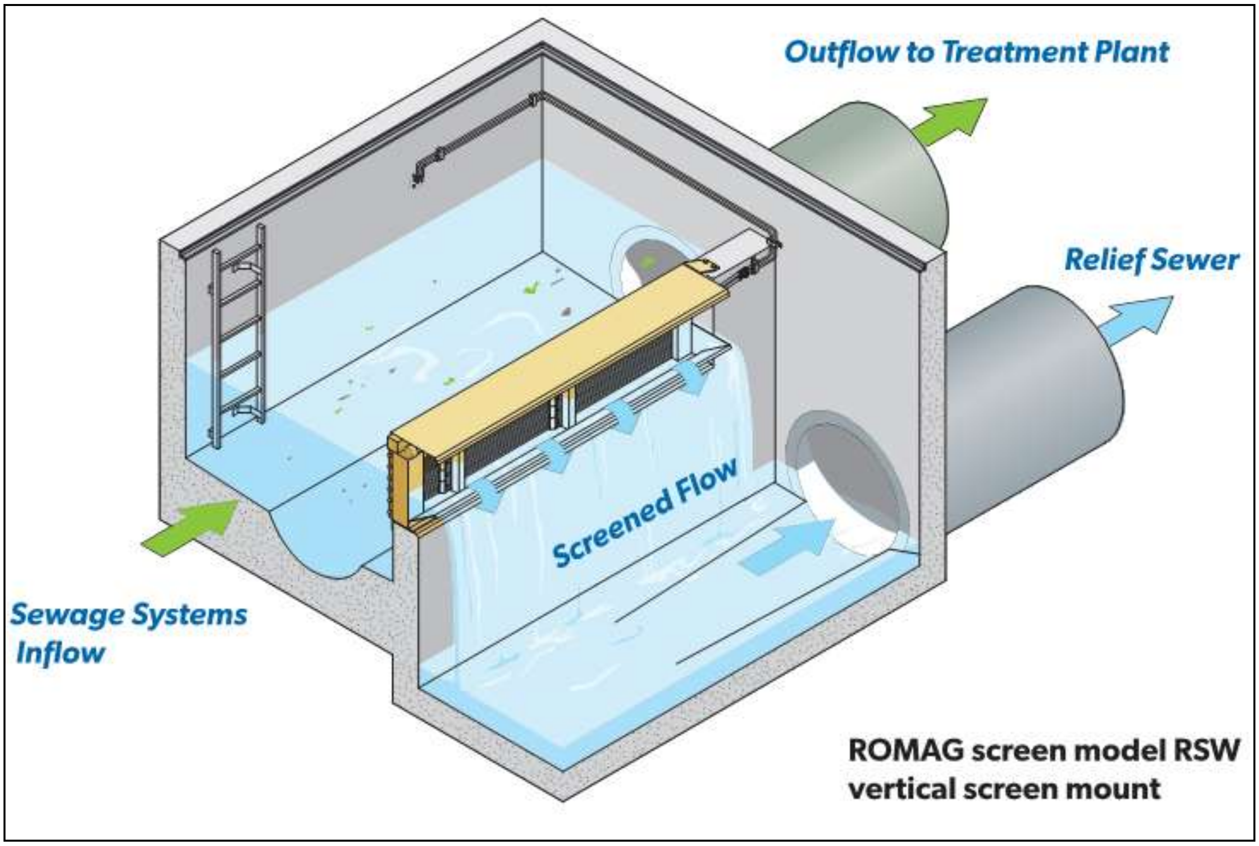
2.2.2 Fine Screens

Description of Process

These screens have openings ranging from 1/8" to 1/2", and will capture suspended and floatable material with smaller dimensions. The equipment evaluated under this category of screenings technology includes ROMAG™ Screens as manufactured by WesTech Engineering, Inc.

The ROMAG™ Screens consist of parallel bars similar to a bar screen, with spacing varying from 0.16" to 0.47". The screens are cleaned by combs, which extend through the rack and are attached to a hydraulically driven mechanism on the downstream side of the screen. The hydraulic unit is located above grade in an enclosure. The material collected on the upstream side of the screen is cleaned off the face of the screen by the combs and kept in the flow in the interceptor. They are not removed or collected, but continue toward the wastewater treatment plant for removal. As the flow increases beyond the capacity of the screens, the upstream water surface rises and overflows a baffle that is part of the screen assembly, discharging directly to the outfall. All the fine screens of this category are located such that the solids are retained on one side of the screen and transported to the interceptor or other facility for ultimate disposal. **Figure 2-3** shows the cross section of vertical mount ROMAG™ Screens.

Figure 2-3 - Cross Section of ROMAG Screens



(Source: WesTech Engineering, Inc.)

Applicability to the Project

Fine screens have proven to be a relatively simple and inexpensive means of removing floatables and visible solids where the overflow is controlled by a weir. They are typically constructed in the regulator, sometimes requiring modifications to the regulator, such as moving the weirs, and extending the weir lengths. The required screening capabilities for the maximum flow rate would need to be provided, since flows exceeding the capacities of the screens will continue to overflow unscreened. See Appendix B for a list of installation of ROMAG™ Screens for CSO application.

Performance Under Similar Conditions

As stated above, fine screens are typically installed in CSO regulators and operate successfully to remove floatables and visible solids over the fluctuations in flow rates seen in CSOs. Slight removal of TSS, total phosphorous, and total nitrogen (typically 10%, 8%, and 5%, respectively) can be achieved with the solids removal.

Hydraulics

The typical head loss reported through the unit is 4 inches, while additional freeboard from the maximum flow through the screens to the baffle height is typically 2 inches. The total head loss through the screen is typically about 6 inches at the design flow.

Flows exceeding the capacity of the screens would overflow the baffle and by-pass the screen. Usually additional weir length is needed so that the existing upstream water surface elevations are maintained after the screen is installed

Generation of Waste Streams

Fine screens are located in the regulator with flow passing up and through the screen, overflowing the weir and going out the outfall. Since the flow direction is up through the screen, the screened material is kept on the interceptor side of the screen, and remains in the interceptor when the cleaning mechanism cleans the face of the screen. Since the screenings remain in the interceptor, there is no collection at the screen and therefore no waste stream. Nevertheless, the limitation is that there be adequate flow and solids transport within the interceptor sewer system. The additional screening material that remains in the interceptor will find its way to any downstream regulators, and eventually to the WWTP.

Complexity

Fine screens can function intermittently, at remote locations with the minimum of instrumentation. A level detector is needed to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer can be utilized to periodically exercise the screen, so it is ready for use.

Limitations

Fine screens would need to be installed on regulators with side overflow weirs. Other types of regulators would require the construction of a weir, at which point the use of a mechanical bar screen may be preferable. Also, any regulators where the fine screens would be installed would need to be accessible for routine inspection and maintenance of the screens. A review of the pollutant removal rates as reported by the manufacturer indicates that only about 10% of the TSS is removed by the screen. While screening of solids may be adequate for the lower treatment objectives (50%, 85%, and 95% removals) where TSS levels are not as critical, the literature does not indicate that screening alone will remove adequate solids to provide for consistent and reliable disinfection at higher treatment objectives. The higher TSS removal rates of fine screens versus mechanical bar screens (10% vs 5% respectively) may result in TSS levels acceptable for disinfection at lower treatment objectives.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-4 for ROMAG™ Screens of design flow ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. This cost estimates assume that the ROMAG™ Screens will be installed in existing regulators. The costs for modifying a side overflow regulator to accommodate the installation of the screen is included in the installation cost. If the existing regulator cannot be modified to accommodate the ROMAG Screen and side overflow, a new and larger regulating chamber will be required at an additional cost. The installation cost is assumed at 50% of the equipment cost based on the complexity of the installation. Budgetary equipment pricing information for ROMAG™ Screen was gathered from equipment manufacturer WesTech Engineering, Inc. Based on vendor provided information, the largest individual screen can potentially handle up to 100 MGD, and in the case of higher demand multiple screens would be applied side by side. Velocities should be restricted to 5 ft/s. The equipment cost includes the controls, hydraulic power pack and everything needed to operate.

The estimated total construction costs for the ROMAG™ Screens are plotted against flowrate from 10 MGD to 450 MGD in

Figure 2-4.

Operation and Maintenance Costs

The operating costs include the electrical cost for operating the hydraulic power pack and an in-tank (hydraulic fluid) heater (700W-120V). The hydraulic pack operates the cleaning comb action across the screen. Each single ROMAG™ Screen has a hydraulic power pack that consists of a 5HP motor to drive the hydraulic pump. An 1HP in-tank heater for each screen is used to keep the hydraulic fluid at right temperature. Routine maintenance of the ROMAG™ Screens includes visits to the site after each storm to inspect the screens for damage, remove any large material in the channels, and cleanup of any screenings on the floor or equipment, and general wash-down of the area. Routine maintenance also includes the monthly maintenance of the screen such as replacing combs, repairing leaks in the hydraulic lines, maintaining the oil level in the hydraulic drive, and cleaning any level sensors, etc.

Estimated annual operation costs for the ROMAGTM Screens are presented on Table 2-5 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-6.

Table 2-6Space Requirements

Since the fine screens would be installed in the regulators, which would probably be located in the street or existing easement, it is anticipated that there would be no additional space requirements for the fine screens.

Case Studies

Chattanooga, Tennessee utilizes ROMAG™ Screens at their downtown CSO treatment facility. Two RSW 8x7 screens were installed in 2000 and are still in use treating approximately 180 MGD. The maintenance of the screens was reported as minimum, and the automatic cleaning function had been working well with the exception of one instance where the screens became stuck.

The City of Binghamton, NY, has been using CSO screens for floatable control at four CSO locations since 2003. According to conversations with the site supervisor, the screens have been trouble-free. Both sides of the screens can be observed without entering the channel, and weekly inspection takes approximately 5 minutes. Typically, operators hose down the screens to remove residual debris after a storm event. Binghamton operators check the tension of the bars annually, and change hydraulic oil and filters per the Operations and Maintenance manual. No parts have required replacement to date.

Chattanooga, Tennessee utilizes ROMAG™ Screens at their downtown CSO treatment facility. Two RSW 8x7 screens were installed in 2000 and are still in use treating approximately 180 MGD. The maintenance of the screens was reported as minimum, and the automatic cleaning function had been working well with the exception of one instance where the screens became stuck.

Table 2-4 - Preliminary Construction Cost Estimates for ROMAG Screens

Flow	System	Length x Depth	Budgetary Equipment Price	Install Cost[1]	GC General Conditions[2]	GC OH&P[3]	Contingency[4]	Total
10 MGD	(1) Model RSW 4x3/4	9'-10" x 1'-9"	$252,000	$126,000	$37,800	$37,800	$226,800	$680,400
25 MGD	(1) Model RSW 7x4/4	13'-2" x 2'-8"	$305,000	$152,500	$45,750	$45,750	$274,500	$823,500
50 MGD	(1) Model RSW 12x4/4	13'-2" x 4'-3"	$393,000	$196,500	$58,950	$58,950	$353,700	$1,061,100
75 MGD	(1) Model RSW 14x5/4	16'-5" x 4'-11"	$450,000	$225,000	$67,500	$67,500	$405,000	$1,215,000
100 MGD	(1) Model RSW 14x6/4	19'-8" x 5'-1"	$475,000	$237,500	$71,250	$71,250	$427,500	$1,282,500
450 MGD	(6) Model RSW 14x5/4	98'-5" x 4'-11"	$2,700,000	$1,350,000	$405,000	$405,000	$2,430,000	$7,290,000

Notes:

Note:
(1) Installation cost is assumed at 50% of the equipment cost.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-4 - Total Estimated Construction Cost of ROMAG Screens

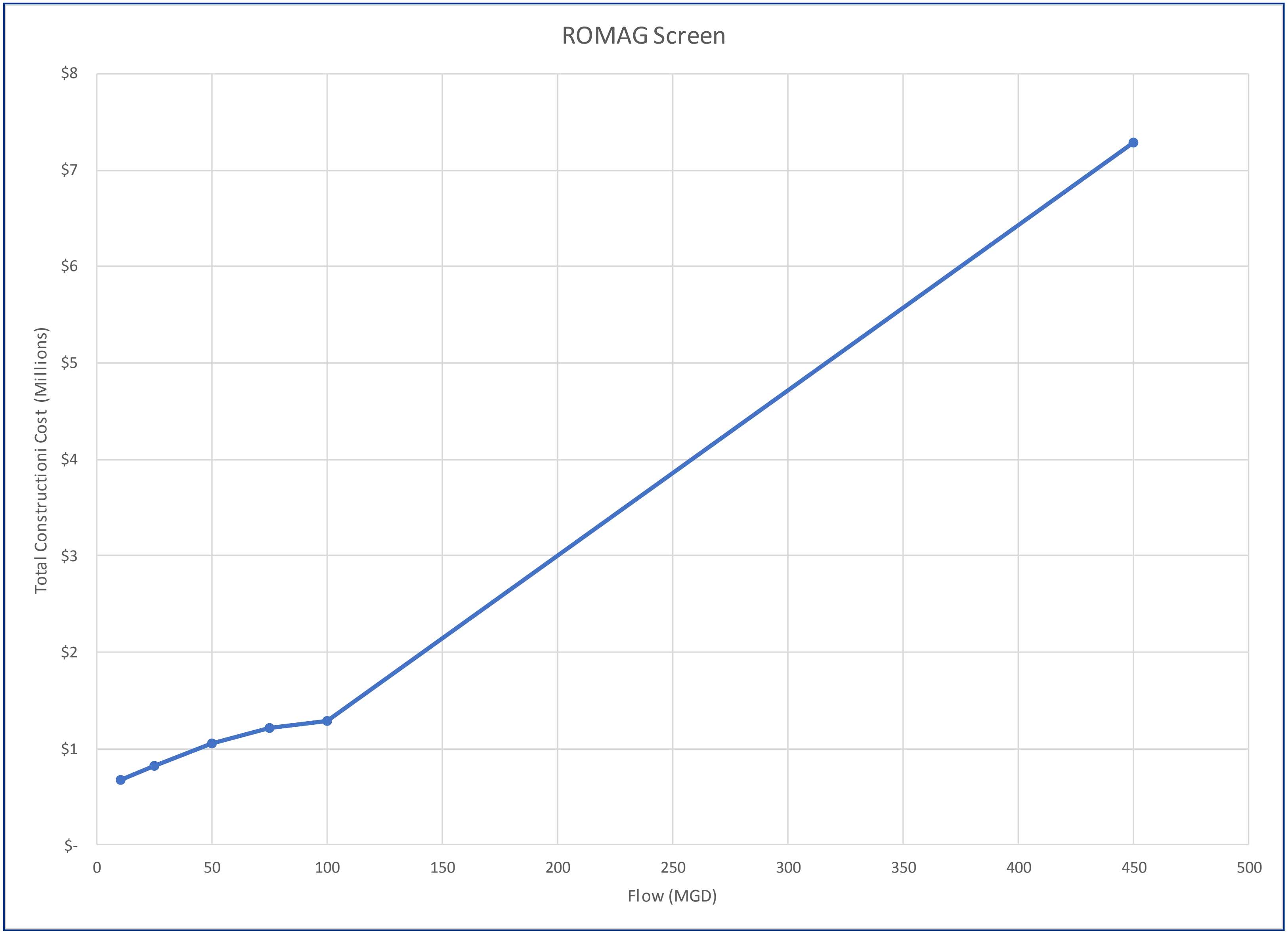


Table 2-5 - Annual Operation Costs of ROMAG Screens

Flow	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD	(1) Model RSW 4x3/4	6	4	2,237	$313
25 MGD	(1) Model RSW 7x4/4	6	4	2,237	$313
50 MGD	(1) Model RSW 12x4/4	6	4	2,237	$313
75 MGD	(1) Model RSW 14x5/4	6	4	2,237	$313
100 MGD	(1) Model RSW 14x6/4	6	4	2,237	$313
450 MGD	(6) Model RSW 14x5/4	30	22	11,186	$1,566

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-6 - Annual Maintenance Labor Costs of ROMAG Screens

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)(2)
Every 100 Operational Hours	Fasteners	Check for tightness	0.5	$375
Monthly	Screen bars	Check for clogging	0.5	$900
Monthly	Cleaning carriage	Check for proper operation	0.25	$450
Monthly	Piston rod locking nut	Check for tightness	0.25	$450
Monthly	Power pack oil level	Check for proper level and Check lines and piston rod for major fluid loss	0.5	$900
Monthly	Oil filter	Replace filter if necessary	0.25	$450
Annually	Screen Bars	Confirm tension with torque wrench	0.5	$75
Annually	Oil Temperature Probe	Check for proper operation and send sample to oil supplier; replace if required	0.5	$75
Annually	Motor	Lubricate	0.5	$75
After Each CSO Event	General Visual Inspection	Check for proper operation	1	$15,000
Total Annual Maintenance Cost				$18,750

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

2.2.3 Band and Belt Screens

Description of Process

The common characteristic of these screens is that they contain stainless steel perforated elements forming a continuous band traveling either parallel or perpendicular to the flow stream. In the case where the band is parallel to the channel, flow enters the center of the screen, turns 90 degrees and passes through the sieve elements, exiting through the sides of the unit. Where the band is perpendicular to the channel flow passes through the screen, with the screened flow continuing down the channel.

Figure 2-5 shows a photo of Finescreen Monster, manufactured by JWC Environmental. These screens utilize either stainless steel, or UHMW sheets with perforations between 0.08" to 0.4" mm in diameter.

Figure 2-5 - Photo of Finescreen Monster

(Source: JWC Environmental)

Applicability for the Project

These screens are typically used for polishing wastewater treatment flows. Their perforated panels are very prone to clogging from fibrous materials and are not easily cleaned. To protect these screens from larger objects that could damage or clog them, the manufacturers recommend installing ¾ inch screens upstream of them. However, that ¾ inch screen upstream of the belt and band screen would have the same pollutant removal efficiency and thus the belt and band screen would be ineffective. Accordingly, it does not appear to be practical to utilize these types of screens in a CSO application. There currently are no known installations on CSO discharges.

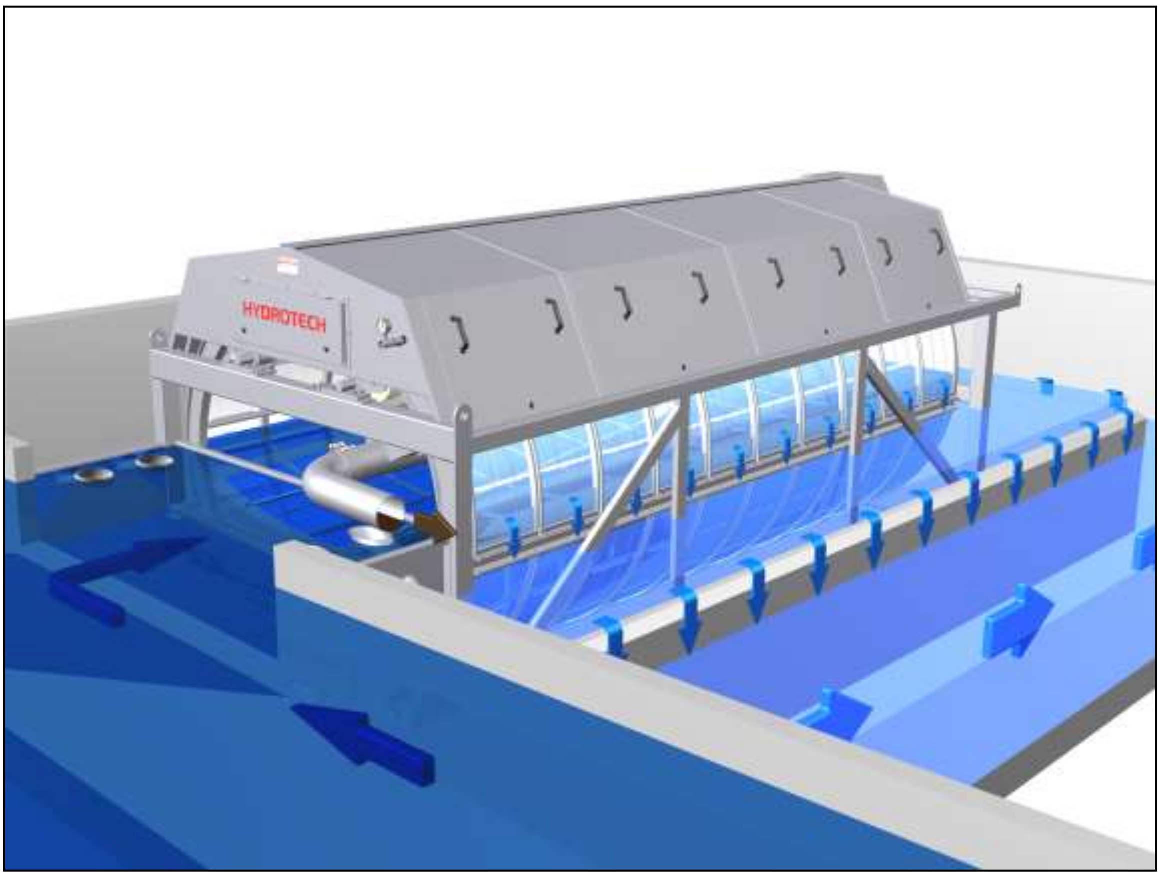
These screens are not considered applicable for CSO treatment and not further evaluated.

2.2.4 Drum Screens

Description of Process

A drum screen is a fine filter with openings from 10 to 1000 microns. The filter cloth is made of acid proof steel or polyester. Three, four, or five filter elements are placed in sections over a rotating drum, depending upon the drum diameter. The drum rotates in a tank. The liquid is filtered through the periphery of the slowly rotating drum. Assisted by the filter elements special cell structure, the particles are carefully separated from the liquid. Separated solids are rinsed off the filter cloth into the solids collection tray and discharged. The operation of the drum can be continuous or automatically controlled. The unit evaluated for this application was the HydroTech Drumfilter by Veolia Water Technologies. Figure 2-6 shows a cross section HydroTech Drumfilter.

Figure 2-6 - Cross Section of HydroTech Drumfilter



(Source: Veolia Water Technologies)

Applicability for the Project

Drum filters are currently used as a polishing unit at WWTPs. The disc media is polyethylene and the size openings are 10 microns for wastewater. The hydraulic loading for drum filters is 50 to 100 gpm/ft^2, based upon an influent TSS concentration of 20 mg/L. The manufacturer expects an influent TSS concentration of 10 to 100 mg/L upstream of the unit. Accordingly, significant TSS removal equipment would be needed upstream of the screen. There currently are no known installations on CSO discharges.

These screens are not considered applicable for CSO treatment and not further evaluated.

2.2.5 Evaluation of Screening Technology

The above sections evaluated each of the screening processes considered for pretreatment of CSO flow relative to criteria on cost, performance, limitations, and ancillary facilities. Each process was rated from 1 to 5, with 5 being the most effective, for approximately twenty different items and totaled. While somewhat subjective, this method does provide a mechanism for comparing each screening unit in relationship to each category and subcategory. The results of the evaluation are illustrated on Table 2-7.

Based upon the evaluation results in Table 2-7, fine screens received the highest results followed by mechanical bar screens, band and belt screens, and drum screen. requirements, which is reflected in their rating. Fine screens and mechanical bar screens should be considered as part of this TGM. Drum screens and band and belt screens were not considered applicable, and did not undergo further consideration.

Table 2-7 - Evaluation of Screening Technology

Criteria	**Mechanical Bar Screens**	**Fine Screens**	**Band and Belt Screens**	**Drum Screens**
Applicability	5	5	1	1
Performance				
TSS	1	3	4	4
Solids and Floatables	1	2	4	4
Hydraulics	4	4	1	1
Waste streams	3	5	1	1
Complexity	5	5	1	1
Limitations	2	2	1	1
Construction Cost	4	2	1	1
Operations	4	4	1	1
Maintenance	4	3	1	1
Space Requirements	3	2	1	1
Total	31	32	16	16

2.3 Pretreatment Technology

Pretreatment technology is used to remove floatable and total suspended solids (TSS) prior to high rate disinfection in CSO applications. The pretreatment technology evaluated for the TGM includes vortex/swirl separation technology, ballasted flocculation, and compressed media filtration.

The choice of a pretreatment technology is a function of construction costs, space requirements, and type of disinfection treatment process downstream. In general, pretreatment is very effective in removing floatable and TSS. It can also remove certain amount of fecal coliform, enterococci, BOD, COD, NH3, TKN, total phosphorous, and total nitrogen, which is attached to the TSS.

The following sections describe the types of pretreatment technology, as well as its capability to remove the various pollutants of concern. At the end of the section a summary of performance, operation, and environmental impacts will be presented.

2.3.1 Vortex/Swirl Separation Technology

Vortex/swirl separation technology utilizes naturally occurring forces to remove solids and floatable material. Flow enters a circular tank tangentially causing the contents to rotate slowly about the vertical axis. The flow spirals down the perimeter allowing the solids to settle out. This process is aided by rotary forces, shear forces, and drag forces at the boundary layer on the wall and base of the vessel. The internal components direct the main flow away from the perimeter and back up the middle of the vessel as a broad spiraling column, rotating at a slower velocity than the outer downward flow. Per manufacturer claims, by the time the flow reaches the top of the vessel it is virtually free of settleable solids and is discharged to the outlet channel. The collected solids are then discharged by gravity or pumped out from the base of the unit to the interceptor sewer or auxiliary storage tank if interceptor capacity is not available.

Conventional vortex separators such as Storm King®, manufactured by Hydro International, and the HYDROVEX® FluidSep manufactured by John Meunier were reviewed for this Technical Guidance Manual. A variation of the typical vortex/swirl separation process - the SanSep equipment from PWTech is evaluated as well.

The following provides a discussion of each of the above referenced unit processes, as well as its reported capability to remove the various pollutants of concern. A summary of performance, operation, and limitations or constraints, is provided at the end of this section.

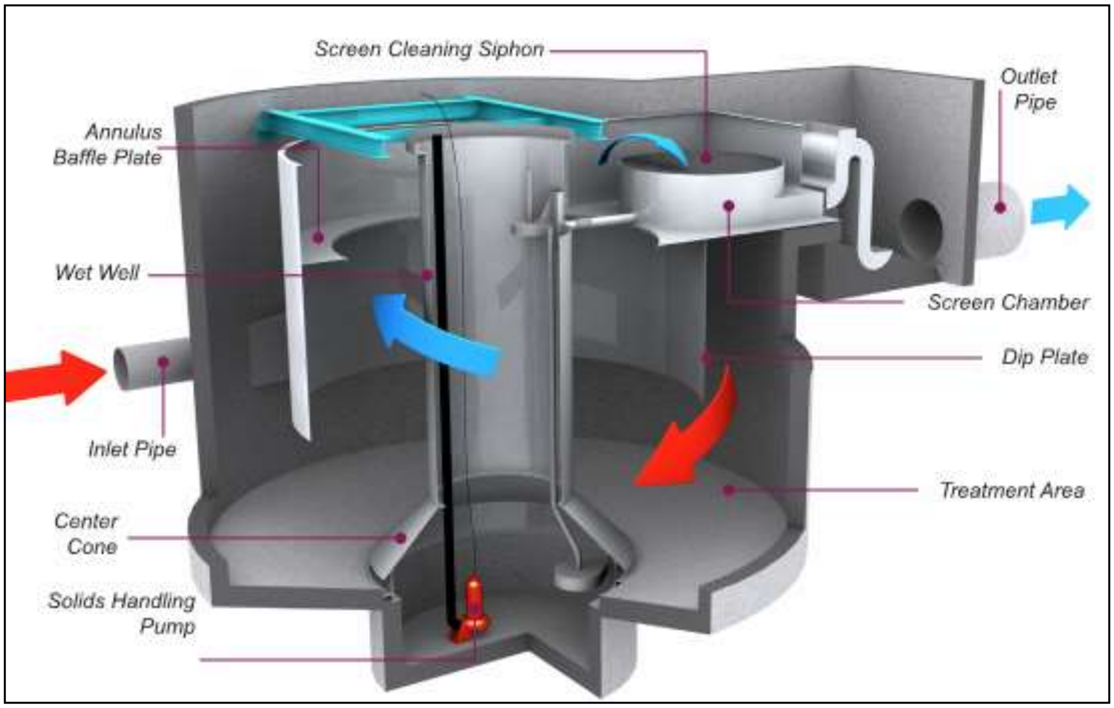
2.3.1.1 Storm King® Vortex Separator

Description of Process

Flow is introduced tangentially into the side of the Storm King®, causing the contents to rotate slowly about the vertical axis. The flow spirals down the perimeter allowing the solids to settle out. This process is aided by rotary forces, shear forces, and drag forces at the boundary layer on the wall and base of the vessel. The internal component directs the main flow away from the perimeter and back up the middle of the vessel as a broad spiraling column, rotating at a slower velocity than the outer downward flow. A dip plate locates the shear zone, the interface between the outer downward circulation and the inner upward circulation, where a marked difference in velocity encourages further solids separation. Settled solids are directed to the helical channel located under the center cone and are conveyed out of the main chamber through the underflow outlet. The flow passes down through the Swirl Cleanse screen which captures floatables and neutrally buoyant material greater than 4mm in diameter. The air regulated siphon provides an effective backwash mechanism to prevent the screen from blinding. Screened effluent is discharged into a receiving watercourse, a storage facility, or continues on to receive further treatment. The collected solids are then discharged by gravity or pumped out from the base of the unit to the sanitary sewer.

Typical design loading rates are from 7 to 44 gpm/sf. This loading rate is based on the flow coming in and the horizontal surface area of the circular vortex unit. Cross section of a Storm King® Vortex Separator in full operation is provided in Figure 2-7.

Figure 2-7 - Cross Section of Storm King Vortex Separator



(Source: Hydro International)

Applicability to the Project

Based on manufacturer publications, Storm King® units have been used for floatables control, primary treatment equivalency of CSOs and wet weather induced flows. The first installation of Storm King® units for CSO application was in mid-1995 in Hartford CT. See Appendix C for a list of Storm King® installation in the US for CSO application.

The units have been installed in remote locations, away from treatment plants and reportedly performed well. There are no moving parts within the vortex unit itself. Underflow from the unit can be discharged by gravity to sewers or continuously pumped to an ancillary tank where it would be stored until there is capacity in the interceptor sewer system. Underflows from the unit run approximately 10% of the design flow and thus the volume from the underflow can be significant.

Performance

The Storm King® vortex separator is most effective in removing heavier settleable solids, floatable material, and inorganic solids. The performance information provided by the manufacturer indicates that the percent removal of TSS, BOD and COD drops off as the hydraulic loading rate increases. TSS removal ranges from 35-50%, and BOD removal is typically 15-25%. Vortex units achieve removal by two means: the consolidation of solids material; and flow separation, which is accomplished by the underflow removal. When the vortex unit operates under low hydraulic loading rates, and there is a significant amount of settleable solids, both removal mechanisms are operating. As the hydraulic loading rate increases, or the settleable solids concentration decreases, there is less consolidation and the vortex unit functions more as a flow separator. At the highest hydraulic loading rates recommended, the unit functions strictly as a flow separator. The vortex units, the Storm King included, usually have an underflow that is 10% of the design capacity of the unit. So even under the worst conditions, when there is no consolidation of solids taking place, they would theoretically remove 10% of the pollutants. While this would hold true for the soluble portion of pollutants, in the case where the pollutant was associated with fine particles, the removal would be less. The reason for this decrease is that since fine particles weigh less, more of these particles would be carried out in the effluent especially at higher hydraulic loading rates. Some of the removals associated with these units are for lower volume storms when the volume associated with the unit acts as a storage system.

In the Bayonne MUA Pilot Study, the Storm King® units experienced operating issues due to their screens clogging with materials that appeared to be primarily toilet paper. Performance issues of less than 10% TSS removals were experienced when Volatile Suspended Solids (VSS) accounted for a high percent of the influent TSS. The TSS removal efficiencies improved when evaluating the inorganic component of TSS, or Fixed Suspended Solids (FSS). The FSS removal efficiencies for Storm King® units averaged around 17%, with the maximum removal efficiencies of 45.2%. The low removal of VSS (or inorganic) fraction of TSS indicated that the Storm King® units will be ineffective on their own with UV disinfection due to low ultraviolet light transmittance of the effluent.

Hydraulics

Vortex units are hydraulically efficient. The head loss through the unit consists of the losses through the inlet to the unit, and the head loss over the effluent weir. The losses in the lower hydraulic loading rates will be limited to less than six inches. At higher hydraulic loading rates, the losses will increase significantly, possibly up to a couple of feet, unless diverted upstream.

Generation of Waste Streams

As discussed under the description of the process and the performance: 10% of the design flow must continuously be removed as underflow. In many cases this flow will need to be pumped from the vortex unit due to the depth of the underflow pipe. While permittees with conveyance facilities must evaluate means of increasing conveyance to the WWTP, it is doubtful that the underflow can be consistently and constantly transported to the interceptor. In locations where interceptor capacity is not available during the overflow, the underflow must be stored in ancillary tanks. The capacity of these ancillary tanks is based upon the underflow flow rate and the duration of the overflow event. Once the event is over the contents of the storage tank can be pumped back into the interceptor. Floatable material captured in the tank is removed at the end of the overflow event as the tank is emptied, and is also sent back into the interceptor.

Complexity

The vortex/swirl separator is a simple process, especially since there are no moving parts within the unit. Removals are achieved using natural forces and no adjustment of equipment is necessary. The only controls that are needed are in the flow coming to the unit to ensure that the unit operates within its hydraulic loading rates. This can be accomplished using sluice gates or overflow weirs. The other area requiring instrumentation would be the control of the underflow sump where underflow is pumped out. The control of the pumping units would be by floats, bubblers, or ultrasonic level sensors.

Limitations

As previously indicated, the hydraulic loading rate is key to the performance of the vortex/swirl separator. Therefore, the limitation to this process occurs for the more stringent treatment objectives. Since a required and consistent effluent TSS must be achieved for the disinfection process to be effective, the variations in flows, particularly above the required hydraulic loading rate, result in a reduced removal of TSS and a corresponding decrease in the efficiency of the disinfection process. If the excess flows are by-passed around the vortex unit, going directly to disinfection, as required by the NJPDES requirement for complete disinfection, the higher TSS concentrations will again result in decreased disinfection efficiency. This represents a limitation on the process for the higher treatment objectives.

Construction Costs

Budgetary equipment pricing information for Storm King® vortex separator was obtained from equipment manufacturer Hydro International, Inc. Table 2-8 presents preliminary planning level construction cost estimates for flows ranging from 10 MGD to 450 MGD. It includes equipment cost, concrete cost associated with the construction of the tank containing the vortex structure, cost for ancillary tank for underflow storage, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing provided by the equipment manufacturer Hydro International includes only the fabricated stainless-steel vortex structures inside. Cost for outside concrete tank enclosure were estimated based on the sizes of the vortex units. Construction costs for excavation, sitework, soil support, and dewatering, as well as the underflow wet well and the pumps are included in the installation costs. The estimated total construction costs for the Storm King® Vortex Separator are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-8.

