SYSTEM CHARACTERIZATION REPORT

CSO Permit Compliance

City of Perth Amboy

Middlesex County, New Jersey

NJPDES Permit No. NJ0156132

Original Submission:

June 29, 2018

CDM Smith

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System Characterization Work Plan Appendices (previously submitted and included by reference for this report):

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- *System Inventory and Assessment Report (SIAR), prepared by CDM Smith, dated May 2004*
- *Monitoring Program Proposal and Work Plan (MPPWP), prepared by CDM Smith, dated September 2006*
- *Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007*

Related Reports

The following reports have been referenced in this Submission (submitted under the auspices of the NJ CSO Group):

- *Baseline Compliance Monitoring Report,* submitted by Passaic Valley Sewerage Commission on behalf of the New Jersey CSO Group, anticipated June 2018

- *Consideration of Sensitive Areas Report,* submitted by Passaic Valley Sewerage Commission on behalf of the New Jersey CSO Group, anticipated June 2018

- *Typical Hydrologic Year Report* , submitted by Passaic Valley Sewerage Commission on behalf of the New Jersey CSO Group, anticipated June 2018

Section 1
Introduction

This document constitutes the City of Perth Amboy's Sewer System Characterization Report (SCR) developed by the City of Perth Amboy on behalf of the City of Perth Amboy and Middlesex County Utilities Authority (MCUA) for the required "Characterization Monitoring and Modeling of the Combined Sewer System" under Part IV Section G.1 of Perth Amboy's New Jersey Pollutant Discharge Elimination System (NJPEDS) permit action (Permit number NJ0156132; October 9, 2015). This document serves as the SCR for the City of Perth Amboy and the portion of the hydraulically connected system that is owned / operated by the MCUA that services the City of Perth Amboy. The MCUA has indicated to the City and the Department that it will work cooperatively with the City in providing information the City may require regarding the MCUA's owned and operated facilities to complete the City's Long-Term Control Plan.

This report documents that Perth Amboy has developed a thorough understanding of its sewerage system, the systems' responses to precipitation events of varying duration and intensity, the characteristics of system overflows, and water quality issues associated with combined sewer overflows (CSOs) emanating from the systems. The objective of the SCR is to provide Perth Amboy with a comprehensive and empirical understanding of the physical nature and hydraulic performance of their respective sewerage systems for use in optimizing the performance of the current systems and in the development of CSO control alternatives.

1.1 Regulatory Context and Objectives

1.1.1 USEPA Combined Sewer Overflow Control Policy

USEPA's CSO Control Policy (Policy) was issued in April of 1994[1-1] to elaborate on the 1989 National CSO Control Strategy and to expedite compliance with the requirements of the Clean Water Act (CWA). The Policy provided guidance to municipal permittees with CSOs, to the state agencies issuing National Pollution Discharge Elimination permits (e.g. NJDEP and NJPDES permits) and to state and interstate water quality standards authorities (e.g. the Delaware River Basin Commission). The Policy establishes a framework for the coordination, planning, selection and implementation of CSO controls required for permittee compliance with the Clean Water Act (CWA).

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

- ***System Characterization*** – The identification of current combined sewer system assets and current performance characteristics;

[1-1] 59 FR 18688 et seq.

- ***Implementation of the Nine Minimum Controls**[1-2]* – identified in the Policy to ensure that the current combined sewer system is being optimized and property maintained; and
- ***Development of a Long-Term Control Plan (LTCP)*** – The analysis and selection of long term capital and institutional improvements to the combined sewer system that once fully implemented will result in compliance with the CWA.

The Policy includes provisions for public and stakeholder involvement (e.g. the CSO Supplemental Committees), the assessment of affordability (rate-payer impacts) and financial capability (permittee ability to finance the long-term controls) as a driver of implementation schedules and two CSO control alternatives. The "presumption" approach is premised on the presumption that the achievement of certain performance standards, e.g. the capture of at least 85% of wet weather flows during a typical year would result in CWA compliance subject to post-implementation verification. Under the "demonstration" approach, permittees demonstrate that their proposed controls do not cause or contribute to a violation of receiving stream water quality standards.

1.1.2 New Jersey Pollution Discharge Elimination System (NJPDES) Permit Requirements

Under Section 1311 of the CWA, all point source discharges to the waters of the United States must be permitted. USEPA Region II has delegated permitting authority in New Jersey to the New Jersey Department of Environmental Protection (NJDEP). The permits are reissued on a nominal five-year cycle. All twenty-one New Jersey municipalities and municipal authorities with combined sewer systems were issued new permits in 2015 that set forth requirements for the completion of the system characterization and the development of LTCPs on the following schedule:

- Submittal of the System Characterization Report to NJDEP – July 1, 2018;
- Development & Evaluation of CSO Control Alternatives – July 1, 2019; and
- Selection and Implementation of Alternatives – June 1, 2020.

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

With minor exceptions such as lists of applicable previous studies, the 2015 permits are standardized. The 2015 information to be included in the System Characterization Report is specified in Part IV (Specific Requirement: Narrative) paragraph G-1 of the permits. These requirements are reproduced on Table B-2 along with the section of this System Characterization

[1-2] The nine minimum controls include: 1) proper operation and regular maintenance; 2) maximizing the use of the collection system for storage where feasible; 3) review and modification of the Industrial Pretreatment Program to minimize CSO impacts; 4) maximization of flow to the wastewater treatment plant; 5) the prohibition of CSOs during dry weather; 6) control of solids and floatables (addressed by NJDEP's requirement of screening or other facilities in the late 2000s); 7) pollution prevention; 8) public notification; and 9) monitoring CSO impacts and controls. 59 FR 18691.

Report in which the requirements are addressed and a list of the principal sources of data used for each requirement.

Table 1-1 summarizes the System Characterization Report elements that will address the requirements set forth in the City's Permit along with the anticipated section number. Anticipated data sources have been identified which include previous characterizations of the City's sewer system, data collected and analyzed in accordance with past permits, and work completed by CDM Smith, the City's consulting engineer for the development of previously required permit documents. The reports referenced in Table 1-1 were submitted between 2004 and 2015.

The SCR will focus on the sewer system within the City of Perth Amboy (see Figure 1-1). All flow from this system is pumped to the Woodbridge Township's Keasbey Interceptor which ultimately gets pumped to the Middlesex County Utilities Authority's Edward J. Patten Water Reclamation Center for treatment. The capacity of the pumping facilities to deliver flow to the plant has been determined and will be accounted for in developing the system characterization for the City of Perth Amboy. The City has sent a letter to Woodbridge Township indicating that information will be requested from them relative to as-built conditions of the Keasbey Interceptor in order to consider conveying additional flow to the MCUA Water Reclamation Center as part of the LTCP. The City will share the System Characterization Report and information developed in preparing the report with MCUA and Woodbridge Township. Once the baseline condition is established for the City's sewer system, the City will coordinate with MCUA and Woodbridge Township in developing the City's Long Term Control Plan as required by the City's permit.

1.2 Combined Sewer System and Service Area Overview

The City of Perth Amboy is served by both combined and separate sewers and owns and operates combined sewer overflows (CSOs). While the City retains ownership of existing sewer infrastructure, the operations of the City's CSO system is performed by Utility Service Affiliates-Perth Amboy (USA-PA), a subsidiary of Middlesex Water Company.

According to the 2010 Census, the total population of City of Perth Amboy was 50,814. An estimated 84% of the City's residents are served directly by a combined sewer system which covers approximately 2.5 square miles. The other 16% of the residents are served directly by a separated sewer system which is conveyed to the combined sewer system. The combined sewer system includes sixteen combined sewer outfalls, with eight outfalls draining to the Arthur Kill and eight outfalls draining to the Raritan Estuary. The separated sewer areas discharge stormwater to the receiving waters and deliver sanitary sewerage to the combined sewer system. Both sanitary and combined sewer flow are conveyed through the City's 4.3 miles of the interceptor pipes which are divided into an Eastside (2.7 miles) and Westside (1.6 miles). The confluence of the two branches is located on the influent sewer line at the City's Main Pumping Station, located on Second Street along the shore of the Raritan Estuary. There are four pump stations within the system: Amboy Avenue Pumping Station, State Street Pumping Station, Front Street Pumping Station, and Main Pumping Station (also known as the Second Street Pumping Station).

All flow from the main pump station is ultimately conveyed to the MCUA Edward J. Patten Water Reclamation Center for treatment. The Main Pump Station is capable of delivering a maximum of

13.7 MGD to MCUA during wet weather. The force main is 24" in diameter. Perth Amboy's flow is recorded in the Perth Amboy meter chamber, which is located upstream of the Woodbridge Township's Keasbey Interceptor. From there, flow is conveyed by gravity sewer to the MCUA's Edison Pump Station and then to the reclamation center headworks, which is located on the Raritan Bay shoreline, upstream and on the opposite bank from Perth Amboy. Figure 1-1displays a map of Perth Amboy's service area system and how it connects to Woodbridge and MCUA.

1.3 Previous Studies

Several reports will be used as references for the System Characterization Report. Copies of these reports have been included in Appendix A of the System Characterization Work Plan submitted to NJDEP. For convenience, the NJDEP-approved System Characterization Work Plan and accompanying appendices are included as digital files as part of the overall System Characterization Report package. Previous Perth Amboy studies and reports included with this package are summarized as follows:

Service Area Drainage and Land Use Report (SADLUR), prepared by CDM Smith, dated May 2004

- The report was submitted in partial fulfillment of the Administrative Consent Order (ACO). The ACO required that the SADLUR provide background information necessary to support and verify the selection of monitoring points and parameters necessary for the SWMM model. The report included data related to the Perth Amboy drainage area, including combined/separate sewer areas, size, population, climate, soils, land use, impervious area, and pollutant loadings. The report also included sewer line data related to the interceptor, CSO diversion structures, tide gates, and pumping stations.

System Inventory and Assessment Report (SIAR), prepared by CDM Smith, dated May 2004

- The report was submitted in partial fulfillment of the Administrative Consent Order (ACO). The ACO required the SIAR as part of the Combined Sewerage Overflow Discharge Characterization Study requirement. The report included information related to the inventory of the system, including drainage areas, the interceptor sewer, and combined sewer overflow sections. The report also included an assessment of the sewer system including the interceptor, CSOs, pumping stations, hydraulic characteristics, and CSO and sewer collection system maintenance.

Monitoring Program Proposal and Work Plan (MPPWP), prepared by CDM Smith, dated September 2006

- The report was submitted in partial fulfillment of the NJ General Permit for Combined Sewer Systems, NJPDES No. NJ0105023. The purpose of the MPPWP was to obtain NJDEP approval of the proposed monitoring and modeling procedures and techniques to be used in the preparation of the Combined Sewage Overflow Discharge Characterization Study which was a requirement of the City's ACO. The report presented a proposed rainfall monitoring study which includes a historic precipitation analysis and installation and operation of two rain gauges. The proposed combined sewer overflow monitoring study consisted of collecting and analyzing representative water quality samples from CSOs at three outfalls. The report also presented the proposed modeling study which would develop and document the relationship between wet-weather events and CSO discharge characteristics.

Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007

- The report was submitted in partial fulfillment of the NJ General Permit for Combined Sewer Systems, NJPDES No. NJ0105023. The study included the data collection and analyses necessary to develop a computer-based, numerical hydrologic and hydraulic model that was used to characterize the annual overflow volume and water quality of discharges from the City of Perth Amboy's combined sewer system. Work performed in the preparation of this study was in compliance with the Monitoring Proposal and Work Plan approved by NJDEP in September of 2006.

The City of Perth Amboy Combined Sewerage System Engineering Assessment, Prepared for Utility Service Affiliates Perth Amboy, dated August 30, 2010

- The report presented the findings of an overall system engineering assessment of the Perth Amboy's collection system and associated components. Investigations were completed on various system components and the assessment incorporated the findings, conclusions and recommendations of these investigations. The focus of the assessment was on the physical components of the system, capital planning, operation and maintenance practices, and organization and management processes.

Flow Monitoring Pilot Study Report, prepared by CDM Smith, dated January 2014

- The report was submitted in partial fulfillment of a Consent Decree issued by the EPA. A 6-month flow monitoring pilot study was conducted from April 15, 2013 to October 17, 2013. The report summarizes the pilot study and compares the pilot study's metered data with the SWMM modeled data for accuracy in estimating flow and depth measured in the combined system.

CSO Activity Report for Calendar Year 2014, prepared by CDM Smith, dated February 2015

- The report summarizes the City of Perth Amboy's 2014 Combined Sewer Overflow (CSO) Monitoring Program. The report presents discharge volumes, frequencies, and durations for four of the City's active CSO outfalls. Discharges were estimated by the SWMM model of the City's CSO system. Following the completion of the required flow monitoring period as part of the Pilot Study, the City issued a Request for Termination of flow and depth monitoring to the EPA on the basis that the SWMM model of the City's CSO sewer system reasonably approximated the overflows and could be used for ongoing reporting. EPA granted this request through the issuance of a flow monitoring modification to the Consent Decree dated February 20, 2014. The flow monitoring modification permitted the City to perform periodic reporting of CSO activity at the four identified CSO discharge points using the SWMM model as the basis for estimating flow volume, frequency, and duration. This was the first report submitted as part of the flow monitoring modification to the Consent Decree.

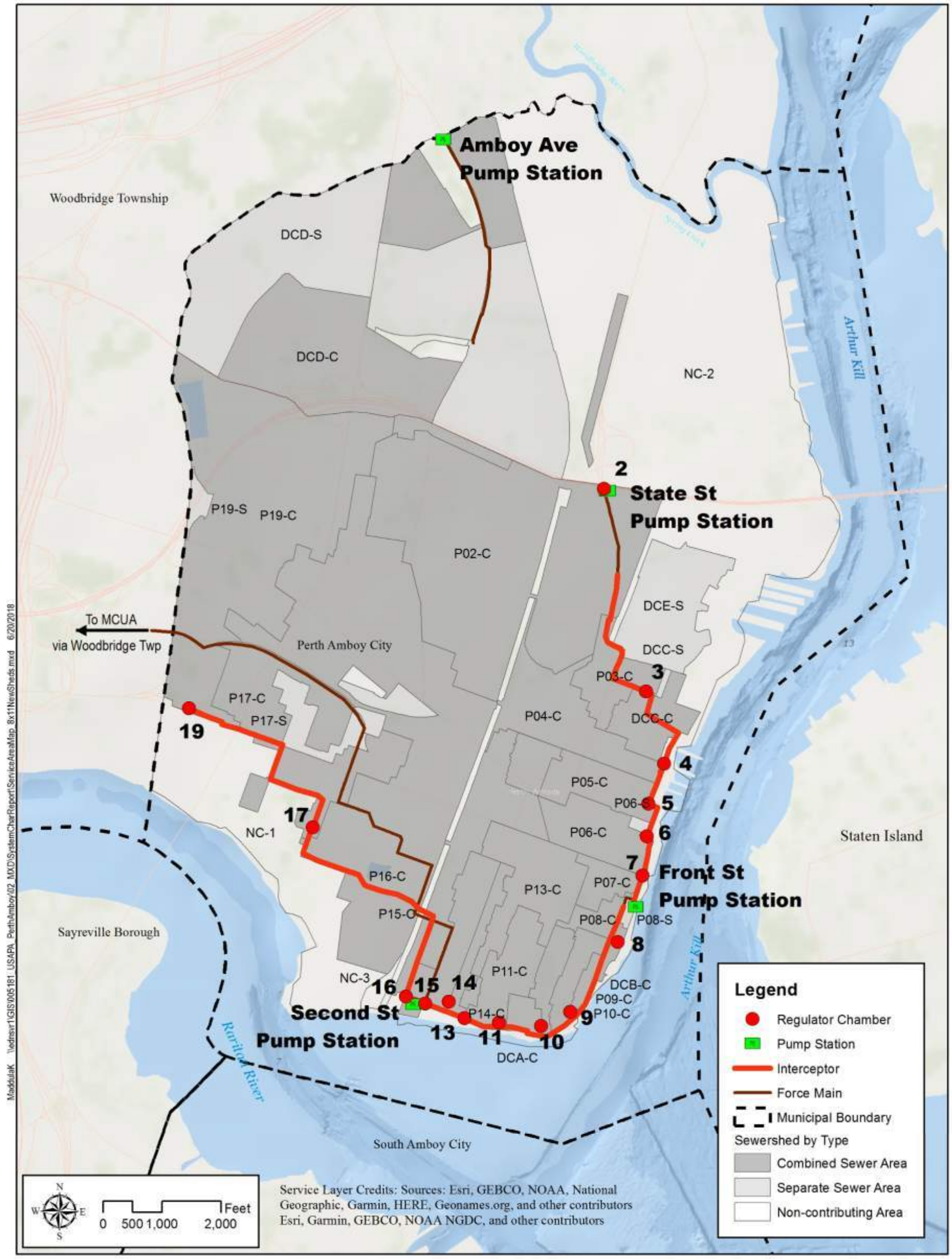

Figure 1-1: Perth Amboy Service Area

1.4 Organization of Report

Table 1-1 provides a summary of the system characterization elements along with the applicable section of the System Characterization Report, and principal data sources that be used to develop the report. The technical approaches for addressing the major elements of the System Characterization Report are detailed for each anticipated section of the report. For the purposes of creating a comprehensive overview of the Perth Amboy collection system, there are additional details included within this SCR beyond the elements required in the permit.

Table 1-1 – Review of Elements of the System Characterization Report

Permit Section	Permit Requirement	System Characterization Report Section	Data Sources Used
Part IV G.1.b	"The characterization shall include a thorough review of the entire collection system that conveys flows to the treatment works including areas of sewage overflows, including to basements, streets and other public and private areas, to adequately address the response of the CSS to various precipitation events"	Section 2	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 ▪ Service Area Drainage and Land Use Report, prepared by CDM Smith, dated May 2004 ▪ System Inventory and Assessment Report, prepared by CDM Smith, dated May 2004 ▪ The City of Perth Amboy Combined Sewerage System Engineering Assessment, Prepared for Utility Service Affiliates Perth Amboy, dated August 30, 2010 ▪ GIS data bases provided by the City of Perth Amboy, as submitted for the January 1, 2016 Permit Deadline ▪ System improvement data provided by the City of Perth Amboy, as retained onsite in spreadsheet form for the January 1, 2016 Permit Deadline and to be submitted/retained in map form for the July 1, 2016 Permit Deadline ▪ System improvement/modification data and identified sewage overflow/flooding data provided by the City of Perth Amboy, as retained onsite in spreadsheet form for the January 1, 2016 Permit Deadline and to be submitted/retained in map form for the July 1, 2016 Permit Deadline
	"The characterization shall identify the number, location, frequency and characteristics of CSOs"	Section 8	▪ Analysis utilizing updated hydrologic and hydraulic (H&H) modeling.
	"The characterization shall identify water quality impacts that result from CSOs"	Section 8	▪ Verification that land use and significant indirect user characteristics have not materially changed since the model was last updated
Part IV G.1.d.i	Rainfall Records Analysis	Section 7	▪ Typical Hydrologic Year Report, Prepared on behalf of NJ CSO Group Permitees by Passaic Valley Sewerage Commission, 2018.

Permit Section	Permit Requirement	System Characterization Report Section	Data Sources Used
Part IV G.1.d.ii	Combined Sewer System Characterization	Section 2	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 ▪ Service Area Drainage and Land Use Report, prepared by CDM Smith, dated May 2004 ▪ System Inventory and Assessment Report, prepared by CDM Smith, dated May 2004 ▪ The City of Perth Amboy Combined Sewerage System Engineering Assessment, Prepared for Utility Service Affiliates Perth Amboy, dated August 30, 2010 ▪ Sewer system records, filed inspections data provided by the City of Perth Amboy ▪ GIS and other system inventory data bases provided by the City of Perth Amboy
Part IV G.1.d.iii	CSO Monitoring	Section 5	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 ▪ Monitoring Program Proposal and Work Plan, prepared by CDM Smith, dated September 2006. ▪ Flow Monitoring Pilot Study Report, prepared by CDM Smith, dated January 2014 ▪ CSO Activity Report for Calendar Year 2014, prepared by CDM Smith, dated February 2015 ▪ QAPP submitted with work plan in 2016
Part IV G.1.d.v	Sensitive Areas	Section 3	▪ Natural Heritage Priority Site – NJ Department of Environmental Protection (NJDEP), office of Natural Lands Management (ONLM), Publication Date: 3/1/2007 ▪ Head of Tide - New Jersey Department of Environmental Protection (NJDEP), Office of Environmental Analysis (OEA), Coast survey Limited (CTD), Publication Date: 1986 ▪ Parks and Recreation – New Jersey Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS); State of New Jersey Composite of Parcels Data and MAOD-IV Tax List ▪ Additional research necessary to ascertain the presence or absence of locations in the sensitive area categories ▪ Other local sources
Part IV G.9	Status of Receiving Water	Section 6	▪ Coordination with data from PVSC

1.5 City of Perth Amboy – Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Luis A. Perez Jimenez /ac 06/29/18

Luis A. Perez Jimenez, P.E., MBA/CME Date
Director of Operations

1.6 Middlesex County Utilities Authority – Certification

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

6/28/18

Joseph P. Cryan
Executive Director

Date

Section 2

Description of the Combined Sewer System Collection and Treatment Facilities

2.1 Combined Sewer Service Area

Perth Amboy's collection system serves 50,814 residents per the 2010 Census and 3,525 business customers (2007, Census Business QuikFacts). An estimated 84% of the City of Perth Amboy's residents are served directly by a combined sewer system which covers approximately 2.5 square miles. The other 16% of the residents are served directly by a separated sewer system which is conveyed to the combined sewer system. The number of residents showed an increase of 7.48% from the 2000 Census data. The 2010 Census population data will be incorporated into the model.

While the City retains ownership of the existing sewer infrastructure, the operation of the City's wastewater collection system is performed by a private subcontractor. The subcontractor officially began management of the system in January 1, 1999.

2.1.1 Residential Services

The City of Perth Amboy is served by both combined and separate sewers and owns and operates combined sewer overflows (CSOs) and pump stations. The system currently operates under a New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Surface Water (DSW) Permit NJ0156132.

The wastewater collection system is a combined system accepting both wastewater and storm water. It is comprised of approximately 366,000 LF of gravity main, ranging in sizes 6" to 84". These mains are constructed of vitrified clay, brick, and concrete. Current practice is to use PVC, ductile iron, and concrete for new sewer pipelines and system repairs. Currently there are approximately 9,750 lateral service connections feeding into this system.

2.1.2 Commercial and Industrial Services

Based on information provided to the City by MCUA, Table 2-1 presents a current list of the significant industrial users (SIUs) that discharge to the Perth Amboy collection system. A map of the locations of all SIUs is included in Figure 2-1.

Table 2-1 – City of Perth Amboy – Significant Industrial Users (SIUs)

Indirect Users	Address	Town	Sewershed	Sub-Sewershed	Average Non-Domestic Reported Flow (MGD)
Amboy Group (Tommy Maloneys)	1 Amboy Ave.	Woodbridge	NC-1	DCD	0.00150
Chemtura Corporation[1]	1000 Convery Boulevard	Perth Amboy	NC-1	DCD	0.07120
Englert, Inc.[1]	1200 Amboy Ave.	Perth Amboy	NC-1	DCD	0.00460
Evans Machine & Tool Co	410 Summit Avenue	Perth Amboy	DCD-S	DCD	Unknown
Grimes Manufacturing Inc. (GMI)	599 State Street.	Perth Amboy	P03-C	P03	Unknown
Illusion Engraved	311 Fayette Street	Perth Amboy	P16-C	P16	Unknown
Kinder Morgan Liquids Terminals LLC	920 State Street	Perth Amboy	NC-2	DCD	0.03160
Lincoln Signs & Awnings, Inc.	895 State Street	Perth Amboy	NC-2	DCD	Unknown
Stand-Out Signs, Inc.	49 W Pond Road	Perth Amboy	DCD-S	DCD	Unknown
Madsen & Howell, Inc.	500 Market Street	Perth Amboy	P17-S	P17	Unknown
Mayab Happy Tacos, Inc.	450 Florida Grove Road	Perth Amboy	P19-3	P19	Unknown
Med-Apparel Services[1]	35 Washington Street	Perth Amboy	P04-C	P04	0.04770
Monogram Center	437 Amboy Avenue	Perth Amboy	P16-C	P16	0.00000
Morton Salt, Inc.	920 High Street	Perth Amboy	NC-2	DCD	Unknown
Power Magne-Tech Corp.	653 Sayre Avenue	Perth Amboy	P19-C	P19	Unknown
Reconserve, Inc.	1250 Amboy Avenue	Perth Amboy	NC-1	DCD	0.00000
Riverdale Color Mfg., Inc.	1 Walnut Street	Perth Amboy	P16-C	P16	0.00006
The Printing Shop Copy Cente	338 State Street	Perth Amboy	P06-C	P06	Unknown
Tropical Cheese Industries, Inc.	450 Fayette Street	Perth Amboy	P17-C	P17	Unknown
V&R Design Co.	941 State Street	Perth Amboy	NC-1	DCD	Unknown
V&S Amboy Galvanizing	1190 Amboy Avenue	Perth Amboy	NC-1	DCD	0.00000
Vira Manufacturing, Inc.	1 Buckingham Avenue	Perth Amboy	NC-2	DCC	0.00000
Wikstrom Machines, Inc.	412 Summit Avenue	Perth Amboy	DCD-S	DCD	Unknown

[1]Industrial Users issued a non-domestic wastewater discharge control document by the Middlesex County Utilities Authority (MCUA) Industrial Pretreatment Program in accordance with the MCUA Rules and Regulations

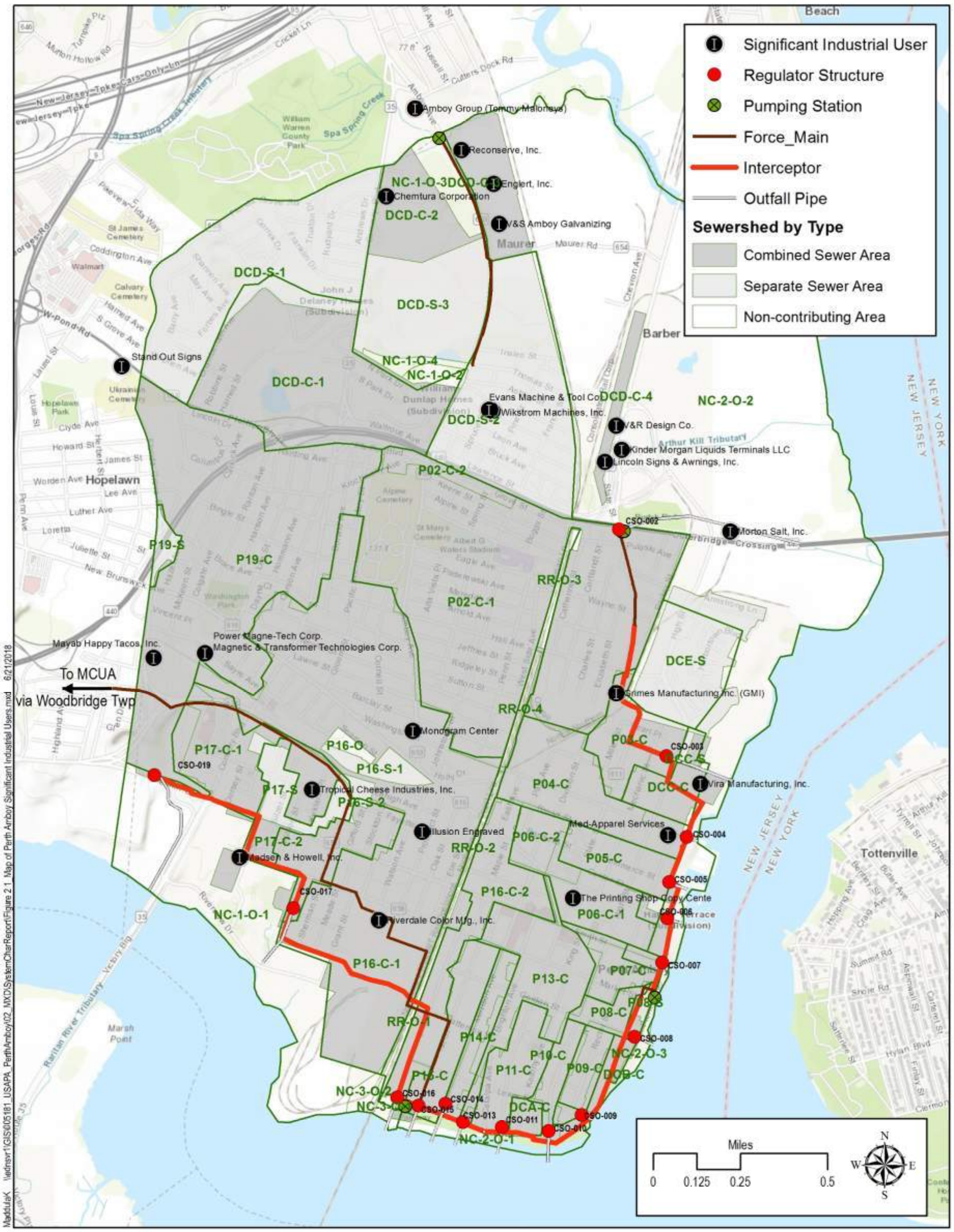

Figure 2-1: Map of Perth Amboy Significant Industrial Users

2.1.3 Combined Sewer Collection System

The City's wastewater collection system is made up of approximately 95 miles of main and trunk pipelines. These pipelines flow into the Eastside or Westside Interceptor Sewer and then flow towards the Second Street Pumping Station for pumping to MCUA. These main and trunk lines installed in the past were constructed of vitrified clay, brick, and concrete. Current practice is to use PVC, ductile iron, and concrete for new sewer pipelines and system repairs. There are approximately 1850 manholes which serve as access points to the collection system, which are as deep as 35 feet. There are approximately 2000 storm sewer inlets that feed into the combined wastewater system. Within the collection system there are no chemical feed sites, no inverted siphons, and no inverted chambers.

The combined sewer system includes sixteen NJDEP-permitted combined sewer outfalls, with eight outfalls draining to the Arthur Kill and eight outfalls draining to the Raritan Estuary. The separated sewer areas discharge stormwater to the receiving waters and deliver sanitary sewerage to the combined sewer system. Both sanitary and combined sewer flow are conveyed through the City's 4.3 miles of the interceptor pipes which are divided into an Eastside (2.7 miles) and Westside (1.6 miles). The confluence of the two branches is located on the influent sewer line at the City's Main Pumping Station, located on Second Street along the shore of the Raritan Estuary. There are four pump stations within the system: Amboy Avenue Pumping Station, State Street Pumping Station, Front Street Pumping Station, and Main Pumping Station (also known as the Second Street Pumping Station).

All flow from the main pump station is ultimately conveyed to the Middlesex County Utilities Authority (MCUA) Edward J. Patten Water Reclamation Center for treatment. The Main Pump Station is capable of delivering a maximum of 13.7 MGD to MCUA during wet weather. The force main is 24" in diameter. Perth Amboy's flow is recorded in the Perth Amboy meter chamber, which is located upstream of the Woodbridge Township's Keasbey Interceptor. From there, flow is conveyed by gravity sewer to the MCUA's Edison Pump Station and then to the reclamation center headworks, which is located on the Raritan Bay shoreline, upstream and on the opposite bank from Perth Amboy.

Historically, Perth Amboy has had very few issues in its sewer system related to CSO related flooding. Fats, oil and grease buildup in the sewers have been known to cause sewer backups in certain areas, however, a regular maintenance program has been instated in these areas which has allowed issues to be resolved in a timely manner. The City of Perth Amboy maintains a phone line to respond to questions or concerns raised by the public. The phone calls are recorded on incident cards and are also entered into a logbook maintained at the second street pumps station.

2.2 Interceptor Sewer System

The Eastside Interceptor branch begins at the State Street Pump Station, which is located beneath the Outerbridge Crossing along the Arthur Kill. The pump station accepts influent flow from the sewershed area tributary to the regulator structure at outfall P-002 and from the area that was previously tributary outfall P-001, which was closed following a sewer separation project. The regulator structure at outfall P-002 is a "leaping weir" structure which is mounted in the crown of the interceptor pipe. Flow enters the leaping weir in an 84" trunk sewer. Incoming flow falls into a 33"interceptor during dry weather conditions. During rainfall events, the flow increases and gains enough energy to "leap" over the interceptor into an 84" overflow pipe which discharges into a small tributary to the Arthur Kill. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe.

The discharge from the State Street Pump Station travels south along State Street and then east along Buckingham Avenue, first by a 24" force main, then by a 24" gravity sewer, and then by a 36" gravity sewer until it reaches the regulator structure on Buckingham Avenue (P-003), which is a leaping weir type structure. Prior to reaching the regulator structure, a small amount of additional contributing area is connected to the interceptor. In addition, there is a known cross-connection between the sewershed areas for outfalls P-002 and P-003 at the corner of Hall Avenue and State Street which diverts high flows from Hall Avenue towards outfall P-003 instead of outfall P-002. The survey was not able to locate the diversion structure, but the downstream end of the connection was confirmed during past field inspections. During dry weather flow conditions, sewerage entering the regulator structure at outfall P-003 drops over the leaping weir and into a 48" interceptor sewer. Overflows "leap" over the weir into the 36" outfall which discharges into the Arthur Kill. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe.

Downstream from the P-003 sewershed, the Eastside Interceptor branch continues through a 48"interceptor to travel south along High Street and then Front Street, picking up an additional sanitary contribution from a large separate sewered development (Harbortown) and the regulated combined sewer flow from diversion structures upstream of outfalls P-004, P-005, P-006 and P-007, which are all leaping weir type structures located on the crown of the interceptor. The influent trunk sewer sizes are 42" by 54", 36", 24" by 36", and 30" by 42", respectively. The overflow pipe sizes are 48", 36", 48", and 42", respectively. All of the overflow pipes have a netting chamber located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe to the Arthur Kill. Outfalls P-005, P-006, and P-007 all have tide gates.

The 48" Eastside Interceptor branch continues to travel south until it reaches the Front Street Pump Station which also accepts the regulated combined sewer flow from the sewershed tributary to outfall P-008, which travels north along Front Street in a 15" sewer. The regulator structure at P-008 is leaping weir type structure with a 36" influent trunk sewer and a 36" overflow pipe that discharges to the Arthur Kill. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe.

The discharge from the Front Street Pump Station travels west by 36"force main and then south by a 36" gravity sewer along Water Street, accepting the regulated flow from the final Arthur Kill regulator structure, upstream of outfall P-009. This structure is a leaping weir type structure located remotely from the interceptor. Flow enters the regulator structure in a 18" trunk sewer. During dry weather flow conditions, flow drops into an 8" lateral which connects to the interceptor near the intersection of Lewis Street and Water Street. During rainfall events, the flow increases and gains enough energy to "leap" over the interceptor into a 24" overflow pipe which discharges into the Arthur Kill. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe.

The 36"interceptor turns west along Sadowski Parkway where it accepts the regulated combined sewer flow from diversion structures P-010, P-011, P-013, P-014, and P-015, which are all leaping weir type structures, before it readies the Main Pump Station. Regular structures at outfalls P-013 and P-015 are located on the crown of the interceptor. Regulator structures at outfalls P-010, P-11 and P-014 are all located remotely from the interceptor and connect to the interceptor via 12" lateral sewers. The influent trunk sewer sizes are each 24" by 36" and the overflow pipes are each 36" with tide gates. All of the overflow pipes have a netting chamber located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe to the Raritan River. All of these outfalls have tide inflow prevention gates.

The Westside Interceptor branch begins at the regulator structure of P-019, located on Smith Street. The diversion structure is a leaping weir type structure in an elevated chamber. Flow enters the chamber in a 72" sewer. During dry weather flow conditions/ sewerage entering the P-019 structure drops over the leaping weir and into a 15" interceptor sewer. Overflows "leap" over the weir into the 72" outfall which discharges into a swale on the Hess Oil property and eventually into Raritan Bay. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe.

The interceptor runs east along Smith Street and eventually south along Sheridan Street, increasing to 24", until it reaches on Sheridan Street, to the regulator structure at outfall P-017. Prior to reaching the diversion structure, some additional contributing area is connected to the interceptor. This includes area which was formerly regulated by the now decommissioned diversion structure at the former P-018 outfall. The diversion structure at outfall P-017 does not have a leaping weir. The structure consists of the 24" influent, a 30" effluent interceptor in the side wall of the chamber, and a 24" overflow pipe with an elevated invert located in-line with the influent pipe. During dry weather flow conditions, sewage entering the P-017 regulator structure continues through the side wall into to 30" effluent interceptor. During wet weather events, when the level in the chamber increases, surcharge conditions in the interceptor develop and the excess flow is discharged through the overflow pipe. The invert of the overflow pipe is only slightly above the crown of the effluent interceptor pipe. During dry weather conditions, it was observed that the effluent interceptor pipe is close to surcharge.

The 30" interceptor continues south along Sheridan Street, turns east along Patterson Street and runs beneath industrial property at the end of Patterson Street, between Grant Street and Elm Street. A 66"trunk sewer connects to the interceptor on Elm Street, and the effluent 78" interceptor continues to Second Street where it increases to 84" and turns south towards the diversion structure at outfall P-016. Regulator structure P-016 is a "leaping weir" structure. The 84" interceptor enters the leaping weir. Incoming flow falls into a 30"sewer during dry weather conditions and combines with the Eastside Interceptor behind the Main Pump Station. During rainfall events, the flow increases and gains enough energy to "leap" over the interceptor into an 84" overflow pipe which discharges into the Raritan River. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged though the outfall pipe and a tide gate is located at the end of the outfall pipe.

A schematic view of the interceptor system is illustrated in Figure 2-3.

2.3 Combined Sewer Regulators

The City of Perth Amboy collection system has been designed to regulate flows into the interceptor sewers via a series of “leaping weir” structures. These regulator structures allow dry weather flow to be conveyed through an orifice leading to the interceptor collection system, and during rainfall events, the flow increases and gains enough energy to “leap” over the orifice and enter the outfall pipe for discharging into the receiving water. A schematic of a leaping weir configuration is displayed in Figure 2-2.

The exact year of installation of all CSO outfalls is unknown; information presented in this report was taken from drawings dated 1934. These drawings, obtained from the City of Perth Amboy sewer department and prepared by Carr Engineering Associates, P. A., for multiple sewer system projects contain the dimensions of the majority of the regulator structures including configurations of leaping weirs. The dimensions for those leaping weirs not identified in the available plans were assumed using information gathered at the other diversion structures. The leaping weir openings were modeled as bottom outlet orifices connecting the influent trunk sewer with the lower interceptor pipe. A summary of combined sewer regulator structures associated with each permitted CSO outfall is presented in Table 2-3, and a summary of the configurations for the leaping weir diversion structures is presented in Table 2-2. Additional information regarding the CSO outfalls is presented in Section 2.4.

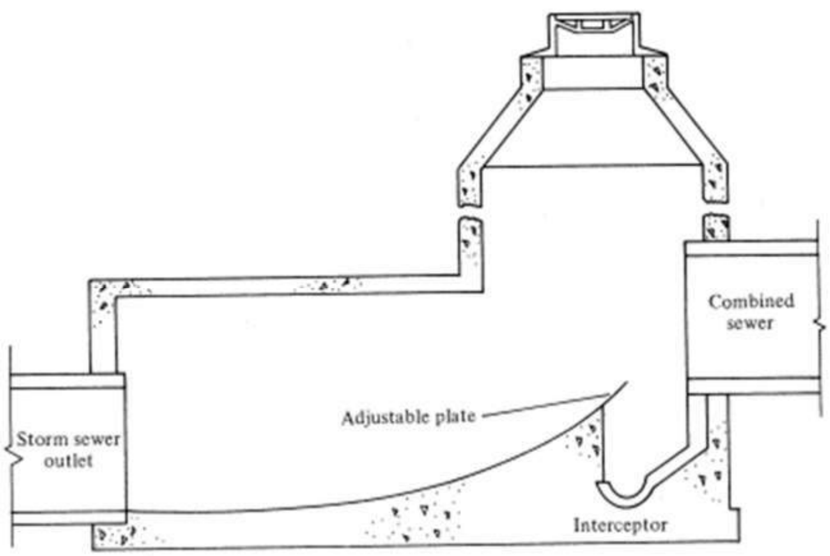

Figure 2-2 Schematic of Adjustable Leaping Weir Regulator Structure

Source: Wastewater Engineering: Collection and Pumping of Wastewater. Metcalf & Eddy, Inc., 1981.

Table 2-2 – City of Perth Amboy Combined Sewer Regulator Structures

CSO Outfall ID	Regulator Location (Street)	Influent Sewer Invert Elevation (ft)	Influent Sewer Size & Material	Outfall Sewer Invert Elevation (ft)	Outfall Sewer Size & Material	Interceptor Sewer Invert Elevation (ft)	Interceptor Sewer Size & Material	Manhole Rim Elevation (ft)	Chamber Dimensions L x W x D (ft)
P-002	Rudyk Park	9.37	33" RCP	9.37	84" Brick	4.77	36" RCP	19.4	4' x 11'-3" x 14'-8"
P-003	Buckingham Ave.	7.6	36" Brick	7.6	36" CIP	5.1	48"RCP	30.3	4' x 7'-6" x 25'-2"
P-004	Washington St.	6	3'-6" x 4'-6" Brick	6	3' x 3'-6" Brick	3	48"RCP	22.8	4' x 8'-2" x 19'-10"
P-005	Commerce St.	4.3	36" Brick	5.32	36" RCP	1.7	48"RCP	11.3	4' x 6'-3" x 9'-7"
P-006	Fayette St.	4.14	2' x 3' Brick	2.94	48" CIP	1.04	48"RCP	15.9	5'-6" x 8' x 14'-10"
P-007	Smith St.	5.5	2'-6" x 3'-6" Brick	5.44	3' x 3'-6" RCP	0.7	48"RCP	11.5	4' x 7'-4" x 10'-10"
P-008	Gordon St.	N/A	36" RCP	N/A	3-4"' x 2'-6" Brick	2.9	15" RCP	15.27	10' x 10' x 9'
P-009	Lewis St.	8.65	15" VCP	8.75	16" CIP	5.68	36" RCP	16.95	4' x 5'-8" x 9'-1"
P-010	High St.	5.28	2' x 3' Brick	5.28	42" Brick	4.22	33" RCP	14	4' x 6'-2" x 10'-1"
P-011	State St.	4.52	2' x 3' Brick	4.52	36" RCP	2.74	33" RCP	16.77	4' x 6'-2" x 13'-8"
P-013	Brighton Ave.	5.02	2' x 3' Brick	3.17	36" RCP	1.65	33" RCP	15.82*	4' x 7'-6" x 14'-2"
P-014	Madison Ave.	5.4	2' x 3' Brick	3.69	36" RCP	N/A	33" RCP	14.88*	4' x 6'-6" x 10'-11"
P-015	First St.	4.49*	2' x 3' Brick	4.14	36" RCP	0.46	33" RCP	9.62*	4' x 7'-2" x 5'-2"
P-016	Second St.	3.32	84" RCP	3.32	84" RCP	0.32	30" RCP	14.3	4' x 11'-3" x 14'
P-017	Sheridan St.	13.53*	24" RCP	13.53	36" DIP	11.67*	30" RCP	29.82*	4' x 6'-2" x 18'-2"
P-019	Outer Smith St.	N/A	72" Brick	N/A	72" Brick	30.32	18" RCP	41.8	4' x 6'-3" x 18'-2"

Legend

CIP – Cast Iron Pipe; DIP – Ductile Iron Pipe; N/A – Not Applicable; RCP – Reinforced Concrete Pipe; VCP – Vitrified Clay Pipe

Elevations marked (*) are N.J. Geological Survey Datum, which equals City Datum +3.62 from 1934 Proposed City Plans.

Table 2-3 – Leaping Weir Diversion Structure Summary

Diversion Structure ID Number	Influent Pipe Size (ft)	Weir Width (ft)	Weir Length (ft)	Weir Width / Influent Pipe Width	Influent Cross Section (ft^2)	Sump Orifice Cross Section (ft^2)
2	7	3.33	0.667	0.48	38.5	2.2
3	3	1.08	0.667	0.36	7.1	0.7
4	3.5 x 4.5	1.67	0.583	0.48	15.8	1.0
5	2 x 3	1.25	0.417	0.63	6.0	0.5
6	2.33 x 3.5	1.83	0.583	0.79	8.2	1.1
7	2.33 x 3.5	1.33	0.542	0.57	8.2	0.7
8	3	1.08	0.667	0.36	7.1	0.7
9	1.25	0.70	0.700	0.56	1.2	0.5
10	2 x 3	1.25	0.458	0.63	6.0	0.6
11	2 x 3	1.25	0.458	0.63	6.0	0.6
13	2 x 3	1.25	0.458	0.63	6.0	0.6
14	2 x 3	1.25	0.458	0.63	6.0	0.6
15	2 x 3	1.25	0.458	0.63	6.0	0.6
16	7	3.33	0.667	0.48	38.5	2.2
17	Not a leaping weir					
19	6	3.33	0.667	0.56	28.3	2.2

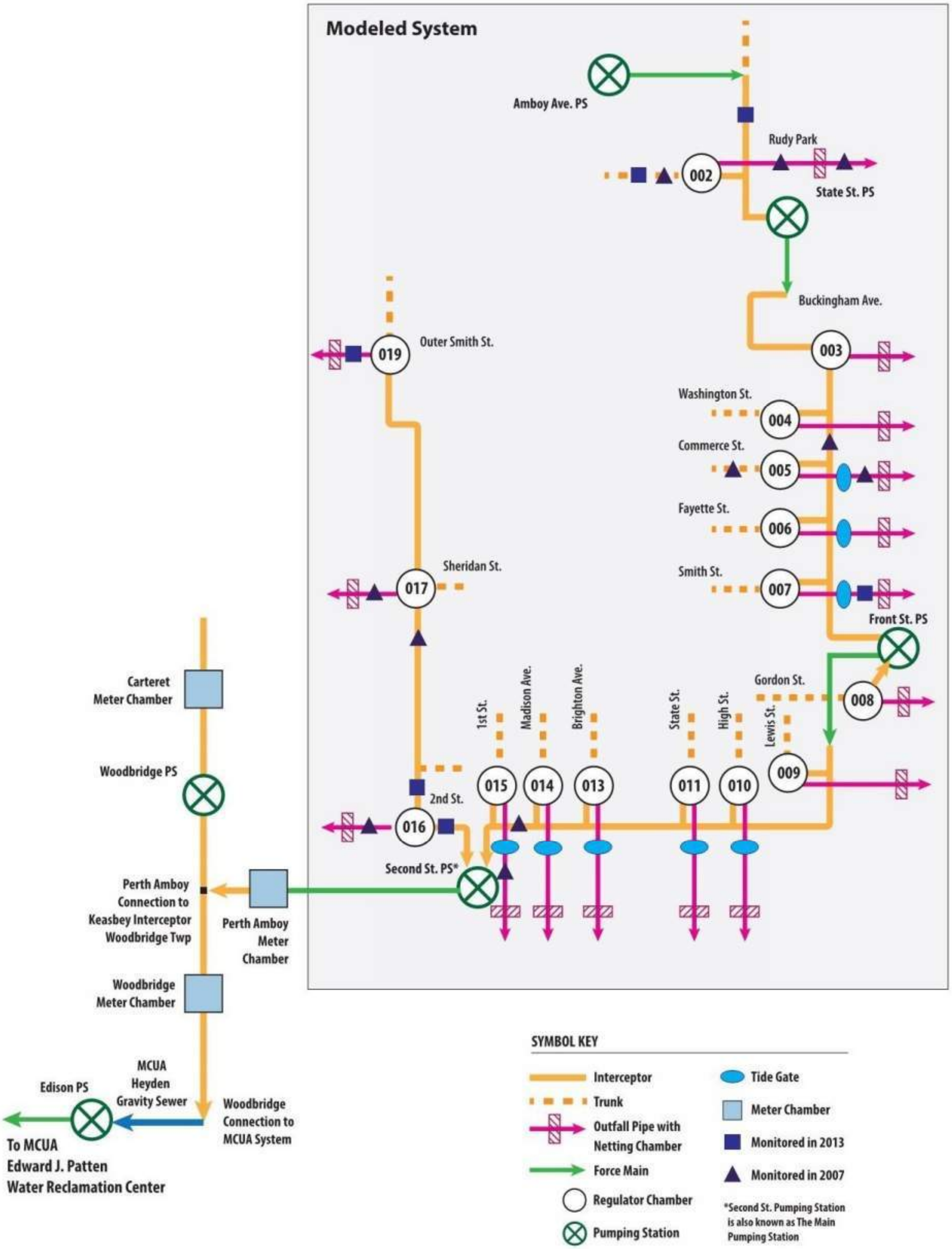

Figure 2-3: Perth Amboy Combined Sewer System Schematic with Historic Locations

2.4 Combined Sewer Outfalls

There are 16 combined sewer outfalls within the City of Perth Amboy, all owned by the city. A summary of these outfalls is located in Table 2-4. The information presented in Table 2-4 is referenced from data contained in the original combined sewer system plans dated 1934; the exact age of the combined sewer outfalls is unknown. All outfalls have solids and floatables controls that were installed in 2000.

Table 2-4 - Combined Sewer Outfall Summary

CSO Outfall Number	CSO Outfall Location	Receiving Water	Outfall Pipe Diameter	Type of Material	Tide Gate?
P-002	Rudyk Park	Arthur Kill	84" elliptical	Brick	No
P-003	Buckingham Ave.	Arthur Kill	36"	Unknown	No
P-004	Washington St.	Arthur Kill	36"	Unknown	No
P-005	Commerce St.	Arthur Kill	36"	Unknown	Yes
P-006	Fayette St.	Arthur Kill	48"	Unknown	Yes
P-007	Smith St.	Arthur Kill	36"*	Brick	Yes
P-008	Gordon St.	Arthur Kill	36"	Unknown	No
P-009	Lewis St.	Arthur Kill	15"	Unknown	No
P-010	High St.	Raritan River	36"	Brick	Yes
P-011[1]	State St.	Raritan River	36"	Unknown	Yes
P-013	Brighton Ave.	Raritan River	24"	Unknown	Yes
P-014	Madison Ave.	Raritan River	36"	Unknown	Yes
P-015	First St.	Raritan River	36"	Unknown	Yes
P-016	Second St.	Raritan River	72"	Unknown	Yes
P-017	Sheridan St.	Raritan River	24"	Unknown	No
P-019	Outer Smith St.	Raritan River	60"	Unknown	No

[1] CSO Outfall P-012 was connected into the State St. outfall (Outfall P-011) during reconstruction of the bulkhead area netting chamber at sidewalk at intersection of Sadowsky Pkwy and Catalpa Ave.

The following is a detailed description of each Perth Amboy combined sewer outfall structure:

- **CSO P-002 (Rudyk Park**) discharges overflow from a leaping weir type regulator structure. It is located on the Eastside Interceptor, upstream of the State Street pumping station. This diversion chamber is located at the northern-most CSO point on the interceptor. The leaping weir is mounted in the crown of the interceptor pipe. The main influent sewer is a 33"RCP pipe. The weir is contained in a reinforced concrete diversion chamber that also has two smaller influent sewers feeding into it. The leaping weir is oriented perpendicular to the main influent sewer. Incoming flow "falls" into the interceptor during dry weather, conditions. During rainfall events, the flow increases and gains enough energy to "leap" over the interceptor pipe and is discharged to the outfall. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The outfall pipe is an 84" brick sewer below the Outerbridge Crossing. The Outfall is located in a marsh area below the bridge. From the outfall, any discharge flows by gravity along a small tributary feeding into the Arthur Kill.

- **CSO P-003 (Buckingham Avenue)** is located on Buckingham Avenue at the eastern edge of the City. The diversion structure is located near the intersection of Buckingham Avenue and High Street. The influent sewer is a 36" RCP pipe. The CSO is a leaping weir type structure. Sewerage entering the CSO drops over the leaping weir during dry-weather conditions, into a 48" RCP interceptor. Overflows “leap” over the weir into a 36" Brick Outfall transitioning to a 36" CIP. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. that discharges to the Arthur Kill. The outfall pipe end is held in place by an existing concrete block at the end of the pipe. The outfall is situated in a tidal area and the outfall pipe becomes submerged entirely during high tides. It should be noted that the pipe from the diversion chamber to the existing outfall pipe was recently replaced. Because the diversion structure is located above the mean high tide elevation, there is no tide gate at this location.

- **CSO P-004 (Washington Street)** is a leaping weir type structure. It is located directly on the 48" RCP Eastside Interceptor at Washington Street. The weir is contained within a rectangular concrete chamber. The influent collector sewer is 3'-6" by 4'-6" brick sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. Influent sewerage “drops” into the interceptor during dry weather periods. During wet weather events when the flow increases the flow “leaps” the weir and bypasses to an outfall pipe. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The 48" RCP outfall pipe discharges to the Arthur Kill at the Perth Amboy Dry Dock Bulkhead. During high tides, the outfall pipe is approximately 50% submerged. The outfall pipe is completely exposed at low tide.

- **CSO P-005 (Commerce Street)** is a leaping weir type structure located directly on the 48" RCP Eastside Interceptor on Commerce Street. The weir is contained within a rectangular concrete chamber. Flow enters the chamber through a 36" RCP influent collector sewer. The influent sewer is oriented perpendicular to the interceptor sewer. Influent sewerage “drops” into the interceptor during dry weather periods. During wet-weather events, when flow increases, the flow “leaps” the weir and is discharged to the Arthur Kill by a 36"RCP outfall pipe. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. This pipe runs to a tide gate chamber located approximately 10 ft downstream of the diversion structure. A 36" tide gate is mounted on the inlet face of the tide gate chamber. Downstream of the tide gate chambers, the outfall pipe is a 24" by 36" brick sewer. The outfall pipe discharges at the end of a service road at the Perth Amboy Dry Dock Company, at Commerce Street. The existing pipe is partially submerged at low tide and completely submerged at high tide.

- **CSO P-006 (Fayette Street)** is a leaping weir type structure. It is located directly above the 48" RCP eastern interceptor at Fayette Street. The weir is contained within a rectangular concrete chamber. Flow enters the chamber through a 24" by 36" brick influent collector sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. Influent sewerage “drops” into the interceptor during dry weather periods. During wet weather events, flow “leaps” the weir and is discharged to the Arthur Kill by a 48" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The outfall sewer is connected to a tide gate chamber located approximately 10 ft downstream of the diversion structure. A 48" tide gate is mounted at the inlet face of to the tide gate chamber. The outfall pipe downstream of the tide gate chamber is a 24" by 36" brick sewer. The outfall pipe discharges point is located at the bulkhead at Fayette Street. The existing outfall pipe transitions to a 48" CIP at the bulkhead. The outfall pipe it not submerged at low tide but is completely submerged at high tide.

- **CSO P-007 (Smith Street)** is a leaping weir type structure. It is located directly on the 48" RCP Eastside Interceptor at Smith Street. The weir is contained within a rectangular concrete chamber. Flow enters the chamber through a 2'-6" by 3'-6" brick influent collector sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. Influent sewerage “drops” into the interceptor during dry weather periods. During wet weather events, the flow “leaps” the weir and is discharged to a 42" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe which is connected to a tide gate chamber located approximately 15 ft downstream of the diversion structure. A 42" tide gate is mounted at the inlet face of the tide gate chamber. Downstream of the tide gate chamber, the outfall pipe is a 24" by 36" brick sewer, which discharges to the Arthur Kill. The outfall pipe discharge is located at the historic landmark “Ferry to Tottenville” ferry launch at Smith Street. The outfall pipe is not visible because it is located under the Ferry Launch Dock.

- **CSO P-008 (Gordon Street)** is a leaping weir type structure located remote from the Eastside Interceptor. The weir is contained in a rectangular concrete chamber. Flow enters the chamber through a 36" RCP influent collector sewer. The leaping weir is oriented perpendicular to the influent sewer and is installed in the crown of a 15" VCP lateral sewer line. This lateral conveys dry weather flow, which “drops” through the weir, to the Eastside Interceptor sewer on Front Street. During wet weather events, when flow increases the flow “leaps” the weir and is discharged to the Arthur Kill by a 36" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The diversion chamber is located above the normal high tide level, and there is no tide gate associated with this outfall. The outfall discharges to the Arthur Kill at a point located at the bulkhead behind the Armory Restaurant. The outfall pipe is partially submerged at high tide.

- **CSO P-009 (Lewis Street)** is a leaping weir type structure. It is located on Lewis Street and is remote from the 36" RCP interceptor on Water Street. The weir is contained in a concrete chamber. Flow enters the chamber from a 15" VCP influent collector sewer. The leaping weir is oriented perpendicular to the influent sewer and is installed in the crown of a 12" RCP lateral sewer line. This lateral conveys dry weather flow, which “drops” through the weir, to the lateral sewer. During wet weather events, when flow increases, the wet weather flow “leaps” the weir and is discharged to the Raritan Bay by a 15" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The outfall invert at the diversion chamber is above the influence of normal high tides, and there is no tide gate associated with this outfall. The outfall pipe discharges to the Raritan Bay, behind the bulkhead at Water Street and Lewis Street.

- **CSO P-010 (High Street)** is a leaping weir type structure located on High Street. The CSO is remote from the 33" RCP interceptor on Sadowski Parkway. The weir is contained in a concrete chamber. Flow enters the chamber from a 2' by 3' brick influent collector sewer. The leaping weir is oriented perpendicular to the influent sewer and is installed in the crown of a 12" RCP lateral sewer line. This lateral conveys dry weather flow, which “drops” through the weir, to the 33" RCP Eastside Interceptor on Sadowski Parkway. During wet weather events, when flows increase the flow “leaps” the weir and is discharged to a 36" RCP outfall pipe. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The outfall pipe is connected to a tide gate chamber approximately 10 ft downstream of the diversion structure. A 36" tide gate is mounted on the inlet of the tide gate chamber. The outfall pipe invert at the chamber is influenced by normal high tides. The outfall pipe downstream of the tide gate chamber is a 24" by 36" brick sewer, which discharges to the Raritan Bay. The outfall pipe transitions to an exposed 36" CIP at the Sadowski Parkway beach. Field inspection of the diversion chamber and tide gate identified no structural damage or signs of deterioration. There were no chronic problems associated with these structures. Inspection of the outfall pipe identified the pipe to be in fair to poor condition. It was noted that the exposed portion of the pipe is exhibiting surface pitting.

- **CSO P-011 (State Street)** is a leaping weir type structure located on State Street. It is located remote from the 33" RCP interceptor on Sadowski Parkway. The weir is contained in a concrete chamber. Flow enters the chamber from a 2' by 3' brick influent sewer. The leaping weir is oriented perpendicular to the influent sewer and is installed in the crown of a 12"VCP lateral sewer line. This lateral conveys dry weather flow, which “drops through the weir, to the 33" RCP Eastside Interceptor on Sadowski Parkway. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. During wet weather events, when flows increase, the flow “leaps” the weir and is discharged to the Raritan Bay by a 36" RCP outfall pipe. The outfall pipe is connected to a tide gate chamber, located approximately 10 ft downstream of the diversion structure. A 36" tide gate is mounted on the inlet of the tide gate chamber. The outfall pipe invert at the chamber and is influenced by normal high tides. The outfall pipe downstream of the tide gate chamber is a 24" by 36" brick sewer. The outfall pipe transitions to an exposed 36" CIP at the Sadowski Parkway beach.

- **CSO P-013 (Brighton Avenue)** is a leaping weir type structure located directly on the 33" RCP eastern interceptor at Brighton Avenue and Sadowski Parkway. The weir is contained within a rectangular concrete chamber. Flow enters the chamber through a 24" by 36" brick influent collector sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. Influent sewerage "drops" into the interceptor during dry weather periods. During wet weather events, when flow increases the flow "leaps" the weir and is discharged to a 36" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. This sewer runs to a tide gate chamber located approximately 5 ft downstream of the diversion structure. A 36" tide gate is mounted at the inlet to the tide gate chamber. The outfall pipe invert at the chamber is influenced by normal high tides. The outfall pipe downstream of the tide gate chamber is a 24" by 36" brick sewer. The outfall pipe transitions to 36" CIP at the Sadowski Parkway beach and discharges to the Raritan Bay. The outfall pipe is partially submerged at low tide and is completely submerged at high tide.

- **CSO P-014 (Madison Avenue)** is a leaping weir type structure located on Madison Avenue, remote from the 33" RCP interceptor on Sadowski Parkway. The weir is contained within a rectangular concrete chamber. Flow enters the chamber through a 24" by 36" brick influent collector sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. During dry-weather influent sewerage "drops" into a 12" VCP lateral sewer, which conveys flow to a manhole located on the 33" interceptor. During wet weather events, when flow increases, the flow "leaps" the weir and is discharged to a 36" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The outfall is connected to a tide gate chamber located approximately 10 ft downstream of the diversion structure. A 36" tide gate is mounted at the inlet to the tide gate chamber. The outfall pipe invert at the chamber is influenced by normal high tides. The outfall pipe from the tide gate chamber is a 2'-4" by 3'-6" brick sewer. This sewer transitions to a 36" CIP before discharging to the Raritan Bay at the Sadowski Parkway beach. The outfall pipe is partially submerged at low tide and is completely submerged at high tide.

- **CSO P-015 (High Street)** is a leaping weir type structure. It is located directly on the 33" RCP eastern interceptor at First Street and Sadowski Parkway. The weir is contained within a rectangular concrete chamber. Flow enters the chamber through a 24" by 36" brick influent collector sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. Influent sewerage "drops" into the interceptor during dry weather periods. During wet weather, when flow increases, the flow "leaps" the weir and is discharged to a 36" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The outfall sewer runs to a tide gate chamber located approximately 5 ft downstream of the diversion structure. A 36" tide gate is mounted at the inlet to the tide gate chamber. The outfall pipe invert at the chamber is influenced by normal high tides. The outfall pipe downstream of the tide gate chamber is a 24" by 36" brick sewer. The outfall transitions to a 36" CIP before discharging to the Raritan Bay at Sadowski Parkway beach. The pipe is partially submerged at low tide and completely submerged at high tide.

- **CSO P-016 (Second Street)** is a leaping weir type structure. It is situated at the invert of the 84" RCP Westside Interceptor at Second Street. The weir is contained within a rectangular concrete chamber. Flow enters the chamber from the 84" RCP interceptor.

This pipe conveys all flow from upstream CSO points. Dry weather flow drops through the weir into a smaller 30" RCP interceptor reach oriented perpendicular to the influent sewer. During wet weather events, when flow increases, the flow “leaps” the weir and is discharged to an 84" RCP outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. An 84" tide gate is located directly at the end of the outfall pipe and head wall at the Sadowski Parkway Beach. The outfall pipe is not submerged at low tide and is nearly one third submerged at high tide.

- **CSO P-017 (Sheridan Street)** does not have a leaping weir. Rather, there is an orifice cut directly in the crown of the 30" RCP Westside Interceptor at Sheridan Street. The orifice is contained within a rectangular concrete chamber. Flow enters the chamber through a 24" RCP influent collector sewer. The diversion chamber orifice is directly in the path of the influent sewer. Influent sewerage “drops” into the orifice during dry weather periods. During wet weather events, when flow to the chamber increases, surcharge conditions develop, and the excess flow discharged to a 24" RCP outfall sewer to the Raritan Bay. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. The chamber is not influenced by high tides. However, the existing outfall pipe end is completely buried in river silt. This blocks the outfall pipe and results in surcharging of the diversion chamber. The installation of a new 36" High Density Polyethylene (HDPE) outfall pipe is being planned. The new out fall pipe will discharge to a creek west of Sheridan Street, tributary to the Raritan Bay. This project will be completed in late 1996.

- **CSO P-019 (Outer Smith Street)** is a leaping weir type structure located on the 18" RCP Westside Interceptor sewer at outer Smith Street. The weir is contained in a rectangular concrete chamber. Flow enters the chamber through a 72" brick influent collector sewer. The leaping weir and interceptor are oriented perpendicular to the influent sewer. Influent sewerage “drops” into the interceptor during dry weather periods. During wet weather events, when flow increases, the flow “leaps” the weir and is discharged to a 72" brick outfall sewer. A netting chamber is located downstream of the diversion chamber to remove solids and floatables before they are discharged through the outfall pipe. There is no tide gate associated with this CSO. The outfall sewer runs from west to east approximately 300 ft, where it collects additional stormwater flow from a junction box, located in a vacant wooded area on the north side of Smith Street. This junction box receives runoff primarily from a shopping center area, to the north, near New Brunswick Avenue. The vacant land area is at a depressed elevation and holds a significant amount of surface water. It was noted that the primary inlet to the junction box is clogged by debris which has resulted in the retention of surface water. It was further noted that numerous floatables are visible on the water surface. From the junction chamber the outfall pipe runs due south below Smith Street, and discharges to a swale on Hess Oil property. From this swale, the outfall transitions to a 48" RCP and discharges at a bulkhead on the Raritan Bay.

2.5 Pump Stations and Force Mains

There are four (4) pump stations (PS) within the combined sewer system. The locations of the pump stations and their respective service areas are shown in Figure 1-1. A summary characterization of the pump stations is provided in Table 2-5.

Table 2-5 – Summary of Perth Amboy Pump Stations

Pumping Station Name	Address	Date Went into Operation	Pump Data			Last Major Rehab. or Upgrade
			Number of Pumps	Motor Size per Pump	Pump Station Capacity (mgd)	
Amboy Avenue Pump Station	15 Amboy Avenue Perth Amboy, NJ	1998	2	25 HP	0.75 MGD 525 gpm @ 70 ft TDH	2004: Rebuilt pump 1 2007: Rebuilt pump 2
State Street Pump Station	806 State Street Perth Amboy, NJ	1998	2	75 HP	4.6 MGD 3,200 gpm @ 50 ft TDH	2003: Rebuilt pump 1 2009: Rebuilt pump 2
Front Street Pump Station	256 Front Street Perth Amboy, NJ	1999	2	125 HP	7 MGD 4,800 gpm @ 58 ft TDH	2009: Overhauled both pumps
Main Pumping Station	End of Second Street (& Sadowsky Pkwy) Perth Amboy, NJ	1988	3	300 HP	13.7 MGD 9,500 gpm @ 175 ft TDH	2004: Overhauled pump 2 2008: Pump 3 VFD replaced 2010: Overhauled pump 1

The following is a detailed description of each Perth Amboy pumping station:

- **Amboy Avenue Pumping Station -** This pumping station is the smallest in capacity, rated at 350 gpm. The station is a steel "can" unit, containing two dry pit vertical centrifugal pumps, one operational and one spare. The pump station is equipped with an emergency generator. The pump conveys a portion of the flow within combined sewer service area #002, via an 8" diameter force main.

- **State Street Pumping Station –** This pumping station is located on the Eastside Interceptor and is the second smallest in capacity, rated at 3,200 gpm. This station pumps are contained in a brick and block building, originally constructed in the late 1930s which has been updated over the years. The station has two dry pit vertical centrifugal pumps, one operational, one standby. The pump station is equipped with an emergency generator. Flow from the entire combined sewer area #002 is conveyed through a 24" force main.

- **Front Street Pumping Station –** This pumping station is located on the Eastside Interceptor and is the second largest in capacity, rated at 4,800 gpm. The pumps are contained in a below grade structure. Two dry-pit vertical centrifugal pumps are located in the station, one operational and one spare. The pumping station receives flow from the Eastside Interceptor above CSO #007 and conveys this flow through a 16" force main along Smith Street. Downstream of this point the Eastside Interceptor resumes gravity flow.

- **Main Pumping Station –** This station is also known as the Second Street Pumping Station. The Main pumping station receives all combined sewerage conveyed by the City's interceptor sewers. It is rated at a capacity of 9,500 gpm. This pumping station was constructed in 1988 at the site of Perth Amboy's decommissioned Wastewater Treatment Plant. The station contains three vertical centrifugal pumps; one operational, one stand by and one spare. Flow entering the pumping station is conveyed to the Keasbey Metering Station in Woodbridge Township. The flow is ultimately received at the MCUA regional wastewater treatment plant. The Hazard Mitigation Improvements at the Second Street PS are currently under construction with completion scheduled by December 2018. Capacity of the station will remain unchanged.

2.6 Other Flow Controls

Historically, much of the Perth Amboy interceptor sewer and collection system has been subject to hydraulic capacity problems. These problems have been associated with tidal intrusion, sewer line blockages and silt and debris accumulation.

Tidal intrusion was the most prolific problem prior to the installation of tide gates in 1988 and 1989. These gates were installed downstream of any CSO structures, where overflow pipe inverts were lower than 6.0 ft in elevation. Such low elevations allow tidal water to enter the combined system during high tide gates largely alleviated this problem. However, occasional problems can develop when tide gates become unseated due to debris. When this situation occurs, tidal water can enter the interceptor system during high tide causing the main pumping station to send river water to the wastewater treatment plant for treatment. A summary of all tide gates associated with Perth Amboy's outfalls is included in Table 2-6.

Perth Amboy installed solids and floatable controls on all of its CSO outfalls in 2000. These systems consist of between ½" mesh nets of dimensions 30" square at the mouth by eight feet long. The outfall chambers have between one and four nets and work in conjunction to the hinged bar screens to reduce the amount of solid and floatables that discharges through the outfall. A summary of all solid and floatable controls associated with Perth Amboy's outfalls is included in Table 2-7.

Table 2-6 – Outfall Tide Gate Summary

CSO Outfall Number	Tide Gate Location (Street)	Tide Gate	Tide Gate Structure Type	Tide Gate Installed (Year)	Tide Gate Diameter (in)	Tide Gate Invert Elevation (ft)	Tide Gate Floor Elevation (ft)	Overflow Sewer Size and Material
P-002	Rudyk Park	No	N/A	N/A	N/A	N/A	N/A	84" Brick
P-003	Buckingham Ave.	No	N/A	N/A	N/A	N/A	N/A	36" CIP
P-004	Washington St.	No	N/A	N/A	N/A	N/A	N/A	3' x 3'-6" Brick
P-005	Commerce St.	Yes	Chamber	1988-1992	36	5.32	4.32	36" RCP
P-006	Fayette St.	Yes	Chamber	1988-1992	48	2.94	1.94	48" CIP
P-007	Smith St.	Yes	Chamber	1988-1992	42*	5.44	4.44	3' x 3'-6" RCP*
P-008	Gordon St.	No	N/A	N/A	N/A	N/A	N/A	3-4"' x 2'-6" Brick
P-009	Lewis St.	No	N/A	N/A	N/A	N/A	N/A	16" CIP
P-010	High St.	Yes	Chamber	1988-1992	36	5.28	4.28	42" Brick
P-011	State St.	Yes	Chamber	1988-1992	36	4.52	3.52	36" RCP
P-013	Brighton Ave.	Yes	Chamber	1988-1992	36	3.17	2.17	36" RCP
P-014	Madison Ave.	Yes	Chamber	1988-1992	36	3.69	2.69	36" RCP
P-015	First St.	Yes	Chamber	1988-1992	36	4.14	3.14	36" RCP
P-016	Second St.	Yes	At Outfall	1988-1992	84	2.2	2.2	84" RCP
P-017	Sheridan St.	No	N/A	N/A	N/A	N/A	N/A	36" DIP
P-019	Outer Smith St.	No	N/A	N/A	N/A	N/A	N/A	72" Brick

Legend

CIP - Cast Iron Pipe; DIP - Ductile Iron Pipe; N/A - Not Applicable; RCP - Reinforced Concrete Pipe; VCP - Vitrified Clay Pipe

Table 2-7 – Solid and Floatable Controls Summary

CSO Outfall ID Number	Control Location (Street)	Type of Solids/Floatable Control	Number of Nets	Dimensions	Material	Netting Chamber Installed (Year)
P-002	Rudyk Park	Netting Chamber	4	30" Square at the mouth by 8 feet long	1/2" Mesh (minimum bar strength of 75 lbs)	All installed in 2000
P-003	Buckingham Ave.	Netting Chamber	4			
P-004	Washington St.	Netting Chamber	2			
P-005	Commerce St.	Netting Chamber	1			
P-006	Fayette St.	Netting Chamber	2			
P-007	Smith St.	Netting Chamber	1			
P-008	Gordon St.	Netting Chamber	2			
P-009	Lewis St.	Netting Chamber	2			
P-010	High St.	Netting Chamber	2			
P-011	State St.	Netting Chamber	1			
P-013	Brighton Ave.	Netting Chamber	1			
P-014	Madison Ave.	Netting Chamber	1			
P-015	First St.	Netting Chamber	1			
P-016	Second St.	Netting Chamber	4			
P-017	Sheridan St.	Netting Chamber	1			
P-019	Outer Smith St.	Netting Chamber	4			

2.7 Existing CSO Control Facilities

There are no existing CSO control facilities in the Perth Amboy service area.

2.8 Regional Wastewater Treatment Plant

Perth Amboy does not own or operate the wastewater treatment plant that serves the Perth Amboy sewer system. All combined and sanitary flow generated within Perth Amboy is conveyed through the Perth Amboy Main Pumping Station to a connection within the Woodbridge Township sewer system via the Keasbey Interceptor. This flow connects to the MCUA collection system via a connection at the Heyden gravity sewer and is processed at the Edward J. Patten Water Reclamation Center facility in Sayreville, NJ. This facility is owned and operated by MCUA, and treatment is provided for the wastewater from Perth Amboy by MCUA (see Section 9 for further information regarding this agreement).

The MCUA facility is rated for an average flow of 147 mgd. All flow is screened and pumped to the plant from off-site pump stations. Wastewater is pumped to the preliminary treatment units and flows through the rest of the plant through the outfalls via gravity.

The preliminary treatment consists of three aerated grit chambers. From the grit chambers, the wastewater flows through the influent venturi meter to six rectangular primary clarifiers with traveling bridge collector mechanisms. Primary effluent is flows to four aeration tanks. The aeration tanks are equipped with mechanical aerators and the oxygen source is a pure oxygen system. From the aeration tanks, the mixed liquor flows to sixteen circular final settling tanks. The secondary effluent is then disinfected using sodium hypochlorite. The treated wastewater is discharged to the Raritan Bay up to a flow rate of approximately 150 mgd. Flows over 150 mgd are directed to the supplemental outfall via rectangular butterfly valves, discharging into the Raritan River.

The primary sludge and the waste activated sludge (WAS) are pumped to eight thickener tanks. The partially thickened sludge is thickened further using ten belt filter presses. The supernatant from the thickener tanks and filtrate from the belt filter presses goes back to the primary settling tanks. The thickened sludge is then stabilized using the facility's DuopHase process.

Section 3

Land Use Analysis

3.1 Sewershed Areas

The total area of the City of Perth Amboy is 3,819 acres. Of this area, 1,606 acres of development are served by the combined sewer system with the remaining area served by separate sanitary sewers and areas that do not contribute flow to the municipal collection system such as highway and parks. The City of Perth Amboy developed delineations for all combined sewered areas as part of its CSO Discharge Characterization Study under the 2007 General Permit. For the purposes of the Perth Amboy Discharge Characterization Model, a sewershed is defined as the area contributing dry weather sewage flow, wet weather storm flow, or a combined dry and wet weather flow to a point of connection on the City's interceptor. In a combined sewer system, these points typically occur when a trunk sewer reaches the interceptor at a diversion structure which regulates how much flow enters the interceptor and how much flow discharges through an overflow pipe. The sewershed delineations for such a configuration are relatively simple as long as the connection within the collection system are well understood. A sewershed which connects directly to the interceptor without a diversion structure is considered "directly connected." Directly connected sewersheds are generally harder to delineate because the point of connection is not as easily identifiable. This can be simplified by merging areas into a single loading point and assuming a connection location.

The City of Perth Amboy has 16 active combined sewer overflow points on its interceptor system. There are 13 overflow points that have typical trunk sewer combined sewer diversion structure points of connection, and three diversion structures regulate flows on the interceptor itself after receiving flow from is tributary contributing area in addition to flow from the closest upstream regulator. Each of these areas were delineated into distinct sewersheds and named based on their downstream regulator. The sewershed delineations for Perth Amboy were obtained using a sewer map prepared by Carr Engineering and obtained from the City. The map, dated September 2003, shows the manhole and pipe location of the trunk sewers and interceptors of the combined sewer collection system. The sewer map was first geographically referenced into GIS using NJDEP 2002 high resolution aerial photographs as a basemap. Once in GIS, the trunk sewer connections were manually reviewed to determine their interceptor point of connection and corresponding sewershed delineations were created.

3.1.1 Pervious & Impervious

The most current information of impervious surface area within Perth Amboy is the 2012 Land Use/Land Cover Update published by NJDEP, in conjunction with the New Jersey Office of Information Resources Management and Bureau of Geographic Information Systems. This data was analyzed to evaluate the changes in imperviousness in each sub-sewershed from 2002 to 2012 in the City. The overall imperviousness of the City's combined area (shown in Table 3-1) had increased by 0.4%. The areas with the most acreage changes were DCD (6.42-acre reduction) and P02 (10.6-acre addition), however, these changes were captured explicitly by the flow meters in 2013. The changes in impervious area for the rest sub-sewersheds were all under 4 acres. The model has been updated using the imperviousness as depicted in the 2012 GIS Land Use Land Cover (LULC) Data, although it has not lead to any significant change in runoff characteristics of these sub-sewersheds.

The percent imperviousness in the separate sewer area within the City had increased by 6%. However, the quantity of inflow and infiltration in the separate sewer area correlates more to the system condition such as how leaky the pipes and manholes are, and how many sump pumps are connected than to land use and imperviousness of the separate sewer area.

Table 3-1 – Percent Impervious Comparison – 2002 vs. 2012

Combined Sewershed	Land Area (acres)	2002 Land Use Data		2012 Land Use Data		Change of Impervious Area 2002-2012 (acres)	Percentage Change of Impervious Area 2002-2012
		Impervious Area (acres)	Percentage of Imperviousness	Impervious Area (acres)	Percentage of Imperviousness		
DCC	17.27	0.4	2%	3.9	23%	3.59	21%
P02	316.54	8.0	3%	18.6	6%	10.55	3%
P03	34.08	0.3	1%	0.8	2%	0.56	2%
P17	94.85	17.7	19%	19.0	20%	1.30	1%
P19	250.82	27.1	11%	30.2	12%	3.11	1%
P06	42.94	4.4	10%	4.6	11%	0.17	0%
DCB	7.00	0.0	1%	0.1	1%	0.02	0%
P07	16.60	0.1	0%	0.1	1%	0.02	0%
P16	397.88	80.8	20%	80.7	20%	-0.05	0%
P09	13.27	0.1	1%	0.1	1%	-0.03	0%
P08	10.25	0.1	1%	0.1	1%	-0.04	0%
P11	28.84	14.2	49%	14.1	49%	-0.11	0%
P13	53.83	2.3	4%	2.1	4%	-0.21	0%
P14	19.39	1.0	5%	0.7	4%	-0.24	-1%
P04	59.58	4.7	8%	3.9	6%	-0.84	-1%
P15	30.71	3.0	10%	2.4	8%	-0.60	-2%
DCD	147.04	9.3	6%	2.8	2%	-6.42	-4%
DCA	5.75	2.9	50%	2.4	41%	-0.52	-9%
P05	25.07	10.1	40%	6.2	25%	-3.87	-15%
Total	**1571.70**	**186.5**	**-**	**192.9**	**-**	**6.4**	**0.4%**

3.1.2 Contributing and Non-Contributing

There are two primary areas within the City of Perth Amboy that do not contribute sewer flow to the Perth Amboy collection system. These areas mostly consist of industrial zoning, railroad corridors or green space adjacent to a waterbody. These areas are displayed in Figure 1-1 including but not limited to three large non-contributing areas. Non-contributing area 1 (NC-1) and non-contributing area 3 (NC-3) are located in the southwest portion of the City, adjacent to the Raritan River. Non-contributing area 2 (NC-2) is located in the northeast portion of the City, adjacent to Arthur Kill. Other areas are NJ Transit railroad running north south through the center of the City and a park area upstream of P016. The total area of these non-contributing areas is 883 acres, which represents approximately 23% of the total area of the City of Perth Amboy.

