SERVICE AREA SYSTEM CHARACTERIZATION REPORT
NBMUA Woodcliff and Guttenberg (WCGB)

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

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

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

“Protecting Public Health and the Environment”

June 2018
SECTION A - INTRODUCTION AND BACKGROUND

A.0 SUMMARY OF CHANGES

A.1 TITLE OF PLAN AND APPROVAL

Title: Service Area System Characterization Report for North Bergen Municipal Utilities Authority (Woodcliff) and Guttenberg

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New Jersey Department of Environmental Protection

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Participating Permittee approval sheets follow:
Service Area System Characterization 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:  
Frank Pestana  
Executive Director, North Bergen Municipal Utilities Authority  

date: 6/25/16

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:  
Frank Pestana  
Executive Director, North Bergen Municipal Utilities Authority  

date: 6/25/16
Service Area System Characterization Report

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

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Approval of this submittal:

Permittee: [Signature]
Frank Pestana
Licensed Operator, Town of Guttenberg

Date: 6/25/18

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.

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Appendix A - Combined Sewer Overflow and Stormwater Sampling Results
A.5 BACKGROUND
The North Bergen Municipal Utilities Authority (NBMUA) provides wastewater collection and treatment to the Township of North Bergen. The combined sewer system (CSS) and sewerage facilities are owned by the Township of North Bergen; however, the NBMUA operates and holds the New Jersey Pollutant Discharge Elimination System (NJPDES) Permit for the facilities.

The total area of North Bergen Township is approximately 3,346 acres including land and water. North Bergen topography is divided into two areas, the western and central area of North Bergen slopes towards the Hackensack River and the eastern area slopes towards the Hudson River. The western and central section of the NBMUA service area is considered part of the Passaic Valley Sewerage Commission (PVSC) Service Area and discussed under the PVSC Service Area System Characterization Report dated June 2018. The extent of the PVSC service area 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 one of the focus areas in this report.

The total area of Guttenberg Township is approximately 124 acres. 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 CSO outfalls located at the Hudson River.

The Woodcliff STP is owned and operated by the NBMUA. It receives sewer flows from the eastern North Bergen and Guttenberg. The combined dry weather flow from these two townships are slightly less than 3 MGD. The Woodcliff STP sewer system includes two CSO outfalls associated with the NBMUA Woodcliff and another CSO outfall associated with the Town of Guttenberg. Both NBMUA Woodcliff 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 and Woodcliff – Guttenberg Service Areas
Figure A-2: The Woodcliff – Guttenberg Service Area
Figure A-3: Flow Schematic of the Woodcliff – Guttenberg Service Area
Permit Requirements

In 2015, the New Jersey Department of Environmental Protection (NJDEP) reissued two NJPDES permits to NBMUA including discharge Permit No. NJ0108898, which includes eight outfalls allowing combined sewer regulator overflow to the Hackensack River, and Permit No. NJ0029084 allowing the Woodcliff STP NJDEP and one combined sewer regulator outfall to discharge to the Hudson River. The Town of Guttenberg was also reissued NJDEP Permit No. NJ0108715 in 2015 allowing one combined sewer regulator to overflow to the Hudson River.

The NJPDES permits issued to each party include requirements for the Woodcliff STP and Guttenberg to cooperatively develop a CSO LTCP to reduce CSO discharges to the receiving waters. To facilitate the CSO LTCP development, at the request of NBMUA and Guttenberg, PVSC’s LTCP Consulting Engineer has been contracted to develop the System Characterization and Landside Modeling Program and Service Area System Characterization Report on behalf of these permitees.

This System Characterization Report constitutes the Woodcliff – Guttenberg Service Area System Characterization Report (SCR) on behalf of the NBMUA (Woodcliff) and the Town of Guttenberg. Any mention in this report of the NBMUA central or western infrastructure which is part of the PVSC Service area is only included where it is necessary in order to properly characterize the NBMUA CSS.

Historical Characterization Reports

Between 2003 and 2007, the NBMUA, representing both North Bergen and Guttenberg, conducted Combined Sewer Overflow Discharge Characterization Studies for all regulators and interceptor sewers owned and operated within their system. This study developed background information on the combined sewer systems tributary to each regulator as well as the analysis of historical rainfall patterns, overflow volumes and pollutants contained in the CSO discharges. The reports were developed under the following studies:

- **CSO Characterization Study Group 1 Dry Weather Quality and Quantity Monitoring Report (March 2003)**
- **CSO Characterization Study Group 2 Dry Weather Quality and Quantity Monitoring Report (June 2003);**
- **CSO Characterization Study Water Quality and Quantity Monitoring Report (March 2005)**

NBMUA and Guttenberg developed a monitoring program that collected dry and wet weather data that was used to calibrate and verify a hydraulic model for each CSO basin upstream of the Woodcliff STP. This data also defined the CSS response to rainfall and determined the quality and quantity of dry weather flow (DWF) in the system as well as determine CSO flow quantities and pollutant concentrations/loadings discharged to receiving streams.

These historical studies developed background information on the combined sewer systems tributary to each regulator as well as the analysis of historical rainfall patterns, overflow volumes and pollutants contained in the CSO discharges. The information collected and the modeling
tools developed under these previous studies were supplemented and updated as part of the System Characterization and Landside Modeling Program Quality Assurance Project Plan (QAPP). Each section of the QAPP summarized the data collected under previous studies (performed under past QAPPs) and outlined the supplemental data collected under the most recent QAPP. Baseline Compliance Monitoring and Receiving Water Quality Modeling of the receiving waters were also addressed under a separate QAPP.

A.6 PURPOSE OF REPORT

Section D.3.b.i of the NJDEP permit indicates that as part of the LTCP requirements a System Characterization Work Plan must be completed and submitted 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 North Bergen Municipal Utilities Authority (MUA) (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 Long Term Control Plan (LTCP).

In accordance with the NJPDES Permits LTCP requirements, a System Characterization Report shall be submitted by July 1, 2018. This System Characterization Report (SCR) has been developed to meet the permit requirements and incorporates the results of the Quality Assurance Project Plan (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. This 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.

A.7 SUMMARY OF WORK PLANS/QAPP

In accordance with consultation with NJDEP as NJPDES permitting authority, the following QAPPs were developed to cover different aspects of the LTCP work activities.

1. System Characterization and Landside Modeling Program QAPP, which includes wastewater collection system sampling and analysis as well as landside modeling. The System Characterization and Landside Modeling Program QAPP outlines the program necessary to address this requirement of the Permit. The results of the System Characterization Wastewater Collection System Sampling and analysis program are included in this System Characterization Report.

2. Baseline Compliance Monitoring QAPP, which includes sampling and analysis of the receiving waters. The results of the sampling and analysis of the Baseline
Compliance Monitoring of the Receiving Waters will be included under a separate report; the Compliance Monitoring Program Report.

3. **Pathogen Water Quality Modeling QAPP**; which includes the computational model of the receiving waters (Not a permit requirement).

The project goals and objectives for the System Characterization and Modeling Program included:

- Supplement and update, as appropriate, the site specific dry and wet weather data to be used to recalibrate and verify the InfoWorks collections system model of those collections systems tributary to the Woodcliff STP.
- Define the CSS’s hydraulic response to rainfall.
- Supplement the existing dry weather water quality and quantity data to be used in the representation of each CSO drainage basin.
- Determine the CSO flows and pathogen concentrations/loadings being discharged to the receiving streams as a result of varied rainfall events.
- Supplement the stormwater quality data for various land use applications.

The purpose of the proposed monitoring program was to quantify and qualify dry weather and wet weather wastewater flow and pathogen concentration variations at key CSO and stormwater drainage basins to calibrate and verify hydrologic and hydraulic model of the CSS within the Town of Guttenberg and North Bergen Township. This work was used to update the mathematical tool (sewer system model) that will be used to assess residual storage and maximum hydraulic conveyance capacity in the NBMUA (Woodcliff) service area, pathogen concentrations and loading distributions during storm events and among CSO discharge points, calculate pathogen loads to the receiving water, and for the development and evaluation of possible long term control alternatives and/or modifications to the water quality standards (WQS) during wet weather events.

Precipitation monitoring, wastewater quality sampling and flow metering were conducted in order to characterize the CSO quantity and quality for each of the combined sewer drainage areas. The characterization of the CSOs included determination of relationships between rainfall, runoff/overflow volume and pathogen loads. The data obtained was used in the validation of the InfoWorks Collections System Model for all the combined sewer drainage basins tributary to the PVSC control facilities and main interceptor sewer. Monitoring included rainfall intensities, volumes, and duration as well as receiving water stage to determine any backwater effects upon tide gates and discharge volumes.

**A.7.1 Receiving Waters Description**

The Hudson River is the CSO impacted water body in the Woodcliff – Guttenberg Service Area. The receiving waters include the combined sewer service area. The Upper New York Harbor is directly downstream of the Hudson River. The Hudson River is located within the Passaic, Hackensack and New York Harbor Complex.
A.8 CONTENTS OF THIS REPORT
This report documents that the NBMUA and 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 overflows, and water quality issues associated with CSOs emanating from the systems.

The objective of the SCR is to provide the NBMUA and the municipalities 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. An overview of the organization and contents of this system characterization report are provided in Table A-1.

<table>
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<td>Documents the program organization, key responsible individuals, problem definition, background, project description, summary and table of contents.</td>
</tr>
<tr>
<td>B Regulatory Requirements</td>
<td>Describes regulatory requirements and context of the System Characterization Report.</td>
</tr>
<tr>
<td>C Overview of Wastewater Facilities and Service Area</td>
<td>Characterizes the municipalities that are the subject of this system characterization report and current wastewater treatment facilities within the service area.</td>
</tr>
<tr>
<td>D Characteristics of the Combined Sewer System</td>
<td>Characterizes the municipal collection sewers, sewer mains, and appurtenances such as pump stations, existing CSO control facilities, regulator structures, and CSO outfalls.</td>
</tr>
<tr>
<td>E Collection of Precipitation and Sewer Flow Monitoring</td>
<td>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.</td>
</tr>
<tr>
<td>F Characteristics of the Receiving Waters</td>
<td>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.</td>
</tr>
<tr>
<td>G Collection of Water Quality Data</td>
<td>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.</td>
</tr>
<tr>
<td>H Typical Hydrologic Period</td>
<td>Documents the requirements for and selection of the typical year and summarizes the hydrologic characteristics of the typical year.</td>
</tr>
<tr>
<td>Section</td>
<td>Topics Covered</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
</tr>
<tr>
<td>I</td>
<td>Hydrologic and Hydraulic Modeling</td>
</tr>
<tr>
<td></td>
<td>Documents the development and scope of the H&amp;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.</td>
</tr>
<tr>
<td>J</td>
<td>References</td>
</tr>
<tr>
<td>K</td>
<td>Abbreviations</td>
</tr>
</tbody>
</table>
SECTION B - REGULATORY REQUIREMENTS

B.1 INTRODUCTION
The NJPDES permits for the NBMUA Woodcliff STP and the Town of Guttenberg set forth requirements for the completion of the System Characterization Report (SCR) and the development of an LTCP on the following schedule:

- System Characterization Work Plan must be completed and submitted to the NJDEP 6 months from the effective date of the permit – January 1, 2016
- Submittal of the System Characterization Report to NJDEP - July 1, 2018;
- (LTCP Report 1) Development & Evaluation of CSO Control Alternatives - July 1, 2019; and

This report has been written to meet these permit requirements for the NBMUA Woodcliff STP and the Town of Guttenberg. Their respective NJPDES permit numbers are listed in Table B-1 below:

Table B-1: Municipalities Covered Under this System Characterization Report

<table>
<thead>
<tr>
<th>Municipality</th>
<th>NJPDES #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Town of Guttenberg</td>
<td>NJ0108715</td>
</tr>
<tr>
<td>North Bergen MUA (Woodcliff)</td>
<td>NJ0029084</td>
</tr>
</tbody>
</table>

Additional requirements for the Existing Service Area Characterization Report are established in the USEPA’s CSO Control Policy (USEPA, 1994). B.2.2. Section II.C.1 of the CSO Control Policy “Characterization, Monitoring and Modeling of the Combined Sewer System” provides further detailed requirements.

The receiving water that is impacted by CSOs is the Hudson River for the Woodcliff - Guttenberg Service Area. The applicable water quality standards for the Hudson River fall within the jurisdiction of the Interstate Environmental Commission (IEC). The IEC water quality standards are further discussed in Section B.2.4 below.

B.2 REGULATORY CONTEXT

B.2.1 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 New Jersey municipalities and municipal authorities with CSSs were issued new permits in 2015 that set
forth requirements for the completion of the system characterization and the development of LTCPs on the following schedule:

- System Characterization Work Plan (QAPP) must be completed and submitted to the NJDEP 6 months from the effective date of the permit – January 1, 2016
- Submittal of the System Characterization Report to NJDEP - July 1, 2018;
- (LTCP Report 1) Development & Evaluation of CSO Control Alternatives - July 1, 2019; and

The System Characterization Reports are to be updated and to utilize where applicable, previous system inventories and evaluations such as the Sewage Infrastructure Improvement Act Planning Studies conducted in the late 1990s. The municipalities documented their implementation of the nine minimum controls under an earlier NJPDES permit cycle.

With minor exceptions such as lists of applicable previous studies, the 2015 permits are standardized. The 2015 information to be included in the System Characterization Report is specified in Part IV (Specific Requirement: Narrative) paragraph G-1 of the permits. Permit paragraphs G.1.d.i through G.1.d.v. describe the major elements that are required to be covered under the Sewer System Characterization Report. These requirements are reproduced Table B-2 along with the section of this System Characterization Report in which the requirements are addressed and a list of the principal sources of data used for each requirement.

Table B-2: Review of NJDEP Permit Requirements Outlining the Major Elements of the System Characterization Report

<table>
<thead>
<tr>
<th>Permit Section</th>
<th>Permit Requirement</th>
<th>SCR Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part IV G.1.a</td>
<td>“The permittee, as per D.3.a and G.10, shall submit an updated characterization study that will result in a comprehensive characterization of the CSS developed through records review, monitoring, modeling and other means as appropriate to establish the existing baseline conditions, evaluate the efficacy of the CSO technology based controls, and determine the baseline conditions upon which the LTCP will be based. The permittee shall work in coordination with the combined sewer communities for appropriate Characterization, Monitoring and Modeling of the Sewer System.”</td>
<td>Entire SCR</td>
</tr>
<tr>
<td>Part IV G.1.b</td>
<td>“The characterization shall include a thorough review of the entire collection system that conveys flows to the treatment works including areas of sewage overflows, including to basements, streets and other public and private areas, to adequately address the response of the CSS to various precipitation events”</td>
<td>Section C: Overview of Wastewater Treatment Facilities and Service Areas Section D: Characteristics of the Combined Sewer System</td>
</tr>
<tr>
<td>Permit Section</td>
<td>Permit Requirement</td>
<td>SCR Section</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>“The characterization shall identify the number, location, frequency and characteristics of CSOs”</td>
<td>Section I: Hydrologic and Hydraulic Modeling</td>
</tr>
<tr>
<td></td>
<td>“The characterization shall identify water quality impacts that result from CSOs”</td>
<td>Section G: Collection of Water Quality Data</td>
</tr>
<tr>
<td>Part IV G.1.c</td>
<td>“The permittee may use previous studies to the extent that they are accurate and representative of a properly operated and maintained sewer system and of the currently required information”</td>
<td>Section F: Characteristics of the Receiving Waters</td>
</tr>
<tr>
<td>Part IV G.1.d.i</td>
<td>Rainfall Records Analysis</td>
<td>Section E: Collection of Precipitation and Sewer Flow Monitoring</td>
</tr>
<tr>
<td>Part IV G.1.d.ii</td>
<td>Combined Sewer System Characterization</td>
<td>Section D: Characterization of the Combined Sewer System</td>
</tr>
<tr>
<td>Part IV G.1.d.iii</td>
<td>CSO Monitoring</td>
<td>Section I: Hydrologic &amp; Hydraulic Modeling</td>
</tr>
<tr>
<td>Part IV G.1.d.iv</td>
<td>System Hydrologic &amp; Hydraulic Modeling</td>
<td>Section F: Characteristics of Receiving Waters</td>
</tr>
<tr>
<td>Part IV G.1.d.v</td>
<td>The permittee shall identify sensitive areas where CSOs occur</td>
<td></td>
</tr>
</tbody>
</table>

**B.2.2 USEPA’s CSO Control Policy**

USEPA’s CSO Control Policy (Policy) was issued in April of 1994[^1] to elaborate on the 1989 National CSO Control Strategy and to expedite compliance with the requirements of the Clean Water Act (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 authorities (e.g. the

[^1]: 59 FR 18688 et seq.
The Policy establishes a framework for the coordination, planning, selection and implementation of CSO controls required for permittee compliance with the Clean Water Act (CWA).