Operation and Maintenance

The operating costs for the Storm King® vortex separator are associated with the power of the underflow pump. The horsepower of the pumps required increases as the size of the vortex separator, and corresponding underflow, increases. Regular maintenance required for the Storm King® unit includes inspection of the vortex separator after each rainfall event, replacement of the underflow pumps every 6 months for overhaul and sharpening of the cutter blades, and vacuuming out the floatable material that will accumulate in the underflow wet well.

Estimated annual operation costs for the Storm King® vortex separator are presented on Table 2-9 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-10.

Space Requirements

The space requirements of the Storm King® vortex separator shall be based upon a square area utilizing the diameter of the tank and a buffer of 5 feet on each side.

Case Studies

According to literature obtained from Hydro International, Bucksport, ME, has been using Storm King® since 2008 as a solution to CSO related flooding caused by the nearby Penobscot River. The installation of satellite treatment within the collection system saved the city from expanding the capacity of their wastewater treatment plant. Solids which settle out from the Storm King® are fed via gravity from the base of the unit to the sewage treatment plant. Additionally, the system is used as a chlorine contact and mixing chamber for the reduction of fecal coliforms before effluent is discharged into the Penobscot River. Since the system was commissioned, all rain events the system has handled have been treated in accordance with regulatory requirements

The 18' (5.5 m) diameter Storm King® system was constructed in a park and is housed within a building which may resemble a restaurant. Residents are impressed with the installation. Bucksport has designed the facility such that a Swirl-Cleanse screening component may be added in the future which will allow capture of all floatables and neutrally buoyant material greater than 4 millimeters in diameter.

According to literature obtained from Hydro International, Saco, ME, has been using a 22-ft diameter Storm King® since November 2006. Sedimentation and screening are followed by disinfection using sodium hypochlorite (NaClO) in the flow tank. A Swirl-Cleanse screen is installed in this system which captures all floatables and neutrally buoyant material greater than 4 millimeters in diameter. Influent Total Suspended Solids (TSS) levels are in the range of 300 mg/L. Treated effluent TSS is typically 60mg/L or lower. Treated effluent is discharged directly into the Saco River, while the collected screenings and settleable solids are pumped back to the wastewater treatment plant for processing.

Engineers who worked on the Saco Sewer Project have been impressed with the performance of the Storm King® even in storms much larger than the set design criteria. The system requires maintenance crews to perform a quick wash down the tank after a storm. Additional maintenance is minimal.

Table 2-8- Preliminary Construction Cost Estimates for Storm King Vortex Separator

Flow	System	Diameter	Budgetary Equipment Price	Concrete Structure Cost	Auxiliary Tank Cost(1)	Install Cost(2)	GC General Conditions (3)	GC OH&P(4)	Contingency(5)	Total
10 MGD	(1) StormKing 10 MGD	28’	$739,000	$82,000	$871,200	$1,269,150	$296,135	$296,135	$1,776,810	$5,330,430
25 MGD	(1) StormKing 25 MGD	38’	$1,403,000	$181,000	$1,573,000	$2,367,750	$552,475	$552,475	$3,314,850	$9,944,550
50 MGD	(2) StormKing 25 MGD	38’	$2,797,000	$291,500	$2,300,000	$4,041,375	$942,988	$942,988	$5,657,925	$16,973,775
75 MGD	(2) StormKing 37 MGD	42’	$3,831,000	$291,500	$3,040,000	$5,371,875	$1,253,438	$1,253,438	$7,520,625	$22,561,875
100 MGD	(3) StormKing 35 MGD	42’	$5,733,000	$359,000	$3,720,000	$7,359,000	$1,717,100	$1,717,100	$10,302,600	$30,907,800
450 MGD	(10) StormKing 45 MGD	44’	$23,463,000	$718,000	$10,890,000	$26,303,250	$6,137,425	$6,137,425	$36,824,550	$110,473,650

Notes:
(1) Auxiliary Tank costs derived from quotation from Mid Atlantic Storage System on Aquastore Glass Fused to Steel Storage Tank of 150,000 gal
(2) Installation cost is assumed at 75% of the equipment cost.
(3) GC general conditions are estimated at 10% of the total direct cost.
(4) GC OH&P are estimated at 10% of the total direct cost.
(5) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-8 - Total Estimated Construction Cost of Storm King Vortex Separator

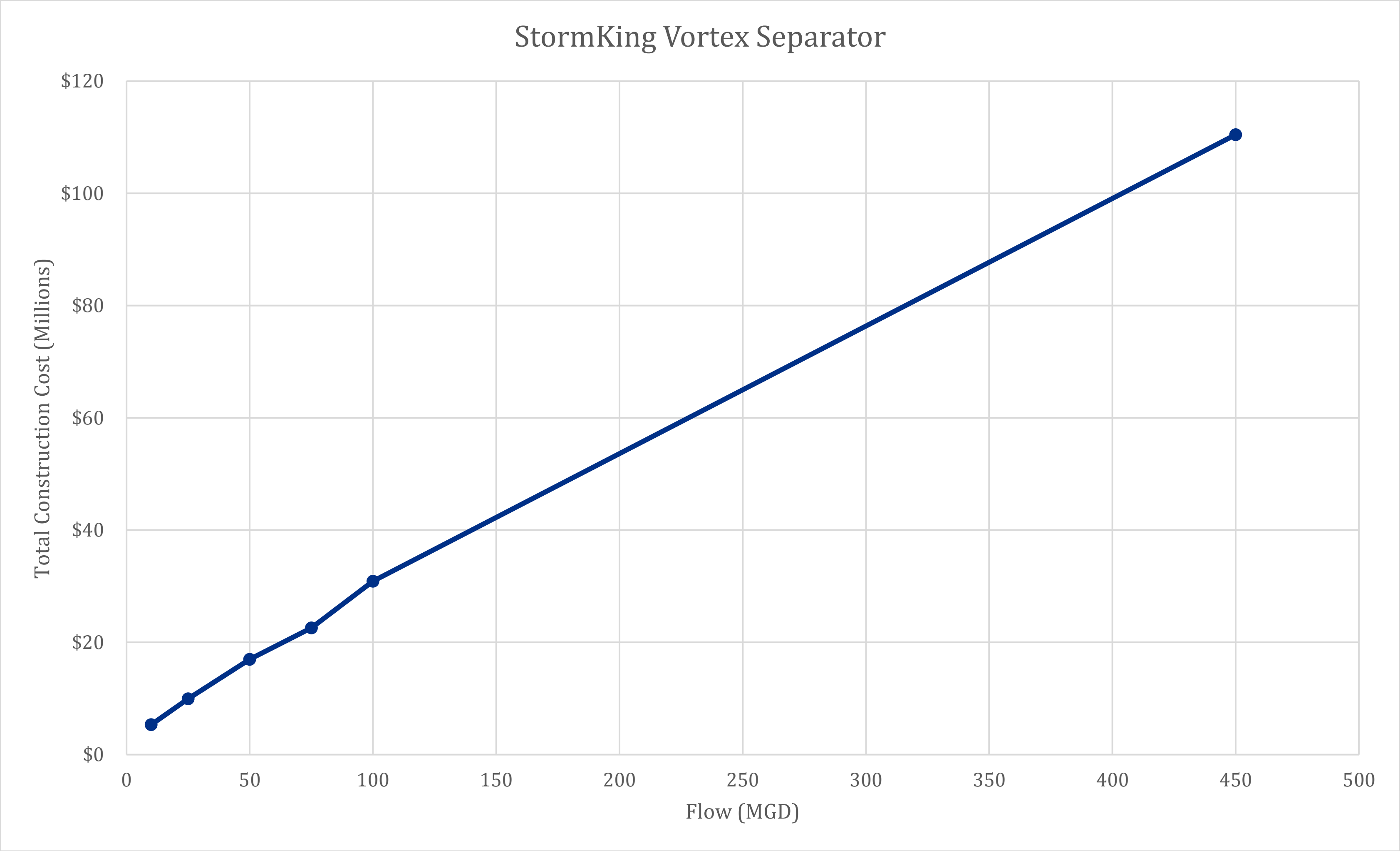


Table 2-9 - Annual Operation Costs of Storm King Vortex Separator

Flow	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD	(1) StormKing 10 MGD	14	10	1	$731
25 MGD	(1) StormKing 25 MGD	35	26	4	$1,827
50 MGD	(2) StormKing 25 MGD	70	52	7	$3,654
75 MGD	(2) StormKing 37 MGD	104	78	11	$5,429
100 MGD	(3) StormKing 35 MGD	139	104	15	$7,256
450 MGD	(10) StormKing 45 MGD	625	466	65	$32,624

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-10 - Annual Maintenance Labor Costs of Storm King Vortex Separator

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)
Biannually	Valve inlet and outlet	Visual check and removal of coarse debris	1	300
Biannually	Underflow pumps	Visual check	1	300
Every three years	Underflow pumps	Replacement of underflow pumps	8	400
Total Annual Maintenance Cost				$1,000

Notes:

(1) Assumes labor rate of $150/hour

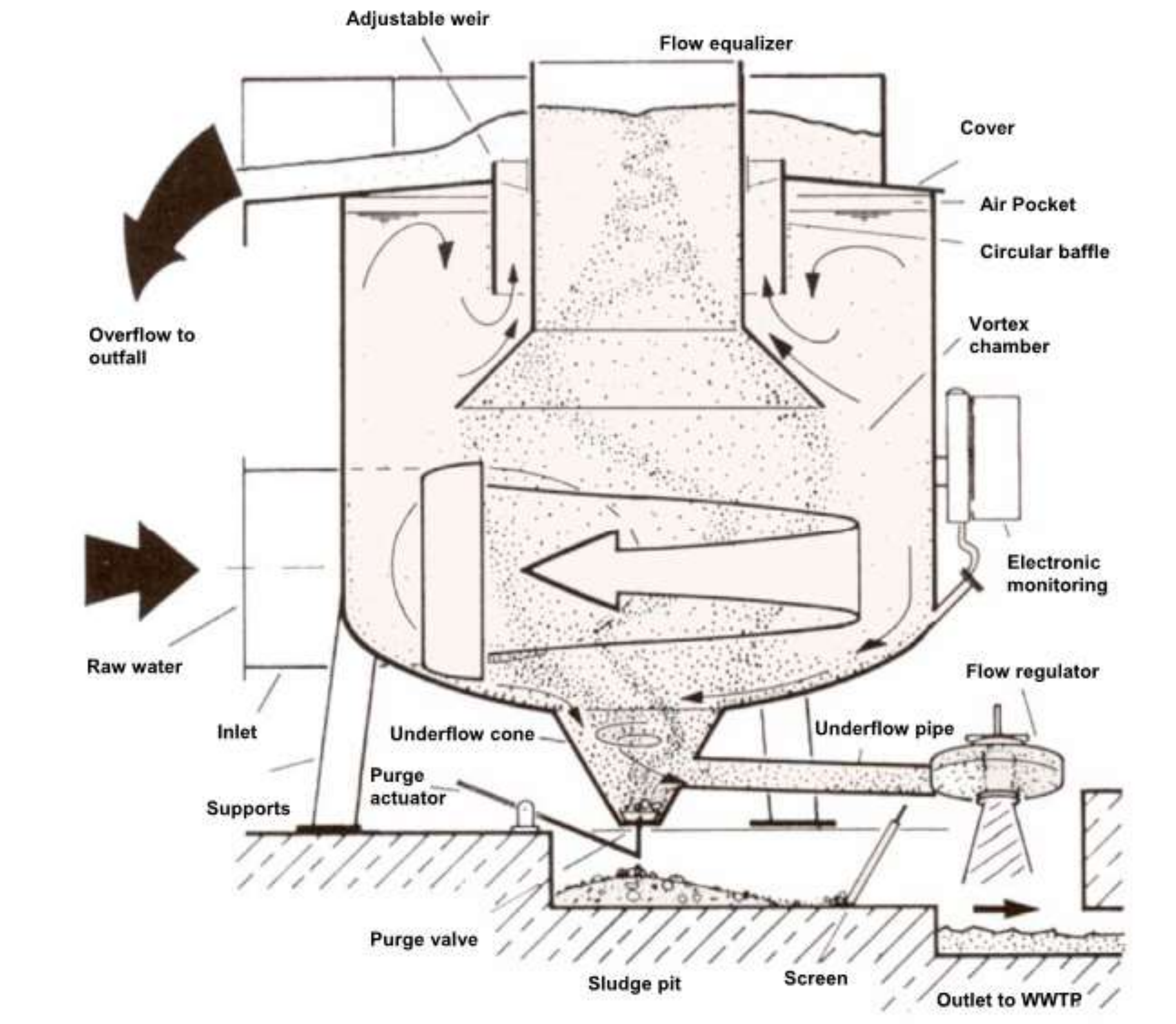
2.3.1.2 HYDROVEX® FluidSep Vortex Separator

Description of Process

In CSO installations, the dry weather flow that enters the HYDROVEX® FluidSep Vortex Separator passes by freely on the sloped bottom towards the central cone of evacuation and then through a flow regulator. During a storm event, the incoming flow becomes greater than the regulated outflow. This will effectively start the filling of the vortex separator. Many minor events can be fully intercepted and contained inside the vortex separator volume without actual overflow. For more intense or more durable storm events, the HYDROVEX® FluidSep Vortex Separator starts overflowing through its central annular overflow weir. This weir is made of two plunging cylindrical treatment baffles providing a double crown arrangement. The overflow water is evacuated through the ring-shaped opening formed by these two treatment baffles. The overflow is fixed in the circular opening of the top cover of the vortex separator structure. The overflowed water falls from the weir on the upper chamber of the separator and is then evacuated, either towards an additional treatment system or directly to the outfall. Due to its tangential inlet port, the incoming water brings the mass of retained water into a rotational movement inside the tank. The resulting flow pattern is non-turbulent and very favorable to the separation of suspended solids. These particles can readily settle and are furthermore pulled by the centrifugal currents towards the wall of the separator. Once the particles are caught on the limit layer along the walls, they fall to the structure bottom and are finally brought to the unit's evacuation cone. From there, they are carried out with the underflow water through the regulator. When the HYDROVEX® FluidSep Vortex Separator is filled, an air pocket is formed under the unit's cover, imprisoned by the baffle partition arrangement. The floatables entering the separator will be caught there and will simply circulate around until the unit progressively gets back to dry time flow conditions. The lower surface of the cover always remains free of water, due to the captured air pocket.

The proper selection of the HYDROVEX® FluidSep implies that the unit operating size is efficient for all flows up to the design flow. When flows higher than the design flow are received, the unit will operate at a lesser efficiency level. The collected solids are then discharged by gravity or pumped out from the base of the unit to the sanitary sewer. Loading rates vary from 3 gpm/sf to 21 gpm/sf. Cross section of a HYDROVEX® FluidSep Vortex Separator in full operation is shown in Figure 2-9.

Figure 2-9 - Cross Section of a HYDROVEX® FluidSep Vortex Separator



(Source: John Meunier, Inc.)

Applicability

The HYDROVEX® FluidSep Vortex Separator was developed in 1985 by a German firm, Umwelt-und Fluid-Technik (UFT) as a tool in the treatment of CSO and stormwater. The first HYDROVEX® Fluidsep unit was installed in 1987 in the City of Tengen near Schaffhausen in Germany. The units are still operating successfully. A special research program that ended in the summer of 1990 supplied evidence of CSO treatment efficiency of the HYDROVEX® FluidSep (H. Brombach, *et al.*, 1993). The program was based on the qualitative evaluation of sampling campaigns performed at the installation.

HYDROVEX® FluidSep is currently in full operation in Germany, France, Canada, and the United States of America. John Meunier Inc./Veolia Water Technologies designs and manufactures HYDROVEX® FluidSep units for the North America under license from UFT. See Appendix D for an installation list of HYDROVEX® FluidSep units in the North America. All the installations included on the list are for CSO applications. HYDROVEX® FluidSep Vortex Separator are most effective on removing settleable solids and floatable material. The units have been installed in remote locations, away from treatment plants and have performed well. There are no moving parts within the vortex unit itself. Underflow from the unit can be discharged by gravity to sewers or continuously pumped to an ancillary tank where it would be stored until there is capacity in the interceptor sewer system.

Performance

The performance of HYDROVEX® FluidSep Vortex Separator is similar to that described above for the Storm King® Vortex Separator in terms of contaminants removal since they use similar mechanism for solids removal.

Hydraulics

Vortex units are hydraulically efficient. The head loss is comparable to that described above for the Storm King® Vortex Separator.

Generation of Waste Streams

As discussed under the description of the process and the performance, 10% of the design flow will continuously be removed as underflow. This flow must be pumped from the vortex unit, and since the interceptor is full, no capacity will exist in the interceptor during an overflow event. Therefore, the underflow must be stored in ancillary tanks. The capacity of the ancillary tanks is based upon the underflow flow rate and the duration of the overflow event. Once the event is over the contents of the storage tank can be pumped back into the interceptor. Floatable material captured in the tank is removed at the end of the overflow event as the tank is emptied, and is also sent back into the interceptor.

Complexity

The vortex/swirl separator is a simple process. Hydraulic loading rates can be controlled using sluice gates or overflow weirs. Floats, bubblers, or ultrasonic level sensors would be used to control the underflow sump similar to the Storm King® Vortex Separator.

Limitations

The limitations of the HYDROVEX® FluidSep Vortex Separator are similar to those described above for the Storm King® Vortex Separator.

Construction Costs

Table 2-11 presents preliminary planning level construction cost estimates for flows ranging from 10 MGD to 450 MGD. It includes equipment cost, concrete cost associated with the construction of the tank containing the vortex structure, cost for ancillary tank for underflow storage, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing provided by the equipment manufacturer Veolia Water Technologies includes only the fabricated stainless-steel vortex structures inside. Cost for outside concrete tank enclosure were estimated based on the sizes of the vortex units. Construction cost for excavation, sitework, soil support, and dewatering, as well as the underflow wet well and the pumps are included in the installation costs. The estimated total construction costs for the HYDROVEX® FluidSep Vortex Separator are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-8.

Operation and Maintenance

The operating costs for the HYDROVEX® FluidSep Vortex Separator are the power costs for the underflow pump. The horsepower of the pumps increases as the size of the vortex separator, and correspondingly the underflow, increase. Maintenance costs for the HYDROVEX® FluidSep unit include inspection of the vortex separator and removal of coarse debris (if any) after first heavy rainfall event and then every six months. Once every year, a full inspection of the unit is recommended, including cleaning of the area, visual inspection for abnormalities, like leaks, cracks in the unit's tank and pipe works. Perform visual inspection of all anchors and bolted assemblies. During visual inspection, all normal safety procedures are recommended to be used to prevent any kind of injury. Underflow pumps are recommended to be replaced every six months for overhaul and sharpening of the cutter blades.

Estimated annual operation costs for the HYDROVEX® FluidSep Vortex Separator are presented on Table 2-12 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-13.

Space Requirements

The space requirements of the HYDROVEX® FluidSep Vortex Separator shall be based upon a square area utilizing the diameter of the tank and a buffer of 5 feet on each side.

Case Study

In 2016, Mattoon, IL installed a HYDROVEX® FluidSep Vortex Separator at their Riley Creek satellite CSO treatment facility. As of September 2017, the unit has not been in service yet. The Riley Creek facility is in a remote location and designed for 15 MGD. The application required a 12" gravity underflow line (at 2 ft/s flow) for 3 or 4 MGD of underflow, which will get pumped back to the wastewater treatment plant. This large amount of underflow requires having almost one pump dedicated to pumping it back to the WWTP.

Table 2-11 - Preliminary Construction Cost Estimates for HYDROVEX Fluidsep Vortex Separator

Flow	System	Diameter x Depth	Budgetary Equipment Price	Concrete Structure Cost	Auxiliary Tank Cost(1)	Install Cost(2)	GC General Conditions (3)	GC OH&P(4)	Contingency(5)	Total
10 MGD	(1) Type 1	20'-0" x 20'-0"	$60,000	$82,000	$871,200	$759,900	$177,310	$177,310	$1,063,860	$3,191,580
25 MGD	(1) Type 2	35'-0" x 19'-6"	$81,000	$181,000	$1,573,000	$1,376,250	$321,125	$321,125	$1,926,750	$5,780,250
50 MGD	(1) Type 2	45'-0" x 24'-6"	$85,700	$291,500	$2,300,000	$2,007,900	$468,510	$468,510	$2,811,060	$8,433,180
75 MGD	(1) Type 2	45'-0" x 24'-5"	$85,700	$291,500	$3,040,000	$2,562,900	$598,010	$598,010	$3,588,060	$10,764,180
100 MGD	(1) Type 2	50'-0" x 27'-5"	$113,900	$359,000	$3,720,000	$3,144,675	$733,758	$733,758	$4,402,545	$13,207,635
450 MGD	(4) Type 2	50'-0" x 27'-5"	$455,600	$718,000	$10,890,000	$9,047,700	$2,111,130	$2,111,130	$12,666,780	$38,000,340

Notes:
(1) Auxiliary Tank costs derived from quotation from Mid Atlantic Storage System on Aquastore Glass Fused to Steel Storage Tank of 150,000 gal
(2) Installation cost is assumed at 75% of the equipment cost.
(3) GC general conditions are estimated at 10% of the total direct cost.
(4) GC OH&P are estimated at 10% of the total direct cost.
(5) 50% of Contingency is used for the planning level of cost estimates.

Figure 2-10 - Total Estimated Construction Cost of HYDROVEX FluidSep Vortex Separator

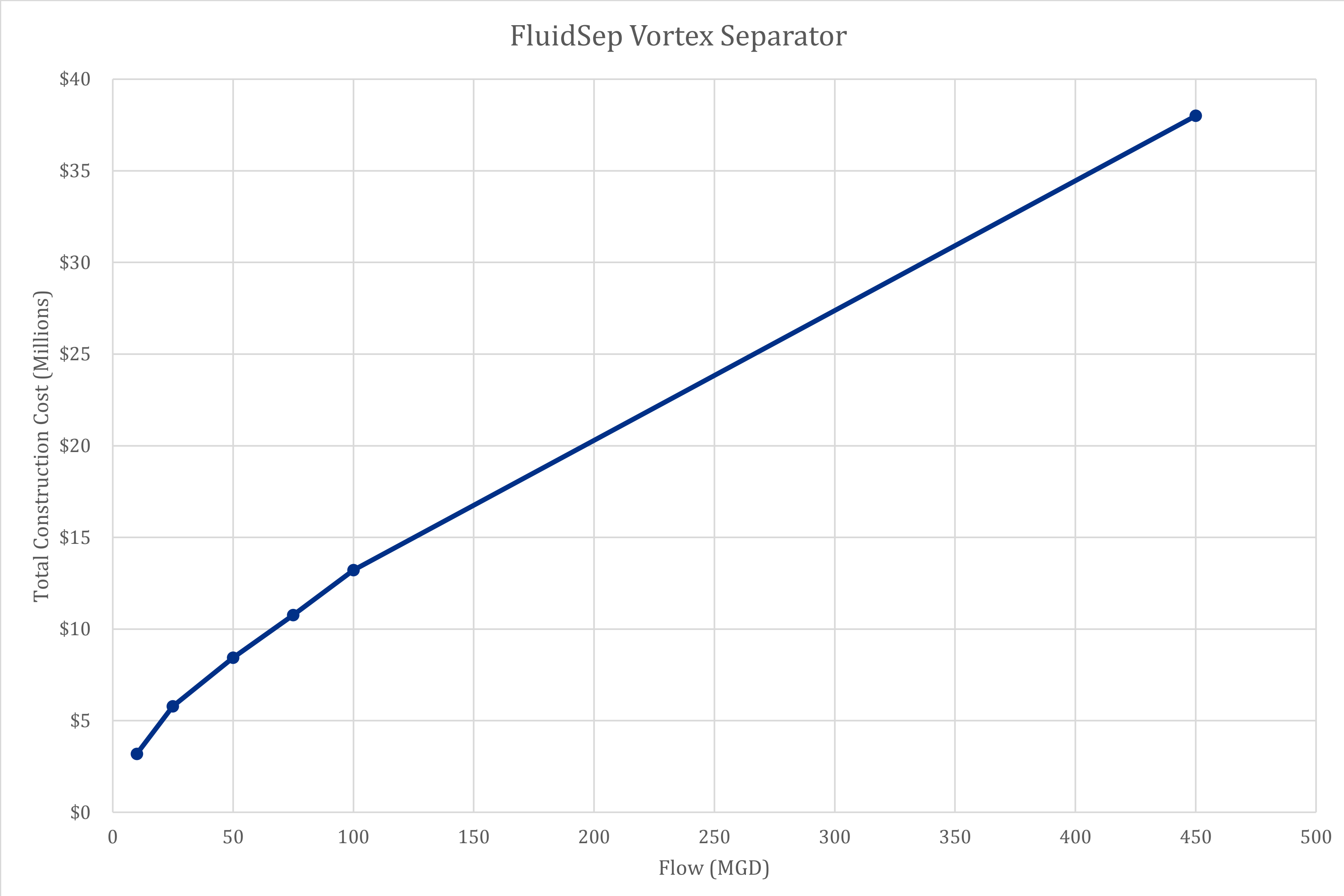


Table 2-12 - Annual Operation Cost of HYDROVEX Fluidsep Vortex Separator

Flow	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD	(1) Type 1	14	10	1	$731
25 MGD	(1) Type 2	35	26	4	$1,827
50 MGD	(1) Type 2	70	52	7	$3,654
75 MGD	(1) Type 2	104	78	11	$5,429
100 MGD	(1) Type 2	139	104	15	$7,256
450 MGD	(4) Type 2	625	466	65	$32,624

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-13 - Annual Maintenance Labor Cost of HYDROVEX Fluidsep Vortex Separator

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)
Biannually	Tank and pipe	Visual check and removal of coarse debris (if any)	1	300
Annually	Full Inspection	Cleaning, check for leaks/cracks in unit tank and pipes; visual inspection of all anchors and bolted assemblies	2	300
Biannually	Underflow pumps	Replacement of underflow pumps	8	400
Total Annual Maintenance Cost				$1,000

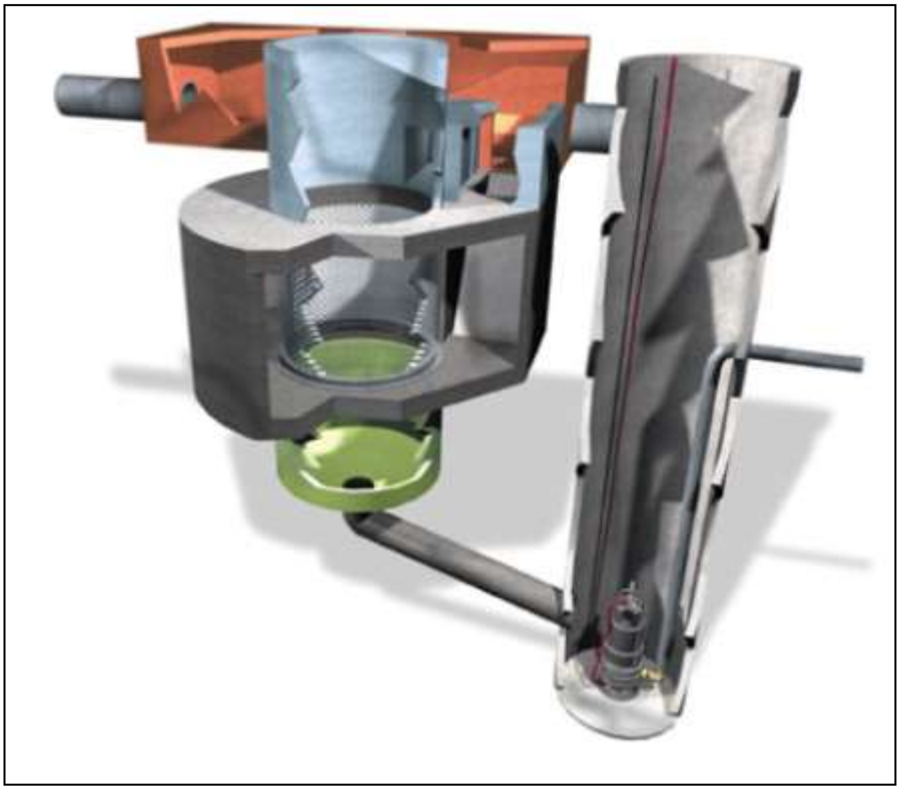
Notes:
(1) Assumes labor rate of $150/hour

2.3.1.3 SANSEP

Description of Process

The SanSep process is a variation of the typical vortex/swirl separation process, in that it utilizes a screen at the mid-depth of the tank where the treated flow exits the tank. Using the patented non-blocking screen, all gross solids larger than 0.04" and finer sediments down to below 0.004" are captured and retained inside the unit. The settleable solid pollutants settle into the lower catchment chamber while the floatables are retained at the surface of the upper chamber. A flow of liquid is maintained across the face of the screen producing a "washing" effect that keeps the solids moving while the fluid passes through the screen. The SanSep is typically automated with an underflow pump, which periodically removes the solids and returns them to the interceptor sewer. The non-blocking screen operates continuously at its maximum design flow. Cross section of a SanSep unit is shown in Figure 2-11.

Figure 2-11 - Cross Section of a SanSep Unit



(Source:PWTech.)

Application to the Project

SanSep was initially developed in Australia as a stormwater treatment system by the corporate predecessor of PWTech (CDS Technologies). The system was introduced in the US in the mid 90's and first used for CSO applications in Louisville Kentucky. Three units have been in continuous operation there since the late 90s. SanSep units have been installed on CSO applications in Cohoes, New York since 2004, and in in Akron, OH and in Weehawken, NJ. since 2004. See Appendix E for an installation list for SanSep for CSO applications in the US, Europe and the Pacific Rim.

Performance

The SanSep unit is more efficient in removal of solids and other pollutants than conventional vortex/swirl separation units due to the use of the screen. The unit removes all solids larger than 1 mm, including organic debris such as vegetation and coarse sediments, fine organic sediments, and significant amounts of BOD and Phosphorus associated with the organic material and fine sediments captured. The SanSep units are also capable of operating at high separation efficiency, over a larger range of hydraulic loading rates than the conventional vortex/swirl separation units. Hydraulic loading rates for conventional units are based upon the horizontal area of the vortex unit, whereas the hydraulic loading rate for the SanSep units are based upon the area of the screen. The screening area, which is greater than the horizontal surface area, and the continuous cleaning action of the flow across the screen enables the SanSep unit to maintain the higher removal rates than conventional units over a wider range of hydraulic loading rates. The performance information from the manufacturer show that there is light drop in removal of TSS as the hydraulic loading rate increases. TSS removal can drop from approximately 70% to 50% as loading rate increases to about 60 gpm/sf.

Hydraulics

Vortex units are hydraulically efficient. The head loss through the unit consists of the losses through the inlet to the unit, and the head loss through the screen. The losses in the lower hydraulic loading rates will be limited to less than six inches. At higher hydraulic loading rates, the losses will increase.

Generation of Waste Stream

The SanSep process has a reduced underflow of 2-3% of the design flow which will continuously be removed as underflow, compared to conventional vortex units with an underflow of 10%. This flow must be pumped from the vortex unit, and since no or limited capacity will exist in the interceptor during an overflow event, the underflow must be stored in ancillary tanks. The capacity of the ancillary tanks is based upon the underflow flow rate and the duration of the overflow event. Once the event is over the contents of the storage tank can be pumped back into the interceptor. Floatable material captured in the tank is removed at the end of the overflow event as the tank is emptied, and is also sent back into the interceptor.

Complexity

The vortex/swirl separator is a simple process, especially since there are no moving parts within the unit. Removals are achieved using natural forces and no adjustment of equipment is necessary. The only controls that are needed are in the flow coming to the unit, in order to ensure that the unit operates within its hydraulic loading rates. This is typically accomplished using sluice gates or overflow weirs. The other area requiring instrumentation would be the control of the underflow sump where underflow is pumped out. The control of the pumping units would be by floats, bubblers, or ultrasonic level sensors.

Limitations

As stated above, the hydraulic loading rate is key to the performance of the vortex/swirl separator. However, since the SanSep unit is able to maintain high removal rates over a wider range of hydraulic loading they perform better in removing TSS, and as a result enable the downstream disinfection processes to be more effective.

Construction Costs

The preliminary report level construction cost estimates provided in Table 2-14 include the equipment, installation, building, land, and contingency for SanSep of design flow ranging from 10 MGD to 100 MGD. Budgetary equipment pricing information for SanSep was gathered from equipment manufacturer Echelon Environmental. Flowrate higher than 100 MGD was considered impractical to use the SanSep unit by the equipment manufacturer. Installation costs are estimated at 150% of the equipment cost per manufacture recommendation. The estimated total construction costs for the SanSep are plotted against flowrate from 10 MGD to 100 MGD in **Figure 2-**12.

Operation and Maintenance

The operating costs for the SanSep vortex separator are the power costs for the underflow pump. The horsepower of the pumps increases as the size of the vortex separator, and correspondingly the underflow, increase. Regular maintenance required for SanSep unit includes inspection of the vortex separator after each rainfall event. After each event, the PLC for the unit initiates a cleaning and wash-down cycle. During this cycle, the underflow pumps empty the unit, followed by a wash-down with clean water directed at the screen through a series of water jets. If a clean water source is not available, the wash-down can also be accomplished using the spray from a vactor truck. The screen should also receive a periodic inspection from the surface to ensure that the cleaning cycle is removing accumulated debris. Unless large debris is accumulating in the structure, it shouldn't be necessary to enter the unit. If it is ever necessary to enter the unit, confined space entry regulations would apply. The underflow pumps are recommended to be replaced every 6 months for overhaul and sharpening of the cutter blades.

Estimated annual operation costs for the SanSep separator are presented on Table 2-15 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-16.

Space Requirements

The space requirements of the SanSep vortex separator shall be based upon a square area utilizing the diameter of the tank and a buffer of 5 feet on each side.

Case Study

The Fort Wayne, Indiana Public Utilities installed the SanSep unit in 2009 at one of their CSO locations to catch floatables half and inch and larger. Prior to the installation, a pilot study was completed in which baskets were installed to observe the types of materials collected. The pilot study showed that the unit was able to capture fine materials. According to the CSO Program Manager, the unit was in use until about 2015 at which point the CSO location was almost entirely eliminated due to Consent Decree regulations. During its operation, there had been no plugging or washdown of the system needed and maintenance consisted of the general routine maintenance. There was also a small pump station which pumps debris back into the wastewater treatment plant. Overall the CSO Program Manager was satisfied with the product.

