North Hudson Sewerage Authority

Long Term Control Plan

Combined Sewer System Characterization Report for the River Road Wastewater Treatment Plant

NJPDES Permit: NJ0025321

Date: July 1, 2018

Status: Final

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Document Name (s): River Road Wastewater Treatment Plant System Characterization Report

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SECTION 1

Acronyms and Abbreviations

ACO	Administrative Consent Order
BCMP	Baseline Compliance Monitoring Program
CCTV	Closed Circuit Television
CIP	Cured in Place Pipe
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
DCIA	Directly Connect Impervious Area
DIP	Ductile Iron Pipe
EDP	Effective Date of Permits
GPCD	Gallons per capita per day
I/I	Infiltration and Inflow
IDM	Inch-Diameter Mile
JOSO	Joint Overflow Sewer Outlet
LTCP	Long Term Control Plan
MGD	Million Gallons per Day
NHSA	North Hudson Sewerage Authority
NJDEP	New Jersey Department of Environmental Protection
NJHDG	New Jersey Harbor Discharges Group
NJPDES	New Jersey Pollution Discharge Elimination System
PACP	Pipeline Assessment and Certification Program
PVSC	PVSC – Passaic Valley Sewerage Commission
PCCP	Pre-stressed Concrete Cylinder Pipe
RCP	Reinforced concrete pipe
RDII	Rainfall Derived Infiltration and Inflow
S/F	Solids/Floatables
SCADA	Supervisory control and data acquisition
STP	Sewage Treatment Plant
TIGER	Topologically Integrated Geographic Encoding and Referencing
USEPA	U.S. Environmental Protection Agency
VCP	Vitrified clay pipe
WWTP	Wastewater Treatment Plant

Regulators

UC1	Union City 1
UC2	Union City 2
WNY1	West New York 1
WNY2	West New York 2

Introduction

The North Hudson Sewerage Authority is required to prepare a long-term control plan (LTCP) to address combined sewer overflows and a component of the LTCP is the Combined Sewer System Characterization Report. This section outlines the regulatory requirements and components of the long-term control plan, and provides an overview of the combined sewer system (CSS) tributary to the River Road Wastewater Treatment Plant (WWTP).

2.1 Background

The North Hudson Sewerage Authority (NHSA, also referred to in this report as the Authority) has been mandated by the New Jersey Department of Environmental Protection (NJDEP) to prepare a long-term control plan (LTCP) to address combined sewer overflows (CSOs). NHSA has already made significant progress towards achievement of its LTCP, having completed mapping of the collection system, closed circuit television (CCTV) inspections, flow monitoring, completion of several work plans and the initiation of a web-based public notification system. This report provides the Combined Sewer System Characterization for the drainage area tributary to the River Road Wastewater Treatment Plant (WWTP) including a sewer system inventory and condition assessment, hydraulic model development which includes calibration and validation, and a baseline system characterization to calculate the system response to the typical year rainfall.

2.2 Regulatory Requirements

NHSA owns two WWTPs and the combined sewer systems (CSS) tributary to these facilities. The Adams Street and River Road WWTPs are regulated by the NJDEP under the New Jersey Pollutant Discharge Elimination System (NJPDES) permit program.

Under this permit, NHSA established and implemented solids and floatables control of combined sewer overflows and undertook and developed various system studies as required to characterize the CSS. The General Permit for CSSs was revoked and re-issued in 2004. Under the 2004 Permit, NHSA continued to address four of the nine minimum controls (Nos. 2, 4, 5, and 7) of the CSO LTCP as listed in the National CSO Control Policy, as required under the permit, and was required to initiate a public participation program and assess CSO control alternatives. NHSA submitted the required documents to the NJDEP in April 2007 to address pollutant and bacteriological water quality improvements, and a review of the means and methods needed to reduce the frequency of CSO discharges.

On March 12, 2015 the NJDEP issued the individual permits, with an effective date of July 1, 2015, to municipalities and authorities that own and operate segments of CSSs. The NJPDES permits address requirements for overall water quality improvements, routine reporting, and development of a CSO LTCP.

Pursuant to NJPDES Permit NJ0025321 (River Road WWTP), Part IV, Combined Sewer Management Section, Section D.3.b.ii., a System Characterization Report for the LTCPs shall be submitted to NJDEP within 36 months of the Effective Date of the Permits (EDP). The EDP for the River Road WWTP permit is July 1, 2015. The System Characterization Report is due July 1, 2018.

2.3 Purpose and Scope

As a component of the overall LTCP, this report provides the collection and treatment system characterization for the drainage area tributary to the River Road WWTP. The collection system characterization provides an understanding of how the sewer system responds to a range of precipitation events, estimates the frequency, duration and volume of CSO discharges and provides an understanding of system limitations which may contribute to other issues such as basement backups, street flooding, or other potential health concerns. The collection system model can serve as a tool for the development and evaluation of CSO controls that will ultimately be identified as the recommended plan in the CSO LTCP.

To develop a comprehensive characterization of the combined sewer system, the following tasks have been carried out, with the findings of each task presented in this report:

- Sewer System Inventory
- Wastewater Treatment Plant Analysis
- Service Area and Land Use Analysis
- Identification of Sensitive Areas
- Collection System Assessment
- Inflow & Infiltration Assessment
- Hydraulic Collection System Modelling
- Baseline Characterization

2.4 System History and Description

The River Road WWTP (NJPDES No. NJ0025321) is located at 6400 Anthony M. Defino Way in West New York (shown in Figure 2.1 below). It was constructed in 1992 as a secondary wastewater treatment facility using trickling filters to provide the required treatment level, and has been upgraded several times since. The service area of the River Road WWTP is approximately 1.4 square miles and includes the Town of West New York as well as parts of Union City and Weehawken. No other communities contribute flows to the system. The estimated population serviced by the River Road WWTP is 73,000. The River Road WWTP is permitted by NJDEP to discharge 10 MGD and has a wet weather capacity of 20 MGD.

The NHSA owns the following facilities in its two WWTP service areas:

- 2 WWTPs (Adams Street and River Road)
- 106 miles of combined sewer (including interceptors, siphons and force mains)
- 9 Wastewater Pump Stations
- 2 Wet Weather Pump Stations
- 17 CSO Regulators
- 10 CSO Outfalls
- 11 Solids/floatables screening facilities

Of these, the River Road service area includes:

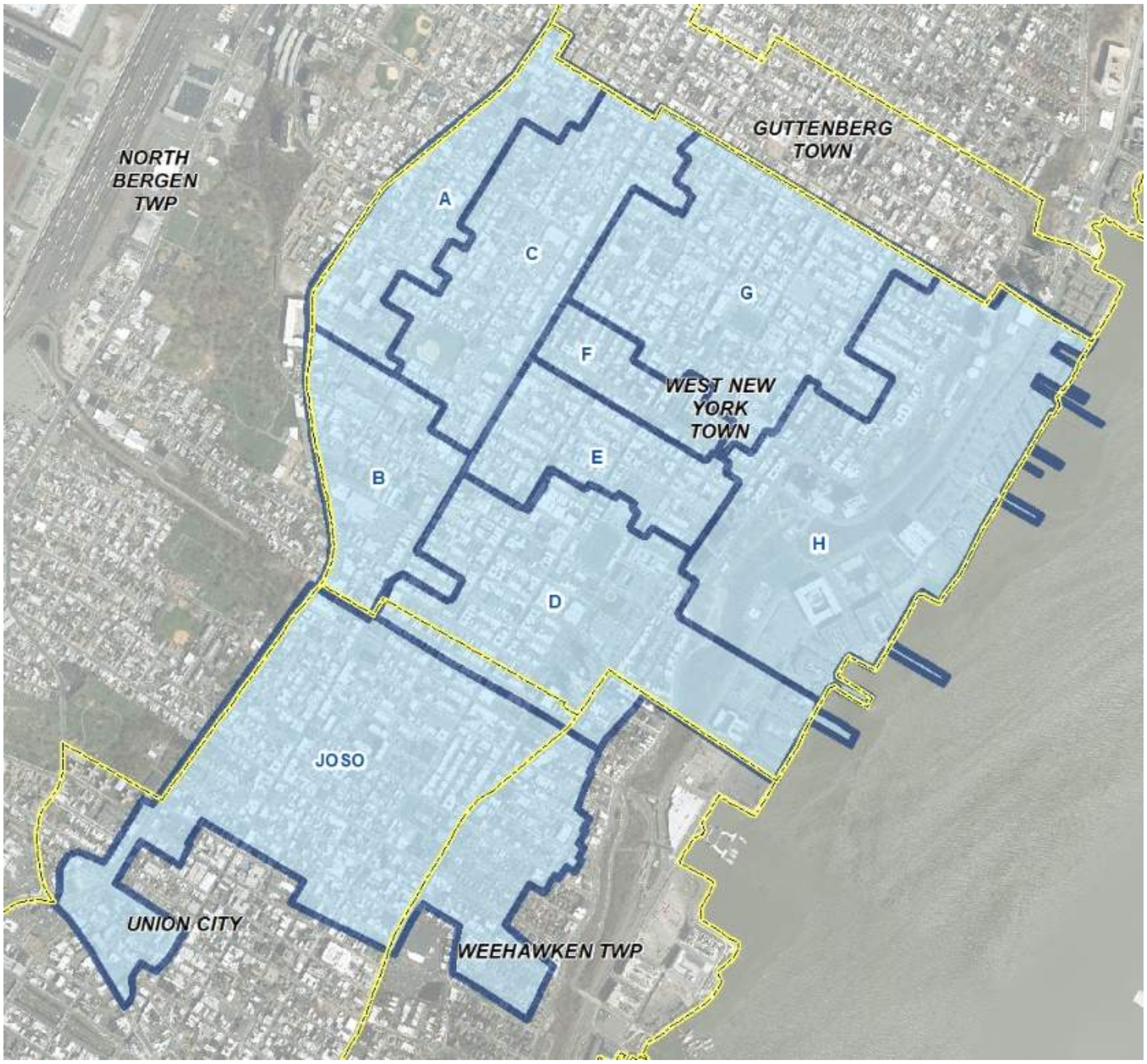
- 1 WWTP (River Road)
- 31.4 miles of combined sewer
- 4 Pumping Stations (49th Street, Landings, Port Imperial, Liberty Place)
- 4 CSO Regulators (UC1, UC2, WNY1, WNY2)
- 2 CSO Outfalls (001A/002A, 003A)
- 2 Solids/floatables screening facilities (WNY1, JOSO)

The River Road WWTP service area is shown in Figure 2.1 below. There are nine drainage basins within the service area of the River Road WWTP. The River Road WWTP service area combined sewers range in diameter from 6 to 96 inches. The piping consists mainly of brick, vitrified clay, and reinforced concrete. The individual connections from buildings to the NHSA sewer mains are owned and maintained by the property owners.

The collection system in the River Road WWTP Service Area was originally designed to convey both sanitary sewage and stormwater directly to the Hudson River. The network of trunk and interceptor sewers that convey wastewater to the River Road WWTP was built in the 1950's. The wastewater collection system includes regulators, pump stations, interceptor sewers, force mains, combined sewers, and local collector and trunk sewers.

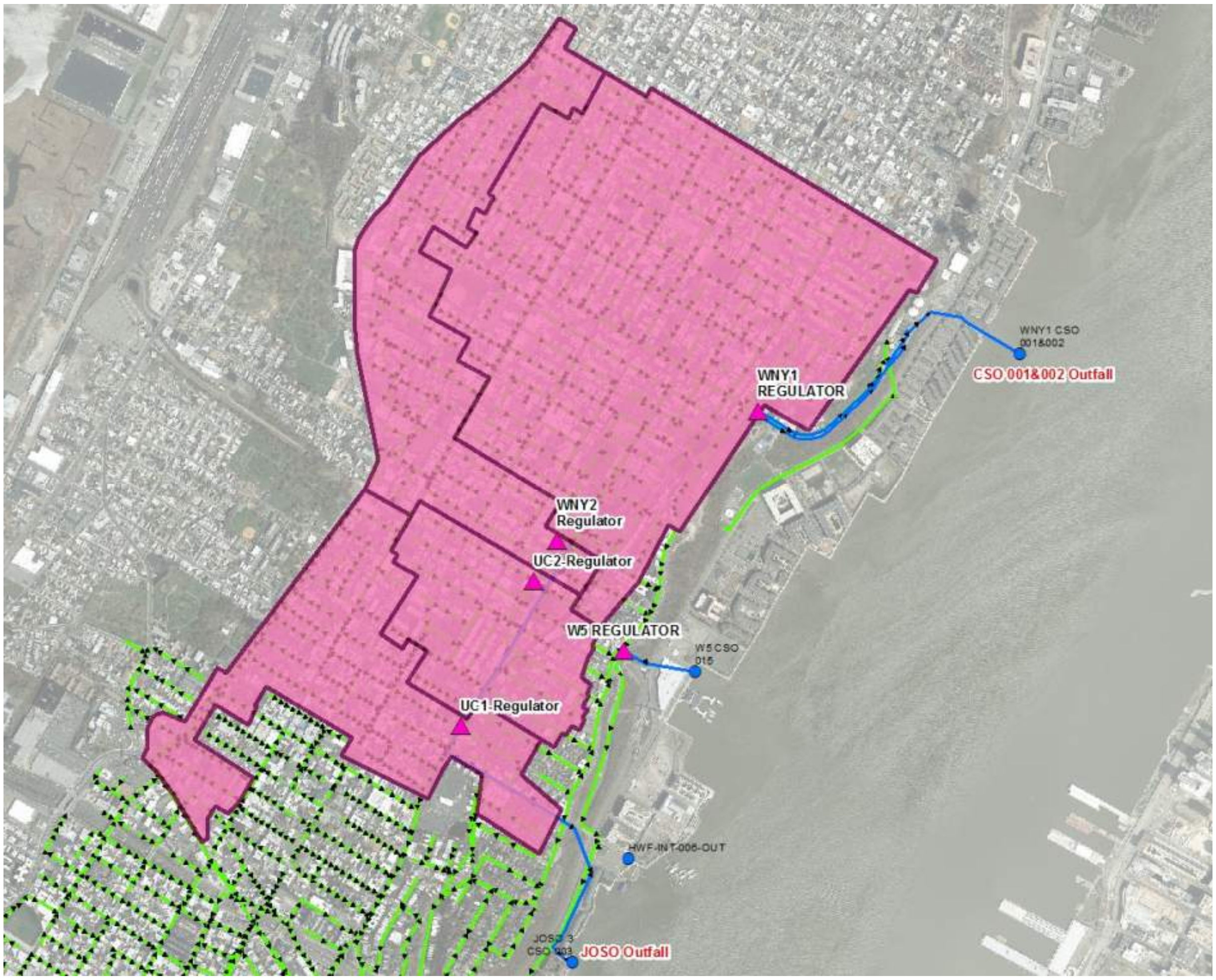
The regulators in the River Road WWTP Service Area direct all sewage flows during dry weather to the River Road WWTP and convey excess flows during large wet weather events directly to the Hudson River. There are a total of four regulators in the River Road WWTP Service Area (shown in Figure 2.2). Regulator WNY1 discharges to outfall 001A/002A and regulates CSO discharges using mechanical float operated regulator. The other three regulators regulate CSOs using side overflow weirs that divert excess combined sewage to the Joint Overflow Sewer Outlet (JOSO) which discharges to the Hudson River.

Figure 2.1: River Road WWTP Service Area



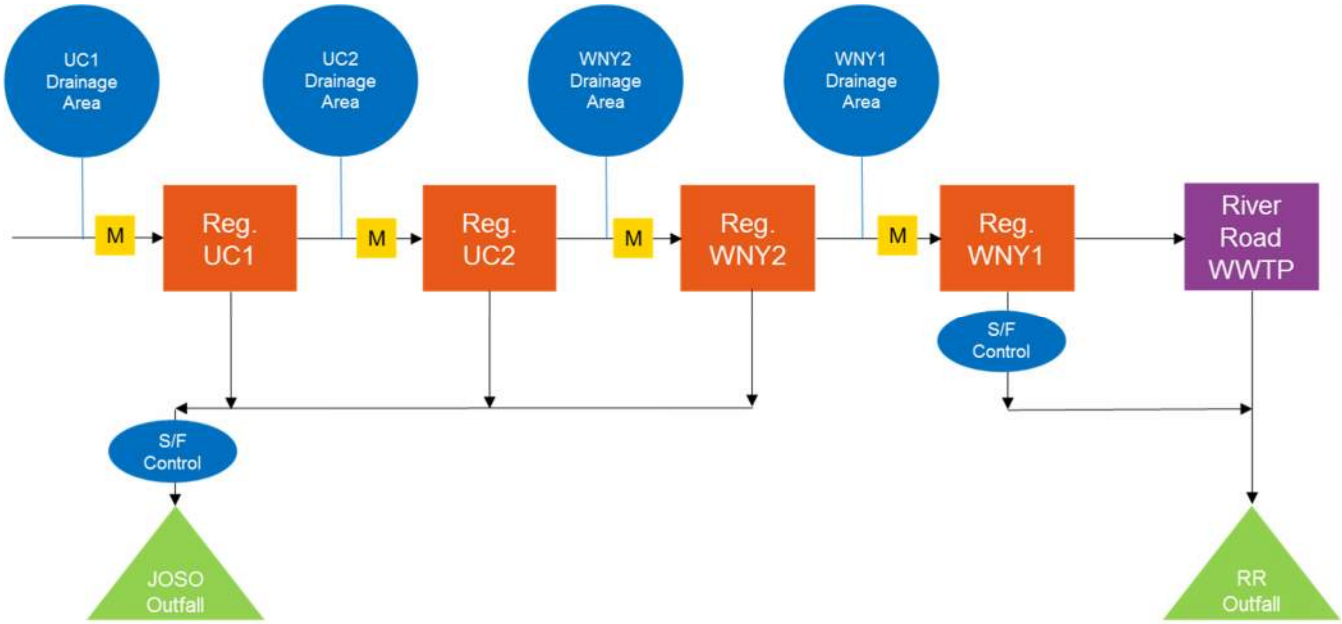
The drainage area to each of the four regulators is shown in Figure 2.2 below:

Figure 2.2: Regulator Drainage Areas



The flow schematic of the system including regulators, the WWTP and outfalls is shown below in Figure 2.3:

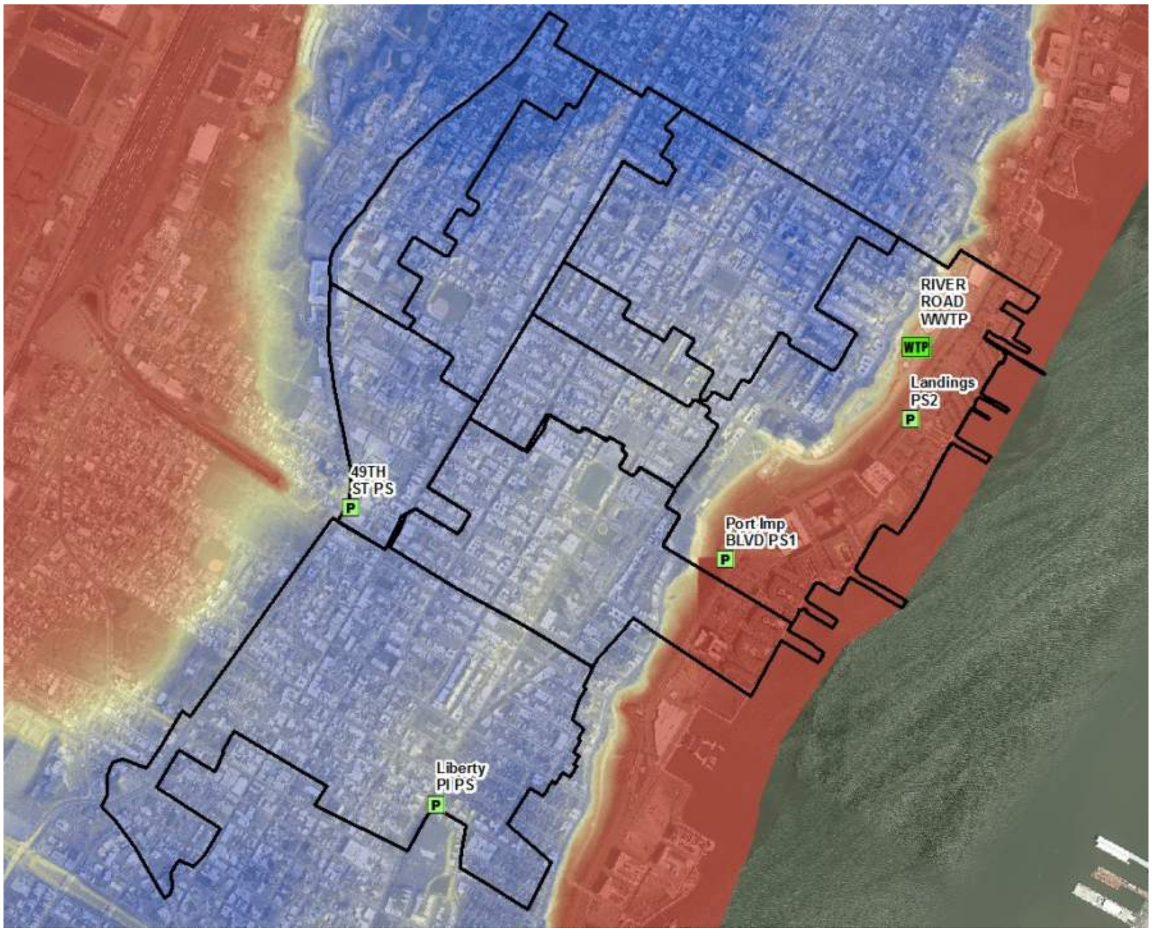
Figure 2.3: Flow Schematic of River Road System



The USGS National Elevation Dataset (NED) One Meter Digital Elevation Model (DEM) was used to evaluate the topography of the service area and its vulnerability to flooding (shown in Figure 2.4). The northern corner of the service area is at a much higher elevation than the rest of the service area, and slopes downward towards in the southeasterly direction. At the northeastern corner, elevations are around 250 ft (NAVD88). The majority of the service area is around 170 feet with a steep cliff drop of about 100 feet located around 1,000 feet from the eastern coast. Much of the area east of the cliffs is only about 10 feet above sea level, thus is vulnerable to storm surge and flooding. However, the area east of the cliffs is separately sewered with both storm and sanitary sewers thus flooding in these areas does not negatively impact CSOs. There is also a localized low-lying area of elevation 150 feet in the middle of the service area, but NHSA staff have indicated that this area is not vulnerable to flooding.

Figure 2.4 below depicts this topography, with blue representing higher elevations and red indicating lower elevations:

Figure 2.4: Study Area Topography



2.5 Surface Water Quality Conditions

The Authority's CSOs discharge to the Hudson River. These saline waters are classified by the State of New Jersey as SE2. The designated uses of SE2 waters are maintenance, migration and propagation of the natural and established biota; migration of diadromous fish; maintenance of wildlife; secondary contact recreation; and any other reasonable uses. The dissolved oxygen water quality standard is never less than 4.0 mg/L. The bacteria water quality standard for fecal coliform is a geometric mean of 770 cfu/100mL.

The State of New Jersey integrates its Water Quality Inventory Report (required under Section 305(b) of the federal Clean Water Act) with their List of Water Quality Limited Segments (required under Section 303(d) of the Clean Water Act), as per a 2001 recommendation by the U.S. Environmental Protection Agency (USEPA). New Jersey submitted its first Integrated Water Quality Monitoring and Assessment Report (Integrated Report) in 2002 and reissues the report every two years. The last readily available report published on the NJDEP's website (http://www.nj.gov/dep/wms/bears/assessment.htm) was the 2014 report. The 2016 report is listed as "in progress" on the NJDEP website at the of writing this document. The 2014 Integrated Report listed both Hudson River assessment units (Hudson River Upper and Hudson River Lower) as not supporting aquatic life-general and not supporting fish consumption. The report lists both Hudson River waters as fully supporting recreation.

Collection System Investigations

A comprehensive characterization of the combined sewer system was developed through records review, monitoring, modeling and other means to establish the baseline conditions for the LTCP.

3.1 Sewer System GIS Update

A sewer atlas was originally developed for the River Road WWTP service area in 1998 by CH2M HILL. NHSA performed a sewer GIS update in 2015. The 1998 Sewer Atlas was used as the basis for the 2015 GIS update. GPS data was obtained in degrees-minutes-seconds for all CSO regulators, pump stations and outfalls, pursuant to Part IV, Combined Sewer Management, Section D.2.a of the NJPDES permits, as well as manholes, catch basins and solids/floatables facilities. This GPS information was included on an updated GIS map that now supersedes the NHSA's Sewer Atlas. The updated GIS data was transmitted to NJDEP on September 17, 2015. Since then, the GIS database of River Road WWTP collection system components has been updated based on as-built drawings, field surveys, and interpolations made in the InfoWorksICM modelling software.

3.2 Condition Assessments

A condition assessment of NHSA's collection system was completed by RedZone between 2017 and 2018 on approximately 350,000 feet of sewers and 2,600 manholes. CCTV inspections were completed throughout the collection system to determine sewer condition as well as gather information on cross-sections, length, material, depth of sediment, connections, etc. Manholes were inspected to determine condition and identify any defects or problems. The results of the condition assessment are discussed in Section 3.

The following resources were utilized and field visits were undertaken to document the properties and conditions of system infrastructure:

- North Hudson Sewerage Authority Long Term Control Plan System Characterization Work Plan for the River Road STP (CH2M Hill, 2016)
- North Hudson Sewerage Authority Fiscal Year 2017 Annual Report (Mott MacDonald, 2017)
- River Road CSO Control Cost and Performance Analysis Report (Metcalf & Eddy | AECOM, 2007)
- River Road WWTP Cost and Performance Analysis Report (Metcalf & Eddy | AECOM, 2007)
- Results of RedZone sewer condition assessment – export from ICOMM database
- Field investigations:
    - 11/30/2017 – regulators
    - 5/11/2018 – regulators and S/F facilities
    - 5/16/2018 – pumping stations, outfalls

3.3 Rainfall Monitoring and Sewer Metering

Rainfall monitoring and combined sewer metering were completed to obtain data with which to calibrate the hydrologic/hydraulic model of the River Road collection system. The metering program was designed to characterize dry and wet weather flow generated by the drainage basins and to determine overflow frequencies. The metering was also used to characterize the response of the system to various precipitation events and to detect and identify infiltration in the system.

3.3.1 Precipitation and Flow Metering

NHSA retained Greeley and Hansen and its subconsultant ADS Environmental Services to install nineteen (19) continuous flow monitoring meters and two (2) rain gauges across their system between May 17, 2016 and November 16, 2016. Four of these flow meters and one rain gauge were located in the River Road drainage area. ADS Flowshark Triton meters were installed from April 25, 2016 to May 16, 2016 and were removed from the system by December 2, 2016.

The rain gauge located at the River Road WWTP recorded precipitation at 5-minute intervals. A tipping bucket rain gage was used, such that rainfall enters the funnel collector and is directed to the tipping bucket assembly. When an incremental amount of precipitation has been collected (0.01 inches of rainfall), the bucket assembly tips discharging the sample through the base of the gage and activates a switch that records the tipping event, and the process is repeated.

Over the monitoring period, a total of 14 rainfall events over 0.5 inches were recorded, with four of those events recording over a total of 1 inch of rain. A total of 43 rain events in which there was at least 24 hours of no rain between events were captured during the 6-month flow monitoring period. The highest intensity rainfall recorded at the River Road WWTP rain gauge (RG1) was on 7/31/16, when a total of 0.3 inches fell during a 5-minute interval yielding an intensity of 3.6 inches/hour.

The flow meters were installed to obtain information to analyze the monitoring tributary areas for dry weather flow, as well as inflow during rain events and infiltration during high groundwater periods. Flow meters were installed upstream of the regulators thus represented flow before the flow split to the overflow line. The four flow metering locations in the River Road drainage area are summarized in Table 3-1 below:

Table 3-1: Flow Monitoring Locations

Meter ID	Location	Pipe Size
UC1	Park Avenue at 43rd Street, Union City	48”
UC2	131 49th Street, Union City	75”
WNY1	East of JFK Blvd and Anthony M. Defino Way Intersection, West New York	75”
WNY2	211 51st Street, West New York	84”

Continuous metering was conducted to record the depth, velocity and flow data in 5-minute intervals throughout the 6-month monitoring period to capture the following conditions:

Table 3-2: Flow Metering Conditions

Condition	Result	Goal Satisfied?
Total precipitation volume is greater or equal to eight (8) inches (water equivalent)	Total rainfall depth over the monitoring period was 17.15 inches	Yes
At least two (2) small rainfall events, with precipitation, excluding contributions from snow melt, less than 0.5” of rainfall in 24 hours	Twenty-one (21) events with depth less than 0.5” of rainfall in 24-hour period	Yes
At least two (2) medium rainfall events, with precipitation, excluding contributions from snow melt, 0.5” to 1.5” of rainfall in a 24-hour period	Eleven (11) events with rainfall depth between 0.5” and 1.5” in 24-hour period	Yes
At least two (2) significant rainfall events, with precipitation, excluding contributions from snow melt, equal to or exceeding 1.5” of rainfall in a 24-hour period	Two (2) events with depth equal to or exceeding 1.5” of rainfall in 24-hour period	Yes

At least two high intensity events during which the hourly rainfall exceed 0.5"/hr	Five (5) events with hourly intensity greater than 0.5"/hr	Yes

The data collected from this program was used as the basis of hydraulic model calibration and validation.

A flow schematic of the River Road system is depicted in Figure 3.1 below, and the drainage area to each regulator/meter (i.e. metershed) is shown on Figure 3.2 below:

Figure 3.1: River Road System Flow Schematic

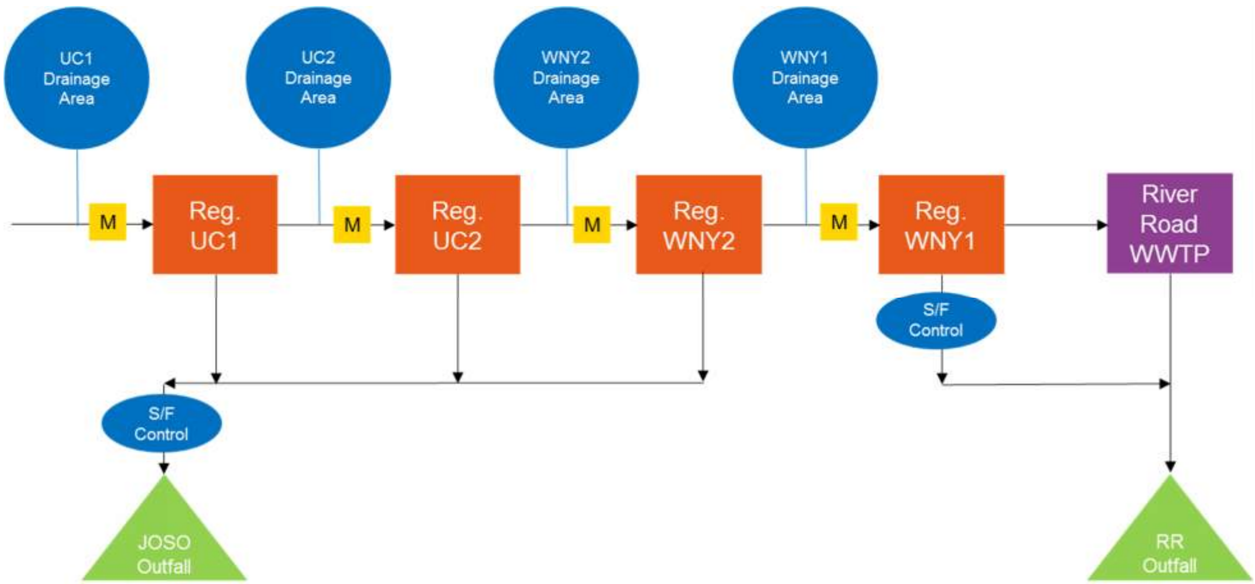
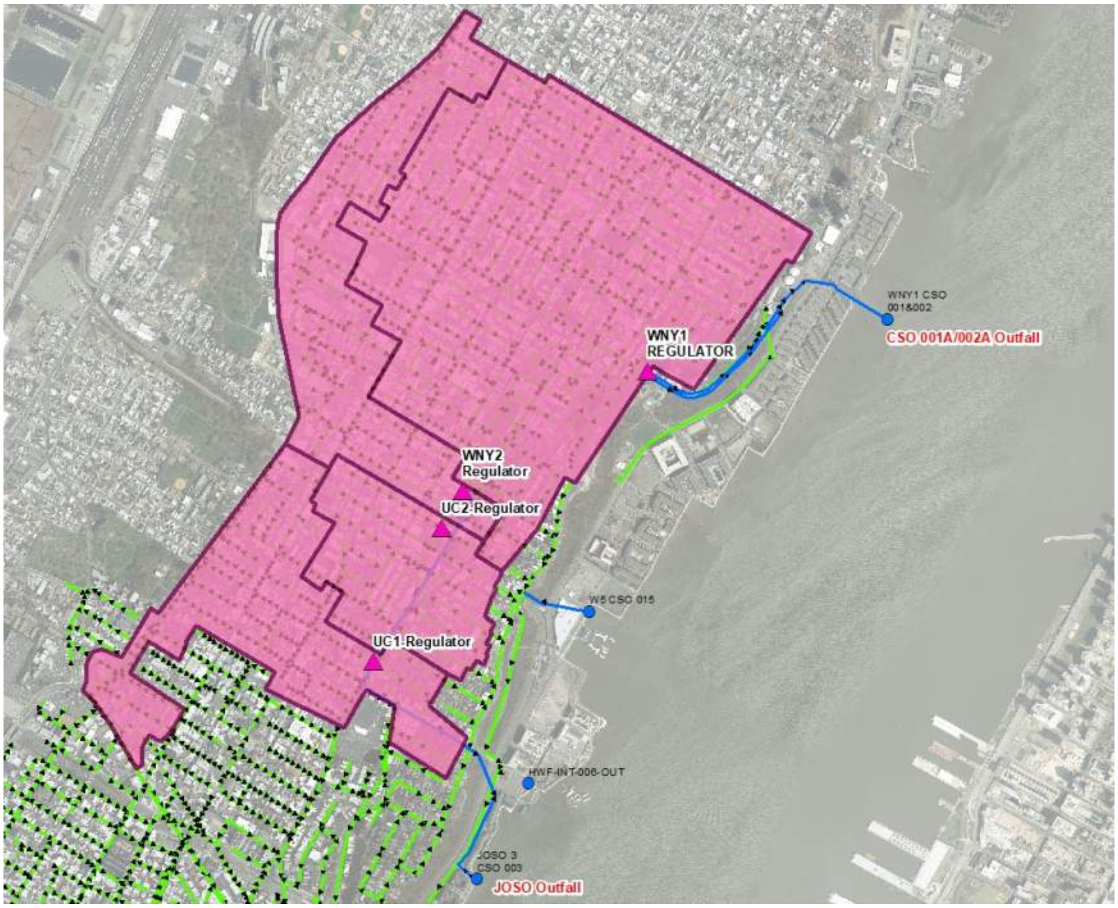


Figure 3.2: Regulator Drainage Areas (Metersheds)



As can be seen in the schematic above, the regulators are located in series along the main WNY interceptor sewer, and one meter was located upstream of each regulator prior to the flow split. As such, the meter upstream of the UC1 regulator is the only meter not impacted during wet weather by the hydraulic performance of the other regulators.

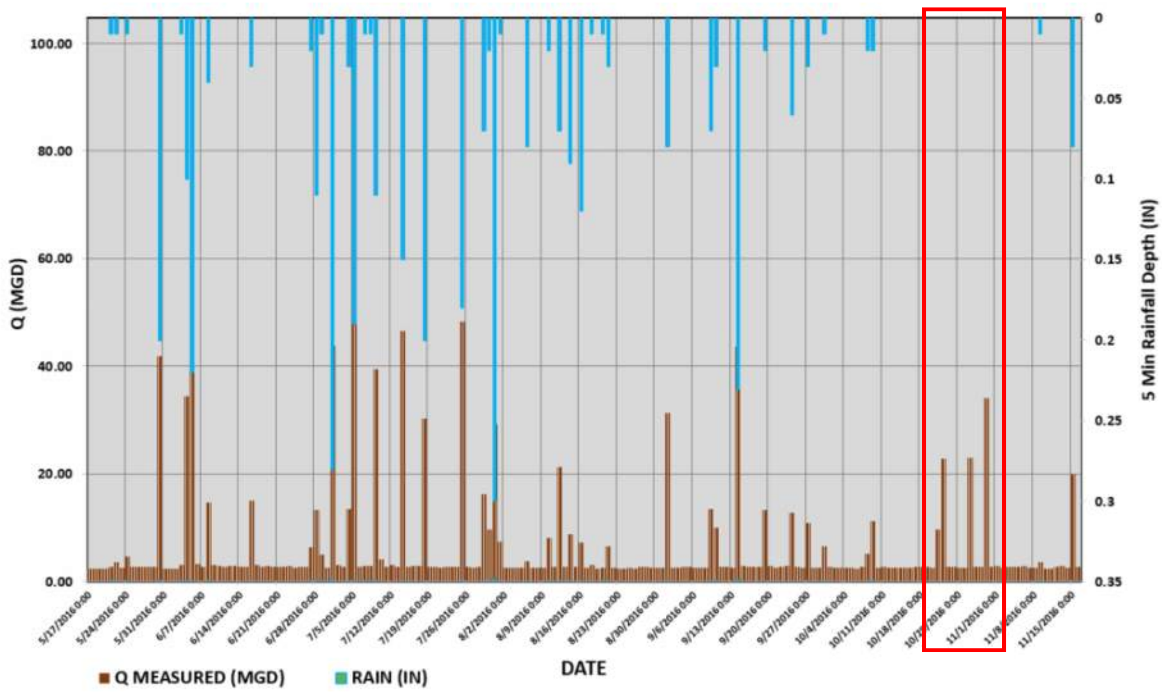
Flow and rainfall data is documented in the "Collection System Flow Monitoring Data Report" produced by Greeley and Hansen in February 2017.

3.3.2 Supplementary Rainfall Data

Rainfall data from the River Road rain gauge was compared with rainfall data from other sources to confirm its accuracy.

When comparing rainfall data from the monitoring program to NOAA 5-minute data from the nearby Teterboro station as well as the flow meter data, the River Road rain gauge did not detect three storms in October 2016. Teterboro rain data was substituted into the rain dataset for this period. This period is shown in Figure 3.3 below:

Figure 3.3: Rainfall Data Checking



An analysis was performed for Passaic Valley Sewerage Commission, which used calibration data from April 2016 to March 2017. The rain data used for this analysis was primarily from the Teterboro rain gauge this data was used to fill in the missing rainfall period in the River Road rain gage time series.

In addition to calibrating the model based on metered rainfall and flow data, the system was further characterized based on CSO performance in a typical year. The NJ CSO Group, a group of municipalities which discharge to the tidally connected waterbodies in the NY/NJ Harbor Estuary that are working cooperatively to fulfill the requirements of the last CSO General Permit, identified 2004 as the typical year. The selection of 2004 as the typical year was summarized in the May 2018 memo submitted to the NJDEP. As such 2004 rainfall data was applied to the hydraulic model to determine the system's typical long-term performance. The findings from this typical year simulation are provided in Section 8.

3.4 CSO Event Monitoring

NHSA records the incidence of CSO events at both River Road outfalls (WNY1 and JOSO) via hydraulic elevation meters which directly relay discharge information to the Mission website, installed in February 2016, as well as the NHSA website.

This Mission data is incorporated into the NHSA's Waterbody Advisory System which provides the public with real-time information related to CSOs into the Hudson River. Figure 3.4 below depicts the waterbody advisory system map designated to alert the public when a CSO event occurs. The map depicts inactive CSOs as green circles, indicating no CSO activity near that outfall. Red circles indicate that the CSO is currently active and contact with the water in areas within 100 feet of the outfall should be avoided. The circles can be clicked on to see the last time the CSO was active.

No complaints of overflows were received from public or private areas; thus, this information could not be used to identify overflow events.

Figure 3.4 NHSA Public Advisory Map

Overflows detected from February 2016 to February 2017 are shown in Table 3-3 below and are based on mission data, noting that an overflow was counted only if it there is a period of no overflow for the 24 hours preceding it.

Table 3-3 Overflows Detected by NHSA from February 2016 to February 2017

Outfall	Regulator	Service Area	Number of Overflows
DSN002A	River Road / WNY	River Road	66
DSN003A	JOSO	River Road	29

Note: JOSO outfall mission data did not indicate overflows from February to April

It is noted that tidal impacts were not considered in this study due to the steep drop in elevation (approximately 200 feet) from the drainage area to the outfalls at the base of the Palisades. In addition, the outfalls have check valves, so there is no tidal influence as a result of backflow. The Mission floats are upstream of the weirs, so they would also not be effected by the tides.

3.5 CSO Water Quality Sampling

The goal of the event sampling was to capture representative combined sewer samples from dry weather as well as three significant wet weather events (precipitation >0.5 inches in 24 hours). All samples collected were analyzed for fecal coliform and enterococcus; freshwater samples were also analyzed for E. coli. The Authority performed water quality sampling of its combined sewer systems from August 2016 to August 2017. CSO water quality sampling was designed to characterize CSO discharges to the Hudson River. The data collected enables a water quality characterization of combined sewer overflow discharges for the Authority's sewer system characterization.

The characterization focused on bacteriological indicators used in current and future recreational standards - fecal coliform and Enterococcus. Representative sampling locations at CSO regulators were selected to enable the water quality characterization of CSO discharges and to facilitate evaluation of LTCP alternatives. Sampling locations were selected based on GIS information of drainage area land use types and availability of monitoring systems to detect overflows. Sampling locations are listed in Table 3-4 with site characteristics.

Table 3-4 CSO Water Quality Sampling Locations

Basin ID	Location	Land Usage	% Imperviousness	Monitoring System
H3	3rd St. at River St. (In crosswalk)	Low/Medium Residential	71%	ADS/Mission (H3 + H4)
H7	14th St. East at Washington St.	Commercial/ Industrial	46%	ADS/Mission (H6 + H7)
18TH Street PS	W 18th St.	Open Space/ Park	39%	Mission
W2	506 Gregory Ave.	High Residential	59%	ADS/Mission
WNY1	John F. Kennedy Blvd. at Anthony M. Defino Way	Mixed Uses	~75%	Mission

Sampling was performed at five regulators during dry and wet weather events from August 2016 to August 2017. The goal of the wet weather sampling was to monitor at least three rain events with rainfall greater than 0.5 inches in a 24-hour period. Sampling and analysis was performed in accordance with the NJDEP approved Quality Assurance/Quality Control Plan that was submitted to the NJDEP on July 27, 2016 as part of the Authority's System Characterization Work Plans for the Adams Street and River Road WWTPs. A description of the sampling effort and the data collected are discussed in an abridged technical memorandum provided in **Appendix B**.

3.6 Baseline Compliance Monitoring Program

The data from the sampling program is being shared with the NJ CSO Group to support the establishment of area-wide ambient water quality conditions in CSO receiving waters. This is documented as part of the Baseline Compliance Monitoring Program (BCMP), which included three parallel data collection efforts:

1. Baseline Sampling, to supplement the approved routine sampling program of the New Jersey Harbor Discharges Group (NJHDG). The sampling frequency was as follows:
    a. Spring (May-Jun): Biweekly (4 dates);
    b. Summer (Jul-Sep): Weekly (12 dates); and
    c. Winter (Oct-Apr): Monthly (7 dates).
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.

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.

The sampling locations as part of the NJ CSO Group's efforts are shown below in Figure 3.5, followed by the findings at sampling locations relevant to the River Road Service Area shown in Figure 3.6 and Figure 3.7.

Figure 3.5 NJ CSO Group Baseline Compliance Monitoring Program Sampling Locations (from Baseline Compliance Monitoring Program Data Summary Memo, HDR Engineering, October 2017)

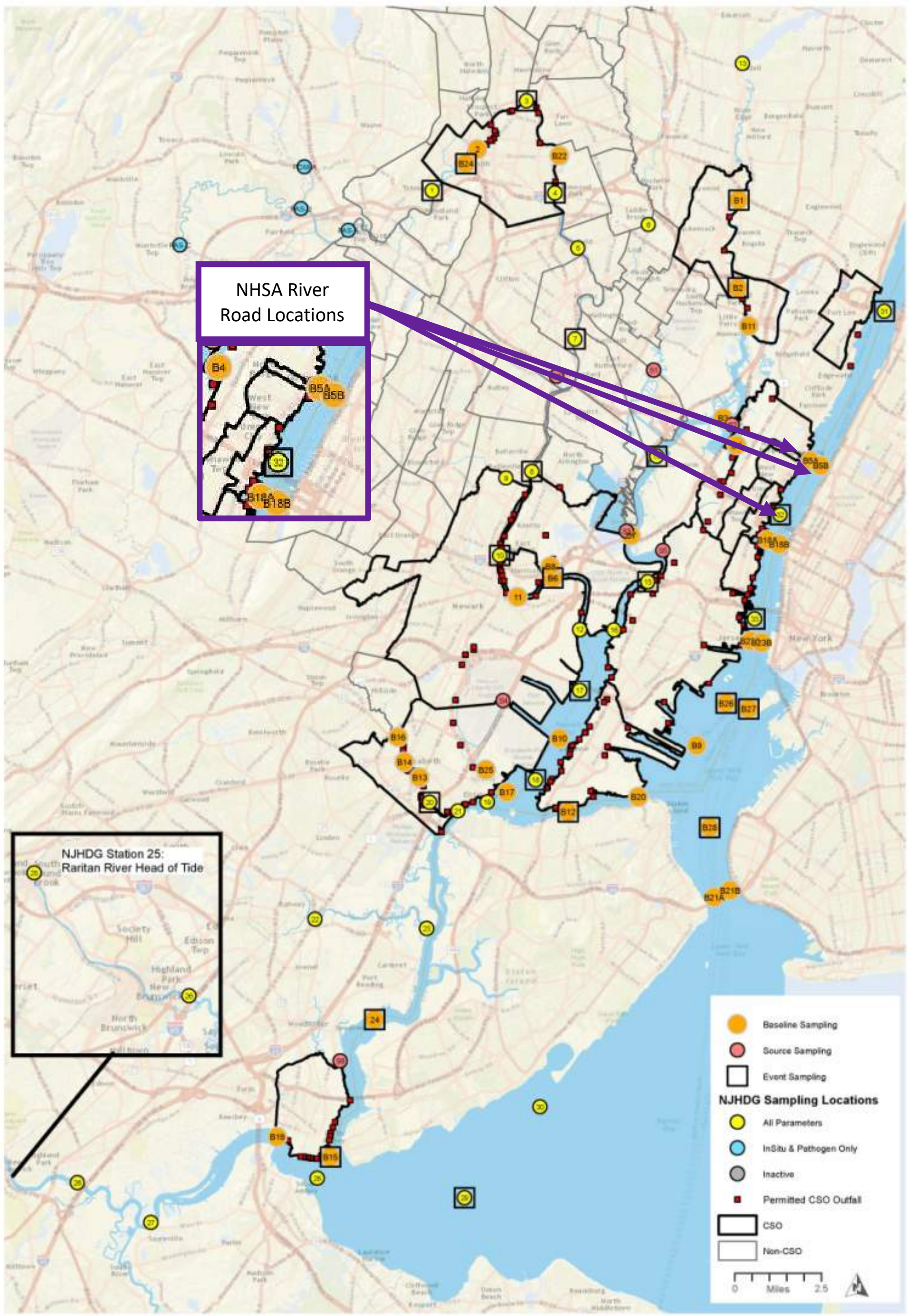
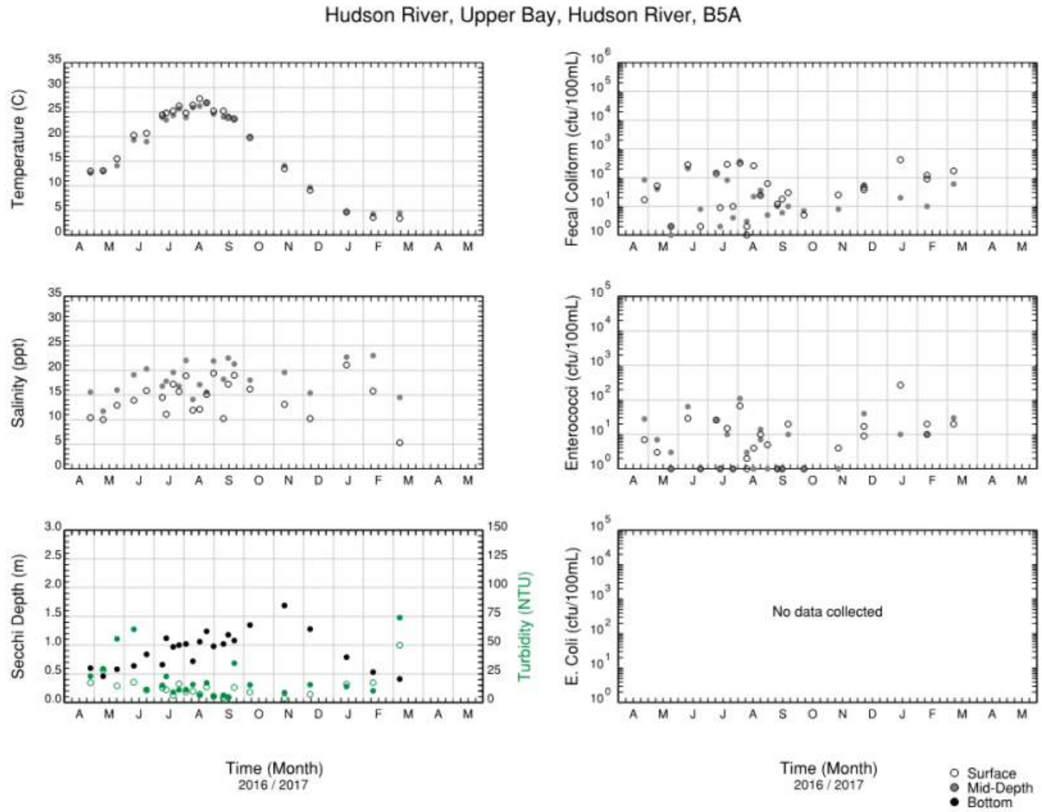


Figure 1 - Source, Routine, and Event Sampling Stations

Figure 3.6 Hudson River Sampling Locations B5A and B



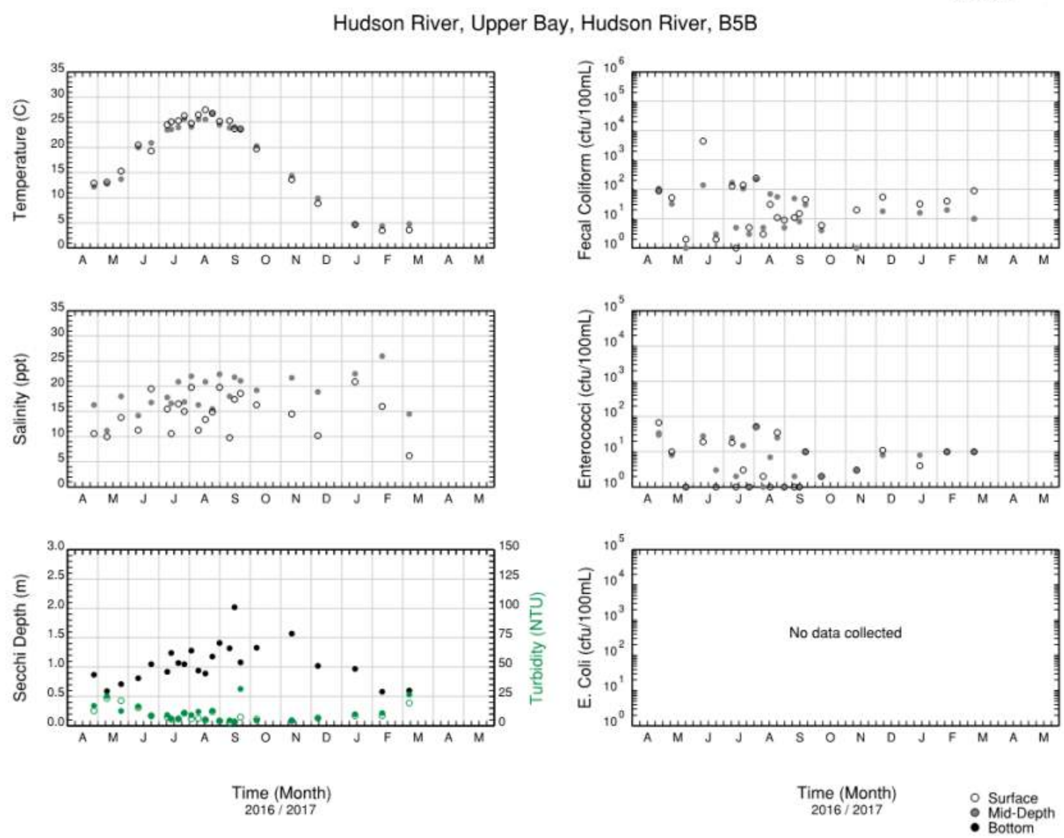
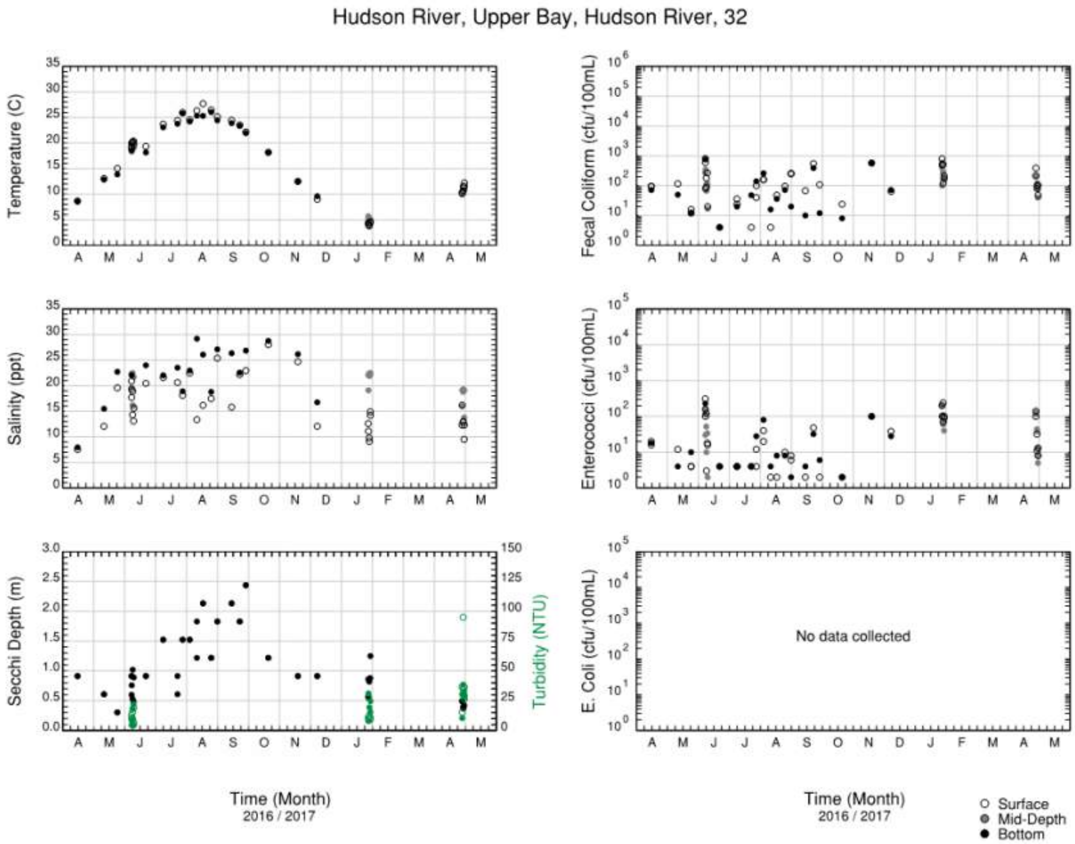


Figure 3.7 Hudson River Sampling Location 32



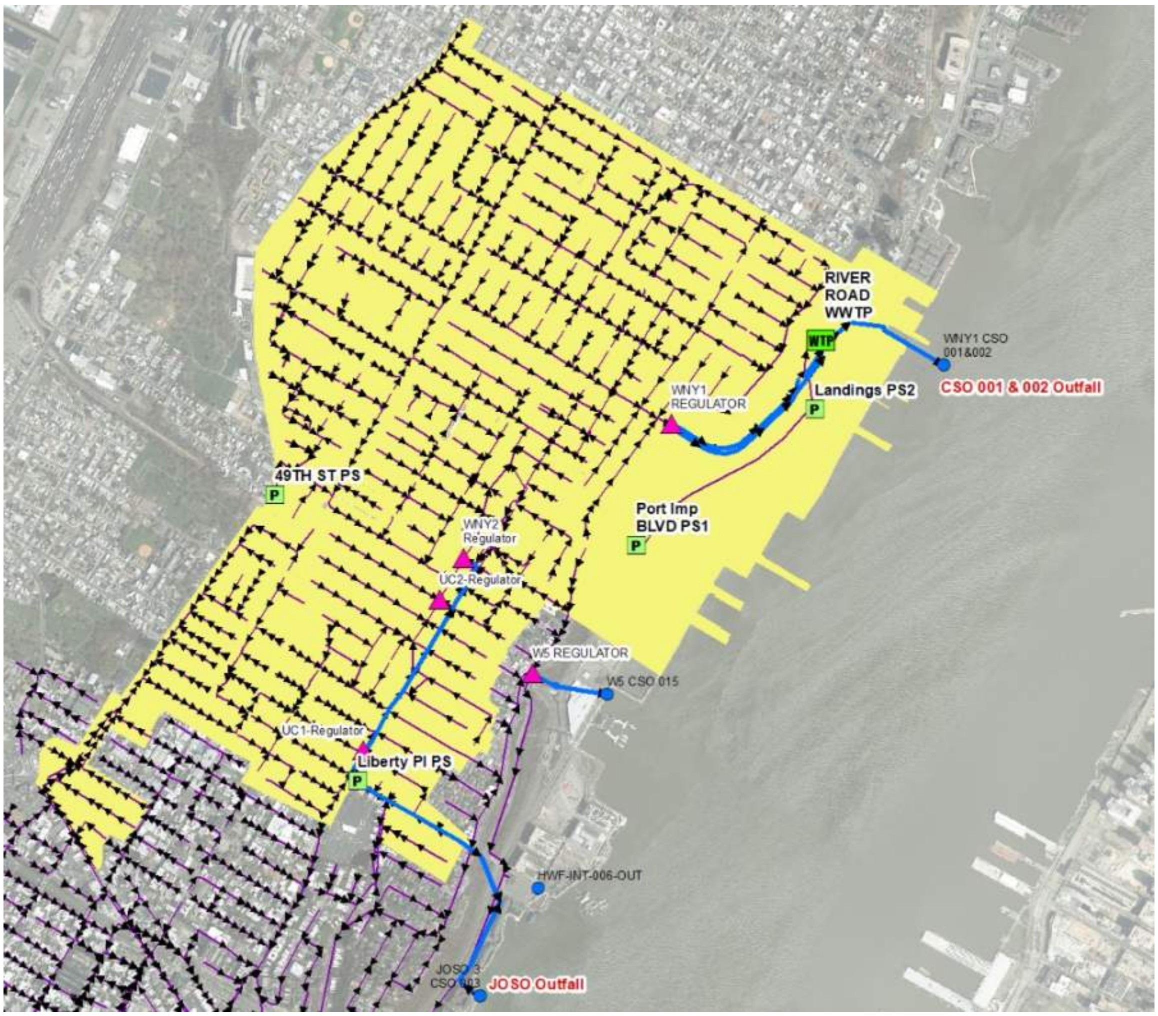
Sewer System Inventory

A critical component of the NHSA system characterization includes reviewing, compiling, and analyzing existing data to identify usable data and data gaps. Existing documents and drawings were reviewed and an inventory and condition assessment was completed to develop a comprehensive GIS representation of the system.

4.1 Combined Sewer Collection System

The GIS database of the collection system provided by the Authority in June 2017 was used as the basis of the sewer system inventory, supplemented by fieldwork and available drawings. The GIS database includes sewer locations, sizing, lengths, manhole inverts and rims, locations of regulating structures, pumping stations and treatment plants. An overall map of the River Road service area is shown below in Figure 4.1:

Figure 4.1: River Road WWTP Service Area



4.1.1 Combined Sewer Inventory

The length of pipe within each basin and the percentage of the total amount are shown in Table 4-1. The pipes are of various materials, shapes and sizes, as can be seen in Table 4-2 through Table 4-4.

Table 4-1 NHSA River Road Service Area Inventory

Basin ID	Number of Manholes	Number of Pipes	Total Length of Pipe (ft)	Percentage of Total Pipe
A	107	107	11,826	7%
B	103	95	9,828	6%
C	166	165	18,084	11%
D	203	191	25,026	15%
E	78	77	9,254	6%
F	33	32	4,029	2%
G	198	199	25,171	15%
H	72	75	16,354	10%
JOSO	414	404	46,371	28%
Total	**1,374**	**1,345**	**165,943**	**100%**

Table 4-2 NHSA River Road Service Area Material Inventory by Basin

Material	A	B	C	D	E	F	G	H	JOSO
BRK	-	-	-	1%	-	-	-	-	15%
CIP	-	-	-	-	-	-	-	-	0.2%
CONC	-	-	-	-	-	-	-	1%	-
DIP	-	-	-	-	-	-	-	8%	-
RCP	-	-	-	-	-	-	-	2%	-
VCP	-	-	-	16%	-	-	-	-	81%
UNKNOWN	100%	100%	100%	82%	100%	100%	100%	89%	4%

As shown in Figure 4.2 below, pipe materials are mainly unknown in West New York, however because the majority of the surrounding sewers in Union City and Weehawken are known to be vitrified clay pipe (VCP), it was assumed that the sewers in West New York are also made of VCP. This is consistent with observations that were made in field work and with the construction materials used when the area was developed. The Manning's number was assigned to these pipes accordingly in the model.

Figure 4.2: Pipe Materials in the River Road Service Area

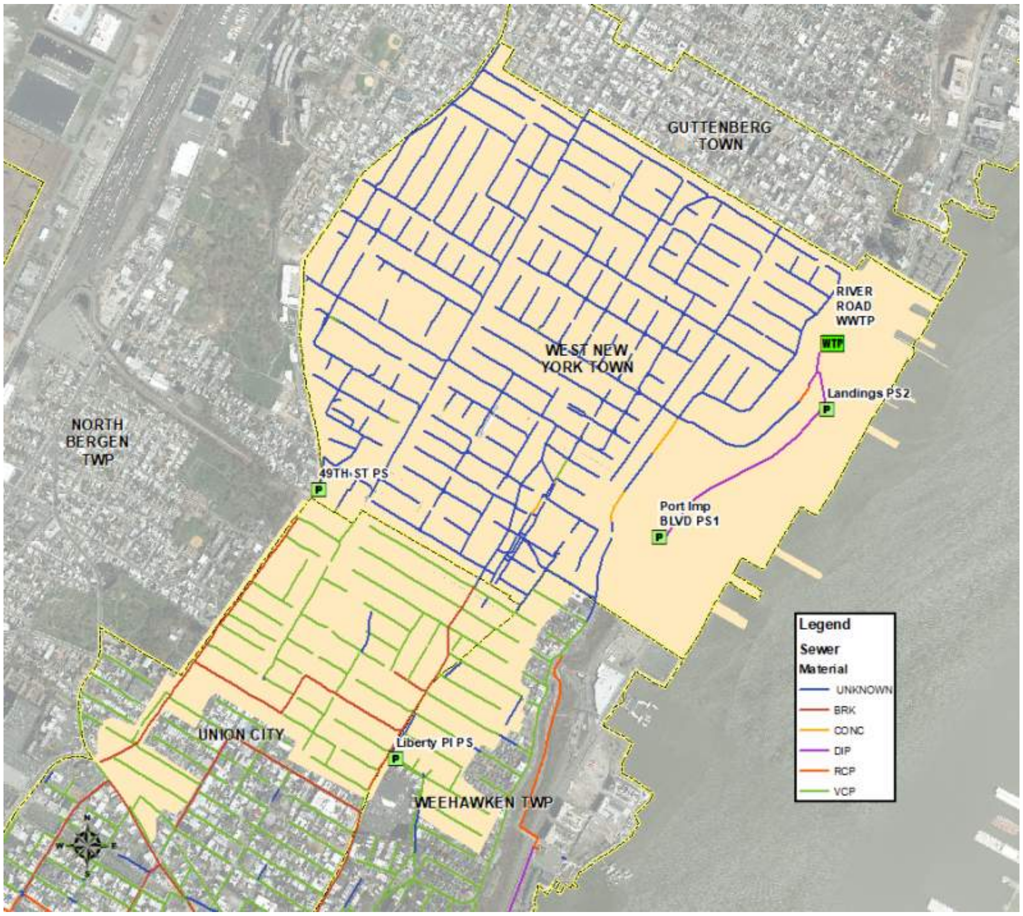


Table 4-3 NHSA River Road Service Area Inventory by Size

Diameter	A	B	C	D	E	F	G	H	JOSO
6”	-	-	-	-	-	-	-	-	0.2%
8”	-	1%	1%	1%	3%	-	0.3%	-	-
10”	7%	-	6%	18%	23%	13%	6%	12%	-
12"	37%	35%	44%	41%	37%	49%	51%	39%	50%
15"	6%	22%	15%	18%	6%	18%	14%	6%	16%
18"	25%	3%	13%	7%	5%	12%	5%	3%	12%
20"	5%	-	-	-	-	-	-	-	1%
24"	3%	-	7%	1%	-	8%	13%	12%	5%
27"	-	-	-	-	-	-	-	11%	-
30"	3%	-	2%	-	-	-	2%	7%	-
36"	11%	-	6%	-	-	-	4%	-	2%
42"	-	-	3%	-	-	-	-	-	-
48"	2%	12%	2%	-	14%	-	4%	-	1%
54"	-	12%	-	-	-	-	-	-	-
60"	-	10%	-	6%		-	-	-	1%
72”	-	-	-	-	-	-	-	-	1%
75"	-	-	-	4%	-	-	-	-	1%
84"	-	-	-	5%	0.3%	-	-	2%	-
90"	-	-	-	-	12%	-	-	2%	-
96"	-	-	-	-	-	-	-	3%	-
24” x 36”	-	-	-	-	-	-	-	-	2%
30” x 45”	-	-	-	-	-	-	-	-	1%
40” x 60”	-	-	-	-	-	-	-	-	1%
50” x 75”	-	-	-	-	-	-	-	-	4%
UNKNOWN	-	6%	-	-	0.3%	-	-	3%	4%

Table 4-4 NHSA Adams Street Service Area Shape Inventory by Basin

SHAPE	A	B	C	D	E	F	G	H	JOSO
CIRCULAR	100%	94%	100%	100%	100%	100%	100%	100%	89%
OVAL	-	-	-	-	-	-	-	-	7%
UNKNOWN	-	6%	-	-	-	-	-	-	4%

4.1.2 Collection System Condition

The WNY-1 interceptor sewer is the main trunk line in the River Road service area. It conveys combined sewage from Regulator WNY-1 to the River Road WWTP and was reportedly installed in bedrock by blasting. A 30-foot section of this interceptor was lined with gunite to prevent rock intrusion. Drawings of this sewer length are not available.

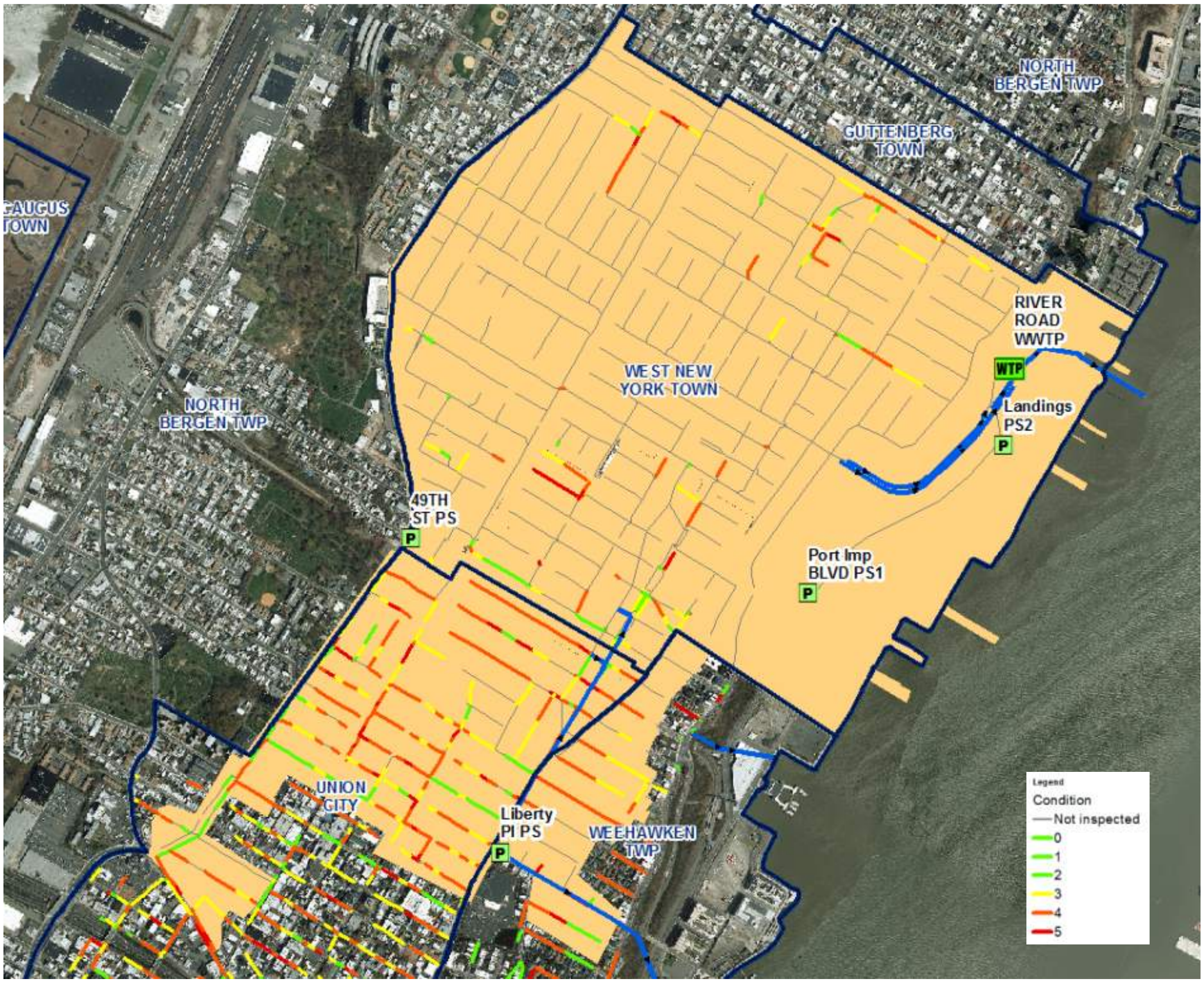
The figure below depicts the results of the condition assessment of the sewers in the River Road service area that was completed by RedZone described in Section 2. The sewers are rated according to the NASSCO Pipeline Assessment and Certification Program (PACP) rating system on a scale of 1 to 5, in which 1 (green) represents least likelihood of failure while 5 (red) represents the greatest likelihood of failure.

The collection system that services the River Road WWTP has been constructed within rock known as the Palisades Formation. When these combined sewers were originally constructed, the blasted rock was used as backfill, which in some cases has caused damage to the pipe. Also, the majority of the material used to construct the small diameter sewers is VCP with joints spaced only at eight to ten feet. This type of construction has created a situation in which has introduced a great deal of Infiltration into the combined sewer system from watermain leaks.

The Authority has utilized the CCTV work to identify watermain leaks and proceed to develop an asset management program to prioritize the cleaning and lining of the combined sewers. The Authority is also working with the local water purveyor to locate and remediate watermain leaks.

The Authority has been very proactive in reducing I&I to the River Road WWTP by collaborating with Suez Water on a leak detection program and has spent almost $2,000,000 on CIPP Lining of the combined sewers in the River Road Service Area.

Figure 4.3: Service Area Condition Assessment



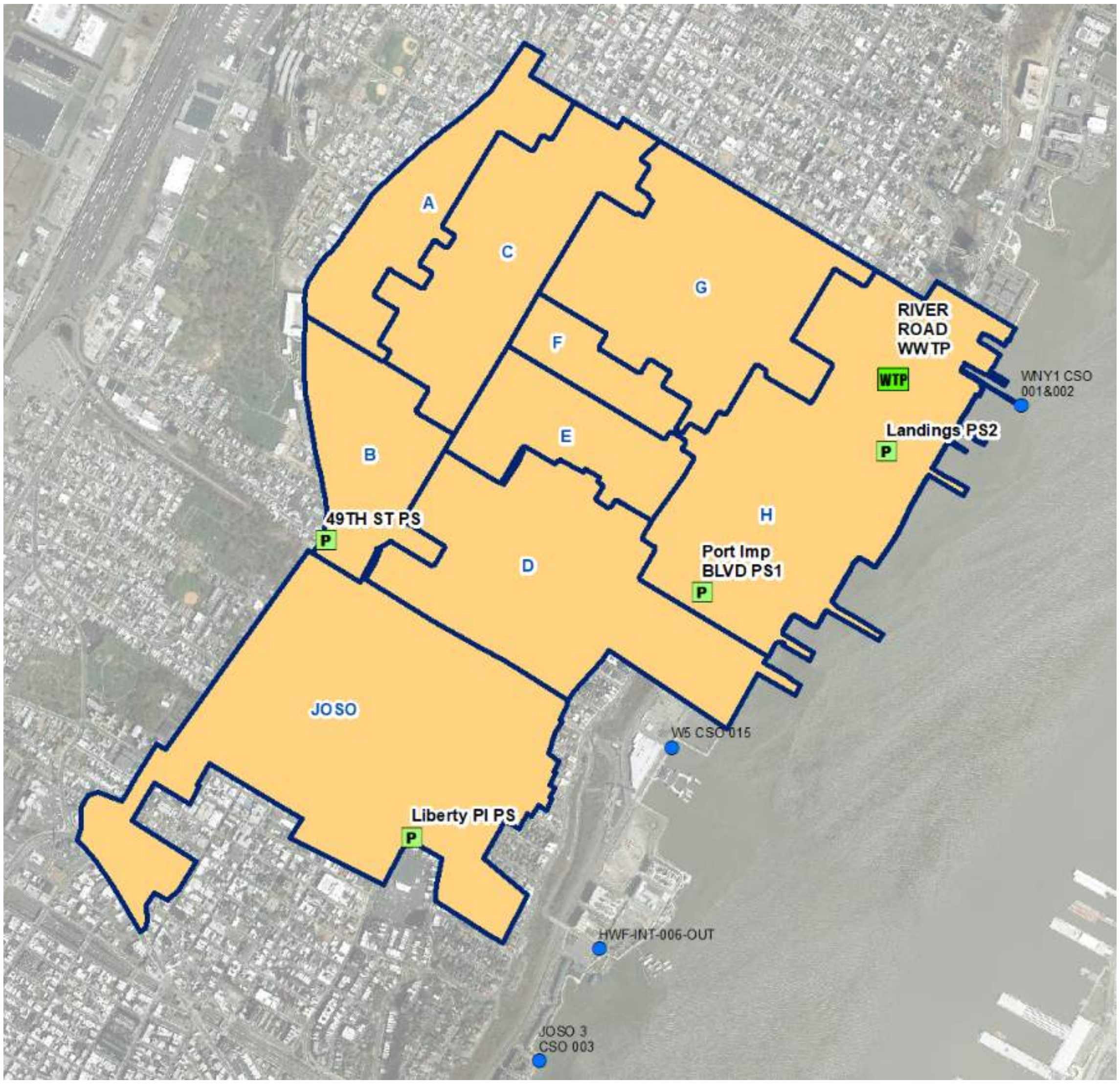
4.2 Pump Stations and Force Mains

There are four pumping stations in the River Road WWTP service area, which are listed in Table 4-5, shown in Figure 4.4 described in the sections below.

Table 4-5 NHSA Pump Station General Information

Pump Station	Basin
49th Street	B
Landings	H
Port Imperial	H
Liberty Place	JOSO

Figure 4.4 Pumping Station Locations and Drainage Basins



4.2.1 Liberty Place Pump Station

The Liberty Place Pump Station pumps sewage from Liberty Place, Eldorado Place and Highwood Avenue into the River Road WWTP via a force main. It receives flow from the nearby residences. The pump station includes two (2) 5 hp submersible pumps and one above-grade electrical cabinet on the sidewalk. The pumps were installed in 2012 by the Authority and are the ABS Contrablock pumps with open impeller design. The pumps could not be inspected, however, they have performed well without clogging. The electrical cabinet is old but operable. There is no bar rack nor comminutor at this station. Excess wet weather flow at the Liberty Place Pump Station flows by gravity to the JOSO outfall for discharge to the Hudson River.

Information on the pump curves was not available; thus the pump properties from the hydraulic model are shown below in Table 4-6 and Table 4-7:

Table 4-6: Liberty Place Pumping Station – Assumed Discharge

	Discharge (MGD)
Pump 1	0.33
Pump 2	0.33

Table 4-7: Liberty Place Pumping Station – Assumed On/Off Settings

	ON (ft AD)	OFF (ft AD)
Pump 1	150	143.3
Pump 2	156.3	150

Photos of the pumping station are provided below in Figure 4.5 and Figure 4.6:

Figure 4.5: Liberty Place PS – External View

Figure 4.6: Liberty Place PS Controls

4.2.2 49th Street Pump Station

The 49th Street Pump Station collects sanitary flow from several businesses and discharges into the gravity sewer at 51st Street and Kennedy Boulevard. The station receives flow from the nearby shopping center and laundromat. The station includes two (2) submersible five (5) hp pumps in a manhole in the street, and one above grade electrical cabinet on the sidewalk. One pump was replaced in 2012 by the Authority. The pumps could not be inspected but no operational issues are reported. The electrical cabinet was recently damaged as it was struck by a vehicle but this has since been repaired. The station and controls are operable. There is no bar rack nor comminutor at this station.

This pump was not included in the model as the pump properties were not known and it is known to be a very small pumping station.

Photos of the pumping station are provided below in Figure 4.7 and Figure 4.8:

Figure 4.7 49th Street PS – External View

Figure 4.8: 49th Street PS – Controls

4.2.3 Landings Pump Station

The Landings Pump Station serves the residential development south of the River Road WWTP. It feeds directly into the treatment plant downstream of regulator WNY1, as such it does not directly contribute to CSO overflows and was not included in the model.

4.2.4 Port Imperial Pump Stations

Port Imperial has three pump stations. Port Imperial Pump Stations 1 & 2 feed directly into the treatment plant downstream of regulator WNY1, as such it does not directly contribute to CSO overflows and was not included in the model. Pump Station 3 flows to Adams Street WWTP thus is not discussed further in this report. Descriptions of Pump Station Nos. 1 and 2 are provided below.

The pump stations serve the nearby residential developments. The stations are very similar. They each consist of a JWC raw sewage grinder with hydraulic drive, three Flygt submersible pumps, VFDs, PLC based pump controls, and standby generator. The generator and controls are housed in a one story, precast concrete building, with brick veneer, to give the appearance of a brick building. The stations are new and in good condition, except as noted below.

4.2.4.1 Port Imperial Pump Station No. 1

Port Imperial Pump Station No. 1 is located on Port Imperial Boulevard (between Riverbend and Riverwalk Place) on the west side of the road. The sanitary flow from this station is conveyed to Pump Station No. 2 and from there to the River Road WWTP. The station was built in 2003 and consists of a wet well housing three (3) submersible pumps, a valve vault and an above ground building which houses an emergency generator and VFDs. The wet well depth is 25.25 ft and the wet well level is currently float controlled.

The station consists of three Flygt CP3152 submersible pumps, rated for 905 gpm @ 42 feet TDH and 20 hp each (one lead, one lag and one stand-by), three Toshiba 20 hp variable frequency drives (VFDs), one Muffin Monster comminutor, and one Cummins Onan 100DGDB diesel generator. There is one air release valve on the force main between Pump Station No. 1 and Pump Station No. 2. Both the grinder and VFDs are not in service, however a project is currently underway to replace the VFDs and level sensors and to upgrade the building HVAC system.

A drawing of Pump Station No.1 is shown below in Figure 4.9.

Figure 4.9 Port Imperial PS No. 1 Layout

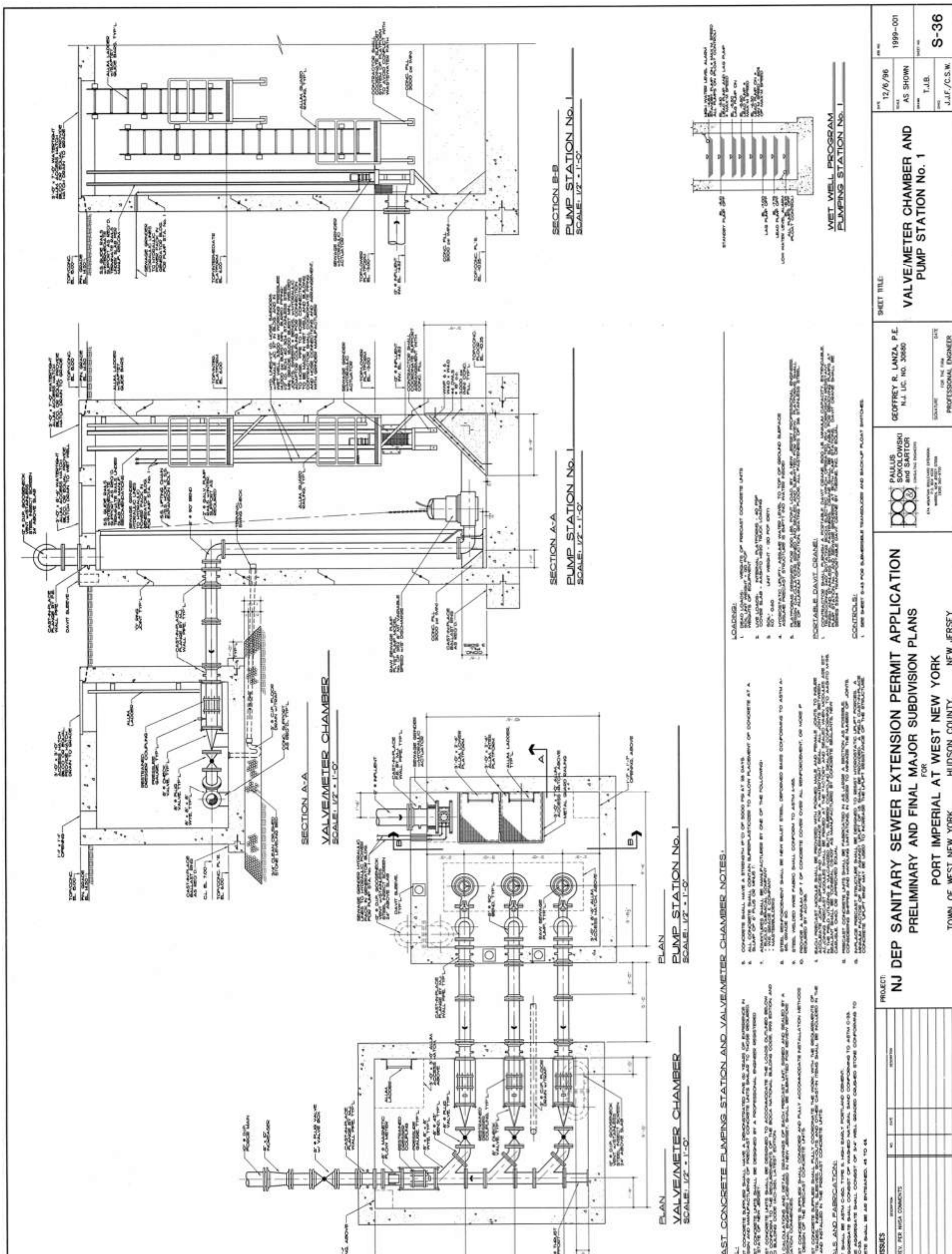


Figure 4.10 below shows the location of Pump Station No. 1 and Figure 4.11 and Figure 4.12 show photos of the Pump Station.