3.2 Sewershed Land Use

Land use and imperviousness data were analyzed on the sub-sewershed level using the NJDEP 2012 Land Use/Land Cover GIS database. A summary of the land use distribution is included in Table 3-2. This data was consolidated into 12 different types, representing a full range of land use information. The predominant land uses are residential and commercial with pockets of industrial areas. The various land use types found in the Perth Amboy combined sewer service area include: Residential; Commercial/Services; Industrial; Transportation, Communication and Utilities; Urban, Vacant and Transitional; Parks and Recreation; and Other Land Use Types (Beaches, Forested, Water and Wetlands).

Table 3-2 – Land Use Distribution in Study Area (2012 Land Use Data)

Combined Sewershed	Land Use Category									Percentage of Total Area
	Commercial / Industrial	Forest/Shrub	Other Open	Other Urban	Recreation	Residential	Transportation / Communications / Utility	Water	Wetlands	
DCD	15%	3%	1%	5%	8%	60%	7%	1%	0%	37%
P02	19%	1%	12%	4%	5%	57%	3%			
P05	17%			13%		70%				
P08	2%		4%		14%	80%				
P09	7%		7%			86%				
P10					9%	91%				8%
P11	4%				5%	91%				
P14	2%			5%	7%	87%				
P15	9%			6%	9%	74%	2%			
P03	38%		2%	8%	7%	31%	13%			
P04	26%	9%	6%	8%	0%	47%	3%			
P06	52%			1%		47%				
P07	27%				8%	65%				51%
P13	42%			3%	3%	53%				
P16	44%	0%	1%	10%		42%	2%	1%	0%	
P17	56%	1%		4%	2%	32%	7%			
P19	10%	9%	3%	8%	3%	57%	8%	3%		

Section 4

Receiving Waterbodies

4.1 Identification and Description of CSO Receiving Waterbodies

As identified in Section 2.4, the City of Perth Amboy owns and operates 16 CSO outfall points which discharge to the following waterbodies:

- 8 outfalls discharge to the Arthur Kill (Saline Estuary SE2); and
- 8 outfalls discharge to the Raritan River (Raritan Estuary) (Saline Estuary SE1).

4.1.1 Arthur Kill

Arthur Kill is a tidal straight of approximately 10 miles that connects Newark Bay with Raritan Bay. Perth Amboy sits on the western shore of the Arthur Kill. Arthur Kill serves as a boundary between New York and New Jersey and is primary used as a navigational channel for nearby industrial sites. It is periodically dredged for maintenance as a navigation route for commercial ship passage. The New Jersey stream classification for Arthur Kill is Saline Estuary 2 (SE2).

4.1.2 Raritan Estuary

The Raritan Estuary is a tidally influenced body of water at that base of the approximately 70 mile Raritan River and extends easterly to the Raritan Bay and further to the Atlantic Ocean. Portions of the estuary are at the border of New Jersey and New York state. The New Jersey stream classification for Raritan Estuary is Saline Estuary 1 (SE1).

4.2 Current Water Quality Conditions

The City of Perth Amboy is a member of the NJ CSO Group. The Passaic Valley Sewerage Commission (PVSC) is conducting extensive receiving waterbody investigations on behalf of the Group, in support of the October 2015 Combined Sewer Management permits issued to each of the Group's members. PVSC has developed a *Baseline Compliance Monitoring Report* (BCMR) which details the current receiving waterbody water quality conditions. This document is due for submission to NJDEP from the lead author, the PVSC, concurrent with the deadline for this report submission.

Preliminary results of the BCMR indicate the following:

- The larger waterbodies (including the Arthur Kill) appear to meet existing water quality criteria.
- The Raritan River may have attainment issues related to pathogen standards for its designation.

4.3 Identification, Evaluation and Prioritization of Environmentally Sensitive Areas

There has been a detailed investigation of the subject waterbodies relative to the established criteria used to designate Sensitive Areas as defined in the USEPA CSO Control Policy (59 FR 18,688; April 19, 1994) and reiterated in the NJDEP Combined Sewer Management permit issued in October 2015 to Perth Amboy. This work has been performed by PVSC on behalf of the NJ CSO Group, as part of the current efforts under the October 2015 Combined Sewer Management permits issued by NJDEP to the individual members of the Group. The reader is directed to the PVSC-developed *Consideration of Sensitive Areas Report*, for further information about Sensitive Areas in the subject waterbodies. *Consideration of Sensitive Areas Report* will be submitted to NJDEP concurrent to the submittal deadline for this report. It should be noted that the PVSC report describes one area in Perth Amboy that the City has identified for special consideration. This area is also described below in this section.

There are existing bathing beaches located on the north shore of the Raritan Bay, near the confluence of the Raritan River and the Arthur Kill, at the southeastern boundary of the City of Perth Amboy, displayed in Figure 4-1 Area of Existing Raritan Bathing Beach (not currently used) . These beaches are not currently designated by the City for recreational bathing use due to water quality concerns, specifically periodic non-attainment of pathogen water quality standards in the vicinity of the beaches. For this reason, signs have been installed by the City at the beaches to advise the public not to swim or enter the water in this area. However, there is significant public interest in restoring public use of the beaches for recreational bathing and there are active discussions underway to accomplish this objective.

The cause or causes of non-attainment are not yet fully known, but the discharge of CSOs at seven CSO outfalls located in the immediate area of the beaches is believed to be a significant factor. The City plans to conduct additional analysis of water quality conditions in the subject waterbody to determine the feasibility of achieving sufficient improvement to support restoration of public use of the beaches for recreational bathing. This analysis may be undertaken in coordination with the forthcoming *Development and Evaluation of Alternatives Report* (due July 1, 2019 under the City's Combined Sewer Management permit), which will include proposed actions (and potentially identify proposed CSO control facilities) to achieve this result.

The City of Perth Amboy advised PVSC of these circumstances for purposes of the aforementioned *Consideration of Sensitive Areas Report* prepared by PVSC on behalf of the NJ CSO Group. The City took this action recognizing that the U.S.EPA CSO Control Policy defines Sensitive Areas to include "waters with primary contact recreation" (which includes recreational bathing beach waters). The CSO Policy states that such areas should be given special consideration in the Long-Term Control Plan, including elimination or relocation of CSO discharges.

Because the subject beaches are not currently designated by the City as public use bathing beaches, and only occasional and unauthorized recreational bathing occurs there, the City does not regard the beaches as a Sensitive Area. Further, as noted above, the City has not yet determined that it is feasible to restore water quality to the extent necessary to support safe public use of the beaches for recreational bathing, as pathogen discharges upstream on the

Raritan River and/or from other sources into the Raritan Bay may preclude attainment of water quality standards even after the local CSO discharges are addressed.

However, because there has been significant public interest in and discussion of restoring the beaches for public use as recreational bathing beaches, this area is being acknowledged here. If the City at some future time determines that it is feasible to achieve sufficient water quality improvement to support safe public use of the beaches for recreational bathing, the subject beach area could be designated as a Sensitive Area at that time.

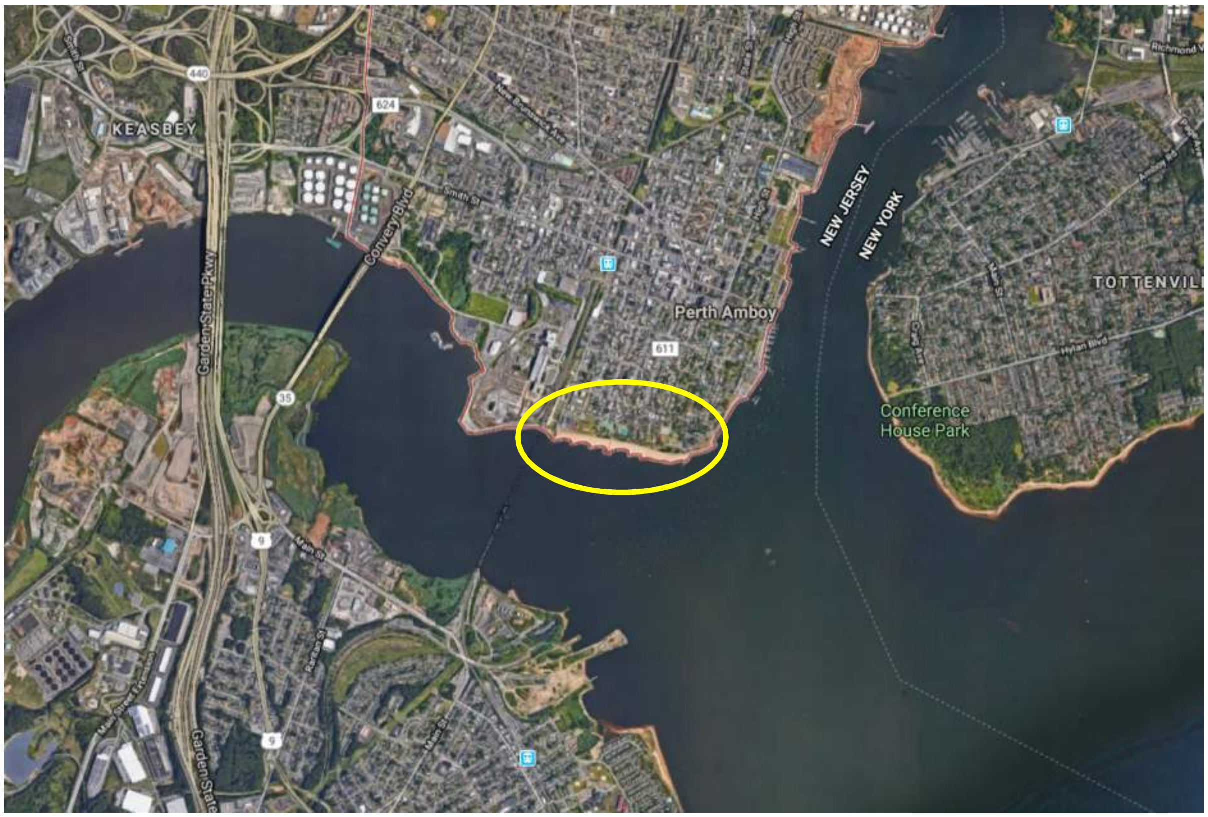

Figure 4-1 Area of Existing Raritan Bathing Beach (not currently used)

Section 5

Combined Sewer System Monitoring and Modeling

5.1 Background and Approach

Perth Amboy's NJDEPS permit (No. NJ0156132) cites the option to use an appropriately calibrated and validated model to aid in system characterization. A model that can accurately characterize the volume, frequency and duration of CSO discharges is widely regarded as essential for system characterization and alternatives analysis under the LTCP.

The H&H model of the City's interceptor sewer system was originally developed and used in analysis for compliance with NJPDES General Permit in 2007. In September 2012 Perth Amboy entered into an Administrative Consent Order (ACO) with the USEPA. As part of that ACO, flow monitoring was conducted in 2013 and the H&H model was subsequently updated. Under the current 2015 permit, the City collected depth velocity and flow data at three locations in the west portion of the system and flows at three pump stations. Two rain gauges were installed to collect the corresponding rainfall data.

These most recent flow and rainfall monitoring locations were discussed with and approved by NJDEP in November 2016. The model was updated to reflect any system changes after 2013 that were relevant to the H&H model and to incorporate the latest imperviousness and population data. Subsequently the model was calibrated to flow data collected in 2017. Meter data collected in 2007 and 2013 was used to supplement the 2017 data in model calibration and validation as appropriate. Where meters were placed at the same location in different periods, data collected from the more recent period was given more weight.

The updated and calibrated model reflects system conditions in 2015 and is the Baseline Condition Model which is used for baseline characterization of system performance reported in Section 8.

5.2 Combined Sewer System Monitoring

Under the current 2015 NJPDES permit, Perth Amboy submitted a System Characterization Report Work Plan which was approved by NJDEP in November 2016. Supplementing the work plan was the Combined Sewer System Rain Gauge and Flow Metering QAPP also approved by NJDEP in November 2016, from which flow monitoring was conducted in 2017. This section covers the details of the metering program and the subsequent rainfall data analysis. Previous metering efforts in 2007 under the General Permit and in 2013 under the ACO with U.S.EPA were described in detail in the documents *Combined Sewer Overflow Discharge Characterization Study* of 2007 and *Flow Monitoring Pilot Study Report* of 2014, both of which were submitted as Appendices to the System Characterization Work Plan.

5.2.1 Collection System and Interceptor Sewer Monitoring

In April 2017, Perth Amboy contracted with the firm Flow Assessment Inc. to install three temporary flow meters along the West Side Interceptor, and three permanent flow recording devices at three pump stations. The location of these meters and gauges recording devices are displayed in Figure 5-1 and Figure 5-2. The most upstream temporary meter was located on the 72-inch diameter trunk sewer immediately upstream of the CSO19 regulator structure on Smith Street. The second temporary meter was located on the 30-inch interceptor between CSO17 and CSO16 regulators off of Elm Street. The third temporary meter was located along the 84-inch diameter interceptor upstream of the CSO16 regulator at Second Street and Lewis Street. All three devices were continuous wave area-velocity type meters which recorded both depth and velocity. The permanent flow recording devices were installed at the State Street, Front Street and Second Street Pump Stations to replace outdated circular flow chart devices. These meters are SCADA-type recording devices which record pump discharge flow data in digital format that can be readily used for model calibration or validation. The temporary flow meters recorded data in 5-minute increments. The temporary metering program ended in early August 2017 after the data adequacy was demonstrated in CDM Smith's June 23, 2017 memorandum to the City included as Appendix B of this report.

Meter data collected in 2007 and 2013 was used to supplement the 2017 data in model calibration and validation as appropriate. Figure 5-2 shows meter locations in a schematic format.

Figure 5-1 Locations of New Flow Meter Installations for 2017 Monitoring

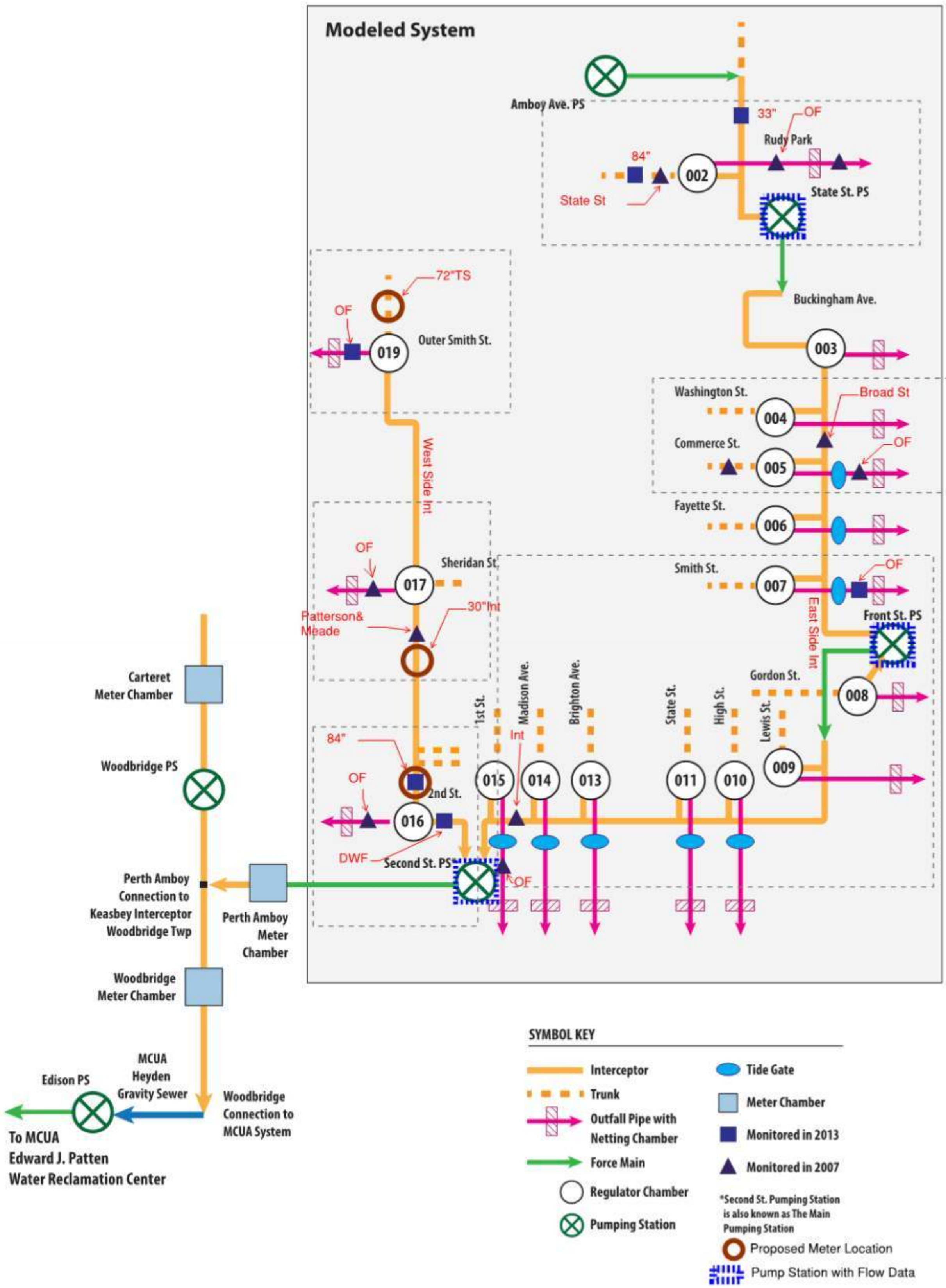

Figure 5-2 Perth Amboy Combined Sewer System Schematic with Flow Monitor Locations

5.2.2 Rainfall Monitoring and Selection of Calibration and Validation Events

5.2.2.1 Precipitation Gauges

To capture the spatial variation in precipitation events, two tipping bucket rain gauges were deployed during the 2017 monitoring period (April – August 2017) with one at Second Street Pump Station and the other one between Florida Grove Road and Christopher Court on the north side of a cemetery (see Figure 5-1). The rain gauges recorded data in 5-minute increments. The same locations were used in 2007 and 2013.

Two regional gauges were selected for quality control Perth Amboy's 2017 project rain gauges, Newark International Airport gauge and New Brunswick gauge. Newark International Airport gauge is maintained by National Weather Service with high quality hourly data. The New Brunswick gauge is part of the Rutgers' gauge network in New Jersey which records precipitation data at 5-minute interval with limited quality control. These two gauges, displayed in Figure 5-3, reside on the north (Newark International Airport) and south (New Brunswick) side of the Perth Amboy system which are helpful in evaluating spatial variability.

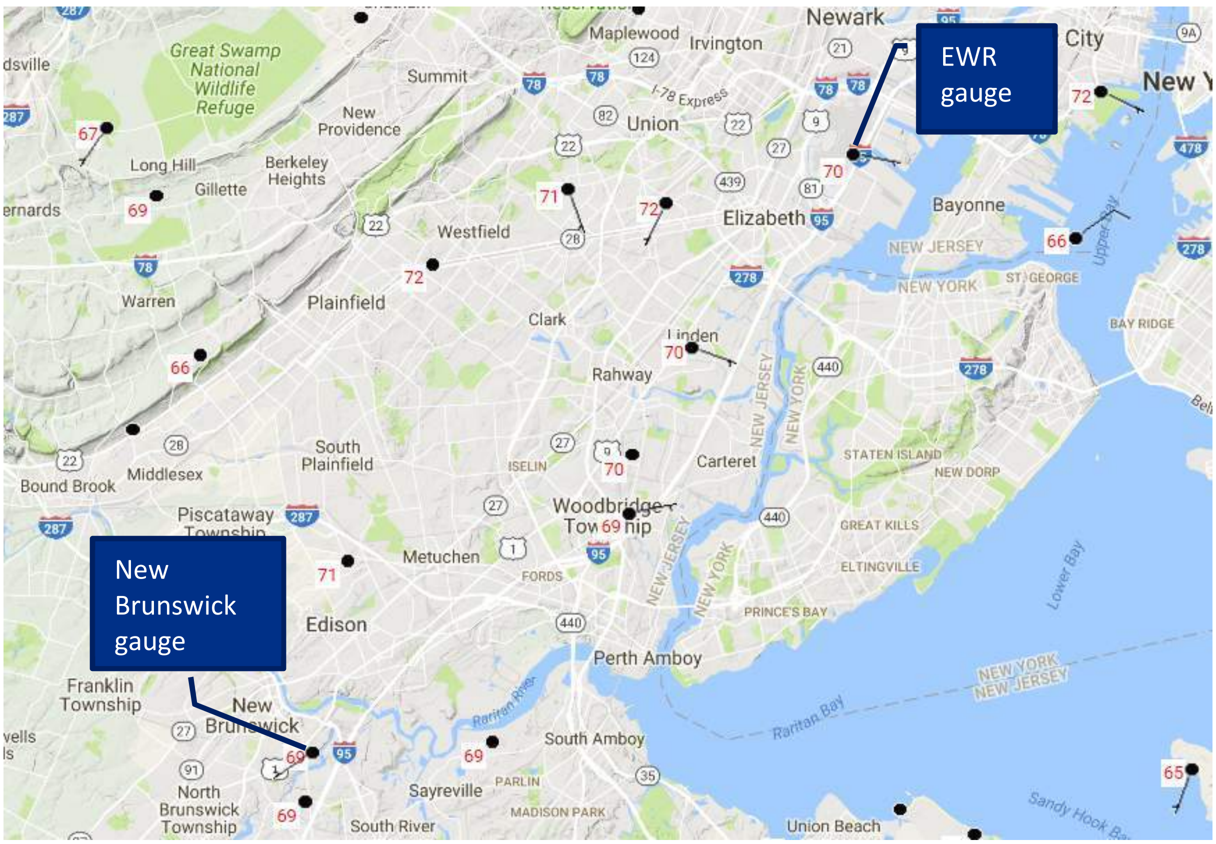

Figure 5-3 Regional Rain Gauges Used for Quality Control of Project Gauges

5.2.2.2 Rainfall Data Analysis and Selection of Events

Cumulative rainfall was calculated for April 10, 2017 and compared among the above mentioned four gauges. Rainfall data collected at Florida Grove Road gauge tracked very closely with both regional gauges as shown in Figure 5-4. The gauge at Second Street Pump Station however did not register any precipitation between May 1st and 25th. During this period, the recorded rainfall at the other three gauges showed limited spatial variability. Thus, the Second St Pump Station rainfall record can be supplemented by that recorded at Florida Grove Road.

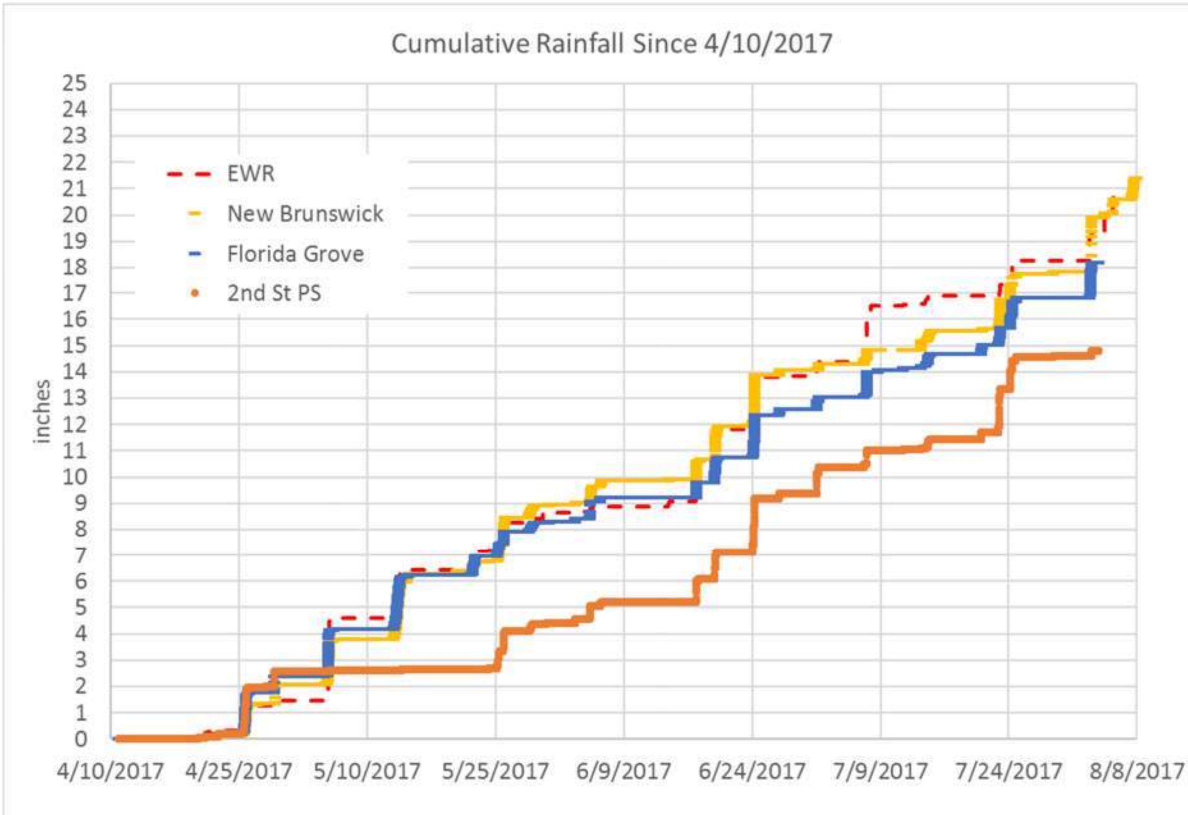

Figure 5-4 - Cumulative Rainfall Since April 10, 2017

During the 2017 metering period from April to early August, there were 15 events that registered larger than 0.5 inches total depth at either one of the two project rain gauges. An inter-event time of 6 hours was used to distinguish individual events. The storms after June 2017 showed significant spatial variation in terms of intensity and total event depth as listed in Table 5-1. The lower spatial resolution of the rain gauges compared to that of the flow meters often makes calibration to highly spatially varied events quite challenging. The recorded rainfall at the relatively sparse locations of the gauges may not accurately reflect actual rainfall in the modeled sewersheds, causing the simulated rainfall response gauge to disagree with the observed flow data. In this situation, where measurement error in the rainfall data (not model error) causes the disagreement, the observed data should never be used for calibration or validation. Therefore, only storms before June were selected for calibration and validation.

As listed in Table 5-1, among the 6 storms before June 2017, three were selected for calibration. They were April 29th, May 13th, and May 25th. Although two storms were identified on May 25, 2017 at the Florida Grove gauge using a 6-hour inter-event time, they were used as a single calibration event with a back-to-back pattern. Two storms were used for model validation which were April 25 and May 5, 2017. The other recorded storms during the 2017 metering program also provided supplemental data to assess model performance during calibration.

Table 5-1 - Rainfall Events Exceeding 0.5 Inches during the 2017 Metering Period

Index	Florida Grove				Second St Pump Station				Comments
	Depth (in)	Starting Time	Event Dur (hrs)	5-m Max (in)	Depth (in)	Starting Time	Event Dur (hrs)	5-m Max (in)	
1	1.59	4/25/2017 5:05	29.83	0.05	1.79	4/25/2017 4:55	24.92	0.06	Validation storm: long duration
2	0.61	4/29/2017 3:50	0.58	0.26	0.58	4/29/2017 3:45	0.58	0.23	Calibration storm: short duration
3	1.75	5/5/2017 1:10	12.08	0.19	Rain gauge issue. Used Florida Grove gauge data.				Validation storm: medium duration, high spatial variability
4	1.97	5/13/2017 1:55	20.58	0.03	Rain gauge issue. Used Florida Grove gauge data.				Calibration storm: long duration
5	0.7	5/22/2017 3:40	11.83	0.04	Rain gauge issue. Used Florida Grove gauge data.				
6	0.49	5/25/2017 3:10	8.33	0.02	1.41	5/25/2017 3:00	23.92	0.14	Calibration storm: back to back storm
	0.46	5/25/2017 21:00	2.33	0.12					Calibration storm: back to back storm
7	0.64	6/4/2017 23:35	3.25	0.26	0.5	6/4/2017 23:40	3.08	0.16	high spatial variability
8	0.58	6/17/2017 10:30	7.75	0.08	0.87	6/17/2017 10:25	7.92	0.22	high spatial variability
9	0.93	6/19/2017 15:20	9.33	0.13	1.05	6/19/2017 15:20	5.17	0.22	high spatial variability
10	1.6	6/24/2017 0:05	7.58	0.13	2.04	6/24/2017 0:10	6.92	0.16	high spatial variability
11	0.45	7/1/2017 13:00	5.67	0.11	0.99	7/1/2017 12:55	5.5	0.2	high spatial variability, small
12	0.98	7/7/2017 0:40	10.42	0.06	0.63	7/7/2017 0:30	9.83	0.3	high spatial variability
13	0.62	7/22/2017 19:00	6	0.02	1.64	7/22/2017 18:50	5	0.23	high spatial variability
14	0.99	7/24/2017 3:20	6.83	0.05	1.06	7/24/2017 3:05	6.5	0.16	high spatial variability
15	1.38	8/2/2017 11:55	5.42	0.09	Rain gauge issue.				high spatial variability

Dur = Duration

5.2.3 CSO Monitoring and Sampling

Perth Amboy conducted monitoring and sampling at combined sewer outfalls in 2007 to characterize the pollutant concentration of the CSO discharge. The City conducted CSO sampling at three locations: CSO-002, CSO-005, and CSO-017. Two wet weather events were captured on June 3 and July 29. Dry weather sampling upstream of one of the CSO outfalls was also conducted on August 14-15, 2007. A summary of the water quality parameters for which the samples were tested is included in Table 5-2. Event mean concentrations (EMC) were calculated for each pollutant and were used for estimating annual pollutant loads into the receiving waters.

Table 5-2 - CSO Water Quality Parameters during the 2007 General Permit

Water Quality Parameters		
BOD5	NH_3	Total Phosphorus (TP)
TSS	NO_2	Hardness
COD	NO_3	Fecal Coliform
SS	TKN	Enterococci
TDS	Orthophosphate, as P (OP)	Flow During Sampling

The results of the water quality sampling can be found in the Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 included as an Appendix to the System Characterization Work Plan.

5.3 Collection System Modeling

As noted above, the H&H model of the City's interceptor sewer system was first developed and used in analysis for compliance with NJPDES General CSO Permit in 2007. In 2012, the model was updated under the ACO with the U.S.EPA. Under the current 2015 permit, the model was updated and calibrated to reflect system conditions in 2015. This section describes the model updates and the calibration and validation process in detail.

5.3.1 Model Extent and Updates

Perth Amboy's Baseline Condition Model uses the U.S. EPA Storm Water Management Model (SWMM 5) software Version 5.1.12. The modeled pipe network is in NAVD88 vertical datum and NAD 1983 New Jersey state plane coordinate system. Figure 5-5 shows the spatial extent of the Baseline Condition Mode.

The City's Baseline Condition Model includes the following hydraulic components:

- The Eastside Interceptor starting from P-2 and the Westside Interceptor starting from P-19;
- Three pump stations modeled as ideal pumps with limiting flow at the influent pipe: State Street, Front Street, Main Pump Station;
- Sixteen combined sewer regulators: P-2, P-3, P-4,P-5, P-6, P-7, P -8, P -9, P -10, P -11, P -13, P -14, P -15, P -16, P17 (the only regulator not configured as a leaping weir), and P -19 (note that CS0 012 was connected to CSO 011 and is now closed and is therefore not included in this list);
- Sixteen combined sewer outfalls with tide gates and tidal boundary condition (defined using the Sandy Hook, NJ, Station 8531680)

Survey data was used as the primary source for the modeled hydraulic elements, supplemented by available as-built drawings and sewer system maps. Field verifications were conducted to further resolve data gaps. Major updates made in 2017 are:

- Manhole rims based on the latest DEM data;
- Pipe sizes near Elm St on the Westside Interceptor between P-17 and P16 based on meter installation reports;
- Pump station wet well dimensions based on field investigations.

The Baseline Condition Model covers approximately 2.6 square miles of combined sewer service area and 0.7 square miles of separate sewer service area in the City. Sewersheds were delineated based on contributing areas to each overflow. The following updates were made in 2017:

- Catchment delineation was updated based on actual geographic areas;
- Catchment type (combined or separate) was updated based on input provided from the City;
- Catchment infiltration parameters (for the Modified Green-Ampt method) were updated based on the most prevalent native soil type for the study area, which is silt loam (National Resources Conservation Service (NRCS) SSURGO soils layer). These parameters were later adjusted during calibration;
- Imperviousness of each catchment was updated using the 2012 land use data published by NJDEP;
- The slope for each model catchment was updated using the average catchment area slope calculated using the 2002 NJDEP 10-Meter DEM.

Other updates include:

- Monthly evaporation factors were updated using published pan evaporation rate data in NOAA NWS TR34 (Table II) and the conversion factor to free water surface evaporation published in TR33.
- Sanitary flow was developed from metering data and distributed into upstream catchments using population data from the 2010 Census.

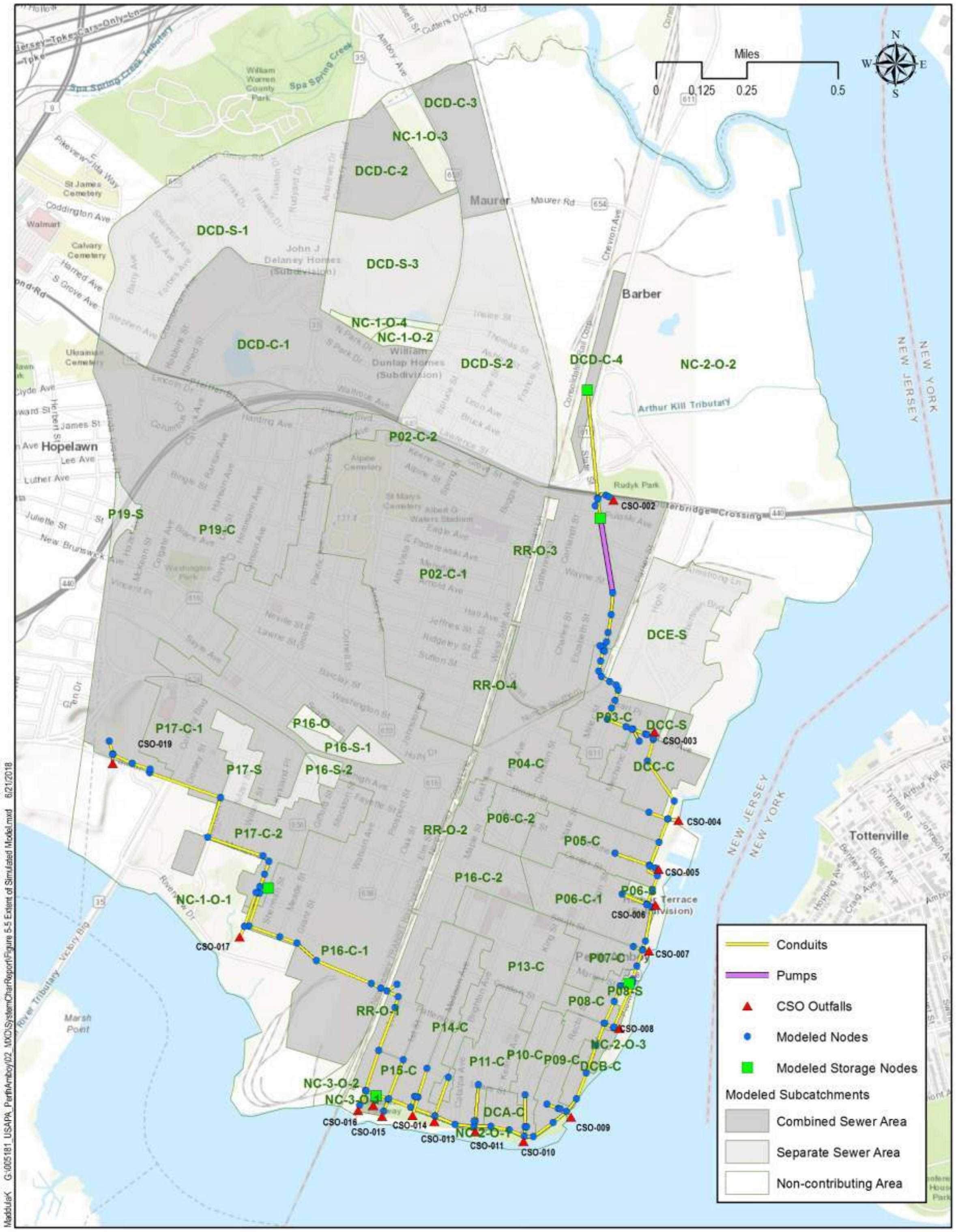

Figure 5-5 Baseline Condition Model Extent

5.3.2 Model Calibration and Validation

The hydrological processes involved in this model include precipitation, evaporation, surface runoff, and infiltration. Calibration was conducted to reproduce metered flow in dry weather as well as during wet weather. In addition to calibrating the hydrologic parameters to observed flow data, the hydraulic parameters in the Baseline Condition Model were also calibrated to depth and velocity data wherever available.

5.3.2.1 Calibration Process

As described in Section 5.2, flow data collected in 2017 was used as the primary dataset for model calibration. Meter data collected in 2007 and 2013 was used to supplement the 2017 data in model calibration and validation as appropriate. Table 5-3 identifies all 22 available meters grouped by key structures. These meters are also shown in Figure 5-2 in a schematic format. Where meters were placed at the same location in different periods, data collected from the more recent period was given more weight. Meters in CSO outfalls often yield lower quality data because of the intermittent, turbulent and rapidly changing wet weather flow conditions, and the instruments often cannot be field-calibrated, as there is typically no flow during installation. More weight was therefore assigned to surrounding sites in the interceptors and trunk sewers during calibration.

Model parameters were adjusted iteratively within reasonable bounds to obtain the best possible agreement with metered data. Model parameters that were adjusted during dry weather calibration include:

- Average baseflow values
- Average sanitary flows
- Monthly baseflow patterns
- Manning's N, minor loss factor, and pipe slope to calibrate to observed depth and velocity

During wet weather calibration, the following parameters were adjusted to best reproduce metered flow volumes and peak rates, as well as hydrograph shapes:

- Soil infiltration rates
- Percentage routed (fraction of rainfall transferred from impervious to pervious surface)
- Catchment width (hydrograph shape factor)
- Unit hydrograph (RTK) processes (used in some areas to represent prolonged post-event responses)
- Pump station capacities (set at the maximum recorded flow)
- Orifice dimensions and overflow weir elevations (to represent the leaping weir configurations).

Table 5-3 – All Available Flow Meters for Model Calibration and Validation

Location	Key Structure	Meter ID
West Side Interceptor	P19	P19_2017_72inTS
		P19_2013_OF
	P17	P17_2017_30inIntDS
		P17_2007_OF
		P17_2007_PattersonMeade
	P16	P16_2017_84inUS
		P16_2013_84inUS
		P16_2013_Capture
		P16_2007_OF
East Side Interceptor	P2	P2_2013_33inInt
		P2_2013_84inTS
		P2_2007_84inTS
		P2_2007_OF
	P5	P5_2007_BroadStInt
		P5_2007_CommerceStTS
		P5_2007_OF
	P7	P7_2013_OF
	P15	P15_2007_MadisonAveInt
		P15_2007_OF
Pump Stations	State St PS	StateStPS_2017
	Front St PS	FrontStPS_2017
	Second St PS	SecondStPS_2017

For separate sanitary sewer areas, twenty percent of the geographical area is assumed to contribute inflow/infiltration (I/I) to the downstream combined sewer system. This is a generally accepted factor used to represent the effective area of the I/I sources in the separate sewer network. Runoff data from the contributing area of some regulators is not available, such as P4, and modeled runoff from these areas was maintained from the previous model version.

5.3.2.2 Model Calibration and Validation Results

To summarize the agreement between the modeled and observed data for all monitored storms, scatter plots were produced comparing peak flow, event volume, peak depth, and peak velocity whenever data was available. These scatter plots are included in Appendix C, along with detailed explanations of noted disagreement where appropriate. Detailed hydrograph comparisons between modeled and observed data for each monitored storm are also provided in Appendix C. A general review of the calibration at the most downstream metering sites in the system is presented in this Section. These sites are generally regarded as the most important sites to characterize overall model reliability, as these sites aggregate flow from the upstream sites and therefore best reflect the overall ability of the model to simulate conditions in the full physical system.

The Westside Interceptor was the focus of the 2017 metering program. Figure 5-6 shows the modeled agreement with metered flow on the 84-inch Westside Interceptor just upstream of Regulator P16. This is the most downstream 2017 meter in the Westside Interceptor and this figure shows the model was well calibrated for the storms during spring and early summer 2017.

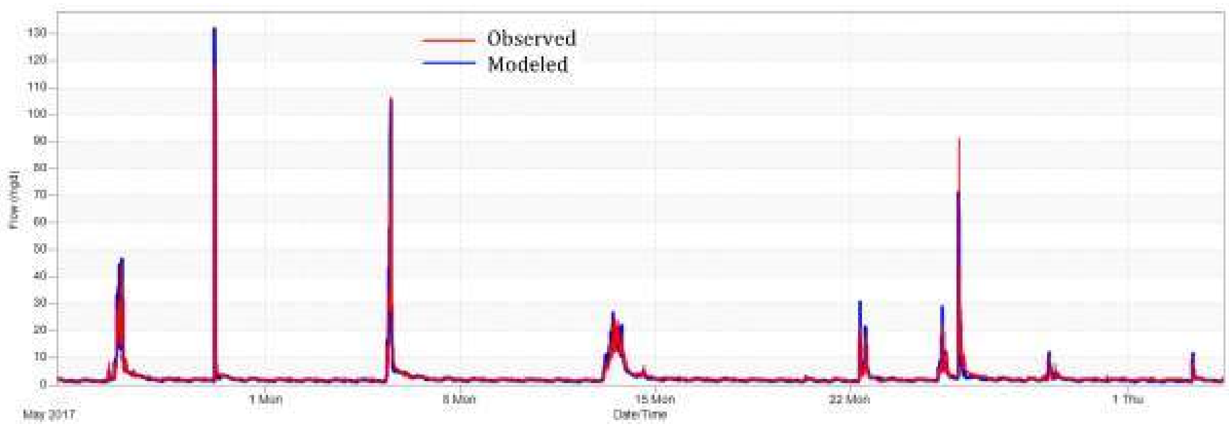

Figure 5-6 - Modeled vs. Observed Flow in the West Side Interceptor Upstream of P16

Figure 5-7 compares modeled vs. metered flow at the 2013 most downstream meter on the West Side Interceptor, P16_2013_Capture. It confirms that the model was well calibrated in the Westside Interceptor.

The most downstream meter on the Eastside Interceptor was placed in 2007 at Madison Avenue, P15_2007_MadisonAveInt. Figure 5-8 illustrates a good fit between modeled and metered flow at this downstream portion of the Eastside Interceptor.

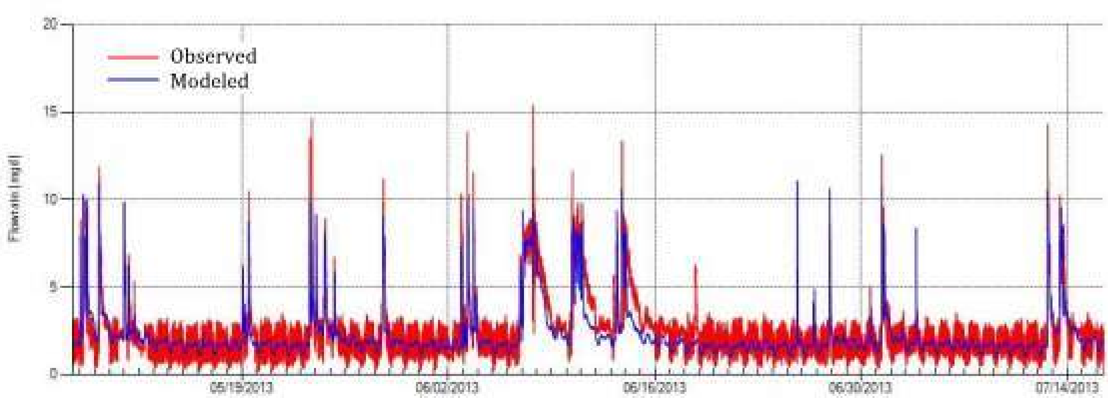

Figure 5-7 Modeled vs. Observed Flow in the West Side Interceptor Downstream of P16

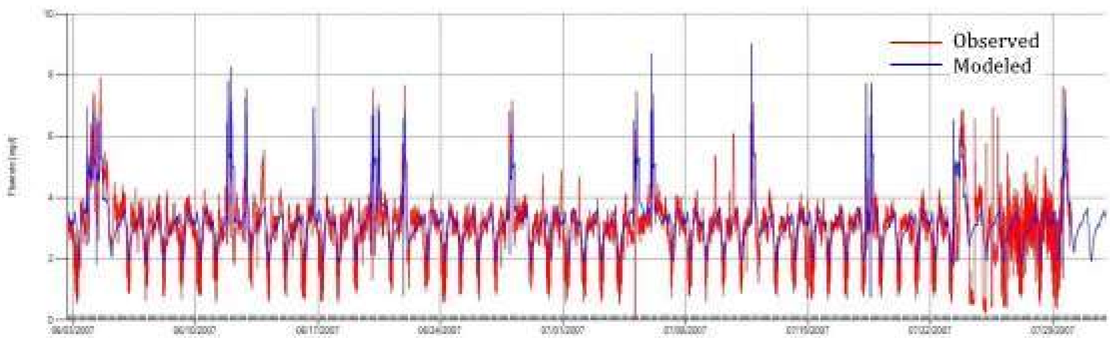

Figure 5-8 Modeled vs. Observed Flow in the East Side Interceptor Downstream of P14

The Second Street Pump Station is the most downstream point in the Perth Amboy sewer system, as well as the downstream boundary of the sewer model. **Error! Reference source not found.** shows the time series of modeled and metered flow at this location during the 2017 metering period. This figure shows the calibrated model represents the system well in terms of dry weather flow, wet weather peak flow, and hydrograph shape. Figure 5-10 includes scatter plots of peak volume and peak flow at the Second Street Pump Station, which once again demonstrate a well calibrated model. A detailed description of scatter plot as well as scatter plots for other meters can be found in Appendix C.

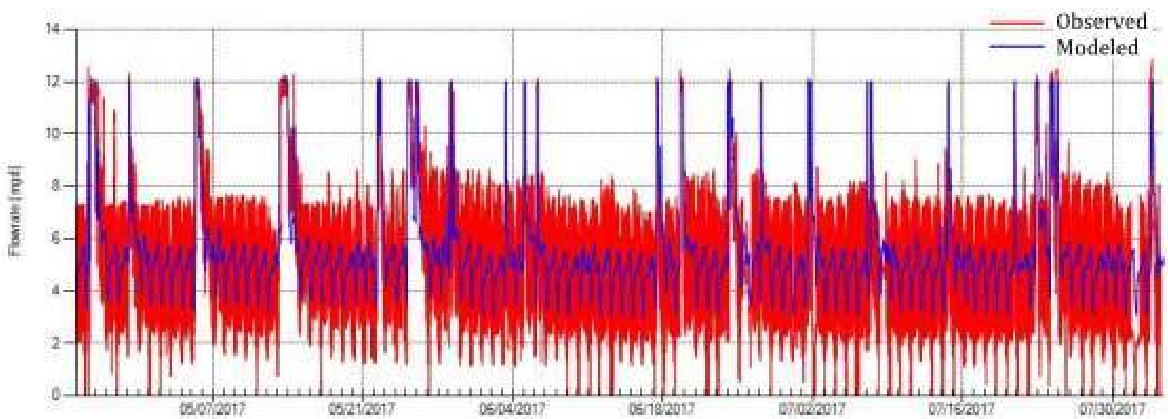

Figure 5-9 Modeled vs. Observed Flow at Second Street Pump Station Effluent

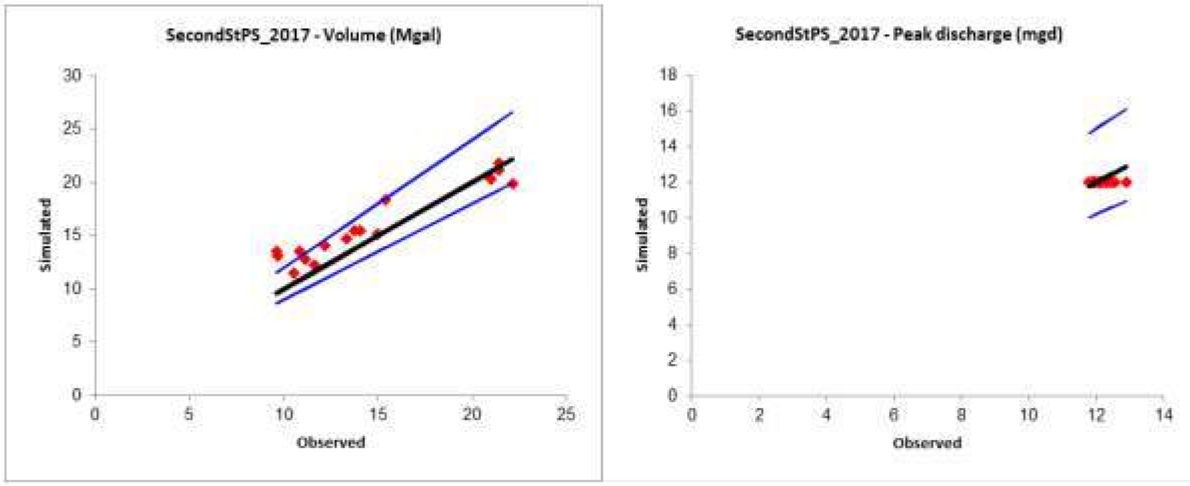

Figure 5-10 Scatter Plots of Modeled vs. Observed Volume and Peak Flow at Second Street Pump Station Effluent

5.3.2.3 Model Calibration and Validation Conclusions

Perth Amboy's calibrated and validated Baseline Condition Model well represents the dry-weather and wet-weather performance of the system. Some discrepancies between the modeled and observed data have been noted, and can be attributed to a variety of causes, including spatial variability of the monitored storms and observed data quality issues as detailed in the appendices. As the graph on the left of Figure 5-10 shows, the model has been calibrated to shift any model bias to slight over-prediction of flows, rather than under-prediction, as a means to ensure that any eventual facility sizing applications will not result in under-sized facilities.

Section 6

Receiving Waterbody Monitoring and Modeling

The City of Perth Amboy is a member of the NJ CSO Group. As the leader of the group, PVSC is conducting extensive receiving waterbody investigations on behalf of the members and in support of the October 2015 Combined Sewer Management permits issued to each member. The reader is directed to the PVSC submission, Baseline Compliance Monitoring Report, for additional information. The City of Perth Amboy is a cooperative partner in this effort.

Section 7

Rainfall Analysis and Typical Annual Hydrologic Record

There has been extensive investigation of long term hydrologic data performed by PVSC as part of their current efforts under the October 2015 Combined Sewer Management permit issued to them by NJDEP. This investigation has been conducted for the purpose of selecting a typical year precipitation record for use in their CSO LTCP development process and is documented in the Typical Hydrologic Year Report (May 2018) submitted by PVSC to NJDEP.

As noted earlier in this report, the City of Perth Amboy is a member of the NJ CSO Group. PVSC has shared with the Group their information on the typical year rainfall analysis, recognizing that individual members of the Group would likely want to coordinate on the use of a common typical year precipitation record for purposes of their individual CSO LTCPs. There is also a need for the Group to coordinate on a common typical year for generating land-side loads from CSOs and plant effluent discharges for the water quality modeling of the CSO receiving waterbodies being performed by the PVSC team on behalf of the Group.

After the extensive investigation by PVSC, their report recommends use of the calendar year 2004 as the typical hydrologic year, specifically use of the unadjusted hourly precipitation record at the Newark Airport for this annual period. Perth Amboy has reviewed the report, certified its approval of the report, and thereby accepted the selected typical year as proposed by PVSC on behalf of the NJ CSO Group members for use in the LTCP development process.

The reader is directed to PVSC *Typical Hydrologic Year Report* and the PVSC System Characterization Report, for further information about the selection of the typical year precipitation record and the supporting analysis.

Section 8

Characterization of System Performance and CSO Impacts

8.1 Characterization Approach

As described in Section 7, the 2004 calendar year precipitation record at Newark Airport was selected by the NJ CSO Group as the typical year to use in their respective LTCP studies. PVSC issued a five-minute interval rainfall record of 2004 at Newark Airport to all the NJ CSO Group members. As a member of the group, the City of Perth Amboy has used this annual record and the Baseline Condition Model to simulate the baseline performance of the system. System performance is characterized by the following metrics,

- CSO volume, frequency, and duration;
- Percentage capture of wet weather combined sewer flow, on a system-wide basis and by each outfall;
- System surcharge conditions and potential flooding (defined in this context as the simulated hydraulic grade line reaching the ground surface elevation).

8.2 Baseline Overflow Statistics

The Baseline Condition Model estimates the total overflow volume in the typical year using 2004 Newark Airport to be 386 MG. In the 2007 Characterization Report, the annual total overflow volume using the 2007 model and 1988 hourly rainfall at JFK Airport as the typical year was reported to be 368 MG Despite the differences in the two models and annual rainfall record used for the typical year (48.36 inches at EWR in 2004 v,s, 40.66 inches at JFK in 1998), the total annual overflow volumes are within the same range.

Table 8-1 lists the simulated annual CSO statistics for each CSO outfall. CSO volume, duration, and frequency were calculated using 24-hour inter event time. Among the 386 MG total CSO volume, 143 MG (37%) discharges to the Arthur Kill from P002 through P009. The remaining volume, 243 MG (63%), discharges to the Raritan River from P010 through P019.

P016 discharges over 100 MG in the typical year and is the largest CSO discharge point by volume, making up 26% of the system wide annual volume. P002 and P019 are the next two largest overflows with each discharging roughly 60 MG in the typical year. Together these three largest CSO discharge points account for about 60% of the total annual CSO volume in the system. Two of these three largest CSO discharge points are located along the Westside Interceptor and discharge to the Raritan River.

The annual overflow duration ranges from over 900 hours to about 80 hours. P003 has the longest overflow duration of 939 hours. This duration is exceptionally long and impacted by two factors. First, P003 is located on the Eastside Interceptor immediately downstream of the State

Street Pump Station. Second, the capacity of the State Street Pump Station is less than the peak flow rate from the upstream trunk sewers during most storms, which requires storage of the excess flow in the wet well and upstream trunk sewers. Stored flow is then gradually released into the downstream interceptor, which causes a prolonged period of elevated flow entering P003 regulator after each storm and long overflow durations. Figure 8-1 depicts the prolonged wet weather flow from State Street Pump Station and resulting overflow at P003.

Table 8-1 - Simulated Annual CSO Volume, Duration and Frequency

Location	Volume (MG/yr)	Duration (Hours/yr)	Frequency (Events/yr)	Peak Overflow Rate (mgd)	Percent of Total CSO	Receiving Water
P002	63.2	501	70	195.9	16%	Arthur Kill
P003	32.0	939	61	46.0	8%	Arthur Kill
P004	9.2	382	71	31.4	2%	Arthur Kill
P005	10.0	321	64	27.5	3%	Arthur Kill
P006	19.0	174	36	62.7	5%	Arthur Kill
P007	5.2	218	64	24.6	1%	Arthur Kill
P008	2.8	132	59	18.5	1%	Arthur Kill
P009	1.7	161	63	15.9	0%	Arthur Kill
P010	1.6	114	59	21.5	0%	Raritan River
P011	10.2	377	66	47.1	3%	Raritan River
P013	33.1	394	69	44.5	9%	Raritan River
P014	12.3	334	65	18.5	3%	Raritan River
P015	14.0	418	71	33.8	4%	Raritan River
P016	101.0	327	61	148.5	26%	Raritan River
P017	8.6	82	33	35.9	2%	Raritan River
P019	62.3	274	56	135.2	16%	Raritan River
System Total	386.4					
Maximum	101.0	939	71	195.9		
Minimum	1.6	82	33	15.9		
Average	24.1	321	61	56.7		
Median	11.3	324	64	34.9		

Outfall-specific overflow frequency ranges from 71 to 33 events for the typical year with a system-wide average of 61 events per year. Peak overflow rate is the largest flow rate that discharges from an outfall during the typical year. It ranges from 16 mgd (P009) to 196 mgd (P002). P016 and P019 also have very high peak overflow rates of over 100 mgd. The outfalls that have high annual CSO volumes also have high peak overflow rates.

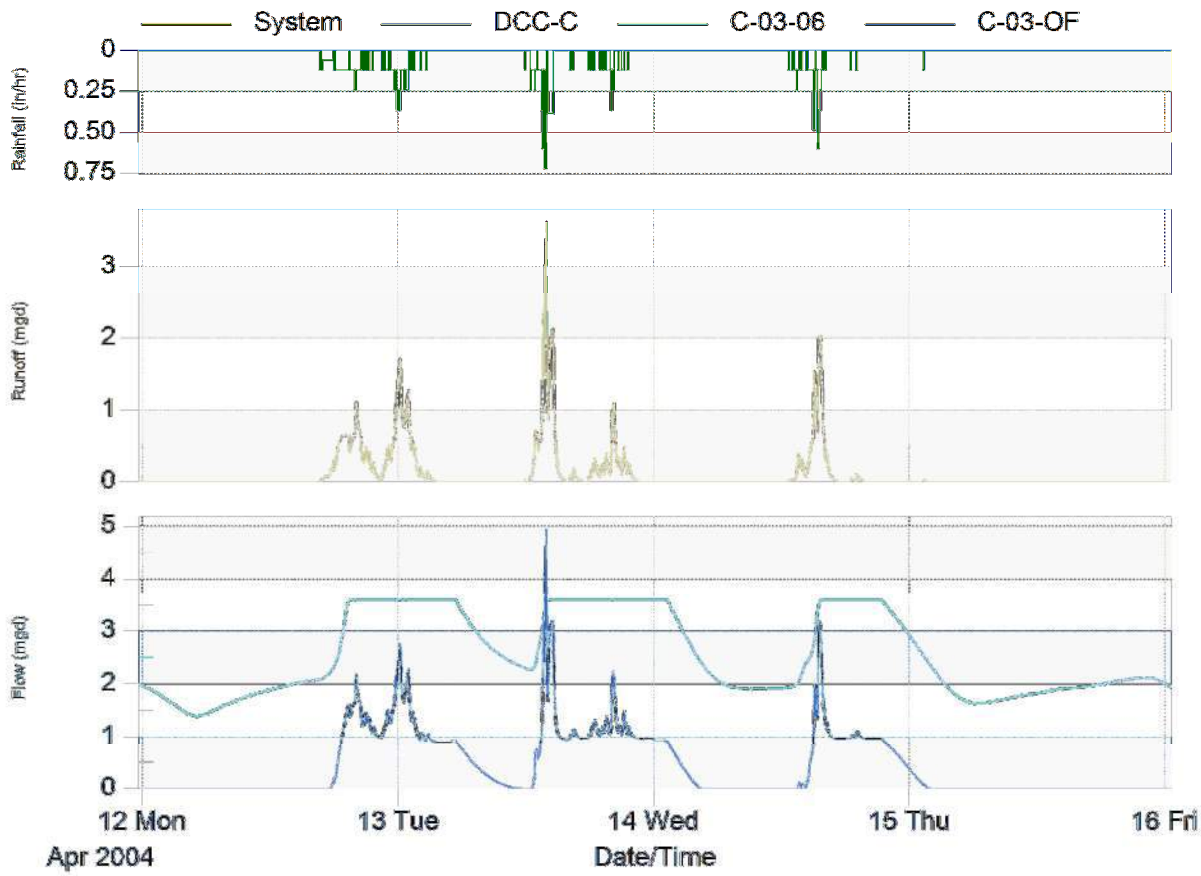

Figure 8-1 Eastside Interceptor Flow Entering P003 Regulator (light blue line) and Overflow (dark blue line)

8.3 Baseline Percentage Capture

Percentage capture is used in the U.S.EPA CSO Control Policy as one means to establish targets for CSO control in the LTCP. This metric is therefore useful for both the characterization of baseline performance and for the forthcoming evaluation of CSO control alternatives. Under the Policy's Presumption Approach, one control option is "the elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS (combined sewer system) during precipitation events on a system-wide annual average basis…" [59 FR 18962 section II-C4(a)(ii)].

Percentage capture is a more complex metric than CSO volume and frequency. This is the fraction (as a percentage) of wet weather flow in the combined sewer system that is captured for treatment. On an individual CSO outfall basis, captured flow is the wet weather flow that passes through the underflow pipe from the combined trunk sewer to the interceptor sewer. On a system wide basis, captured flow is the wet weather flow that passes through the headworks of the treatment plant or in Perth Amboy's case, it is the discharge of the Second Street Pump Station. Of all the wet weather flow that enters the sewer system, the portion that is not captured includes overflows to area waterways at the CSO outfalls or to the surface as combined sewer system flooding.

To calculate percentage capture, first the wet weather period needs to be defined. In this case, simulated total flow entering the sewer system is compared to the dry weather flow rate (base groundwater flow and sanitary diurnal flow) for every time step. When the former is more than 10% greater than the latter, this time step is flagged as a wet weather time step. Wet weather time steps are flagged for the entire typical year. Simulated total wet weather flow (total system wet weather inflow) that entered the modeled sewer network is then summed for all the wet weather time steps. Finally, the system wide percentage capture is calculated using the following formula for fraction captured (which can be converted to a percentage):

$$Percentage\ Capture = 1 - \frac{(Total\ CSO\ Volume + Total\ Flooding\ Volume)}{(Total\ System\ Wet\ Weather\ Inflow)}$$

The system wide capture for Perth Amboy is 63%. The percentage capture by overflow for the typical year is listed in Table 8-2. It should be noted that the percentage capture calculation cannot be applied to outfalls that are located directly on the interceptor, as opposed to those on a trunk sewer, as there is no specific sewershed that can be associated with interceptor outfalls. This applies to P003, P017, and P016, and these three outfalls have therefore been omitted from the table.

Table 8-2 - Percentage Capture by Overflow

Overflow	Percentage Capture	Rank in Descending Order
PP002	42%	8
P004	65%	4
P005	24%	10
P006	33%	9
P007	45%	5
P008	44%	6
P009	70%	2
P010	68%	3
P011	44%	7
P013	-6%	12
P014	-15%	13
P015	9%	11
P019	73%	1

Except P004 and P019, all other eleven of the thirteen outfalls in the above table experience back flow in the underflow pipe which is the connection between the regulator and the interceptor. This means that most of the CSOs serve as a hydraulic relief for the interceptor flow. With the lowest overflow elevations on the Eastside Interceptor downstream of Front St PS, P013 and

P014 are the most extreme cases where the amount of flow diverted into the interceptor is far less than the flow "pushed back" from the interceptor. Therefore the percent capture values at these two outfalls are less than 0, which means the overflow volume during the typical year exceeds the wet weather flow generated from the respective sewershed.

For the overflows with positive percent capture, P019 has the highest percent capture (73%) while P015 has the lowest capture (9%). P009, P010, and P004 all have more than 65% capture. P005 and P006 have less than 35% capture, as these outfalls have the lowest overflow elevations between the State Street and Front Street Pump Stations and therefore provide relief for this section of the Eastside Interceptor during wet weather.

8.4 Baseline System Capacity

The 20 largest rainfall events were reported by PVSC in the Typical Hydrologic Year Report. It is reproduced here as Table 8-3. The September 17, 2004 event had the highest hourly intensity and as expected produces the highest wet weather response in the combined sewer system in Perth Amboy (see Figure 8-2). However, when examining surcharge in different parts of the system, it was found that peak surcharge during the typical year does not necessarily occur in some locations during this event.

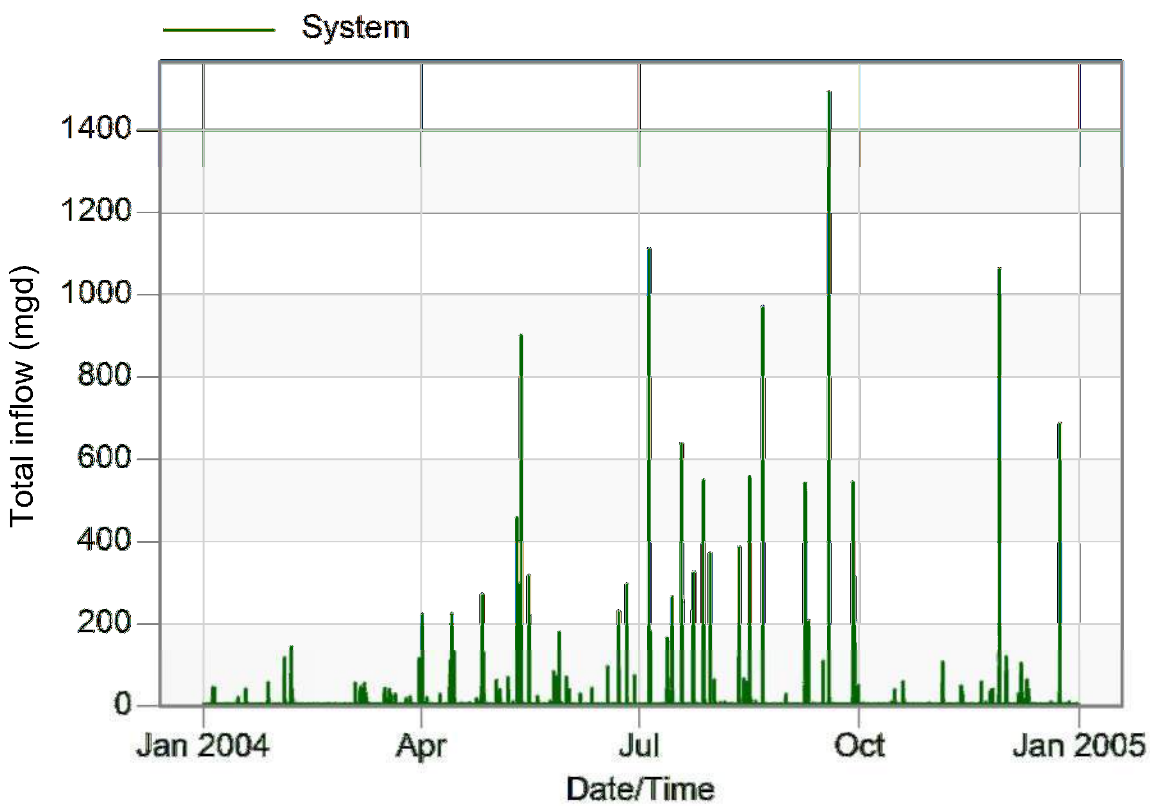

Figure 8-2 Simulated Total System Inflow During the 2004 Typical Year

Table 8-3 - Largest 20 Rainfall Events by Depth in 2004

Rank	Event Start	Duration (hr)	Total Depth (in)	Max Intensity (in/hr)	Average Intensity (in/hr)	Average Return Interval
1	9/28/2004 1:00	28	3.68	0.53	0.13	2-yr
2	9/8/2004 4:00	25	2.21	0.63	0.09	1-yr
3	7/12/2004 9:00	27	1.99	0.32	0.07	
4	4/12/2004 17:00	30	1.67	0.25	0.06	
5	4/25/2004 14:00	35	1.67	0.25	0.05	
6	7/23/2004 10:00	24	1.66	0.33	0.07	
7	2/6/2004 5:00	33	1.63	0.33	0.05	
8	7/18/2004 16:00	14	1.6	0.64	0.11	
9	11/28/2004 2:00	12	1.5	0.85	0.13	
10	7/27/2004 15:00	18	1.45	0.41	0.08	
11	9/17/2004 22:00	12	1.44	1.25	0.12	1-yr
12	6/25/2004 17:00	5	1.39	0.4	0.28	
13	11/12/2004 7:00	23	1.08	0.1	0.05	
14	5/12/2004 16:00	2	1.08	0.99	0.54	
15	11/4/2004 14:00	16	1.03	0.2	0.06	
16	7/5/2004 3:00	12	1	0.69	0.08	
17	12/1/2004 4:00	10	1	0.18	0.1	
18	8/16/2004 0:00	21	0.94	0.6	0.04	
19	8/21/2004 14:00	3	0.84	0.81	0.28	
20	12/6/2004 12:00	39	0.83	0.2	0.02	

Source: Table 2-6 of PVSC *Typical Hydrological Year Report*, May, 2018

Simulated peak HGL along the Westside and Eastside Interceptors are shown in Figure 8-3 through Figure 8-6. Despite two regulators providing direct relief for the Westside Interceptor, capacity limitations still cause simulated flooding of the interceptor during the peak of the September 17, 2004 storm. Where ground elevations are relatively low, simulated flooding occurs (red dots in the profile).

On the Eastside Interceptor, it is evident that the performance of the interceptor segments immediately upstream of the Pump Stations, i.e. State St and Front St, are significantly impacted by the pump station capacity limits. However, the interceptor sections immediately downstream of the pump stations have ample capacity, even during the peak of the largest storms. This suggests that increasing pump station capacities along the Eastside Interceptor, as well as at Second Street Pump Station, would reduce or eliminate surcharge conditions along these parts of the system during the typical year. This will be evaluated further in the forthcoming development and evaluation of CSO control alternatives.

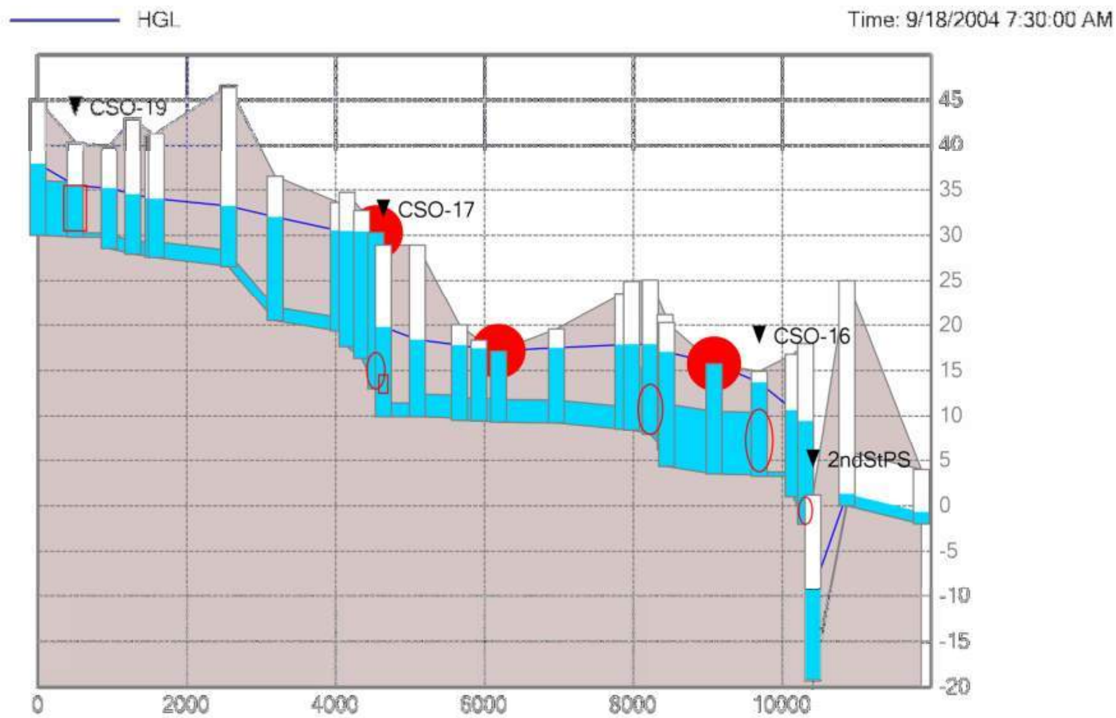

Figure 8-3 Peak HGL in Westside Interceptor During Sept 17, 2004 Event

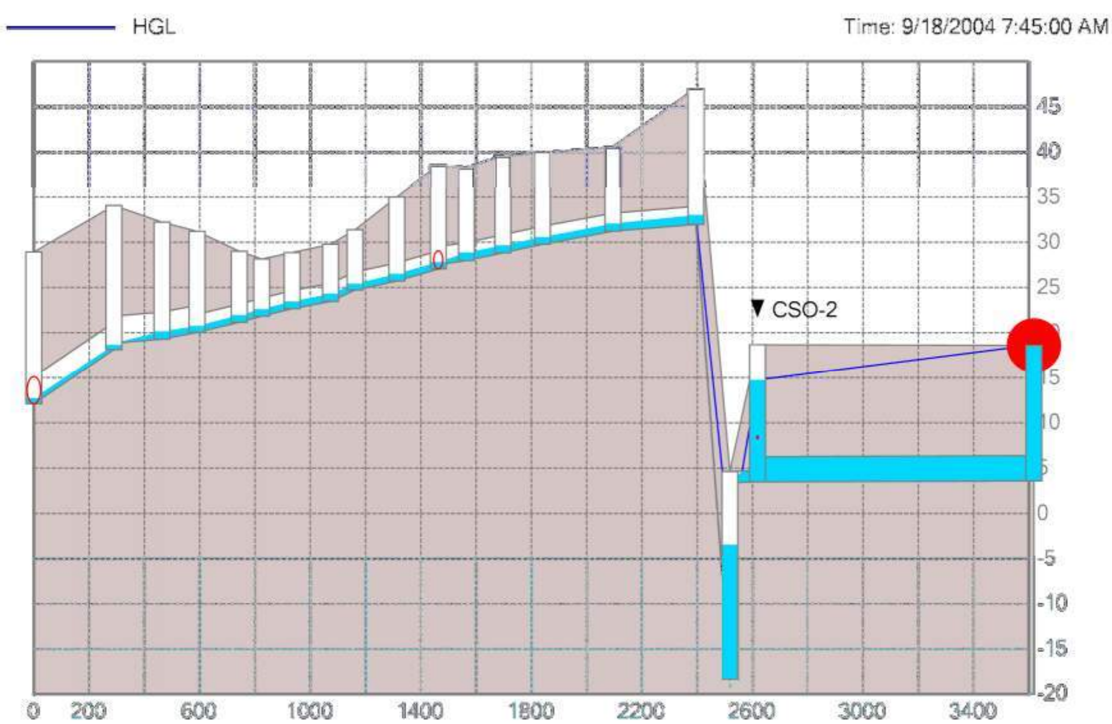

Figure 8-4 Peak HGL in Eastside Interceptor P002 to P003 During Sept 17, 2004 Event

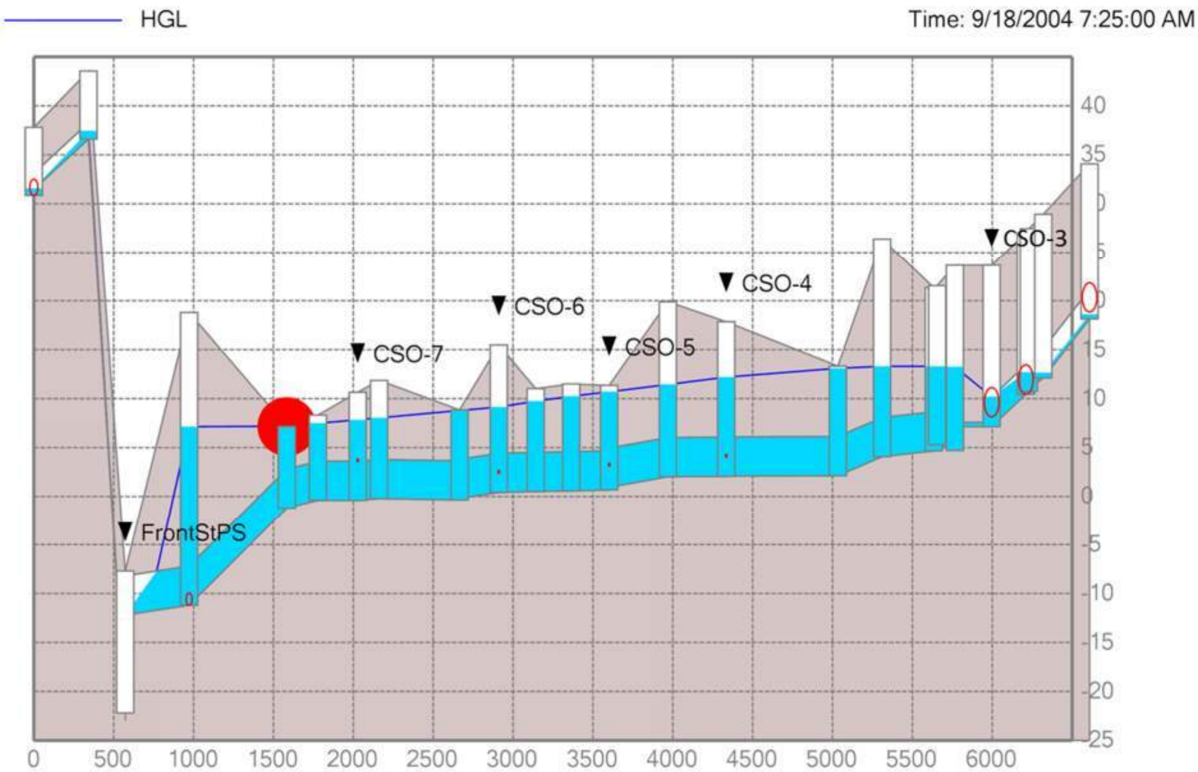

Figure 8-5 Peak HGL in Eastside Interceptor P003 to Front St PS During Sept 17, 2004 Event

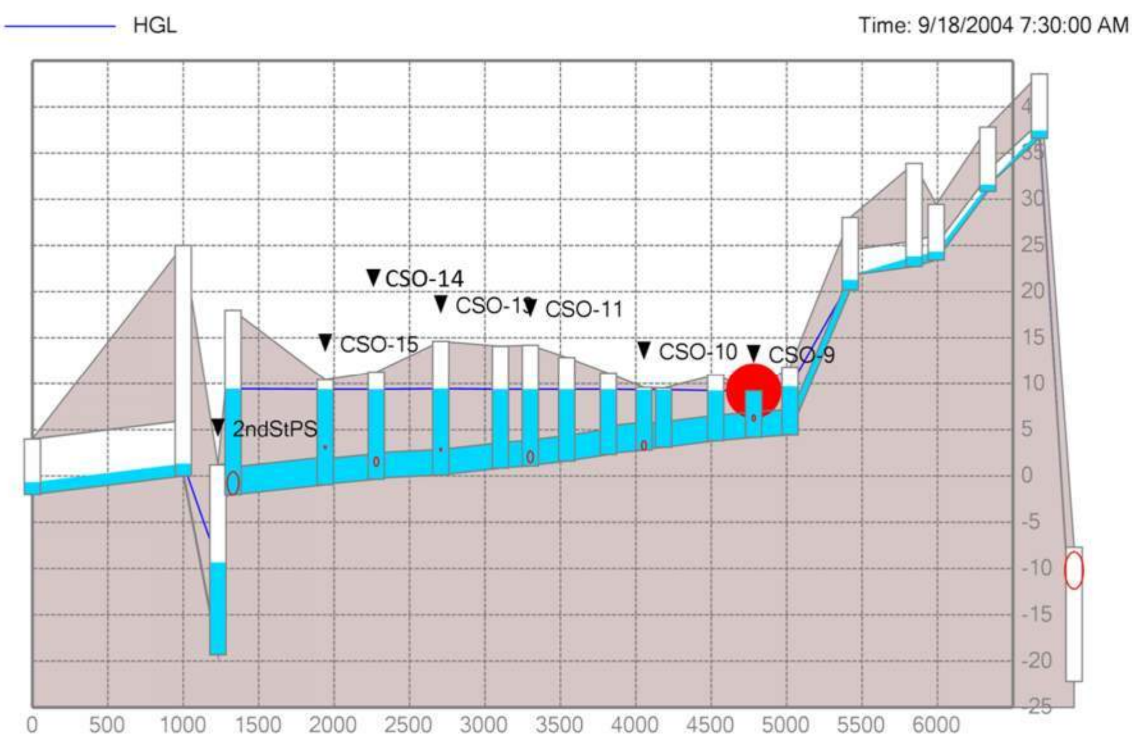

Figure 8-6 Peak HGL in Eastside Interceptor Front St PS to Second St PS During Sept 17, 2004 Event

Other than simulated flooding shown in the above profiles, there is also simulated flooding in other parts of the system (see red symbols in Figure 8-7). The total simulated annual flooding volume in the Perth Amboy combined sewer system during the typical year is 3.6 MG, less than 1% of the simulated annual total CSO volume. This is the total volume of flow that discharges from the sewer system at a flooded node in the model, i.e. discharge to the surface due to system surcharge reaching the manhole rim elevation.