Table 2-14 - Preliminary Construction Cost Estimates for SanSep

Flow	System	Length X Width	Budgetary Equipment Price	Auxiliary Tank Cost	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) Model 80_80	23'-0" x 25'-6"	$300,000	$420,000	$1,080,000	$180,000	$72,000	$1,026,000	$3,078,000
25 MGD	(2) Model 80_80	42'-0" x 25'-6"	$430,000	$680,000	$1,665,000	$277,500	$111,000	$1,581,750	$4,745,250
50 MGD	(3) Model 80_80	42'-0" x 38'-6"	$560,000	$1,000,000	$2,340,000	$390,000	$156,000	$2,223,000	$6,669,000
75 MGD	(4) Model 80_80	42'-0" x 51'-0"	$690,000	$1,300,000	$2,985,000	$497,500	$199,000	$2,835,750	$8,507,250
100 MGD	(4) Model 80_80	42'-0" x 51'-0"	$690,000	$1,570,000	$3,390,000	$565,000	$226,000	$3,220,500	$9,661,500

Notes:
(1) Installation costs are estimated at 150% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Figure 2-12 - Total Estimated Construction Cost of SanSep

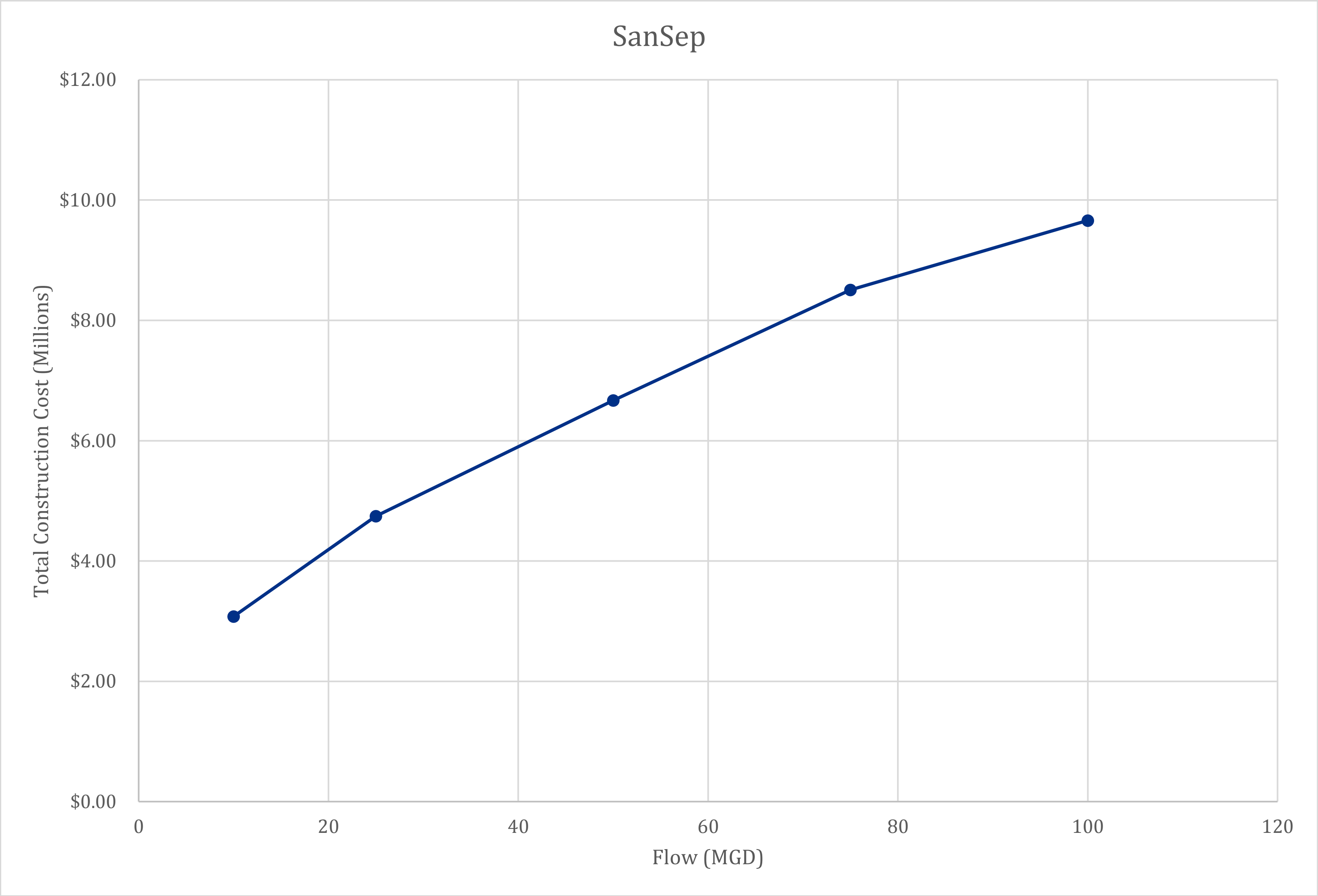


Table 2-15 - Annual Operation Cost of SanSep

Flow	System	Total Horsepower (HP)	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Cost(3)
10 MGD	(1) Model 80_80	6	4	1	$313
25 MGD	(2) Model 80_80	10	7	1	$522
50 MGD	(3) Model 80_80	10	7	1	$522
75 MGD	(4) Model 80_80	15	11	2	$783
100 MGD	(4) Model 80_80	20	15	2	$1,044

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr

Table 2-16 - Annual Maintenance Labor Cost of SanSep

Maintenance Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)
Biannually	Tank and pipe	Visual check and removal of coarse debris (if any)	1	$300
Annually	Full Inspection	Cleaning, check for leaks/cracks in unit tank and pipes; visual inspection of all anchors and bolted assemblies	2	$300
Biannually	Underflow pumps	Replacement of underflow pumps	8	$400
Total Annual Maintenance Cost				$1,900

Notes:
(1) Assumes labor rate of $150/hour

2.3.2 Ballasted Flocculation

Ballasted flocculation, also known as high rate clarification, is a physical-chemical treatment process that uses microsand, or sludge and a variety of additives to improve the settling properties of suspended solids through improved floc bridging. The objective of this process is to form floc particles with a specific gravity of greater than two. Faster floc formation and decreased particle settling time allow clarification to occur up to ten times faster than with conventional clarification, allowing treatment of flows at a significantly higher rate than allowed by traditional unit processes. Ballasted flocculation units function through the addition of a coagulant, such as ferric chloride; an anionic polymer; and a ballast material such as microsand, a microcarrier, or chemically enhanced sludge. When coupled with chemical addition, this ballast material has been shown to be effective in reducing coagulation-sedimentation time.

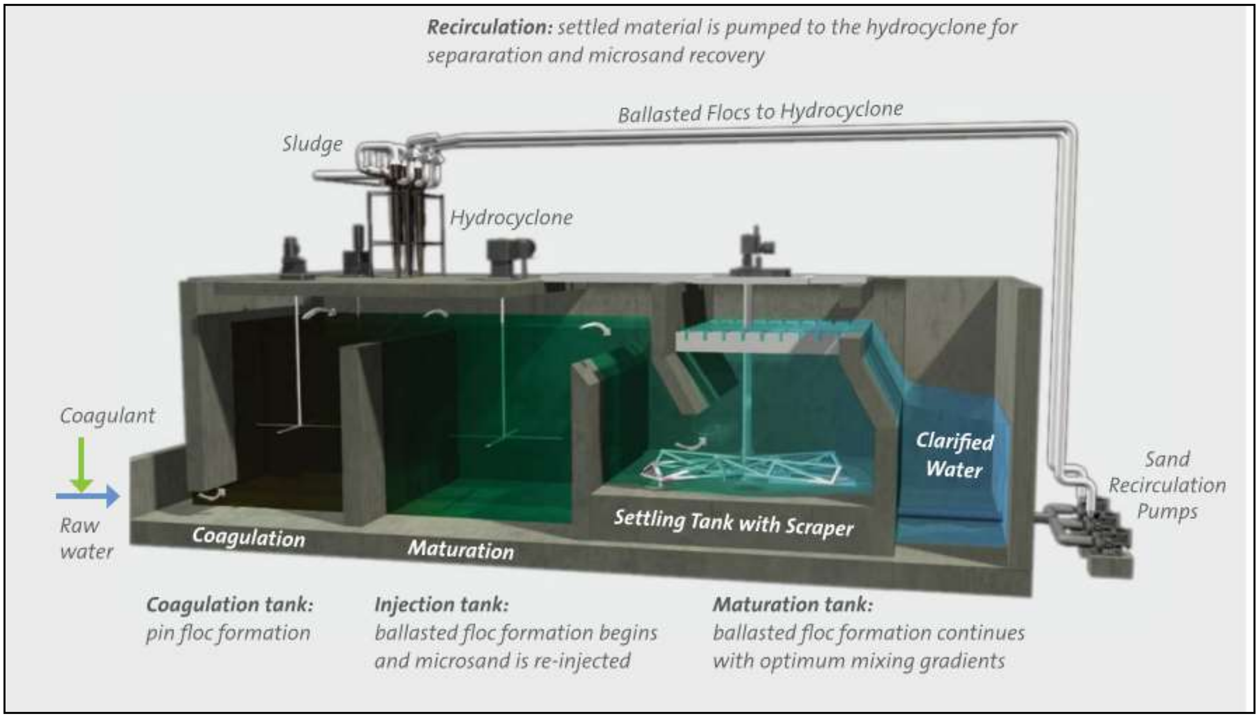
The ballasted flocculation processes, using chemical addition as a critical part of their operation, have higher removal percentages than vortex/swirl separation processes for virtually all the pollutants with the exception of total nitrogen and NH_3. The compact size of ballasted flocculation units can significantly reduce land acquisition and construction costs. This technology has been applied both within traditional treatment trains and as overflow treatment for peak wet weather flows. Several different ballasted flocculation systems are discussed in more details in sections below.

2.3.2.1 ACTIFLO® Ballasted Flocculation Process

Description of Process

ACTIFLO® is a microsand ballasted clarification process that may be used to treat water or wastewater. The process begins with the addition of a coagulant, such as an iron or aluminum salt, to destabilize suspended solids. The flow enters the coagulation tank for flash mixing to allow the coagulant to rapid mix with the flow after which it overflows into the injection tank where microsand is added. The microsand serves as a seed for floc formation, providing a large surface area for suspended solids to bond to, and is the key to the ACTIFLO® process. The larger flocculation particles allow solids to settle out more quickly, thereby requiring a smaller footprint than conventional clarification. Polymer may either be added in the injection tank or at the next step, the maturation tank. Mixing is slower in the maturation tank, allowing the polymer to help bond the microsand to the destabilized suspended solids. Finally, the settling tank effectively removes the floc with help from the plate settlers. The plate settlers allow the settling tank size to be reduced. Clarified water exits the process by overflowing weirs above the plate settlers. The sand and sludge mixture is collected at the bottom of the settling tank with a conventional scraper system and pumped back to a hydrocyclone, located above the injection tank. The hydrocyclone converts the pumping energy into centrifugal forces to separate the higher-density sand from the lower density sludge. The sludge is discharged out of the top of the hydrocyclone while the sand is recycled back into the ACTIFLO® process for further use. Screening is required upstream of ACTIFLO® so that particles larger than 0.1 - 0.25 mm do not clog the hydrocyclone. Cross section of ACTIFLO® unit is shown in Figure 2-13.

Figure 2-13 - Cross Section of ACTIFLO® Unit



(Source: Veolia Water Technologies)

Applicability to the Project

High rate clarification (HRC) was traditionally used for water treatment until in the late 1990s when HRC demonstration testing programs were performed to verify whether HRC technology would be able to be used for wastewater and CSO treatment. The results of the demonstration programs indicated that HRC can be used for CSO treatment and the effluent quality produced during pilot-testing surpassed CSO treatment standards, making it amenable to subsequent UV disinfection.

The ACTIFLO® system, as one type of HRC that uses ballasted flocculation, can be installed at the treatment plant or at a satellite facility within the collection system. The Actiflo process can be fully automated and the process train(s) can sit idle for extended periods of time and still be fully operational within 15 minutes of start-up. Installations at the WWTP also enable the sludge produced by the unit to be processed with existing systems. When installing the ACTIFLO® unit in a remote CSO location, the flows will vary widely, and the sludge must be stored in ancillary tanks so it can be put back into the interceptor during periods of low flow. Appendix F summarizes ACTIFLO® installations in the USA. The table lists only installations used for wastewater treatment operations. System applications include Primary WW, Primary WW/CSO, Primary WW/ Tertiary WW, CSO, CSO/Tertiary WW, and Tertiary WW treatment operations.

Performance

The ACTIFLO® ballasted flocculation process is sized for the peak hour or day flow to prevent flow from exceeding the capacity of the unit. The units are designed for a surface-loading rate of 60 gallons per minute per square foot, at a peak hydraulic loading rate of 150%. When starting up the unit it takes between 15-30 minutes for the process to reach steady state conditions. Accordingly, the initial 15-30 minutes of operation receives only little or partial treatment. The ACTIFLO® ballasted flocculation process is very effective in removing most of the pollutants; especially since the addition of flocculants and polymers helps remove smaller particles. Performance for removal of pollutants is reportedly constant up to for a surface-loading rate of 60 gallons per minute per square foot. See Table 2-17 for manufacturer provided performance efficiency. Performance deteriorates quickly for higher surface loading rates than 60 gallons per minute per square foot.

Table 2-17 - Anticipated Performance Efficiency

Parameter	Removal Rate
TSS	80 - 95%
COD	50 - 70%
Total BOD	50- 80%
Soluble BOD	10 - 20%
Total P	80 - 95%
TKN	15 -20%
Heavy Metals	85 -100%
Oils & Grease	50 -80%
Fecal Coliform	85 -95%

Hydraulics

The head loss through the units at peak flow rates are reported at less than two feet.

Generation of Waste Streams

As previously noted, the initial 15-30 minutes of operation of the unit provides no or only partial treatment. Since the disinfection process requires consistent pretreatment removals of TSS, the discharge of this partially treated flow will result in only partial disinfection. One potential means of eliminating this problem would be to provide ancillary tanks for storage of the initial discharge. This storage can then be reintroduced to the treatment process once the unit is fully operational. Under the description of the process, sludge is produced and separated in a hydrocyclone unit. The solids percentage of the waste sludge will vary depending on the concentration of the influent TSS and the coagulant dosage. In most cases the solids concentrations will vary from 0.1 to 1.0% with an average of 0.3%. Sludge from the ACTIFLO® process is easily treated and dewatered. When the ACTIFLO® process is located at the WWTP the sludge is sent back to the head of the plant or primary clarifiers, in some cases it is sent to intermediate gravity thickeners and then on to centrifuges or belt thickeners for final processing. The sludge production is approximately 4.8% of the design capacity of the unit.

Complexity

The ACTIFLO® ballasted flocculation process is more complex than the vortex/swirl separator process. The ACTIFLO® ballasted flocculation process consists of chemical addition, which must be controlled by the flow rate, mixers and flocculators, sludge pumps and a hydrocyclone, which separates the sludge from the microsand.

Limitations

The startup time for the ACTIFLO® process of from 15 to 30 minutes is a limitation in that for stringent treatment objectives the flow from the unit during this time period must be stored and fed back into the system later. For some drainage areas, this startup period may correspond to the first flush when the loading is the greatest. Also, the ACTIFLO® process has 4:1 turndown ratio, which means the minimum flow through the unit is 25% of the unit's capacity. Flows lower than this result in process problems. There is a maximum TSS limit on the ACTIFLO® process at the higher loading rate of 60 gpm/sf, of between 500 to 1000 mg/L TSS. This value is high and should not provide a routine problem in the operation of the unit. In remote locations, the ACTIFLO® process will see intermittent operation which will make operation more challenging.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-18 for ACTIFLO® Ballasted Flocculation Unit of design flow ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing information for ACTIFLO® Ballasted Flocculation Unit was gathered from equipment manufacturer Veolia Water Technologies. The equipment price includes engineering and project management time. Cost for concrete structure and auxiliary tank for waste sludge storage were also estimated based on equipment sizing and design flowrate. Installation cost was assumed at 115% of equipment cost based on equipment manufacturer's recommendations. The installation cost includes assembly of the ACTIFLO® ballasted flocculation unit, excavation and backfilling, and the cost of the Chemical Building and the chemical feed equipment. The estimated total construction costs for the ACTIFLO® Ballasted Flocculation Unit are plotted against flowrate from 10 MGD to 450 MGD in **Figure 2-**14.

Operation and Maintenance

Operating costs for the ACTIFLO® Ballasted Flocculation unit consists of the power and chemical costs. Power costs are based upon the horsepower of the mixers, flocculators, chemical feed equipment and pumps. Chemical costs are based on usage of coagulant and polymer. Regular maintenance includes routine lubrication and maintenance of the mixers, scrapers, pumps, hydrocyclones and other mechanical components. Weekly inspections and preventive maintenance are important to keep an intermittent-use facility ready to operate at a moment's notice. When the unit will be offline for more than 8 hours, the units will be completely drained and all equipment stopped.

Estimated annual operation costs for the ACTIFLO® system are presented on Table 2-19 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on Table 2-20.

Space Requirements

The space requirements of the ACTIFLO® units consist of the size of the tanks and a buffer of 5 feet around the unit for access and maintenance.

Case Study

The Water Environment Federation's (WEF) February 2012 issue of Water Environment and Technology (WE&T) provided a case study on the use of HRC in the city of Bremerton, Washington. Bremerton adopted a proprietary high rate compact clarification process to reduce its CSO discharges. Followed by an ultraviolet disinfection treatment, the HRC process was piloted by CDM Smith in 1999. The pilot testing determined effluent capable of being discharged into sensitive waterways would be produced by the HRC process and that a UV disinfection treatment could be added to the process. This project received the 2002 Grand Award in Small Projects by the American Academy of Environmental Engineers (Annapolis, MD).

The process takes wet weather flow that cannot be handled by the wastewater treatment plant, and puts it through a flash mixing tank with polymer added, and a maturation tank before it is sent through a clarifier. Reduction of BOD5 and TSS is typically 60-65% and 90-95%, respectively. Sludge from the clarifier is pumped back to the hydrocyclone and then either to the solids processing plant, or through a microsand filter and into the flash mixing tank. The facility utilizes a 10 MGD nominal capacity with a maximum hydraulic capacity of 20MGD. Additionally, flow to the facility is minimized by a 100,000-gallon storage tank, which has reduced overall CSO occurrences by 80% in the surrounding collection system. The HRC facility only receives flow when the storage tank fills over a weir wall.

Weekly inspection and maintenance is required to ensure the facility is ready to operate when the next rainfall occurs. Additionally, a small flow (less than 3 gal/min) of chlorinated potable water is discharged into the injection tank during periods of dry weather to eliminate the chance of biofouling on lamella tubes and other components. The facility has had issues with UV ballast burnout due to short durations of high intensity operation. Since installation, operators have adjusted the coagulant injection point to increase flocculation time. Additionally, the discharge was relocated from the hydrocyclone to the far side of the storage tank to reduce sand loss and resuspension of separated solids. Operators spent several years altering the chemical dosing to meet permitted discharge requirements as there are very few events each year which trigger the HRC.

Table 2-18 - Preliminary Construction Cost Estimates for ACTIFLO Ballasted Flocculation Unit

Flow	System	Length X Width of ACTFLO Unit	Auxiliary Tank Volume	Budgetary Equipment Price	Concrete Cost	Auxiliary Tank Cost	Install Cost(1)	GC General Conditions(2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) 10 MGD	44'-9" x 14'-0"	0.1 MG	$1,325,000	$204,300	$610,000	$1,604,475	$374,378	$374,378	$2,246,265	$6,738,795
25 MGD	(1) 25 MGD	60'-9" x 22'-0"	0.25 MG	$1,900,000	$341,100	$970,000	$2,408,325	$561,943	$561,943	$3,371,655	$10,114,965
50 MGD	(1) 50 MGD	82'-3" x 32'-0"	0.5 MG	$2,725,000	$532,800	$1,570,000	$3,620,850	$844,865	$844,865	$5,069,190	$15,207,570
75 MGD	(3) 25 MGD	60'-9" x 66'-0"	0.75 MG	$4,725,000	$675,000	$2,100,000	$5,625,000	$1,312,500	$1,312,500	$7,875,000	$23,625,000
100 MGD	(2) 50 MGD	82'-3" x 64'-0"	1.0 MG	$5,250,000	$801,900	$2,300,000	$6,263,925	$1,461,583	$1,461,583	$8,769,495	$26,308,485
450 MGD	(6) 75 MGD	116'-0" x 73'-2"	4.5 MG	$10,000,000	$3,204,900	$6,900,000	$15,078,675	$3,518,358	$3,518,358	$21,110,145	$63,330,435

Notes:
(1) Installation costs are estimated at 115% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Figure 2-14 - Total Estimated Construction Cost of ACTIFLO® Ballasted Flocculation Unit

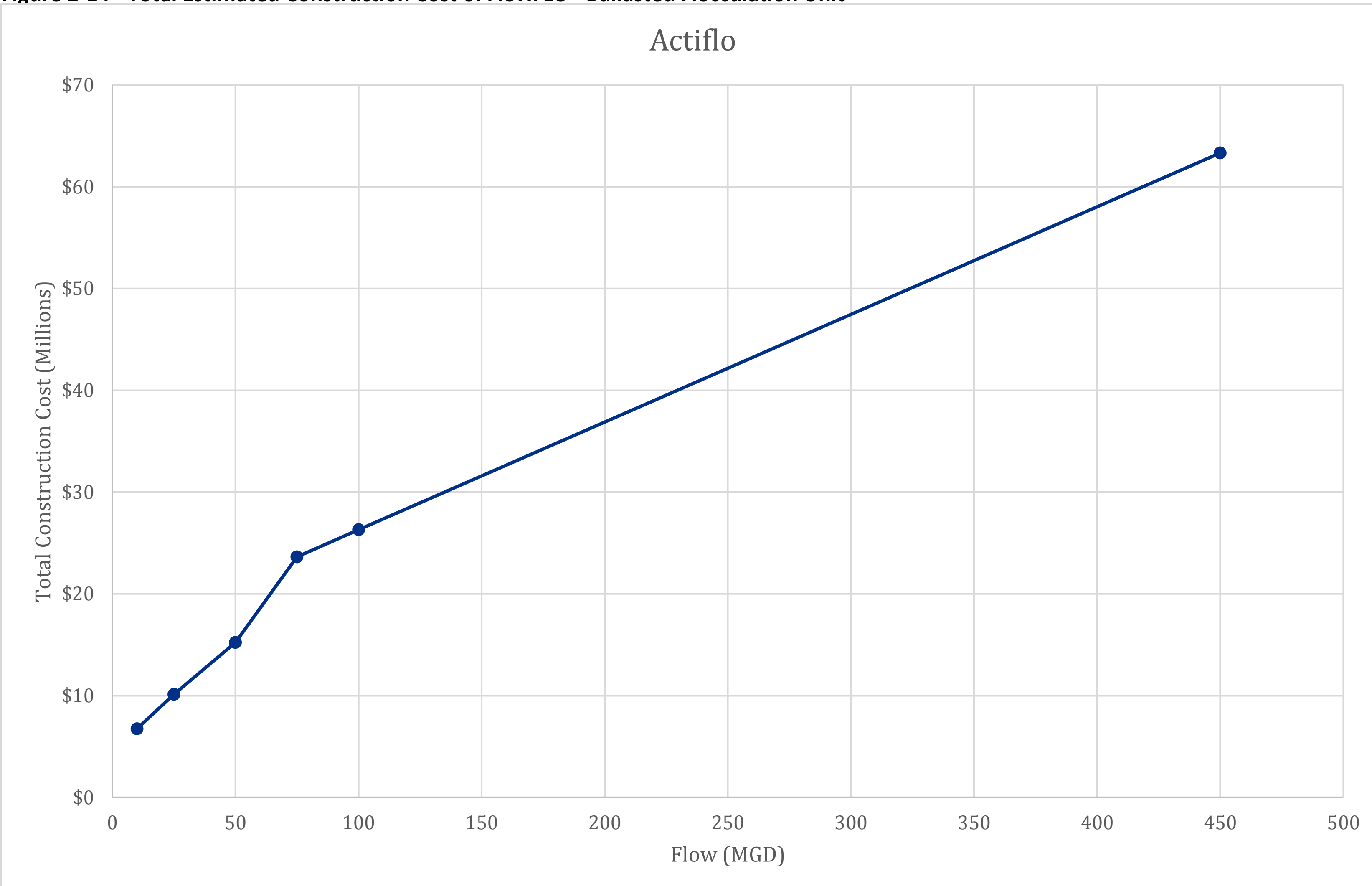


Table 2-19 - Annual Operation Cost of ACTIFLO® Ballasted Flocculation

Flow	Required Horsepower (HP)						Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Power Cost(3)	Alum Usage (lbs)(4)	Polymer Usage (lbs)(5)	Alum Cost(6)	Polymer Cost(7)	Total Annual Cost
	Coag-ulation Mixer	Matur-ation Mixer	Scraper Drive & Mech-anism	Sand Pump	Chemical Pump	Total HP								
10 MGD	10	7.5	2	80	0.5	100	75	37,285	$5,220	173,854	3,477	$10,014	$6,676	$21,910
25 MGD	25	20	7.5	100	0.5	153	114	57,046	$7,986	434,635	8,693	$25,035	$16,690	$49,711
50 MGD	20	30	15	120	1	186	139	69,350	$9,709	869,271	17,385	$50,070	$33,380	$93,159
75 MGD	75	60	22.5	300	1	458.5	342	170,952	$23,933	1,303,906	26,078	$75,105	$50,070	$149,108
100 MGD	80	60	30	240	1.5	411.5	307	153,428	$21,480	1,738,542	34,771	$100,140	$66,760	$188,380
450 MGD	360	270	135	1,080	2	1847	1,377	688,654	$96,412	7,823,438	156,469	$450,630	$300,420	$847,462

Notes:

(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr
(4) Assume an alum dosage of 100 mg/L
(5) Assumes a polymer dosage of 2 mg/L
(6) Assumes an alum cost of $0.0576/lb
(7) Assumes a polymer cost of $1.92/lb

Table 2-20 - Annual Maintenance Labor Cost of ACTIFLO Ballasted Flocculation Unit

Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)(2)
Biannually	Coagulation Mixers	Change oil and grease bearings	1	$300
Biannually	Maturation Tank Mixer	Change oil and grease bearings	1	$300
Biannually	Scraper	Change oil and grease bearings	1	$300
Annually	Chemical pumps	Grease bearings	0.5	$75
Biannually	Sand Pumps	Grease bearings	0.5	$150
Annually	Sand Pumps	Change belts	1	$150
Annually	Hydrocyclone	Inspect / change apex tips	0.25	$38
Monthly	Lamella	Cleaning	1 / basin	$3,600
Weekly	System	Inspection and preventive maintenance	0.5	$3,900
After each overflow event	System	System shut down and drain	2	$30,000
Total Annual O&M Cost				$38,813

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

2.3.2.2 DensaDeg® Ballasted Flocculation Process

Description of Process

The DensaDeg® is a is a high-rate settling clarifier process combining solids contact, ballast addition and solids recirculation to provide enhanced, high-rate settling of solids. Different from ACTIFLO®, recycled sludge, instead of microsand, is added to increase floc density and precipitation. The process consists of:

1. Rapid mix / coagulation stage: Raw water flows into the rapid (flash) mix zone where a coagulant is added. Coagulation is the destabilization of colloidal particles, which facilitates their aggregation and is achieved by the injection of a coagulant such as alum or ferric chloride.

2. Flocculation zone: Coagulated water then flows to the flocculation zone where, with a lower energy vertical turbine mixer, a continuous ballast media recirculation feed and a low dose of a flocculating agent (polymer) are added to begin the process of agglomerating the coagulated water into floc particles.

3. Maturation zone: Flocculated particles are then developed and grown into large, very dense mature particles. This is achieved with optimized mixing energy and detention time. The result is a floc which settles at extremely high rates.

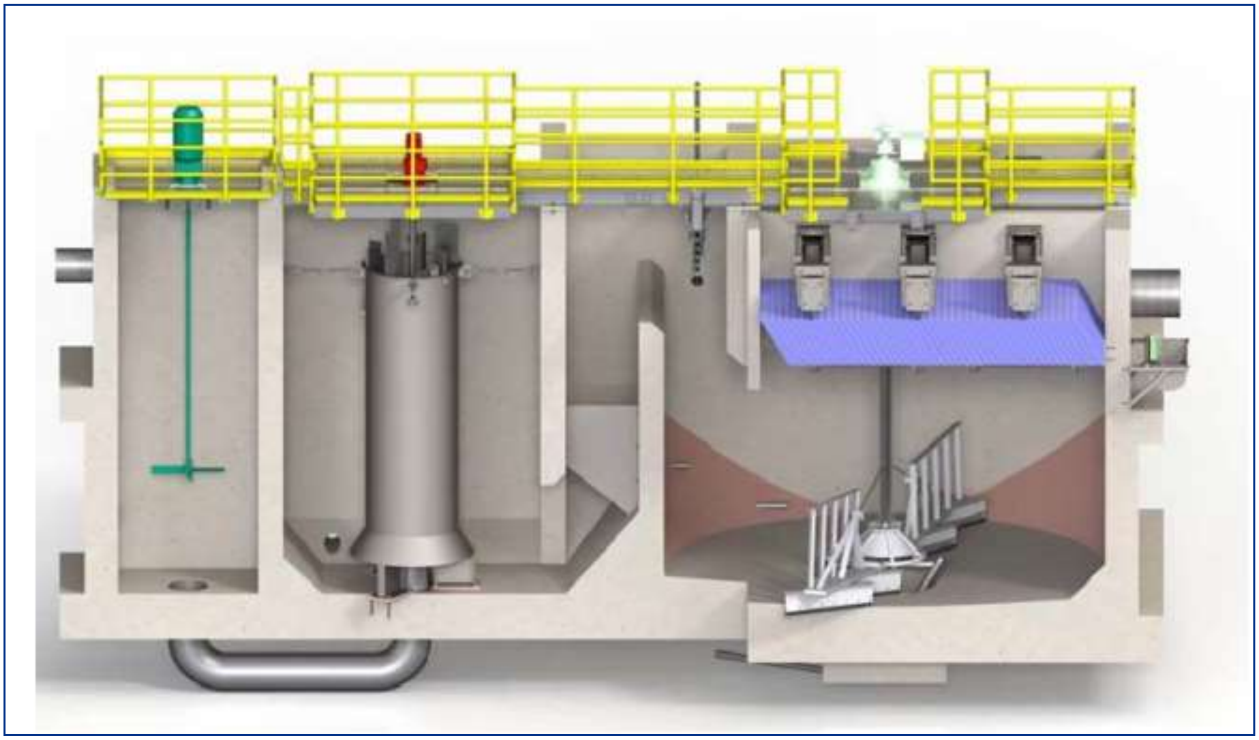
4. Settling & clarification zone: Flocculated solids enter the settling zone, over a submerged weir wall, where dense, suspended matter settles to the bottom of the clarifier. Clarified water is displaced upward from the downward moving slurry, through inclined plate settlers. The plate modules act as a polishing step for lighter, low density solids.

5. Hydrocyclone and ballast recovery: Settled sludge is continuously recycled via a recirculation pump to the hydrocyclone where the ballast media is separated from the waste stream. Ballast is returned to the flocculation zone and the waste stream is sent to sludge handling.

6. Effluent Collection: Uniform collection of clarified water is accomplished in effluent launders above the settling plate assembly.

Cross section of a DensaDeg® unit is shown in Figure 2-15.

Figure 2-15 - Cross Section of a DensaDeg Unit



(Source: Suez North America)

Applicability to the Project

The DensaDeg® ballasted flocculation process is a treatment process that combines solids contact, ballast addition and solids recirculation in a packaged system. It started with the original solids-contact clarifier, the Accelator, which was the first to incorporate internal sludge recycling. In the late 1980's the original DensaDeg clarifier was introduced to the market for high-rate sludge ballasted and solids recirculation systems. The earliest DensaDeg® CSO installation was in 1995.

The DensaDeg® process can be fully automated and the process train(s) can sit idle for extended periods of time and still be fully operational within 30 minutes of start-up. It can be installed at the treatment plant or at a satellite facility within the collection system. Installations at the WWTP also enable the sludge produced by the unit to be processed. When installing the DensaDeg unit in a remote CSO location, the flows will vary widely, and the sludge must be stored so it can be put back into the interceptor at periods of low flow.

Appendix G presents a list of select installations for the original DensaDeg® in CSO/SSO applications.

Performance

The DensaDeg® ballasted flocculation process is sized for the peak hour or day flow to prevent flow from exceeding the capacity of the unit. The units are designed for a surface-loading rate of 40-60 gallons per minute per square foot. When starting up the unit it takes 30 minutes for the process to reach steady state conditions and no sludge inventory is required for startup. The DensaDeg® ballasted flocculation process is very effective in removing vast quantities of pollutants. Its performance is comparable to ACTIFLO® in terms of contaminants removal with TSS removal of 80-90%, typically providing effluent <30mg/L TSS (inlet dependent) and BOD %-removal similar in magnitude to TSS %-removal, when treating typical municipal WW which is 30-40% of total BOD. Removal could be higher depending on soluble ratio.

Hydraulics

The head loss through the units at peak flow rates are reportedly less than two feet.

Generation of Waste Streams

As previously indicated in the description of the process, a portion of the sludge is wasted. The solids percentage of the waste sludge will vary depending on the concentration of the influent TSS and the coagulant dosage. In most cases the solids concentrations will 4%. The quantity of sludge is approximately equal to 0.5% of the capacity of the DensaDeg® unit. When the DensaDeg® process is located at the WWTP, the sludge is sent back to the head of the plant or primary clarifiers, in some cases it is sent to intermediate gravity thickeners and then on to centrifuges or belt thickeners for final processing.

Complexity

Similar to ACTIFLO®, the DensaDeg® ballasted flocculation process consists of chemical addition, which must be controlled by the flow rate, mixers and flocculators, and sludge pumps.

Limitations

DensaDeg® has similar limitations as previously stated for ACTIFLO® plus it requires a longer start time.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-21 for DensaDeg® ballasted flocculation equipment of design flow ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing information for DensaDeg® ballasted flocculation units was gathered from equipment manufacturer Suez. The equipment price includes engineering and project management time. Cost for concrete structure and auxiliary tank for waste sludge storage were also estimated based on equipment sizing and design flowrate. Installation cost was assumed at 115%. The installation cost includes assembly of the DensaDeg® ballasted flocculation unit, excavation and backfilling, and the cost of the Chemical Building and the chemical feed equipment. The estimated total construction costs for the DensaDeg® ballasted Flocculation Unit are plotted against flowrate from 10 MGD to 450 MGD in **Figure 2-**16.