Figure 4.10: Port Imperial Pump Station No. 1 Location

Figure 4.11: Port Imperial Pump Station No. 1 External

Figure 4.12: Port Imperial Pump Station No. 1 Wet Well

4.2.4.2 Port Imperial Pump Station No. 2

Port Imperial Pump Station No. 2 is located at the intersection of Port Imperial Boulevard and North Park Court and conveys flow to the River Road WWTP. The station was constructed 1998. The station consists of three Flygt CP3300 submersible pumps, rated for 1935 gpm @90 feet TDH and 88 hp each (one lead, one lag and one stand-by), three Toshiba 100 hp variable frequency drives (VFDs), one Muffin Monster comminutor, and one Cummins Onan 250 DFAC diesel generator. The generator and VFDs are housed in the building and the pumps and comminutor are located in the below-ground wet well. Wet well depth is 30.5 ft. A project is underway to replace the VFDs and upgrade the HVAC system.

A drawing of Pump Station No.2 is shown below in Figure 4.13.

Figure 4.13 Port Imperial PS No. 2 Layout

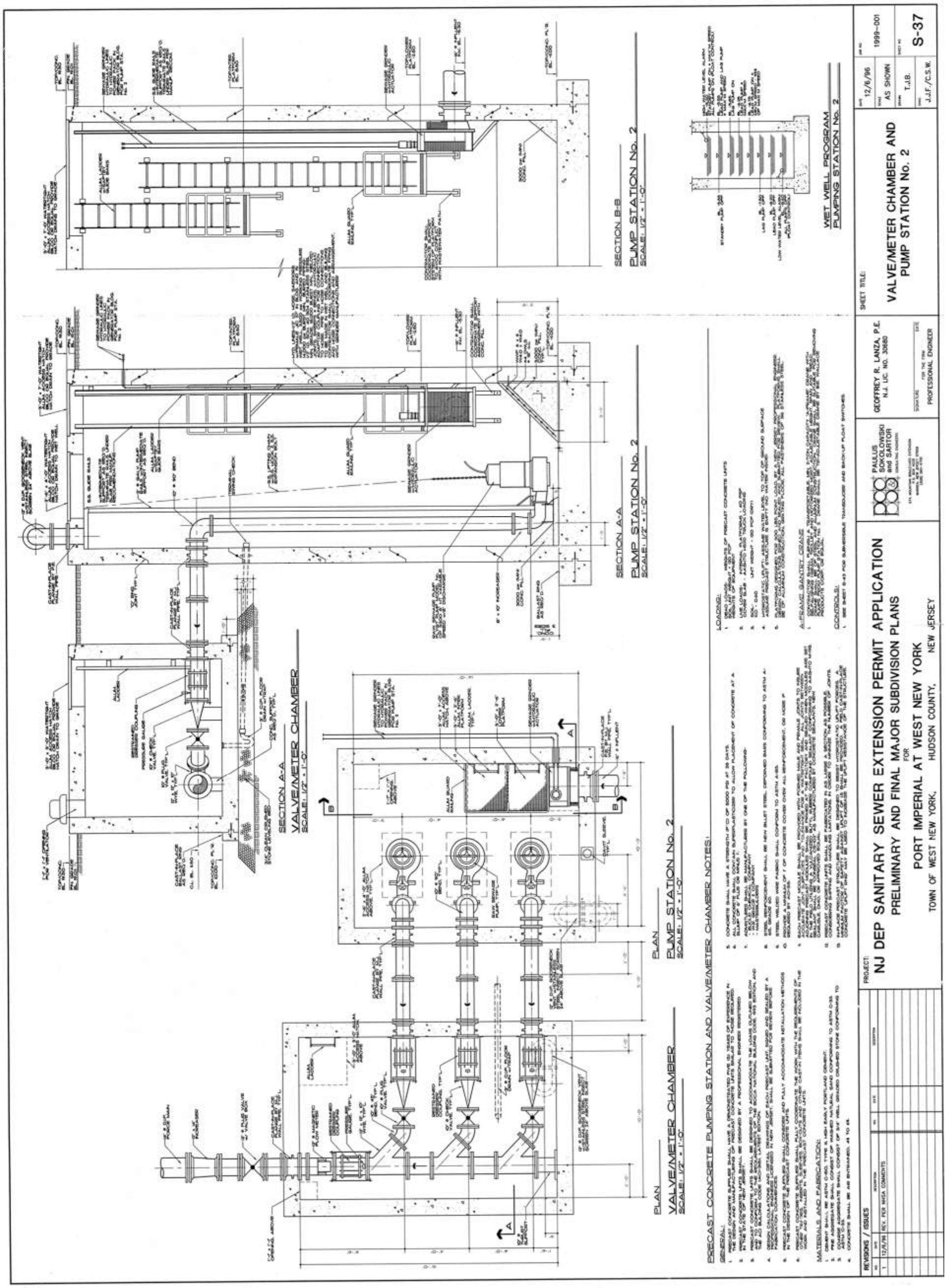


Figure 4.14 below shows the location of Pump Station No. 2 and Figure 4.15 and Figure 4.16 show photos.

Figure 4.14 Port Imperial Pump Station No. 2 Location

Figure 4.15: Port Imperial Pump Station No. 2 External

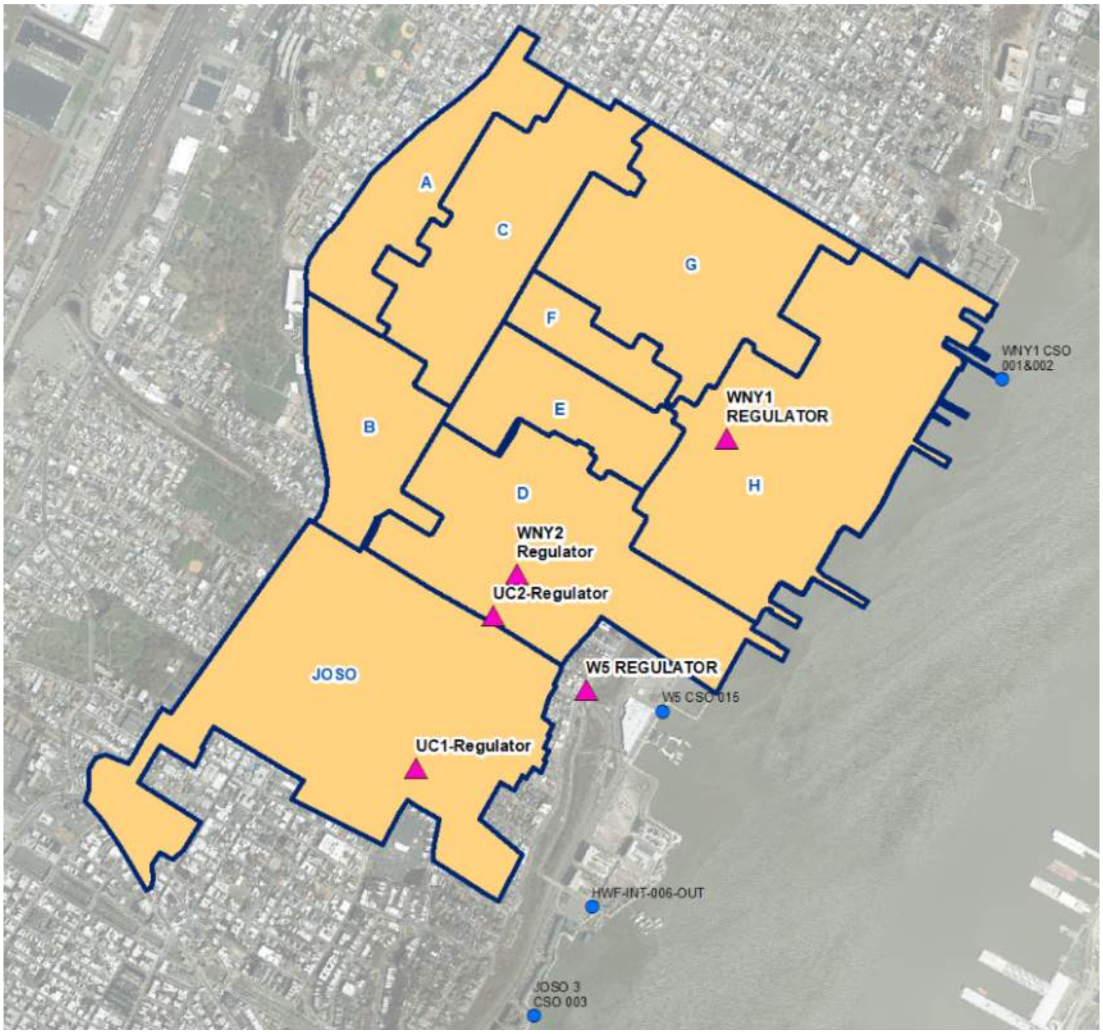
Figure 4.16: Port Imperial Pump Station No. 2 Wet Well

4.3 CSO Regulators

The regulators in the River Road WWTP Service Area direct all sewage flows during dry weather to the River Road WWTP and convey excess flows during wet weather events directly to the Hudson River. There are four regulators in the River Road WWTP Service Area, shown in in Figure 4.17 below, which are all located in series along the main WNY interceptor sewer. WNY1 regulator regulates CSO discharges using mechanical floats. This regulator conveys up to 10 million gallons per day (MGD) of flow to the River Road WWTP. The other three regulators (UC1, UC2 and WNY2) regulate CSOs using overflow weirs that divert sewage through the JOSO outfall.

All regulators were originally constructed in the 1950s and 1960s. Regulator WNY1 underwent rehabilitation in 2015.

Figure 4.17 Regulator Locations



4.3.1 Weir Regulators UC-1, UC-2 and WNY-2

There are three side overflow weir-operated regulators that discharge excess wet weather flow into the JOSO relief sewer that combines flows from the Town of West New York, Union City and Weehawken. Two regulators are located in Union City: as shown in Figure 4.17, UC- 1 is located on Park Avenue just north of 43rd Street, and UC-2 is located on 49th Street just west of Broadway. The third regulator, WNY-2 is located in West New York on 51st Street, just west of Broadway. The JOSO relief sewer directs the excess wet weather flow to the Hudson River.

Drawings were not available for the regulators so field measurements were taken by Mott MacDonald staff, shown below in Figure 4.18 through Figure 4.20.

Figure 4.18: Regulator UC1 Field Notes

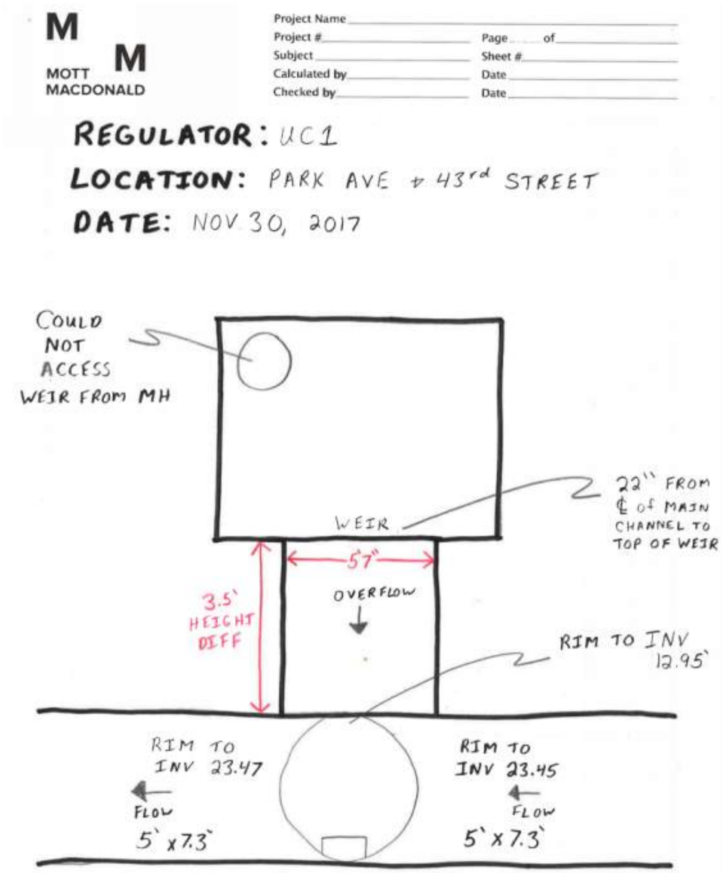


Figure 4.19: Regulator UC 2 Field Notes

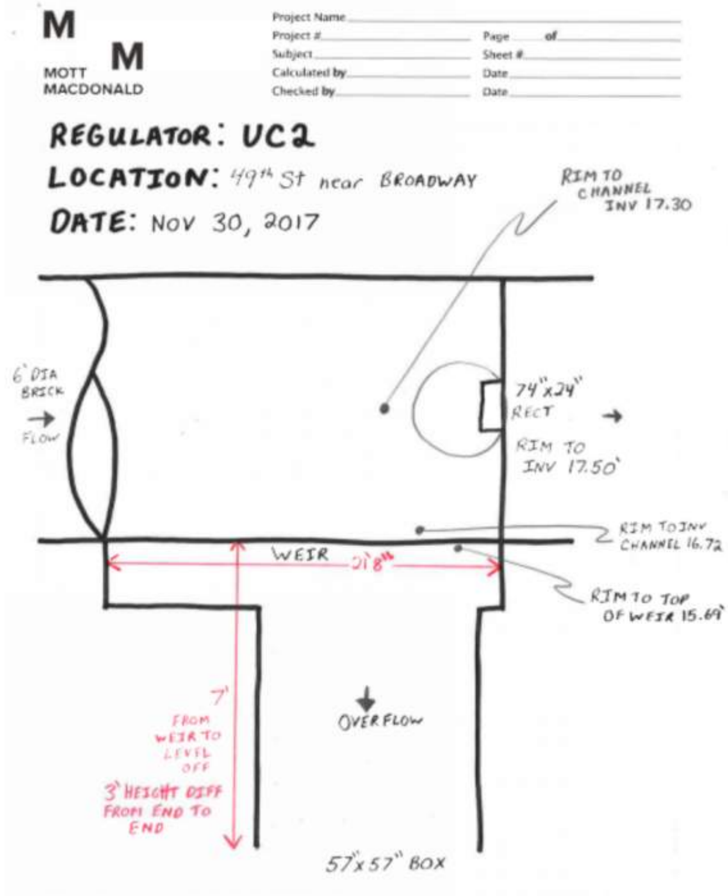
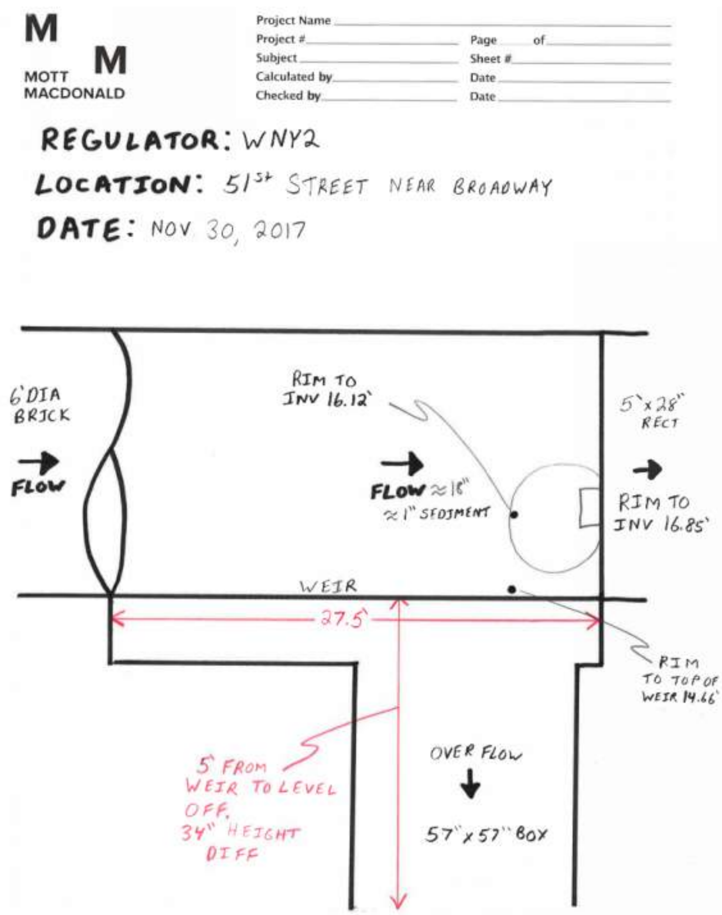


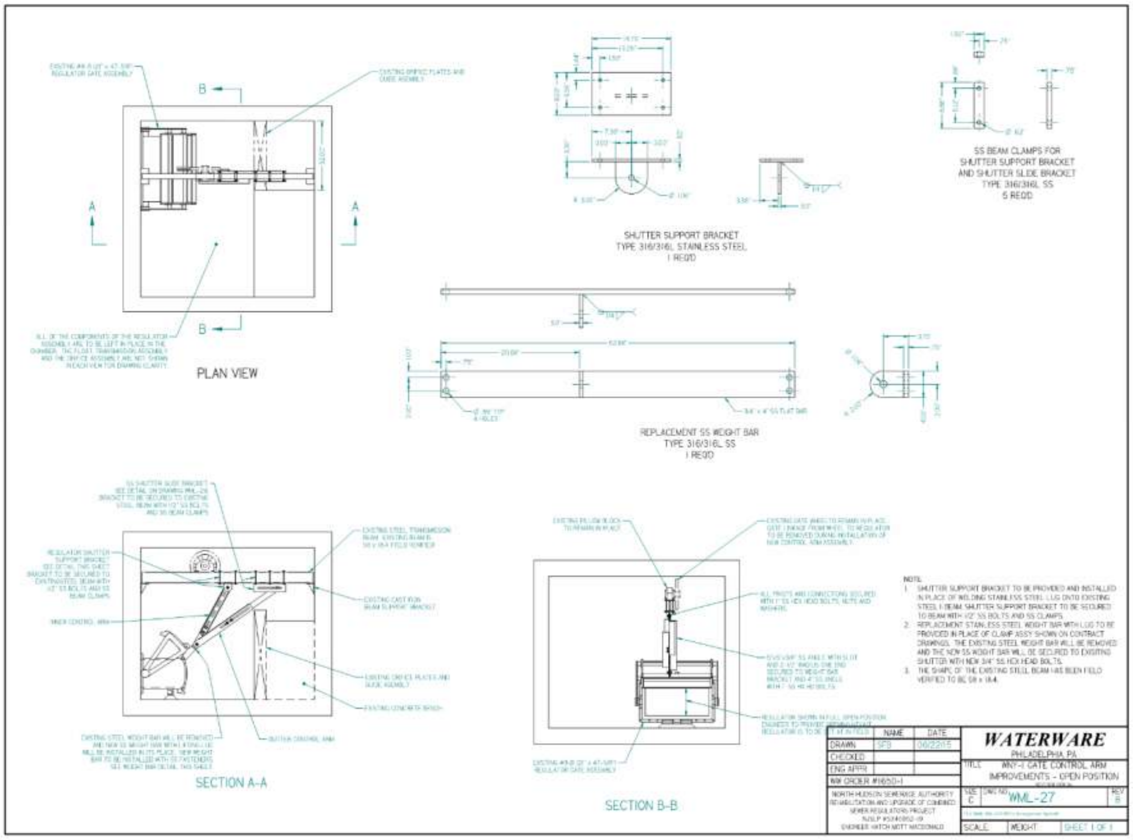
Figure 4.20: Regulator WNY2 Field Notes



4.3.2 Mechanical Regulator WNY-1

This weir controlled regulator is located on Anthony M. Defino Way, just east of the Intersection with John F. Kennedy Boulevard in West New York. The regulator is similar to those in Hoboken, with a weir and a regulator float gate. The influent line is an 84-inch diameter pipe which receives all combined sewer flows originating from the River Road WWTP service area, with the exception of overflows directed to the Joint Overflow Sewer Outlet (JOSO) for discharge to the Hudson River. A 27-inch diameter interceptor directs flow to the River Road WWTP. The River Road WWTP outfall joins the WNY-1 54-inch diameter outfall pipe prior to discharging to the Hudson River. This regulator was recently rehabilitated as part of the NHSA Regulators Improvements Project, shown in the drawings below in Figure 4.21 and the field notes are included as Figure 4.22.

Figure 4.21 Regulator WNY1 Rehabilitation Drawings



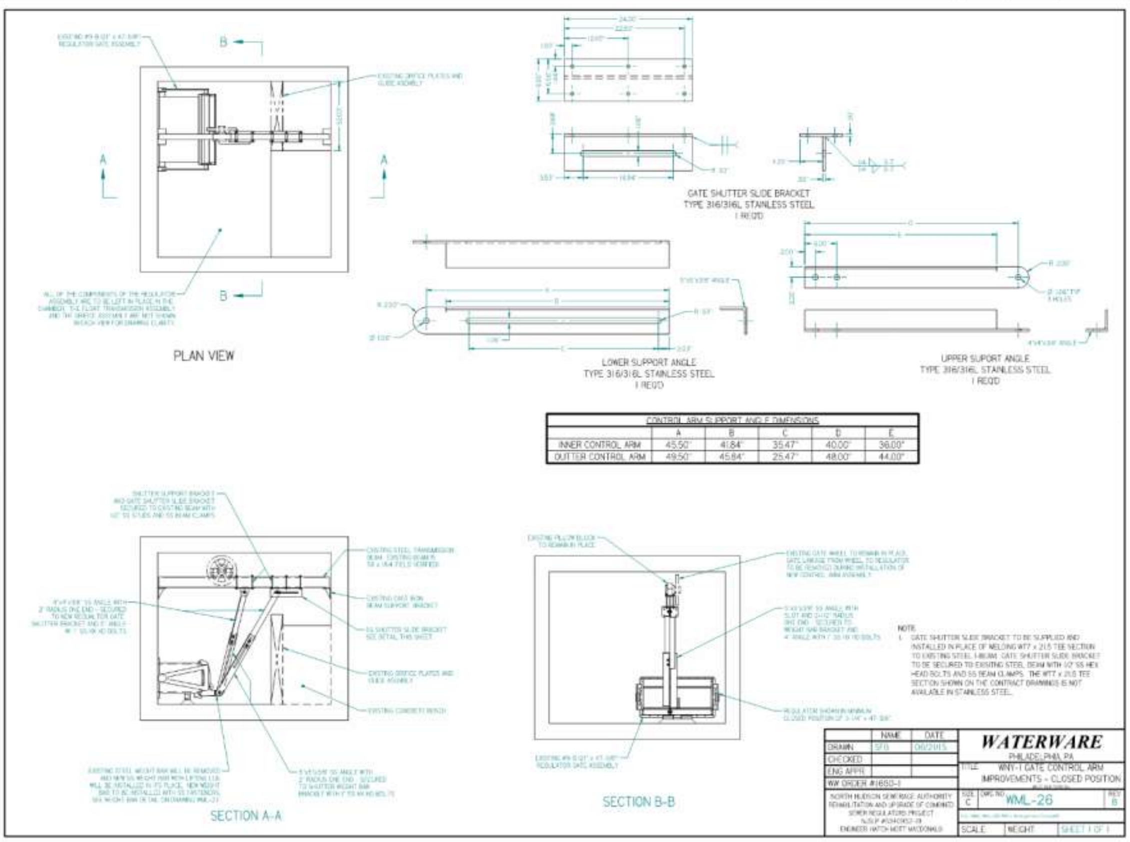
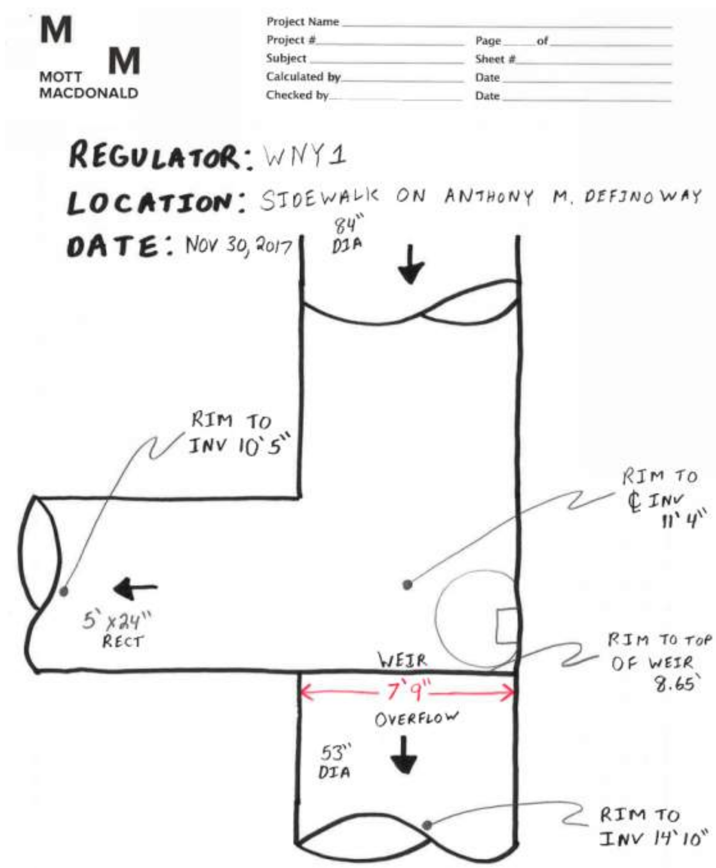


Figure 4.22: Regulator WNY1 Field Notes



4.4 CSO Outfalls

There are two CSO outfalls in the River Road WWTP service area which discharge to the Hudson River. Regulator WNY1 discharges wet weather flows to Outfall 002A, and directs dry weather flow to the River Road WWTP. CSO Outfall 002A continues down Anthony M. Defino Way where the flow is passed through the WNY1 solids and floatables facility, which provides ½ screening. After being screened it joins the WWTP outfall (001A) to form Outfall 001A/002A which continues as a single pipe extending into the Hudson River. The other outfall is JOSO/003A, as described below in Table 4-8.

Table 4-8 Summary of River Road CSO Outfalls

Outfall	NHSA Name	Basin	Dimensions	Type of Material	Location	Associated Regulator(s)
002A	WNY1	WNY1	54” circular	RCP	East of River Road WWTP in West New York, off Half Moon Ct.	WNY1
003A	JOSO	JOSO	60” circular	RCP	At the end of Liberty Place, Weehawken	UC1, UC2, WNY2

The general slope of the River Road outfall pipe was determined based on known elevations at the regulator, at the WWTP and at the outfall. The WWTP effluent is discharged by gravity into the 54-inch diameter outfall pipe (001A) which receives CSO flow just downstream of the WWTP (002A), and the WWTP discharge and CSO are conveyed together through a single pipe prior to discharging to the Hudson River. The pipe also receives overflow from the upstream regulator during wet weather events.

Figure 4.23: River Road Outfall Pipe at Low Tide

The River Road outfall pipe was inspected by divers in May 2010. It was determined that the pipeline and supporting structure are in fair condition overall, with a few repairs required to remedy some deflection in the pipeline as well as typical maintenance on minor cracking and coating loss on the support structure. There are no current capital improvement projects in progress for the River Road Outfall, and there are no future proposed capital improvement projects.

Drawings of the JOSO outfall pipe (003A) are not available, however it is known from NHSA staff that there is a drop structure located at the end of Liberty Place, which has been included in the hydraulic model. No invert elevation was available in GIS, however the sizing of the outfall pipe was confirmed in GIS. The elevation at the outfall is known, and was included in the model. A photo of the outfall sign at the JOSO outfall is included below as Figure 4.24:

Figure 4.24: JOSO Outfall Sign

4.5 Solids/Floatables Facilities

In October 2003, NJDEP issued Administrative Consent Order ID# NEA 020001-47081 (ACO 020001-47081 for Solids/Floatables Control) to NHSA. ACO 020001-47081 consisted of requirements to construct two solids/floatable construction projects, one for DSN 002 (001A/002A) and one for DSN 003 (JOSO). The solids/floatable projects for both DSN 002 and DSN 003 were completed in the summer of 2012 thus satisfying the ACO requirements. There are two solids/floatables control facilities in the River Road WWTP service area which discharge to the Hudson River. These correspond to the two outfalls 001A/002A (WNY/WWTP) and 003A (JOSO).

4.5.1 WNY1 Solids/Floatables Structure

The WNY1 solids/floatables facility treats overflows from the WNY-1 regulator. It was constructed in 2009 and is located in a building adjacent (south) of the River Road WWTP. The facility has an 84” influent PCCP pipe and a 78” effluent PCCP pipe. The facility has ½ inch bar screens which are 5’-6” in width with a span of 20’-6”. Drawings of this structure are provided below in Figure 4.25 and Figure 4.26.

Figure 4.25: WNY1 Solids/Floatables Facility

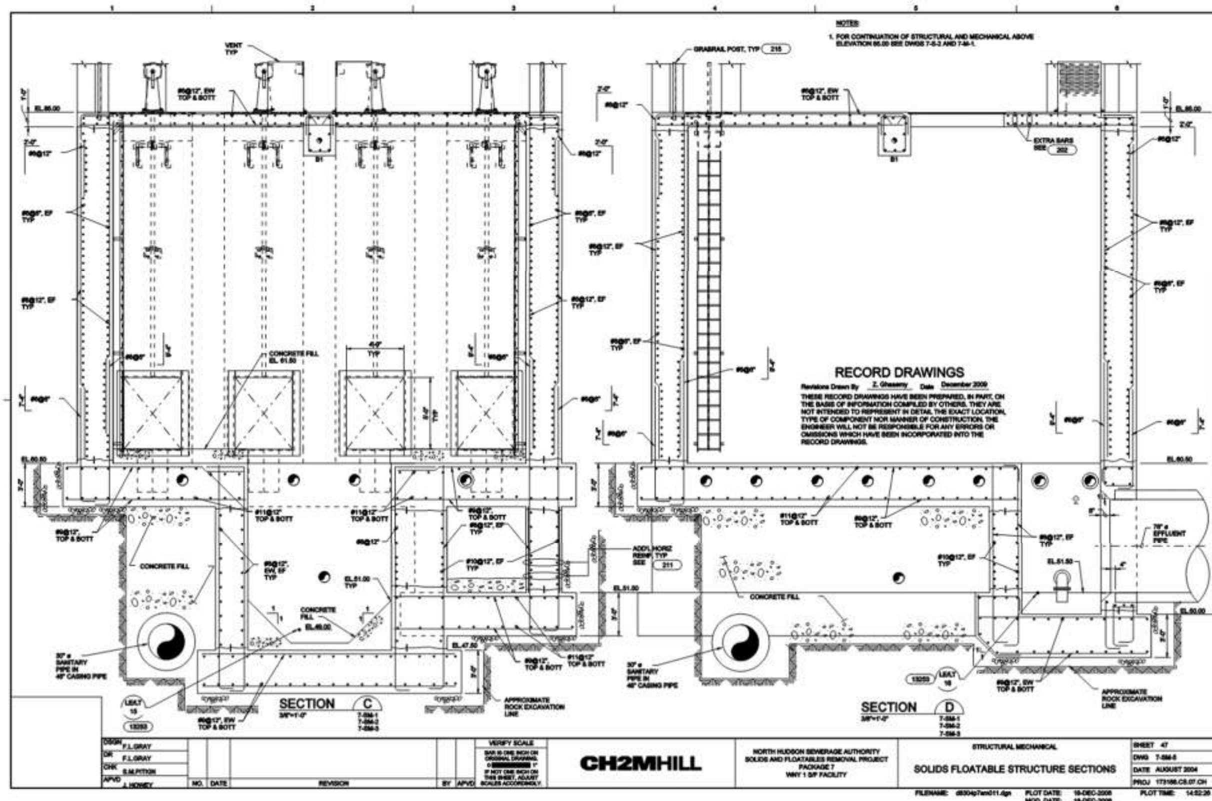
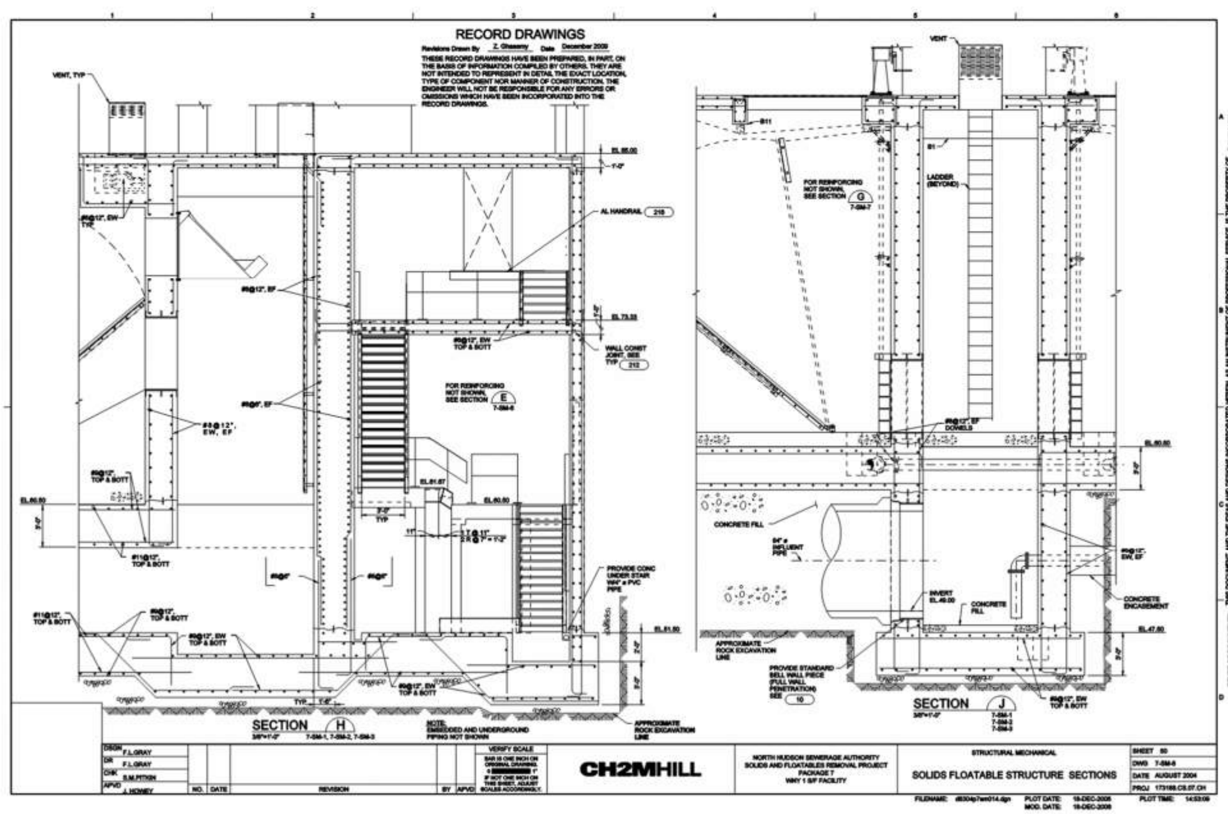


Figure 4.26 WNY1 Solids/Floatables Facility



4.5.2 JOSO Solids/Floatables Structure

The JOSO solids/floatables facility treats overflows from the UC1, UC2 and WNY2 regulators. It was constructed in 2005 and is located in a subsurface facility at the end of Henry Place, upstream (west) of the JOSO outfall. The facility has an 72” influent RCP pipe and a 72” effluent RCP pipe. The facility has bar screens are 5’-6” in width with a span of 15’-0”. It has 48” Tideflex check valves and 48” x 54” sluice gates.

Drawings of this structure are provided below in Figure 4.27 through Figure 4.29.

Figure 4.27 JOSO Solids/Floatables Facility

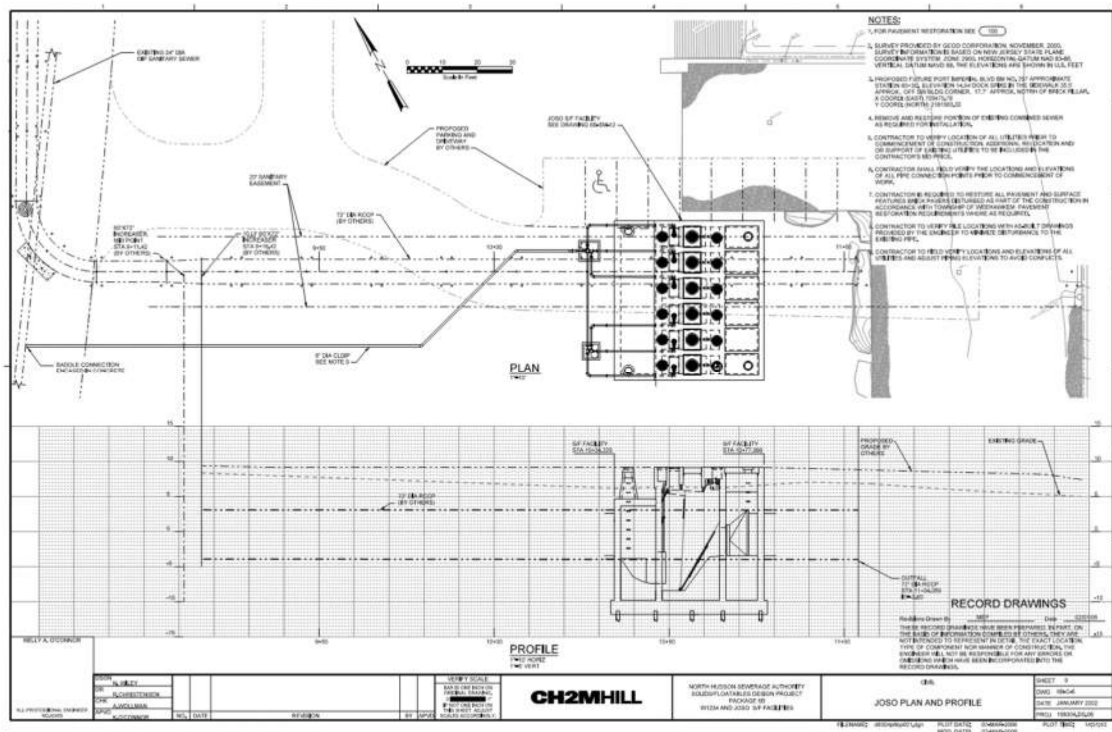


Figure 4.28 JOSO Solids/Floatables Facility

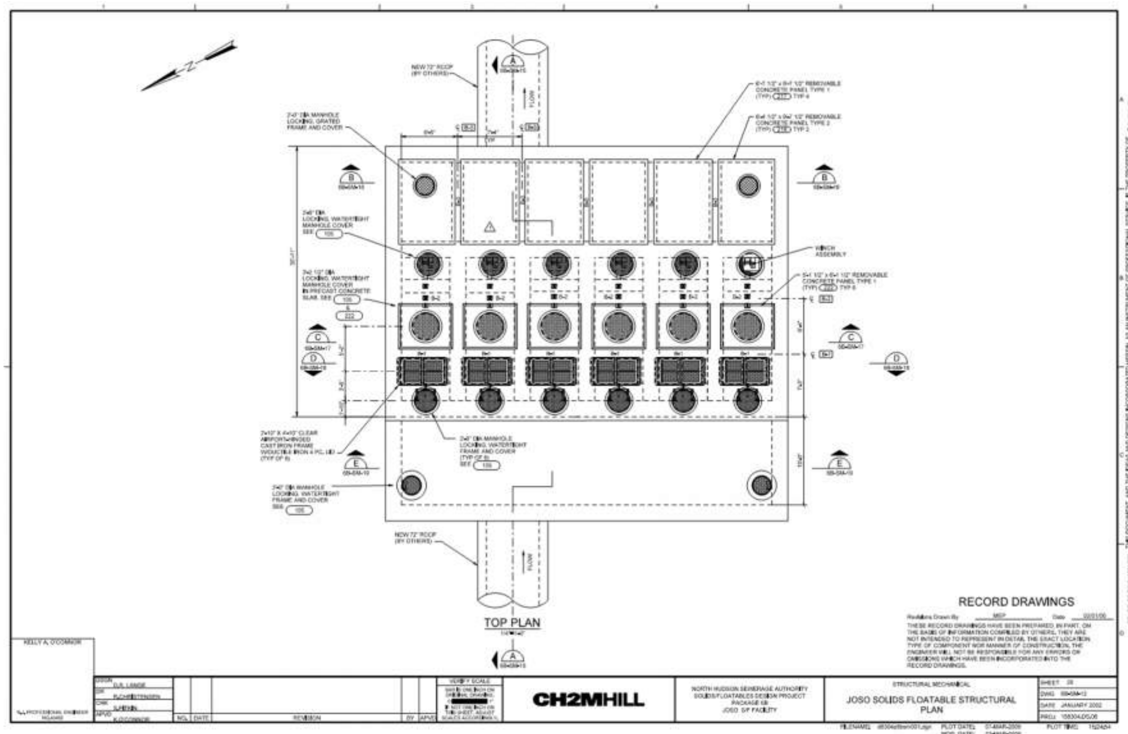
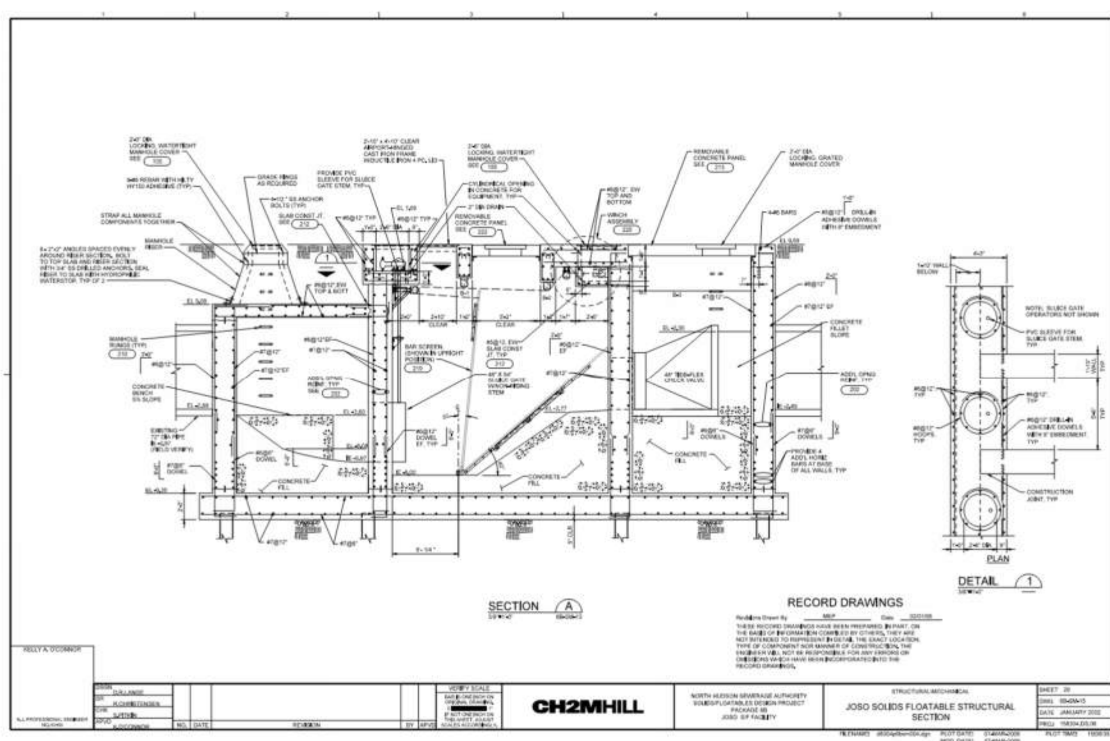


Figure 4.29 JOSO Solids/Floatables Facility



Wastewater Treatment Plant

This section outlines the characteristics of the River Road WWTP, including processes, flow data, influent loadings, effluent data, and removal data associated with permit compliance.

5.1 Facility Overview

The River Road WWTP is located at 6400 Anthony M. Defino Way in West New York. The WWTP was constructed as a primary treatment plant in 1953 with a design capacity of 10.0 MGD and 20 MGD peak flow. In 1992, an upgrade to the plant was completed to provide secondary treatment using the trickling filter biological treatment process. The plant treats the sewage from the Town of West New York and from a section of Union City and Weehawken covering an area of approximately 1.4 square miles and three communities. The average flow to the facility has approached the plant capacity of 10.0 MGD in the past, but has been decreasing in recent years with aggressive I/I reduction efforts. Effluent is discharged to the Hudson River in accordance with the NJPDES permit NJ0025321.

The treatment process at the plant includes preliminary treatment consisting of influent screening and grit removal using vortex type units, micro-strainers in lieu of primary clarifiers, trickling filters, secondary clarification, effluent disinfection using sodium hypochlorite and de-chlorination using sodium bisulfite, solids handling including sludge storage and sludge thickening using two belt presses and odor control. The process flow diagram for the River Road WWTP is provided below in NHSA assumed ownership of the River Road WWTP and associated collection and conveyance facilities on November 1, 1996. The following sections describes the condition of each facility, presents any ongoing repairs/replacements, and discusses planned capital improvements to the system.

Figure 5.1, the treatment capacities superimposed on an aerial in Figure 5.2.

NHSA assumed ownership of the River Road WWTP and associated collection and conveyance facilities on November 1, 1996. The following sections describes the condition of each facility, presents any ongoing repairs/replacements, and discusses planned capital improvements to the system.

Figure 5.1: River Road WWTP Process Flow Diagram

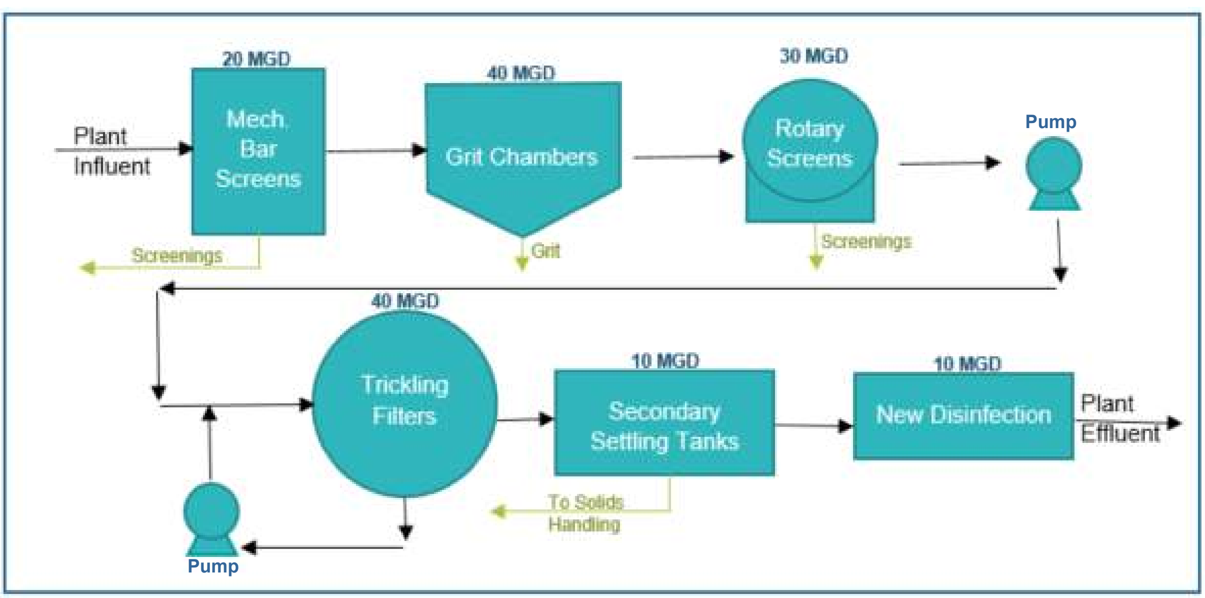


Figure 5.2 River Road Wastewater Treatment Plant

5.2 Treatment Capacities

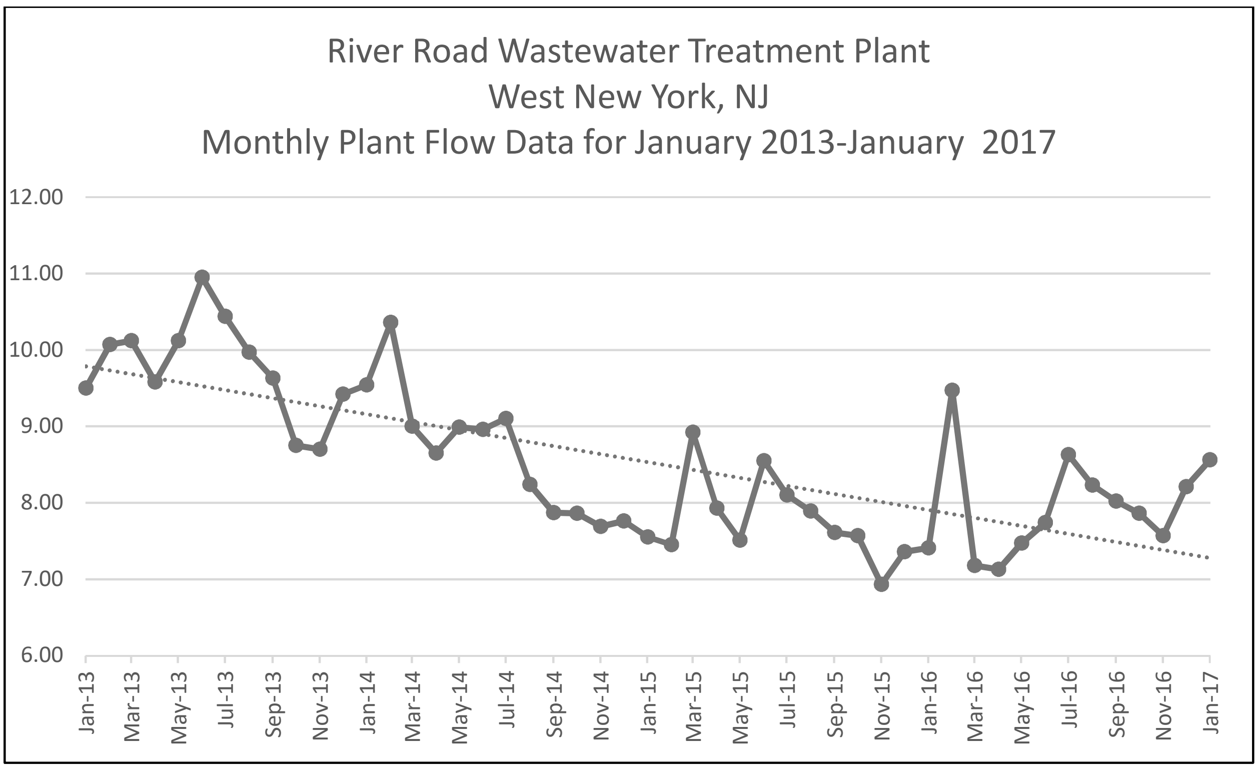
The River Road WWTP was designed for an average flow of 10 MGD, and has been able to meet the permit requirements for the last 5 years under these flow conditions due to plant improvements. The plant is limited by the capacity of its secondary settling tanks and work was performed by the Authority to evaluate the actual treatment capacity of these tanks. It was determined that the capacity of the secondary settling tanks is 8.1 MGD. This is because the secondary settling tanks were designed as primary settling tanks and have a shorter sidewall depth than is typically used for secondary settling tanks. The settling tanks are also overloaded and when an average loading rate is used their capacity is 8.1 MGD.

The required treatment capacity is defined as “the minimum flow, which should be used to determine the size of the treatment, achieving NJPDES General Permit limits. This flow shall be based upon the facility’s permitted flow and shall include appropriate allowances for non-excessive infiltration/inflow (I/I) and daily or seasonal variations encountered by the facility”. The NJPDES General Permit does not limit the WWTP flow. The Permit sets effluent limitations for TSS and BOD for both mass discharges (kg/day) and concentrations (mg/L). The Permit also identifies a flow value of 10 MGD which was used in determining the load calculations. The required treatment capacity is considered equal to the flow value listed in the General Permit and defined as 10 MGD.

The primary treatment capacity is defined as "the maximum flow i.e. daily, weekly or monthly that can receive primary treatment at the existing primary treatment facilities". Currently, there are no existing primary settling tanks at the River Road WWTP. Microscreens that are designed for 10% BOD removal and 18% TSS removal are provided. Typical removal efficiencies for primary treatment facilities when treating municipal wastewater are 50 to 70% TSS removal and 25 to 40% BOD removal.

The NHSA has in place a Leak Detection Program in cooperation with Suez Water (Suez) to address infiltration into the gravity sewer of the West New York collection system. Upon obtaining results from a flow monitoring study performed by Emnet, Inc., it was determined that significant amounts of infiltration from the Suez water distribution system was entering the collection system. This infiltration drove the influent flows entering the WWTP over the facility's design capacity of 10 MGD. The Authority has initiated an ongoing collaboration with Suez to systematically address leaks within their water distribution system. As a direct result of this program, there has been a reduction in flows from a peak month of 11 MGD prior to program commencement to less than 9 MGD, as shown in Figure 5.3. The plant monthly average flow is near the design capacity for the plant.

Figure 5.3: Historic Flow Rates 2013-January 2017, River Road Wastewater Treatment



5.2.1 WWTP Facilities Review

Using the 2017 Annual Report and prior facilities reports the condition of the WWTP was evaluated to provide an understanding if LTCP work could be coupled with other planned improvements.

5.2.1.1 Preliminary Treatment

The Preliminary Treatment Building (PTB) houses the screening, grit removal and micro-strainer equipment. The influent sewage flows through two (2) stainless steel, mechanical bar screens where rags and debris are removed. The rags and debris are conveyed to a dumpster. The sewage then flows through a channel to two (2) vortex type grit removal units where heavy sand and grit settle to a grit sump. The organics in the sewage flow are maintained in suspension by a rotating paddle to maintain velocity within the vortex unit. The grit is pumped by vacuum primed grit pumps manufactured by Smith and Loveless. The grit is pumped to two (2) grit classifiers which wash and dewater the grit and convey it to containers, see Figure 5.4.

Figure 5.4: Mechanical Screen and Grit Removal System

The deck grating above the influent channels to the screening facility were replaced during FY2016. The mechanical bar screens appear to be in good working order. The grit equipment including the vortex unit paddles and drives, and the grit pumps are at the end of their useful life and should be replaced and updated. The grit classifiers were replaced in kind in 2012. The grit pumps are vacuum primed “pista grit” pumps that are reported to have reached the end of their useful life and require periodic patching of the volutes due to the abrasive nature of the grit. A possible improvement is the replacement of the vacuum primed pumps with self- priming type pumps. The self-priming pumps do not require the separate, often maintenance intensive, vacuum priming system. Materials of construction for the new grit removal equipment should be carefully selected for corrosion resistance and should include stainless steel as much as possible.

In general, the area contains high levels of moisture which leads to corrosion of the exposed steel in the building structure. This is caused by the extremely humid and wet conditions from the exposed sewage and the gasses generated from the sewage. This area is known as the “Operations Deck” and currently has no odor control. Odorous air is discharged directly outside. It is recommended that all channels and water surfaces be covered with lightweight aluminum or fiberglass. A small odor control system could be added to create a slightly negative pressure beneath the covers to pull odorous air from the channels and treat it before discharge to the outside, see Figure 5.5. The covers and small odor control system would improve the working atmosphere in the building and help to prevent further corrosion which eventually could lead to costly structural repairs. The covering of the open channels, tanks and equipment as discussed above would also reduce the odor emissions from this area, possibly without the addition of a large odor control system for treating the entire volume of air in the building.

Figure 5.5: Odor Control System

The influent and effluent gates need replacement and new air monitoring equipment in the building is needed to detect Hydrogen Sulfide (H2S), Lower Explosive Limit (LEL), Carbon Monoxide (CO) and Oxygen (O2). The current unit monitors LEL only.

5.2.1.2 Micro-strainers

The micro-strainers are designed to remove the solids in the wastewater that are not removed by the screens and vortex grit removal units. The units are used in lieu of primary clarifiers to further remove solids prior to treatment in the trickling filters. The micro-strainers remove material that is greater than 0.03 inches in diameter. There are six (6) units with internal hot water nozzles for cleaning. The micro-strainers discharge the removed debris to a screw conveyor which conveys the debris to two (2) screenings presses that dewater the material and discharge it to a pipe that dumps into a container located on the deck level.

Four (4) of the six units were replaced in 2010 and the remaining two (2) units were replaced in 2016. The sump pumps are located in the lower area that is difficult to access for maintenance and cleaning and were subject to frequent clogging and. New sump pumps and controls were installed. Chopper type sump pumps were selected due to the debris that is required to be pumped.

5.2.1.3 Trickling Filters and Intermediate Pump Station

The trickling filter system includes the intermediate pump station (IPS) and two (2) 100-foot diameter trickling filters with aluminum covers and 28-foot deep cross-flow type plastic media. The trickling filter system also includes forced air ventilation, two odor control systems and a Recirculation Pump Station. The Intermediate Pump Station pumps micro-strainer effluent plus recirculation flow to the rotary distributors located on the top of each trickling filter. The recirculation pump station pumps recirculation flow to the intermediate pump station, see Figure 5.6.

Figure 5.6: Trickling Filters and Pumps

During FY 2008, the media in the north trickling filter (TF 2) collapsed and the media was replaced by June 2009. In addition, the hydraulically operated rotary distribution mechanism was replaced with a mechanically driven unit and the trickling filter floor and underdrain system were repaired. In FY 2011, inspection of the media in TF 1 revealed that it was in poor condition and sections may have failed. The media in TF 1 was replaced in FY 2012. The failure of the media results in the trickling filter producing an effluent below design performance and above NJPDES discharge permit requirements which, in part, caused the Administrative Consent Order (ACO). The repairs of TF 1 and TF 2 were part of the remedies to satisfy the requirements of the ACO.

The TF recirculation pumps and the intermediate pump station VFDs were replaced in FY 2011. The replacement consisted of installing four (4) new VFDs such that each pump speed is controlled by a dedicated VFD. All four Intermediate Pump Station pumps are reported to have had operational problems. The pumps have been rebuilt several times and will need to be replaced in the next 5-10 years. One of the four check valves at the Intermediate Pump Station was replaced in FY 2009 due to improper seating and severe corrosion and two of the remaining three were cleaned and made operational in FY 2010. All four check valves are being replaced in 2018.

The Intermediate Pump Station pumps the micro-strainer effluent from the Intermediate Pump Wet Well to the Trickling Filters. The wet well is very small and changes in flow quickly fill or deplete the wet well. If the pumps stop for any reason, the wet well rapidly fills and overflows to a catch basin system that returns the overflow to the treatment plant. The pumps are vertical type centrifugal pumps with the motors mounted on the top of the pumps. The pumps are elevated high above the operating floor which makes accessibility for maintenance difficult. Normally, it is recommended that the low level in the wet well be maintained slightly above the volute of the pump to maintain a flooded suction condition and help prevent air binding. The vertical orientation of the pumps causes the pump volute to be significantly higher than the suction piping which reduces the effective volume of the small wet well.

The current odor control system is a wet scrubber type system that uses sodium hypochlorite as the oxidizing chemical, however this system is currenly being removed and will be replaced with a ventilation fan system. Caustic (sodium hydroxide) and the Oxidation Reduction Potential (ORP) control system are not used.

Future capital improvement plans include replacing intermediate pumps and repairing spalled concrete at precast concrete wall panels and joints between panels. A new pump control system (programmable logic controller (PLC) and ultrasonic level meter) are currently being installed.

5.2.1.4 Secondary Clarifiers

There are two (2) 90-foot by 90-foot secondary clarifiers (SC), see Figure 5.7. Each vessel contains 9-feet of water. These units were originally constructed in 1953 as primary clarifiers. The units are equipped with circular sludge collection mechanisms that include corner sweeps. The sludge collection mechanism consists of a set of rakes that push the settled sludge to a center sludge pit where the sludge is removed by the secondary sludge pumps, see Figure 5.8. The secondary clarifiers were upgraded about 10 years ago. The addition of energy dissipating baffles upstream of the secondary clarifiers greatly improved treatment performance of the plant.

Figure 5.7: Secondary Clarifier

Figure 5.8: Secondary Pumping

Secondary sludge is pumped from the clarifiers to a sludge storage tank prior to sludge thickening. The sludge pumping system includes three (3) Wemco vortex type sludge pumps.

5.2.1.5 Disinfection System

Sodium hypochlorite is used for disinfection and sodium bisulfite is used for de-chlorination in order to meet the chlorine produced oxidants (CPO) permit requirements that were imposed in 2006. Contact time is provided by a chlorine contact tank that is located just east of the secondary clarifiers. Hypochlorite is dosed to the effluent of the clarifiers prior to the chlorine contact tank and bisulfite is dosed at the end of the chlorine contact tank just prior to the flow entering the 54" diameter outfall pipe to the Hudson River. The existing chlorine contact tank (CCT) provides a very short contact time. At 9 MGD flow, the contact time is only 13 minutes which does not meet NJDEP standards. (30 minutes at average flow and 20 minutes at peak flow). The tank appeared to have excessive freeboard that could potentially be used to increase the water depth in the tank and increase the detention time without adversely impacting the plant hydraulics, however calculations demonstrated that increasing the water level would not meaningfully impact the contact time. In addition, there is available space at the southern end of the tank for a potential tank addition to increase the available volume. The size of the chlorine contact tank is inadequate to provide the required contact time for consistent disinfection. In order to achieve the required degree of disinfection, additional sodium hypochlorite is dosed which also requires additional sodium bisulfite for de-chlorination. The sodium bisulfite system includes a tank and pump system, a standby pump and heat traced and insulated chemical feed lines. New chemical feed pumps were installed about 3 years ago. Sodium hypochlorite is stored in four (4) fiberglass storage tanks that are located in the chlorine building, installed during 2016.

5.2.1.6 Solids Handling

Sludge from the treatment plant is limited to the secondary sludge that is pumped from the secondary clarifiers. Secondary sludge is pumped to a single sludge storage tank where it is mixed and aerated. The sludge is then pumped to two (2) belt filter presses that were converted to gravity belt thickeners (GBT) and the sludge is thickened to up to 6.5% solids, see Figure 5.9. The thickened sludge is then stored in a "frac tank" and hauled to the Passaic Valley Sewerage Commission (PVSC) treatment plant in Newark for processing and disposal.

Figure 5.9: Solids Handling

5.3 Performance

FY2017 BOD and TSS removal performance of the River Road WWTP is presented in the table below. The NPDES discharge permit also stipulates routine monitoring of several effluent parameters. These criteria include reporting of maximum and/or average conditions of flow, BOD5, TSS, dissolved oxygen, effluent pH, oil and grease and fecal coliform. The plant demonstrated compliance with 99% of the permit criteria during FY2017, see Table 5-1 and Table 5.2.

Table 5-1 River Road WWTP Monthly Performance, FY2017

	Average Daily Flow	Average BOD5			Average TSS		
Month	Influent (MGD)	Influent (mg/l)	Effluent (mg/l)	Removal Efficiency (%)	Influent (mg/l)	Effluent (mg/l)	Removal Efficiency (%)
Feb. 2016	9.47	123	16	87	145	13	91
Mar. 2016	7.18	164	18	89	184	14	92
Apr.2016	7.13	156	13	92	147	11	93
May 2016	7.58	167	15	91	155	16	90
Jun 2016	7.75	174	16	91	151	12	92
July 2016	8.63	170	17	90	209	18	91
Aug. 2016	8.23	178	16	91	221	17	92
Sept. 2016	8.02	186	16	91	199	15	92
Oct. 2016	7.86	175	20	89	178	20	89
Nov. 2016	7.57	167	20	88	162	18	89
Dec. 2016	8.18	154	22	86	162	20	88
Jan. 2017	8.56	126	22	83	170	23	86
Average	8.01	165	18	89	176	17	90
Maximum	9.47	186	22	92	221	23	93
Minimum	7.13	126	13	83	147	11	86
NPDES Permit Limit	NA	N/A	25	85	N/A	30	85

Table 5-2: River Road WWTP Performance Summary, FY2017

Parameter	**Permit Limit**	**WWTP Operation Data**		
		Annual	Minimum	Maximum
Flow	Report Only	8.01	7.13	9.47
pH Influent, Monthly Maximum	Report Only	8.42	8.1	8.9
pH Influent, Monthly Minimum	Report Only	7.1	6.8	8.9
pH Effluent, Monthly Maximum	9.00 SU	7.6	7.4	7.9
pH Effluent, Monthly Minimum	6.00 SU	6.85	6.4	7.3
TSS Effluent	30 MG/L Monthly Ave.	16.4	11	23
	85 Percent Removal Monthly Ave.	90.5	86	93
CBOD Effluent	25 mg/L Monthly Ave.	17.58	13	22
	85 Percent Removal Monthly Ave.	88.9	83	92
Oil and Grease	10 mg/L Monthly Ave.	4.66	0.70	9.8
Fecal Coliform	200 CFU Monthly Geometric Mean	11.83	1	30
	400 CFU Weekly Geometric Mean	76	3	442
Chlorine	0.13 MG/L Daily Max	0.07	0.02	0.29
Dissolved Oxygen, Minimum Weekly Average	4 MG/L Weekly Ave. Min	8.02	6.34	10.91

Service Area and Land Uses

Service area and land use were analyzed to delineate and characterize CSO drainage basin areas and subareas for use in developing the hydraulic model and in planning modifications and improvements to NHSA's service area. GIS software was used to obtain, organize, and process the population and land use/land cover data.

6.1 Service Area Drainage Basins

The service area for the River Road WWTP is entirely urbanized land, with land uses shifting from industrial towards higher density residential in recent years. Land uses, zoning and percent impervious characteristics of the study area are described in the following section.

There are nine drainage basins within the service area of the River Road WWTP, shown in Figure 6.1 below and listed in Table 6-1:

Figure 6.1: Basins within the River Road WWTP Service Area

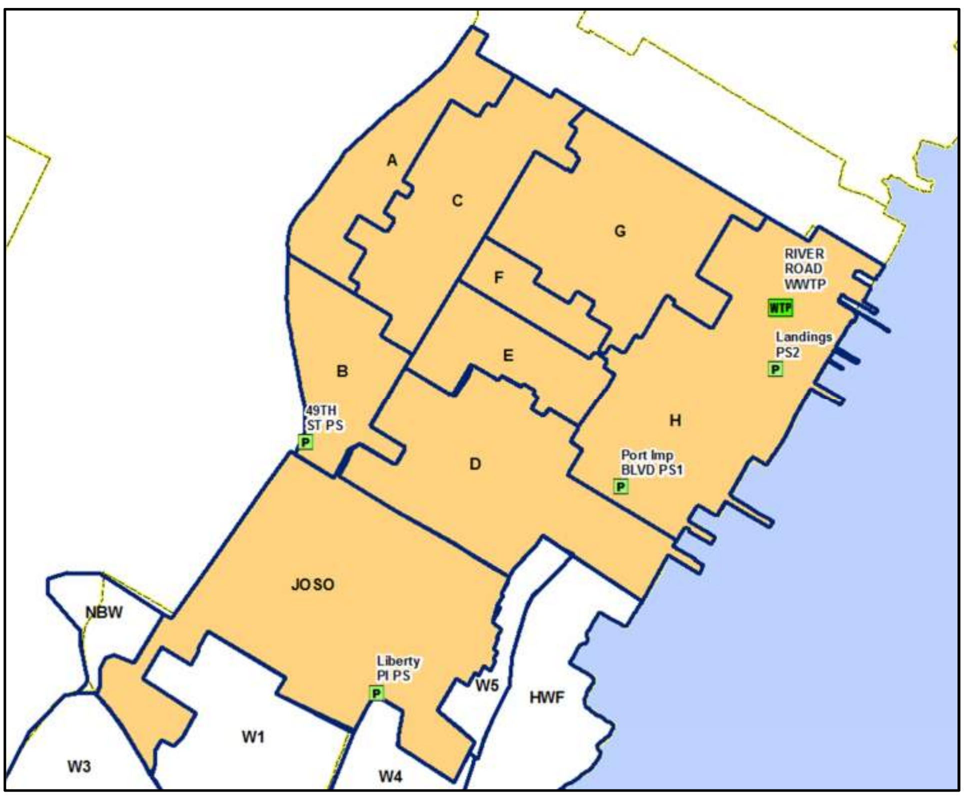


Table 6-1: River Road Basin Areas

Basin	Area (acres)
A	53.44
B	53.53
C	85.84
D	122.08
E	44.06
F	22.44
G	108.91
H	167.20
JOSO	205.36
TOTAL	**862.86 acres = 1.35 sq. mi.**

Most of the area is serviced by a combined sewer system, with the eastern portion of Basin H serviced by a separate storm sewer which bypasses the treatment plant.

6.2 Land Uses, Zoning and Imperviousness

This section summarizes the land cover characteristics within the River Road service area.

6.2.1 Zoning

As per the Master Plan for the Town of West New York, adopted in January 2015 (see Figure 6.2 and Figure 6.3 for existing and proposed zoning maps from Master Plan) the existing zoning in West New York is primarily medium-density residential with some areas of high-density residential, several commercial corridors and the waterfront zoned as controlled waterfront development. The proposed zoning maintains the controlled waterfront development area, with some of the commercial areas re-zoned as high-density residential. Industrial lands have also been re-zoned as high-density residential, as well as the additional of several parcels re-zoned as public lands. There is also an area in the south-west corner of the town zoned as transit-oriented development which is contiguous to the similarly zoned area in Union City. Two small areas of one- and two-family housing have been preserved.

Figure 6.2: West New York - Existing Zoning

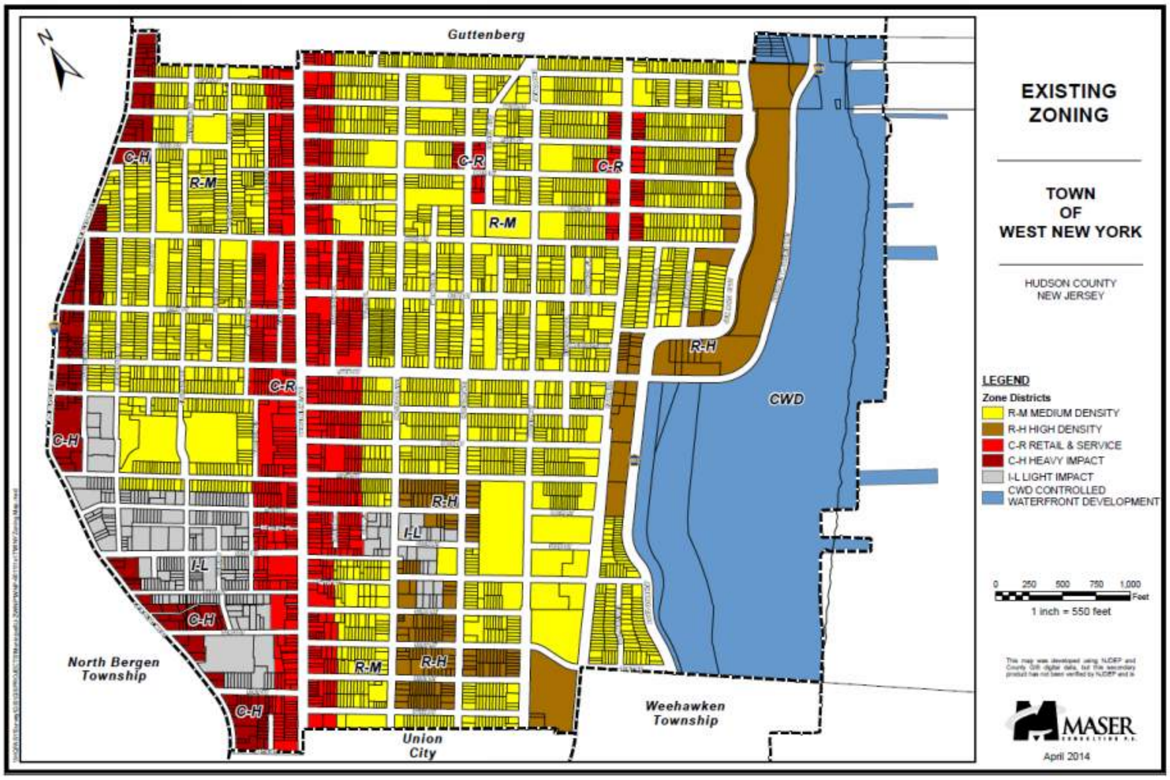
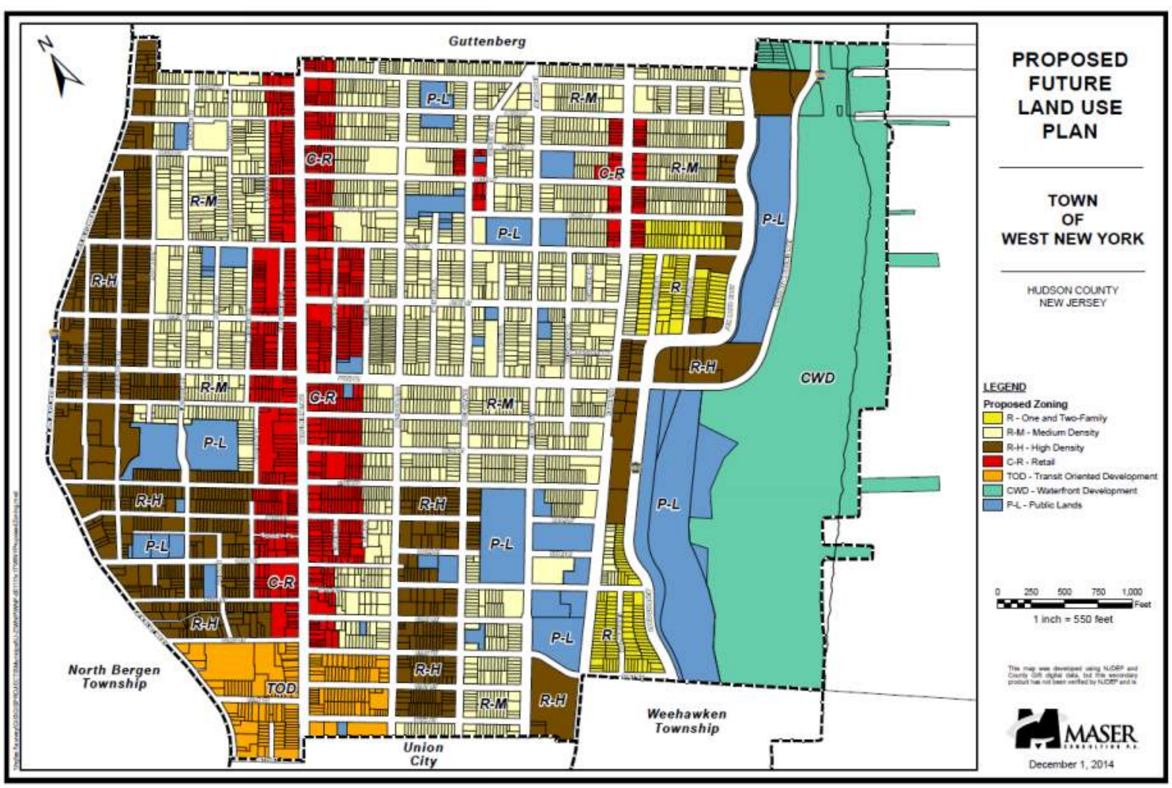
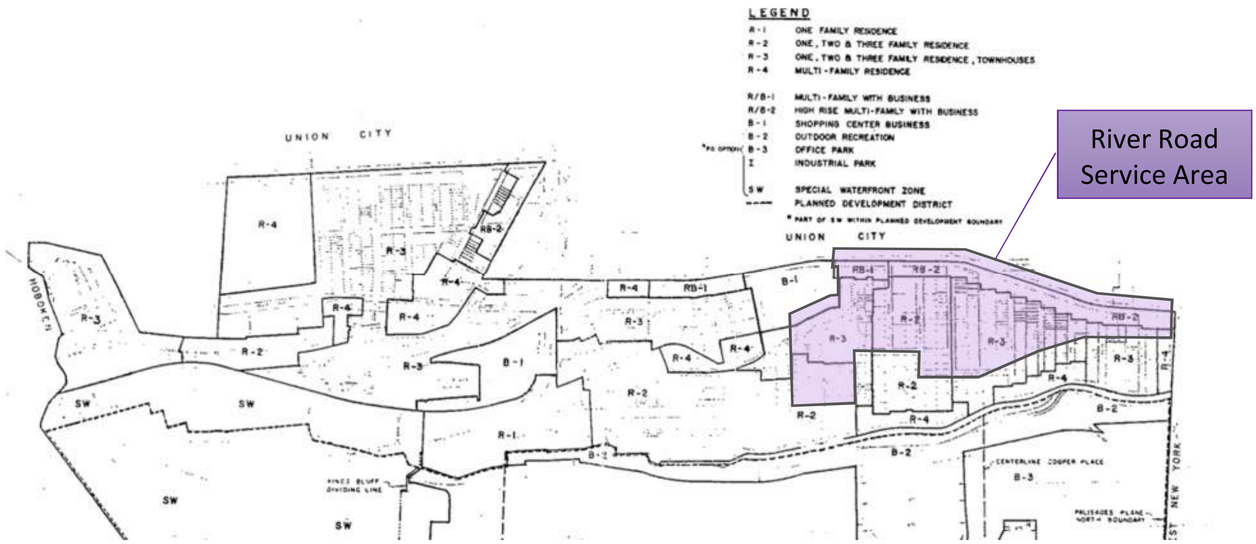


Figure 6.3: West New York - Proposed Zoning



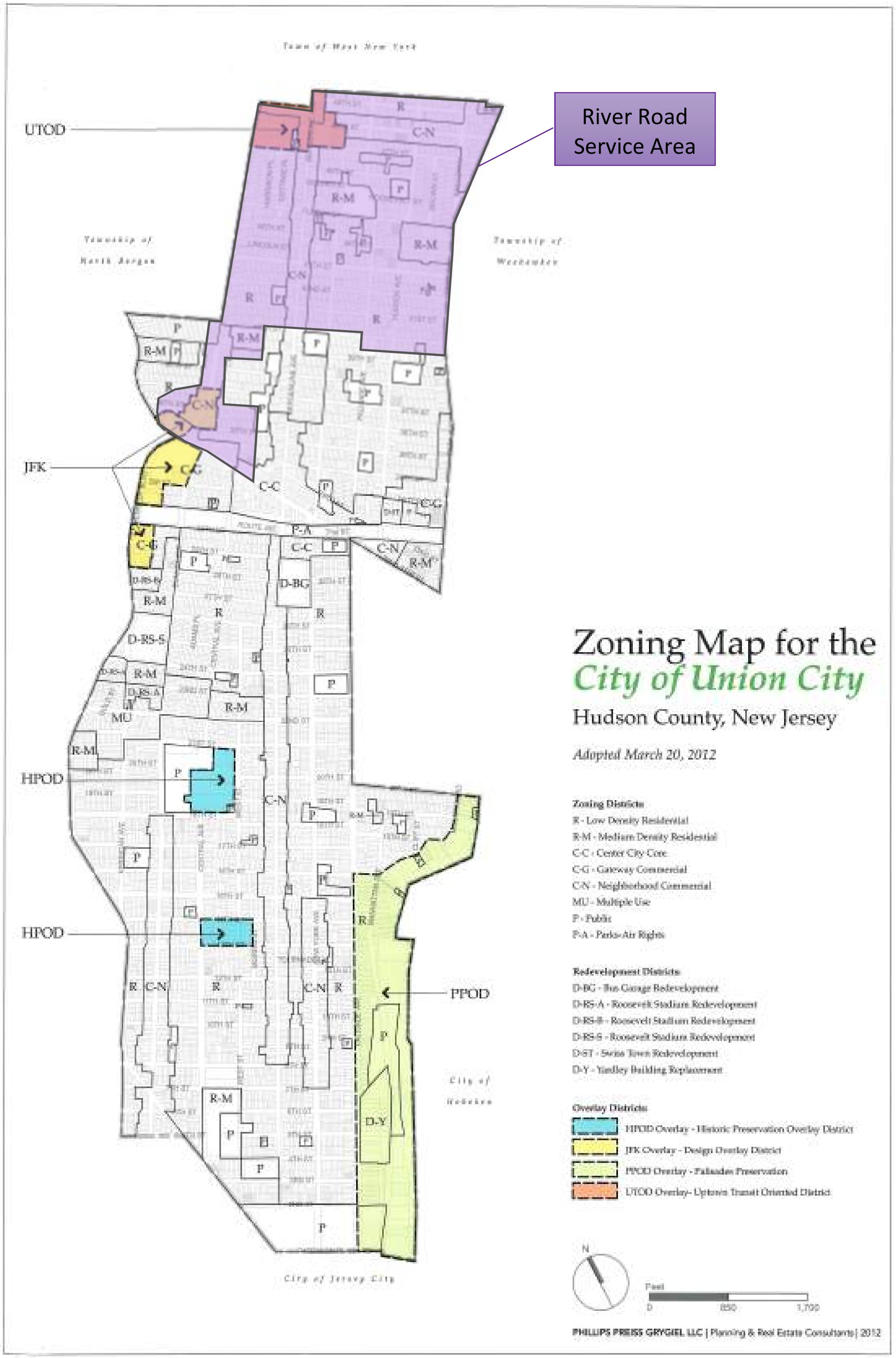
As per the August 1974 Zoning Map (see Figure 6.4) provided by the Township of Weehawken, the area of Weehawken within the service area is zoned as entirely residential. It is primarily R-3 (one, two and three-family residences and townhouses) and R-2 (one, two and three family residence). There are also smaller areas zoned as RB-1 (multi-family with business) and RB-2 (high rise multi-family with business).

Figure 6.4: Weehawken Zoning



As per the 2012 Zoning Map for the City of Union City (see Figure 6.5), the majority of the portion of Union City that falls within the service area of the River Road WWTP is zoned as primarily low-density residential, with a few interspersed areas zoned as medium-density residential and parking. There is also one area of commercial-neighborhood and a section in the north-west zoned as transit-oriented development.

Figure 6.5: Union City Zoning



6.2.2 Land Uses

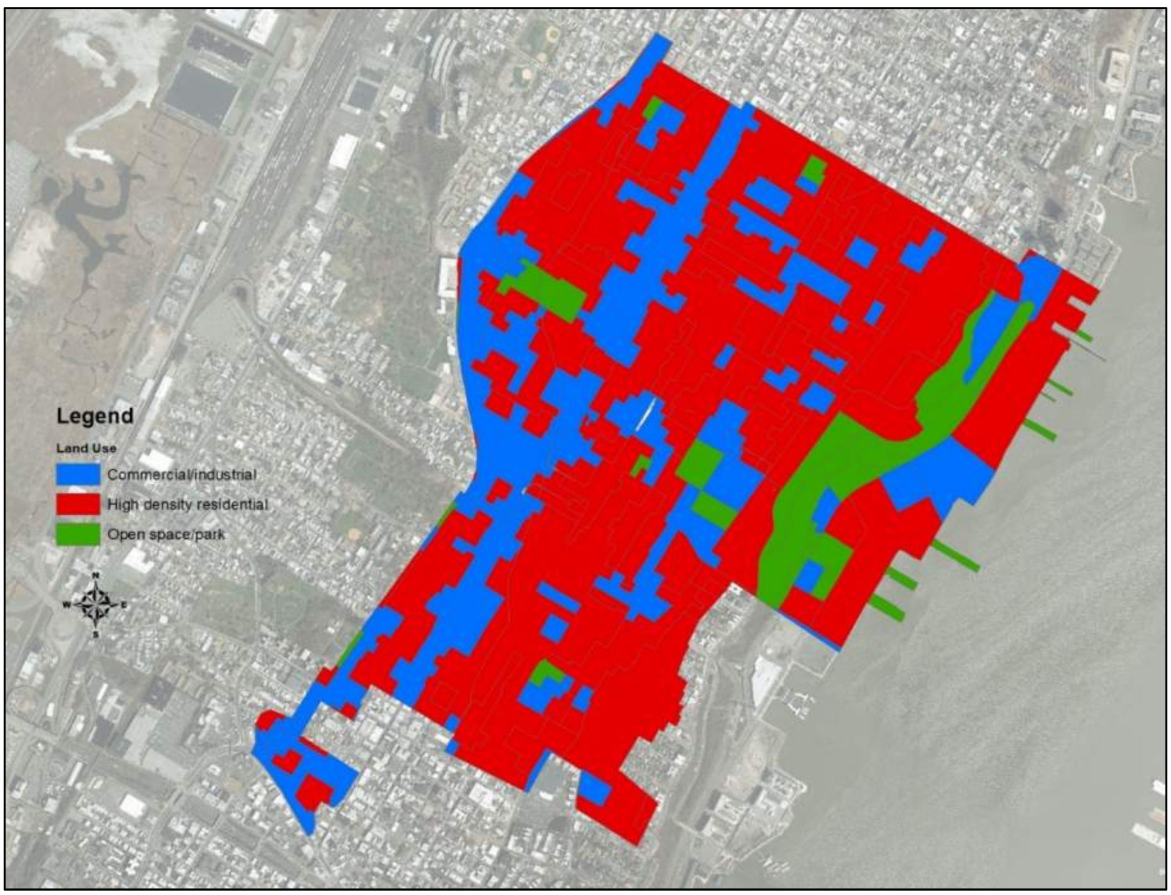
Data from NJ-GeoWeb state database was used to classify land use throughout the total service area based on 2012 land use classifications. As can be seen in Table 6-2 below, the primary land uses in this area are high density residential and commercial/industrial.