When reviewing these flooding estimates it should be recognized that because the model only includes a relatively small sub-set of the combined sewer pipes, and does not model the smaller upstream pipes and catch basins, modeled flooding is not a comprehensive estimate of current flooding conditions in the combined sewer system. Among the simulated flooding locations shown in Figure 8-7, two are the most upstream modeled nodes where multiple modeled subcatchments are loaded to the modeled pipe network. As a result relatively high flows are loaded instantaneously into the modeled pipe network at these locations (rather than being routed through the upstream smaller sewer pipes over time). Since simulated flooding at these locations is caused by the model resolution in the pipe network, and no observed flooding during wet weather was reported, the simulate flooding is considered to be a modeling anomaly and is therefore ignored at these three locations.

Although simulated flooding occurs at the above locations for short durations at the peak of intense storms in the typical year, the City reports no evidence of flooding in recent history. Therefore, the model can be considered conservative, in that it appears to somewhat over-predict the peak hydraulic grade line elevations at these locations. These results are also useful, as we can interpret the locations with simulated flooding to identify those sections of the system that have the highest potential risk of flooding. The City will evaluate these locations more critically to further mitigate the potential risk of flooding as part of the analysis of alternatives phase of the LTCP.

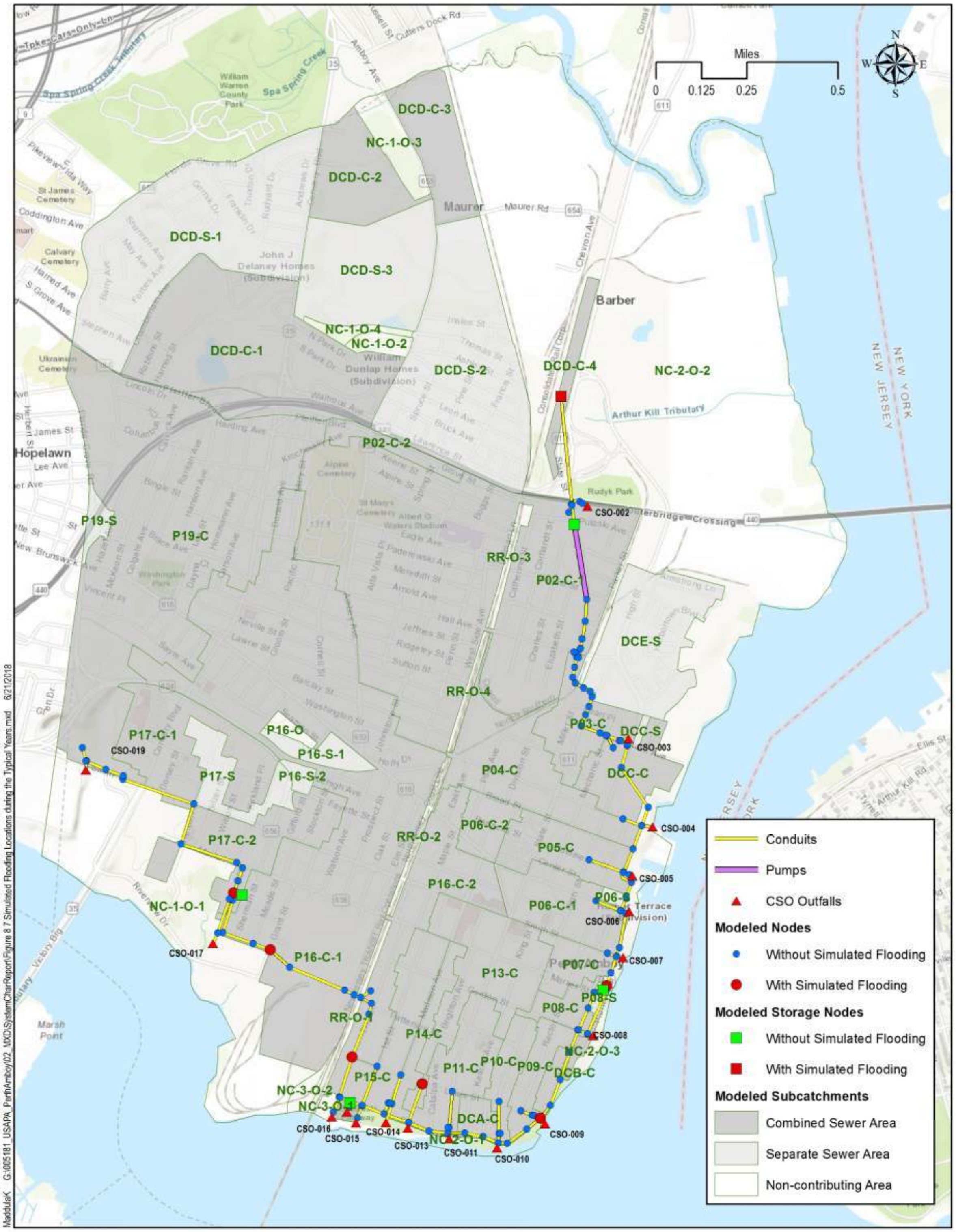

Figure 8-7 Simulated Flooding Locations during the Typical Year

8.5 Characterization of Impacts

The Perth Amboy system performance characterization modeling effort has resulted in the following conclusions:

- System wide annual volume at the CSO outfalls during the typical year is 386 MG, flooding volume is 3.6 MG and system-wide percent capture is 63%.
- Several outfalls stand out as having a significant impact on overall system performance: 58% of the total CSO volume discharged at the outfalls during the typical year occurs at three locations. P016 contributes the largest annual CSO volume (101 MG, or 26% of the system total). P002 and P019 together contribute 32% of the total system CSO volume.
- Pump station capacity limitations have a significant impact on system performance, and CSO volumes could potentially be reduced with expanded pumping capacity. This will be evaluated further during the forthcoming development and evaluation of CSO control alternatives.
- As result of capacity limitations in both the interceptors and pumping stations, reverse flows occur during wet weather in many of the underflow pipes connecting the interceptor sewers and combined trunk sewers. When this occurs, flow in the interceptor sewer is directed back to the regulator and discharged at the outfall. At two locations, that net negative percent capture was found during the typical year, meaning surcharge in the system limited the periods when the leaping weirs were functioning as intended for the tributary sewersheds. In addition to the potential pumping improvements noted above, the potential to use real-time controls may be evaluated as a means to reduce CSO volumes caused by these flow reversals.
- The model predicts minimal interceptor and trunk sewer flooding during the typical year, and it represents only about 1% of the total flow volume lost from the modeled combined sewer system. The other 99% is discharged at the CSO outfalls. The approaches to system performance improvement noted above could potentially reduce or eliminate the simulated interceptor flooding.

As part of the forthcoming development of the LTCP, the Baseline Condition Model will be used to evaluate the potential system performance improvements noted above, along with a variety of other CSO control approaches.

Section 9

Institutional Context

9.1 Roles and Responsibilities

9.1.1 Ownership and Control of the Combined Sewer System

The City of Perth Amboy owns the combined sewer system, and all associated gravity sewers, interceptors, pumping stations and force mains. The City entered into a contract for the operation and maintenance of the combined sewer system with United Service Affiliates – Perth Amboy (USA-PA), a joint venture of Middlesex Water Company (MWCo) and Joseph Jingoli & Son, Inc. (JJS). The term of this agreement will expire in late 2018. Accordingly, the City is currently soliciting proposals related to their intent to enter into a subsequent 10-year contract for the operation and management of the City's combined sewer system.

9.1.2 Operation and Maintenance

The City's system is operated and maintained in compliance with the NJPDES Permit (NJ0156132). Contained within the permit, under Combined Sewer Management - Section F, are detailed requirements related to the Nine Minimum Controls that collectively address minimum best management practices related to the combined sewer system. Key permit requirements in the context of collection system operation and maintenance include:

- The implementation and annual update of an O&M Program as documented through its O&M manual;
- Visual inspections to provide reasonable assurance that unpermitted discharges, obstructions, damage and dry weather overflows are detected;
- Provisions for a gravity sewer and catch basin inspection and cleaning schedule;
- Provisions for a system for tracking and documenting residential complaints concerning blockages, basement and street flooding, etc.;
- Timely removal of obstructions or blockages contributing to overflows due to debris, fats, oils and grease, and sediment buildups; and to
- Minimize the introduction of sediment and obstructions into the collection system.

Additional details are contained within the City's Operation and Maintenance Manual such as Standard Operating Procedures, Preventive Maintenance, and Emergency Response Program.

The operation and maintenance of the City's combined sewer system is governed by the Perth Amboy Sewerage Department Operation and Maintenance Manual, most recently revised December 2015.

9.2 Financial and Legal Controls

The City's combined sewer systems are owned pursuant to Title 40A of New Jersey Statutes (Municipalities and Counties)(N.J.S.40A:26A-1 et seq. Municipal and County Sewerage Act.. New Jersey municipalities are authorized and empowered to:

- "…acquire, construct, improve, extend, enlarge or reconstruct and finance sewerage facilities and to operate, manage and control all or part of these facilities and all properties relating thereto…"
- "To issue bonds of the local unit or units to pall all or part of the costs of the purchase, construction, improvement, extension, enlargement or reconstruction of sewerage facilities";
- "To make and enter into all contracts and agreements necessary or incidental to the performance…";
- "To fix and collect rates, fees, rents and other charges…"
- "To prevent toxic pollutants from entering the sewerage system.";
- "To exercise any other powers necessary or incidental to the effectuation of the general purpose of N.J.S.40A:26A-1 et seq."

The financial management of the cities' combined sewer systems are regulated under Chapter 4 of Title 40A. Municipalities are required to establish public utility funds to isolate sewer system costs and revenues from the municipal general funds:

> "All moneys derived from the operation of publicly owned or operated utility or enterprise and any other moneys applicable to its support, shall be segregated by the local unit and kept in a separate fund which shall be known as "utility fund" and shall bear a further designation identifying the utility or enterprise and, except as provided in section 40A:4-35, shall be applied only to the payment of the operating and upkeep costs, and the interest and debt redemption charges upon the indebtedness incurred for the creation of such utility or enterprise."

The annual budgets for municipal sewerage systems are controlled through the Local Budget Law, codified at N.J.A.40A:4-1 et seq. Annual operating, debt service, revenue and five-year capital improvement budgets are developed using forms and excel templates specified by the New Jersey Department of Community Affairs. The draft budgets are reviewed and approved by the Department prior to final adaption of the budget by the municipalities prior to the start of the fiscal year.

Section 10

Conclusions

The following conclusions are evident based on the analysis documented within this System Characterization Report.

1. The Land Use Analysis shows the great majority of the use within the City is commercial/industrial and residential. This analysis updated the 2007 CSO study to include the most recent available data, which showed relatively little change in the land use or imperviousness of the combined sewer area.

2. Preliminary results of the BCMR indicate the following:

   a. The larger waterbodies (including the Arthur Kill) appear to meet existing water quality criteria.

   b. The Raritan River may have attainment issues related to pathogen standards for its designation.

3. The CSO model has been calibrated and validated against past and current monitoring data to properly represent the dry-weather and wet-weather performance of the Perth Amboy combined sewer system. The model has been calibrated to shift any model bias to slight over-prediction of flows, rather than under-prediction, as a means to ensure that any eventual facility sizing applications will not result in under-sized facilities.

4. The City utilizes 2004 as the typical year precipitation record for system characterization purposes. This is consistent with the NJCSO Group choice.

5. System wide percent capture is 63%. Capture is limited by the interceptor sewer system (including the pump stations within the system), and at eleven outfalls there is back flow up through the leaping weir during the typical year simulations. This means that most of the CSOs in the system effectively serve as a hydraulic relief for the interceptor flow that cannot be pumped or conveyed by gravity in the interceptors.

6. Several outfalls stand out as having a significant impact on overall system performance: 58% of the total CSO volume discharged at the outfalls during the typical year occurs at three locations. P016 contributes the largest annual CSO volume (101 MG, or 26% of the system total). P002 and P019 together contribute 32% of the total system CSO volume.

7. As noted above, pump station capacity limitations have a significant impact on system performance, and CSO volumes could potentially be reduced with expanded pumping capacity. This will be evaluated further during the forthcoming development and evaluation of CSO control alternatives.

8. The model predicts minimal interceptor and trunk sewer flooding during the typical year, and it represents only about 1% of the total volume lost from the modeled combined sewer system. The other 99% is discharged at the CSO outfalls. The approaches to system performance improvement noted above could potentially reduce or eliminate the simulated interceptor flooding.

Appendix A

System Characterization Work Plan

State of New Jersey

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Mail Code – 401-02B
Division of Water Quality
Bureau of Surface Water Permitting
P.O. Box 420 – 401 E State St
Trenton, NJ 08625-0420
Phone: (609) 292-4860 / Fax: (609) 984-7938

BOB MARTIN
Commissioner

November 10, 2016

Luis A. Perez Jimenez, Superintendent
Utility Service Affiliates (Perth Amboy) Inc.
590 Smith Street
Perth Amboy, NJ 08861

Re: Approval of Sewer System Characterization Work Plan
New Jersey Pollutant Discharge Elimination System (NJPDES)
Combined Sewer Overflow (CSO) Permit, NJPDES Permit No. NJ0156132

Dear Mr. Perez Jimenez:

This letter is written to acknowledge receipt of and provide a determination on your revised submission dated November 2016 "Combined Sewer System Rain Gauge & Flow Metering QAPP" as submitted on November 9, 2016. This submission is an amended version of the QAPP dated August 2016 and is an Appendix of the Work Plan, entitled "System Characterization Work Plan" dated December 2015 (as revised May 18, 2016 and August 29, 2016). The Department previously provided technical comments on these submissions in letters dated March 18, 2016, July 14, 2016 and October 3, 2016, respectively.

Based on a review of the work plan and Flow Metering QAPP, the Department has determined that all technical comments have been addressed to the Department's satisfaction for the purposes of the work plan process and that the necessary work plan elements have been addressed as per CSM Part IV.G.1. . The Department is conditioning this approval on quarterly status updates throughout the development of the System Characterization Report (due July 1, 2018) through scheduled meetings or conference calls during each calendar quarter beginning with the quarter that begins with January 1, 2016. The scheduling of quarterly status update calls can be directed to Dwayne Kobesky of this bureau at Dwayne.kobesky@dep.nj.gov. Note that these quarterly status updates are in addition to the written quarterly progress reports required by CSM Part IV.D.4 of the Permit.

Given that this amended QAPP is approved, you may proceed with implementation. The Department has attached the signature page with signatures from the Bureau of Surface Water Permitting and the Office of Quality Assurance.

Thank you for your continued cooperation. Feel free to contact me at (609) 292-4860 if you have any questions regarding this letter.

Sincerely,

Susan Rosenwinkel

Susan Rosenwinkel
Section Chief
Bureau of Surface Water Permitting

C: Kevin Aiello, MCUA
Joseph Mannick, Bureau of Surface Water Permitting
Dwayne Kobesky, Bureau of Surface Water Permitting
Marzooq Alebus, Bureau of Surface Water Permitting
Marc Ferko, Office of Quality Assurance
Corey Anen, Bureau of Nonpoint Pollution Control

Attachment
QAPP signature page

SYSTEM CHARACTERIZATION WORK PLAN

CSO Permit Compliance

City of Perth Amboy

Middlesex County, New Jersey

NJPDES Permit No. NJ0156132

Original Submission: December 2015

Revised Submission No. 1: May 2016

Revised Submission No. 2: August 2016

CDM Smith

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Section 1

Introduction

1.1 Work Plan Introduction

This document serves as the System Characterization Work Plan for the City of Perth Amboy and the portion of the hydraulically connected system that is owned / operated by the Middlesex County Utilities Authority (MCUA) that services the City of Perth Amboy. The MCUA has indicated to the City and the Department that it will work cooperatively with the City in providing information the City may require regarding the MCUA's owned and operated facilities to complete the City's Long Term Control Plan. This Work Plan has been developed to define the City's approach to compliance with Part IV Section G.1 "Characterization Monitoring and Modeling of the Combined Sewer System" of the City of Perth Amboy's New Jersey Pollutant Discharge Elimination System (NJPDES) Permit Number NJ0156132. Table 1-1 summarizes the System Characterization Report elements that will address the requirements set forth in the City's Permit along with the anticipated section number. Anticipated data sources have been identified which include previous characterizations of the City's sewer system, data collected and analyzed in accordance with past permits, and work completed by CDM Smith, the City's consulting engineer for the development of previously required permit documents. The dates of the reports referenced in Table 1-1 were submitted between 2004 and 2015. Sections 2 thru 7 of this Work Plan further describe the elements that will be included in the System Characterization Report. This Work Plan identifies system characterization elements that have been developed to date and those that will be completed in preparing the System Characterization Report.

The system characterization will focus on the sewer system within the City of Perth Amboy (see Figure 1-1). All flow from this system is pumped to the Woodbridge Township's Keasbey Interceptor which ultimately gets pumped to the Middlesex County Utilities Authority's Edward J. Patten Water Reclamation Center for treatment. The capacity of the pumping facilities to deliver flow to the plant has been determined and will be accounted for in developing the system characterization for the City of Perth Amboy. The City has sent a letter to Woodbridge Township indicating that information will be requested from them relative to as-built conditions of the Keasbey Interceptor in order to consider conveying additional flow to the MCUA Water Reclamation Center as part of the LTCP. The City will share the System Characterization Report and information developed in preparing the report with MCUA and Woodbridge Township. Once the baseline condition is established for the City's sewer system, the City will coordinate with MCUA and Woodbridge Township in developing the City's Long Term Control Plan as required by the City's permit.

This Work Plan revision includes the *Combined Sewer System Rain Gauge and Flow Metering QAPP* (CDM Smith, August 2016) located in Appendix A. In accordance with direction received from the NJDEP, the City of Perth Amboy plans to complete flow monitoring prior to performing calibration and validation on the current hydrologic and hydraulic model and in advance of finalizing the System Characterization Report.

Table 1-1 - Review of Major Elements of the System Characterization Report

Permit Section	Permit Requirement	System Characterization Report Section	Anticipated Data Sources
Part IV G.1.b	"The characterization shall include a thorough review of the entire collection system that conveys flows to the treatment works including areas of sewage overflows, including to basements, streets and other public and private areas, to adequately address the response of the CSS to various precipitation events"	Section 2	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 ▪ Service Area Drainage and Land Use Report, prepared by CDM Smith, dated May 2004 ▪ System Inventory and Assessment Report, prepared by CDM Smith, dated May 2004 ▪ The City of Perth Amboy Combined Sewerage System Engineering Assessment, Prepared for Utility Service Affiliates Perth Amboy, dated August 30, 2010 ▪ GIS data bases provided by the City of Perth Amboy, as submitted for the January 1, 2016 Permit Deadline ▪ System improvement data provided by the City of Perth Amboy , as retained onsite in spreadsheet form for the January 1, 2016 Permit Deadline and to be submitted/retained in map form for the July 1, 2016 Permit Deadline ▪ System improvement/modification data and identified sewage overflow/flooding data provided by the City of Perth Amboy, as retained onsite in spreadsheet form for the January 1, 2016 Permit Deadline and to be submitted/retained in map form for the July 1, 2016 Permit Deadline
	"The characterization shall identify the number, location, frequency and characteristics of CSOs"	Section 7	▪ Analysis utilizing updated hydrologic and hydraulic (H&H) modeling.
	"The characterization shall identify water quality impacts that result from CSOs"	Section 5	▪ Verification that land use and significant indirect user characteristics have not materially changed since the model was last updated
Part IV G.1.d.i	Rainfall Records Analysis	Section 3	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007

Permit Section	Permit Requirement	System Characterization Report Section	Anticipated Data Sources
Part IV G.1.d.ii	Combined Sewer System Characterization	Section 2	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 ▪ Service Area Drainage and Land Use Report, prepared by CDM Smith, dated May 2004 ▪ System Inventory and Assessment Report, prepared by CDM Smith, dated May 2004 ▪ The City of Perth Amboy Combined Sewerage System Engineering Assessment, Prepared for Utility Service Affiliates Perth Amboy, dated August 30, 2010 ▪ Sewer system records, filed inspections data provided by the City of Perth Amboy ▪ GIS and other system inventory data bases provided by the City of Perth Amboy
Part IV G.1.d.iii	CSO Monitoring	Section 4	▪ Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007 ▪ Monitoring Program Proposal and Work Plan, prepared by CDM Smith, dated September 2006. ▪ Flow Monitoring Pilot Study Report, prepared by CDM Smith, dated January 2014 ▪ CSO Activity Report for Calendar Year 2014, prepared by CDM Smith, dated February 2015
Part IV G.1.d.v	Sensitive Areas	Section 6	▪ Natural Heritage Priority Site – NJ Department of Environmental Protection (NJDEP), office of Natural Lands Management (ONLM), Publication Date: 3/1/2007 ▪ Head of Tide - New Jersey Department of Environmental Protection (NJDEP), Office of Environmental Analysis (OEA), Coast survey Limited (CTD), Publication Date: 1986 ▪ Parks and Recreation – New Jersey Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS); State of New Jersey Composite of Parcels Data and MAOD-IV Tax List ▪ Additional research necessary to ascertain the presence or absence of locations in the sensitive area categories ▪ Other local sources
Part IV G.9	Status of Receiving Water	Section 7	▪ Coordination with data from PVSC

1.2 Report Summaries

Several reports will be used as references for the System Characterization Report. Copies of these reports have been included in Appendix A and summaries of the reports are as follows:

Service Area Drainage and Land Use Report (SADLUR), prepared by CDM Smith, dated May 2004

- The report was submitted in partial fulfillment of the Administrative Consent Order (ACO). The ACO required that the SADLUR provide background information necessary to support and verify the selection of monitoring points and parameters necessary for the SWMM model. The report included data related to the Perth Amboy drainage area, including combined/separate sewer areas, size, population, climate, soils, land use, impervious area, and pollutant loadings. The report also included sewer line data related to the interceptor, CSO diversion structures, tide gates, and pumping stations.

System Inventory and Assessment Report (SIAR), prepared by CDM Smith, dated May 2004

- The report was submitted in partial fulfillment of the Administrative Consent Order (ACO). The ACO required the SIAR as part of the Combined Sewerage Overflow Discharge Characterization Study requirement. The report included information related to the inventory of the system, including drainage areas, the interceptor sewer, and combined sewer overflow sections. The report also included an assessment of the sewer system including the interceptor, CSOs, pumping stations, hydraulic characteristics, and CSO and sewer collection system maintenance.

Monitoring Program Proposal and Work Plan (MPPWP), prepared by CDM Smith, dated September 2006.

- The report was submitted in partial fulfillment of the NJ General Permit for Combined Sewer Systems, NJPDES No. NJ0105023. The purpose of the MPPWP was to obtain NJDEP approval of the proposed monitoring and modeling procedures and techniques to be used in the preparation of the Combined Sewage Overflow Discharge Characterization Study which was a requirement of the City's ACO. The report presented a proposed rainfall monitoring study which includes a historic precipitation analysis and installation and operation of two rain gages. The proposed combined sewer overflow monitoring study consisted of collecting and analyzing representative water quality samples from CSOs at three outfalls. The report also presented the proposed modeling study which would develop and document the relationship between wet-weather events and CSO discharge characteristics.

Combined Sewer Overflow Discharge Characterization Study, prepared by CDM Smith, dated September 2007

- The report was submitted in partial fulfillment of the NJ General Permit for Combined Sewer Systems, NJPDES No. NJ0105023. The study included the data collection and analyses necessary to develop a computer-based, numerical hydrologic and hydraulic model that was used to characterize the annual overflow volume and water quality of discharges from the City of Perth Amboy's combined sewer system. Work performed in the preparation of this study was in compliance with the Monitoring Proposal and Work Plan approved by NJDEP in September of 2006.

The City of Perth Amboy Combined Sewerage System Engineering Assessment, Prepared for Utility Service Affiliates Perth Amboy, dated August 30, 2010

- The report presented the findings of an overall system engineering assessment of the Perth Amboy's collection system and associated components. Investigations were completed on various system components and the assessment incorporated the findings, conclusions and recommendations of these investigations. The focus of the assessment was on the physical components of the system, capital planning, operation and maintenance practices, and organization and management processes.

Flow Monitoring Pilot Study Report, prepared by CDM Smith, dated January 2014

- The report was submitted in partial fulfillment of a Consent Decree issued by the EPA. A 6-month flow monitoring pilot study was conducted from April 15, 2013 to October 17, 2013. The report summarizes the pilot study and compares the pilot study's metered data with the SWMM modeled data for accuracy in estimating flow and depth measured in the combined system.

CSO Activity Report for Calendar Year 2014, prepared by CDM Smith, dated February 2015

- The report summarizes the City of Perth Amboy's 2014 Combined Sewer Overflow (CSO) Monitoring Program. The report presents discharge volumes, frequencies, and durations for four of the City's active CSO outfalls. Discharges were estimated by the SWMM model of the City's CSO system. Following the completion of the required flow monitoring period as part of the Pilot Study, the City issued a Request for Termination of flow and depth monitoring to the EPA on the basis that the SWMM model of the City's CSO sewer system reasonably approximated the overflows and could be used for ongoing reporting. EPA granted this request through the issuance of a flow monitoring modification to the Consent Decree dated February 20, 2014. The flow monitoring modification permitted the City to perform periodic reporting of CSO activity at the four identified CSO discharge points using the SWMM model as the basis for estimating flow volume, frequency, and duration. This was the first report submitted as part of the flow monitoring modification to the Consent Decree.

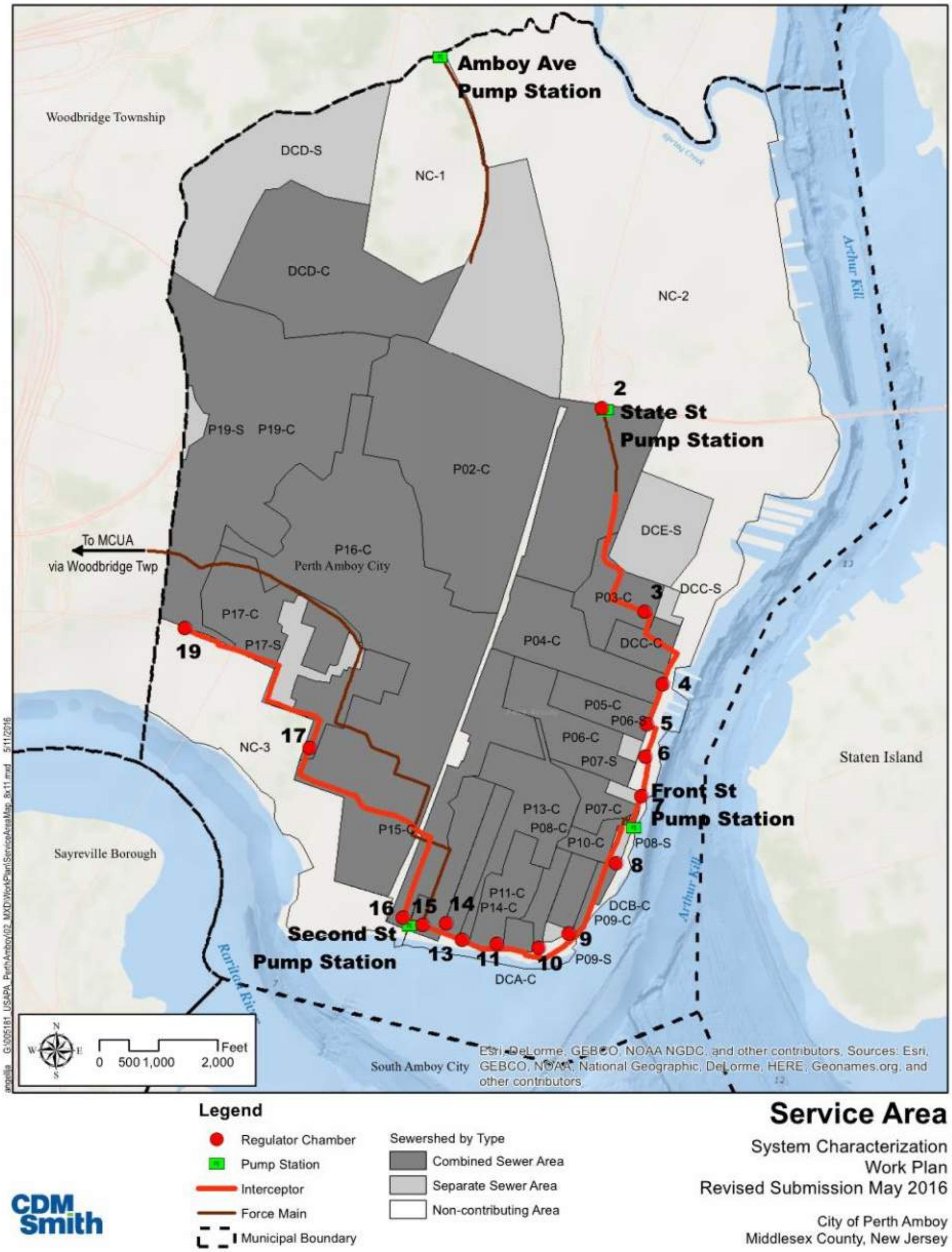

Figure 1-1 - Perth Amboy Service Area

1.3 City of Perth Amboy – Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Luis C. Perez-Jimenez 8/25/16

Luis Perez-Jimenez
Director of Operations, City of Perth Amboy, Water and Sewer Department

Date

1.4 Middlesex County Utilities Authority – Certification

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

8-26-16

Richard L. Fitamant
Executive Director, Middlesex County Utilities Authority

Date

Section 2

Characterization of the Combined Sewer System

2.1 General Description of Service Area

The City of Perth Amboy is served by both combined and separate sewers and owns and operates combined sewer overflows (CSOs). While the City retains ownership of existing sewer infrastructure, the operations of the City's CSO system is performed by Utility Service Affiliates-Perth Amboy (USA-PA), a subsidiary of Middlesex Water Company.

An estimated 41,045 of the City of Perth Amboy's residents are served directly by a combined sewer system which covers approximately 2.5 square miles. An additional 9,796 residents are served directly by a separated sewer system which is conveyed to the combined sewer system. The combined sewer system includes sixteen combined sewer outfalls, with eight outfalls draining to the Arthur Kill and eight outfalls draining to the Raritan Estuary. An estimated 7,200 residents are served by separate sewers which covers approximately 0.55 square miles of the City. The separated sewer areas discharge stormwater to the receiving waters and deliver sanitary sewerage to the combined sewer system. Both sanitary and combined sewer flow are conveyed through the City's 4.3 miles of the interceptor pipes which are divided into an Eastside (2.7 miles) and Westside (1.6 miles). The confluence of the two branches is located on the influent sewer line at the City's Main Pumping Station, located on Second Street along the shore of the Raritan Estuary. There are four pump stations within the system: Amboy Avenue Pumping Station, State Street Pumping Station, Front Street Pumping Station, and Main Pumping Station (also known as the Second Street Pumping Station).

All flow from the main pump station is ultimately conveyed to the Middlesex County Utilities Authority (MCUA) Edward J. Patten Water Reclamation Center for treatment. The Main Pump Station is capable of delivering a maximum of 13.7 MGD to MCUA during wet weather. The forcemain is 24" in diameter. Perth Amboy's flow is recorded in the Perth Amboy meter chamber, which is located upstream of the Woodbridge Township's Keasbey Interceptor. From there, flow is conveyed by gravity sewer to the MCUA's Edison Pump Station and then to the reclamation center headworks, which is located on the Raritan Bay shoreline, upstream and on the opposite bank from Perth Amboy. See Figure 2-1 for a schematic of Perth Amboy's system and how it connects to Woodbridge and MCUA.

Historically, Perth Amboy has had very few issues in its sewer system related to CSO related flooding. Fats, oil and grease buildup in the sewers have been known to cause sewer backups in certain areas, however, a regular maintenance program has been instated in these areas which has allowed issues to be resolved in a timely manner. The City of Perth Amboy maintains a phone line to respond to questions or concerns raised by the public. The phone calls are recorded on incident cards and are also entered into a logbook maintained at the second street pumps station.

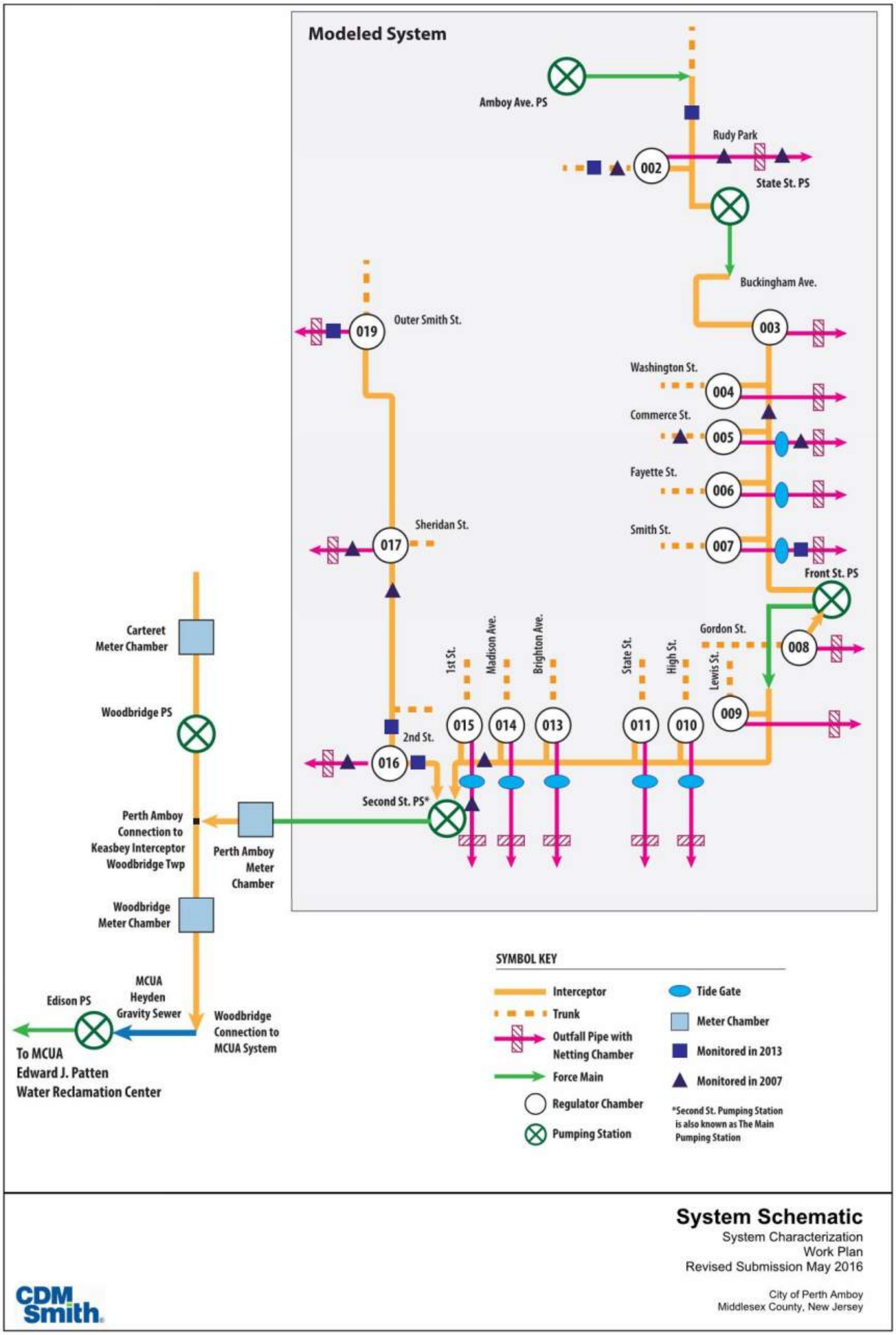

Figure 2-1 - Perth Amboy System Schematic

2.2 Inventory and Assessment of the Sewer System/Facilities

The City will present a comprehensive summary of the previous studies on the sewer system and its facilities in the System Characterization Report. Supplemental information on any recent changes to the City's sewer system will also be provided. The sewer system components will include, at a minimum, the following:

- CSO Outfalls;
- Tide Gates;
- Solids/Floatables Control (Netting Facilities);
- Regulators;
- Gravity Lines and Force Mains;
- Pump Stations;
- Significant indirect Users; and
- Specific Locations with Historical Issues.

2.3 City of Perth Amboy Land Use Analysis

The total area of the City of Perth Amboy is 3,819 acres. Of this area, 1,606 acres of development are served by the combined sewer system. In the CSO Discharge Characterization Study under the 2007 General Permit, the City's service area was divided into 20 sub-sewersheds based on the sewer map. The sub-sewersheds include 16 sheds that each contribute flow to an outfall and four sheds where the flow enters directly into the interceptor. Land use and imperviousness data were analyzed on the sub-sewershed level using the NJDEP 2002 Land Use/Land Cover GIS database**.** This data was consolidated into 12 different types, representing a full range of land use information. The predominant land uses are residential and commercial with pockets of industrial areas. The various land use types found in the Perth Amboy combined sewer service area include:

- Residential;
- Commercial/Services;
- Industrial;
- Transportation, Communication and Utilities;
- Urban, Vacant and Transitional;
- Parks and Recreation; and
- Other Land Use Types (Beaches, Forested, Water and Wetlands).

NJDEP published the 2012 Land Use/Land Cover Update recently. It was analyzed to evaluate the changes in imperviousness in each sub-sewershed from 2002 to 2012 in the City. The overall imperviousness of the City's combined area (shown in Table 2-1) had increased by 0.4%. The areas with the most acreage changes were DCD (6.42 acre reduction) and P02 (10.6 acre addition), however, these changes were captured explicitly by the flow meters in 2013. The changes in impervious area for the rest sub-sewersheds were all under 4 acres. The model will be updated using the imperviousness as depicted in the latest GIS Land Use Land Cover (LULC) Data, although it is not likely to lead to any significant change in run off characteristics of these sub-sewersheds.

The percent imperviousness in the separate sewer area within the City had increased by 6%. However, the quantity of inflow and infiltration in the separate sewer area correlates more to the system condition such as how leaky the pipes and manholes are, and how many sump pumps are connected than to land use and imperviousness of the separate sewer area.

Table 2-1 - Table Percent Impervious Comparison – 2002 vs. 2012

Combined sewer area	Acre	2002 impervious area, acre	2002 %imperviousness	2012 impervious area, acre	2012 %imperviousness	change of impervious area, ac	% change of impervious area
DCC	17.27	0.4	2%	3.9	23%	3.59	21%
P02	316.54	8.0	3%	18.6	6%	10.55	3%
P03	34.08	0.3	1%	0.8	2%	0.56	2%
P17	94.85	17.7	19%	19.0	20%	1.30	1%
P19	250.82	27.1	11%	30.2	12%	3.11	1%
P06	42.94	4.4	10%	4.6	11%	0.17	0%
DCB	7.00	0.0	1%	0.1	1%	0.02	0%
P07	16.60	0.1	0%	0.1	1%	0.02	0%
P16	397.88	80.8	20%	80.7	20%	-0.05	0%
P09	13.27	0.1	1%	0.1	1%	-0.03	0%
P08	10.25	0.1	1%	0.1	1%	-0.04	0%
P11	28.84	14.2	49%	14.1	49%	-0.11	0%
P13	53.83	2.3	4%	2.1	4%	-0.21	0%
P14	19.39	1.0	5%	0.7	4%	-0.24	-1%
P04	59.58	4.7	8%	3.9	6%	-0.84	-1%
P15	30.71	3.0	10%	2.4	8%	-0.60	-2%
DCD	147.04	9.3	6%	2.8	2%	-6.42	-4%
DCA	5.75	2.9	50%	2.4	41%	-0.52	-9%
P05	25.07	10.1	40%	6.2	25%	-3.87	-15%
Total	1571.70	186.5	-	192.9	-	6.4	0.4%

2.4 Service Area Population and SIUs

Perth Amboy's collection system serves 50,814 residents per the 2010 Census and 3,525 (2007, Census Business QuikFacts) business customers. The estimation of population served by the combined and separated sewer systems is included in section 2.1.The number of residents showed an increase of 7.48% from the 2000 Census data. The 2010 Census population data will be incorporated into the model.

Based on information provided to the City by MCUA, Table 2-2 presents a current list of the significant industrial users (SIUs) that discharge to the Perth Amboy collection system. More details will be presented in the System Characterization Report such as flow rate and sewershed each SIU is located in.

Table 2-2 - City of Perth Amboy – Significant Industrial Users (SIUs)

Indirect Users	Address	Town	Sub-sewershed
Amboy Group (Tommy Maloneys)	1 Amboy Ave.	Woodbridge	DCD
Chemtura Corporation[1]	1000 Convery Boulevard	Perth Amboy	DCD
Englert, Inc.[1]	1200 Amboy Ave.	Perth Amboy	DCD
Evans Machine & Tool Co	410 Summit Avenue	Perth Amboy	DCD
Grimes Manufacturing Inc. (GMI)	599 State Street.	Perth Amboy	P03
Illusion Engraved	311 Fayette Street	Perth Amboy	P16
Kinder Morgan Liquids Terminals LLC	920 State Street	Perth Amboy	DCD
Lincoln Signs & Awnings, Inc.	895 State Street	Perth Amboy	DCD
Stand-Out Signs, Inc.	49 W Pond Road	Perth Amboy	DCD
Madsen & Howell, Inc.	500 Market Street	Perth Amboy	P17
Mayab Happy Tacos, Inc.	450 Florida Grove Road	Perth Amboy	P19
Med-Apparel Services[1]	35 Washington Street	Perth Amboy	P04
Monogram Center	437 Amboy Avenue	Perth Amboy	P16
Morton Salt, Inc.	920 High Street	Perth Amboy	DCD
Power Magne-Tech Corp.	653 Sayre Avenue	Perth Amboy	P19
Magnetic & Transformer Technologies	653 Sayre Avenue	Perth Amboy	P19
Reconserve, Inc.	1250 Amboy Avenue	Perth Amboy	DCD
Riverdale Color Mfg., Inc.	1 Walnut Street	Perth Amboy	P16
The Printing Shop Copy Cente	338 State Street	Perth Amboy	P06
Tropical Cheese Industries, Inc.	450 Fayette Street	Perth Amboy	P17
V&R Design Co.	941 State Street	Perth Amboy	DCD
V&S Amboy Galvanizing	1190 Amboy Avenue	Perth Amboy	DCD
Vira Manufacturing, Inc.	1 Buckingham Avenue	Perth Amboy	DCC
Wikstrom Machines, Inc.	412 Summit Avenue	Perth Amboy	DCD

[1]Industrial Users issued a non-domestic wastewater discharge control document by the Middlesex County Utilities Authority (MCUA) Industrial Pretreatment Program in accordance with the MCUA Rules and Regulations

Section 3

Rainfall Records Analysis

3.1 Local Precipitation Gauges

The City of Perth Amboy covers approximately 3,819 acres (5.97 square miles). During the study under the 2007 General Permit, the City installed two continuous recording tipping bucket precipitation gauges to account for any potential spatial variation. One gauge was installed at the City reservoir on Florida Grove Road in the northeast part of the City and another one was installed at the main pump station site on the south side of the City. The details were described in the Monitoring Proposal and Work Plan, dated September 2006. The same two locations were used during monitoring under the ACO in 2013. The monitoring periods are listed in Table 3-1 below.

Table 3-1 - Local Precipitation Gauge Dates

2007 Dates	2013 Dates
June - August 2007 (15 events >= 0.02")	April 15 – July 15, 2013 (23 events >= 0.05") July 15 - October 17, 2013 (15 events >= 0.05")

The City is currently procuring the installation of two permanent rain gauges. The outcome of this procurement will be presented in the System Characterization Report.

3.2 Regional Precipitation Gauges

A few National Weather Service (NWS) rain gauges exist around Perth Amboy. During the CSO Discharge Characterization in 2007, rainfall statistics were evaluated using long term hourly rainfall data at New Brunswick (COOP286055) Rahway (COOP287393)) and Newark International Airport (COOP286026). The New Brunswick and Rahway gauges were closed in February 2006 and June 2003 respectively.

The remaining high quality NWS rain gauges are Newark International Airport 13 mile north of Perth Amboy (COOP286026) and JFK International Airport, 28 miles northeast of Perth Amboy (COOP305803). These regional precipitation data can be used for quality check of the local rain gauge data. The available long term record can also be used for identifying storms with specific return periods as well as representative year.

3.3 Average Hydrologic Year (The Typical Year)

In the NJDEP General Permit (2007), the average hydrologic year for Perth Amboy was identified as 1988 hourly precipitation record at JFK International Airport. This annual rainfall was used for establishing system CSO discharge baseline as well as evaluating efficacies of different CSO reduction technologies.

The City of Perth Amboy intends to use the same Typical Year as the New Jersey CSO Group, subject to confirmation by the City. As part of the System Characterization Report, recent rainfall data will be analyzed to confirm that the Typical Year selected by the New Jersey CSO Group is appropriate for the City of Perth Amboy.

Section 4

System Monitoring

Perth Amboy conducted a comprehensive CSO monitoring program in 2007 that measured the frequency, duration, flow rate, volume and pollutant concentration of a representative selection of areas/CSOs within the City's sewer system. Additionally in 2013, a six month pilot study of flow monitoring near four CSO outfall locations was completed. The monitoring and sampling activities are summarized in Table 4.1 below.

Table 4-1 - Flow Monitoring and CSO Sampling Timeline

Development Year	2007	2013
Flow Monitoring	May 30 - August 20, 2007 at 5 CSOs 11 flow meters State St., Front St., and Second St. PS	April 15 – July 15, 2013 flow at 2 CSO 4 flow meters April 15 - October 17, 2013 at 2 CSO 2 depth meters State St., Front St., and Second St. PS
CSO Sampling	3 wet weather events (June 3, July 29, August 14, 2007) 24-hr dry weather period 3 locations (CSO2, 5, 17)	None

The City continues to record flow at all three pump stations using circular charts, but this data is not available digitally.

At NJDEP's request, the City has agreed to perform additional monitoring in accordance with the *Combined Sewer System Rain Gauge and Flow Metering QAPP* (CDM Smith, August 2016) included in Appendix B.

The previous monitoring programs and proposed rain gauge and flow metering program will serve as the foundation for the Perth Amboy combined sewer system (CSS) hydrologic and hydraulic model.

4.1 Flow Metering under the General Permit

The flow metering was conducted for approximately three months in 2007 at 11 locations throughout the combined sewer system. A summary of the flow metering sites has been included in Table 4-2, below. The selection of the metering sites was based on the size of the sub-sewershed and land use distribution as show in Table 4-3. DCD and P02 were monitored which made up 37% of the total combined area. Among the sub-sewersheds where residential is the predominant land use (P05 – P15), P05 and P15 were monitored. The sub-sewersheds with substantial residential as well as commercial/industrial land use made up to 51% of the total combined area. Within these sub-sewersheds, P16 and P17 were metered. The metered area was 62% of the total combined area.

The results of the flow metering program will be described in more detail in the System Characterization Report.

Table 4-2 - Summary of Flow Metering Sites

Meter #	Location Description	Pipe Size	Data Range
1	Broad and Front (East Interceptor)	48”	5/30/2007 – 8/20/2007
2	Commerce Street Overflow CSO-005	24”x36”	5/30/2007 – 8/20/2007
3	Commerce Street Trunk	24”x36”	5/30/2007 – 8/20/2007
4	CSO-002 Outfall (Downstream Nets)	84”	5/30/2007 – 8/20/2007
5	CSO-002 Outfall (Upstream Nets)	84”	5/30/2007 – 8/20/2007
6	CSO-015 Outfall	36”	6/3/2007 – 8/20/2007
7	CSO-016 Outfall	84”	5/31/2007 – 8/20/2007
8	CSO-017 Outfall	36”	5/30/2007 – 8/20/2007
9	Madison Ave (East Interceptor)	33”	5/31/2007 – 8/20/2007
10	Patterson and Meade (West Interceptor)	27”	6/12/2007 – 8/20/2007
11	State Street Trunk	84”	5/31/2007 – 8/20/2007

Table 4-3 - Land Use Distribution in Study Area (2012 Land Use Data)

Sub-sewershed	Commercial/Industrial	Forest/Shrub	Other Open	Other Urban	Recreation	Residential	Trans/Communications/ Utility	Water	Wetlands	Percentage of total area
DCD	15%	3%	1%	5%	8%	60%	7%	1%	0%	37%
P02	19%	1%	12%	4%	5%	57%	3%			
P05	17%			13%		70%				8%
P08	2%		4%		14%	80%				
P09	7%		7%			86%				
P10					9%	91%				
P11	4%				5%	91%				
P14	2%			5%	7%	87%				
P15	9%			6%	9%	74%	2%			
P03	38%		2%	8%	7%	31%	13%			51%
P04	26%	9%	6%	8%	0%	47%	3%			
P06	52%			1%		47%				
P07	27%				8%	65%				

Sub-sewershed	Commercial/Industrial	Forest/Shrub	Other Open	Other Urban	Recreation	Residential	Trans/Communications/ Utility	Water	Wetlands	Percentage of total area
P13	42%			3%	3%	53%				
P16	44%	0%	1%	10%		42%	2%	1%	0%	
P17	56%	1%		4%	2%	32%	7%			
P19	10%	9%	3%	8%	3%	57%	8%	3%		

4.2 CSO Water Quality Characterization under the General Permit

Perth Amboy also conducted water quality sampling during two storms in the summer of 2007 at each of three CSO discharge points, as well as during a 24-hour dry weather period. A summary of the water quality parameters which the samples were tested for is included in Table 4-4. Event mean concentrations (EMC) were calculated for each pollutant and were used for calculating annual pollutant load into the receiving waters. In light of the water quality sampling effort led by PVSC, the EMC developed in 2007 will be re-evaluated against the newly available data. Representative values will be selected for use from all available data for both combined sewage and separated storm water wherever applies. The comparison and evaluation of the water quality data will be presented in detail in the System Characterization Report.

Table 4-4 – CSO Water Quality Parameters Tested during the 2007 General Permit

Water Quality Parameters		
BOD5	NH_3	Total Phosphorus (TP)
TSS	NO_2	Hardness
COD	NO_3	Fecal Coliform
SS	TKN	Enterococci
TDS	Orthophosphate, as P (OP)	Flow During Sampling

4.3 Flow Monitoring Study under the Administrative Consent Order

In September 2012 Perth Amboy entered into an Administrative Consent Order (ACO) with the USEPA. In compliance with that ACO, the City conducted a 6-month (April – October, 2013) monitoring program near four CSO outfall locations, including:

- CSO-002 (Rudyk Park)
  - *Flow Monitoring* - The service area of CSO-002 was selected because it is the second largest in the entire CSS accounting for approximately 17% of the total contributing

CSO area. The service area collecting flow entering the northern end of the Eastside interceptor consists of 21% of the overall combined service areas. Accordingly, flow monitoring at this location represents 38% of the combined service areas of the City.

- CSO-007 (Smith Street)
  - *Stage (Depth) Monitoring* – CSO-007 is located in the eastern interceptor, near the Arthur Kill. The sewershed for CSO-007 is characterized largely by significant portion of high density residential use with some commercial/industrial land which is similar to a number of other sewersheds in its vicinity the service area (P3, P4, P6, P13, P17). Accordingly, the unit area data obtained from CSO-007 can be applied to the surrounding sewersheds. Collectively, the combined service areas represent approximately 17% of the City's contributing CSO area.
- CSO-016 (Second Street)
  - *Flow Monitoring* - has the largest service area in the CSS representing 21% of the City's contributing CSO area. Flow monitoring at this site provided flow data for a significant portion of the City's CSS.
- CSO-019 (Outer Smith Street)
  - *Stage (Depth) Monitoring* - CSO-019 has the third largest service area in the CSS representing approximately 13% of the City's contributing CSO area. Unit data provided by this site is applicable to the entire service area.

Collectively, the data obtained during the 2013 monitoring period was representative of almost 90% of the City's total contributing CSO area.

Following the completion of this monitoring, the City issued a Request for Termination of flow and depth monitoring to the Environmental Protection Agency (EPA). The request was submitted on the basis that the Storm Water Management Model (SWMM) of the City's CSO sewer system reasonably approximated the overflows and could be used for ongoing reporting. EPA granted this request through the issuance of a flow monitoring modification to the Administrative Consent Order dated February 20, 2014. The flow monitoring modification permits the City to perform periodic reporting of CSO activity at the four identified CSO discharge points using the SWMM model as the basis for estimating flow volume, frequency, and duration. The next section provides more information on how the monitoring program aided in the development and improvement of the model.

Section 5

System Hydrologic and Hydraulic (H&H) Modeling

This section describes the evolution of the hydrologic and hydraulic (H&H) model that is used for the system baseline characterization and to develop CSO controls.

The H&H model of the sewer system was originally developed and used for analysis for compliance with NJPDES General Permit in 2007. As noted above, in September 2012 Perth Amboy entered into an Administrative Consent Order (ACO) with the USEPA. As part of that ACO, flow monitoring was conducted in 2013 and the H&H model was subsequently updated.

In this study, the City will collect and consolidate information on any collection system upgrade and improvements after 2013 that are relevant to the H&H model. The model will be updated to reflect these system changes. Additional information on service area change will also be investigated and incorporated into the model. The model will also be updated with the latest imperviousness data and population data. The model will be adjusted to the 2013 monitoring data, the latest pump station data, and the rain gauge and flow metering data to be obtained as part of the flow monitoring program described in the QAPP in Appendix B to establish the latest system baseline for the LTCP.

5.1 H&H Model Developed during 2007 NJPDES General Permit

An H&H model of Perth Amboy was developed in EPA SWMM5 to establish the baseline condition and was subsequently used for LTCP analysis to satisfy the requirements of the General Permit in 2007.

5.1.1 Model Development

The model covered the entire city of Perth Amboy as the drainage area and included only the interceptor sewers and pump stations.

The hydraulic components included

- The east interceptor starting from P-2 and the west interceptor starting from P-19;
- Three pump stations modeled as ideal pumps with limiting flow at the u/s pipe: State Street, Front Street, Main Pump Station(at second Street pumping Perth Amboy's flow to MCUA's system);
- Sixteen combined sewer regulators: P-2, P-3, P-4,P-5, P-6, P-7, P -8, P -9, P -10, P -11, P -13, P -14, P -15, P -16, P17 (the only non-leaping weir), and P -19 (note that CS0 012 was connected to CSO 011 and is now closed and is therefore not included in this list);
- Sixteen combined sewer outfalls with tide gates and tidal boundary condition (Sandy Hook, NJ, Station8531680)

Survey data was used as the primary source for hydraulics supplemented by interceptor as-built drawings, diversion chamber reconstruction plans, and the sewer system map provided by the City. Field verification were conducted to further help resolving data gaps.

The hydrologic components included

- Rainfall runoff;
- Evaporation;
- Infiltration using Green-Ampt method;
- Snow pack and snow melt process;
- RTK for separated areas;
- Combined and separated sewer catchments covers the entire City

GIS and municipal collection system information were used to derive the sewershed boundary and area delineations. NJDEP 2002 land use and imperviousness were used to develop the initial imperviousness for the modeled catchments which later was calibrated. The slope for each model catchment was the average slope of a slope grid created from the USGS 10 meter DEM grid.

For soil parameters used for Green-Ampt equation, native soil was used as the initial input to the model wherever possible. Based on the National Resources Conservation Service (NRCS) SSURGO soils layer, Perth Amboy is primarily silt loam, however, City staff report there may be clayey soils present as well. In areas where no soil information was available (indicated as Urban in NRCS soil layer) the average parameters of the surrounding native soil was used as the initial values. The soil parameters were adjusted during calibration No groundwater process was modeled.

Sanitary flow was developed from metering data and distributed using population data from the 2000 Census.

5.1.2 Model Validation and Baseline Overflow Condition

The flow in the system was monitored between the end of May and late August in 2007 as described in Section 4. The hydrological processes involved in this model included precipitation, evaporation, surface runoff, and infiltration. Calibration was conducted by adjusting percentage imperviousness and soil hydraulic conductivity within reasonable ranges to balance among evaporation, surface runoff, and infiltration so that the resulted surface runoff can replicate the volume under the metered hydrographs during different storms at the following locations:

- Trunk sewer flow at P-2 and P5;
- Overflow at P-17, P-2, P-15, , P -16, P-5;
- Interceptor flow at u/s of P-5, u/s of P-15, and d/s of P-17

The validated model was then used to establish the baseline overflow condition in the typical year as shown in Table 5-1. No overflow frequency was reported in the 2007 System

Characterization Report. The baseline overflow volume and frequency will be presented in the System Characterization Report using the updated baseline model as described in Section 5.3.

Table 5-1 - Simulated Annual Baseline Overflow Conditions (2007) Volume

Outfall	Overflow Volume (MG)
CSO-002	90.9
CSO-003	28.2
CSO-004	9.8
CSO-005	4.8
CSO-006	14.1
CSO-007	2.5
CSO-008	0.9
CSO-009	2.1
CSO-010	1.3
CSO-011	7.1
CSO-013	18.3
CSO-014	6.9
CSO-015	9.8
CSO-016	120.7
CSO-017	3.5
CSO-019	47.4
Total	**368.4**

5.2 Model Update Under ACO

As required by the September 2012 ACO with U.S.EPA, flow monitoring was conducted in 2013 at the following locations

- Interceptor flow at u/s of P-2, u/s and d/s of P-16
- Trunk sewer flow at P-2
- Overflow at P-7 and P-19

The H&H model was updated using the latest data sources including

- Pipe connectivity, diameter, and condition information from CCTV and sonar inspection by RedZone
- Pipe diameter based on meter site sketches

- Catchment width and R values from calibrating to fall 2013 meter data

This calibration effort greatly improved the representation of the model at three of its CSO regulators which generate the biggest CSO volume during the 2007 model assessment. USEPA Region 2 was satisfied with the model and agreed to terminate the flow monitoring program.

5.3 Model Update Under This Permit

The City will collect and consolidate information on any collection system upgrade and improvements after 2013 that are relevant to the H&H model. The model will be updated to reflect these system changes. There appears to be changes in the sewer service area which are under investigation. The model will also be updated with the latest imperviousness data, population data, adjusted to the 2013 monitoring data, and the rain gauge and flow metering data to be obtained as part of the flow monitoring program described in the QAPP in Appendix B to establish the latest system baseline for the LTCP.

The model input file will be included in the appendix of the System Characterization Report. The sources of the input parameters will be documented as well as how they were adjusted during the calibration process. The model output can be provided upon the Department's request.

Section 6

Identification of Sensitive Areas

Perth Amboy will evaluate the receiving stream reaches to which its CSOs discharge to identify any areas which may be defined as sensitive areas pursuant to the newly issued permit and the EPA's Combined Sewer Overflow (CSO) Control Policy (59 FR 7518692):

- Outstanding National Resource Waters;
- National Marine Sanctuaries;
- Waters with threatened or endangered species and their habitat;
- Primary contact recreation waters (including, but not limited to bathing beaches);
- Public drinking water intakes or their designated protection areas; and
- Shellfish beds.

The locations of CSOs in relation to the sensitive areas, the nature of the sensitive areas and the available information regarding CSO impacts on any sensitive areas that are identified will be detailed in the System Characterization Report. The databases and records searches used to identify sensitive areas will be documented in the report. Sources will include the published reports and databases identified in Table 1-1, as well as information from the municipalities, stakeholders and public comments. These sources will be used to identify any conditions which may include those of sensitive areas as defined in the CSO Control Policy.

Section 7

Baseline Conditions for the LTCP

7.1 Performance Characteristics of the Existing Combined Sewer System

As detailed in Section 5, the H&H model of the City's interceptor sewer system was developed in 2007 and updated in 2013 in accordance with previous regulatory requirements. As part of the most recent CSO Permit issued October 9, 2015, the City will update the model. The City will collect and consolidate information on collection system upgrades and improvements completed after 2013 which are relevant to the H&H model. The model will be updated to reflect these system changes. The model will also be updated with the latest imperviousness and population data, and most recent rain gauge and flow metering information as previously described in Section 5. The typical year will be selected after the analysis described in Section 3 has been completed and it is decided whether the period selected by the New Jersey CSO Group is appropriate for the City of Perth Amboy. With the updates described, the model will be used to establish the system baseline for the System Characterization Report and Long Term Control Plan, including CSO volume and frequency, system surcharge condition, flooding, and etc.

As part of the LTCP CSO control analysis, the model will be used to evaluate the capacity of the pumping facilities to deliver flow to the MCUA plant, as well as CSO control alternatives such as green infrastructure; maximizing flow to the plant, increased storage capacity in the collection system; I/I reduction; sewer separation; treatment of the CSO discharge; and CSO related bypass of the secondary treatment portion of the STP.

7.2 Receiving Water Quality

Perth Amboy has confirmed their intent to participate in the Ambient Monitoring and Modeling and the Public Notification and Alert System being developed by the Passaic Valley Sewerage Commission (PVSC) in a letter to PVSC dated October 27, 2015. The Ambient Monitoring and Modeling program being developed by PVSC will serve as Perth Amboy's Compliance Monitoring Program for receiving stream assessment(s) and it is expected to be in compliance with the QAPP format. In accordance with the permit requirements, the City will be submitting the Compliance Monitoring Program Work Plan prepared by PVSC.

Per the draft work plan provided by PVSC to the New Jersey CSO Group in October 2015, "The Baseline Compliance Monitoring Program includes three parallel data collection efforts:

- Baseline Sampling, which will coincide with and enhance the ongoing New Jersey Harbor Discharges Group (NJHDG) annual program;
- Source Sampling, which will target the major influent streams within the study area to establish non-CSO loadings, and will coincide with the NJHDG and Baseline Sampling; and

- Event Sampling, which is timed to coincide with rainfall to capture three discrete wet weather events over the course of the year.”

The results of the baseline sampling efforts will ultimately be used in preparing future reports including the System Characterization Report and the Selection and Implementation of Alternatives Report in the final LTCP.

Appendix A

CDM Smith

Appendix B

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COMBINED SEWER SYSTEM RAIN GAUGE & FLOW METERING QAPP

CSO Permit Compliance

City of Perth Amboy

Middlesex County, New Jersey

NJPDES Permit No. NJ0156132

AUGUST 2016

CDM Smith

City of Perth Amboy Rain Gauge and Flow Metering QAPP

Prepared for:
The City of Perth Amboy

Prepared by:
CDM Smith Inc.
110 Fieldcrest Ave #8
6th Floor
Edison, NJ 08837

Date: August 2016

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Abbreviations and Acronyms

CSO	Combined Sewer Overflow
CSS	Combined Sewer System
EPA	United State Environmental Protection Agency
LTCP	Long Term Control Plan
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System

1.0 Title of Plan and Approval

Title: **Rain Gauge and Flow Metering QAPP**

Preparer:

Project Officer: Hond S Matter 8-22-2016

Howard Matteson, P.E., BCEE — Date

QA Officer: EH Burgess 8-22-2016

Edward Burgess, P.E., BCEE — Date

City of Perth Amboy:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for purposely, knowingly, recklessly, or negligently submitting false information.

Luis C. Perez-Jimenez 8/23/16

Luis Perez-Jimenez — Date

Director of Operations, City of Perth Amboy, Water and Sewer Department

New Jersey Department of Environmental Protection

DEP Permits

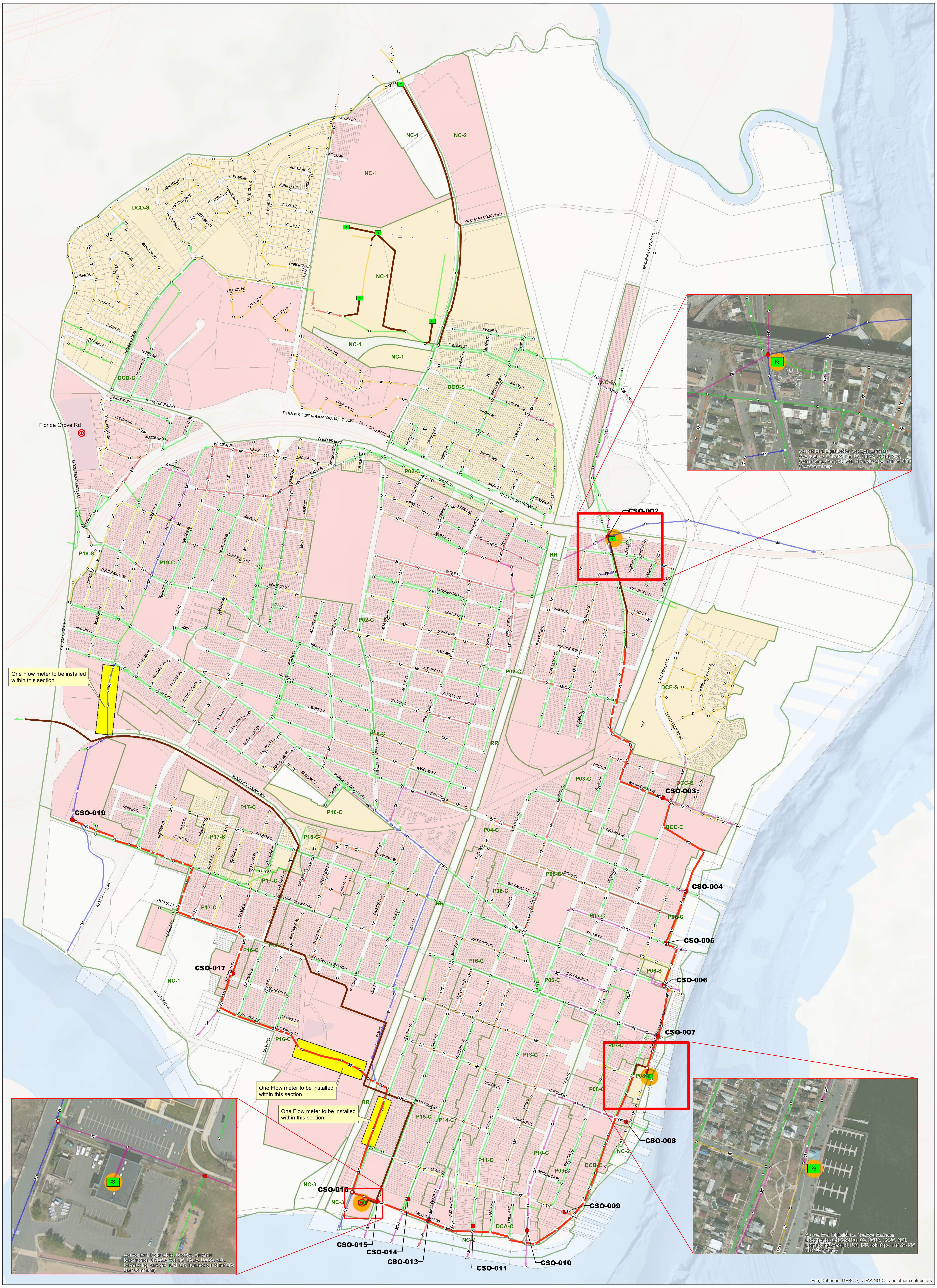
Joseph Mannick, CSO Coordinator — Date

DEP QA

Marc Ferko, Office of Quality Assurance — Date

2.0 Introduction

The intent of this Rainfall and Flow Metering QAPP is to comply with the NJDEP requirements outlined in the letter from Dwayne Kobesky to Luis Perez Jimenez dated July 14, 2016. The City of Perth Amboy has agreed to perform supplemental rainfall and flow monitoring in the City's CSS for System Characterization. Figure 2-1 shows the geographical location of the proposed flow meters and rain gauges. Figure 2-2 shows the location of the flow meters relative to other components in the CSS system as a schematic diagram.



Feet
0 250 500 1,000

- New Flow Meter Location
- New Data Logging Device
- Regulator Structure
- Pump Station
- Manhole
- Rain gage
- Outfalls
- Interceptor
- Force Main

Collection System by Diameter

- 4 - 10 inches
- 11 - 16 inches
- 17 - 27 inchtes
- 28 - 54 inches
- 55 - 84 inches
- Sewer with Unknown Diameter
- Sewershed Boundary

Sewershed Type

- Combined Sewer Area
- Separate Sewer Area
- Non-contributing Area

Figure 2-1 Meter Location
Perth Amboy
Proposed New Monitoring Locations

CDM Smith

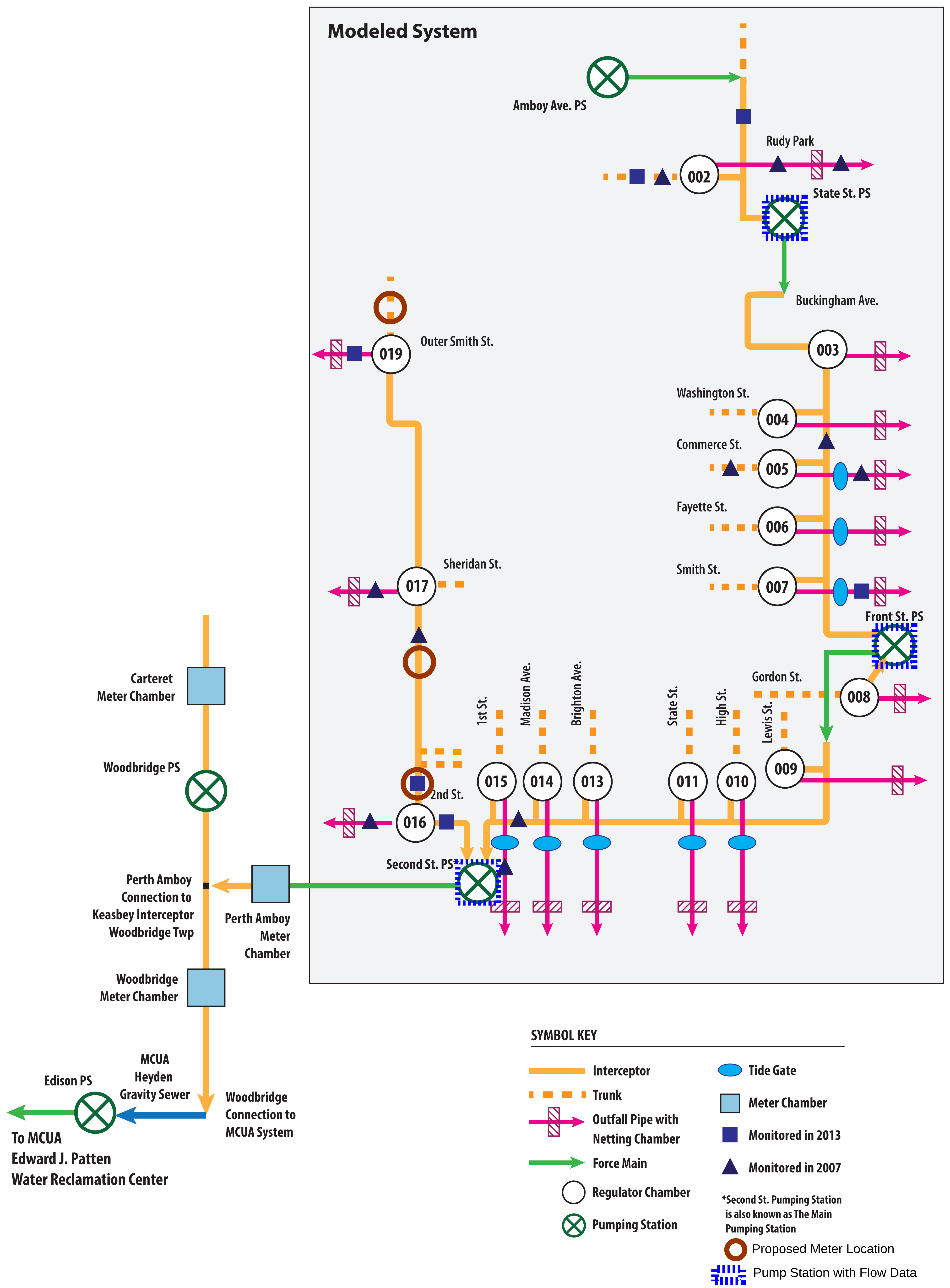


Figure 2-2 System Schematic with Flow Meters

System Characterization Work Plan

CDM Smith

City of Perth Amboy
Middlesex County, New Jersey

3.0 Project and Task Organization

The members of the project team are listed in the table below. Since the selection of the flow metering subconsultant has not yet started, not all of the personnel for the listed roles can be determined at this time. An amendment to the QAPP will be submitted to NJDEP once the flow metering subconsultant is procured and all the roles are filled with specific personnel.

Table 3-1 - Roles and Responsibilities

Project Roles	Team Member
Project Manager	Howard Matteson
Quality Assurance Officer	Ted Burgess
Local Project Manager	TBD
Rainfall and Flow Meter Manager	TBD
Assistant Field and Crew Manager	TBD
Data Manager, Data QA/QC, Data Platform	TBD
Data Technician, Data QA/QC, Data Platform	TBD

4.0 Special Training and Needs/Certifications

Perth Amboy intends to procure the services of an experienced and nationally recognized flow and precipitation monitoring service contractor to provide, operate and maintain rental equipment for the temporary flow monitoring program. All staff from the procured contractor who will work on this project are expected to already have the required training and certifications, and will maintain their certifications during the project. No additional training is deemed necessary for this project.

5.0 Problem Definition and Background

The problem is defined as the need to update the CSS model with additional system flow and rainfall monitoring data in order to confirm the ability of the City's combined sewer system model to accurately characterize the number, location, frequency and other characteristics of CSOs under the baseline condition of the CSS system in support of the system characterization and long-term control planning requirements of the City's combined sewer system permit (NJPDES Permit No. NJ0156132).

Flow meters and rain gages were installed in 2007 and 2013 to capture precipitation events and quantify sewer flows in Perth Amboy's CSS system. See the schematic in Figure 2-2 for the locations of these meters. There are circular flow charts at the two pump stations on the East Side Interceptor (State Street Pump Station and Front Street Pump Station) and the most downstream Main Pump Station. These permanent flow recording devices provide a good understanding of the flow in the East Side Interceptor. The Westside Interceptor however, despite having two of the three largest CSOs (CSO16 and CSO19), does not have any permanent meters. As requested by NJDEP, the City has agreed to perform supplemental rainfall and flow monitoring in the City's CSS for System Characterization. Additional background information in regard to this program, is discussed in more detail in Section 4 of the System Characterization Work Plan (SCWP).

6.0 Project/Task Description

Perth Amboy proposes to install 3 temporary flow meters along the West Side Interceptor of the CSS system and 3 permanent flow recording devices at the State St, Front St, and Second St Pump Stations. Two rain gauges will also be deployed during the temporary monitoring period for system characterization. The locations are shown on Figure 2-1 and schematically on Figure 2-2. The temporary monitoring period will include at least three representative precipitation events, with a rainfall depth of at least 0.5 inches producing an observable hydrologic response in the CSS system. The rain gauge and flow meter data capture resolution will be at 5 minute increments electronically and 15 minutes for hardcopy reports over the full monitoring period.

7.0 Quality Objectives

The criteria used to assess data quality include precision, accuracy, sensitivity, completeness, comparability, and representativeness. A brief description of the criteria is provided below.

Precision is the measure of agreement among repeated measurements.

Bias/Accuracy is the systematic or persistent distortion of a measurement process causing errors in one direction.

Completeness is the fraction of planned data that must be collected in order to be sufficient for the intended use of the data.

Comparability is defined as the extent to which data from one data set can be compared directly to similar or related data sets and/or decision making standards.

Representativeness is the extent to which measurements represent the true system.

Sensitivity is essentially the lowest detection limit of the method or instruments for each of the measurement parameters of interest. The rain gauge should measure as low as 0.01" of rain per minute, the volume of the tipping bucket within the gauge. The sensitivity of flow meters will be provided once the metering subconsultant is procured and the specific meter type is selected.

Quality control procedures will be implemented to address each of the quality criterion as shown in Table 7-1.

Table 7-1 – Quality Control Procedures for Meeting Data Quality Criteria

Data Quality Criteria	QC Procedure for Flow Meters	QC Procedure for Rain Gauges
Precision	Monthly preparation and analysis of scatter plots of the collected data to verify measurement consistency and agreement.	Initial verification of tipping bucket volume and functionality; weekly review of the collected data
Accuracy	During installation and field maintenance visits, depth and velocity will be manually measured with an independent portable device to verify the data recorded by the flow meter; weekly review of the collected data	Field verification of suitable gauge siting conditions; weekly review of the collected data; wind shield could be used if necessary
Completeness	Weekly review of collected data via telemetry or direct download to confirm logging and sensor operation are continuous, promptly detect any maintenance issues, and dispatch any required maintenance	Weekly review of collected data via telemetry or direct download to ensure logging during storms, and to promptly detect any maintenance issues
Comparability	Review and compare the envelope curves of the data scatter plots to verify hydraulic consistency of the data; use redundant depth monitoring sensors and technologies at monitoring sites	Comparison between the data from both rain gauges; Comparison with National Weather Service gauge at Newark Liberty International Airport; temporal comparison of storm events to sewer

Data Quality Criteria	QC Procedure for Flow Meters	QC Procedure for Rain Gauges
		system responses as reflected by the three flow meters.
Representativeness	Field reconnaissance for meter location to ensure that hydraulic conditions will allow reliable and accurate data to be collected	The gauge locations were successfully used in the past and provide good representation of spatial variability of rainfall events
Sensitivity	Will be updated once the metering company is procured and the specific meter type is determined	0.01-inches of rainfall

8.0 Field Monitoring Program and Requirements

The components of the field monitoring program are described in this section. The general requirement for each component is provided. An amendment to the QAPP will be provided once a flow monitoring subconsultant is procured and specific flow meter type(s) is/are selected.

8.1 Permanent Flow Monitoring

Circular flow chart has been used at State Street Pump Station, Front Street Pump Station, and the Main Pump Station to record effluent flows. Although it provides recorded data, to use it for modeling purposes can be cumbersome. Perth Amboy will install SCADA type of data recorder to replace the circular flow chart at the three pump stations. This will allow the data to be recorded digitally and be readily used for model calibration or validation.