Operation and Maintenance

Similar to ACTIFLO® ballasted flocculation system, operating costs for the DensaDeg® Ballasted Flocculation unit consist of the power and chemical costs. Power costs are based upon the horsepower of the mixers, flocculators, chemical feed equipment and pumps. Chemical costs are based on usage of coagulant and polymer. Routine maintenance and preventive care measures are similar to those for ACTIFLO® unit.

Estimated annual operation costs for the DensaDeg® Ballasted Flocculation unit are presented on

containing factors for calculation of operating costs; while estimated DensaDeg® Ballasted Flocculation unit annual maintenance labor cost including cost factors are included on Table 2-23.

Space Requirements

The space requirements of the DensaDeg® unit shall consist of the size of the tanks and a buffer of 5 feet around the unit for access and maintenance.

Case Study

Veolia Water Technologies provided a white paper[1] detailing the City of Akron, OH, BIOACTIFLO™ demonstration project. Beginning in March of 2012, a pilot plant at the City of Akron Water Reclamation Facility (WRF) was constructed to demonstrate effectiveness of the BIOACTIFLO™ technology. Incorporating high-rate activated sludge in the ACTIFLO™ high-rate ballasted flocculation process, BIOACTIFLO™ is designed to remove soluble BOD that would not otherwise be removed. Influent flow to the pilot plant was pumped from a location that had already undergone preliminary treatment, consistent with plans for the full-scale configuration. Return activated sludge (RAS) was supplied to the pilot plant from the gravity belt thickener building of the WWTP, consistent with plans for the full-scale configuration. Optimal doses for coagulant (alum) and polymer were determined. Both BIOACTIFLO™ and main plant secondary effluent were disinfected in a 0.53 MLD (0.14 mgd) pilot UV disinfection system and comparable results were obtained. Following all testing, effluent from the BIOACTIFLO™ pilot was sent back to the main plant for complete secondary treatment.

The pilot unit was operated during a total of twenty (20) wet weather events between April and December 2012, however the last two events (19 and 20) were performed using slightly different Operational Criteria. Pilot plant operation and sampling was conducted over a range of event durations and volumes, ranging from just under an hour to nearly a day in duration. Results showed an average 85% reduction in CBOD (90% reduction for events 19 and 20). Soluble CBOD concentration dropped from 9.2 mg/L in the influent of the BIOACTIFLO™ to 4.1 mg/L in the effluent from the BIOACTIFLO™. Meanwhile, TSS was reduced by 97%, from influent 144.8 mg/L to 4.0 mg/L effluent. Overall results document the effectiveness of BIOACTIFLO™ as a potential parallel wet weather treatment process at facilities facing wet weather treatment challenges.

[1] Heath, Gregory; Gsellman, Patrick; Hanna, Genny; Starkey, Daniel. Pilot Testing of BIOACTIFLO for Wet Weather Treatment at the Akron, Ohio Water Reclamation Facility

Table 2-21 - Preliminary Construction Cost Estimates for DensaDeg Ballasted Flocculation Unit

Flow	System	Length X Width	Budgetary Equipment Price	Concrete Cost	Auxiliary Tank Cost	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	(1) XRC-2 Concrete	39' x 16'	$988,000	$204,300	$210,000	$1,612,645	$301,495	$301,495	$1,808,967	$5,426,901
25 MGD	(1) XRC-5 Concrete	54' x 22'	$1,111,400	$341,100	$320,000	$2,038,375	$381,088	$381,088	$2,286,525	$6,859,575
50 MGD	(1) XRC-8 Concrete	78' x 32'	$1,405,800	$532,800	$420,000	$2,712,390	$507,099	$507,099	$3,042,594	$9,127,782
75 MGD	(3) XRC-5 Concrete	54' x 66'	$2,458,320	$675,000	$550,000	$4,235,818	$791,914	$791,914	$4,751,483	$14,254,448
100 MGD	(2) XRC-8 Concrete	78' x 64'	$2,811,600	$801,900	$610,000	$4,857,025	$908,053	$908,053	$5,448,315	$16,344,945
450 MGD(5)	(8) XRC-9 Concrete	84' x 136'	$5,727,000	$3,204,900	$1,570,000	$12,077,185	$2,257,909	$2,257,909	$13,547,451	$40,642,353

Notes:
(1) Installation costs are estimated at 115% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.
(5) The cost was conservatively higher based on nine units of 50 MGD system.

Figure 2-16 - Total Estimated Construction Cost of DensaDeg Ballasted Flocculation Unit

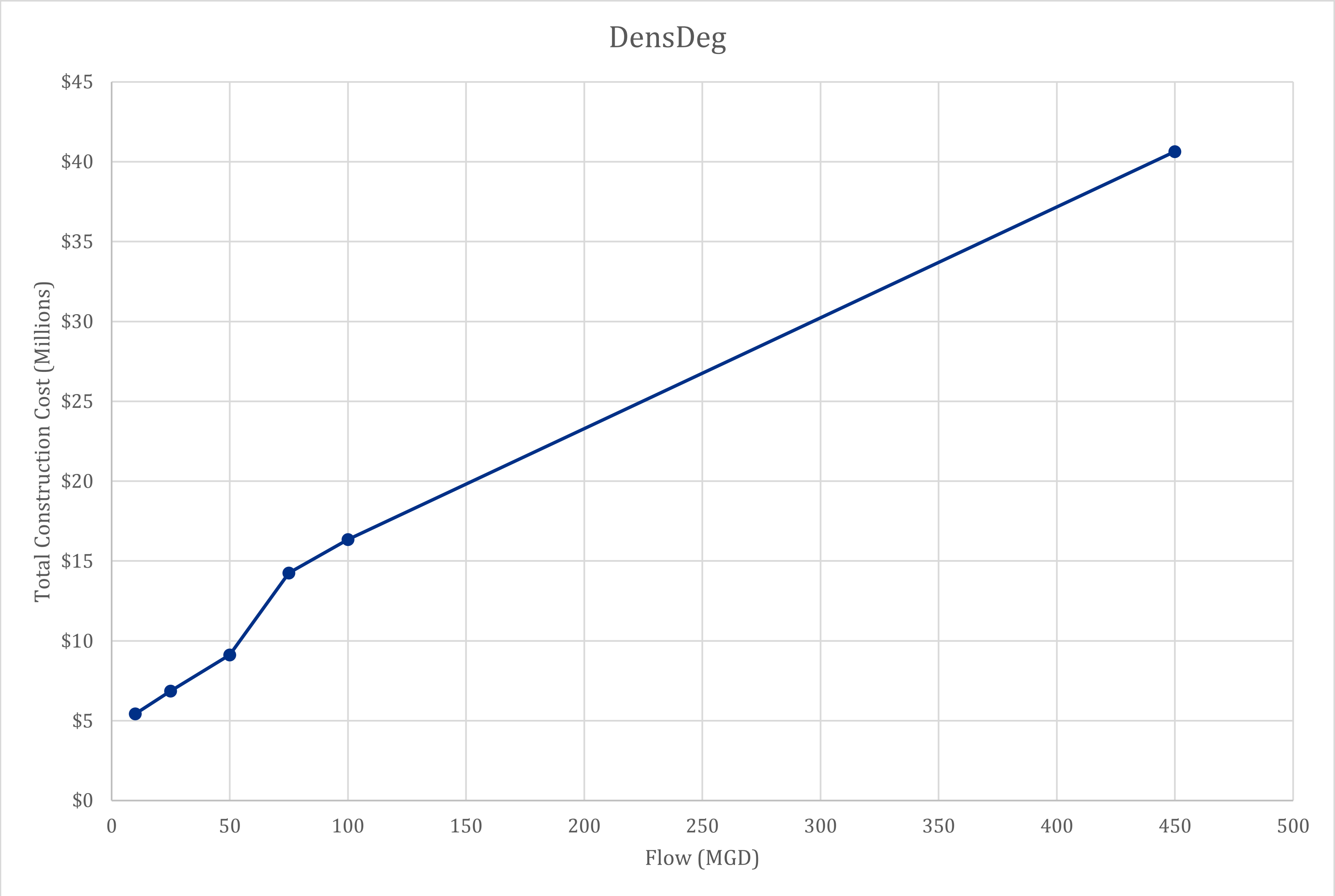


Table 2-22 - Annual Operation Cost of DensaDeg Ballasted Flocculation Unit

Flow	Required Horsepower (HP)						Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Power Cost(3)	Alum Usage (lbs)(4)	Polymer Usage (lbs)(5)	Alum Cost(6)	Polymer Cost(7)	Total Annual Cost
	Rapid Mixer	Reactor Drive	Scraper Drive	Recycle Pump	Chemical Pump	Total HP								
10 MGD	3	5	0.5	30	0.5	39	29	14,541	$2,036	173,854	3,477	$10,014	$6,676	$18,726
25 MGD	5	15	0.5	50	0.5	71	53	26,472	$3,706	434,635	8,693	$25,035	$16,690	$45,431
50 MGD	7.5	15	0.75	50	1	74.25	55	27,684	$3,876	869,271	17,385	$50,070	$33,380	$87,326
75 MGD	12	25	1.25	75	1	114.25	85	42,598	$5,964	1,303,906	26,078	$75,105	$50,070	$131,139
100 MGD	15	30	1.5	100	1.5	148	110	55,182	$7,725	1,738,542	34,771	$100,140	$66,760	$174,625
450 MGD	45	240	6	350	2	643	479	239,743	$33,564	7,823,438	156,469	$450,630	$300,420	$784,614

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr
(4) Assume an alum dosage of 100 mg/L
(5) Assumes a polymer dosage of 2 mg/L
(6) Assumes an alum cost of $0.0576/lb
(7) Assumes a polymer cost of $1.92/lb

Table 2-23 - Annual Maintenance Labor Cost of DensaDeg Ballasted Flocculation Unit

Frequency	Parts	Description	Estimated Man-Hours	Annual Cost(1)(2)	Frequency
Biannually	Coagulation Mixers	Change oil and grease bearings	1	150	$300
Biannually	Maturation Tank Mixer	Change oil and grease bearings	1	150	$300
Biannually	Scraper	Change oil and grease bearings	1	150	$300
Biannually	Sludge Pumps	Inspect, lubricate pumps and valves, and clean them	2	150	$600
Annually	Chemical pumps	Grease bearings	0.5	150	$75
Annually	Hydrocyclone	Inspect / change apex tips	0.25	150	$38
Monthly	Lamella	Cleaning	1 / basin	150	$3,600
Weekly	System	Inspection and preventive maintenance	0.5	150	$3,900
After each overflow event	System	System shut down and drain	2	150	$30,000
Total Annual O&M Cost					$39,113

Notes:
(1) Assumes 100 events per year
(2) Assumes labor rate of $150/hour

2.3.3 Compressible Media Filtration Process

Description of Process

The compressible media filtration is a process that uses a synthetic, porous filter media. The filter is unusual in a number of ways: (1) the synthetic media is highly porous (89%), (2) filter media and bed properties can be modified because the media is compressible, (3) the fluid to be filtered flows both around and through the media instead of only flowing around the filtering media (as in granular media filters), (4) the fluid that is filtered is used to backwash the filter, (5) to backwash the filter, filter bed volume is increased mechanically, and (6) the filter operates at high filtration rates (up to 40 gal/min/sq. ft.) Performance of the filter, with respect to removal of turbidity and total suspended solids, is similar to the performance of other more conventional filters with the exception that filtration rate is more than 3 to 6 times the rate of other filters. Also, percent backwash water required is significantly less than that used in conventional filtration technologies (typically 1 to 2% versus 6 to 15%).

Compressible media filtration is commercially available as either the "Fuzzy Filter" by Schreiber Industries or the "FlexFilter" by WesTech (both are proprietary technologies covered by patents or pending patents). Both technologies use synthetic fiber spheres as filter media; however, they have different flow configuration, method of bed compression, composition of the synthetic fibers, and media washing details.

The Fuzzy Filter receives the influent at the inlet pipe located at the bottom of the unit. The influent is pressurized upward through the compressed filter media and the effluent is piped out towards the top of the unit, as shown in the process diagram found in Figure 2-17. Porous plates are used to both compress the filter media as well as open up the filter bed to allow movement during backwashing. Figure 17 provides a cross-sectional view of the Fuzzy Filter process, and Figure 2-18 provides an overall picture of the Fuzzy Filter Unit.

Figure 2-17 - Fuzzy Filter Process Diagram

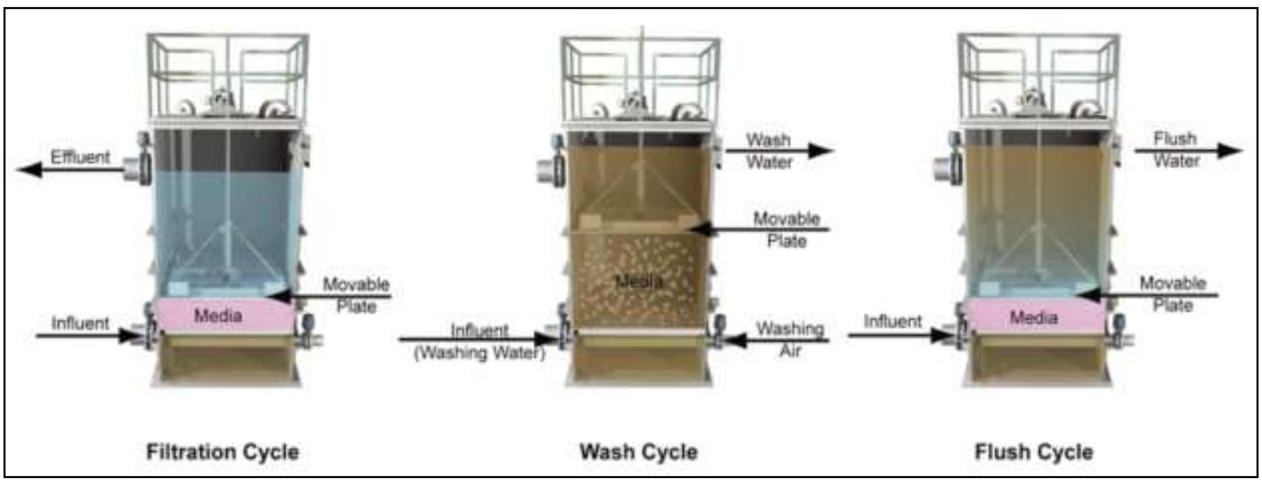
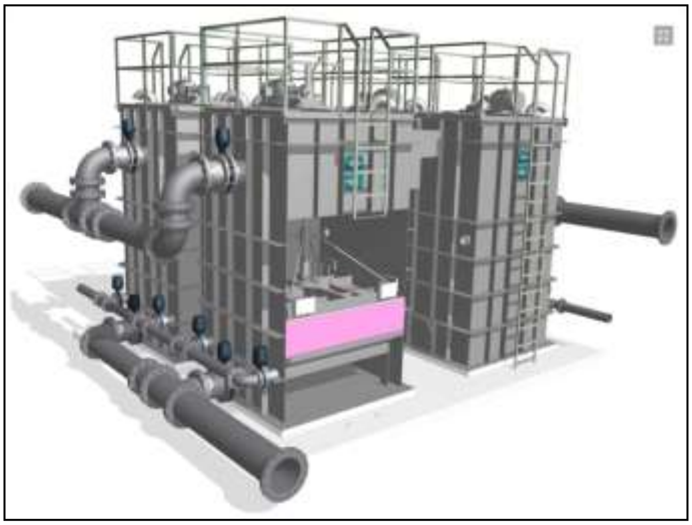


Figure 2-18 - Fuzzy Filter Unit

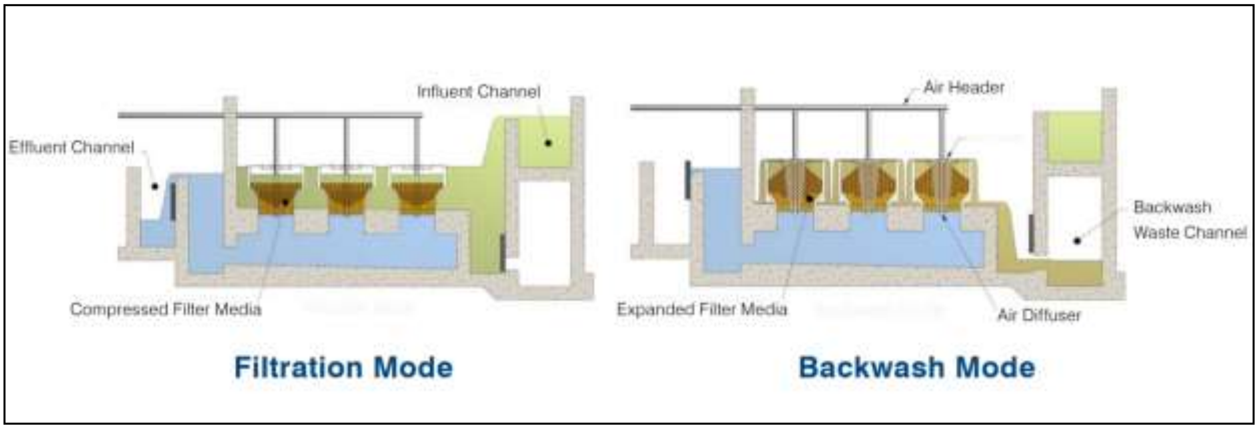


(Source: Schreiber, LLC.)

The FlexFilter receives the inflow from the influent channel. The influent channel is connected to the influent basin where the filter vessels are located. As the influent water accumulates in the influent basin, compression is added to the reinforced rubber sidewalls on the bottom of the filter vessel and compresses the filter bed laterally as the water elevation rises. As the water level in the influent basin reaches the inlet weir elevation, the influent water pours over the influent weir and passes downward through the compressed media bed. Since the bottom of the filter bed compresses more than the top of the filter bed, a porosity gradient is established through the filter bed to capture the largest particles in the upper portion of the filter bed while reserving the deeper portions of the bed to trap finer particles. As particles collect within the media bed, the influent level above the bed rises to a point that signals the need for the media to be cleaned.

The filters use air scouring in the wash cycle to clean the media. During the wash cycle, the feed to the filter is stopped, allowing the media to uncompress. The air scour is initiated along with a small amount of backwash water. The length of the backwash cycle is adjustable. Once cleaned, the filter is put back into service. Figure 2-19 provides a cross-sectional view of the FlexFilter process, and Figure 2-20 provides an overall picture of the FlexFilter Unit.

Figure 2-19 - FlexFilter Process Diagram (Source: WesTech)



(Source: WesTech Engineering, Inc.)

Figure 2-20 - FlexFilter Unit (Source: WesTech)

(Source: WesTech Engineering, Inc.)

Applicability to the Project

The Fuzzy Filter is only used as a polishing step for CSO treatment to meet the most stringent treatment objectives. It does not have a history of treating flows larger than 50 MGD while the FlexFilter has been applied at the 100 MGD Springfield Ohio WWTP treating combined sewer overflow. In addition, the FlexFilter is a simple gravity system requiring no moving parts. The compression of the media is accomplished through a lateral hydraulic force applied from the incoming liquid, eliminating mechanically actuated internal components. For the purpose of the Technical Guidance Manual, FlexFilter was selected for further evaluation.

Performance

For CSO applications FlexFilter is typically operated at 4 gpm/sq. ft. HLR during the first flush portion of a CSO event and gradually increases the operating HLR as the CSO flow rate increases and solids concentration decrease. The maximum HLR of CSO treatment is typically limited to 10 gpm/sq. ft. at design peak flow. The performance information provided by the manufacturer indicates that the contaminants removal efficiency of WWETCO FlexFilter in CSO application ranges from 73% to 94% for TSS removal and 16% to 69% for CBOD removal.

In the Bayonne MUA pilot study, FlexFilter was evaluated in terms of TSS removal. The influent to the FlexFilter was pumped from the Storm King effluent. No raw CSO feed to the FlexFilter was evaluated due to limited wet weather events during the time of the pilot test. The FlexFilter units experienced operating issues primarily related to the pumps and the time needed to backwash. Shorter filter run times and frequent backwashing were experienced when testing was conducted at the higher end of the filter loading rate recommended for CSO treatment.

The pilot study showed that the compressed media filter was consistent and effective in removing finer and organic suspended solids. Overall the FlexFilter was capable of removing 90% of the TSS even at a HLR of 12 to 18 gpm/sq. ft. The unit as tested spent up to 1/2 of the typical four hour run time in backwash cycle, however it was operated at 3 to 4 the recommended hydraulic loading rate in order to supply downstream disinfection with higher flows. TSS removal rates for the FlexFilter improved the ultraviolet transmittance (UVT) of the effluent flow; however, UVT values were still modest. The effluent from the FlexFilter averaged approximately 25 mg/L for TSS and 40% on UVT.

Hydraulics

The headloss through the FlexFilter structure, under the conditions stated above, is about 8 feet.

Generation of Waste Streams

The only waste stream produced by the FlexFilter is the backwashing of the filters. The FlexFilter utilizes low head air to accomplish the media scrubbing while lifting the backwash water to waste, thus minimizing backwash waste volumes. Portions of the backwash water would be diluted with filter drains and recycled back to filter influent. The concentrated backwash water would be stored and put back into the interceptor system when there was available capacity, for removal at the WWTP.

Complexity

As a result of how this unit operates; the automated valves, hydraulically operated porous plate, the air injection into the beds during backwashing, and the monitoring needed for the flow and headloss conditions, this process is the most complex of the pretreatment processes being considered as part of this Technical Guidance Manual.

Limitations

The influent TSS concentration to the FlexFilter is limited to less than 100 mg/L. Higher TSS concentrations will increase the backwash time resulting in overall reduced performance of the units. The 7 feet of headloss through the units is also a limitation since there is usually minimal head available from the regulator to the discharge at the water body. The valves in the FlexFilter unit are an issue during outdoor operation in freezing weather conditions.

Construction Costs

The preliminary planning level construction cost estimates are provided in Table 2-24 for FlexFilter design flows ranging from 10 MGD to 450 MGD. It includes equipment cost, installation costs, GC field general conditions, GC OH&P, and contingency. Budgetary equipment pricing information for FlexFilter was gathered from equipment manufacturer WesTech Engineering, Inc. The equipment price includes engineering and project management time. Installation cost was assumed at 150% of equipment cost based on equipment manufacturer's recommendations. The installation cost includes assembly of the FlexFilter system, excavation and backfilling, conduits, filter matrix, and backwash and effluent pumping. The estimated total construction costs for the FlexFilter are plotted against flowrate from 10 MGD to 450 MGD in Figure 2-21.

Operation and Maintenance

Estimated annual operation and maintenance costs for FlexFilter unit are presented Table 2-25 based on vendor provided information. It consists of the power costs for the blowers, recycle pumps, and backwash pumps as well as media change-out cost, labor for preventative and routine maintenance, and labor for post event clean-out.

Case Study

According to literature obtained from WWETCO (a subsidiary of WesTech), the FlexFilter™ was installed at the Weracoba Creek Stormwater Treatment system in Columbus, GA. This 10 MGD filter capacity with 2 MGD UV disinfection capacity, was funded by a $0.9 million EPA 319(h) grant to evaluate treatment of urban stormwater runoff. The treatment system has been in operation since 2007. Influent solids ranged from 300 mg/L to 100 mg/L TSS. Effluent TSS was between 5 mg/L and 15 mg/L. Additionally, total maximum daily load (TMDL) requirements for fecal coliform and macro-invertebrates were met. This facility also installed the WWETCO FlexFlow™ Control Valve which allows aquatic biology passage during dry weather flow and causes the head differential needed to operate the filter during wet-weather flow.

Table 2-24 - Preliminary Construction Cost of the FlexFilter

Flow	# Cells	Cell Filter Area (ft^2)	Budgetary Equipment Price	Install Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	5	720	$739,000	$1,108,500	$184,750	$184,750	$1,108,500	$3,325,500
25 MGD	5	1,800	$1,403,000	$2,104,500	$350,750	$350,750	$2,104,500	$6,313,500
30 MGD	5	2,340	$2,797,000	$4,195,500	$699,250	$699,250	$4,195,500	$12,586,500
100 MGD	10	7,200	$3,831,000	$5,746,500	$957,750	$957,750	$5,746,500	$17,239,500
200 MGD	18	12,960	$5,733,000	$8,599,500	$1,433,250	$1,433,250	$8,599,500	$25,798,500
450 MGD	32	23,040	$23,463,000	$35,194,500	$5,865,750	$5,865,750	$35,194,500	$105,583,500

Notes:
(1) Installation costs are estimated at 115% of the equipment cost per manufacture recommendation.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Figure 2-21 - Total Estimated Construction Cost of FlexFilter

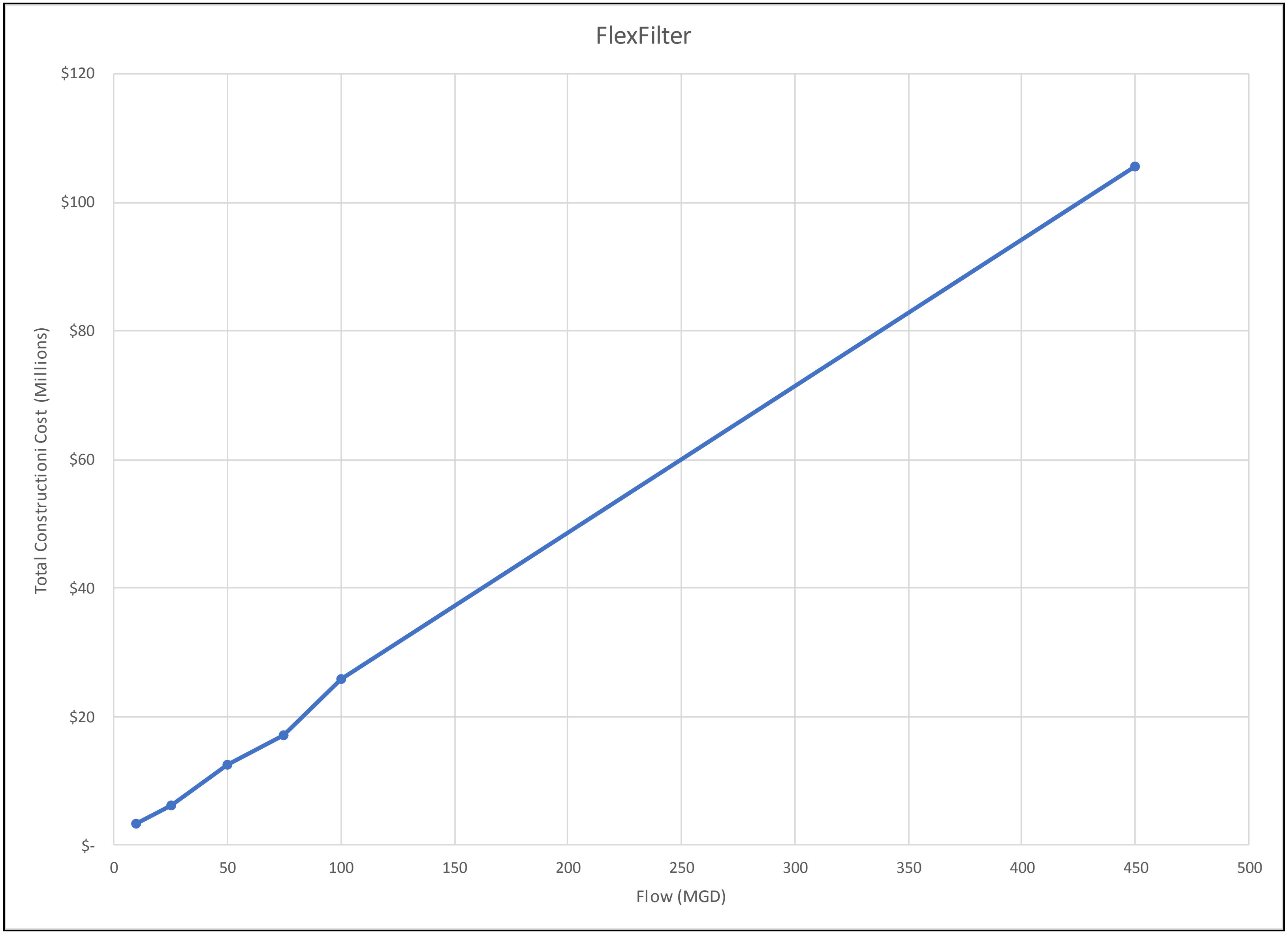


Table 2-25 - Annual Operation and Maintenance Cost of FlexFilter

Flow	Blower Power (kw-hr/MG Treated)	Blower Energy Costs(1)(2)	Media Addition after 10 yrs(3)	Event Labor	Preventative O&M	Backwash & Recycle Pumping	Effluent Pumping	Total Annual O&M
10 MGD	47	$700	$2,254	$20,000	$800	$703	$879	$25,336
25 MGD	48	$1,750	$5,636	$20,000	$2,000	$1,758	$2,198	$33,342
50 MGD	50	$3,500	$7,326	$20,000	$2,400	$2,110	$2,637	$37,973
100 MGD	48	$5,250	$22,542	$20,000	$8,000	$7,033	$8,791	$71,616
200 MGD	53	$7,000	$40,576	$20,000	$16,000	$14,066	$17,582	$115,224
450 MGD	50	$31,500	$72,135	$20,000	$36,000	$31,648	$39,561	$230,844

Notes:
(1) Assumes 500 hours of annual operation
(2) Assumes energy costs of $0.14/kW-hr
(3) Media cost is distributed annually based on given future cost

2.3.4 Evaluation of Pretreatment Technologies

The above process descriptions provide general information on pretreatment processes that may be required for disinfection of CSO discharges. These processes have been evaluated for pretreatment of CSO flow relative to criteria on cost, performance, limitations, and ancillary facilities. Each process was rated from 1 to 5, with 5 being the highest, for approximately twenty different items and totaled. While somewhat subjective, this method does provide a mechanism for comparing each pretreatment process in relationship to each category and subcategory. The results of the evaluation are illustrated in Table 2-26.

Based upon the evaluation results in Table 2-26, the SANSEP process has the highest rating, followed by the ACTIFLO® ballasted flocculation, the DensaDeg® ballasted flocculation, FluidSep vortex units and Storm King®. The Compressible Media Filter received the lowest rating, however this process is used only for polishing the effluent from the other processes in the most stringent treatment objective.

For the vortex/swirl process, the performance of the Storm King® and FluidSep vortex units are essentially the same, but the construction cost of the FluidSep is significantly less, due to the limited use of fabricated metal components, as compared to the Storm King® Unit.

For the ballasted flocculation processes, a similar simplification is possible. The ACTIFLO® process produces less sludge than the DensaDeg® process requiring less ancillary tankage, no cyclone separator and no sand replacement.

Table 2-26 - Evaluation of Pretreatment Technology

Criteria	Vortex Separator		Modified Vortex	Ballasted Flocculation		Polishing Filter
	Fluidsep Vortex	StormKing Vortex	SANSEP	ACTIFLO® Ballasted Flocculation	DensaDeg® XRC Ballasted Flocculation	FlexFilter
Applicability	5	5	4	4	4	2
Performance						
TSS	3	3	5	5	5	5
Hydraulics	3	3	4	3	3	1
Wastestreams	1	1	4	3	3	2
Complexity	5	5	4	3	3	1
Limitations	2	2	4	4	3	3
Construction Cost	4	2	5	3	3	1
Operations	4	4	4	2	2	1
Maintenance	4	4	4	2	2	1
Space Requirements	3	3	3	4	4	2
Requiring:						
Ancillary Tanks	1	1	4	3	3	5
Total	35	33	45	36	35	24

2.4 Disinfection

This section evaluates the implementation of the following chemical and physical disinfection technologies:

- Chlorination (consisting of Chlorine Dioxide, Sodium Hypochlorite, and Calcium Hypochlorite)
- Peracetic Acid
- Ultraviolet (UV) Disinfection
- Ozonation

The evaluation will consist of a description of the particular disinfection technology, the concentrations or intensities normally needed and the equipment or process used to apply the disinfectant. The evaluation will also discuss any limitations of the process or equipment. Also considered in the evaluation will be any inhibiters that will interfere with the disinfection process, and the need for any for dechlorination. The analysis will also consider the safety of the process and the availability of the chemicals or the equipment to produce them.

Disinfection is more difficult to design and operate in CSO applications than in wastewater treatment plants due to the complex characteristics of CSOs. The flowrates of CSOs are highly variable which makes it difficult to regulate the addition of disinfectant. The concentration of suspended solids is high and the temperature and bacterial composition varies widely. Pilot studies are commonly conducted to characterize the range of conditions that exist for a particular area and the design criteria to be considered.

In the cases of chemical addition; chlorine dioxide, sodium hypochlorite, calcium hypochlorite, and peracetic acid, the disinfectant must be mixed with the liquid to be disinfected. Experience has shown that the long contact time required for conventional wastewater treatment is not appropriate for the treatment of CSOs; however, chemical disinfection of CSOs can be accomplished using high-rate disinfection. High-rate disinfection is defined as employing high-intensity mixing to accomplish disinfection within a short contact time, generally five minutes. For this TGM, a chemical induction flash mixer, such as manufactured by The Mastrr Company, will be used to mix either the gas or liquid with the flow to be disinfected. The mixer develops a "G" value of 1,000/sec. The detention time in the mixing zone of the mixer is 3 seconds. Following the mixer, a tank area with a detention time of 5 minutes at the design rate, will be used to provide adequate mixing. In the case of sodium hypochlorite and calcium hypochlorite, a second induction mixer will be used to mix the dechlorination chemicals, sodium bisulfite, with the flow before discharging to the receiving water. No tankage would be provided following the addition of dechlorination chemicals.

The efficiencies of virtually all the disinfection processes being considered in this TGM are dependent upon the TSS concentration of the liquid being disinfected. The required TSS concentration for each of the disinfection processes for different treatment objectives is shown in

Table 2-27.

Table 2-27 - Maximum TSS Concentration for Each Disinfection Process

Fecal Coliform Objectives (MPN/100ml)	Maximum TSS Concentration (mg/L)			
	Chlorine Dioxide	Sodium Hypochlorite	Peracetic Acid	Ultraviolet Disinfection
200	70	45	70	25
770	70	45	70	25
1,500	70	45	70	25

2.4.1 Chlorine Dioxide

Process Description

Chlorine dioxide (ClO_2) is most commonly used for drinking water treatment to oxidize reduced iron, manganese, sulfur compounds, and certain odor-causing organic substances in raw water. Chlorine dioxide is often used as a pre-oxidant because, unlike chlorine, it will not chlorinate organic compounds and therefore will not react with organic matter in the water to form trihalomethanes (THMs) or other byproducts. In industrial markets, chlorine dioxide has been most readily used in the paper and pulping industry. In this application, chlorine dioxide is used as bleach for paper pulp since it does not react with the organic lignin in the wastewater to form by-products such as the THMs.