Table 6-2: Overall River Road Land Use Areas

Land Use	**Area (acres)**	**Percentage**
Low/medium density residential	0	0%
High density residential	554.2	64%
Commercial/industrial	235.8	27%
Open space/park	72.8	8%
Total	**862.8**	**100%**

This categorization is shown in Figure 6.6 below.

Figure 6.6: 2012 Land Use in River Road Service Area



Divided by basin, the land use breakdown is Table 6-3 and Table 6-4 as follows:

Table 6-3: River Road Land by Basin – Areas (acres)

Land Use	A	B	C	D	E	F	G	H	JOSO	Total Area (acres)
Low/medium density residential	0	0	0	0	0	0	0	0	0	0
High density residential	32.9	18.2	50.2	74.1	34.9	18.6	86.2	94.9	144.2	554.2
Commercial/industrial	17.8	35.2	30.9	29.9	9.2	3.9	21.4	28.7	58.8	235.8
Open space/park	2.7	0.1	4.7	18.1	0.0	0.0	1.3	43.6	2.3	72.8
Total	**53.4**	**53.5**	**85.8**	**122.1**	**44.1**	**22.4**	**108.9**	**167.2**	**205.4**	**862.8**

Table 6-4: River Road Land by Basin – Percentages (%)

Land Use	A	B	C	D	E	F	G	H	JOSO
Low/medium density residential	0%	0%	0%	0%	0%	0%	0%	0%	0%
High density residential	4%	2%	6%	9%	4%	2%	10%	11%	17%
Commercial/industrial	2%	4%	4%	3%	1%	0%	2%	3%	7%
Open space/park	0%	0%	1%	2%	0%	0%	0%	5%	0%
Total	**6%**	**6%**	**10%**	**14%**	**5%**	**3%**	**13%**	**19%**	**24%**

6.2.3 Impervious Cover

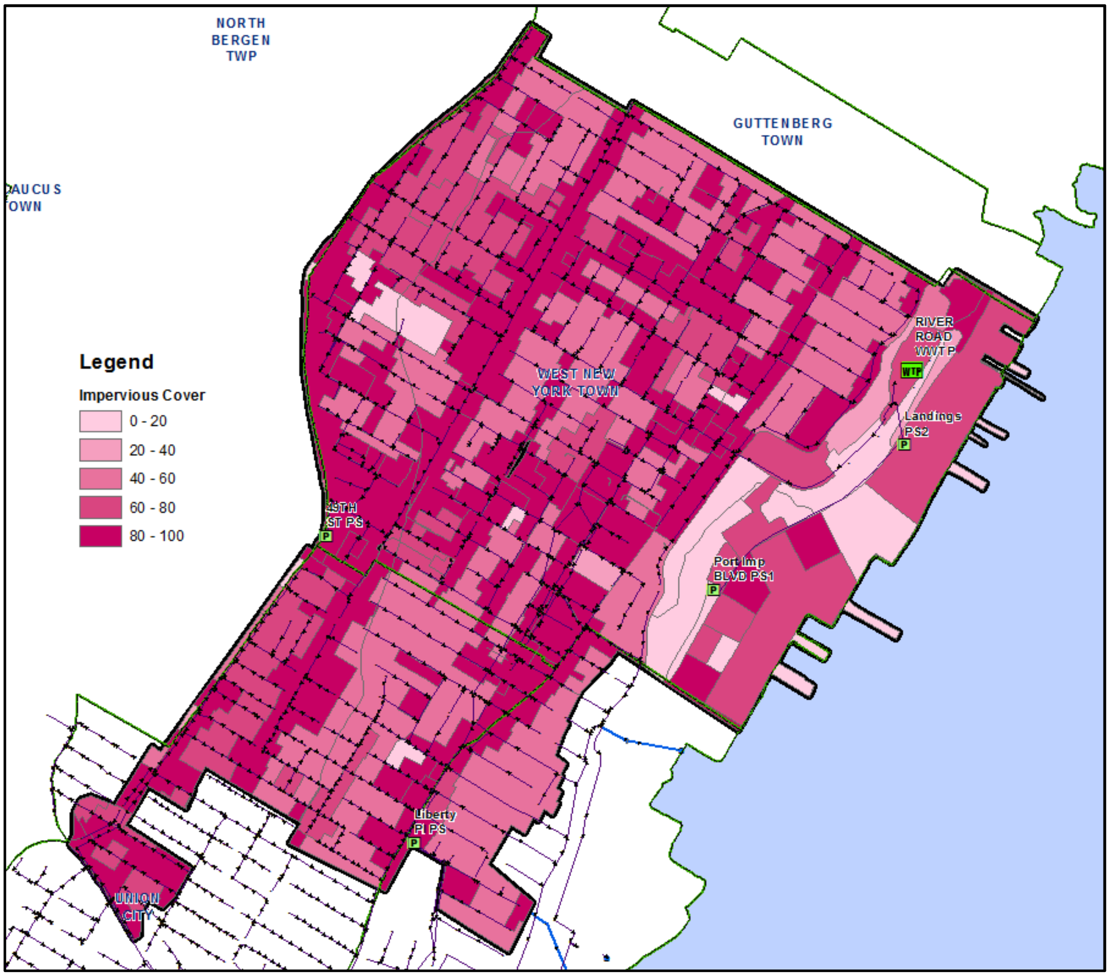
Statewide land use/land cover data is publicly available through the New Jersey Department of Environmental Protection (NJDEP), Bureau of GIS. The latest available data that was used for this study is dated 2012. This data divides all areas by unique land-cover-type polygons and captures the percent imperviousness of each polygon depending on the land-cover type.

The percent impervious attribute of each land-cover polygon in the NJDEP dataset was used to calculate the acreage of impervious and pervious land surfaces for each basin, see Table 6-5. Sewershed areas which are basins sub-divided into areas less than 5 acres, were also analyzed by land use, see Figure 6.7. The overall area is about 78% impervious.

Table 6-5: River Road Impervious Area

Basin	Percent Impervious
A	77%
B	86%
C	73%
D	77%
E	73%
F	69%
G	79%
H	81%
JOSO	78%
Overall	**78%**

Figure 6.7: Percent Impervious Cover in River Road WWTP Service Area



6.3 Population and Sewage Flows

All of West New York is within the service area of the River Road WWTP. The US Census indicates that the population of West New York was 49,708 as of April 2010. The population density was 49,363 persons/square mile with a land area of 1.01 square miles. The average household size is 2.64 persons.

A portion of Union City is within the service area of the River Road WWTP. The US Census indicates that the population of Union City was 66,455 as of April 2010. The population density was 51,797 persons/square mile with a land area of 1.28 square miles. The portion of Union City in the River Road WWTP service area is 0.26 square miles. The average household size is 2.88 persons.

A portion of Weehawken is within the service area of the River Road WWTP. The US Census indicates that the population of Weehawken was 12,554 as of April 2010. The area of Weehawken is 0.79 square miles and the portion of Weehawken in the River Road WWTP service area is 0.08 square miles. The average household size is 2.2 persons.

The population distribution within the service area was analyzed on a sewershed-level basis as part of the process of quantifying the dry weather flow through the system. Population data was obtained for each block in the study area from TIGER (Topologically Integrated Geographic Encoding and Referencing) line files from the US Census Bureau, based on 2010 Census data. Spatial analysis was performed on this data to develop a population estimate for each sewershed, as well as the area captured by each of the four meters (metersheds) described in Section 8. The percent increase in population of Hudson County of 6.89% from April 2010 to July 2016 as determined by the New Jersey Department of Labor and Workforce Development was applied to these populations to determine estimates for 2016. These populations were applied to the sewersheds in the model.

The population estimate for each metershed is shown in Table 6-6 below, with a total estimated population of about 73,000 in the service area.

Table 6-6: Total Estimated Service Population

Location	**Population**
West New York	13,116
Union City	8,710
Weehawken	51,191
Total	**73,017**

6.4 Significant Indirect Users

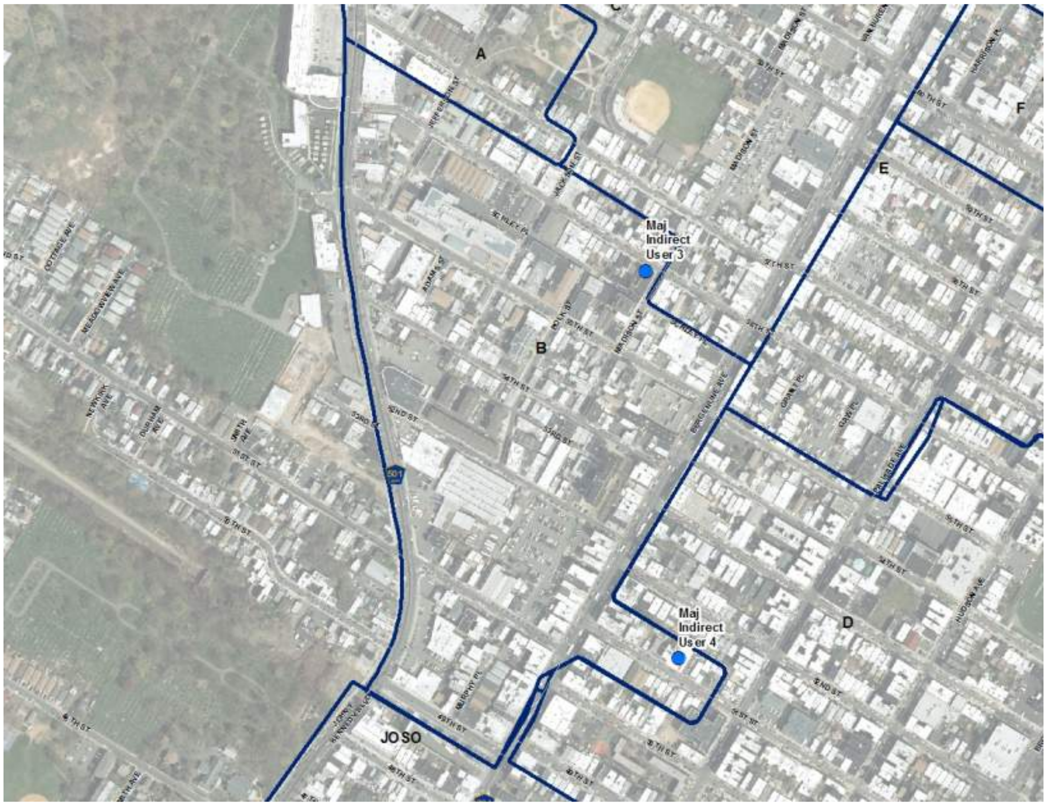
NJDEP has identified two significant indirect users (SIUs) within the River Road service area, both located in West New York in Basin B, see Figure 6.8.

The first is located at 420 51st Street, in a building operated by Prime Uniform Supply Incorporated (DEP Site ID WNYMUA005), which is a laundering company providing commercial linen, uniform rentals, and cleaning services. They have an air flotation pretreatment system, and they produce a quarterly analysis. Their average daily flow is 9,522 GPD (0.0095 MGD).

The second is located at 543 56th Street, in a building owned by Hill Cross Company (DEP Site ID NJ0145998), which is an electroplating company. They submit discharge monitoring reports to the NJDEP. Their average daily flow is 2,234 GPD (0.0022 MGD).

The wastewater flow from both of these users is directed to regulator WNY2 and then WNY1 further downstream, and they are tributary to the 001A/002A outfall. Given the small flows from the SIUs of approximately 0.01 MGD, no special analysis is required to allocate flow within the collection system model.

Figure 6.8: Locations of Major Indirect Users



Infiltration and Inflow Assessment

Flow through the sewer system was analyzed by basin, per capita consumption, average dry weather flow, and estimated infiltration and inflow. This section summarized this analysis.

7.1 Interpreting information from Condition Assessment

As shown in Figure 3.3 of this report, which depicts the results of the RedZone condition assessments, many of the sewers investigated in Weehawken and Union City were categorized as category 4 or 5 on the PACP rating scale, indicating that they are more susceptible to failure. This finding is consistent with the sewer metering results, in which the metered flow tended to be slightly higher than the initially modelled flow, demonstrating that there is likely some inflow/infiltration into the collection system as a result of leakage/damage. The degree of inflow/infiltration as a result of the condition of the collection system is further quantified in the following sections.

In addition, the greatest amount of pipes in poor condition were identified in metershed UC1, which is consistent with the analysis below which shows the greatest amount of groundwater infiltration per inch-mile of sewer relative to the other three metersheds.

7.2 Components of Combined Sewer Flow

Combined sewer flow is assumed to be made up of three components:

- Base Sanitary Flow (BSF) - Dry weather flow (DWF) component that is the residential, commercial, institutional, and industrial flow discharged to a sanitary sewer system. BSF normally varies with water use patterns within a service area throughout a 24-hour period with higher flows during the morning period and lower during the night (diurnal pattern). BSF typically represents the majority of the flows treated at wastewater treatment facilities. It is typically estimated based on population and land use.
- Groundwater infiltration (GWI) - DWF component that represents the infiltration of groundwater that enters the collection system through leaking pipes, pipe joints, and manhole walls. It follows a continuously gradually varying pattern that varies in response to changing seasons or antecedent moisture conditions and usually occurs when the groundwater level is above the sewer invert level. The trends higher in late winter and spring as groundwater levels and soil moisture levels rise, and subsides in late summer or after an extended dry period. It is assumed to be 90% of the observed minimum average night time flow, as per EPA guidance.

GWI and BSF together comprise the Dry Weather Flow (DWF) that occurs in a sanitary sewer system.

- Rainfall Derived Inflow and Infiltration (RDII) – Wet weather flow (WWF) that enters the collection system through pipe defects, laterals and other entry points

The flow monitoring data collected between May 17, 2016 and November 16, 2016 was disaggregated into these three components as the first step of the model calibration and validation process.

7.2.1 Identification of Dry Weather Days

To separate the DWF component of the flow from the total sewer flow, the dry weather days were identified; these are days with minimal rainfall input to the sewer system and as such, the data recorded by flow meters on these days will primarily reflect sanitary flow and groundwater infiltration inputs.

To facilitate the separation of baseflow and sanitary flow, the flow meter data was examined against the rain gage data to identify the dry weather days. For the purposes of this project, dry weather days were defined as:

- Minimum three (3) days of no rainfall following a day with rainfall more than 0.25 inches, OR,
- Minimum two (2) days of no rainfall following a day with rainfall less than 0.25 inches, AND,
- No rainfall on that day itself.

Days with less than 0.02” of rain were considered to as “no rainfall” for this purpose. Using this method, seventy-three (73) dry weather days were identified during the May 19 – November 14, 2016 flow monitoring period (184 days total). Of the 73 dry weather days, fifty-two (52) were weekdays while twenty (21) were weekend days.

Once the dry weather days were identified, the days were split into weekdays and weekends. This breakdown was based upon the fact that InfoWorksICM has the ability to use two (2) diurnal patterns to model sanitary flows. The assumption is that all weekdays exhibit the same flow patterns, as do all weekend days.

The days identified as dry vs. wet weather days are listed in Appendix C.

7.2.2 Dry Weather Flow Analysis

Once the two categories of data were verified, the metered flows for the dry weather days were combined by averaging corresponding time steps together throughout a full 24-hour day. Any data showing notable irregularities was classified as an outlier and not included in the average. These days were identified by visually inspecting the data and looking for days with missing data or data grossly different from the typical trends, for example during the Labor Day long weekend. Once this data cleaning process was completed, average DWF were established for the typical weekday and weekend for each flow meter.

The next step was to extract the groundwater infiltration (GI) component of the overall DWF. The infiltration component was extracted by assuming the groundwater infiltration was 90% of the observed average minimum night time flows. This is a widely used technique to extract groundwater infiltration from DWF, and is applicable to this primarily residential area.

The difference of the overall DWF and the GI yields the base sanitary flow (population input). Diurnal patterns for these flows were analyzed for weekday and weekends. The diurnal patterns are represented by hourly peak flow factors that were calculated by the ratio of the flow value for an individual time step to the average value of the entire day. Once all the hourly factors were calculated for all flow meters, these were input into InfoWorksICM model, along with the calculated average sanitary flows and GI, for dry weather flow generation.

Representative figures from the DWF analysis are shown below in Figure 7.1 through Figure 7.4, see Appendix D for graphs of all meters.

Figure 7.1: Weekday Dry Weather Flow Analysis (UC2)

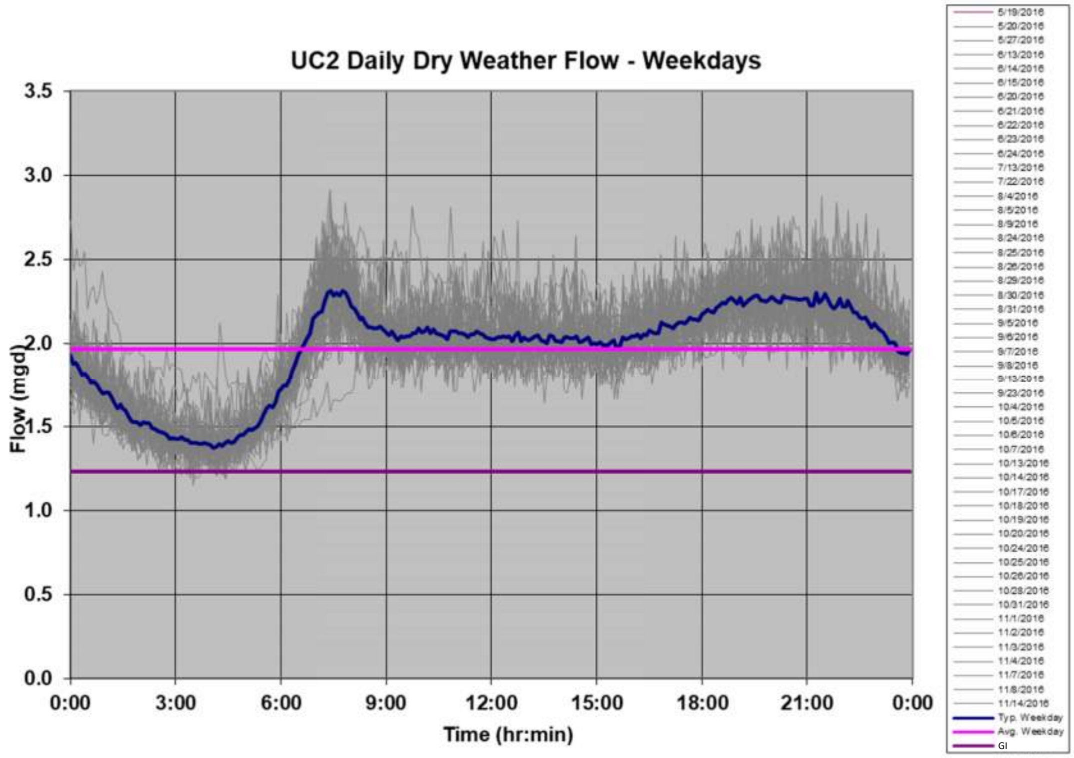


Figure 7.2: Weekend Dry Weather Flow Analysis (UC1)

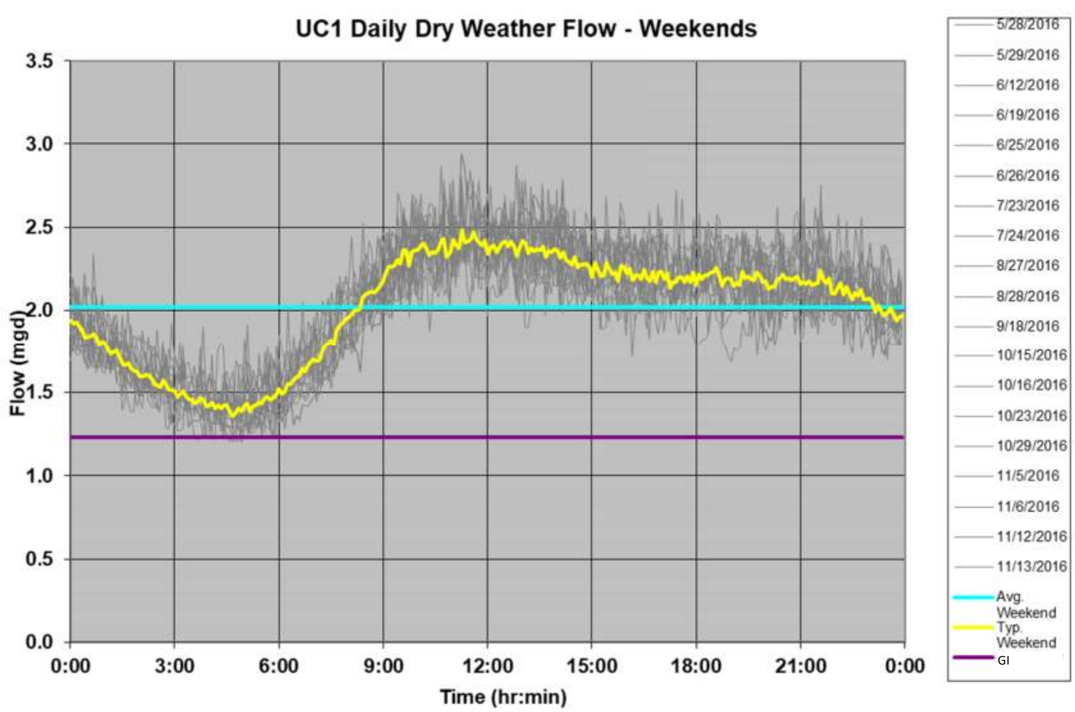


Figure 7.3: Dry Weather Flow Diurnal Peak Factors (UC1)

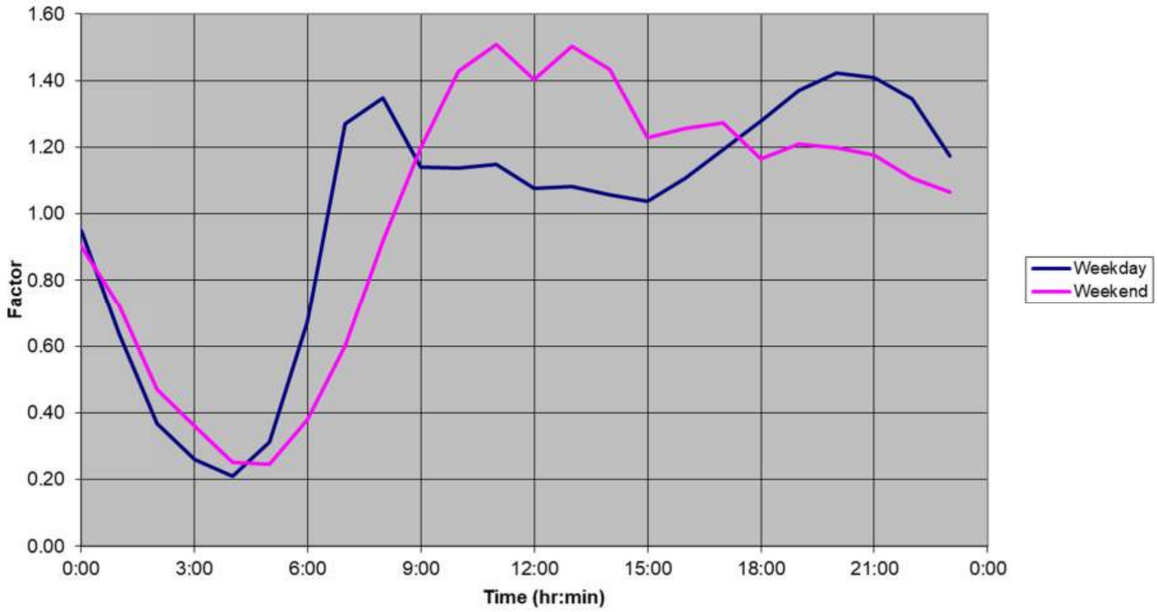
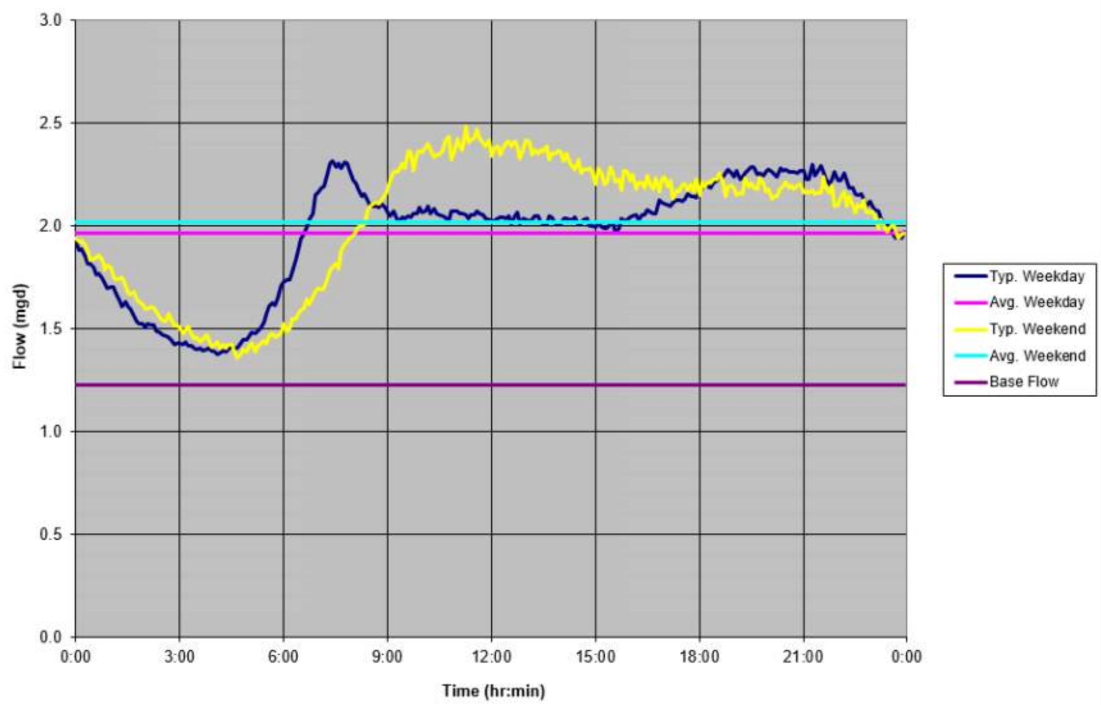


Figure 7.4: Dry Weather Flow Summary (UC1)



A general trend is that the peak flows on a weekday occur approximately before and after work/school hours and on weekends the peak flow occurs later in the day and extends for a longer period. In addition, the average flow is slightly higher on weekends than on weekdays, consistent with people spending more time at home on weekends.

After the volumes and flow patterns were been established for each meter, that information was applied throughout the collection system. In a highly residential area such as the River Road system, distributing the flow by population is appropriate. It is noted that only the River Road combined sewer system was metered and that the combined sewers are pumped directly to the WWTP for these areas.

7.2.3 Population Analysis and Per-Capita Sanitary Flows

As described in the earlier sections of this report, influent sewersheds to the four flow meters were delineated using available GIS and publicly available DEM data. The approach was to correlate the demographic characteristics in the service area to the corresponding flow meter data from which population based flow estimates (sanitary flows, gallons/capita/day) can be estimated.

Population data from the US Census Bureau was used in this study. Census block level population data is publicly available from the US Census Bureau's American Fact Finder web platform. The population count is available for download in table format, while the census blocks are available in GIS format. These two datasets were used to create a GIS spatial layer of the census blocks with total population count in each block. This GIS dataset was compared with the delineated metersheds to calculate total population at each metershed.

Once the population count by metersheds were available, this data was correlated with the flow meter data. Previously, as part of the flow meter data analysis, the sanitary component of the overall DWF was extracted (in Million Gallons/day) from the recorded meter data. This value, divided by the metershed population, provides an estimate of the sanitary flow rates at each metershed level in gallons per capita per day (GPCD). Wastewater profiles were created in the collection system model for each of the four unique metersheds. Each such wastewater profile had the GPCD flow estimate as the average sanitary flow, coupled with the diurnal peak factors for weekday and weekends calculated earlier.

The population analysis was re-run with the 232 individual sewersheds, representing the metersheds further delineated into drainage areas less than 5 acres. Each sewershed was assigned a wastewater profile corresponding to the metershed they fall under. With this, each sewershed generates sanitary flows utilizing the sewershed population and the GPCD estimates from meter data. This is shown in Table 7-1 below. It is noted that UC1 flows into UC2, which flows into WNY2, which flows into WNY1. As such, upstream metersheds contribute to the downstream metersheds. To account for this, the upstream flow contributions were subtracted from the downstream meters.

Table 7-1: GPCD Summary

Location	**Original BSF (MGD)**	**Revised BSF (subtracting upstream flows) (MGD)**	**Population**	**GPCD**
UC1	0.76	0.76	10,886	70
UC2	1.05	0.29	8,522	34
WNY2	1.57	0.52	10,395	50
WNY1	3.08	1.50	37,974	40

7.2.4 Inch-Mile Analysis for Groundwater Infiltration (GWI)

Groundwater infiltration into the sewer system can be estimated by performing an Inch Diameter Mile Length (IDM) analysis. Using spatial analysis in GIS, the length of sewer in each sewershed and metershed was calculated. This was multiplied by the sewer diameters to obtain a sum of inch-miles of sewer, which was representative of the infiltration potential within that area.

The calculated sanitary flows and groundwater infiltration for the meters are shown in Table 7-2.

Table 7-2: Summary of Sanitary and Groundwater Inflows for Metersheds

Meter #	GWI (MGD)	Revised GWI (subtracting upstream flows) (MGD)	In-Miles	GWI Baseflow/In-Mile (MGD)
UC1	1.23	1.23	126.293	0.010
UC2	1.28	0.05	90.679	0.001
WNY2	1.80	0.52	127.708	0.004
WNY1	3.27	1.47	295.072	0.005

The GWI for the UC1 area is much higher than the other areas. This is consistent with the sewer system condition assessment results from RedZone which indicated that the sewers in UC1 are in poor condition.

Hydraulic Collection System Modeling

The Authority developed a hydraulic model of the River Road WWTP service area using existing the GIS database submitted to the NJDEP in 2015. The GIS data is based on field collected data on sewer lengths, elevations, size, material and connectivity. The model calibration and validation process are describing in the following sections.

8.1 Collection System Model

The goal of the modeling process was to create a model that would accurately reflect the combined sewer system's dry and wet weather flow generation and response to conveying flow, and that would provide a basis for evaluating future system improvements and modifications. To understand the existing operation of the combined sewer system and the impacts of future projects, a computer model of the Authority's combined sewer system was developed to serve as a tool to evaluate the "baseline" conditions in the network. The model is intended to be used in the baseline and alternatives evaluation of the typical year. As such the calibration was focused on the rainfall similar to those occurring in the typical year i.e. the model was not calibrated around high-return period storms.

8.1.1 Model Development

The hydraulic model was constructed using the Innovyze Infoworks® ICM computer program, which is a distributed and dynamic rainfall-runoff simulation model that can be used for single event or long-term (continuous) simulation of runoff quantity and quality. It is capable of simulating 1D flow in conveyance links, 2D overland flows and runoff flows in drainage systems, components of which can be represented by using a combination of nodes, links, mesh elements, weirs, orifices etc. available in the program. InfoWorksICM provides the capability to simulate backwater effects, flow reversals, surcharging, looped connections, pressure flows, tidal outfalls, and interconnected ponds by using the full dynamic wave (hydrodynamic) flow routing option. The dynamic wave algorithms solve the one-dimensional unsteady state St. Venant's continuity and momentum equations to produce theoretically accurate results for a drainage scenario. InfoWorksICM is widely used in major combined and separate system modelling throughout the world. The software is capable of loading all physical inputs from a GIS based platform such as a geodatabase or shapefile.

Three types of flow inputs are necessary for combined sewer models, namely, sanitary, storm, and groundwater flows. The components of sewer flow were discussed in further detail in Section 7. Sanitary flows were calculated based on population. Groundwater flows are based on the inch-mile analysis of the network.

Storm flow was applied to the network via subcatchments which are characterized based on land surface, pervious vs. impervious area, which impacts the amount of runoff from the subcatchment than enters the sewer system. Pervious surfaces are considered to infiltrate a portion of the rainfall based on empirical equations (e.g. Horton Equation). The basic premise of such equations is that the portion of the rainfall infiltrated can be estimated based on the characteristics of the underlying soil. Rainfall will continue to infiltrate as long as the intensity of rain is less than the soil absorption capacity. More intense and/or prolonged rainfalls will produce surface runoff which will enter the downstream collection system. Impervious surfaces (e.g. buildings, paved roads) in an urban environment such as the River Road service area are considered as Directly Connected Impervious Areas (DCIA) have only a small amount of initial losses from depression storage, and as a result a major portion of the rainfall will become runoff.

The physical inputs of to the InfoWorksICM model were based on the GIS data that was gathered previously and updated by survey and physical inspection using closed circuit television (CCTV). The GIS data was processed to define connections between sewers and adjacent manholes to form a complete network, and to define pipe sizing in inches, prior to exporting to the model software. Pipe profiles throughout the system were checked in the model to ensure no anomalies or missing information. In addition to filling in missing data, the model was checked to identify any anomalies such as locations of negative slopes, orphan pipes, inconsistent pipe sizes, and inconsistent inverts. Any changes made in the model were flagged with data field flags.

The model's flow inputs were based upon data gathered from the land use and population analysis described in previous sections. Flow data from the meters that were installed at the regulators were used for calibration and verification of the dry weather flow (DWF) and wet weather flow (WWF) estimations from the model.

8.1.2 Model Geometry

The model geometry is made up of pipes, manholes, structures, regulators, pump stations etc. that regulate and/or impact flows in a sewer system. The Authority's GIS dataset of the combined sewer network was obtained from the Authority in June 2017 and was imported into InfoWorksICM for model development. InfoWorksICM has a GIS interface to import/export GIS data to aid in rapid model construction. The manholes and inlets were coded as node objects, while the pipes were coded as links that connect multiple nodes.

The majority of structure and pipe geometry data (size, material, inverts etc.) was available in GIS, however there were instances when certain geometry data could not be obtained due to lack of information in GIS and absence of as-built drawings or survey information. Under such circumstances, the geometry data was inferred based on known data, surveys were conducted to obtain information, or as a last option, assumptions were made. InfoWorksICM can infer (interpolate) missing pipe inverts based on upstream and downstream known inverts, connecting pipe slopes, or known inverts at a connecting structure with multiple pipe connections. This is a reasonable approach, because the pipes are expected to have positive slope downstream. The missing information can be filled in with reasonable assumptions made based on known data. As-built drawings were referenced and field visits were completed to further increase the accuracy of the representation of the system. Some pipes in the system, which may have previously been coded "0" or "-99" in GIS and then re-labeled as "null", were tagged as having inverts about 100 feet above ground level. As such, an inference was designed in the model to interpolate these pipe inverts. Data field flags were used to identify where pipe elevation data was interpolated or if any changes or assumptions based on sound judgement were made that differed from what was in the original GIS.

Once the initial model geometry was determined, the project team met with operations staff from the Authority on January 31, 2018 to discuss the model and clarify any operational requirements as well as assumptions that were made to ensure that the model provides an accurate representation of the system. Operations staff indicated that UC1, UC2, WNY2 are all static regulators and are not adjustable, while regulator WNY1 has a float operated regulator mechanism to limit flows to 18 MGD. The operation of the gate was represented in the model as a customized hydraulic structure. Operations staff indicated that there is no chronic flooding in this drainage basin due to elevations, and that there is a JOSO drop structure located at the end of Liberty Street. They confirmed that flow from the Port Imperial pumping station is conveyed directly to the plant. This information was incorporated into the model.

8.1.2.1 Pipe Roughness

Hydraulic roughness, which is represented by the Manning's roughness coefficient ("n"), accounts for the effect on the resistance to flow of pipe materials, irregularities, debris, and other obstructions. Flow through pipes can incur a higher headloss depending on the roughness. As such, it is important to capture the roughness accurately in a system to properly identify the flow patterns.

Pipe roughness was assigned to links in the model based on pipe materials identified during the GIS dataset development, as shown in Table 8-1 below.

Table 8-1 Summary of Manning's Roughness Coefficients Used in Model

Pipe/ Lining Material	**Label**	**Manning's N used in Model**	**Source of Manning's N**
Clay/ Terracotta Pipe	VCP	0.014	NJDOT Drainage Design Manual
Brick Pipe	BRK	0.015	NJDOT Drainage Design Manual, VT chow
Reinforced Concrete Pipe	RCP	0.012	NJDOT Drainage Design Manual
Concrete Lining	CONC	0.012	VT Chow
Cured-in-Place Pipe	CIP	0.012	Same as RCP and Concrete Pipe
Ductile Iron Pipe	DIP	0.013	http://www.concretepipe.org/wp-content/uploads/2014/09/DD_10.pdf

As noted in Section 3, pipe materials were mainly unknown in West New York. Because the majority of the surrounding sewers in Union City and Weehawken are known to be VCP, it was assumed that the sewers in West New York are also made of VCP and the Manning's number was assigned to these pipes accordingly in the model.

8.1.2.2 Subcatchments

Publicly available Digital Elevation Model (DEM) data from US Geological Survey National Elevation Dataset as well as the GIS dataset representing the pipe network was analyzed to divide the study area into sewersheds having drainage areas of typically five acres or less.

232 sewersheds were delineated within the River Road drainage area, having areas of less than 5 acres each. The goal of this was to strategically divide the area into smaller sewersheds so that the model could be used to evaluate hydraulic characteristics of smaller areas efficiently. A figure depicting the delineation of the 232 sewersheds is provided in Figure 8.1.

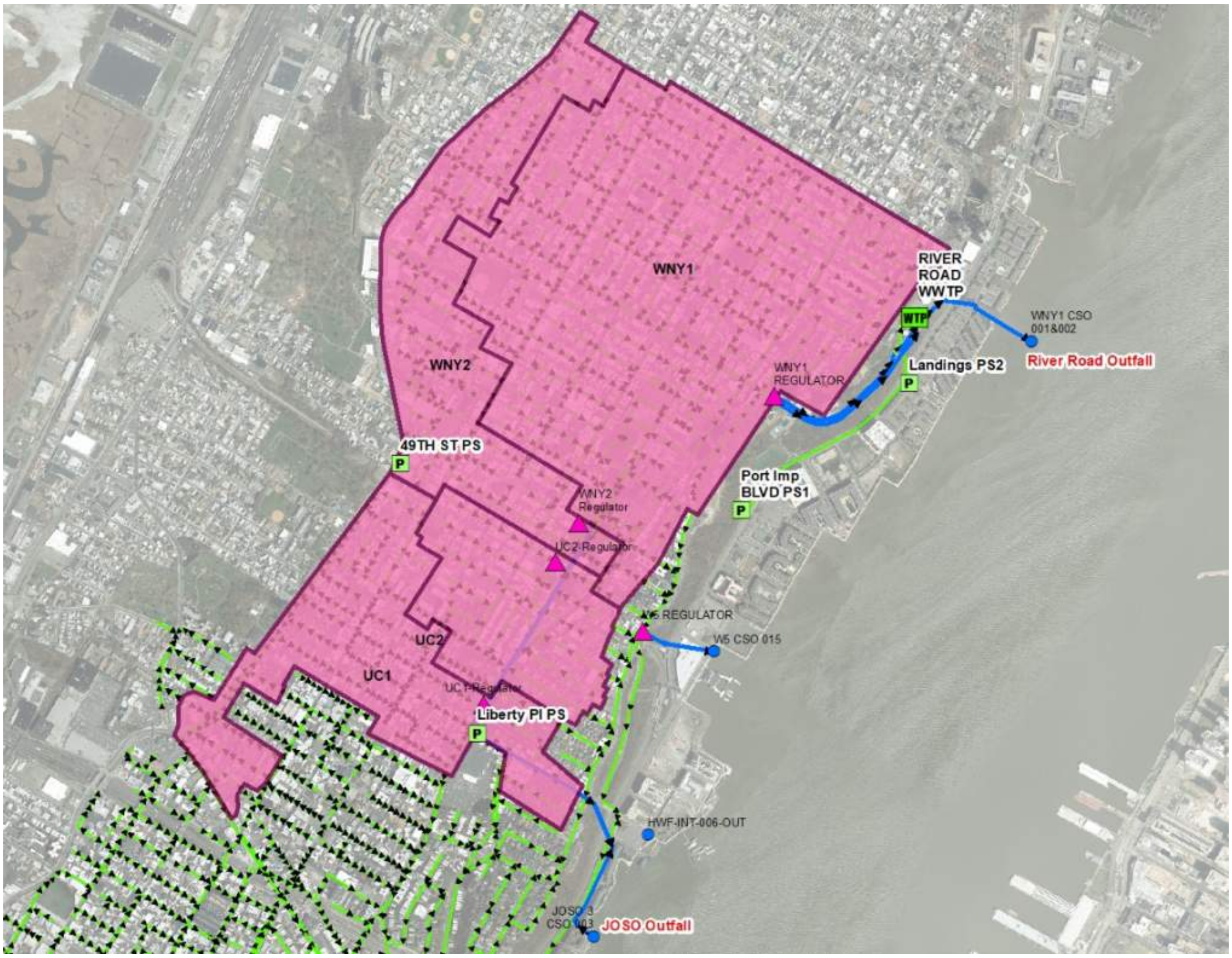
Figure 8.1 Sewersheds Delineation

The large subcatchment located immediately south of the River Road WWTP represents the separately sewered area at the base of the Palisades. This area is connected directly to the plant node in the model, thus does not impact the flow through the regulators or CSO flow estimations.

The sewersheds were parameterized with the population, land cover and baseflow information that was determined in previous sections. Slopes of the sewersheds range primarily from 0% to 6%, with a couple of steeply sloped sewersheds (12.5% and 39.3%) at the northwest end of the service area where there are steep drops in elevation.

Figure 8.2 representing the drainage areas to the four meters is presented below:

Figure 8.2 River Road Metersheds



8.1.2.3 Pumping Stations

Only the Liberty Street pumping station is represented in the model. The Port Imperial pumping station and Landings pumping station convey combined sewer flow from the homes at the base of the Palisades up to the WWTP. This flow is conveyed directly to the WWTP, so was not represented in the model as it has no impact on the occurrence of CSO events. There was no information on the pump curves at the 49th Street Pump Station and because it services only a few commercial buildings, it was not included in the model.

8.1.2.4 Regulators

Hydraulic flow control structures, such as regulators divide the incoming flow based on the elevation of the hydraulic grade line at the upstream side of the structure. For a combined sewer system, accurate depiction of such structures is important since the hydraulic model computes system overflows based on the flow hydraulics at these structures.

The River Road regulators consist of side flow weirs and a short segment of reduced pipe size. Refer to the regulator sketches in Section 3. As the level of the incoming flow increases inside the structure, when the water level exceeds the top (crest) of the weir, a portion of the flow is diverted to an outfall.

For the purposes of hydraulic modeling, flow regulators were modeled using weir links to capture the flow split in the system. Under dry weather flow conditions, the incoming flow passes through the regulator and the overflow line is dry. Under wet weather flow conditions, when the hydraulic grade line inside the structure is higher than the crest of the weir, a portion of the flow overtops the weir and continues to flow through the overflow line. All four regulators are included in the model and the modelled discharge coefficients are presented below:

Table 8-2 Regulator Characteristics in Model

Regulator	Discharge Coefficient
UC1	0.50
UC2	0.53
WNY2	0.53
WNY1	0.80

It is noted that elevations of the outfall pipes were inferred in the model based on known elevations, however this would not have any hydraulic impact because of the steep drop in ground elevation of the land between the regulators and the outfall elevations. Because of the steep drop in elevation, tidal impacts on the outfalls were not considered in this study.

8.2 Rainfall Data Analysis

Precipitation is one of the model forcing functions in a rainfall-runoff simulation. Stormwater runoff generated and entering the sewer system is directly dependent on the amount of precipitation and its intensity, both of which may vary spatially for a large storm system. Even for small sewersheds, runoff generation and consequent model predictions may be very sensitive to spatial variations of the rainfall. For instance, thunderstorms (convective rainfall) may be highly localized, and nearby rain gages may have very dissimilar readings. While rainfall may be spatially variable over any area, given the study area size of 1.4 square miles the use of a single gauge was considered appropriate.

The total sewershed area that contributes flows into the River Road combined sewer system is approximately 900 acres (1.4 square miles). Table 8-3 below summarizes the start and end times, depth, duration and maximum 1-hr and 15-min rainfall intensity of the rainfall events measured by the rain gauge over the monitoring period of May 17, 2016 to November 16, 2016.

The rain gauge was not working for a period of time in October 2016, thus the three storms that took place during this time are not shown below.

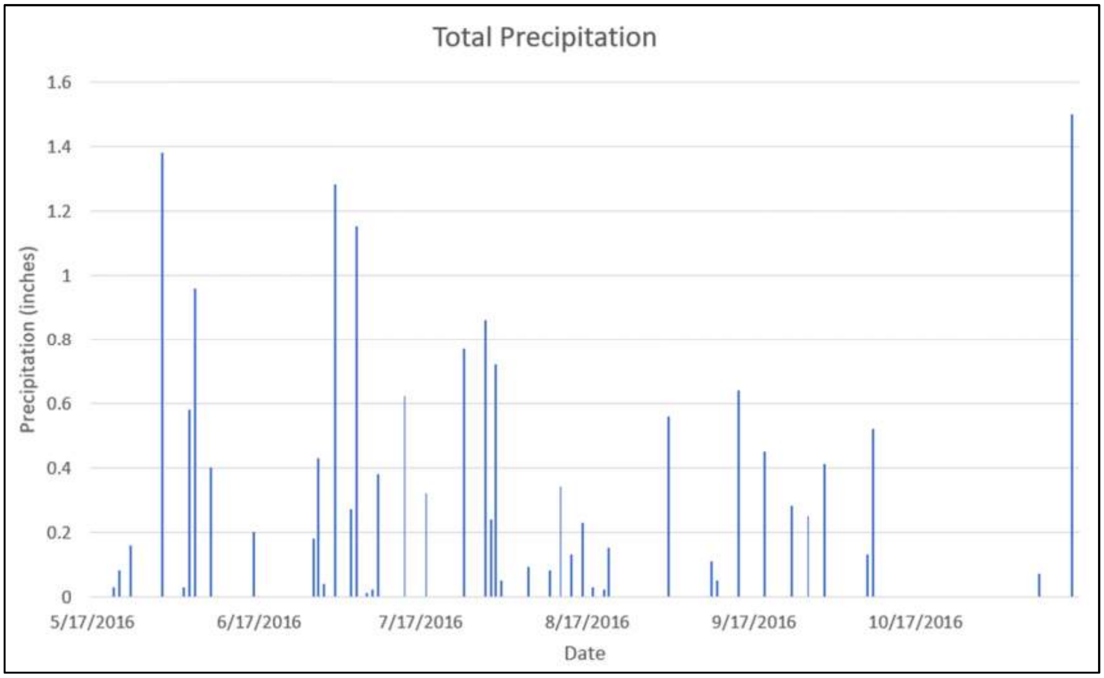
Table 8-3 Start and End Times of Rainfall Events and Calculated Intensities

Storm #	START DATE	END DATE	START TIME	END TIME	RAINFALL DEPTH (IN)	RAINFALL DURATION (HRS)	AVG. 1-HR INTENSITY (IN/HR)	MAX 1-HR INTENSITY (IN/HR)	MAX 15-MIN INTENSITY (IN/HR)
1	5/21/2016	5/22/2016	19:30	6:20	0.11	10.83	0.01	0.05	0.12
2	5/24/2016	5/24/2016	2:40	9:20	0.16	6.67	0.02	0.05	0.12
3	5/30/2016	5/30/2016	1:20	10:40	1.38	9.33	0.15	0.86	2.32
4	6/3/2016	6/3/2016	8:40	9:00	0.03	0.33	0.09	0.03	0.08
5	6/4/2016	6/5/2016	19:10	20:05	1.54	24.92	0.06	0.49	1.48
6	6/8/2016	6/8/2016	12:55	16:25	0.40	3.50	0.11	0.28	0.44
7	6/16/2016	6/16/2016	4:25	8:10	0.20	3.75	0.05	0.17	0.44
8	6/27/2016	6/29/2016	21:35	1:10	0.65	27.58	0.02	0.32	0.80

Storm #	START DATE	END DATE	START TIME	END TIME	RAINFALL DEPTH (IN)	RAINFALL DURATION (HRS)	AVG. 1-HR INTENSITY (IN/HR)	MAX 1-HR INTENSITY (IN/HR)	MAX 15-MIN INTENSITY (IN/HR)
9	7/1/2016	7/1/2016	15:45	22:20	1.28	6.58	0.19	0.87	2.52
10	7/4/2016	7/5/2016	20:45	5:35	1.42	8.83	0.16	0.81	2.16
11	7/9/2016	7/9/2016	22:20	23:30	0.38	1.17	0.33	0.37	1.12
12	7/14/2016	7/14/2016	16:05	16:30	0.62	0.42	1.49	0.62	2.12
13	7/18/2016	7/18/2016	16:45	17:35	0.32	0.83	0.38	0.32	0.96
14	7/25/2016	7/25/2016	16:10	20:10	0.77	4.00	0.19	0.49	1.04
15	7/29/2016	7/29/2016	1:15	9:20	0.86	8.08	0.11	0.34	0.56
16	7/30/2016	7/30/2016	15:45	21:35	0.24	5.83	0.04	0.11	0.24
17	7/31/2016	8/1/2016	8:35	0:50	0.77	16.25	0.05	0.49	1.48
18	8/6/2016	8/6/2016	16:30	16:35	0.09	0.08	1.08	0.09	0.36
19	8/10/2016	8/10/2016	12:50	13:15	0.08	0.42	0.19	0.08	0.24
20	8/12/2016	8/12/2016	0:15	19:05	0.34	18.83	0.02	0.29	0.76
21	8/14/2016	8/14/2016	19:25	19:35	0.13	0.17	0.78	0.13	0.52
22	8/16/2016	8/16/2016	16:25	20:55	0.23	4.50	0.05	0.17	0.64
23	8/18/2016	8/18/2016	4:45	5:20	0.03	0.58	0.05	0.03	0.08
24	8/21/2016	8/21/2016	4:50	21:40	0.15	16.83	0.01	0.07	0.24
25	9/1/2016	9/1/2016	1:15	15:25	0.56	14.17	0.04	0.34	1.04
26	9/9/2016	9/10/2016	21:55	23:30	0.16	25.58	0.01	0.10	0.40
27	9/14/2016	9/14/2016	10:10	18:20	0.64	8.17	0.08	0.62	2.28
28	9/19/2016	9/19/2016	6:25	15:20	0.45	8.92	0.05	0.21	0.32
29	9/24/2016	9/24/2016	0:50	5:20	0.28	4.50	0.06	0.24	0.40
30	9/27/2016	9/27/2016	2:20	10:45	0.25	8.42	0.03	0.19	0.40
31	9/30/2016	9/30/2016	10:05	23:00	0.41	12.92	0.03	0.10	0.16
32	10/8/2016	10/9/2016	14:20	12:50	0.65	22.50	0.03	0.17	0.28
33	11/9/2016	11/9/2016	11:30	19:00	0.07	7.50	0.01	0.04	0.08
34	11/15/2016	11/15/2016	4:05	16:50	1.50	12.75	0.12	0.39	0.68

Figure 8.3 below shows the precipitation totals for each day during the monitoring period.

Figure 8.3: Daily Precipitation Totals (inches)



Based on experience with local rainfall patterns and definitions in the QAPP, rainfall events with a broad distribution of total rainfall volume and peak 15 min intensities were used for calibration. A preference was applied towards larger events that would allow the model to be calibrated most accurately around events similar to the 5th largest storms event. Events were selected for calibration based on:

- Depth
  - Low <0.50 inches
  - Medium 0.50-1.50 inches
  - High >1.50 inches
- 15 min intensity
  - Low intensity <0.25 in/hr
  - Medium Intensity 0.25>0.5 in/hr
  - High intensity >0.50 in/hr

The following storms were selected for calibration and validation:

- May 30, 2016 high volume (1.38 inches) high intensity (2.32 in)
- September 19, 2016 low volume (0.45 inches) low intensity (0.21 in/hr)
- September 24, 2016 low volume (0.28 inches) medium intensity (0.40 in/hr)
- November 15, 2016 high volume (1.50 inches) medium intensity (0.39 in/hr)

Similarly, storms were selected for validation:

- July 1, 2016 high volume (1.28 inches) high intensity (2.52 inches)
- September 14, 2016 medium volume (0.64 inches) high intensity (2.28 in/hr)
- October 8, 2016 medium volume (0.65 inches) medium intensity (0.28 in/hr)

8.3 Model Calibration

The usefulness of a computer model representation of a sewer system is dependent upon how well the model can simulate the real-world performance of the combined sewer system. To formulate a model that closely matches measured values, a process of calibration and validation was performed to refine the model input parameters to best match the flow meter data collected in the field. The first step, which has been described in the previous sections was to provide the model with the most accurate input data available. Calibrating a sewer collection system model consists of changing various characteristics of the sewer conveyance network and sewersheds in the hydraulic model to achieve close agreement between calculated and observed flows, depths and velocities based on the monitoring data collected during the monitoring program. It is also critical that the model accurately reproduce the flow monitoring data collected at the regulators. The calibration process typically takes multiple time periods from the flow monitoring data and refines the model input parameters to achieve a good fit with the measured data across a wide variety of system conditions (i.e. wet weather calibration will typically involve selecting storms of different intensity and durations).

Calibration was performed in two stages. The first stage was completion of dry weather flow (DWF) calibration to ensure the hydraulics of the model operate similar to the actual sewer system under typical dry weather (sunny day) conditions. Only minor model adjustments were needed for the hydrologic and hydraulic model to accurately reproduce the DWFs since the DWF inputs were directly calculated from the flow meter data and known population statistics. After successfully completing DWF calibration, the model was evaluated under wet weather conditions as the second stage. Wet weather calibration ensure the hydraulic model accurately mimics the sewer system's response to rainfall. Since the hydrologic factors that affect wet weather flow generation are more complex, more user adjustment of variables to achieve an acceptable agreement between the model predicted output and the observed flow meter data was needed. The overall goal of the model calibration process was to adjust the internal parameters so that the model calculations of flow, velocity, and depth match the observed flow monitoring data collected from the observed rain events. The River Road model was calibrated using a continuous simulation that covered a range of conditions.

Different monitored rainfall periods were utilized for the calibration to ensure the model could represent a range of varying rainfall conditions. In addition, the model was run continuously over the calibration period and compared against the collected flow monitoring data. This calibration method was devised to provide a hydraulic model that is accurate in long-term continuous simulations for watershed and long-term control planning.

After the model was successfully calibrated under dry weather and wet weather conditions, it was verified under conditions not used during model calibration. This verification process confirmed the expected performance of the model under rainfall conditions separate and distinct from the data used for calibration. It is important to verify the model under a wide range of possible dry weather and wet weather conditions to ensure model calculation confidence under a broad range of rainfall and seasonal conditions. The storms used to verify the model are storms not used during calibration.

8.3.1 Dry Weather Flow Calibration

Succesful calibration was based upon matching the dry weather period as described earlier. Statistical criteria shown in Table 8-3 below, based on the industry standard Chartered Institution of Water and Environmental Management (CIWEM) Code of Practice for the Hydraulic Modelling of Urban Drainage Systems, Version 01, November 2017. CIWEM is the successor document to the WAPUG criteria typically applied to collection system network modeling. These standards were applied to give a numerical evaluation of each flow meter used for model calibration and verification. In addition, some "common sense" checks like no overflows during dry weather days were also employed during this process. Table 8-4 summarizes the CIWEM criteria for DWF calibration.

Table 8-4 CIWEM DWF Calibration and Validation Criteria

Criteria	Calibration Range	Notes
Peak Flow Rate	±10% or 0.1MGD	Use of actual value instead of percentage applied to meters with very small flows
Volume	±10% or 0.1MGD	Use of actual value instead of percentage applied to meters with very small flows
Timing of Peaks	±1 Hour	For both peaks (high flows) and troughs (low flows)
Depth	0.33 feet to +0.33 feet of observed peak depth	
Shape	The shape of the measured and simulated curves should be similar for flow and depth	

8.3.2 Depth Calibration

Initially, there was a discrepancy between the metered and modeled flow depth in spite of good agreement between the flows. The metered scattergraph was reviewed and it was determined that the flow velocity would drop to zero before the depth reached zero, as shown in Figure 8.4 through Figure 8.6. There are several potential causes for this, both of which relate to a downstream obstruction, either in the form of an adversely sloped pipe or sediment. Portions of the interceptor blocked by sediment were simulated in the to the modeled pipe profiles to replicate this effect.

Figure 8.4 UC1 Depth Versus Velocity Plot

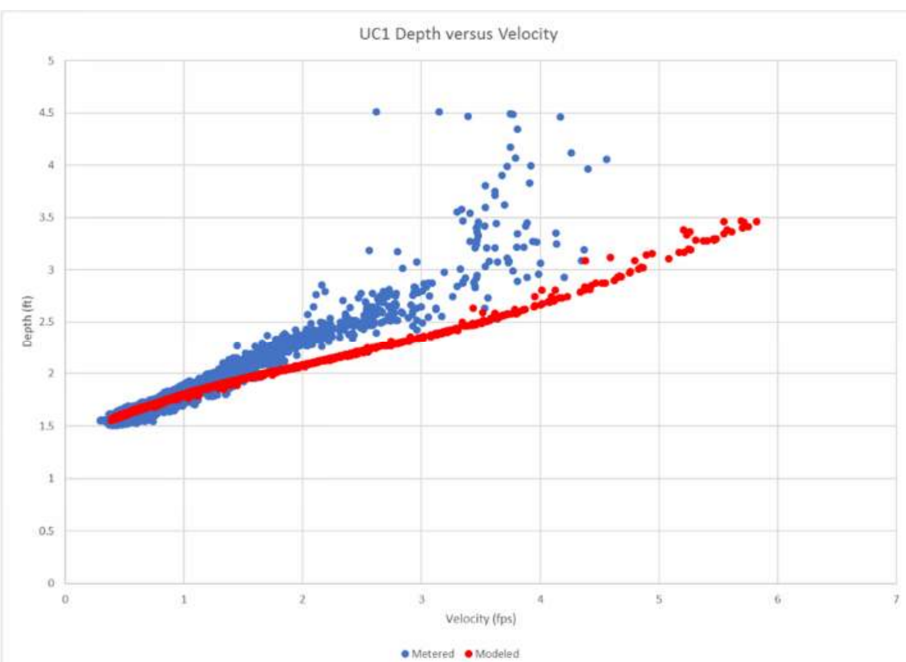


Figure 8.5 UC2 Depth Versus Velocity Plot

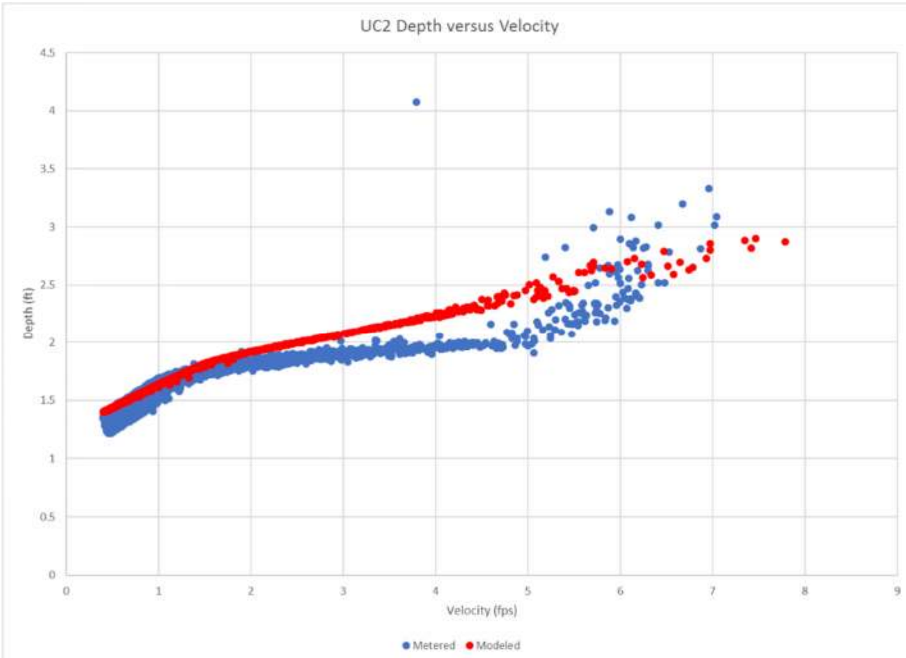
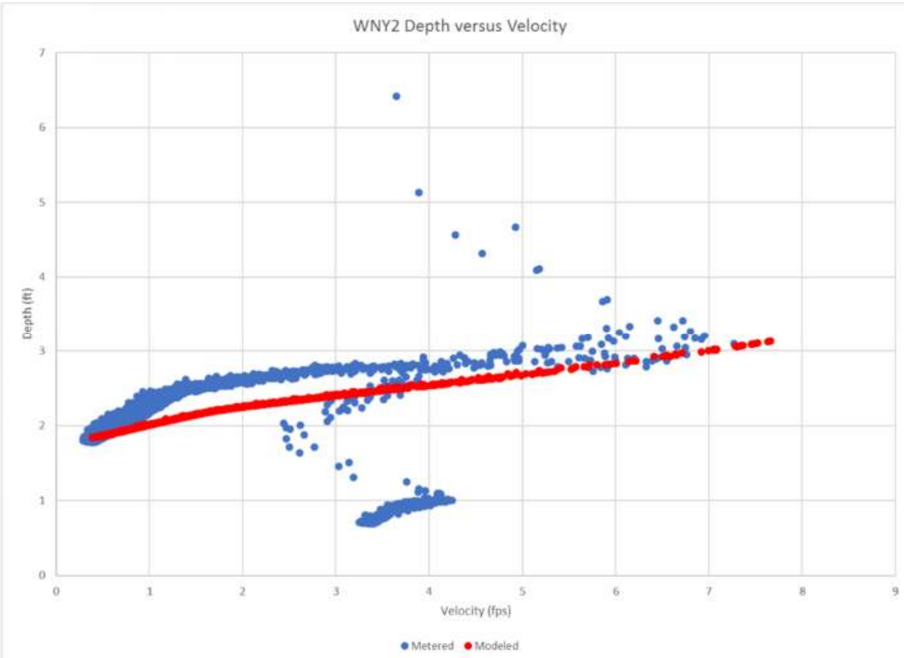


Figure 8.6 WNY2 Depth Versus Velocity Plot



8.3.3 Dry Weather Flow Calibration Results

The following figures are examples of measured vs. calculated flows for DWF calibration. The blue line represents the measured (metered) flow hydrograph, and the red line represents the calculated (modeled) hydrograph. The goal of calibration is to make the calculated hydrograph match the measured hydrograph as closely as possible, by varying model input parameters that impact flow generation. As can be seen from the figure, the model was able to closely match the peaks and troughs of DWF, and also accurately capture their timings and the general shape of the DWF hydrograph. Overall, the dry weather flow results from the model compared favorably with those from the flow meter data. The overall calibration statistics are provided in Table 8-5. Below are examples of the modeled versus measured results for UC1 and WNY1 for the period of June 19 through June 26, this period encompasses both weekdays (6/20-6/24) and weekends (6/19, 6/25, 6/26). As can be seen there is good agreement between both flow rates, depth and flow patterns. Occasionally the model fails to capture the peak flow within the CIWEM prescribed 10%, however likely this is due to meter noise. The results of this period are summarized in Figure 8.7 through Figure 8.10 and in Table 8-5. Comparison graphs and charts of dry weather flow calibration for all flow meters are provided in the appendices of this report.

Figure 8.7: Comparison of Measured vs. Simulated Dry Weather Flows (UC1)

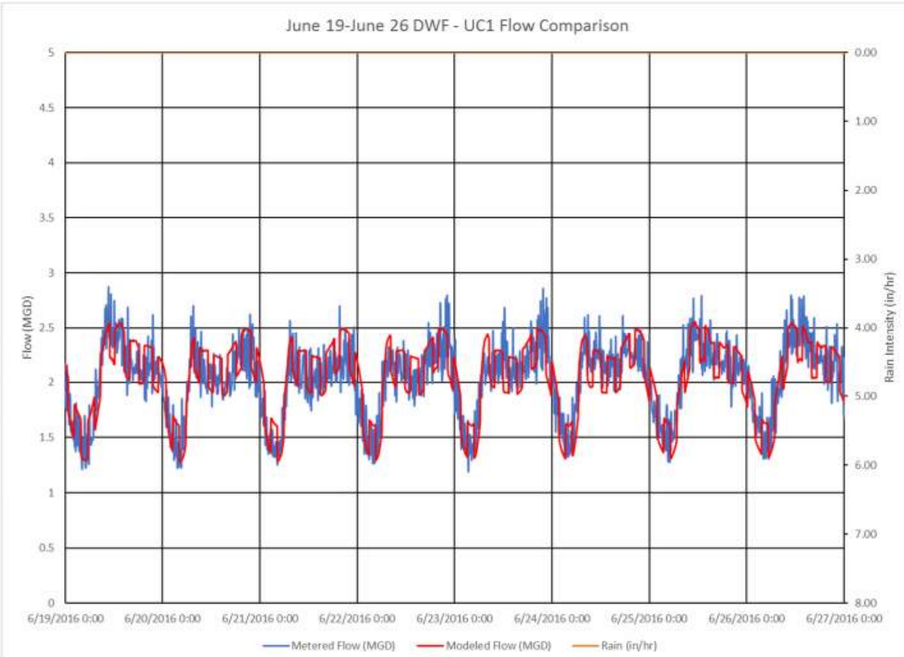


Figure 8.8 Comparison of Measured vs. Simulated Dry Weather Flow Depths (UC1)

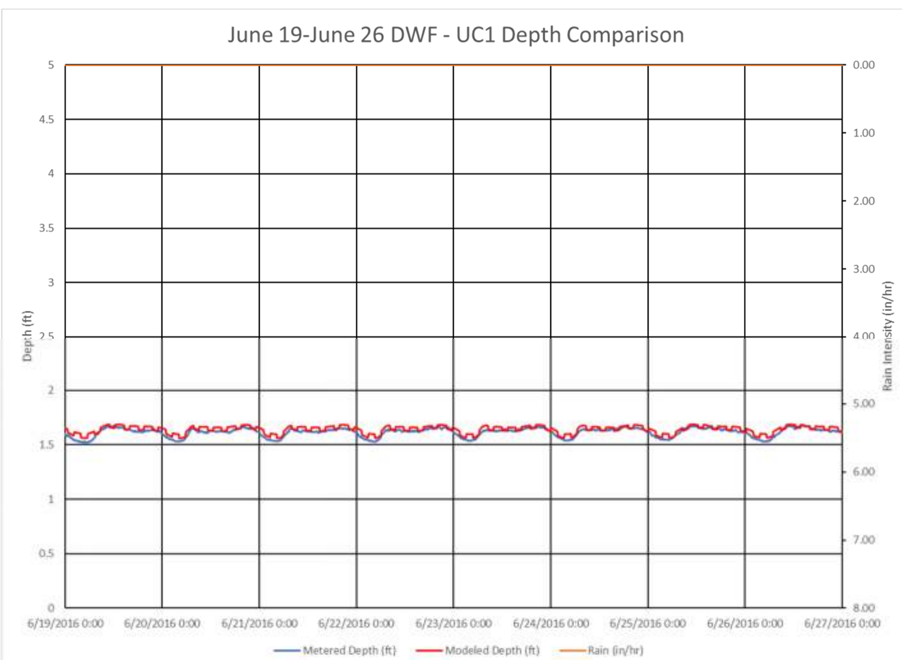


Figure 8.9 Comparison of Measured vs. Simulated Dry Weather Flows (WNY1)

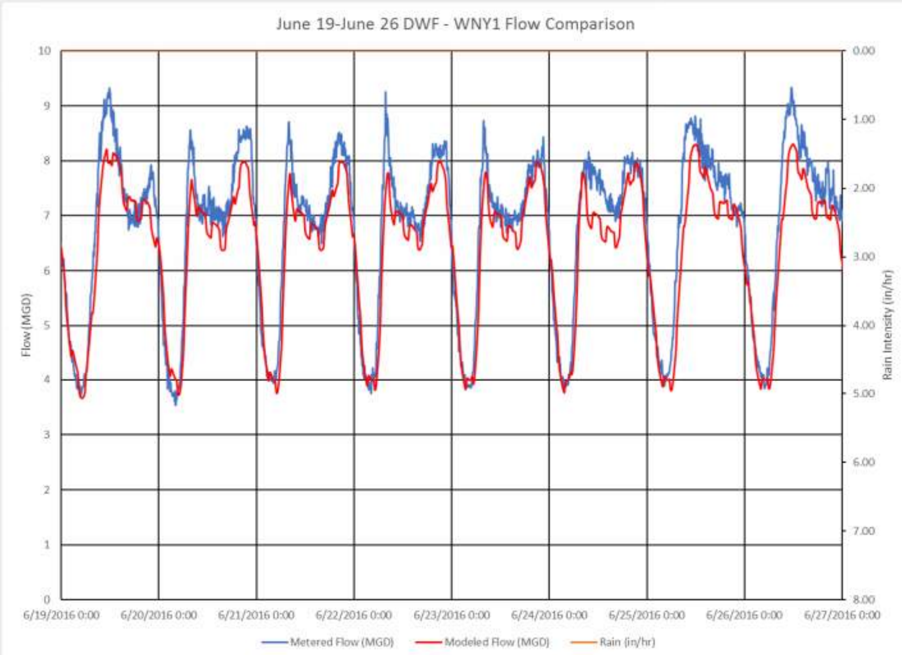


Figure 8.10 Comparison of Measured vs. Simulated Dry Weather Flow Depths (WNY1)

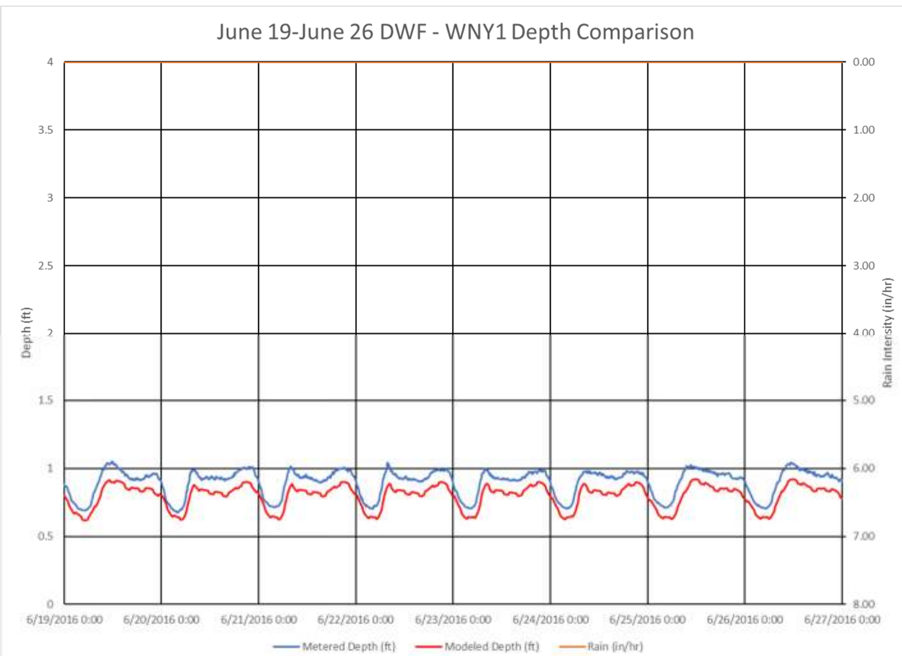


Table 8-5 - Summary of Dry Weather Flow Period Modeling

Regulator	Metered Volume (MG)	Modeled Volume (MG)	Volume Diff %	Peak Flow (MGD)	Modeled Peak (MGD)	Peak Diff %	Meter Depth (ft)	Modeled Depth (ft)	Depth Diff (ft)
UC1	16.2	16.4	1%	2.9	2.6	-11%	1.7	1.7	0.0
UC2	18.0	18.6	3%	3.1	3.0	-5%	1.4	1.5	0.1
WNY2	26.3	26.8	2%	4.6	4.3	-7%	2.0	2.0	-0.1
WNY1	54.1	51.3	-5%	9.3	8.3	-11%	1.1	0.9	-0.1

Meets CIWEM Criteria

8.3.4 Wet Weather Flow Calibration

The process of calibrating the hydraulic model for wet weather flow was more complex than for dry weather flows. Pre-selected rainfall events (calibration and validation storms) were modelled and compared to the wet weather flow response to the corresponding measured data for those periods. Model parameters were adjusted within reasonable limits to match the flow meter response. Table 8-6 summarizes the CIWEM criteria for WWF calibration.

Table 8-6 CIWEM WWF Calibration and Validation Criteria

Criteria	**Calibration Range**	**Notes**
Peak Flow Rate	+25% to -15%	Use of actual value instead of percentage applied to meters with very small flows
Volume	+20% to -10%	Use of actual value instead of percentage applied to meters with very small flows
Timing of Peaks	Timing for peaks (high flows) and troughs (low flows) should be similar having regard to the duration of the event	
Depth	0.33 feet to +0.33 feet of observed peak depth for non-surcharge conditions -0.33 feet to +1.64 feet of observed peak depth for surcharged conditions	
Shape	The shape of the measured and simulated curves should be similar until the flow has substantially returned to DWF rates	

8.3.4.1 Initial Abstraction and Runoff Coefficients

Initial abstraction and runoff coefficients are the fundamental mechanisms of conversion of rainfall to runoff. Initial abstraction, sometimes referred to as depression storage, is the volume that must be filled prior to the occurrence of surface runoff on both pervious and impervious surfaces. It represents the “loss” caused by phenomena such as surface ponding, surface wetting, interception and/or evaporation that depletes an initial fraction of the rainfall after which surface runoff occurs, regardless of the storm intensity or duration. Evaporation was assumed to be 0.1 in/day. Once runoff begins, the volume of runoff generated for a given rainfall is dependent on the surface type. Runoff coefficient is the ratio of the total volume of runoff to total rainfall volume, over the study area.

The initial abstraction and runoff coefficients for the runoff surfaces were used as calibration parameters that were adjusted to match the model hydrographs with flow meter data. The main adjustment that was made to the model in this regard was that UC1 was adjusted slightly to have more infiltration. In general, initial abstraction rates were very low, which is in line with the highly urbanized nature of the drainage area.

The land cover was categorized into four types based on the land use characteristics of each of the four metersheds. The characteristics of these four types input into the model are summarized in the table below:

Table 8-7 Sewershed Subcatchment Characteristics

Runoff Surface	**Surface Type**	**Runoff Routing Value**	**Initial Loss Value (ft)**	**Runoff Coefficient**	**Horton Initial (in/hr)**	**Horton Limiting (in/hr)**	**Horton Decay (1/hour)**	**Horton Recovery (1/hour)**
1	Pervious	0.035	0.0167	N/A	2.5	0.15	2.0	0.41

Runoff Surface	Surface Type	Runoff Routing Value	Initial Loss Value (ft)	Runoff Coefficient	Horton Initial (in/hr)	Horton Limiting (in/hr)	Horton Decay (1/hour)	Horton Recovery (1/hour)
2	Impervious (WNY1/WNY2)	0.015	0.0025	0.75	N/A	N/A	N/A	N/A
3	Impervious (UC1)	0.015	0.0025	0.87	N/A	N/A	N/A	N/A
4	Impervious (UC2)	0.015	0.0025	0.90	N/A	N/A	N/A	N/A

8.3.4.2 Initial Subcatchment Width Selection

Subcatchment width is used to determine the length of the overland flow within the subcatchment for the kinematic wave routing that is performed by the computer model using the SWMM method. It can be used as a calibration parameter. To set the initial value, the subcatchment area was divided by the square root of the subcatchment area as that was taken to represent the distance across the diagonal of an assumed square shaped subcatchment. This width can them be adjusted to fine tune the calibration if needed. If was found that because the subcatchments were relatively small, the subcatchment width did not have much impact on the peak flow rate at the meters.

The sewershed widths range as follows, with the two largest sewersheds being the separately sewered area and the area that the treatment plant is located on.

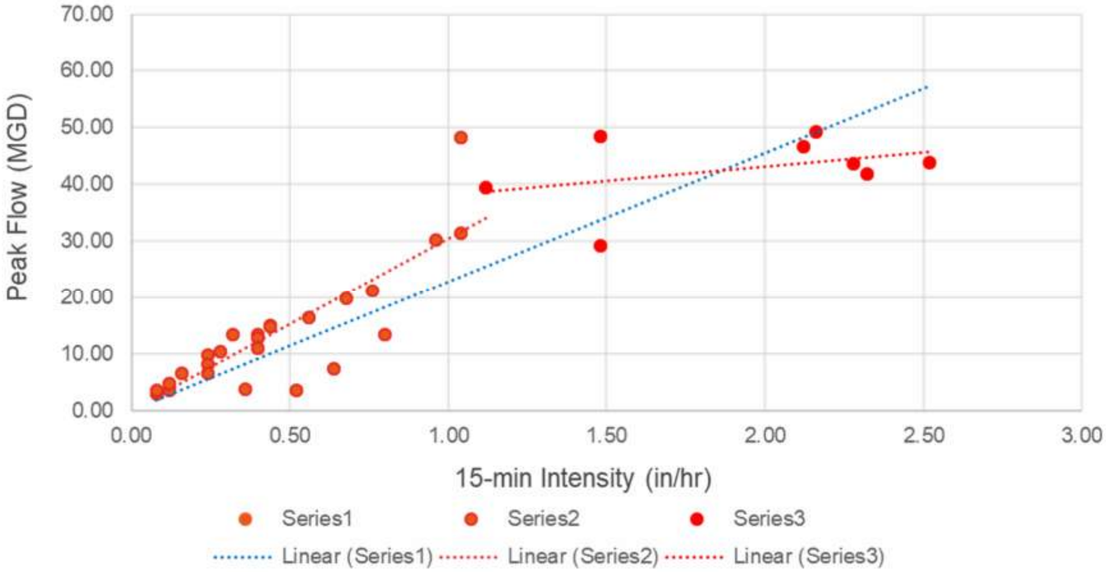
Table 8-8 Sewershed Widths

Width	Count
100 ft < W < 300 ft	30
300 ft < W < 500 ft	200
500 ft < W	2

8.3.5 Inlet Openings

During the calibration process, peak flow in the system seemed to increase at a slower rate and almost flatline for high intensity storms (>1"/hr), as shown below in Figure 8.11 of the monitored peak 15-min intensity vs. peak flow. The initial model run exhibited good agreement for volumes but modeled peak flows were typically high. Efforts to reduce the peak flows through typical methods such as adjusting subcatchment width and runoff coefficients were either ineffective or detrimental to the lower intensity storm calibration. It was suspected that the capacity of the inlets was limiting the flow entering the collection system during these high intensity events. This was supported by checking the profiles and determining that the collection system piping was not the limiting factor. To replicate this, the manholes with flow inputs were converted into inlets, and the inlet openings were reduced in order to replicate the reduction in peak flow. This adjustment was effective in better replicating the flow characteristics of the sewer system.

Figure 8.11: Monitored Peak Flow vs. 15-min Intensity



8.4 Calibration Results

Overall, the hydraulic model's performance compared acceptably with the measured flow meter data. Flow volumes and peak overflows matched well. Example graphs of UC1 for the three calibration storms are provided below Figure 8.12 through Figure 8.15, and the complete calibration charts and individual flow meter calibration are included in Appendix D.