The Policy includes three major activities required of municipalities with CSO related permits:

- **System Characterization** – The identification of current CSS assets and current performance characteristics;
- **Implementation of the Nine Minimum Controls** – identified in the Policy to ensure that the current CSS is being optimized and properly maintained; and
- **Development of a Long-Term Control Plan (LTCP)** – The analysis and selection of long term capital and institutional improvements to the CSS that once fully implemented will result in compliance with the CWA.

The Policy includes provisions for public and stakeholder involvement (e.g. the CSO Supplemental Committees), the assessment of affordability (rate-payer impacts) and financial capability (permittee ability to finance the long-term controls) as a driver of implementation schedules and two CSO control alternatives. The “presumption” approach is premised on the presumption that the achievement of certain performance standards, e.g. no more than an average of four overflow events per year; or the elimination or capture of at least 85% by volume of the combined sewage collected in the CSS during precipitation events; or the elimination or removal of no less than the mass of the pollutants for the volume that would be eliminated or captured of wet weather flow (WWF) during a typical year, would result in CWA compliance subject to post-implementation verification. Under the “demonstration” approach, permittees demonstrate that their proposed controls do not cause or contribute to a violation of receiving stream preclude the attainment of water quality standards.

The Policy includes regulations for the collection of water quality data required of municipalities with CSO related permits. Section II.C.1 of the CSO Control Policy “Characterization, Monitoring and Modeling of the Combined Sewer System” states:

“In order to design a CSO control plan to adequately 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

---

B-2 The Interstate Environmental Commission (IEC) is a tristate air and water pollution control agency – that is, a joint agency – serving the states of New York, New Jersey, and Connecticut. The nine minimum controls include: 1) proper operation and regular maintenance; 2) maximizing the use of the collection system for storage where feasible; 3) review and modification of the Industrial Pretreatment Program to minimize CSO impacts; 4) maximization of flow to the wastewater treatment plant; 5) the prohibition of CSOs during dry weather; 6) control of solids and floatables (addressed by NJDEP’s requirement of screening or other facilities in the late 2000s); 7) pollution prevention; 8) public notification; and 9) monitoring CSO impacts and controls. 59 FR 18691.
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 CSO Control Policy states that the major elements of a sewer system characterization include:

**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.”

**CSS 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.”

**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.”

**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.”

**B.2.3 USEPA CSO Guidelines**

The data collection, analyses and this characterization report were written and conducted in conformance with the applicable USEPA guidance documents as shown in **Table B-3.**
### Table B-3: USEPA Guidance Documents Used in the Preparation of the System Characterization Report

<table>
<thead>
<tr>
<th>Title</th>
<th>Date</th>
<th>Document Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined Sewer Overflows Guidance for Long-Term Control Plan</td>
<td>1995</td>
<td>EPA 832-B-95-002</td>
</tr>
<tr>
<td>Combined Sewer Overflows Guidance for Screening and Ranking</td>
<td>1995</td>
<td>EPA 832-B-95-004</td>
</tr>
<tr>
<td>CSO Post Construction Compliance Monitoring Guidance</td>
<td>2011</td>
<td>EPA-833-K-001</td>
</tr>
<tr>
<td>Guidance for Quality Assurance Project Plans</td>
<td>2002</td>
<td>EPA/240/R-02/009</td>
</tr>
<tr>
<td>Guidance: Coordinating CSO Long-Term Planning with Water Quality Standards Reviews</td>
<td>2001</td>
<td>EPA-833-R-01-002</td>
</tr>
<tr>
<td>Manual: Combined Sewer Overflow Control</td>
<td>1993</td>
<td>EPA/625/R-83-007</td>
</tr>
<tr>
<td>NPDES Permit Writer's Manual</td>
<td>2010</td>
<td>EPA-833-K-10-001</td>
</tr>
<tr>
<td>Sewer System Infrastructure Analysis &amp; Rehabilitation</td>
<td>1991</td>
<td>EPA/625/6-91-030</td>
</tr>
</tbody>
</table>

### B.2.4 Interstate Environmental Commission Requirements

The Woodcliff-Guttenberg Service Area falls within the jurisdiction of the Interstate Environmental Commission (IEC). The Interstate Environmental Commission (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 interstate 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\(^4\) and the New Jersey Water Pollution Control Act.\(^5\)

The IEC has specified two classes of waters:\(^6\)

**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.

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\(^4\) 33 U.S.C. Chapter 26

\(^5\) N.J.S.A 58:10A-1 et seq.

\(^6\) Source: IEC website: http://www.iec-nynjct.org/wq.regulations.htm
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.”

- **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-1**.

![Figure B-1: Interstate Environmental Commission Water Quality Classifications](image)

As shown in **Figure B-1**, 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-4** 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-4: IEC Water Quality Standards for IEC Class B Waters

<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>Class B-1</td>
<td>≥ 4 milligrams per liter</td>
</tr>
<tr>
<td>Class B-2</td>
<td>≥ 5 milligrams per liter</td>
</tr>
<tr>
<td>Classes B-1 &amp; B-2</td>
<td>Further, all sewage or other polluting matter discharged or permitted to flow into waters of the District shall first have been 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 feet below the surface.</td>
</tr>
<tr>
<td>Fecal Coliform (effluent discharges)</td>
<td>• 200 per 100 ml on a 30 consecutive day geometric average; • 400 per 100 ml on a 7 consecutive day geometric average; • 800 per 100 ml on a 6 consecutive hour geometric average; and • no sample may contain more than 2400 per 100 ml.</td>
</tr>
</tbody>
</table>

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.

Additional information about the applicable water quality standards and the current use attainment status of the receiving waters is provided in Section F of this report.

B.2.5 New Jersey Administrative Code

New Jersey Administrative Code 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 the CSO receiving water body for the Woodcliff – Guttenberg Service Area. The Hudson River classification and water quality standards are detailed in Section F.
SECTION C - OVERVIEW OF WASTEWATER TREATMENT FACILITIES AND SERVICE AREAS

C.1 WASTEWATER TREATMENT FACILITIES

C.1.1 Town of Guttenberg
The Town of Guttenberg does not own a wastewater treatment facility. All its wastewater is conveyed to the North Bergen MUA-Woodcliff STP for treatment.

C.1.2 North Bergen MUA (Woodcliff)
The NBMUA owns and operates the Woodcliff STP located on River road. The treatment facility receives a daily sewer flow of approximately 3 MGD from the Township of North Bergen (Northeast) and Guttenberg. The plant is permitted to discharge its effluent wastewater to the Hudson River. The Woodcliff Plant sanitary outfall is identified in NBMUA Woodcliff NJPDES permit as outfall No 001A. The existing facility has a NJPDES permitted flow value of 2.91 MGD and currently discharges a monthly average flow of approximately 2.8 MGD.

The Woodcliff STP is currently undergoing an upgrade to the facilities. As a result of this upgrade, NBMUA has submitted a request to the NJDEP to change the existing permit conditions specifically re-rating of the Woodcliff STP discharge capacity. The NJDEP is considering this modification to the existing permit (subsequently modified in 2015) to incorporate requirements for an expanded average monthly flow of 3.46 MGD (Final Construction Phase) from the current flow of 2.91 MGD (Initial Construction Phase). This action also proposes to approve the permittee’s No Feasible Alternatives (NFA) analysis which will allow the permittee to use an interim bypass line to accept additional WWF if allowed by a Treatment Works Approval.

The NJDEP will consider this permit change request from NBMUA to rerate the flow capacity from 2.91 MGD to 3.46 MGD only if NBMUA provides 6 consecutive months of analyses that demonstrates compliance with the acute toxicity limit set forth in the permit and complies with all other statutory and regulatory requirements applicable to a flow capacity re-rating.

An aerial view of the existing Woodcliff STP is shown below in Figure C-1.
C.2 SERVICE AREAS

C.2.1 Combined Sewer Service Area

The Woodcliff – Guttenberg service area is comprised of combined sewer areas and separate sewer areas that contribute flow to the Woodcliff STP. The Woodcliff – Guttenberg service area is made up of 305 total acres contributing area, 252 acres of combined sewer area and 53 of separated sewer area. The combined sewer area makes up approximately 83 % of the total contributing area; 141 acres from the North Bergen Woodcliff area and 111 acres from the Guttenberg.

The NBMUA is permitted to discharge combined sewage from two regulators (NB-1 and NB-2) to its outfall pipe. The outfall pipe passes to the north of the Woodcliff STP bending south on River Road to a manhole, where it combines with the treatment plant effluent. The combined effluent/CSO pipe proceeds east discharging to the Hudson River. The Town of Guttenberg is permitted to discharge combined sewage from one CSO outfall which incorporates a netting system for solids and floatables removal installed just prior to the discharge.
The municipalities, their service area acreage and the number of CSO outfall are listed in Table C-1 below.

Table C-1: Municipality Combined and Separate Sewer Service Area

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Total Contributing Area (acres)</th>
<th>Contributing area (acres)</th>
<th>Number of CSOs Located within Service Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Combined</td>
<td>Sanitary</td>
<td></td>
</tr>
<tr>
<td>NBMUA Woodcliff</td>
<td>181</td>
<td>141</td>
<td>40</td>
</tr>
<tr>
<td>Guttenberg</td>
<td>124</td>
<td>111</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>305</td>
<td>252</td>
<td>53</td>
</tr>
</tbody>
</table>

NOTE: The total acreage in the table above includes only the subcatchment areas in the model that contribute flow to the Woodcliff STP. The acreage does not include rivers, creeks or unsewered areas within a municipality.

C.2.2 Separate Sewer Service Area

The Woodcliff – Guttenberg service area includes 53 acres of separate sanitary sewer systems, approximately 17% of the total service area. Guttenberg service area includes 13 acres and NBMUA Woodcliff area includes 40 acres of separate sewers. All the separate sewers from each municipality is hydraulically connected to the NBMUA Woodcliff STP.
SECTION D - CHARACTERISTICS OF THE COMBINED SEWER SYSTEM

D.1 CHARACTERISTICS OF COMBINED SEWER SYSTEM

In order to characterize the CSS in the PVSC Service Area, the following previous reports were reviewed and utilized as sources of collection system data:

- North Bergen MUA CSO Characterization Study (March 2005)

D.1.1 Description of CSO System

The Woodcliff – Guttenberg Service Area CSS consists of approximately 13 miles of gravity sewers, three regulators, two CSO outfalls, 618 manholes and two pump stations. Flow to the Woodcliff STP is conveyed via gravity sewers. The Woodcliff – Guttenberg combined sewer network is illustrated in Figure D-1 below.
D.1.2 Trunk Sewers
The Woodcliff – Guttenberg Service Area CSS consists of approximately 550 gravity sewers. Guttenberg owns and operates 212 gravity sewers that have a total length of about 25,000 feet, while North Bergen Township, Woodcliff area, owns and operates 338 gravity sewers that have a total length of about 43,000 feet. The gravity sewers collect domestic sewage as well as stormwater from curb inlets and are hydraulically connected to the Woodcliff STP.

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.1.3 Flow Diversion Structures and CSO Regulators
There are a total of 3 active regulating chambers in the Woodcliff STP service area: 2 in North Bergen-Woodcliff, and 1 in Guttenberg. These regulating chambers are equipped with sandcatcher chambers to collect grit prior to flow entering the flow regulating structure. Under dry weather flow conditions, the flow passes through the sandcatcher and is diverted to the regulator chamber through a regulator gate or an orifice and then to the interceptor. Under wet weather conditions, as the height of the wet weather flow rises in the regulator, it overflows the weir and the excess flow is diverted to the overflow chamber and discharged to the receiving waters as combined sewer overflow.

NBMUA owns and operates two dynamic type regulators in the North Bergen Woodcliff area; NB-1 and NB-2. The regulators are located in close proximity to each other near the intersection of 74th Street and East John F. Kennedy Boulevard. Both regulators convey overflows to the same CSO outfall under the NJPDES permit. The NBMUA regulators located in the Woodcliff area are listed in Table D-1.

<table>
<thead>
<tr>
<th>Regulator</th>
<th>NJPDES</th>
<th>Associated CSO</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB-1</td>
<td>NJ0029084</td>
<td>NB004</td>
<td>73rd St. &amp; East JFK Blvd.</td>
</tr>
<tr>
<td>NB-2</td>
<td>NJ0029084</td>
<td>NB004</td>
<td>74th St. &amp; East JFK Blvd.</td>
</tr>
</tbody>
</table>
The Town of Guttenberg owns one regulator, which is a dynamic type regulator that is located near the intersection of 70th Street and East John F. Kennedy Boulevard. The regulator is owned by Guttenberg but operated by NBMUA. The Guttenberg regulator are listed in Table D-2.

Table D-2: Guttenberg Regulators

<table>
<thead>
<tr>
<th>Regulator</th>
<th>NJPDES</th>
<th>Associated CSO</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>GU-1</td>
<td>NJ0108715</td>
<td>GU001</td>
<td>70th St. &amp; East JFK Blvd.</td>
</tr>
</tbody>
</table>

D.1.4 Pump Stations

There are two pump stations in the Woodcliff – Guttenberg Service Area. Both are located at 7109 River Road, one is the Woodcliff treatment plant pump and the other is the pump station to pump flows from the River Road to the plant. The Woodcliff pump stations are listed below in Table D-3.

Table D-3: The Woodcliff STP Pump Stations

<table>
<thead>
<tr>
<th>Name</th>
<th>Designator</th>
<th>Associated Discharging Point</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodcliff T.P.</td>
<td>PS01W</td>
<td>Trickling Filters then CSO/STP-001</td>
<td>7109 River Road</td>
</tr>
<tr>
<td>Woodcliff P.S. (River Road)</td>
<td>PS01W</td>
<td>Head of Treatment Plant then CSO/STP-001</td>
<td>7109 River Road</td>
</tr>
</tbody>
</table>

D.1.5 CSO Outfalls and CSO Control Facilities

Both Guttenberg and NBMUA Woodcliff own one CSO Outfall each. Both of the CSO outfalls, associated permittees, permit numbers and receiving waterbodies are listed in Table D-4.