The pump stations are also equipped with depth sensors in the wet wells. Knowing the configurations and volumes of the wet wells, the time series of digital depth data can be used as surrogate measurements of flow rate.

8.2 Temporary Flow Monitoring

Three flow meters will be installed on the Westside Interceptor. The most upstream meter will be located on the 72 inch diameter trunk sewer upstream of the CSO19 regulator structure. The second meter will be located along the interceptor between the CSO17 and CSO16 regulators, uptream of the points of connection with two major trunk sewers in the contributing area of CSO16. The third meter will be located along the 84 inch diameter interceptor above the 016 regulator. See Figure 2-1 and 2-2 for the proposed locations. These three meters will allow characterization of the flows coming from the contributing areas to each of the three CSOs along the Westside Interceptor. The specific manhole location for each of the meters will need to be field verified to access the access, safety and hydraulic suitability of the site to provide accurate and reliable flow data.

The temporary meters will be deployed to collect data for a minimum of three separate rainfall events over 0.5 inches in rainfall depth, with sufficient intensity, duration, and volumes to produce observable hydrologic responses. The metering program is planned to start in March 2017.

Perth Amboy intends to procure the services of an experienced and nationally recognized flow metering service contractor to provide, operate and maintain rental equipment for the temporary flow monitoring program. The contractor will be required to recommend and document the specific monitoring and telemetry equipment, technologies and installation configurations that will result in accurate and reliable monitoring data. It is anticipated that the equipment will have the capability to collect data remotely through cellular telemetry.

Prior to the deployment of the temporary flow meters, the flow service contractor will check and assess each of the proposed monitoring sites, and the manholes immediately adjacent to these proposed sites, for site access and safety, traffic control, structural configuration, hydraulic conditions, and any other relevant factors to verify the suitability of the site to provide accurate and reliable flow data. Traffic control approvals and permits will be obtained as necessary from the City.

It is anticipated that the flow monitoring equipment will be programmed to record wastewater depth, velocity, and flow data in 5-minute intervals and that times will be recorded in 24-hour military format with each hour beginning at 00 minutes. Depths will be recorded in inches, and velocities will be recorded in feet per second. Flows will be calculated in million gallons per day (mgd).

8.3 Temporary Precipitation Monitoring

Two rain gauges were installed in 2007 and 2013, one at the Main Pump Station in the southern end of the City and another one at the Florida Grove Road Pump Station in the Northeast corner of the City (see Figure 2-1). These two sites were selected based on access conditions and site safety, security concerns, potential interferences from surrounding buildings and trees, and local wind conditions. They sufficiently represented the spatial variation of rainfall over the sewer system service area. Perth Amboy anticipates to install a rain gauge at each of these same locations for system characterization. The rain gauges are expected to be tipping bucket type and will be deployed for the same period as the temporary flow meters. The same flow metering service contractor will provide the rainfall monitoring service.

The precipitation monitoring equipment will be programmed to record data in 5-minute intervals. Times will be recorded in 24-hour military format with each hour beginning at 00 minutes.

9.0 Analytical Requirements

Time series and scatter plots of the collected monitoring data will be prepared and analyzed on a monthly basis to convert the raw flow data into final quality-reviewed data sets. Time series plots will be used to flag any inconsistencies in the monitored diurnal cycles that could not be attributed to precipitation or seasonal changes to groundwater levels. The redundantly monitored wastewater depths will be compared to one another to verify that they are internally consistent, thus adding confidence to the accuracy or the monitored levels. Scatter plots will be produced and field-measured calibration points will be superimposed over the monitoring data to ensure the equipment is properly calibrated. A depth-flow relationship with a consistent envelope curve and a minimal degree of scatter in the data would verify optimal hydraulic conditions within the monitoring manhole.

Two general categories of data errors are identified through the quality assurance analyses: short-term or random errors and long-term or systematic errors. Short-term errors are generally caused by temporary hydraulic conditions or intermittent sensor fouling lasting for a brief duration. Since these brief periods of errant data are surrounded by reliable monitoring points, both depth and velocity errors can usually be corrected by interpolating between adjacent points. Long-term errors are caused by ongoing hydraulic conditions, extended sensor fouling, and/or equipment failures. Errant data identified through the review analyses are either flagged unusable, or corrected using approved techniques such as a rating curve (i.e. an established depth-flow relationship developed based on reliable monitored data).

The completed quality assurance analytical reviews will be able to confirm and verify the collected flow monitoring data is of sufficient accuracy and reliability. The completed analyses are also able to identify errant or unacceptable data and ensure that unreliable data will not be incorporated into subsequent sewershed characterization analyses or hydrologic/hydraulic model development and validation.

10.0 Testing, Inspection, Maintenance, and Calibration Requirements

10.1 Instrument/Equipment Testing, Inspection and Calibration

The temporary flow monitoring equipment will be installed with equipment configurations determined as best applicable; based on the site verification and inspection and the best professional judgement of the professional flow monitoring subconsultant. The flow service contractor will calibrate the equipment and document the equipment installation configurations and calibration verification activities and report any problems and problem resolutions.

A dimensioned field sketch, and profile section and plan view drawings of the equipment installation configuration will be prepared and included as part of the field documentation. Bench and initial field calibration of flow monitoring equipment shall be performed as applicable for the monitor type. The flow monitoring contractor will record site set-up information such as but not limited to measured sensor offsets, site name, manhole number, sewer pipe size, CSO discharge pipe size, and calibration data shall be documented on field sheets. The contractor will utilize portable velocity meters for velocity profiling to obtain field measurement flow points for the quality assurance reviews and analyses.

An equipment settling-in period of up to two weeks will be implemented for each installed flow monitor. During the settling-in period, the monitors will be interrogated, checked, and maintained, and independent field points will be obtained with a portable velocity meter, until the equipment is verified to be performing properly.

For the two rain gauges, the flow monitoring contractor will verify the calibration and tipping bucket operation of the equipment and document the equipment installations and calibration activities. During the flow monitor settling-in period, the equipment for each gauge site will be interrogated, checked, and maintained until the equipment is verified to be performing properly.

10.2 Maintenance

After the successful completion of the equipment settling–in period, the metering data will be interrogated on a frequent and regular schedule via telemetry or direct download, and the monitors will be visited and inspected at a regular interval, or when a maintenance is deemed necessary via reviewing the data through telemetry or direct download. The sensors will be inspected to check for the presence of debris and solids that may have hung-up on the sensors and/or oily substances that may have deposited on the sensors. Battery charge, desiccants and vent tubes shall be checked. At every field data interrogation, time-series plots will be generated in the field on the wireless notebook computers. These plots will be checked in the field, or via telemetry in the office, to verify that the equipment has been functioning properly, to identify problems and malfunctioning equipment, to make required corrections and equipment substitutions as soon as possible, and to minimize equipment down time. The specific details and requirements of field maintenance procedures, and data checking in the field will be discussed and agreed upon between Perth Amboy and the flow metering contractor based upon the determination of site specific requirements.

10.3 Quality Control Procedures

Quality control procedures during meter/gauge installation and maintenance are:

- Prior to the deployment of the temporary flow meters, the flow service contractor will check and assess each of the proposed monitoring sites for items such as but not limited to: site access and safety, traffic control, structural configuration and hydraulic conditions to verify the suitability of the site to provide accurate and reliable flow data.
- When installing the rain gauges, potential interferences from surrounding buildings and trees, and local wind conditions will be considered. Wind shield will be used as necessary to ensure high quality rainfall data.
- Calibration of the flow meters and rain gauges during installation
- An equipment settling-in period of up to two weeks will be implemented for each installed flow monitor. During the settling-in period, the monitors will be interrogated, checked, and maintained until the equipment is verified to be performing properly
- Routine maintenance, calibration verification, and depth sensor adjustments as necessary after installation

Quality control procedures during data collection and processing include:

- The data generated by the flow meters and rain gauges will be collected remotely through cellular telemetry, or will be downloaded directly, which will enable timely quality review and detection of field maintenance problems
- The raw data will be checked for the quality criteria listed in Section 1.5 of this QAPP
- The flow metering contractor will process the interrogated data through the appropriate software. Scatter-plots and time-series plots will be prepared and reviewed prior to submission of digital flow monitoring data to Perth Amboy to verify that the monitoring equipment is functioning correctly and to identify problems and remedies
- The data quality assurance analyses described in Section 9.0 of this QAPP will be used to confirm and verify the collected flow monitoring data is of sufficient accuracy and reliability, and to identify any errant or unacceptable data
- The raw data will be preserved and any data with systematic errors that cannot be corrected will be flagged as unreliable and unusable

11.0 Data Management

The flow metering contractor will be required to document the following information/data

- The specific monitoring and telemetry equipment, technologies and installation configurations
- The equipment installations and calibration activities and report any problems and problem resolutions
- A dimensioned field sketch, and profile section and plan view drawings of the equipment installation configuration
- Site set-up information such as but not limited to measured sensor offsets, site name, manhole number, sewer pipe size, CSO discharge pipe size, and calibration data
- Maintenance log and changes to equipment conditions
- Raw data collected by meters and gauges
- Processed and quality controlled data (Data with systematic errors that cannot be corrected will be flagged as unreliable and unusable.)

All this data and information should be made available online via the cellular telemetry units of through direct download to allow quality control by the City and its monitoring consultant during the metering program. Time-series and scatter plots and the quality reviewed data will be posted on a monthly basis. Once the program is completed, this data and information will be compiled into final datasets and reports for final submission.

12.0 Assessment/Oversight

The City will oversee the City's consultant team. The City's consultant will have oversight over the flow monitoring subconsultant. After the initial setup of the instruments is documented, and both the QA officer and flow monitoring subconsultant Team concur that the meters are functioning properly and generating good quality data, the monitoring period will begin. During the monitoring period, the Rainfall and Flow Meter Manager from the flow monitoring subconsultant team will be monitoring/managing the day to day checks and maintenance operations of the monitoring program. Each week, typically on or near a weekend, and before any significant corrective actions are taken, the Data Technician will review the collected data and notify the QA officer of the status and operating conditions associated with the monitoring equipment. Typical corrective actions, like changing a damaged or malfunctioning sensor, part, or component, will be reported to the Flow Meter manager, scheduled with the field crew during the following week, and reported to the QA officer in a timely manner after these typical corrective actions are taken. The Data Technician will subsequently verify that the implemented corrective action was successful. Significant corrective actions such as moving the location of an instrument or entirely replacing a meter or gauge will not be done unless approved by the QA officer. The QA officer will review and obtain confirmation of the approval of all proposed Significant Corrective actions with the Project Officer and/or Program Manager prior to commencement of such actions. NJDEP will be notified of such changes and the reasons for the change.

13.0 Data Review, Verification, Validation, and Usability

As described in Section 8.2 of this QAPP, an equipment settling-in period of up to two weeks may be required for each installed flow monitor. During this period, the data generated will be interrogated and independent field points will be obtained to ensure that the equipment is performing properly. The flow data will be subject to:

- Flow balance analysis using immediate upstream and downstream meters
- Compare to relevant data from 2007 and 2013
- Compare metered runoff response relative to the rainfall intensity and duration
- Scatter plots of depth, velocity, and flow versus depth
- Time series plot of depth, velocity and flow versus depth

The rainfall data from the two temporary rain gauges will be compared to each other as well as to the National Weather Station gauge at Newark Liberty International Airport for rainfall total, intensity and duration.

After the successful completion of the equipment settling-in, period, the data generated by the flow meters and rain gauges will continue to be collected remotely through cellular telemetry or through direct download which will enable timely quality review as described above to identify abnormalities and quick response and correction. Periodic field points obtained after the installation will provide necessary validation that the meters and gauges function properly.

The flow metering contractor will process the raw data through the appropriate software. Scatter-plots and time-series plots will be prepared and reviewed prior to submission of digital flow monitoring data to Perth Amboy. The raw data will be preserved and any data with systematic errors that cannot be corrected will be flagged as unreliable and unusable. Only the quality controlled final data will be used for sewer system characterization, model calibration and validation.

14.0 Reporting, Documents, and Records

The City's consultant will summarize the data resulted from the Supplemental Monitoring Program in the System Characterization Report including the following:

- A tabular summary of the data will be provided for each of the 2 rain gauges, 3 temporary flow meters, 3 permanent flow meters;
- A description of the data and observed patterns;
- Statistical analysis of rainfall data and selection of events for model calibration;
- An appendix containing a DVD of raw data from flow meters and rain gauges and time series plots.

Appendix B

June 23, 2017 Memorandum from CDM Smith to City Regarding 2017 Metering Program

Memorandum

To: *Luis Perez Jimenez*

From: *Cindy Huang*
Ted Burgess
Howard Matteson

Date: *June 23, 2017*

Subject: *Perth Amboy 2017 Metering Program Update*

During the System Characterization planning phase, NJDEP approved Perth Amboy's plan to meter depth, velocity, and flow at three locations in the west portion of the system, flow at three pump stations, and collect precipitation data at Florida Grove Rd, and the 2nd St Pump Station. See attached schematic and map for detailed locations.

The metering program commenced in the second week of April 2017 and has been collecting data for 8 weeks. This memo presents the analysis of data collected through June 16th and evaluation on the efficacy of these data for system characterization.

Rainfall Data Quality Control and Analysis

Precipitation data were collected at two locations in Perth Amboy (see Figure 1). Quality control was performed on these data by comparing to rainfall records at regional gages and the return period of the recorded storms were subsequently identified.

Quality control rainfall data

Two regional gages were selected for quality control Perth Amboy's project rain gages, Newark International Airport gage and New Brunswick gage. Newark International Airport gage is maintained by National Weather Service with high quality hourly data. The New Brunswick gage is part of the Rutgers rain gage network in New Jersey which records precipitation data at a 5-minute interval with limited quality control. These two gages reside on the north (Newark International Airport, aka EWR) and south (New Brunswick) side of the Perth Amboy system which will be helpful in evaluating rainfall special variability.

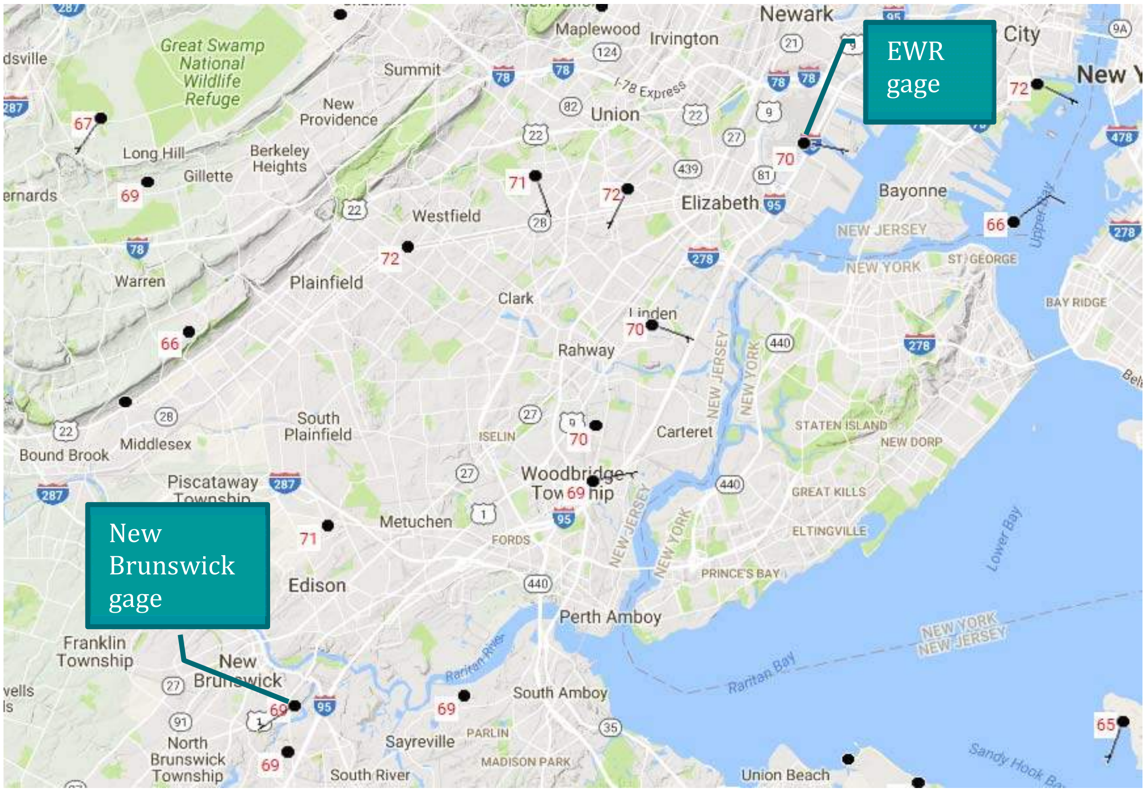


Figure 1 Rain gage location map

Cumulative rainfall was calculated from April 10, 2017 and compared among the four gages (see Figure 2). Rainfall data collected at the Florida Grove Road gage tracked very closely with both regional gages as shown below. The gage at 2nd St Pump Station however did not register any precipitation between May 1 and May 25. During this period, the recorded rainfall showed limited spatial variability. Thus the 2nd St Pump Station rainfall record is considered missing data for the May 1-25 period and can be supplemented with the data recorded at the Florida Grove Road gage.

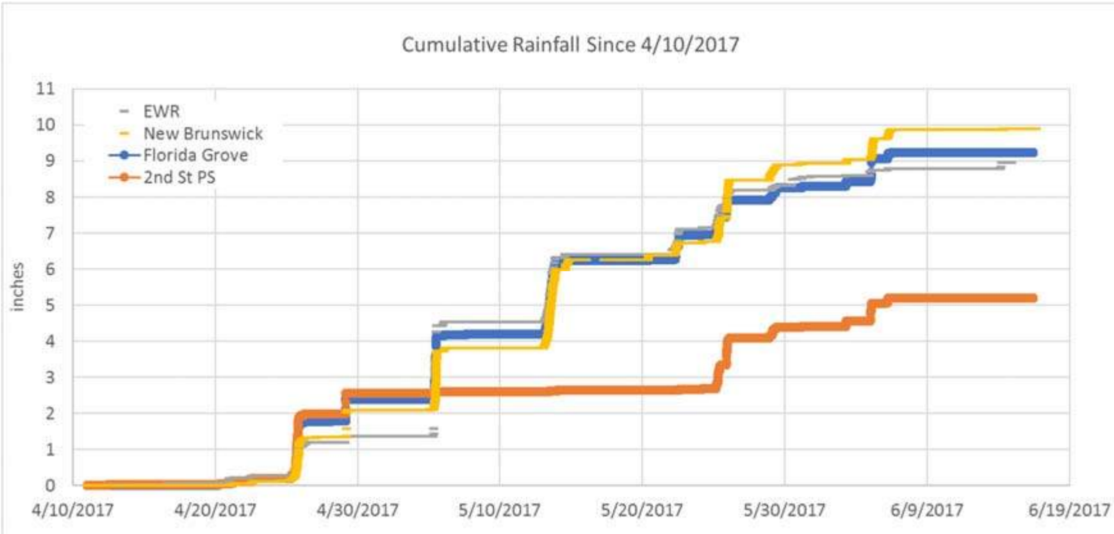


Figure 2 Cumulative plot of rainfall at each rain gage (April 2017 to present).

Identification of storm return period

The rainfall collected at Florida Grove Road gage was used for identifying the return periods of the storms. The first step in the analysis was identification of storms meeting the threshold of 0.5 inches in total event precipitation depth defined in the approved System Characterization Work Plan (August 2016) for consideration as potential calibration/validation events.

There were eight events that registered roughly 0.5 inches or more in total depth. Three storms have a return period of approximately 6-months with very different duration and intensity. Two storms were identified on May 25, 2017 using a 6 hour inter-event time and were both slightly less than 0.5 inches. Although independent events by this measure, they can also be used as a single calibration event with a back to back pattern.

Rainfall Events (Florida Grove Road Gage)				Return Period (based on EWR 1948 - 2016)				
Date/Start Time	Total Depth, in	Total Duration, hr	5-min Max, in	Full duration	1hr	2hr	6hr	12hr
4/25/2017 5:05	1.59	29.83	0.05	1-3m				
4/29/2017 3:50	0.61	0.58	0.26	~6m				
5/5/2017 1:10	1.75	12.08	0.19	<6m	3-6m	6m-1yr	6m-1yr	3-6m
5/13/2017 1:55	1.97	20.58	0.03	3-6m				3m
5/22/2017 3:40	0.7	11.83	0.04	2w-1m				
5/25/2017 3:10	0.49	8.33	0.02	~2w				
5/25/2017 21:00	0.46	2.33	0.12	<1m				
6/4/2017 23:35	0.64	3.25	0.26	>1m	<3m			

Potential Calibration and Validation Events

Based on the storm statistics listed in the above table, the following storms have been selected for use in model calibration:

- Short duration high intensity storm: 4/29/2017
- Long duration storm: 5/13/2017
- Back to back storms: 5/25/2017

The following two storms have been selected for model validation:

- 4/25/2017
- 5/5/2017

These recorded rainfall events exhibit characteristics that should enable successful use as model calibration and validation events. However, prior to finalizing the selection of these events, flow meter data for the same event periods must be reviewed to confirm that sufficient hydrologic responses were observed and flow data successfully captured at the flow meter sites for these storms.

Metered Hydrologic Responses

Flow meters were deployed at three locations in the western portion of the system to record depth velocity and flow. Data recorders were installed at the effluent side of the three pump stations to obtain digital flow data (previously only circular chart data was available at these locations). General data quality and the strength of the hydrologic responses during the identified storms were evaluated.

Depth, velocity, and flow data

As shown in the attached schematic, the three meters were located at the trunk sewer upstream of P019 overflow (72”), interceptor downstream of P017 overflow (30”), and interceptor immediately upstream of P016 overflow (84”). Data were plotted in the sequence mentioned above.

All data recorded at the 72” site showed very good quality and distinctive responses during all storms (see Figure 3).

All data recorded at the 30” site showed good quality and distinctive responses during all storms. Backwater conditions were observed during the April 29 storm, evident by the excessive high depth accompanied by a drop in velocity (see Figure 4).

All data recorded at the 84” site showed good quality and distinctive responses during all storms. Backwater conditions were observed during all storms, evident by the excessive high depth accompanied by a drop in velocity (see Figure 5).

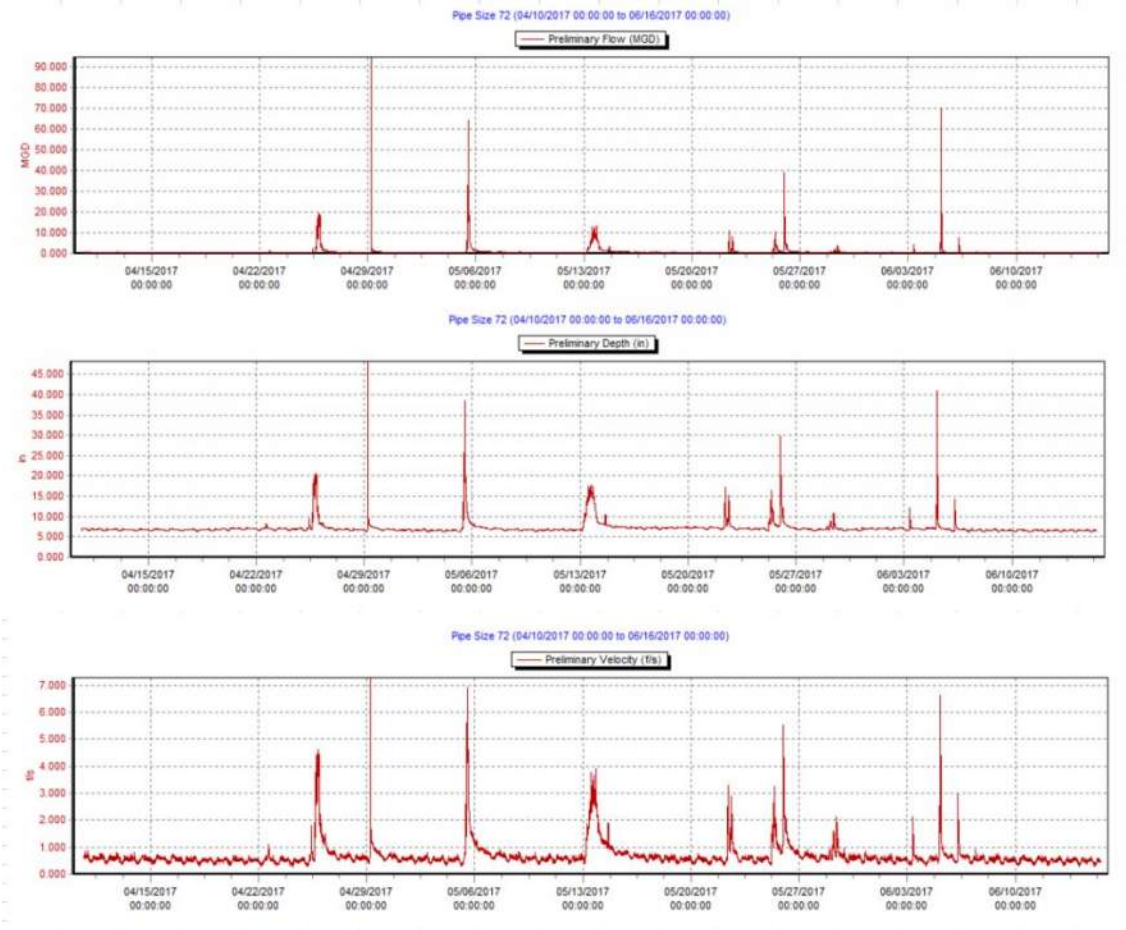


Figure 3 Observed flow data – 72” site

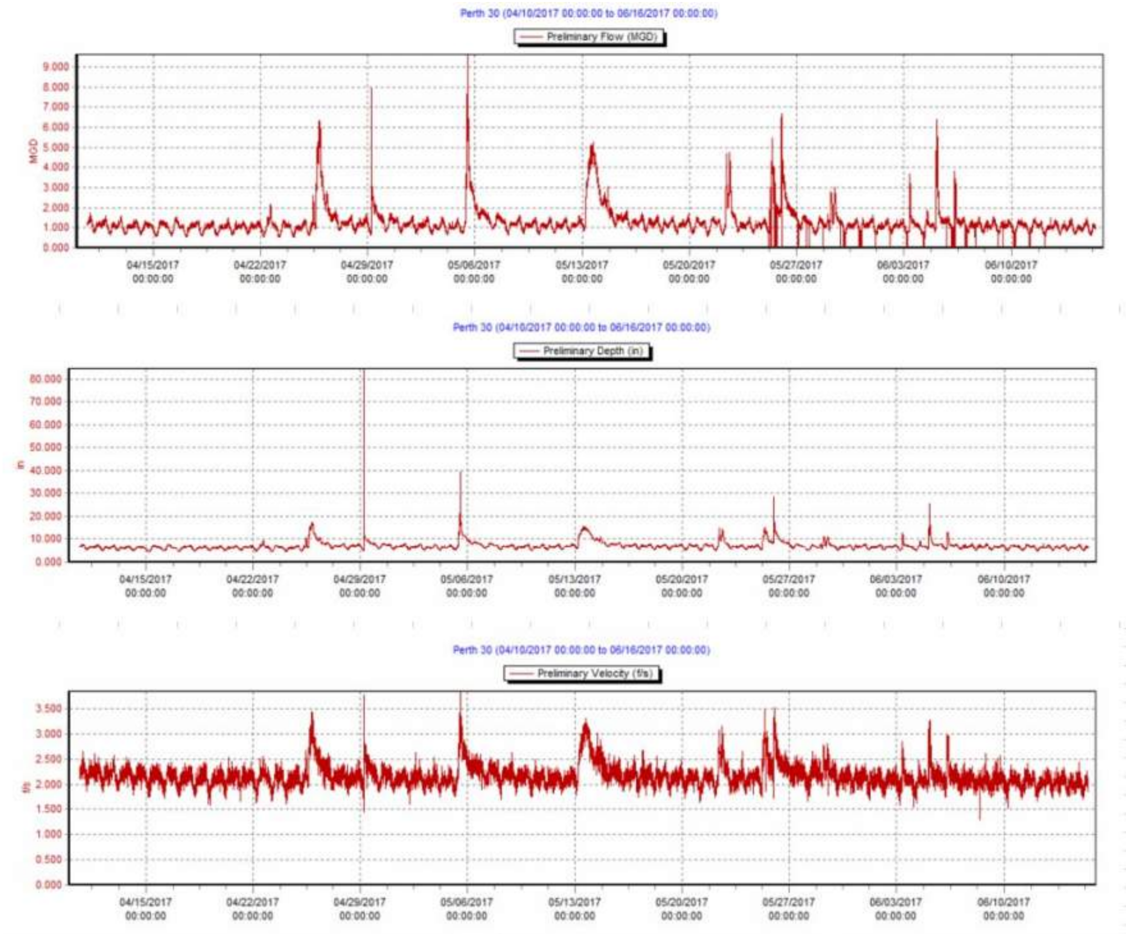


Figure 4 Observed flow data – 30" site

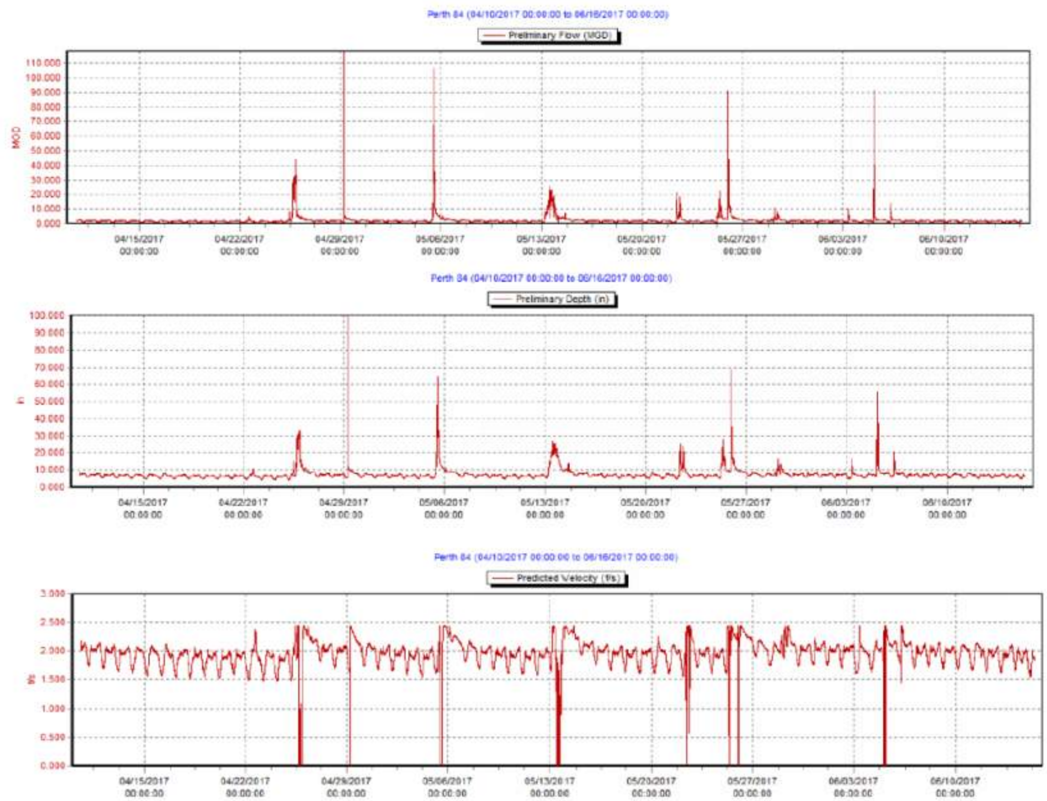


Figure 5 Observed flow data – 84” site

Pump station effluent data

The recorded pump station effluent flows are shown on Figure 6 below. For the two upstream pump stations, State St and Front St, flows were shown in gallons per minute (gpm) due to the relatively small capacity of these stations. At the 2nd St pump station, flow was plotted in million gallons per day (mgd). During dry weather the pumps were turning on and off and only during wet weather events the pumps would stay on for an extended period of time. Other than State St pump station, which had data issues before April 28th, all three pump stations recorded the system response to the recorded storms.

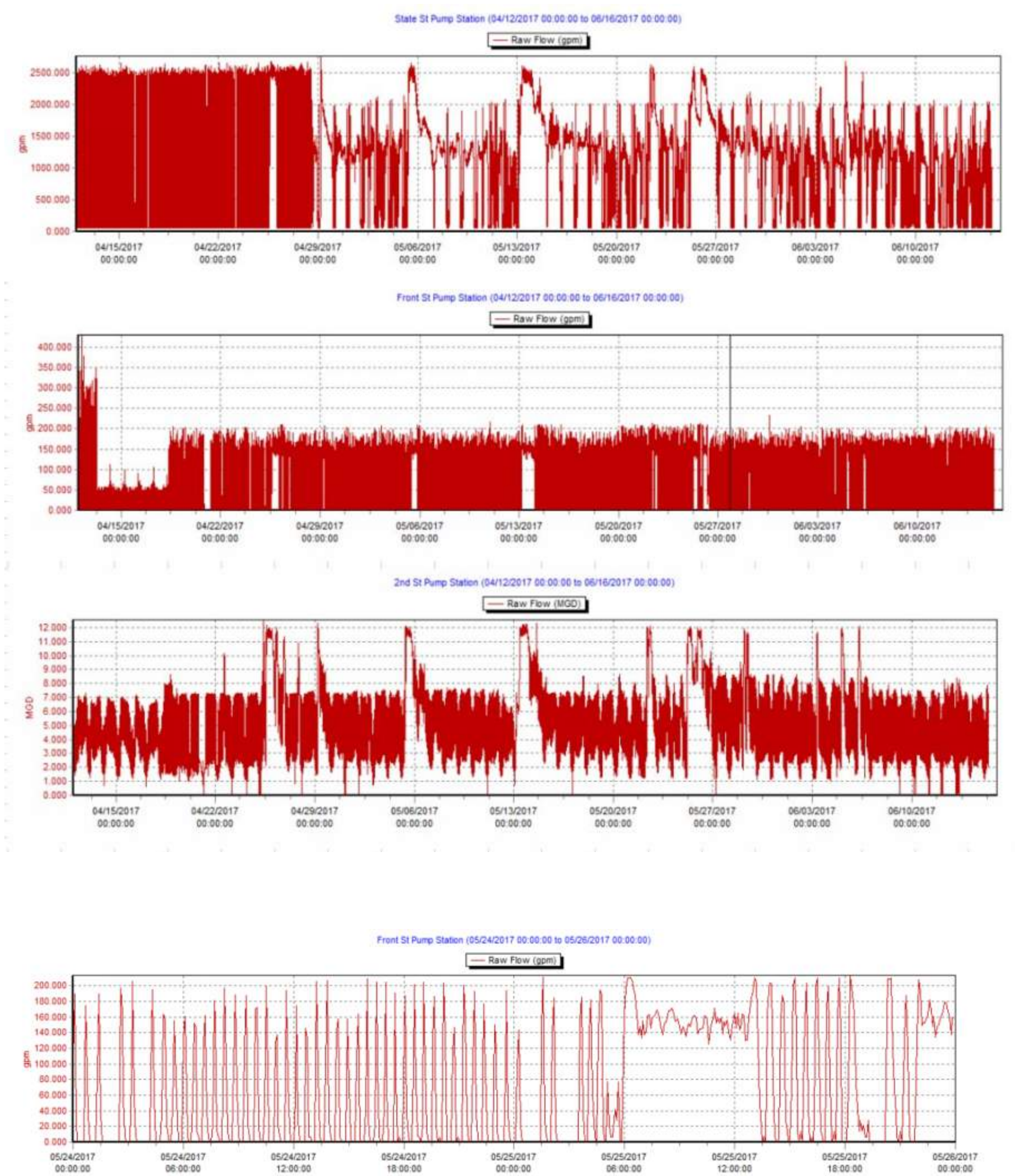


Figure 6 Observed flow data – 2nd Street, State Street and Front Street Pump Station sites

Conclusions

The approved System Characterization Work Plan stated that "the temporary monitoring period will include at least three representative precipitation events, with rainfall depth of at least 0.5 inches producing an observable hydrologic response in the combined sewer system". Since the metering program commenced during the second week of April, 5 at least six precipitation events had been identified which fully satisfy the defined precipitation and system response requirements. In addition, two others effectively meet the 0.5 inch precipitation threshold (0.49 and 0.46 are effectively equal to 0.5) and meet the system response requirements.

Based on the above conclusions, we are confident that the available flow and precipitation data fully satisfy the System Characterization Work Plan requirements to support model calibration and validation.

cc: CDM Smith Project File: 110875

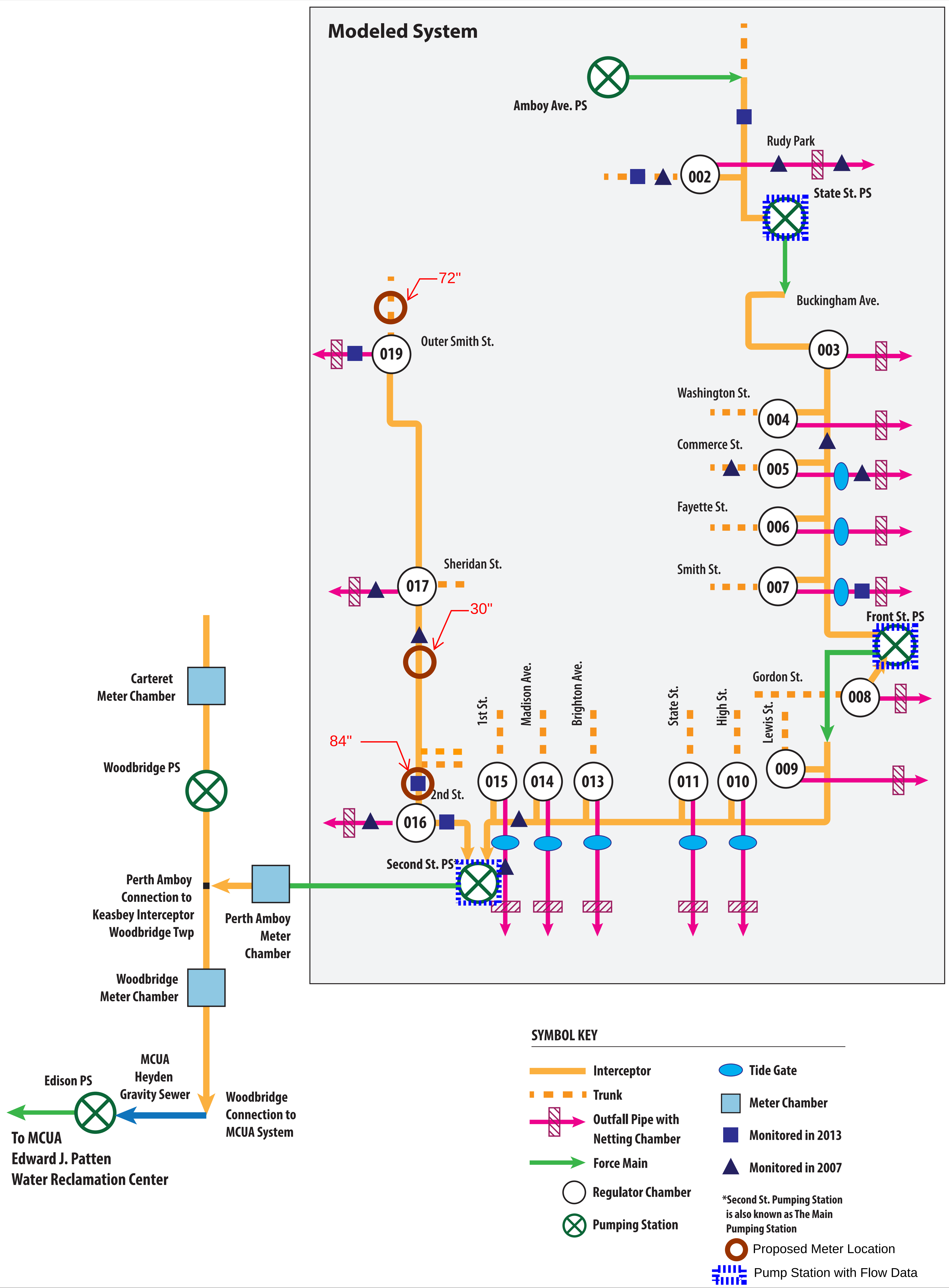


Figure 2-2 System Schematic with Flow Meters

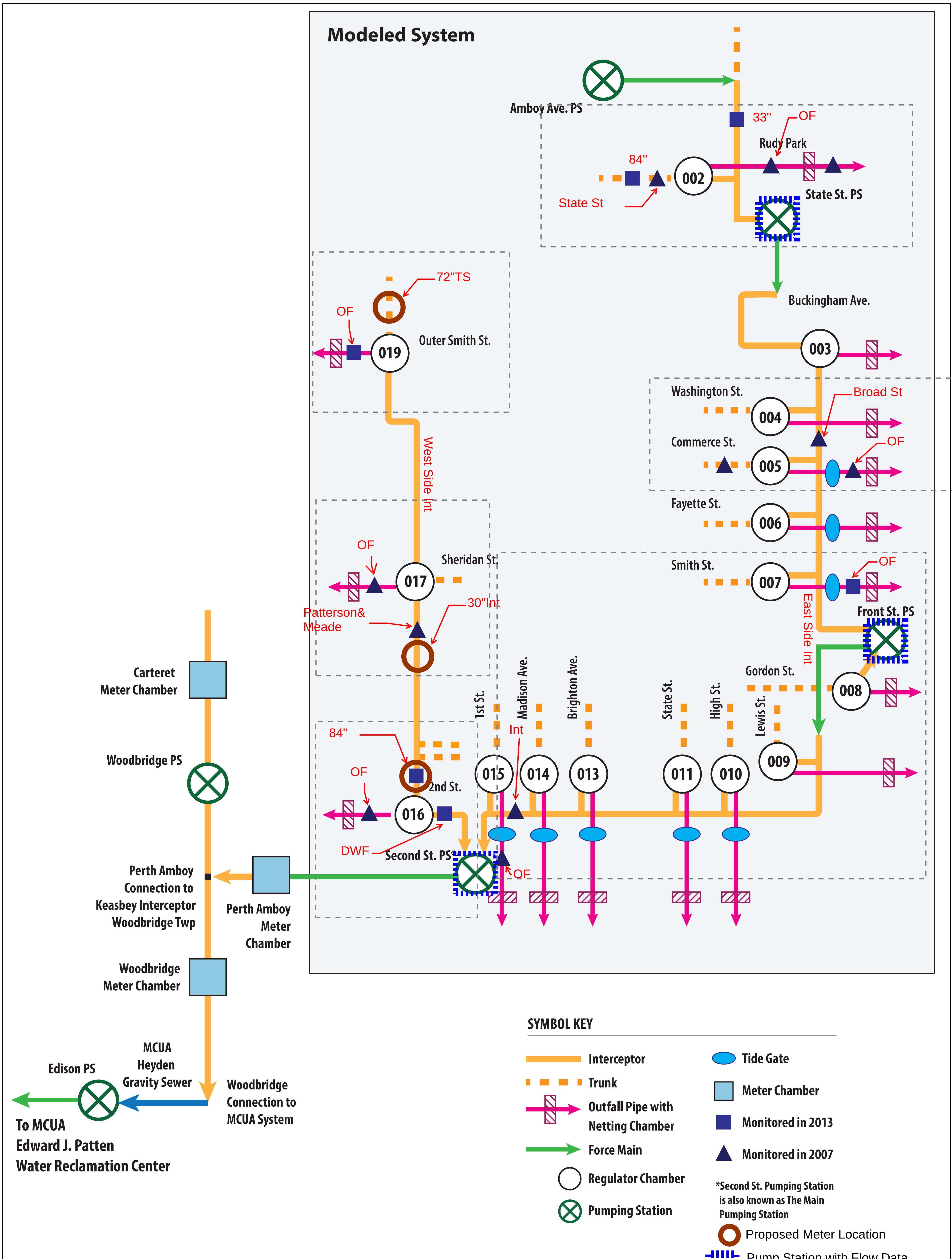
System Characterization Work Plan

CDM Smith

City of Perth Amboy
Middlesex County, New Jersey

Appendix C

Scatterplots and Hydrographs



System Schematic with Flow Meters

System Characterization Report

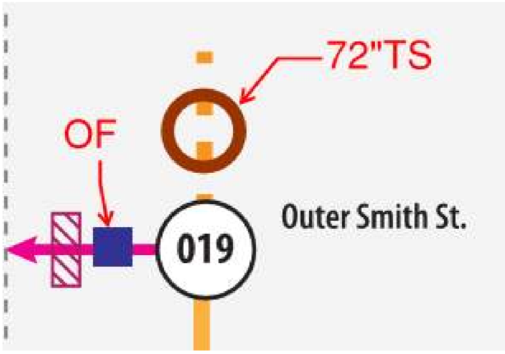
CDM Smith

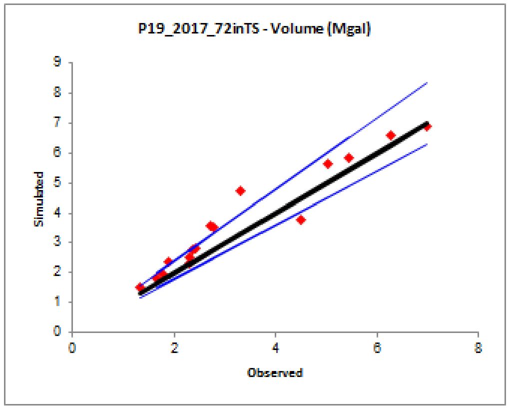
City of Perth Amboy
Middlesex County, New Jersey

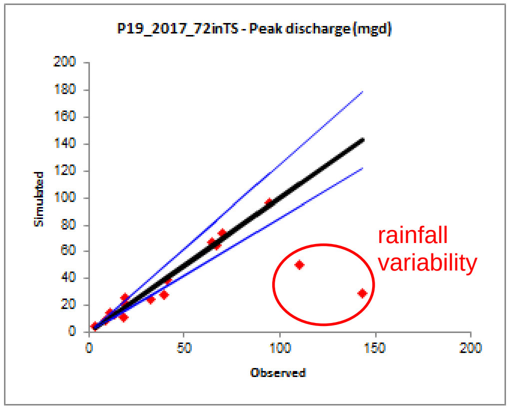
The goodness of fit of model calibration and validation is summarized using scatter plots. The scatter plots compare modeled and observed values with one value pair representing each storm. The parameters evaluated are flow volume, peak flow rate, peak depth, and peak velocity. At sites where only depth data are available, only peak depths are shown. The black 45-degree line indicates an ideal fit, with modeled values matching observations. The blue lines bracketing the black line are adapted from guidelines published by the UK's Chartered Institution of Water and Environmental Management Urban Drainage Group (CIWEM, 2017). The ranges used in the scatter plots are:
volume +20% to -10%
Peak flow +25% to -15%
Peak depth +1.6' to -0.3'
Peak velocity +25% to -15%

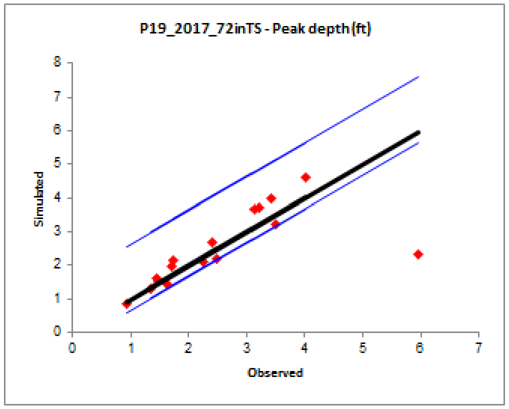
The calibration process involves assessing the qualitative weight to assign among different, and possibly conflicting datasets. Two such challenges involve weighting recent and historic data, and working with data obtained under difficult hydraulic conditions. Where meters were placed at the same location in different years, calibration of the more recent year was given more weight. Meters in CSO outfalls often yield lower quality data, as low velocity and low depth conditions often prevail, and the instruments often cannot be field-calibrated, as there is no dry weather flow. More weight was assigned to surrounding sites in the interceptors and trunk sewers.

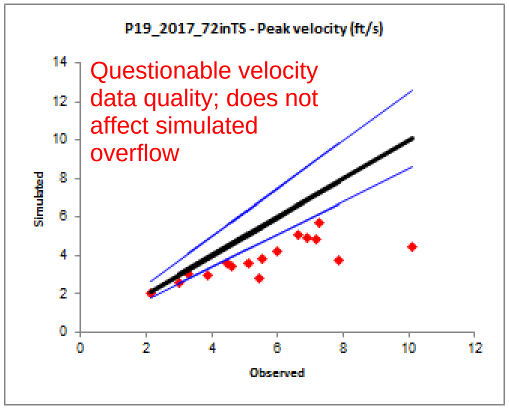
West Side P19 Scatter Plots

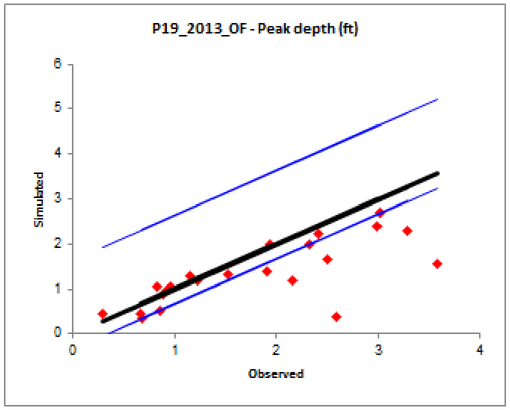




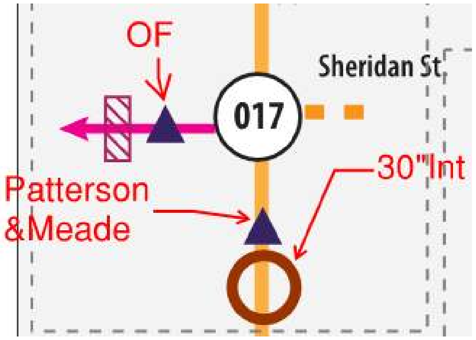


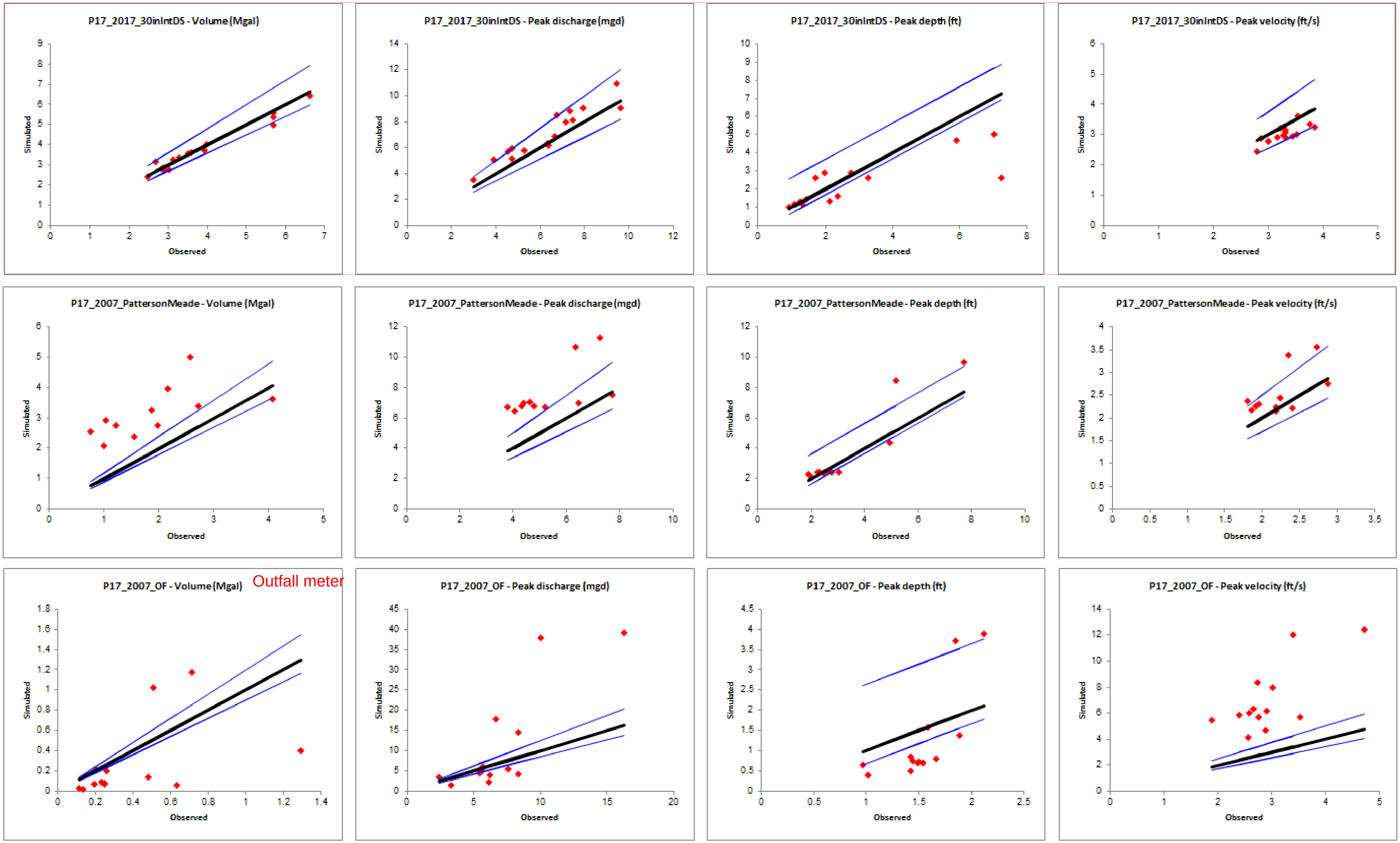




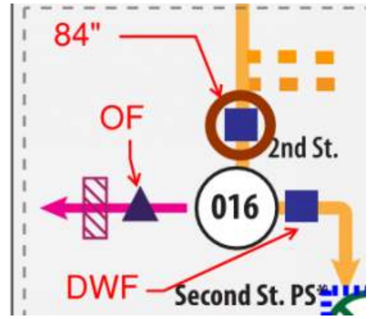


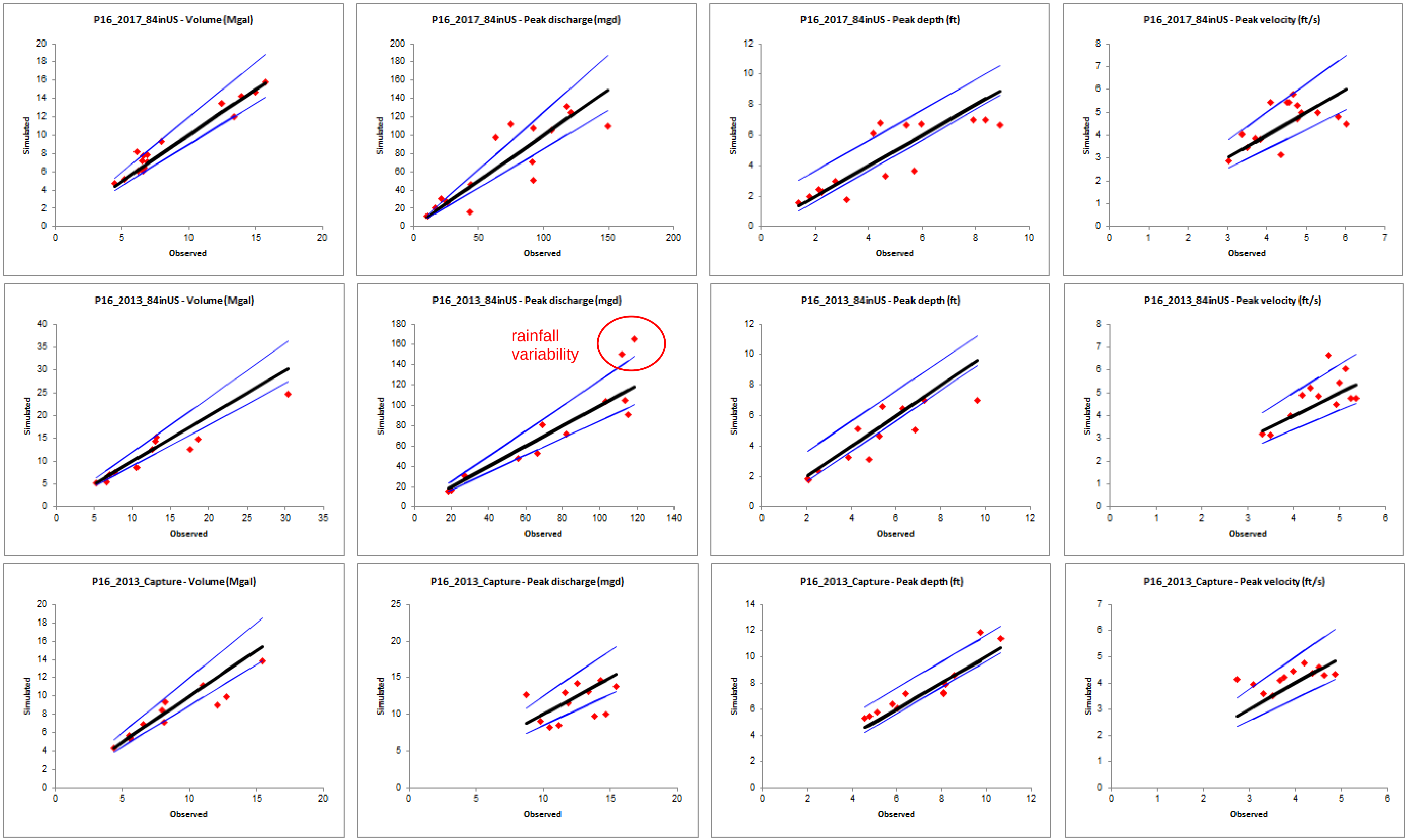
West Side P17 Scatter Plots



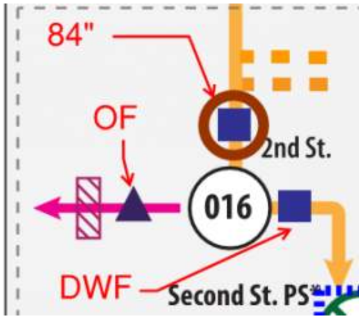


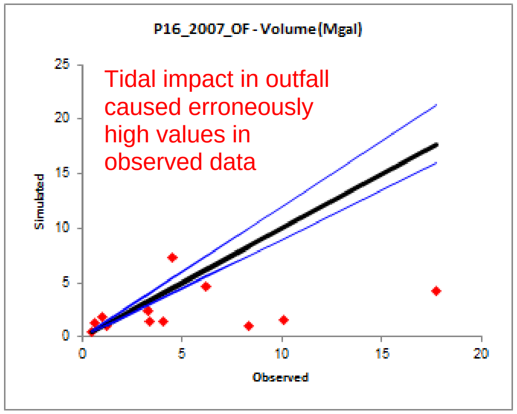
West Side P16 Scatter Plots

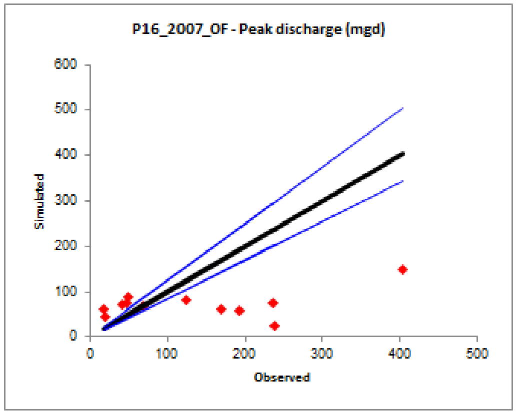


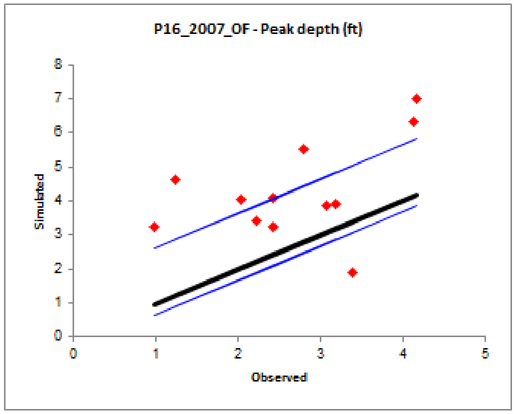


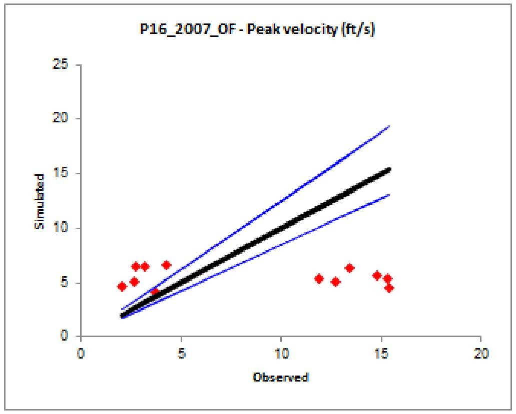
West Side P16 Scatter Plots (Cont.)