Figure 8.12: May 30, 2016 Calibration Storm Flows (UC1)

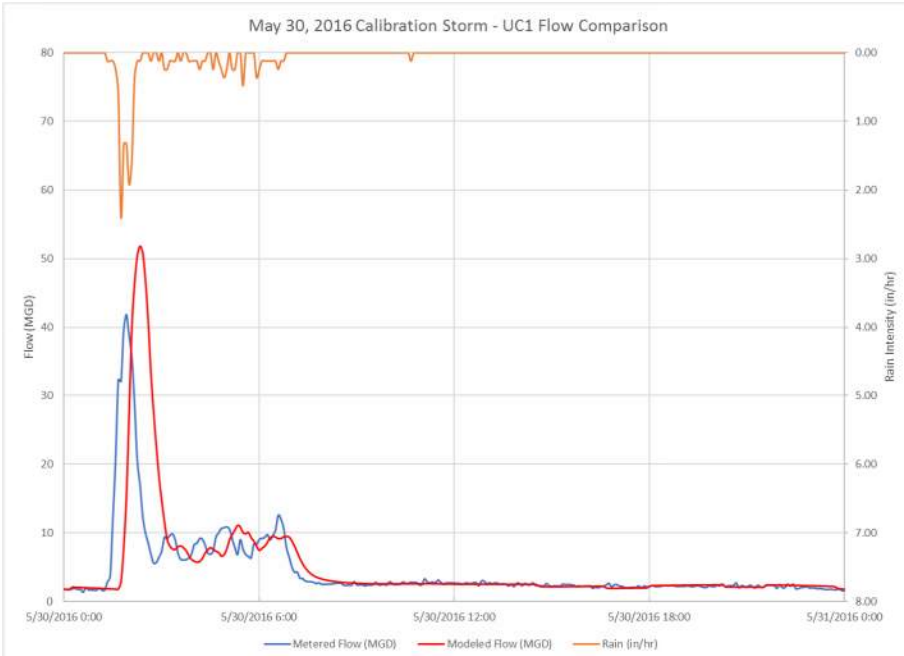


Figure 8.13 May 30, 2016 Calibration Storm Flow Depths (UC1)

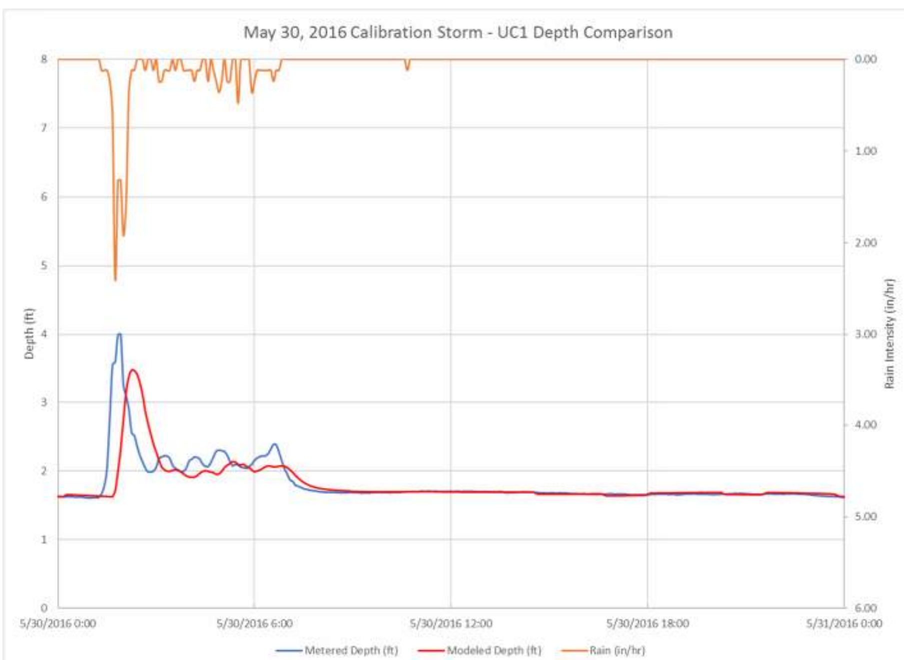


Figure 8.14: November 15, 2016 Calibration Storm Flows (UC1)

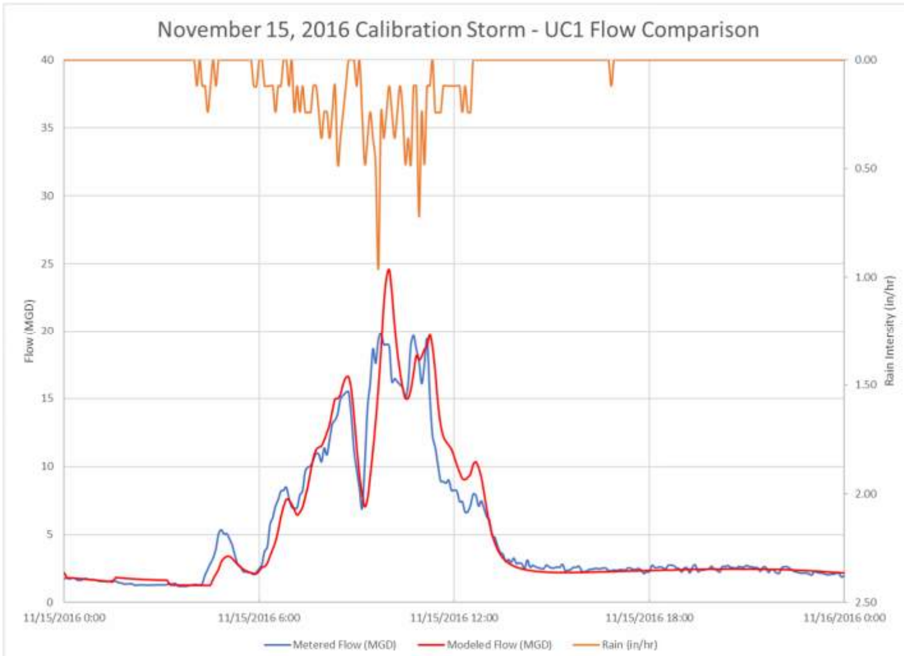
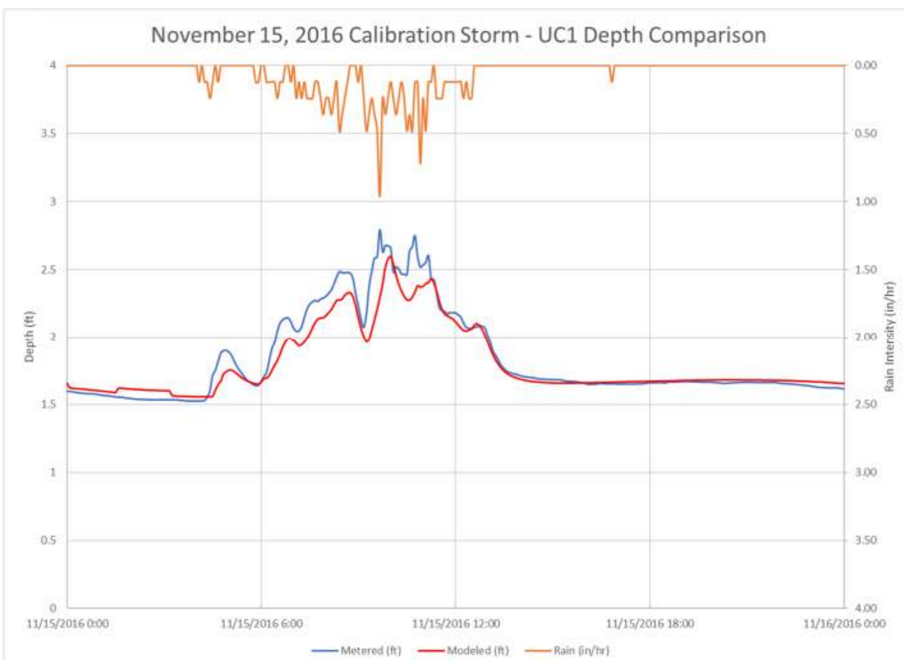


Figure 8.15 November 15, 2016 Calibration Storm Flow Depths (UC1)



The scatterplot for WNY2 (Figure 8.6) shows a discrepancy in a portion of the metering data. This may be the result of a downstream obstruction such as sediment being washed away during a storm or an error in the meter. This discrepancy impacted the calibration of the November 15, 2016 storm. At UC1, UC2 and WNY1 there was good agreement, however at WNY2 the results for flow and depth were quite poor, as can be seen in Figure 8.16 and Figure 8.17. A review of the graph shows a conflict between the dry weather flow depth and flow rate before and after the storm, accordingly this storm was omitted from consideration at WNY2.

Figure 8.16 November 15, 2016 Calibration Storm Flows (WNY2)

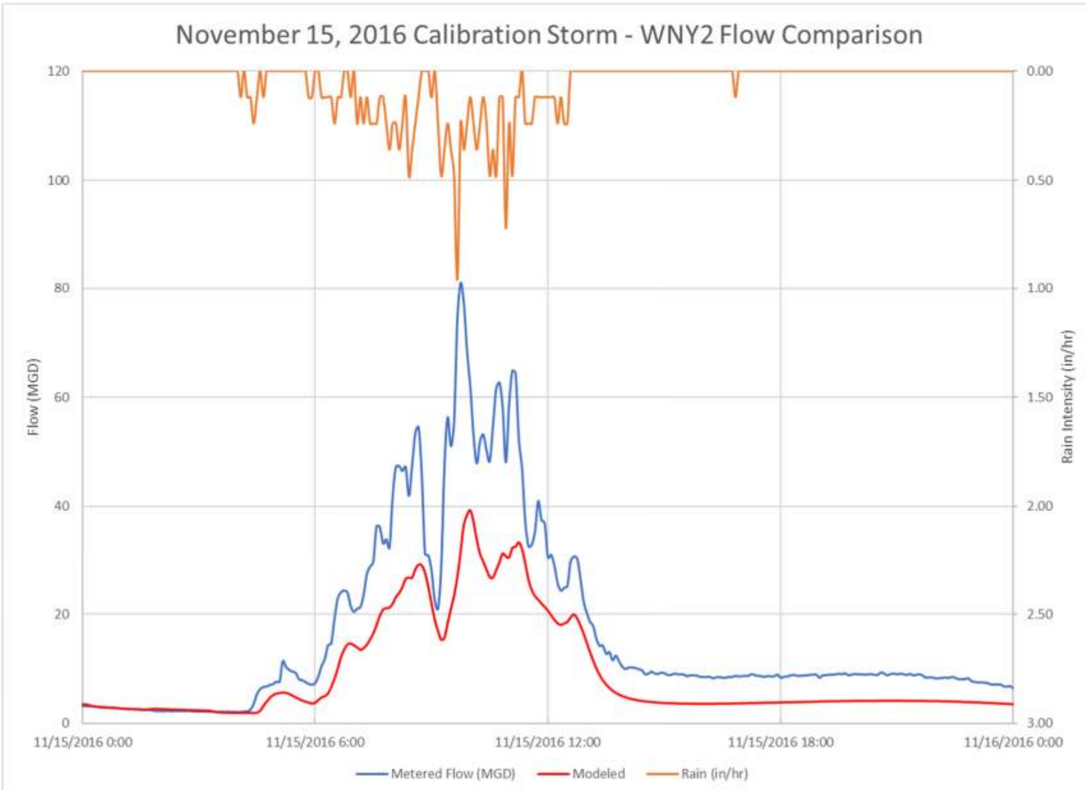
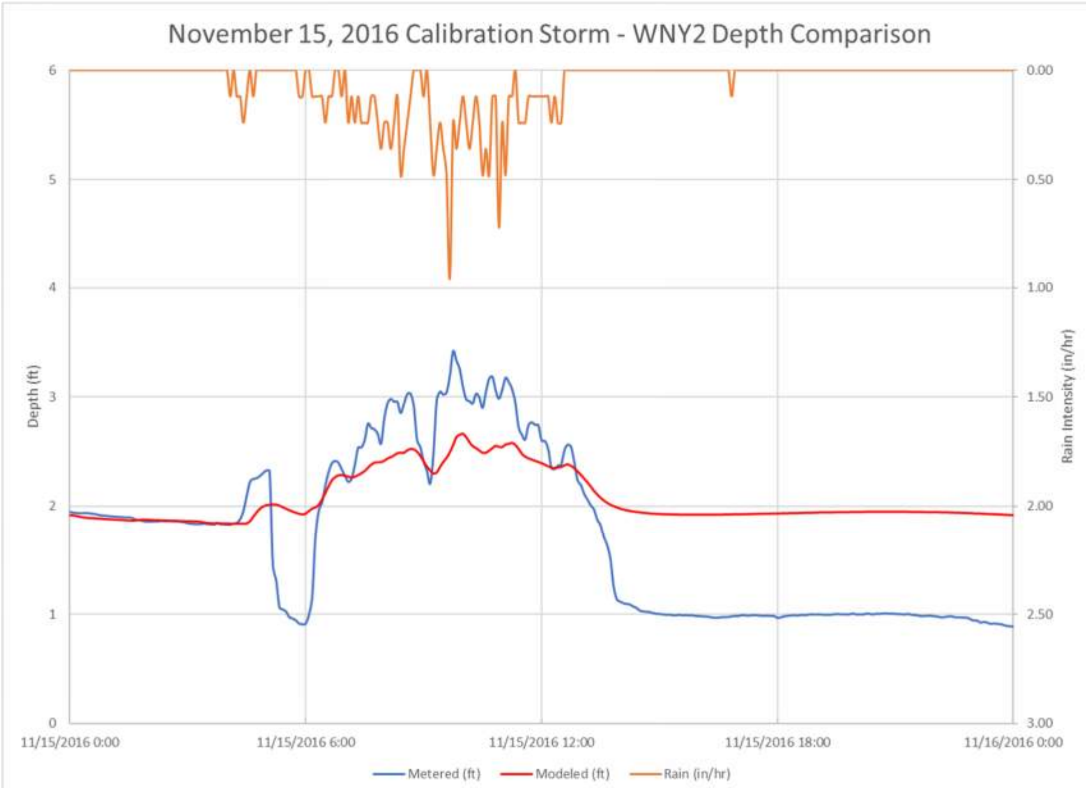
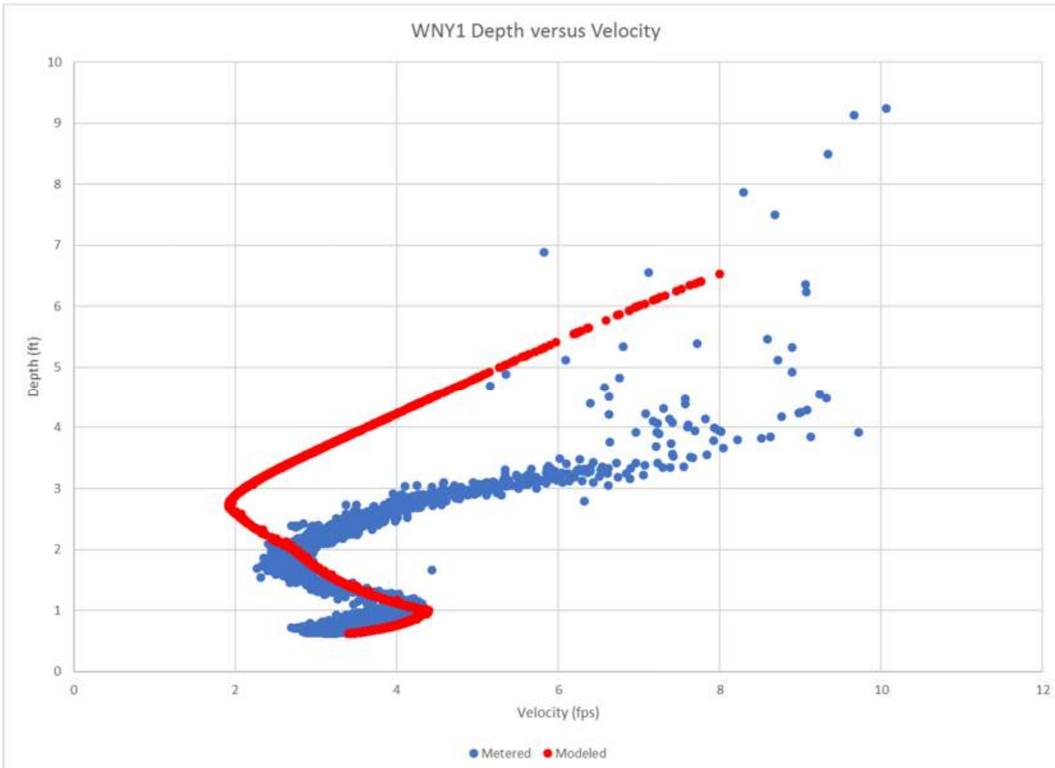


Figure 8.17 November 15, 2016 Calibration Storm Flow Depths (WNY2)



There was also a challenge matching depths for the higher flows at WNY1. The gate performance was aligned to the flow versus depth relationship for lower flows and then limited to 24 MGD (the maximum flow the plant sees) when the interceptor is fully surcharged. However, the flow versus depth relationship from the metered data implies that the weir is lower than measured in the field. Since the flows to the plant are limited by the gate, this was not thought to have a major impact on the overflow rates or volumes and the field measured elevation of the weir was used. The flow to depth relationship can be seen below in Figure 8.18.

Figure 8.18 WNY1 Depth versus Velocity Plot



8.5 Model Validation

The validation process followed the calibration process by using a sample of the monitoring data for the model that was completely independent of those used for the calibration process. If the model reasonably reproduced the results of the validation event(s), the model is considered validated.

Three different storms (small, medium, large) were selected from the metering period, and measured data was tested against the calibrated model. Example graphs of UC1 for two validation storms are provided below in Figure 8.19 through Figure 8.22, and the complete validation charts are included in Appendix D.

Figure 8.19: May 30, 2016 Validation Storm Flows (UC1)

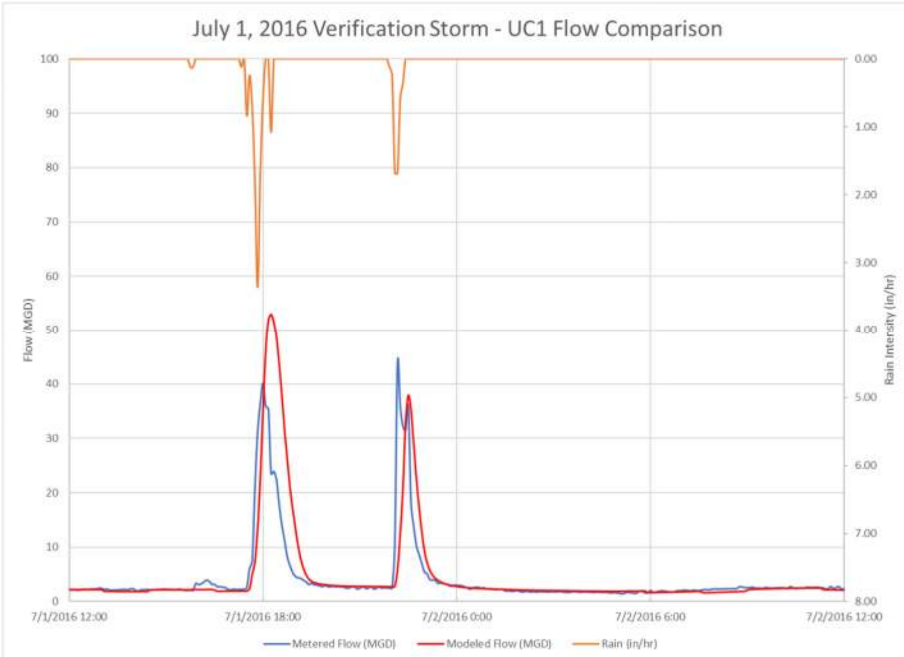


Figure 8.20 May 30, 2016 Validation Storm Flow Depths (UC1)

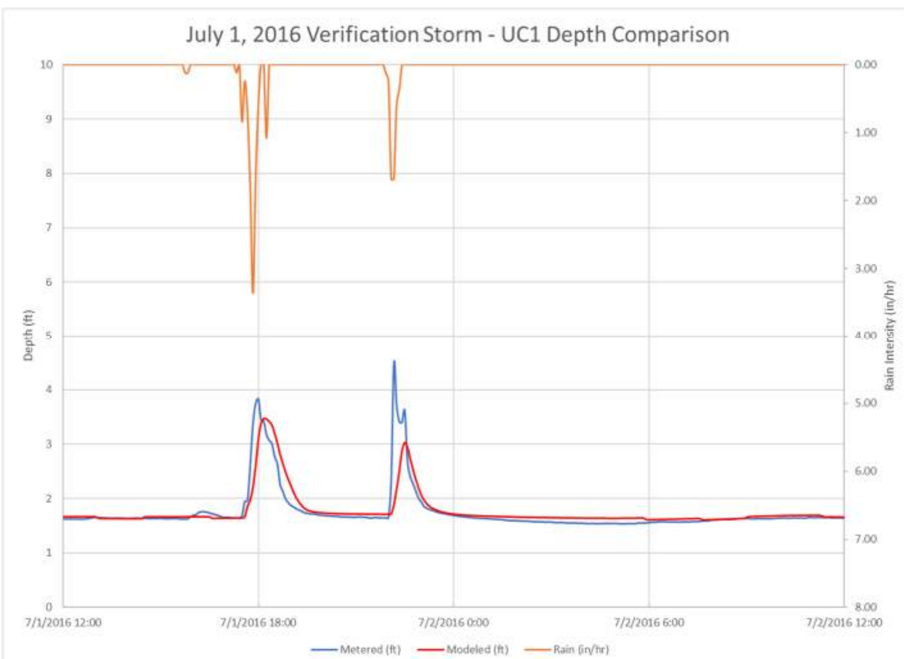


Figure 8.21: September 14, 2016 Validation Storm Flows (UC1)

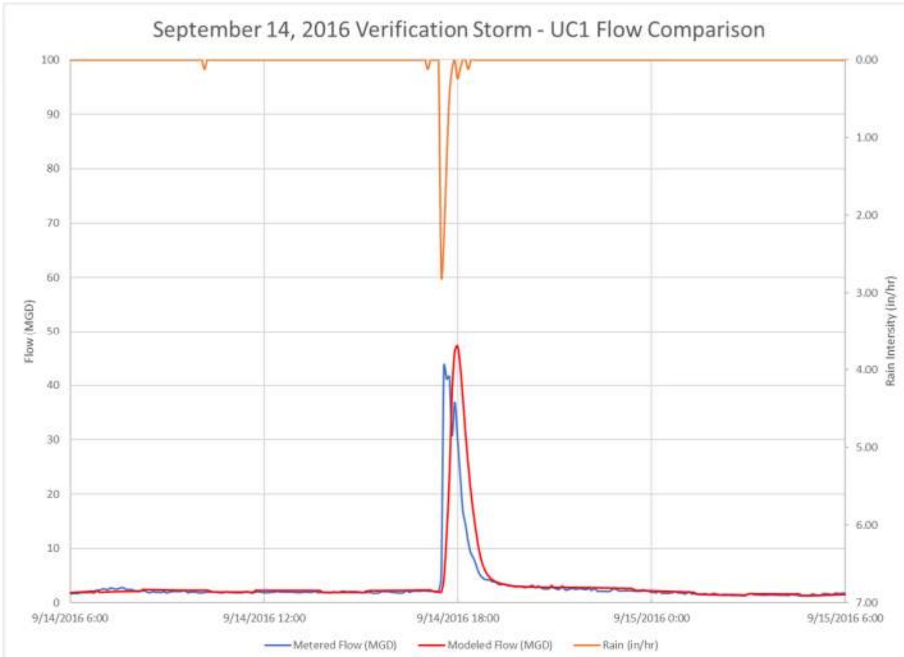
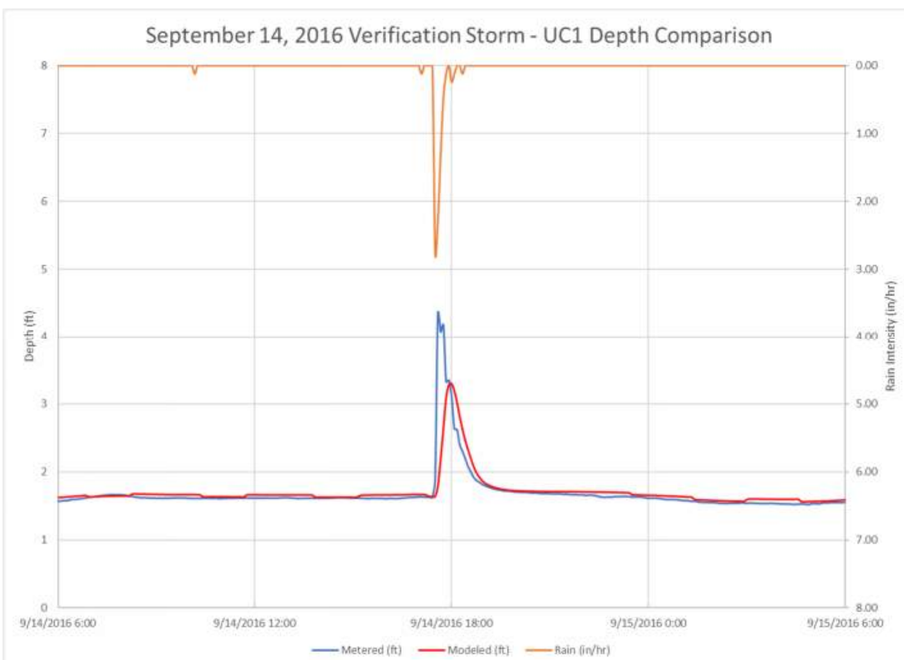


Figure 8.22September 14, 2016 Validation Storm Flow Depths (UC1)



Overall, the hydraulic model's performance compared acceptably with the measured flow meter data. Flow volumes and peak overflows matched well. The goodness-of-fit in terms of the flow volumes is the most important when it comes to wet weather flow calibration and validation. The goodness-of-fit plots shown below in Figure 8.23 through Figure 8.30 for all flow meters across the calibration and validation events include lines to reflect the range of CIWEM criteria. These figures show that the model generally provided good simulation of flow generation and overall system hydraulics and performed well under varied rainfall totals, durations and intensities.

The goal of the calibration and validation process was that 2/3 of the data should meet the CIWEM criteria, which in general was achieved as shown in the figures below.

Figure 8.23: Goodness-of-Fit Plot Peak Flow UC1

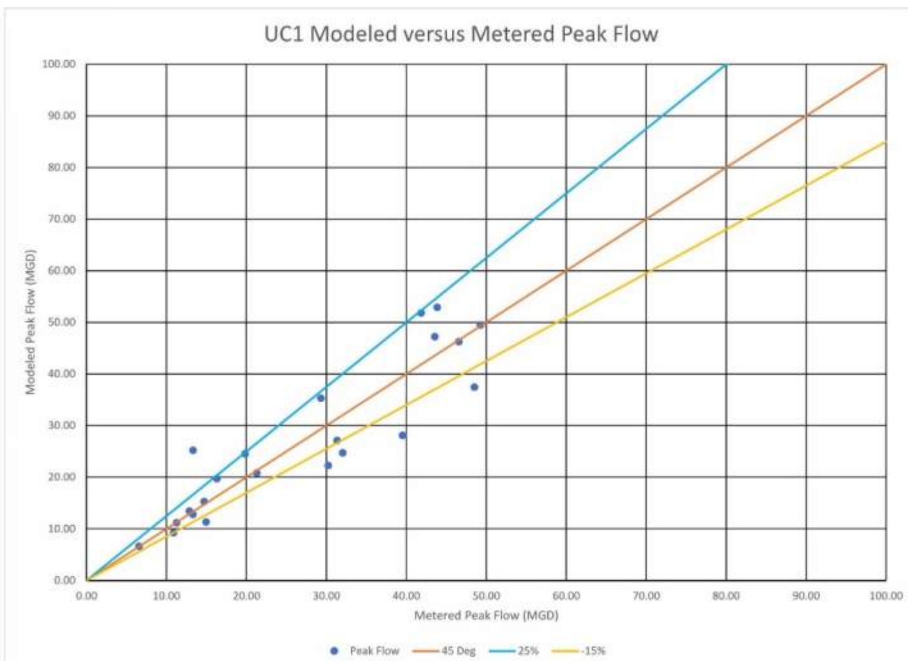


Figure 8.24 Goodness-of-Fit Plot Volume UC1

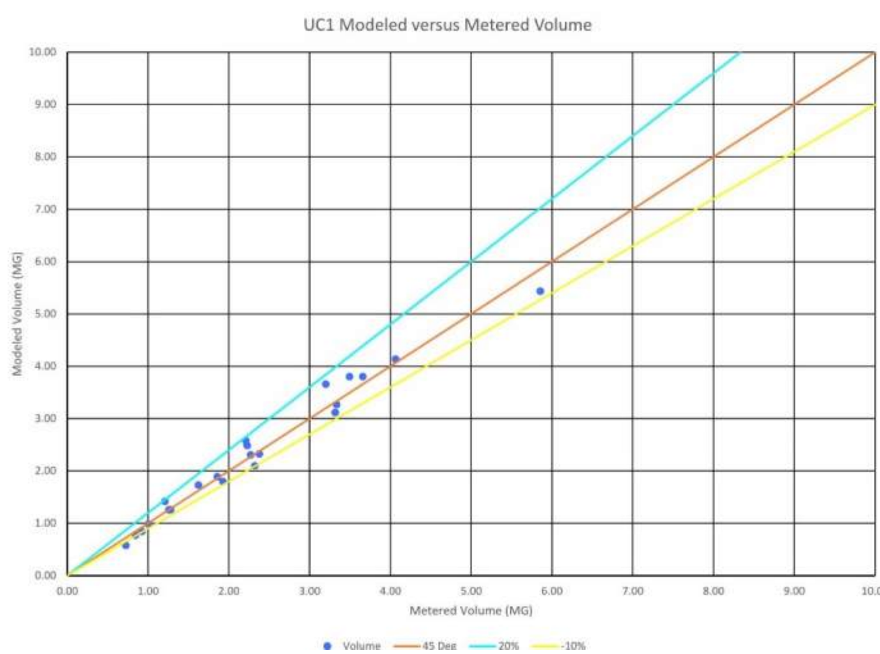


Figure 8.25: Goodness-of-Fit Plot Peak Flow UC2

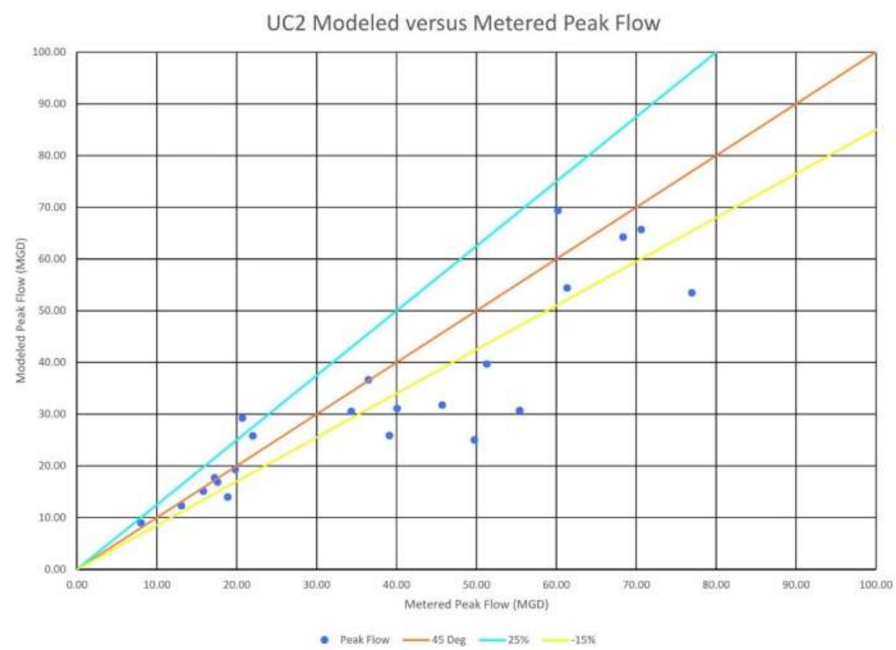


Figure 8.26 Goodness-of-fit Plot Volume UC2

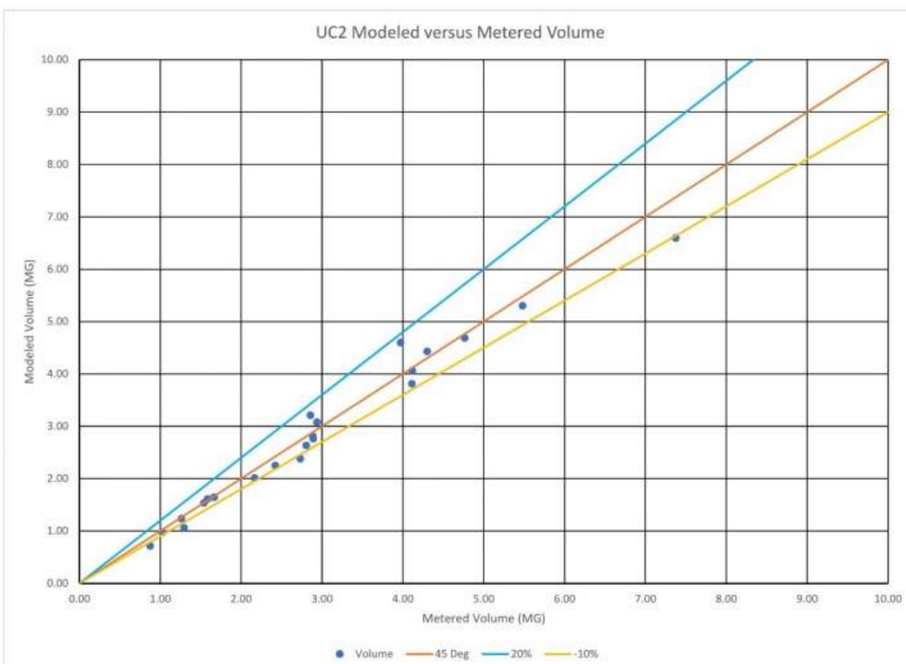


Figure 8.27: Goodness-of-Fit Plots Peak Flow WNY2

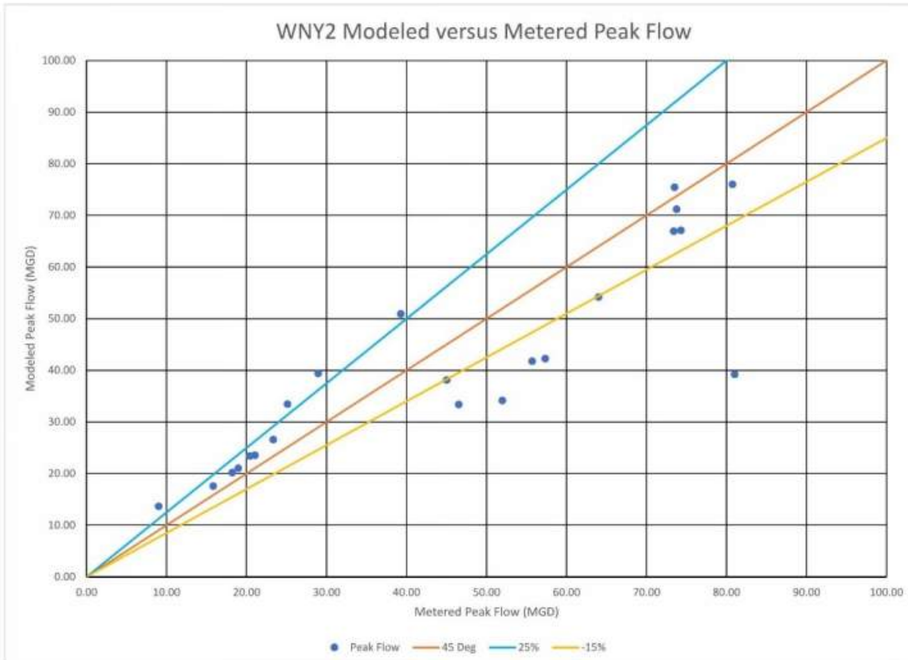


Figure 8.28 Goodness-of-Fit Plot Volume WNY2

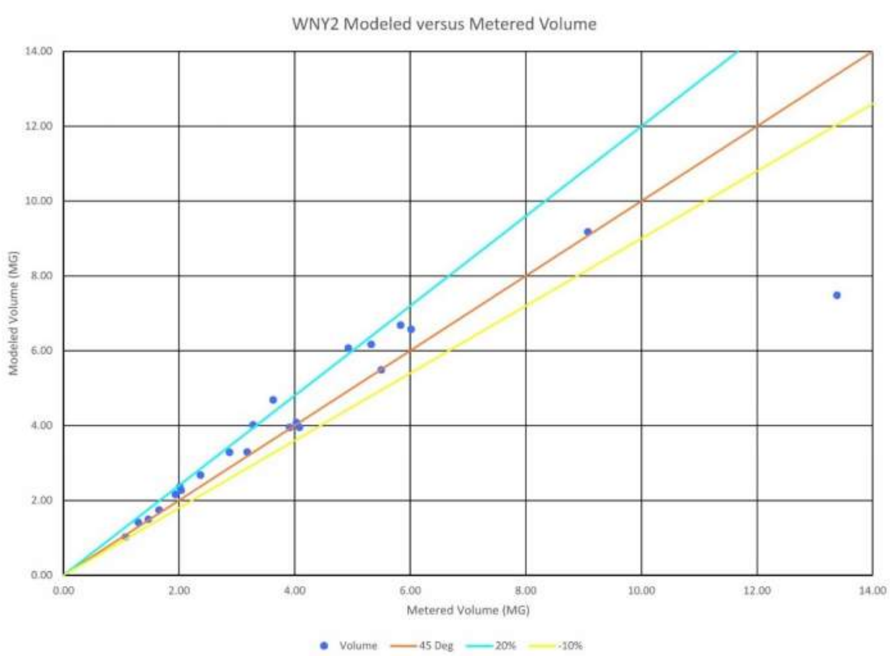


Figure 8.29: Goodness-of-Fit Plot Peak Flow -WNY1

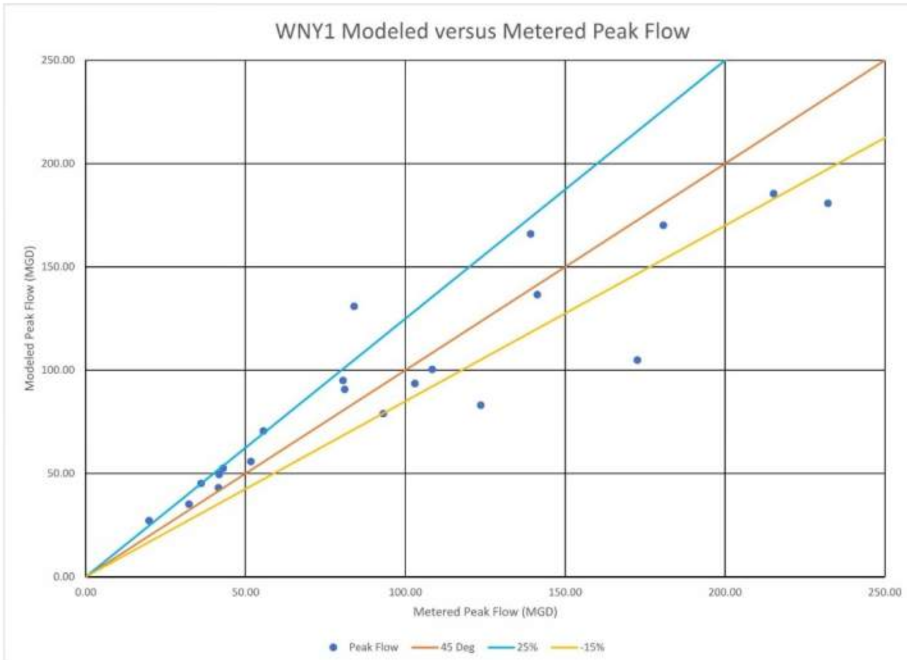
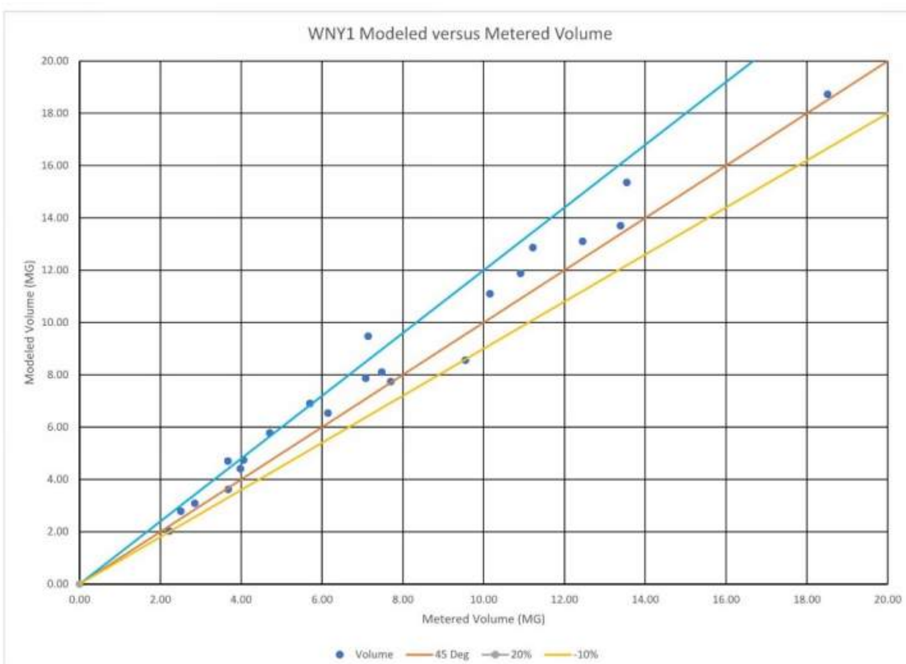


Figure 8.30 Goodness-of-Fit Plots Volume WNY1



The number of overflows calculated during the metering period of May 17, 2016 to November 16, 2016 was also measured, and was compared with mission data from NHSA as another test of the accuracy of the model. Although the mission data did not measure the volumes of CSO discharges, it provided the start and end times of CSO events by means of a float mechanism. While 33 CSO events were measured at River Road and 24 were measured at JOSO, the modelled rainfall did not include the three days of rain in October when the River Road rain gauge did not work. Taking this into account, the comparison of modeled events to measure events is shown below in Table 8-9. NHSA staff indicated that the float switches which measure overflow events are very sensitive, so may overestimate the number of overflows occurring.

Table 8-9 Mission vs. Modelled Overflows

	CSOs observed during metering period	**CSOs simulated in model**	**% Difference**
WNY1 (002A)	30	28	-7%
JOSO (003A)	21*	28	33%*

The model corresponds well with the mission results for WNY1 but shows less agreement for JOSO. The Mission System data for the JOSO line registered no overflows from May 26, 2016 through June 23, 2016, whereas at least three (3) significant rainfall events occurred, so it is thought that the recorded number of overflow may be lower than the actual number of overflows and the models prediction of overflow are more accurate than listed in Table 8-9.

Baseline Characterization

The calibrated model was used to identify the number, location, frequency and volumes of overflows expected for a typical year, and to calculate inputs to a pathogen water quality model of New York-New Jersey Harbor being developed by the NJ CSO Group.

9.1 Typical Year Selection

In accordance with the USEPA CSO Control Policy the CSO control alternatives are to 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.

NHSA is part of the NJ CSO Group, a group of municipalities which discharge to the tidally connected waterbodies in the NY/NJ Harbor Estuary that are working cooperatively to fulfill the requirements of the last CSO General Permit. Passaic Valley Sewerage Commission (PVSC) was selected to lead the technical work required for CSO permit compliance and led the analysis for the selection of the typical year which would be used for the long-term continuous precipitation modeling. The typical year of rainfall used in this baseline characterization is based on the "Typical Hydrologic Year Report" produced by PVSC in May 2018.

The typical year was selected by PVSC based on statistical analysis of precipitation records in recent 46 years (1970-2015). The objective of selecting the typical year was to provide a representative and unbiased approximation of future expected conditions in terms of both averages and historical variability. Based on data from the Newark Liberty International Airport rain gauge, the PVSC report recommended that 2004 should be selected as the typical hydrologic year for the CSO LTCP. This is because 2004 had the least deviation from criteria including annual rainfall, river flow, storm volume, number of events, peak intensity, etc. The 2004 rainfall year also contains a wide range of storms and antecedent conditions, and it has close to an average CSO volume and event number based on the hydrologic and hydraulic model results.

Hourly precipitation data for 2004 was obtained for the Newark rain gauge for the completion of the typical year analysis.

9.2 Frequency and Volumes of CSO Discharges

The River Road model was run under the 2004 rainfall typical yield rainfall condition to calculate CSO overflow characteristics under these conditions. The results are as follows:

- WNY1 (002A) – 60 overflows
- JOSO (003A) – 61 overflows

The overflow characteristics are summarized in Figure 9.1 through Figure 9.4 below and provided in detail in Appendix E.

The following charts depict the volume and peak flows of all calculated overflows in the typical year and highlight the 5th largest storms for each outfall which would be consistent with the level of control requiredunder the presumptive approach which allows for four (4) overflow in a typical year.

Figure 9.1: WNY1 (002A) – Typical Year CSO Volumes

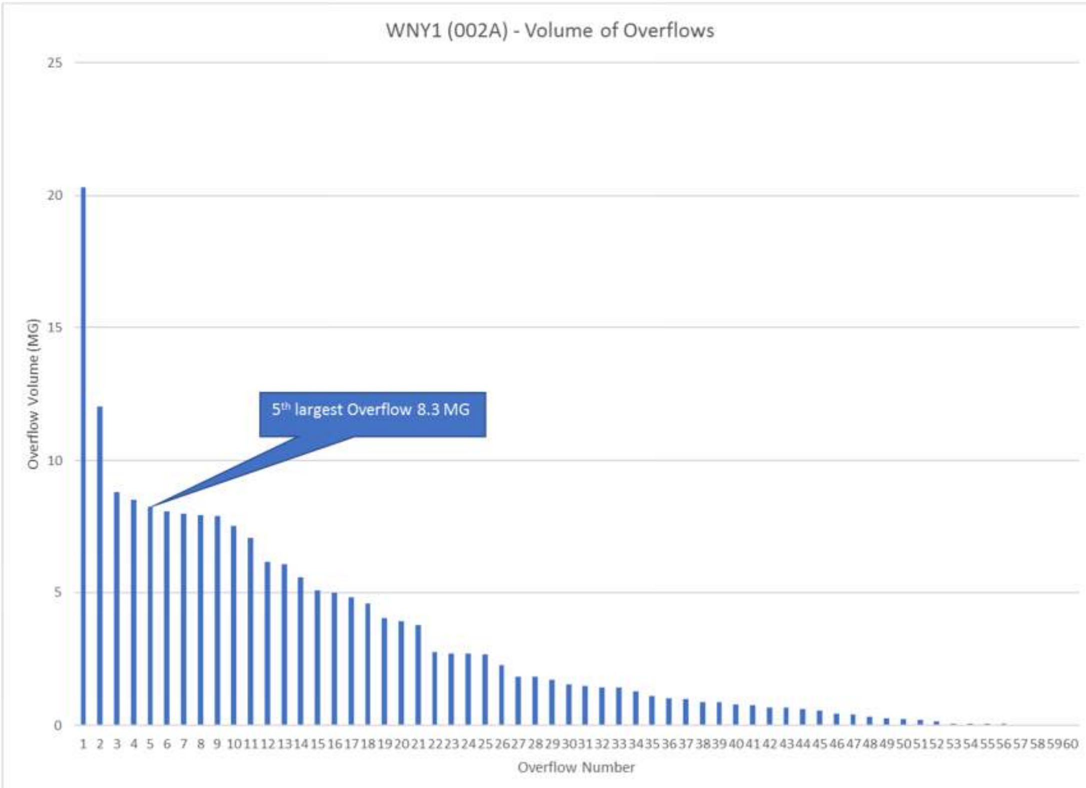


Figure 9.2: JOSO (003A) – Typical Year CSO Volumes

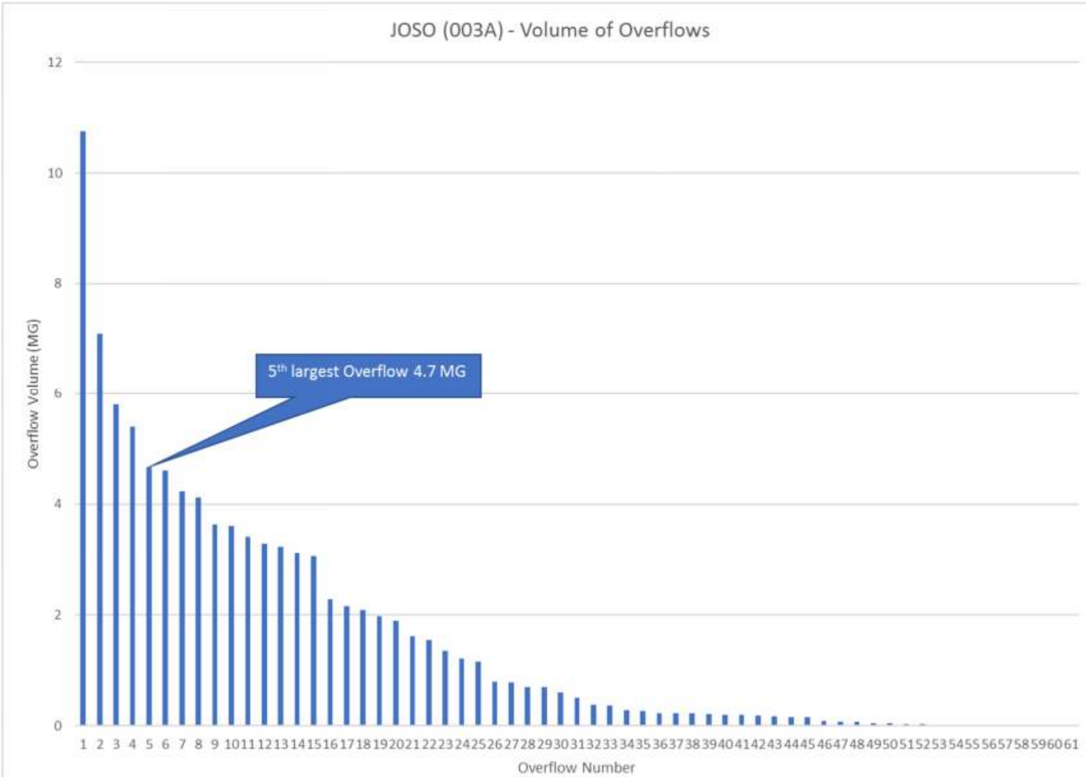


Figure 9.3: WNY1 (002A) – Typical Year CSO Peak Flows

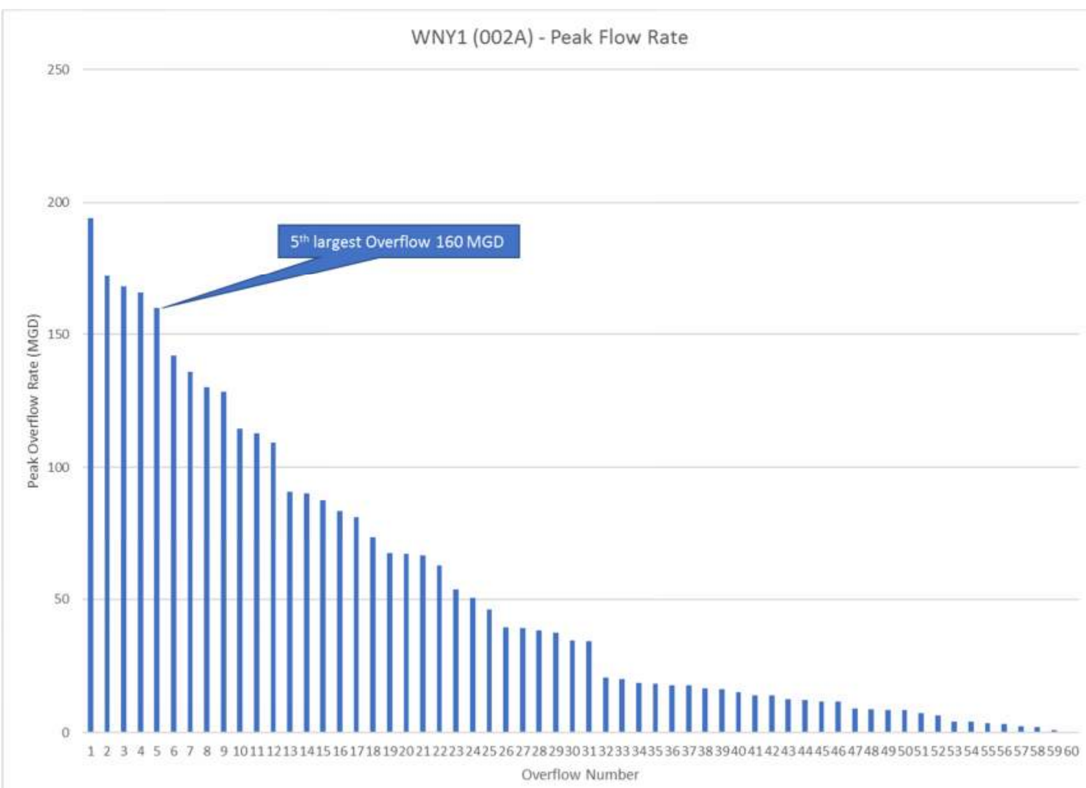
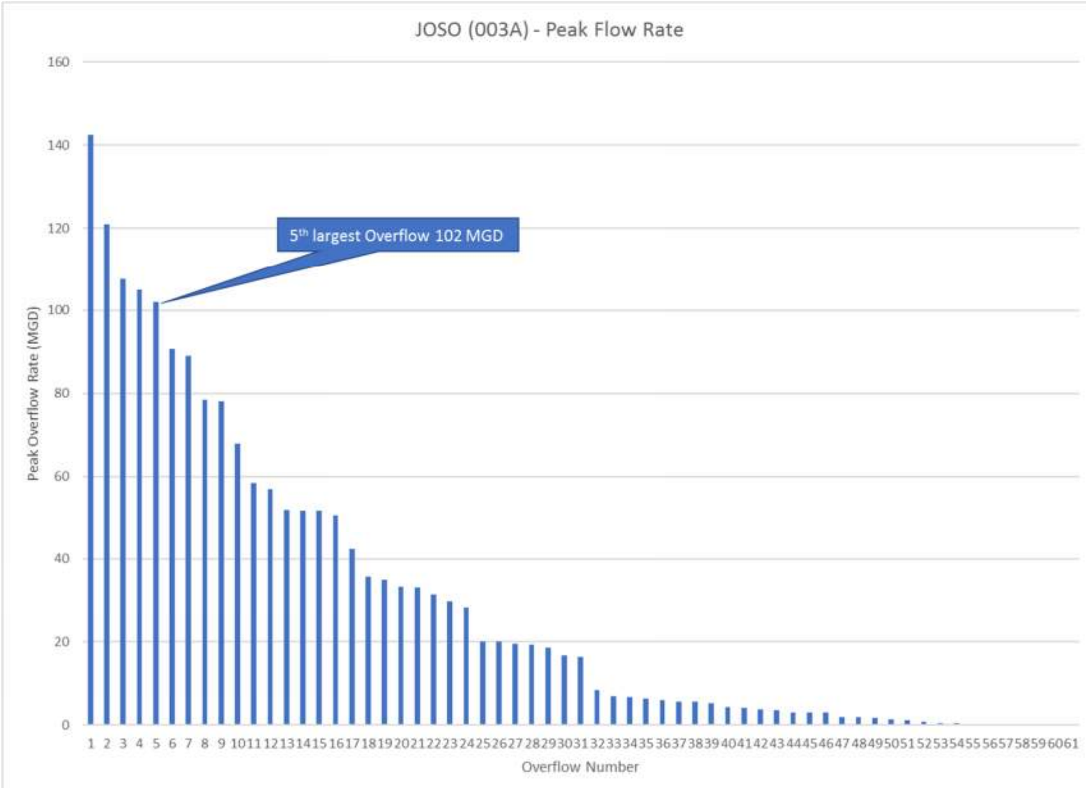


Figure 9.4: JOSO (003A) – Typical Year CSO Peak Flows



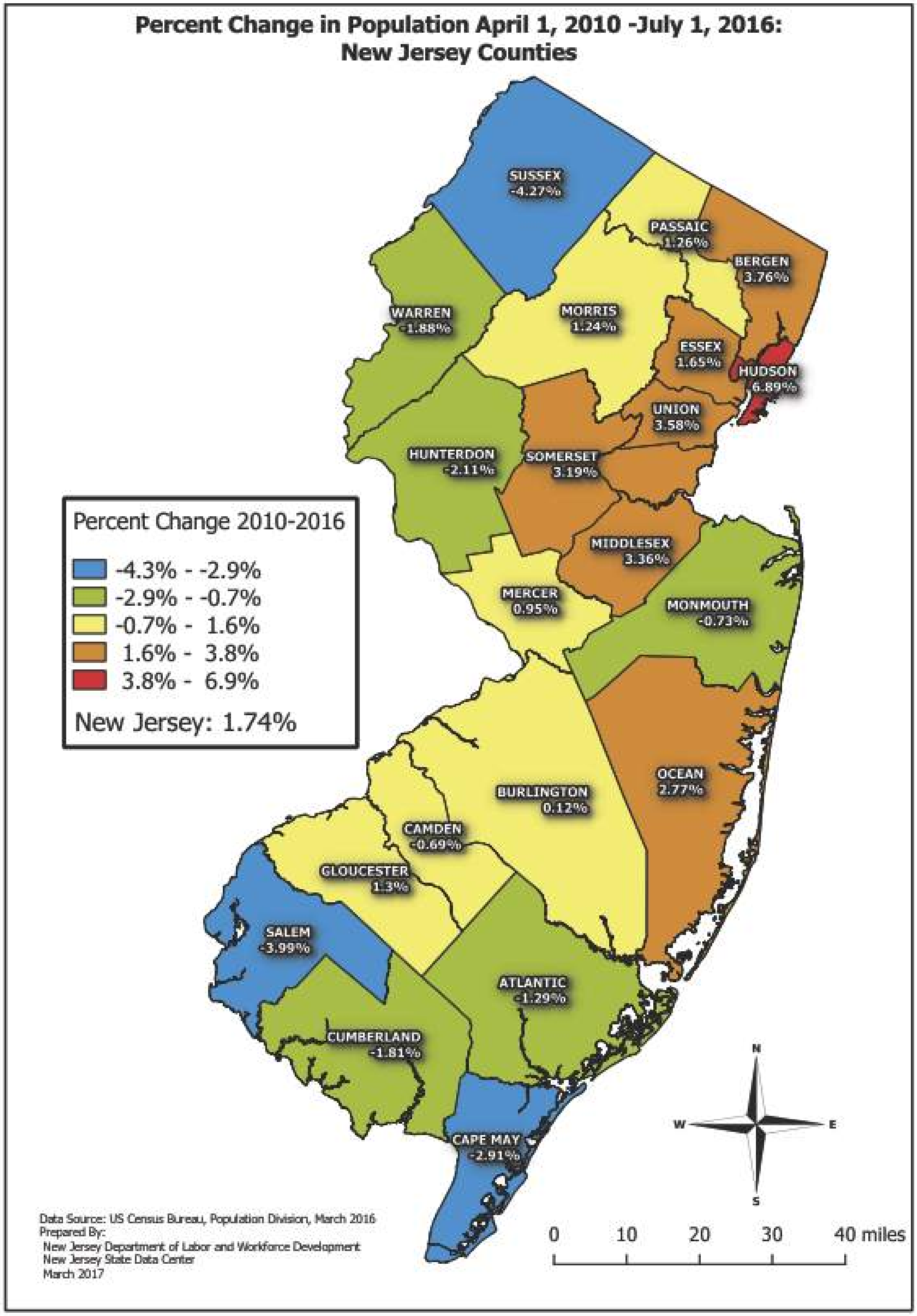
SECTION 10

References

1. North Hudson Sewerage Authority Long Term Control Plan System Characterization Work Plan for the River Road STP (CH2M Hill, 2016)
2. North Hudson Sewerage Authority Fiscal Year 2017 Annual Report (Mott MacDonald, 2017)
3. River Road CSO Control Cost and Performance Analysis Report (Metcalf & Eddy | AECOM, 2007)
4. River Road WWTP Cost and Performance Analysis Report (Metcalf & Eddy | AECOM, 2007)
5. Underwater Investigation of the North Hudson Sewer Treatment Outfall, West New York, NJ, May 17-20, 2010 (Ocean and Coastal Consultants, 2010)
6. Chartered Institution of Water and Environmental Management (CIWEM) Code of Practice for the Hydraulic Modelling of Urban Drainage Systems, Version 01, November 2017
7. Results of RedZone sewer condition assessment – export from ICOMM database
8. Field investigations:
    a. 11/30/2017 – regulators
    b. 5/11/2018 – regulators and S/F facilities
    c. 5/16/2018 – pumping stations, outfalls

Appendices

11.1 Appendix A – Population Change



11.2 Appendix B – CSO Water Quality Sampling Memo

DRAFT TECHNICAL MEMORANDUM

North Hudson Sewerage Authority Long Term Control Plan Combined Sewer Overflow Water Quality Sampling

PREPARED FOR:	Fredric Pocci, PE
COPY TO:	Don Conger, PE; Phil Reeve
PREPARED BY:	Erin McGovern; Amy Gao, PE
DATE:	June 21, 2018
PROJECT NUMBER:	676549
REVISION NO.:	**DRAFT FINAL**
APPROVED BY:	Bill McMillin, PE

CH2M performed water quality sampling of the North Hudson Sewerage Authority's combined sewer systems from August 2016 to August 2017. The data collected will enable a water quality characterization of combined sewer overflow discharges for the Authority's sewer system characterization and will aid in development of a Long Term Control Plan. This technical memorandum describes the sampling effort and the data collected.

1.0 Introduction

The following provides information on this effort, its goals and the sampling plan.

1.1 Background

The North Hudson Sewerage Authority (the Authority or NHSA) owns and operates the Adams Street and River Road Wastewater Treatment Plants (WWTPs) and their associated collection systems in Hoboken, West New York, Weehawken and Union City. The collection systems in all of these communities are combined sewer systems (CSS). The Adams Street and River Road WWTPs are regulated by the New Jersey Department of Environmental Protection (NJDEP) and under the New Jersey Pollutant Discharge Elimination System (NJPDES) permit program. The Authority's CSS and WWTPs are operated under a long-term contract with Operations Management International (OMI).

On March 12, 2015, the NJDEP issued final individual NJPDES permits to municipalities and authorities that own and operate segments of CSS. The final NJPDES permits address requirements for overall water quality improvements, routine reporting, and development of a Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP). The NJPDES requires that 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 characterization must include a thorough review of the entire collection system to adequately address the response of the CSS to various precipitation events and to identify the number, location, frequency and characteristics of CSOs.

The Authority submitted a Sewer System Characterization Work Plan to the NJDEP in December 2015 that was prepared by CH2M. The Work Plan describes collection system water quality monitoring that has since been performed to characterize bacterial concentrations in CSO discharges to the Hudson River. Dry and wet weather sampling has been performed to assure that representative Fecal Coliform and Enterococcus concentrations will be used for CSO discharges in surface water quality modeling to determine baseline compliance and for developing the LTCP.

1.2 Project Description

The CSO Water Quality Sampling Program was designed to characterize CSO discharges to the Hudson River. Sampling was performed at five regulators during dry and wet weather events from August 2016 to August 2017. The goal of the wet weather sampling was to monitor at least three rain events with rainfall greater than 0.5 inches in a 24-hour period.

1.2.1 Sampling Locations

Sampling locations were selected at CSO regulators based on GIS information of drainage area land use types evaluated by CH2M and availability of monitoring systems to detect overflows. Maps of the Authority's service area with sampling locations highlighted is provided at the end of this document. The sampling locations are also listed in Table 1-1 with site characteristics.

Regulator overflows are monitored by the Authority with Mission float sensors at CSO regulators. These sensors monitor water surface elevations in the sewers at the regulators and are linked to the Authority's Supervisory Control and Data Acquisition (SCADA) system. They indicate in real time that an overflow may be occurring when the water surface elevation rises above the regulator overflow weir elevation. The system is also used for the Authority's public notification system and records the times when overflows may be occurring. The sensors at regulators in Hoboken may indicate an overflow but tidal conditions may be higher than the water surface in the CSS preventing an overflow. All other regulators are above tidal ranges and are overflowing when the Mission sensor indicates so.

Hydraulic elevations were also metered upstream of CSO regulators from April to December 2016 under a separate LTCP characterization effort by ADS as a subcontractor to Greeley & Hansen.

TABLE 1-1
CSO Water Quality Sampling Locations

Basin ID	Location	Land Usage	% Impervious	Monitoring System
H3	3rd St. at River St. (In crosswalk)	Low/Medium Residential	71%	ADS/Mission (H3 + H4)
H7	14th St. East at Washington St.	Commercial/ Industrial	46%	ADS/Mission (H6 + H7)
18TH Street PS	W 18th St.	Open Space/ Park	39%	Mission
W2	506 Gregory Ave.	High Residential	59%	ADS/Mission
WNY1	JF Kennedy Blvd. at Anthony Delfino Way	Mixed Uses	~75%	Mission

1.2.2 Scope of Sampling

Dry weather event sampling was performed by collecting three (3) samples over a six-hour period at each designated sampling location. Dry weather event sampling was preceded by 24 hours of dry weather and monitored flows at the WWTP during the time of sampling were consistent with dry weather conditions.

The goal for wet weather sampling was to sample at least three (3) wet weather events between the months of August 2016 and August 2017 at each location. Mobilization for sampling was initiated when wet weather events were forecasted with rainfall of 0.5 inches or greater in a 24-hour period preceded by three (3) days of dry weather. Samples were to be collected at the following time intervals following the start of overflow at a regulator: 0.5, 1, 2, 4, 6, and 8 hours. Sampling ended following the 8th hour of overflow from the first regulator that opened, or when the overflow stopped, whichever came first. Samples were transported to the Eurofins QC Laboratories where they were analyzed for the parameters identified in Table 1-2.

TABLE 1-2
Analytical Parameters

Parameter	Description	Method
FC	Fecal Coliform	Membrane Filter Technique (SM 9222D-1997)
EC	Enterococci	Membrane Filter Technique (EPA 1600)

1.3 Quality Control

The Quality Assurance Project Plan (QAPP) integrated quality control policies and project-specific work tasks to successfully conduct water quality monitoring to support development of the CSO Long Term Control Plan. The QAPP was submitted to NJDEP on July 27, 2016 as part of the Authority's System Characterization Work Plans for the Adams Street and River Road WWTPs. The same QAPP was submitted in both work plans. All laboratory services were performed by Eurofins QC Laboratories.

2.0 Dry and Wet Weather Sampling

One dry weather sampling event and several wet weather events were sampled between August 2016 and August 2017. Sampling was suspended during winter months. The following describes the dry and weather sampling events and the data collected.

2.1 Dry Weather Sampling

Dry weather sampling was conducted at five (5) regulator locations on August 23, 2016. This sampling event was preceded by more than 24 hours of dry weather. Three representative samples were grabbed from each of the sampling locations at different times throughout the day. Enterococcus concentrations ranged from <100,000 cfu/100 mL to approximately 4.5 million cfu/100 mL. Fecal Coliform concentrations ranged from <100,000 cfu/100 mL to approximately 18 million cfu/100 mL. The results of dry weather sampling are shown below in Table 2-1.

TABLE 2-1
Dry Weather Sampling Event – August 23, 2016

Sampling Location	Time	Enterococcus Concentration (cfu/100mL)	Fecal Coliform Concentration (cfu/100mL)
H3	9:30	1,900,000 Q	1,200,000 Q
	13:02	3,600,000	7,000,000 E
	15:30	300,000	<100,000
H7	9:56	<100,000 Q	900,000 Q
	13:20	1,900,000	18,000,000
	15:50	100,000	200,000
18th Street PS	9:42	<100,000 Q	900,000 Q
	13:06	600,000	1,000,000
	16:05	<100,000	300,000
W2	8:50	400,000 Q	700,000 Q
	12:53	3,800,000	3,900,000

TABLE 2-1

Dry Weather Sampling Event – August 23, 2016

Sampling Location	Time	Enterococcus Concentration (cfu/100mL)	Fecal Coliform Concentration (cfu/100mL)
	15:23	100,000	500,000
WNY1	8:30	<100,000	1,600,000 [Q]
	12:34	4,500,000	4,800,000
	14:58	<100,000	600,000

Notes:

E - Count is outside of recommended range of test. Reported value may be considered estimate.

Q - Samples analyzed outside of hold time.

2.2 Wet Weather Sampling

Wet weather sampling was performed during four (4) events on the following dates:

- October 27, 2016
- November 29, 2016
- April 25, 2017
- August 8, 2017

Wet weather sampling events are defined as events with total rainfall of 0.5 inches or greater within a 24-hour period. Rainfall data, collected from the Authority's rain gage at the Baldwin Avenue Pump Station, confirms that all the wet weather sampling events had rainfall greater than 0.5 inches within a 24-hour period. Table 2-2 summarizes rainfall data for each of the wet weather events sampled including total rainfall depth, duration and maximum intensity.

TABLE 2-2

Wet Weather Sampling Rainfall Data

Event #	Date	Total Rainfall (inches)	Duration (hours)	Maximum Intensity (inches/hour)
1	10/27/16	1.15	13.00	0.15
2	11/29/16	1.97	12.25	0.14
3	4/25/17	0.70	6.75	0.13
4	8/7/17	0.59	11.00	0.04

Wet weather sampling was conducted as regulators opened. Some events did not provide sufficient rainfall to open all five (5) regulators that were desired for sampling. A summary of the number of samples that were analyzed at each sampling location per wet weather event is shown in Table 2-3.

TABLE 2-3

Wet Weather Sampling Event Summary

	# of Samples Taken				
Sampling Location	**10/27/2016 ***	**11/29/2016**	**4/25/2017**	**8/7/2017**	**Total # Wet Weather Samples/ Location**
H3	0	0	0	0	0
H7	0	6	0	0	6
18th Street PS	0	0	0	1	1
W2	0	6	4	5	15
WNY1	1	6	0	6	13

*Unfavorable event, insufficient rainfall to continue sampling

2.2.1 Wet Weather Event 1 - October 27, 2016

On October 27, 2016, one (1) water quality sample was collected from the WNY1 sampling location. The sampling team mobilized at 6:00 am to capture the forecasted rainfall, however, increased rainfall accumulation did not occur until later in the evening as shown in Figure 2-1. Sampling was called off after the WNY1 regulator opened at 11:27 am and then closed shortly after at 12:08 pm due to a lack of precipitation. Total rainfall recorded on October 27, 2016 was 1.15 inches with a majority of the rainfall occurring later in the evening. The data from this sampling event are shown in Table 2-4.

FIGURE 2-1

Wet Weather Sampling Event 1 – October 27, 2016 – Rainfall Accumulation

* This is the initial opening of the regulator. Regulator closed and re-opened several times during the event.

TABLE 2-4

Wet Weather Sampling Event 1 – October 27, 2016

Sampling Location	Time from Regulator Opening (mins)	Sample Time	Enterococcus Concentration (cfu/100mL)	Fecal Coliform Concentration (cfu/100mL)
WNY1	40	11:27	30,000,000	120,000,000 E

E - Count is outside of recommended range of test. Reported value may be considered estimate.

2.2.2 Wet Weather Event 2 - November 29, 2016

On November 29, 2016 eighteen (18) water quality samples were collected. During this event, 1.97 inches of rainfall was recorded over 12.25 hours, the H7, W2 and WNY1 regulators opened as shown in Figure 2-2 below.

FIGURE 2-2

Wet Weather Sampling Event 2 – November 29, 2016 – Rainfall Accumulation

Regulators H7, W2 and WNY1 remained open for the duration of rainfall allowing the sampling team to grab samples at each of the target times following the start of overflow (approximately 0.5, 1, 2, 4, 6, and 8 hours). The concentrations of Enterococcus and Fecal Coliform for this wet weather event are shown in Figures 2-3 and 2-4, respectively. The data from this sampling event are also shown in Table 2-5.

FIGURE 2-3

Wet Weather Sampling Event 2 – November 29, 2016 – Enterococcus Concentrations

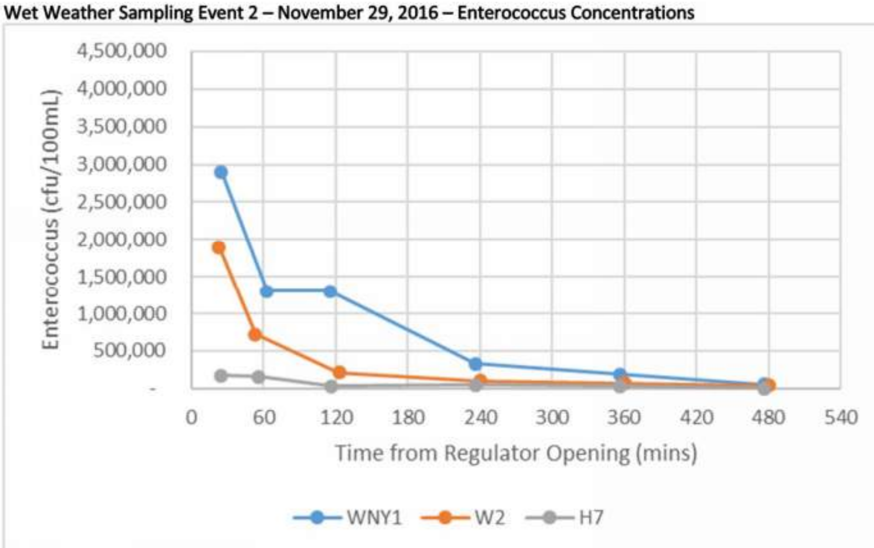


FIGURE 2-4

Wet Weather Sampling Event 2 – November 29, 2016 – Fecal Coliform Concentrations

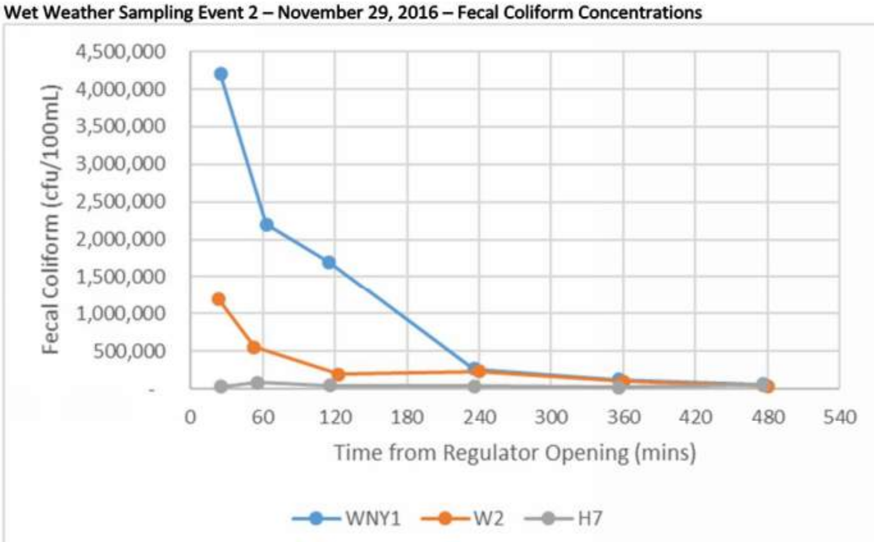


TABLE 2-5

Wet Weather Sampling Event 2 – November 29, 2016

Sampling Location	Time from Regulator Opening (mins)	Sample Time	Enterococcus Concentration (cfu/100mL)	Fecal Coliform Concentration (cfu/100mL)
WNY1	25	9:50	2,900,000	4,200,000
	63	10:28	1,300,000 E	2,200,000
	115	11:20	1,300,000 E	1,700,000 E
	236	13:21	330,000	260,000
	356	15:21	190,000 E	120,000 E
	476	17:21	57,000	58,000
W2	23	10:10	1,900,000 E	1,200,000 E
	53	10:40	720,000 E	550,000
	123	11:50	210,000	190,000
	240	13:47	100,000 E	230,000
	360	15:47	71,000 E	98,000 E
	480	17:47	42,000 E	40,000
H7	25	11:40	170,000 E	27,000
	56	12:11	160,000 E	81,000 E
	116	13:11	35,000	44,000
	236	15:11	47,000	35,000
	356	17:11	35,000	23,000
	476	19:11	1,800 E	50,000 E

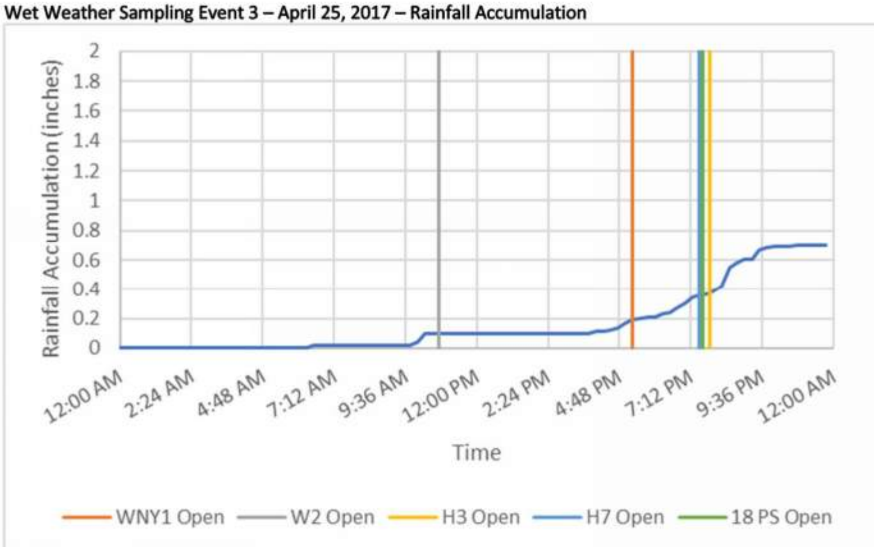
E - Count is outside of recommended range of test. Reported value may be considered estimate.

2.2.3 Wet Weather Event 3 - April 25, 2017

Sixteen (16) water quality samples were collected on April 25, 2017 between 11:00 am and 4:00 pm. The rainfall recorded during the event was 0.7 inches from about 10:00 am to 9:30 pm. The Authority's Mission system was being monitored and initially indicated that overflows may have been occurring once the rainfall started. Upon collecting Mission system data after the event, only the W2 regulator had elevations indicating an overflow may have been occurring during the sampling period. The Mission system data indicated that Regulators WNY1, H3, H7 and the 18th Street Pump Station likely discharged later in the evening as rainfall accumulation increased. But weather flow from about 0.1 inches of rainfall was in the CSS during sampling. See Figure 2-5 below for rainfall accumulation and Mission data.

FIGURE 2-5

Wet Weather Sampling Event 3 – April 25, 2017 – Rainfall Accumulation



Only the samples collected from W2 are likely representative of a wet weather event. The observed concentrations of enterococcus and fecal coliforms are shown in Figures 2-6 and 2-7, respectively. The data of all other samples are likely not representative of a wet weather event as the other regulators did not open until later in the evening when the rainfall intensity increased and sampling had ended. The bacteria data for all samples are shown in Table 2-6.

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FIGURE 2-6

Wet Weather Sampling Event 3 – April 25, 2017 – Enterococcus Concentrations

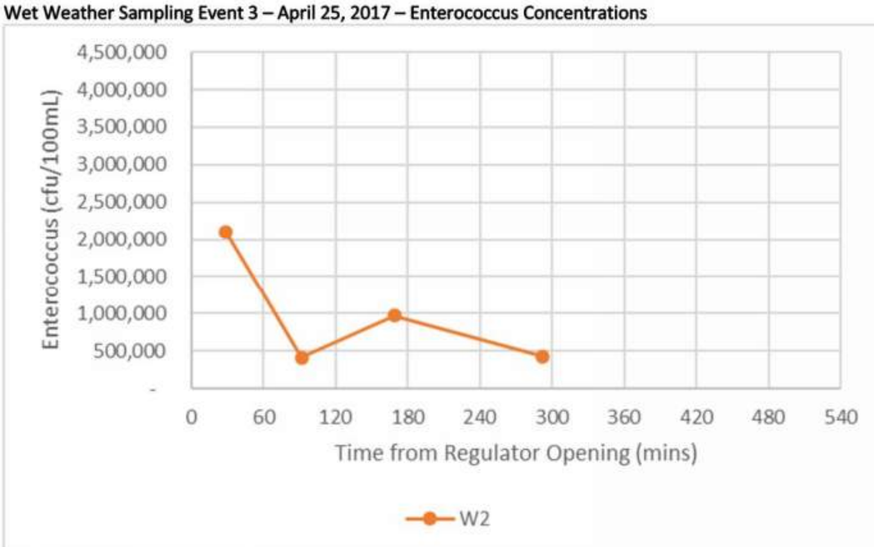

FIGURE 2-7

Wet Weather Sampling Event 3 – April 25, 2017 – Fecal Coliform Concentrations

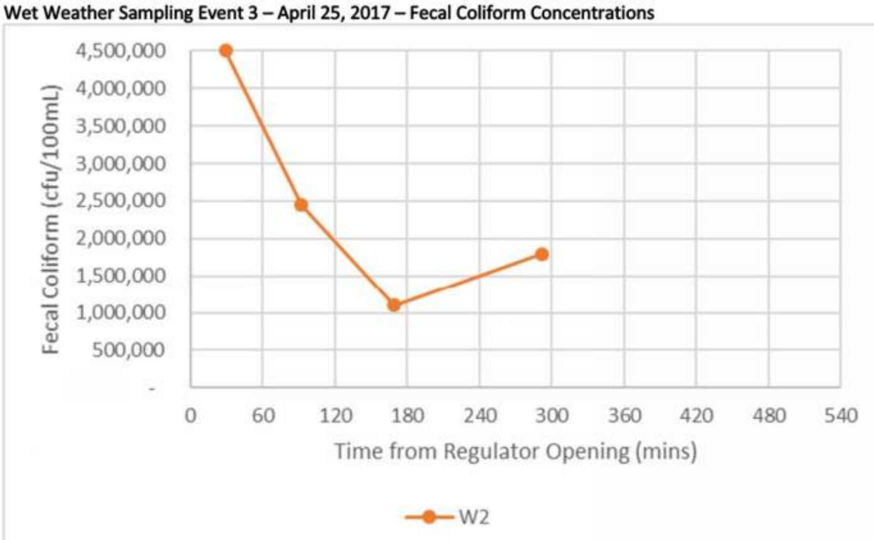

TABLE 2-6
Wet Weather Sampling Event 3 – April 25, 2017

Sampling Location	Time from Regulator Opening (mins)	Sample Time	Enterococcus Concentration (cfu/100mL)	Fecal Coliform Concentration (cfu/100mL)
WNY1	30	11:00	210,000	390,000
	90	12:00	420,000	2,500,000
	168	13:18	700,000 E	2,500,000
	275	15:05	450,000	1,400,000 E
W2	29	11:12	2,100,000	4,500,000
	92	12:15	410,000	2,450,000 E
	169	13:32	972,973 E	1,100,000 E
	292	15:35	430,000	1,800,000 E
H7	30	11:30	380,000	3,200,000
	90	12:32	540,000	2,500,000
	147	13:47	250,000	620,000 E
	275	15:40	280,000	763,636 E
H3	30	11:50	300,000	630,000 E
	92	12:50	240,000	1,700,000 E
	167	13:57	1,500,000 E	1,600,000 E
	280	16:05	2,600,000	3,100,000

E - Count is outside of recommended range of test. Reported value may be considered estimate.

2.2.4 Wet Weather Event 4 - August 7, 2017

On August 7, 2017, a total of twelve (12) water quality samples were collected. The rainfall recorded was 0.59 inches of over eleven hours. Rainfall and Mission system data showing overflow conditions for Regulators W2, WNY1 and the 18th Street Pump Station are shown in Figure 2-8.

FIGURE 2-8

Wet Weather Sampling Event 4 – August 7, 2017 – Rainfall Accumulation

* This is the initial opening of the regulator. Regulator closed and re-opened several times during the event.

The sampling of this event was modified slightly from the QAPP to collect viable samples. The WNY1 regulator opened and closed several times throughout the event. Samples taken from WNY1 followed the QAPP in that they were taken until approximately eight hours after the initial regulator opening. Some samples were grabbed while the regulator was not overflowing but wet weather flow was in the CSS. The data for this sampling event are shown in Figures 2-9 and 2-10 below as well as in Table 2-7.

FIGURE 2-9

Wet Weather Sampling Event 4– August 8, 2017 – Enterococcus Concentrations

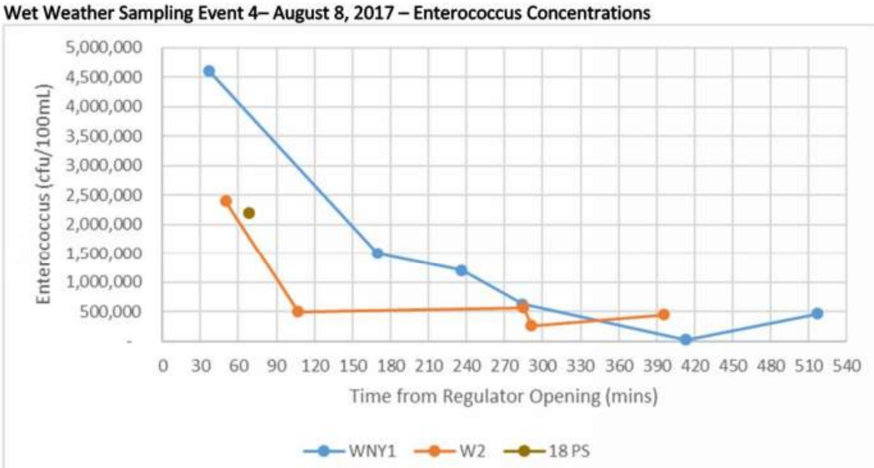

FIGURE 2-10

Wet Weather Sampling Event 4– August 8, 2017 – Fecal Coliform Concentrations

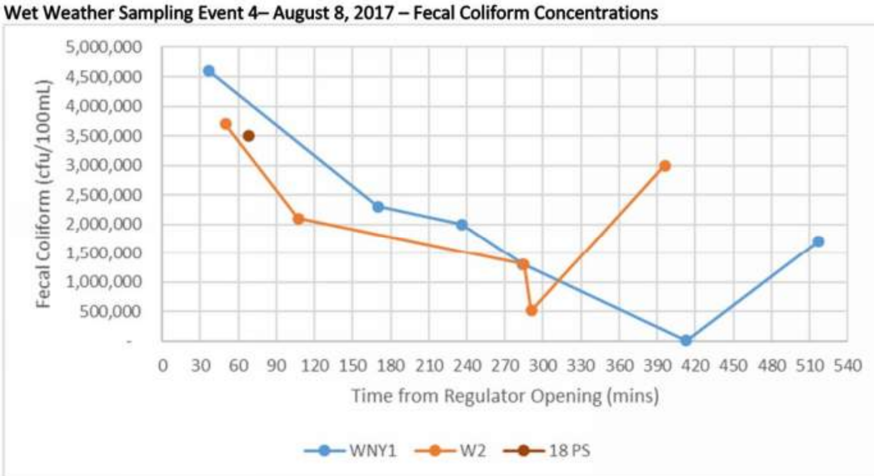

TABLE 2-7

Wet Weather Sampling Event 4 – August 8, 2017

Sampling Location	Time from Regulator Opening (mins)	Sample Time	Enterococcus Concentration (cfu/100mL)	Fecal Coliform Concentration (cfu/100mL)
WNY1	37	10:20	4,600,000	4,600,000
	170	12:33	1,500,000 E	2,300,000
	236	13:39	1,200,000 E	2,000,000
	284	14:27	630,000 E	1,300,000 E
	413	16:36	25,000	4,100
	517	18:20	470,000	1,700,000 E
W2	50	12:50	2,400,000	3,700,000
	107	13:47	500,000	2,100,000
	285	14:45	570,000	1,300,000
	291	16:51	260,000	520,000
	396	18:36	450,000	3,000,000
18 PS	68	19:21	2,200,000	3,500,000

E - Count is outside of recommended range of test. Reported value may be considered estimate.