The data for chlorine dioxide shows that it is a more effective disinfectant than sodium hypochlorite. However, chlorine dioxide needs to be generated on site because it is too unstable even for short periods of time. There is one type of chlorine dioxide generator that utilizes hydrochloric acid and sodium chlorite in either commercially available or diluted concentrations to generate chlorine dioxide. They produce chlorine dioxide and consistently maintain a product yield greater than 95%, making it ideal for drinking water treatment. The use of chlorine gas is not required when using these systems. These systems produce relatively small amounts of chlorine dioxide for disinfection in water systems where low concentrations of ClO_2 are needed.

There is a second process, which produces "large quantities" of gas for disinfection of drinking water and wastewater. This is the Ben Franklin™ process, manufactured by CDG Environmental, LLC. The Ben Franklin™ process uses the chemical reaction of hydrochloric acid with sodium chlorate to generate chlorine dioxide to produce a mixture of chlorine and chlorine dioxide, both in the gas phase. These gases, as produced by the Ben Franklin™ generator, may be applied directly to water as a combination, or they may be separated and applied at different points in the water treatment process. In its most direct application, the mixed chlorine/chlorine dioxide product can be injected into the water to be treated. The result is a mixed disinfectant containing chlorine dioxide and chlorine. The chlorine dioxide acts as a very rapid disinfectant/oxidant while the chlorine persists longer. This can be an advantage in the water systems where a residual is desired but a disadvantage in the receiving water where disinfection byproduct is a concern.

The use of chlorine dioxide in wastewater disinfection has been very limited in US. Technologies are currently unavailable to provide an easier and safer way to produce chlorine dioxide at a concentration for CSO treatment at remote satellite locations. Chlorine dioxide is extremely unstable and explosive and any means of transport is potentially hazardous. Chlorine dioxide can produce potentially toxic byproducts such as chlorite and chlorate. Chlorine dioxide will not be considered further.

2.4.2 Sodium Hypochlorite

Description of Process

Hypochlorite is a commonly used disinfectant in water and wastewater treatment and has been applied as a CSO disinfectant. It can be produced on site or can be delivered in tanker trunks with concentrations between 3 to 15% of available chlorine. Hypochlorite decays over time. The decay rate can increase as a result of exposure to light, time, temperature increase or increased concentration of the compound. The solution can be stored for 60 to 90 days before the disinfecting ability degrades below recommended values (5% concentration). Degradation of the solution over time is a major disadvantage of sodium hypochlorite for CSO applications, due the variability of the size and frequency of rain events. There are two types of hypochlorite: Sodium hypochlorite (NaOCl) and Calcium hypochlorite ($Ca(ClO)_2$). Sodium hypochlorite is often referred to as liquid bleach or soda bleach liquor, while Calcium hypochlorite is manufactured either as a grain or powder under various names, and all have either approximately 35% or 65% available chlorine content. Sodium hypochlorite is the most widely used of the hypochlorites for potable water and waste treatment purposes. Although it requires much more storage space than high-test calcium hypochlorite and is costlier to transport over long distances, it is more easily handled and gives the least maintenance problems with pumping and metering equipment. It will be used as the basis for evaluating disinfection alternatives.

Based on molecular weight, the amount available as chlorine is 0.83 lbs/gal for a 10% solution of sodium hypochlorite and 1.25 lbs/gal for a 15% solution.

Required Concentrations

The application of sodium hypochlorite as a disinfectant was studied by the USEPA in Syracuse, New York. An equation was developed to estimate the chlorine concentration needed to achieve a particular log-kill of fecal coliform. The parameters included in the equation include the pH of the liquid, the influent fecal coliform count to the disinfection process, the TSS concentration, and the mixing factor of GT. The equation is as follows:

Log-kill = (0.08C^0.36) * (GT^0.42) * (SS^-0.07) * (FC^0.02) * (10^(-0.03pH))

Where: C = concentration of disinfectant (mg/L as Cl_2)
SS = concentration of SS (mg/L)
FC = Influent level of fecal Coliform, (counts/100 ml)
pH = pH
GT = mixing intensity x detention time.

This is based upon the G of 1000 discussed above, and a three second detention time in the mixing zone of the mixer.

Computations done using this equation, for the range of parameters expected in CSO waters, indicate that a chlorine concentration of between 18-24 mg/L will disinfect the fecal coliform concentrations to the levels expected in the LTCP treatment objectives.

Equipment Needed

Sodium hypochlorite is delivered to the site in liquid form as either a 10% or 15% solution. The sodium hypochlorite is stored in a tank and is fed into a rapid induction type mixer at a rate established by the flow, through a chemical feed pump. A 12.5% solution may degrade to 10% in 6 to 8 weeks, in which case the degradation rate slows. Typically it is stored as a 5% solution of available chlorine. It should be stored at temperatures below 85 degrees Fahrenheit in a corrosion resistant tank and protected from light exposure. For the purpose of this TGM, the chemical storage is estimated to store enough chemical for 24-hours of continuous treatment at the design overflow rate plus a safety factor of 1.5.

The chemical storage tank and the feed pump would be stored in a building with the induction mixer installed in a channel, followed by a detention tank with a 5-minute detention time, as described at the beginning of this section.

Limitations

One of the problems with sodium hypochlorite is that the solutions are vulnerable to a significant loss of available chlorine in a few days. This is described as the shelf life of the chemical. The stability of hypochlorite solutions is greatly affected by heat, light, pH, and the presence of heavy metal cations. The higher the concentration, and the temperature the higher the deterioration. A 15% solution will deteriorate to half strength in approximately 120 days. A 10% solution will take approximately 220 days.

The limited shelf life of sodium hypochlorite makes it difficult in an intermittent application like a CSO to ensure that the correct amount of disinfectant is being introduced into the waste stream. This can lead to under or over disinfecting, which can make it difficult to achieve the required treatment objective.

Inhibitors

High TSS concentrations would be an inhibitor to disinfection using sodium hypochlorite, primarily by shielding the fecal Coliform from the disinfectant.

Need for Dechlorination

The use of chlorine disinfection of wastewater can result in several adverse environmental impacts especially due to toxic levels of total residual chlorine in the receiving water and formation of potentially toxic halogenated organic compounds. Chlorine residuals have been found to be acutely toxic to some species of fish at very low levels. Other toxic or carcinogenic chlorinated compounds can bioaccumulate in aquatic life and contaminate public drinking water supplies. For this reason, excess chlorine must be dechlorinated. Gaseous sulfur dioxide, liquid sodium bisulfite, sodium thiosulfate, sodium sulfite, and sodium metabisulfite can be used for this purpose. Sodium bisulfite is the most commonly used chemical for dechlorination due to the ease of handling, fewer safety concerns, economic reasons, and availability. For this TGM the use of sodium bisulfite is assumed. Typical characteristics are shown in the Table 2-28 below. Sodium bisulfite can decay about 40 % over a period of six-months. The storage should consider the release of sulfur dioxide when the sodium bisulfite is stored in a warm environment; a water scrubber is typically used to diffuse and dissolve off-gas. Another operational problem is the crystallization of sodium bisulfite when the temperature drops below the saturation point: -6.7^{0}C for 25% solutions and 4.4^{0}C for 38% solutions.

Table 2-28 - Sodium Bisulfite Key Properties

Property	Value
Concentration	38% (25% solutions)
Molecular Weight	104.06
Boiling Point	> 100˚C
Freezing Point	-12˚C
Saturation Temperature	4.4˚C @ 38%
Vapor Pressure	78 mm Hg @ 37.7˚C
Specific Gravity	1.36 @25˚C
pH	3 to 4
Solubility in water	Completely

Sodium bisulfite could be stored indoors in a conditioned building to minimize the degradation due to high temperature and sunlight exposure. To minimize the potential of chemical interaction the storage tanks of sodium hypochlorite and sodium bisulfite have to be isolated from each other.

A rapid induction mixer located in a channel downstream of the contact chamber, as described earlier in this section will accomplish the mixing of sodium bisulfite. Since the Dechlorination process is essentially instantaneous, no contact chamber is required downstream of the injection.

Costs

The costs for the sodium hypochlorite disinfection system include several components including chlorine contact tank, the chemical storage facility for sodium hypochlorite and sodium bisulfite, pumping system for disinfection and dechlorination, mixers, piping and storage tanks.

The preliminary report level construction cost estimates provided in Table 2-29 include the equipment, installation, building, and contingency for a sodium hypochlorite disinfection system of design flow ranging from 10 MGD to 450 MGD. Budgetary equipment pricing information was gathered from equipment manufacturers.

Operation and Maintenance

Operating costs for hypochlorite disinfection systems consist of the power and chemical costs. Power costs are based upon the horsepower of the metering pumps and rapid mixers. Chemical costs are based on usage of sodium hypochlorite and sodium bisulfite.

The equipment would be housed in a building; therefore, maintenance costs consist of labor costs for housekeeping of the building, preventative and corrective maintenance of the mechanical equipment including the chemical metering pumps, mixers, and other appurtenances, and restocking of the chemicals. The chlorine contact tanks will also need periodic maintenance to clean debris.

Estimated annual operation costs for the hypochlorite disinfection system are presented on Table 2-30 containing factors for calculation of operating costs; while estimated annual maintenance labor cost including cost factors are included on

Table 2-31.

Space Requirements

The space requirements of the facilities required for disinfection using sodium hypochlorite are based upon the size of the mixing chamber/tank size for chlorination, the chemical building size for chlorination and de-chlorination, the size of the mixing chamber for de-chlorination, and a buffer of 5 feet around each.

Table 2-29 - Preliminary Construction Cost for Chlorination Systems

Flow	Chlorine Contact Tank Cost	Building Cost	Hypochlorite Pump System and Apprt. Cost	Bisulfite Pump System and Apprt. Cost	Hypochlorite Storage Tank Cost	Bisulfite Tank Cost	Mixer and control valves Cost
10 MGD	$125,000	$156,475	$28,000	$16,450	$21,495	$7,900	$150,000
25 MGD	$310,000	$336,159	$35,700	$16,450	$44,990	$8,495	$200,000
50 MGD	$620,000	$507,778	$49,000	$19,250	$97,485	$10,685	$380,000
75 MGD	$930,000	$681,742	$50,750	$19,250	$129,980	$13,183	$450,000
100 MGD	$1,240,000	$820,039	$61,250	$27,300	$162,475	$13,483	$550,000
450 MGD	$5,580,000	$3,883,107	$231,000	$105,000	$779,880	$50,872	$2,000,000

Flow	Installation Cost(1)	GC General Conditions (2)	GC OH&P(3)	Contingency(4)	Total
10 MGD	$757,980	$126,330	$126,330	$757,980	$2,273,939
25 MGD	$1,427,690	$237,948	$237,948	$1,427,690	$4,283,071
50 MGD	$2,526,297	$421,050	$421,050	$2,526,297	$7,578,891
75 MGD	$3,412,357	$568,726	$568,726	$3,412,357	$10,237,072
100 MGD	$4,311,820	$718,637	$718,637	$4,311,820	$12,935,461
450 MGD	$18,944,788	$3,157,465	$3,157,465	$18,944,788	$56,834,364

Notes:
(1) Installation costs are estimated at 150% of the equipment cost.
(2) GC general conditions are estimated at 10% of the total direct cost.
(3) GC OH&P are estimated at 10% of the total direct cost.
(4) 50% of contingency is used for the planning level of cost estimates.

Table 2-30 - Annual Operation Cost for Hypochlorite Disinfection

Flow	Sodium Hypochlorite Metering Pump(8)	Sodium Bisulfite Metering Pump(8)	Total HP	Total Power (kW)(1)	Annual Energy Usage (kW-hr)(2)	Annual Power Cost(3)	Sodium Hypochlorite Usage (lbs)(4)	Sodium Bisulfite Usage (lbs) (5)	Sodium Hypochlorite Cost(6)	Sodium Bisulfite Cost(7)	Total Annual Cost
10 MGD	1.5	0.5	2	1	746	$104	39,986	8,693	$19,993	$17,385	$37,483
25 MGD	2	0.5	2.5	2	932	$130	99,966	21,732	$49,983	$43,464	$93,577
50 MGD	5	1	6	4	2237	$313	199,932	43,464	$99,966	$86,927	$187,206
75 MGD	7.5	1	8.5	6	3169	$444	299,898	65,195	$149,949	$130,391	$280,784
100 MGD	5	1.5	6.5	5	2424	$339	399,865	86,927	$199,932	$173,854	$374,126
450 MGD	25	4	29	22	10813	$1,514	1,799,391	391,172	$899,695	$782,344	$1,683,553

Notes:
(1) HP x 0.7457
(2) Assumes 500 hours of annual operation
(3) Assumes energy costs of $0.14/kW-hr
(4) Assumes a sodium hypochlorite dosage of 23 mg/L
(5) Assumes a sodium bisulfite dosage of 5 mg/L
(6) Assumes a sodium hypochlorite cost of $0.50/lb
(7) Assumes a sodium bisulfite cost of $2/lb
(8) Metering pump HP based on quotations by Pyrz Water Supply Co., Inc.

Table 2-31 - Annual Maintenance Labor Cost of Hypochlorite Disinfection

Frequency	Estimated Man-Hours	Annual Cost
Daily Check	1	$54,750
Weekly Check	4	$31,200
Monthly Check	8	$14,400
Quarterly Clean and Check	12	$7,200
Total Annual Maintenance Cost		$107,550

Notes:
(1) Assumes labor rate of $150/hour

2.4.3 Peracetic Acid Disinfection

Description of Process

Peracetic acid (CH_3CO_3H), also known as PAA, is an organic peroxy compound, which has strong oxidizing properties. In the presence of water (H_2O), it breaks down into a mixture of hydrogen peroxide (H_2O_2) and acetic acid (CH_3CO_2H). The mixture is clear and colorless with no foaming capabilities and has a strong pungent acetic acid (vinegar) odor. PAA is a very strong oxidizing agent and has a stronger oxidation potential than chlorine or chlorine dioxide. It has been used as a bactericide and fungicide in various industries including the food and beverage industries, the textile and pulp and paper industries, as well as smaller, more confined applications, including hospital settings.

The U.S. EPA approved peracetic acid as a primary disinfectant for wastewater in 2007 while PAA has been used to treat wastewater in Europe for over a decade. Since the EPA approval, only a limited number of wastewater treatment plants in the United States have adopted PAA as a primary disinfectant, including a wastewater treatment plant in St. Augustine, Florida that discharges treated flow to environmentally-sensitive wetlands. Case studies have also been conducted at a number of treatment plants including a wastewater treatment plant in Frankfort, Kentucky and the Bayonne MUA pilot study for CSO treatment.

PAA decomposes quickly and its ultimate fate in the environment is the basic molecules of carbon dioxide, oxygen, and water. Toxicity studies were conducted on PAA in the 1980's to evaluate impact of PAA disinfected primary effluent on the bay environment. The study concluded that there was no toxicity impact. The Bayonne MUA pilot study and other studies on PAA disinfection of wastewater did not experience toxicity of residual PAA. However, more studies are still required to prove that residual PAA poses no toxicity to aquatic life.

Solutions of PAA for wastewater disinfection are typically of 10% and 15% concentrations, higher concentrations have issues with stability. The shelf life of PAA is normally 12 months. However, PAA must be stored at the site where it is dispensed, as underground piping is not permitted. PAA are fed using a diaphragm pump with Teflon diaphragms and polypropylene, Teflon materials and degassing heads are recommended for feeding. The product should be fed into the waste stream at an area of good mixing to promote rapid dispersion. It may be introduced continuously or intermittently depending upon the needs of the user.

Required Concentrations

This is an area where more research and investigation needs to be done, particularly as it related to disinfection of CSOs. The application of PAA as a disinfectant was studied in the Bayonne MUA pilot study. PAA disinfection tests were performed with PAA dose of typically 2 to 3 mg/L, but up to 7 mg/L, targeting PAA residual in 1 to 2 mg/L range. The best-defined relationship derived from the study results was that between the applied dose of PAA as normalized by COD present in the wastewater and the log reduction of pathogen indicators. PAA dose of 0.01 mg/L of PAA per mg/L of COD present in wastewater resulted in 3-log reduction of fecal coliforms (on average), with slightly higher effectiveness for E. coli and slightly lower for Enterococci. Increasing the relative dose to above 0.015 mg/L of PAA per mg/L of COD increased log reduction to 4. Further increase of the PAA dose appeared to have limited effect on further increasing reduction of the bacterial densities, although data in that range are too limited to allow for a firm conclusion.

Equipment Needed

PAA is typically delivered to the site in liquid form as a 12% solution. The PAA is stored in a tank and is fed into a rapid induction type mixer at a rate established by the flow, through a chemical feed pump. The chemical storage tank and the feed pump would be stored in a building with the induction mixer installed in a channel, followed by a detention tank. Pilot testing has determined that the majority of kill happens in the first 10 minutes regardless of the concentration of PAA. Therefore, the contact time required by PAA has been determined to be between 2 and 10 minutes.

Limitations

The use of peracetic acid in wastewater disinfection has been very limited in the US. There is no known application of peracetic acid in CSO disinfection in the US. In addition, the cost of PAA may be of concern largely due to small consumer market worldwide and the limited production capacity. One manufacturer has listed the price per pound between $0.50 and $0.70 in 2008 dollars, which corresponds to between $3 per gallon and $5.50 per gallon depending on concentrations. Use of peracetic acid in CSO locations could also be complicated by a need for on-site storage of the chemical, which requires secondary containment and appropriate safety measures.

Inhibitors

Studies have shown that variations in water quality parameters related to NH3, TSS, COD, dissolved oxygen and pH, did not have significant effect on the performance of PAA and PAA produces negligible disinfection by-products.

Need for Dechlorination

At the time of this TGM, there is no indication that de-chlorination will be required. The short half-life means that PAA is not persistent and rarely needs to be neutralized prior to discharge.

Costs

The Bayonne MUA pilot study presented equipment cost of PeraGreen, INJEXX TM unit for flowrate ranging from 5 MGD to 250 MGD (Figure 2-22). The costs provided include the cost of equipment delivered to the site and are 2017 dollars as well the cost of a contact tank providing three minutes of hydraulic retention time.

Operation and Maintenance

O&M costs were also provided by the Bayonne MUA pilot study to maintain a PAA residual of 0.8-1.0 mg/l in flowrate ranging from 5 MGD to 250 MGD (Figure 2-23).

Figure 2-22 - Equipment Cost for Peracetic Acid System

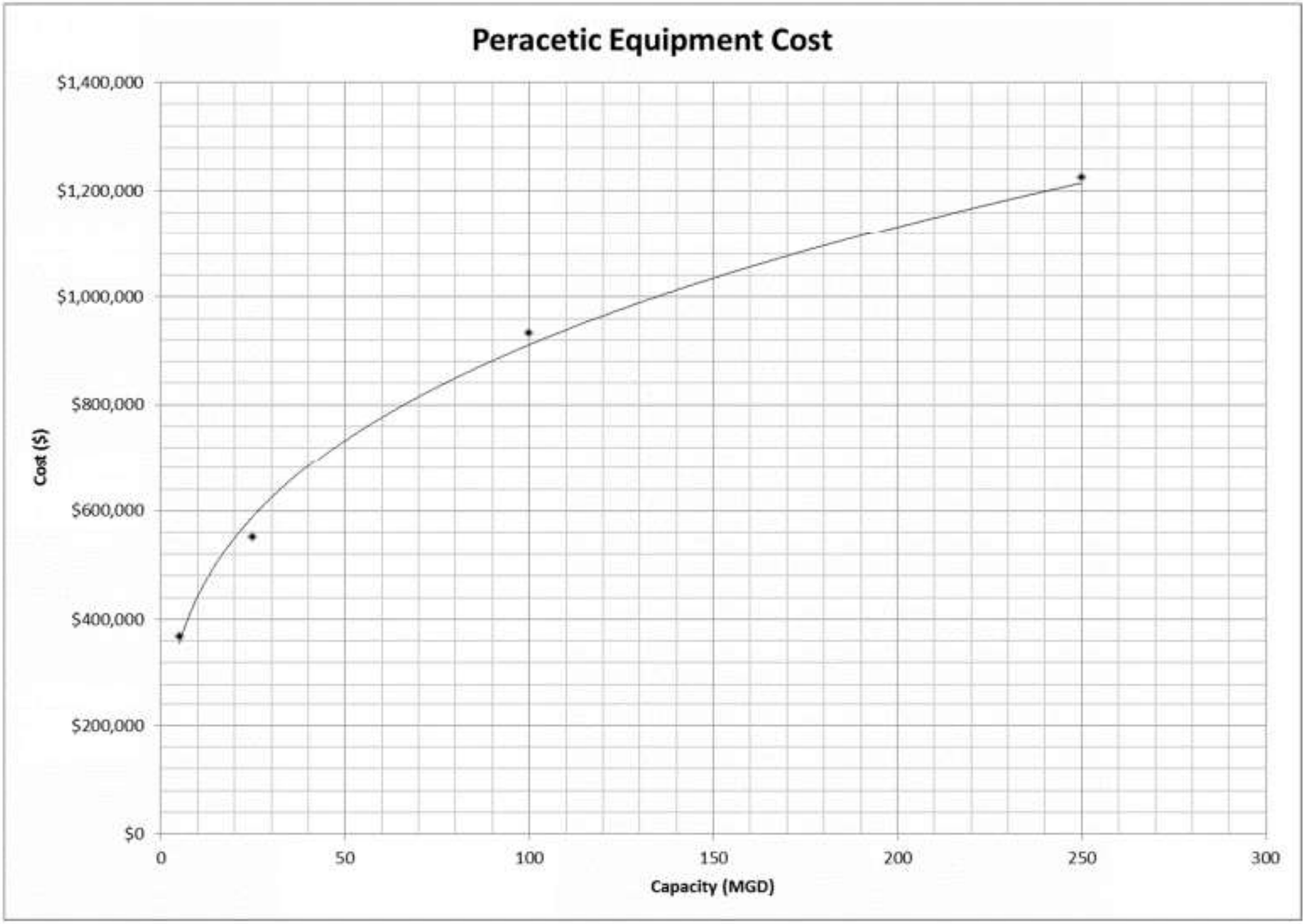
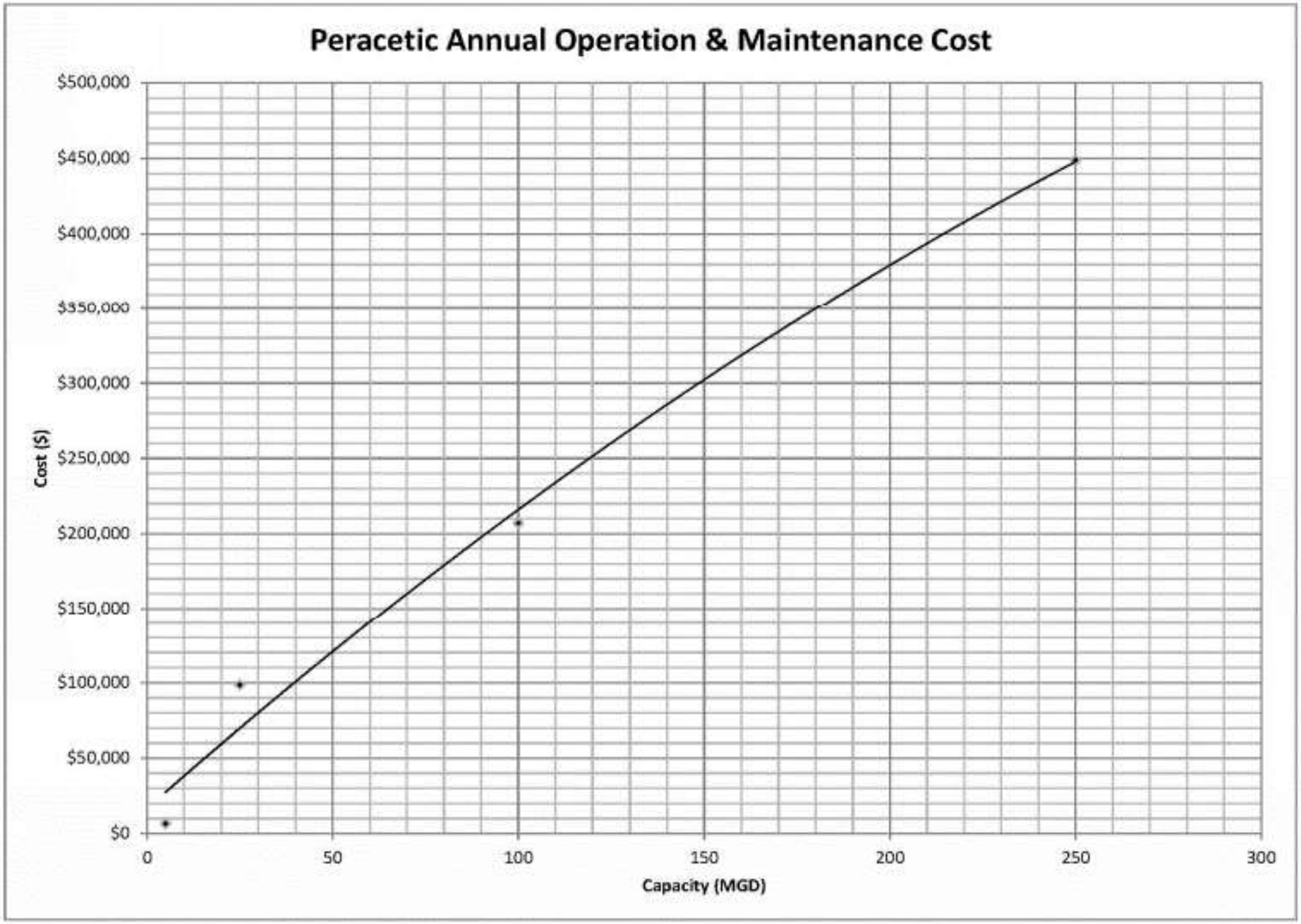


Figure 2-23 - Annual O&M Cost for Peracetic Acid System



2.4.4 Ultraviolet Disinfection

Description of Process

The use of ultraviolet (UV) light is one of the common methods for disinfection of treated wastewaters. In fact, UV disinfection has become the favored technology for new plants and upgrades for existing plants. There are reportedly over 3,500 UV wastewater disinfection systems currently operating in North America, treating flows of up to 300 mgd. UV disinfection eliminates the operational and environmental hazards associated with the use of chlorine compounds, which is a strong oxidant (and sulfite compounds when dechlorination is required), and is cost-competitive with alternative technologies. UV systems are modular and since they require smaller volumes than a chlorination contactor, they can be easily retrofitted into existing chlorination channels.

UV disinfection is a physical process, relying on the transfer of electromagnetic energy released from UV lamps to be absorbed by the nucleic acids (DNA and RNA) in the microorganisms. When the nucleic acids of the organisms are subjected to sufficient quantity of UV radiation (the "dose"), the energy damages the DNA strands by causing specific thymine monomers to combine, which in turn prevents the cell from replicating. This inability to reproduce is, in itself, the lethal effect of UV. Organisms rich in thymine such as *C. parvum* and *G. muris* tend to be more sensitive to UV radiation. The UV radiation in the spectral region between 220 and 320 nm is germicidal, where the wavelengths between 255 nm to 265 nm are considered to be most effective for microbial inactivation. UV disinfection is very effective in inactivation of protozoa, bacteria and viruses, where viruses generally require higher UV radiation dose than protozoa and bacteria.

Electrode type lamps are used to produce light at UV wavelength. Based on the internal operation of these lamps, there are three categories of UV lamps available for use in water/wastewater treatment. These are *low-pressure low-intensity/output (LP-LO)*, *low-pressure high-intensity/output (LP-HO)* and *medium-pressure high intensity/output (MP-HO)* configurations.

In the low-pressure design, lamp output is optimized via mercury vapor pressure and electric current control to generate a broad spectrum of essentially monochromatic radiation in 200nm to 280 nm range (UV-C). Low-pressure lamps produce an intense peak at 254nm which is close to 260nm wavelength considered to be the most effective for microbial inactivation. These low-pressure lamps are highly efficient, converting 30-50% of their input energy to germicidal range of UV light, where 85 – 88 % of this light is at 254 nm. The difference between low-pressure low-intensity and high-intensity lamps are low-intensity lamps use liquid mercury where high intensity lamps use mercury-indium amalgam. Because of this difference, output of LP-LO lamps decreases when the lamp wall is not near optimum temperature of 40°C. LP-HO lamps operate at temperature range of 100 -150°C and can maintain greater stability of lamp output over a wide range of temperatures. In addition, UV output of LP-HO lamps can be modulated between 30 – 100% to adjust the UV dose.

The absolute output of LI-LO lamps is relatively low, with typical UV ratings of 25 to 27 Watts per lamp at 254 nm, for 40 to 100 W input lamps. In LP-HO higher input power (200 to 500 W) have resulted in higher lamp output at 254 nm (60 to 400 W), while retaining their highly efficient energy conversion characteristic.

A number of medium-pressure high-intensity/output UV lamps have been developed over the last decade. MP-HO lamps operate at vapor pressure of 10^2 to 10^4 mm Hg while the low-pressure lamps operating at less than 0.8 mm Hg. Also, the operation temperature of MP-HO lamps are significantly higher (600 – 800°C)_than the LP lamps. With the higher mercury pressures, the lamps are driven at substantially higher input power levels (in the range of 1,000 w to13,000 W). Medium-pressure lamps are polychromatic, effectively radiating 20 to 50 times more the total UV-C output (200 to 280 nm) compared to LP-HO lamps. However, MP-HO lamps have lower efficiency than LP-LO and LP-HO lamps. MP lamps can convert about 7 to 9% of their input power to 254 nm output, and 10 to 15% of the total output is in the germicidal region. Overall, the efficiency of the MP-HO lamps is 4 to 5-fold less than the efficiency of the low-pressure lamps. In addition, the lamp, sleeve and ballast life of MP-HO lamps are significantly lower than LP lamps. However, because of their much higher absolute output levels, fewer lamps are needed, often resulting in a smaller footprint for the UV system.

The actual application of UV to wastewater disinfection is fairly simple. The lamps are enclosed in quartz sleeves (highly transmissible in the UV region), and submerged in the flowing wastewater. The lamp/quartz assemblies are typically arranged in modules, with several modules comprising a bank of lamps. In wastewater applications, these banks of lamps are typically placed in open channels, either horizontally or vertically oriented, with level control devices that maintain water levels above the submergence level of the lamps. Pressure units, using closed-vessel reactors, are also used for wastewaters, although pressure units are more frequently applied in drinking water applications. Generally, automatic cleaning systems/wipers are integrated with each bank of lamps to periodically clean the surface of the quartz sleeve and prevent fouling of the sleeve surface and maintain high transmissivity of the sleeves.

There are many benefits associated with UV disinfection:

1. Since no harmful chemicals are added to the wastewater and no known disinfection byproducts are produced as a result of UV radiation.
2. UV system has a compact footprint and the inactivation of microorganisms occur almost instantaneously as the water passes through the UV lamps. Therefore, UV disinfections systems are set up as a modular system and can be easily configured in one or more channels.
3. Chemical storage, transportation and handling is eliminated for the purpose of disinfection.

UV disinfection does, however, require more power than chemical disinfection, which could be a significant consideration for the larger overflow applications.

Required Concentration

There are several factors that affect the design of a UV system for wastewater disinfection. These center about the design goal to efficiently deliver the necessary UV dose to the targeted microorganisms. Dose is defined as the product of the intensity of UV energy (the rate at which it is being delivered, mJ/cm^2 and the exposure time of the organism to this intensity. Ideally, these factors can be applied such that every element in the water receives the same dose as it passes through the UV unit. However, in practice, the UV dose will not be identical for all particles in the water. There is a variation in the intensity field within the unit and variation in the exposure times, resulting in a dose distribution. Effective design optimizes this dose distribution and avoids any appearance of hydraulic short circuiting through the UV unit. Exposure time is dependent on the hydraulic characteristics of the unit, reflecting the spacing of the quartz/lamp assemblies, inlet and outlet conditions, and hydraulic loading rates. The output energy of the lamps, the transmissibility of the quartz sleeves, and the transmittance of the wastewater itself affect intensity. The loss of energy due to the aging of the lamps and degradation of the quartz sleeve transparency must be incorporated in the design of the UV units. Generally, the lamp output will decrease to between 50% and 80% of their nominal output by the end of lamp life (typically LP-HO lamps have 9,000 to 15,000 hours and MP-HO lamps have 3,000 to 8,000 hours lamp life). Sleeve fouling will typically account for a 20% to 30% decrease in transparency through the life of the quartz sleeve, even if they get cleaned regularly. The transmittance of treated wastewater effluents will range between 50% and 75%, depending on the influent water quality and the degree of treatment provided before disinfection. Combined sewer overflows and storm water have significantly low UV transmittances and it is generally in the range of 20% to 50% per cm at 254 nm. Since this directly affects the portion of the energy from UV lamps reaching the microorganism, design should call for closely spacing the lamps and using higher-powered lamps. The medium-pressure lamp units can meet these criteria, as can the LP-HO lamp technologies, although to a lesser degree. Head losses are generally manageable for these systems, typically in the order of 6 to 24 inches for the medium-pressure units. Typically, a dose of 30 to 40 mJ/cm^2 is specified for treated wastewater disinfection, where three to four log inactivation rates are generally required to meet disinfection targets. Demonstration that the proposed unit will deliver this dose under design conditions (flow, UV transmittance, end-of-lamp life output, degraded quartz surfaces, etc.) is often required either as a prequalification for bidding, or at the time of commissioning. This is done through direct bio-dosimetric testing on full-scale or scaled systems, whereby a challenge organism of known dose-response is injected into the UV unit under design flow and UV transmittance conditions. By measuring the kill of the organism, the dose that was delivered by the unit can be estimated. This method has become an industry standard for validating the performance of UV systems. These protocols are articulated by the USEPA UV Design Guidance Manual (November 2006), the NWRI/AWWA RP UV Guidance (May 2003), and the USEPA Environmental Verification Program protocols for reuse, secondary effluents, and wet weather flows (2002). This method accounts for the variations in hydraulics through the UV lamps and UV radiation intensity in a system, and allows for a more consistent comparison of performance expectations and design sizing between different UV technology configurations.

The Bayonne MUA pilot study evaluated performance of Trojan UV3000Plus unit using low-pressure lamps. Correlation of all the individual data from the study indicated required approximately 25 mJ/cm^2 effective irradiation dose input to achieve 3log inactivation of pathogen indicators.