Table D-4: CSO Outfalls within the Guttenberg-Woodcliff Service District

<table>
<thead>
<tr>
<th>SPDES</th>
<th>Permittee</th>
<th>CSO Number</th>
<th>Receiving Water Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>NJ0108715</td>
<td>Guttenberg</td>
<td>GU001</td>
<td>Hudson River</td>
</tr>
<tr>
<td>NJ0029084</td>
<td>North Bergen MUA (Woodcliff)</td>
<td>NB004</td>
<td>Hudson River</td>
</tr>
</tbody>
</table>

Both CSO outfalls are equipped with CSO netting chambers. Netting chambers are a form of floatables control technology that are designed to trap the floating solid waste that is often present in CSO discharges. NBMUA own and operate the regulators and CSO netting facilities for their CSO outfall in North Bergen –Woodcliff. Guttenberg owns the regulators and netting facilities for their CSO outfall however NBMUA operates the netting facilities for Guttenberg.
SECTION E - COLLECTION OF PRECIPITATION AND SEWER FLOW MONITORING DATA

E.1 INTRODUCTION
This section presents information on the collection of precipitation and sewer flow data to meet the requirements of Paragraphs II.A.C.1.a and b of the USEPA’s CSO Control Policy.

A temporary flow monitoring program was conducted from April 2016 to August 2016, installing eighteen (18) flow meters in the PVSC sewer system and three (3) flow meters in the NBMUA Woodcliff STP sewer system. This section contains a summary of the monitoring data associated with the Woodcliff STP system.

E.2 FLOW MONITORING DATA
Three temporary flow meters installed in the Woodcliff STP sewer system are consist of two meters on the North Bergen Woodcliff regulator outfall pipes, and one meter on the Guttenberg regulator outfall pipe. Meter information is summarized in Table E-1 and meter location is shown in Figure E-1.

Availability of flow monitoring data is illustrated in Figure E-2. Flow meter North Bergen 004A has data from 5/11/16 to 8/31/16, North Bergen 004B has data from 5/18/16 to 8/11/16, and Guttenberg 001A has data from 5/11/16 to 8/17/16. H&H model calibration of Woodcliff STP system was performed together with the PVSC system, therefore wet weather calibration events were picked from the period from 5/20/16 to 8/9/16 where most of the flow meters have valid monitoring data.

Table E-1: Flow Meter Identification and Locations

<table>
<thead>
<tr>
<th>Meter Identification</th>
<th>Municipality</th>
<th>Location</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guttenberg 001A (G-1)</td>
<td>Guttenberg</td>
<td>Near 70th and JFK Blvd E</td>
<td>Outfall</td>
</tr>
<tr>
<td>North Bergen 004A (NBW-1)</td>
<td>North Bergen</td>
<td>Near 73rd and JFK Blvd E</td>
<td>Outfall</td>
</tr>
<tr>
<td>North Bergen 004B (NBW-2)</td>
<td>North Bergen</td>
<td>Near 74th and JFK Blvd E</td>
<td>Outfall</td>
</tr>
</tbody>
</table>

Paper copies of the Woodcliff STP plant influent data was also obtained for model calibration purposes. The received Woodcliff STP plant flow includes North Bergen flow and Guttenberg flow separately, both are at one-hour interval. Data was received for two time periods: 5/25/16 – 6/2/16 and 7/22/16 – 8/3/16.

Flow hydrographs are shown in Figure E-3 for the three temporary meters (NB 004A, NB004B, and GU 001A). Figure E-4 shows flow hydrographs for the Woodcliff STP influent flows (North Bergen influent flow and Gutenberg influent flow).
Figure E-3: Flow Hydrograph for the Temporary Flow Meters
DWF ANALYSIS

A “dry weather” condition was defined as a period with no precipitation that begins 48 hours after the last wet weather event ends and lasts until the beginning of the next precipitation event (i.e. the rain gauge read a 0.01 inch value). DWF periods based on this definition are illustrated in the hydrograph shown in Figure E-5.
The dry weather flow analysis was only performed for the Woodcliff STP plant influent flow. The analysis was not performed for the temporary flow meters because all three temporary flow meters are located on the CSO outfall pipes, which only measure CSO overflows under wet weather conditions. The dry weather flows analyzed from the available Woodcliff STP influent flow data are summarized in the Table E-2 below. The monthly variance of dry weather flow is not significant for the time periods used for the analysis. DWF is estimated to be 1.43 MGD for the flows from North Bergen and 1.14 MGD for the flows from Guttenberg.

<table>
<thead>
<tr>
<th>Period</th>
<th>North Bergen DWF (MGD)</th>
<th>Guttenberg DWF (MGD)</th>
<th>Total (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/25/16 – 6/2/16</td>
<td>1.41</td>
<td>1.13</td>
<td>2.54</td>
</tr>
<tr>
<td>7/22/16 – 8/3/16</td>
<td>1.46</td>
<td>1.15</td>
<td>2.61</td>
</tr>
<tr>
<td>Overall</td>
<td>1.43</td>
<td>1.14</td>
<td>2.57</td>
</tr>
</tbody>
</table>

The DWF varies throughout the day, with the highest flows normally occurring around noon and the lowest rates between midnight and early morning. Received Woodcliff STP flow data from the dry weather periods were used to develop diurnal patterns. Due to the limited data points, diurnal pattern does not differentiate weekdays and weekends. Figure E-6 shows the diurnal factor for flows from North Bergen to the plant and from Guttenberg to the plant. The diurnal patterns were input into the model along with the overall average values discussed above.
WWF is the combination of DWF and additional flow that enters the system during wet weather conditions. The additional flow comes from the surface runoffs from combined sewer service area and the Rainfall Derived Infiltration and Inflow (RDII) flows from all sewer service area. Inflow normally occurs when rainfall enters the system through direct connections such as roof leaders, yard drains, catch basins, sump pumps, manhole covers and frame seals or indirect connections with storm sewers. Inflow is usually recognized graphically by large magnitude, short duration spikes immediately following a rain event. Infiltration occurs during wet weather conditions when water enters a sewer system from the ground through means which include, but not limited to, deteriorated pipes, pipe joints, connections, or manholes. It is significantly influenced by the size and duration of the rainfall event. Infiltration is often recognized graphically by a gradual increase in flow after a wet weather event. The increased flow typically sustains for a short period after rainfall has stopped and then gradually drops off.

The peaking factor represents the ratio of the peak WWF to the average DWF. Peaking factors were analyzed for the Woodcliff STP influent flows. Figure E-7 shows an example plot of Guttenberg flow with a peak hourly flow of 4.4 MGD, with the average dry weather flow at 1.14 MGD, the peaking factor is estimated to be 3.85. The immediate flow increase shortly after the rainfall indicates significant surface runoff and inflow into the collection pipes, and the tail back to the base flow indicates some infiltration occurrence at the site as well.
E.5 WET WEATHER EVENT SELECTION FOR MODEL CALIBRATION AND VALIDATION FLOW ANALYSIS

Based on the rainfall and flow monitoring data analysis, the rainfall events shown in Table E-3 were selected for model calibration and validation. The events were selected from the rain events that are shown in Table E-4. The calibration and validation events cover variations in terms of rainfall depth, intensity, duration, and antecedent conditions.

<table>
<thead>
<tr>
<th>Event Start</th>
<th>Event End</th>
<th>Duration (hr)</th>
<th>Depth (in)</th>
<th>Max Intensity (in/hr)</th>
<th>Average Intensity (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/25/16 16:05</td>
<td>7/25/16 18:50</td>
<td>2.75</td>
<td>1.81</td>
<td>1.68</td>
<td>0.66</td>
</tr>
<tr>
<td>5/29/16 23:50</td>
<td>5/30/16 5:20</td>
<td>5.50</td>
<td>1.60</td>
<td>1.09</td>
<td>0.29</td>
</tr>
<tr>
<td>7/29/16 0:20</td>
<td>7/29/16 8:35</td>
<td>8.25</td>
<td>0.85</td>
<td>0.42</td>
<td>0.10</td>
</tr>
<tr>
<td>7/31/16 8:35</td>
<td>7/31/16 22:35</td>
<td>14.00</td>
<td>0.69</td>
<td>0.49</td>
<td>0.05</td>
</tr>
</tbody>
</table>

E.6 SEWER FLOW MONITORING DATA SUMMARY

The three flow meters measured flow, level and velocity data for each flow monitoring site at 5-minute intervals. Metering data was analyzed for DWF and WWF for each monitoring site.

E.7 RAINFALL MONITORING LOCATIONS AND ANALYSIS

Precipitation data for the flow monitoring period were obtained from NJ Weather, National Weather Service Automated Surface Observing System (NWS ASOS), and Citizen Weather Observer Program (CWOP). The New York rain gauge rain fall data was obtained from NWS.
ASOS and used as the source for the rainfall analysis. Rainfall data was obtained in 1 minute intervals and integrated to 5 minute intervals for use as input to the model. The rain gauge location is shown in Figure E-8.

Figure E-8: Rain Gauge Locations

E.8 RAIN EVENT SUMMARY
The rainfall events were characterized by event start time, event end time, duration, rainfall depth, maximum intensity and average intensity. As an initial screening criterion, rainfall events with a minimum of 0.4 inches of rainfall were identified. Further screening based on requiring at least two dry days prior to the event resulted in the candidate calibration and validation events and are listed in Table E-4.
Table E-4: Candidate Storm Events for Calibration

<table>
<thead>
<tr>
<th>Rain Start</th>
<th>Rain End</th>
<th>Duration (hr)</th>
<th>Depth (in)</th>
<th>Max Intensity (in/hr)</th>
<th>Average Intensity (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/25/16 16:05</td>
<td>7/25/16 18:50</td>
<td>2.75</td>
<td>1.81</td>
<td>1.68</td>
<td>0.66</td>
</tr>
<tr>
<td>5/29/16 23:50</td>
<td>5/30/16 5:20</td>
<td>5.50</td>
<td>1.6</td>
<td>1.09</td>
<td>0.29</td>
</tr>
<tr>
<td>7/29/16 0:20</td>
<td>7/29/16 8:35</td>
<td>8.25</td>
<td>0.85</td>
<td>0.42</td>
<td>0.10</td>
</tr>
<tr>
<td>5/2/16 22:40</td>
<td>5/3/16 9:50</td>
<td>11.17</td>
<td>0.7</td>
<td>0.17</td>
<td>0.06</td>
</tr>
<tr>
<td>7/31/16 8:35</td>
<td>7/31/16 22:35</td>
<td>14.00</td>
<td>0.69</td>
<td>0.49</td>
<td>0.05</td>
</tr>
<tr>
<td>7/4/16 19:20</td>
<td>7/5/16 2:50</td>
<td>7.50</td>
<td>0.63</td>
<td>0.23</td>
<td>0.08</td>
</tr>
<tr>
<td>5/6/16 2:30</td>
<td>5/6/16 12:25</td>
<td>9.92</td>
<td>0.6</td>
<td>0.19</td>
<td>0.06</td>
</tr>
<tr>
<td>7/16/16 14:50</td>
<td>7/16/16 15:35</td>
<td>0.75</td>
<td>0.56</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>6/8/16 11:25</td>
<td>6/8/16 14:10</td>
<td>2.75</td>
<td>0.49</td>
<td>0.3</td>
<td>0.18</td>
</tr>
<tr>
<td>7/9/16 21:30</td>
<td>7/9/16 22:05</td>
<td>0.58</td>
<td>0.48</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>4/4/16 7:45</td>
<td>4/4/16 17:00</td>
<td>9.25</td>
<td>0.43</td>
<td>0.12</td>
<td>0.05</td>
</tr>
</tbody>
</table>

E.9 SUMMARY
The rainfall and flow monitoring data analysis was performed to provide adequate data for the development, calibration and validation of the H&H and Water Quality Models. Rainfall data was collected for rain gauges throughout the Model Area. The rainfall data was analyzed to determine which wet weather events would be used for model calibration. The flow meter data was analyzed for dry weather flows and diurnal patterns for model inputs.
SECTION F - CHARACTERISTICS OF THE RECEIVING WATERS

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.

F.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 F-1.

F.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 F-1 lists all of the CSO outfalls and the waterbodies into which they discharge.

<table>
<thead>
<tr>
<th>NJPDES</th>
<th>Permittee</th>
<th>CSO Number</th>
<th>Receiving Water Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>NJ0108715</td>
<td>Guttenberg</td>
<td>001A</td>
<td>Hudson River</td>
</tr>
<tr>
<td>NJ0029084</td>
<td>North Bergen MUA</td>
<td>004A (Plant outfall)</td>
<td>Hudson River</td>
</tr>
</tbody>
</table>

F.2 POLLUTANTS OF CONCERN IN THE RECEIVING WATERS

F.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 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 Sections E, G, H and I of this report. The NJDEP determined POCs for the Hudson River relative to the NBMUA (Woodcliff) and Guttenberg CSO discharges are Fecal Coliform, Escherichia coli (E. coli) and Enterococcus.
Figure F-1: Woodcliff - Guttenberg Service District
RECEIVING WATER USE DESIGNATIONS AND APPLICABLE WATER QUALITY STANDARDS

F.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 F-2:

<table>
<thead>
<tr>
<th>Sublist</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sublist 1</td>
<td>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.)</td>
</tr>
<tr>
<td>Sublist 2</td>
<td>The assessment unit is fully supporting the designated use but is not supporting all applicable designated use(s).</td>
</tr>
<tr>
<td>Sublist 3</td>
<td>Insufficient data and information are available to determine if the designated use is fully supported.</td>
</tr>
<tr>
<td>Sublist 4</td>
<td>One or more designated uses are not supported or are threatened but TMDL development is not required because of one of the following reasons:</td>
</tr>
<tr>
<td>Sublist 4A</td>
<td>A TMDL has been completed for the parameter causing designated use non-support.</td>
</tr>
<tr>
<td>Sublist 4B</td>
<td>Other enforceable pollutant control measures are reasonably expected to result in fully supporting the designated use in the near future.</td>
</tr>
<tr>
<td>Sublist 4C</td>
<td>Non-support of the designated use is caused by something other than a pollutant.</td>
</tr>
<tr>
<td>Sublist 5</td>
<td>One or more designated uses are not supported or are threatened by a pollutant(s) that requires development of a TMDL.</td>
</tr>
<tr>
<td>Sublist 5A</td>
<td>Arsenic does not attain standards, but concentration are below those demonstrated to be from naturally occurring conditions.</td>
</tr>
<tr>
<td>Sublist 5L</td>
<td>Designated use impairment is caused by a “legacy” pollutant that is no longer actively discharged by a point source.</td>
</tr>
<tr>
<td>Sublist 5R</td>
<td>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.</td>
</tr>
</tbody>
</table>

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.

F.3.2 Interstate Environmental Commission (IEC) Water Quality Regulations
The Interstate Environmental Commission (IEC) is an air and water pollution control agency that serves the Interstate Environmental District within the states of New York, New Jersey, and Connecticut. The Commission’s goal is to protect the environment and assure compliance with and enforcement of its Water Quality Regulations. For more information about IEC Regulations, see Section B.2.4.

F.3.3 New Jersey Administrative Code
New Jersey Administrative Code 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 F.4.6.

F.4 HUDSON RIVER
F.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 F-2 below for location of the CSO Outfalls in the Lower Hudson River.

F.4.2 Physical Characteristics
North Bergan (Woodcliff) and Guttenberg are heavily populated urban environments. Guttenberg and the East side of North Bergen (Woodcliff area) is 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.

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.

**F.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.

**F.4.4 Shoreline Characteristics**

The Hudson River shoreline at North Bergen (Woodcliff) and 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 is in riprap and natural shoreline.