3.0 Summary of Findings

This work effort was performed to characterize bacterial concentrations in CSO discharges to the Hudson River. The procedures in the QAPP were executed and quality control was followed. Many analytical results were outside the recommended range of tests and should be considered estimates. Bacterial samples collected from wastewater, stormwater, combined sewage and surface waters can vary by orders of magnitude at the same location on the same day in dry and wet weather depending on the conditions when the sample was collected.

Dry weather sampling provided a range of baseline concentrations for sanitary enterococcus and fecal coliform within the CSS. Dry weather enterococcus samples ranged from less than 100,000 cfu/100mL to 4,500,000 cfu/100mL. Fecal coliform samples ranged from less than 100,000 cfu/100mL to 18,000,000 cfu/100mL.

Wet weather sampling provided a range of concentrations that may be expected to be discharged at times of combined sewer overflows. Wet weather enterococcus samples generally ranged from 1,800 cfu/100mL to 4,500,000 cfu/100mL, although a 30,000,000 cfu/100mL was reported in one sample. Fecal coliform samples generally ranged from 4,100 cfu/100mL to 4,600,000 cfu/100mL, although a 120,000,000 cfu/100mL was reported in one sample. All wet weather samples showed data starting with high concentrations at the beginning of the event and dropping during the event, indicating a first flush followed by more dilution as rainfall fell and wet weather flow increased.

The NJ CSO Group was also performing stormwater and CSO sampling at the same time for the hydraulically connected permittees in northern New Jersey. CSO samples were collected in Paterson, Newark, Harrison and Kearny. In general, their wet weather CSO data ranged from 625,000 cfu/100mL to 8,500,00 cfu/100mL for enterococcus and 2,700.000 cfu/100mL to 72,000,000 cfu/100mL for fecal coliform. The Authority's data was in the same range as the NJ CSO Group data.

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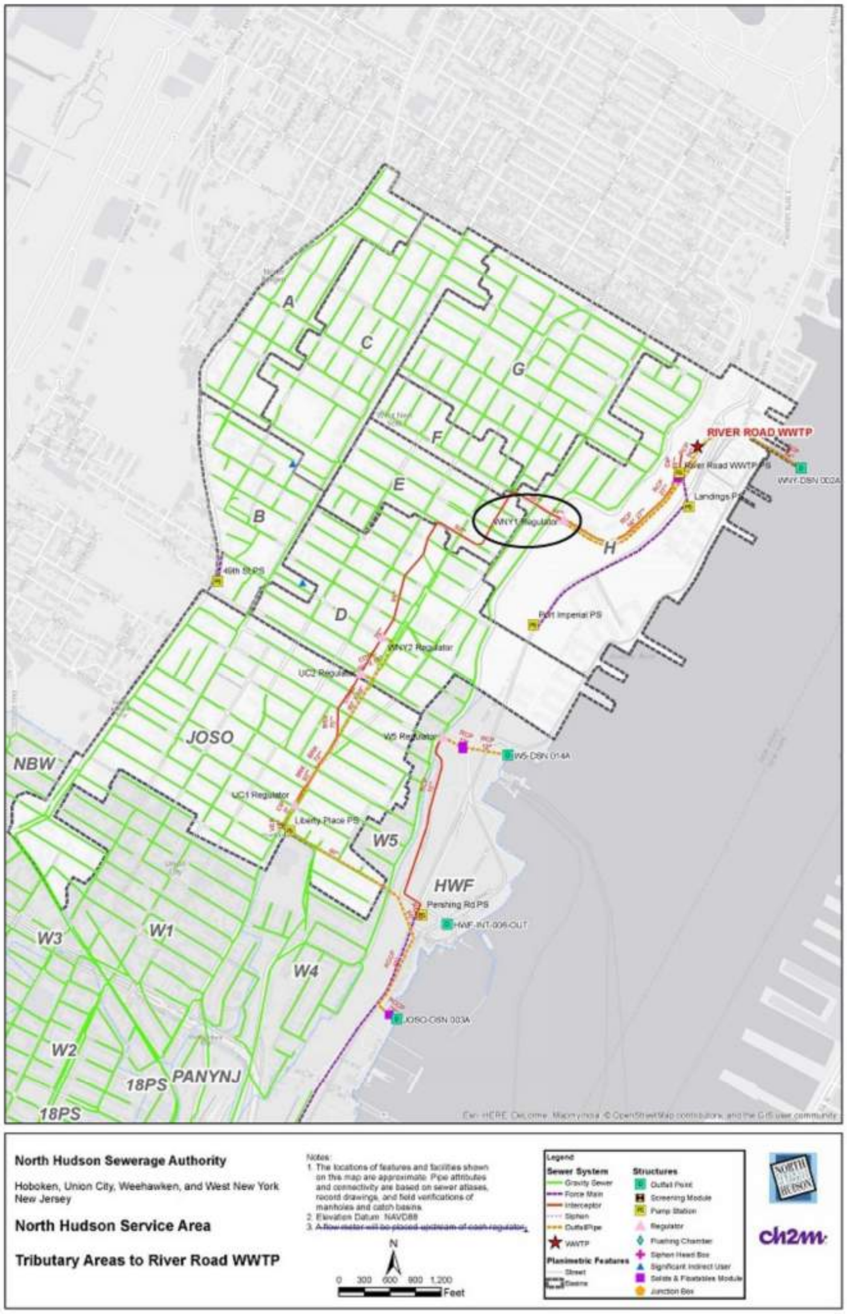
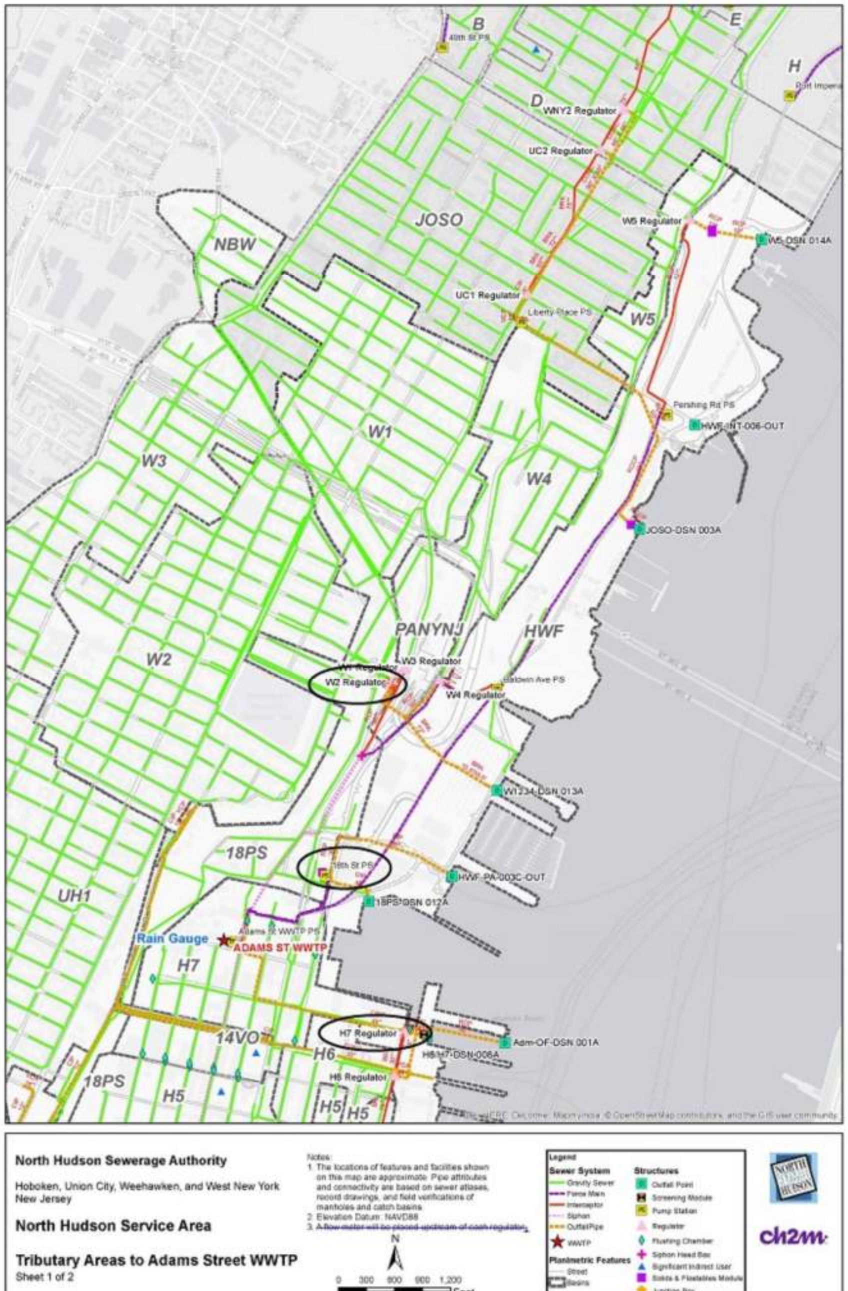


CH2M HILL ENGINEERS, INC. 15 OF 17

NORTH HUDSON SEWERAGE AUTHORITY
LONG TERM CONTROL PLAN COMBINED SEWER OVERFLOW WATER QUALITY SAMPLING



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W3
W2
W2 Regulator
W4 Regulator
PANYNJ
18PS
W1234-DSN 013A
HWF
HWF-PA-003C-OUT
18PS-DSN 012A
UH1
Rain Gauge
ADAMS ST WWTP
H7
H7 Regulator
Adm-OF-DSN 001A
H6/H7-DSN-008A
14VO
H6
H6 Regulator
18PS
H5 Regulator
H5-DSN 006A
H3
H5
H4
HSI
H3
H4
HSI/Stevens Regulator
H4 Regulator
H3/H4/HSI-DSN 005A
H1
H3
H3 Regulator
H2
H2 Regulator
H2-DSN-003A
H1 WWPS
H1 Regulator
HWF
H1-DSN-002A
North Hudson Sewerage Authority
Hoboken, Union City, Weehawken, and West New York
New Jersey
North Hudson Service Area
Tributary Areas to Adams Street WWTP
Sheet 2 of 2
Notes:
1. The locations of features and facilities shown on this map are approximate. Pipe attributes and connectivity are based on sewer atlases, record drawings, and field verifications of manholes and catch basins.
2. Elevation Datum: NAVD88
3. ~~A flow meter will be placed upstream of each regulator.~~
N
0 300 600 900 1,200
Feet
Legend
Sewer System
Gravity Sewer
Force Main
Interceptor
Siphon
OutfallPipe
WWTP
Planimetric Features
Street
Basins
Structures
Outfall Point
Screening Module
Pump Station
Regulator
Flushing Chamber
Siphon Head Box
Significant Indirect User
Solids & Floatables Module
Junction Box
ch2m

11.3 Appendix C– Wet and Dry Days

Summary of Dry and Wet Weather Days for the Monitoring Period

DATE	Rainfall (in)	Dry/Wet	Weekday/Weekend
5/17/2016	0.00	Wet	Weekday
5/18/2016	0.00	Wet	Weekday
5/19/2016	0.00	Dry	Weekday
5/20/2016	0.00	Dry	Weekday
5/21/2016	0.03	Wet	Weekend
5/22/2016	0.08	Wet	Weekend
5/23/2016	0.00	Wet	Weekday
5/24/2016	0.16	Wet	Weekday
5/25/2016	0.00	Wet	Weekday
5/26/2016	0.00	Wet	Weekday
5/27/2016	0.00	Dry	Weekday
5/28/2016	0.00	Dry	Weekend
5/29/2016	0.00	Dry	Weekend
5/30/2016	1.38	Wet	Weekday
5/31/2016	0.00	Wet	Weekday
6/1/2016	0.00	Wet	Weekday
6/2/2016	0.00	Wet	Weekday
6/3/2016	0.03	Wet	Weekday
6/4/2016	0.58	Wet	Weekend
6/5/2016	0.96	Wet	Weekend
6/6/2016	0.00	Wet	Weekday
6/7/2016	0.00	Wet	Weekday
6/8/2016	0.40	Wet	Weekday
6/9/2016	0.00	Wet	Weekday
6/10/2016	0.00	Wet	Weekday
6/11/2016	0.00	Wet	Weekend
6/12/2016	0.00	Dry	Weekend
6/13/2016	0.00	Dry	Weekday
6/14/2016	0.00	Dry	Weekday
6/15/2016	0.00	Dry	Weekday
6/16/2016	0.20	Wet	Weekday
6/17/2016	0.00	Wet	Weekday
6/18/2016	0.00	Wet	Weekend
6/19/2016	0.00	Dry	Weekend
6/20/2016	0.00	Dry	Weekday
6/21/2016	0.00	Dry	Weekday
6/22/2016	0.00	Dry	Weekday

DATE	Rainfall (in)	Dry/Wet	Weekday/Weekend
6/23/2016	0.00	Dry	Weekday
6/24/2016	0.00	Dry	Weekday
6/25/2016	0.00	Dry	Weekend
6/26/2016	0.00	Dry	Weekend
6/27/2016	0.18	Wet	Weekday
6/28/2016	0.43	Wet	Weekday
6/29/2016	0.04	Wet	Weekday
6/30/2016	0.00	Wet	Weekday
7/1/2016	1.28	Wet	Weekday
7/2/2016	0.00	Wet	Weekend
7/3/2016	0.00	Wet	Weekend
7/4/2016	0.27	Wet	Weekday
7/5/2016	1.15	Wet	Weekday
7/6/2016	0.00	Wet	Weekday
7/7/2016	0.01	Wet	Weekday
7/8/2016	0.02	Wet	Weekday
7/9/2016	0.38	Wet	Weekend
7/10/2016	0.00	Wet	Weekend
7/11/2016	0.00	Wet	Weekday
7/12/2016	0.00	Wet	Weekday
7/13/2016	0.00	Dry	Weekday
7/14/2016	0.62	Wet	Weekday
7/15/2016	0.00	Wet	Weekday
7/16/2016	0.00	Wet	Weekend
7/17/2016	0.00	Wet	Weekend
7/18/2016	0.32	Wet	Weekday
7/19/2016	0.00	Wet	Weekday
7/20/2016	0.00	Wet	Weekday
7/21/2016	0.00	Wet	Weekday
7/22/2016	0.00	Dry	Weekday
7/23/2016	0.00	Dry	Weekend
7/24/2016	0.00	Dry	Weekend
7/25/2016	0.77	Wet	Weekday
7/26/2016	0.00	Wet	Weekday
7/27/2016	0.00	Wet	Weekday
7/28/2016	0.00	Wet	Weekday
7/29/2016	0.86	Wet	Weekday
7/30/2016	0.24	Wet	Weekend
7/31/2016	0.72	Wet	Weekend
8/1/2016	0.05	Wet	Weekday
8/2/2016	0.00	Wet	Weekday
8/3/2016	0.00	Wet	Weekday
8/4/2016	0.00	Dry	Weekday

DATE	Rainfall (in)	Dry/Wet	Weekday/Weekend
8/5/2016	0.00	Dry	Weekday
8/6/2016	0.09	Wet	Weekend
8/7/2016	0.00	Wet	Weekend
8/8/2016	0.00	Wet	Weekday
8/9/2016	0.00	Dry	Weekday
8/10/2016	0.08	Wet	Weekday
8/11/2016	0.00	Wet	Weekday
8/12/2016	0.34	Wet	Weekday
8/13/2016	0.00	Wet	Weekend
8/14/2016	0.13	Wet	Weekend
8/15/2016	0.00	Wet	Weekday
8/16/2016	0.23	Wet	Weekday
8/17/2016	0.00	Wet	Weekday
8/18/2016	0.03	Wet	Weekday
8/19/2016	0.00	Wet	Weekday
8/20/2016	0.02	Wet	Weekend
8/21/2016	0.15	Wet	Weekend
8/22/2016	0.00	Wet	Weekday
8/23/2016	0.00	Wet	Weekday
8/24/2016	0.00	Dry	Weekday
8/25/2016	0.00	Dry	Weekday
8/26/2016	0.00	Dry	Weekday
8/27/2016	0.00	Dry	Weekend
8/28/2016	0.00	Dry	Weekend
8/29/2016	0.00	Dry	Weekday
8/30/2016	0.00	Dry	Weekday
8/31/2016	0.00	Dry	Weekday
9/1/2016	0.56	Wet	Weekday
9/2/2016	0.00	Wet	Weekday
9/3/2016	0.00	Wet	Weekend
9/4/2016	0.00	Wet	Weekend
9/5/2016	0.00	Dry	Weekday
9/6/2016	0.00	Dry	Weekday
9/7/2016	0.00	Dry	Weekday
9/8/2016	0.00	Dry	Weekday
9/9/2016	0.11	Wet	Weekday
9/10/2016	0.05	Wet	Weekend
9/11/2016	0.00	Wet	Weekend
9/12/2016	0.00	Wet	Weekday
9/13/2016	0.00	Dry	Weekday
9/14/2016	0.64	Wet	Weekday

DATE	Rainfall (in)	Dry/Wet	Weekday/Weekend
9/15/2016	0.00	Wet	Weekday
9/16/2016	0.00	Wet	Weekday
9/17/2016	0.00	Wet	Weekend
9/18/2016	0.00	Dry	Weekend
9/19/2016	0.45	Wet	Weekday
9/20/2016	0.00	Wet	Weekday
9/21/2016	0.00	Wet	Weekday
9/22/2016	0.00	Wet	Weekday
9/23/2016	0.00	Dry	Weekday
9/24/2016	0.28	Wet	Weekend
9/25/2016	0.00	Wet	Weekend
9/26/2016	0.00	Wet	Weekday
9/27/2016	0.25	Wet	Weekday
9/28/2016	0.00	Wet	Weekday
9/29/2016	0.00	Wet	Weekday
9/30/2016	0.41	Wet	Weekday
10/1/2016	0.00	Wet	Weekend
10/2/2016	0.00	Wet	Weekend
10/3/2016	0.00	Wet	Weekday
10/4/2016	0.00	Dry	Weekday
10/5/2016	0.00	Dry	Weekday
10/6/2016	0.00	Dry	Weekday
10/7/2016	0.00	Dry	Weekday
10/8/2016	0.13	Wet	Weekend
10/9/2016	0.52	Wet	Weekend
10/10/2016	0.00	Wet	Weekday
10/11/2016	0.00	Wet	Weekday
10/12/2016	0.00	Wet	Weekday
10/13/2016	0.00	Dry	Weekday
10/14/2016	0.00	Dry	Weekday
10/15/2016	0.00	Dry	Weekend
10/16/2016	0.00	Dry	Weekend
10/17/2016	0.00	Dry	Weekday
10/18/2016	0.00	Dry	Weekday
10/19/2016	0.00	Dry	Weekday
10/20/2016	0.00	Dry	Weekday
10/21/2016	0.00	Dry	Weekday
10/22/2016	0.00	Dry	Weekend
10/23/2016	0.00	Dry	Weekend
10/24/2016	0.00	Dry	Weekday
10/25/2016	0.00	Dry	Weekday
10/26/2016	0.00	Dry	Weekday
10/27/2016	0.00	Dry	Weekday

DATE	Rainfall (in)	Dry/Wet	Weekday/Weekend
10/28/2016	0.00	Dry	Weekday
10/29/2016	0.00	Dry	Weekend
10/30/2016	0.00	Dry	Weekend
10/31/2016	0.00	Dry	Weekday
11/1/2016	0.00	Dry	Weekday
11/2/2016	0.00	Dry	Weekday
11/3/2016	0.00	Dry	Weekday
11/4/2016	0.00	Dry	Weekday
11/5/2016	0.00	Dry	Weekend
11/6/2016	0.00	Dry	Weekend
11/7/2016	0.00	Dry	Weekday
11/8/2016	0.00	Dry	Weekday
11/9/2016	0.07	Wet	Weekday
11/10/2016	0.00	Wet	Weekday
11/11/2016	0.00	Wet	Weekday
11/12/2016	0.00	Dry	Weekend
11/13/2016	0.00	Dry	Weekend
11/14/2016	0.00	Dry	Weekday
11/15/2016	1.50	Wet	Weekday
11/16/2016	0.00	Wet	Weekday

11.4 Appendix D Model Calibration and Output

Calibration Summary Tables

Dry Weather Flow Plots

Modeled versus Metered Plots

Calibration and Validation Individual Storm Plots

UC1 Calibration Summary

START DATE	END DATE	Calibration Validation	RAINFALL DEPTH (IN)	Rainfall in/hr	Metered Volume	Modeled Volume	Volume Diff %	Peak Flow	Modeled Peak	Peak Diff %	Meter Depth	Modeled Depth	Depth Diff
6/19/2016 0:00	6/27/2016 0:00	Dry	0.00	0.0	16.16	16.37	1%	2.87	2.56	-11%	1.7	1.7	0.0
5/30/2016 1:20	5/30/2016 10:40	Calibration	1.38	2.4	3.20	3.66	14%	41.86	51.82	24%	4.0	3.5	-0.5
7/1/2016 15:45	7/1/2016 22:20	Validation	1.28	2.8	2.21	2.58	17%	43.55	47.23	8%	4.3	3.3	-1.0
9/14/2016 10:10	9/14/2016 18:20	Validation	0.64	0.7	1.62	1.73	7%	12.86	13.46	5%	2.4	2.2	-0.2
9/19/2016 5:25	9/19/2016 16:20	Calibration	0.45	3.4	1.93	1.80	-7%	43.85	52.93	21%	4.5	3.5	-1.0
9/24/2016 0:50	9/24/2016 5:30	Calibration	0.28	0.2	0.84	0.77	-8%	11.27	11.21	-1%	2.3	2.1	-0.2
10/8/2016 13:20	10/9/2016 13:50	Validation	0.65	0.2	3.33	3.27	-2%	13.31	12.82	-4%	2.4	2.2	-0.2
11/15/2016 4:05	11/15/2016 16:50	Calibration	1.50	1.0	4.06	4.14	2%	19.83	24.55	24%	2.8	2.6	-0.2
6/4/2016 18:10	6/5/2016 21:05	Check	1.54	0.1	5.86	5.44	-7%	6.58	6.63	1%	2.0	1.9	-0.1
6/8/2016 11:55	6/8/2016 17:25	Check	0.40	2.3	1.26	1.26	0%	49.28	49.46	0%	4.5	3.4	-1.1
6/16/2016 4:25	6/16/2016 8:10	Check	0.20	1.8	0.73	0.58	-20%	46.56	46.29	-1%	4.0	3.3	-0.7
6/27/2016 20:35	6/29/2016 2:10	Check	0.65	0.8	3.49	3.80	9%	16.31	19.74	21%	2.6	2.4	-0.1
7/4/2016 19:45	7/5/2016 6:35	Check	1.42	0.4	3.66	3.80	4%	10.88	9.26	-15%	2.3	2.1	-0.2
7/9/2016 21:20	7/10/2016 0:30	Check	0.38	1.3	1.01	0.99	-2%	13.34	25.24	89%	2.4	2.6	0.2
7/14/2016 15:05	7/14/2016 17:30	Check	0.62	2.2	1.21	1.42	17%	32.04	24.72	-23%	3.1	2.6	-0.5
7/18/2016 15:45	7/18/2016 18:35	Check	0.32	0.5	0.92	0.84	-9%	14.71	15.28	4%	2.5	2.3	-0.2
7/25/2016 16:10	7/25/2016 20:10	Check	0.77	3.6	1.86	1.89	2%	29.31	35.32	20%	3.2	2.9	-0.3
7/29/2016 0:15	7/29/2016 10:20	Check	0.86	1.0	2.23	2.48	11%	31.34	27.13	-13%	3.4	2.7	-0.7
7/31/2016 7:35	8/1/2016 1:50	Check	0.77	0.8	3.32	3.12	-6%	21.29	20.83	-2%	2.8	2.5	-0.3
8/12/2016 0:00	8/12/2016 20:05	Check	0.34	0.4	2.38	2.33	-2%	14.96	11.35	-24%	2.5	2.1	-0.3
9/1/2016 0:15	9/1/2016 16:25	Check	0.56	2.4	2.27	2.31	2%	30.24	22.29	-26%	3.2	2.5	-0.7
9/27/2016 1:20	9/27/2016 11:45	Check	0.25	2.6	1.28	1.26	-2%	48.52	37.47	-23%	4.5	3.0	-1.5
9/30/2016 9:05	9/30/2016 23:59	Check	0.41	1.3	2.32	2.10	-10%	39.52	28.10	-29%	4.5	2.7	-1.8

Meets CIWEM Criteria

UC2 Calibration Summary

START DATE	END DATE	Calibration Validation	RAINFALL DEPTH (IN)	Rainfall in/hr	Metered Volume	Modeled Volume	Volume Diff %	Peak Flow	Modeled Peak	Peak Diff %	Meter Depth	Modeled Depth	Depth Diff
6/19/2016 0:00	6/27/2016 0:00	Dry	0.00	0.0	18.01	18.62	3%	3.10	2.96	-5%	1.4	1.5	0.1
5/30/2016 1:20	5/30/2016 10:40	Calibration	1.38	2.4	4.30	4.43	3%	70.62	65.72	-7%	3.1	2.9	-0.2
7/1/2016 15:45	7/1/2016 22:20	Validation	1.28	2.8	2.94	3.08	5%	76.96	53.48	-31%	3.3	2.7	-0.7
9/14/2016 10:10	9/14/2016 18:20	Validation	0.64	0.7	2.17	2.01	-7%	17.22	17.71	3%	1.9	2.1	0.2
9/19/2016 5:25	9/19/2016 16:20	Calibration	0.45	3.4	2.42	2.25	-7%	60.19	69.37	15%	4.1	2.9	-1.2
9/24/2016 0:50	9/24/2016 5:30	Calibration	0.28	0.2	1.03	0.97	-5%	15.82	15.14	-4%	1.9	2.0	0.1
10/8/2016 13:20	10/9/2016 13:50	Validation	0.65	0.2	4.12	4.06	-1%	17.61	16.86	-4%	1.9	2.1	0.1
11/15/2016 4:05	11/15/2016 16:50	Calibration	1.50	1.0	5.48	5.30	-3%	34.33	30.54	-11%	2.2	2.3	0.2
6/4/2016 18:10	6/5/2016 21:05	Check	1.54	0.1	7.37	6.60	-11%	8.01	8.96	12%	1.8	1.9	0.1
6/8/2016 11:55	6/8/2016 17:25	Check	0.40	2.3	1.59	1.61	2%	68.35	64.27	-6%	3.0	2.8	-0.2
6/16/2016 4:25	6/16/2016 8:10	Check	0.20	1.8	0.88	0.72	-18%	61.34	54.42	-11%	3.1	2.7	-0.4
6/27/2016 20:35	6/29/2016 2:10	Check	0.65	0.8	3.97	4.60	16%	22.01	25.81	17%	2.0	2.2	0.3
7/4/2016 19:45	7/5/2016 6:35	Check	1.42	0.4	4.76	4.69	-2%	13.07	12.29	-6%	1.9	2.0	0.1
7/9/2016 21:20	7/10/2016 0:30	Check	0.38	1.3	1.26	1.24	-2%	20.71	29.25	41%	1.9	2.3	0.4
7/14/2016 15:05	7/14/2016 17:30	Check	0.62	2.2	1.67	1.65	-1%	55.42	30.71	-45%	2.9	2.3	-0.5
7/18/2016 15:45	7/18/2016 18:35	Check	0.32	0.5	1.29	1.06	-18%	19.78	19.36	-2%	1.9	2.1	0.2
7/25/2016 16:10	7/25/2016 20:10	Check	0.77	3.6	2.73	2.38	-13%	36.47	36.65	1%	2.2	2.4	0.2
7/29/2016 0:15	7/29/2016 10:20	Check	0.86	1.0	2.86	3.21	12%	45.70	31.77	-30%	2.5	2.3	-0.2
7/31/2016 7:35	8/1/2016 1:50	Check	0.77	0.8	4.11	3.81	-7%	39.10	25.89	-34%	2.3	2.2	-0.1
8/12/2016 0:00	8/12/2016 20:05	Check	0.34	0.4	2.89	2.76	-5%	18.87	13.99	-26%	1.9	2.0	0.1
9/1/2016 0:15	9/1/2016 16:25	Check	0.56	2.4	2.88	2.82	-2%	49.74	25.04	-50%	2.7	2.2	-0.5
9/27/2016 1:20	9/27/2016 11:45	Check	0.25	2.6	1.54	1.54	0%	51.31	39.70	-23%	2.6	2.5	-0.2
9/30/2016 9:05	9/30/2016 23:59	Check	0.41	1.3	2.80	2.63	-6%	40.07	31.09	-22%	2.3	2.3	0.0

Meets CIWEM Criteria

WNY2 Calibration Summary

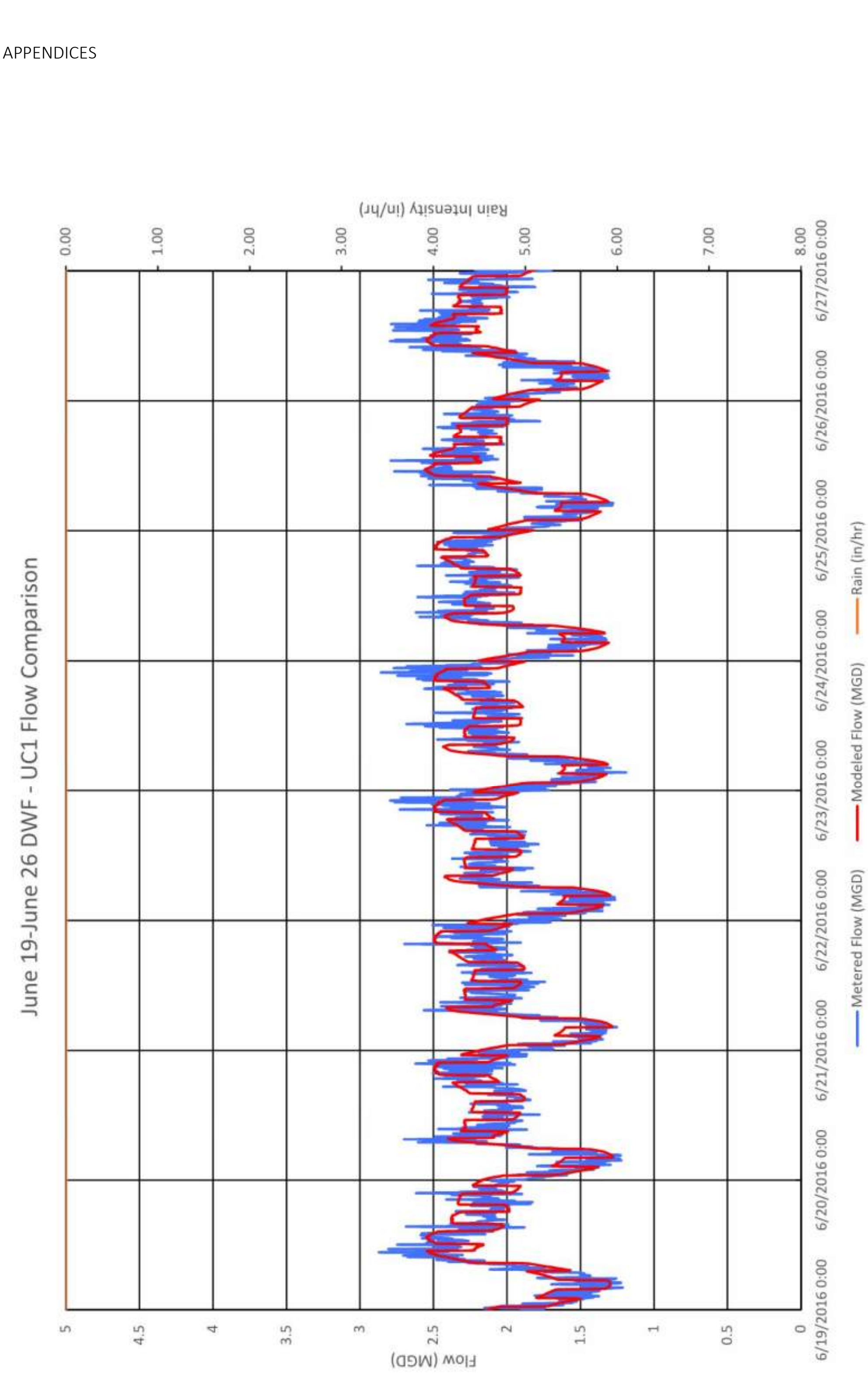
START DATE	END DATE	Calibration Validation	RAINFALL DEPTH (IN)	Rainfall in/hr	Metered Volume	Modeled Volume	Volume Diff %	Peak Flow	Modeled Peak	Peak Diff %	Meter Depth	Modeled Depth	Depth Diff
6/19/2016 0:00	6/27/2016 0:00	Dry	0.00	0.0	26.32	26.80	2%	4.63	4.31	-7%	2.0	2.0	-0.1
5/30/2016 1:20	5/30/2016 10:40	Calibration	1.38	2.4	5.32	6.17	16%	73.50	75.47	3%	4.1	3.1	-1.0
7/1/2016 15:45	7/1/2016 22:20	Validation	1.28	2.8	3.91	3.95	1%	73.41	66.96	-9%	4.3	3.0	-1.3
9/14/2016 10:10	9/14/2016 18:20	Validation	0.64	0.7	2.37	2.68	13%	21.05	23.55	12%	2.7	2.4	-0.2
9/19/2016 5:25	9/19/2016 16:20	Calibration	0.45	3.4	3.18	3.29	4%	80.75	76.01	-6%	6.4	3.1	-3.3
9/24/2016 0:50	9/24/2016 5:30	Calibration	0.28	0.2	1.29	1.41	9%	18.96	21.02	11%	2.7	2.4	-0.3
10/8/2016 13:20	10/9/2016 13:50	Validation	0.65	0.2	4.93	6.07	23%	20.41	23.42	15%	2.7	2.4	-0.2
11/15/2016 4:05	11/15/2016 16:50	Calibration	1.50	1.0	13.38	7.48	-44%	81.03	39.23	-52%	3.4	2.7	-0.8
6/4/2016 18:10	6/5/2016 21:05	Check	1.54	0.1	9.07	9.18	1%	9.03	13.69	52%	2.5	2.3	-0.2
6/8/2016 11:55	6/8/2016 17:25	Check	0.40	2.3	2.01	2.36	17%	73.77	71.20	-3%	4.6	3.1	-1.5
6/16/2016 4:25	6/16/2016 8:10	Check	0.20	1.8	1.07	1.02	-4%	74.30	67.12	-10%	3.7	3.0	-0.7
6/27/2016 20:35	6/29/2016 2:10	Check	0.65	0.8	5.83	6.68	15%	25.12	33.44	33%	2.7	2.6	-0.2
7/4/2016 19:45	7/5/2016 6:35	Check	1.42	0.4	6.02	6.57	9%	15.83	17.58	11%	2.6	2.3	-0.3
7/9/2016 21:20	7/10/2016 0:30	Check	0.38	1.3	1.65	1.74	5%	28.95	39.40	36%	2.7	2.7	-0.1
7/14/2016 15:05	7/14/2016 17:30	Check	0.62	2.2	1.94	2.16	11%	45.03	38.13	-15%	2.9	2.6	-0.2
7/18/2016 15:45	7/18/2016 18:35	Check	0.32	0.5	1.47	1.50	2%	23.33	26.58	14%	2.7	2.5	-0.2
7/25/2016 16:10	7/25/2016 20:10	Check	0.77	3.6	2.87	3.28	14%	39.29	50.92	30%	2.8	2.8	0.0
7/29/2016 0:15	7/29/2016 10:20	Check	0.86	1.0	3.63	4.68	29%	55.72	41.77	-25%	2.9	2.7	-0.2
7/31/2016 7:35	8/1/2016 1:50	Check	0.77	0.8	5.50	5.49	0%	46.53	33.40	-28%	2.9	2.6	-0.3
8/12/2016 0:00	8/12/2016 20:05	Check	0.34	0.4	4.08	3.96	-3%	18.20	20.21	11%	2.6	2.4	-0.3
9/1/2016 0:15	9/1/2016 16:25	Check	0.56	2.4	4.03	4.08	1%	51.99	34.18	-34%	2.9	2.6	-0.3
9/27/2016 1:20	9/27/2016 11:45	Check	0.25	2.6	2.03	2.27	12%	64.01	54.19	-15%	3.0	2.9	-0.1
9/30/2016 9:05	9/30/2016 23:59	Check	0.41	1.3	3.28	4.02	23%	57.33	42.26	-26%	2.9	2.7	-0.2

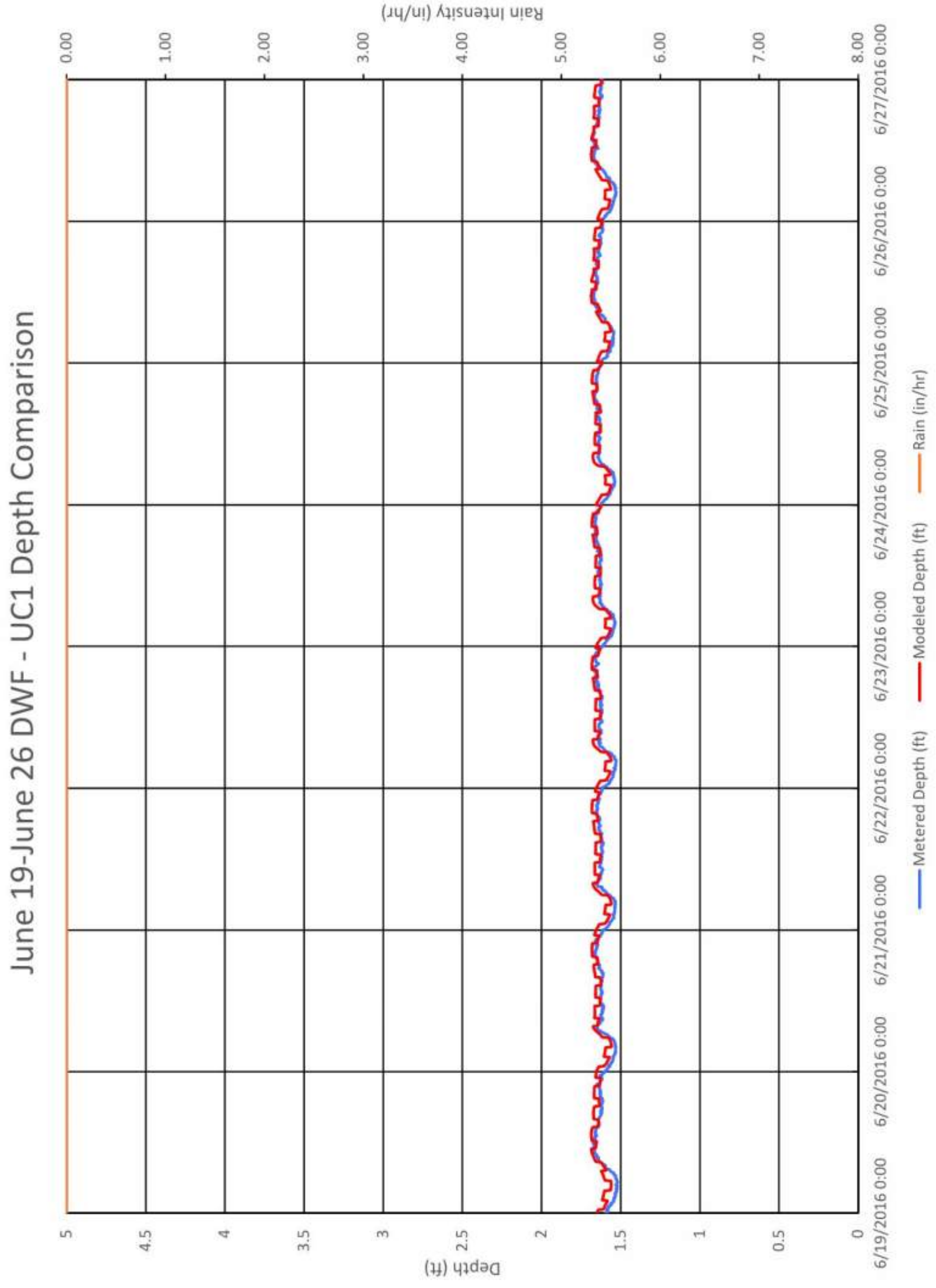
Meter Data Inconsistent   Meets CIWEM Criteria

WNY1 Calibration Summary

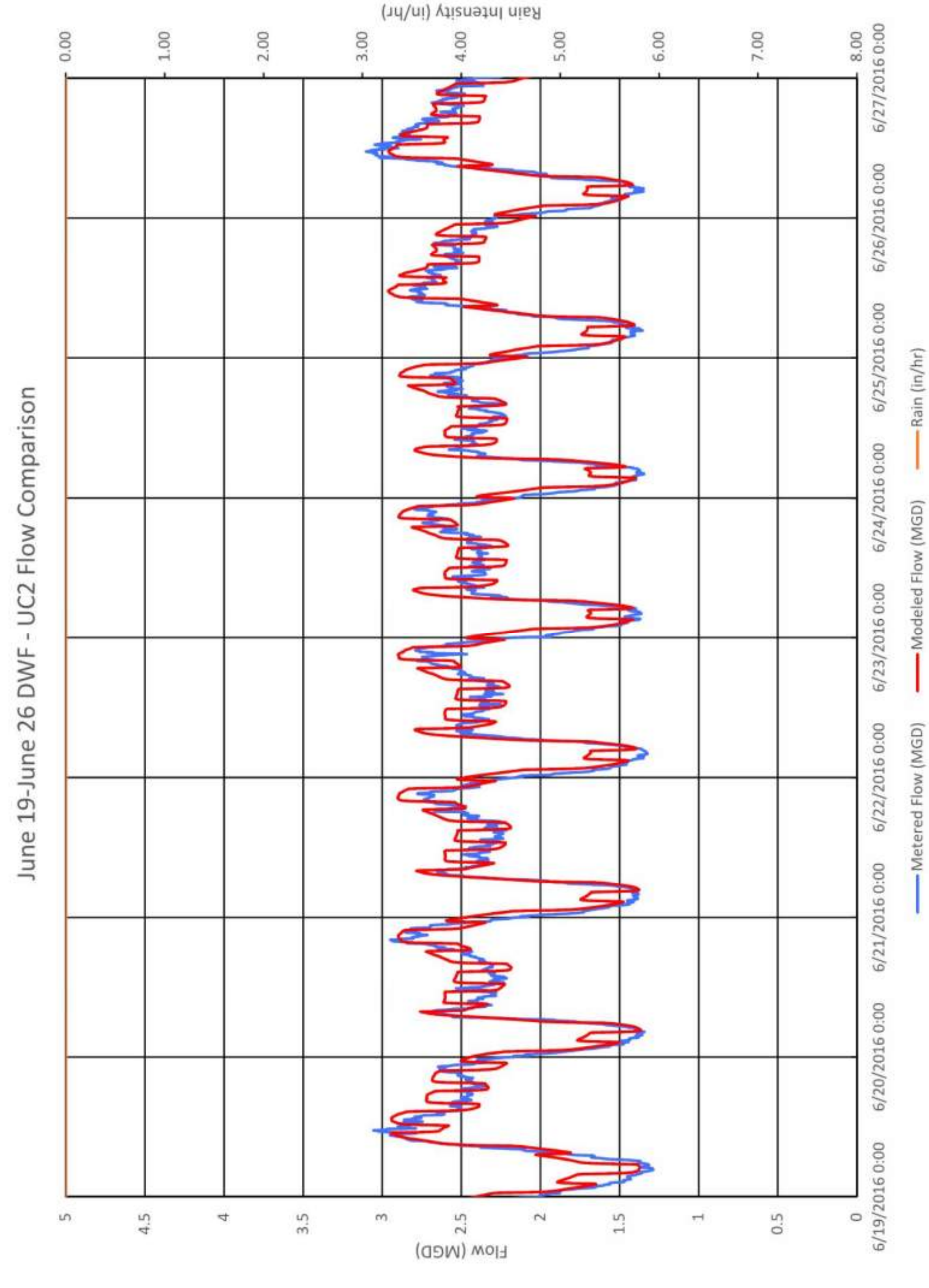
START DATE	END DATE	Calibration Validation	RAINFALL DEPTH (IN)	Rainfall in/hr	Metered Volume	Modeled Volume	Volume Diff %	Peak Flow	Modeled Peak	Peak Diff %	Meter Depth	Modeled Depth	Depth Diff
6/19/2016 0:00	6/27/2016 0:00	Dry	0.00	0.0	54.09	51.26	-5%	9.34	8.30	-11%	1.1	0.9	-0.1
5/30/2016 1:20	5/30/2016 10:40	Calibration	1.38	2.4	11.22	12.87	15%	215.20	185.47	-14%	6.9	6.4	-0.5
7/1/2016 15:45	7/1/2016 22:20	Validation	1.28	2.8	9.55	8.56	-10%	180.70	170.21	-6%	5.3	6.2	0.9
9/14/2016 10:10	9/14/2016 18:20	Validation	0.64	0.7	4.71	5.78	23%	43.01	52.55	22%	2.8	4.0	1.2
9/19/2016 5:25	9/19/2016 16:20	Calibration	0.45	3.4	6.15	6.54	6%	250.30	193.05	-23%	9.2	6.5	-2.7
9/24/2016 0:50	9/24/2016 5:30	Calibration	0.28	0.2	2.51	2.79	11%	36.11	45.20	25%	2.7	3.8	1.1
10/8/2016 13:20	10/9/2016 13:50	Validation	0.65	0.2	10.91	11.88	9%	41.77	49.59	19%	2.8	3.9	1.1
11/15/2016 4:05	11/15/2016 16:50	Calibration	1.50	1.0	13.54	15.36	13%	81.03	90.77	12%	3.4	4.8	1.4
6/4/2016 18:10	6/5/2016 21:05	Check	1.54	0.1	18.51	18.73	1%	19.83	27.23	37%	2.2	3.2	1.1
6/8/2016 11:55	6/8/2016 17:25	Check	0.40	2.3	4.06	4.75	17%	232.20	180.82	-22%	8.5	6.3	-2.2
6/16/2016 4:25	6/16/2016 8:10	Check	0.20	1.8	2.22	2.03	-9%	139.20	166.02	19%	3.9	6.1	2.2
6/27/2016 20:35	6/29/2016 2:10	Check	0.65	0.8	12.45	13.11	5%	55.57	70.58	27%	3.1	4.4	1.3
7/4/2016 19:45	7/5/2016 6:35	Check	1.42	0.4	13.39	13.70	2%	32.32	35.17	9%	2.7	3.5	0.8
7/9/2016 21:20	7/10/2016 0:30	Check	0.38	1.3	3.68	3.62	-2%	80.50	95.08	18%	3.3	4.9	1.6
7/14/2016 15:05	7/14/2016 17:30	Check	0.62	2.2	3.67	4.71	28%	103.00	93.60	-9%	3.9	4.9	1.0
7/18/2016 15:45	7/18/2016 18:35	Check	0.32	0.5	2.85	3.09	8%	51.69	55.86	8%	3.0	4.1	1.1
7/25/2016 16:10	7/25/2016 20:10	Check	0.77	3.6	5.70	6.91	21%	83.97	130.92	56%	3.5	5.5	2.1
7/29/2016 0:15	7/29/2016 10:20	Check	0.86	1.0	7.14	9.48	33%	108.40	100.43	-7%	4.1	5.0	0.9
7/31/2016 7:35	8/1/2016 1:50	Check	0.77	0.8	10.15	11.10	9%	93.08	78.99	-15%	3.5	4.6	1.1
8/12/2016 0:00	8/12/2016 20:05	Check	0.34	0.4	7.70	7.74	1%	41.57	43.10	4%	2.9	3.7	0.8
9/1/2016 0:15	9/1/2016 16:25	Check	0.56	2.4	7.48	8.11	8%	123.60	83.11	-33%	4.8	4.7	-0.2
9/27/2016 1:20	9/27/2016 11:45	Check	0.25	2.6	3.98	4.41	11%	141.30	136.61	-3%	4.5	5.6	1.1
9/30/2016 9:05	9/30/2016 23:59	Check	0.41	1.3	7.08	7.87	11%	172.60	104.87	-39%	6.6	5.1	-1.5

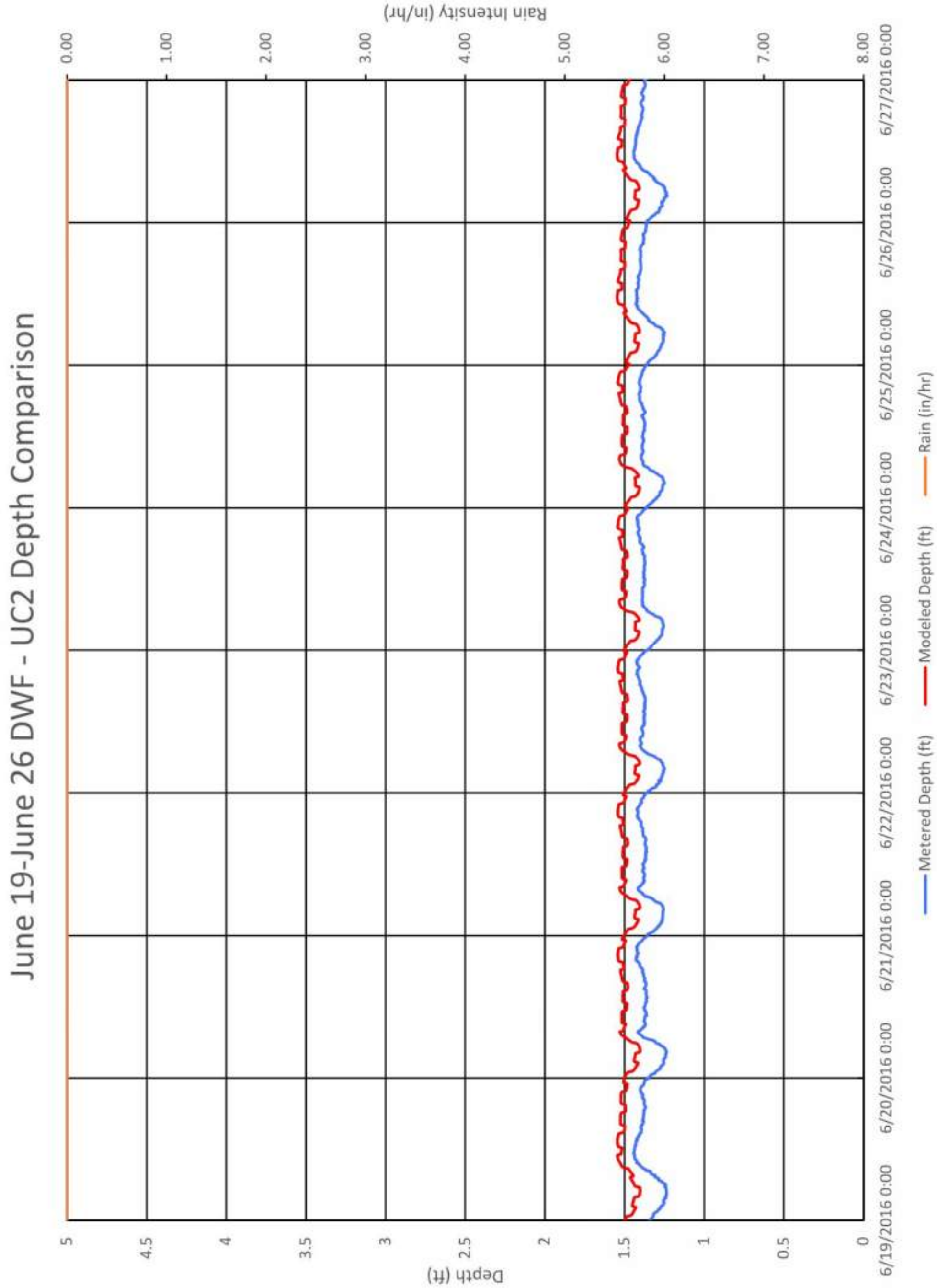
Meets CIWEM Criteria

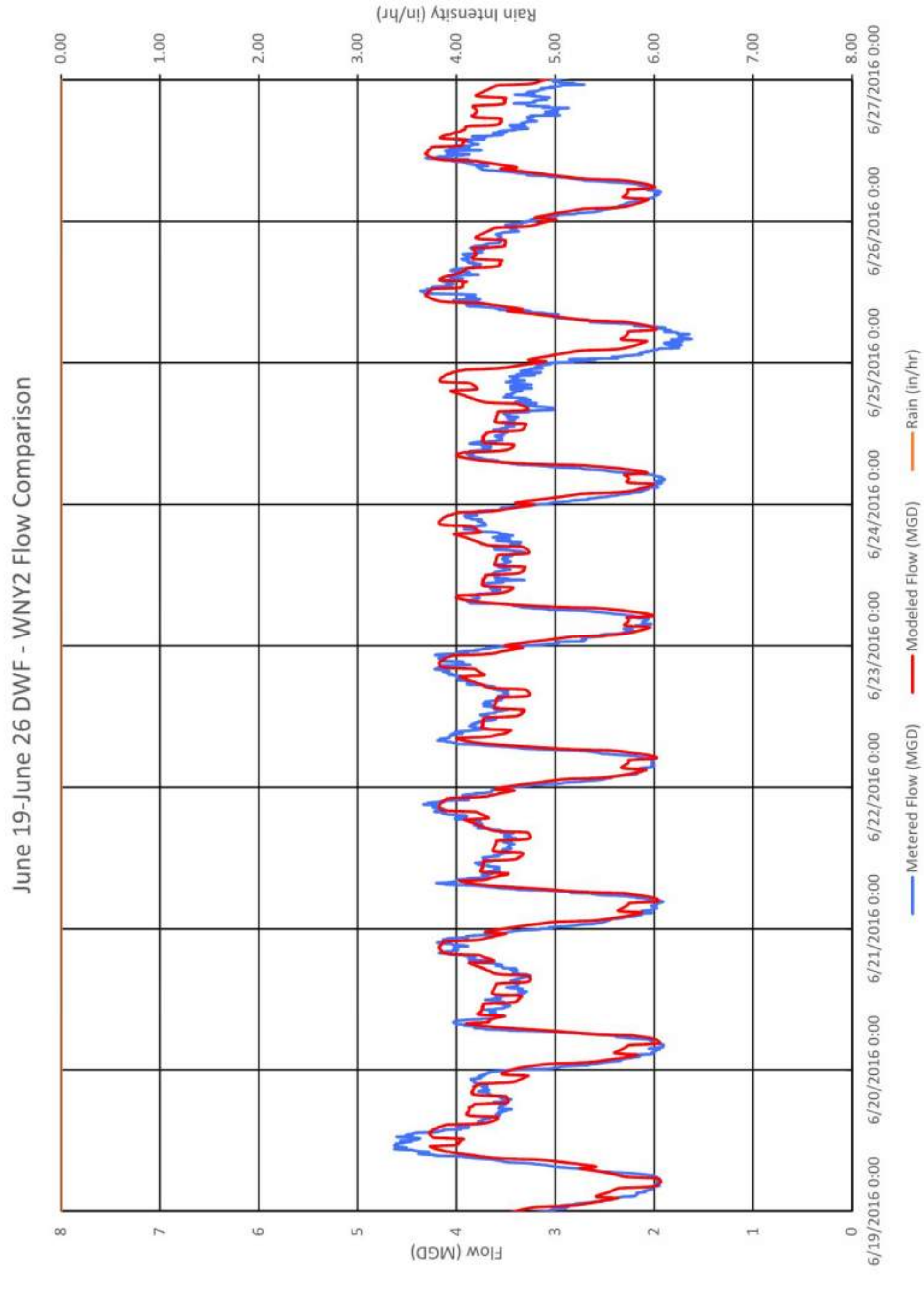

June 19-June 26 DWF - UC1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

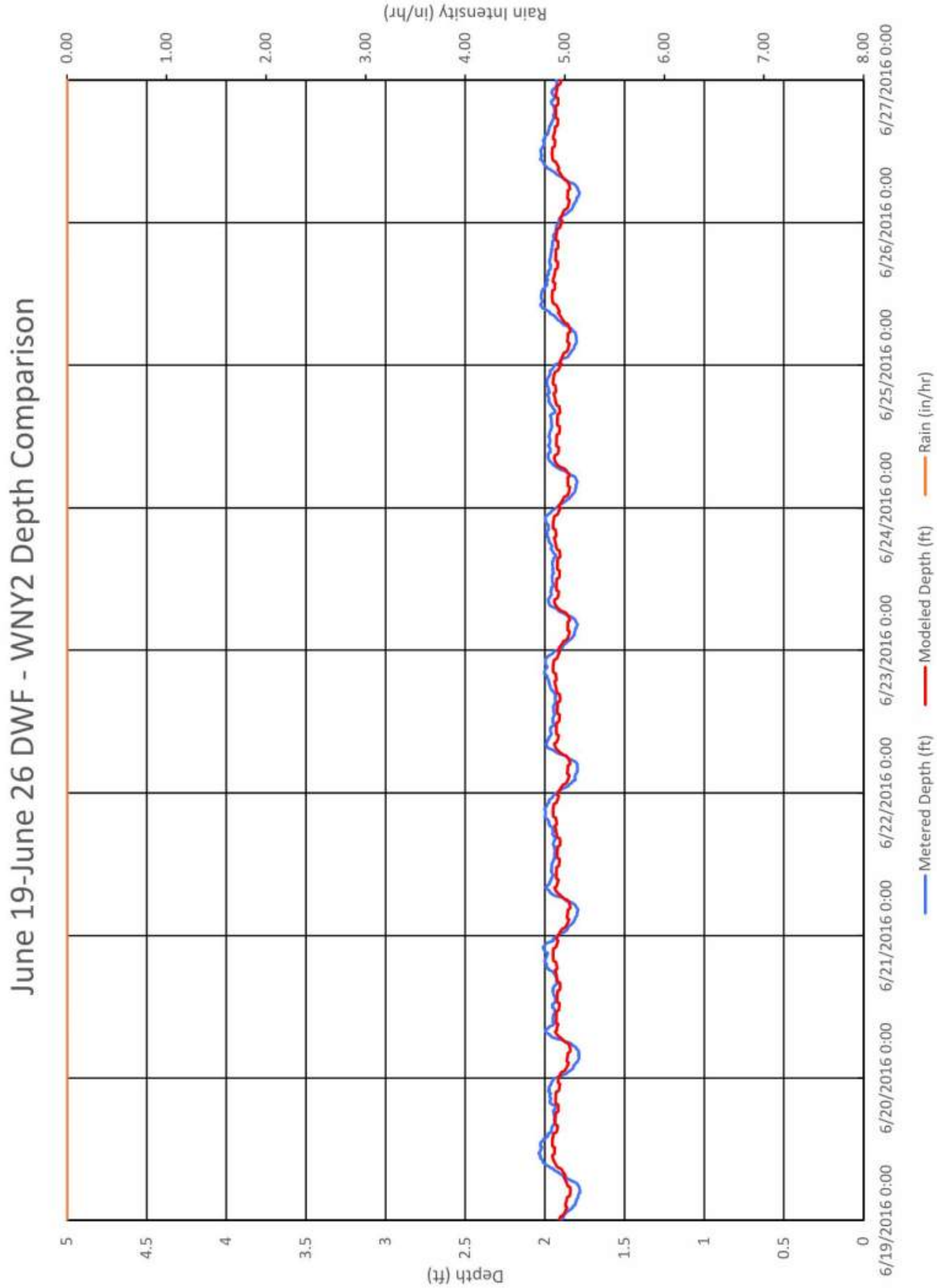


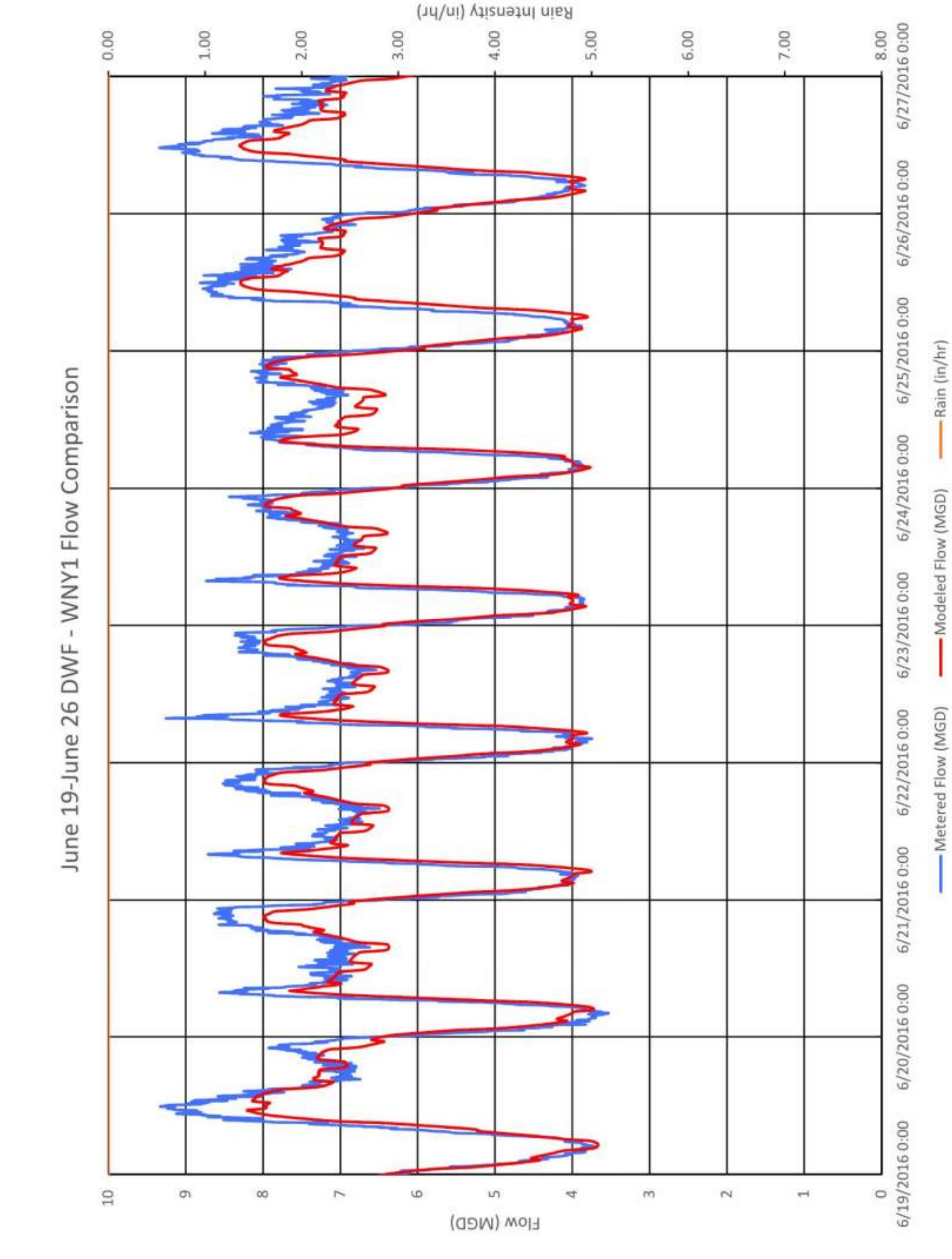
June 19-June 26 DWF - UC1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Depth (ft)
Modeled Depth (ft)
Rain (in/hr)

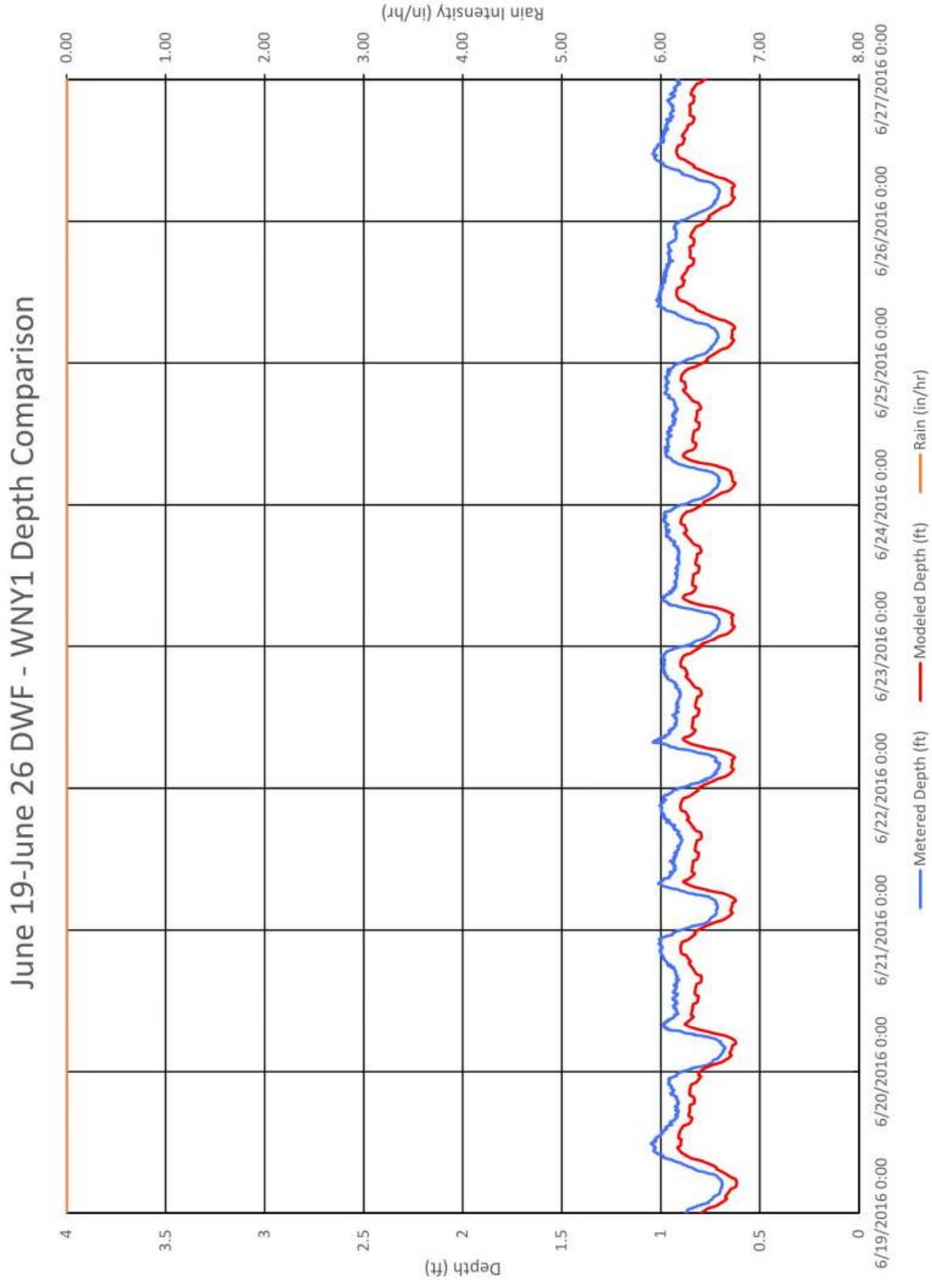

June 19-June 26 DWF - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

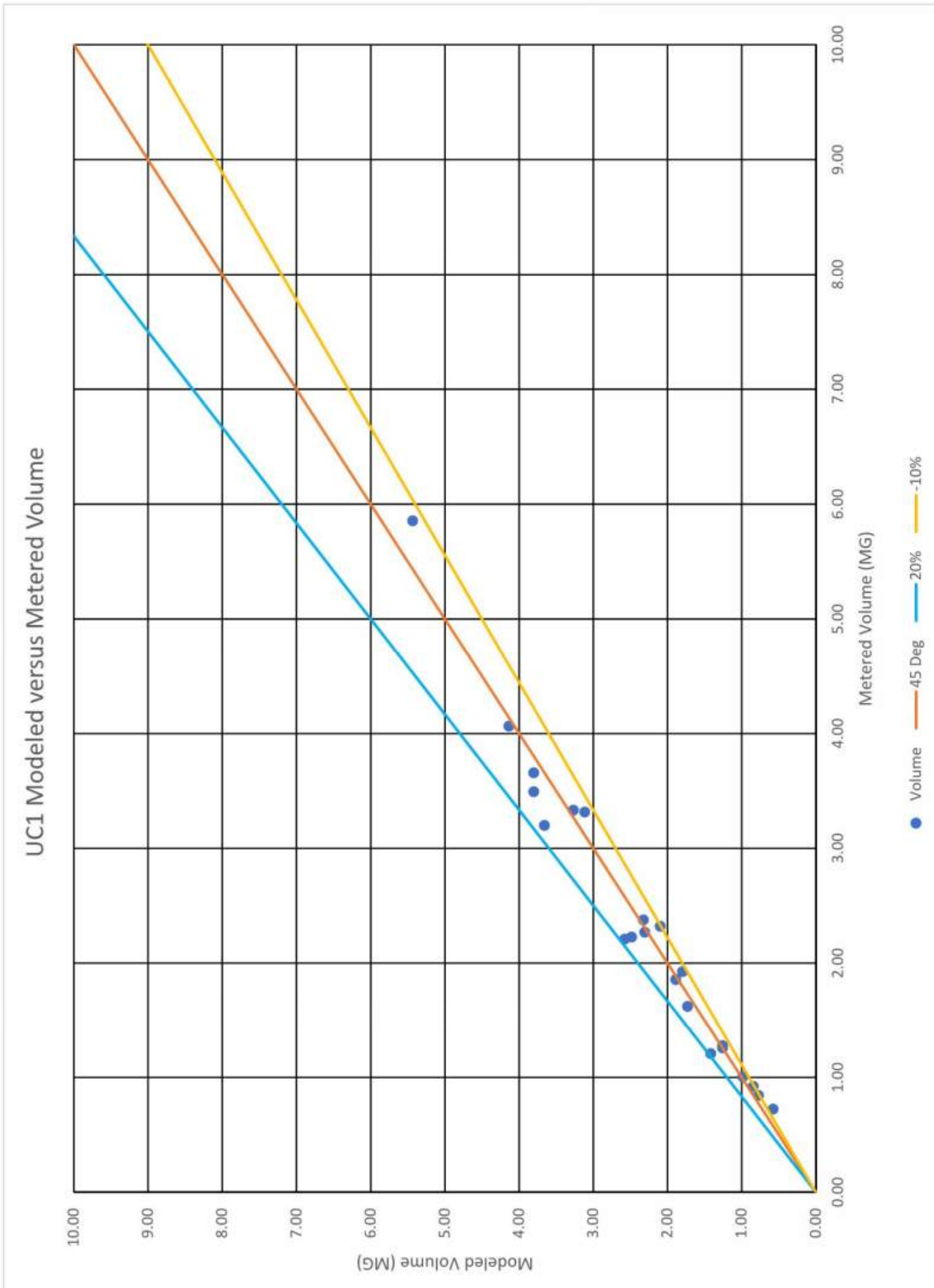

June 19-June 26 DWF - UC2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Depth (ft)
Modeled Depth (ft)
Rain (in/hr)

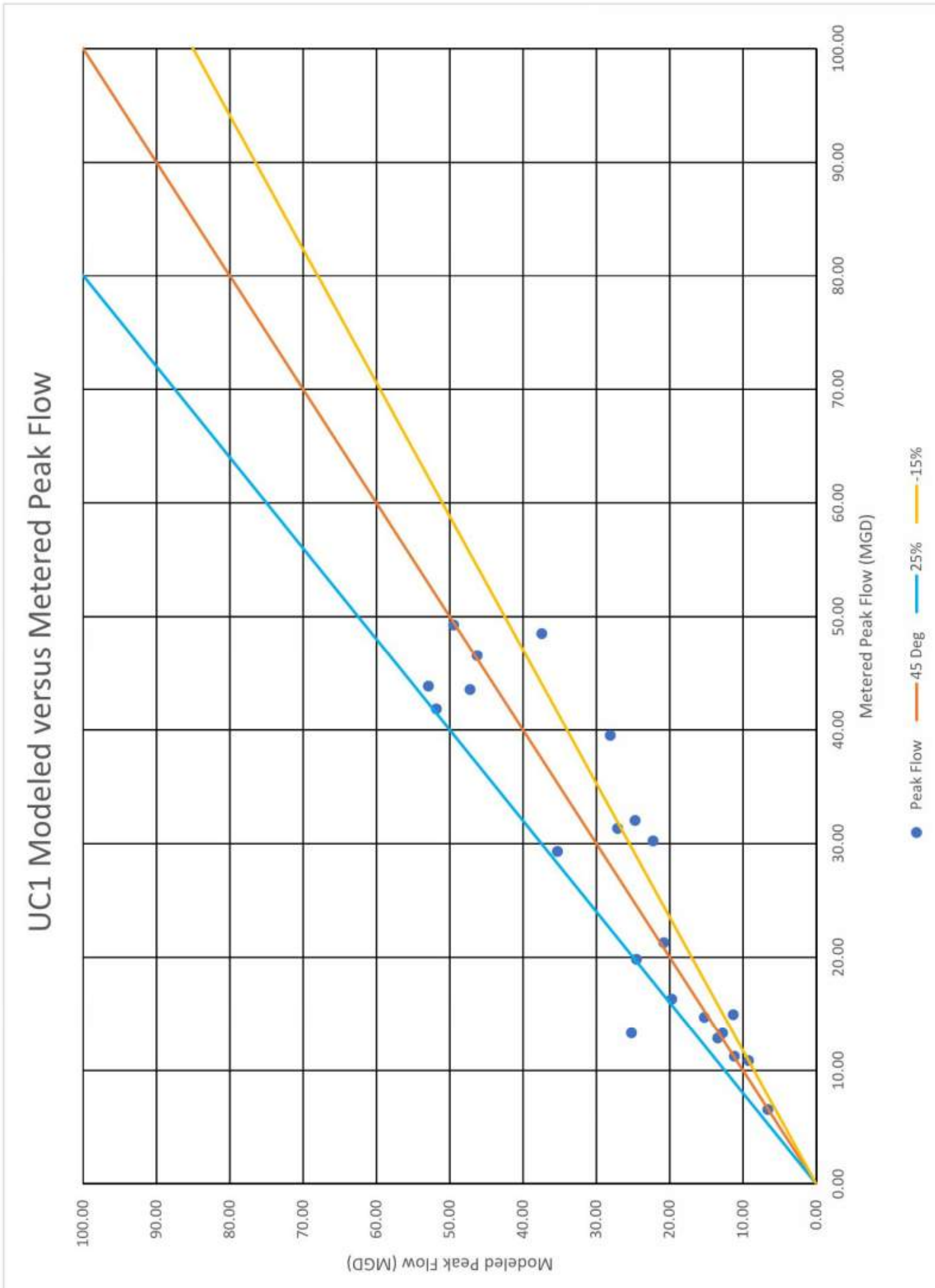

June 19-June 26 DWF - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

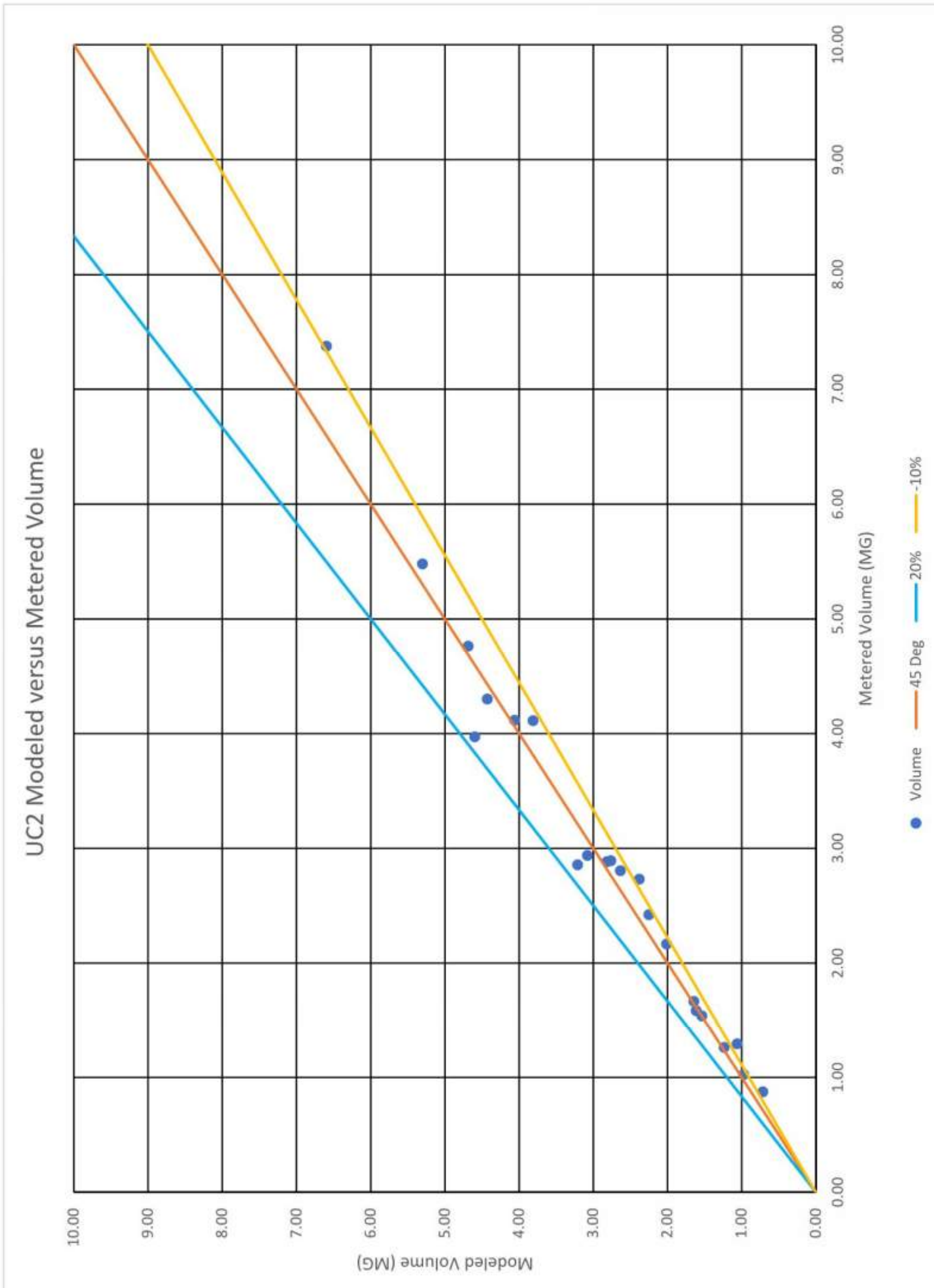

June 19-June 26 DWF - WNY2 Depth Comparison
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Depth (ft)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Depth (ft)
Modeled Depth (ft)
Rain (in/hr)

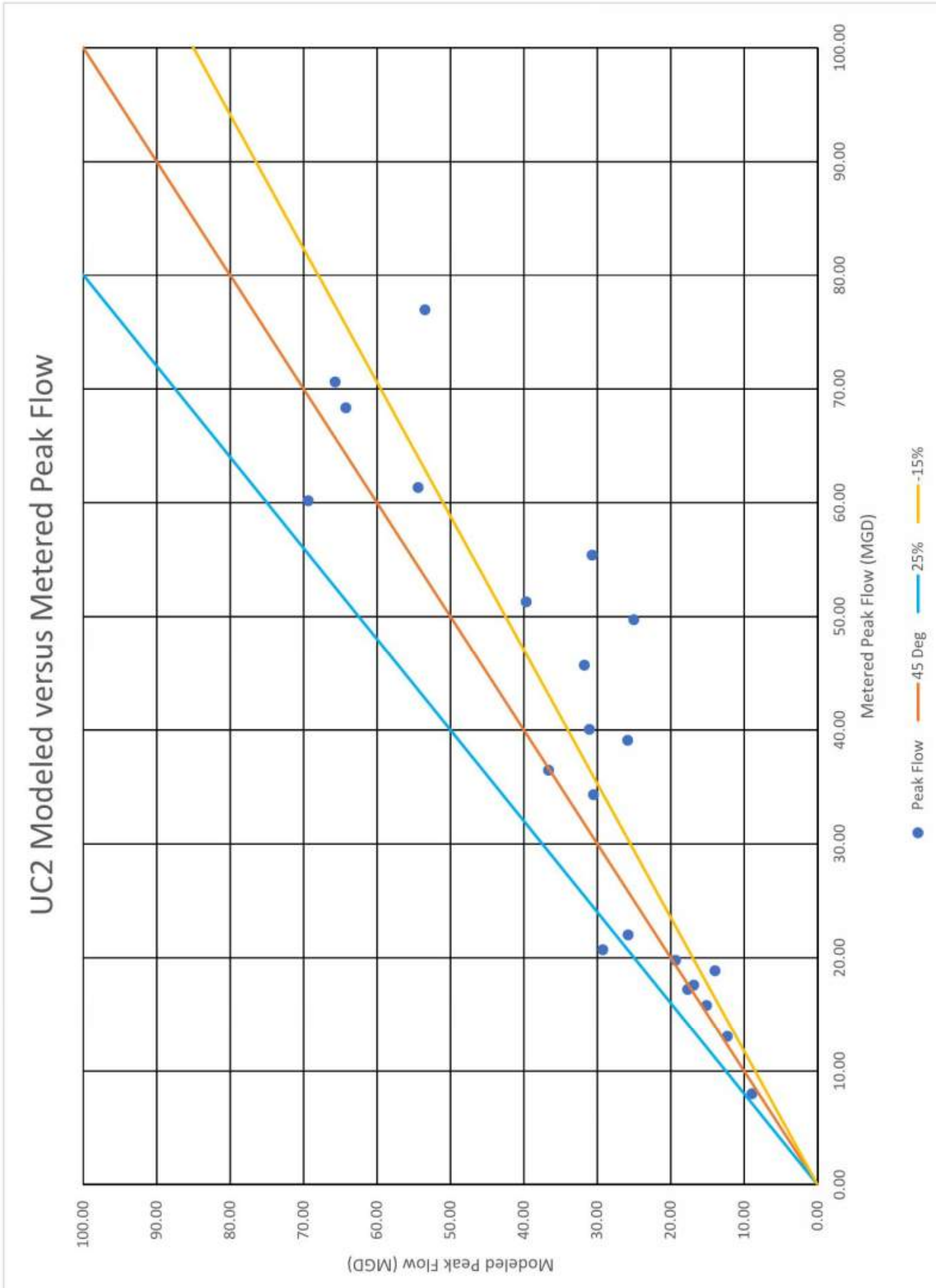

June 19-June 26 DWF - WNY1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
7
8
9
10
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