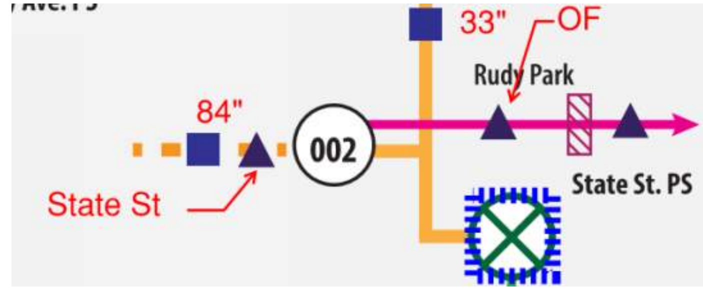


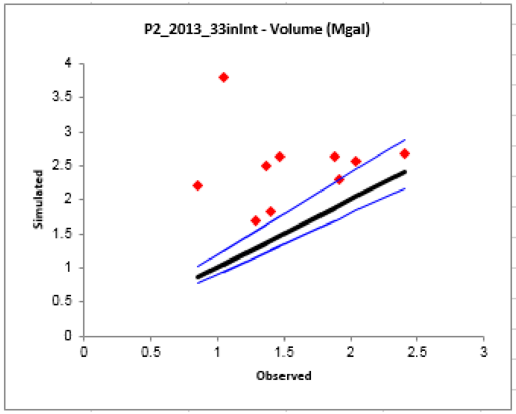


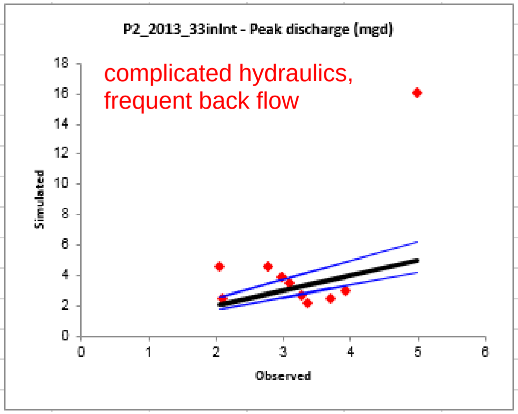


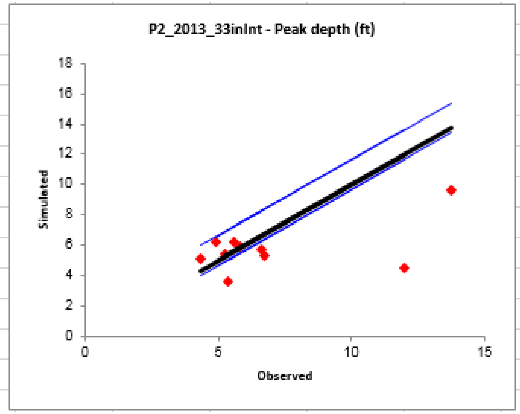


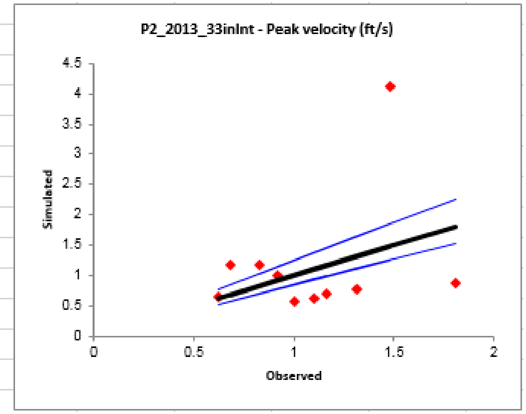
East Side P2 Scatter Plots

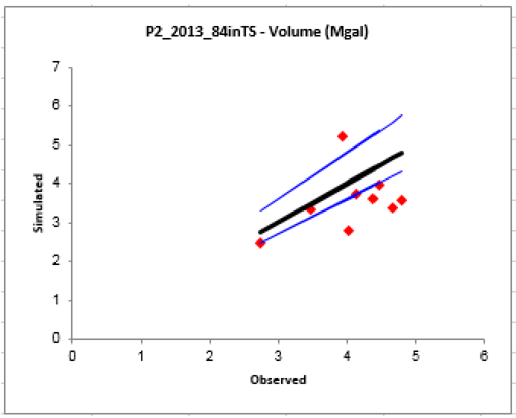


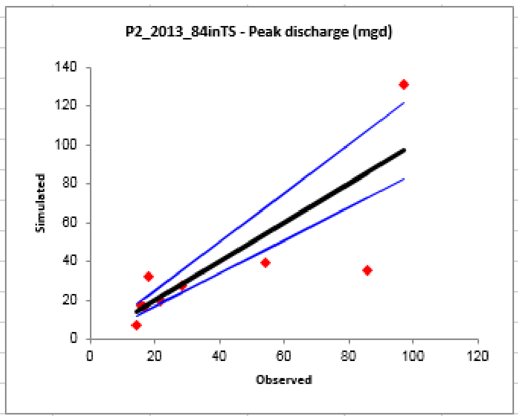


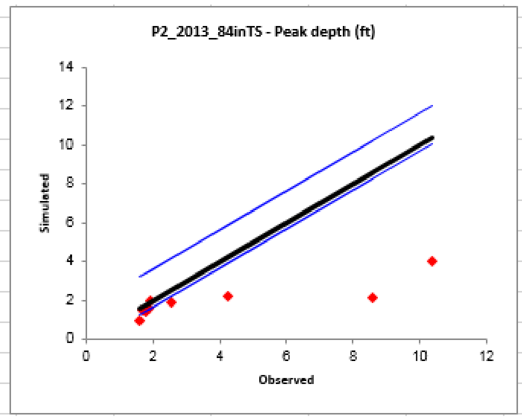


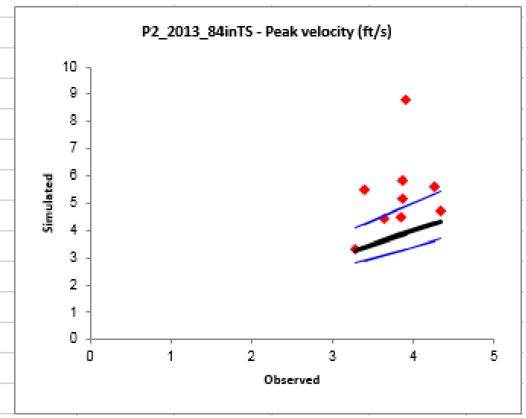




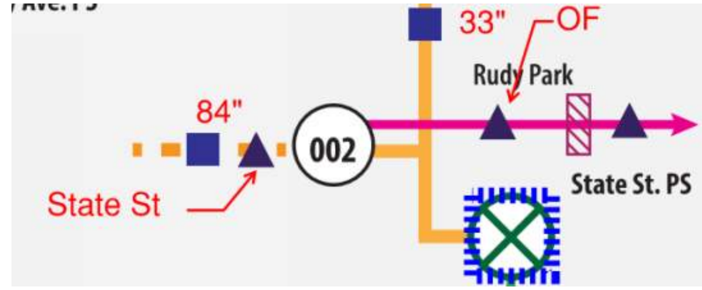


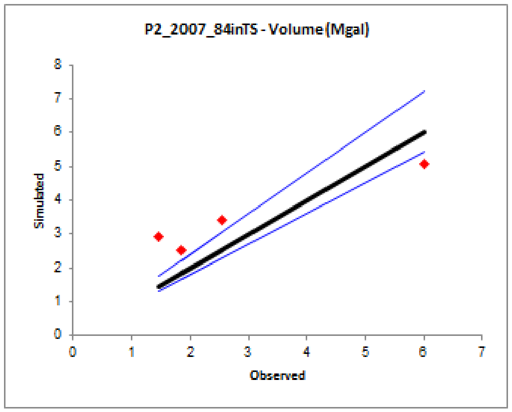


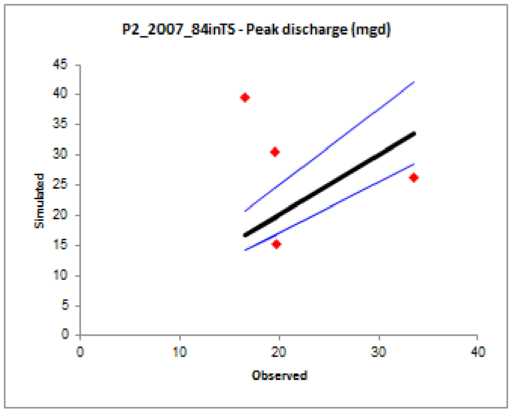


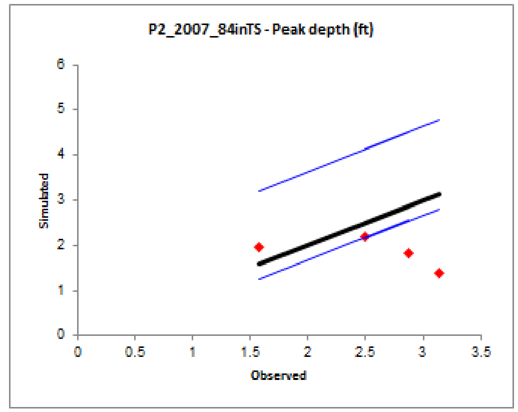


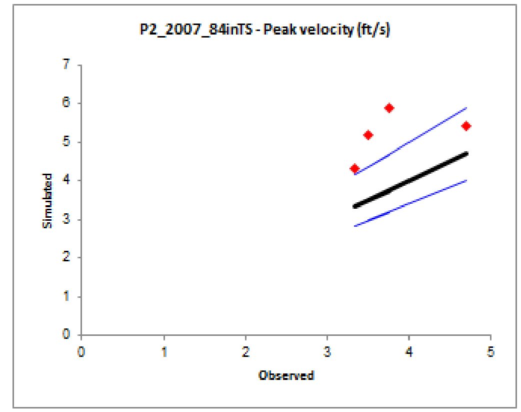
East Side P2 Scatter Plots

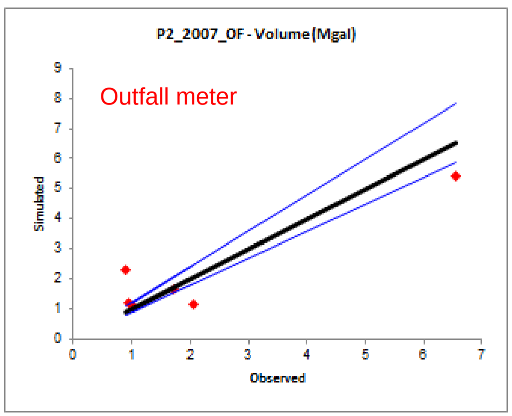


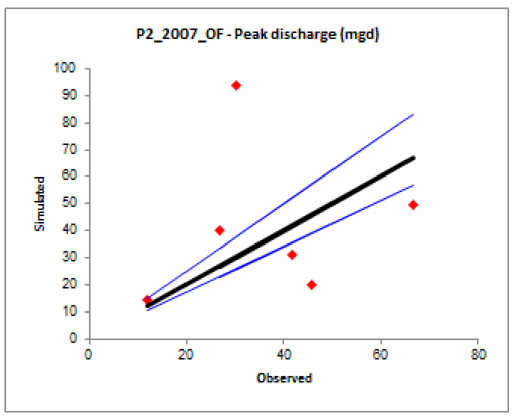


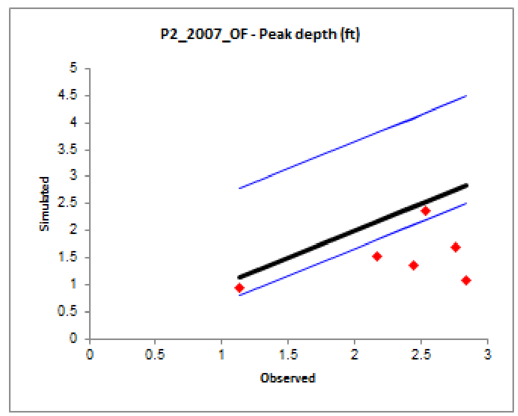


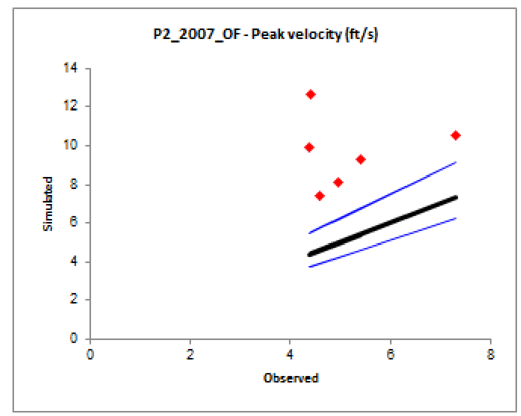




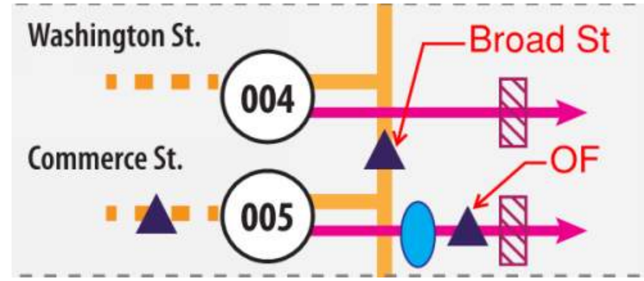


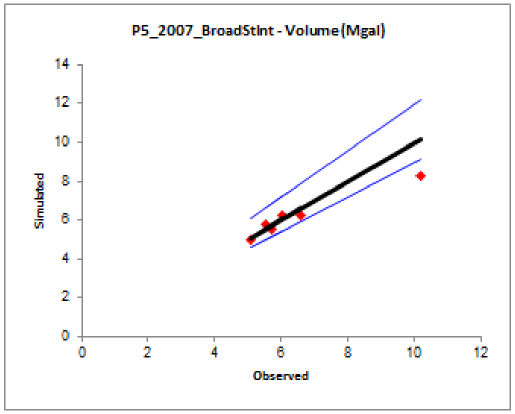


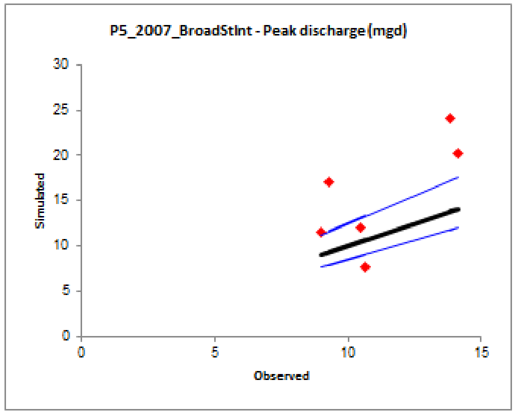


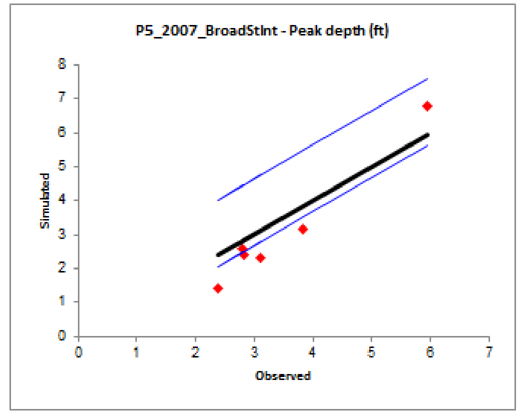


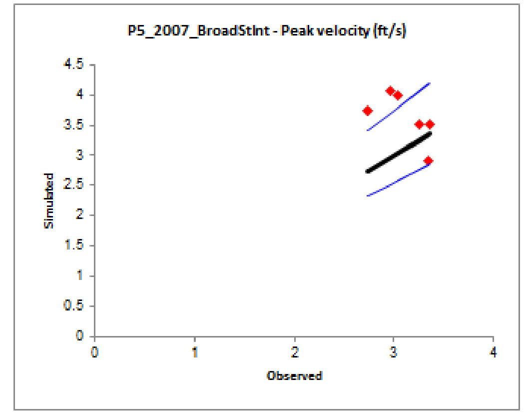
East Side P5 Scatter Plots

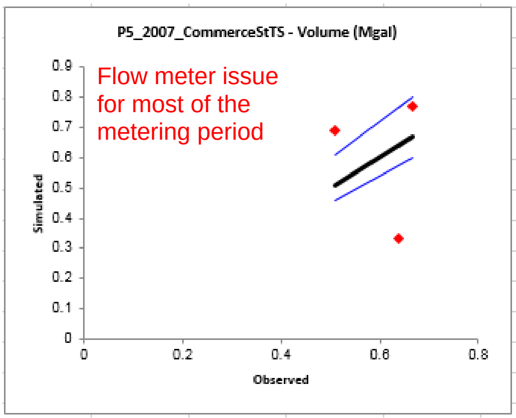


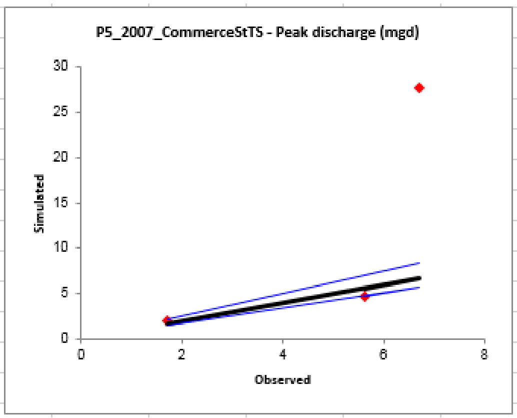


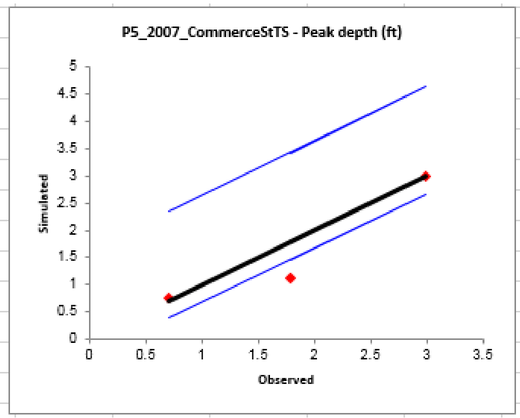


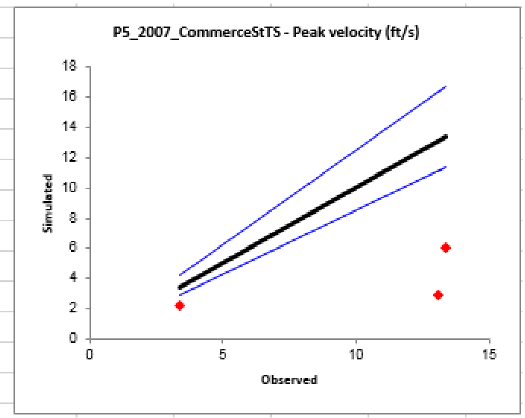


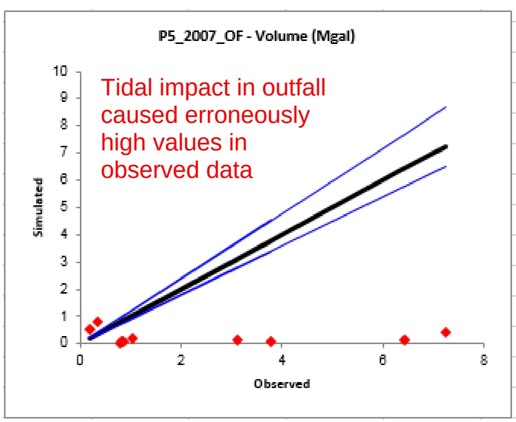


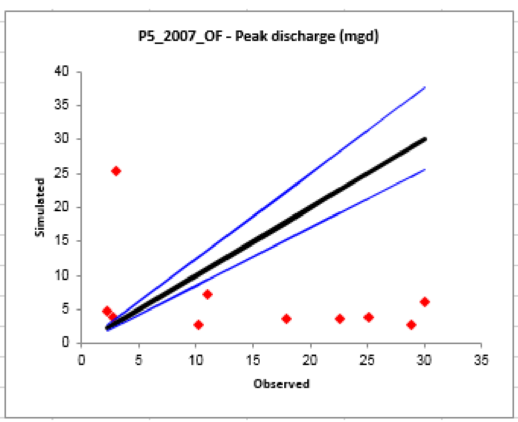


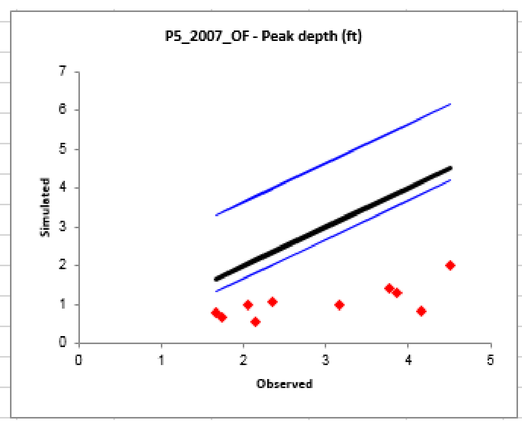


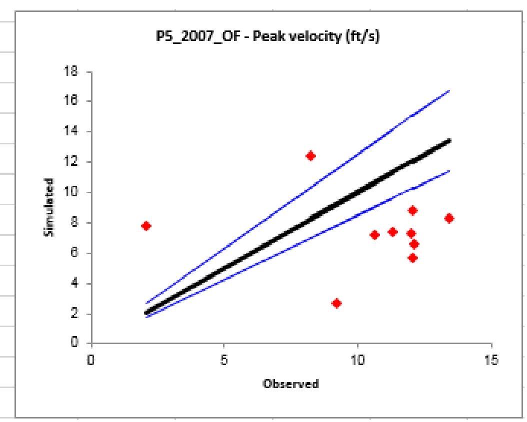




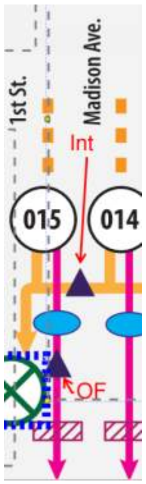


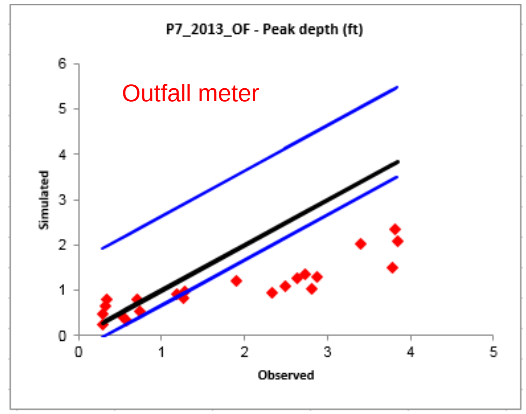


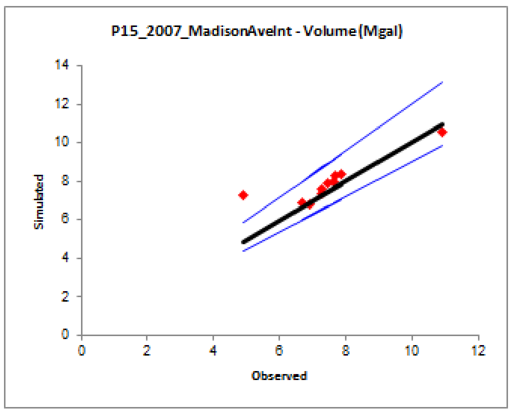


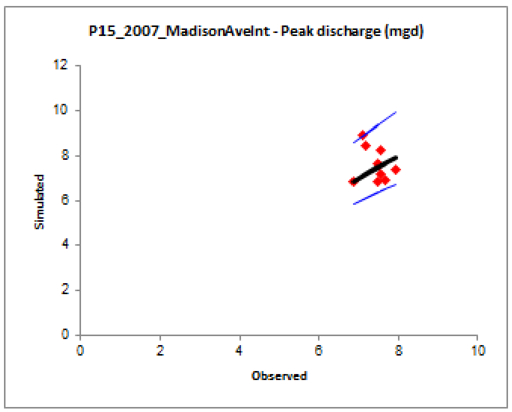


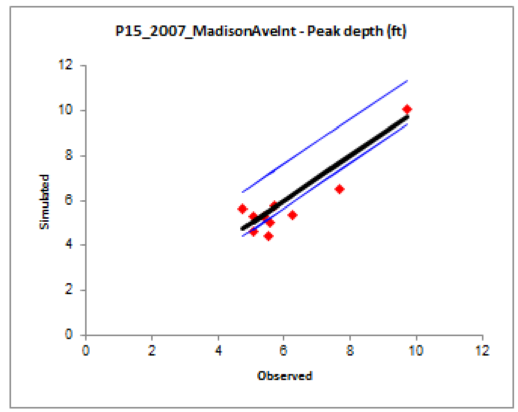
East Side Others Scatter Plots

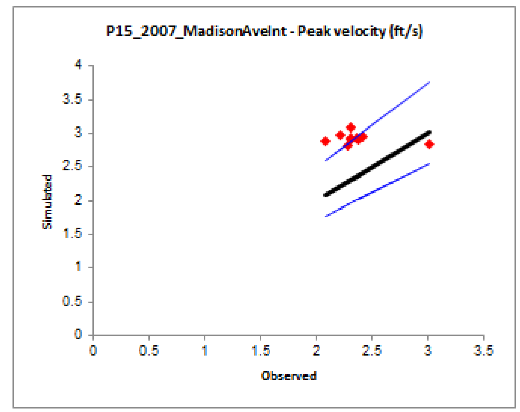


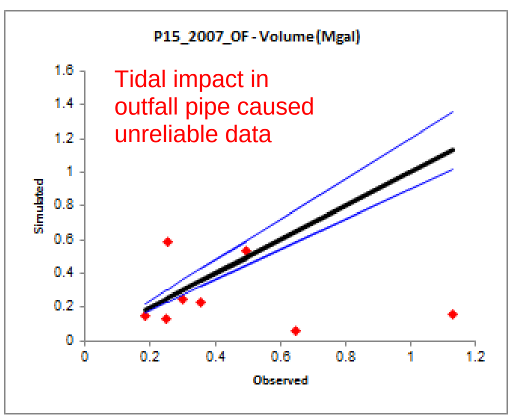


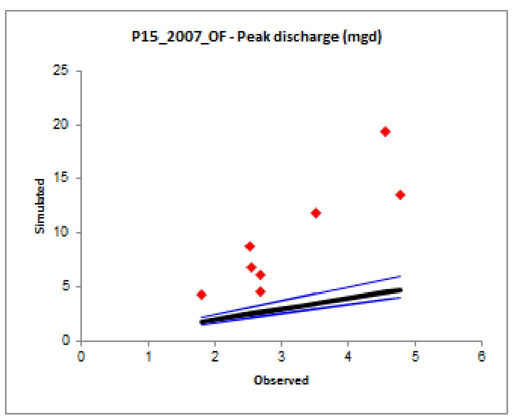


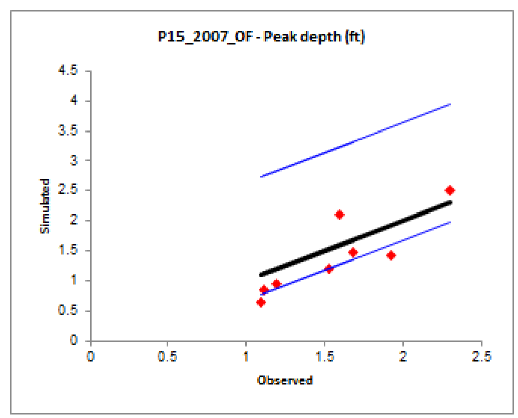


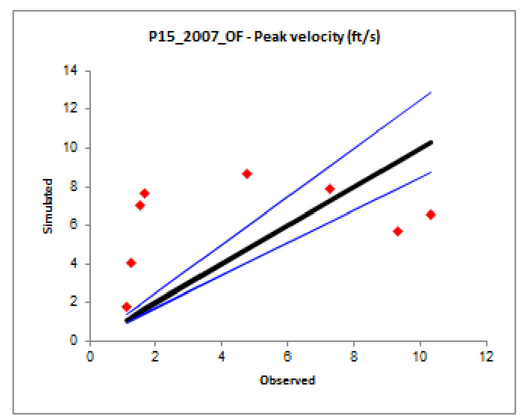




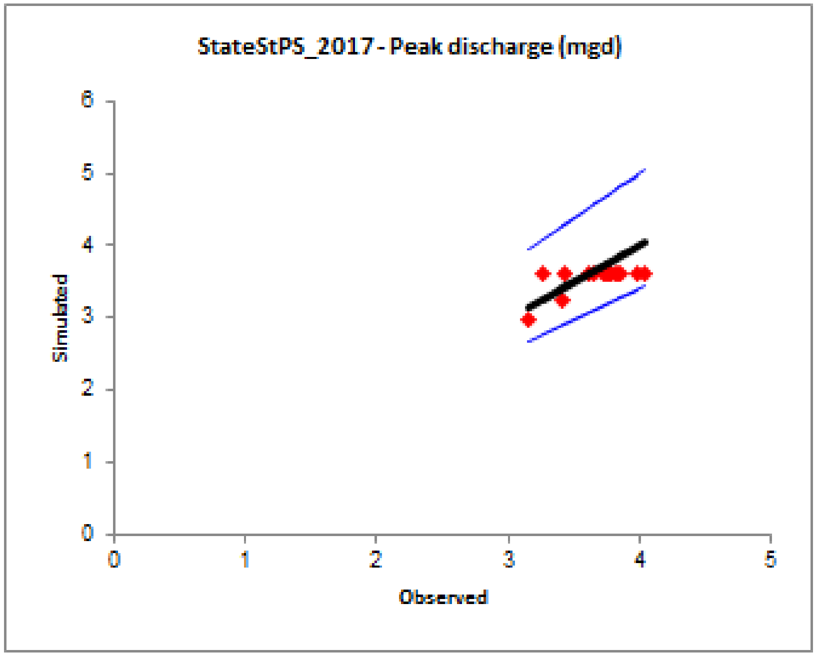


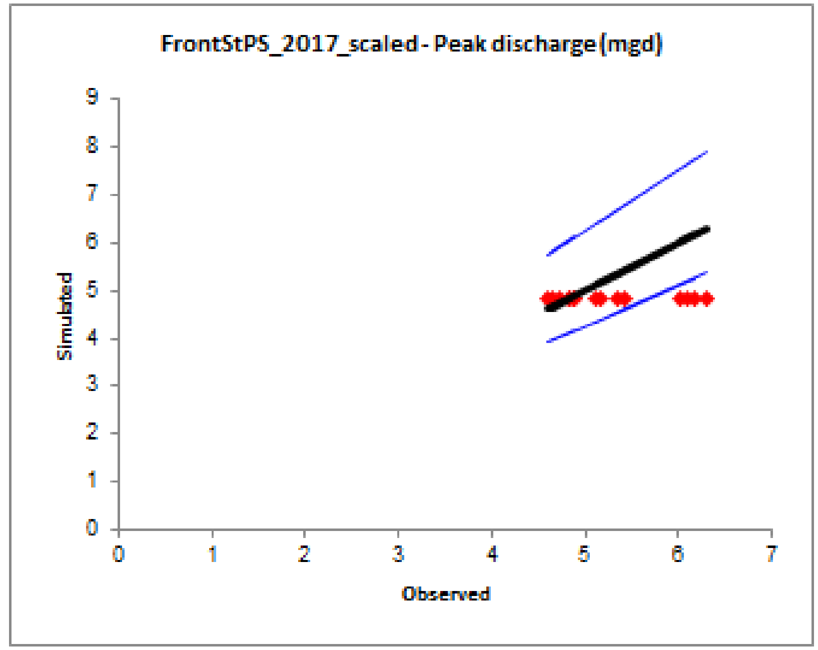


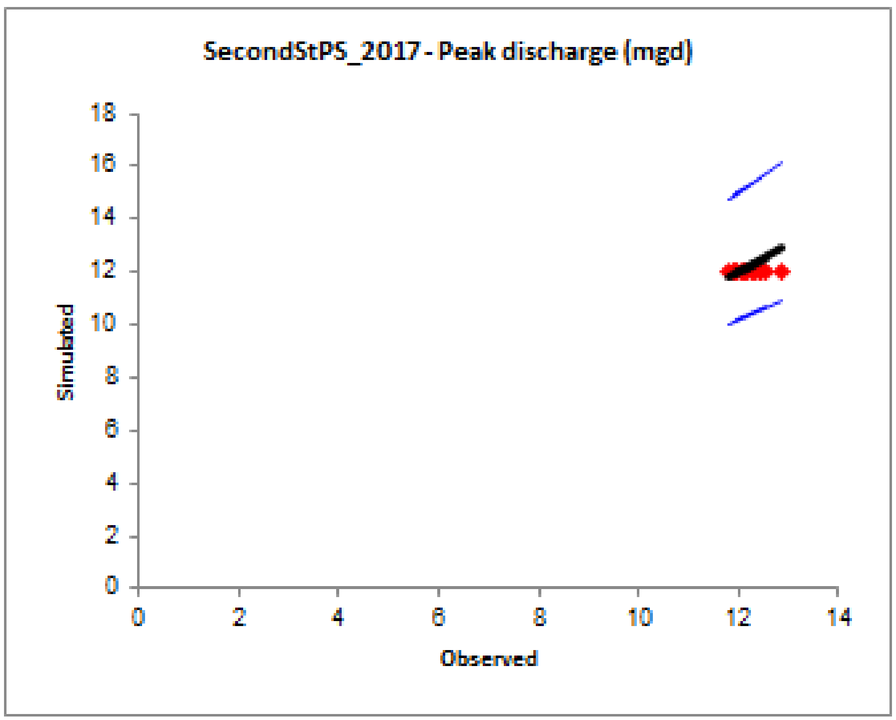




Pump Station Peak Flow Scatter Plots



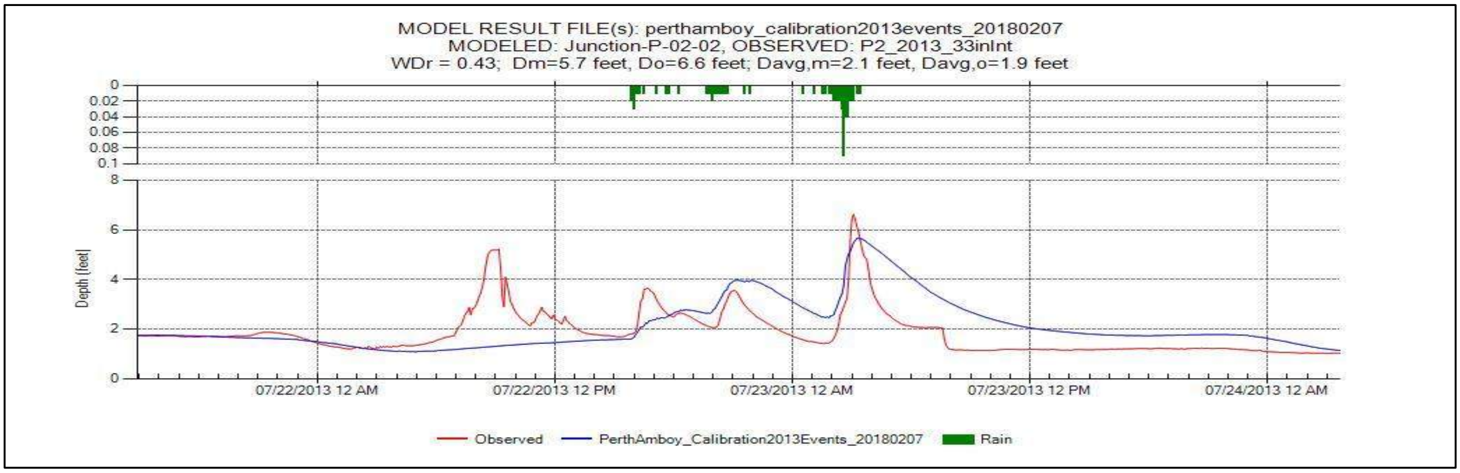


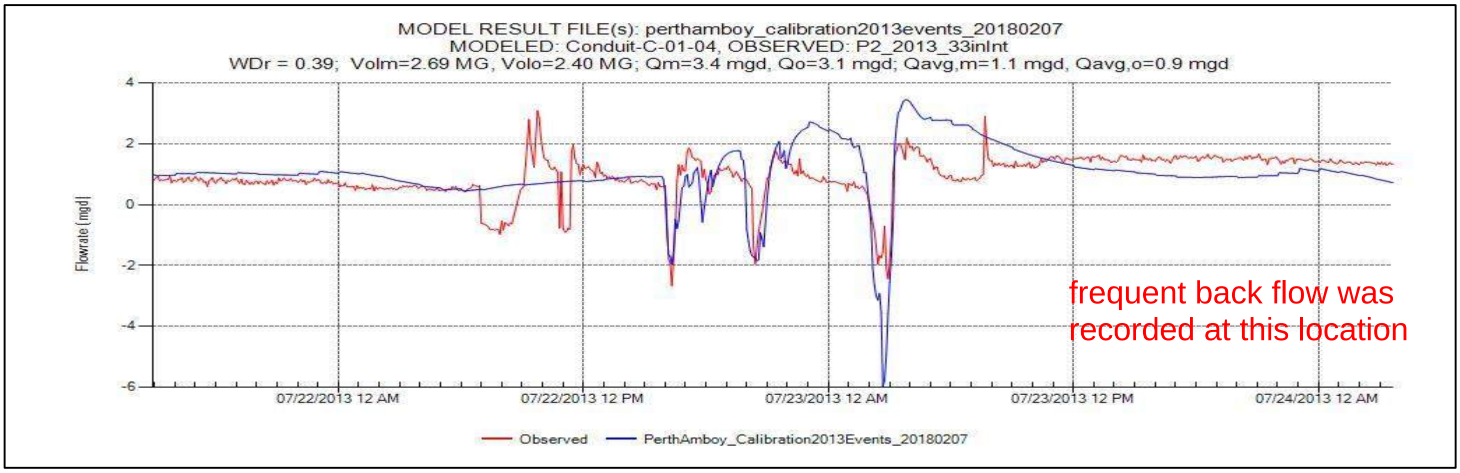


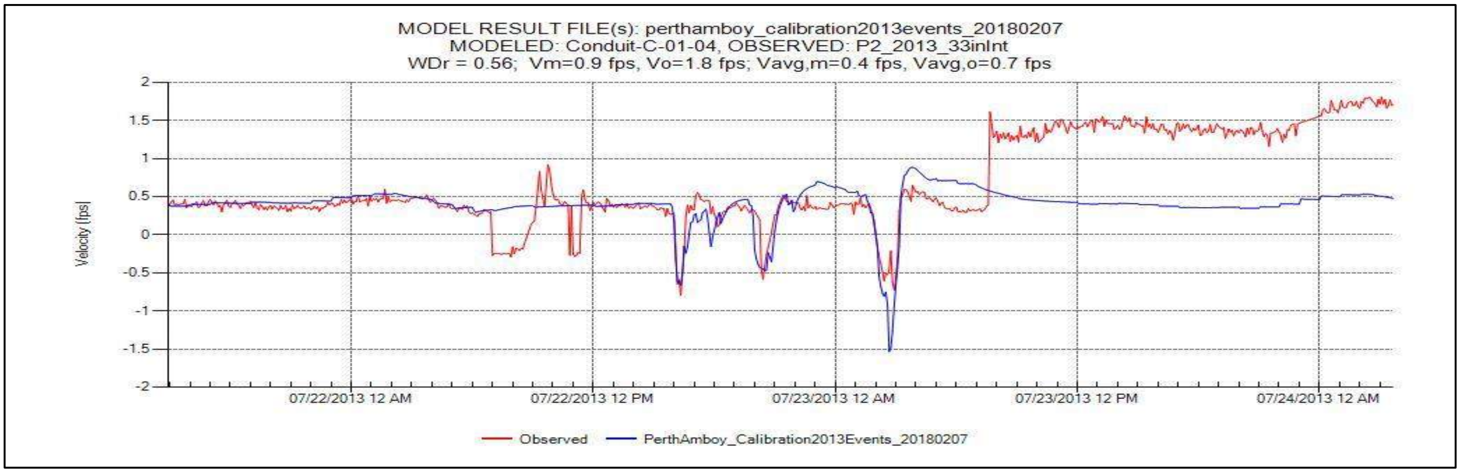
Appendix C - Time Series Plots

Time Series Plots:
Eastside Interceptor

P2_2013_33inInt







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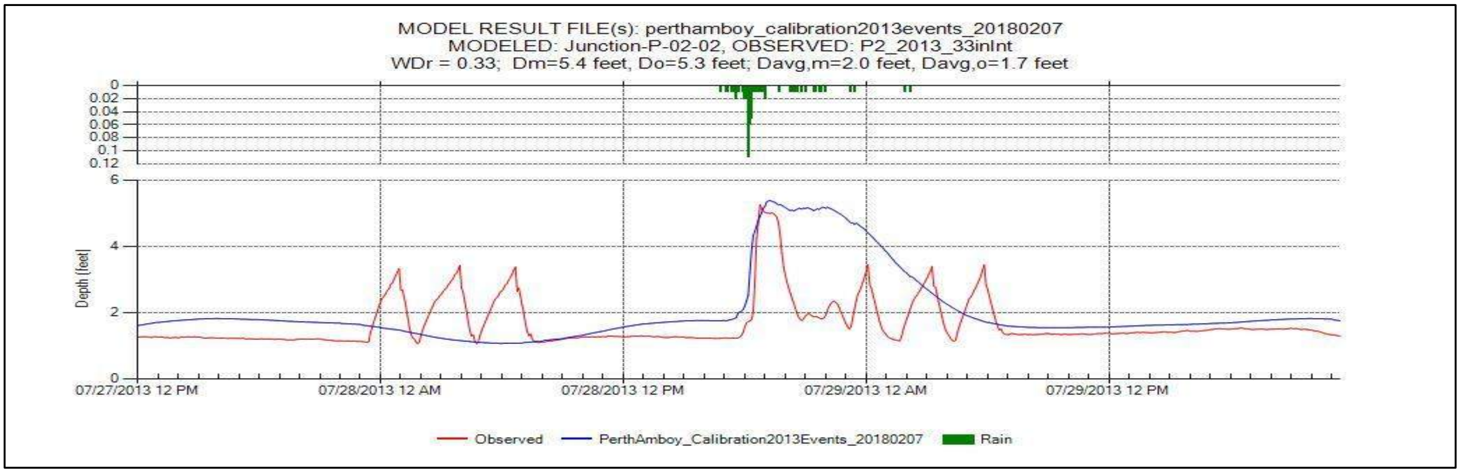

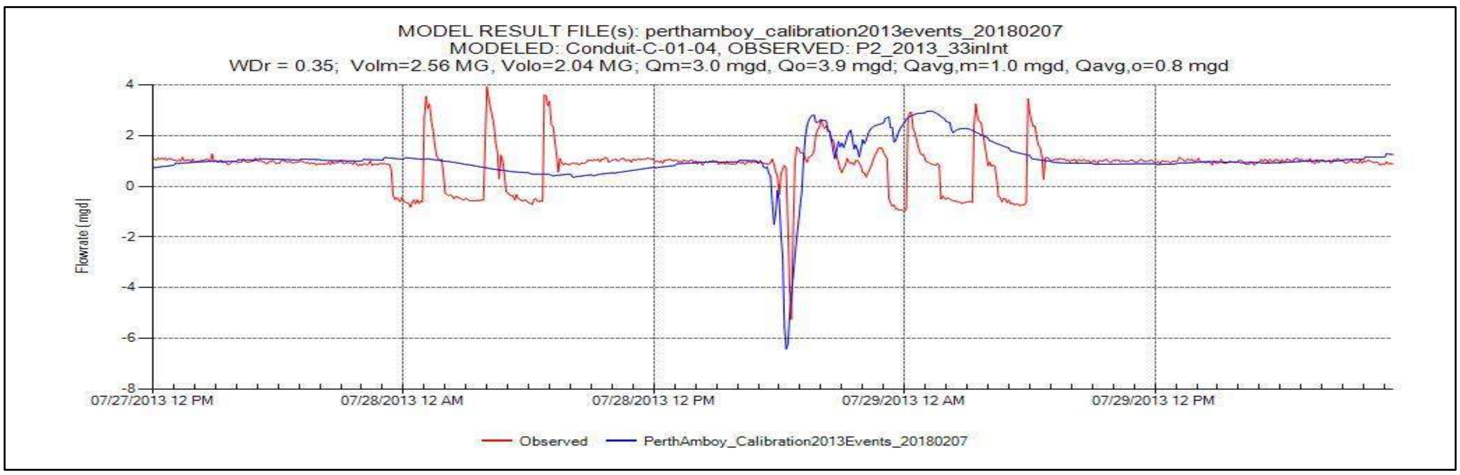

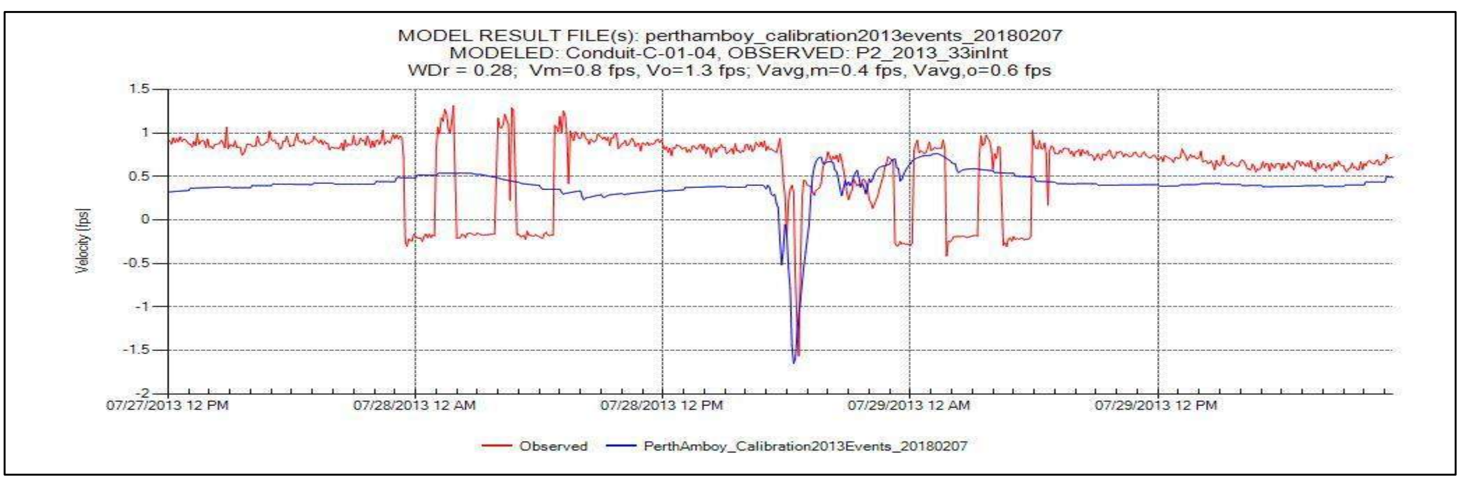

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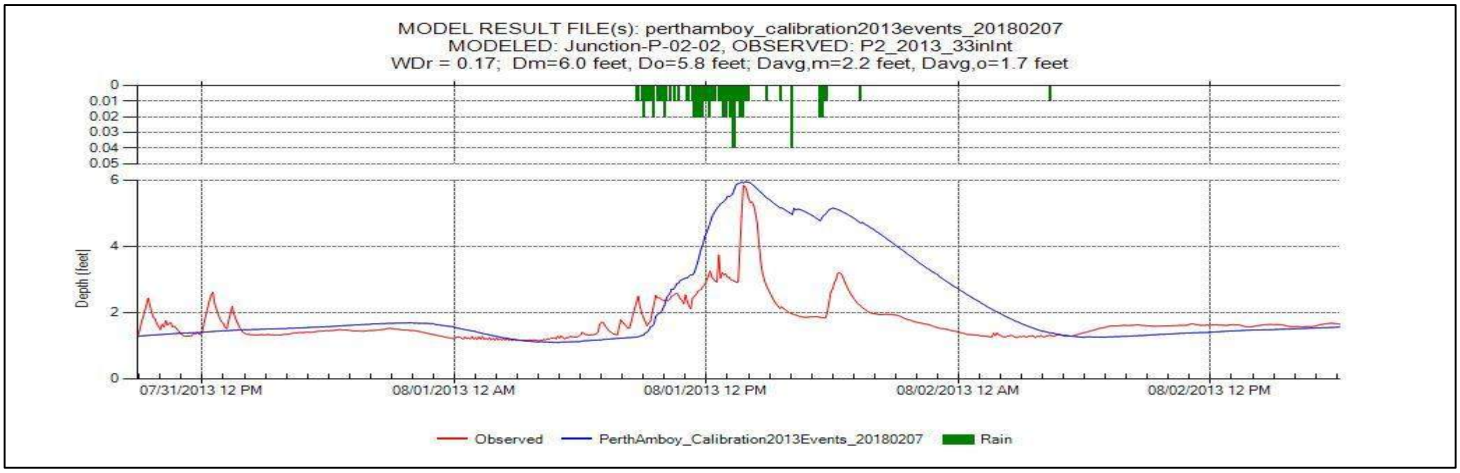

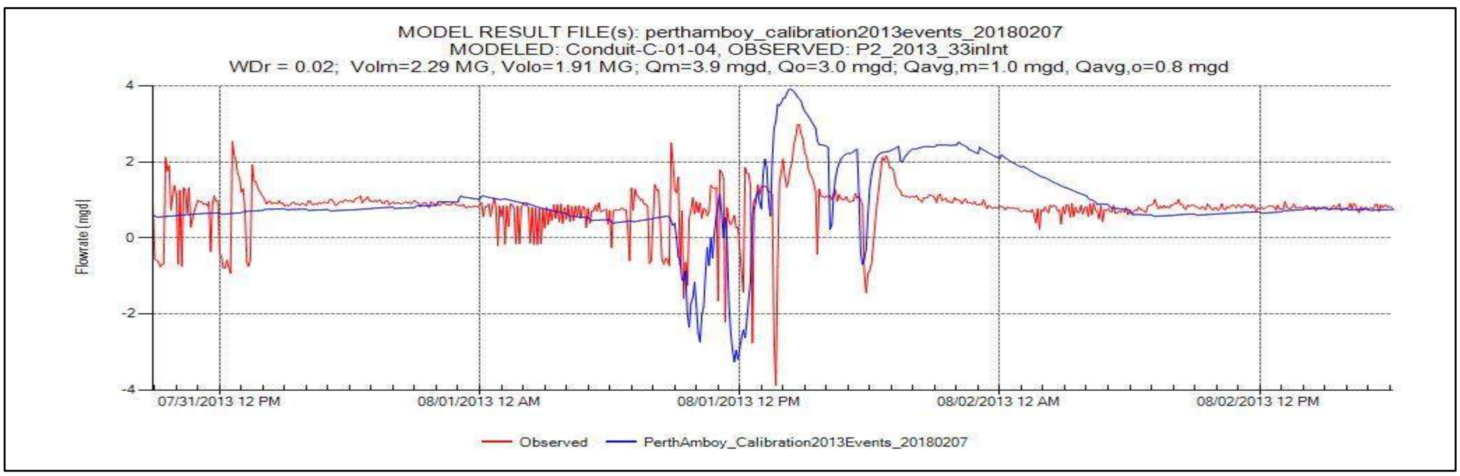

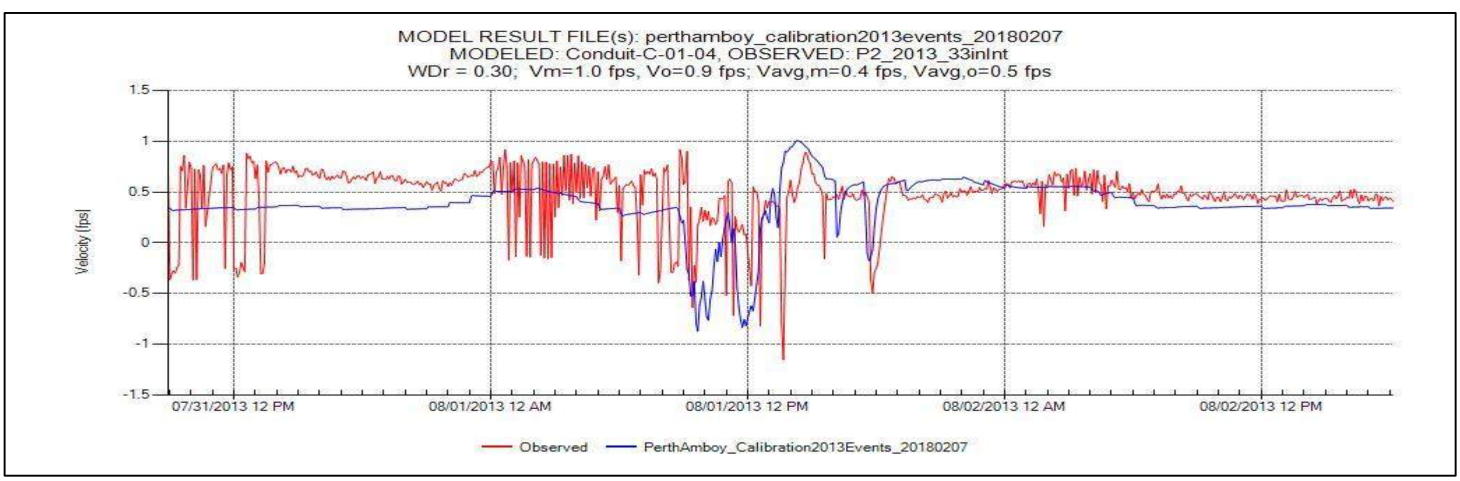

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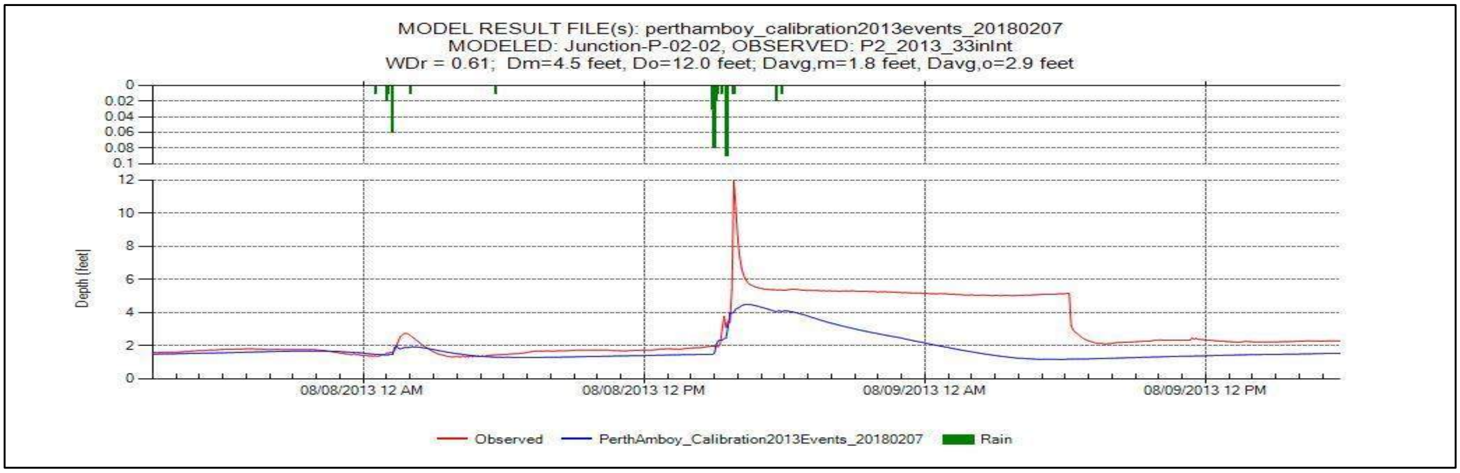

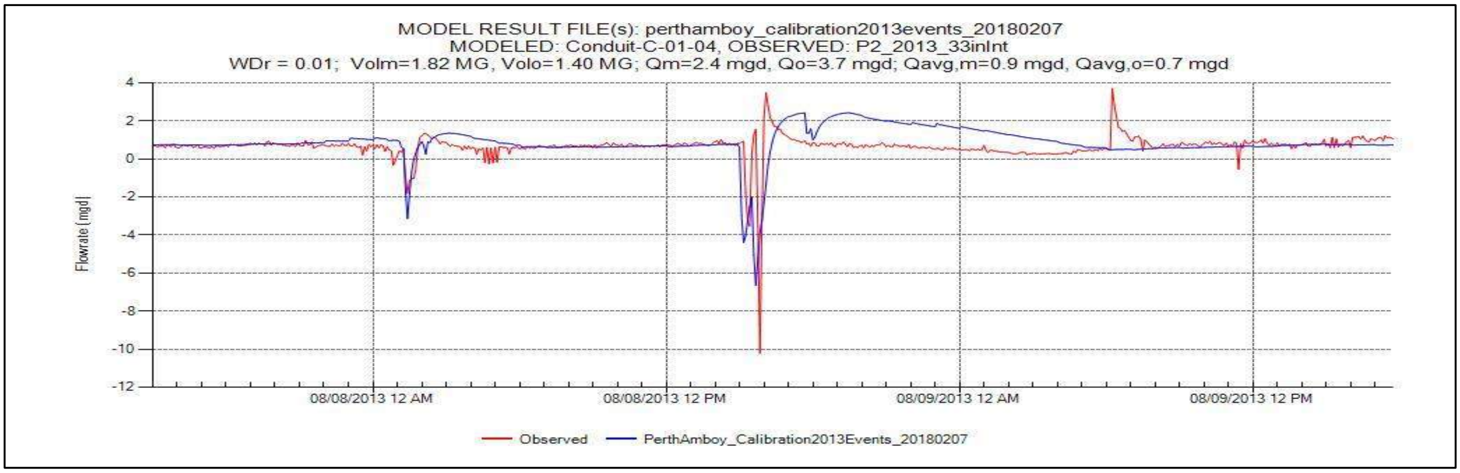

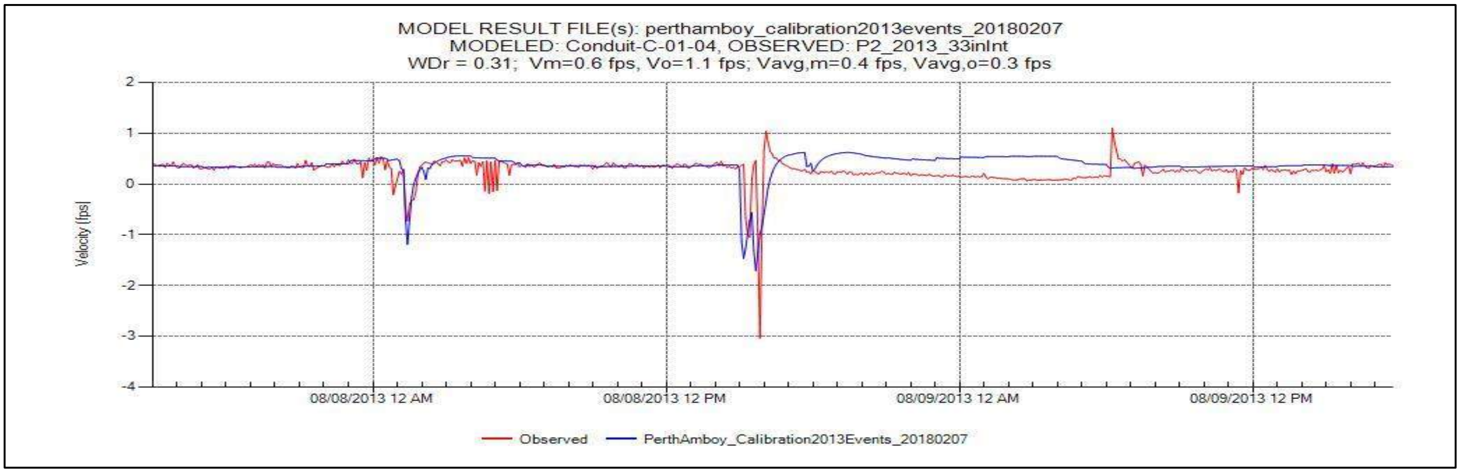

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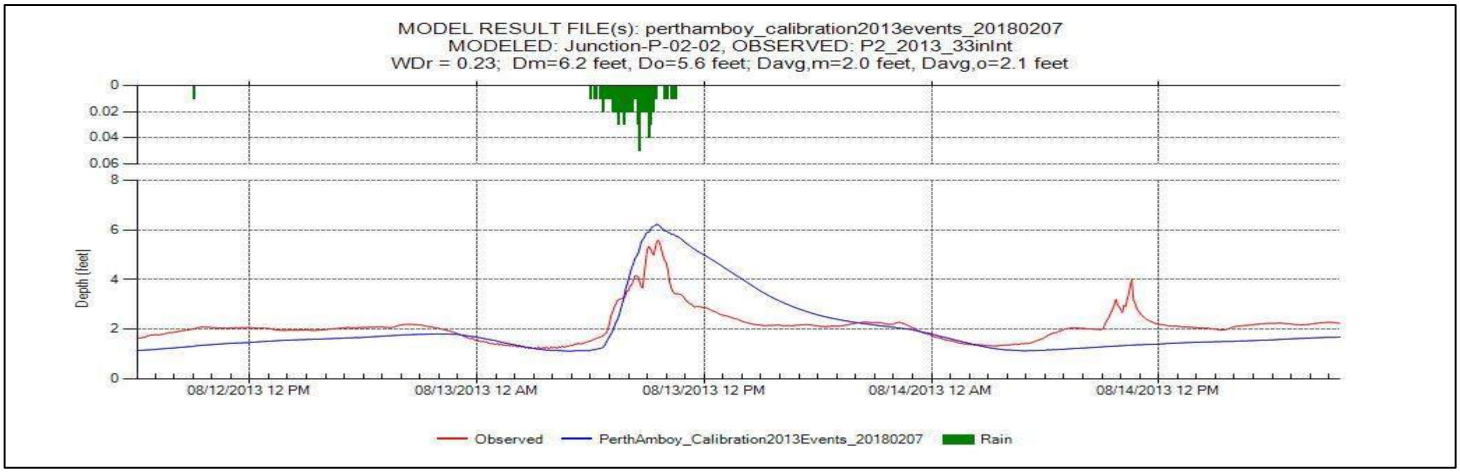

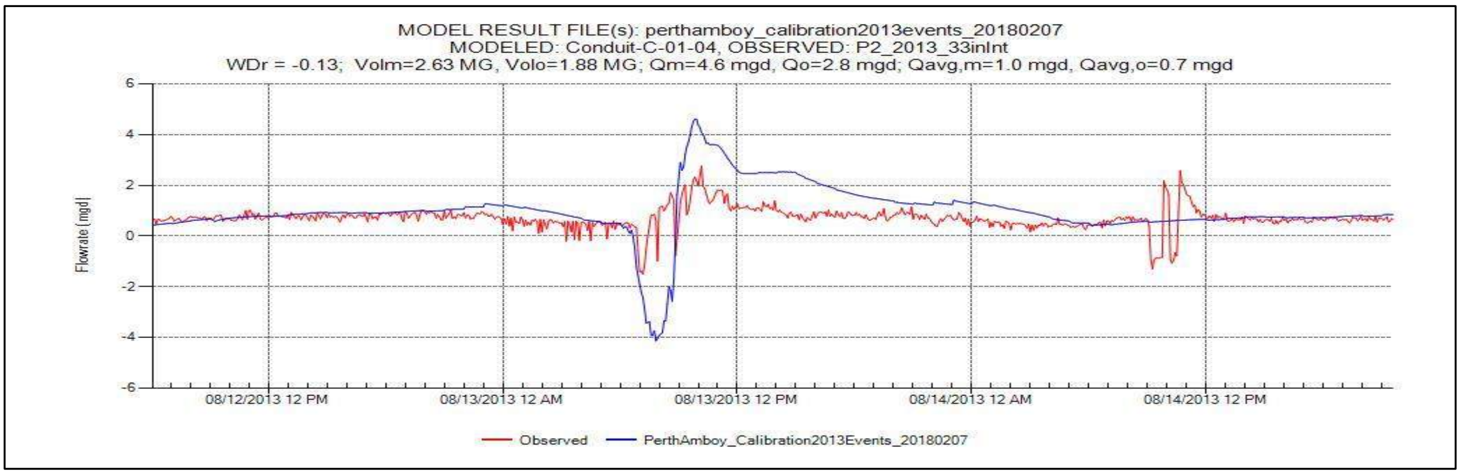

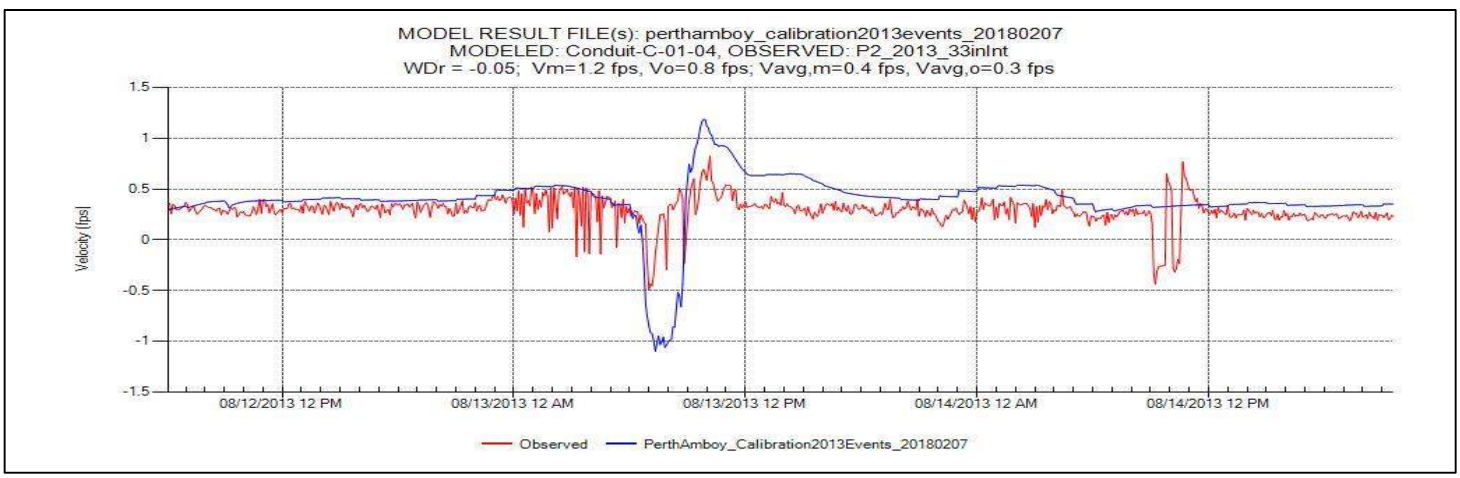

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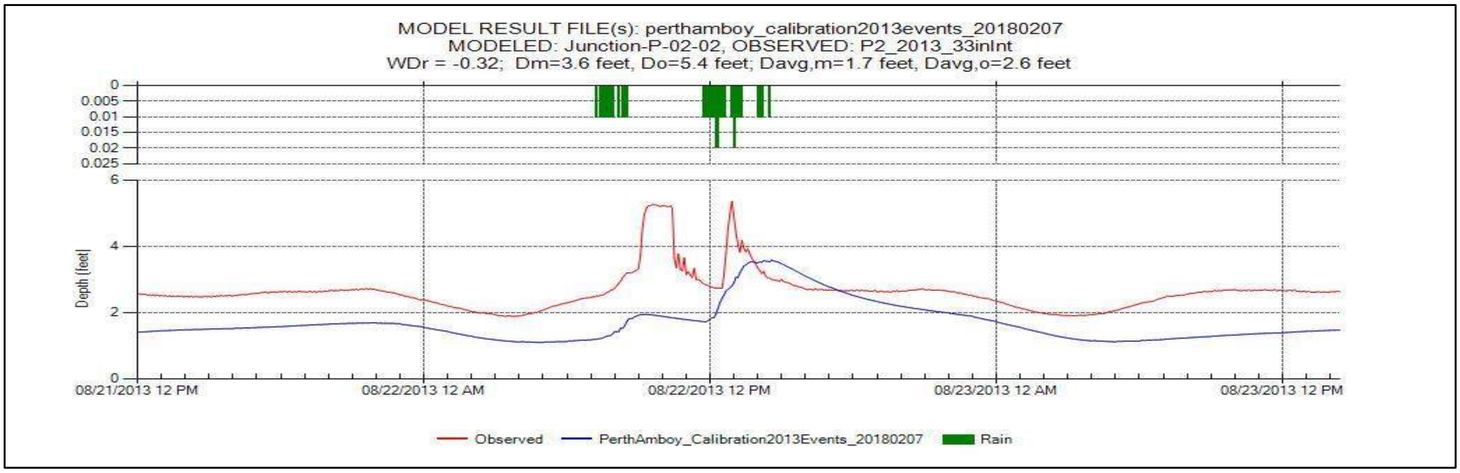

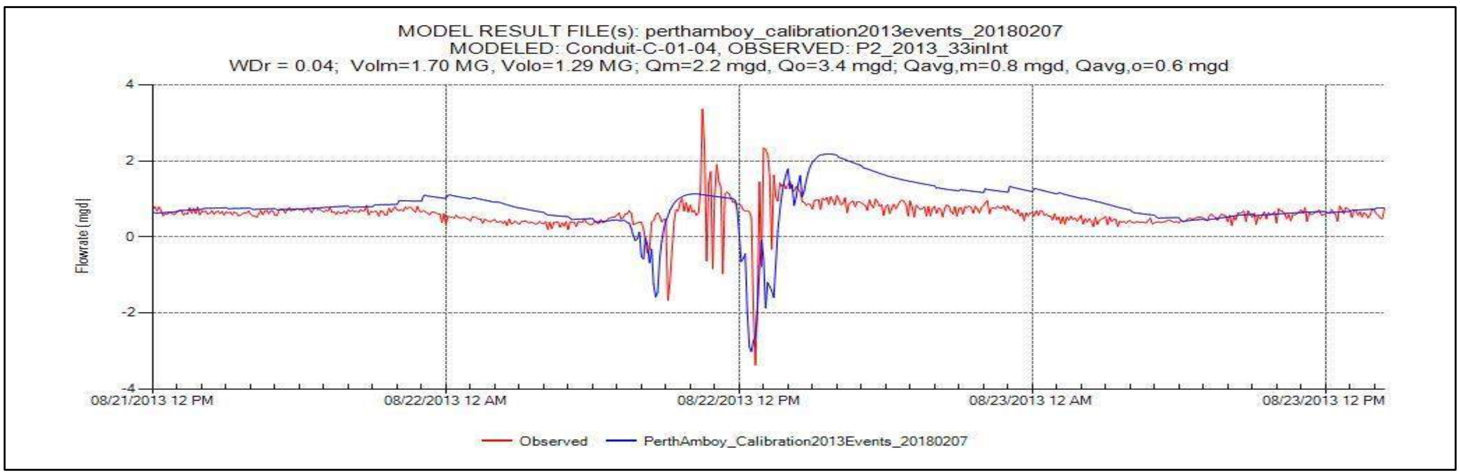

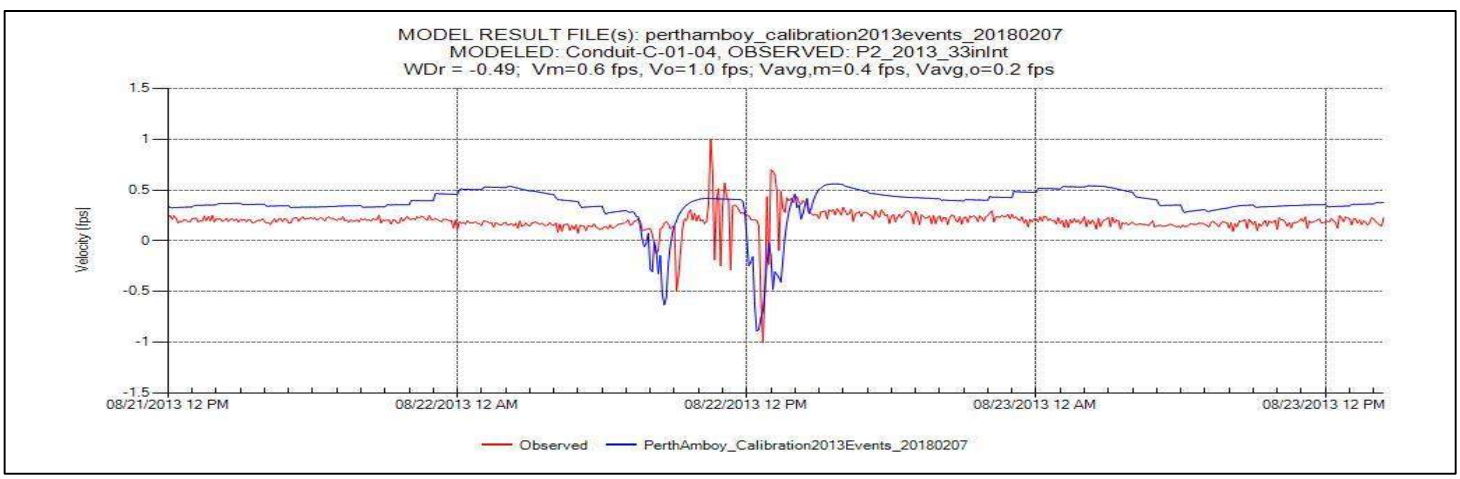

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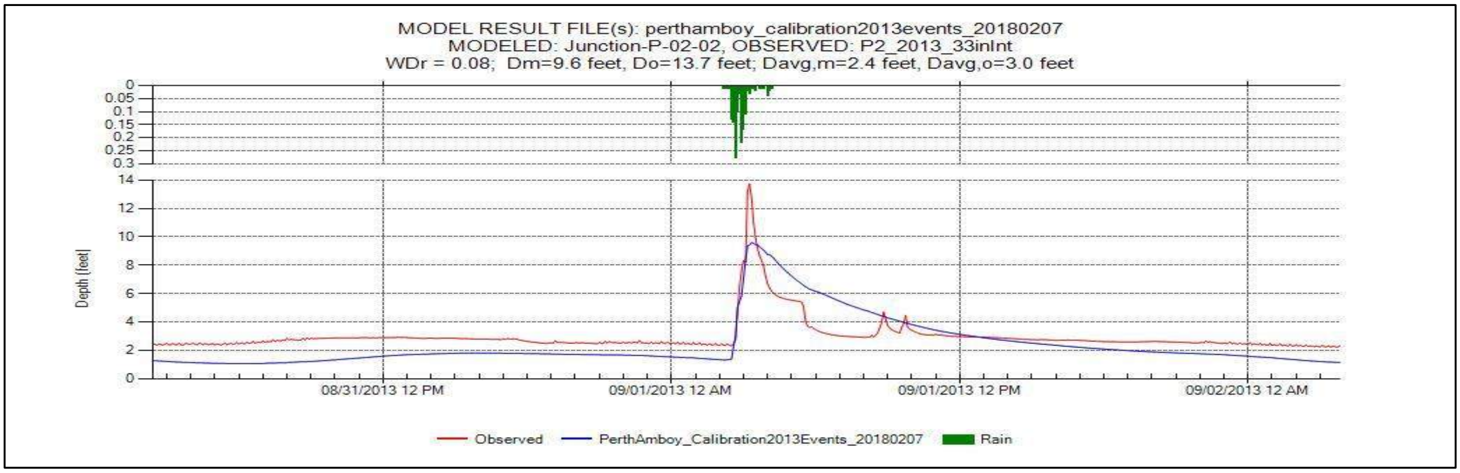

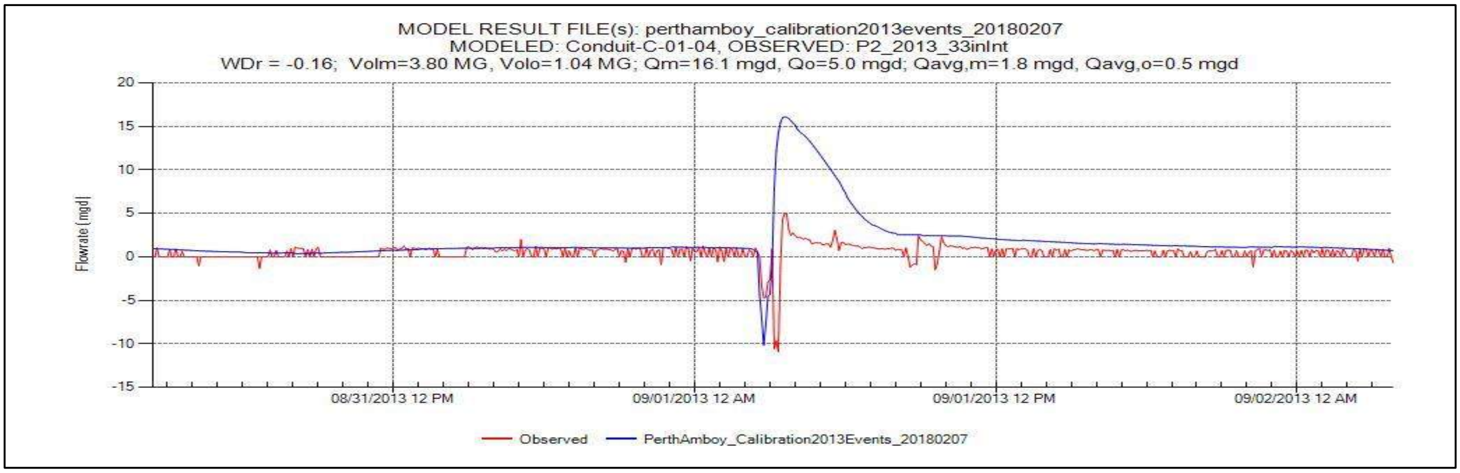

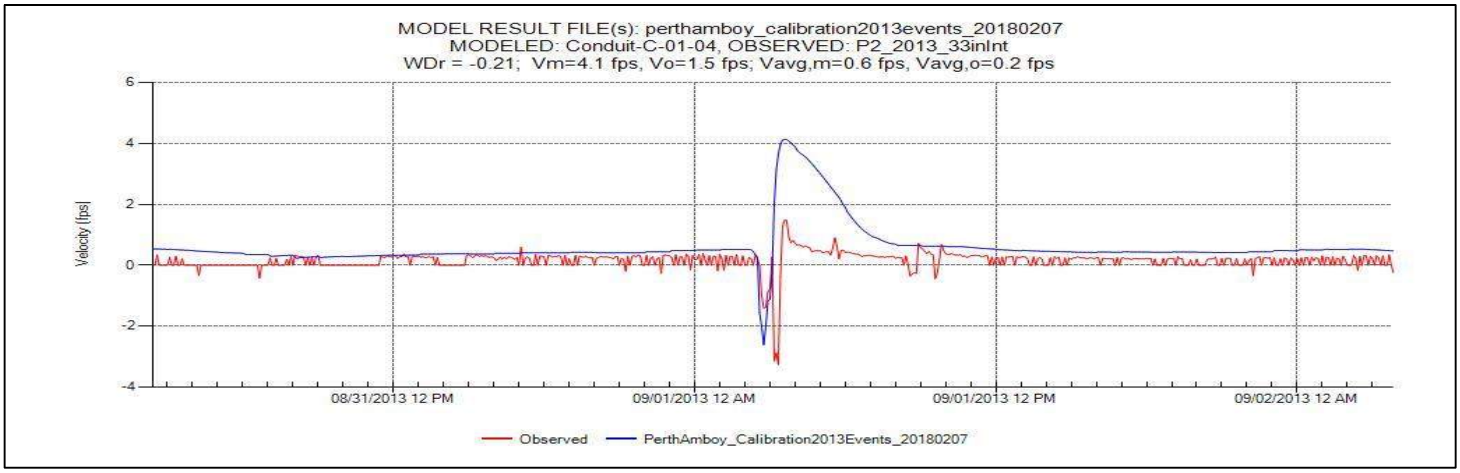

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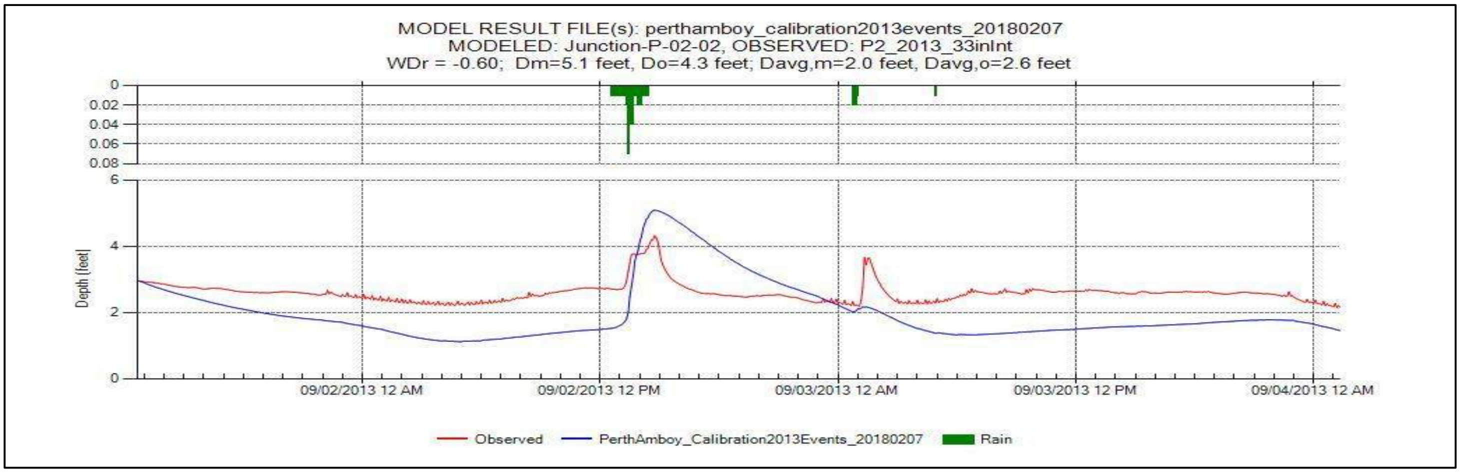

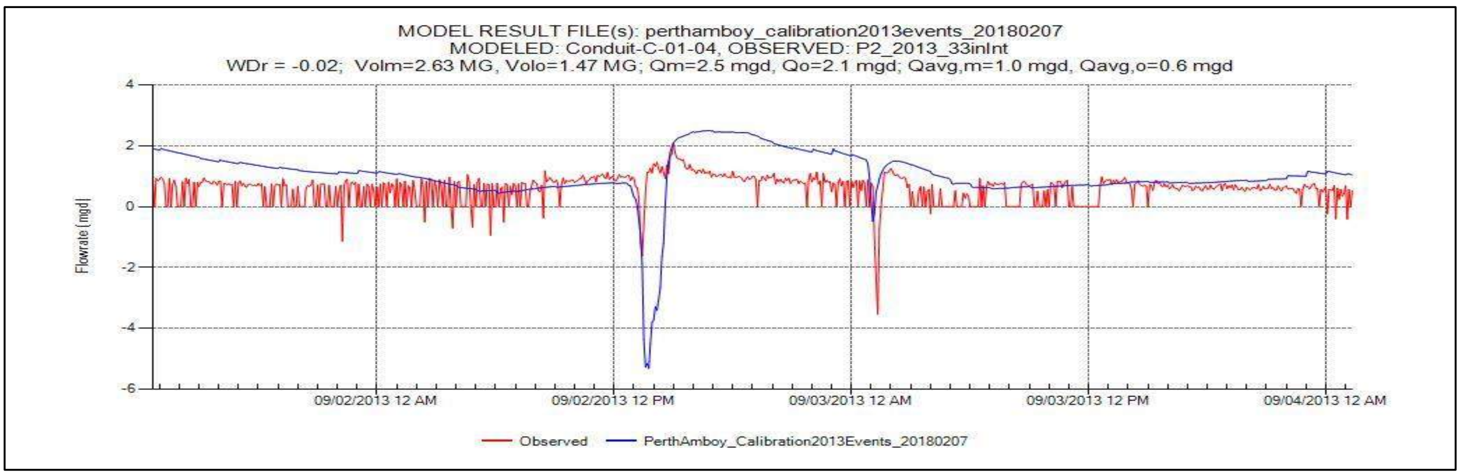

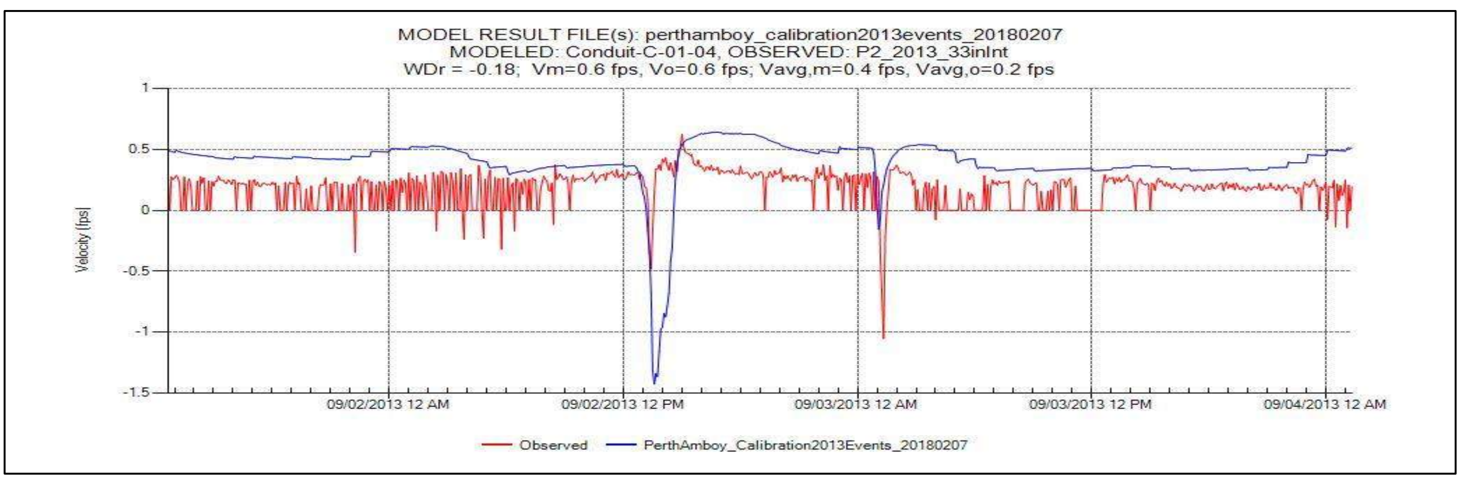

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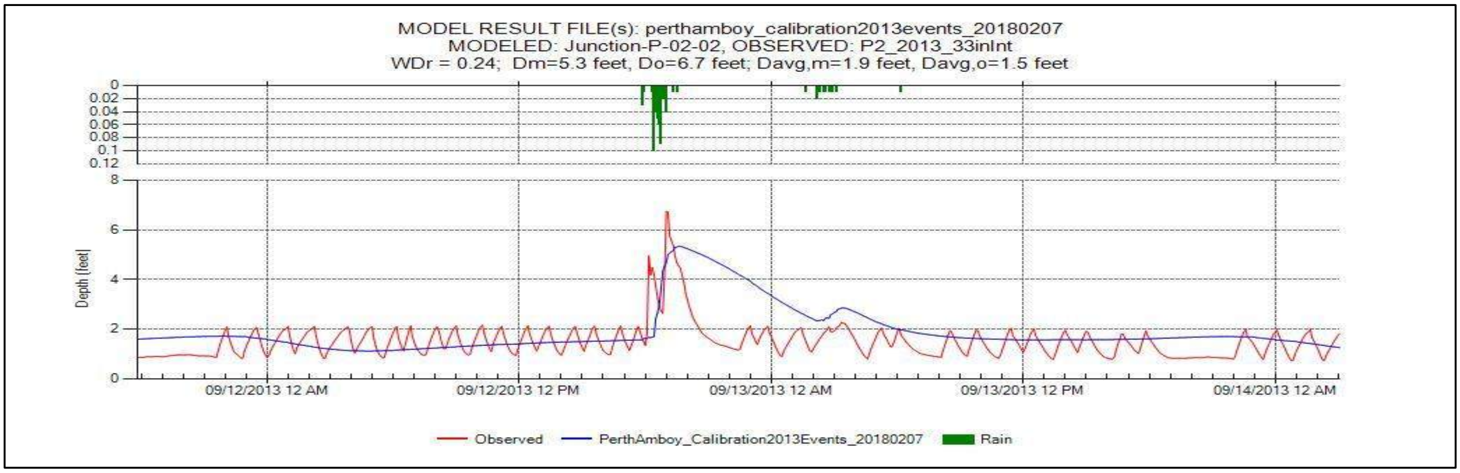
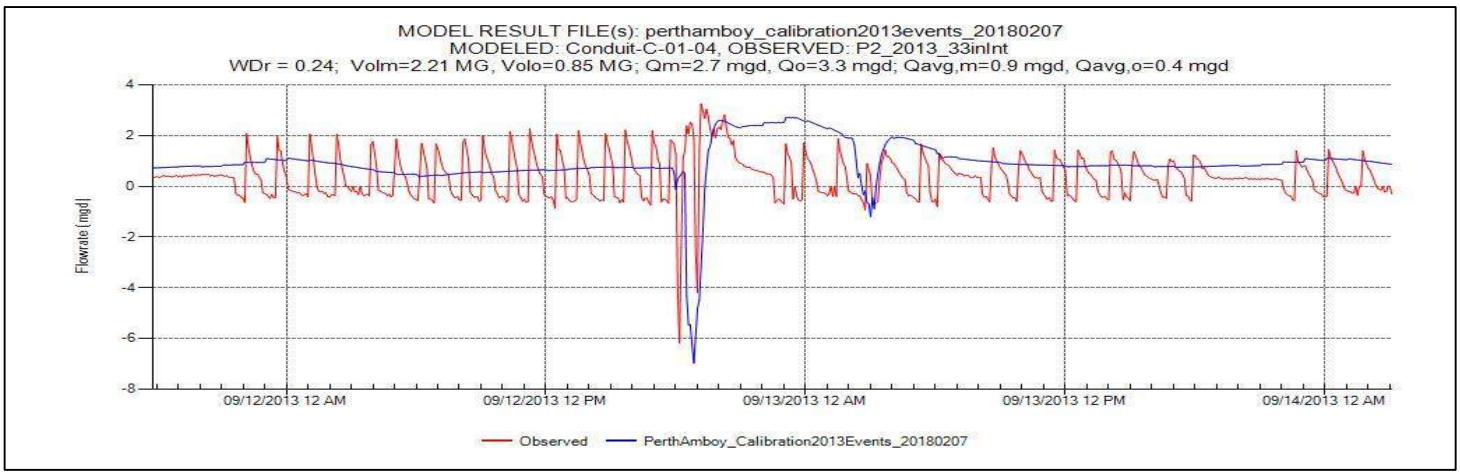
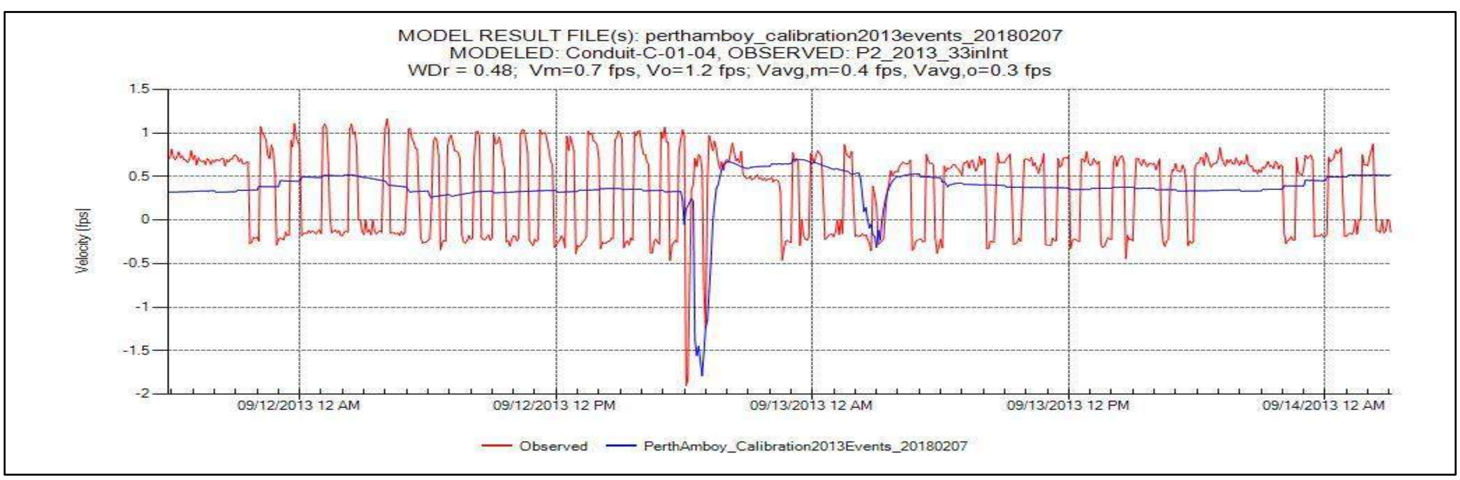
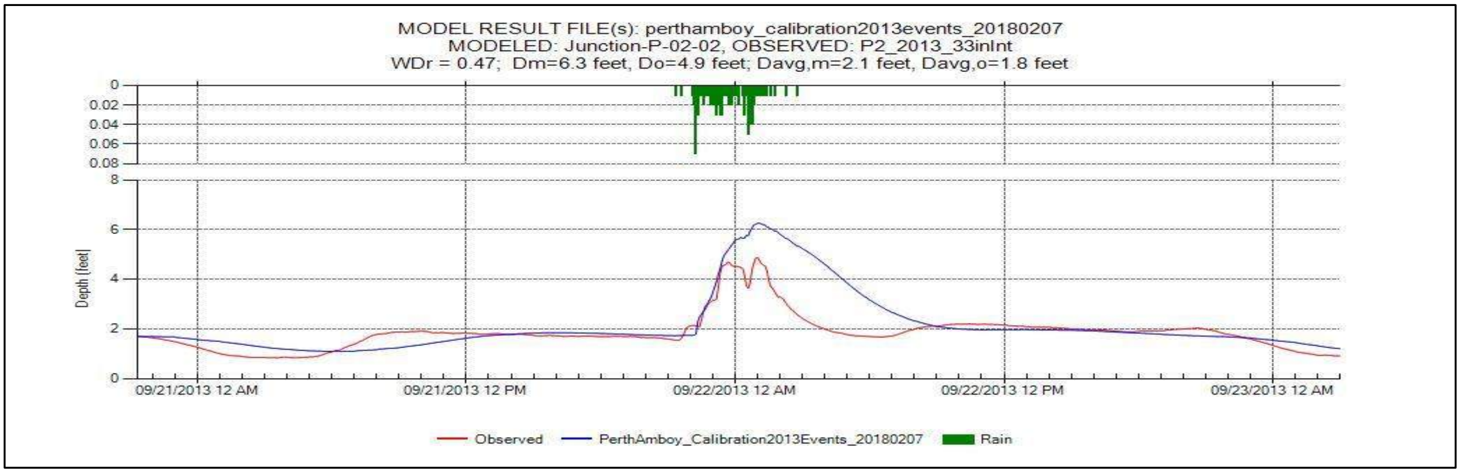