F.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

F.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 New Jersey Administrative Code 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 F-3 below.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Designated Use(s)</th>
<th>Indicator Bacteria</th>
<th>Criteria (per 100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE2</td>
<td>Secondary Contact</td>
<td>Fecal Coliform</td>
<td>770 GM</td>
</tr>
</tbody>
</table>

F.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.2.4.
F.5 IDENTIFICATION OF SENSITIVE AREAS

F.5.1 Regulatory Requirements

Requirements of the USEPA’s CSO Control Policy and Sensitive Areas Definition

The USEPA’s 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 CSO Control Policy states the six (6) criteria for defining an area as a “Sensitive Area” include:

1. Designated Outstanding National Resource Waters
2. National Marine Sanctuaries
3. Waters with threatened or endangered species and their habitat
4. Waters with primary contact recreation
5. Public drinking water intakes or their designated protected areas
6. Shellfish beds

The CSO Control Policy states that if Sensitive Areas are present and impacted, the LTCP should include provisions to:

- Prohibit new or significantly increased overflows
- Eliminate or relocate overflows wherever physically possible and economically achievable
- Treat overflows where necessary
- Where elimination or treatment is not achievable, reassess impacts each permit cycle

NJDES Permit Requirements

Sensitive Areas should be considered prior to the evaluation of CSO control alternatives. This allows a CSO community to identify and estimate costs for controls that could eliminate or relocate CSOs from Sensitive Areas where pollutant loadings pose a high environmental or public health risk and where control efforts should be focused. The cost of these controls can then be considered, along with the community’s financial capability, to evaluate cost-effective controls for all of the receiving waters.

The NJPDES permits indicate that the permittee’s LTCP shall give the highest priority to controlling overflows to sensitive areas. The NJPDES Permit further states that “Sensitive areas include designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters used for primary contact recreation (including but not limited to bathing beaches), public drinking water intakes or their designated protection areas, and shellfish beds.”
The NJPDES Permits indicate that if Sensitive Areas are present and impacted, the following requirements will apply:

- Prohibit new or significantly increased CSOs.
- Eliminate or relocate CSOs that discharge to sensitive areas wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment.
- Where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, the permittee shall provide the level of treatment for remaining CSOs deemed necessary to meet WQS for full protection of existing and designated uses.

**F.5.2 Summary of Sensitive Areas**

A comprehensive review of online databases, direct observations and correspondence with regulatory agencies and local environmental organizations was conducted to identify potential Sensitive Areas within the CSS portion and in the associated receiving waters of NBMUA Woodcliff.

Outstanding National Resource Waters (ONRW) are maintained and protected by Tier 3 of the USEPA’s Anti-degradation Policy. Only waters of “exceptional ecological significance” qualify as ONRWs, as determined by States and Tribes. No Outstanding National Resource Waters were located within the NBMUA Woodcliff boundaries.

The Office of National Marine Sanctuaries (ONMS) is the trustee of all national marine sanctuaries which currently recognizes fourteen (14) national marine sanctuaries, none of which are located within the NBMUA Woodcliff Service Area.

The US Fish and Wildlife Service, National Oceanic and Atmospheric Administration (NOAA), New Jersey Heritage Program (NJHP), and New Jersey DEP Division of Fish and Wildlife identified several Endangered or Threatened species which potentially could live in the project area. All species listed by United States Fish and Wildlife Service are included in NJDEP’s lists. NOAA maps show potential areas that may have endangered or threatened species during parts of the year as shown in Figure F-3 below. A CSO outfall discharges to the Hudson River, which is a known habitat of the endangered Shortnose sturgeon. However, both NJHP and NJDEP’s correspondence indicate there are no critical habitats for these species found in the receiving waters of the Service Area. Shortnose sturgeon have surpassed the recovery criteria in the adult population for the past few decades. NOAA has reported that the Atlantic sturgeon’s recovery is not impeded by water quality, and does not report any impacts on the sturgeon caused by human enteric pathogens. The current water quality and habitat protections are viewed as adequate to maintain a healthy sturgeon population. The impact of human enteric pathogens on sturgeon should not have any negative effects on sturgeon at any life stage of the fish both now and in the future, and only commercial bycatch is viewed as a stressor threatening sturgeon recovery.

There are no waters designated for primary contact within the service area.
There are no commercial shellfish harvesters that operate within the Service Area.

There are no drinking water intakes located in the Service Area.

For details of the Sensitive Area Study see the Identification of Sensitive Areas Report dated June 2018 submitted to the NJDEP on behalf of the participating permittees by the PVSC.

Figure F-3: Federal and State Endangered Species from NOAA Map 20C - North Bergen and Guttenberg
SECTION G - COLLECTION OF WATER QUALITY DATA

G.1 BACKGROUND
The NJDEP, NBMUA and Guttenberg have agreed to a cooperative or regional approach to the development of a single CSO LTCP, and PVSC agreed to develop a sewer system characterization work plan on their behalf from its QAPPs for its hydraulically connected CSO Permittees. Several coordination meetings have been held with representatives of the CSO permittees tributary to PVSC’s conveyance and treatment facilities, along with other participating CSO permittees. PVSC has agreed to lead the Combined Sewer System Characterization and Landside Modeling Tasks, as well as the Baseline Compliance Monitoring Program, on behalf of the participating permittees.

In accordance with consultation with NJDEP, multiple Sewer System Characterization Work plans QAPPs were developed to cover different aspects of the LTCP work activities for the eight municipalities. The QAPPs for the Baseline Compliance Monitoring Program (BCMP) and Receiving Water Quality Modeling were submitted separately from the Sewer System Characterization Work Plan QAPP.

The Sewer System Characterization Work Plan was developed to quantify and qualify wastewater and pathogen concentration variations at key CSO and stormwater drainage basins. The Sewer System Quality Monitoring Program is outlined in Section G.3 and the results are provided under Section G.4 below.

The Baseline Compliance Monitoring Program (BCMP) is modeled in part on the program performed by the New Jersey Harbor Dischargers Group. NJHDG is a similarly allied collaborative undertaking that includes nine (9) sewerage agencies representing eleven (11) wastewater treatment plants in northeastern New Jersey that discharge into the New Jersey portion of the NY/NJ Harbor Estuary. The purpose of NJHDG’s long-term water quality monitoring program is to develop ambient water quality data for the Hackensack River, Passaic River, Rahway River, Elizabeth River, Raritan River, Raritan Bay, Newark Bay, and the New Jersey portions of the Hudson River, Upper New York Harbor, and the Arthur Kill, allowing long-term evaluation of water quality in these areas by providing baseline and annual information on water quality in these waterbodies as it relates to current water quality standards. This evaluation identifies changes in water quality over time under varying seasonal conditions, providing a basis for documenting pollution sources and water quality improvements resulting from the implementation of pollution control programs. The Receiving Water Quality Monitoring Program focuses on the CSO receiving waters and is outlined in Section G.6 and a summary of the results are provided in Section G.7 below. The complete Water Quality BCMP results and analysis are provided under a separate report, Baseline Compliance Monitoring Program Report.
G.2 REGULATORY REQUIREMENTS

G.2.1 NJPDES Permit Requirements
In accordance with consultation with NJDEP as the NJPDES permitting authority, the following QAPPs have been developed for NBMUA Woodcliff and Guttenberg to cover sampling and analysis of the stormwater, wastewater and receiving water of the service area.

4. System Characterization, which includes wastewater collection system sampling and analysis as well as landside modeling. The System Characterization and Landside Modeling Program QAPP outlines the program necessary to address this requirement of the Permit. The purpose of the proposed monitoring program is to quantitatively and qualitatively dry weather and wet weather wastewater flow and pathogen concentration variations at key CSO and stormwater drainage basins to calibrate and verify the hydrologic and hydraulic model of the CSS within the Town of Guttenberg and North Bergen Township. This work has been used to update the sewer system model that will be used to assess residual storage and maximum hydraulic conveyance capacity in the Woodcliff – Guttenberg Service Area, pathogen concentrations and loading distributions during storm events and among CSO discharge points, calculate pathogen loads to the receiving water, and for the development and evaluation of possible long term control alternatives and/or modifications to the water quality standards (WQS) during wet weather events. The results of the System Characterization Wastewater Collection System Sampling and analysis program are included in this System Characterization Report.

5. Baseline Compliance Monitoring, which includes sampling and analysis of the receiving waters. The results of the sampling and analysis of the Baseline Compliance Monitoring of the Receiving Waters will be included under a separate report; the Compliance Monitoring Program Report.

6. Pathogen Water Quality Modeling; which includes the computational model of the receiving waters (Not a permit requirement).

For more information regarding NJPDES Permit Regulations, see Section B.2.1.

G.2.2 USEPA’s CSO Control Policy and Guidelines
USEPA’s CSO Control Policy (Policy) provides guidance to municipal permittees with CSOs, to the state agencies and to state and interstate water quality standards authorities. The Policy establishes a framework for the coordination, planning, selection and implementation of CSO controls required for permittee compliance with the Clean Water Act. For more information regarding the USEPA’s CSO Control Policy, see Section B.2.1.

Requirements for the Monitoring and Modeling Plan are established in the USEPA’s CSO Guidance for Monitoring and Modeling. For more information on other USEPA CSO Guidelines, see Section B.2.3.
G.2.3 Interstate Environmental Commission Requirements
The Interstate Environmental Commission (IEC) is an air and water pollution control agency that serves the Interstate Environmental District within the states of New York, New Jersey, and Connecticut. The Commission’s goal is to protect the environment and assure compliance with and enforcement of its Water Quality Regulations. For more information on IEC, see Section B.2.4.

G.3 OVERVIEW OF SEWER SYSTEM QUALITY MONITORING PROGRAM

G.3.1 Sewer System Quality Monitoring Objectives
The purpose of the monitoring program was to quantify and qualify dry weather and wet weather wastewater flow and pathogen concentration variations at key CSO and stormwater drainage basins to calibrate and verify hydrologic and hydraulic model of the CSSs within the Town of Guttenberg and North Bergen Township. This data was used to update the mathematical tool (sewer system model) that will be used to assess residual storage and maximum hydraulic conveyance capacity in the NBMUA (Woodcliff) service area, pathogen concentrations and loading distributions during storm events and among CSO discharge points, calculate pathogen loads from CSOs and stormwater to the receiving water, and for the development and evaluation of long term control alternatives and/or modifications to the water quality standards (WQS) during wet weather events.

G.3.2 Sewer System Quality Sampling Locations
The original Quality Assurance Project Plan (QAPP) targeted two CSO locations in the Guttenberg and North Bergen service area and eight stormwater locations that were distributed throughout the PVSC region by municipality and land use. The CSO locations can be seen in Figure G-1. The goal of the sampling protocol was to obtain three wet-weather events of sufficient depth, intensity, and duration for valid model calibration at each targeted location. This was the case for all eight stormwater locations; however, only one of the two CSO locations was sampled (location 001A), with the other not sampled at all due to access or other logistical issues (location 004A).

The protocol for CSO sampling was the CSO location was to be sampled prior to overflow, then at the following intervals: 0.5 hour, 1 hour, 2 hours, 4 hours, and 8 hours. During the execution of the sampling, the last of these samples was often truncated because the event stopped, so crews routinely collected the last sample any time after 6 hours from tipping. Stormwater locations were sampled four times per event, generally on an hourly basis but adjustments were made as events progressed to capture as much of a precipitation event as possible.

G.3.3 Analytical Parameters
Water quality sampling at each location included grab samples and analysis for fecal coliform and enterococcus. Grab samples for analysis of E. coli were also collected at monitoring sites where the outfall discharges to a fresh water receiving waterbody, outside of the Guttenberg and North Bergen service area. Table G-1 lists these parameters, along with their respective laboratory methods, preservation temperatures, holding times, and reporting limits.
Figure G-1: Sewer System Quality Sampling Locations, North Bergen and Guttenberg

Table G-1: Lab Methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Laboratory Method</th>
<th>Preservation</th>
<th>Holding Time</th>
<th>Reporting Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal Coliform</td>
<td>EPA Micro Manual p. 124 (1978), Single Step Membrane Filtration</td>
<td>Cool &lt; 4°C</td>
<td>6 hrs</td>
<td>1, 2, 4, 10 CFU/100 mL</td>
</tr>
<tr>
<td>Enterococcus</td>
<td>EPA 1600 (Dec 2009), Membrane Filtration</td>
<td>Cool &lt; 4°C</td>
<td>6 hrs</td>
<td>1, 2, 4, 10 PE/100 mL</td>
</tr>
<tr>
<td>E. coli</td>
<td>EPA 1603 (Dec 2009), Membrane Filtration</td>
<td>Cool &lt; 4°C</td>
<td>6 hrs</td>
<td>1, 2, 4, 10 CFU/100 mL</td>
</tr>
</tbody>
</table>

CFU: colony forming units; PE: presumptive enterococci.
G.3.4 Sampling Schedule and Dates
In accordance with the System Characterization and Landside Modeling Program Quality Assurance Project Plan for NBMUA Woodcliff and Guttenberg, dated 11/21/2017, event sampling is based on the reliance of the sampling results from the System Characterization and Landside Modeling Program Quality Assurance Project Plan Parts 1 and 2 for such information. The event sampling, as well as the stormwater locations were sampled between July, 2016 and August, 2017. The exact dates and locations for the event sampling and stormwater sampling can be found in the PVSC System Characterization Report (June 2018).

G.3.5 System Characterization and Landside Modeling QAPP Goals
The System Characterization and Modeling Program achieved the following project goals and objectives:

- Supplement and update, as appropriate, the site specific dry and wet weather data to be used to recalibrate and verify a new InfoWorks model derived from the SWMM collection system model tributary to the Woodcliff STP.
- Define the CSS hydraulic response to rainfall.
- Supplement the existing dry weather water quality and quantity data to be used in the representation of each CSO drainage basin.
- Determine the CSO flows and pathogen concentrations/loadings being discharged to the receiving streams.
- Supplement the stormwater quality data for various land use applications.

G.4 SEWER SYSTEM QUALITY RESULTS
CSO sampling teams were deployed to CSO sampling location 001A on 07/13/2017 and 08/7/2017 for precipitation events, but no overflows occurred. However the sampling teams followed the sampling protocols and collected one pre-overflow sample during each event. The results are presented in Table G-3. The data represent sanitary flow, but may be partially diluted by stormwater.

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (°C)</th>
<th>Salinity (psu)</th>
<th>Fecal Coliform (CFU/100mL)</th>
<th>Enterococcus (PE/100mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/13/2017</td>
<td>26.4</td>
<td>0.4</td>
<td>1,400,000 E(1)</td>
<td>84,000 E</td>
</tr>
<tr>
<td>8/7/2017</td>
<td>23.8</td>
<td>0.2</td>
<td>2,300,000</td>
<td>620,000 E</td>
</tr>
</tbody>
</table>

(1) E = Estimate

Graphs of stormwater data collected by HDR during April 2016 through March 2017 are presented in Appendix A. Each location-event is presented as a single four-panel page showing fecal coliform, enterococci, E. coli, and salinity as a function of time over the survey date. Pages are ordered by station, then chronologically.
G.5 OVERVIEW OF HISTORICAL RECEIVING WATER QUALITY MONITORING

G.5.1 Historic Water Quality Sampling

The New Jersey Harbor Dischargers Group (NJHDG) is an allied collaborative undertaking that includes nine (9) sewerage agencies representing eleven (11) wastewater treatment plants in northeastern New Jersey that discharge into the New Jersey portion of the NY/NJ Harbor Estuary. PVSC, BCUA, JMEUC, MCUA, NBMUA, NHSA are overlapping members of NJHDG and the NJ CSO Group. These agencies collaborate, jointly fund, and perform various water quality studies in the region.