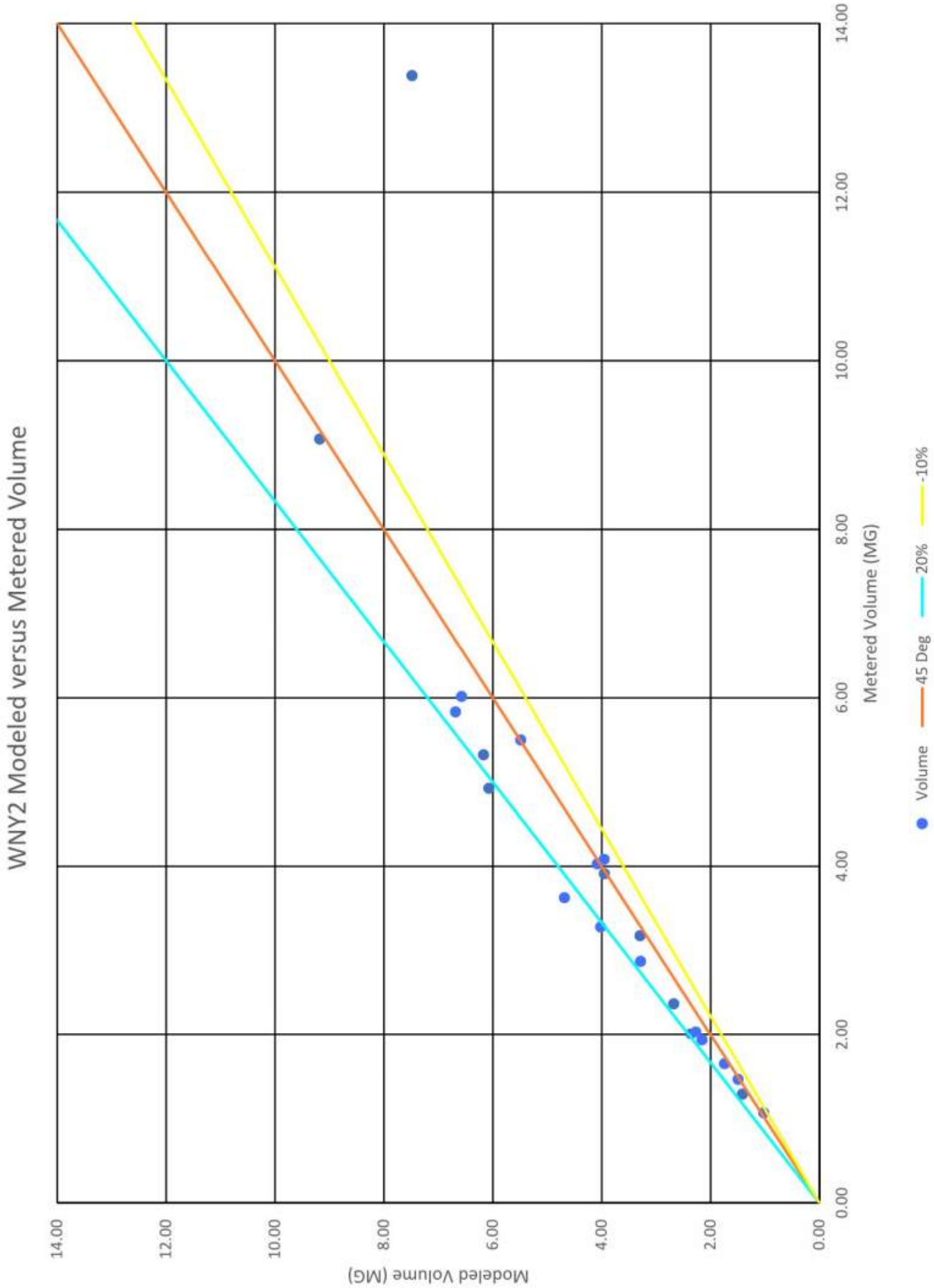

June 19-June 26 DWF - WNY1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
6/19/2016 0:00
6/20/2016 0:00
6/21/2016 0:00
6/22/2016 0:00
6/23/2016 0:00
6/24/2016 0:00
6/25/2016 0:00
6/26/2016 0:00
6/27/2016 0:00
Metered Depth (ft)
Modeled Depth (ft)
Rain (in/hr)

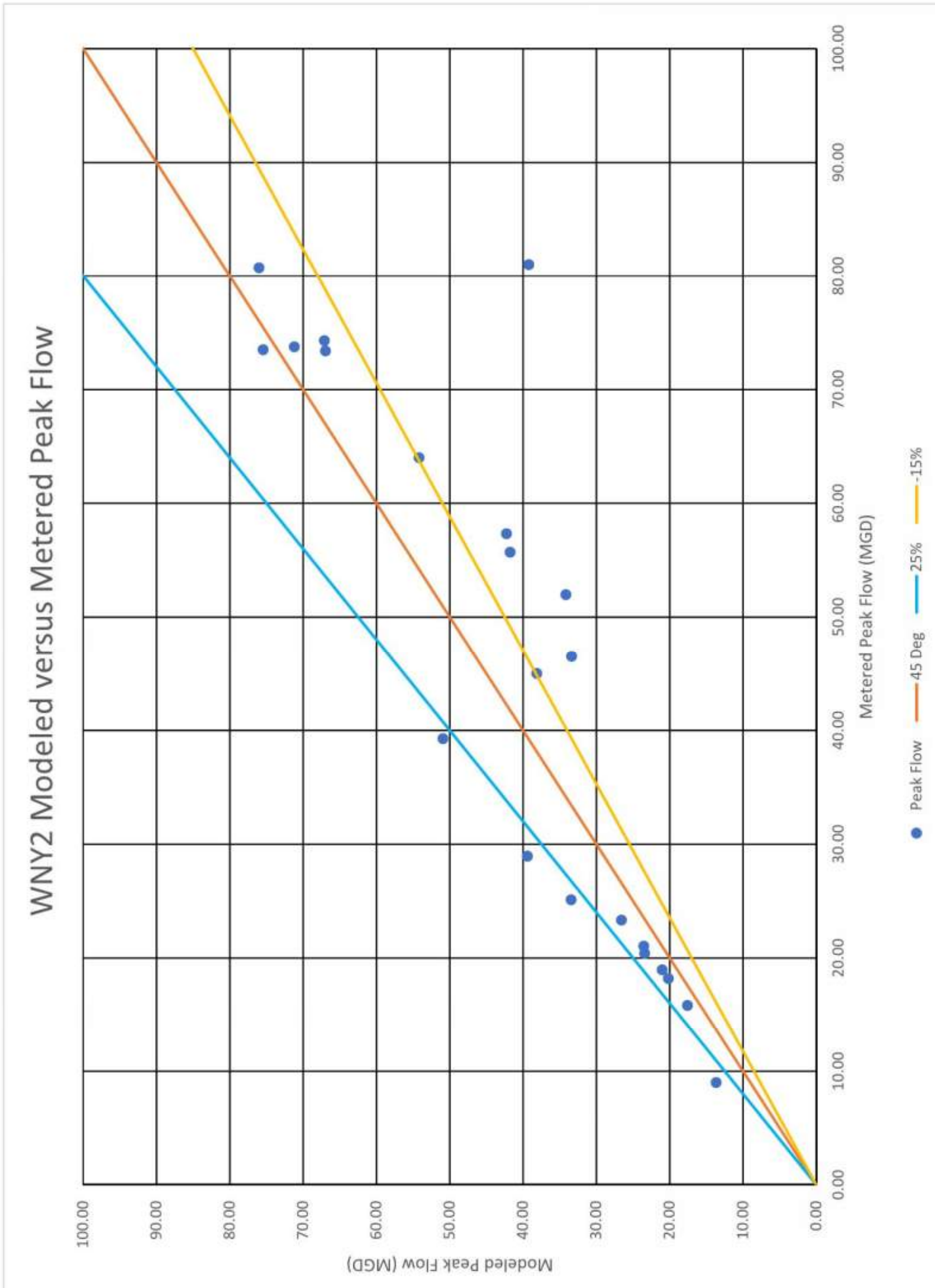

UC1 Modeled versus Metered Volume
Modeled Volume (MG)
Metered Volume (MG)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Volume
45 Deg
20%
-10%

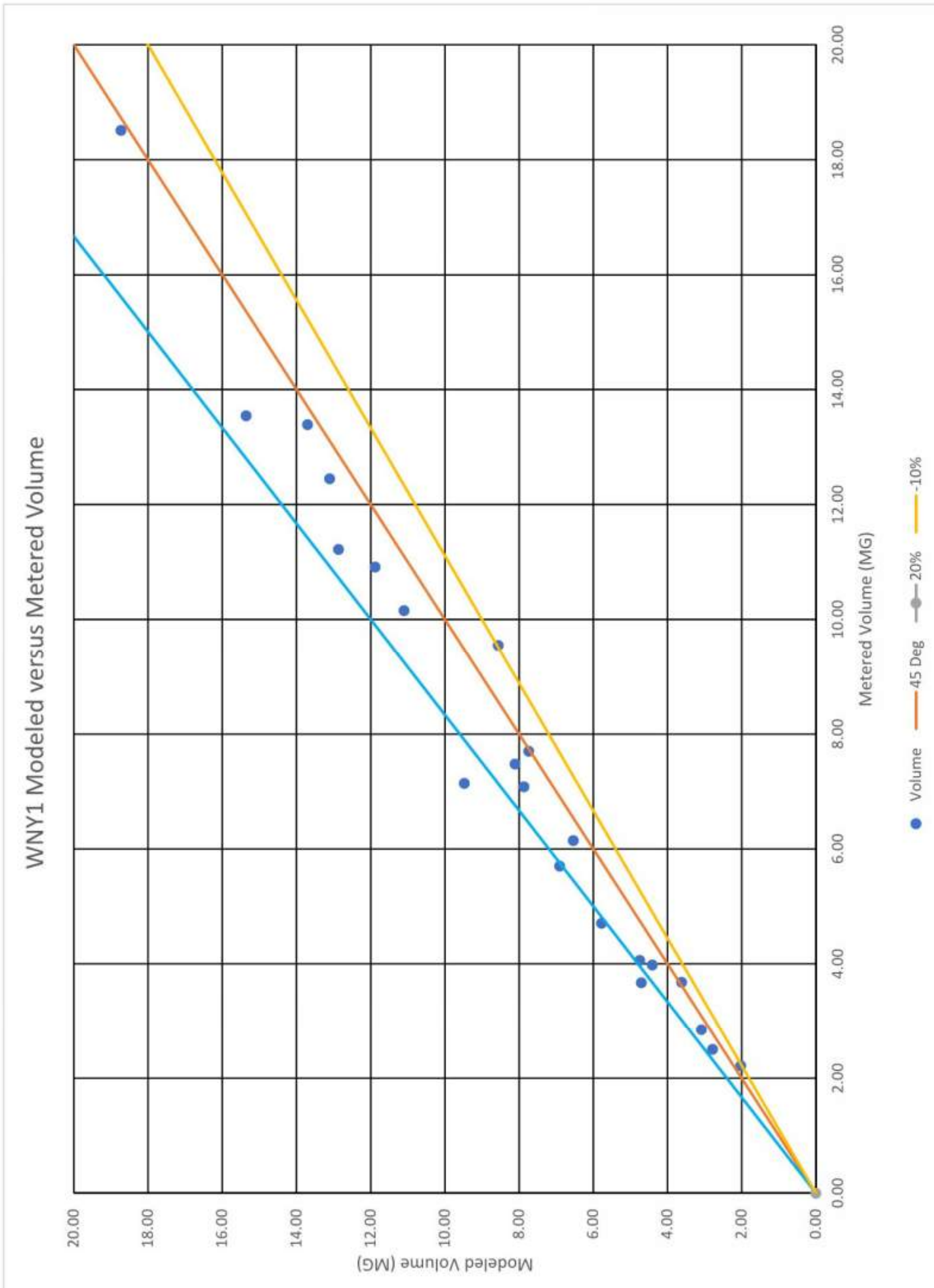

UC1 Modeled versus Metered Peak Flow
Modeled Peak Flow (MGD)
Metered Peak Flow (MGD)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Peak Flow
45 Deg
25%
-15%

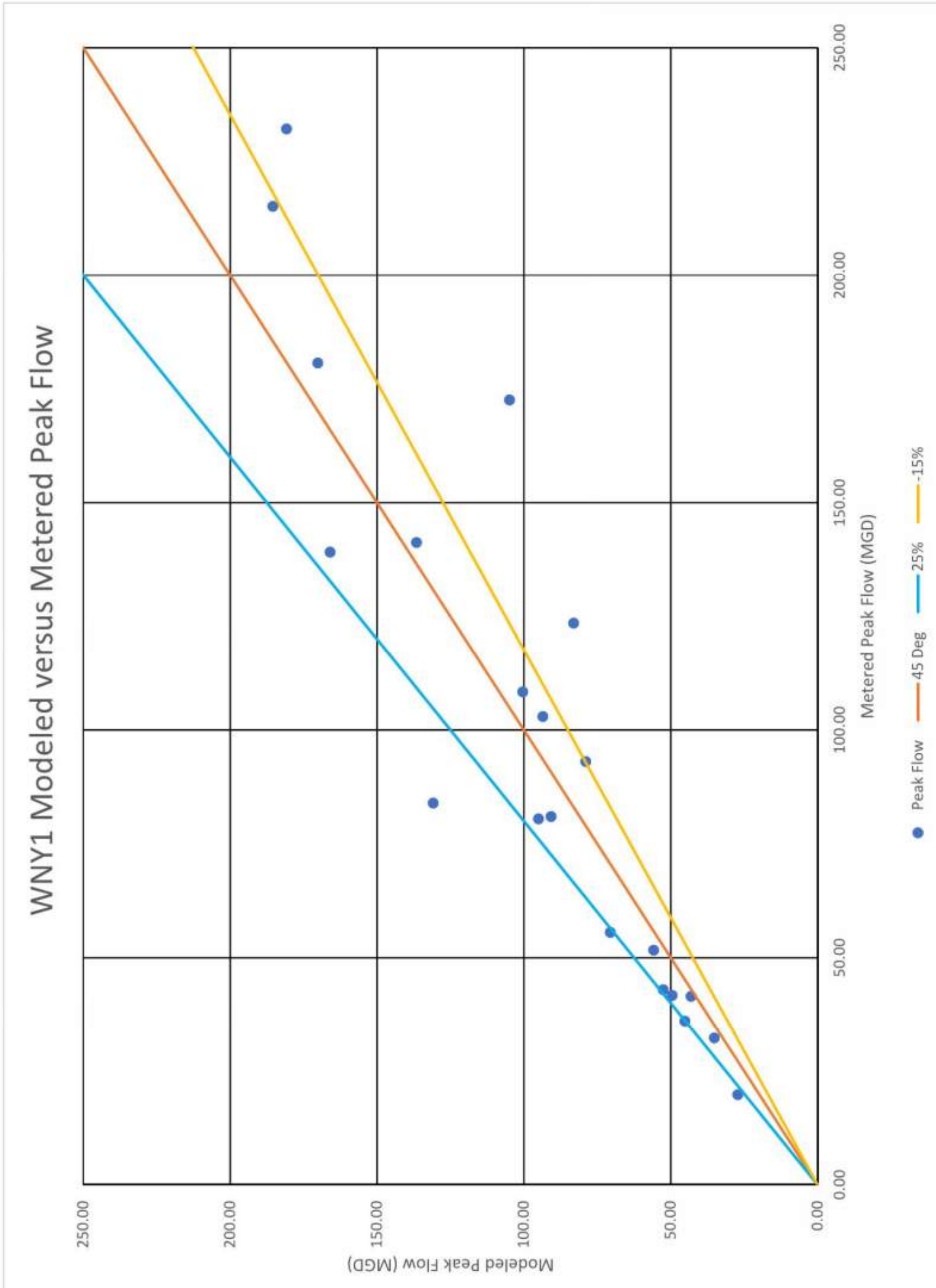

UC2 Modeled versus Metered Volume
Modeled Volume (MG)
Metered Volume (MG)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Volume
45 Deg
20%
-10%

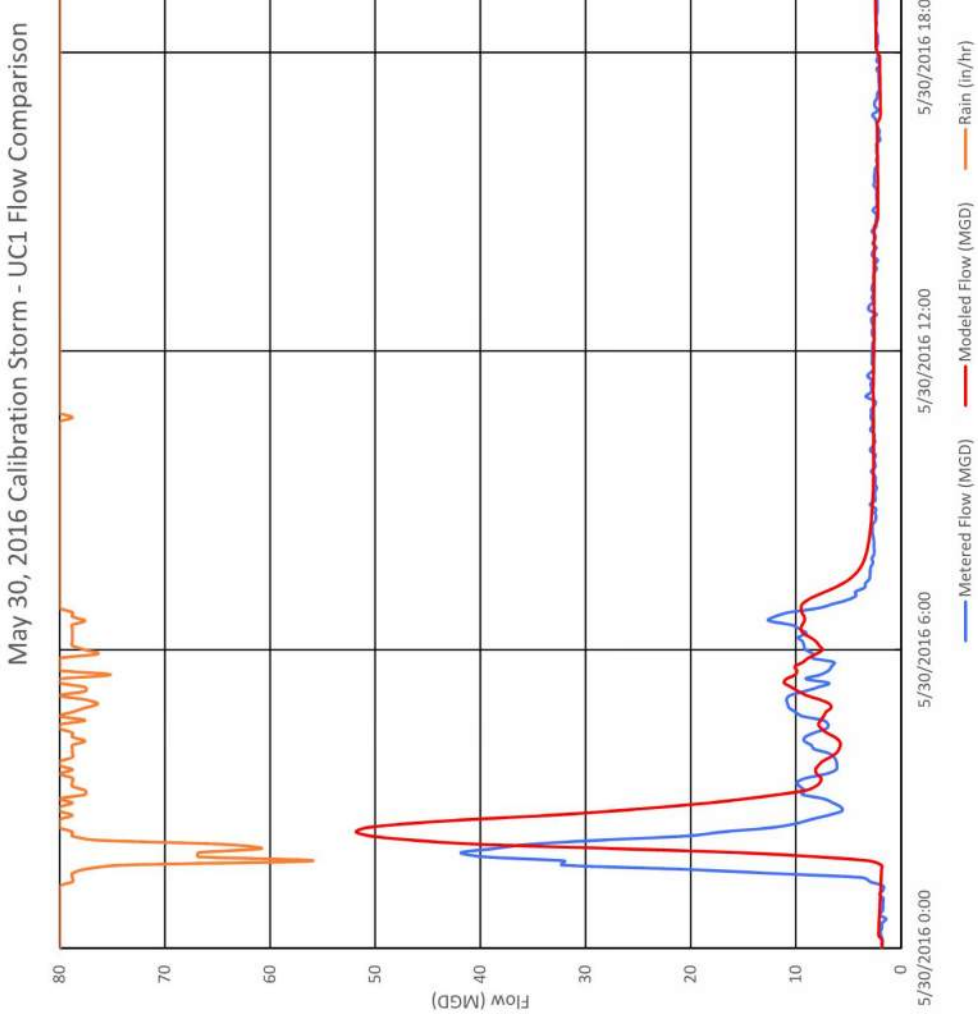

UC2 Modeled versus Metered Peak Flow
Modeled Peak Flow (MGD)
Metered Peak Flow (MGD)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Peak Flow
45 Deg
25%
-15%

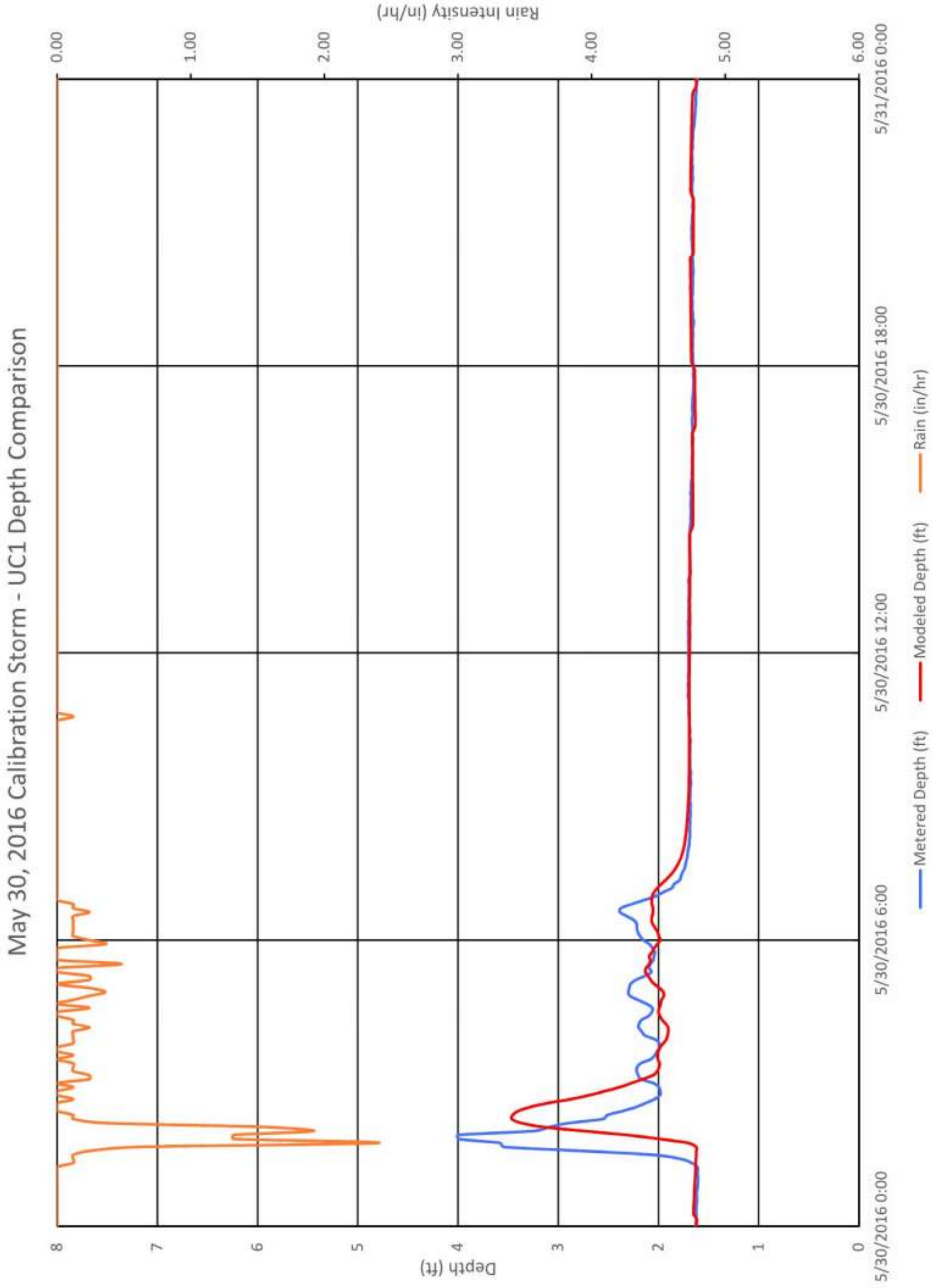

WNY2 Modeled versus Metered Volume
Modeled Volume (MG)
Metered Volume (MG)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Volume
45 Deg
20%
-10%

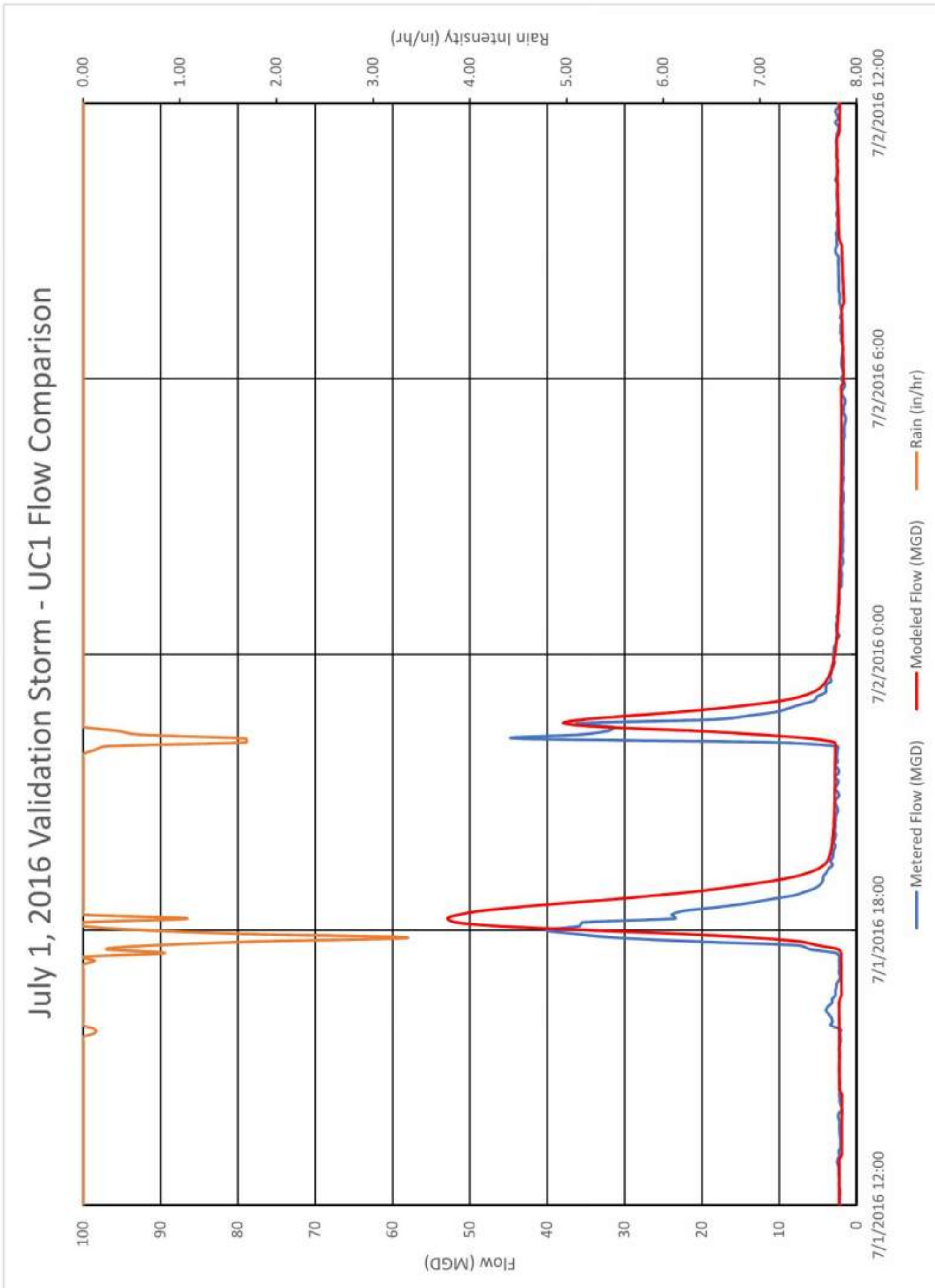

WNY2 Modeled versus Metered Peak Flow
Modeled Peak Flow (MGD)
Metered Peak Flow (MGD)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Peak Flow
45 Deg
25%
-15%

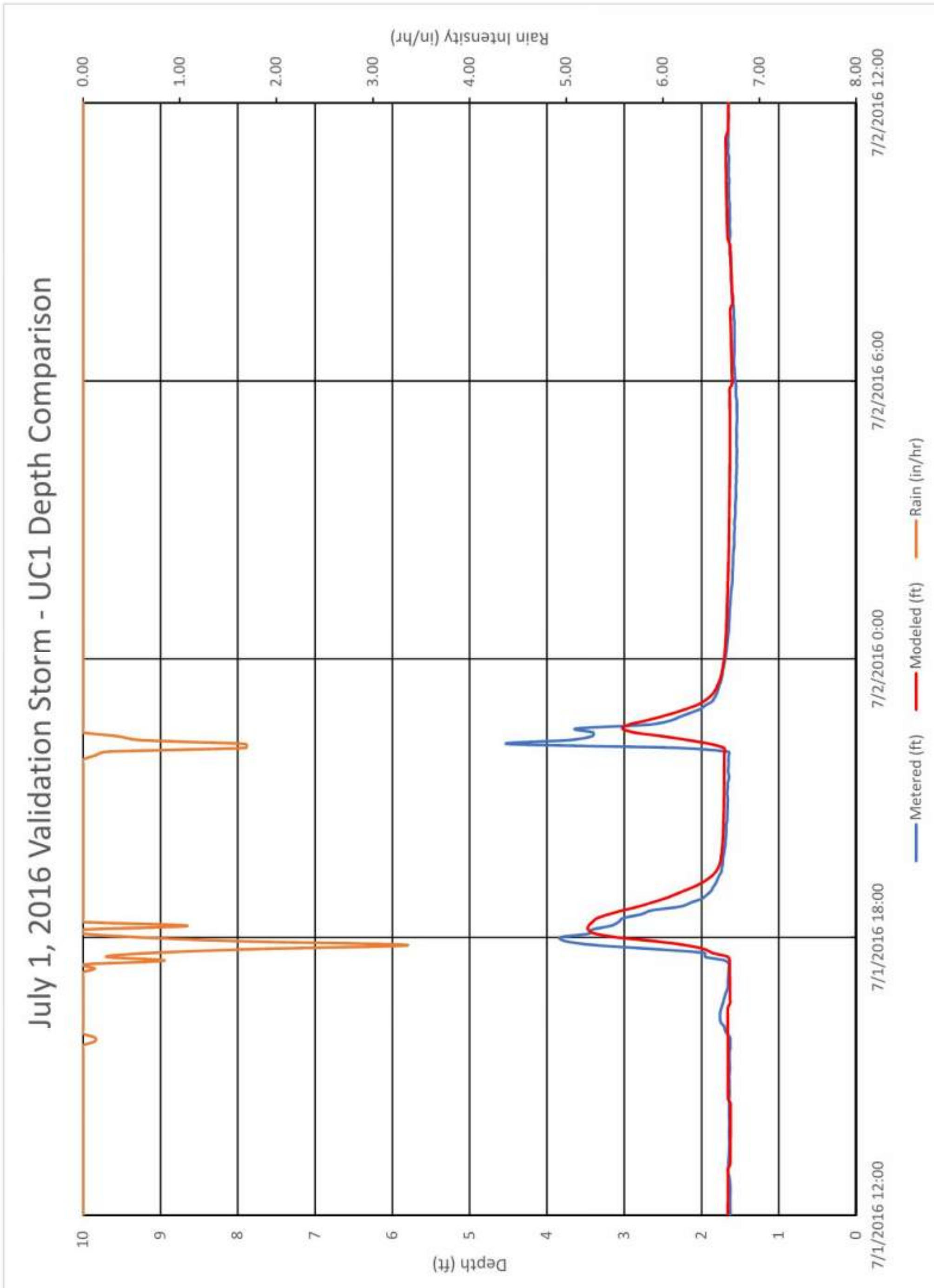

WNY1 Modeled versus Metered Volume
Modeled Volume (MG)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
Metered Volume (MG)
Volume
45 Deg
20%
-10%

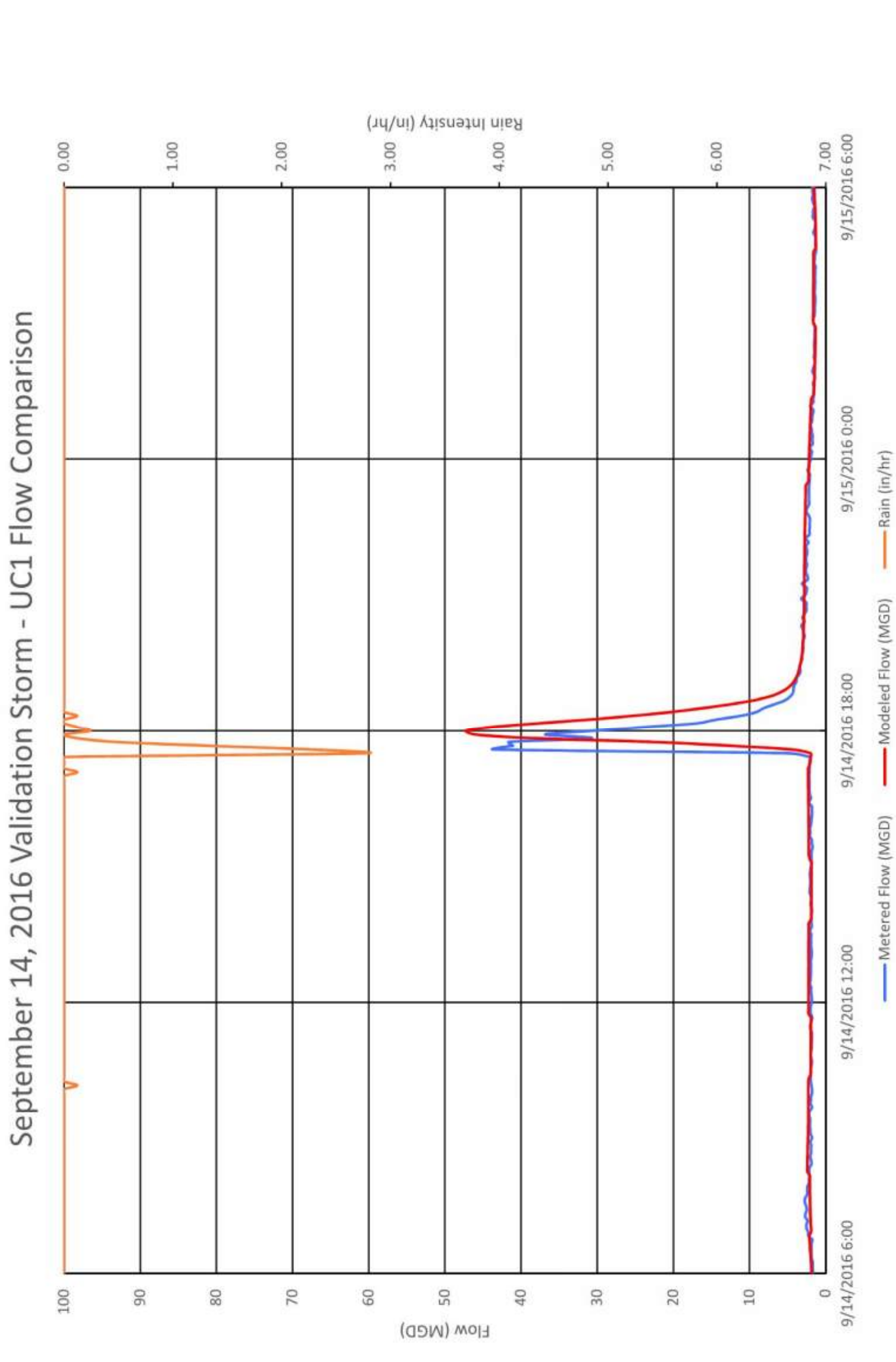

WNY1 Modeled versus Metered Peak Flow
Modeled Peak Flow (MGD)
0.00
50.00
100.00
150.00
200.00
250.00
Metered Peak Flow (MGD)
0.00
50.00
100.00
150.00
200.00
250.00
Peak Flow
45 Deg
25%
-15%

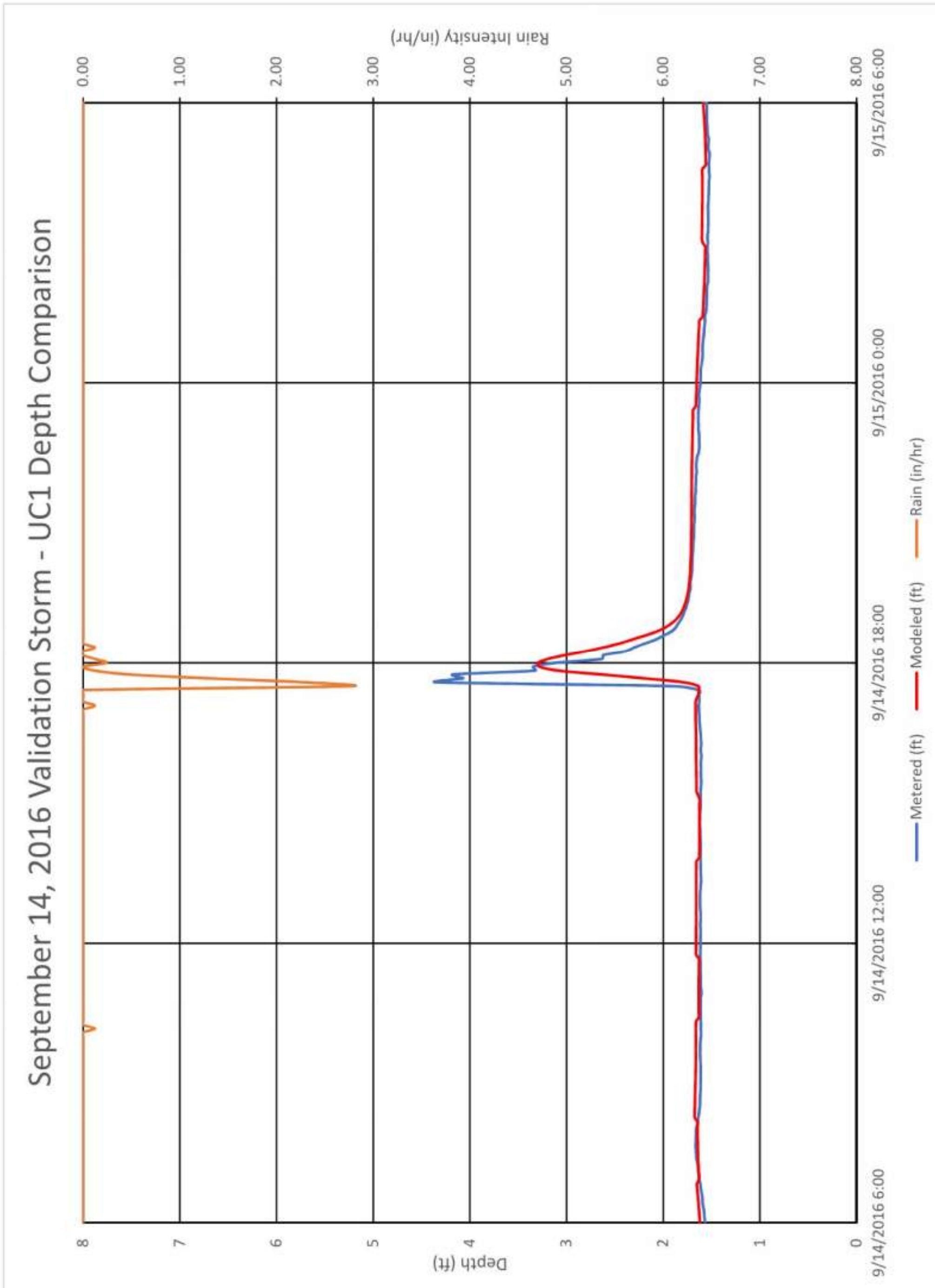

May 30, 2016 Calibration Storm - UC1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
10
20
30
40
50
60
70
80
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

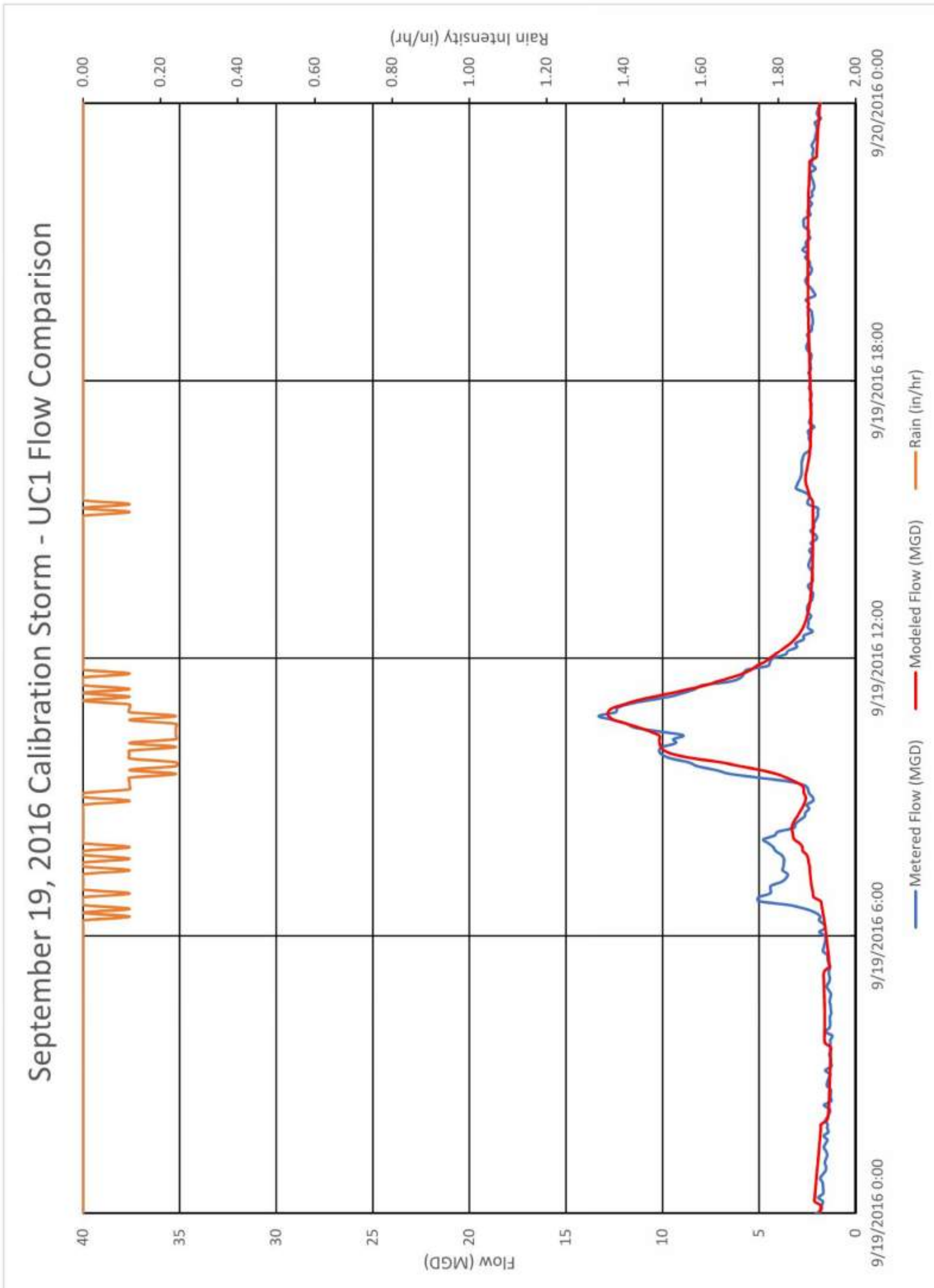

May 30, 2016 Calibration Storm - UC1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
7
8
0.00
1.00
2.00
3.00
4.00
5.00
6.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered Depth (ft)
Modeled Depth (ft)
Rain (in/hr)

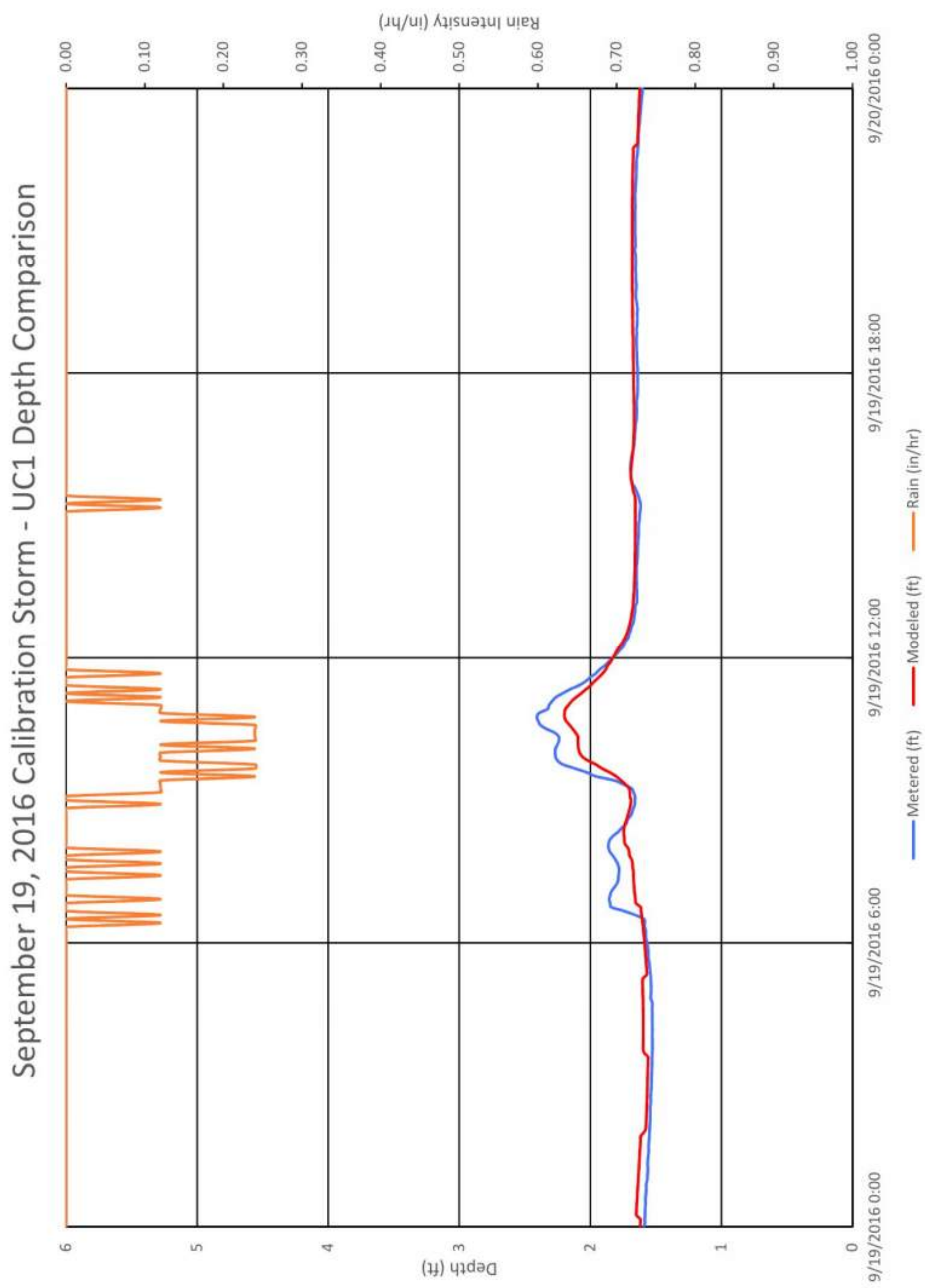

July 1, 2016 Validation Storm - UC1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
100
90
80
70
60
50
40
30
20
10
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

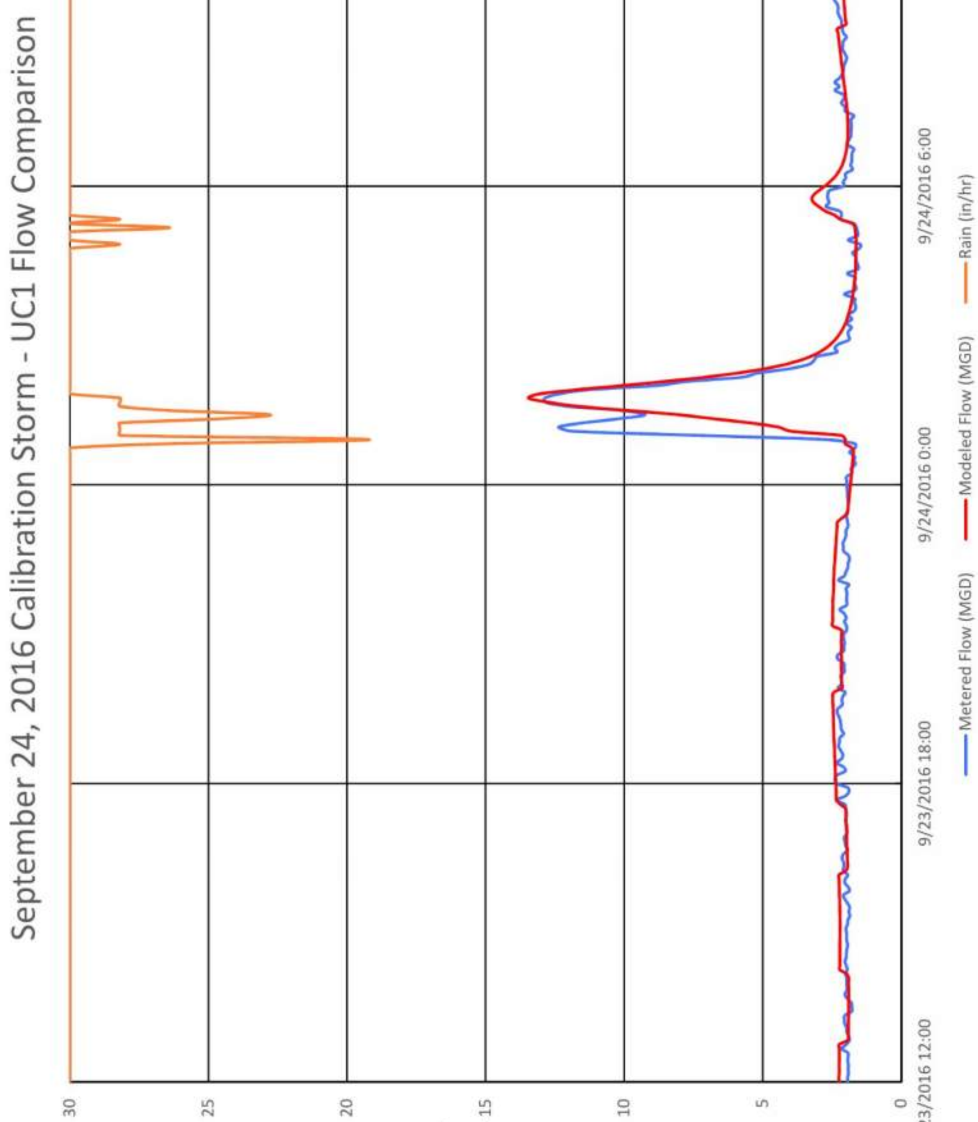

July 1, 2016 Validation Storm - UC1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
10
9
8
7
6
5
4
3
2
1
0
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

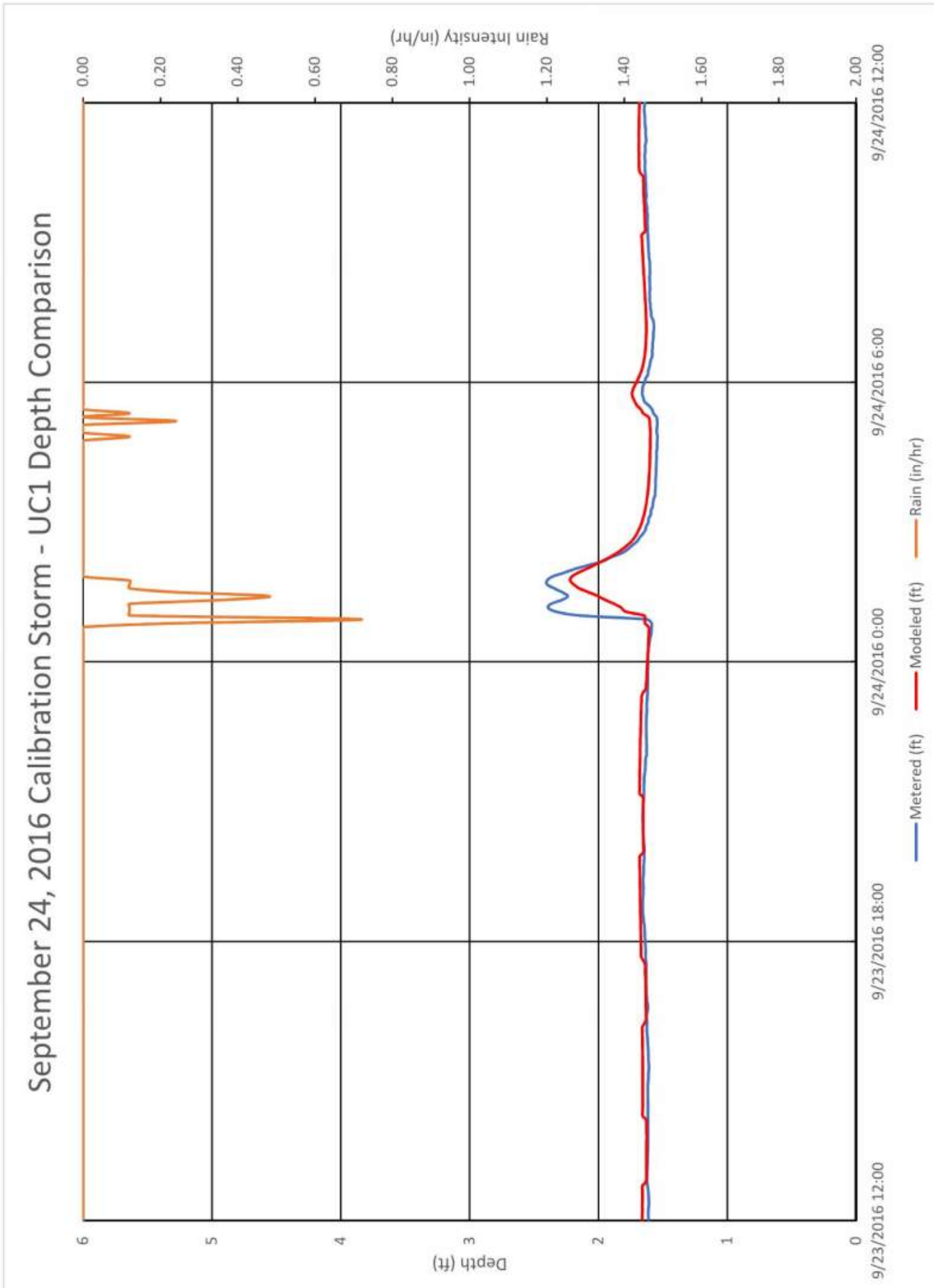

September 14, 2016 Validation Storm - UC1 Flow Comparison
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Flow (MGD)
100
90
80
70
60
50
40
30
20
10
0
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

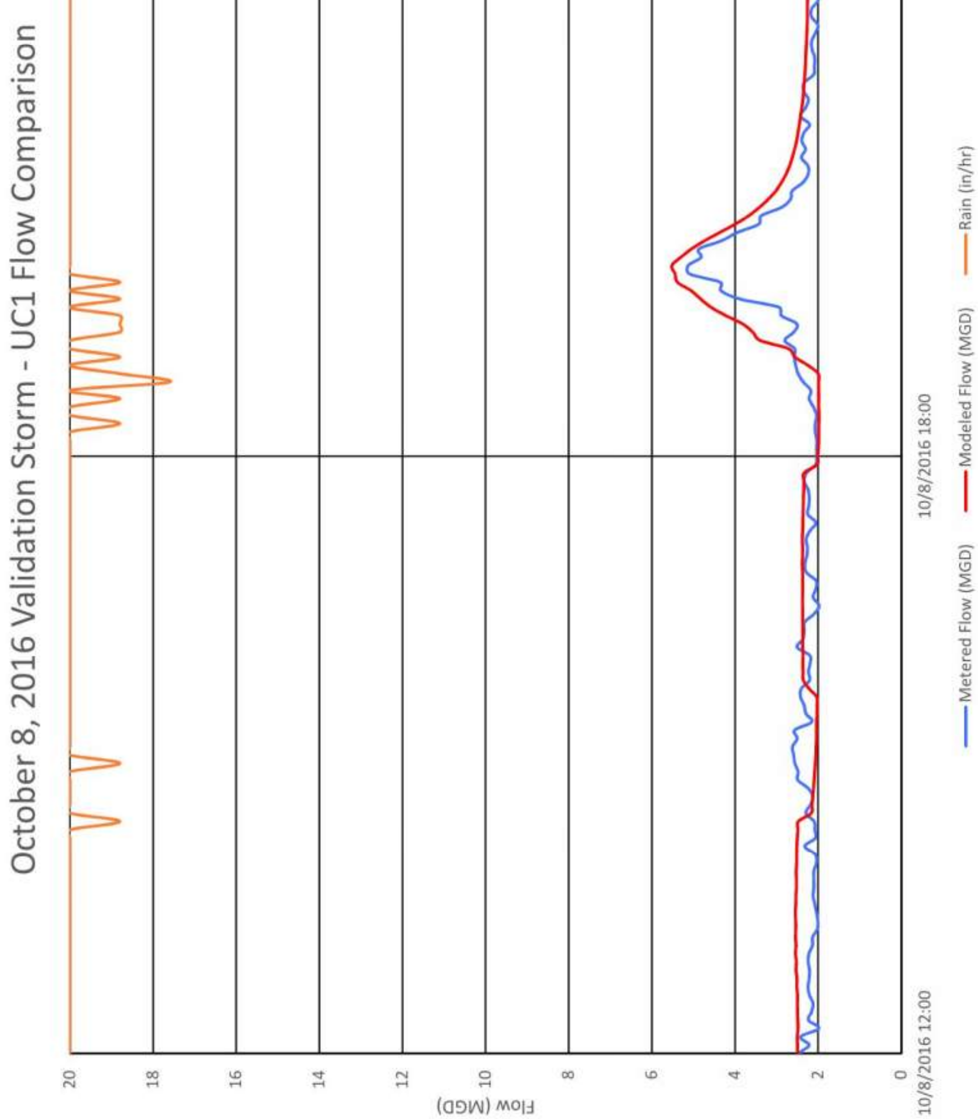

September 14, 2016 Validation Storm - UC1 Depth Comparison
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Depth (ft)
8
7
6
5
4
3
2
1
0
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

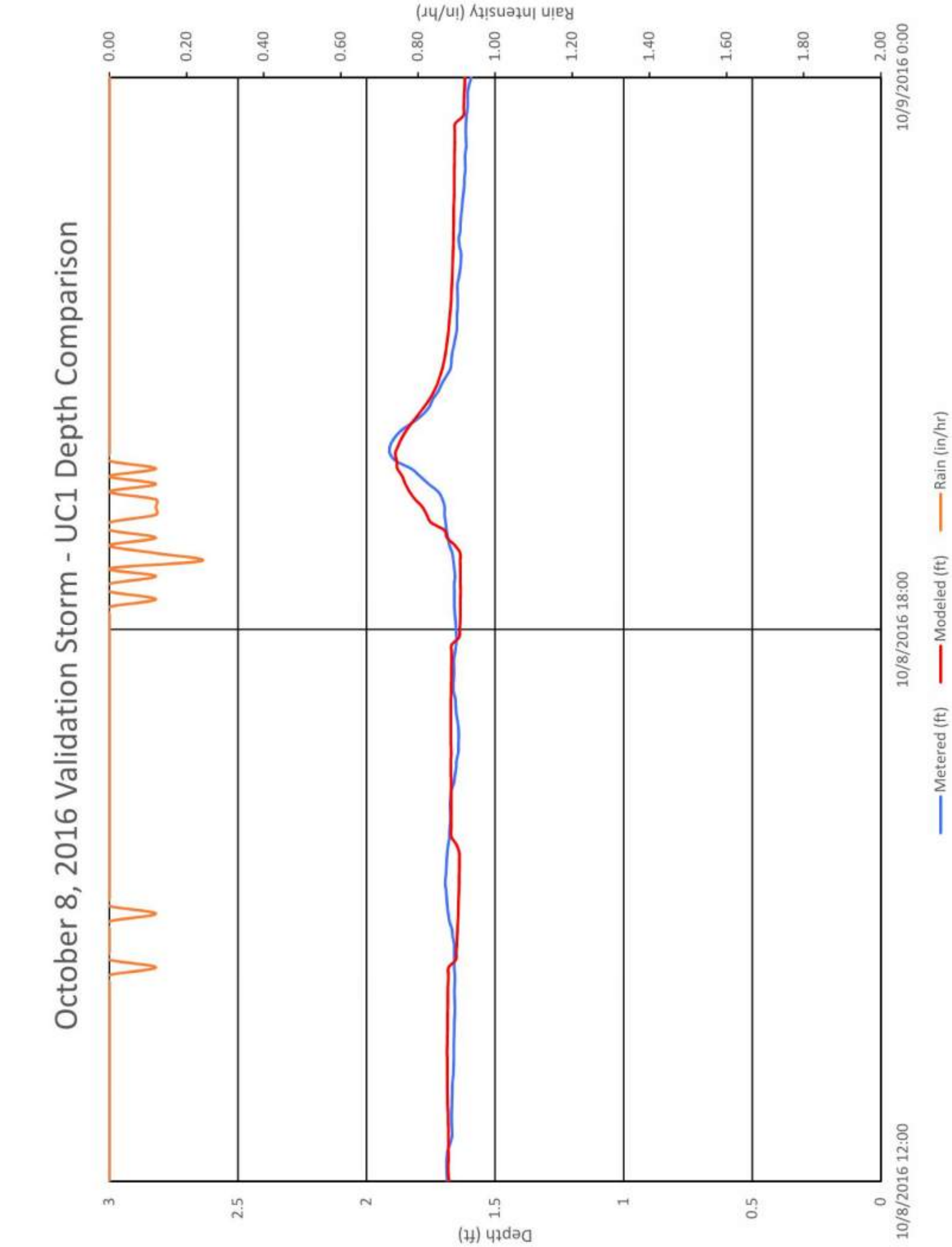

September 19, 2016 Calibration Storm - UC1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
5
10
15
20
25
30
35
40
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

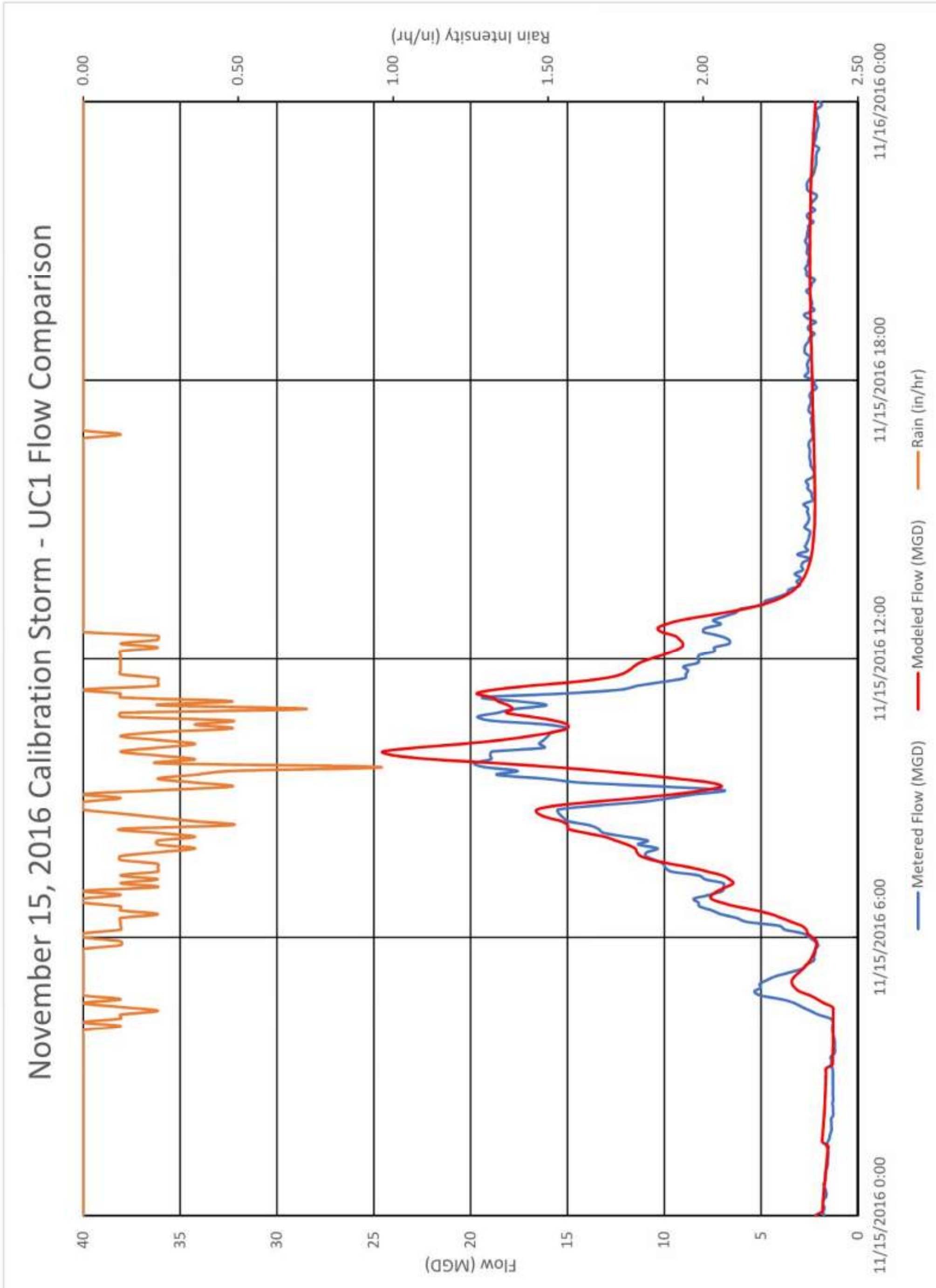

September 19, 2016 Calibration Storm - UC1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)


September 24, 2016 Calibration Storm - UC1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
5
10
15
20
25
30
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

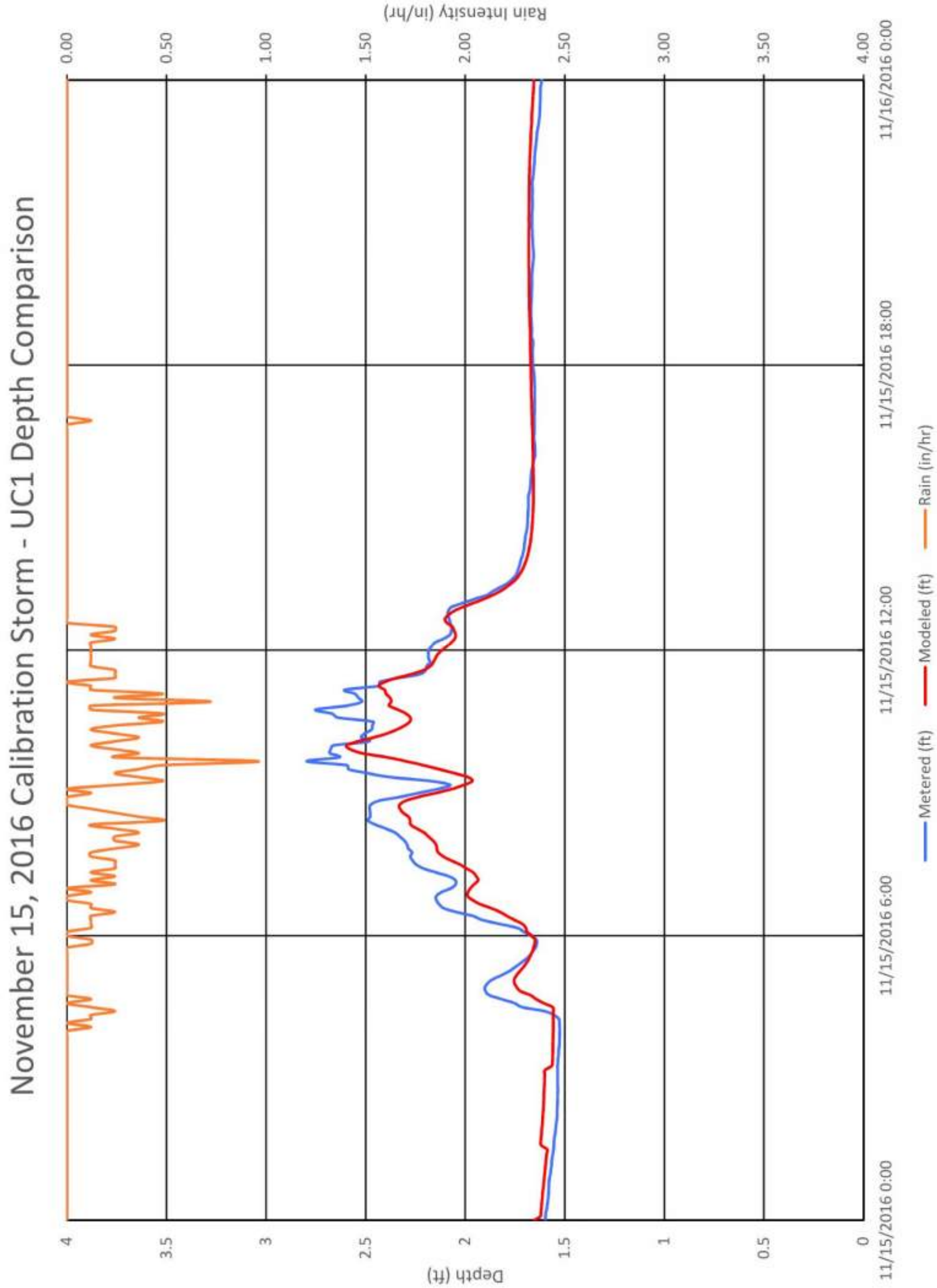

September 24, 2016 Calibration Storm - UC1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

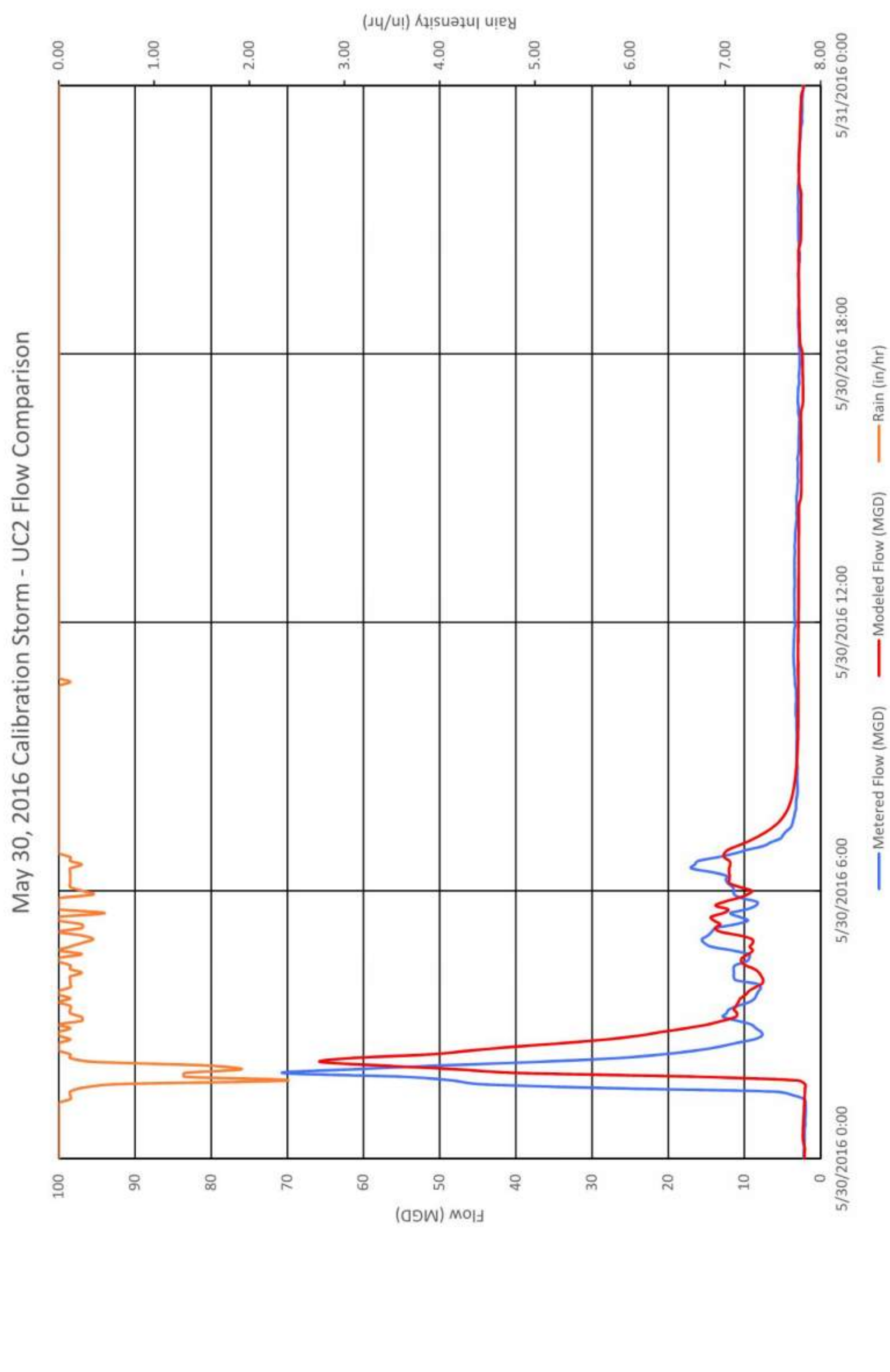

October 8, 2016 Validation Storm - UC1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

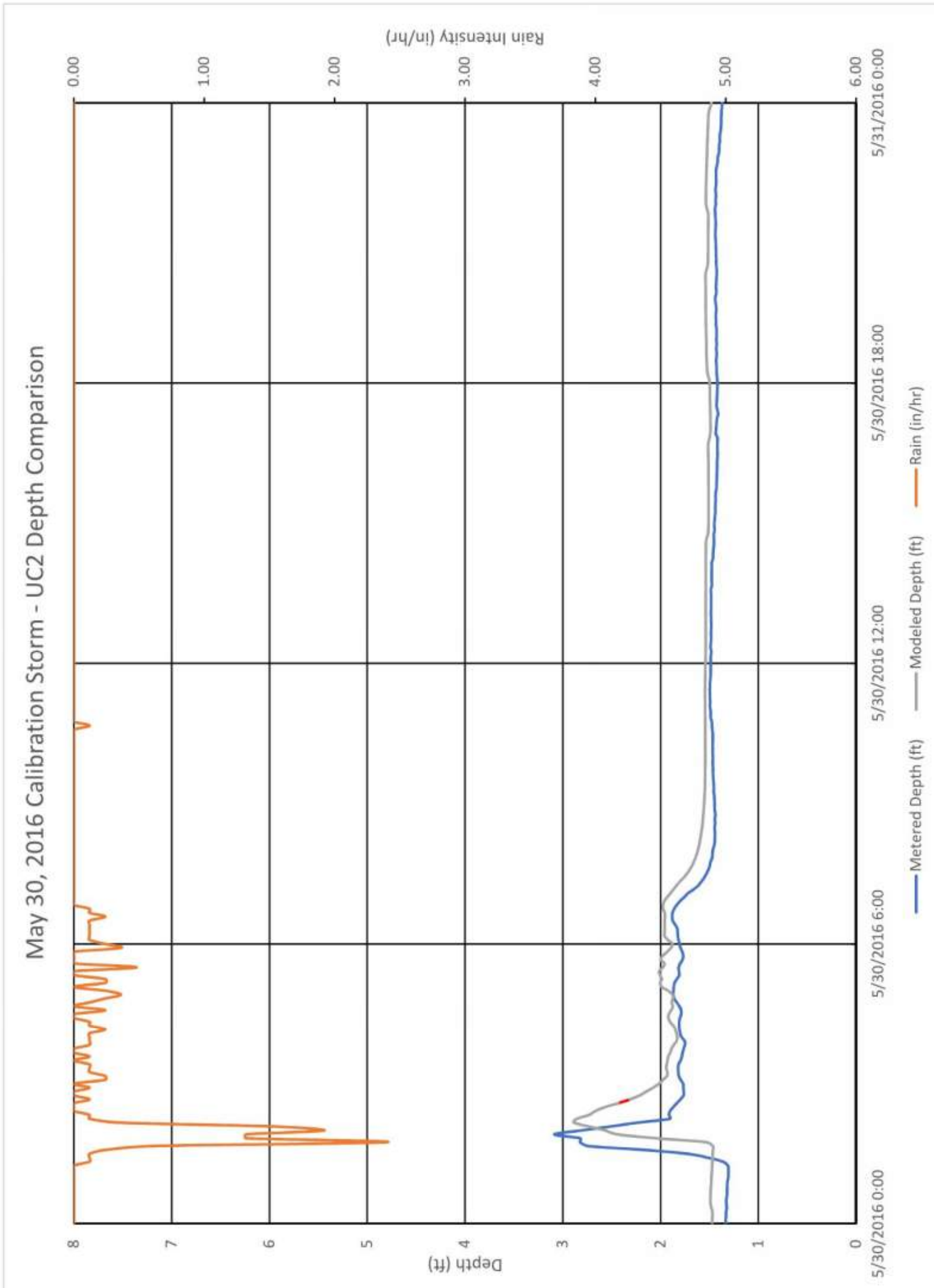

October 8, 2016 Validation Storm - UC1 Depth Comparison
Depth (ft)
0
0.5
1
1.5
2
2.5
3
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

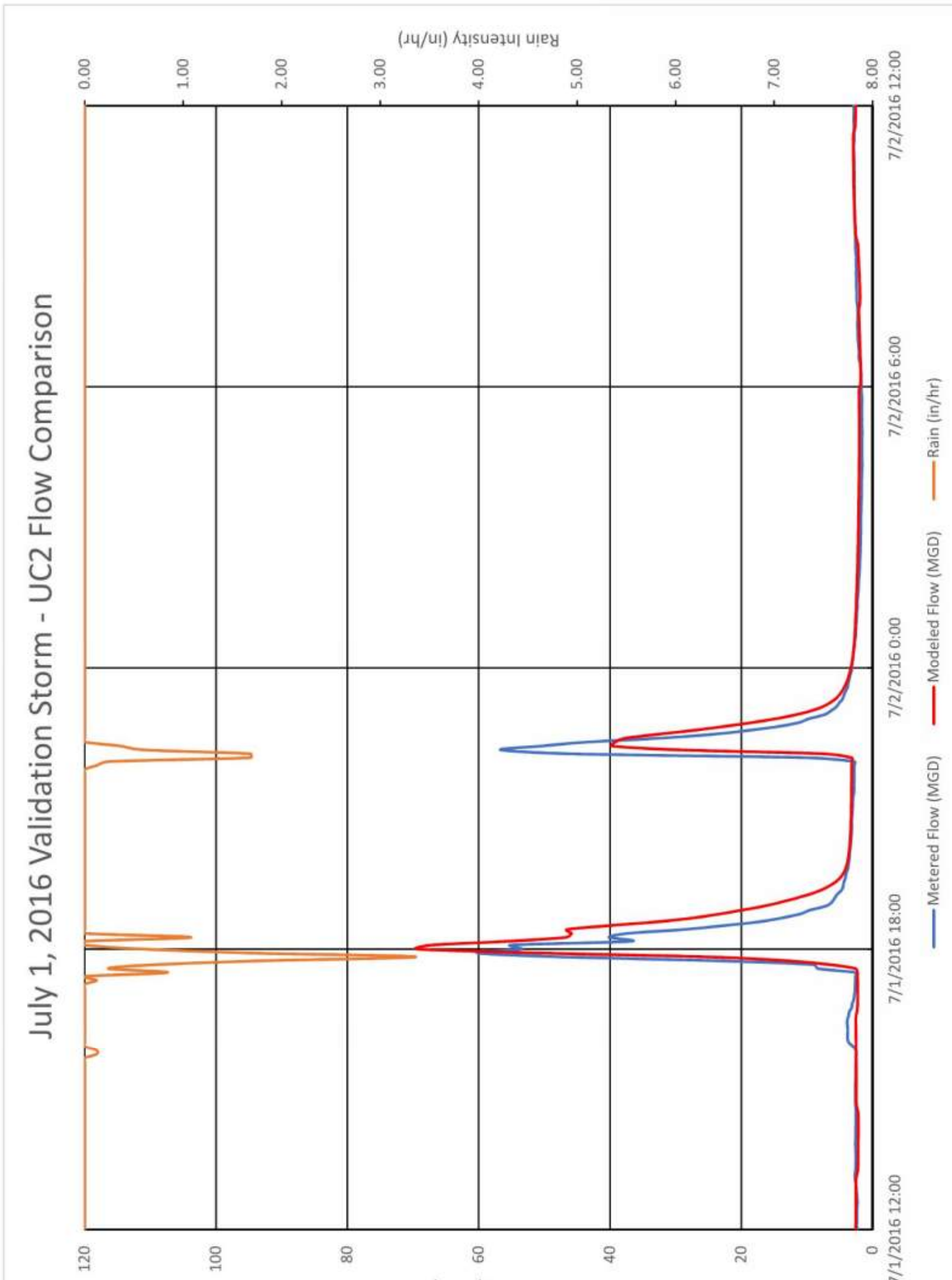


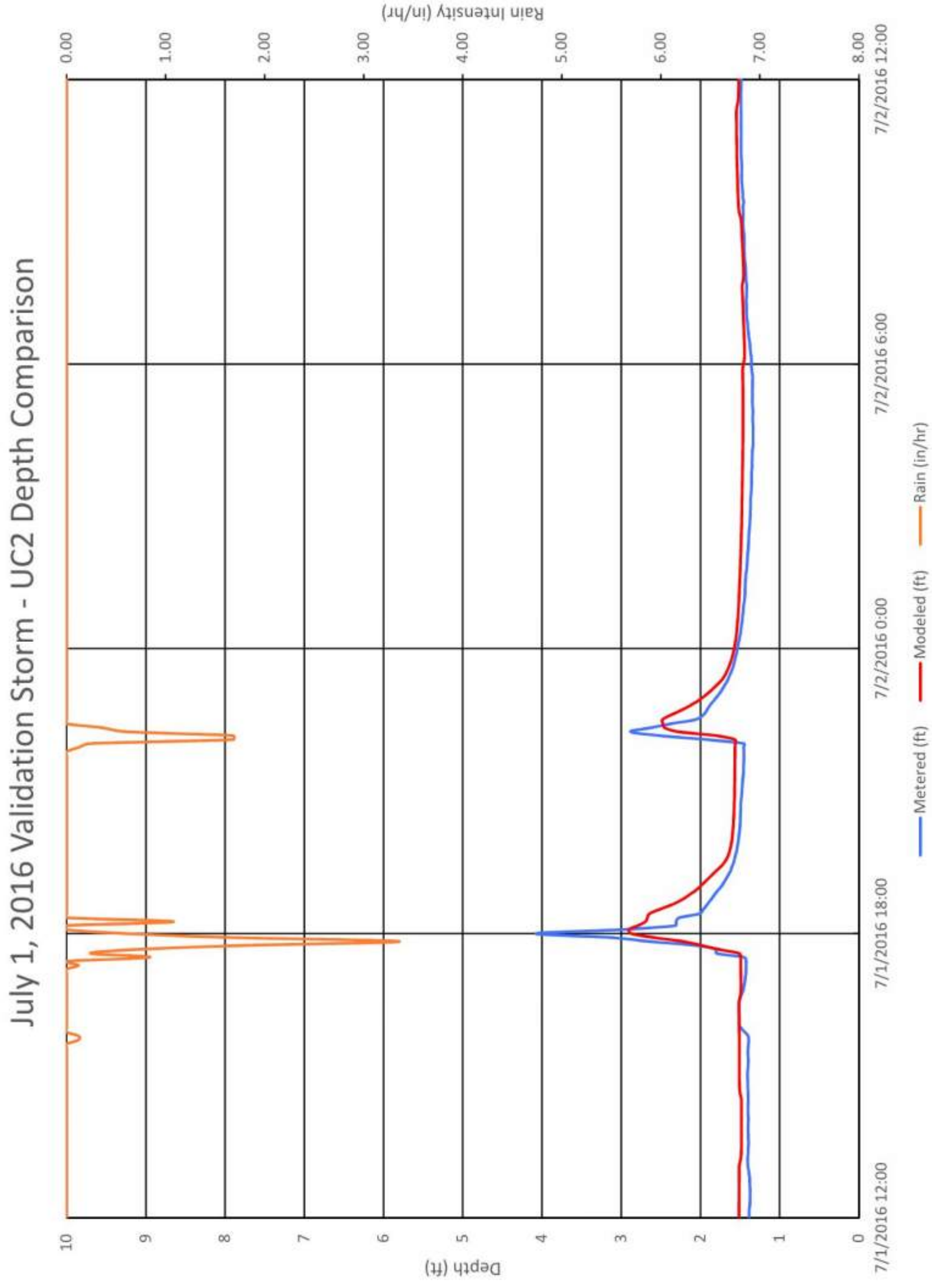
November 15, 2016 Calibration Storm - UC1 Flow Comparison
Flow (MGD)
0
5
10
15
20
25
30
35
40
Rain Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)