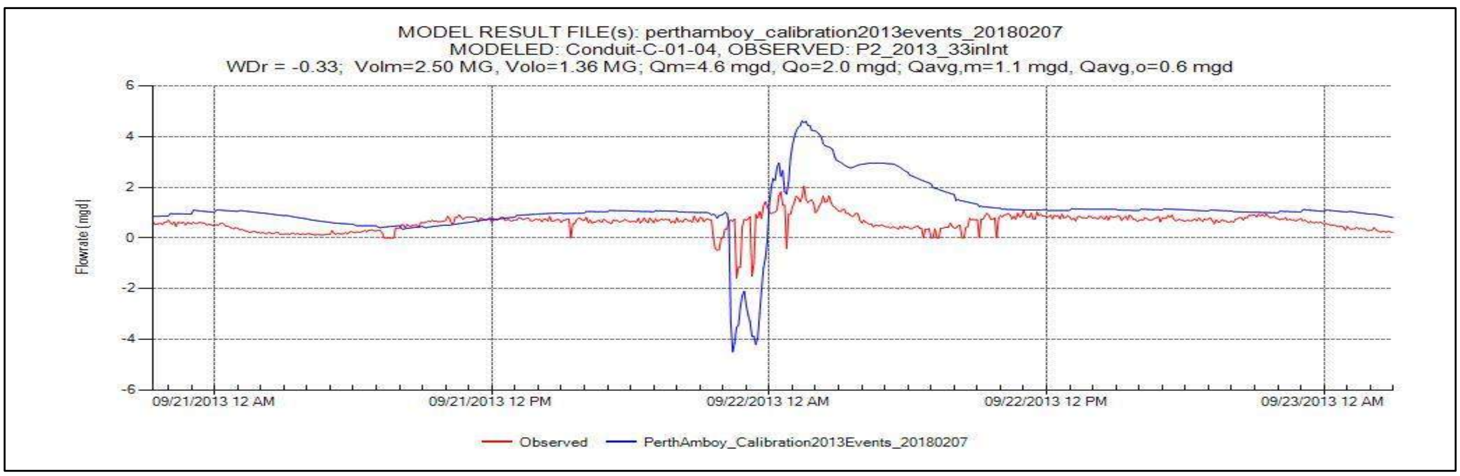


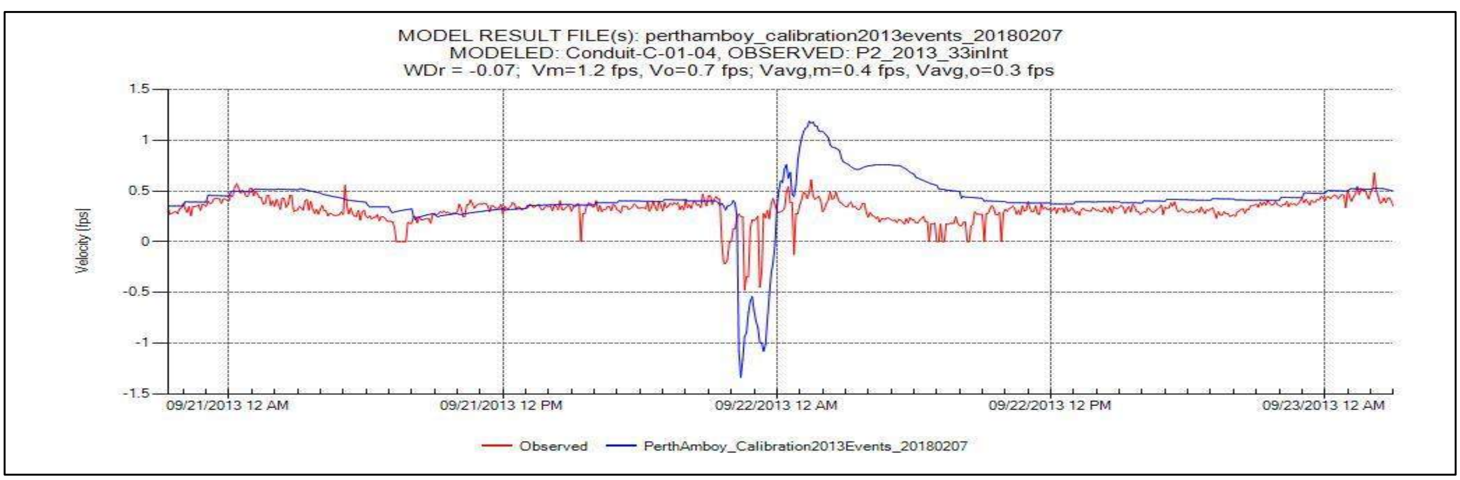


Simulated Versus Observed Flow at Flow Meter Sites

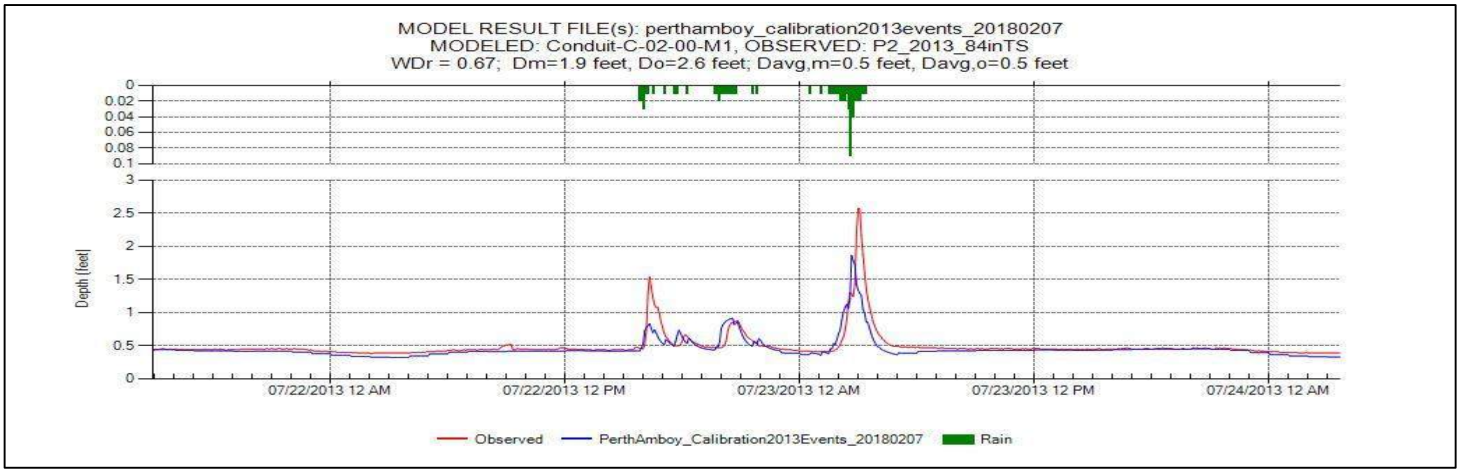
P2_2013_33inInt

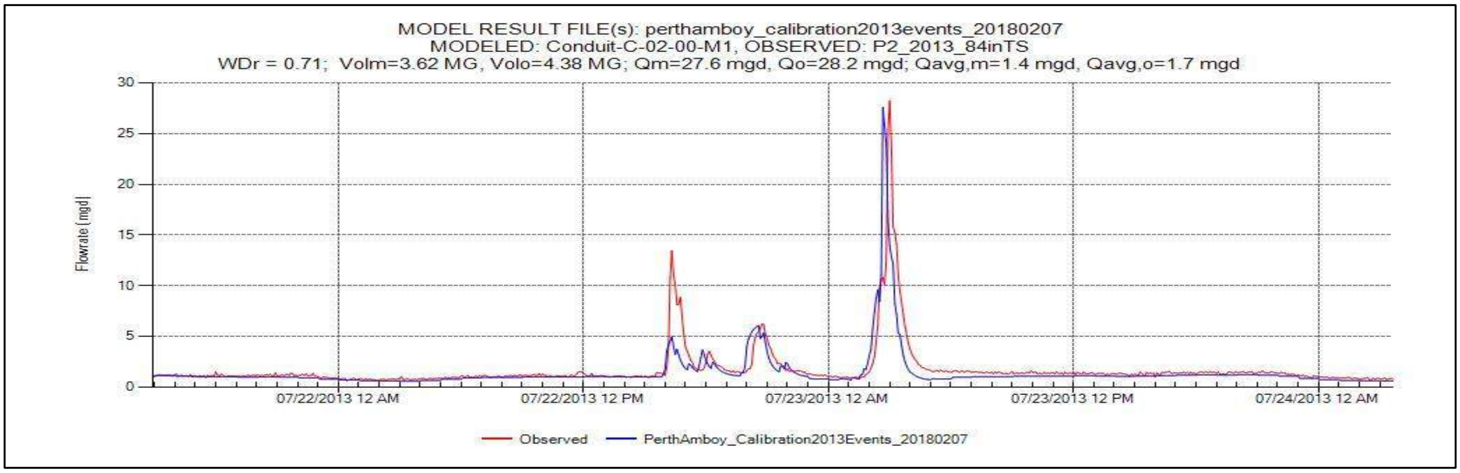


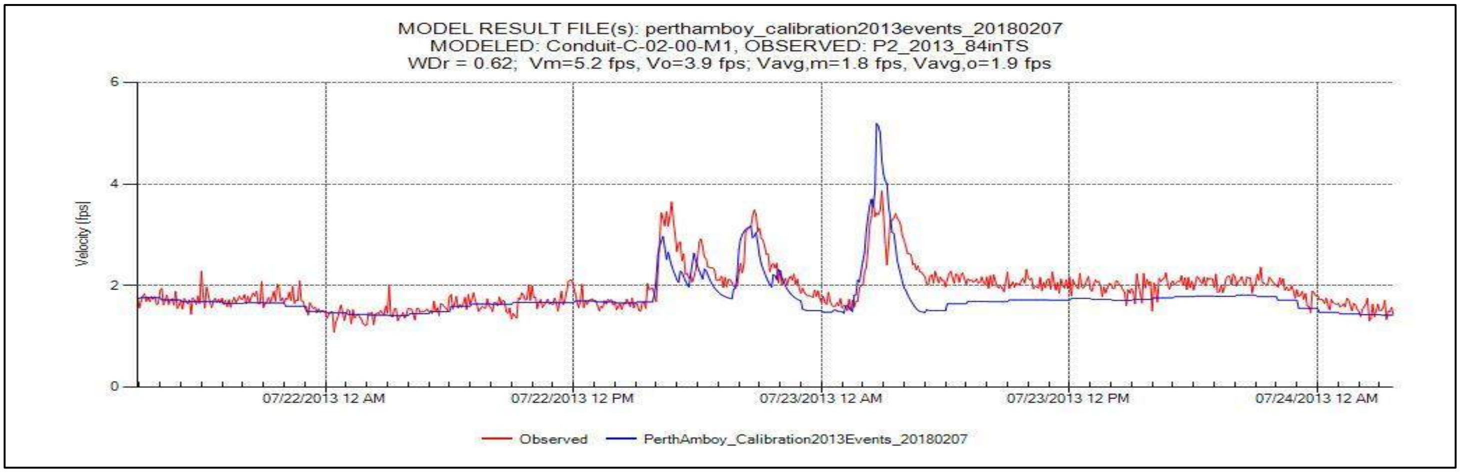




P2_2013_84inTS







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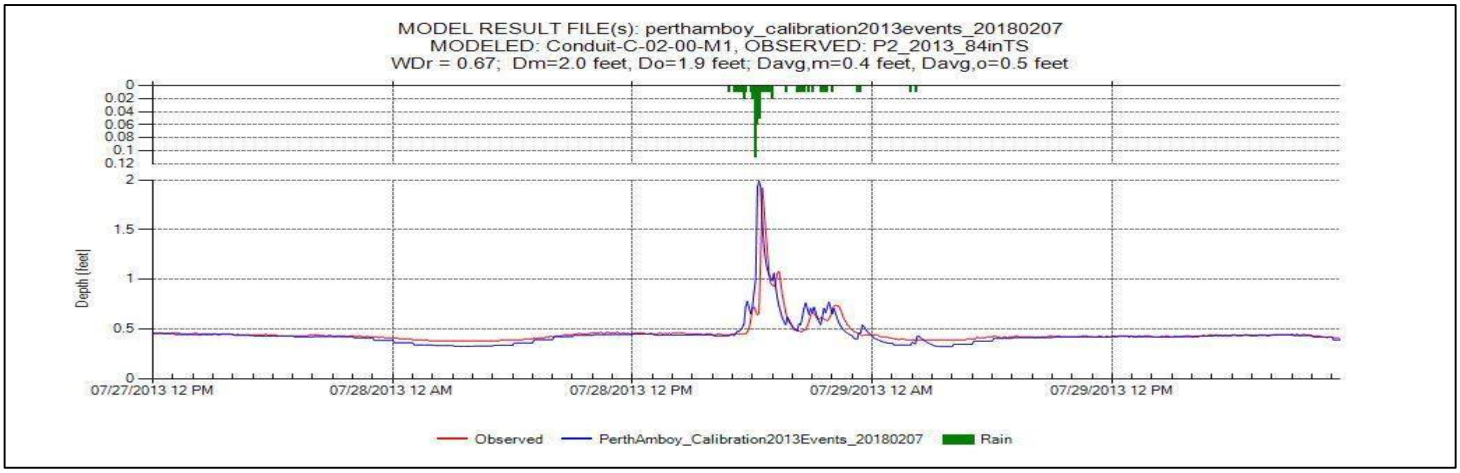

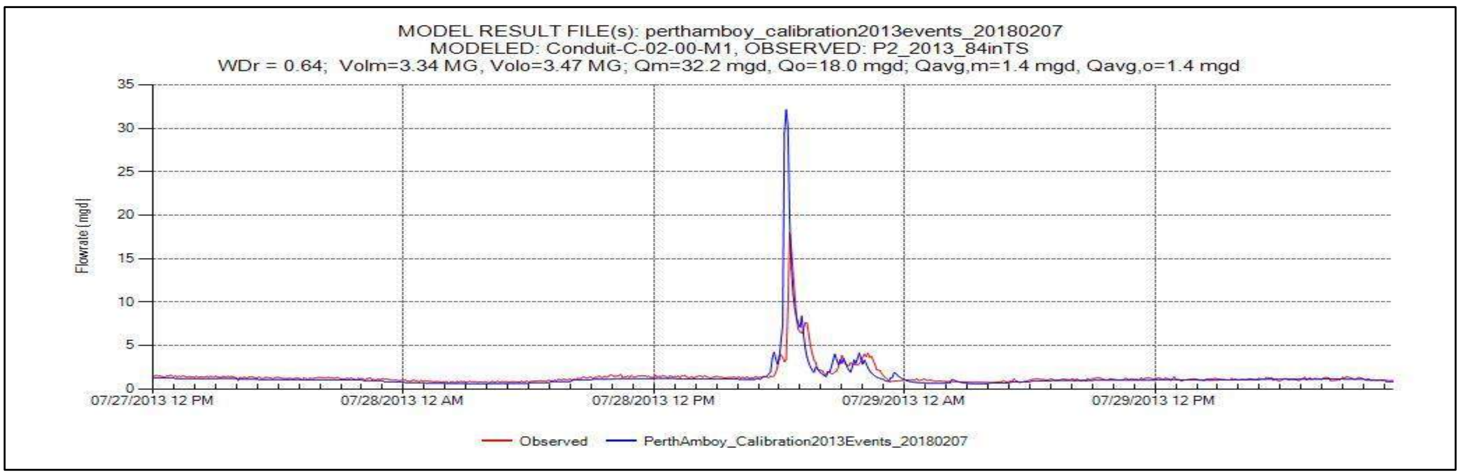

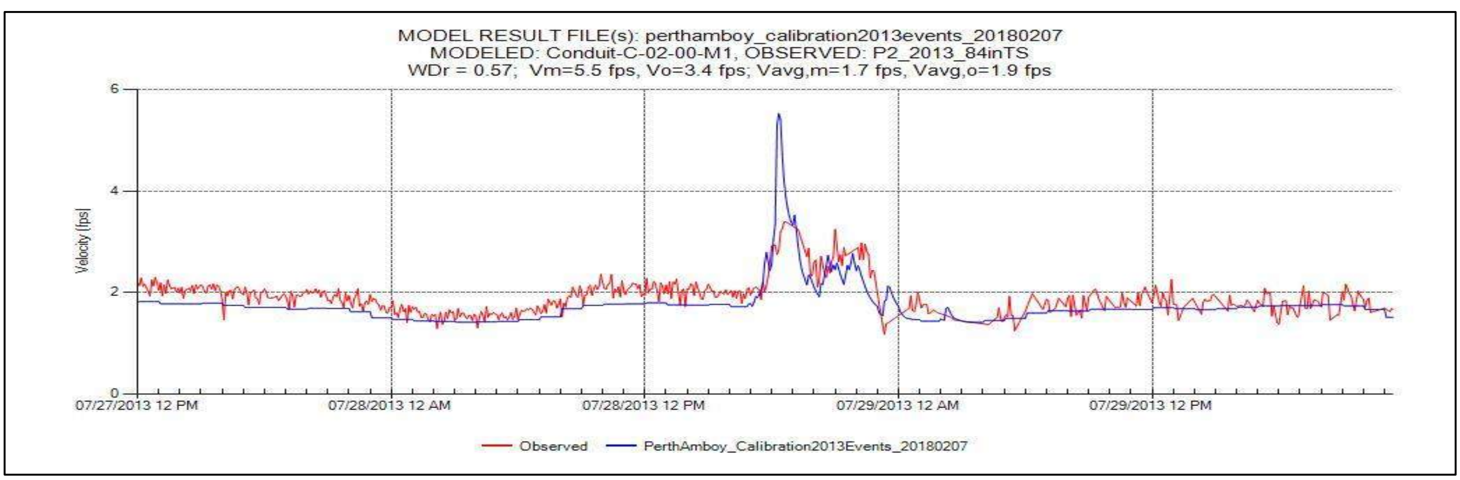

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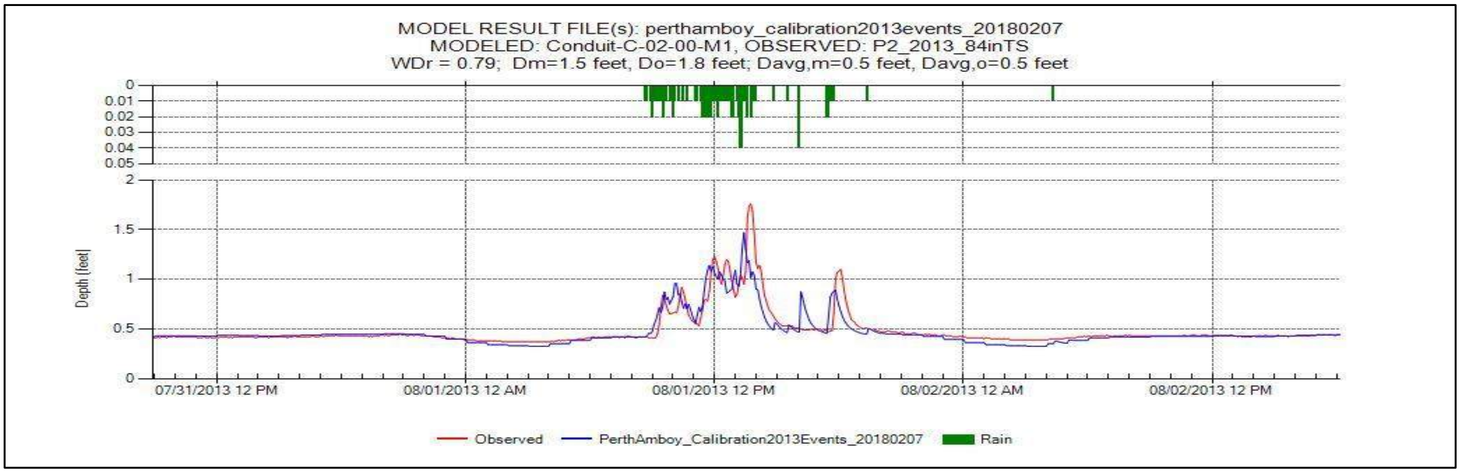

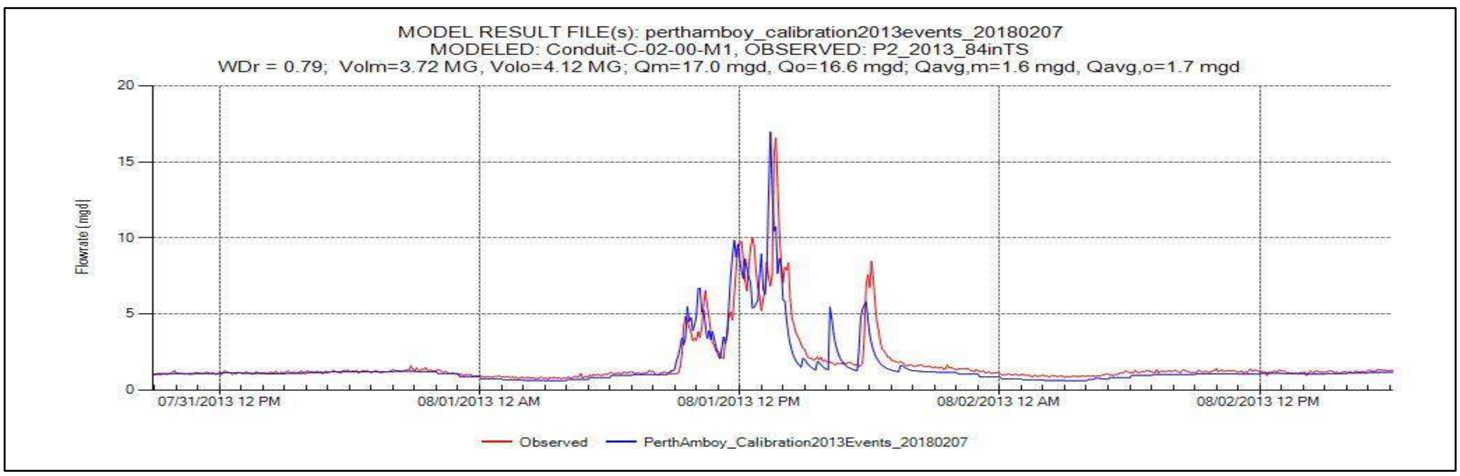

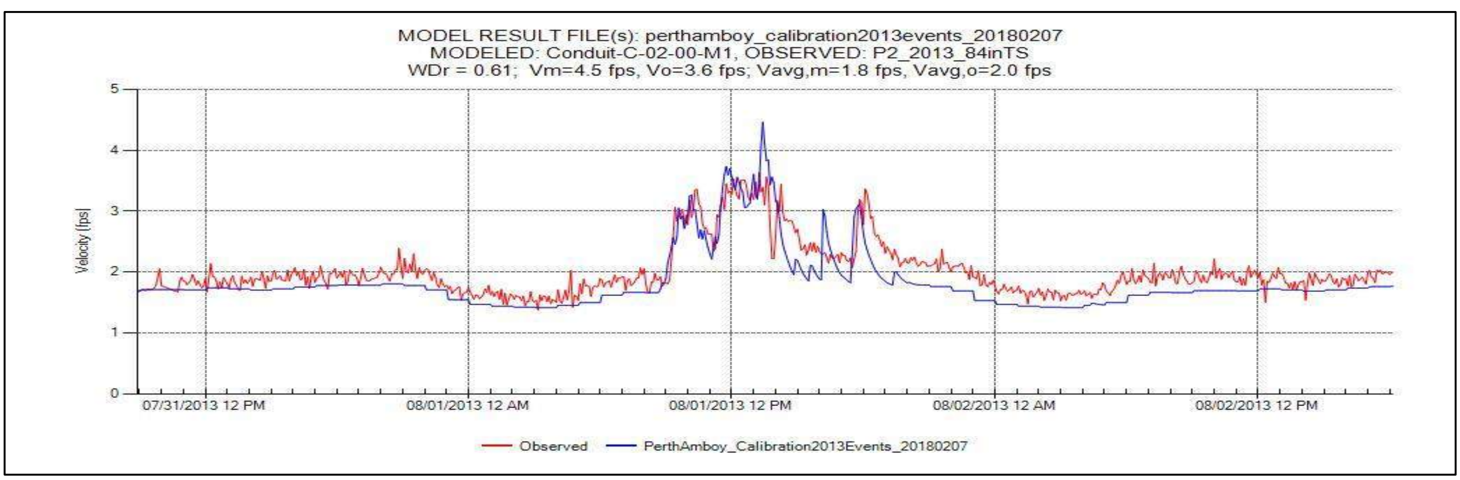

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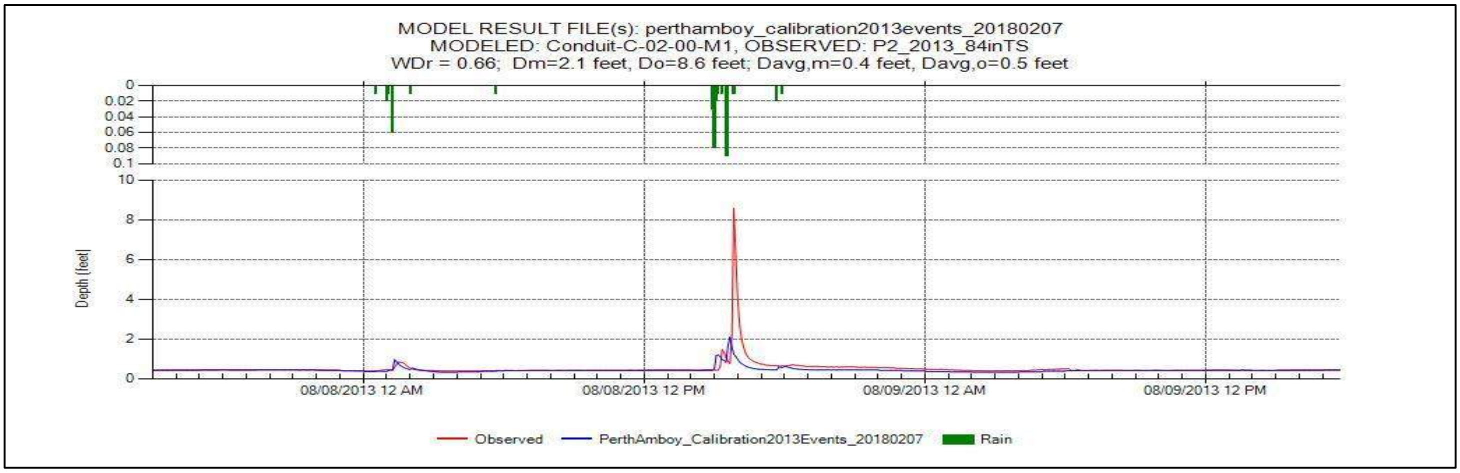

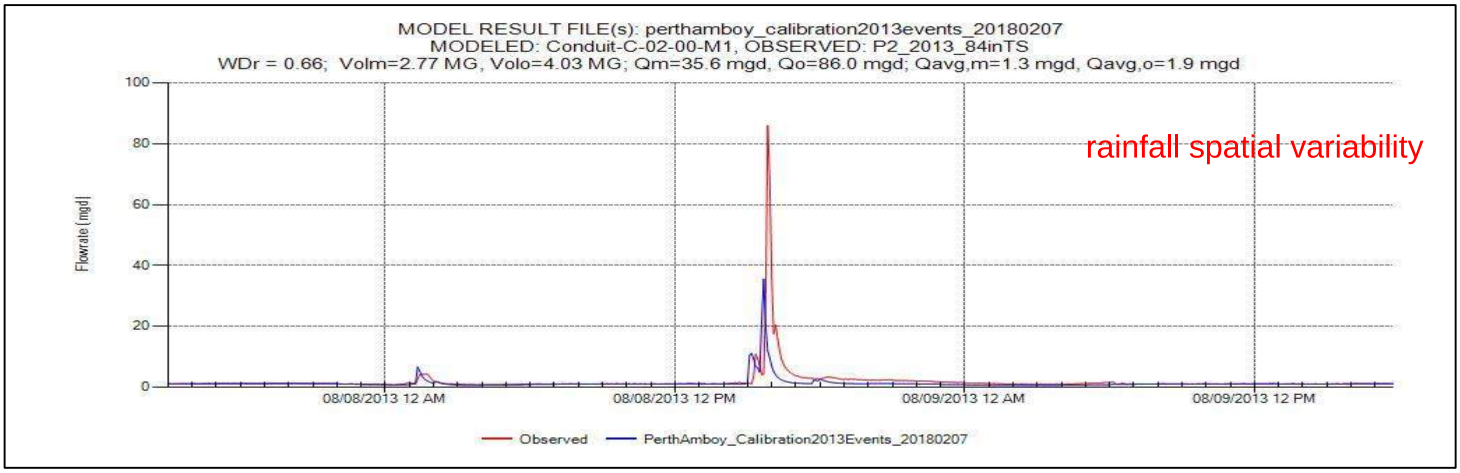

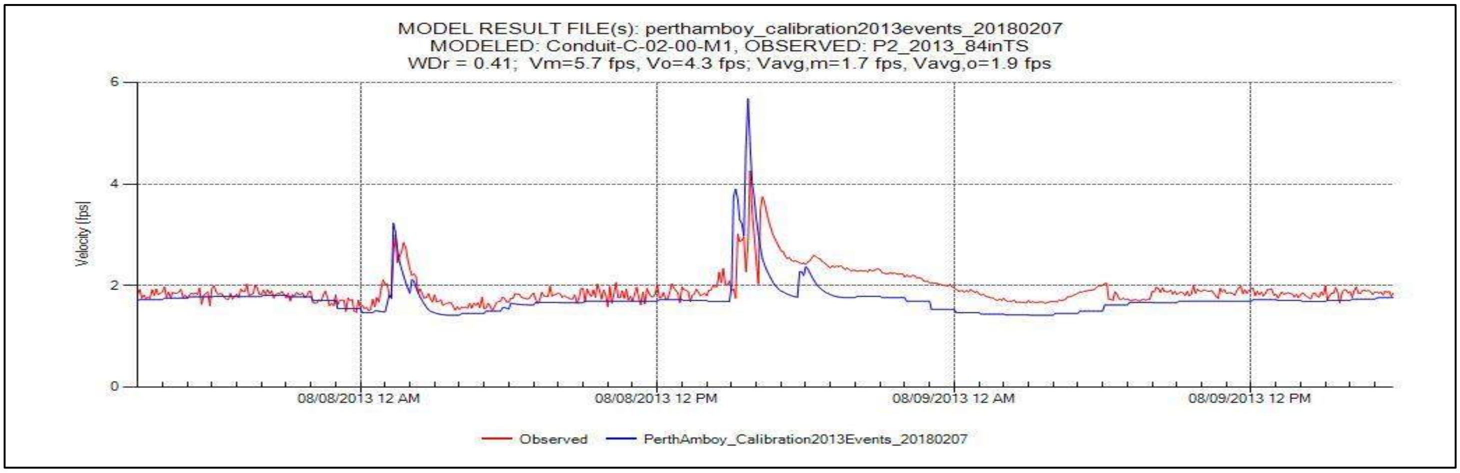

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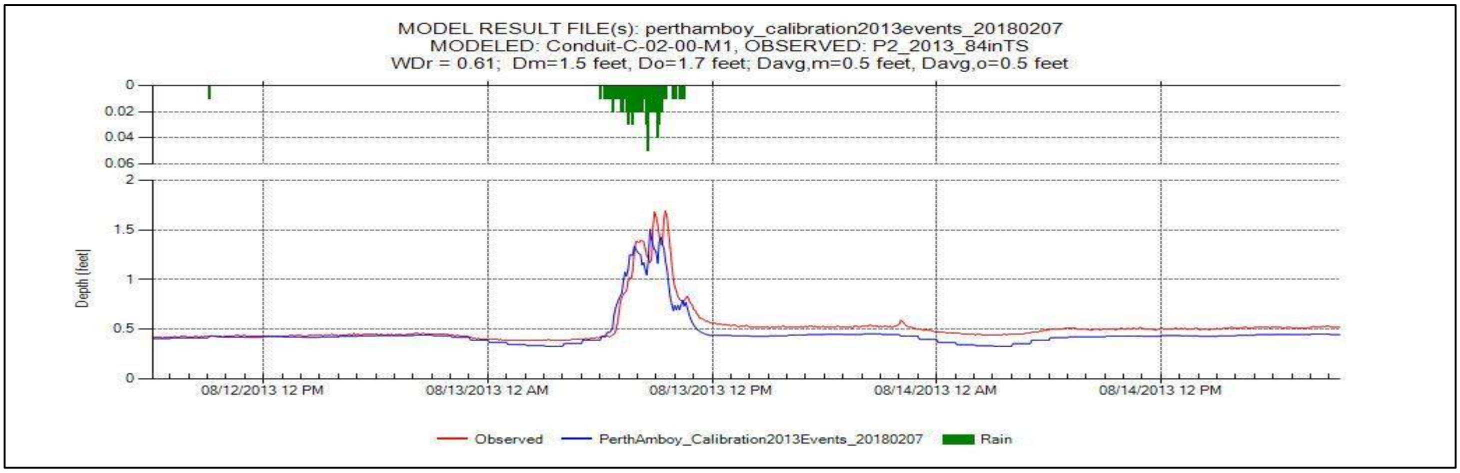

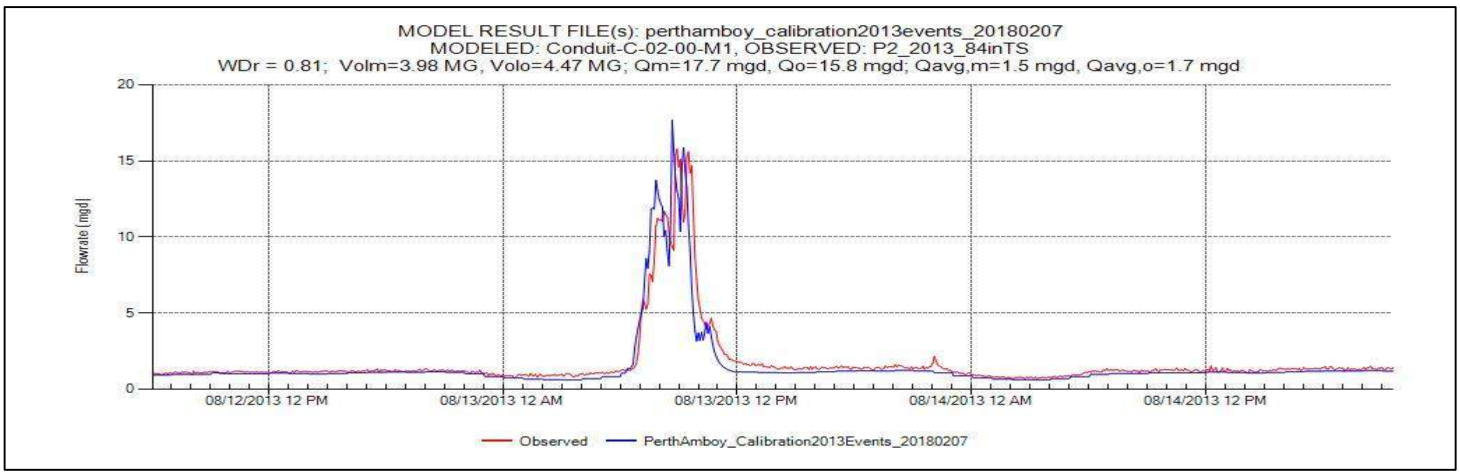

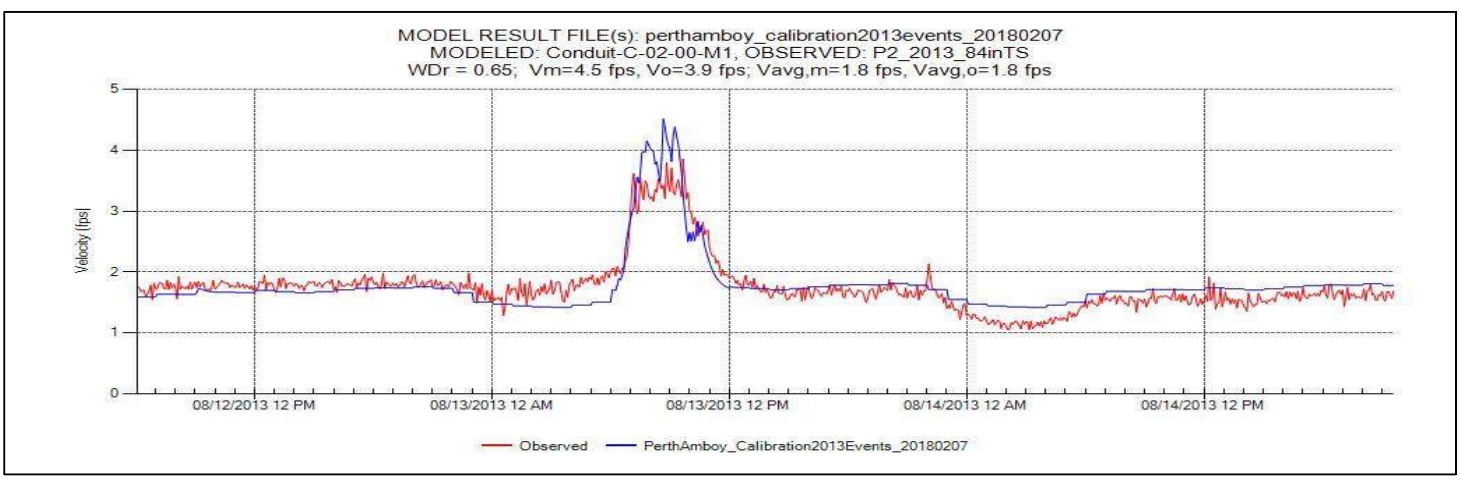

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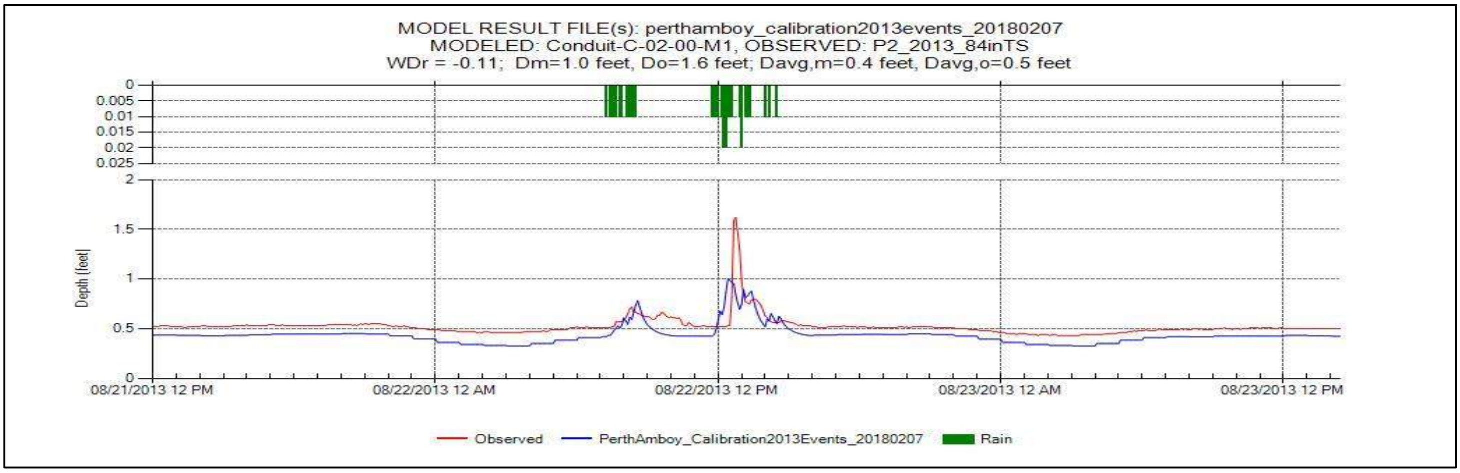

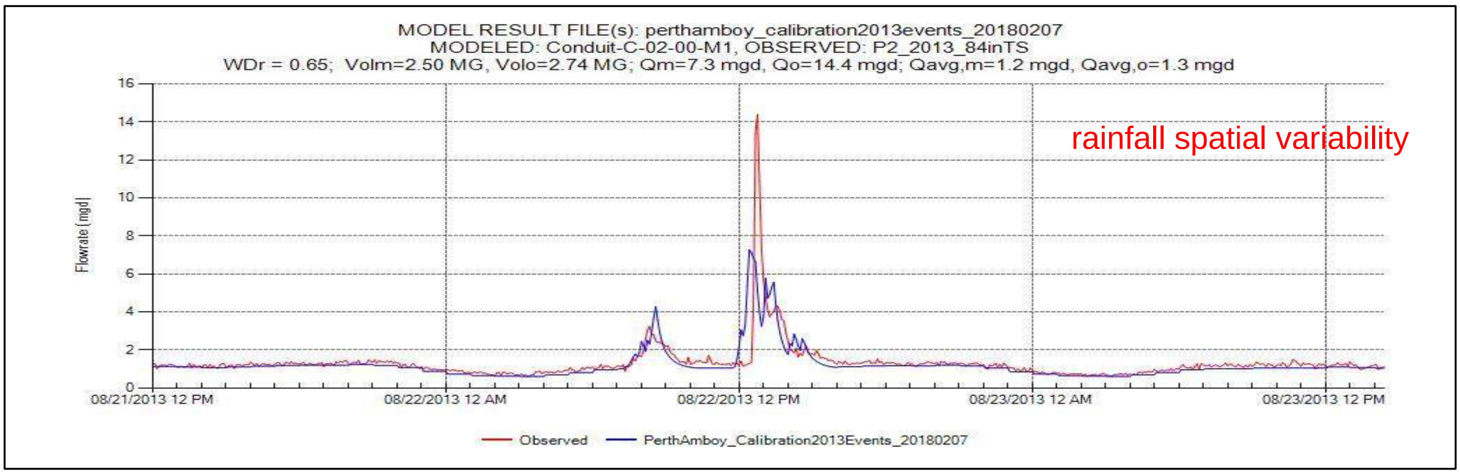

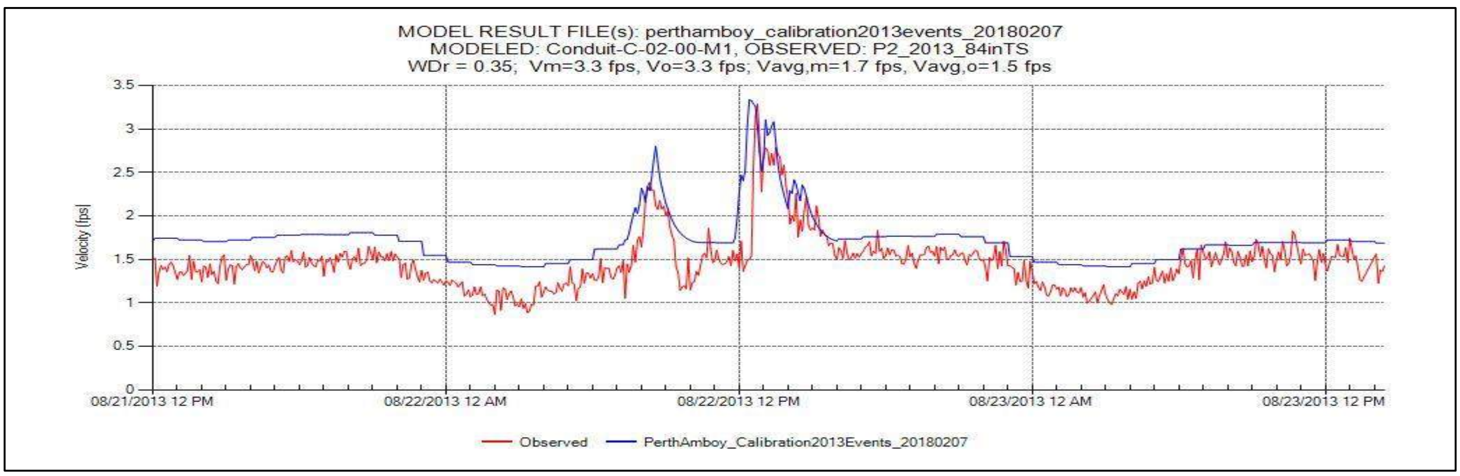

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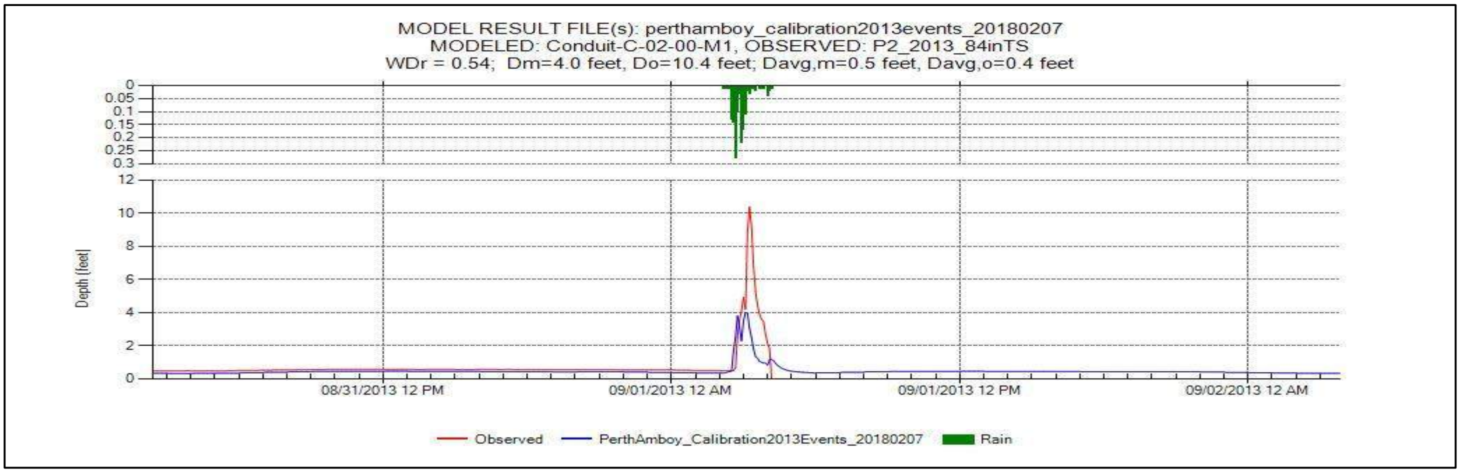
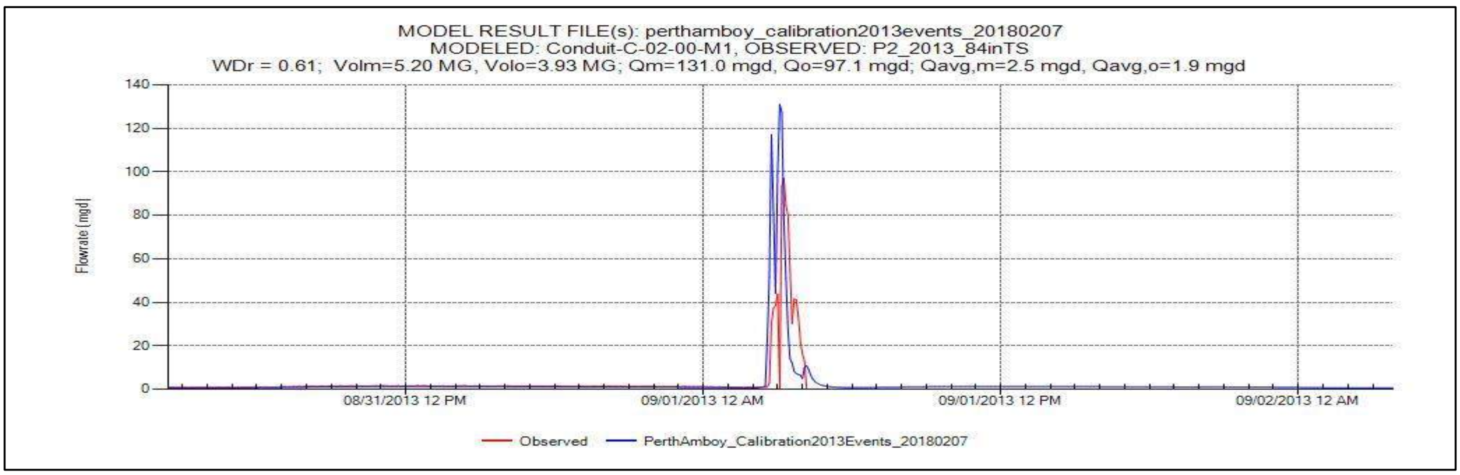
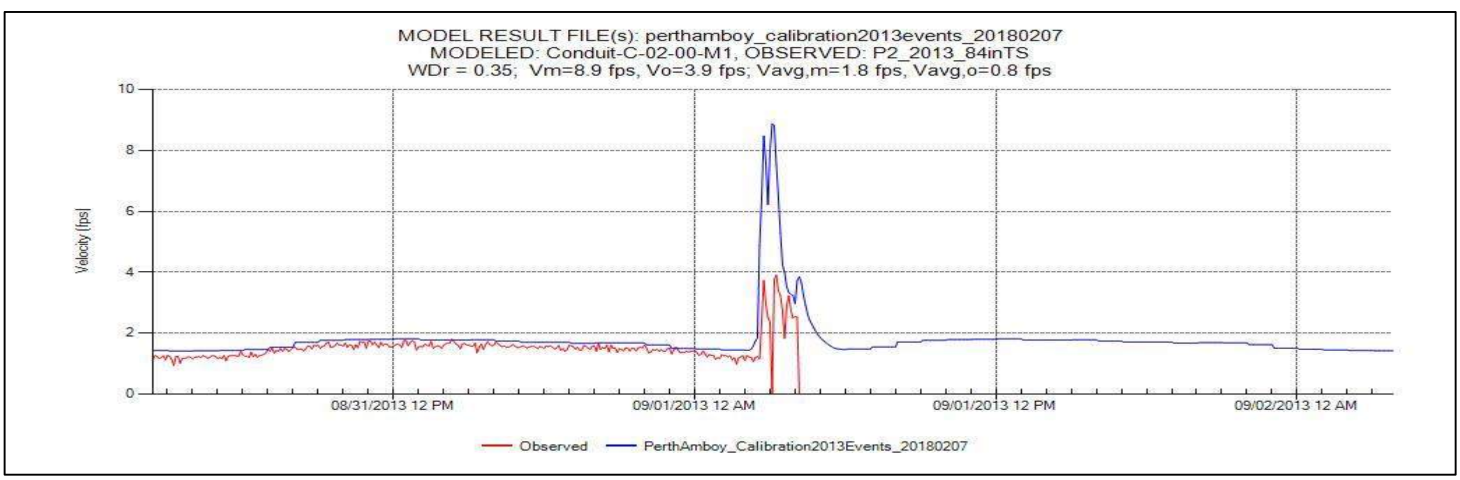
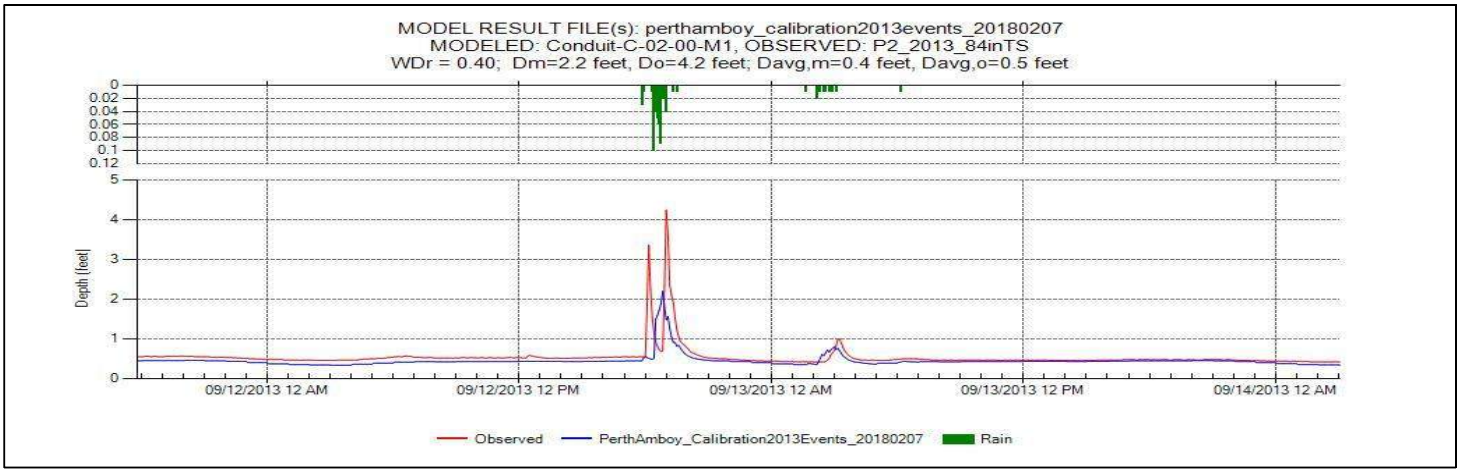