In 2003, the NJHDG initiated a Long-Term Ambient Water Quality Monitoring Program for the NJ portion of the NY/NJ Harbor Estuary. PVSC had previously initiated a long-term ambient water quality monitoring program of the Passaic River, Hackensack River, and Newark Bay in 2000, and has taken the lead for the NJHDG monitoring program. The NJHDG monitoring program is modeled after the successful New York City Department of Environmental Protection (NYCDEP) Harbor Survey. The main objective of the NJHDG program is to develop a comprehensive database on the existing water quality of the NY/NJ Harbor by routinely and extensively monitoring the waters of the Hackensack River, Passaic River, Rahway River, Elizabeth River, Raritan River, Raritan Bay, Newark Bay, and the New Jersey portions of the Hudson River, Upper New York Harbor, and the Arthur Kill. The data collected allows long-term evaluation of water quality in these areas by providing baseline and annual information on water quality in these waterbodies as it relates to current water quality standards. This evaluation identifies changes in water quality over time under varying seasonal conditions, providing a basis for documenting pollution sources and water quality improvements resulting from the implementation of pollution control programs.

Thirty-four locations throughout the region are monitored for a list of 18 conventional chemical water quality parameters including: temperature, pH, dissolved oxygen (DO), salinity, Secchi depth, total suspended solids (TSS), 5-day carbonaceous biochemical oxygen demand (CBOD-5), total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO3-N), nitrite-nitrogen (NO2-N), ammonia-nitrogen (NH3-N), total phosphorus (TP), orthophosphate (OP), dissolved organic carbon (DOC), chlorophyll-a (Chlor-a), fecal coliform bacteria and Enterococcus bacteria. Figure G-X presents the monitoring station locations. Monitoring is performed at each station biweekly during May and June, weekly from July through September and monthly from October through April. All resources for the monitoring program, including sampling personnel and laboratory analyses, are provided by the NJHDG member agencies.

The NJHDG program has effectively served to eliminate the data gap for NJ waters of the NY/NJ Harbor Estuary system by monitoring waterbodies that are not currently monitored by the NJDEP Surface Water Quality Monitoring Network, United States Geological Survey (USGS) Surface Water Quality Gages, or the United States Environmental Protection Agency (USEPA) New York Bight Water Quality Monitoring Program.

This program formed the basis of the LTCP sampling program as described in Section G.4.
G.6 OVERVIEW OF THE RECEIVING WATER QUALITY MONITORING PROGRAM

G.6.1 Receiving Water Quality Monitoring Objectives and Baseline Compliance Monitoring

The Baseline Compliance Monitoring Program had the following objectives:

- Fulfilling the CSO Permit requirement under paragraph D.3.c and under paragraph G.9 for ambient monitoring.
- Generating sufficient data for establishing existing ambient water quality conditions for pathogens to foster appropriate regulatory decisions based on current water quality measurements.
- Generating sufficient relevant data under wet and dry conditions to be used to update, calibrate and validate a pathogen water quality model of the receiving water bodies.
- Supporting the goals of the other components of the LTCP (System Characterization and Receiving Water Quality Modeling).

The Baseline Compliance Monitoring Program included three parallel data collection efforts to achieve these objectives:

1. Baseline Sampling, which supplemented data from the ongoing NJHDG annual program;
2. Source Sampling, which targeted the major influent streams within the study area to establish non-CSO loadings, and coincided with the NJHDG and Baseline Sampling; and
3. Event Sampling, which was timed to coincide with rainfall to capture three discrete wet-weather events over the course of the year on each segment of the NY-NJ Harbor complex impacted by CSOs.

G.6.2 Receiving Water Quality Sampling Locations

Sampling stations were located to supplement the existing NJHDG monitoring program to provide additional spatial coverage and ensure that each permittee had at least one monitoring station in its local waterbody. A total of six additional baseline monitoring stations were added to the existing NJHDG station. The NJHDG station was also chosen for event sampling. An additional source sampling station was added to identify other sources of bacteria to the system. All of the monitoring stations are presented in Figure G-2. Shallow stations were sampled at mid-depth and deeper stations were sampled at near surface and mid-depth.

G.6.3 Analytical Parameters

The focus of the LTCP is pathogens. Accordingly, the sampling program was created to measure pathogens and the factors that can affect their concentrations.

Field Testing

The following parameters were directly measured in the field:

- Dissolved Oxygen (DO)
- Temperature
- pH
Figure G-2: Receiving Water Quality Sampling Locations
- Salinity
- Secchi depth (where applicable)
- Turbidity

Methods, reporting limits, method detection limits and holding times are presented in **Table G-3**.

**Laboratory Testing**

The following parameters were analyzed at Eurofins QC, Inc.:
- Fecal Coliform (all locations)
- Enterococcus (all locations)
- E. coli (freshwater locations only; Elizabeth River & Upper Passaic River)

Methods, reporting limits, preservation and holding times are presented in **Table G-4**.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Laboratory Method</th>
<th>Preservation</th>
<th>Holding Time</th>
<th>Reporting Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal Coliform</td>
<td>EPA Micro Manual p. 124 (1978), Single Step Membrane Filtration</td>
<td>Cool ≤ 4°C</td>
<td>6 hrs</td>
<td>1, 2, 4, 10 CFU/100 mL</td>
</tr>
<tr>
<td>Enterococcus</td>
<td>EPA 1600 (Dec 2009), Membrane Filtration</td>
<td>Cool ≤ 4°C</td>
<td>6 hrs</td>
<td>1, 2, 4, 10 PE/100 mL</td>
</tr>
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<td>E. coli</td>
<td>EPA 1603 (Dec 2009), Membrane Filtration</td>
<td>Cool ≤ 4°C</td>
<td>6 hrs</td>
<td>1, 2, 4, 10 CFU/100 mL</td>
</tr>
</tbody>
</table>

CFU: colony forming units; PE: presumptive enterococci.
G.6.4 Sampling Schedule and Dates
The Baseline Sampling was modeled after the approved routine sampling program of the NJHDG. However, the Baseline Sampling targeted additional locations to supplement NJHDG data and enhance overall spatial coverage. The Baseline sampling occurred over a period of 12-months from April 2016 through March 2017. The sampling frequency matched the NJHDG program, varying with time of year as follows:

- Spring (May-Jun): Biweekly (4 dates)
- Summer (Jul-Sep): Weekly (12 dates)
- Winter (Oct-Apr): Monthly (7 dates)

The Baseline Sampling and the NJHDG program provided a seasonally-based characterization of existing water quality. All sampling dates for the Baseline Sampling were predetermined at the initiation of the program. For the purposes of the Baseline Compliance Monitoring Program, a sampling date was considered to be wet weather if 0.2 inches of rain or more fell within 24 hours prior to sample collection. Source Sampling coincided with Baseline Sampling.

G.6.5 QAPP Overview
The Baseline Compliance Monitoring Program QAPP was finalized on February 19, 2016. The QAPP included four standard sections: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Validation and Usability as outlined in Guidance for Quality Assurance Project Plans, EPA QA/G-5 (EPA 2002). The plan outlined the necessary steps to achieve a successful monitoring program.

Table G-5 presents the quality targets outlined in the QAPP.

<table>
<thead>
<tr>
<th>Data Quality Indicator</th>
<th>Performance Criterion</th>
<th>Assessment Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness</td>
<td>Valid data from 90% of collected samples</td>
<td>Percentage of valid measurements</td>
</tr>
<tr>
<td>Precision</td>
<td>RPD^1 &lt; 30% for duplicates</td>
<td>1 field duplicate/crew-day</td>
</tr>
<tr>
<td>Representativeness</td>
<td>Blanks &lt; MDL^2</td>
<td>1 field blank/crew-day, 1 equipment blank/crew-day</td>
</tr>
</tbody>
</table>

^1 Relative Percent Difference on a log basis; non-representative when (a) both the original and duplicate results are not detected or are less than 5x the reporting limit or (b) either result is estimated, rejected, or suspected of contamination. ^2 Method Detection Limit, calculated where applicable.

The sampling program achieved its targeted performance criteria. The data collected in this program should provide an adequate characterization of the variable water quality of receiving waters in the project area.

G.7 RECEIVING WATER QUALITY RESULTS
The field work completed consisted of Baseline Sampling, Source Sampling and Event Sampling as outlined in Section G.4. Field work for these three elements was completed on April 28,
2017; the last of the laboratory results were provided June 10, 2017. A total of 23 baseline and source sampling events were completed. The goal of the event sampling was to capture three significant wet weather events (precipitation >0.5 inches in 24 hours) at each targeted station, which was completed across four sampling events (one set of samples was collected across two precipitation events). All samples collected were analyzed for fecal coliform and enterococcus; freshwater samples were also analyzed for E. coli.

The data collected under the Baseline Compliance Monitoring Program appears to be sufficient for the intended goal of calibrating the water quality model to be used for Guttenberg and North Bergen LTCPs. The BCMP was not designed to provide an adequate data volume for assessing attainment of water quality standards, which would have required five samples per 30-day period at each sampling location to compute 30-day geometric means. However, a review of the data collected can indicate the likelihood of attainment in a particular area:

- The lower regions of the Passaic and Hackensack Rivers appear likely to violate water quality criteria, but attainment appears to improve closer to Newark Bay.
- The larger waterbodies (Newark Bay, Hudson River, Arthur Kill, and Kill Van Kull) appear to meet existing water quality criteria. Newark Bay and the Kills are primarily SE3 waterbodies, and Raritan Bay is subject to more stringent shellfishing water quality standards.
- Several smaller riverine waterbodies appear unlikely to meet attainment. This includes the Rahway River, Saddle River, Second River, and Elizabeth River. The Raritan River may also have attainment issues.
- Many rivers without CSOs have high bacteria loads. Data collected at source sampling locations indicate non-attainment of waters entering the Passaic and Hackensack Rivers, contributing pollutant loads into the study area from areas that do not have CSOs.

The companion document Baseline Compliance Monitoring Program Data Summary provides a more comprehensive summary of the water quality results.
SECTION H - TYPICAL HYDROLOGIC PERIOD

H.1 INTRODUCTION

H.1.1 Typical Year for CSO LTCP Development
Precipitation generates urban storm water and combined sewer overflows (CSOs). These will contribute bacteria and pollutants to the New York-New Jersey Harbor and its surrounding major tributaries. The effect of these contributors on the receiving streams mainly depends on the magnitude and duration of rainfall events and on the prevailing ambient river conditions controlling dilution and transport of the pollutants. This variability and complexity poses a significant challenge for assessing the performance of wet weather and CSO control alternatives.

In accordance with the Combined Sewer Overflows - CSO Control Policy from the U.S. Environmental Protection Agency, Office of Water, Washington, DC, EPA 830-B-94-001, April 1994 and the NJDEP Master General Permit issued January 1995, the CSO control alternatives should be assessed on a “system-wide, annual average basis”. This is accomplished by continuous simulation using a typical hydrologic period for the combined sewer system (CSS) and receiving water quality modeling applications. The CSO Policy supports continuous simulation modeling, i.e., using long-term precipitation records rather than records for individual storms. Long-term continuous precipitation records enable simulations to be based on a sequence of storms so that the additive effect of storms occurring close together can be examined. They also enable storms with a range of characteristics to be included.

The typical year is intended to contain the closest to average year for the years with available data. Average year conditions are defined as the arithmetic average of the predictions for the selected period.

H.1.2 Annual Precipitation Trend 1948-2015
Average U.S. precipitation has increased since 1900, but there are regional differences, with some areas having larger increases, and others, decreases. Local climate change should be considered when selecting appropriate data records for the typical period analysis.

Daily precipitation data from Newark Liberty International Airport were obtained from the National Oceanic and Atmospheric Administration (NOAA) from 1948 through 2015 to evaluate precipitation trend.

Figure H-1 shows annual precipitation depth from 1948 to 2015. An average straight trend line using sum of least squares is also shown in the figure for characterizing long-term precipitation pattern. During 1948 through 2015, annual precipitation depth ranges from 26.9 to 69.91 inches, with the driest year in 1963 and the wettest year in 2011. The figure splits to show the trend line change from 1948 to 1970 contrasted to 1970 to 2015. From 1948 to 1970 shows a declining pattern with an approximate change of 0.337 inch per year. From 1970 to 2015 shows an inclining pattern with an approximate change of 0.032 inch per year. The latter trend line is more relevant to present day. Therefore, it is determined that the typical period for the LTCP to
be selected, based on statistical analysis of precipitation records is the most recent 46 years (i.e., 1970-2015).

![Figure H-1: Historical Annual Precipitation at Newark Liberty International Airport](image)

**H.1.3 Methodology of Typical Year Selection**

The typical hydrologic year is selected to provide representative and unbiased approximations of expected conditions in terms of both averages and historical variability. Representativeness is assessed using objective criteria for each of the ambient factors. As indicated in the previous section, the selection of the typical hydrologic period is based on the historical records in the past 46 years from 1970 through 2015. The following datasets are used for the analysis of the typical hydrologic period:

- Hourly precipitation data for the National Climate Data Center gauge at Newark Liberty International Airport for 1970 - 2015 is used for analyzing individual rainfall event and event characteristics.
- Daily precipitation data for the National Climate Data Center gauge at Newark Liberty International Airport for 1970 - 2015 is used for analyzing annual and seasonal precipitation amounts.

Criteria used in this typical year analysis were developed based on requirements listed in the presumption approach and the demonstration approach, and potential operational and maintenance considerations for CSO control facilities (EPA's CSO Control Policy, 1994).

Key criteria parameters used in the evaluation are listed in Table H-1. Each parameter is given a weighting factor to describe the individual importance on the averageness of the analyzed time period.
Table H-1: Typical Hydrologic Year Ranking Parameters

<table>
<thead>
<tr>
<th>Criteria Parameter</th>
<th>Weighing Factor</th>
<th>Description / Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual rainfall depth</td>
<td>30%</td>
<td>Impacting annual overflow volume and storage volume</td>
</tr>
<tr>
<td># of events with rainfall depth ≥ 0.2 in</td>
<td>10%</td>
<td>Rainfall depth to trigger overflow in existing system</td>
</tr>
<tr>
<td># of events with rainfall depth ≥ 0.1 in</td>
<td>5%</td>
<td>Rainfall depth to trigger surface runoff</td>
</tr>
<tr>
<td>5th largest storm volume</td>
<td>5%</td>
<td>Determining max storage capacity or WRRF capacity</td>
</tr>
<tr>
<td>Rainfall volume for 85% captured</td>
<td>5%</td>
<td>Determining max storage capacity or WRRF capacity</td>
</tr>
<tr>
<td># of back-to-back rainfall events</td>
<td>10%</td>
<td>Determining antecedent conditions and potential storage facility operation</td>
</tr>
<tr>
<td>Maximum peak intensities of the 5th largest storm and less</td>
<td>5%</td>
<td>Determining the sizing of conveyance pipes, diversions, regulators, pumps, etc.</td>
</tr>
<tr>
<td># of storms with return frequency ≥ 1-year</td>
<td>5%</td>
<td>Extremely large storms to be avoided</td>
</tr>
<tr>
<td>Average Rainfall Duration</td>
<td>15%</td>
<td>Determining storage capacity</td>
</tr>
<tr>
<td>Average Rainfall Intensity</td>
<td>10%</td>
<td>Determining storage capacity including pipes, regulators, diversions, etc.</td>
</tr>
</tbody>
</table>

H.2  TYPICAL YEAR SELECTION

H.2.1  Annual Rainfall Statistics

The 46-year hourly precipitation data (1970 - 2015) from the Newark Liberty International Airport was analyzed to evaluate all individual rainfall events in the period. An inter-event time (IET) of 6 hours (i.e. minimum dry time of six hours between rainfall events) was used to differentiate between individual rainfall events. All rainfall events for the data period were analyzed for duration, inter-event time, total rainfall amount, as well as maximum rainfall intensities.