Equipment Needed

For purposes of this preliminary assessment of cost associated with the disinfection of combined sewer overflows, the low-pressure high intensity lamp technology is considered. As discussed earlier, the LPHO lamps are very efficient and with advancement in UV lamp technology, there are up to 1,200 W lamps available.   The Sigma low-pressure high-intensity lamps offered by Trojan

Technologies has been used for preliminary sizing, layout, design and costs estimation; however, it is not the intent of this exercise to recommend a given manufacturer for such applications.

Limitations

In large applications, significant power is required for operation of UV system. In some locations power availability can be a limitation.

Inhibitors

Certain water quality parameters can have a big impact on the disinfection efficiency of the UV system. UV transmittance or UV absorbance is one the key parameter which impact the UV dose that the microorganisms get subjected to. Iron, ozone, manganese, natural organic matter (NOM), TSS are strong absorbers of UV light, which would reduce the UV transmittance. The threshold values for Ferric iron, Ferrous iron and ozone are set as 0.057 mg/L, 9.6 mg/L and 0.071 mg/L, respectively. If iron salts are used within the treatment process, alternative should be evaluated to compare savings of smaller UV system compared to cost associated with change of precipitation aid. Alkalinity, hardness (Ca, Mg and other salts) and TDS can form mineral deposits on quartz tubes and reduce the UV dose reaching microorganisms and would increase the frequency and sleeve cleaning. Alkalinity and pH also effect the solubility of metals carbonate which may absorb UV light. Oil and grease in the wastewater would accumulate on the quartz sleeves and reduce the UV transmittance.

Need for De-chlorination

Since no chemical is used in UV disinfection and there is no residual disinfectant in the wastewater due to UV disinfection, de-chlorination or residual disinfectant removal is not required in UV disinfection systems. If any chemical disinfectant is added in upstream of the UV disinfection, residual disinfectant removal may be required specific to chemical disinfectant used.

Costs

The costs for the ultraviolet disinfection system consist of the equipment cost, including its installation, the cost of the channels for the ultraviolet disinfection equipment.

The preliminary report level construction cost estimates provided in Table 2-32 include the equipment, installation, building, and contingency for UV disinfection system of design flow ranging from 10 MGD to 450 MGD. Budgetary equipment pricing information was gathered from equipment manufacturers.

Operation and Maintenance

UV disinfection systems have been used for continuous operation for many years at various treatment facilities. Routine operating and maintenance programs and guidelines have been established for these continuous operations. However, in the case of CSO discharges, the O&M requirements for the UV disinfection technology would be intermittent during the year and be based on the number of storm events per week, month or year. The CSO locations at remote sites would require field crews to be on site before a storm event to make sure the system is in operating conditions and after the storm event to perform general washdowns and maintenance check.

The O&M requirements would center on lamp cleaning, parts replacement, and general maintenance. Recent applications of UV lamps have cleaning systems that employ chemically-assisted mechanical wipers, which are effective for low-grade wastewater applications such as CSOs. This has significantly reduced labor time required for lamp cleaning and has also improved lamp effectiveness. However, one of the main challenges with CSO systems is that the lamps are not always submerged in the water and when there is long period between storm events, dust will accumulate on the sleeves. These dust particles would scratch the surface of the sleeve and reduce the penetration/transmittance of the UV light. Therefore, additional precaution and manual cleaning would be required from time to time. It is recommended that UV banks would be raised and inspected for debris after each event to ensure that there is not large debris caught up in the system. The wipers have a debris scraper that will handle smaller debris and push it out of the way, but it will be a good practice to inspect the equipment after each event.

Parts replacement is another major maintenance requirement and would include the replacement of lamps, ballasts, wipers and quartz sleeves. Since the UV system is not going to be operating continuously, lamp replacement is not going to be as often as continuously operating systems in wastewater treatment plants. While some manufacturers offer a lamp warranty only for set operation hours ranging from 12,000 hours to 16,000 hours for LP-HO lamps, which equates to 24 to 32 years of warranty for lamps. This long duration of lamp operation is not believed to be reasonable due to operational conditions of CSO systems. On the other hand, some manufacturers provide a warranty based on a set limit of operation hours or a set duration, which occurs first. The output of UV lamps decreases as lamps age. Generally, after 12,000 to 15,000 hours of operation, the lamps need to be replaced due to low power output. In this report, it is assumed that UV lamps would be replaced every 10 years. In addition to lamp replacement, the ballasts, a type of transformer that is used to limit the current to the lamps, will need to be replaced. For the specific brand and model used for cost estimation in this report, each ballast serves 2 lamps and has an expected life of 5 years.

The third major maintenance requirement would be general O&M requirements at the CSO site. General maintenance at each UV disinfection site would include repairs, cleaning the channels and surrounding areas, maintaining product inventories, system monitoring, and documenting site visits. Assuming that there would be a two-person field crew visiting each site for one hour before and after each storm event, the estimated maintenance hours per event would be 4 to 8 hours depending on the system sizes. UV disinfection systems for CSO discharges can be designed to operate intermittently during the year and also during winter conditions.Instrumentation for intermittent disinfection operations would be incorporated into the UV reactor's operation including monitoring CSO flows, CSO characteristics such as UVT and CSO water levels in the reactor and support channel. These controls would be programmed to turn the reactor on and off, increase or decrease the lamps' intensity based on UVT and open appropriate valves to drain the reactor when not in operation. Operations in the winter, however, would include other specific requirements in the reactor for controlling freezing conditions in the reactor. These requirements would include any or all of the following guidelines:

1. Drain the reactor and apply warm air to the module to maintain temperature above 32°F; and
2. Manually drain the cleaning solution from the wipers and refill the wipers before the next storm event (approximately 5 minutes per lamp). Leave the reactor full of water and

provide a heat source to maintain the water temperature above 32°F during freezing temperatures.

Space Requirements

The space requirements of the facilities required for disinfection using UV are based upon the size of the contact chamber and a buffer of 5 feet on upstream and downstream of the UV lamps.

Table 2-32 - Preliminary Construction Cost Estimates for UV Disinfection

Flow	Length x Width X Depth(1)	Budgetary Equipment Price	Concrete Cost(2)	Install Cost(3)	GC General Conditions (4)	GC OH&P(5)	Contingency(6)	Total
10 MGD	4'-0" x 4'-0" x 9'-0"	$300,000	$885,600	$1,778,400	$296,400	$296,400	$1,778,400	$5,335,200
25 MGD	50'-5" x 5'-1" x 9'-0"	$625,000	$1,138,536	$2,645,304	$440,884	$440,884	$2,645,304	$7,935,912
50 MGD	50'-5"x 5'-1" x 9'-0"	$1,100,000	$1,959,552	$4,589,328	$764,888	$764,888	$4,589,328	$13,767,984
75 MGD	53'-5"x 5'-1" x 9'-0"	$1,400,000	$2,076,192	$5,214,288	$869,048	$869,048	$5,214,288	$15,642,864
100 MGD	52'-3" x 4'-10" x 9'-0"	$1,600,000	$2,931,552	$6,797,328	$1,132,888	$1,132,888	$6,797,328	$20,391,984
450 MGD	68'-8" x 8'-11" x 11'-9"	$8,480,000	$12,060,757	$30,811,136	$5,135,189	$5,135,189	$30,811,136	$92,433,408

Notes:
(1) Channel size based on assumed channel size with length of twice the width before and after UV lamp banks, and 1.5 feet of free board for the side walls
(2) Concrete costs based upon assumed $900 per cubic yard
(3) Installation costs are estimated at 150% of the equipment cost.
(4) GC general conditions are estimated at 10% of the total direct cost.
(5) GC OH&P are estimated at 10% of the total direct cost.
(6) 50% of contingency is used for the planning level of cost estimates.

Table 2-33 - Annual Operation Cost for Ultraviolet Disinfection

Flow	Total Number of UV Lamps	Power Consumption per Lamp (kW)	Total Power (kW)	Annual Energy Usage (kW-hr)(1)	Total Cost(2)
10 MGD	32	1	32	16,000	$2,240
25 MGD	66	1	66	33,000	$4,620
50 MGD	132	1	132	66,000	$9,240
75 MGD	176	1	176	88,000	$12,320
100 MGD	240	1	240	120,000	$16,800
450 MGD	1152	1	1152	576,000	$80,640

Notes:
(1) Assumes 500 hours of annual operation
(2) Assumes energy costs of $0.14/kW-hr

Table 2-34 - Annual Maintenance Cost for Ultraviolet Disinfection

		Annual Number of Units Replaced			
Flow	**Lamps**	**Lamps(1)**	**Ballasts(2)**	**Sleeves(3)**	**Wipers(4)**
10 MGD	32	3	3	6	16
25 MGD	66	7	7	13	33
50 MGD	132	13	13	26	66
75 MGD	176	18	18	35	88
100 MGD	240	24	24	48	120
450 MGD	1152	115	115	230	576

	Annual Maintenance Labor Costs (5)						
	Lamps	**Ballasts**	**Sleeves**	**Wipers**	**Check UV Sensors(6)**	**Routine(7)**	**Total Annual Labor**
Estimated Man Hours per Unit	*0.25*	*0.25*	*1*	*1*	*2*	*4 to 8*	
10 MGD	$150	$150	$1,050	$2,400	$7,800	$60,000	$71,550
25 MGD	$300	$300	$2,100	$4,950	$7,800	$60,000	$75,450
50 MGD	$600	$600	$4,050	$9,900	$7,800	$75,000	$97,950
75 MGD	$750	$750	$5,400	$13,200	$7,800	$90,000	$117,900
100 MGD	$900	$900	$7,200	$18,000	$7,800	$90,000	$124,800
450 MGD	$4,350	$4,350	$34,650	$86,400	$7,800	$120,000	$257,500

	Annual Maintenance Equipment Costs					
	Lamps	**Ballasts**	**Sleeves**	**Wipers**	**Total Annual**	**Total Annual Maintenance**
Unit Costs	*$300*	*$750*	*$175*	*$30*		
10 MGD	$960	$2,400	$1,120	$480	$4,960	$76,510
25 MGD	$1,980	$4,950	$2,310	$990	$10,230	$85,680
50 MGD	$3,960	$9,900	$4,620	$1,980	$20,460	$118,410
75 MGD	$5,280	$13,200	$6,160	$2,640	$27,280	$145,180
100 MGD	$7,200	$18,000	$8,400	$3,600	$37,200	$162,000
450 MGD	$34,560	$86,400	$40,320	$17,280	$178,560	$436,060

Notes:
(1) Assumes lamps replaced every 10 years
(2) Assumes ballasts replaced every 5 years
(3) Assumes sleeves replaced every 5 years
(4) Assumes wipers replaced every 2 years
(5) Assumes labor rate of $150/hour
(6) Assumes UV sensors are inspected bi-weekly
(7) Routine inspection and maintenance should be performed after each event with 4hr for 10MGD and 25 MGD system, 5 hours for 50 MGD System, 6 hours for 75MGD and 100 MGD systems, and 8 hours for 450 MGD system. Assumed 100 events.

2.4.5 Ozone Disinfection

Description of Process

Ozone (O_3) is an unstable gas that is produced when oxygen molecules are dissociated into atomic oxygen and subsequently collide with another oxygen molecule to produce ozone. Due to the instability of ozone, it must be generated on-site from air or oxygen carrier gas. The most efficient method of producing ozone today is by the electric discharge technique, which involves passing the air or oxygen carrier gas across the gap of narrowly spaced electrodes under a high voltage. Due to this expensive method of producing ozone, it is extremely important that the ozone is efficiently transferred from the gas phase to the liquid phase. The two most often used contacting devices are bubble diffusers and turbine contactors. With the bubble diffusers, deep contact tanks are required. Ozone transfer efficiencies of 85% and greater can be obtained in most applications when the contactor is properly designed. The contactors must be covered to control the off-gas discharges. Since any remaining ozone would be extremely irritating and possibly toxic, the off-gases from the contactor must be treated to destroy the remaining ozone. Ozone destruction is normally accomplished by thermal or thermal-catalytic means.

An ozonation system can be considered to be relatively complex to operate and maintain compared to chlorination. The process becomes still more complex if pure oxygen is generated on site for ozone production. Ozonation system process control can be accomplished by setting an applied dose responsive to wastewater flow rate (flow proportional), by residual control, or by off-gas control strategies. Ozone disinfection is relatively expensive with the cost of the ozone generation equipment being the primary capital cost item, especially since the equipment should be sized for the peak hourly flow rate as with all disinfectant technologies. Operating costs can also be very high depending on the power costs, since Ozonation is a power intensive system.

Since ozonation is expensive to operate, and maintain, produces off-gas that can be toxic, is a complex system, and not utilized for disinfection at wastewater treatment plants where flow is more controlled and less variable, we feel it is not an acceptable application for disinfection of CSO flows and will not be evaluated further.

2.4.6 Evaluation of Disinfection Technologies

The above sections evaluated each of the disinfection technologies considered for treatment of CSO flow relative to criteria on cost, performance, limitations, and ancillary facilities. Each process was rated from 1 to 5, with 5 being the most effective, for approximately twenty different items and totaled. While somewhat subjective, this method does provide a mechanism for comparing each screening unit in relationship to each category and subcategory. The results of the evaluation are illustrated on Table 2-35.

Table 2-35 presents the relative effectiveness of the different disinfection technologies with respect to bacteria, viruses, and encrusted parasites. For the purposes of this table the bacteria are identified as pathogens, E. coli, enterococci, and salmonella. Viruses are identified as the polio virus, with encrusted parasites consisting of giardia and cryptosporidium.

Table 2-35 - Evaluation of Disinfection Technologies

Criteria	Sodium Hypochlorite	Peracetic Acid	Ultraviolet Disinfection
Complexity	5	5	2
Safety	4	4	5
Limitations	3	3	3
Inhibitors	3	5	3
De-chlorination Requirement	1	5	5
Commercial Product Availability	5	1	5
CSO Application	5	2	2
Total	26	25	25

Section 3

Storage Technologies

Storage technologies are used to store flow for subsequent treatment at the wastewater treatment facility when downstream conveyance and treatment capacity are available. Two general types of storage need to be considered: in-line storage, which is storage in series with the sewer; and off-line storage, which is storage in parallel with the sewer. More detailed information on each type and sub-type is provided below.

3.1 In-Line Storage

In-line storage is generally developed in two ways. One way would be to use control structures to store the flows from smaller storm events (those below the design storm for the facilities) using the excess pipe capacity within the existing sewer. The other, also used with a control structure, is to replace segments of the existing sewer with larger diameter pipes to act as storage units. In both cases the use of in-line storage typically needs large diameter pipe with flat slopes. In-line storage within the existing combined sewer system is currently provided to some extent by the overflow weir typically used in existing CSO control facilities. Maximizing that storage, selecting the location of other flow control structures, and sizing of these facilities must be determined and verified by using a calibrated and verified hydraulic model.

In-line storage facilities require an extensive control and monitoring network. These includes flow regulators, such as orifices, weirs, flow throttle valves, automated gates and continues monitoring network such as level sensors, rain gages, flow monitors, and overflow detectors. Effective and efficient in-line storage requires the utilization of site-specific information together with modeling data and information on downstream flow elevations and available capacity.

3.1.1 Using Existing Sewers

Existing sewers can sometimes provide additional in-line storage by installing an in-line weir structure or flow regulator within a pipe section or at a manhole. On large diameter sewers, the weir structure would typically consist of an inflatable rubberized fabric dam, which could be pressurized to create an impoundment on the upstream of the regulator and thus create inline storage. Another flow regulator that has been used to develop in-line storage is an automatically controlled sluice gate. Instrumentation is typically provided for automatic control to prevent overloading the system. Sections of pipe utilized for in-line storage should not have any service lateral connections, or should be deep enough to prevent sewage backups within the system.

The storage available in a sewer is directly related to the cross-sectional area of the sewer that is typically unused during typical wet weather events. Typical storage requirements for wet weather flows are in the tens or hundreds of thousands of gallons. A 4-foot (48- inch) diameter circular pipe has a total capacity of less than 100 gallons per foot, a 6- foot (72-inch) pipes has a total capacity of around 210 gallons per foot, while a 6-foot x 12-foot rectangular section has a total capacity of around 540 gallons per foot.

Most combined sewer systems within the region were constructed during the period of 1880 through 1920 when few paved roads and concrete sidewalks and other impervious areas were limited to roofs. Land development, changes within land use, and changes in sewer utilization over the past century have all impacted the flow characteristics of most combined sewer systems. Most of the combined sewer systems within the region have a diameter of 48-inch or less. These sewers are expected to have little or no storage capacity due to increase inflow rates and limited pipe size and slope.

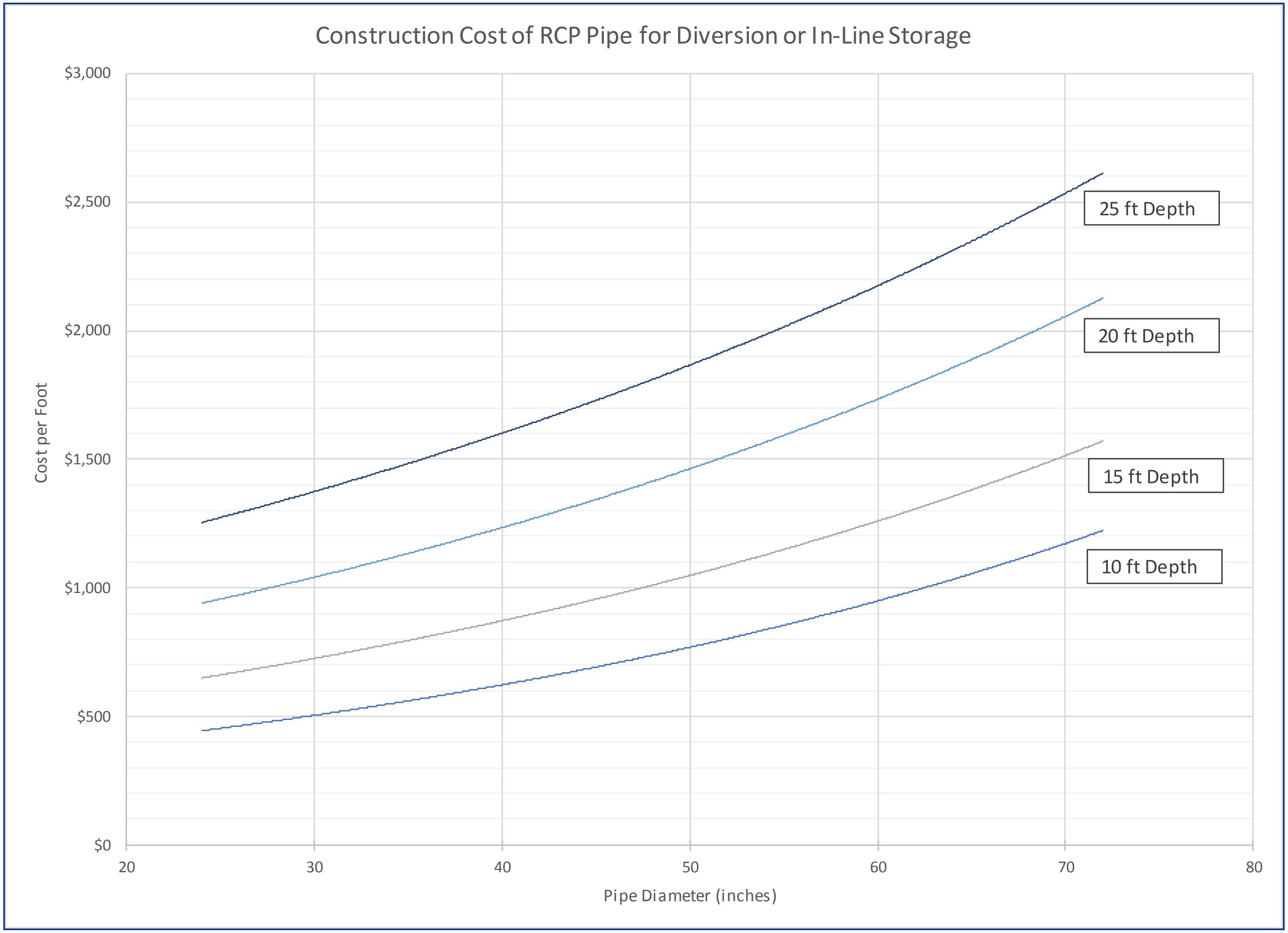
A CSO Facility Plan was completed by Killam Associates (now Mott MacDonald) in 1983 for the Passaic Valley Sewerage Commissioners on the combined sewer systems within the Cities of Newark and Paterson, and Towns of Harrison and Kearny, and the Borough of East Newark. The evaluation of in-line storage was conducted to review the feasibility of inline storage within the region. This study concluded that, with the exception of a few areas within the City of Newark, the volume of inline storage available within the sewer system was insignificant. It is anticipated that in-line storage using existing sewer will not provide a significant volume of storage.

3.1.2 Using New Large Dimension Sewers

In-line storage can also be developed by the construction of new large diameter sewers in place of, or parallel to existing combined sewers. The general principal that governs inline storage in either existing or new sewers are the same. In-line storage developed by replacing segments of the existing combined sewer system with larger diameter pipes still requires extensive controls and monitoring to assure proper operation. Accordingly, the cost of constructing the additional sewer capacity must be determined in addition to the cost of the control and monitoring network.

The original Technical Guidance Manual provided cost information suitable for the preliminary analysis of in-line storage using newly constructed large dimensional sewers in place of existing pipe. Those cost estimates were based on an assumed minimum replacement length of 500 feet for circular conduit sizes varying from 24-inch to 72-inch, and were based on an Engineering News Record (ENR) Construction Cost Index (CCI) of 7630. For this TGM update, that cost information was obtained from those cost curves and escalated to 2017 dollars using the October 2017 ENR CCI of 10817. The resultant cost estimates for the construction of segments of large diameter pipe are provided in Figure 3-1. The cost of the control and monitoring network is site specific, and should also be considered when evaluating the use of in-line storage.

Figure 3-1 - Construction Cost Estimates for RCP Pipe for Diversion or In-Line Storage



3.1.3 System Evaluation

Effective control of in-line storage can be achieved through proper flow regulator equipment and hardware selection, a SCADA system that provides early warning and accurate storm forecast. Seasonal storm patterns and types need to be identified and thoroughly evaluated to assure that the control system can properly handle current and potential rainfall patterns within the drainage area. The cost of implementation is significant for areas with limited existing storage due to the cost and challenges associated with the construction of new sewers especially in urban areas, where the access to sewer can be limited and above ground vehicle and pedestrian traffic is heavier. One advantage of in-line storage is the potential of reducing flooding and other system problems that may be localized within the system.

Operational problems that have been noted include computer programming and hardware problems especially with telemetry or data transmission, which could lead to a loss of accuracy in system control. In addition, deposition of solids in the sewers can occur, since the flow velocity during dry weather can be lower than self-cleansing velocity in large diameter sewers. In areas where smaller diameter sewers are replaced with large diameter sewers to provide in-line storage, consideration should be given to provide a low flow channel within the invert. A thorough analysis should be conducted for the potential of sewage backups in service laterals due to surcharging the system above previous hydraulic grades.

3.2 Off-line Storage

Off-line storage is storing the combined sewage in a storage system that is not on the typical flow path of dry weather flow. Off-line storage systems use tanks, basins, tunnels or other structures located adjacent to the sewer system for storing wet weather flow that is above the capacity of the conveyance system. The wastewater flows from the collection or conveyance system is diverted to off-line storage when conveyance capacity of the collection system has been exceeded. They can be used to attenuate peak flows, capture the first flush, or to reduce the frequency and volume of overflows. Wastewater flows diverted to storage facilities must be stored until sufficient conveyance or treatment capacity becomes available in downstream facilities. Off-line storage is typically accomplished by the construction of storage tanks, lagoons, basins, or deep tunnels.

Off-line storage is the predominant form of CSO prevention method currently in operation throughout the United States. The major advantages of off-line storage include:

- It can accommodate intermittent and variable storms.
- It is not impacted by varying water quality flow characteristics.
- It can accommodate solids deposition and control; and
- Storage tanks are easily accessible.

Off-line storage is not a flow through facility and thus ancillary facilities must be constructed for a complete installation. Ancillary facilities typically include some type of flow diversion or regulator structure, possibly coarse screening to keep large solids from entering the tank, and some type of tank drain facility to divert the sewage back to sewer system. To keep solids from accumulating within the tank, most storage facilities also provide facilities to flush solids from the bottom of the tanks into the pumping sump or gravity sewer.

Two types of off-line storage are typically used in CSO system depending on the volume of the overflows that need to be captured. The most prevalent form of off-line storage is a concrete storage tank/structure. These tanks/structures can be constructed above or below ground. The second form is the deep tunnel, wherein a large diameter tunnel is constructed to capture and store CSO discharges. While other forms, including uncovered earthen basins, have been used in less populated areas, open forms of CSO storage would not be applicable to highly urbanized areas.

3.2.1 Off-line Storage Tanks

The most prevalent form of off-line storage for CSO discharges is the concrete/steel tank. While large diameter parallel sewers can provide a mechanism for off-line storage, the storage volumes associated with these facilities are limited and thus are typically used within the collection system to prevent or minimized the surcharging associated with local restrictions or conditions. Large volume storage requirements can best be accommodated by the construction of off-line storage facilities at or near the CSO outfall. The design and sizing of these facilities are based upon computer modeling of drainage area and collection system to develop an understanding of the frequency and volumes associated with individual outfalls.

Advantages of off-line storage using concrete tanks are simplicity of operation and maintenance, and capability to handle high flow and water quality variations. In addition, storage tanks have the capacity for storage and collection of solids even when storm events exceed the design capacity of the off-line storage tank. In these cases, the off-line storage tank acts like a sedimentation tank. Storage tanks, in conjunction with fine screening of CSO discharges above the storage volume, are used as a primary means of CSO control throughout Europe.

As with in-line storage, the original Technical Guidance Manual provided cost information for off line storage that was obtained and escalated to 2017 dollars based on the ENC CCI. Those cost estimates were developed for concrete tanks of various storage volumes and are inclusive of all ancillary facilities and include construction costs for coarse screens, diversions, control gates, pumping facilities, flushing facilities and ventilation. The resultant cost curves are presented in Figures 3-2 through 3-4.

Figure 3-2 - Construction Cost Estimates for Off-Line Storage – 15' SWD Rectangular < 1 MG

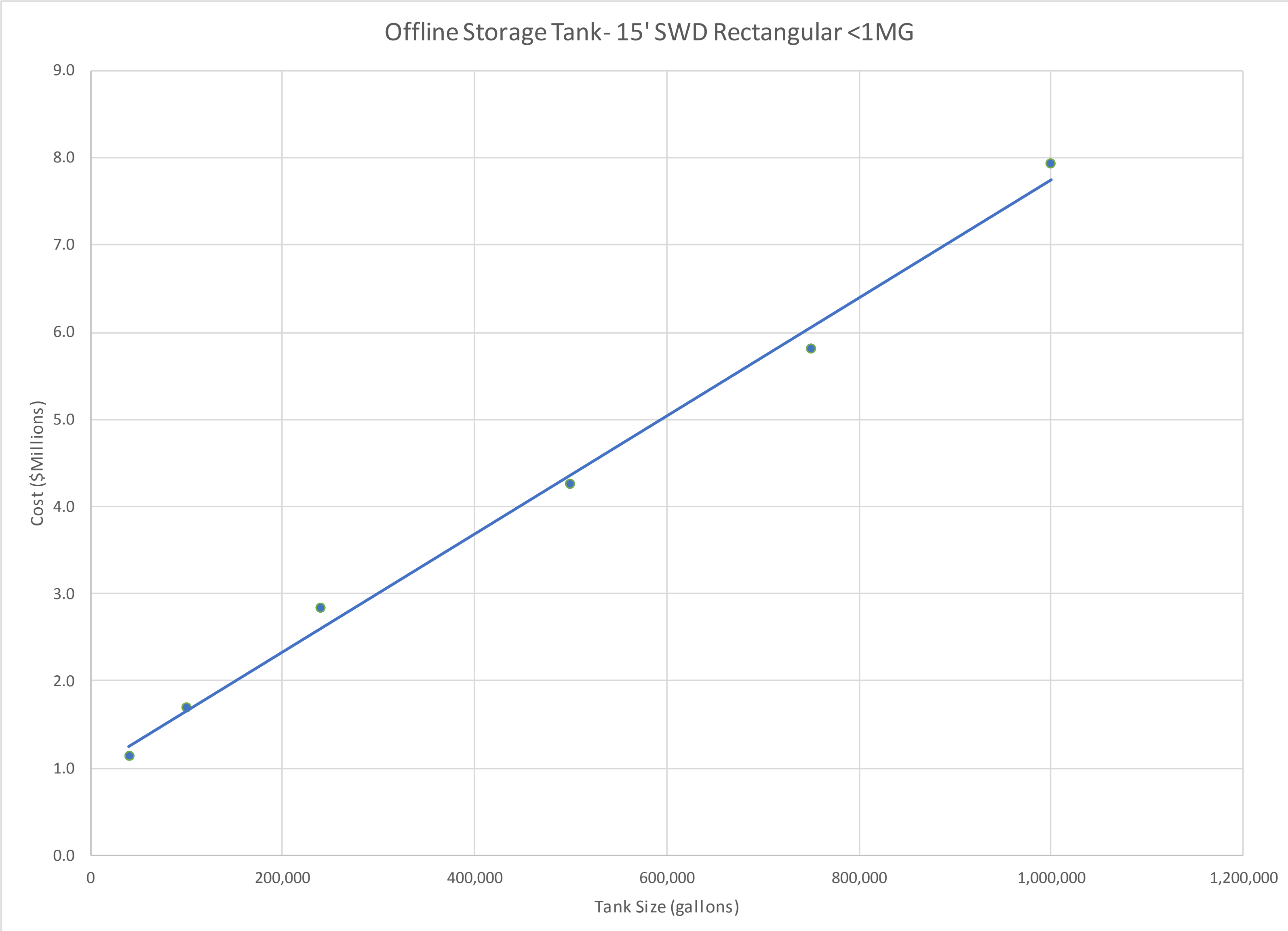


Figure 3-3 - Construction Cost Estimates for Off-Line Storage – 15' SWD Rectangular > 1 MG

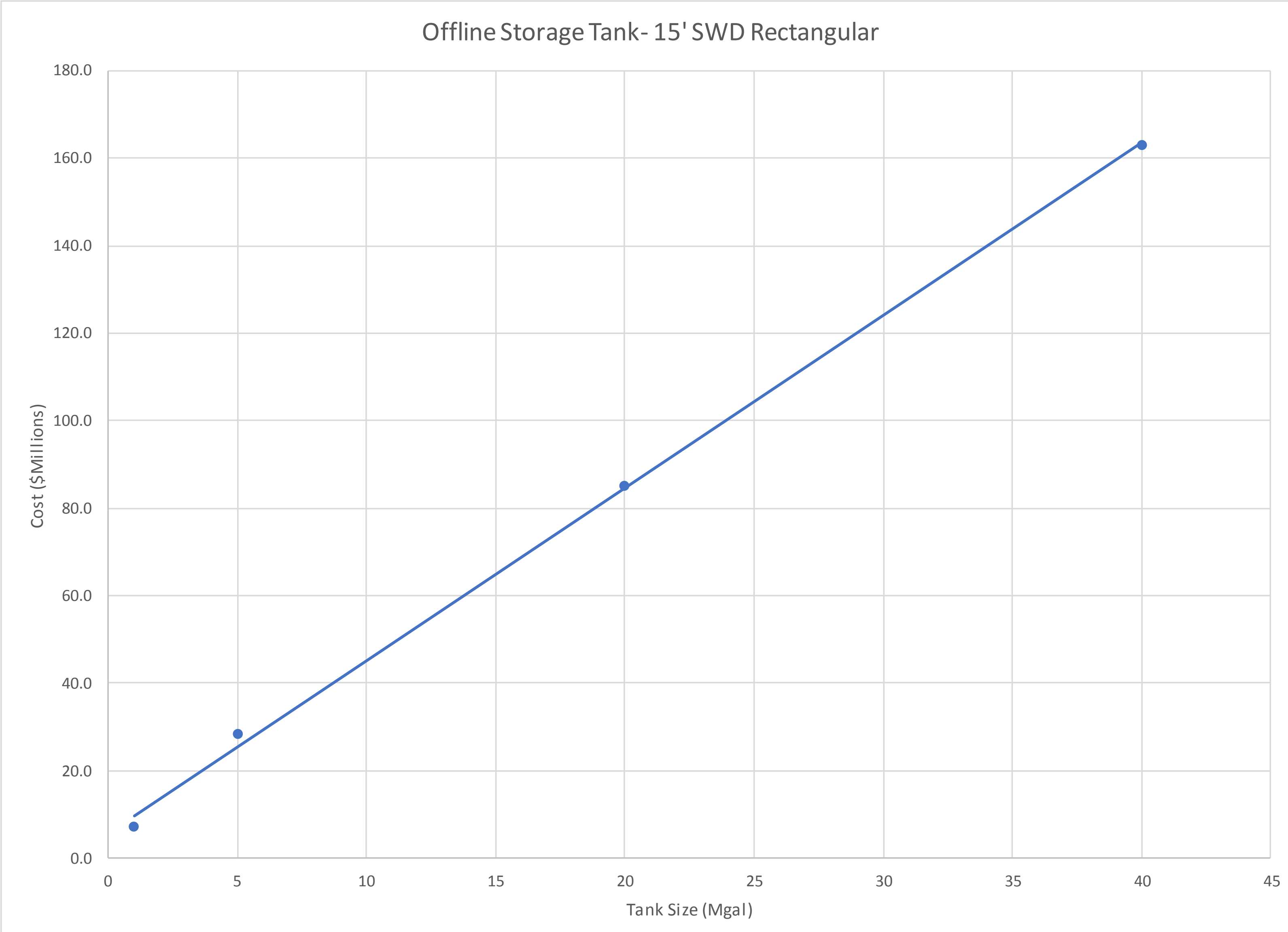


Figure 3-4 - Construction Cost Estimates for Off-Line Storage – 22’ SWD Rectangular

3.2.2 Deep Tunnel Storage

Deep tunnel storage has been gaining popularity as a positive means of reducing the volume of CSO discharges, especially in large urban areas where property values and disruptions to existing utilities and structures prohibit other forms of control. This control alternative involves the capture and storage of CSO discharges in a tunnel during wet weather events, and pumping the stored overflow back into sewer when conveyance and treatment capacity is available. New methods of construction have made deep tunnel storage a competitive option when considering the relatively low land requirements. Limitations of deep tunnels primarily include the need for specialized high-lift pumping stations and the inability to provide any treatment when the overflow exceeds the deep tunnel storage volume.