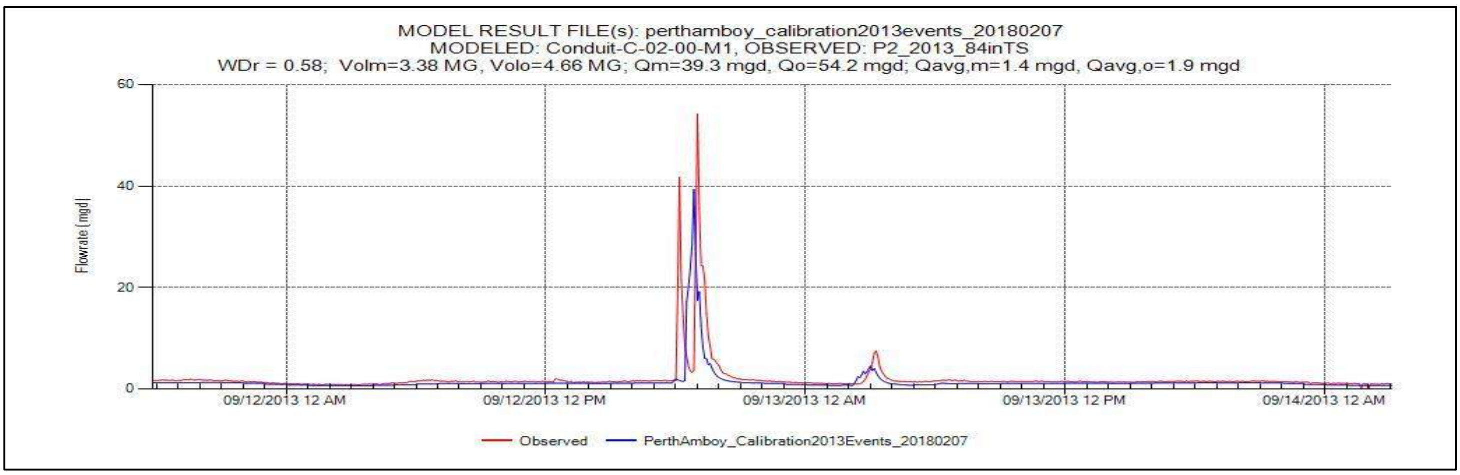


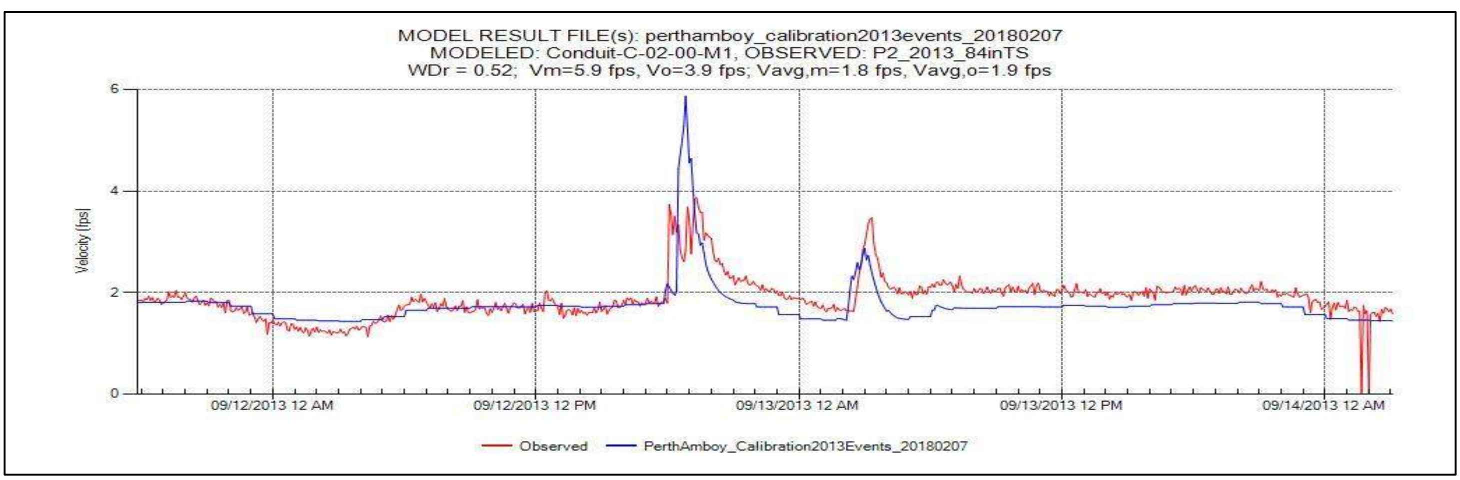


Simulated Versus Observed Flow at Flow Meter Sites

P2_2013_84inTS

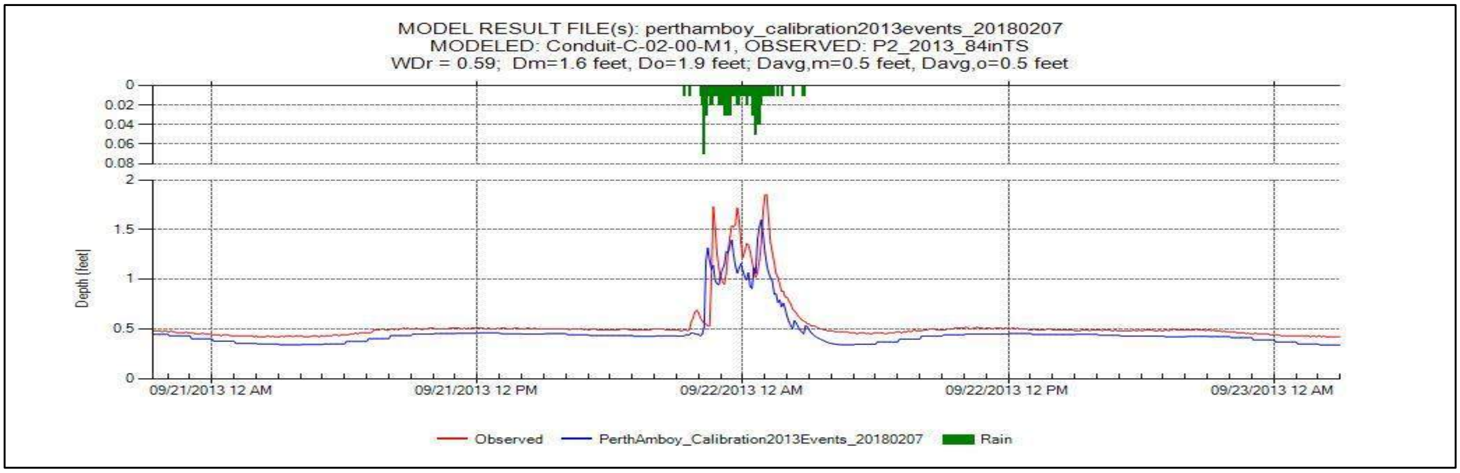


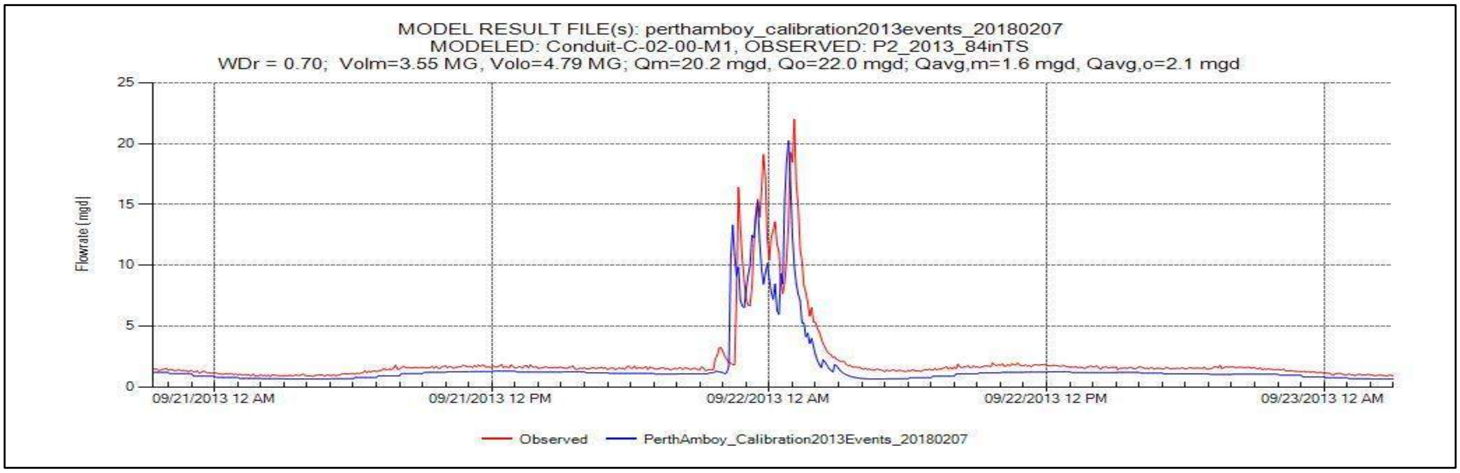


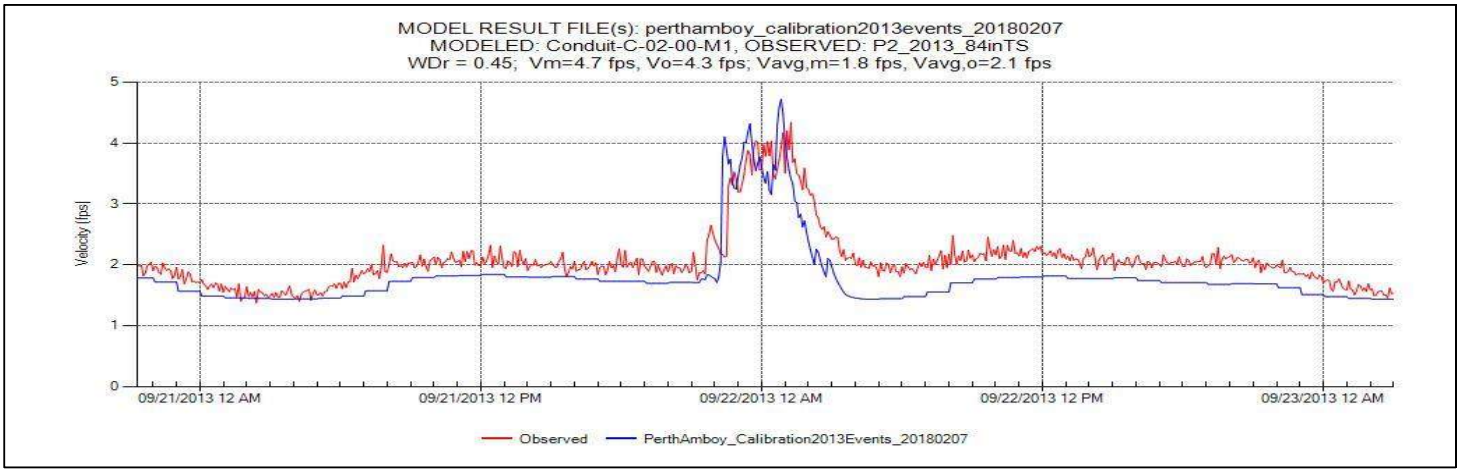


Simulated Versus Observed Flow at Flow Meter Sites

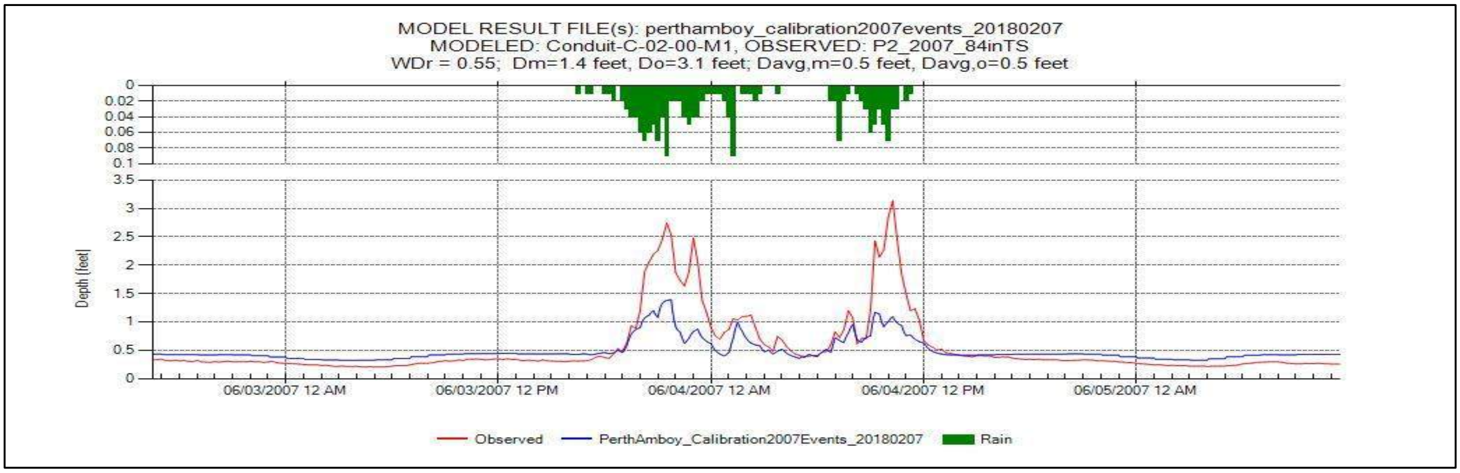
P2_2013_84inTS

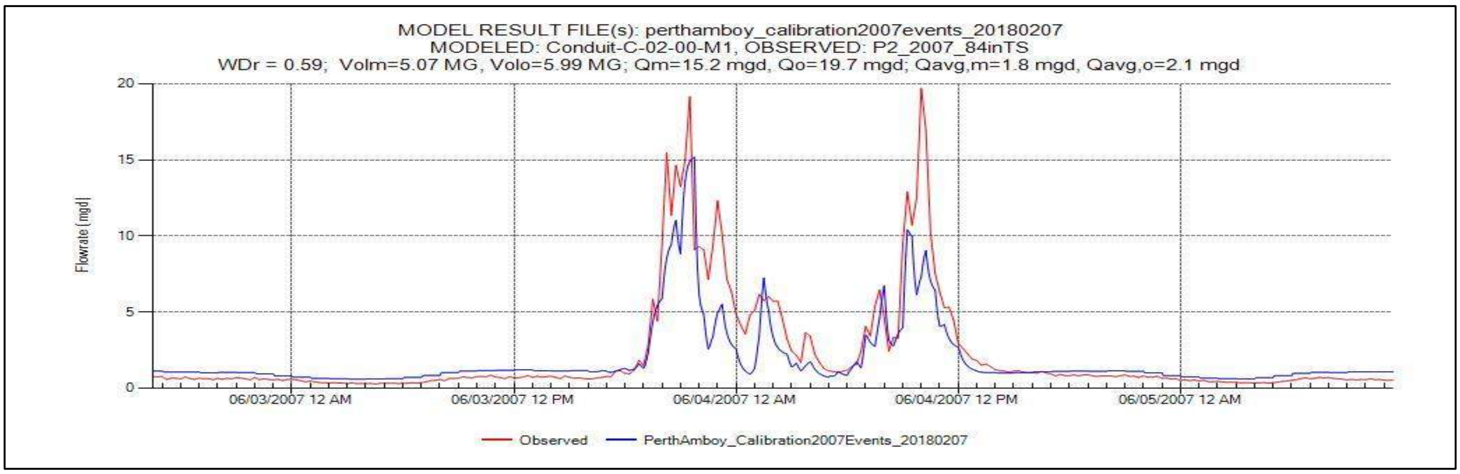


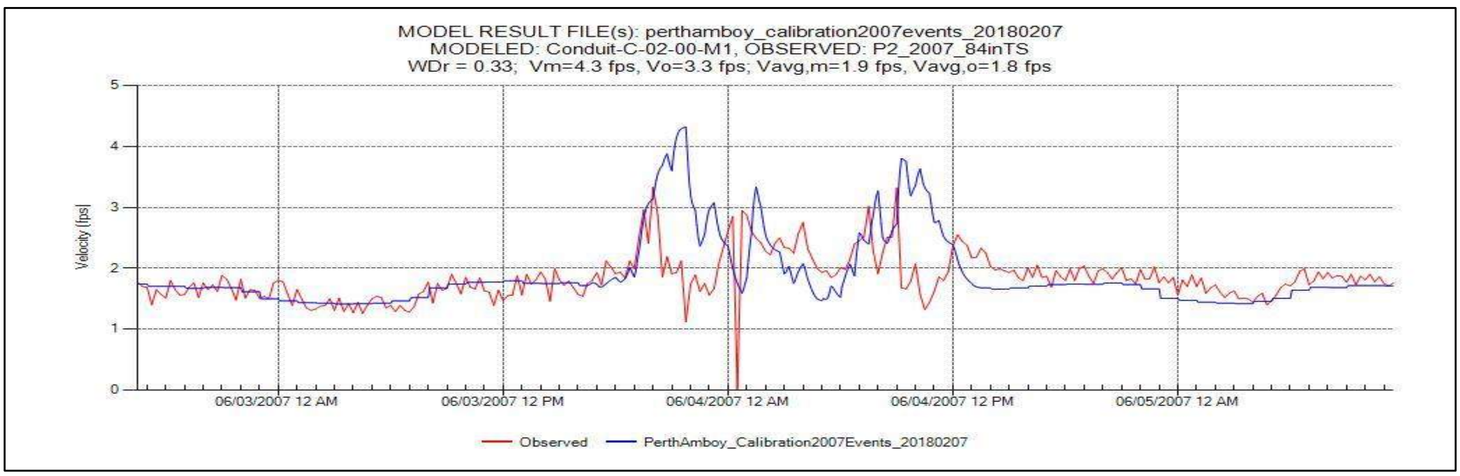




P2_2007_84inTS

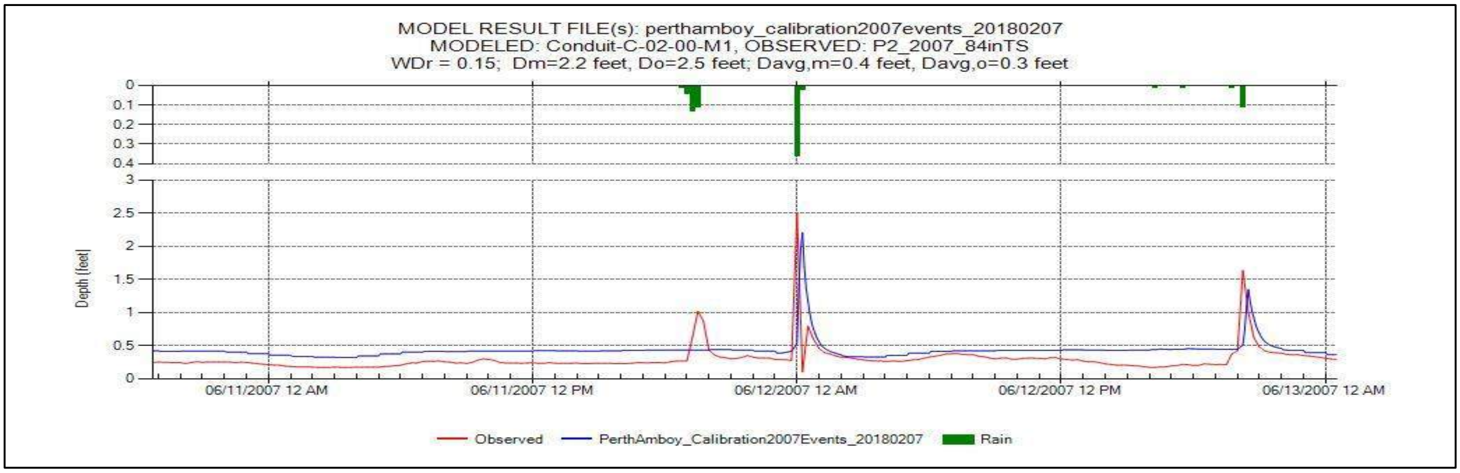


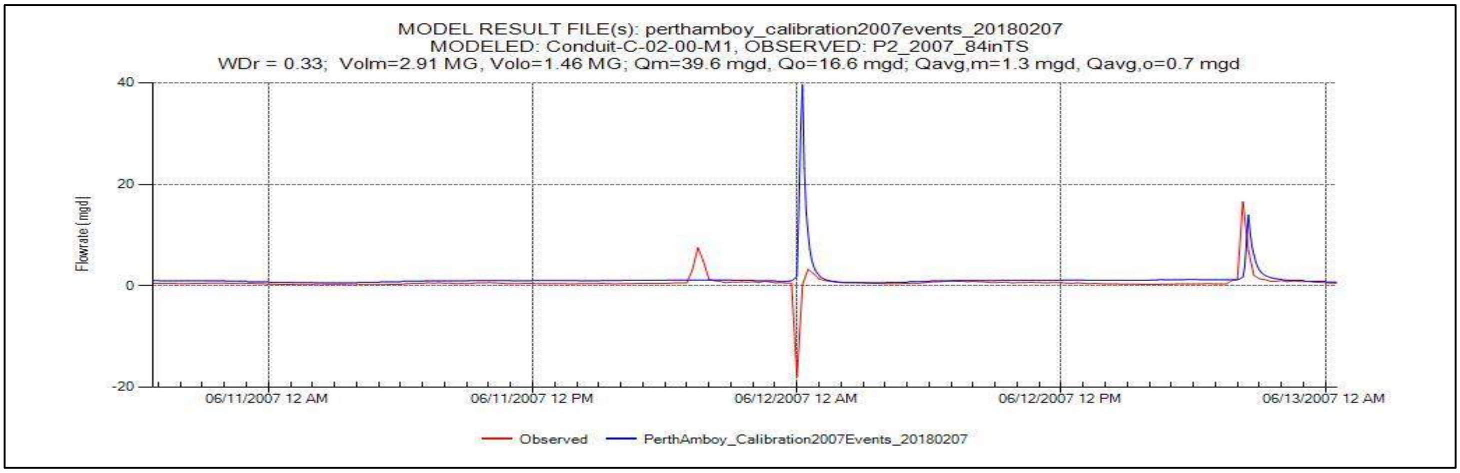


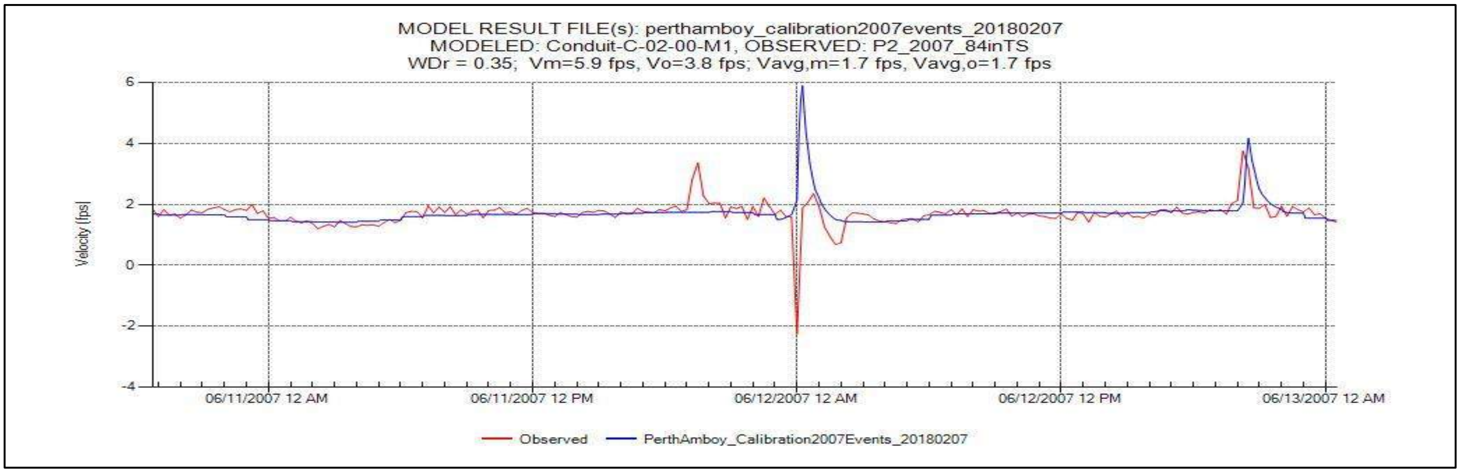


Simulated Versus Observed Flow at Flow Meter Sites

P2_2007_84inTS

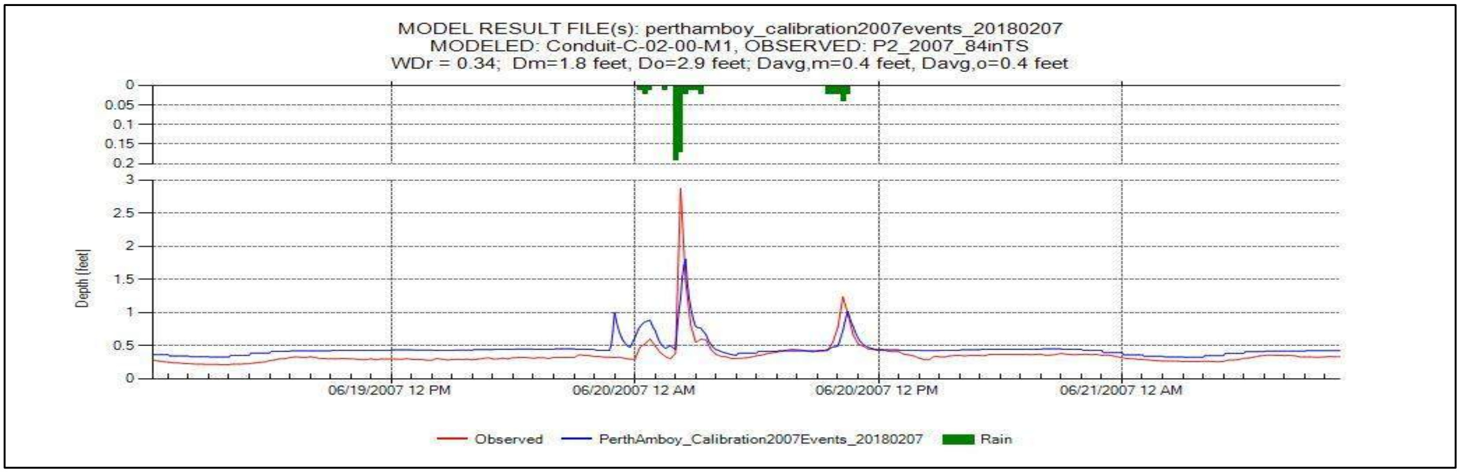


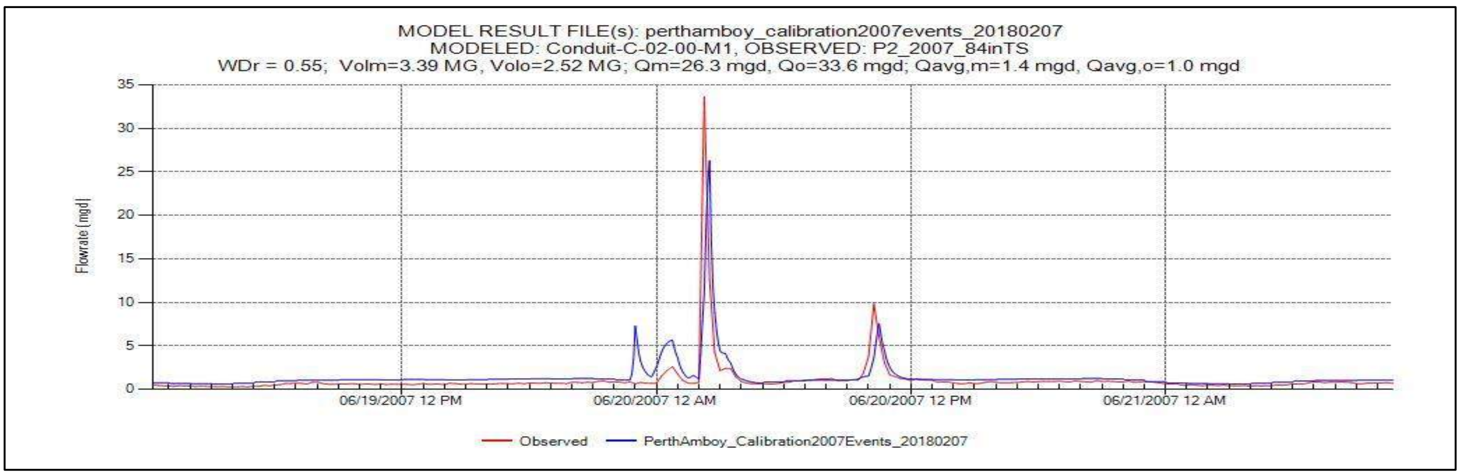


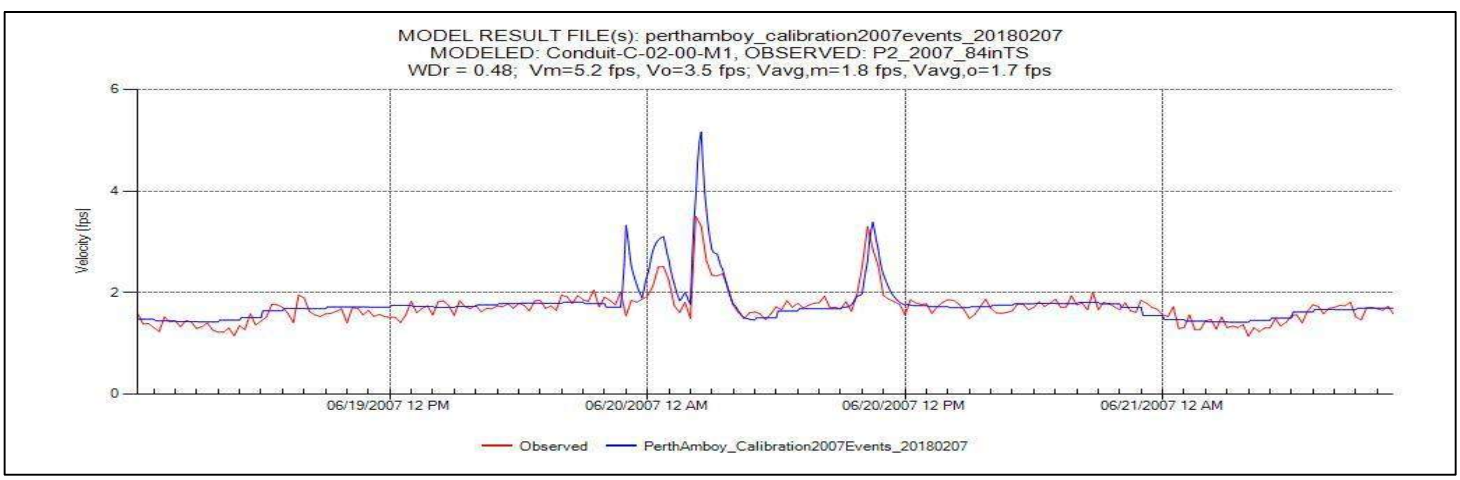


Simulated Versus Observed Flow at Flow Meter Sites

P2_2007_84inTS







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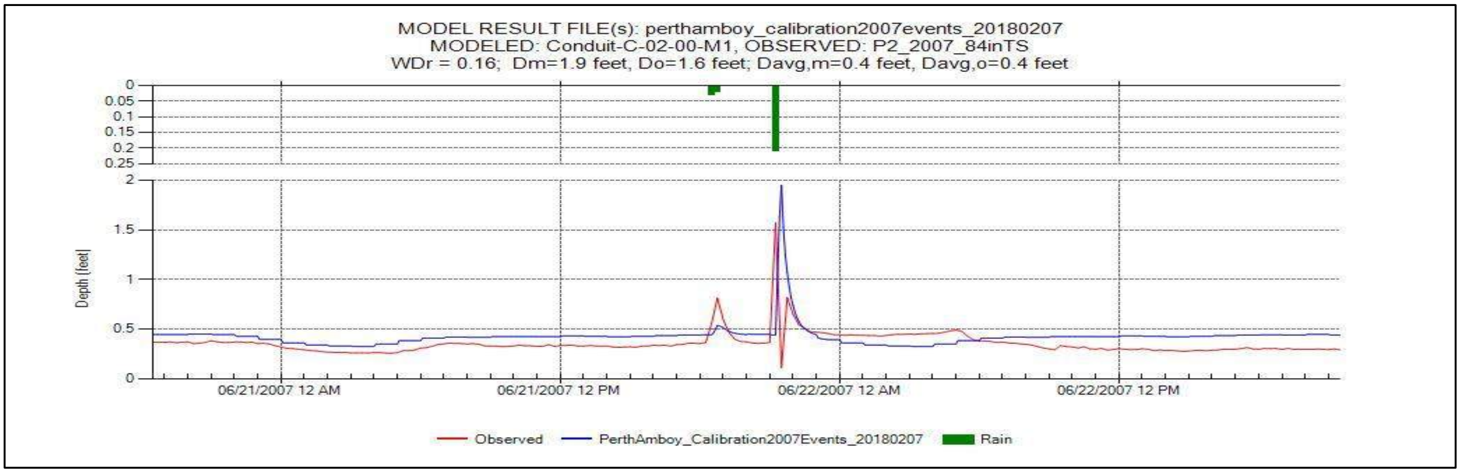
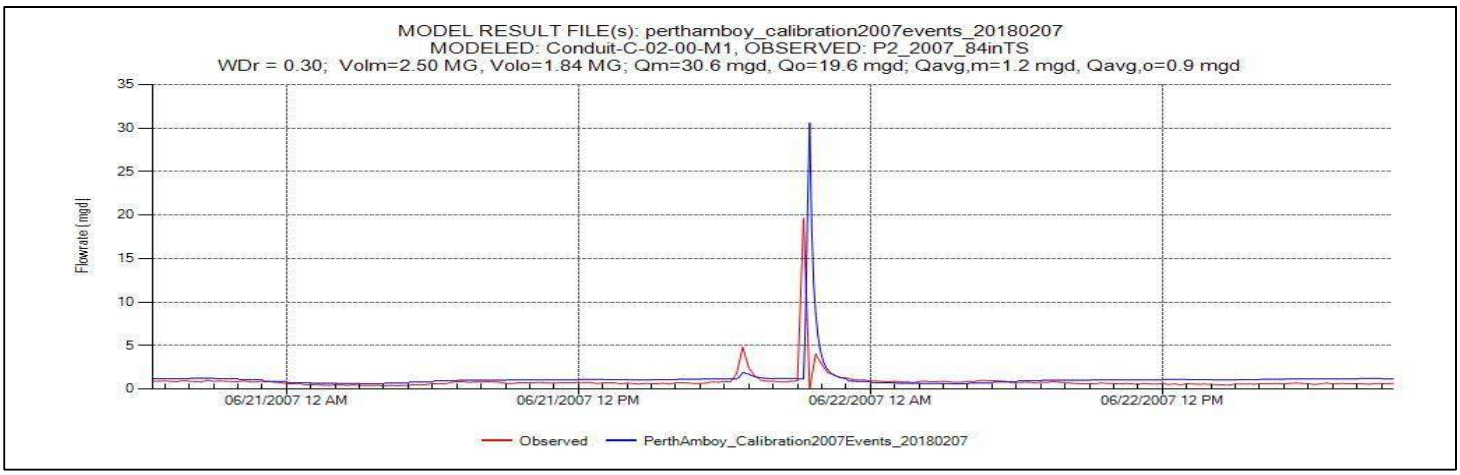
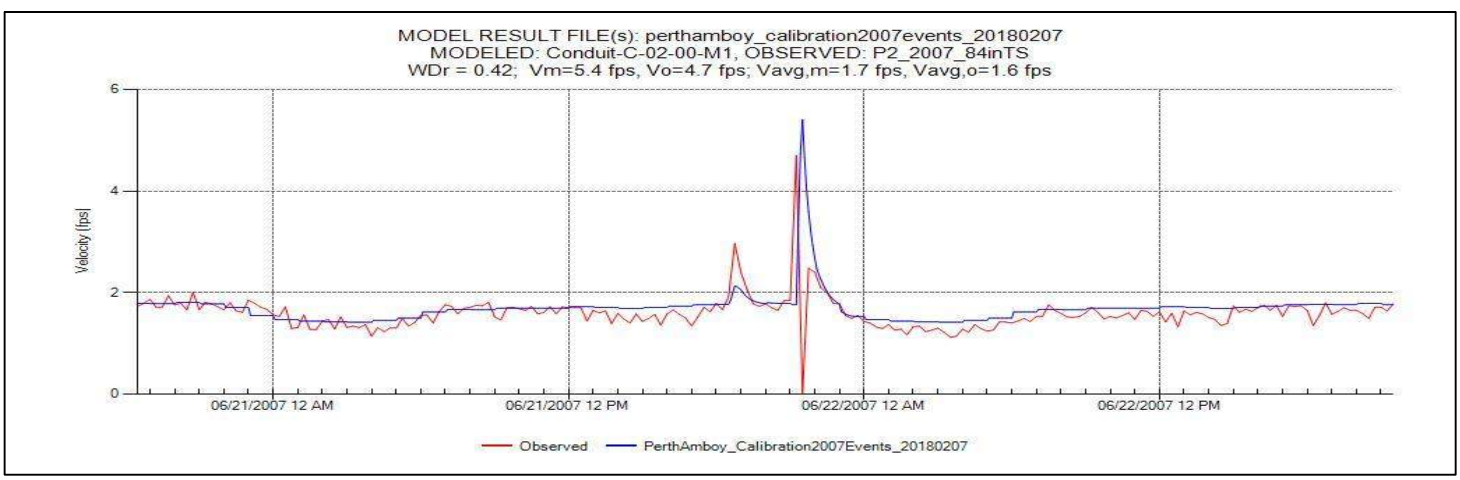
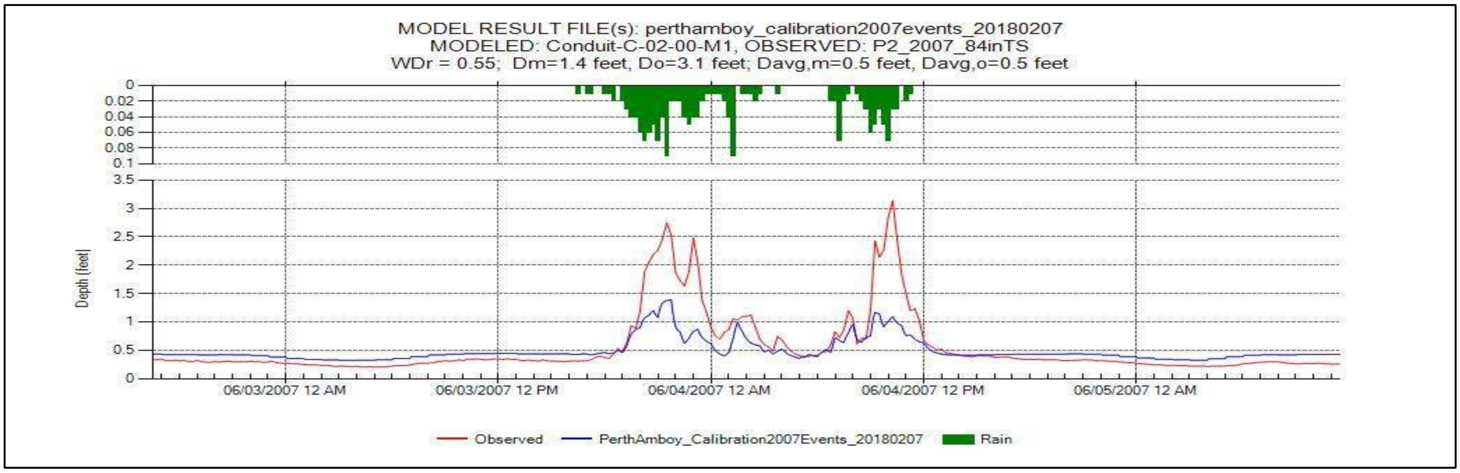
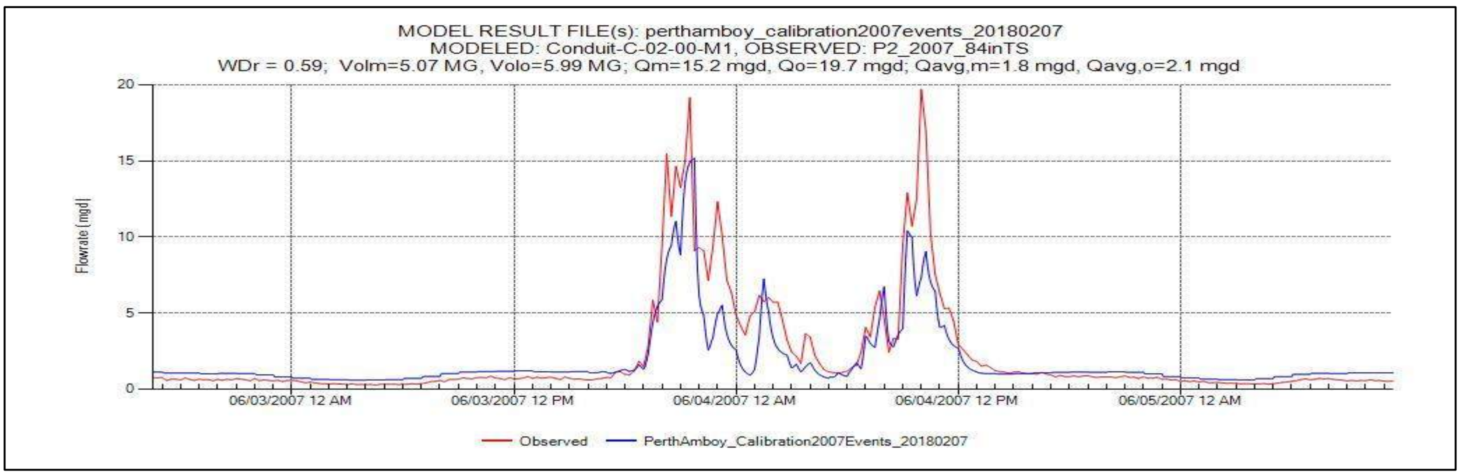


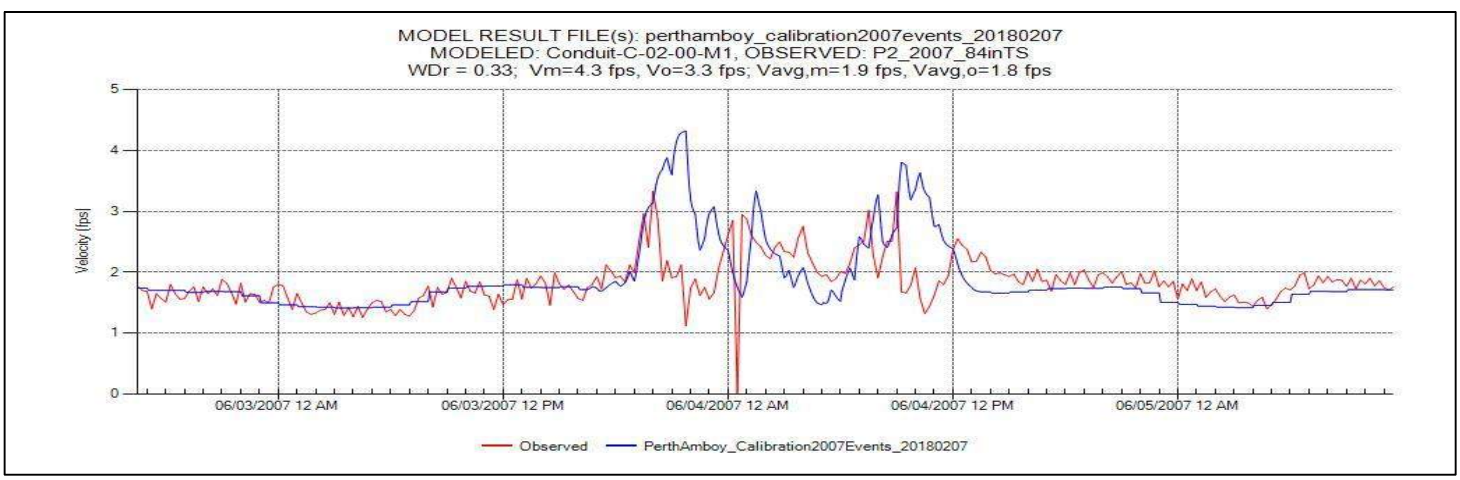




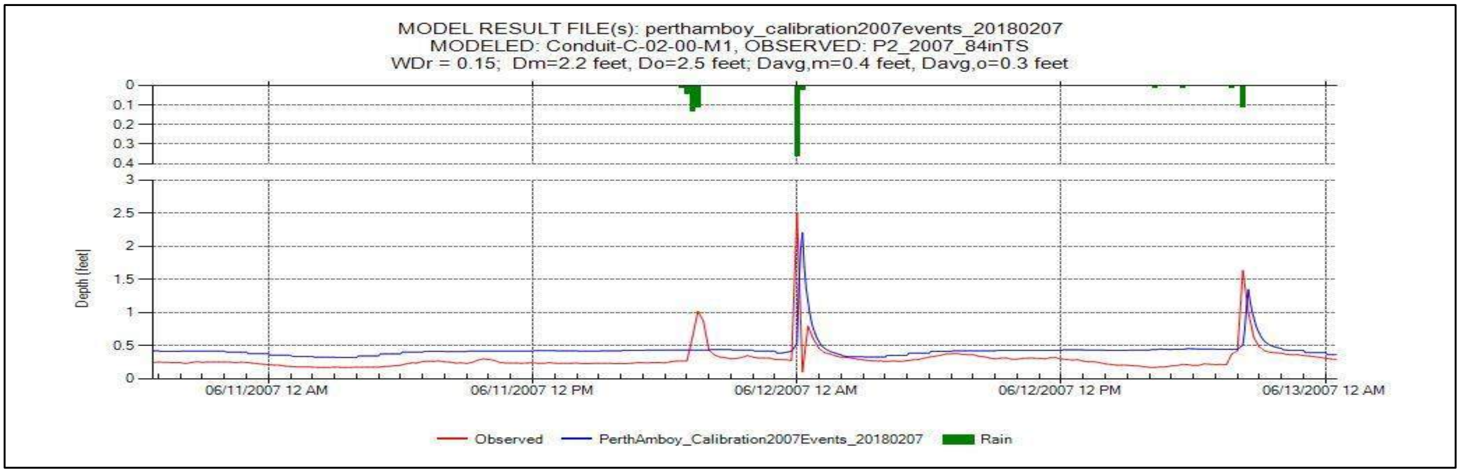
P2-2007-OF

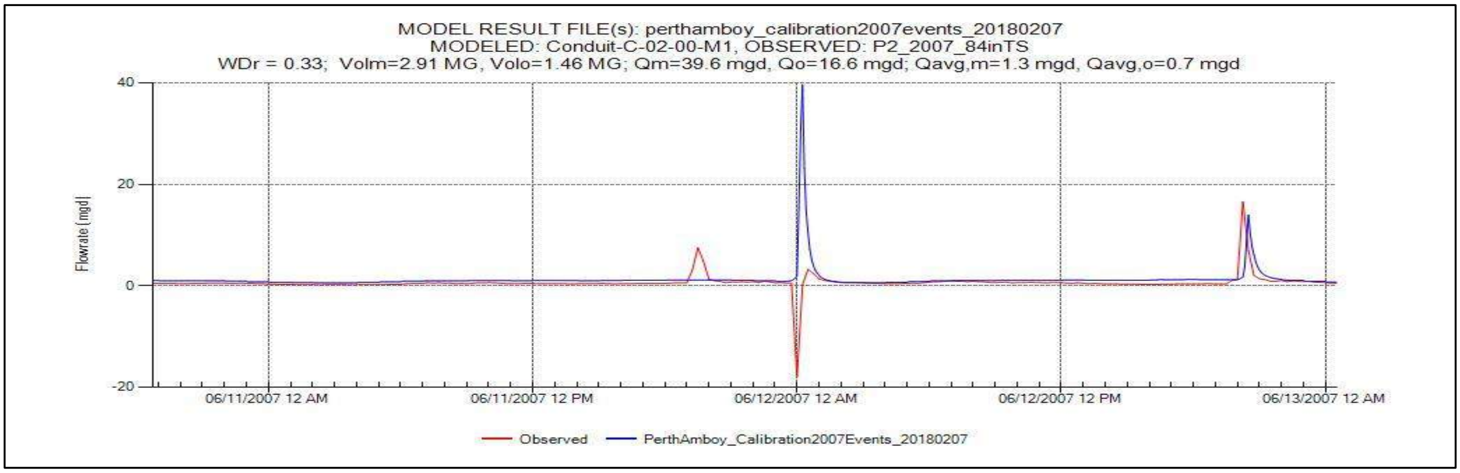

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.55; Dm=1.4 feet, Do=3.1 feet; Davg,m=0.5 feet, Davg,o=0.5 feet
Depth (feet)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

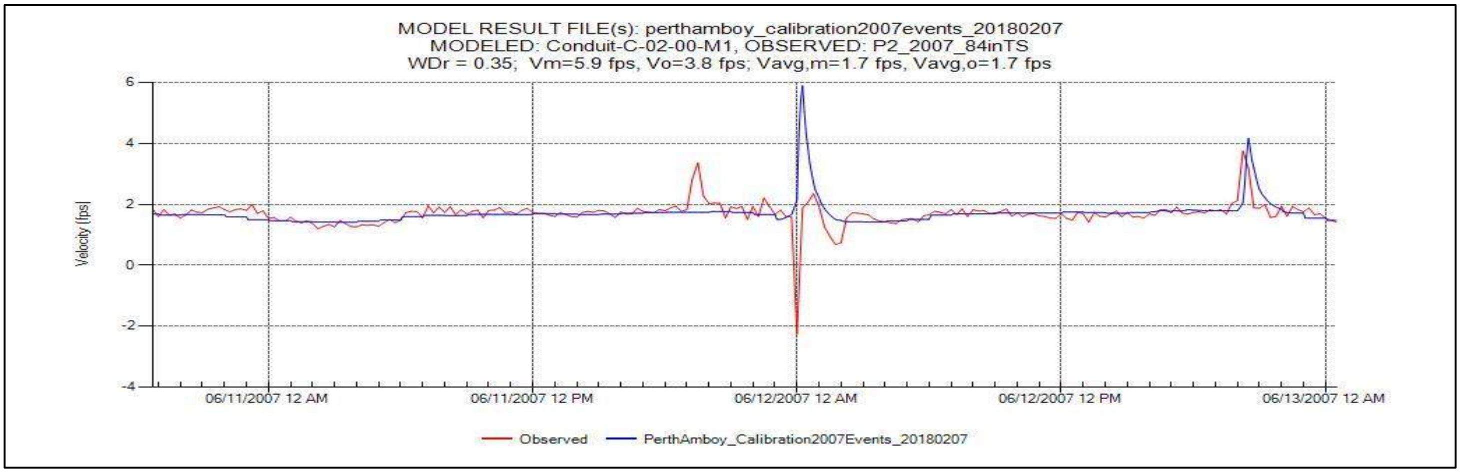

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.59; Volm=5.07 MG, Volo=5.99 MG; Qm=15.2 mgd, Qo=19.7 mgd; Qavg,m=1.8 mgd, Qavg,o=2.1 mgd
Flowrate (mgd)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.33; Vm=4.3 fps, Vo=3.3 fps; Vavg,m=1.9 fps, Vavg,o=1.8 fps
Velocity (fps)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

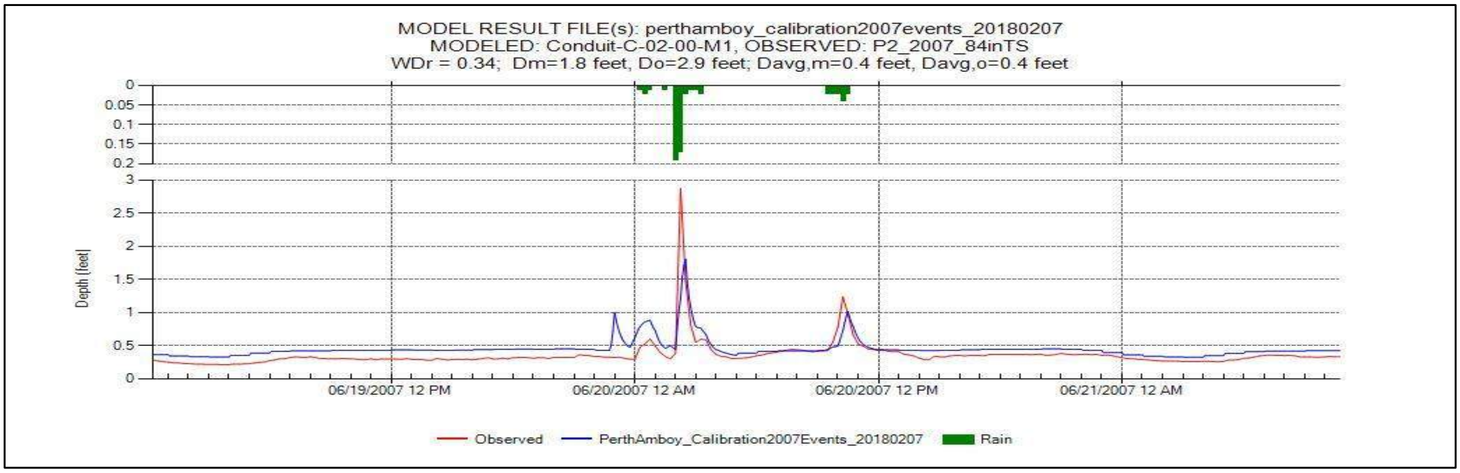
P2-2007-OF

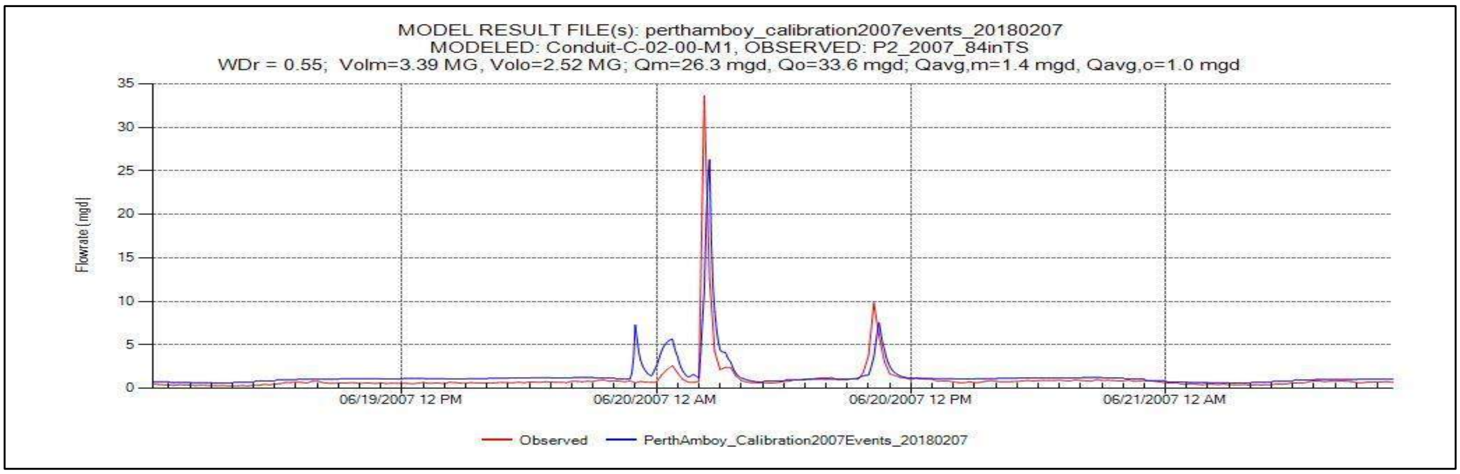

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.15; Dm=2.2 feet, Do=2.5 feet; Davg,m=0.4 feet, Davg,o=0.3 feet
Depth (feet)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

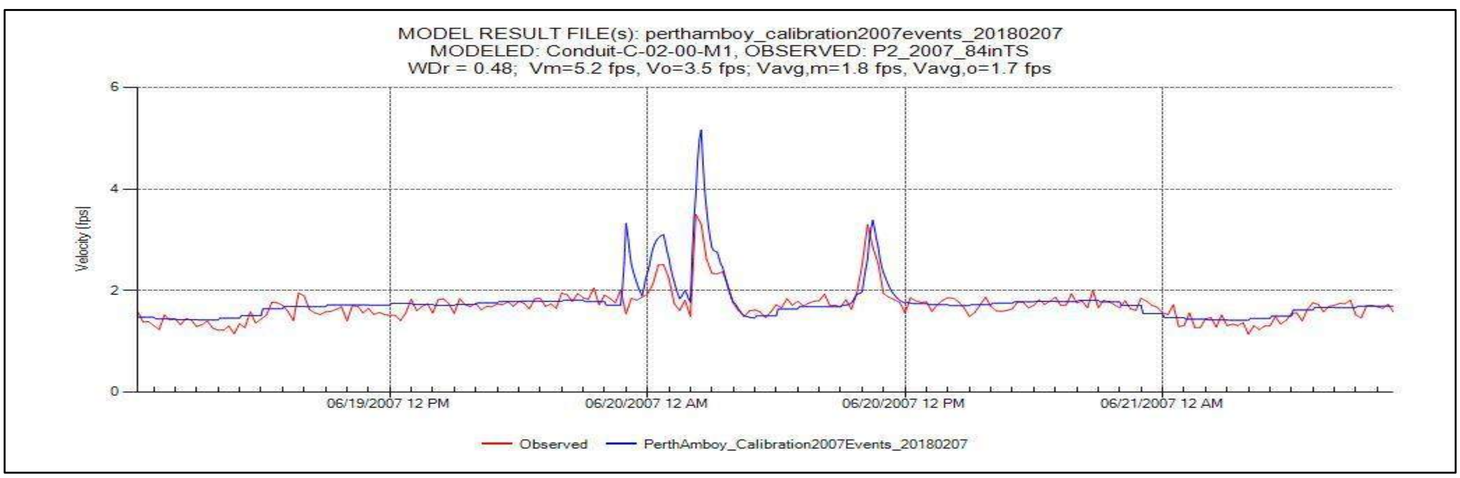

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.33; Volm=2.91 MG, Volo=1.46 MG; Qm=39.6 mgd, Qo=16.6 mgd; Qavg,m=1.3 mgd, Qavg,o=0.7 mgd
Flowrate (mgd)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.35; Vm=5.9 fps, Vo=3.8 fps; Vavg,m=1.7 fps, Vavg,o=1.7 fps
Velocity (fps)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

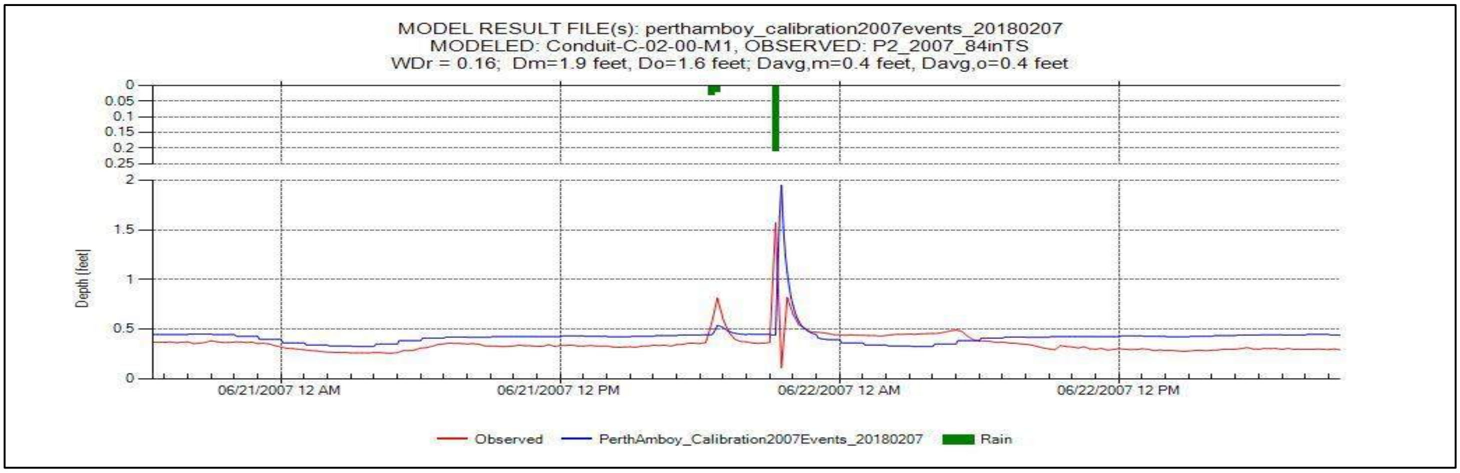
P2-2007-OF

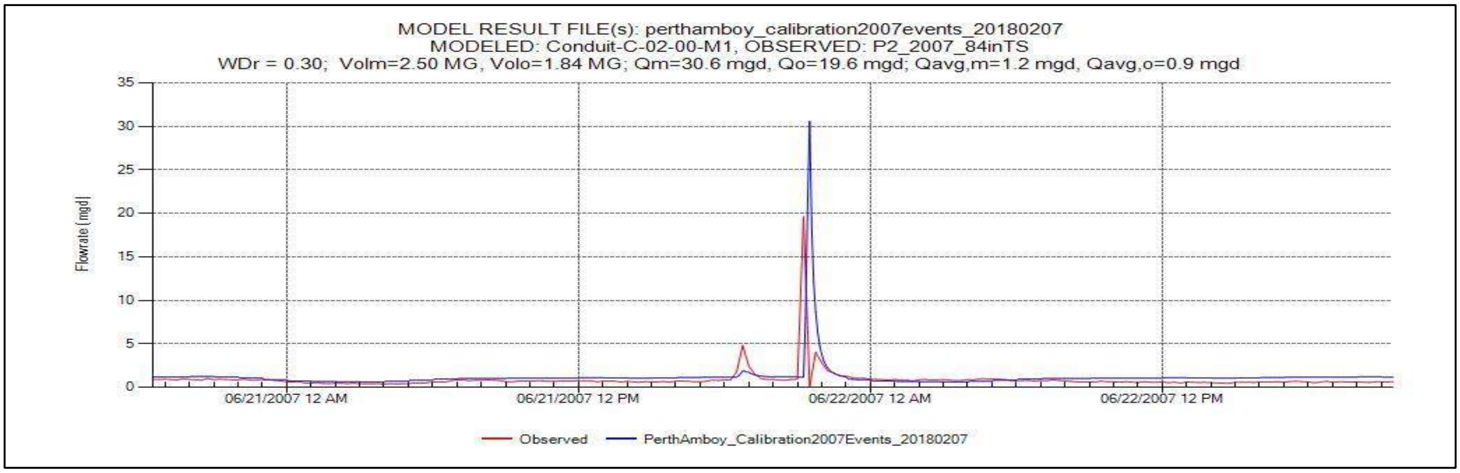

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.34; Dm=1.8 feet, Do=2.9 feet; Davg,m=0.4 feet, Davg,o=0.4 feet
Depth (feet)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

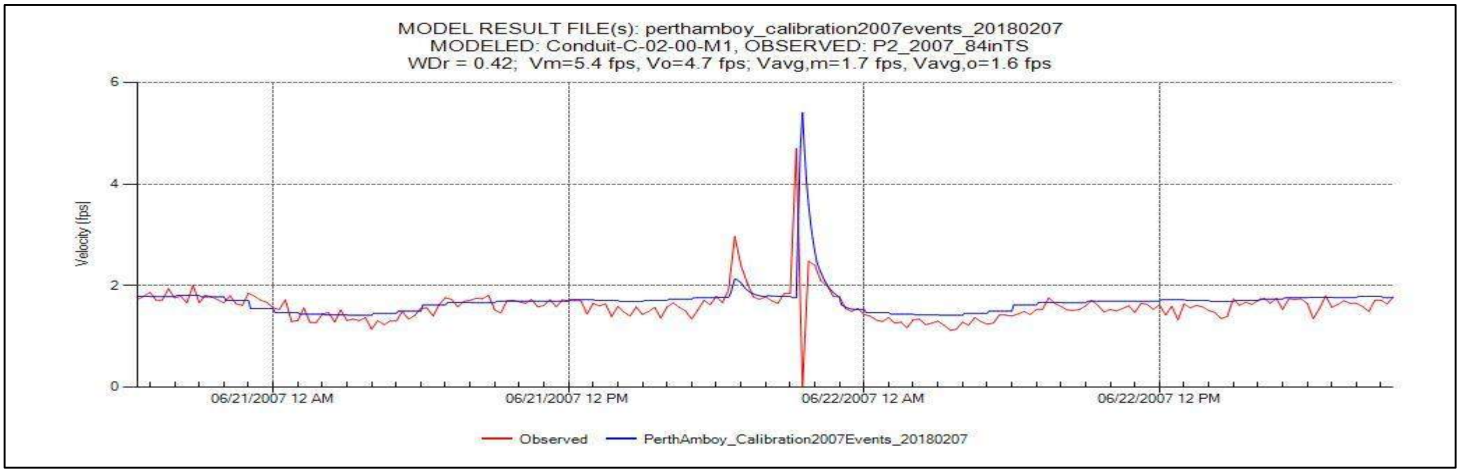

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.55; Volm=3.39 MG, Volo=2.52 MG; Qm=26.3 mgd, Qo=33.6 mgd; Qavg,m=1.4 mgd, Qavg,o=1.0 mgd
Flowrate (mgd)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.48; Vm=5.2 fps, Vo=3.5 fps; Vavg,m=1.8 fps, Vavg,o=1.7 fps
Velocity (fps)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

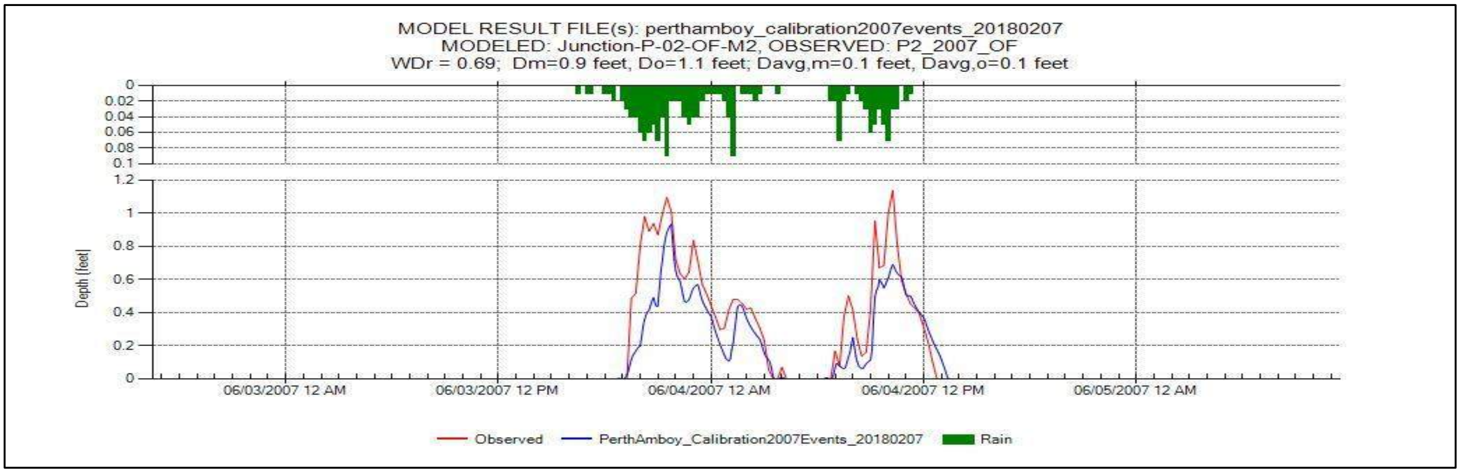
P2-2007-OF

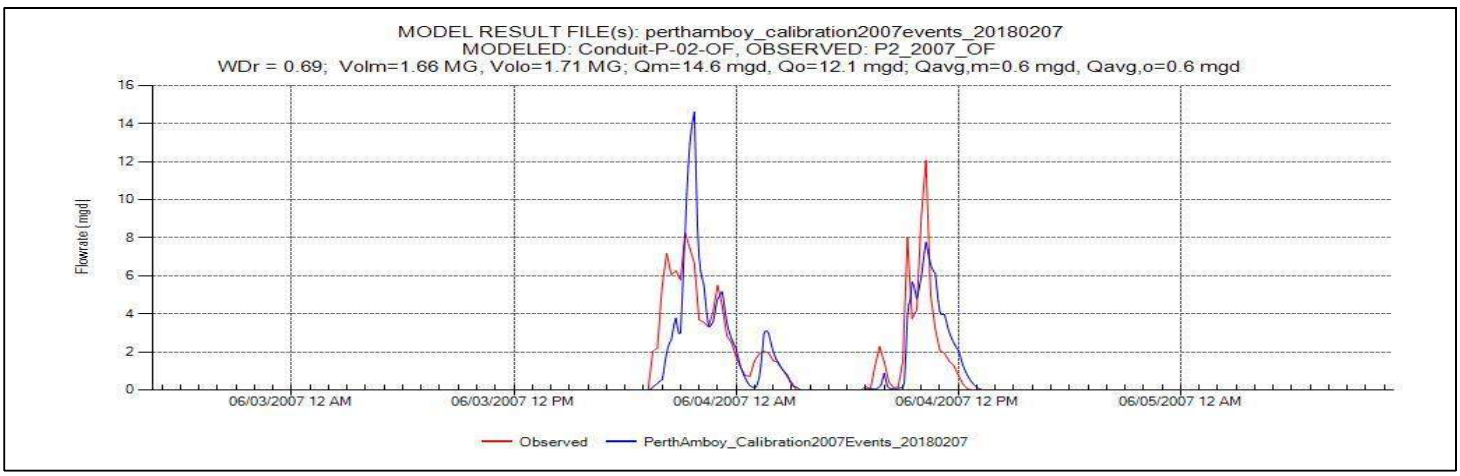

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.16; Dm=1.9 feet, Do=1.6 feet; Davg,m=0.4 feet, Davg,o=0.4 feet
Depth (feet)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

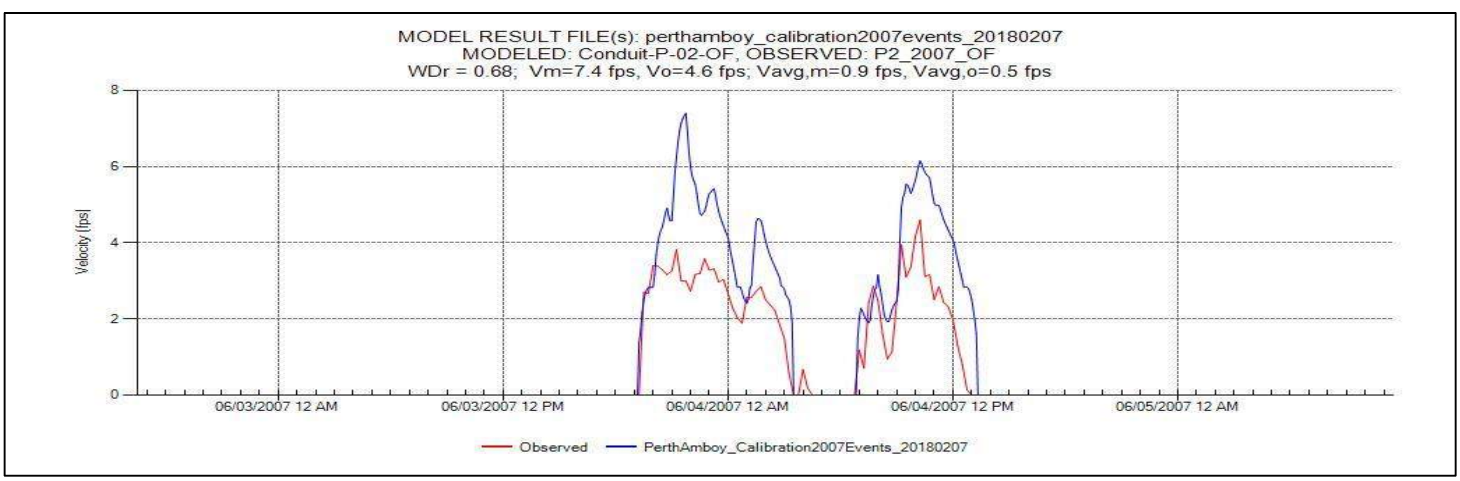

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.30; Volm=2.50 MG, Volo=1.84 MG; Qm=30.6 mgd, Qo=19.6 mgd; Qavg,m=1.2 mgd, Qavg,o=0.9 mgd
Flowrate (mgd)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-02-00-M1, OBSERVED: P2_2007_84inTS
WDr = 0.42; Vm=5.4 fps, Vo=4.7 fps; Vavg,m=1.7 fps, Vavg,o=1.6 fps
Velocity (fps)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

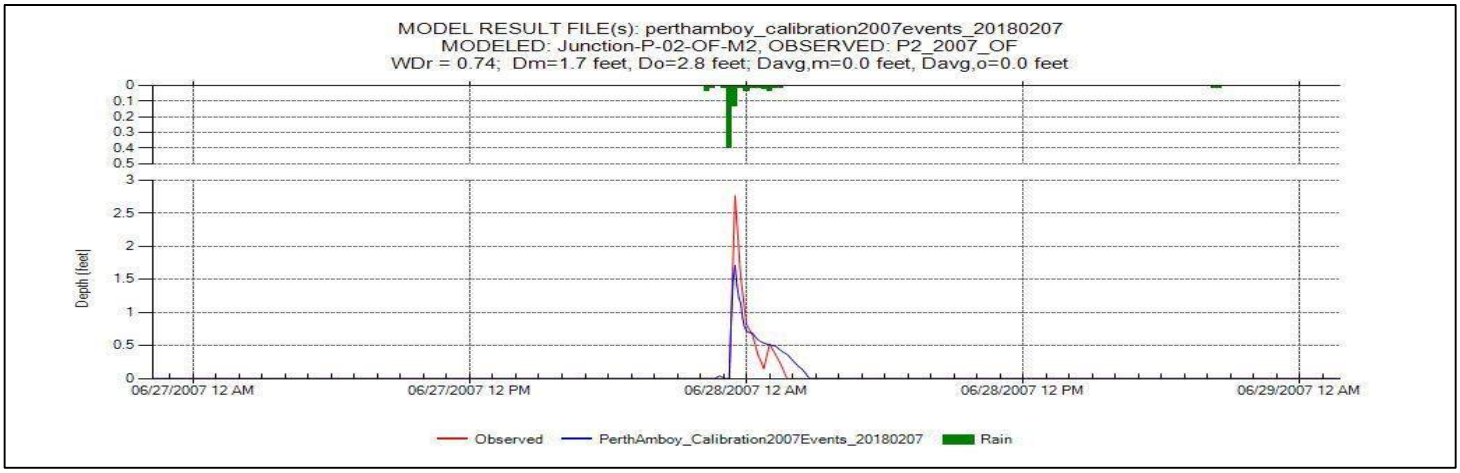
P2-2007-OF

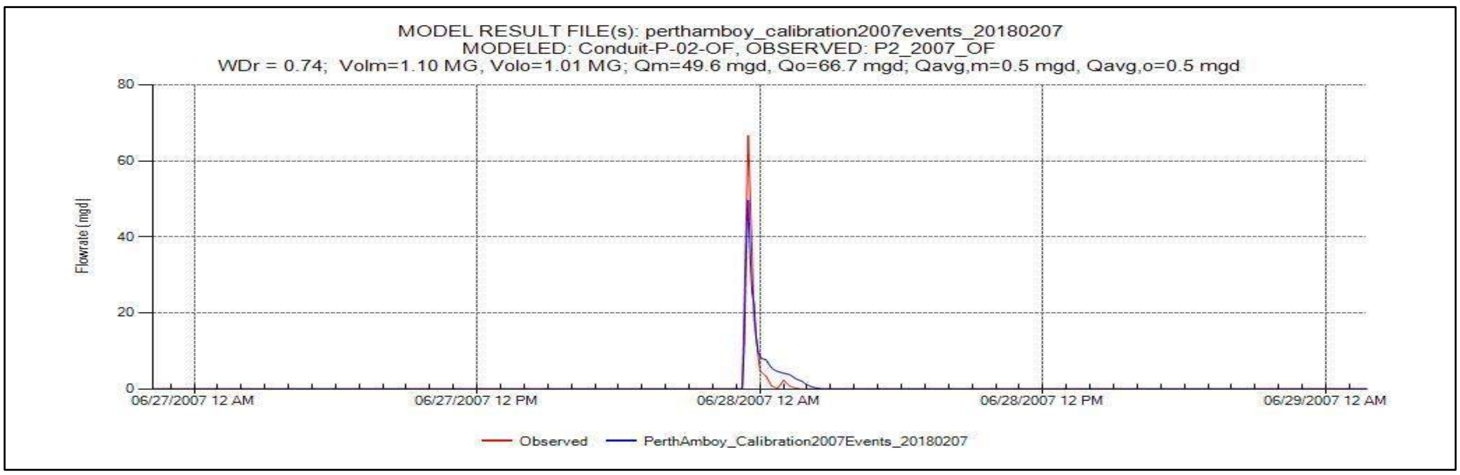

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-02-OF-M2, OBSERVED: P2_2007_OF
WDr = 0.69; Dm=0.9 feet, Do=1.1 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

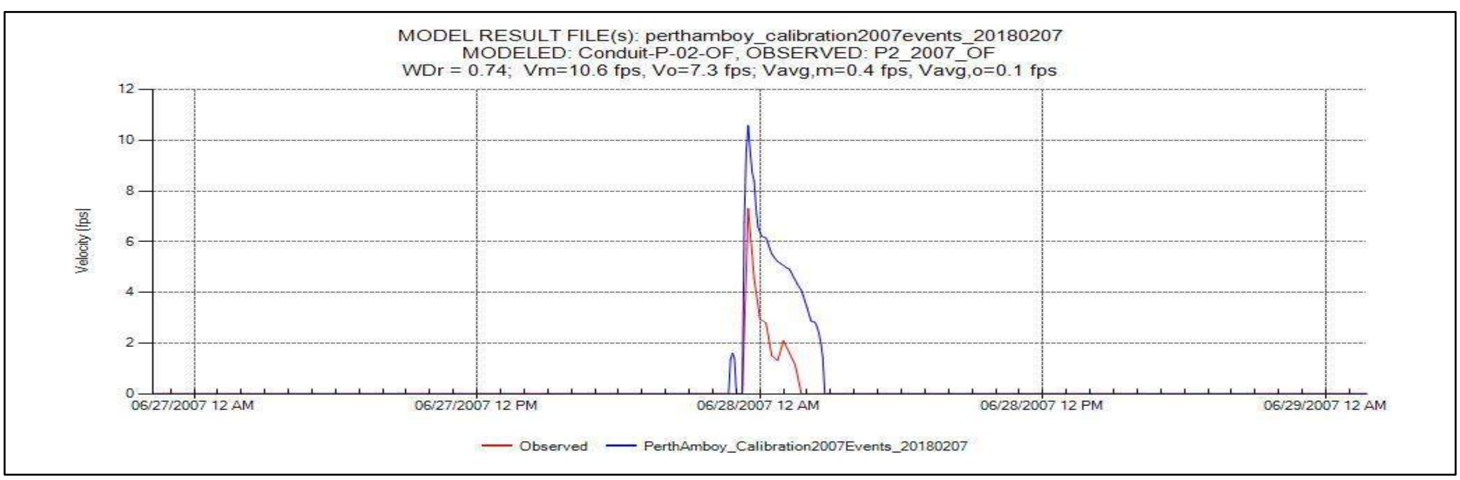

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.69; Volm=1.66 MG, Volo=1.71 MG; Qm=14.6 mgd, Qo=12.1 mgd; Qavg,m=0.6 mgd, Qavg,o=0.6 mgd
Flowrate (mgd)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.68; Vm=7.4 fps, Vo=4.6 fps; Vavg,m=0.9 fps, Vavg,o=0.5 fps
Velocity (fps)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

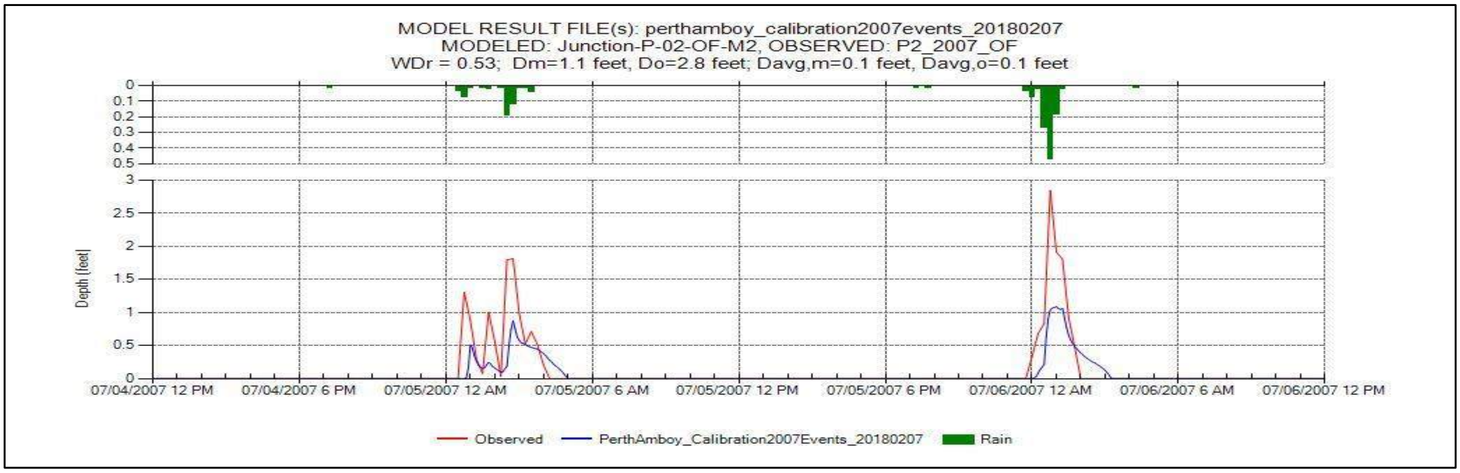
P2-2007-OF

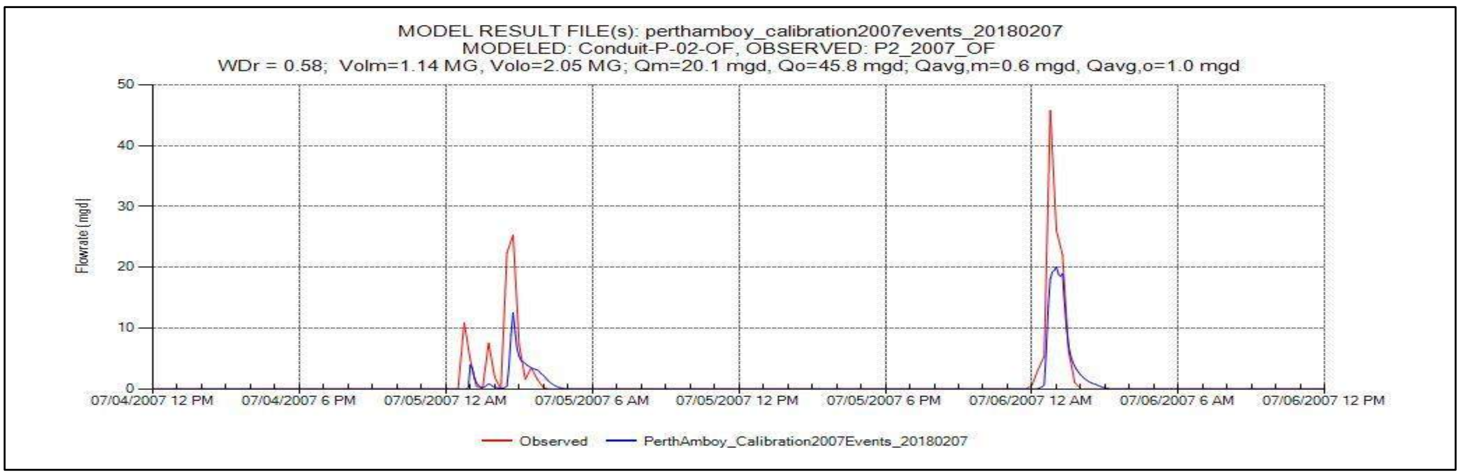

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-02-OF-M2, OBSERVED: P2_2007_OF
WDr = 0.74; Dm=1.7 feet, Do=2.8 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

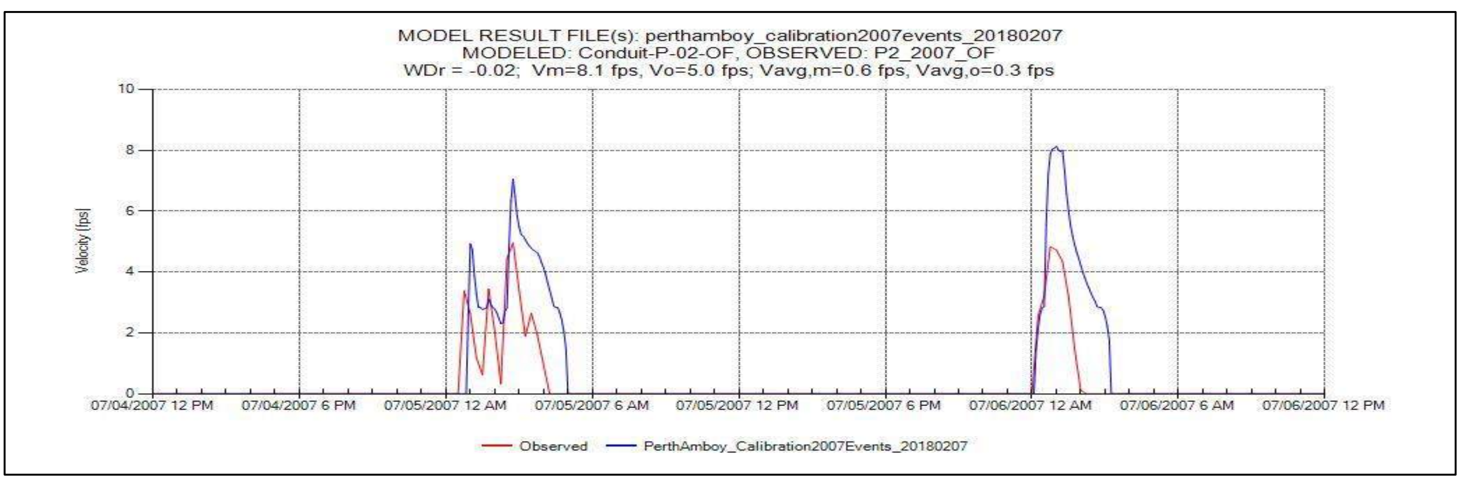

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.74; Volm=1.10 MG, Volo=1.01 MG; Qm=49.6 mgd, Qo=66.7 mgd; Qavg,m=0.5 mgd, Qavg,o=0.5 mgd
Flowrate (mgd)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.74; Vm=10.6 fps, Vo=7.3 fps; Vavg,m=0.4 fps, Vavg,o=0.1 fps
Velocity (fps)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

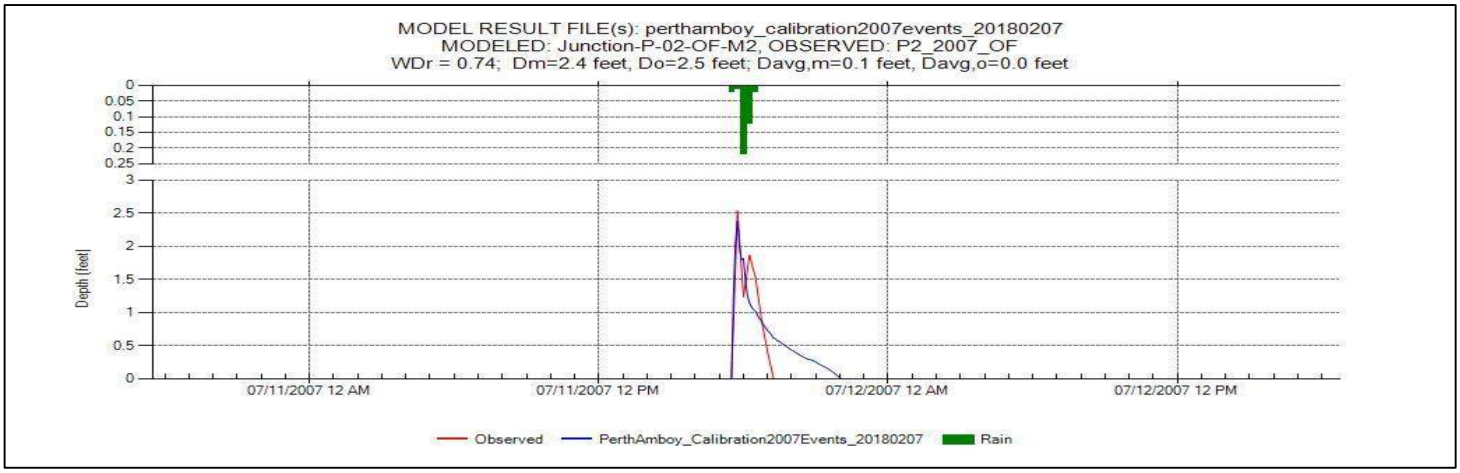
P2-2007-OF

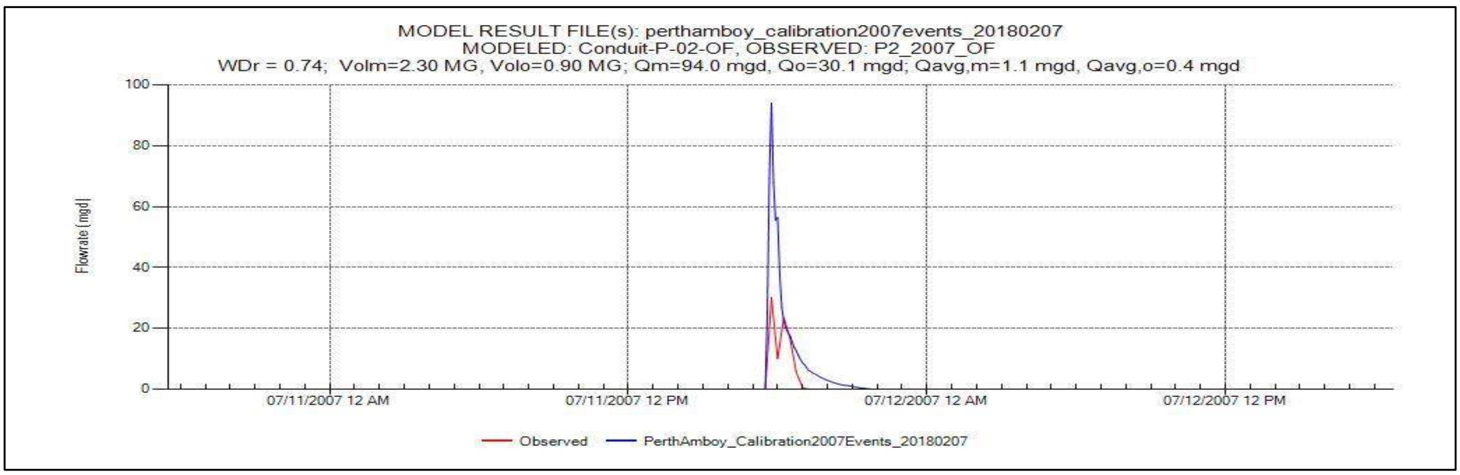

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-02-OF-M2, OBSERVED: P2_2007_OF
WDr = 0.53; Dm=1.1 feet, Do=2.8 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

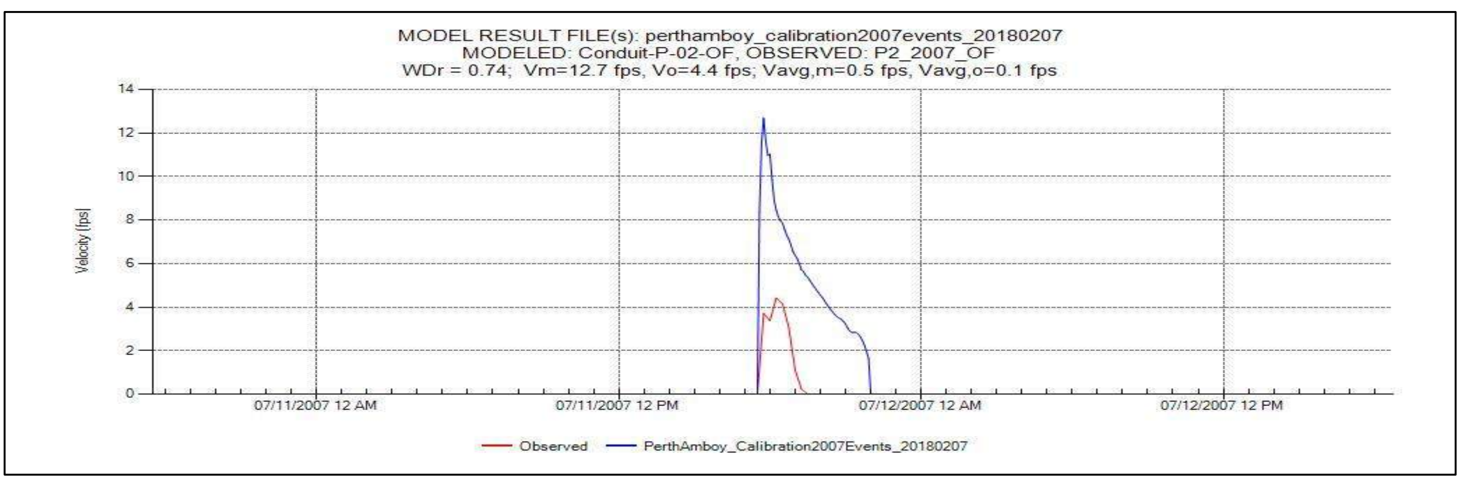

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.58; Volm=1.14 MG, Volo=2.05 MG; Qm=20.1 mgd, Qo=45.8 mgd; Qavg,m=0.6 mgd, Qavg,o=1.0 mgd
Flowrate (mgd)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = -0.02; Vm=8.1 fps, Vo=5.0 fps; Vavg,m=0.6 fps, Vavg,o=0.3 fps
Velocity (fps)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

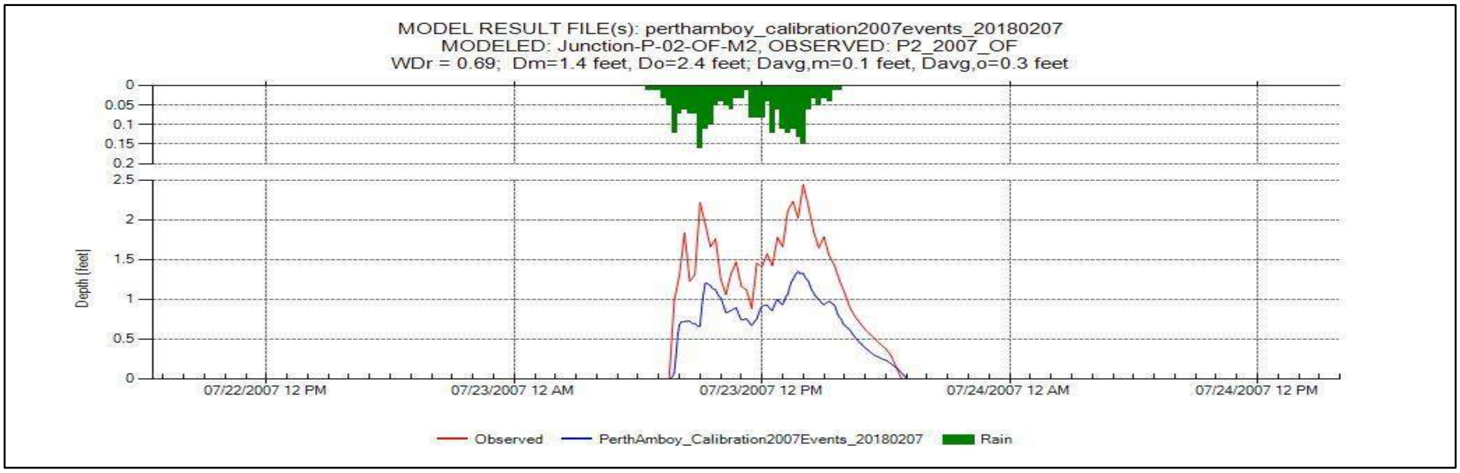
P2-2007-OF

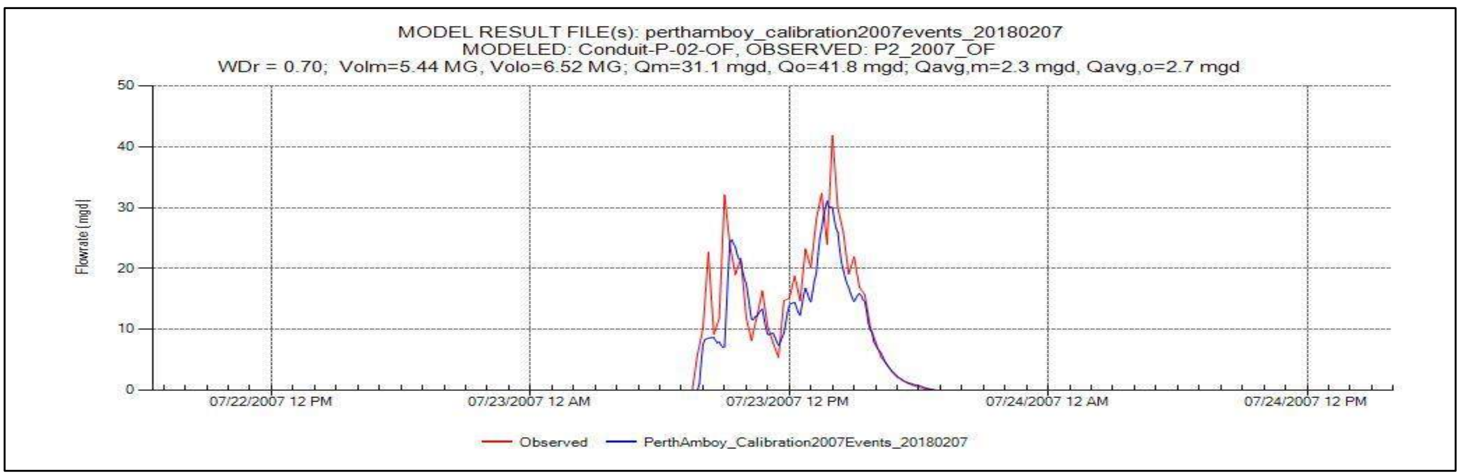

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-02-OF-M2, OBSERVED: P2_2007_OF
WDr = 0.74; Dm=2.4 feet, Do=2.5 feet; Davg,m=0.1 feet, Davg,o=0.0 feet
Depth (feet)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

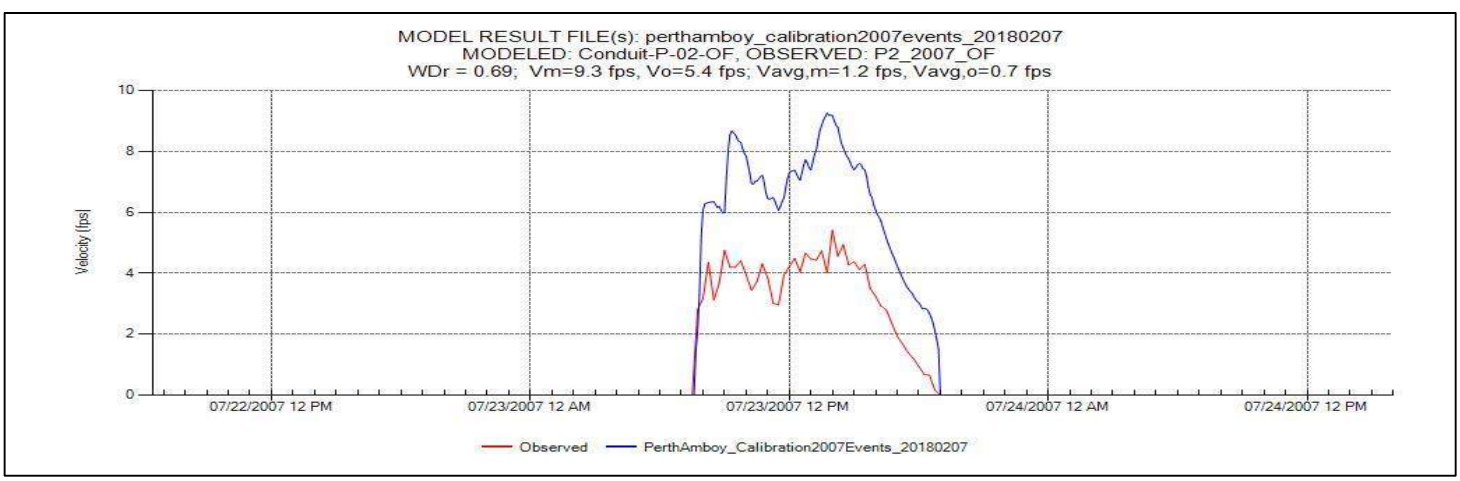

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.74; Volm=2.30 MG, Volo=0.90 MG; Qm=94.0 mgd, Qo=30.1 mgd; Qavg,m=1.1 mgd, Qavg,o=0.4 mgd
Flowrate (mgd)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.74; Vm=12.7 fps, Vo=4.4 fps; Vavg,m=0.5 fps, Vavg,o=0.1 fps
Velocity (fps)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

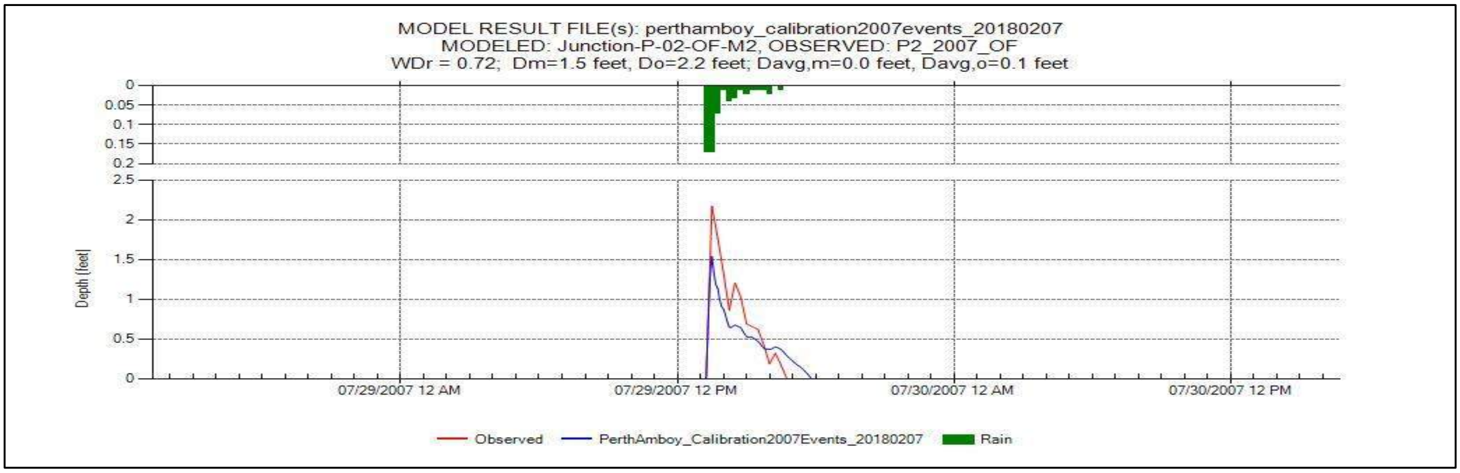
P2-2007-OF

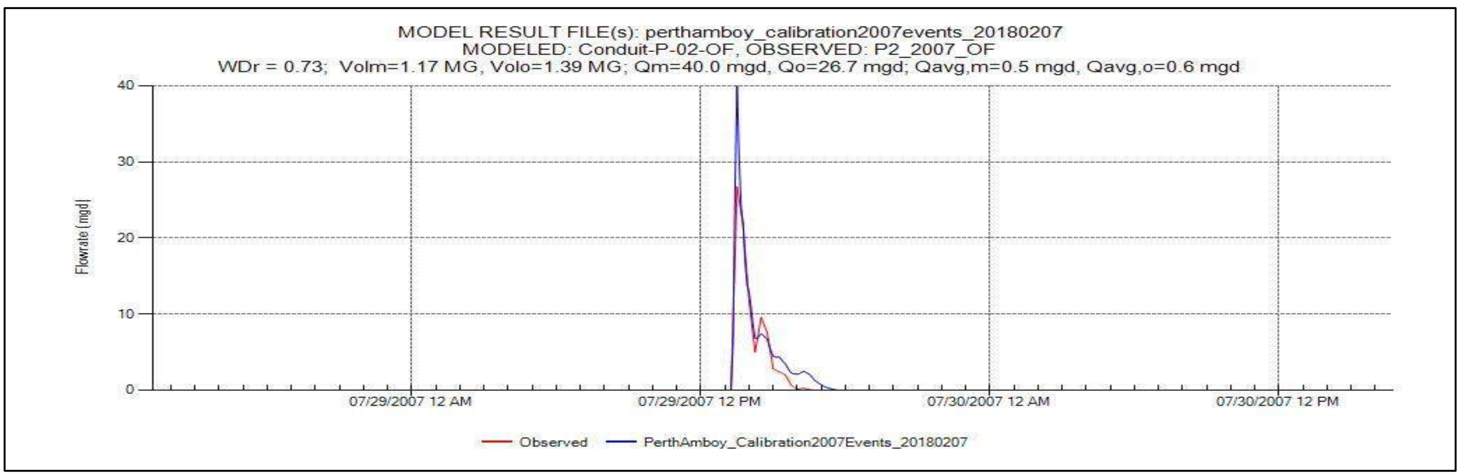

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-02-OF-M2, OBSERVED: P2_2007_OF
WDr = 0.69; Dm=1.4 feet, Do=2.4 feet; Davg,m=0.1 feet, Davg,o=0.3 feet
Depth (feet)
07/22/2007 12 PM
07/23/2007 12 AM
07/23/2007 12 PM
07/24/2007 12 AM
07/24/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

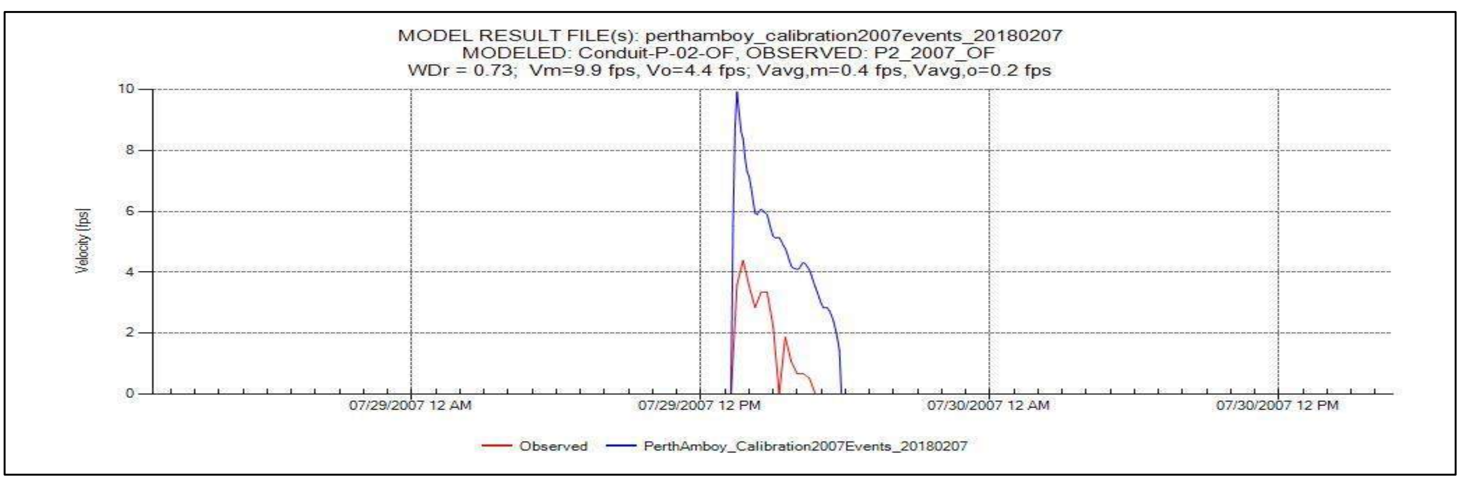

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.70; Volm=5.44 MG, Volo=6.52 MG; Qm=31.1 mgd, Qo=41.8 mgd; Qavg,m=2.3 mgd, Qavg,o=2.7 mgd
Flowrate (mgd)
07/22/2007 12 PM
07/23/2007 12 AM
07/23/2007 12 PM
07/24/2007 12 AM
07/24/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.69; Vm=9.3 fps, Vo=5.4 fps; Vavg,m=1.2 fps, Vavg,o=0.7 fps
Velocity (fps)
07/22/2007 12 PM
07/23/2007 12 AM
07/23/2007 12 PM
07/24/2007 12 AM
07/24/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