A total of 4,812 rainfall events were counted for the period of 1970 - 2015 (3,022 events with a total depth ≥ 0.1 inch). Events with a total precipitation depth equal to or greater than 0.1 inch are used for further analysis. Table H-2 summarizes rainfall events on an annual basis for annual rainfall depth, number of events above 0.2 inch, number of events above 0.1 inch, the 5th largest storm volume, rainfall volume for 85% captured, number of back-to-back rainfall events, maximum peak intensity of 5th largest and smaller events, number of events with return frequency of one-year and above, average rainfall duration, and average rainfall intensity. The average of the 46 years is shown at the end of the table for each criteria parameter.
### Table H-2: Annual Rainfall Statistics 1970-2015

<table>
<thead>
<tr>
<th>Year</th>
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<th># of Events &gt; =0.1&quot; Rainfall Depth</th>
<th>5th Largest Storm (in)</th>
<th>Rainfall Volume for 85% Captured (in)</th>
<th># of back-to-back events</th>
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<th># of Storms with Return Freq &gt; 1-yr</th>
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### H.2.2 Ranking Analysis

With the weighting factors listed in Table H-1, a deviation score was developed for each individual period. The steps to perform the ranking analysis is discussed in detail in the Typical Hydrologic Year Report prepared for Passaic Valley Sewerage Commission (PVSC). The 1-year periods were then ranked based on the deviation score. The lower deviation score (Figure H-2 Y-axis), the higher the rank for the hydrologic period (i.e., the closer it is to the average condition). Figure H-2 shows the ranking results of the 46 hydrologic years,

<table>
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<tr>
<th>Year</th>
<th>Annual Rainfall (in)</th>
<th># of Events &gt; =0.2&quot; Rainfall Depth</th>
<th># of Events &gt; =0.1&quot; Rainfall Depth</th>
<th>5th Largest Storm (in)</th>
<th>Rainfall Volume for 85% Captured (in)</th>
<th># of back-to-back events</th>
<th>Maximum Peak Intensity of 5th Largest &amp; Smaller</th>
<th># of Storms with Return Freq &gt; 1-yr</th>
<th>Average Rainfall Duration (hr)</th>
<th>Average Rainfall Intensity (in/hr)</th>
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</table>

![Figure H-2: Ranking Score of 1970-2015](image)
H.2.3 Top Ranked Hydrologic Years

Table H-3 summarizes top 20 ranked years based on the ranking analysis. It was decided that a more recent period be used for the PVSC CSO LTCP study to reflect recent climate conditions. It was also determined that the typical year should be selected from years with an annual precipitation depth greater than the average value (highlighted with green background in Table H-3) to be more conservative. Therefore, the following five years are the top years to be considered for typical year selection:

- 1: 2004
- 2: 2014
- 3: 1973
- 4: 2008
- 5: 2006

Table H-3: Top 20 Ranked Years

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<th>Preliminary Rank</th>
<th>Year</th>
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<th>Annual Rainfall (in)</th>
<th># of Events &gt;=0.2” Rainfall Depth</th>
<th># of Events &gt;=0.1” Rainfall Depth</th>
<th>5th Largest Storm (in)</th>
<th>Rainfall Volume for 85% Captured (in)</th>
<th># of back-to-back events</th>
<th>Maximum Peak Intensity of 5th Largest &amp; Smaller</th>
<th># of Storms with Return Freq &gt; 1-yr</th>
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</table>
Rainfall return frequency was analyzed to understand the distribution of the large rainfall events with return frequencies above one year. **Table H-4** summarizes quantity of large rainfall events with return frequencies for the above-mentioned top ranked hydrologic periods.

**Table H-4: Top 5 Ranked Years – Quantity of Rainfall Events**

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<td></td>
</tr>
<tr>
<td>2</td>
<td>2014</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1973</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2008</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2006</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**H.2.4 Selected Hydrologic Period**

The year 2004 will be used as the typical hydrologic year for the CSO LTCP. The year 2004 was ranked first in the criteria described above and contains a wide range of storms and antecedent conditions. Year 2004 also has close to an average CSO volume and event number based on the hydrologic and hydraulic model results.

A summary of the parameters and the percent difference is shown below in **Table H-5**.

**Table H-5: Summary of the Recommended Typical Year - 2004**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Precipitation*</td>
<td>48.37 in (4.5% greater than average 46.27)</td>
</tr>
<tr>
<td>Number of Events &gt;=0.2&quot; Rainfall Depth</td>
<td>54 (5% greater than average 51.2)</td>
</tr>
<tr>
<td>Number of Events &gt;=0.1&quot; Rainfall Depth</td>
<td>73 (11% greater than average 66)</td>
</tr>
<tr>
<td>5th Largest Storm Volume</td>
<td>1.63 in (5% less than average 1.70)</td>
</tr>
<tr>
<td>Rainfall Volume for 85% Capture</td>
<td>1.18 in (12% less than average 1.35)</td>
</tr>
<tr>
<td>Back-to-Back Storm Events</td>
<td>12 (14% greater than average 10.5)</td>
</tr>
<tr>
<td>Max Peak Intensity of 5th Largest Storm &amp; Smaller</td>
<td>0.99 in/hr (9.5% greater than average 0.90)</td>
</tr>
<tr>
<td>Extreme Storm</td>
<td>1 Year Storm (2)</td>
</tr>
<tr>
<td></td>
<td>2 Year Storm (1)</td>
</tr>
<tr>
<td>Average Rainfall Duration</td>
<td>10.3 hr (4.8% less than average 10.8)</td>
</tr>
<tr>
<td>Average Rainfall Intensity</td>
<td>0.084 in/hr (3.8% greater than average 0.081)</td>
</tr>
</tbody>
</table>

*Note: Includes snowfall*
Characteristics of the top 20 rainfall events (by rainfall depth) in the hydrologic year are shown in Table H-6.

Table H-6: Top 20 Rainfall Events by Depth in 2004

<table>
<thead>
<tr>
<th></th>
<th>Event Start</th>
<th>Duration (hr)</th>
<th>Precipitation Depth (in)</th>
<th>Max Rainfall Intensity (in/hr)</th>
<th>Average Rainfall Intensity (in/hr)</th>
<th>Return Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9/28/2004 1:00</td>
<td>28</td>
<td>3.68</td>
<td>0.53</td>
<td>0.13</td>
<td>2-yr – 24hr</td>
</tr>
<tr>
<td>2</td>
<td>9/8/2004 4:00</td>
<td>25</td>
<td>2.21</td>
<td>0.63</td>
<td>0.09</td>
<td>1-yr – 6hr</td>
</tr>
<tr>
<td>3</td>
<td>7/12/2004 9:00</td>
<td>27</td>
<td>1.99</td>
<td>0.32</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4/12/2004 17:00</td>
<td>30</td>
<td>1.67</td>
<td>0.25</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4/25/2004 14:00</td>
<td>35</td>
<td>1.67</td>
<td>0.25</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>7/23/2004 10:00</td>
<td>24</td>
<td>1.66</td>
<td>0.33</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2/6/2004 5:00</td>
<td>33</td>
<td>1.63</td>
<td>0.33</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>7/18/2004 16:00</td>
<td>14</td>
<td>1.60</td>
<td>0.64</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>11/28/2004 2:00</td>
<td>12</td>
<td>1.50</td>
<td>0.85</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>7/27/2004 15:00</td>
<td>18</td>
<td>1.45</td>
<td>0.41</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>9/17/2004 22:00</td>
<td>12</td>
<td>1.44</td>
<td>1.33</td>
<td>0.12</td>
<td>1-yr – 2hr 2-hr – 1hr</td>
</tr>
<tr>
<td>12</td>
<td>6/25/2004 17:00</td>
<td>5</td>
<td>1.39</td>
<td>0.40</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>11/12/2004 7:00</td>
<td>23</td>
<td>1.08</td>
<td>0.10</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>5/12/2004 16:00</td>
<td>2</td>
<td>1.08</td>
<td>0.99</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>11/4/2004 14:00</td>
<td>16</td>
<td>1.03</td>
<td>0.20</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>7/5/2004 3:00</td>
<td>12</td>
<td>1.00</td>
<td>0.69</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>12/1/2004 4:00</td>
<td>10</td>
<td>1.00</td>
<td>0.18</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>8/16/2004 0:00</td>
<td>21</td>
<td>0.94</td>
<td>0.60</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>8/21/2004 14:00</td>
<td>3</td>
<td>0.84</td>
<td>0.81</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>12/6/2004 12:00</td>
<td>39</td>
<td>0.83</td>
<td>0.20</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>
SECTION I - HYDROLOGIC AND HYDRAULIC MODELING

1.1 BACKGROUND

Hydrologic and Hydraulic (H&H) modeling of the NBMUA eastern service area was included as part of the integrated PVSC LTCP model (Figure I-1). The integrated PVSC LTCP model includes service area (except Jersey City) draining to the PVSC WRRF (detailed in a separate report “PVSC Service Area System Characterization Report”), and NBMUA eastern service area draining to the NBMUA Woodcliff STP (detailed in this report).

Prior to this modeling efforts, two H&H models were already developed separately for the North Bergen Woodcliff area and the Guttenberg service areas. Detailed modeling information including communities, permittees, STP, and modeling software are summarized in Table I-1. The service area locations served by each individual models are shown in the highlighted area in Figure I-1. Brief descriptions of these two models are included in the following subsections.

<table>
<thead>
<tr>
<th>Model</th>
<th>Community</th>
<th>WRRF</th>
<th>Permittee</th>
<th>Software</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 PVSC Interceptor Model</td>
<td>City of Paterson</td>
<td>Paterson City</td>
<td></td>
<td>InfoWorks CS</td>
<td>Passaic</td>
</tr>
<tr>
<td></td>
<td>City of Newark</td>
<td>Newark City</td>
<td></td>
<td></td>
<td>Essex</td>
</tr>
<tr>
<td></td>
<td>Town of Kearny</td>
<td>Town of Kearny</td>
<td></td>
<td></td>
<td>Hudson</td>
</tr>
<tr>
<td></td>
<td>Borough of East Newark</td>
<td>East Newark Borough</td>
<td></td>
<td></td>
<td>Hudson</td>
</tr>
<tr>
<td></td>
<td>Town of Harrison</td>
<td>Harrison Town</td>
<td></td>
<td></td>
<td>Hudson</td>
</tr>
<tr>
<td>2 Bayonne Model</td>
<td>City of Bayonne</td>
<td>City of Bayonne</td>
<td></td>
<td>InfoWorks CS</td>
<td>Hudson</td>
</tr>
<tr>
<td>3 &amp; 4 North Bergen Model (PVSC)</td>
<td>Township of North Bergen</td>
<td>North Bergen MUA</td>
<td>PC-SWMM (2 models)</td>
<td></td>
<td>Hudson</td>
</tr>
<tr>
<td>5 Jersey City</td>
<td>City of Jersey City</td>
<td>Jersey City MUA</td>
<td>XP-SWMM</td>
<td></td>
<td>Hudson</td>
</tr>
<tr>
<td>6 North Bergen (Woodcliff)</td>
<td>Township of North Bergen</td>
<td>NBMUA Woodcliff STP</td>
<td>North Bergen MUA</td>
<td>PC-SWMM</td>
<td>Hudson</td>
</tr>
<tr>
<td>7 Guttenberg</td>
<td>Town of Guttenberg</td>
<td>Town of Guttenberg</td>
<td>SWMM</td>
<td></td>
<td>Hudson</td>
</tr>
</tbody>
</table>

Table I-1 also lists five pre-LTCP models developed for the PVSC WRRF service areas, the first four of which were used during PVSC model integration, including PVSC Interceptor Model, Bayonne Model, and two North Bergen models. Integration of the North Bergen Woodcliff model and Guttenberg model into the PVSC LTCP H&H model (InfoWorks ICM v7.5) was performed after the PVSC WRRF service areas and model networks were completely incorporated in the model. Putting Woodcliff STP service areas and PVSC WRRF service areas in the same model provides the benefits of saving model simulation time and saving model result extraction and analysis time.
I.1.1 EXISTING NBMUA Woodcliff Model

The existing North Bergen Woodcliff model was received in January 2017. The model was last updated by Kleinfelder. It was originally created in PCSWMM; however, the received model
was converted to EPA SWMM5 for the convenience of model integration in InfoWorks ICM. **Figure I-2** shows the received NBMUA Woodcliff model in EPASWMM. The model is a simple skeleton SWMM models developed in earlier days.

The received NBMUA Woodcliff model has the following features:

- Two subcatchments, not GIS referenced
- Eleven circular pipes and nine junction nodes
- Two outfall nodes, including Outfall NB004 and Woodcliff STP (simulated as an outfall)
- No hydraulic control features (weir, orifice, and pump etc.) in the model
- Two dry weather inputs, no diurnal pattern included
- No RDII elements
- No real time control rules.

The datum used in the existing NBMUA Woodcliff model is NGVD29.
I.1.2 Guttenberg Models

The Guttenberg model was received in March 2016. The model was lastly updated by HDR. The model was created in SWMM. Figure I-3 shows the model networks in EPASWMM. The received Guttenberg model is a simple skeleton SWMM models developed in earlier days.

The received Guttenberg model has the following features:

- Six subcatchments, not GIS referenced
- 34 junction nodes
- One storage node to simulate regulator chamber

![Guttenberg Model](image)
Two free outfall nodes, including Outfall GU001 and another outfall node for simulating flow sending to the Woodcliff STP

- 33 circular/ellipse pipes
- One weir and one orifice for simulating Guttenberg Regulator
- One pump to pump flow of 1 MGD from a separate sewer area
- 33 dry weather inputs, each with 1 MGD except one with 2 MGD. No diurnal pattern included
- No RDII elements
- No real time control rules.

The datum used in the Guttenberg model is NGVD29.

1.2 WOODCLIFF STP H&H MODEL INTEGRATION & DEVELOPMENT

The Woodcliff STP Model was created as a subset of the newly developed PVSC LTCP H&H model in InfoWorks ICM v7.5. Both of the received NBMUA Woodcliff model and Guttenberg model were integrated in the PVSC LTCP model. Separate sewer service areas contributing flows to the Woodcliff STP were also included in the final model.

1.2.1 Integration of NBMUA Woodcliff Model

The received NBMUA Woodcliff model (Figure I-2, EPASWMM) was imported to the InfoWorks ICM. This import is to obtain the input information for subcatchment, node and link for the integrated ICM model. The model network (including subcatchments, nodes, and links) is not GIS based, therefore efforts were made to prepare GIS based model network for NBMUA Woodcliff area.

**NBMUA Woodcliff Subcatchment**

A paper copy of the North Bergen subcatchment delineation was obtained from the modeling document “Adaptation of SWMM to Simulate the Combined Sewer Overflows of the North Bergen MUA” (January 2007, by Najarian Associates). The paper copy was used to prepare a digitized a polygon shape file in the GIS to represent subcatchments (Figure I-4). The subcatchment ID was assigned to the polygons according to the acreage information in the model document (Figure I-5).