As with in -line and off-line storage, the original Technical Guidance Manual provided cost information for deep tunnel storage. Preliminary tunnel cost estimating graphs were prepared using compiled cost data from previously completed projects for the following tunneling scenarios:

- Tunnel in soft ground above the water table using an open faced boring machine with ribs and lagging primary liner and cast-in-place concrete final liner.
- Tunnel in soft ground below the water table driven using an earth pressure balanced boring machine with full gasketed concrete segmental liner erected immediately behind.
- Tunnel in rock driven using a rock-boring machine with pattern rock bolting and mesh reinforcement in the tunnel crown for primary support, and cast-in-place concrete final liner.

Since ground conditions may be unknown, an idealized cost estimate using certain assumptions on the amount of difficult conditions was also presented. A determination will need to be made as to the method that would need to be used based on general soil classifications and conditions within the region.

Notwithstanding the above, construction costs on tunneling projects are influenced by a multiplicity of factors. Tunnel cost estimates should only be used as a general initial guideline as they are based on a number of base assumptions and are not at all project specific. The major factors influencing costs on tunneling projects are described below:

- Tunnel length - assuming similar size and type of tunnels, a longer tunnel will generally have a lower unit rate than a smaller tunnel due to economies of scale. The original Technical Guidance Manual cost graphs assumed a 1.5 miles length of tunnel.
- Tunnel depth relative to the surface - deeper tunnels have deeper access shafts, which adds to the overall cost of the project. The original Technical Guidance Manual cost graphs assumed a tunnel no deeper than 30ft.
- Ground type & water table elevation - this can often be the most important cost factor as it influences the advance rates achieved, and choice of equipment and tunnel support. The original Technical Guidance Manual cost graphs assumed reasonable ground conditions and minimal water ingress problems to hinder the tunneling effort.

- Rate of advance achieved in the prevailing ground conditions. Average advance rates were assumed in the preparation of the tunnel cost graphs.

- Local labor conditions including availability of experienced personnel, prevailing wage rates, and union rules governing workers conditions, hours, and the minimum number of personnel which should be utilized for construction of the tunnel. The tunnel cost graphs presented in the original Technical Guidance Manual utilized labor conditions and numbers, which were believed to be appropriate for New Jersey.

- Local availability of appropriate tunneling equipment. The tunnel original Technical Guidance Manual cost graphs assumed that appropriate tunneling equipment is readily available in New Jersey.

- Occurrences of unforeseen ground conditions and obstructions. The original Technical Guidance Manual cost graphs assumed no major unforeseen conditions.

- Presence of sub-surface utilities and structures above requiring advance protection or monitoring during construction. The original Technical Guidance Manual cost curves assumed that no advance protection is required.

The foregoing list represents only a few of the factors which influence tunnel construction costs, and beyond the earliest stages of conceptual design it is recommended that all tunnel cost estimating be undertaken by an experienced tunneling engineer with an intimate awareness of the factors influencing tunnel costs. To cater for the unknown components inherent in preparation of the cost curves a relatively large cost contingency of 65% was applied throughout. In practical cost estimating, the cost contingency is reduced to as low as 5% as the design develops and more is known about the conditions which are likely to be encountered, and the tunneling techniques which will be utilized for the project.

In addition to tunnel costs, there are costs associated with conveying the flow into the tunnels. Typically, the discharges from outfalls are consolidated to decrease the number of drop shafts that will be needed. In addition, drop shafts are needed to transport flow from the regulators to the tunnel. The drop shaft consists of a large diameter shaft in which a vortex drop tube, vent shaft and access way are constructed. The space between the various components in a large diameter shaft is backfilled upon completion.

The original Technical Guidance Manual deep tunnel cost information was obtained and escalated to 2017 dollars based on the ENC CCI. The resultant cost curves are presented in Figures 3-6 through 3-8.

Figure 3-6 - Estimated Cost of Deep Tunnels Less Than 10,000 Linear Feet

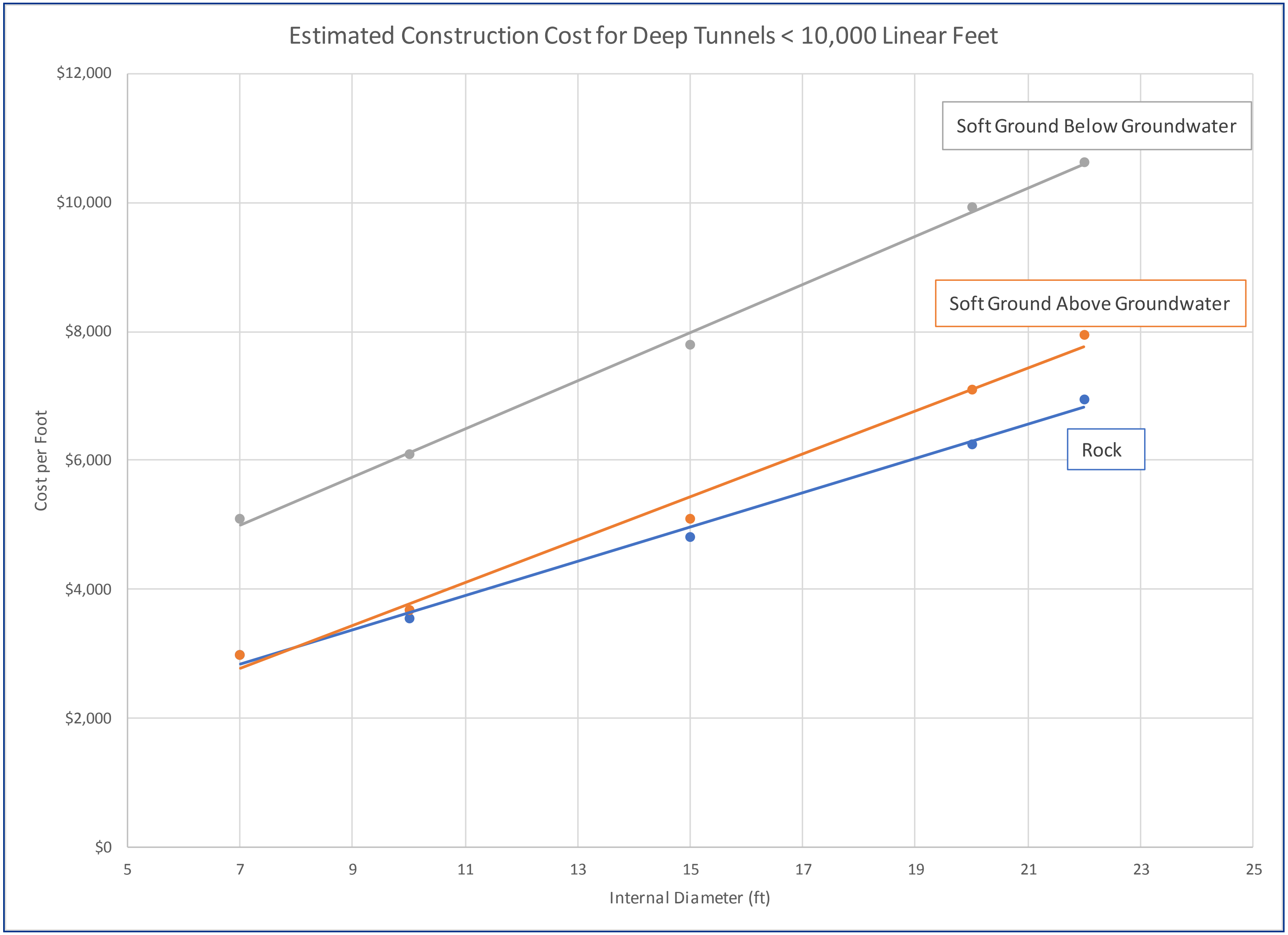


Figure 3-7 - Estimated Cost of Deep Tunnels Greater Than 10,000 Linear Feet

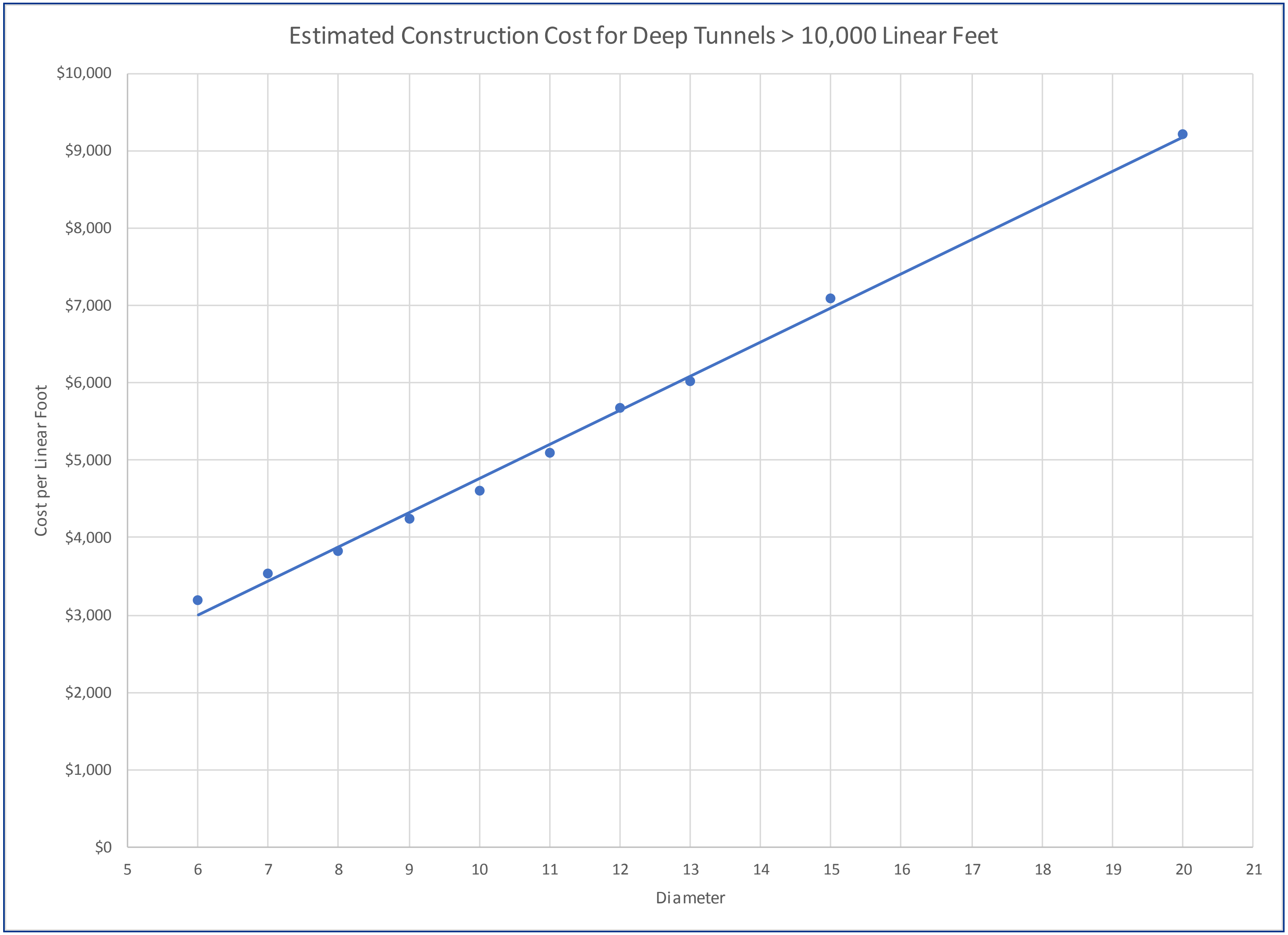
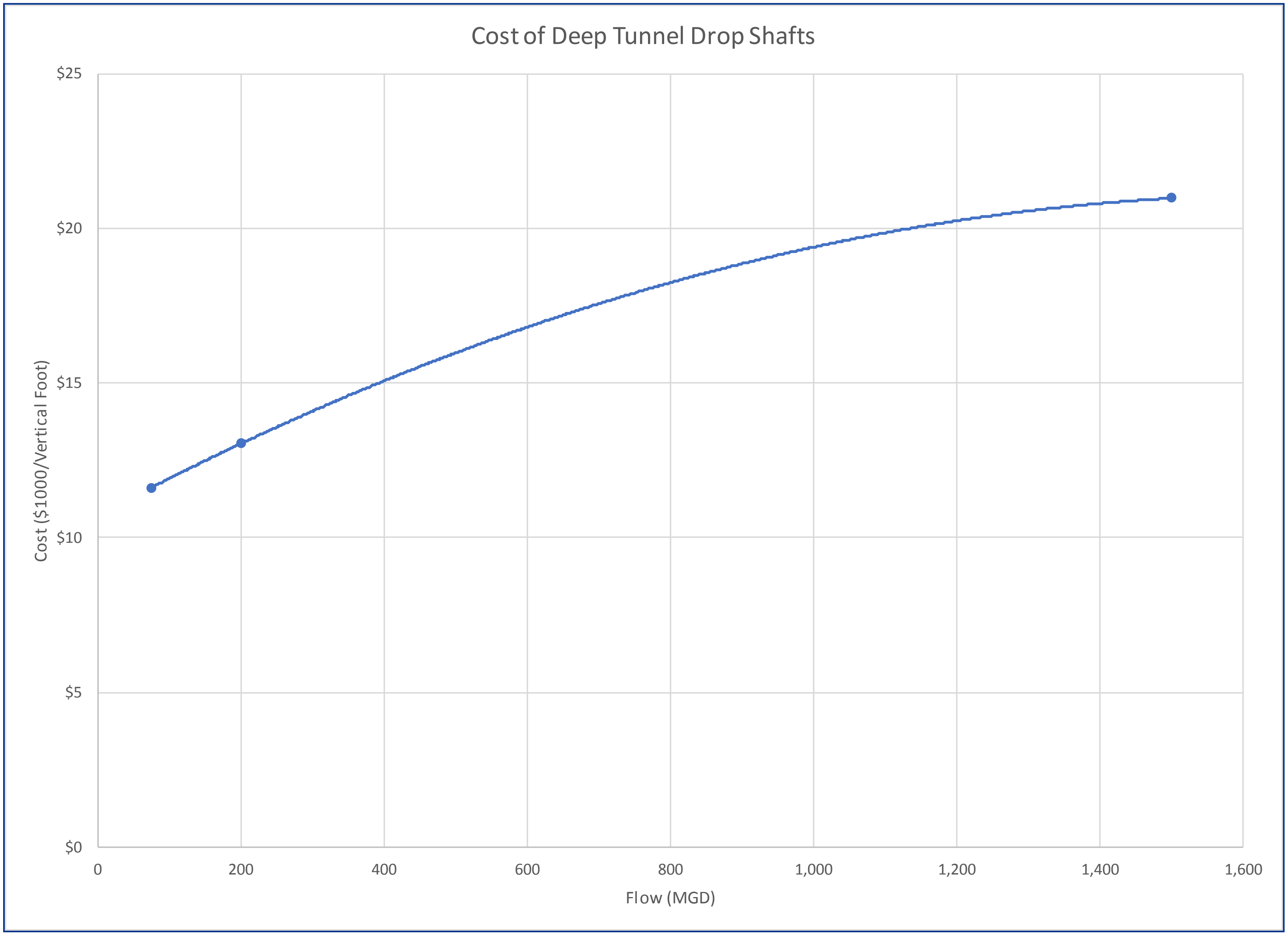


Figure 3-8 - Construction Cost Estimates for Tunnel Drop Shaft



Section 4

Green Infrastructure

The evaluation of Green Infrastructure for CSO control was not required by the prior NJPDES permit, and therefore was not included in the original Technical Guidance Manual. The NJPDES permits issued in 2015 however require permittees to evaluate Green Infrastructure as one of the CSO control alternatives.

The term "Green Infrastructure" is sometimes used to describe an array of source controls measures designed to capture stormwater before it enters the combined sewer collection system, as well as initiatives and regulatory requirements that reduce or limit runoff and pollutant loads. The Green Infrastructure described in this section of the TGM refers to physical structures that retain or detain stormwater runoff near where it originates. These structures are not necessary "green" in terms of being vegetated.

Green Infrastructure practices are designed to reduce the volume and/or peak of stormwater runoff that entering the combined sewer system. In retention systems, such as a rain garden, the runoff is routed to a permeable surface and allowed to infiltrate back into the ground. By preventing this stormwater from ever entering the collection system, the volume of overflow and associated pollutant loads discharging to the receiving waters is reduced. In detention systems, runoff is routed to a storage unit and returned to the combined sewer collection system, ideally after conveyance and treatment capacity have returned. By attenuating these flows, the conveyance system can accept a greater percentage of the overall runoff volume over a longer period of time, resulting in a net reduction of overflow volume and pollutant loads to the receiving waters.

4.1 Vegetated Practices

Many green infrastructure practices are in fact "green", in that they have a vegetative layer. That vegetative layer usually aides in the retention of stormwater runoff through transpiration, and the root system helps to promote soil porosity and aids infiltration. The green infrastructure practices also provide ancillary benefits, such as beautifying neighborhoods, improving air quality, and reducing urban heat. Through this section, several vegetated green infrastructure practices will be discussed:

- Rain Gardens
- Right-of-Way Bioswales
- Tree Pits
- Green Roofs
- Downspout Disconnection

4.1.1 Rain Gardens

Description of Practice

A rain garden consists of a shallow depressed area that is designed to collect stormwater runoff from surrounding surfaces. The collected water infiltrates into the ground, evaporates back into the atmosphere, or is transpired by the vegetation. To increase water absorption and promote infiltration, rain garden designs typically include an upper layer of amended soil with high porosity.

Plant selection and maintenance is critical to the long-term viability of a rain garden. Native plants should be selected that are capable of withstanding periods of ponded water as well as periods of dryness. Using native plants helps to reduce the amount of maintenance that will be required. Figure 4-1 provides a picture of a typical rain garden.

Figure 4-1 - Photo of Rain Garden

(Source: http://nemo.uconn.edu/raingardens/)

Applicability to The Project

Rain gardens can be implemented on public and private properties to capture and retain runoff. When properly designed and maintained they can provide aesthetic improvements to the urban landscape, natural wildlife habitat, and education opportunities for schools. Their shallow and relatively simple design means they can often be constructed without the use of heavy machinery.

Rain gardens are already used in CSO programs across the Country, and within the State of NJ. The Camden County MUA has installed an ~800 square foot rain garden that captures runoff from ~2,000 square feet of surrounding roadway.

Limitations

Proper rain garden design generally allows for a loading ratio of 5:1, with a maximum of about 10:1. The loading ratio is the ratio of contributing drainage area to the available infiltration area. In other words, to control runoff from a 500 square foot rooftop, a 100 square foot rain garden would be required. Infiltration practices that function at higher loading ratios have increased risk for failure due to the higher hydraulic, sediment, and pollutant loads.

The small loading ratio means that rain gardens require relatively large amounts of space. This makes them impractical for wide-spread public right-way application where such space is not available.

Construction Costs

The cost for constructing a rain garden can vary significantly based upon the complexity of the design, the location it is being built, and other local factors. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $11/sf to $35/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using the 5:1 loading ratio, this range of construction costs is $96,000 to $305,000 per acre controlled which is in-line with local project experience.

4.1.2 Right-of-Way Bioswales

Description of Practice

The right-of-way bioswale is a curb-side green infrastructure design being widely employed as part of New York City's green infrastructure program for CSO control. To date several thousand units have been constructed or are in construction. There are several variations of the design with different widths and depth (right-of-way greenstrips, right-of-way raingardens) but the functionality is essentially the same.

The typical right-of-way bioswale is between 4 and 5 feet wide by 10 to 20 feet long. They are constructed in the existing sidewalk, with curb cuts to allow street runoff traveling along the gutter to enter the bioswale on the upstream side and excess flow to return to the street on the downstream side. It is this conveyance aspect of the practice that makes it a bioswale instead of a deep raingarden.

On the surface, the right-of-way bioswale looks and functions much like a rain garden described above. The unit includes a shallow ponding area, and a vegetative surface that may or may not include a tree. However, whereas a raingarden is generally less than a foot deep, the right-of-way bioswale is approximately 4 ½ feet deep. The first 2 ½ to 3', depending on the design is made up of an engineered soil designed to allow for rapid infiltration. The lower portion of the bioswale is a stone base to provide storage. A rendering of a New York City bioswale is provided in Figure 4-2.

Figure 4-2 - Rendering of Right-of-Way Bioswale

(Source www.nyc.gov/html/dep/html/stormwater/bioswales.shtml)

Applicability to The Project

The right-of-way makes up a significant amount of a city's impervious cover. Sidewalks and streets are generally pitched to capture and convey runoff directly towards the collection system, making them efficient locations to intercept the flow. Furthermore, the municipality already has ownership of these areas.

New York City is constructing thousands of right-of-way bioswales to capture urban runoff before it enters their combined sewer collection systems. The designs could easily be adapted to meet the needs of other combined sewer municipalities.

Limitations

The New York City standard design process sizes the bioswales based upon the calculated volume that can be managed through infiltration through the native surrounding soils, and storage within the unit, during a specified period. This generally results in loading ratios well above standard rule of thumb loading ratios for bio-infiltration practices. To date New York City's post construction monitoring program has shown that overall the units are functioning at or beyond their intended designs, but long-term monitoring results are not yet available. Permittees should consider the potential failure risks of utilizing similarly high loading ratios. Infiltration practices that function at higher loading ratios have increased risk for failure due to the higher hydraulic, sediment, and pollutant loads.

Constructing bio-infiltration practices in the sidewalk requires that the existing sidewalks are wide enough to allow for the feature while still maintaining functionality for pedestrian traffic. The ability to site right-of-way bioswales will have to be determined by each permittee.

Construction Costs

The actual construction costs for right-of-way bioswales is estimated to be approximately $15,000 unit, which equates to approximately $150,000 per acre controlled. These costs are based on large construction contracts generally including 100 – 200 units where an economy of scale can be achieved. For single unit or low quantity construction estimates, the costs can be significantly higher.

Prior to construction, identifying appropriate and effective locations for right-of-way bioswales requires planning, field work, and geotechnical investigations. When attempting to implement a wide-scale right-of-way green infrastructure program, many locations will be screened out due to site constraints or poorly infiltrating soils. Typical per-site survey and geotechnical costs can be approximately $4,000 to $5,000 per location. When sites are screened out after these costs have been incurred, the programmatic cost per constructed unit goes up to as much as $50,000 per unit.

4.1.3 Enhanced Tree Pits

Description of Practice

Enhanced tree pits, or stormwater trees, can appear similar to a standard city tree pit. Unlike a standard tree pit, however, they utilize an underground system designed to infiltrate runoff. The underground system includes engineered soil capable of rapidly infiltrating water, crushed stone, and an underdrain system. Although they can be built individually, they become more effective when they are installed as a connected multi-unit linear system. In such a system, permeable pavement can be used between the tree pits to allow additional water to infiltrate into a subsurface stone layer that connects the tree pits. A photo of an enhanced tree pit is provided in Figure 4-3.

Figure 4-3 - Photo of Enhanced Tree Pits

(Source: NJ Tree Foundation)

Applicability to The Project

Enhanced tree pits are already in use in cities across the United States as stormwater control measures. They can be constructed in sidewalks, in parking lots, courtyards, etc.

Limitations

The design of enhanced tree pits can vary greatly based on capture needs. The limitation for applicability are similar to those described for rain gardens and bioswales, depending on the desired loading ratio and available space.

Construction Costs

Pre-fabricated tree pits are available for approximately $10,000 each, and cost about $5,000 to install.

4.1.4 Green Roofs

Description of Practice

A green roof generally consists of a vegetated layer on top of a lightweight soil medium, below which lies an underdrain system and waterproof membrane. The depth of the soil medium will determine the type of vegetation that can be sustained and also the weight of the vegetated roof.

A portion of the precipitation that falls on the vegetated surface is retained in the soil medium and eventually released back to the atmosphere through evaporation and taken up through transpiration. The underdrain system acts as additional detention system before the excess water is eventually discharged through the buildings downspouts to the ground or directly into the combined sewer system. A photo of the green roof on Chicago's City Hall is shown in Figure 4-4.

Figure 4-4 - Photo of Green Roof on Chicago City Hall

(Source: www.greenroofs.com/)

Applicability to The Project

Green roofs have been constructed in cities around the world and across the country, including as part of CSO programs.

Limitations

Wide spread application of green roofs is generally cost prohibitive. Most existing buildings cannot support the additional weight of a green roof without costly retrofitting.

Green roofs are generally designed with a loading ratio of 1:1, meaning that the managed area is limited to the footprint of the vegetated area itself.

Construction Costs

The cost for constructing a green roof can vary significantly based upon the complexity of the design, the location it is being built, and other local factors. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $11/sf to $56/sf for construction costs, in 2016 dollars, compiled from projects across the United States. Using the 1:1 loading ratio, this range of construction costs is $480,000 to $2,440,000 per acre controlled which is in-line with local project experience.

4.1.5 Downspout Disconnection

Description of Practice

In many urban areas, downspouts are connected directly into the combined sewer system. Disconnecting these downspouts provides opportunity for rooftop runoff to be infiltrated or intercepted before entering the combined sewer system. For buildings with exterior downspouts, disconnection can be as simple as cutting the existing downspout, installing an elbow, and routing the downspout to a pervious surface or storage unit, such as a rain barrel. For buildings with interior downspouts the process can be more complicated and may not be practical. However, opportunities may still exist where the internal drain can be located and re-routed through an exterior wall. A photo of the disconnected external downspout is shown in Figure 4-5.

Figure 4-5 - Photo of Disconnected Downspout

(Source: https://www.mmsd.com/what-you-can-do/downspout-disconnection)

Applicability to The Project

Many cities across the United States have adopted programs either requiring or encouraging downspout disconnection. A downspout disconnection program often provides the simplest and lowest cost for reduction in wet weather flow to the sewer system. The combined sewer communities within the PVSC service area should evaluate the potential for adopting such a program.

Construction Costs

Exterior downspout disconnections are usually simple, and can be accomplished for approximately $25 to $50.

4.2 Permeable Pavements

The term Permeable Pavements refers to several distinct surfaces, each of which are intended to provide a reduction in stormwater runoff as compared with traditional paving methods. The nomenclature for these different surfaces is often used interchangeably and can be confusing. The major types of permeable pavements will be discussed in this section, including:

- Porous Asphalt
- Pervious Concrete
- Permeable Pavers

4.2.1 Porous Asphalt

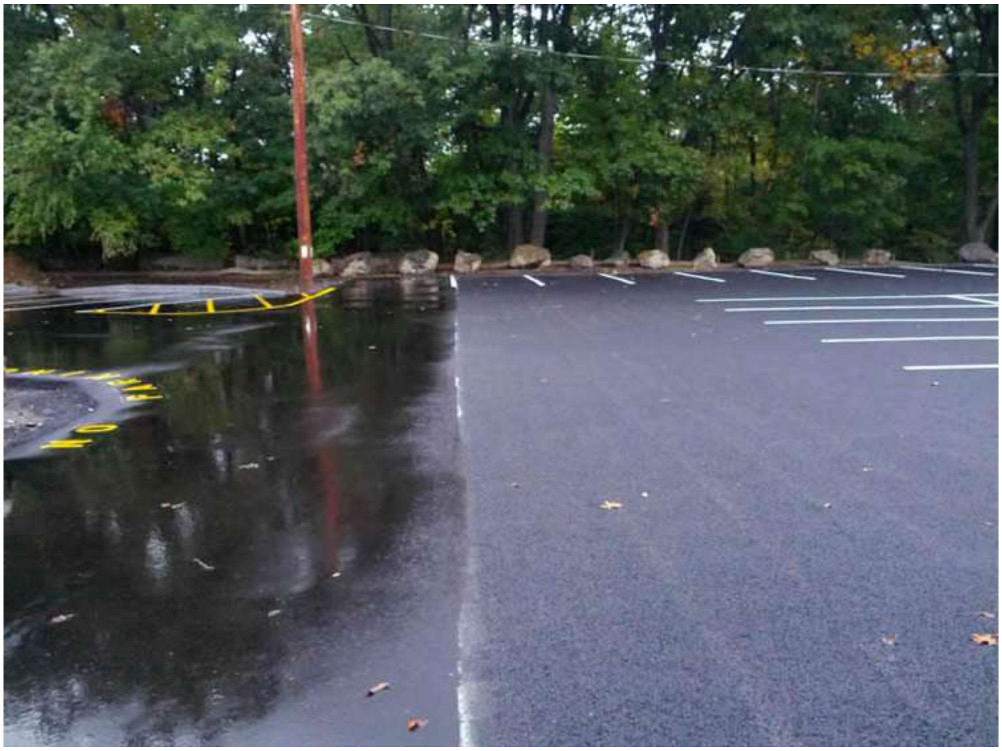
Description of Practice

Upon closer inspection, porous asphalt looks like a somewhat courser version of traditional asphalt, or “blacktop”. Porous and traditional asphalt are made in a similar fashion, but the fine particles are left out of the porous asphalt mix. Without the fines, air becomes trapped in the asphalt mix creating pore space through which water can migrate.

Below the porous asphalt layer, a stone layer acts as a reservoir to store water before it infiltrates into the native soil. An underdrain system may also be included

Figure 4-5 provides a picture of a parking lot in which half was paved using porous asphalt (right side of photo) and the other half was paved using traditional asphalt (left side of photo).

Figure 4-5 - Porous Asphalt Parking Lot



(Source: https://www.epa.gov/soakuptherain/soak-rain-permeable-pavement)

Applicability to The Project

Porous pavement has been used successfully for decades to reduce ponding , flooding, and stormwater discharges. Many combined sewer cities are now using porous pavement as part of their CSO control strategy. Porous asphalt should be considered when roads or parking lots are to be constructed or repaved.

Limitations

Porous pavement requires additional maintenance, including regular service with a vacuum truck to help maintain the open pore space. The use of salt or sand for snow melting is also discouraged. Applications of porous asphalt are typically not recommended in high traffic or heavy industrial sites due to the increased sediment and pollutant loads.

Construction Costs

The cost for porous asphalt can vary significantly based upon whether it new surface or a retrofit. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $12/sf to $25/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using a 2:1 loading ratio, this range of construction costs is $260,000 to $545,000 per acre controlled which is in-line with local project experience.

4.2.2 Pervious Concrete

Description of Practice

Pervious concrete is a concrete mix containing little or no sand, which creates pore space through which water can migrate. Pervious concrete functions similarly to porous asphalt in that water migrates through the pavements void space down into an underlying stone bed, and either infiltrates to the natural soil or enters an underdrain system. A photo of a pervious concrete application is shown in Figure 4-6. Pre-fabricated pervious concrete panels were installed in the parking stalls.

Figure 4-6 – Pervious Concrete Panels

Applicability to The Project

Pervious concrete pavement has been used successfully for decades to reduce ponding, flooding, and stormwater discharges. Many combined sewer cities are now using pervious concrete as part of their CSO control strategy. Pervious concrete can be considered for sidewalks, courtyards, or anywhere else that traditional concrete may be used.

Limitations

Pervious concrete requires additional maintenance, including regular service with a vacuum truck and pressure washing to help maintain the open pore space. The use of salt or sand for snow melting is also discouraged.

Construction Costs

The cost for pervious concrete can vary significantly based upon the type of application. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $14/sf to $28/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using a 2:1 loading ratio, this range of construction costs is $305,000 to $610,000 per acre controlled which is in-line with local project experience.

4.2.2 Permeable Interlocking Concrete Pavers (PICP)

Description of Practice

Unlike pervious concrete, permeable pavers do not allow water to pass through the concrete. Instead, the joints between the impervious concrete pavers are filled with a permeable medium such as small stone or sand, allowing water to infiltrate between the pavers. The subsurface includes as stone base and an underdrain, if required.

A photo of a Philadelphia parking lot utilizing concrete permeable pavers is shown in Figure 4-7.

Figure 4-7 – Permeable Interlocking Concrete Pavers (source: EPA)

Applicability to The Project

As with the other types of permeable pavements, permeable interlocking concrete pavers are being used across the country for stormwater control.

Limitations

Permeable interlocking concrete pavers require regular service with a vacuum truck. Proper erosion control is required on the surrounding areas to prevent additional loading to the pavers and clogging.

Construction Costs

The cost for permeable pavers can vary significantly based upon the desired design and type of application. The NJDEP guidance document "Review of GI as a Component of LTCPs" provides a range of $12/sf to $34/sf for construction costs, in 2016 dollars, compiled from projects across the United States. For wide-scale green infrastructure planning, costs are often normalized to units of dollars per impervious acre controlled. Using a 4:1 loading ratio, this range of construction costs is $130,000 to $370,000 per acre controlled which is in-line with local project experience.

Section 5

Water Conservation

Reducing overall water consumption can provide some reduction in CSO discharge volume by providing additional wet weather capacity in the collection system and helping to alleviate the stress on the existing wastewater treatment facilities. It is difficult to quantify the CSO reduction provided through water conservation practices without modeling, and this Technical Guidance Manual does not attempt to do so. The CSO reduction benefits provided through water conservation measures will be dependent upon the coincidence of wet weather events and the highs and lows of daily water usage

Water consumption reduction can be achieved through a variety of measures including public outreach and education; distribution system leak detection and repair; water efficient landscaping; and water efficient plumbing fixtures (i.e., toilets and urinals, faucets, and showerheads). Assuming that nearly all water use inside residences and commercial users will ultimately be disposed of in the sewer, outside water use, such as lawn watering and leaks in the distribution system will not be addressed in the TGM.

This section will focus on water efficient plumbing fixtures and discuss the water saving and costs while implementing water efficient plumbing fixtures.

5.1 Water Efficient Toilets and Urinals

Nearly one-third of total water consumption returns to the sewer system through flushed toilets and urinals. Many plumbing fixtures still in use today were designed at a time when little concern was given to water conservation. Prior to 1950, typical toilets consumed 7-gallons-per-flush (gpf). Toilets installed between 1950 and 1994 consumed 4-5 gpf. Federal laws enacted in 1994 required that residential toilets use no more than 1.6 gpf. A similar limit was established for commercial toilets in 1997, and urinals were limited to 1.0 gpf by the 1997 requirements.

Average water savings by using low-volume toilets compared to high-volume ones is shown for residential households in Table 5-1, and for industrial and commercial facilities in Table 5-2. Average water savings by using low-volume urinals compared to high-volume ones in industrial and commercial facilities only is shown in Table 5-3.

Table 5-1 - Estimated Water Savings Provided by Low Volume Toilets in Households

Year Installed	Average Toilet Water Use Rate (gpf)	Estimated Water Use (gal/household/day)	Estimated Water Use Annually (gal/household/year)	Estimated Annual Water Savings (gal/household/year)
1994 - Present	1.6	32	11,680	-
1980-1994	4.0	80	29,200	17,520
1950s - 1980	5.0	100	36,500	24,820
Pre-1950s	7.0	140	51,100	39,420

Notes: Assume a 4-person household at 5 uses per person per day.