November 15, 2016 Calibration Storm - UC1 Depth Comparison
Depth (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
Rain Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

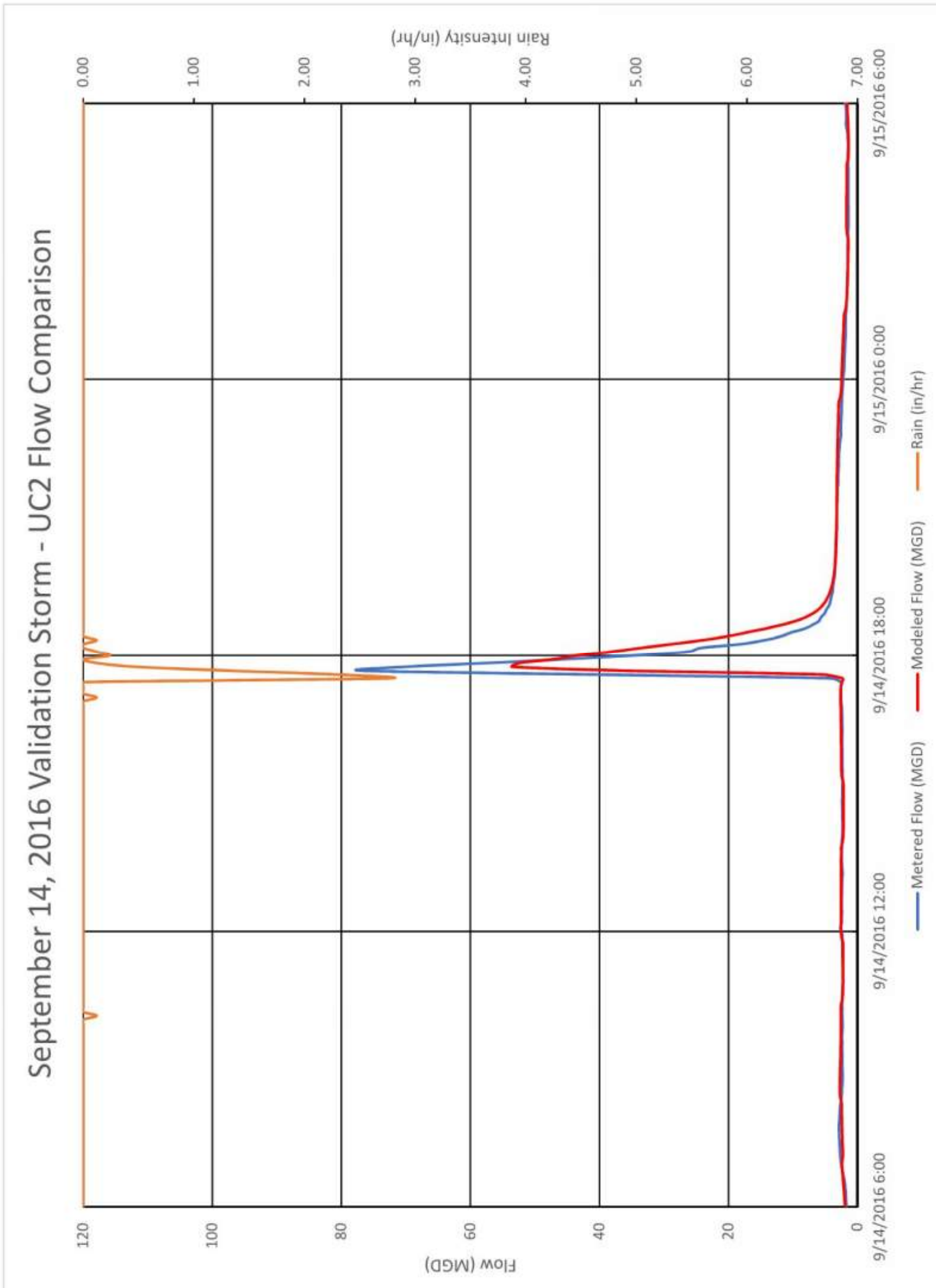

May 30, 2016 Calibration Storm - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
10
20
30
40
50
60
70
80
90
100
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

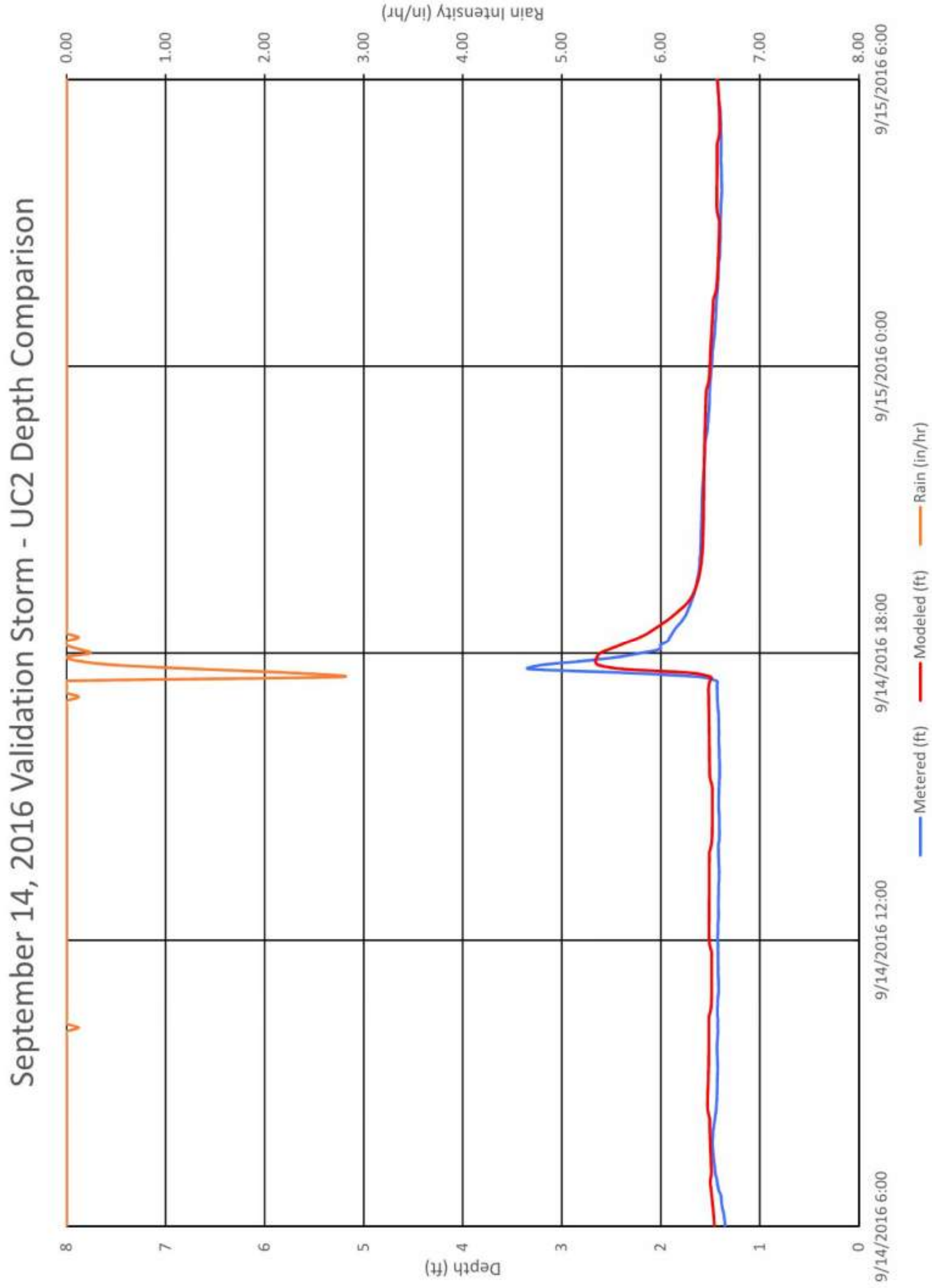

May 30, 2016 Calibration Storm - UC2 Depth Comparison
Depth (ft)
0
1
2
3
4
5
6
7
8
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered Depth (ft)
Modeled Depth (ft)
Rain (in/hr)

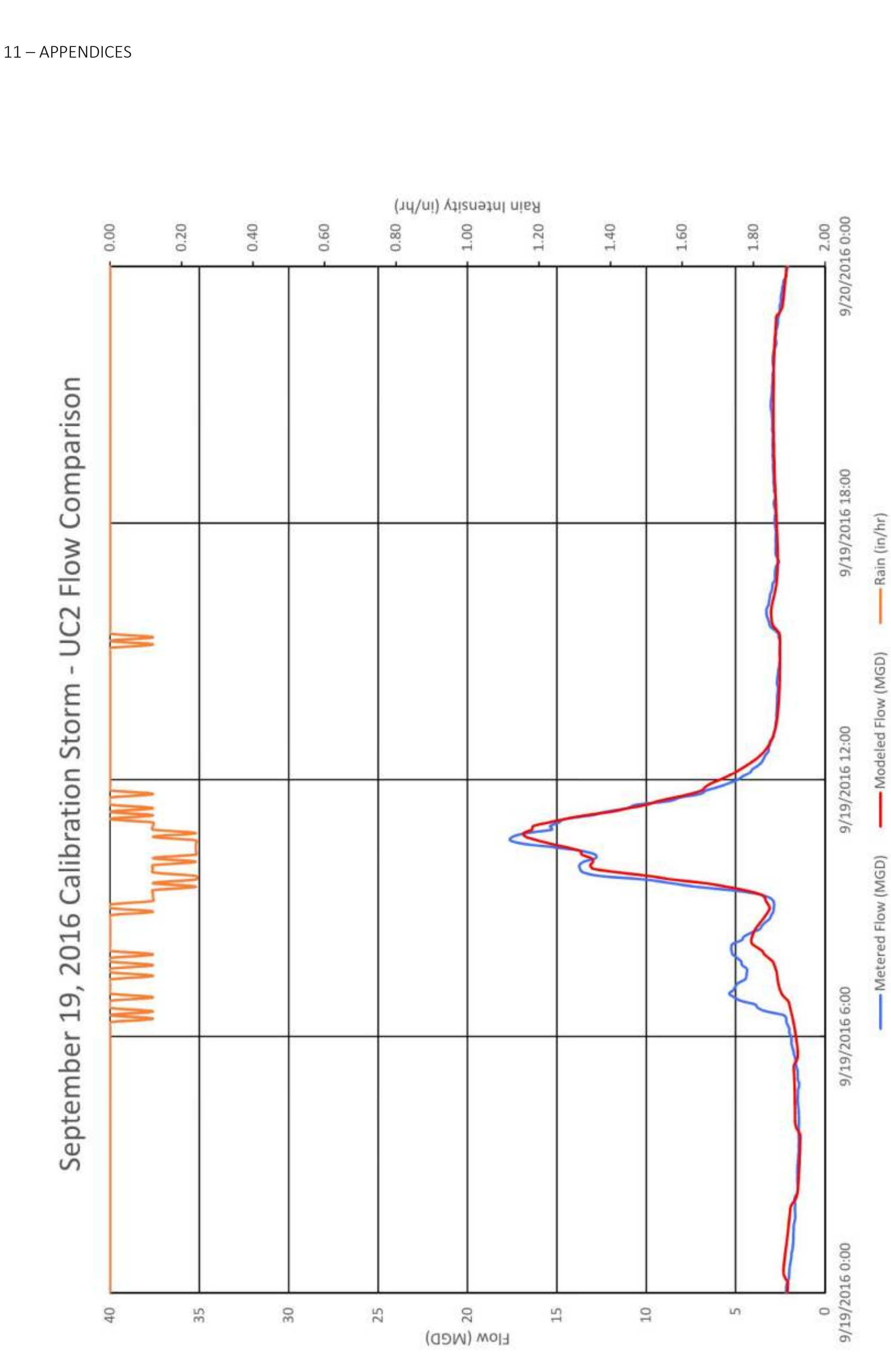

July 1, 2016 Validation Storm - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
20
40
60
80
100
120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

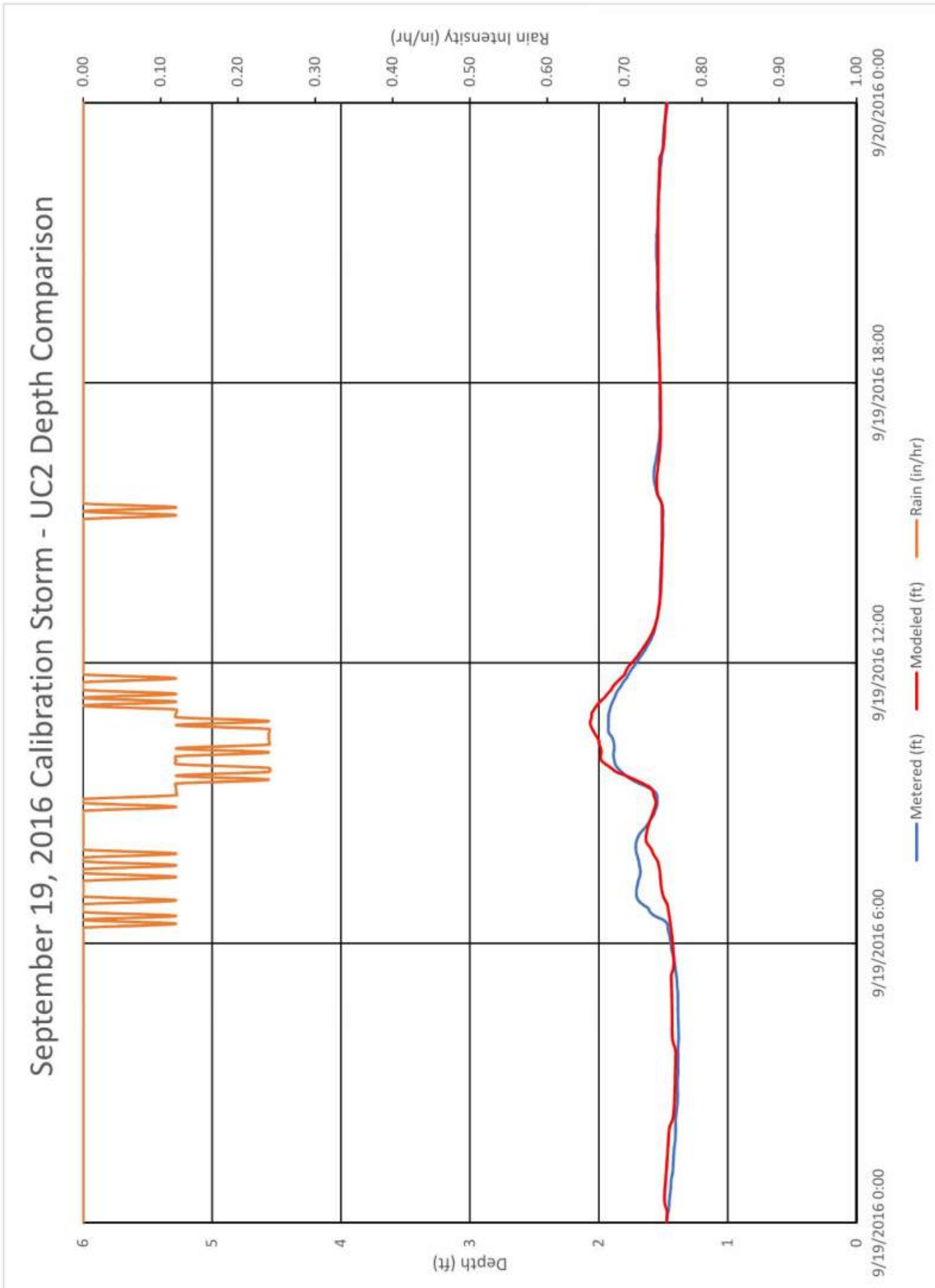


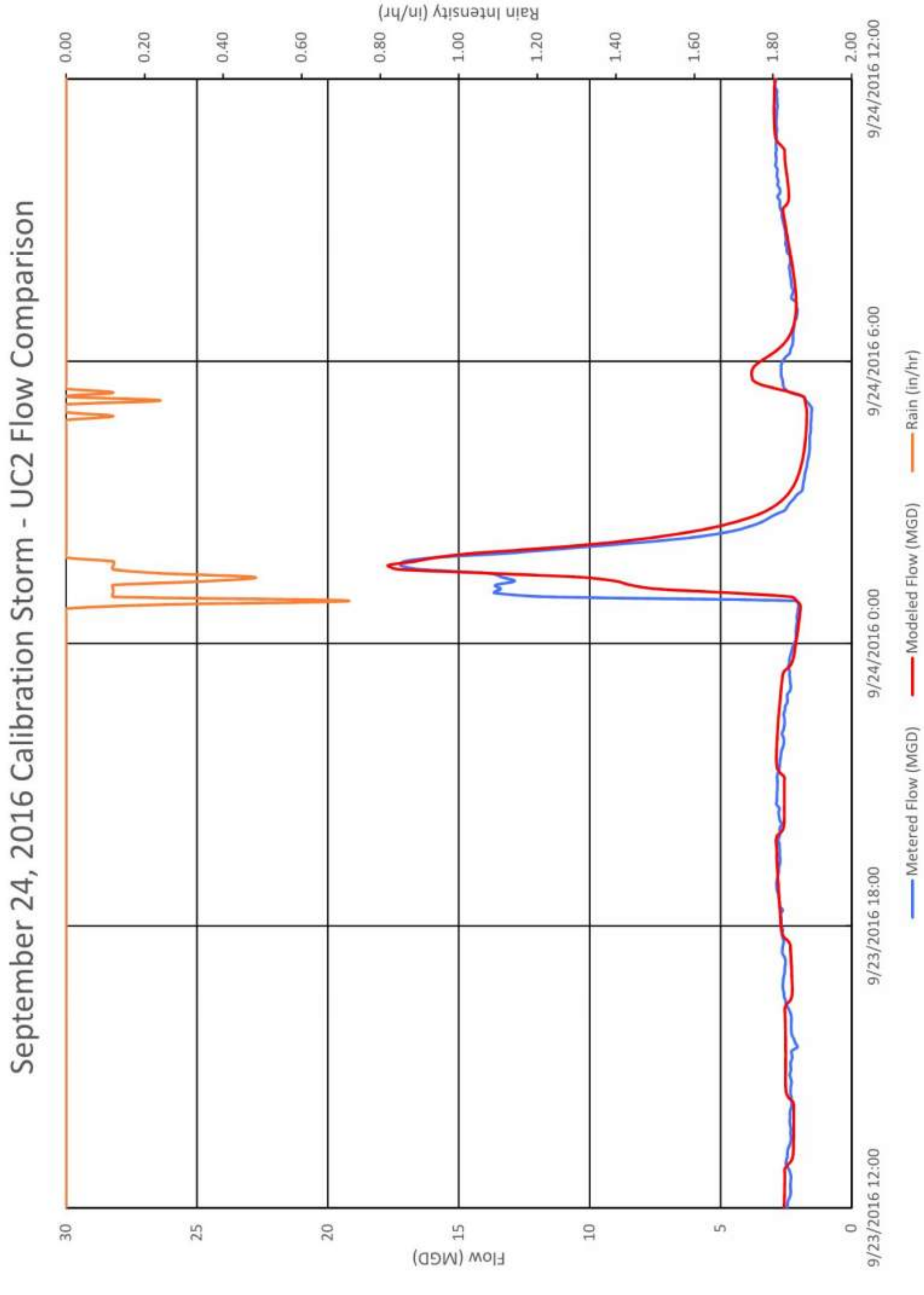
July 1, 2016 Validation Storm - UC2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
10
9
8
7
6
5
4
3
2
1
0
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

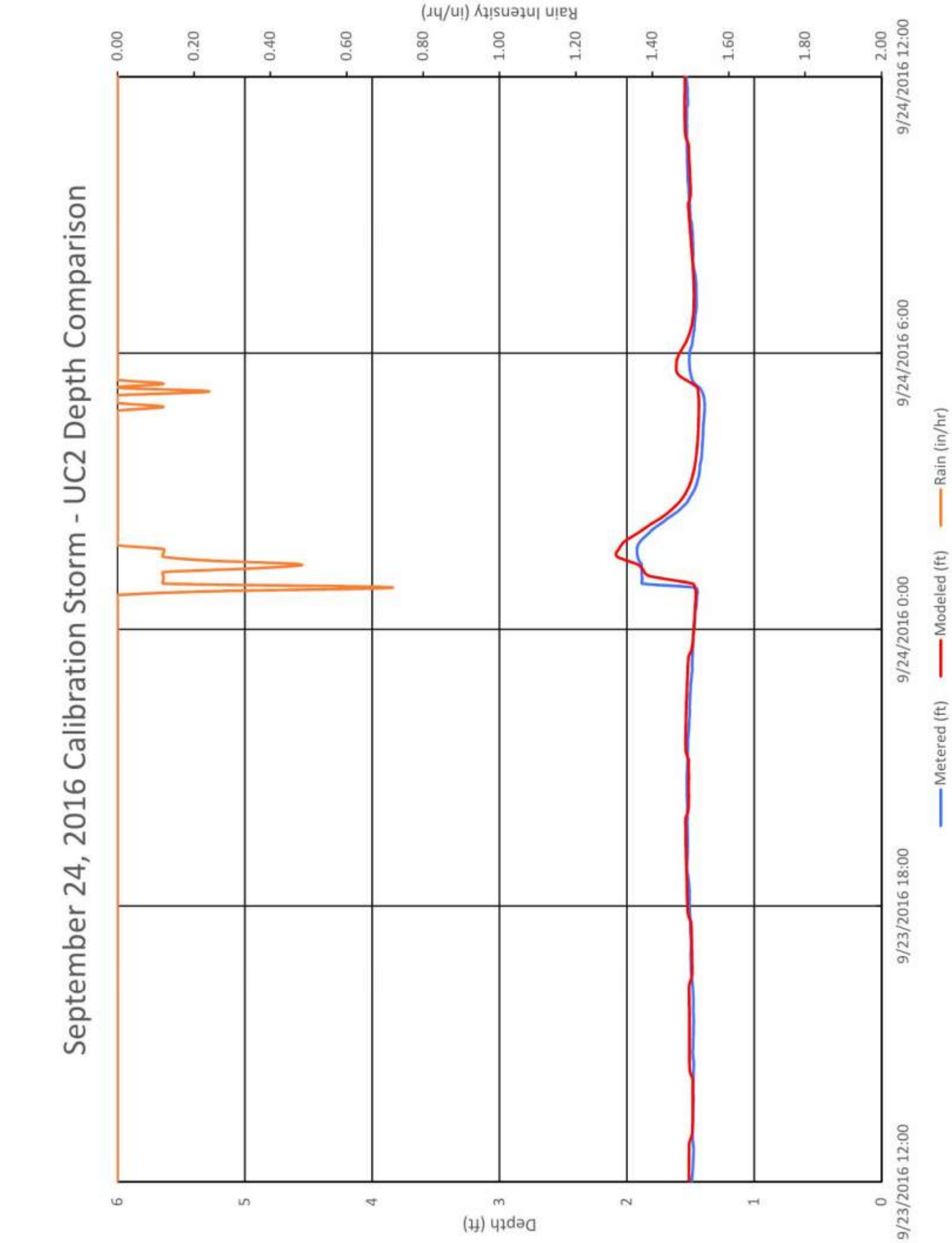

September 14, 2016 Validation Storm - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
20
40
60
80
100
120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

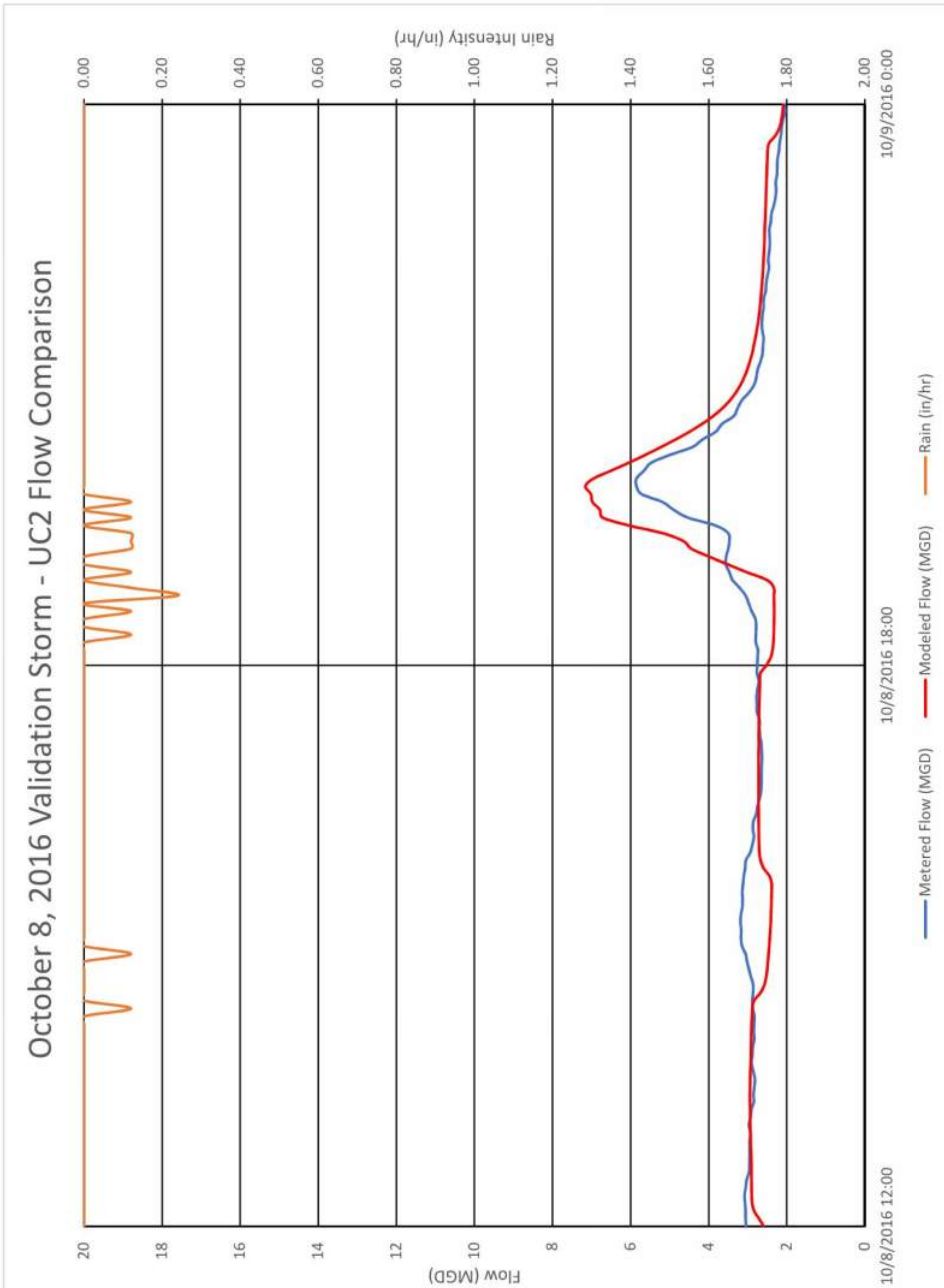

September 14, 2016 Validation Storm - UC2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
7
8
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered (ft)
Modeled (ft)
Rain (in/hr)


September 19, 2016 Calibration Storm - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
5
10
15
20
25
30
35
40
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

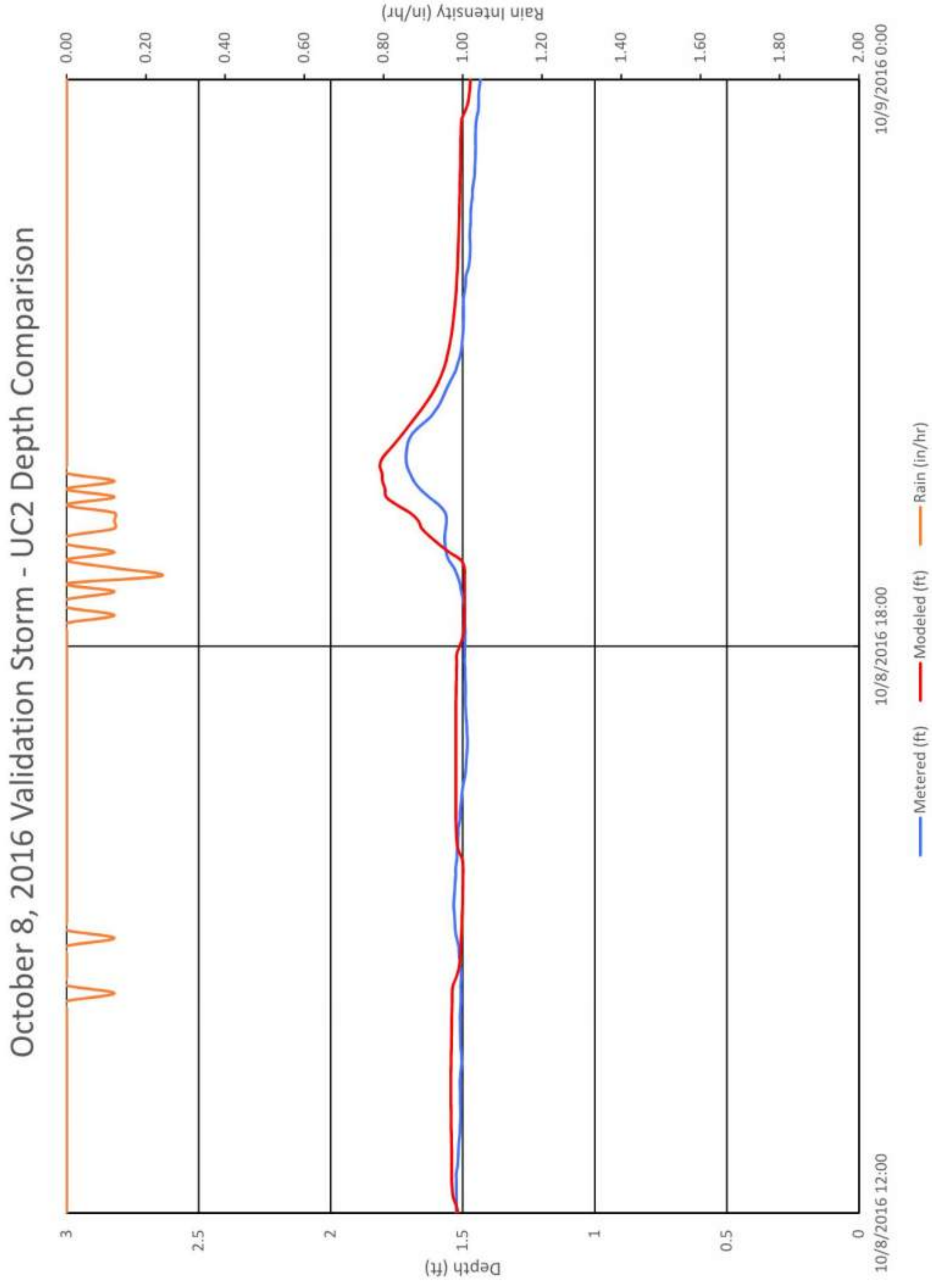

September 19, 2016 Calibration Storm - UC2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

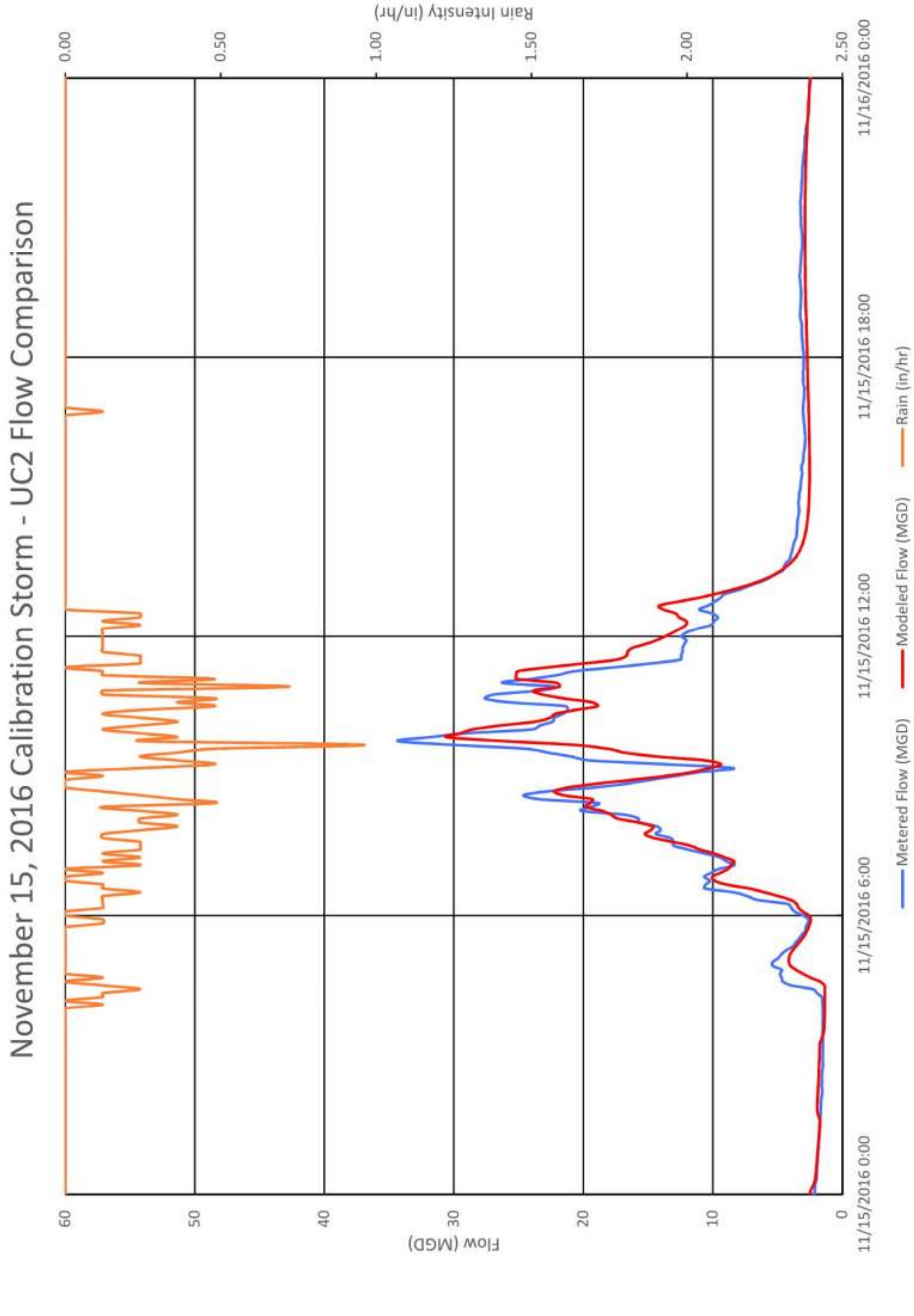

September 24, 2016 Calibration Storm - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
5
10
15
20
25
30
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

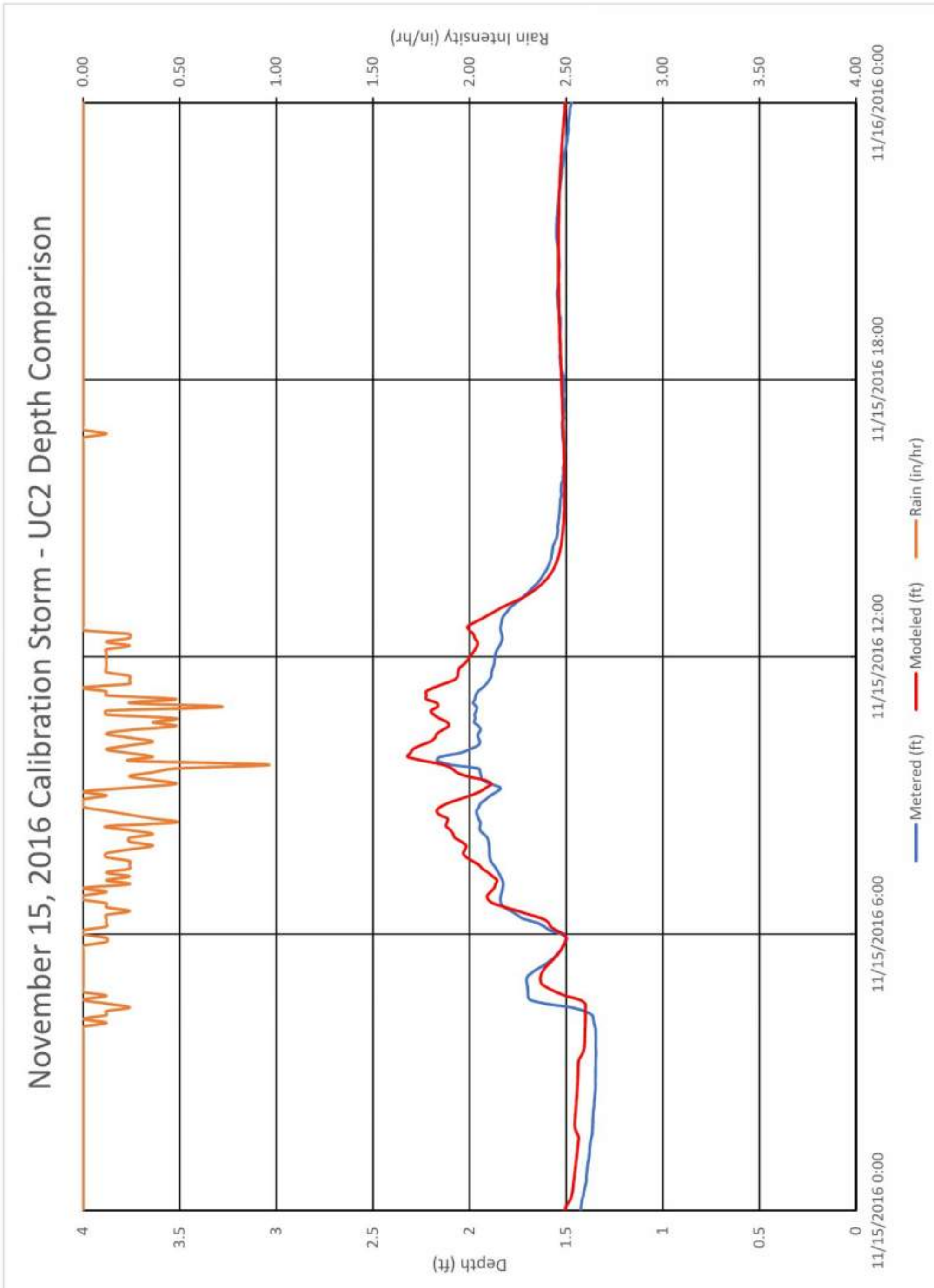

September 24, 2016 Calibration Storm - UC2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

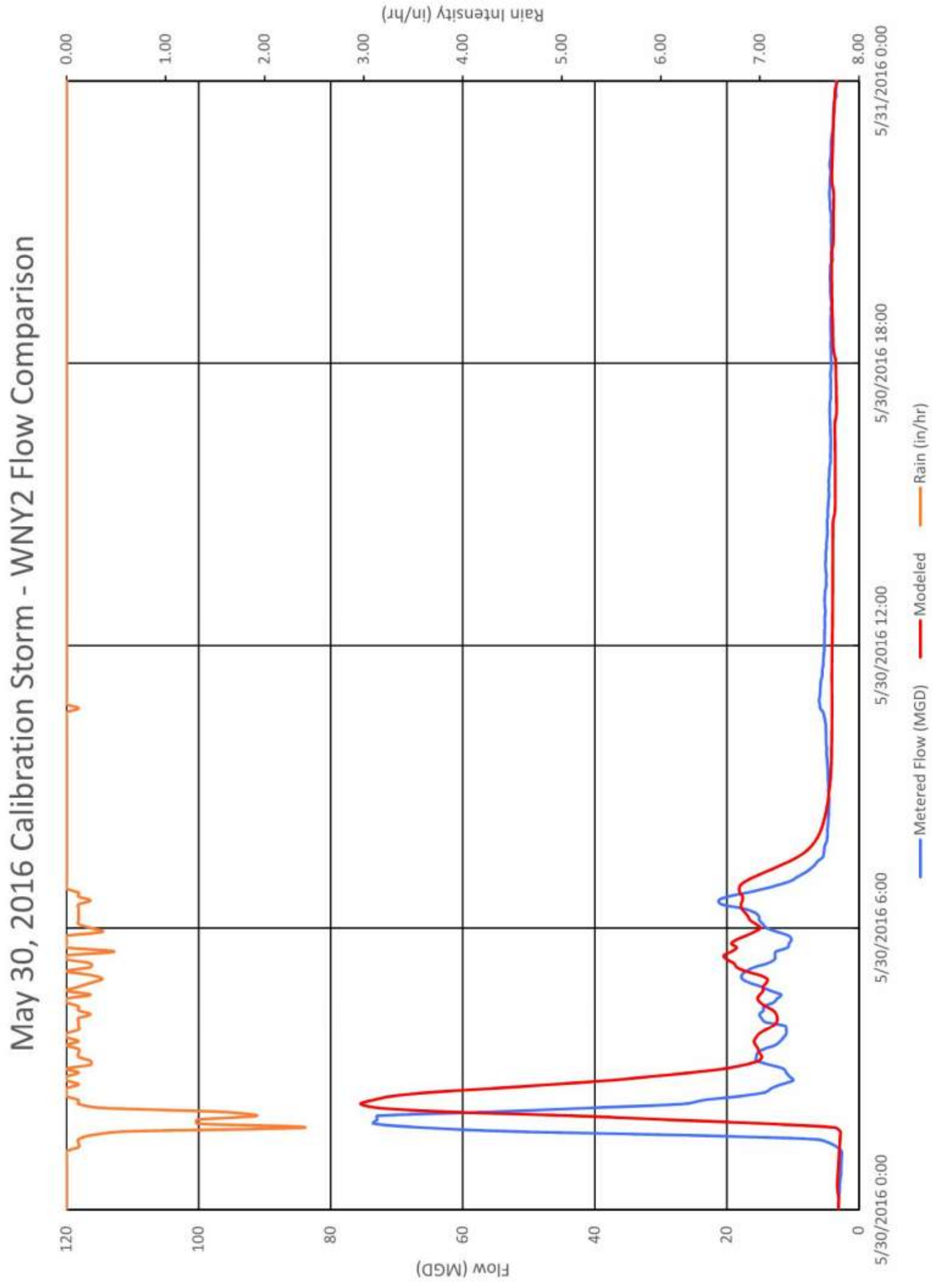


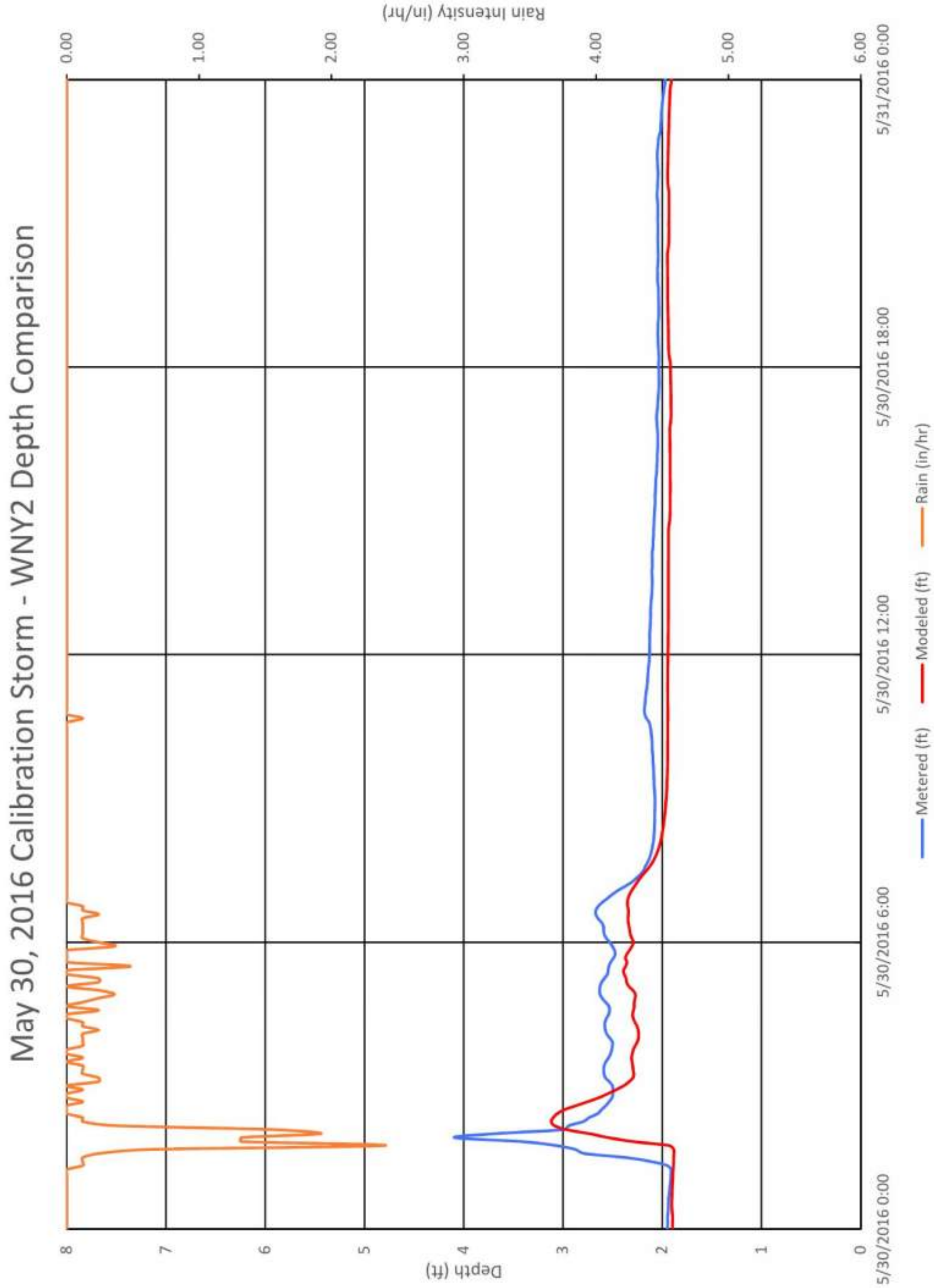
October 8, 2016 Validation Storm - UC2 Flow Comparison
Flow (MGD)
0
2
4
6
8
10
12
14
16
18
20
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

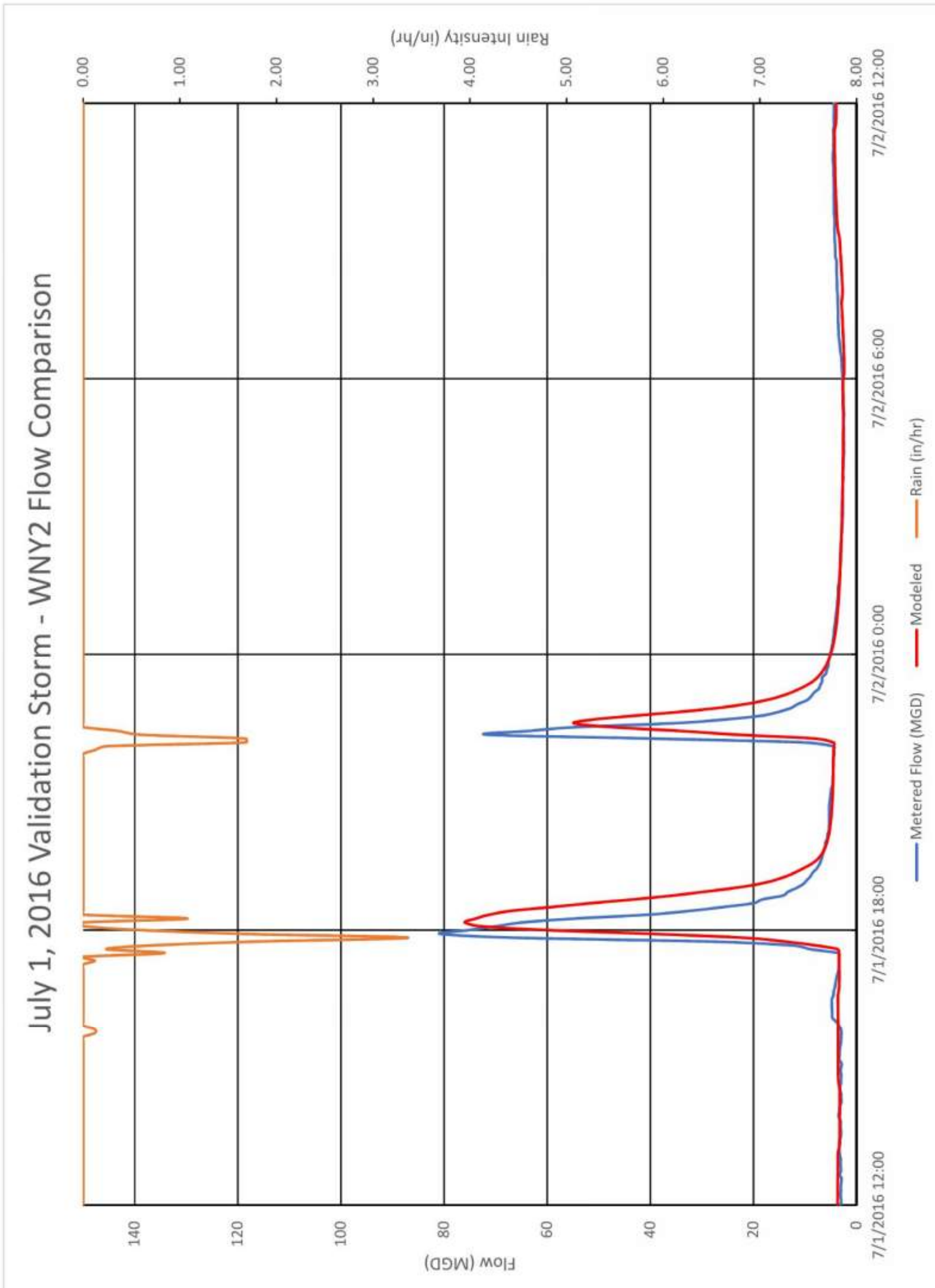

October 8, 2016 Validation Storm - UC2 Depth Comparison
Depth (ft)
0
0.5
1
1.5
2
2.5
3
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

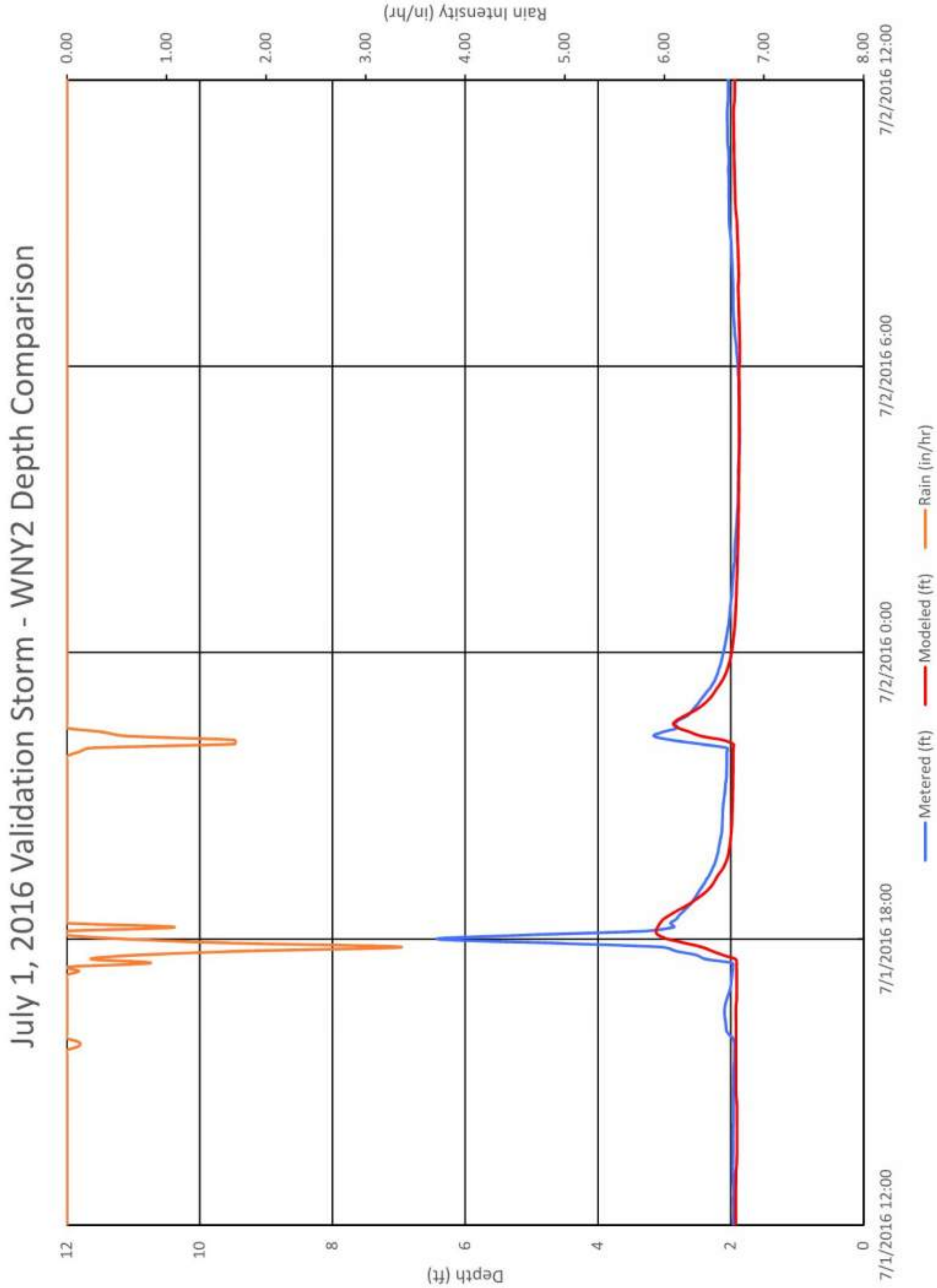

November 15, 2016 Calibration Storm - UC2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
10
20
30
40
50
60
0.00
0.50
1.00
1.50
2.00
2.50
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)


November 15, 2016 Calibration Storm - UC2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
0.5
1
1.5
2
2.5
3
3.5
4
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

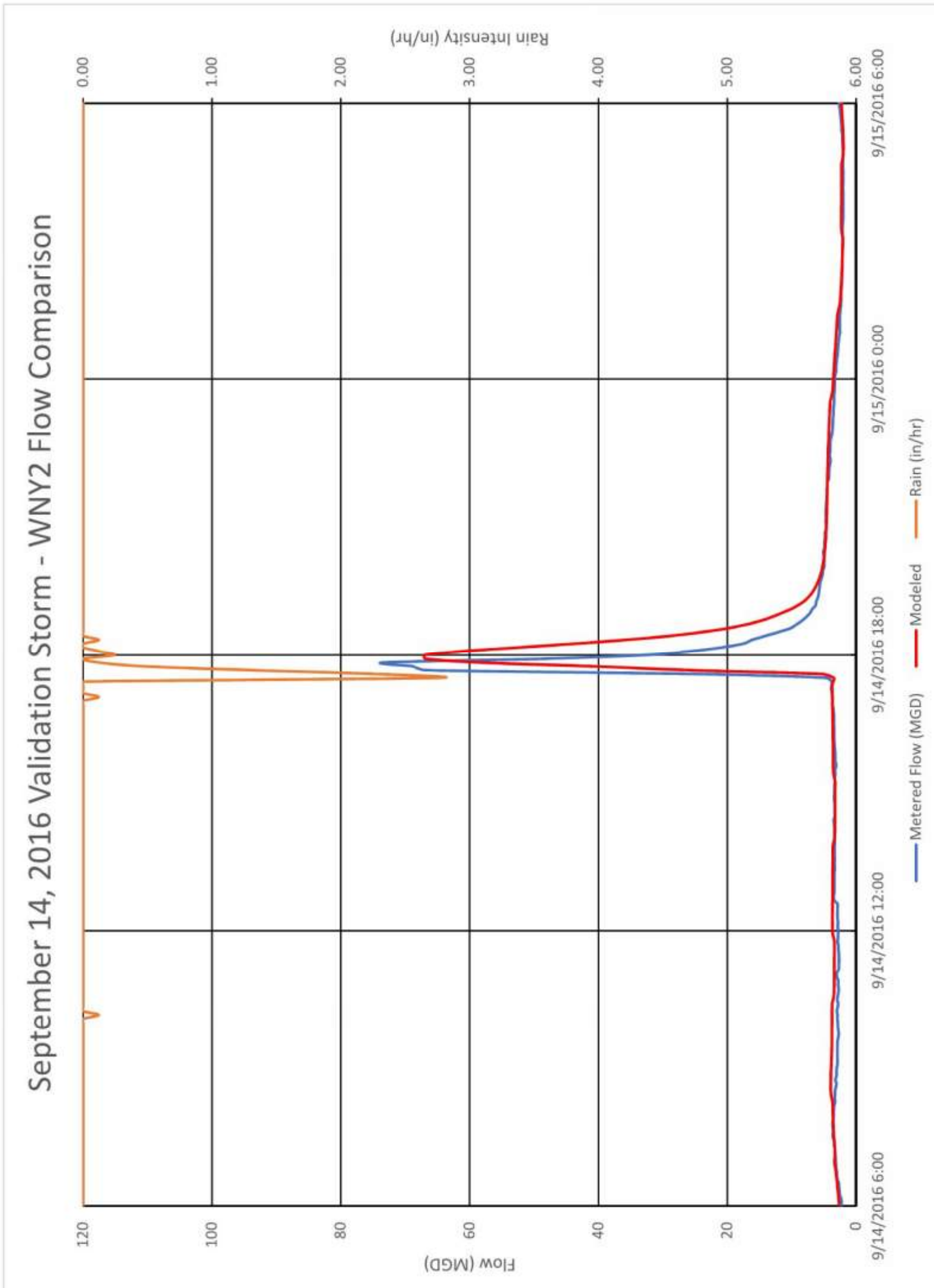

May 30, 2016 Calibration Storm - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
20
40
60
80
100
120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

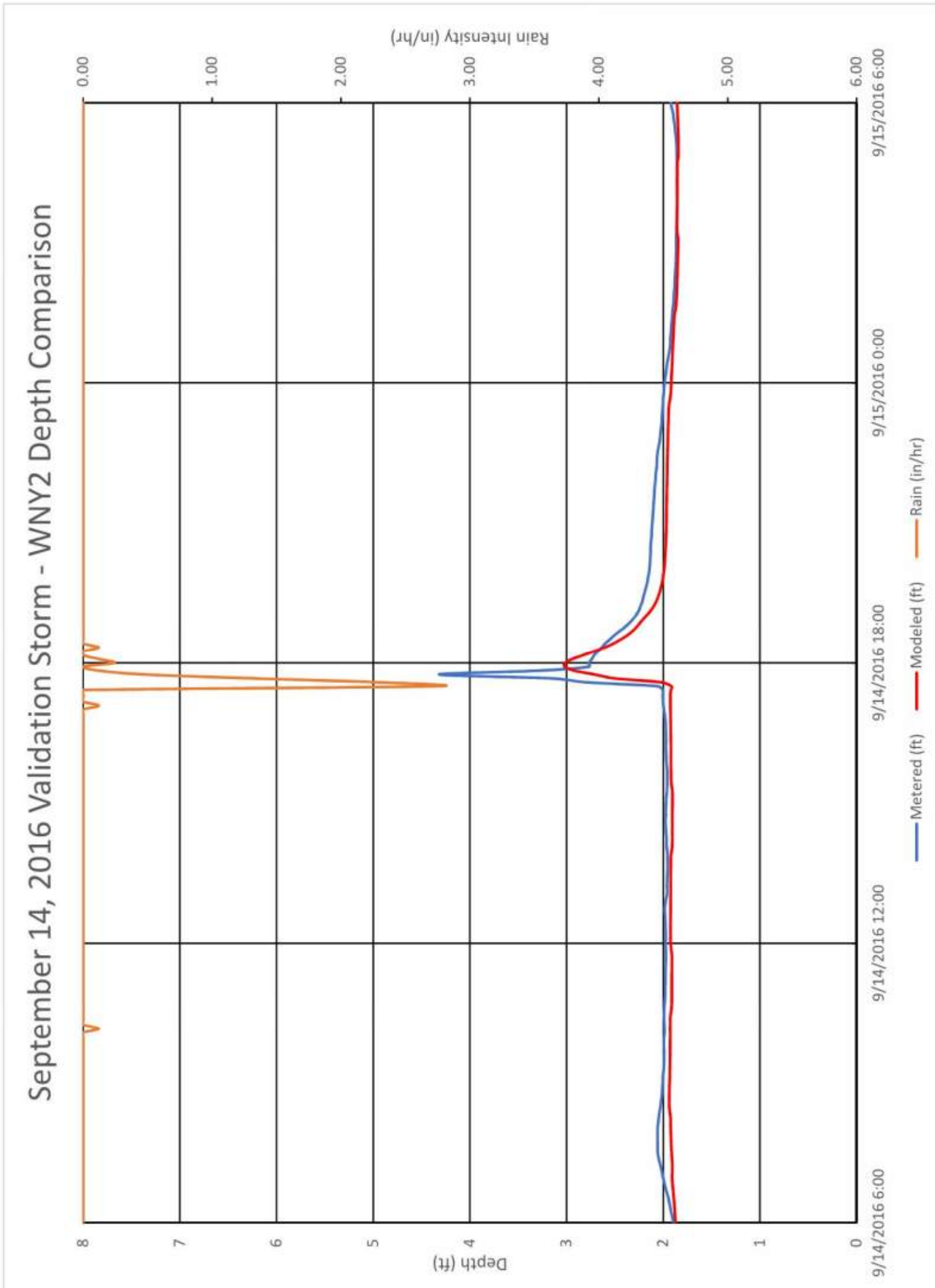

May 30, 2016 Calibration Storm - WNY2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
1
2
3
4
5
6
7
8
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

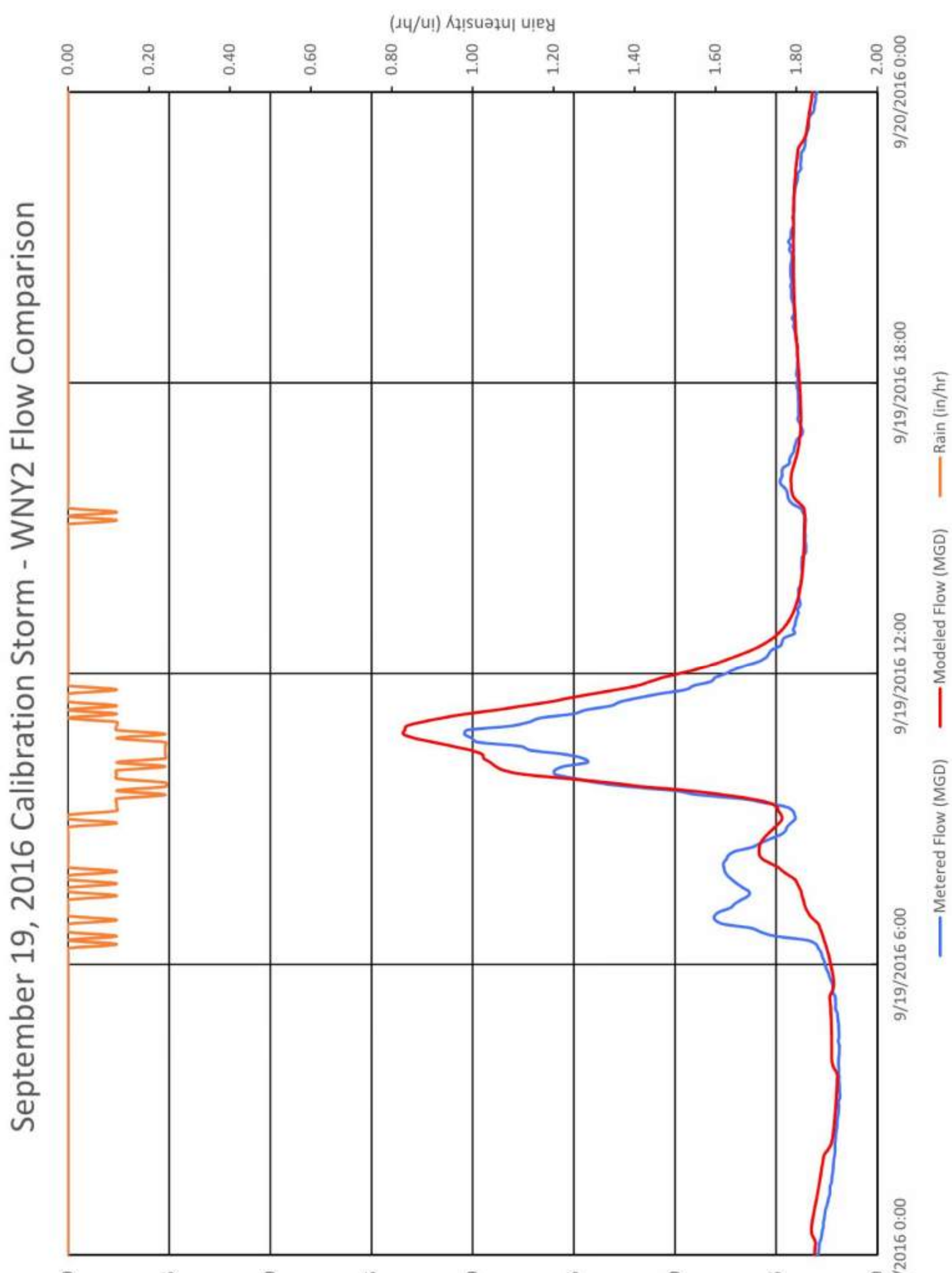

July 1, 2016 Validation Storm - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
20
40
60
80
100
120
140
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

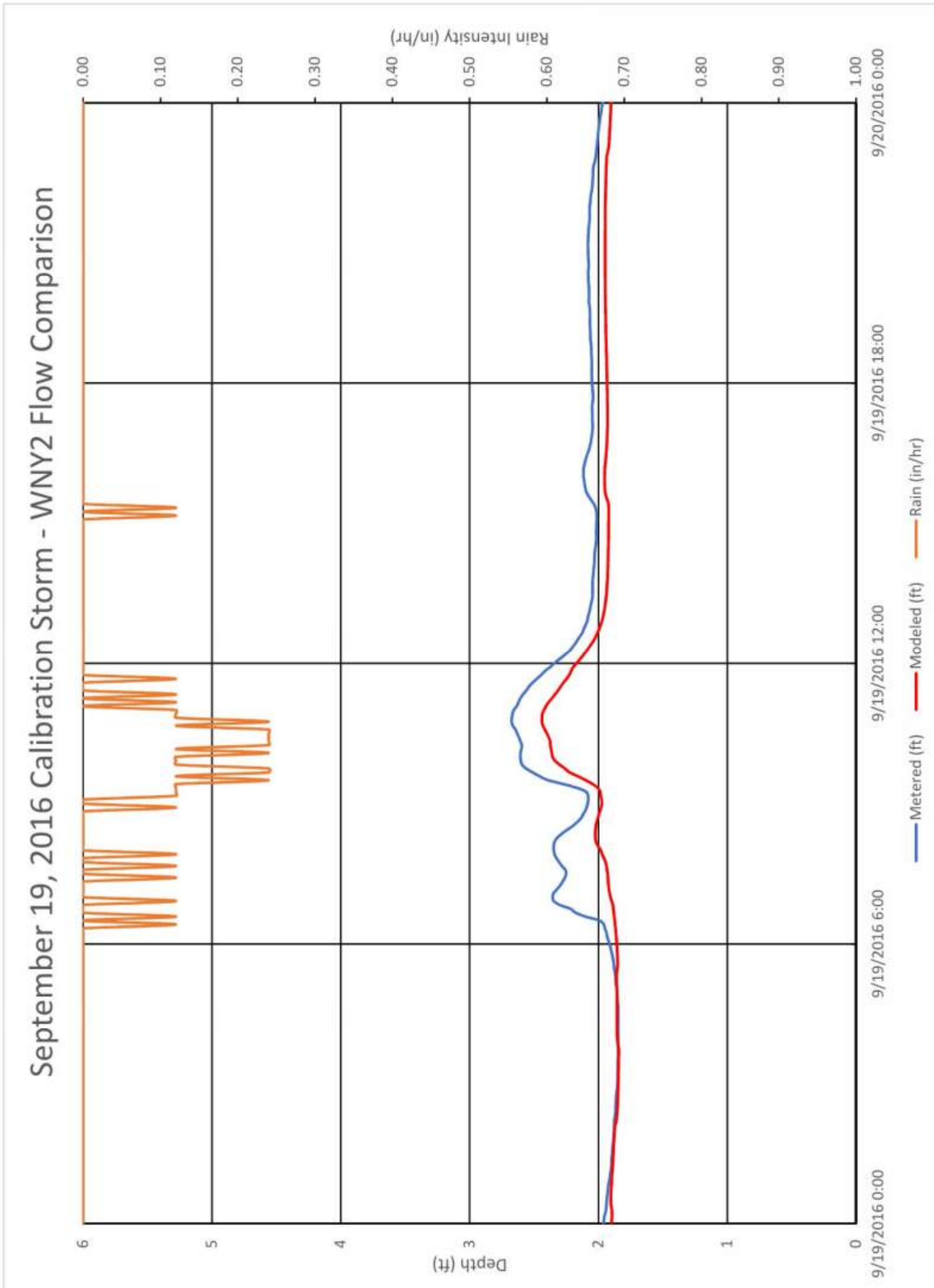


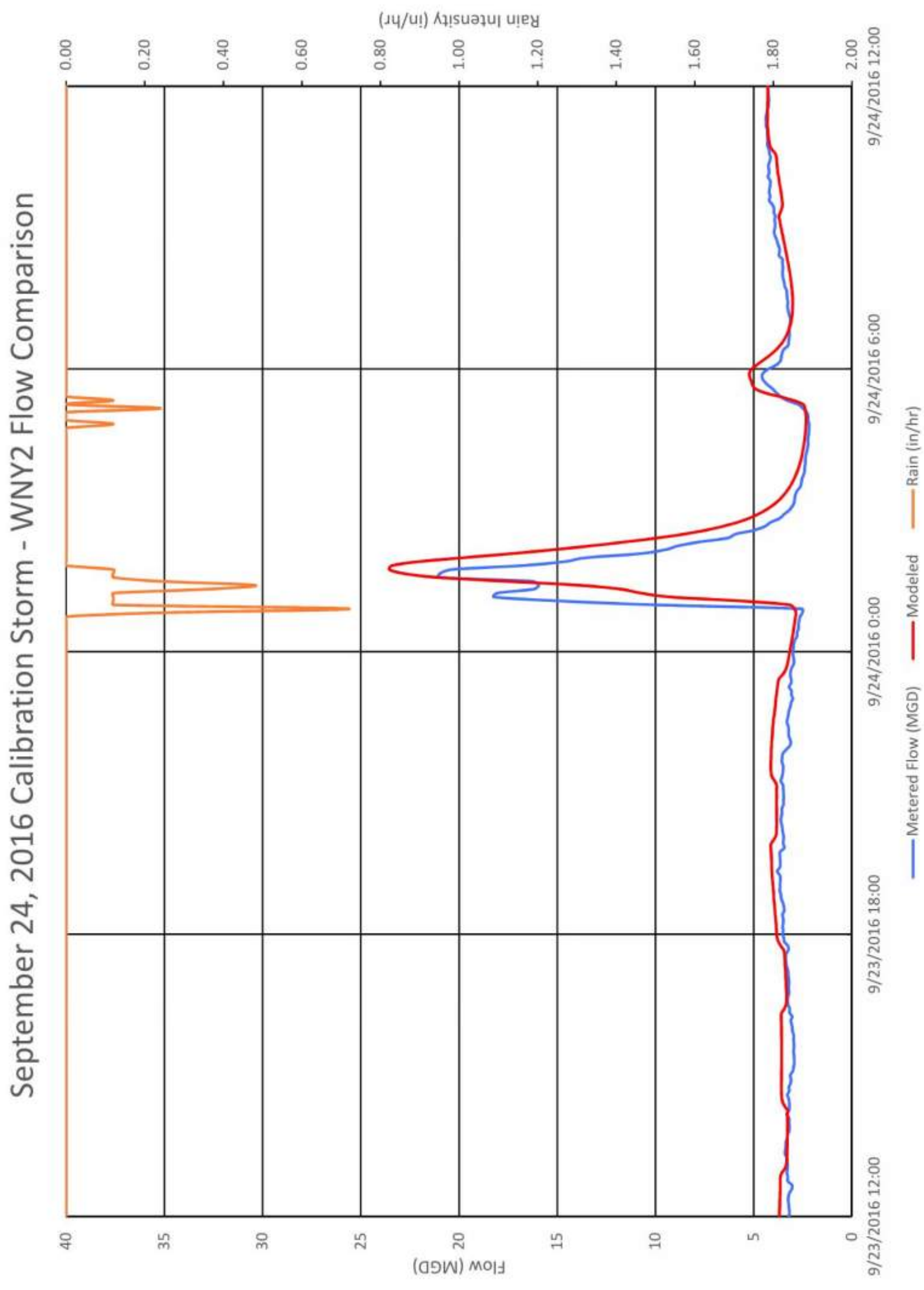
July 1, 2016 Validation Storm - WNY2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
2
4
6
8
10
12
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

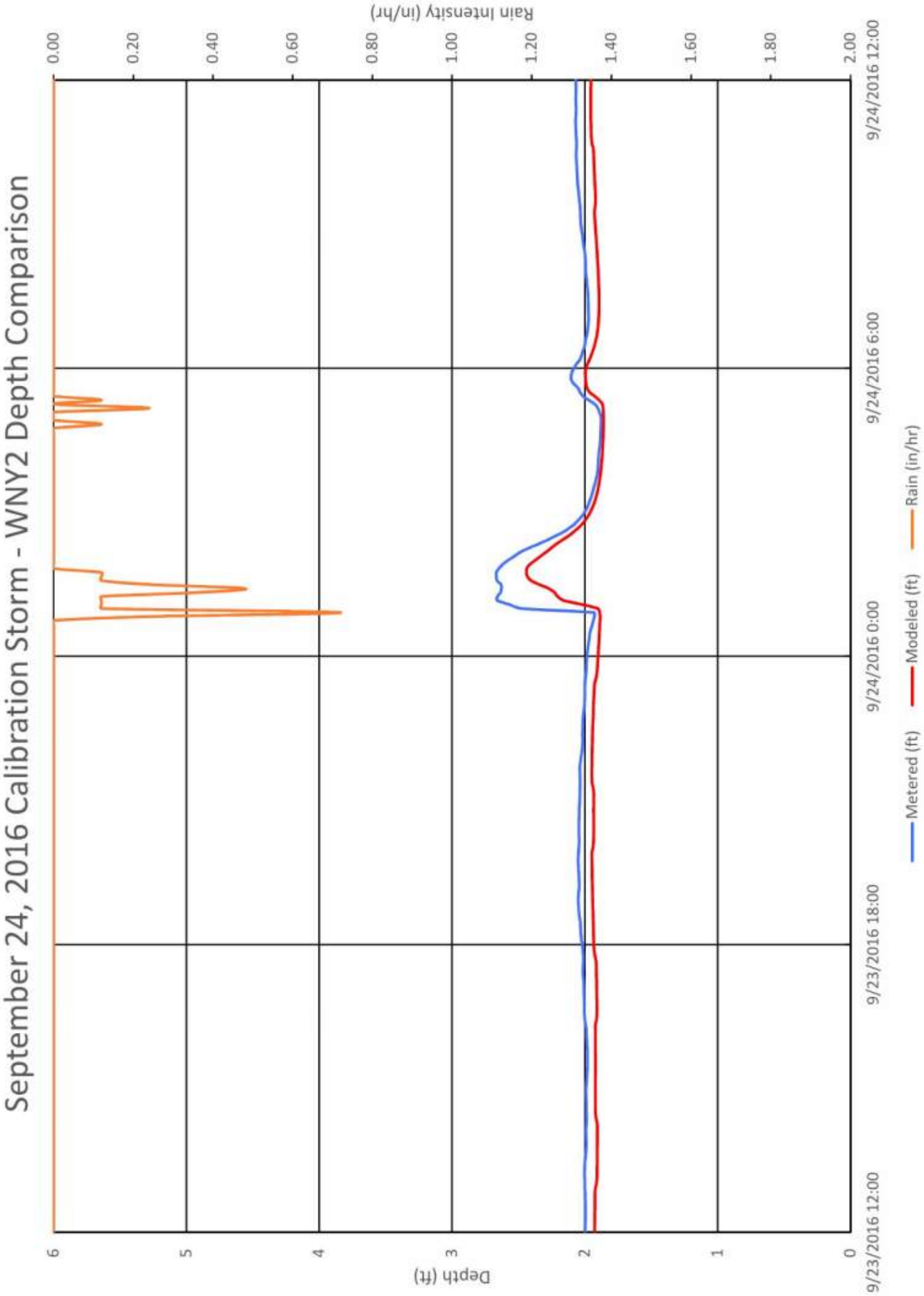

September 14, 2016 Validation Storm - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
20
40
60
80
100
120
0.00
1.00
2.00
3.00
4.00
5.00
6.00
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

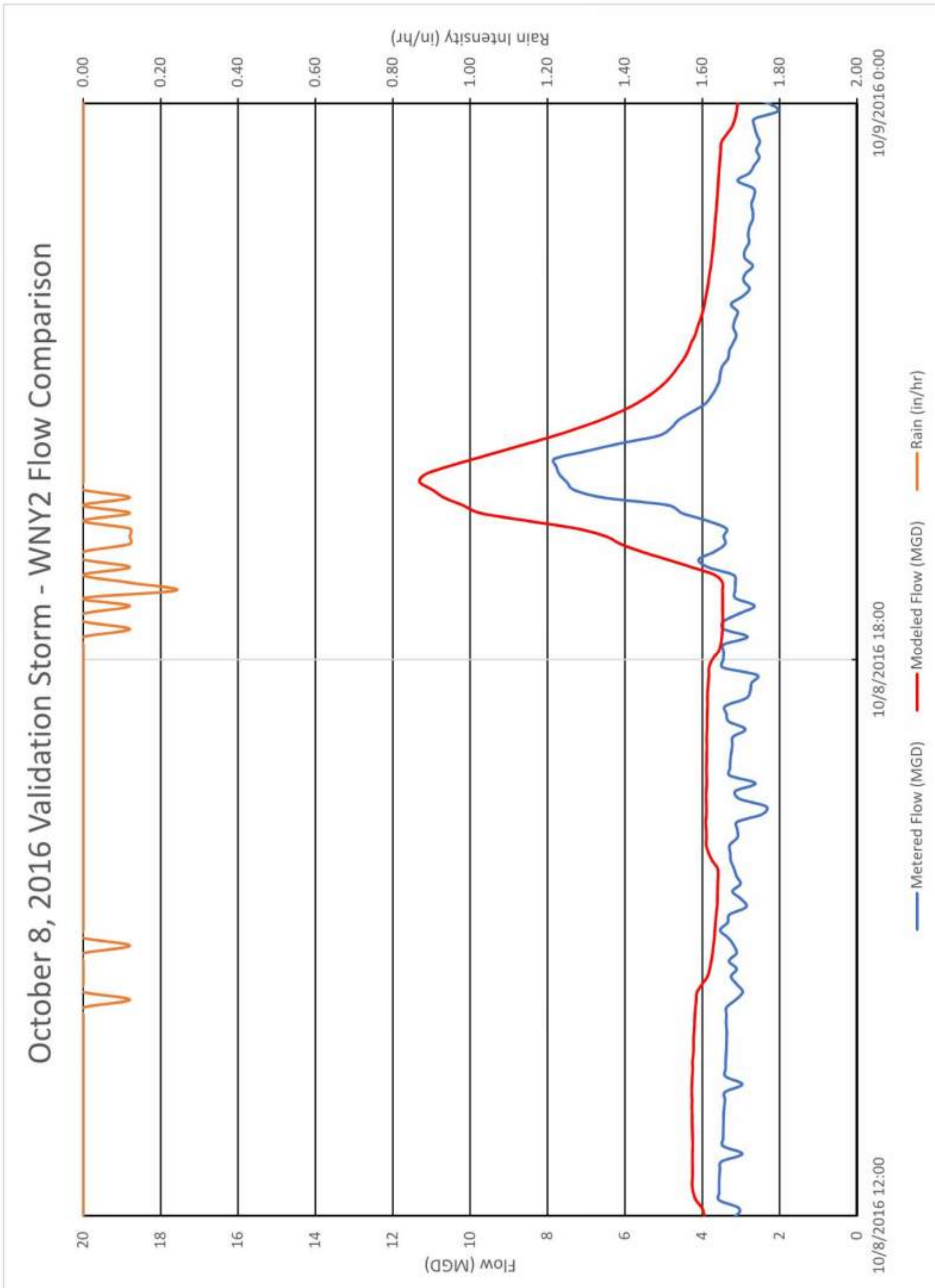

September 14, 2016 Validation Storm - WNY2 Depth Comparison
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Depth (ft)
0
1
2
3
4
5
6
7
8
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

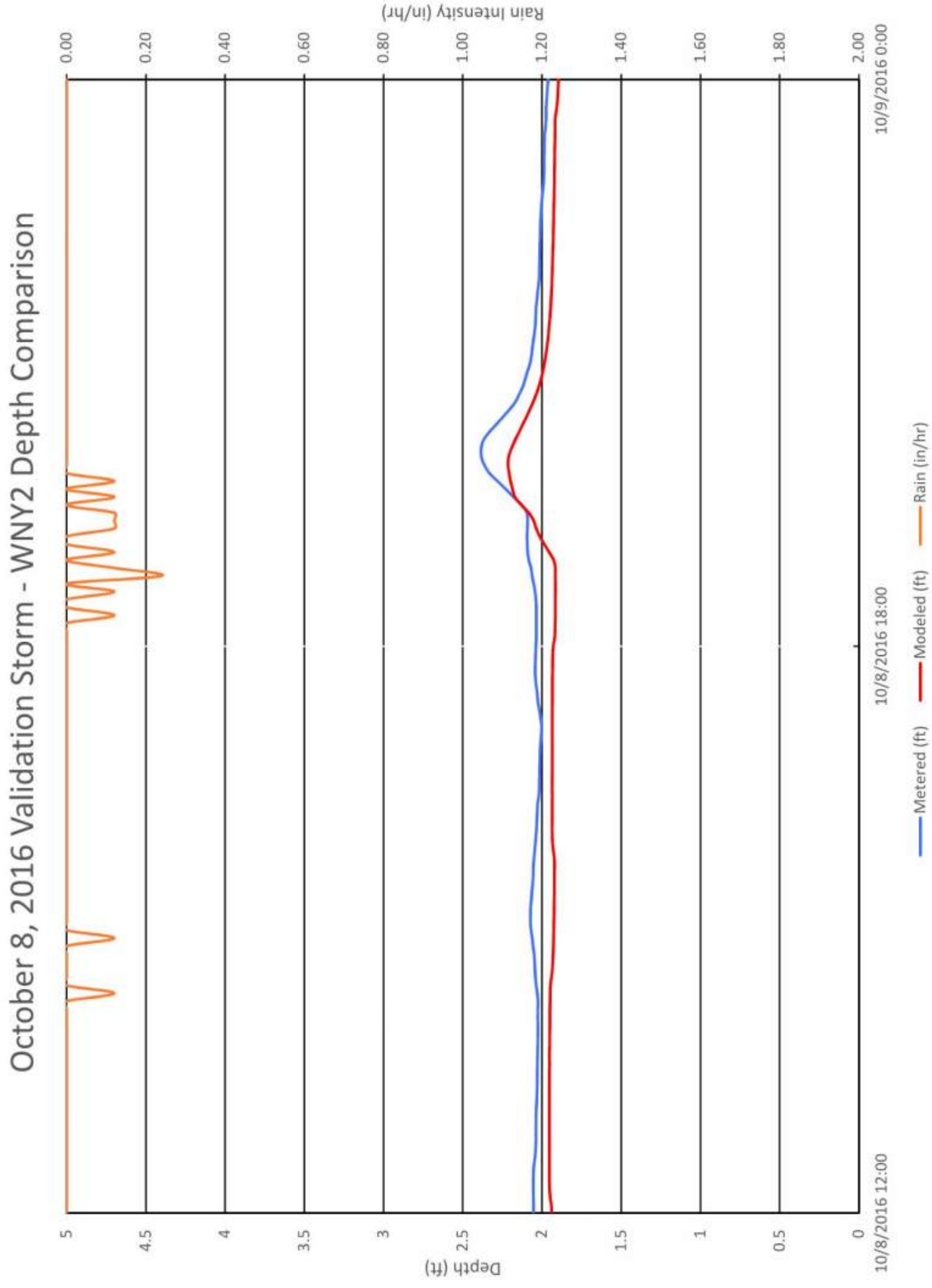

September 19, 2016 Calibration Storm - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
0
5
10
15
20
25
30
35
40
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