Based on sewer network from the received NBMUA Woodcliff GIS file, the area north of the James J. Braddock North Hudson County Park (between Baar Pl. and River Rd, Woodcliff Ave. and Hudson Pl., red highlighted area in Figure I-4) is also connected to the Woodcliff STP through the 18-inch River Road Interceptor. This area is served by separate sewers based on 1996 report “CSO Planning Study for Area III, Vol. 1_Feb 1996.pdf (Page 32, Figure 4-1)”. The area was added to the subcatchment shape file during digitizing process.

The subcatchment shape file was then incorporated into the integrated model through “Data Import Centre”.

The datum used in the Guttenberg model is NGVD29.
North Bergen Sewer Network

The North Bergen manholes and sewers to be included in the integrated model were selected based on sewer connectivity shown in GIS shape files (Figure I-6) and schematic sewers shown in the EPASWMM model (Figure I-2). Manholes and sewers along the 18-in River Road Interceptor are also selected to put in the model to convey flows from the separate area north of the James J. Braddock North Hudson County Park. The selected manholes and sewers were then incorporated into the integrated model through “Data Import Centre”.

Detail sewer data (invert, dimension, etc.) and manhole data (invert, rim elevation, etc.) were not available from the sewer GIS file, therefore the invert and pipe size information from the received EPASWMM model were used for the integrated model.
North Bergen in the Integrated Model

In a summary, the integration of the North Bergen includes the following major steps:

- Updated IDs of subcatchments, nodes and links to start with “NB1C_”
- Model inputs are mostly derived from the received EPASWMM model
- Subcatchment and model network were updated to GIS-based, and expanded to include sewer conveyance from the separate sewer area north of the James J. Braddock North Hudson County Park.
- Converted dry weather inputs to subcatchment inflows

Model network of NBMUA Woodcliff area in the integrated model is shown in **Figure I-7**. Model network of the Guttenberg area is also shown in the figure. Total numbers of the subcatchments, nodes and links are also shown in the map. Temporary meters indicated in the map are the meters used for model calibration.
Integration of Guttenberg Model
The received Guttenberg model (Figure I-3, EPASWMM) was imported to the InfoWorks ICM. This model import is to obtain the input information for subcatchment, node and link for the integrated ICM model. The model network (including subcatchments, nodes, and links) is not GIS based, therefore efforts were made to prepare GIS based model network for the Guttenberg area.

Guttenberg Subcatchment
The subcatchment delineation for the Guttenberg is performed based on the subcatchment layout in the received model (Figure I-3) and sewer connectivity from the Guttenberg sewer utility GIS shapefile. It was determined that five subcatchments were sufficient to represent the Guttenberg service area. Figure I-8 shows the map of the subcatchments and Table I-2 summarizes area of the subcatchments and correlation between the new delineated subcatchments and the subcatchments in the received model.
The subcatchment shape file was then incorporated into the integrated model through “Data Import Centre”.

Figure I-8: Digitizing Model Subcatchment (NBMUA Woodcliff)

<table>
<thead>
<tr>
<th>Subcatchment ID in New Model</th>
<th>Area (acres)</th>
<th>Corresponded to Subcatchments in the Received Model</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB_C1R1C2</td>
<td>33.9</td>
<td>C1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>5</td>
</tr>
<tr>
<td>GB_R2</td>
<td>51.4</td>
<td>R2</td>
<td>49</td>
</tr>
<tr>
<td>GB_C3</td>
<td>5.3</td>
<td>C3</td>
<td>7</td>
</tr>
<tr>
<td>GB_R3</td>
<td>20.4</td>
<td>R3</td>
<td>17</td>
</tr>
<tr>
<td>GB_C4</td>
<td>13.4</td>
<td>Not in received model</td>
<td>NA</td>
</tr>
</tbody>
</table>
Guttenberg Sewer Network
The Guttenberg manholes and sewers to be included in the integrated model were selected based on sewer connectivity shown in GIS shape files (Figure I-9). The selected manholes and sewers were then incorporated into the integrated model through “Data Import Centre”.

Detail sewer data (invert, dimension, etc.) and manhole data (invert, rim elevation, etc.) were not available from the sewer GIS file, therefore the invert and pipe size information from the received EPASWMM model were used for the integrated model.

Figure I-9: Selected Manhole and Sewers for Model Network (Guttenberg)

Guttenberg in the Integrated Model
In a summary, the integration of the Guttenberg model includes the following major steps:

- Updated IDs of subcatchments, nodes and links to start with “GB_”
- Model inputs are mostly derived from the received EPASWMM model
- Subcatchment and model network were updated to GIS-based
- The 33 dry weather input with a total of 34 MGD in the received model is questionable, dry weather input was developed based on Guttenberg flow data received from the client.
Model network of Guttenberg area in the integrated model is shown in Figure I-7. Model network of the NBMUA Woodcliff area is also shown in the figure. Total numbers of the subcatchments, nodes and links are also shown in the map. Temporary meters indicated in the map are the meters used for model calibration.

1.3 H&H MODEL COMPONENT AND INPUTS

1.3.1 Rainfall
Rainfall data assigned to a subcatchment within the model represent the average precipitation that falls on the area within a defined time interval. Rainfall data was entered in the model as rainfall intensity occurring within a time interval. The rainfall time interval can be as short as a minute or as long as an hour. Generally, the model results satisfactorily match observed flow monitor data when the rainfall input time interval is at a maximum of 15 minutes. 5-minute rainfall data were used in the model for both model calibration and typical year simulation.

Model Calibration Rainfall: Rainfall records from New York rainfall stations were used during model calibration of the Woodcliff STP model. Figure I-10 shows locations of rainfall stations for the full PVSC LTCP model and summarizes data source and available time interval in the table. Five minute rainfall data was developed for model input based on the available time interval.

Typical Year Simulation Rainfall: Typical hydrologic period was analyzed based on rainfall records from the Newark station and Year 2004 was selected as the typical year (Section H.2). 5-minute rainfall data was developed based on the Newark NWS ASOS 1-min precipitation records for model input. This precipitation was used in the model for the typical year simulation.

1.3.2 Subcatchment
The model’s surficial hydrology maintains the EPA SWMM runoff method used in the prior PVSC interceptor model and the Bayonne, North Bergen, and Guttenberg models that were incorporated into the comprehensive PVSC model. The SWMM methodology separately computes runoff from impervious and pervious surfaces based on a simplification of Manning’s equation for shallow flow. Manning’s equation computes discharge as:

\[ Q = \frac{1.49}{n} A_w R_h^{2/3} S^{1/2} \]

Where:
Q = discharge (ft³/s)
n = Manning’s roughness coefficient
A_w = wetted area (ft²)
R_h = hydraulic radius (ft)
S = slope
The SWMM runoff method represents flow from a subcatchment as having $A_w = dW$, where $d$ is the depth of sheet flow and $W$ is the representative width of sheet flow across the subcatchment orthogonal to the principal flow path. The hydraulic radius (wetted area divided by wetted perimeter) of this flow is $dW/(W + 2d)$. As $W$ is much larger than $d$ (i.e., the width of runoff from a subcatchment is measured in feet, while sheet flow depth is typically a fraction of an inch), the hydraulic radius effectively equals $d$ (e.g., for a sheet flow depth of 0.01 ft and width of 50 ft, $R_h = 0.01 \times 50 / [50 + 0.02] \approx 0.01$). Manning’s equation can then be rewritten as:

$$Q = \frac{1.49}{n} (dW) d^{2/3} S^{1/2} \quad \text{or} \quad Q = \frac{1.49}{n} W d^{5/3} S^{1/2}$$

Instantaneous discharge from a subcatchment to its inlet is thus calculated from the depth of water over the subcatchment’s “reservoir”, Manning’s “$n$”, representative width, and subcatchment slope. This is known as the SWMM non-linear reservoir runoff model. $W$ is the...
SWMM width parameter, identified in InfoWorks as the “dimension” parameter. It is usually calibrated during model development to control hydrograph shape: a large width increases instantaneous runoff and yields a sharp, rapidly-responsive hydrograph, whereas a small width yields a flatter hydrograph with a smaller peak and longer response. Manning’s “n” and subcatchment slope are usually held constant during calibration, as adjusting these values has the same effect as adjusting \( W \) (the differing exponents mean that the response may be inverted or less pronounced, but the overall effect on the hydrograph is the same). The model is applied separately for impervious and pervious surfaces, and considers that initial abstraction (e.g. puddles) is applicable across most of a subcatchment, except on roofs and other steep surfaces.

**Subcatchment Area**

Table I-3 summarizes the number and size of subcatchments in each combined sewer community. Modeled contributing areas are generally smaller than total community area; some areas drain directly to receiving waters. Others, such as the James J. Braddock North Hudson County Park, are not served by sewers. As the model was assembled from various component models, the level of detail varies considerably among communities. The NBMUA Woodcliff area has subcatchment sizes ranging from 18 acres to 123 acres, with an average of 60 acres. The Guttenberg area has subcatchment sizes ranging from 5 acres to 51 acres, with an average of 25 acres.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Area (acres)</th>
<th>Contributing area (acres)</th>
<th>Subcatchment</th>
<th>Acres per subcatchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBMUA Woodcliff Area</td>
<td>181</td>
<td>141</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>Guttenberg</td>
<td>124</td>
<td>111</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>305</td>
<td>252</td>
<td>53</td>
<td>8</td>
</tr>
</tbody>
</table>

*NOTE: The total acreage in the table above includes only the subcatchment areas in the model that contribute flow to the Woodcliff STP. The acreage does not include rivers, creeks or unsewered areas within a municipality.*

**Subcatchment Percent Imperviousness**

Effective imperviousness is calibrated in the combined sewer communities through adjustment of the “Runoff routed internally (%)” parameter, which identifies the fraction of the impervious surface of a subcatchment that drains onto adjacent pervious ground (e.g. roof leaders that drain to lawns). Table I-4 presents total and effective impervious area and percentages for each combined sewer community. Average imperviousness for all the combined sewer subcatchments computed from NLCD is 77 percent, while effective imperviousness was calibrated as 38 percent. The disparity between these values suggests that the contributing area for the collection system is smaller than the modeled areas; while Table I-4 shows that modeled areas are already smaller than the community extent, the true contributing areas appear to be smaller still. While the difference between total and effective impervious area suggests that modeled areas may be overestimated, the table indicates the comparative extent of effective impervious area among the communities: both NBMUA Woodcliff and Guttenberg account for 50 percent of the impervious area across the combined sewer service area.
### Table I-4: Impervious and Effective Impervious Area for the Combined Sewer Service Area

<table>
<thead>
<tr>
<th>Community</th>
<th>Modeled Area (ac)</th>
<th>Total Impervious Area (ac)</th>
<th>Effective Impervious Area (ac)</th>
<th>Total Imperviousness (%)</th>
<th>Effective Imperviousness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBMUA Woodcliff Area</td>
<td>141</td>
<td>99</td>
<td>49</td>
<td>70</td>
<td>34</td>
</tr>
<tr>
<td>Guttenberg</td>
<td>111</td>
<td>95</td>
<td>48</td>
<td>86</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>252</td>
<td>194</td>
<td>96</td>
<td>77</td>
<td>38</td>
</tr>
</tbody>
</table>

### Subcatchment Width

Subcatchment width is a principal calibration parameter, as hydrograph timing has many controlling factors such as catch basin density and conveyance characteristics of pipes omitted from the hydraulic model. For this study, widths in areas that had not been recently calibrated were initially specified based on a regression relationship for existing widths in the model, with width (feet) calculated as $300 A^{0.6}$, where $A$ is area in acres. For example, the median subcatchment area across all the combined sewer communities is 42 acres. The estimated width for a 42-acre subcatchment is 2800 feet, or 67 ft/ac. This can also be considered as an overland flow length of 650 feet, although the SWMM method does not explicitly account for overland flow. While unit width depends on various factors, higher values are generally associated with faster runoff and lower values with attenuated runoff. As shown in Table I-5, NBMUA Woodcliff and Guttenberg have unit widths of 6.9 ft per acre and 9.5 ft per acre respectively.

#### Table I-5: Subcatchment Unit Width

<table>
<thead>
<tr>
<th>Community</th>
<th>Unit Width (ft/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Bergen</td>
<td>6.9</td>
</tr>
<tr>
<td>Guttenberg</td>
<td>9.5</td>
</tr>
</tbody>
</table>

### Subcatchment Slope

Subcatchment slope was transferred from the received models into the integrated model with only minor adjustments. Average values by community are shown in Table I-6. Slope on its own is not of key importance, since, as discussed above, it is composited with width and Manning’s “$n$” for computing runoff rates, and the width parameter was adjusted through calibration.

#### Table I-6: Average Slope %

<table>
<thead>
<tr>
<th>Community</th>
<th>Slope (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Bergen</td>
<td>3.0</td>
</tr>
<tr>
<td>Guttenberg</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Depression Storage
Impervious area was partitioned so that 75 percent of each subcatchment has an initial abstraction depth of 0.05 inches, and 25 percent of the area has no initial abstraction (representative of pitched roofs). Pervious areas were specified with initial abstraction of 0.1 inches. During continuous simulation, available initial abstraction depth is restored based on evaporation.

Manning’s “n” Roughness Coefficient
Overland flow travels slower or faster depending on the roughness of the surface in the subcatchment. The higher the roughness coefficient, the greater the friction and the slower the flow travels. Again, this is a model parameter that cannot be practically measured. A typical range of Manning’s “n” suggested by the SWMM is 0.011-0.024 for impervious area and 0.05-0.80 for pervious area. The initial values were set to 0.02 for impervious surfaces and 0.05 for pervious surfaces. Roughness is an empirical value and may be treated as a calibration parameter if necessary.

Soil Infiltration
Pervious areas were uniformly modeled using the Horton infiltration equation with an initial infiltration rate of 5 inches per hour, and a limiting rate of 2 inches per hour. This typical infiltration rate was estimated from review of soils data for the area. Much of the area is identified in the national soils database as “urban land”, for which no hydraulic properties are identified. The predominant named soil types are Boonton, Riverhead, Greenbelt, Whippany, and Parsippany, each of which has a saturated conductivity between 1 and 4 inches per hour. As few storms have sustained rainfall exceeding 2 inches per hour, runoff from pervious area is simulated for only a few hours a year. Most runoff in the combined sewer service area comes from impervious surfaces. It is thus not possible to distinguish the impact of pervious area runoff from the available flow metering data.

I.3.3 Trunk sewer and Main Interceptor
Most of the gravity sewer mains in the final model were imported from the previous models during model integration. Sewer size, shape, invert, and Manning’s “n” value were inherited from the previous models as well. A small amount of new sewer lines were added as needed during model expansion or refinement. Input for the new sewer lines were prepared based on available sewer GIS information or with appropriate assumptions (for example: assuming constant slope for neighboring sewers).

Manning’s roughness coefficient is related to the pipe material. Manning’s “n” values in the model are in the range of 0.010 to 0.014. The Manning’s “n” may be changed during calibration to account for minor loss or additional sediment depositions in the pipe.

I.3.4 Manhole
Most of the manholes invert and rim were inherited from the previous models. A small amount of new manholes were added as needed during model refinement. Input for the new sewer lines were prepared based on available sewer GIS information or with appropriate assumptions (for
example: assuming constant slope for neighboring sewers, manhole rim at the ground contour, etc.).