Table 5-2 - Estimated Water Savings Provided by Low Volume Toilets in Commercial and Industrial Facilities

Year Installed	Average Toilet Water Use Rate (gpf)	Average Daily Use (gal/toilet/day)	Estimated Water Use Annually (gal/toilet/year)	Estimated Annual Water Savings (gal/toilet/year)
1997 - Present	1.6	38.4	14,016	-
1980-1994	4.0	96	35,040	21,024
1950s - 1980	5.0	120	43,800	29,784
Pre-1950s	7.0	168	61,320	47,304

Notes: Assume an average daily use of 24 times per toilet per day.

Table 5-3 - Estimated Water Savings Provided by Low Volume Urinals in Commercial and Industrial Facilities

Year Installed	Average Toilet Water Use Rate (gpf)	Estimated Average Daily Use (gal/urinal/day)	Estimated Water Use Annually (gal/urinal/year)	Estimated Annual Water Savings (gal/urinal/year)
1997 - Present	1	16	5,840	-
1980-1994	2.0	32	11,680	5,840
Pre 1980	5.0	80	29,200	23,360

Notes: Assume an average daily use of 16 times per urinal per day.

An estimate of the typical costs associated with replacing a toilet or urinal was developed using construction cost estimating database such as R.S. Means. In 2017 dollar, the equipment and labor costs were:

- Residential Floor Mounted Toilets = $645 per fixture
- Commercial Wall Hung Toilets = $1,225 per fixture
- Urinals = $615 per fixture

5.2 Water Efficient Faucets and Showerheads

Significant amounts of water and energy can be wasted through use of non-water efficient faucets and showerheads. Even a brief five-minute shower can consume 15-35 gallons of water with a conventional showerhead with a flow rate of 3-7 gpm.

Prior to 1980, typical faucets had a flowrate of 4 gpm. Faucets installed between 1980 and 1994 flowed at approximately 3 gpm. Federal guidelines in 1994 required that all lavatory and kitchen faucets and replacement aerators use no more than 2.5 gpm measured at normal water pressure (typically 80 pounds per square inch, psi). A similar limit was established for showerheads in 1994, which reduced the typical flowrate of a showerhead from 3-7 gpm to 2.5 gpm.

Average water savings by using low-flow faucets compared to high-flow ones is shown for residential households in Table 5-4, and for industrial and commercial facilities in Table 5-5. Average water savings by using low-flow showerheads compared to high-flow ones in residential households is shown in Table 5-6.

Table 5-4 - Estimated Water Savings Provided by Low Flow Faucets in Households

Year Installed	Average Faucet Flowrate (gpm)	Estimated Faucet Use (gal/household/day)	Estimated Water Use Annually (gal/household/year)	Estimated Annual Water Savings (gal/household/year)
1994 - Present	2.5	100	36,500	-
1980-1994	3.0	120	43,800	7,300
Pre-1980s	4.0	160	58,400	21,900

Notes: Assume a 4-person household at 10-minutes uses per person per day.

Table 5-5 - Estimated Water Savings Provided by Low Flow Faucets in Commercial and Industrial Facilities

Year Installed	Average Faucet Flowrate (gpm)	Average Daily Use (gal/faucet/day)	Estimated Water Use Annually (gal/faucet/year)	Estimated Annual Water Savings (gal/faucet/year)
1994 - Present	2.5	180	65,700	-
1980-1994	3.0	216	78,840	13,140
Pre-1980s	4.0	288	105,120	39,420

Notes: Assume an average daily use of 72 minutes per faucet per day.

Table 5-6 - Estimated Water Savings Provided by Low Flow Showerheads in Households

Year Installed	Average Showerhead Flowrate (gpm)	Average Daily Use (gal/household/day)	Estimated Water Use Annually (gal/household/year)	Estimated Annual Water Savings (gal/household/year)
1997 - Present	2.5	62.5	22,813	-
1980-1994	3.0	75	27,375	4,563
Pre 1980	7.0	175	63,875	41,063

Notes: Assume a 4-person household at 25-minutes uses per person per day.

An estimate of the typical costs associated with replacing a toilet or urinal was developed using construction cost estimating database such as R.S. Means. In 2017 dollar, the equipment and labor costs were:

- Residential Faucet Replacement = $189
- Residential Showerhead Replacement (including built-in, head, arm, and 2.5 gpm valve) = $350

Commercial Faucet Replacement (with automatic sensor and operator) = $675

Appendix A

Climber Screens® Installation List

(Source: Suez, formerly Infilco Degremont, Inc.)

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1445	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1446	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1447	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1448	00012	NY	Brooklyn	Red Hook WPCP (Replaced 84-949)	2000	1	IIS	70.0	MGD	72	100.25	72	1	429.5	316SS	316SS
CS-1478	00103	PA	Erie	Erie WWTP - East Headworks	2000	1	IIS	58.0	MGD	72	120	90	1	120	Carbon Steel	304SS
CS-1479	00103	PA	Erie	Erie WWTP - East Headworks	2000	1	IIS	58.0	MGD	72	120	90	1	120	Carbon Steel	304SS
CS-1480	00103	PA	Erie	Erie WWTP - East Headworks	2000	1	IIS	58.0	MGD	72	120	90	1	120	Carbon Steel	304SS
CS-1499	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	88	82	1	450	Carbon Steel	304SS
CS-1500	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	88	82	1	450	Carbon Steel	304SS
CS-1501	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	114	108	1	474	Carbon Steel	304SS
CS-1502	01138	NY	Albany	Albany County WWTP	2001	1	IIS	50.0	MGD	48	114	108	1	474	Carbon Steel	304SS
CS-1503	01137	NY	Suffolk County	Bergen Point STP	2001	1	IIS			72	258		0.75			
CS-1527	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1528	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1529	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1530	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1531	01205	NY	Bronx	Hunts Point WPCP (Replaced 84-904)	2001	1	IIIAS	80.0	MGD	84	144	132	0.5	144	Carbon Steel	304SS
CS-1539	02253	NY	Binghamton	Binghamton-Johnson County WWTP	2002	1	IIS		MGD	48	270		0.75	381	Carbon Steel	304SS
CS-1540	02253	NY	Binghamton	Binghamton-Johnson County WWTP	2002	1	IIS		MGD	48	270		0.75	381	Carbon Steel	304SS
CS-1559	01137	NY	Suffolk County	Bergen Point STP	2001	1	IIS		MGD	72	258	135	0.75	414	304SS	304SS
CS-1560	01137	NY	Suffolk County	Bergen Point STP	2001	1	IIS		MGD	72	258	135	0.75	414	304SS	304SS
CS-1594	04401	NY	Brooklyn	Coney Island WPCP (Replaced 84-927 CS-32	2004	1	IIS		MGD	60	218.438		0.75	218.4375	Carbon Steel	304SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1595	04401	NY	Brooklyn	Coney Island WPCP (Replaced 84-927 CS-32	2004	1	IIS		MGD	60	218.438		0.75	218.4375	Carbon Steel	304SS
CS-1596	04401	NY	Brooklyn	Coney Island WPCP (Replaced 84-927 CS-32	2004	1	IIS		MGD	60	218.438		0.75	218.4375	Carbon Steel	304SS
CS-1599	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1600	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1601	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1602	05462	NJ	Sayreville	Sayreville PS	2005	1	IIS	100.0	MGD	60	296.5		1	440.5	304SS	304SS
CS-1604	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1605	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1606	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1607	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Coarse)	2004	1	IIIAS			81	174		1.25	336	Carbon Steel	304SS
CS-1608	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1609	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1610	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1611	04451	NY	Brooklyn	Owls Head WPCP (Replaced 84-926 Fine)	2004	1	IIIAS			81	174		0.75	336	Carbon Steel	304SS
CS-1621	05476	NJ	Camden County	Camden County WWTP	2005	1	IIS	150.0	MGD	72	276	126	1	276	Carbon Steel	304SS
CS-1622	05476	NJ	Camden County	Camden County WWTP	2005	1	IIS	150.0	MGD	72	276	126	1	276	Carbon Steel	304SS
CS-1623	05476	NJ	Camden County	Camden County WWTP	2005	1	IIS	150.0	MGD	72	276	126	1	276	Carbon Steel	304SS
CS-1624	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1625	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1626	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1627	04441	NY	New York	13th St. Manhattan PS (Replaced 85-032)	2004	1	IIIAS	100.0	GPM	66	144	120	1	522	Carbon Steel	316SS
CS-1629	05486	NY	Onondaga County	Baldwinsville Senera Knolls	2005	1	IIS		MGD	48	66		1	360	304SS	304SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1630	05486	NY	Onondaga County	Baldwinsville Senera Knolls	2005	1	IIS		MGD	48	66		1	360	304SS	304SS
CS-1631	05486	NY	Onondaga County	Ley Creek PS	2005	1	IIS		MGD	48	260.5		1	260.5	304SS	304SS
CS-1632	05486	NY	Onondaga County	Ley Creek PS	2005	1	IIS		MGD	48	260.5		1	260.5	304SS	304SS
CS-1633	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	71	203.5		0.75	203.5	304SS	304SS
CS-1634	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	71	203.5		0.75	203.5	304SS	304SS
CS-1635	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	72	150.625		1.5	150.625	304SS	304SS
CS-1636	05486	NY	Onondaga County	Metropolitan Syracuse Effluent Channel	2005	1	IIS		MGD	72	150.625		1.5	150.625	304SS	304SS
CS-1650	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1651	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1652	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1653	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1654	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1655	05504	NJ	Rahway	Rahway Valley WWTP	2005	1	IIS	52.5	MGD	72	145	72	3	369	Carbon Steel	304SS
CS-1657	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1658	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1659	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1660	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1661	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1662	05509	NY	Brooklyn	Paerdegat PS	2005	1	IIIAS	333.0	MGD	108	322	168	1.25	322	Carbon Steel	316SS
CS-1690	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS
CS-1691	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS
CS-1692	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1693	08610	NY	Brooklyn	Newtown Creek WPCP (Replaced 86-119)	2008	1	IIIAS	100.0	MGD	78	148.5	86	1	496.5	Carbon Steel	316SS
CS-1720	09657	NY	New York	Powell's Cove PS (Replaced 84-937)	2009	1	IIS		MGD	54	90		1.25	408	Carbon Steel	316LSS
CS-1739	09671	NY	Albany	Albany North & South WWTP	2009	1	IIS		MGD	60	114		1	468	Carbon Steel	304LSS
CS-1740	09671	NY	Albany	Albany North & South WWTP	2009	1	IIS		MGD	48	88		1	444	Carbon Steel	304LSS
CS-1751	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1752	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1753	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1754	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1755	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1756	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1757	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1758	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1759	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1760	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1761	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1762	10700	NY	Brooklyn	Newtown Creek WPCP (Secondary)	2010	1	IIS	70.0	MGD	76	276	156	0.375	276	Carbon Steel	304SS
CS-1768	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	98.5	98.5	1	300.5625	Carbon Steel	304SS
CS-1769	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	98.5	98.5	1	300.5625	Carbon Steel	304SS
CS-1770	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	102	102	1	288	Carbon Steel	304SS
CS-1771	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	93	93	1	413.25	Carbon Steel	304SS
CS-1772	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	93	93	1	413.25	Carbon Steel	304SS
CS-1773	10703	NY	Brooklyn	26th Ward WPCP (Replaced 89-441)	2010	1	IIIAS	45.0	MGD	66	88	88	1	413.25	Carbon Steel	304SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1794	11751	NY	Troy	Rensselear County District #1 WWTP	2011	1	IIS	30.0	GPM	48	119	119	0.75	119	Carbon Steel	304SS
CS-1795	11751	NY	Troy	Rensselear County District #1 WWTP	2011	1	IIS	30.0	GPM	48	119	119	0.75	119	Carbon Steel	304SS
CS-1799	11762	NJ	Sayreville	MCUA Sayreville PS	2011	1	IIS	56.0	GPM	72	297		0.625	471	304SS	304SS
CS-1800	11762	NJ	Sayreville	MCUA Sayreville PS	2011	1	IIS	56.0	GPM	72	297		0.625	471	304SS	304SS
CS-1801	11762	NJ	Sayreville	MCUA Sayreville PS	2011	1	IIS	56.0	GPM	72	297		0.625	471	304SS	304SS
CS-1806	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1807	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1808	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1809	11771	NY	Jamaica	Jamaica WPCP (Replaced 88-271)	2011	1	IIIAS	67.0	MGD	99	112.5	112.5	1	398.5	Carbon Steel	304SS
CS-1816	13819	PA	Allentown	Kline's Island WWTP	2013	1	IIS	88.0	MGD							
CS-1817	13819	PA	Allentown	Kline's Island WWTP	2013	1	IIS	88.0	MGD							
CS-1818	13821	NY	Syracuse	Metro Grit Facility	2013	1	IIS	45.0	MGD							
CS-1819	13821	NY	Syracuse	Metro Grit Facility	2013	1	IIS	45.0	MGD							
CS-1820	13821	NY	Syracuse	Metro Grit Facility	2013	1	IIS	45.0	MGD							
CS-1839	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1840	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1841	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1842	14846	NY	Hempstead	Bay Park STP	2014	1	IIS	80.0	MGD	66						
CS-1850	15866	NY	Astoria	Bowery Bay WPCP	2015	1	IIIAS	80.0	MGD	84	102	102	1	255	Carbon Steel	304SS
CS-1851	15866	NY	Astoria	Bowery Bay WPCP	2015	1	IIIAS	80.0	MGD	84	102	102	1	255	Carbon Steel	304SS
CS-1852	15866	NY	Astoria	Bowery Bay WPCP	2015	1	IIIAS	80.0	MGD	84	102	102	1	255	Carbon Steel	304SS
CS-1862	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS

Climber Screen® Installation List
Type IIS and IIIAS
NJ, NY, PA
2000-2015

Serial Number	Contract#	State	Location	Name	Year	Qty	Type	Design Flow Rate	Unit of Measure	Channel Width	Channel Depth	Max. Water Depth	Clear Spacing	Channel Invert to Operating Floor	Material - Non Wetted	Material - Wetted
CS-1863	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
CS-1864	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
CS-1865	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
CS-1866	15893	NY	Flushing	Flushing Bay CSO	2015	1	IIIAS	280.0	MGD	138	367		1.25	367	Carbon Steel	304SS
				Total Number:		**106**										

Appendix B

ROMAG™ Installation List

(Source: WesTech Engineering, Inc.)

Job No.	Year	Location				Qty	Size	Equipment/Model
20855	2009	MUNCIE, IN WPCF	MUNCIE	IN	US	1		ROMAG CSO SCREEN RSW854
21335	2012	10TH STREET PUMP STATION	JEFFERSONVI LLE	IN	US	1	1 Meters	ROMAG CSO SCREEN RSW115.54
21629	2013	FOURTH CREEK WWTP	KNOXVILLE	TN	US	1	1 Meters	ROMAG CSO SCREEN RSW-K1034
22138	2014	ARCHBALD WWTF	JERMYN	PA	US	1	1 Meters	ROMAG CSO SCREEN RSW724
22156	2014	CLINTON CSO LONG TERM CONTROL PLAN PHASE 1	CLINTON	IN	US	1	4 Meters	ROMAG CSO SCREEN RSW724
22430	2015	GLENS FALLS WWTP	GLENS FALLS	NY	US	1	16 MGD	ROMAG CSO SCREEN RSW-K724
22440	2015	LANCASTER NORTH PUMPING STATION	LANCASTER	PA	US	2	160 MGD	ROMAG CSO SCREEN RSW1254
22463	2016	TOWN BRANCH WET WEATHER STORAGE FACILITY	LEXINGTON	KY	US	1	57 MGD	ROMAG CSO SCREEN RSW864
22596	2016	WOLF RUN WET WEATHER STORAGE FACILITY	LEXINGTON	KY	US	1	7.3 MGD	ROMAG CSO SCREEN RSW824
22676	2016	KENTUCKY AVENUE INTERCEPTOR SEWER IMPROVEMENTS	FRANKFORT	KY	US	1	20 MGD	ROMAG™ CSO SCREEN RSW634
22742	2016	LOWER CANE RUN WET WEATHER STORAGE	LEXINGTON	KY	US	1	20 MGD	ROMAG™ CSO SCREEN RSW634
23133	2017	JOLIET CSO WET WEATHER TREATMENT FACILITY	JOLIET	IL	US	1		ROMAG™ CSO Screen RSW884

Total Qty = **13**

Appendix C

Storm King® Vortex Separator Installation List

(Source: Hydro International)

Storm King Installation List

Plant / Job Name	Start-up Date	Contact	Plant Peak Flow, mgd	Equipment	Engineer	Rep	Appl
Hartford, CT WPCP	Jun-95		60.0	(2) 30' Storm King®	Blasland & Bouck Engineers	Aqua Solutions	CSO
Columbus, GA 19th Street - Uptown Park WRF Advanced Demostration Facility	Dec-95	Mike Burch 706-617-4981 mburch@cwwga.org	48 4.9	(6) 32' Storm King® (1) 8.5' FSU Grit King® (1) Classifier	Parsons Engineering Science	PEI	CSO-HW
Columbus, GA State Docks WRF South Commons	Sep-95	Mike Burch 706-617-4981 mburch@cwwga.org	48.0 4.0	(6) 35' Storm King® (2) 8' FSU Grit King® (2) Classifier	JJ & G	PEI	CSO
Lemont, IL WRP Wet Weather Treatment Facility and Reservoir	Jun-15		7.0	(1) 24' Storm King®	CH2M Hill	Drydon	CSO
Round Lake Beach, IL Round Lake Sanitary District	Jan-16		25.0	(1) 30' Storm King®	Christopher Burke Engineering 9575 W. Higgins Road, # 600 Rosemont, IL 60018	Drydon	CSO
Boonville, IN CSO North and South Basin	Feb-12		84.0	(2) 44' Storm King®	Midwestern Engineers	HPT	CSO
Bucksport, ME CSO	Apr-08	David Michaud, Opterator (207)469-0021 DEMichaud@aquaamerica.com	2.9	(1) 18' Storm King®	Wright Pierce Engineers	Aqua Solutions	CSO
Saco, ME CSO Treatment Facility	Nov-06	John Hart Superintendent (207) 282-3564	5.6 8.6	(1) 22' Storm King® (1) 12' ISU Grit King® (1) Type 2 Classifier	Deluca-Hoffman Associates	Aqua Solutions	HW/CSO
Redford, MI Rogue River CSO Retention Basin	Oct-96		61.0	(1) 35' Storm King®		Pumps Plus	CSO
New York, NY Corona Avenue	Oct-01		130.0	(1) 43' Storm King®	URS		CSO
Browndale, PA Clinton WWTP	Feb-06	Glenn Butler Bill Stanvitch Mike Dodgson	15.0	(1) 32' Storm King® (1) 6' ISU Grit King® (1) 12" Classifier	Montgomery Watson Harza	Sherwood Logan	CSO
Conyngham Borough, PA CSO	Nov-99	Jamie Wasilewski Operator (570)788-0608 ext.1	2.0	(1) 18' Storm King®	RDK Engineering	Sherwood Logan	CSO
Hazelton, PA Greater Hazelton JSC - CSO 002	May-11		14.0	(1) 30' Storm King®	Gannett Fleming	Sherwood Logan	CSO
Hazelton, PA Sixth & Ridge CSO	Jun-08	Chris Carcia Director of Operations (570)454-0851	2.6	(1) 18' Storm King®	Gannett Fleming		CSO

Appendix D

HYDROVEX® FluidSep Vortex Separator Installation List

(Source: Veolia Water Technologies)

4105 Sartelon, Saint-Laurent, Québec, Canada, H4S 2B3
T: 514-334-7230
F: 514-334-5070
cso@veolia.com | www.hydrovex.com

HYDROVEX® FluidSep Vortex Separator
Installation List

	Country	Project	Qty	Type	Diameter (m)	Diameter (ft)	Inlet Flow Rate (L/s)	Inlet Flow Rate (MGD)	Installation Year
1	USA	Burlington, Vermont	1	2.5	12.20	40.03	2629	60	1990
2	USA	Decatur, Illinois, Lincoln Park	4	2.5	13.40	43.96	18230	416	1990
3	USA	Decatur, Illinois, 7th Ward	1	3	13.40	43.96	4951	113	1990
4	USA	Decatur, Illinois, Oakland Park	1	1.35	8.10	26.57	920	21	1991
5	USA	Saginaw, Michigan, 14th Street	3	2.5	11.00	36.09	8500	194	1991
6	USA	Saginaw, Michigan, Weiss	1	3	11.00	36.09	2848	65	1992
7	USA	Cincinnati, Ohio, Daly Rd.	1	3	12.20	40.03	2973	68	1993
8	USA	New York City, C80 #3	1	3	13.10	42.98	5663	129	1994
9	USA	Richmond, Virginia	1	1	2.60	8.53	150	3	1995
10	Canada	The Regional Municipality of Niagara, ON	2	2	12.00	39.37	2000	46	2006
11	USA	Riley Creek CSO, Mattoon, IL	1	2	6.40	21.00	657	15	2016
		Total	**17**	**Units**					

www.hydrovex.com

Revised: July 13, 2017

Appendix E

SanSep Installation List

(Source: Echelon Environmental)

SANSEPtm INSTALLATION & CONTACT LIST

YEAR INSTALLED	LOCATION	OWNER	ENGINEER	DETAILS
1999	LOUISVILLE, KY CSO 50	LOUISVILLE & JEFFERSON CTY MSD Roddy Williams (now works for Strand Associates in Louisville) Derek Guthrie (now works for HDR in Louisville)	HDR (OMNI ENGINEER'ING) Gary Boblett Louisville & Jefferson Cty MSD Darren Thompson	Single PCS50_50; 10 cfs
2000	LOUISVILLE, KY CSO 108	LOUISVILLE & JEFFERSON COUNTY MSD	HDR (OMNI ENGINEERING)	Twin PCS70_70; 38 cfs
2002	AKRON, IN CITY LAKE CSO TREATMENT FACILITIES	AKRON, IN PUBLIC WORKS DEPT Marty Gearhart, Superintendent (574) 893-4674	COMMONWEALTH ENGINEERS Mark Sullivan, PE 7256 Company Drive Indianapolis, IN 46237 (317) 888-1177	PCSC56_40; 10 cfs. PCSC30_30; 4 cfs
2004	COHOES, NY N. NIAGARA AVE CSO OUTFALL	CITY OF COHOES, NY PUBLIC WORKS DEPT. Billy Kane, Maintenance Mgr. Office - (518) 488-8622 ALBANY REGIONAL SEWER DIST. Timothy S. Murphy, Permit Compliance Mgr. Office - (518) 447-1614	MALCOLM PIRNIE Robert E. Ostapczuk, PE 855 Route 146 Suite 210 Clifton Park, NY 12065 Office – (518) 250-7305	PCS100_100; 42 cfs
2004	WEEHAUKEN, NJ W5	NORTH HUDSON SEWER DISTRICT, WEEHAUKEN, NJ CONTRACT OPERATOR – OMI SERVICES JAMES HOWEY, Regional Mgr. 10 Brondesbury Drive Cherry Hill, NJ 08003 856-751-0213 Mohankumar Boraiah CH2M Hill 1600 Adams Street Hoboken, NJ 07030 Ph: 201-386-9847 Cell: 201-344-2783	CH2M-HILL Vincent Rubino, PE Kelly O'Connor, PE 119 Cherry Hill Road Parsippany, NJ 07054-1102 973-316-9300	Twin PCS70_80; 64 cfs

SANSEP^tm INSTALLATION & CONTACT LIST

YEAR INSTALLED	LOCATION	OWNER	ENGINEER	DETAILS
2006	NIAGARA FALLS, ON, CANADA MUDDY RUN PUMP STA. HRT COMPARISON	NIAGARA FALLS REGION AUTHORITY		Single PCS40_30 Demonstration site with StormKing 8 ft diameter unit.
2008	FORT WAYNE CSO 58, FORT WAYNE, IN.	FORT WAYNE PUBLIC UTILITIES Wendy Reust, PE, CSO Program Mgr. One Main St., Room 480 Fort Wayne, IN 46801-1804 Office - 260-427-1367	CDM Karl E. Tanner, PE 151 N. Delaware St. Suite 1520 Indianapolis, IN 46204 Office - 317-637-5424	Twin PCS70_70; 10 cfs
2013	CSO 026 – HARBOR BROOK WETLANDS PILOT PROJECT	ONONDAGA COUNTY DEPT OF WATER ENVIRONMENT	CHA – CH2M-HILL JOINT Rich DeGuida, PE (CHA) 441 S Salina St. Syracuse, NY 13202 Office – 315-471-3920	Double 80-80, 44 cfs
2015	Taylorville, Illinois	City of Taylorville	Crawford, Murphy and Tilly Jeffery Large 217 572-1131	Single 70_70 with gravity underdrain
EUROPEAN INSTALLATIONS				
2005	LONDON	LONDON SEWER DEPT		PCS70_70; 450 l/sec
PACIFIC RIM				
1998	SYDNEY, AUSTRALIA		CDS TECHNOLOGIES PTY LTD.	PCS100_100; 1000 l/sec
2002	BRISBANE, AUSTRALIA		CDS TECHNOLOGIES PTY LTD.	PCS65_65; 400 l/sec
2002	SEOUL, S. KOREA, CHUNG GAE CSO FACILITY	SEOUL PUBLIC WORKS DEPT	KOGET ENVIRONMENTAL TECH.	6 each PCS100_100, 1,000 l/sec each

Appendix F

ACTIFLO® Ballasted Flocculation Unit Installation List

(Source: Veolia Water Technologies)

KRÜGER

ACTIFLO Wet Weather Installation List

Jul-17

Installation Number	Name	Application	Location	Year Startup	Total Capacity	Number of Trains
1	St. Bernard, LA	ACTIFLO	At WWTP	2001	10	1
		BIOACTIFLO	At WWTP	2011	7.5	1
2	Bremerton, WA	ACTIFLO	Satellite	2001	10	1
3	Lawrence, KS	ACTIFLO	At WWTP	2003	40	2
4	Fort Smith, AR (P Street)	ACTIFLO	At WWTP	2004	31	1
5	Port Clinton, OH	Dual Mode ACTIFLO*	At WWTP	2004	24	2
6	Greenfield, IN	Dual Mode ACTIFLO*	At WWTP	2004	8	2
7	Fort Worth, TX	ACTIFLO	At WWTP	2005	110	2
8	Port Orchard, WA	ACTIFLO	At WWTP	2006	6.7	1
9	Cincinnati SSO 700, OH	ACTIFLO	Satellite	2006	15	1
10	Heart of the Valley (HOV) Kaukauna, WI	Dual Mode ACTIFLO*	At WWTP	2007	60	2
11	Salem, OR	ACTIFLO	Satellite	2007	50	2
12	Cincinnati, OH Sycamore Creek	ACTIFLO	At WWTP	2008	32	2
13	Tacoma, WA	ACTIFLO	At WWTP	2008	76	2
14	Geneva, NY	ACTIFLO	Satellite	2008	23	1
15	Nashua, NH	ACTIFLO	At WWTP	2008	60	2
16	Fort Smith, AR (Sunnymede Pump Station)	ACTIFLO	Satellite	2010	25	1
17	Newark, OH	ACTIFLO	At WWTP	2011	28	2
18	Wilson Creek, TX Phase 1	Dual Mode BIOACTIFLO*	At WWTP	2012	36	1
	Wilson Creek, TX Phase 2 (under construction)		At WWTP	2017	36	1
19	Lowell, IN	ACTIFLO	At WWTP	2013	10	1
20	Rock Creek, OR	Dual Mode ACTIFLO*	At WWTP	2013	30	2
21	Knoxville, TN	BIOACTIFLO	At WWTP	2013	11	2
22	Terra Haute, IN	ACTIFLO	Satellite	2016	16.5	1
23	Nappanee, IN (under construction)	ACTIFLO	Satellite	2017	5	1
24	Cox Creek, MD (under construction)	BIOACTIFLO	At WWTP	2017	12	1
25	McHenry, IL (under construction)	BIOACTIFLO	At WWTP	2017	10	1
26	DC Water (under construction)	ACTIFLO	At WWTP	2018	250	3

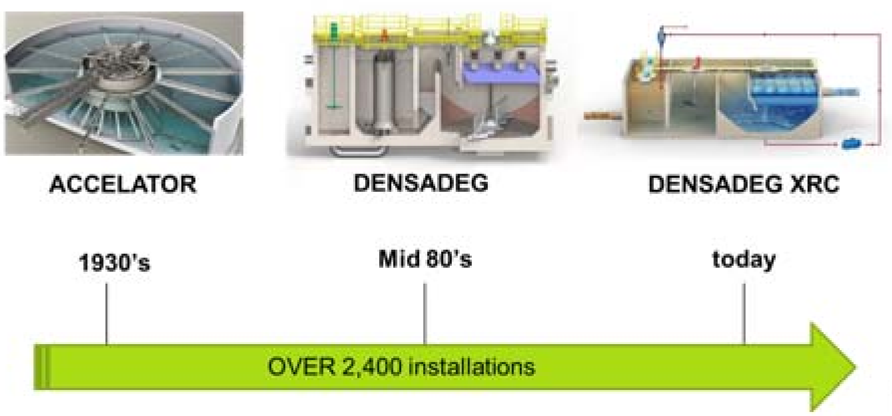
* Note: Dual mode means the ACTIFLO treatment train is used during dry weather flows for either primary or tertiary treatment.

Appendix G

DensaDeg® Ballasted Flocculation Installation List

(Source: Suez)

SUEZ has been providing high rate solids contact system for over 85 years. The new DensaDeg XRC™ has been born out of decades of improvements, starting with the original solids-contact clarifier, the Accelator, which was the first to incorporated internal sludge recycling. In the late 1980's the original DensaDeg clarifier was introduced to the market and continues to lead the industry for high-rate sludge ballasted and solids recirculation systems. While the DensaDeg XRC™ is recently introduced in 2015, it is merely an improvement upon a history of existing installations and operating principles, including over 2,400 installations over this span.



DENSADEG XRC

A year-long pilot study was conducted at Petersburg WWTP, VA, which included testing of the primary influent and secondary effluent from the plant. A case study summary is provided in **Addendum 3** of this proposal.

CSO/SSO REFERENCES

Below you will find a list of select installations for the original DensaDeg in CSO/SSO applications.

1 – McLoughlin Point WWTP, British Columbia, Canada – 64.5 MGD, 2019

2 – Shreveport WWTP, Louisiana – 40 MGD, 2006

3 – Toledo WWTP, Ohio – 232 MGD, 2006

Mr. Alan Ruffle, 419-727-2618

4 – Halifax WWTP, Nova Scotia, Canada – 92 MGD, 2005

5 – Edinborough, Scotland, UK -- 2002

6 – Aix-En-Provence (De La Pioline) WWTP, France – 25MGD, 2001

7 – Bourg-End-Bresse (De Majornas) WWTP, France – 22MGD, 2000

8 – Limoges WWTP, France – 23.8 / 33.6 MGD, 2000

9 – Meru (De L'Eau D'Amont) WWTP, France – 3.2MGD, 1999

10 – Saint-Chamond WWTP, France – 63.5MGD, 1999

11 – Colombes (Seine Centre) WWTP, France – 277MGD, 1998

12 – Bonneuil-En-France WWTP, France – 81.5 MGD, 1996

13 – Metz (Station Nord) WWTP, France – 68.5MGD, 1995

Appendix H

FlexFilter Installation List

(Source: WesTech Engineering, Inc.)

WWETCO FlexFilter™

Installation and Reference List

This partial list is composed of our key installations for this product. If you would like an expanded or more customized installation or reference list, please contact WesTech Engineering, Inc.

Plant Name	Location City/Sate	Quantity Size	Capacity Equipment Application	Contact Information
Springfield WWTP	Springfield, Ohio	11 30 ft. x 27 ft.	100 MGD Flex Filters CSO Treatment	Bill Young: Plant Superintendent, Springfield WWTP P: (937) 328.7626 E: byoung@springfieldohio.gov
Choctaw Pines	Dry Prong, Louisiana	2 2 ft. x 2 ft.	60 gpm FlexFilters Tertiary Treatment	Russell Turnage: Owner, Turnage Environmental Services P: (318) 447.5291 E: russellturnage@aol.com
Lamar WWTP	Lamar, Missouri	3 6 ft. x 6 ft.	2 MGD FlexFilter Lagoon Effluent Filtration	Rick Hornbeck: Water Plant Superintendent, City of Lamar P: 417-682-4480 E: rhornbeck@cityoflamar.org
Heard County	Franklin, Georgia	2 4 ft. x 4 ft.	0.75 MGD FlexFilters Tertiary Treatment	Jimmy Knight: Director, Heard County Water Authority P: (706) 594.2486 E: jknight@myhcwa.com
Weracoba Creek	Columbus, Georgia	3 6 ft. x 18 ft.	10 MGD FlexFilters Stormwater Treatment	Lynn Campbell: Vice President, Division of Water Resources, Operations, Columbus Waterworks P: (706) 649.3459 E: lcampbell@cwwga.org

WWETCO FlexFilter™

Installation List

This partial list is composed of our key installations for this product. If you would like an expanded or more customized installation or reference list, please contact WesTech Engineering, Inc.

Plant Name	Location City/Sate	Quantity Size	Capacity Equipment Application
Solvay Polymer	Marietta, Ohio	3 6 ft. Diameter	1.44 MGD, Flex Filters Tertiary Treatment
Hope East WWTP	Hope, Arkansas	3 6ft. x13 ft	1.6 MGD, Flex Filters Tertiary Treatment
Hope West WWTP	Hope, Arkansas	3 6ft. x16 ft	2 MGD, Flex Filters Tertiary Treatment
Upper Tuscarawas WWTP	Akron, Ohio	10 6 ft. x 10 ft.	100 MGD, Flex Filters CSO Treatment
Springfield WWTP	Springfield, Ohio	11 30 ft. x 27 ft.	100 MGD, Flex Filters CSO Treatment
Choctaw Pines	Dry Prong, Louisiana	2 2 ft. x 2 ft.	60 gpm, FlexFilters Tertiary Treatment
Lamar WWTP	Lamar, Missouri	3 6 ft. x 6 ft.	2 MGD, FlexFilter Lagoon Effluent Filtration
Heard County	Franklin, Georgia	2 4 ft. x 4 ft.	0.75, MGD FlexFilters Tertiary Treatment
Weracoba Creek	Columbus, Georgia	3 6 ft. x 18 ft.	10 MGD, FlexFilters Stormwater Treatment