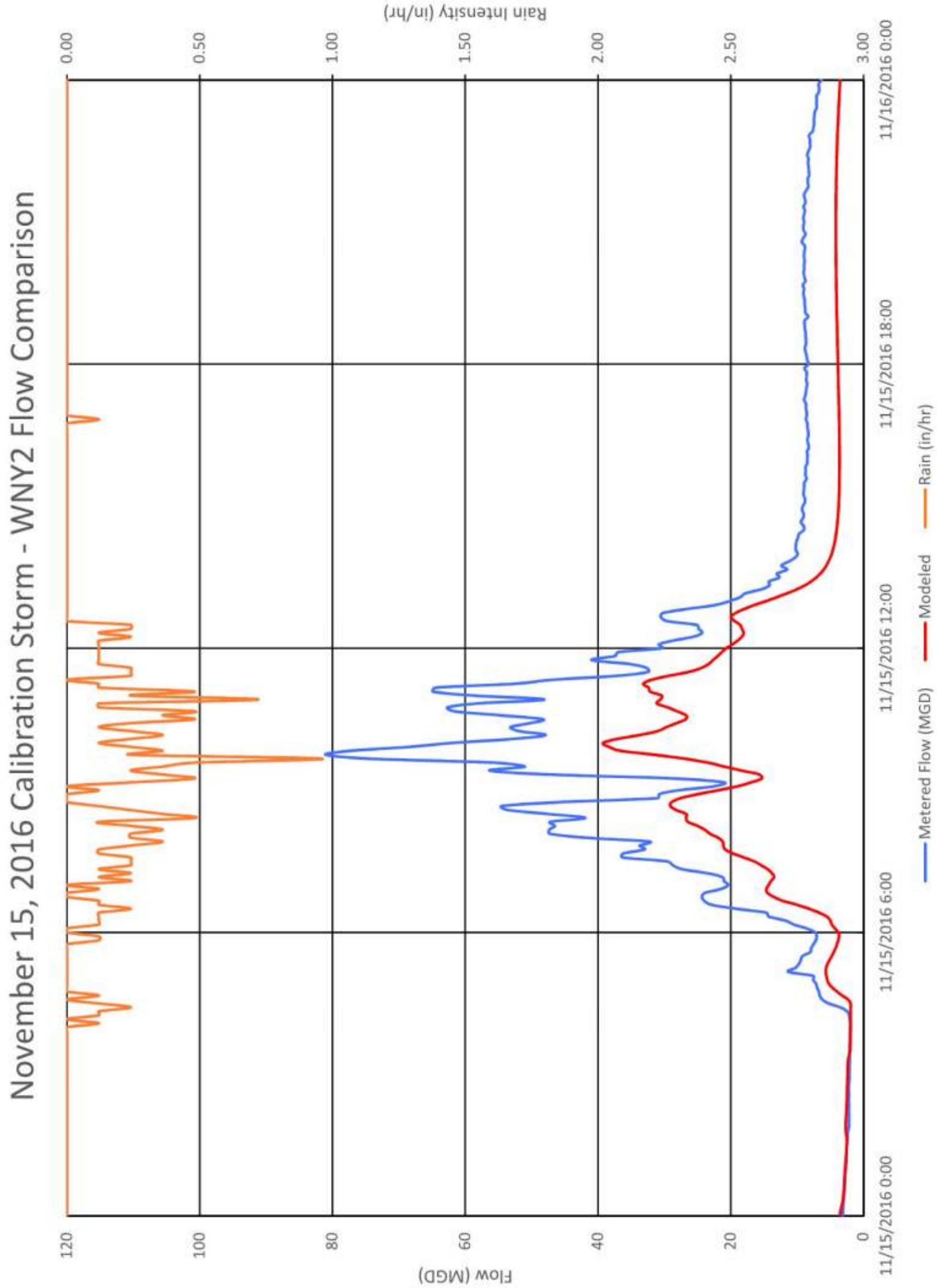

September 19, 2016 Calibration Storm - WNY2 Flow Comparison
Depth (ft)
0
1
2
3
4
5
6
Rain Intensity (in/hr)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

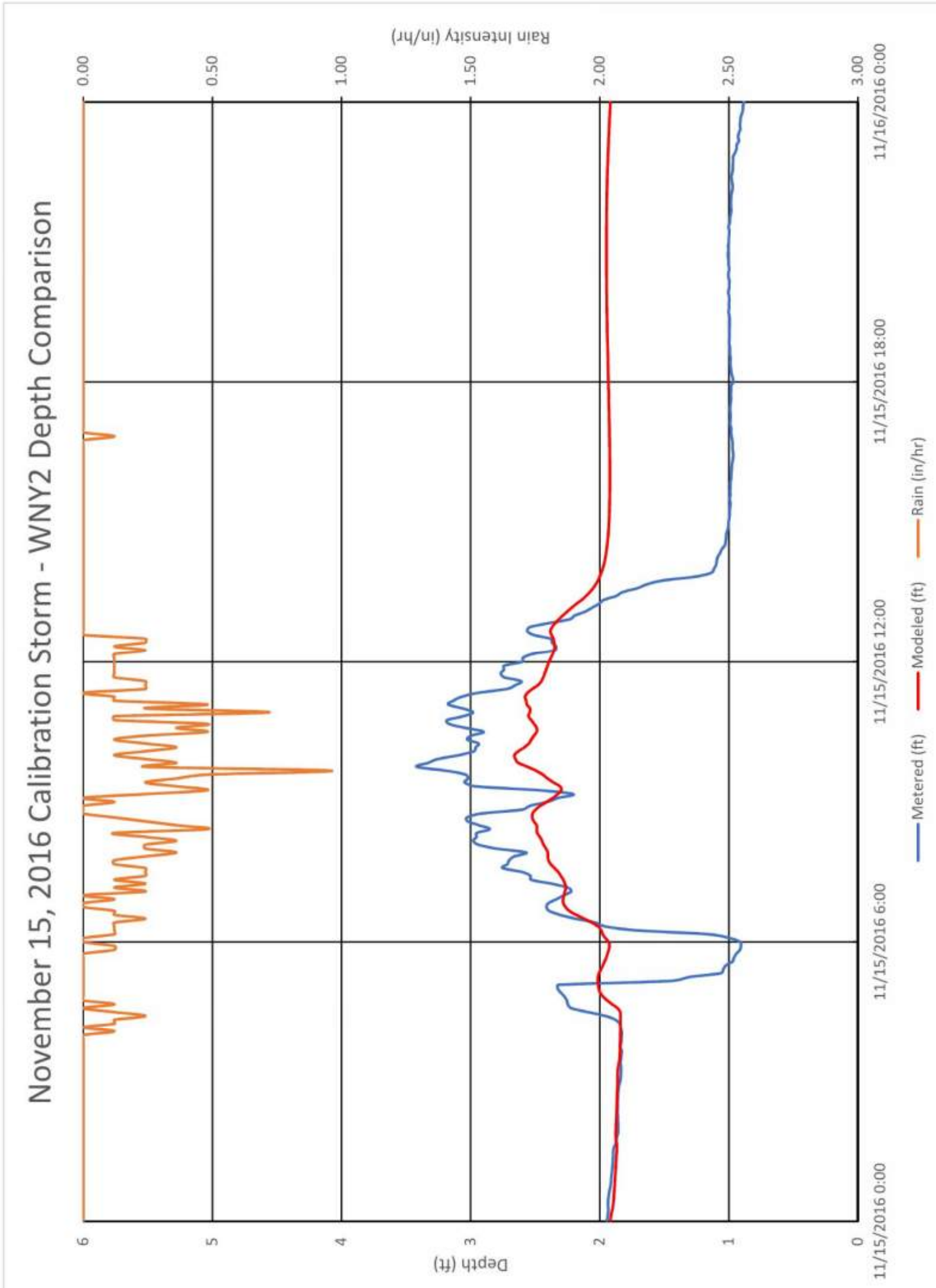

September 24, 2016 Calibration Storm - WNY2 Flow Comparison
Flow (MGD)
0
5
10
15
20
25
30
35
40
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

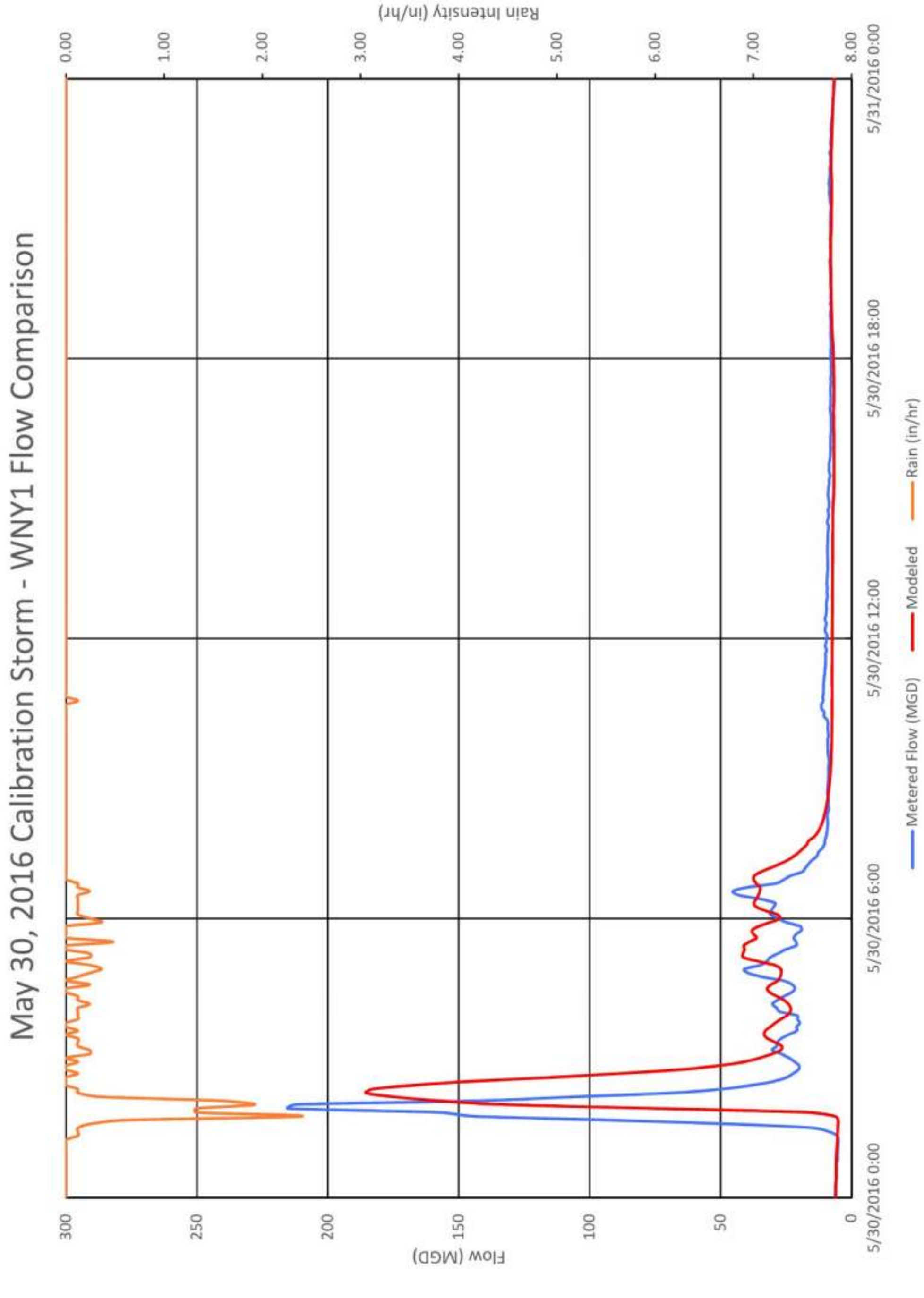

September 24, 2016 Calibration Storm - WNY2 Depth Comparison
Depth (ft)
0
1
2
3
4
5
6
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

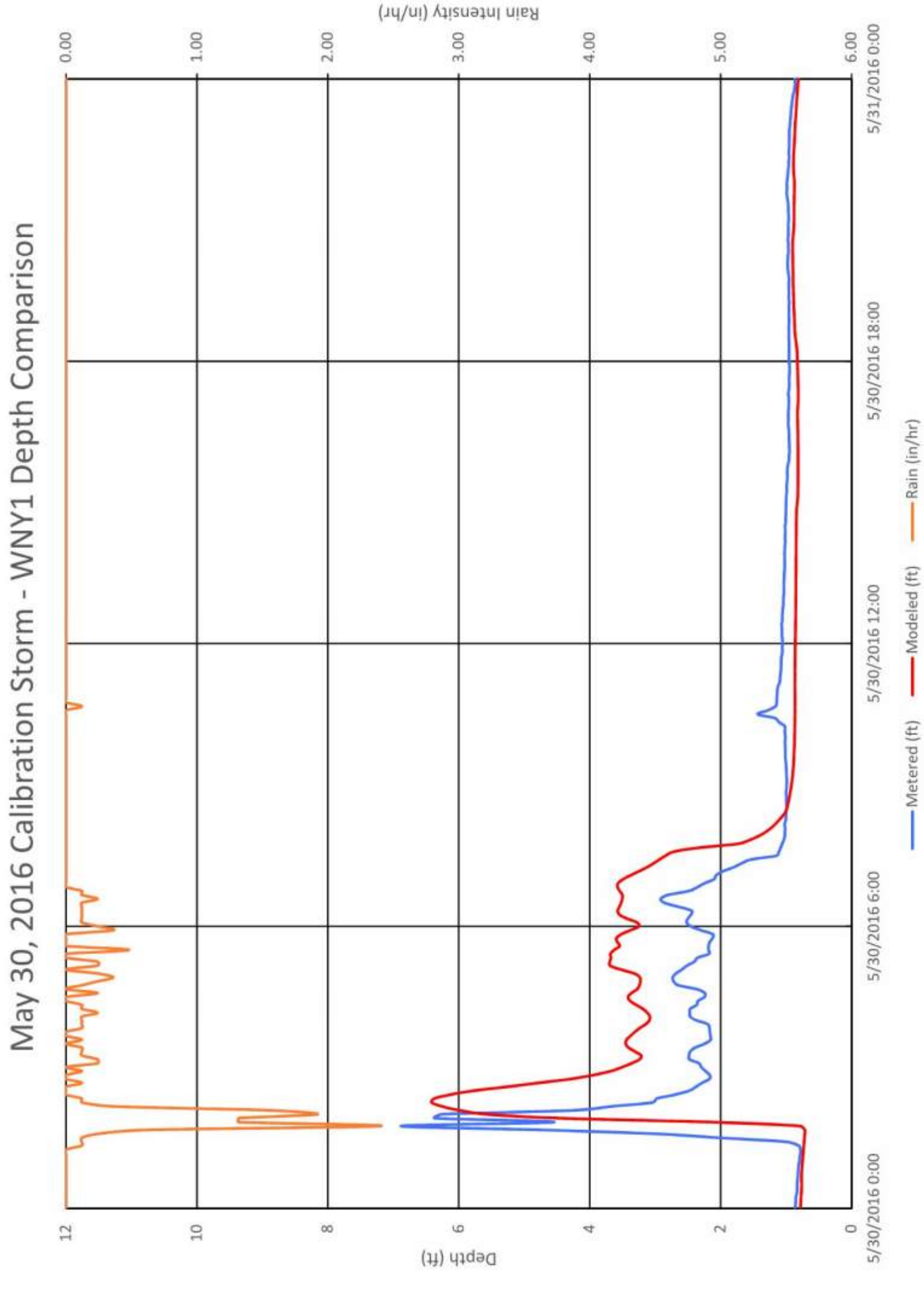

October 8, 2016 Validation Storm - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)


October 8, 2016 Validation Storm - WNY2 Depth Comparison
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Depth (ft)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

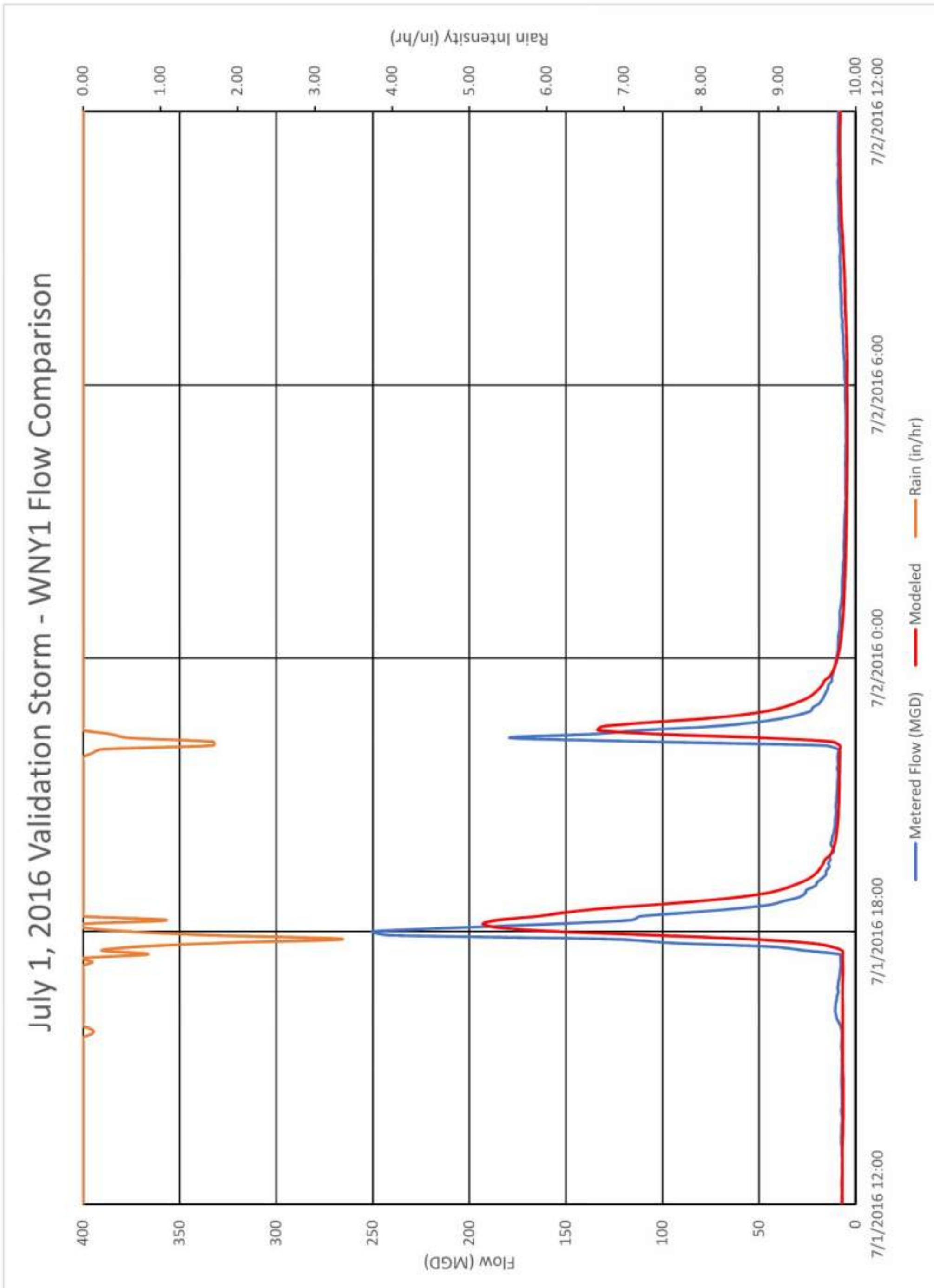

November 15, 2016 Calibration Storm - WNY2 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
120
100
80
60
40
20
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

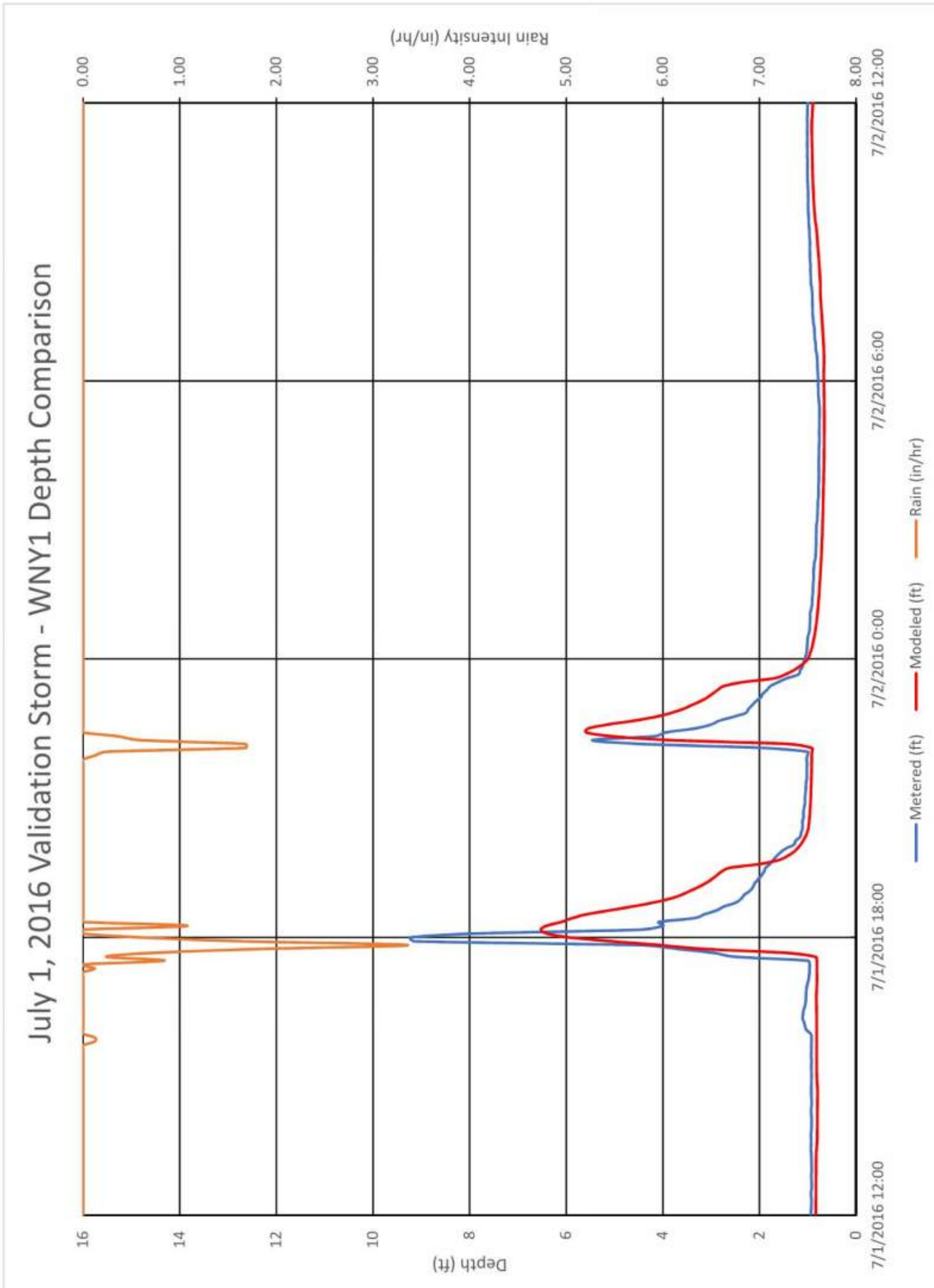

November 15, 2016 Calibration Storm - WNY2 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
0.00
0.50
1.00
1.50
2.00
2.50
3.00
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

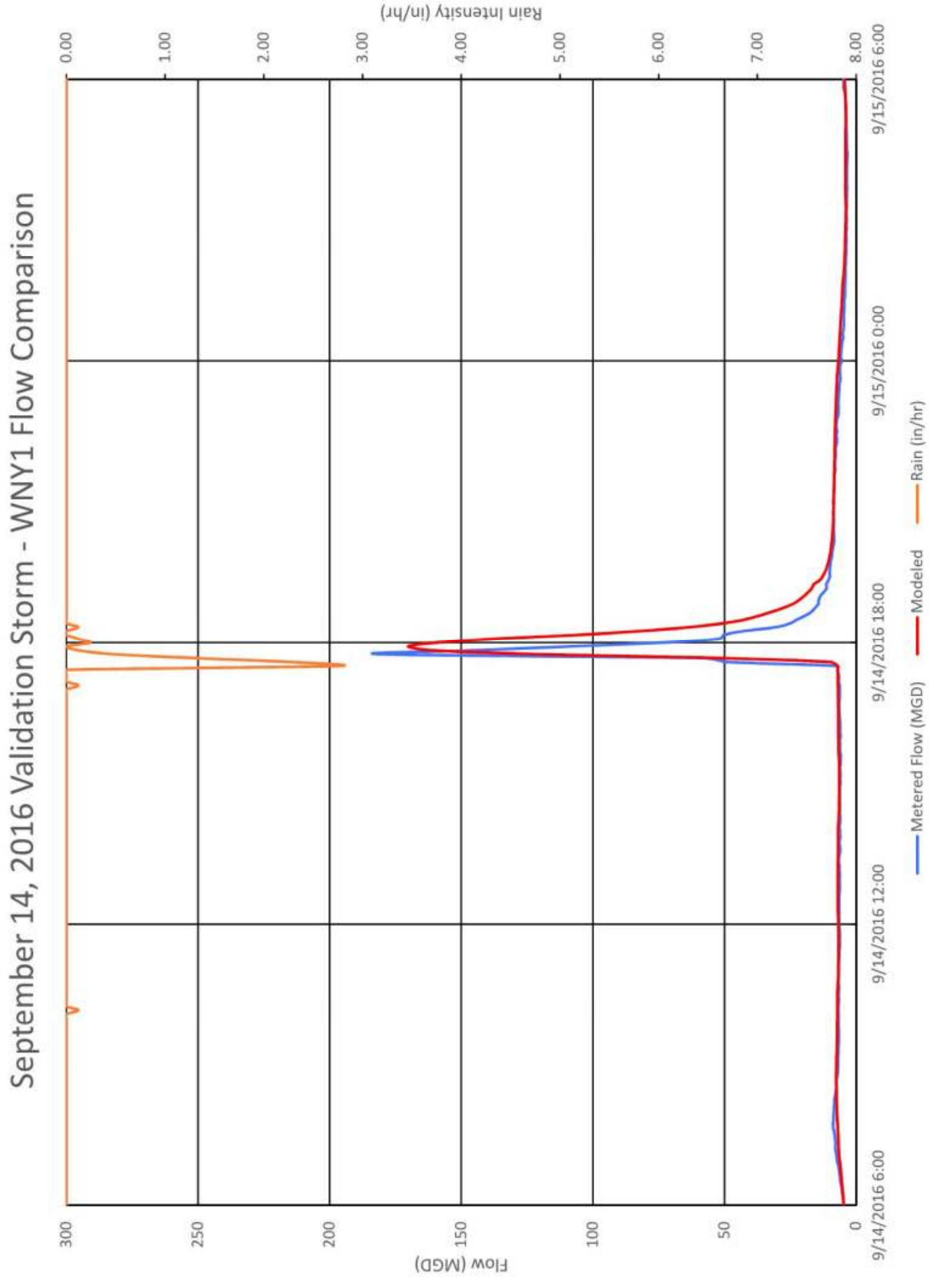

May 30, 2016 Calibration Storm - WNY1 Flow Comparison
Flow (MGD)
300
250
200
150
100
50
0
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

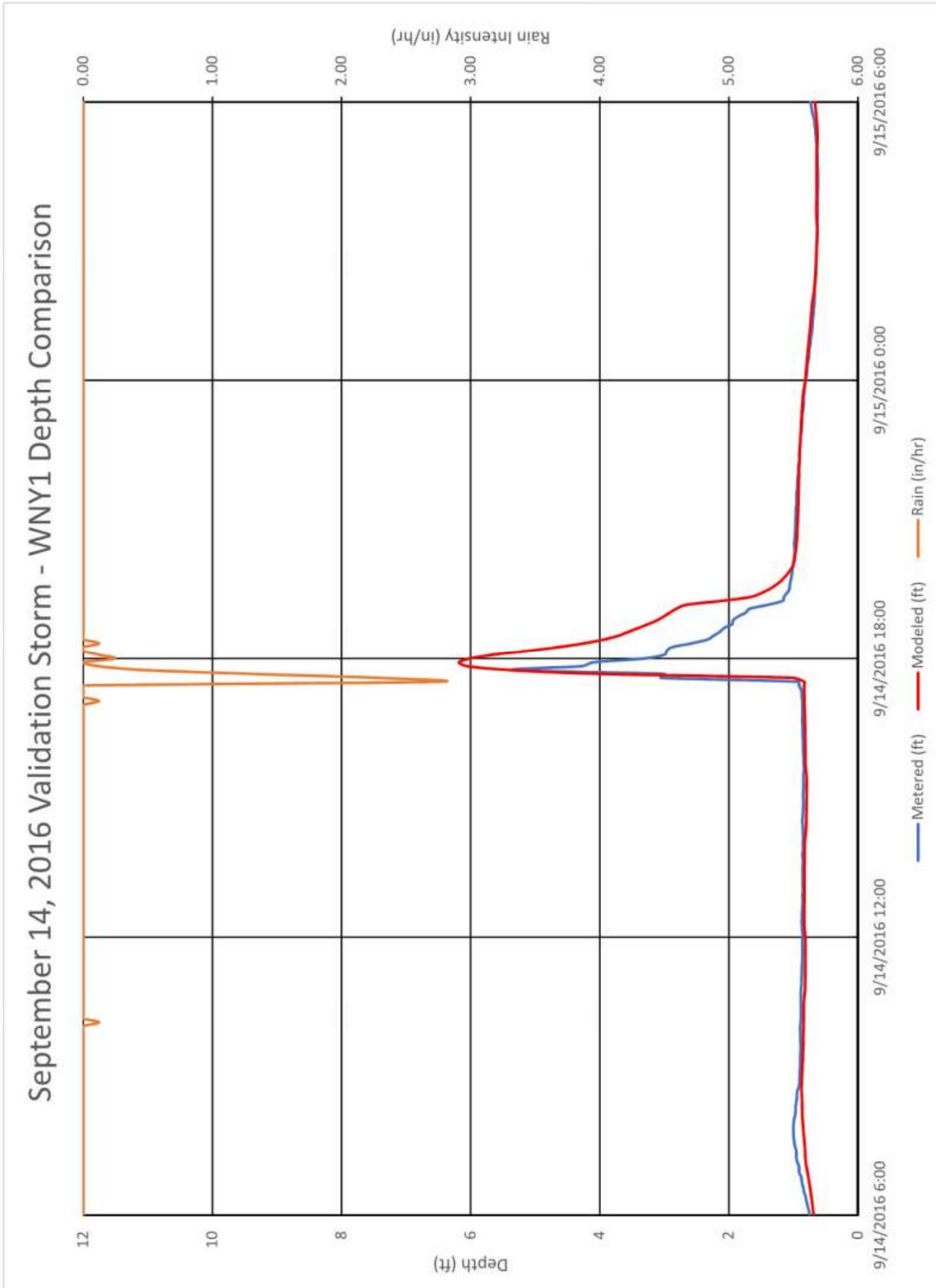


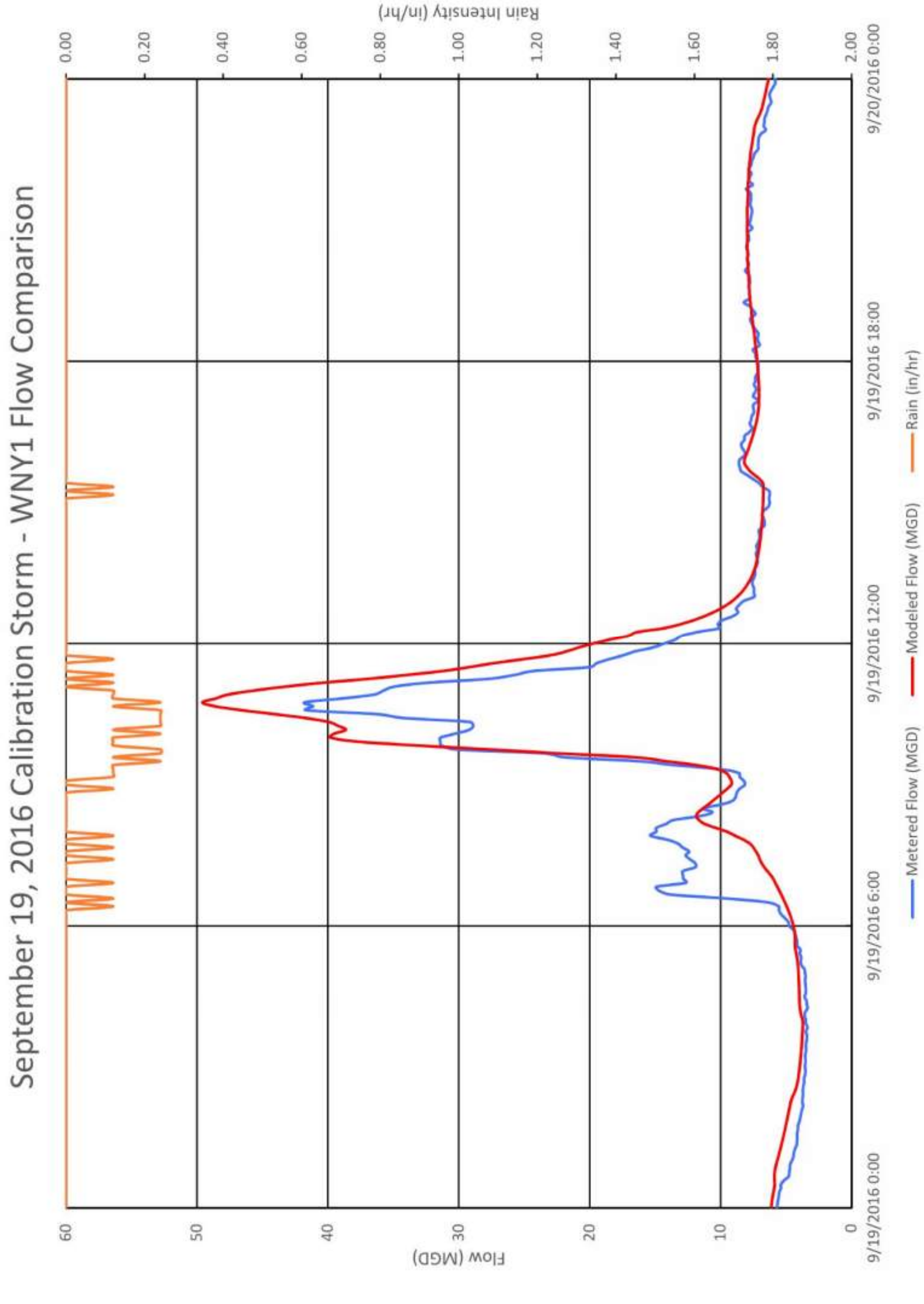
May 30, 2016 Calibration Storm - WNY1 Depth Comparison
Depth (ft)
0
2
4
6
8
10
12
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
5/30/2016 0:00
5/30/2016 6:00
5/30/2016 12:00
5/30/2016 18:00
5/31/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

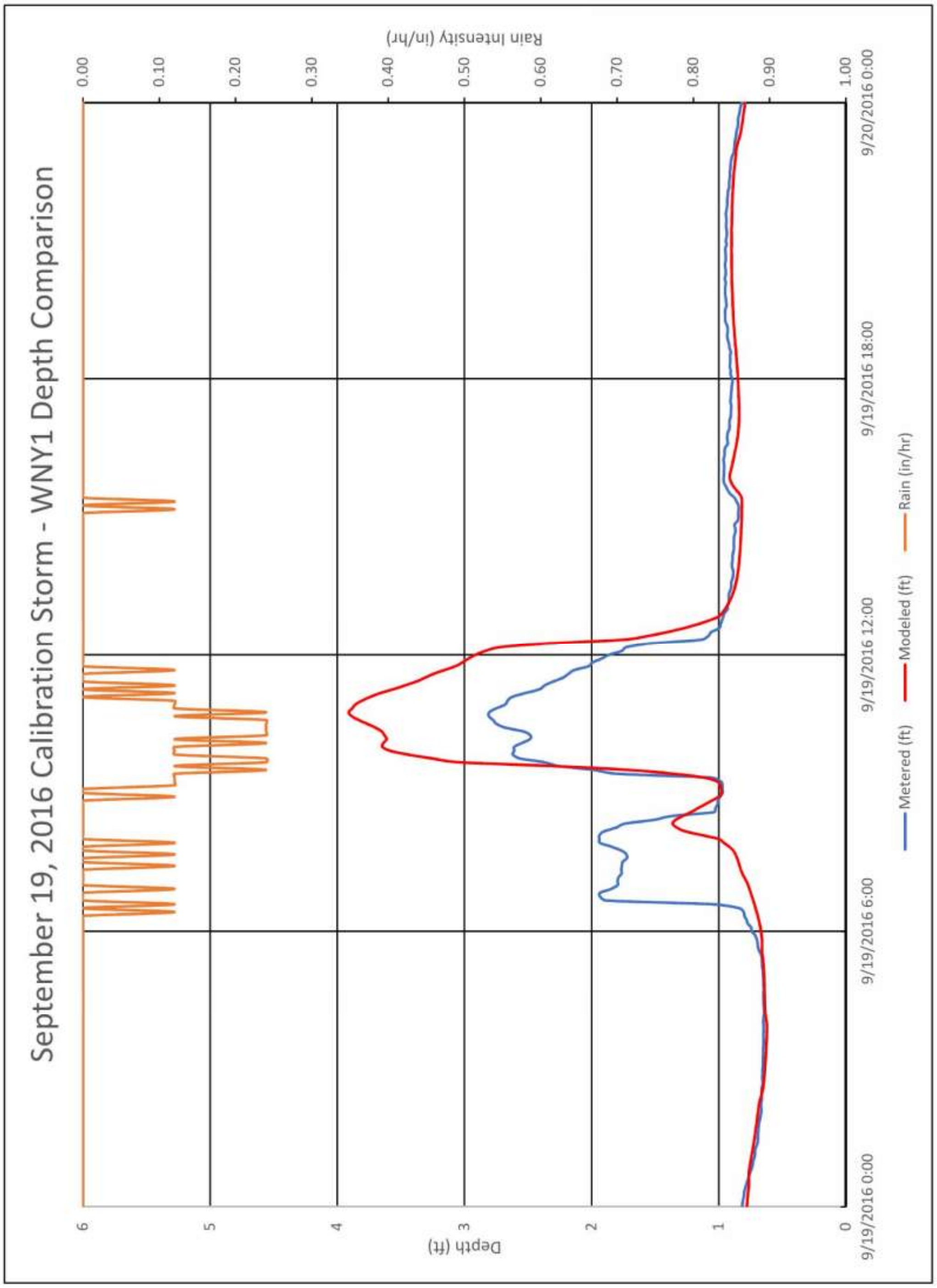

July 1, 2016 Validation Storm - WNY1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
400
350
300
250
200
150
100
50
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

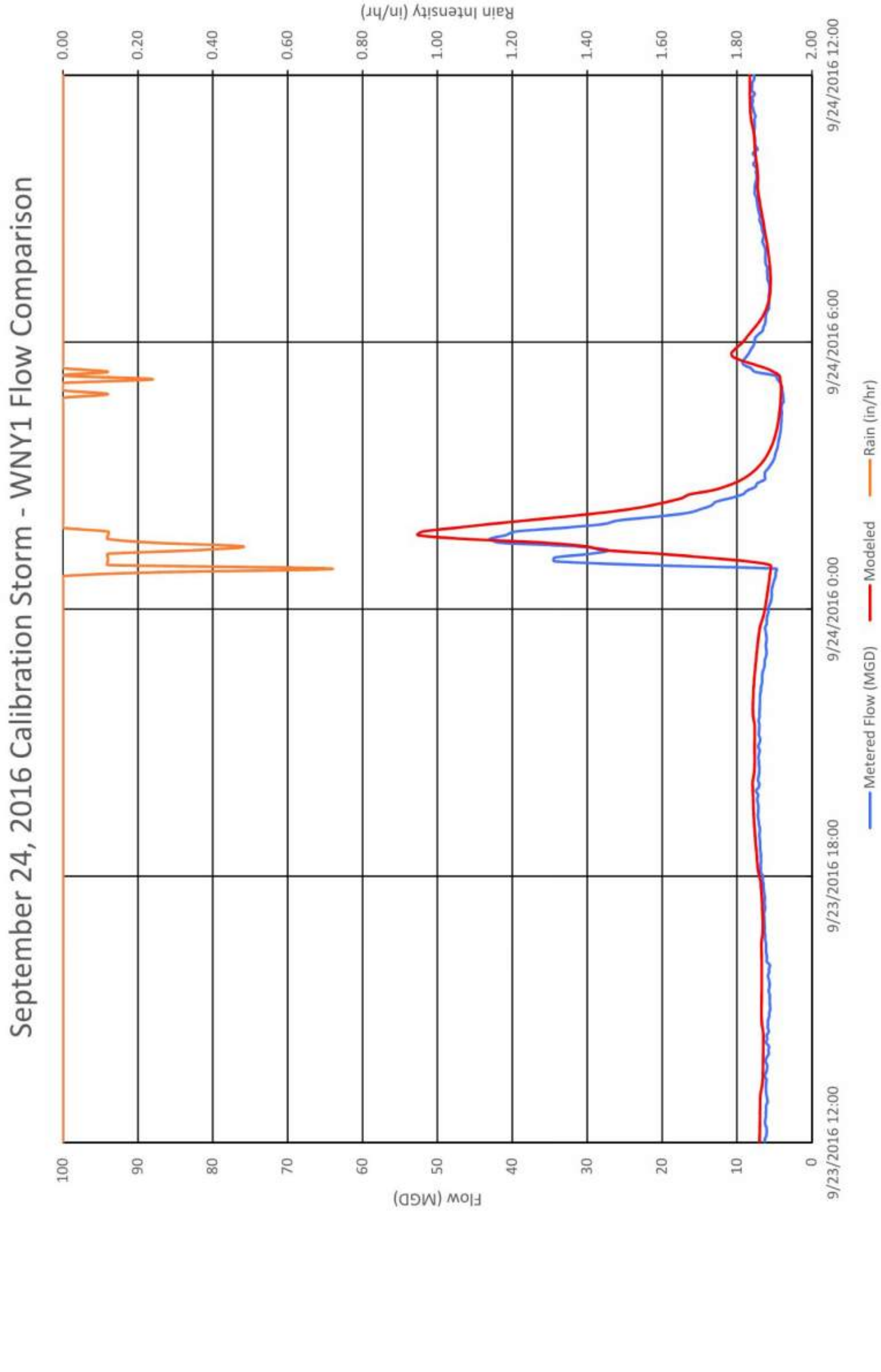

July 1, 2016 Validation Storm - WNY1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
2
4
6
8
10
12
14
16
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
7/1/2016 12:00
7/1/2016 18:00
7/2/2016 0:00
7/2/2016 6:00
7/2/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

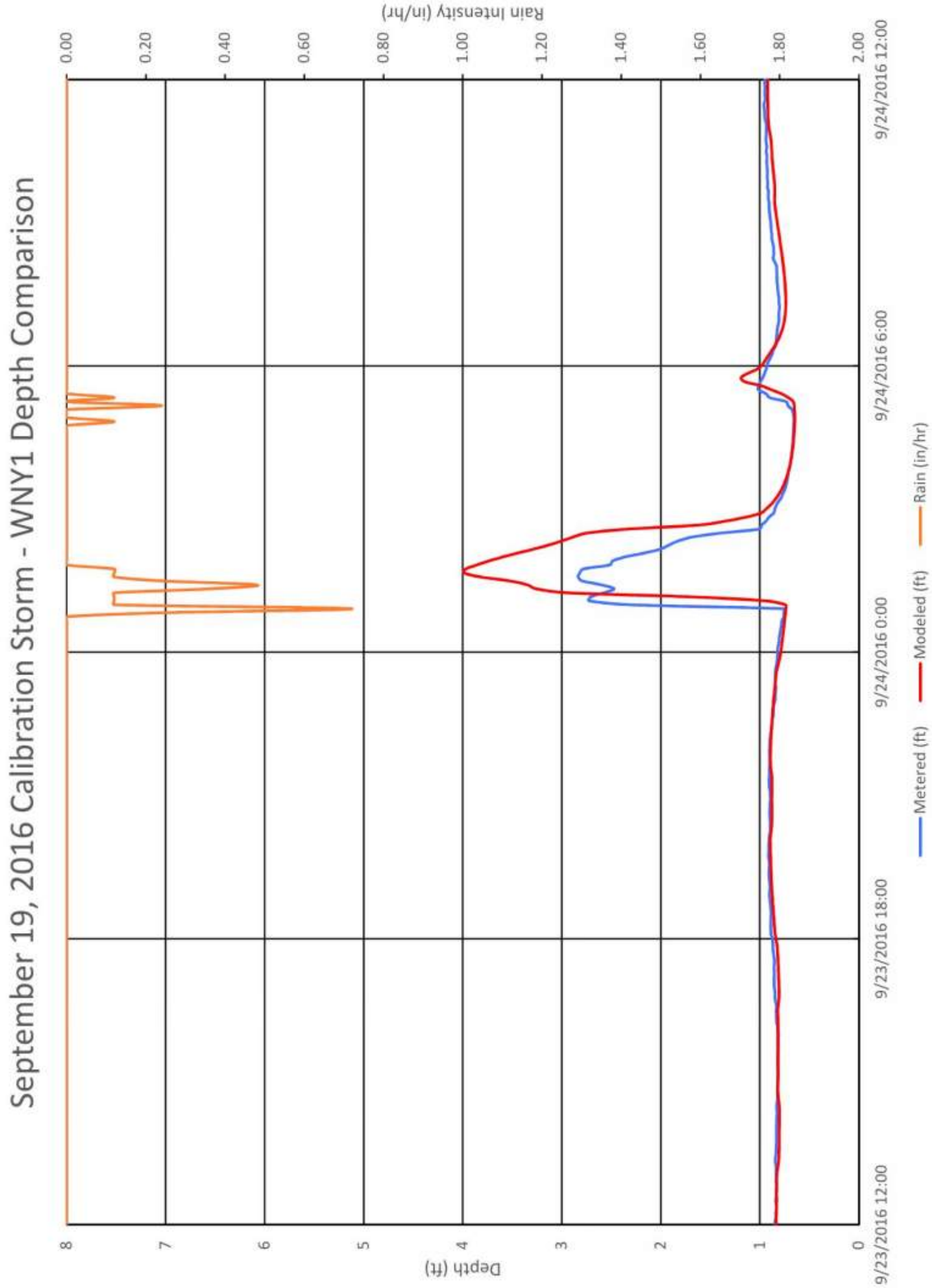

September 14, 2016 Validation Storm - WNY1 Flow Comparison
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Flow (MGD)
300
250
200
150
100
50
0
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered Flow (MGD)
Modeled
Rain (in/hr)

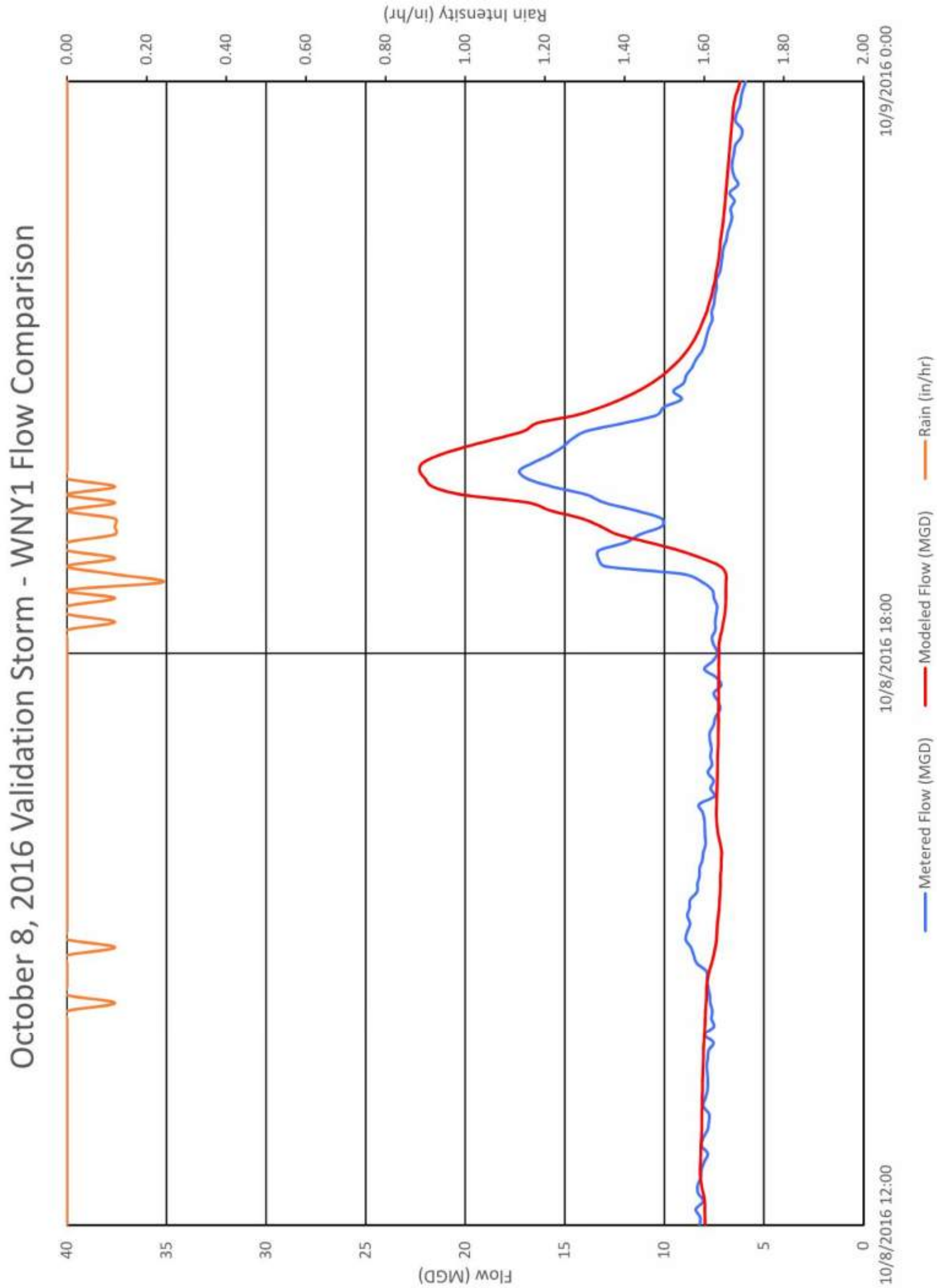

September 14, 2016 Validation Storm - WNY1 Depth Comparison
Rain Intensity (in/hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Depth (ft)
12
10
8
6
4
2
0
9/14/2016 6:00
9/14/2016 12:00
9/14/2016 18:00
9/15/2016 0:00
9/15/2016 6:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

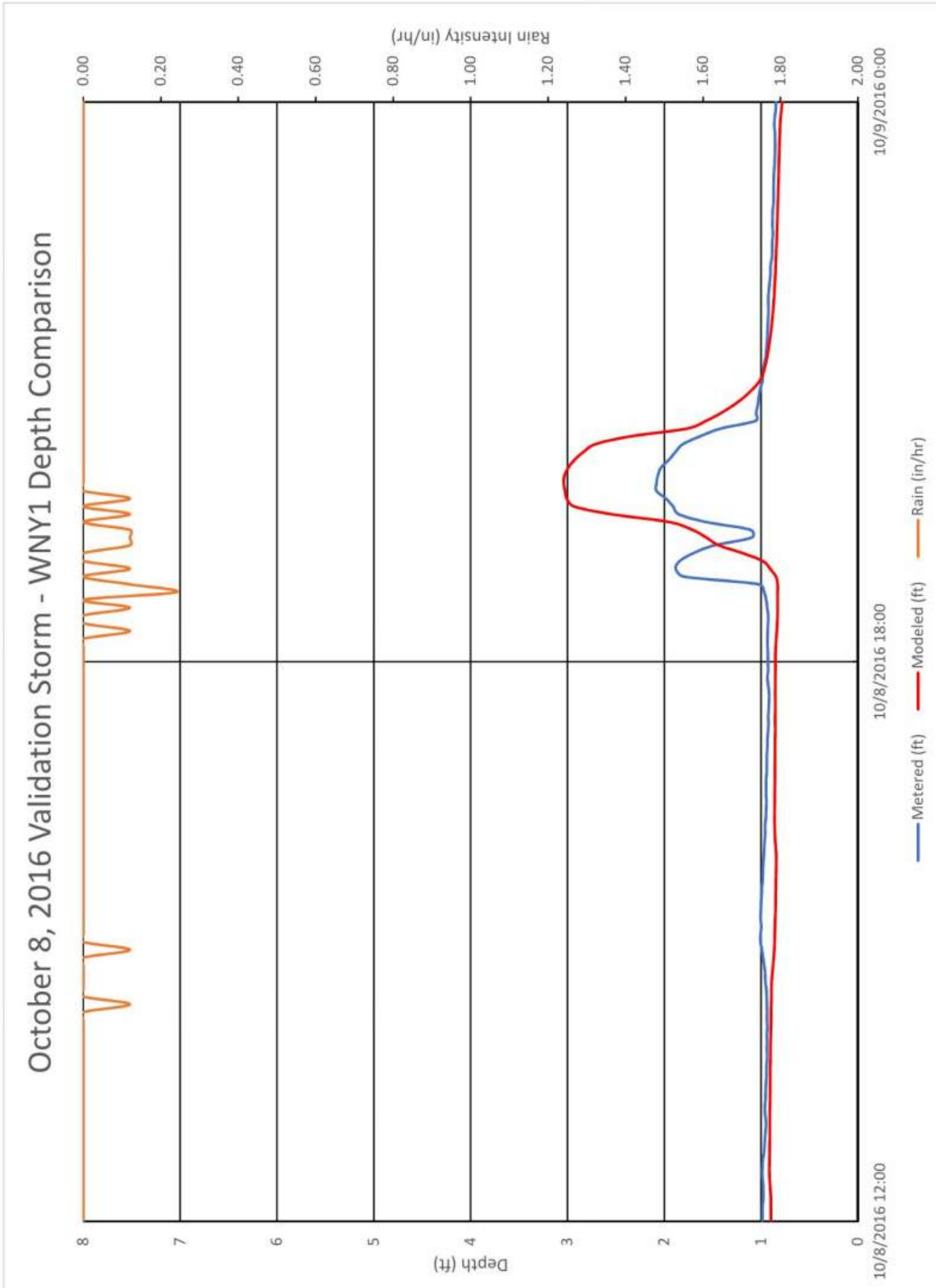

September 19, 2016 Calibration Storm - WNY1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
10
20
30
40
50
60
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)

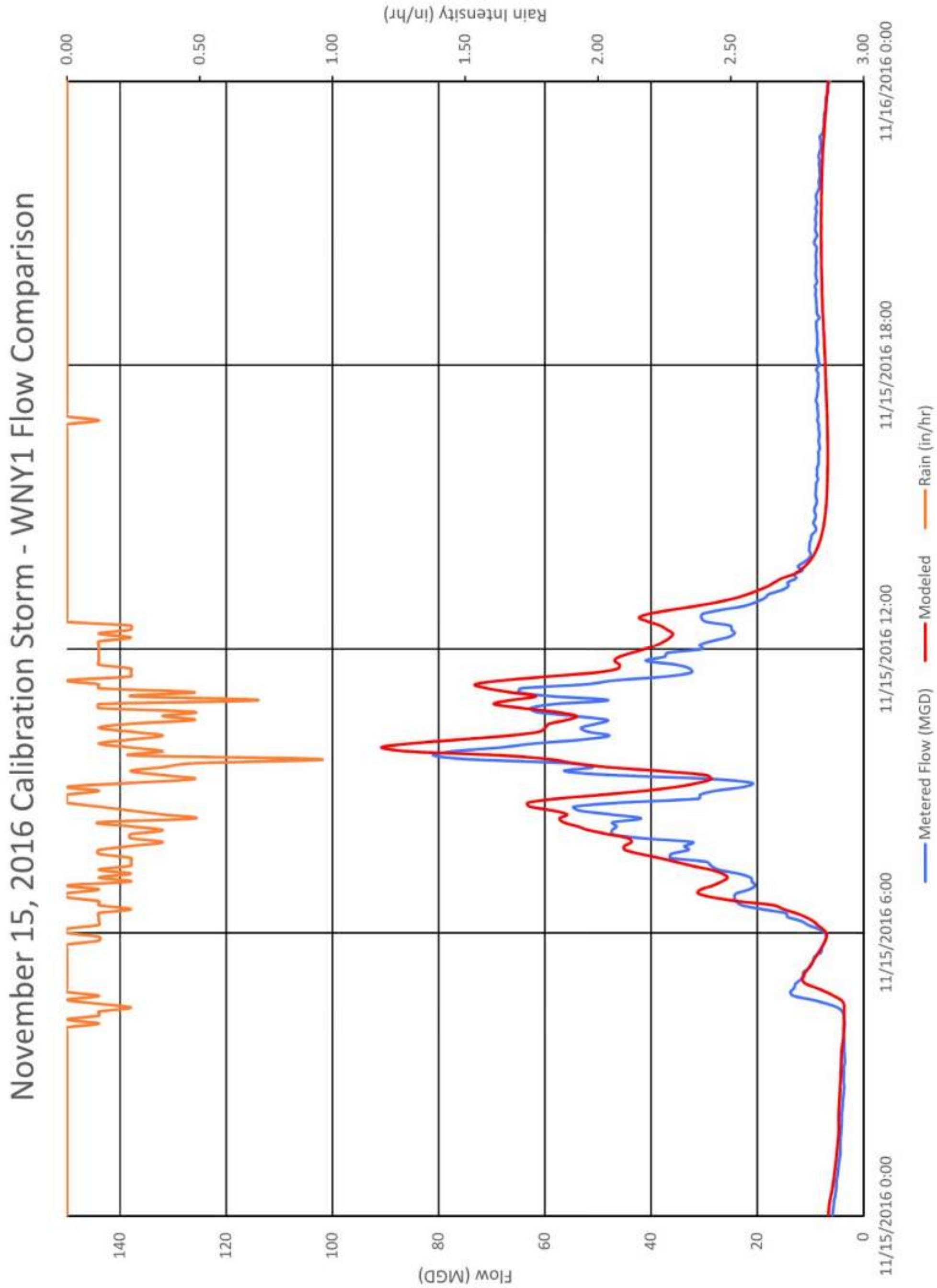

September 19, 2016 Calibration Storm - WNY1 Depth Comparison
Depth (ft)
0
1
2
3
4
5
6
Rain Intensity (in/hr)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
9/19/2016 0:00
9/19/2016 6:00
9/19/2016 12:00
9/19/2016 18:00
9/20/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

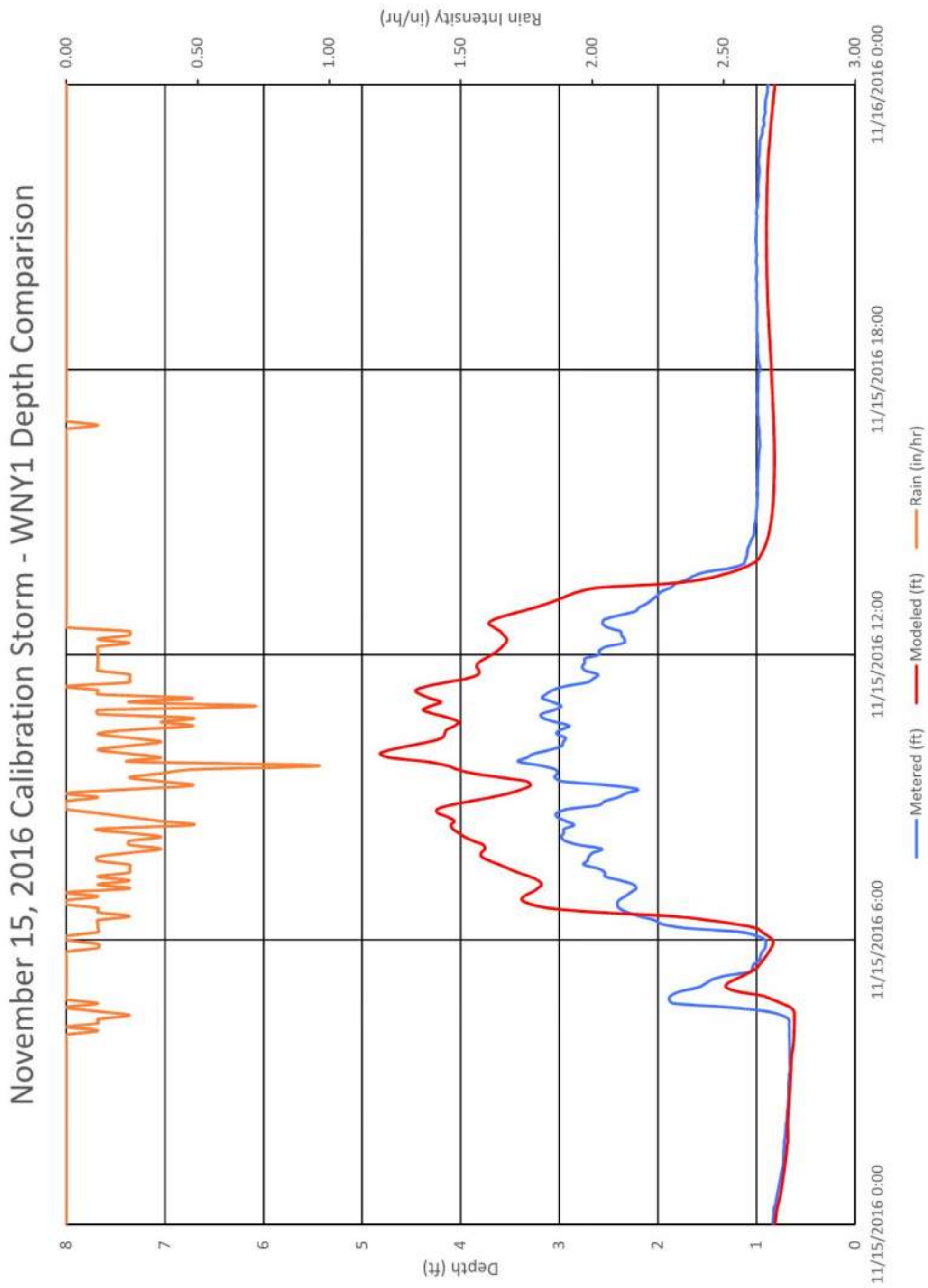

September 24, 2016 Calibration Storm - WNY1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
0
10
20
30
40
50
60
70
80
90
100
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered Flow (MGD)
Modeled
Rain (in/hr)


September 19, 2016 Calibration Storm - WNY1 Depth Comparison
Depth (ft)
0
1
2
3
4
5
6
7
8
Rain Intensity (in/hr)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
9/23/2016 12:00
9/23/2016 18:00
9/24/2016 0:00
9/24/2016 6:00
9/24/2016 12:00
Metered (ft)
Modeled (ft)
Rain (in/hr)


October 8, 2016 Validation Storm - WNY1 Flow Comparison
Flow (MGD)
Rain Intensity (in/hr)
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered Flow (MGD)
Modeled Flow (MGD)
Rain (in/hr)


October 8, 2016 Validation Storm - WNY1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
7
8
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
10/8/2016 12:00
10/8/2016 18:00
10/9/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)


November 15, 2016 Calibration Storm - WNY1 Flow Comparison
Flow (MGD)
0
20
40
60
80
100
120
140
Rain Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered Flow (MGD)
Modeled
Rain (in/hr)



November 15, 2016 Calibration Storm - WNY1 Depth Comparison
Depth (ft)
Rain Intensity (in/hr)
0
1
2
3
4
5
6
7
8
0.00
0.50
1.00
1.50
2.00
2.50
3.00
11/15/2016 0:00
11/15/2016 6:00
11/15/2016 12:00
11/15/2016 18:00
11/16/2016 0:00
Metered (ft)
Modeled (ft)
Rain (in/hr)

11.5 Appendix E Typical Year Overflow Rates and Volumes

WNY1 (CSO 002A)

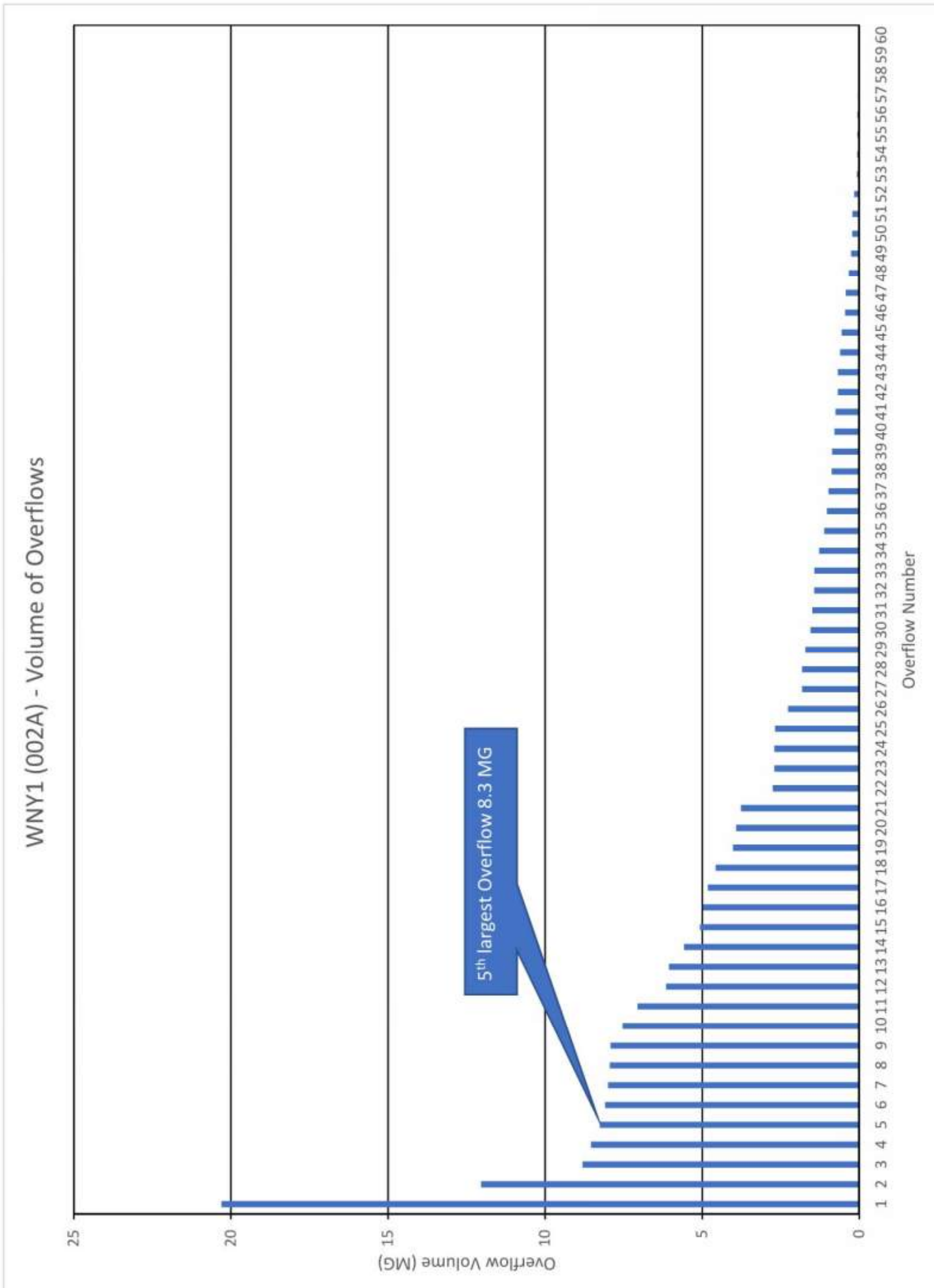
Overflow Number	Spill Volume (MG)	Peak Flow (MGD)
1	20.3	194.0
2	12.0	172.3
3	8.8	168.2
4	8.5	165.8
5	8.3	160.0
6	8.1	141.9
7	8.0	135.9
8	7.9	130.2
9	7.9	128.5
10	7.5	114.6
11	7.1	112.7
12	6.2	109.4
13	6.1	90.8
14	5.6	90.2
15	5.1	87.4
16	5.0	83.5
17	4.8	81.1
18	4.6	73.6
19	4.0	67.4
20	3.9	66.9
21	3.8	66.3
22	2.8	62.6
23	2.7	53.6
24	2.7	50.5
25	2.7	46.2
26	2.3	39.4
27	1.8	39.1
28	1.8	38.4
29	1.7	37.5
30	1.5	34.4
31	1.5	34.3
32	1.4	20.8
33	1.4	20.1
34	1.3	18.6
35	1.1	18.4
36	1.0	17.9
37	1.0	17.7

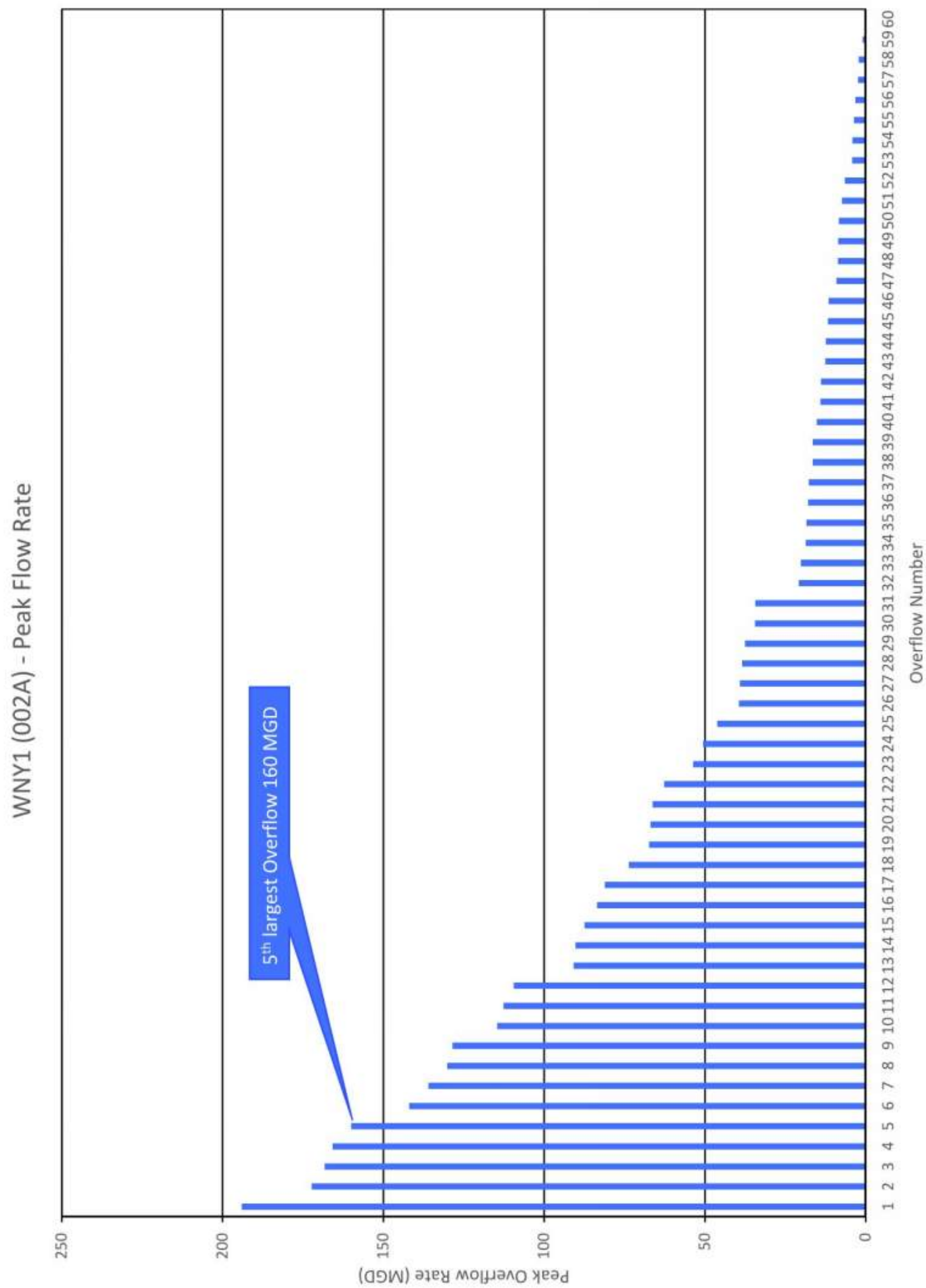
38	0.88	16.5
39	0.86	16.4
40	0.79	15.2
41	0.76	14.1
42	0.68	13.9
43	0.68	12.5
44	0.61	12.4
45	0.56	11.8
46	0.45	11.5
47	0.43	9.0
48	0.33	8.6
49	0.26	8.5
50	0.23	8.3
51	0.22	7.4
52	0.16	6.4
53	0.07	4.2
54	0.07	4.2
55	0.06	3.6
56	0.06	3.2
57	0.04	2.4
58	0.02	2.2
59	0.01	0.9
60	0.00	0.1

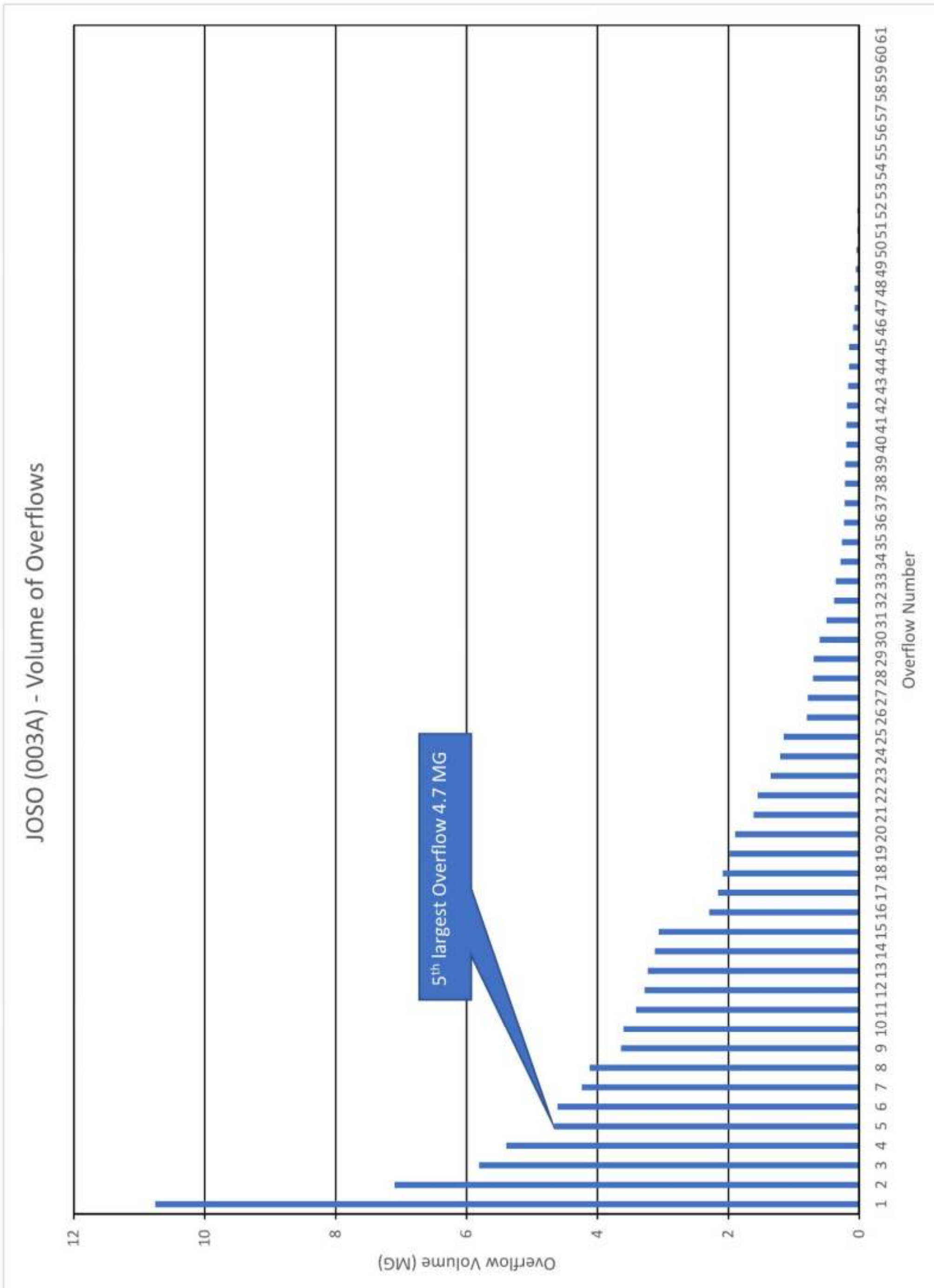
JOSO (CSO 003A)

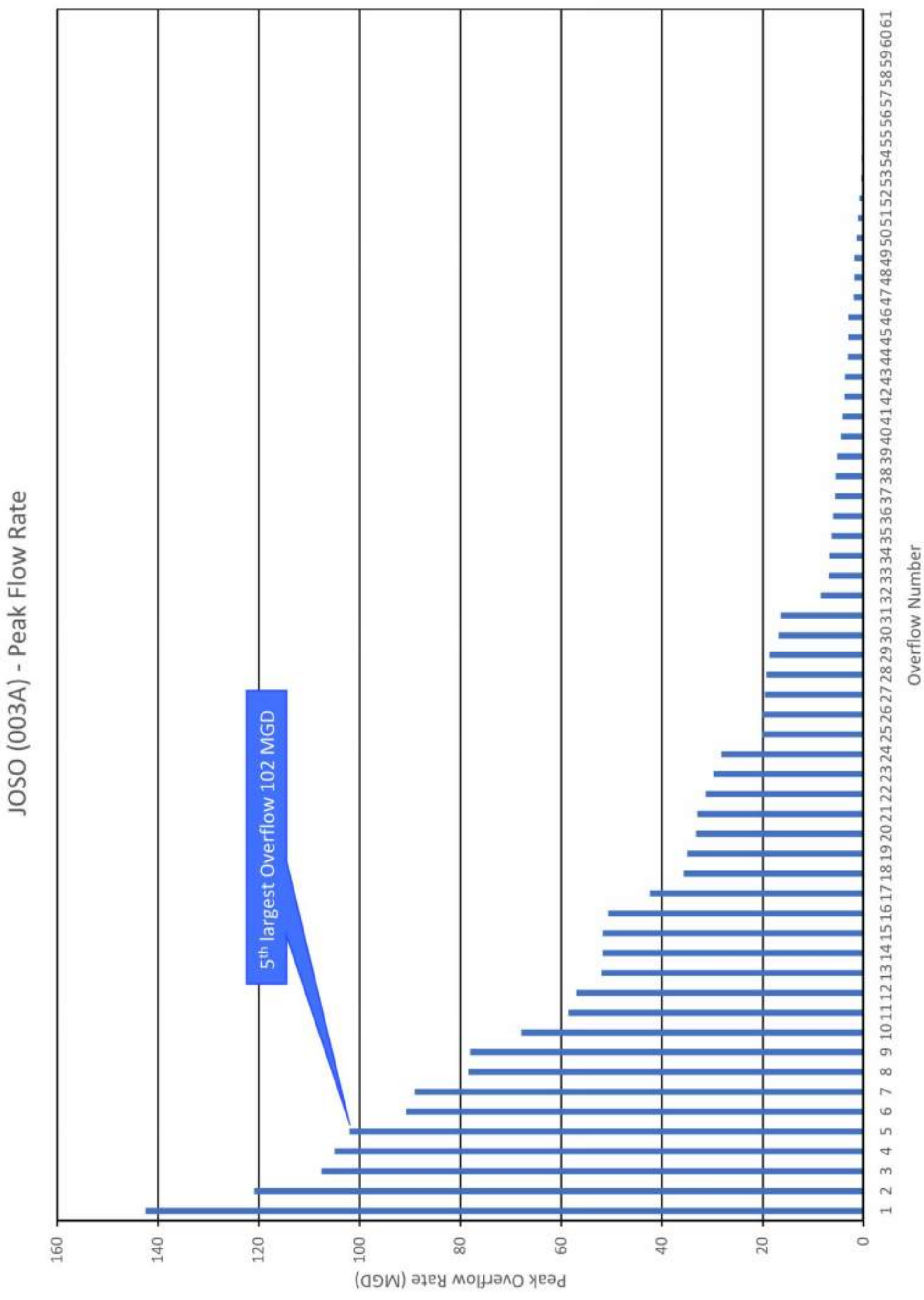
Overflow Number	Spill Volume (MG)	Peak Flow (MGD)
1	10.8	142.5
2	7.1	120.9
3	5.8	107.5
4	5.4	105.0
5	4.7	102.0
6	4.6	90.8
7	4.2	89.1
8	4.1	78.4
9	3.6	78.0
10	3.6	67.9
11	3.4	58.5
12	3.3	56.9
13	3.2	52.0
14	3.1	51.7
15	3.1	51.7
16	2.3	50.6
17	2.2	42.4
18	2.1	35.7
19	2.0	35.0
20	1.9	33.2
21	1.6	33.0
22	1.5	31.3
23	1.4	29.7
24	1.2	28.2
25	1.2	20.1
26	0.80	20.0
27	0.79	19.6
28	0.70	19.2
29	0.69	18.7
30	0.60	16.8
31	0.50	16.4
32	0.38	8.4
33	0.36	6.9
34	0.28	6.7
35	0.26	6.3
36	0.23	6.0
37	0.22	5.6
38	0.22	5.5
39	0.22	5.2
40	0.20	4.4

41	0.19	4.1
42	0.19	3.8
43	0.17	3.7
44	0.16	3.1
45	0.16	3.0
46	0.09	3.0
47	0.07	1.9
48	0.07	1.8
49	0.05	1.8
50	0.04	1.4
51	0.03	1.1
52	0.03	0.8
53	0.01	0.4
54	0.01	0.3
55	0.01	0.3
56	0.01	0.3
57	0.01	0.3
58	0.01	0.2
59	0.00	0.2
60	0.00	0.1
61	0.00	0.1


WNY1 (002A) - Volume of Overflows
5th largest Overflow 8.3 MG
Overflow Volume (MG)
Overflow Number
0
5
10
15
20
25


WNY1 (002A) - Peak Flow Rate
5th largest Overflow 160 MGD
Peak Overflow Rate (MGD)
Overflow Number
0
50
100
150
200
250


JOSO (003A) - Volume of Overflows
5th largest Overflow 4.7 MG
Overflow Volume (MG)
0
2
4
6
8
10
12
Overflow Number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61


JOSO (003A) - Peak Flow Rate
5th largest Overflow 102 MGD
Peak Overflow Rate (MGD)
Overflow Number
0
20
40
60
80
100
120
140
160