### I.3.5 CSO Outfall

There are two permitted/active CSO outfalls included in the Woodcliff STP model. One for the NBMUA Woodcliff area (NB004) and one for the Guttenberg area (GU001). Both do not have flap gates to prevent water backup from receiving water body.

### I.3.6 Regulator

CSO regulators and outfalls serve as combined sewer reliefs necessitated by stormwater entering the sewer system and exceeding the hydraulic capacity of the sewers and/or treatment plant. WWF in excess of the collection system’s capacity are discharged to the receiving water body.

There are 3 CSO regulators included in the Woodcliff STP service area. Regulator gate and weir dimensions and elevations were derived from received document drawings (Table I-7).

#### Table I-7: Woodcliff STP Regulator

<table>
<thead>
<tr>
<th>Regulator #</th>
<th>Overflow Weir</th>
<th>Regulating Sluice Gate / Orifice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drawing</td>
<td>Received Model</td>
</tr>
<tr>
<td></td>
<td>Crest</td>
<td>Width</td>
</tr>
<tr>
<td>NB-1 (73rd St. &amp; JFK Blvd. E.)</td>
<td>169.73</td>
<td>4&quot;</td>
</tr>
<tr>
<td>NB-2 (74th St. &amp; JFK Blvd. E.)</td>
<td>144.08</td>
<td>4&quot;</td>
</tr>
<tr>
<td>GU-1 (JFK Blvd. E to Hudson River)</td>
<td>156.26</td>
<td>4.5</td>
</tr>
</tbody>
</table>

* Estimated based on drawing.

### I.3.7 Rainfall Derived Infiltration and Inflow (RDII)

The model uses the RTK unit hydrograph (UH) to estimate RDII into the separate sewer system areas. As shown in Figure I-11, a RTK UH set contains up to three hydrographs (Muleta & Boulos, 2008): one for a short-term response (UH1), one for an intermediate-term response (UH2), and one for a long-term response (UH3). UH1 represents the most rapidly responding inflow component and has a short T value, UH2 includes both inflow and infiltration and has a longer T value, and UH3 includes infiltration that may continue long after the storm event has ended and has the longest T value. The unit hydrograph is defined by the following three parameters:

- **R**: the fraction of rainfall volume that enters the sewer system and equals to the volume under the hydrograph,
- **T**: the time from the onset of rainfall event to the peak of the unit hydrograph in hours, and
- **K**: the ratio of time to recession of the unit hydrograph to the time to peak.
The same set of RDII parameters were applied in the same metershed because of the availability of the flow hydrograph for model calibration. The initial values of RTK were estimated based on previous modeling document. The RTK values are calibration parameters to be refined during model calibration.

I.3.8 Dry Weather Flow
The DWF of the NBMUA Woodcliff STP and Guttenberg was developed based on the hourly flow data received. Same weekday and weekend DWF diurnal patterns was applied due to limited data. The DWF was assigned to the subcatchments proportional to the service area. Concentration of Pollutant PL1 was assumed to be 100 for all dry weather input, this allows users to differentiate WWF quantity from the DWF quantity.

I.3.9 Real Time Control
There is no real time control rules created for the Woodcliff STP service area. None of the NBMUA Woodcliff and Guttenberg regulators are assumed to be regulated during wet weather conditions according to the received models.
I.4 SUMMARY
The NBMUA Woodcliff STP model was appended to the integrated PVSC LTCP model in InfoWorks ICM 7.5. The Woodcliff – Guttenberg Service Area was incorporated into the model based on the received individual models for NBMUA Woodcliff and Guttenberg. The Woodcliff STP model has the following features (Figure I-7):

- Eight subcatchments, including six combined and two separate subcatchments
- 49 nodes, including 45 manholes, three (3) outfalls, and one (1) storage. The three outfall nodes include two CSO outfalls (GB001 and NB004) and one outfall representing Woodcliff STP. The one storage is for simulating Guttenberg regulator chamber.
- 49 links, including 43 conduits, three (3) weirs, and three (3) sluice gates. None of the sluice gate (regulator gate) are regulated during wet weather conditions.
- DWF based on received Woodcliff STP flow data.
- WWF simulated as runoff from the combined sewer service areas and RDII from the separate areas.
- No real time control applied.

I.5 H&H MODEL CALIBRATION
Model credibility is developed through model calibration and validation. Model calibration involves application of the model to known external inputs (e.g., rainfall), evaluation of the model’s ability to replicate monitored conditions (e.g., flow and volume), and adjustment of key model parameters as needed until an acceptable level of agreement is reached between simulated and monitored conditions.

The collection system H&H Model was calibrated in conjunction with the flow monitoring. The H & H Model was calibrated by running the model with rainfall data collected from selected storms and then comparing the calculated results to the actual flow monitoring data collected. The model parameters were adjusted and the process repeated until the calculated results approximated the actual flow monitoring measurements. Goals for the model calibration included:

- To visually match the shape of the curve between model and flow monitor.
- To match model runoff volumes (volume under curve) to actual runoff volumes.
- To match model runoff peak flow rates to actual runoff peak flow rates.

Once the model was calibrated to the selected storms, at least one additional storm was run through the model to validate that the model was sufficiently calibrated.
Flows used for calibration are from the three temporary flow meters and Woodcliff STP plant flows, detailed flow monitoring locations are listed below:

- Temporary meters on overflow pipes
  - North Bergen regulator at 73rd St & JFK Blvd. East
  - North Bergen regulator at 74th St & JFK Blvd. East, and
  - Guttenberg regulator at 70th St & JFK Blvd. East
- Woodcliff STP flows
  - NBMUA Woodcliff flow
  - Guttenberg flow

### 1.5.1 DWF Calibration

Usually DWF analysis was based on the rainfall and flow monitoring results. DWF distribution in the collection system was based on land use data. Weekday, weekend and monthly diurnal factors from the DWF analysis were applied for each flow meter service area. Upstream meters in the system were calibrated first, then flows through the system to the STP were balanced.

Dry weather calibration typically follows the criteria below:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be within 1 hour of the observed,
- The simulated peak flow will be within 10% of the observed flow, and
- The simulated flow volume over 24 hours will be within 10% of observed flow.

Dry weather calibration is not performed for the Woodcliff STP model because all the three temporary flow meters are located on the CSO overflow pipe, which would not have flow recorded under dry conditions.

### 1.5.2 WWF Calibration

WWF includes surface runoff from the combined sewer service area, RDII from the entire service area, and connected rooftops, if any, from the separate area. Surface runoff parameters from the combined sewer service area and RDII parameters from the separate area were adjusted to calibrate the system response to the wet weather conditions.

Four (4) wet weather events were selected for wet weather calibration. Final selections include wet weather events with various rainfall intensities and volume. Larger storm events will have more weighting factor in the calibration process because the large events are the ones that dominate the total overflow volume.

The WWF calibration goals are:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be similar having regard to the duration of the event,
- The simulated peak flow for significant peaks will be within the range of -15% to +25%.
- The simulated flow volume will be within the range of -20% to +20%.

Four storm events selected for calibration of the collection system model met all the desired storm characteristics as describe in Section E of this Report. The July 25, 2016 storm was a 1.81-inch storm with a duration of approximately 3 hours and a maximum intensity of 1.68 in/hr. The May 29, 2016 storm was a 1.60-inch storm with a duration of 5.5 hours and a maximum intensity of 1.09 inches/hour. The July 29, 2016 storm was a 0.85 inch storm with a duration of 8.25 hours and a maximum intensity of 0.42 in/hr. The July 31, 2016 rain event was a 0.69-inch storm with a duration on 14 hours and a maximum intensity of 0.49 in/hr. Data on these storms is shown in Table I-8.

Table I-8: Wet Weather Events for Model Calibration and Validation

<table>
<thead>
<tr>
<th>Event Start</th>
<th>Event End</th>
<th>Duration (hr)</th>
<th>Depth (in)</th>
<th>Max Intensity (in/hr)</th>
<th>Average Intensity (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/25/16 16:05</td>
<td>7/25/16 18:50</td>
<td>2.75</td>
<td>1.81</td>
<td>1.68</td>
<td>0.66</td>
</tr>
<tr>
<td>5/29/16 23:50</td>
<td>5/30/16 5:20</td>
<td>5.50</td>
<td>1.60</td>
<td>1.09</td>
<td>0.29</td>
</tr>
<tr>
<td>7/29/16 0:20</td>
<td>7/29/16 8:35</td>
<td>8.25</td>
<td>0.85</td>
<td>0.42</td>
<td>0.10</td>
</tr>
<tr>
<td>7/31/16 8:35</td>
<td>7/31/16 22:35</td>
<td>14.00</td>
<td>0.69</td>
<td>0.49</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Examples of model calibration results are shown in the following figures for the observed and simulated flow (Figure I-12 to Figure I-15). The one-to-one plots for modeled versus observed volumes, and the one-to-one plots for modeled versus observed peak flows are also shown for the temporary meter calibration (Figure I-12 to Figure I-14). A well calibrated model will result in plotted values that are close to a one-to-one relationship. Significant runoff parameter adjustments would be needed to achieve an ideal one-to-one relationship between the monitoring data and the model results. This was not recommended and performed due to limited data available for calibration, which resulted in over-estimation of CSO overflow volume and peak flow for the North Bergen NB004A and NB004B. Calibration of Guttenberg is also challenging because the metered flow pattern is not consistent with the rainfall pattern. For example meter data shows overflow occurrence prior to the precipitation on July 25 storm event. One potential reason is that the rainfall data applied in the model may not be representative of the local rainfall characteristics.

- Figure I-12 to Figure I-14 for temporary flow meter calibration
- Figure I-15 for NBMUA Woodcliff STP plant flow calibration
Figure I-12: Calibration Plot for North Bergen NB004A

Note:
1. The monitored flow data was not consistent with the observed rainfall records for the events. The calibration was performed to reflect the largest peak flow on May 29, 2018 event, to be conservative.
1. The monitored flow data was not consistent with the observed rainfall records for the events. In order to reflect the monitored overflow data for the three events in July, the modeled effective imperviousness of the drainage area to Regulator NB004B would have to be significantly reduced. This approach was not applied in the calibration due to lack of the regulator influent flow data for verification.
Figure I-14: Calibration Plot for Guttenberg GU001

Note:
1. The monitored flow data was not consistent with the observed rainfall records for the events on July 25, 2016 and July 29, 2016. The calibration was performed to have a balanced calibration on both overflow volume and peak.
1.6 TYPICAL YEAR MODEL RESULTS

The calibrated model was simulated for the selected typical year of 2004 for evaluating the collection system performance under the existing conditions.

Rainfall data with interval of 5 minutes were developed from the 1-minute NOAA ASOS (Automated Surface Observing System, National Centers for Environmental Information) for Newark. The 5-minute rainfall data was then validated with hourly and daily data for missing gaps. The same set of rainfall data was applied uniformly to all subcatchments in the model.

Model results were extracted from the completed InfoWorks simulation for all CSO overflow points and for WWTP and other community effluent flows. The raw 5-minute flow data was converted to 15-minute data for the convenience of data analysis. Twelve hours is used as the inter-event-time (IET) for overflow event analysis.

### 1.6.1 Overflow Statistics

Overflow volume and frequency in the typical year are summarized for both CSO overflow points in Table I-9. Duration of each discharge for each CSO in number of days under Compliance Monitoring Program (CMP) can be found in the monthly Discharge Monitoring Reports (DMRs) that are submitted by the each CSO Permittee each month to the NJDEP.
### Table I-9: Typical Year CSO Overflow Volume and Frequency

<table>
<thead>
<tr>
<th>CSO ID</th>
<th>Overflow Volume (MG)</th>
<th>Overflow Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB004</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>GU001</td>
<td>12</td>
<td>28</td>
</tr>
</tbody>
</table>

### I.6.2 Percent Capture

Wet weather percent capture was calculated for the CSO communities contributing flows to the NBMUA Woodcliff STP. The estimated percent capture for the typical year is approximately 89%.

### Table I-10: Typical Year % Capture

<table>
<thead>
<tr>
<th></th>
<th>Woodcliff STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total WWF Volume (MG)</td>
<td>229</td>
</tr>
<tr>
<td>Total CSO Volume (MG)</td>
<td>25</td>
</tr>
<tr>
<td>% Capture</td>
<td>89%</td>
</tr>
</tbody>
</table>
SECTION J - REFERENCES


Hatch Mott MacDonald. (2007). Bayonne Municipal Utilities Authority Combined Sewer Overflow LTCP.


SECTION K - ABBREVIATIONS

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
GIS: Geographic Information System
H&H: Hydrologic and Hydraulic
LTCP: Long Term Control Plan
MGD: million gallons per day
NJPDES New Jersey Pollutant Discharge Elimination System
PCBs: polychlorinated biphenyls
QAPP: Quality Assurance Project Plan
USEPA: United States Environmental Protection Agency
WRRF: Water Resources Recovery Facility
WWF: Wet Weather Flow
APPENDIX A

Combined Sewer Overflow and Stormwater Sampling Results
## Stormwater Sampling Schedule and Dates

A summary of the Stormwater sampling dates with corresponding locations and sample station identification numbers are shown in the table below. The Sampling Identification is noted at the top of each page in Appendix A.

<table>
<thead>
<tr>
<th>Date</th>
<th>Locations</th>
<th>Stormwater Sample Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/29/2016</td>
<td>2</td>
<td>OAK-LR4, PAT-LR1</td>
</tr>
<tr>
<td>9/19/2016</td>
<td>2</td>
<td>NWK-CI2, PAT-LR1</td>
</tr>
<tr>
<td>9/30/2016</td>
<td>2</td>
<td>NWK-CI2, OAK-LR4</td>
</tr>
<tr>
<td>10/21/2016</td>
<td>1</td>
<td>NWK-HR1</td>
</tr>
<tr>
<td>11/15/2016</td>
<td>4</td>
<td>NWK-CI2, NWK-HR1, OAK-LR4, PAT-LR1</td>
</tr>
<tr>
<td>12/6/2016</td>
<td>1</td>
<td>NWK-HR1</td>
</tr>
<tr>
<td>1/17/2017</td>
<td>2</td>
<td>NWK-HR2, NWK-LR2</td>
</tr>
<tr>
<td>5/5/2017</td>
<td>4</td>
<td>HAW-LR3, NWK-HR2, NWK-LR2, PAT-CI1</td>
</tr>
<tr>
<td>5/22/2017</td>
<td>2</td>
<td>NWK-HR2, NWK-LR2</td>
</tr>
<tr>
<td>5/25/2017</td>
<td>2</td>
<td>HAW-LR3, PAT-CI1</td>
</tr>
<tr>
<td>7/6/2017</td>
<td>2</td>
<td>HAW-LR3, PAT-CI1</td>
</tr>
</tbody>
</table>

**Total**  11  **Unique Stormwater Locations**

**Total**  24  **Stormwater Location-Events**
Station: S1-NWK-LR2
Station: S1-OAK-LR4

- Fecal Coliform (cfu/100mL)
- Enterococci (cfu/100mL)
- E. Coli (cfu/100mL)
- Salinity (ppt)
- Temperature (°C)
Station: S1-PAT-CI1
Station: S1-PAT-LR1

- **Fecal Coliform (cfu/100mL)**
- **Enterococci (cfu/100mL)**
- **E. Coli (cfu/100mL)**
- **Salinity (ppt)**
- **Temperature (C)**

**Graph Details:**
- Time (Hrs since 12 AM)
- Log scale on the y-axis for bacteria concentrations.
- Linear scale on the y-axis for salinity and temperature.
Station: S1-PAT-LR1