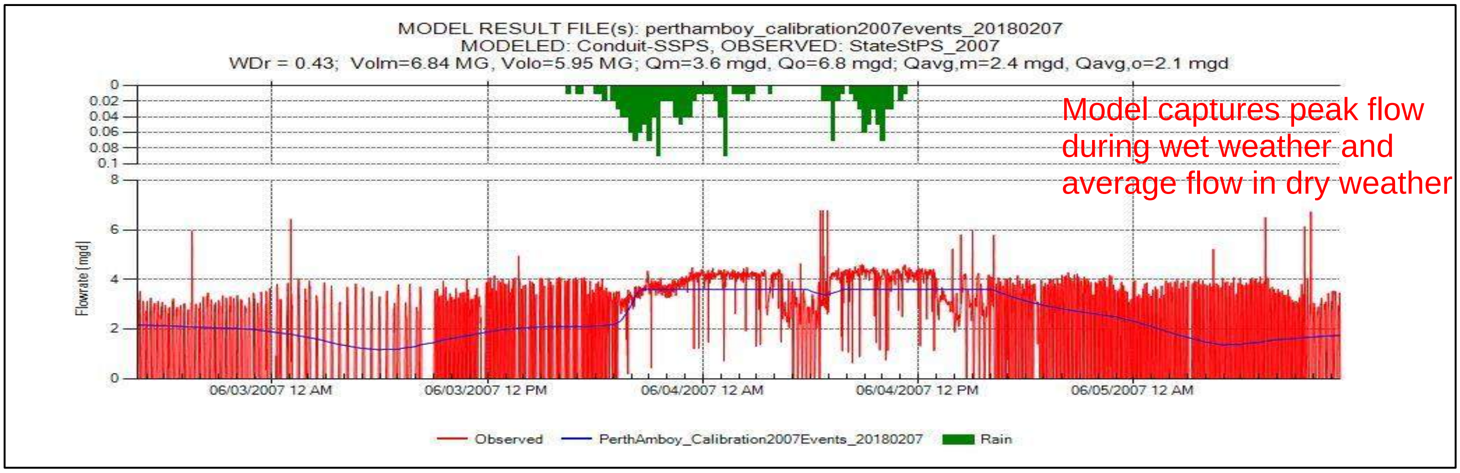
P2-2007-OF

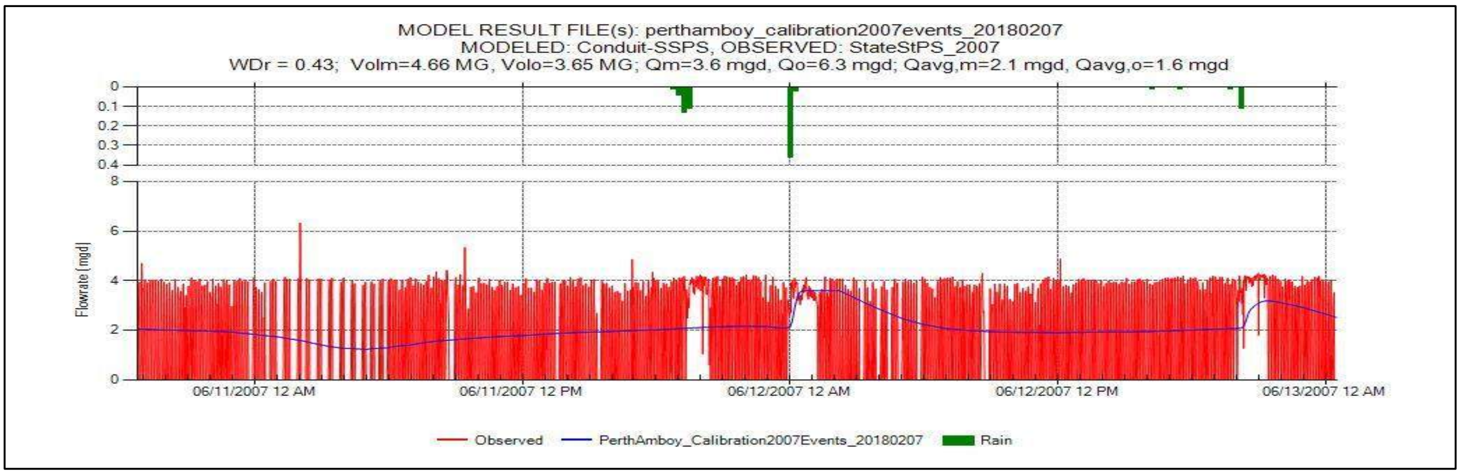

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-02-OF-M2, OBSERVED: P2_2007_OF
WDr = 0.72; Dm=1.5 feet, Do=2.2 feet; Davg,m=0.0 feet, Davg,o=0.1 feet
Depth (feet)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

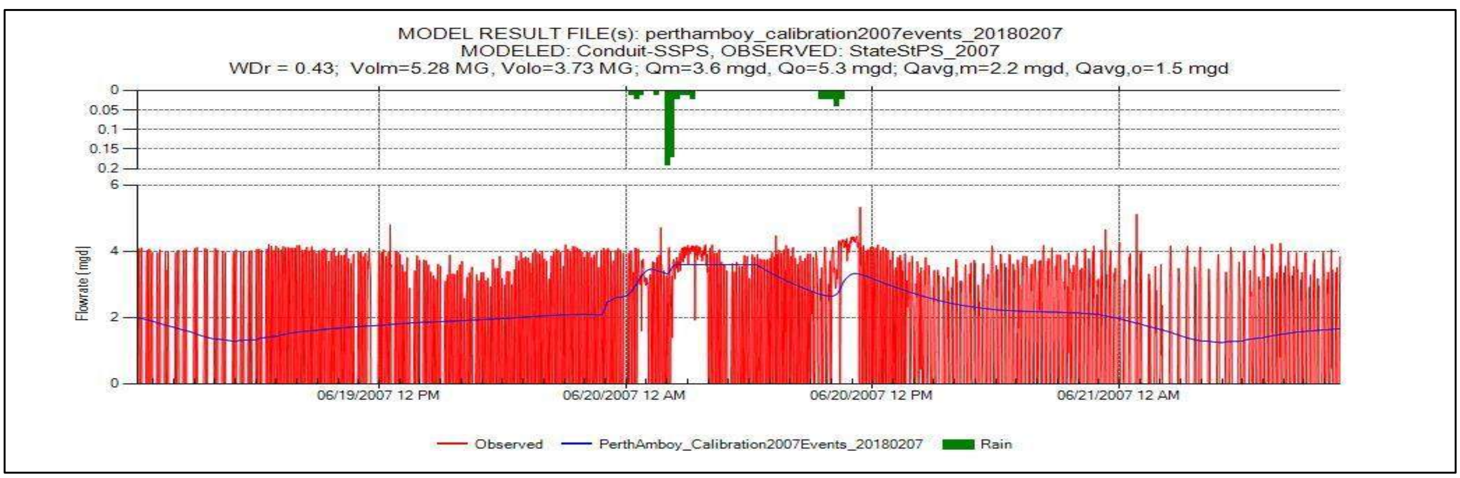

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.73; Volm=1.17 MG, Volo=1.39 MG; Qm=40.0 mgd, Qo=26.7 mgd; Qavg,m=0.5 mgd, Qavg,o=0.6 mgd
Flowrate (mgd)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-02-OF, OBSERVED: P2_2007_OF
WDr = 0.73; Vm=9.9 fps, Vo=4.4 fps; Vavg,m=0.4 fps, Vavg,o=0.2 fps
Velocity (fps)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

StateStPS - 2007

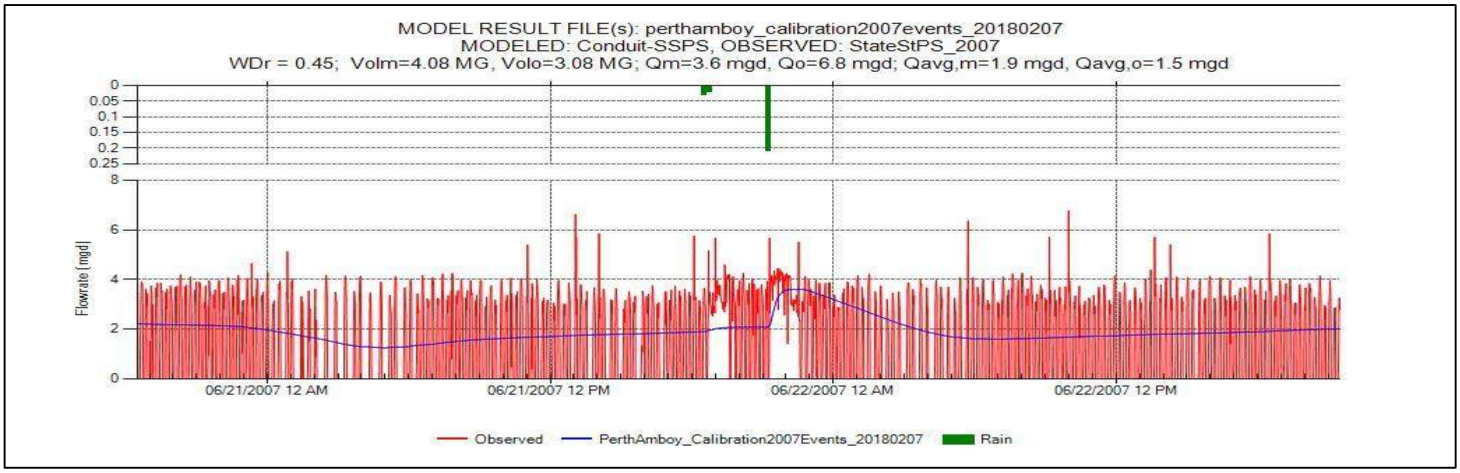


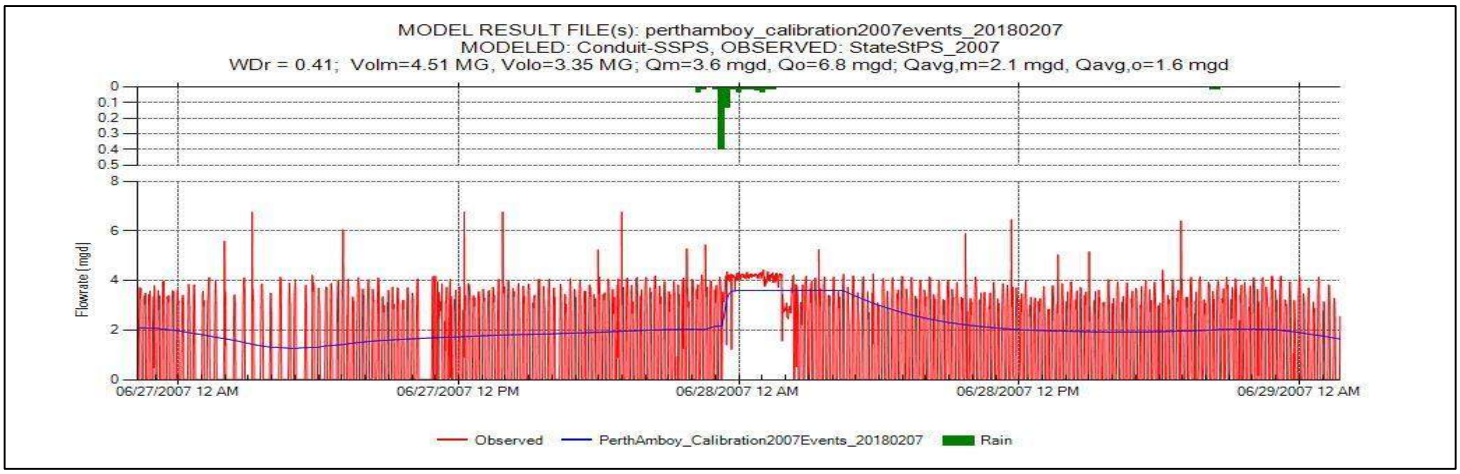


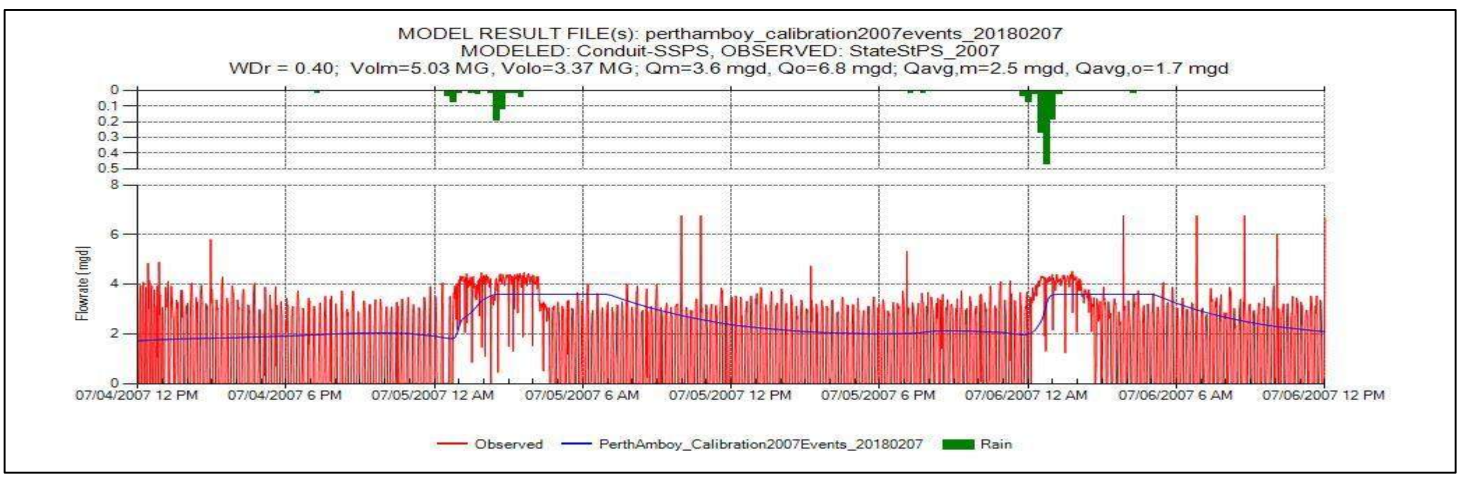


Simulated Versus Observed Flow at Flow Meter Sites

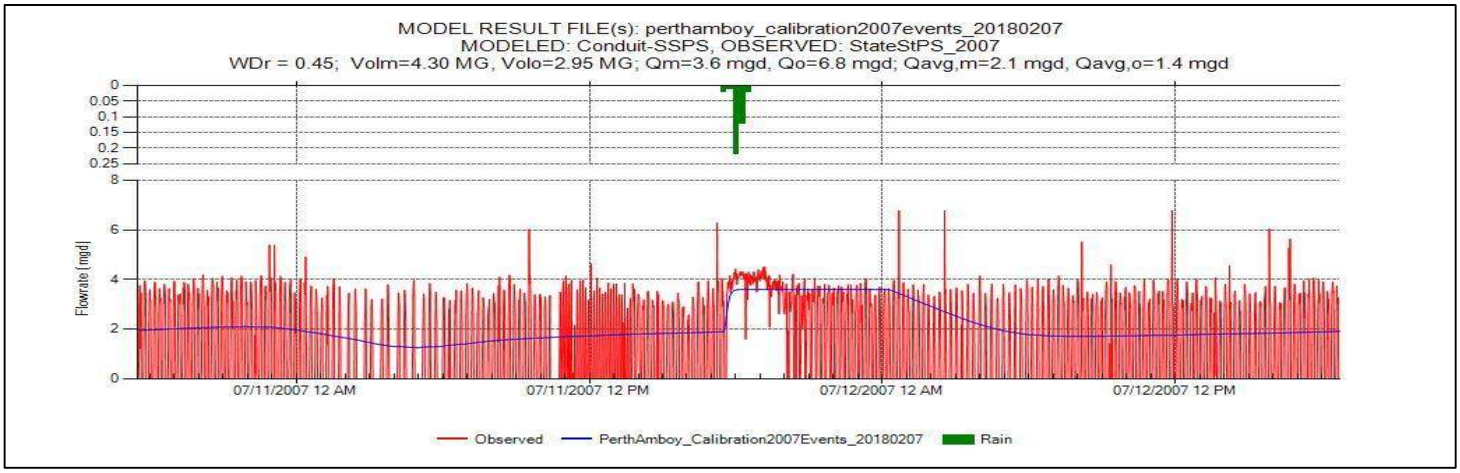
StateStPS - 2007

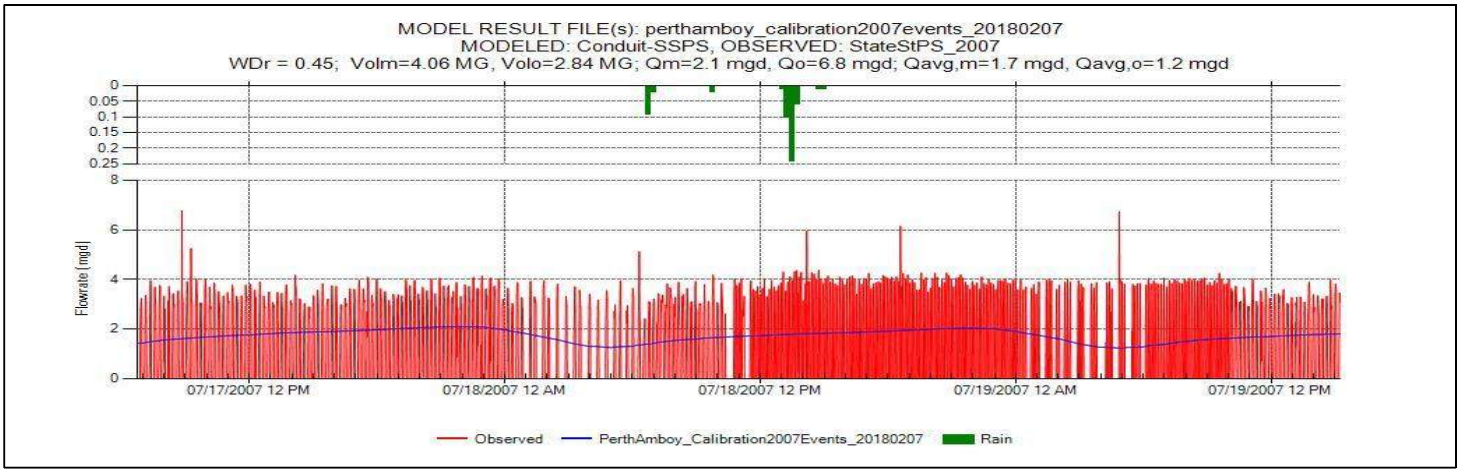


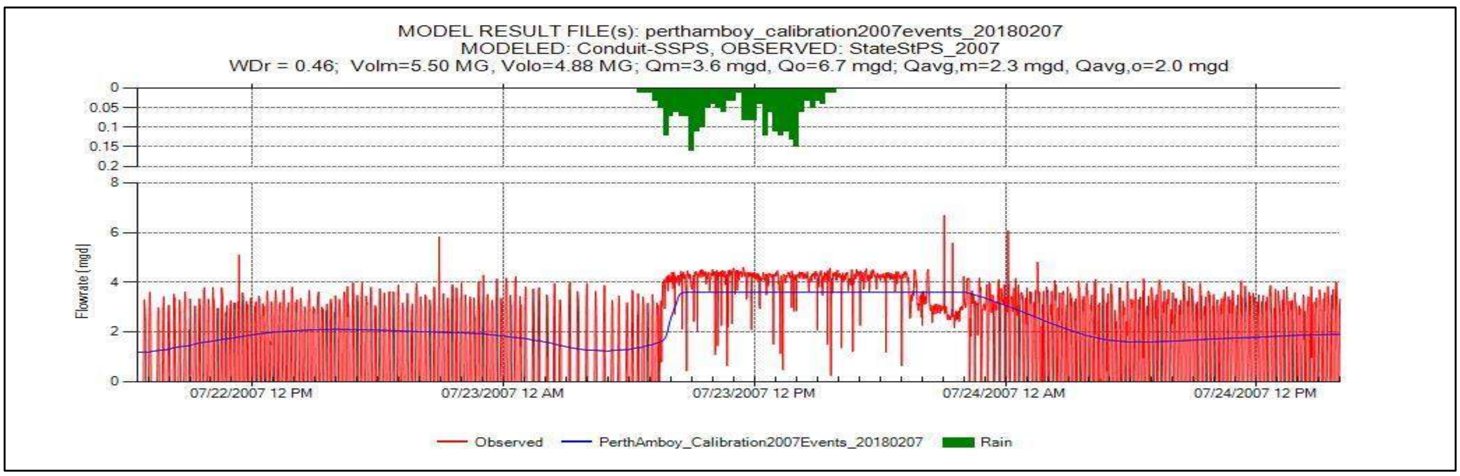




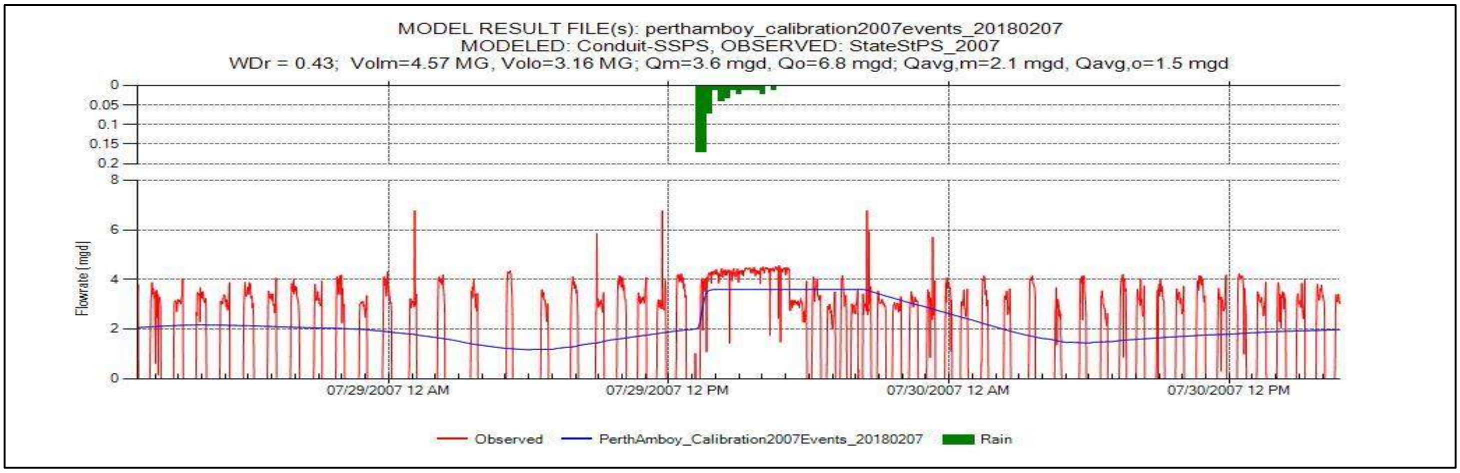
StateStPS - 2007

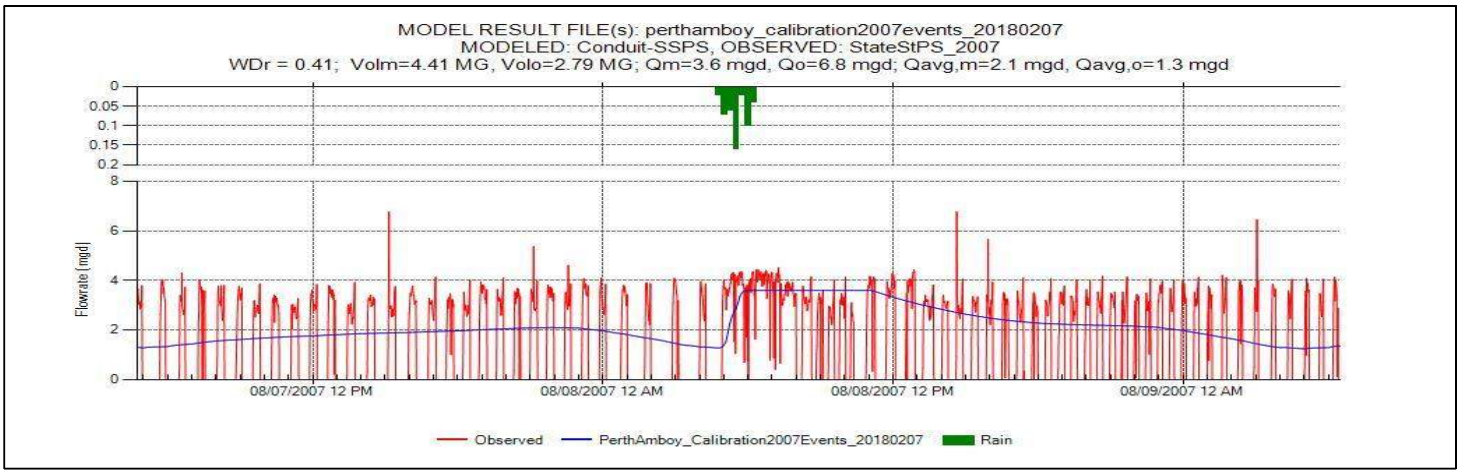


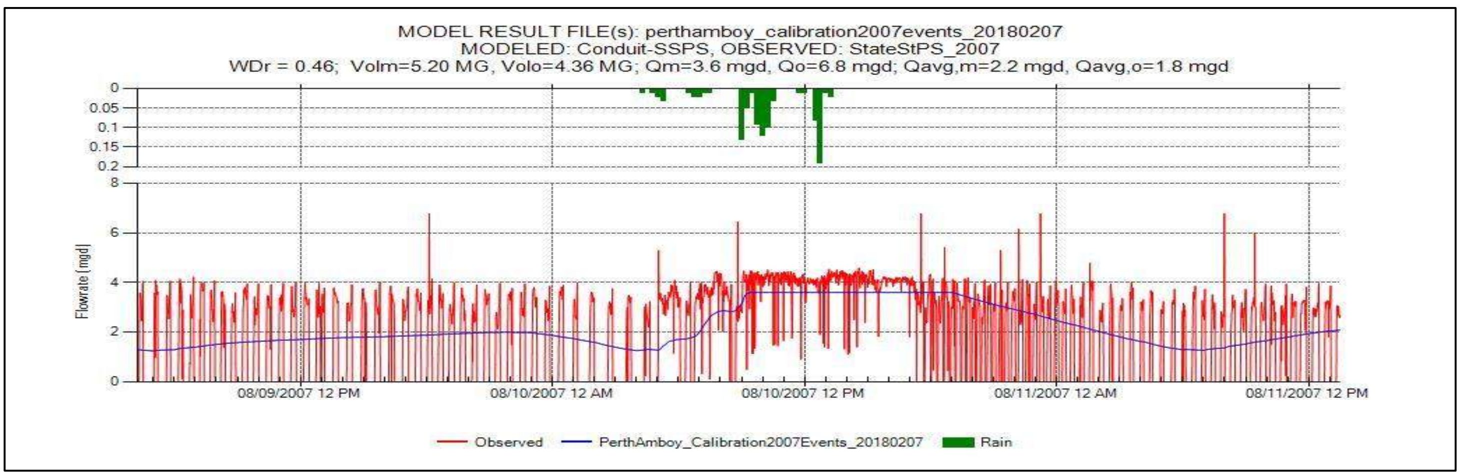




StateStPS - 2007

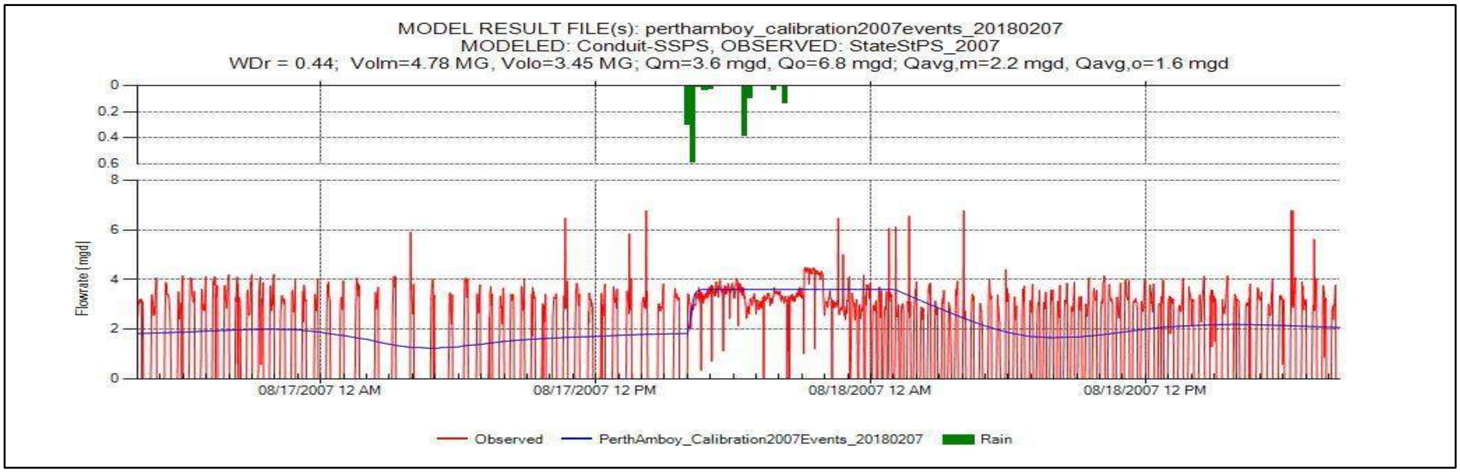




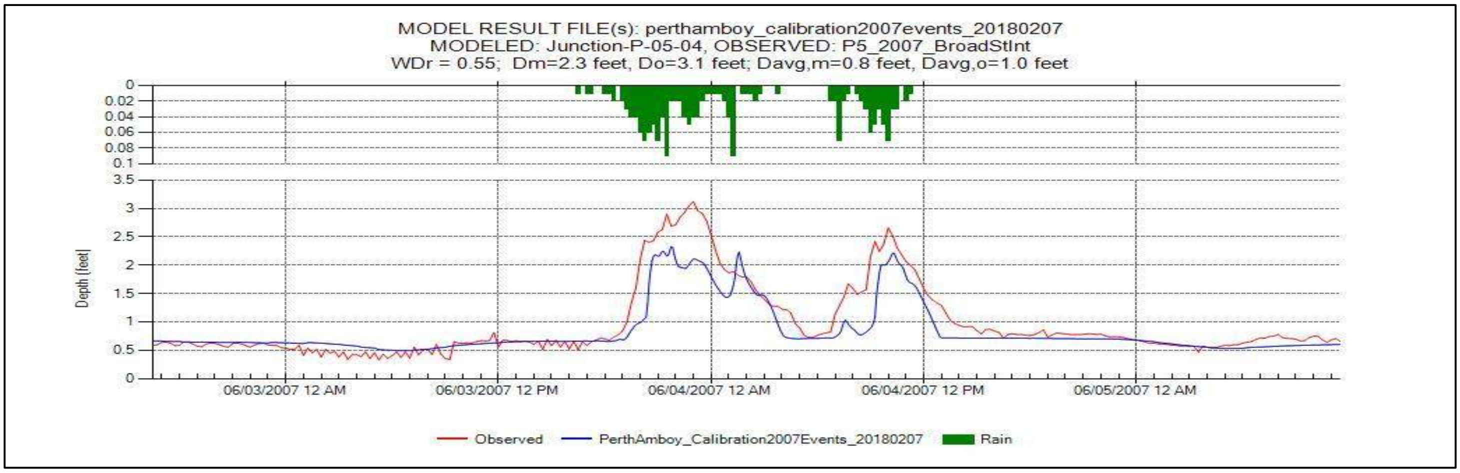


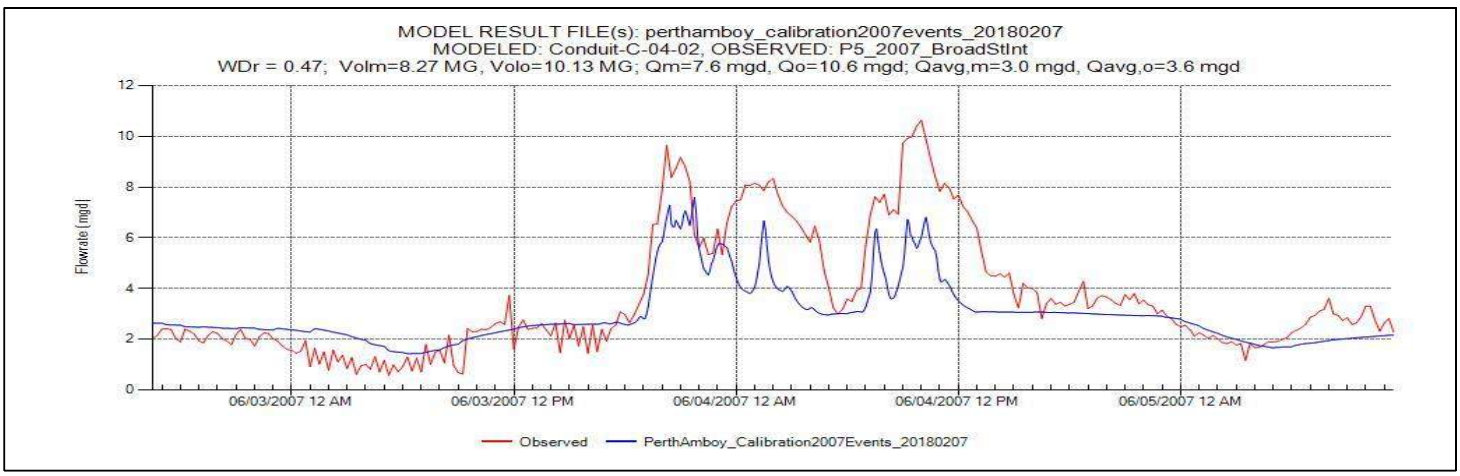
Simulated Versus Observed Flow at Flow Meter Sites

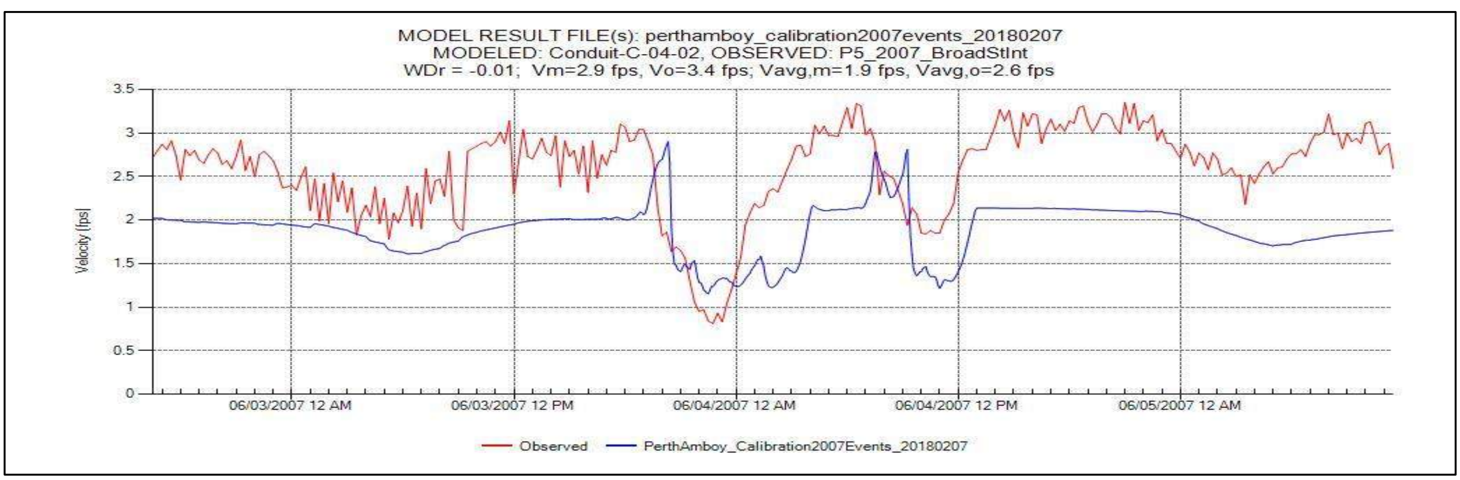
StateStPS - 2007



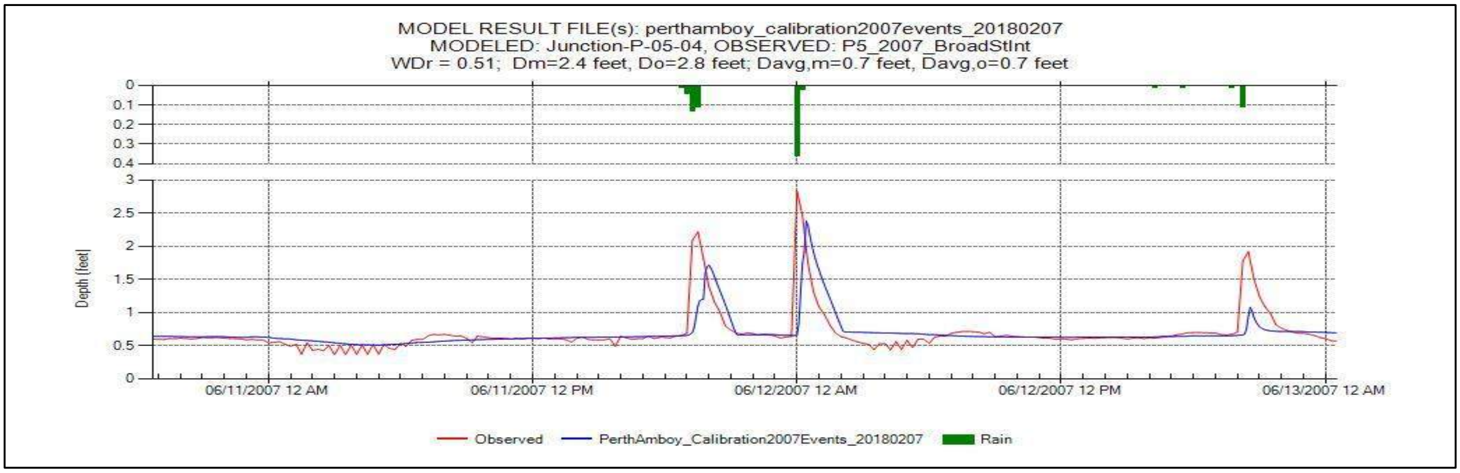
P5_2007_BroadSt

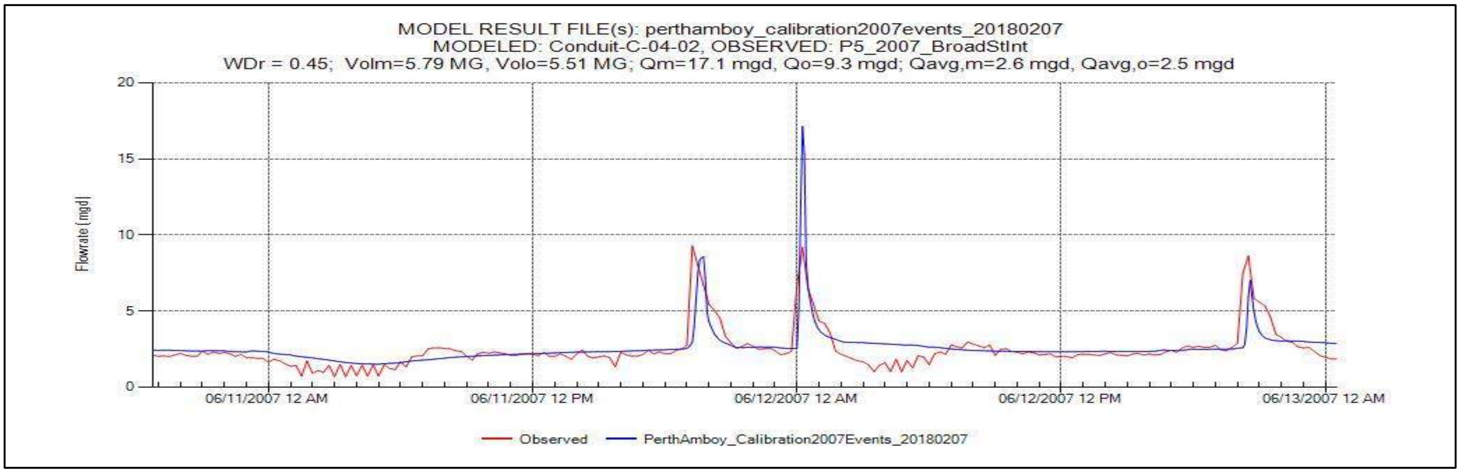


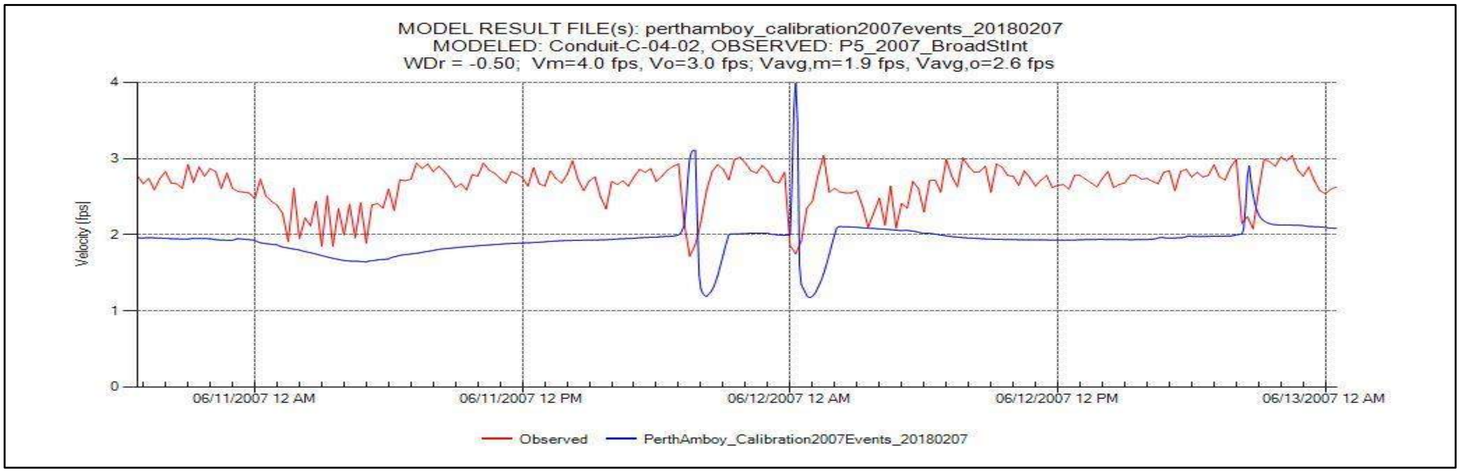




P5_2007_BroadSt

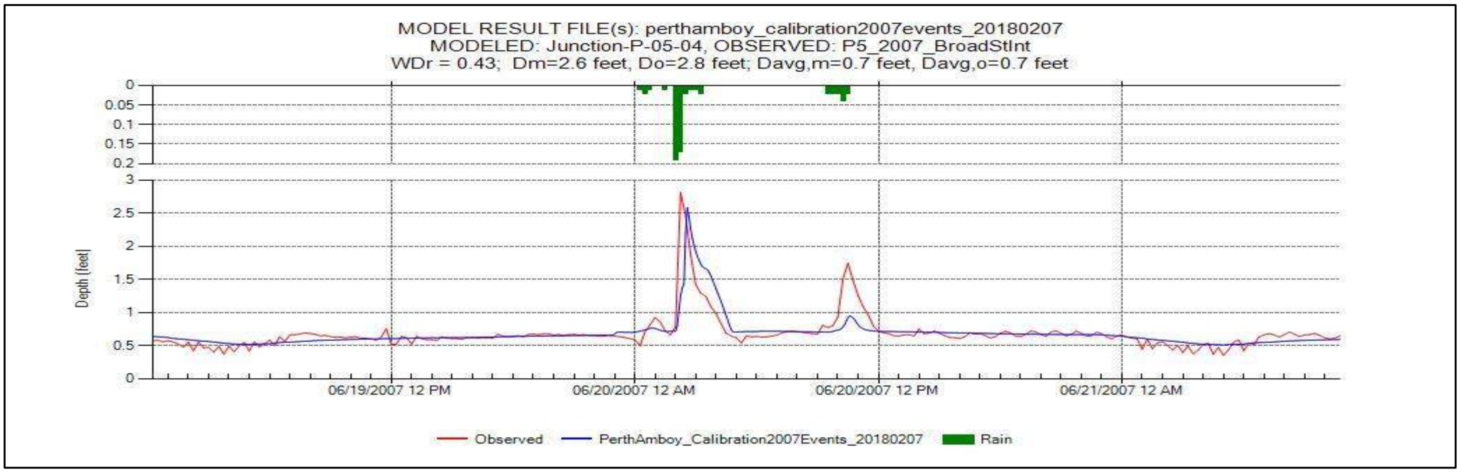


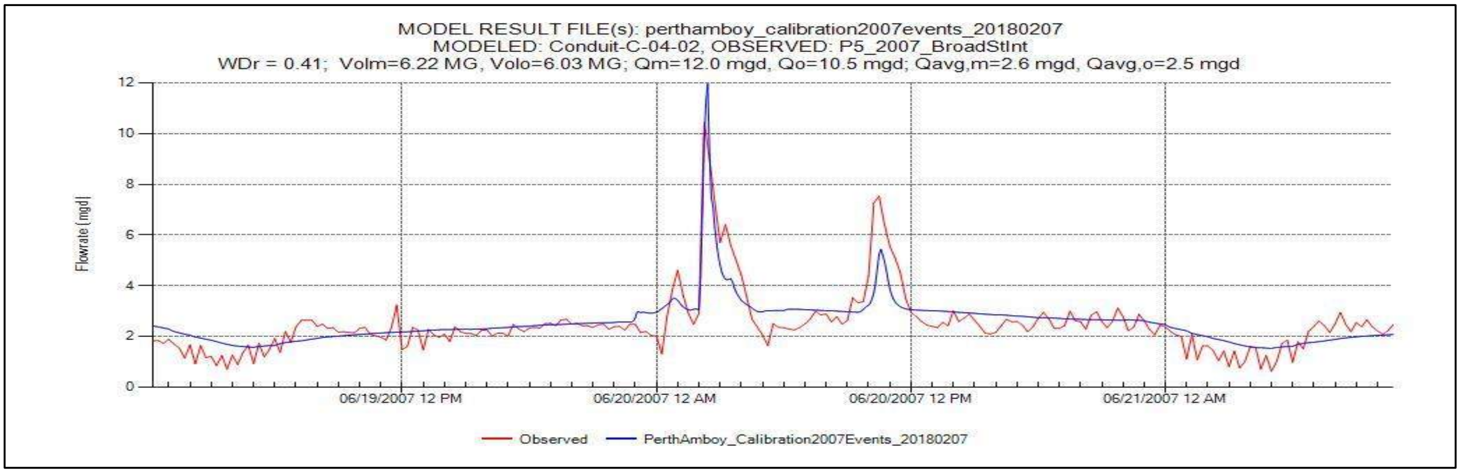


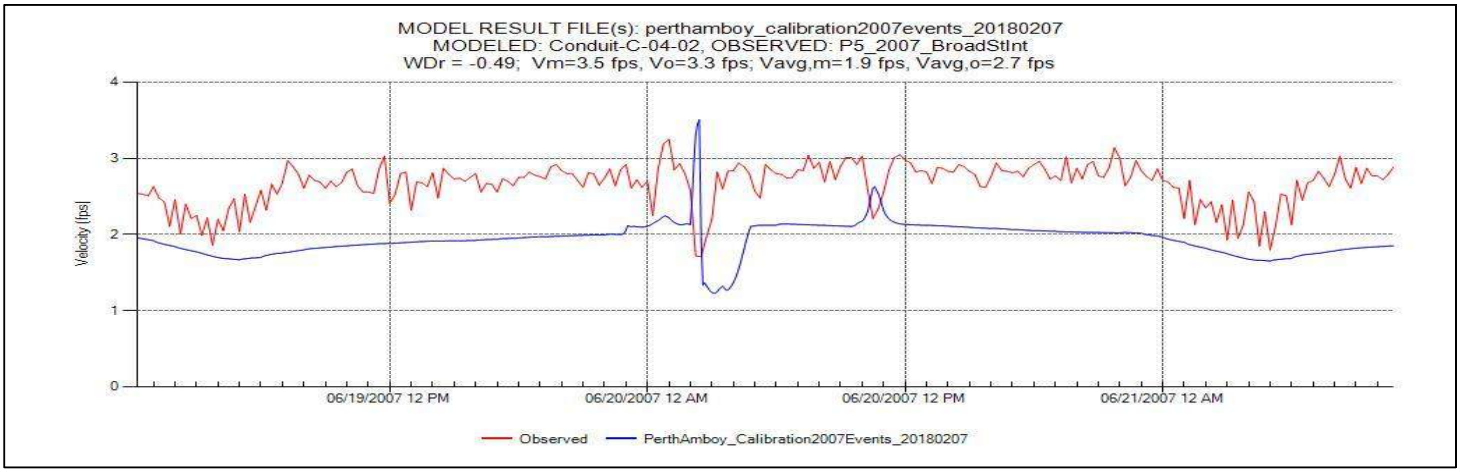


Simulated Versus Observed Flow at Flow Meter Sites

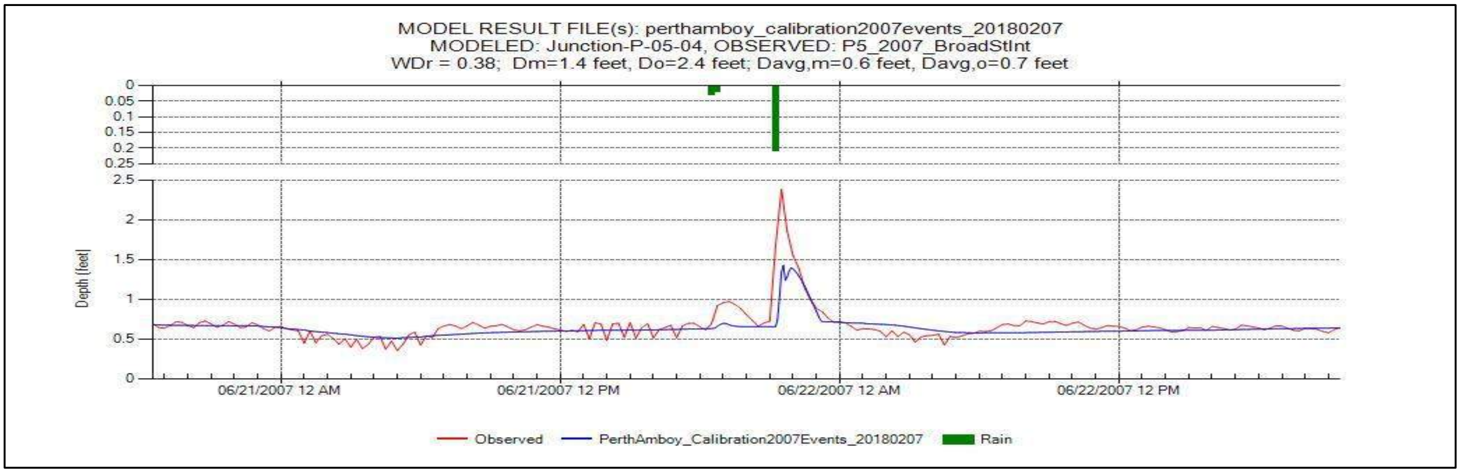
P5_2007_BroadSt

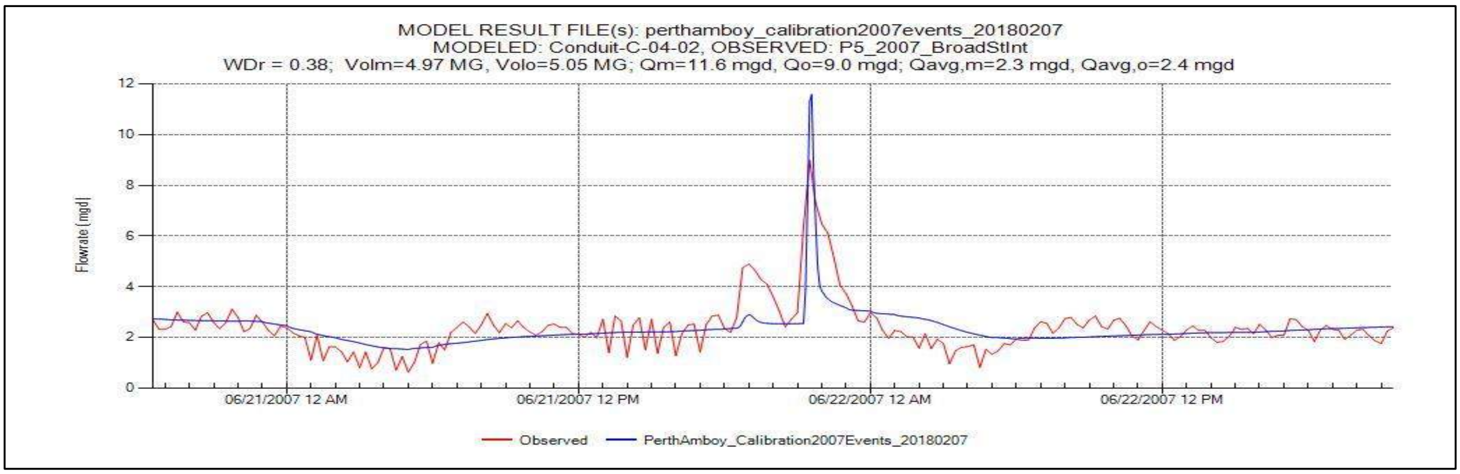


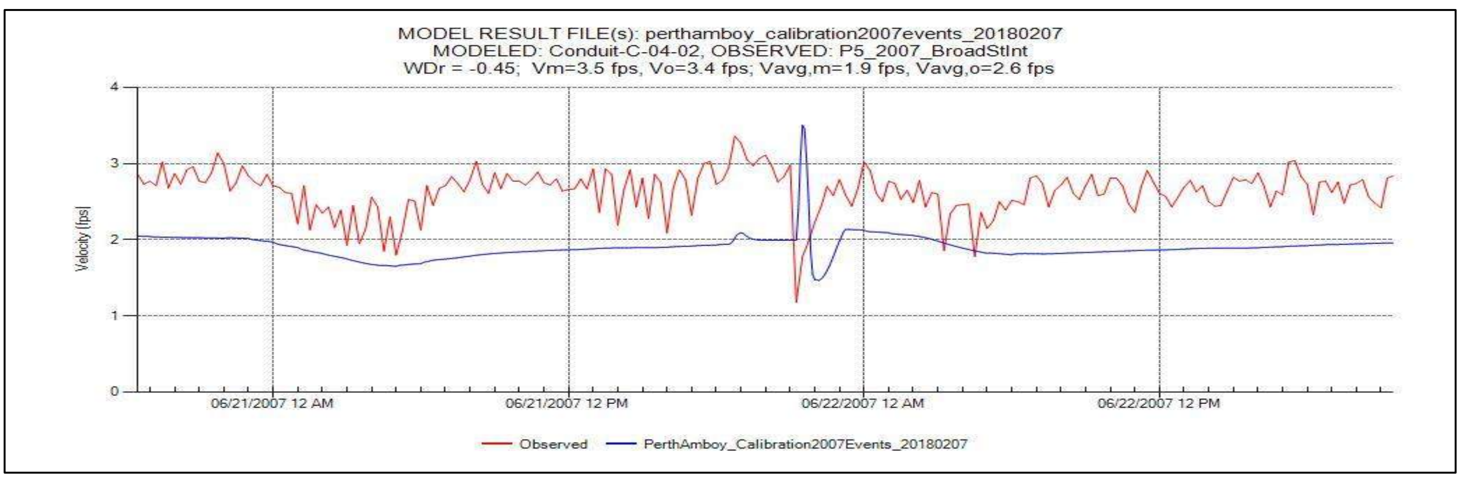




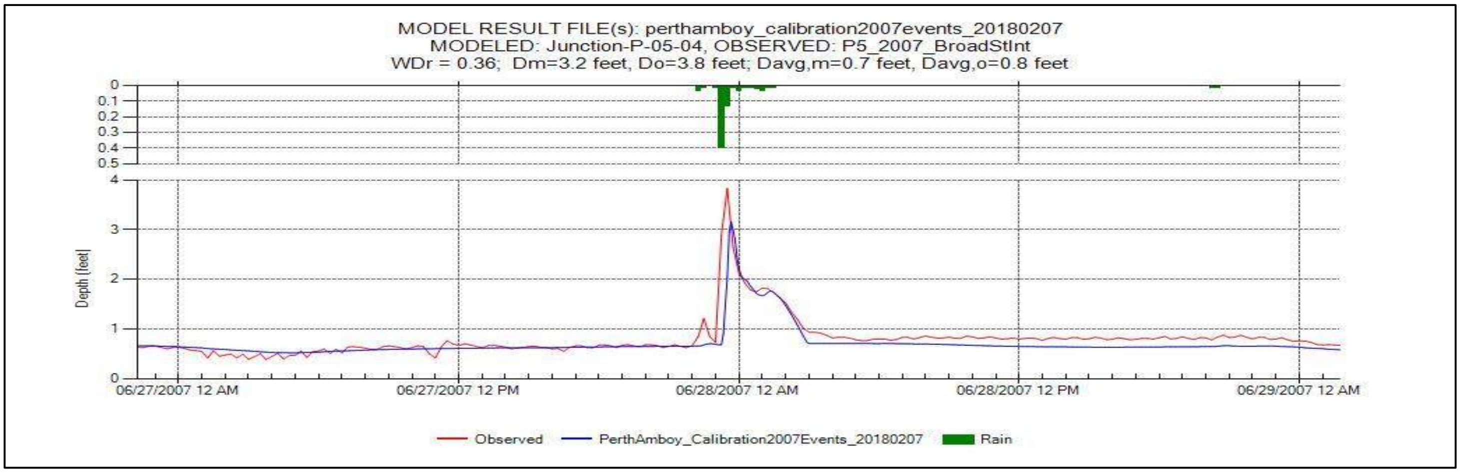
P5_2007_BroadSt

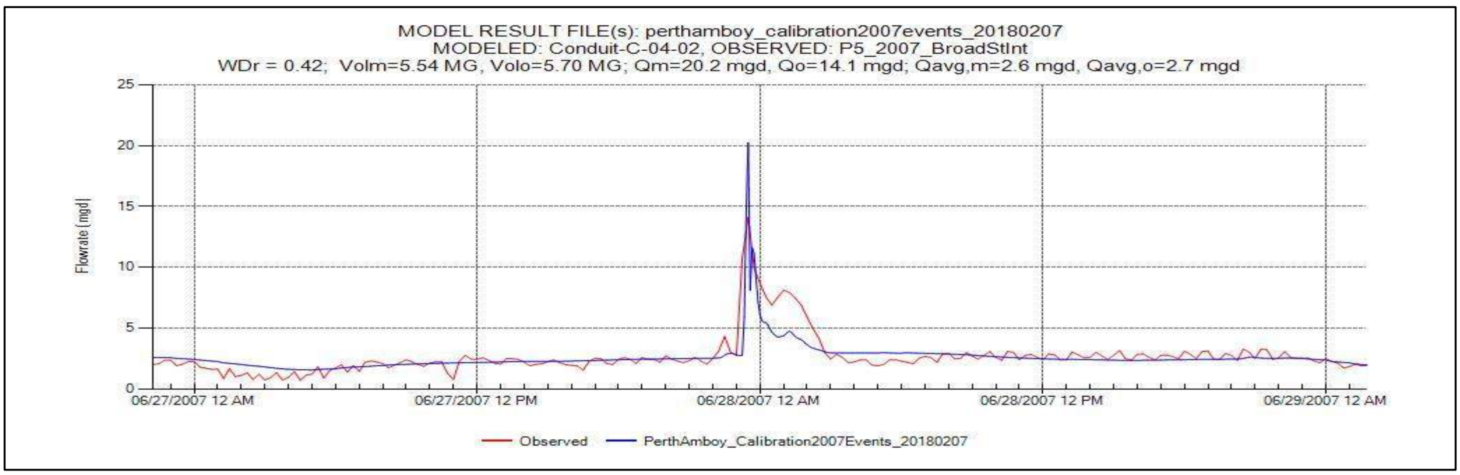


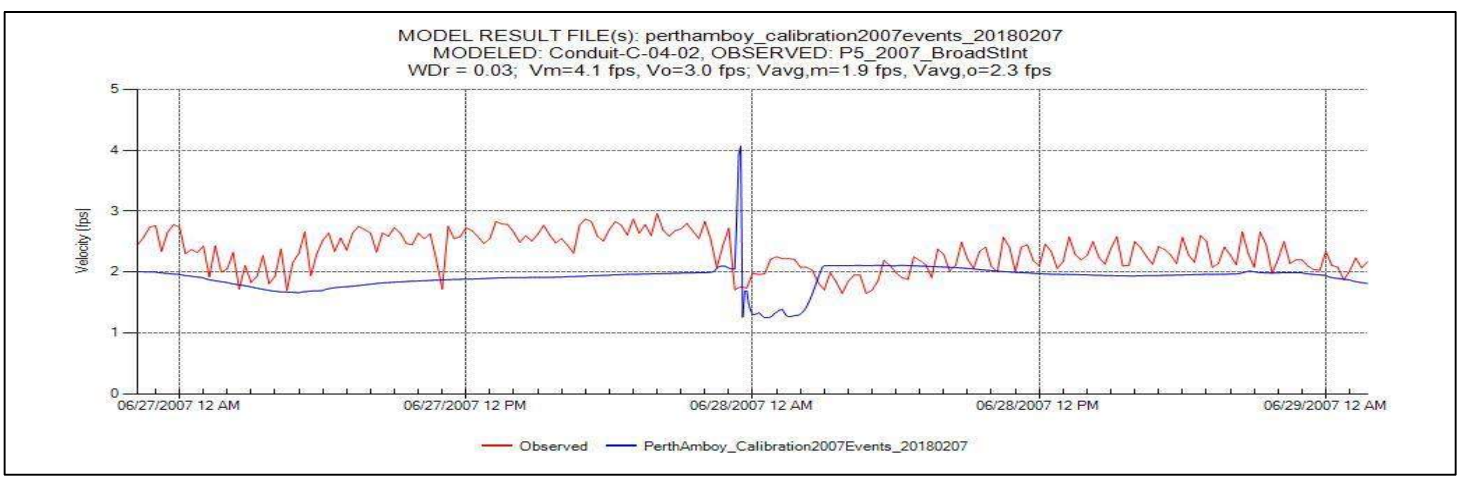




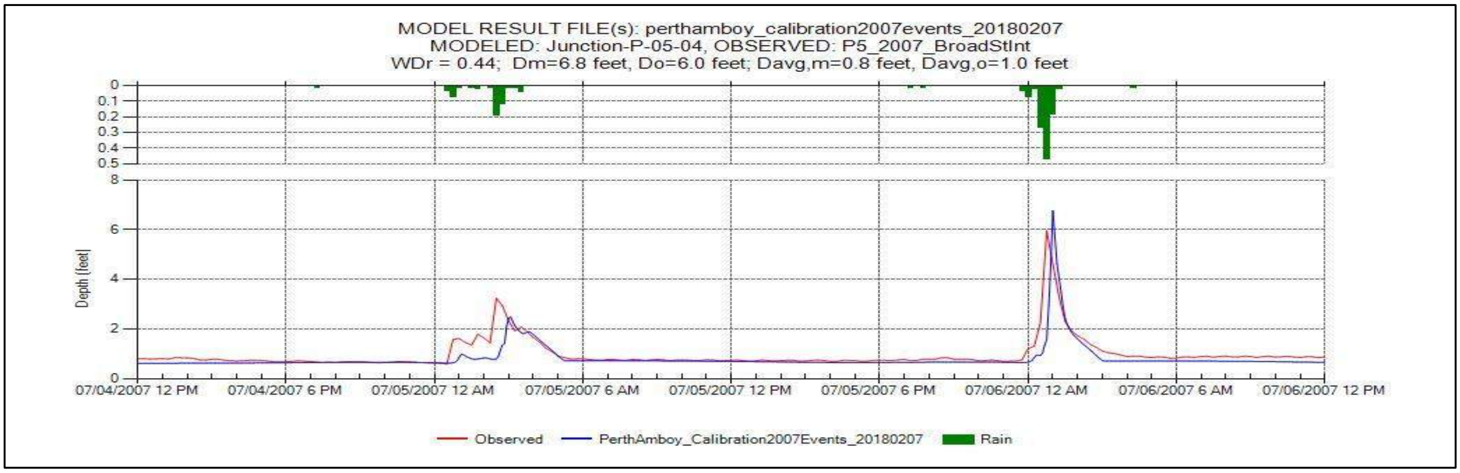
P5_2007_BroadSt

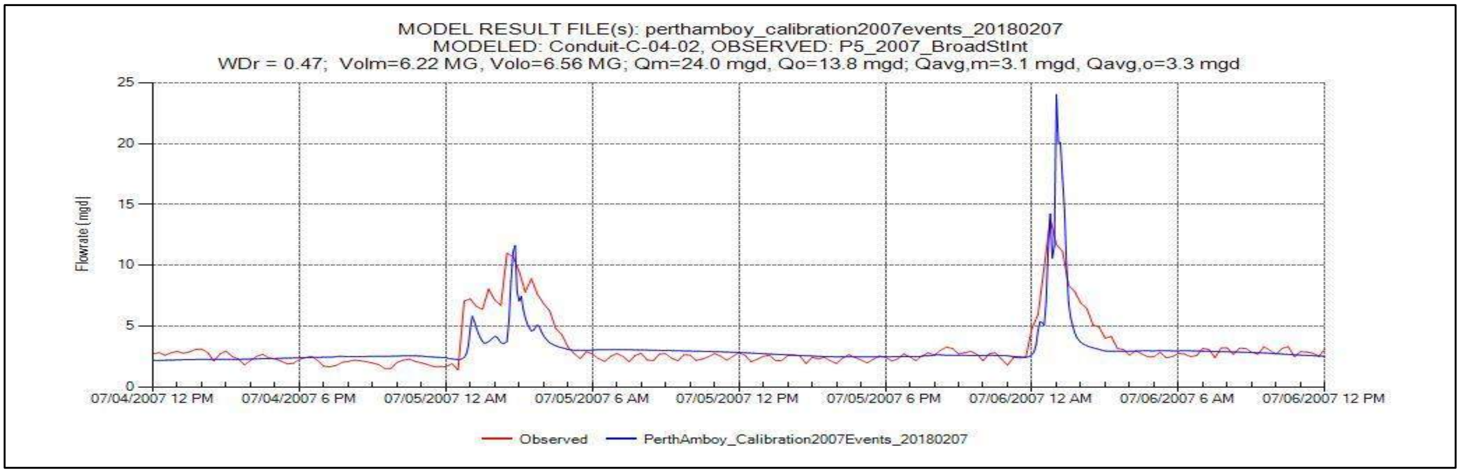


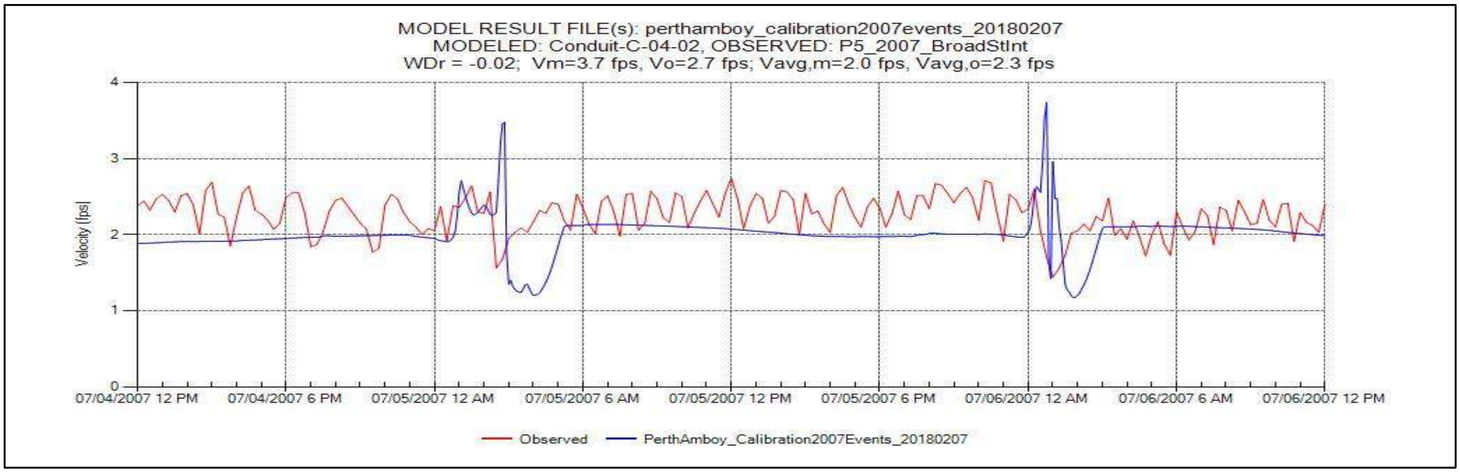




P5_2007_BroadSt

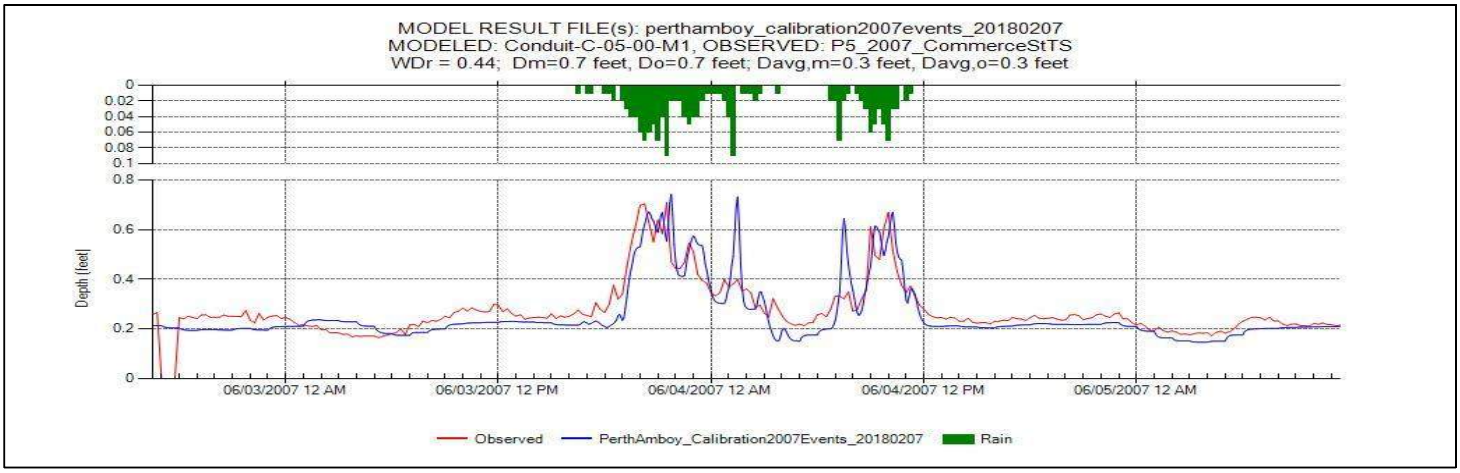


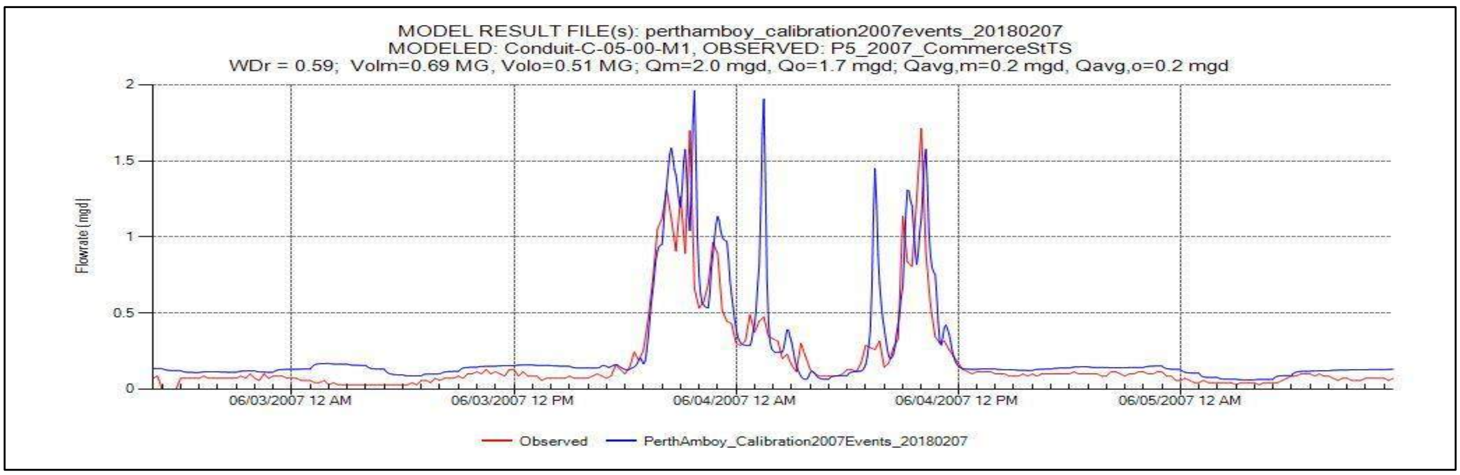


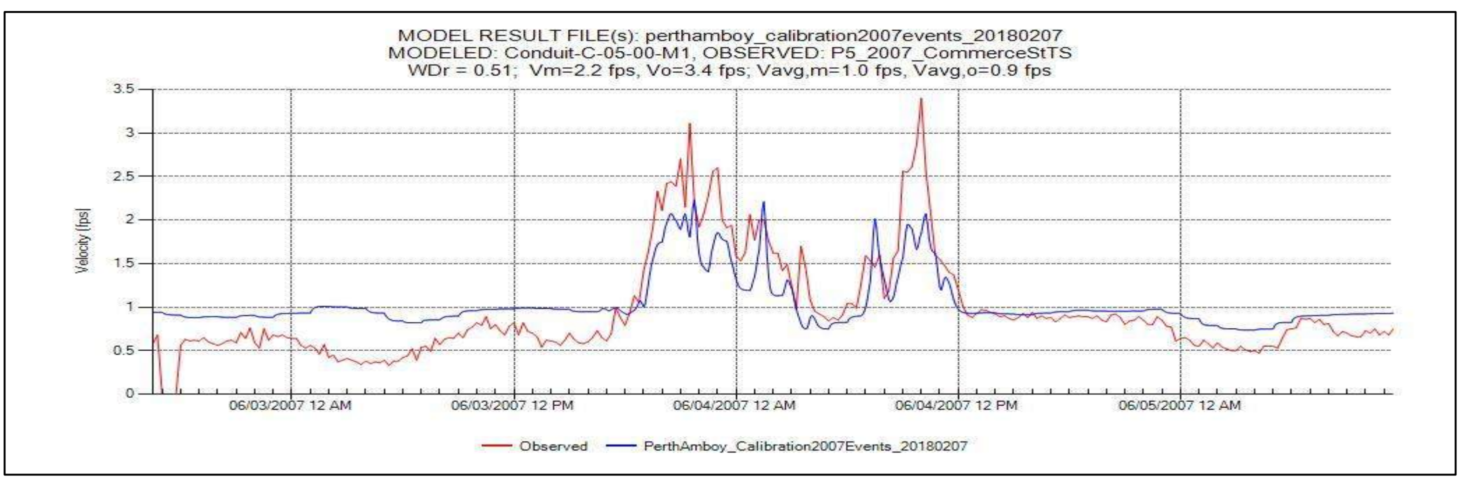


Simulated Versus Observed Flow at Flow Meter Sites

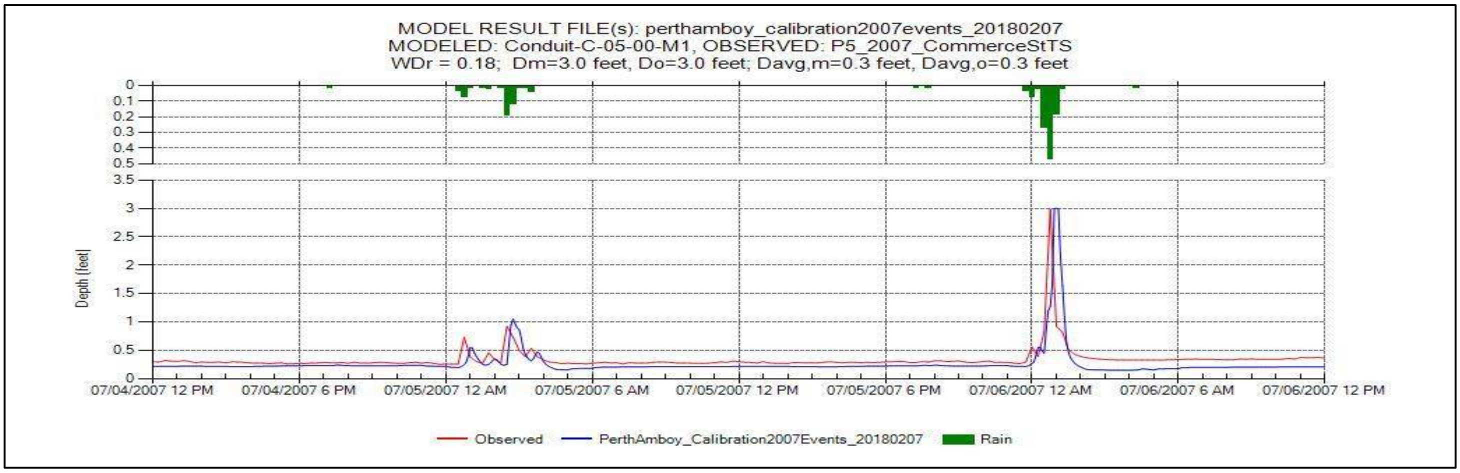
P5_2007_CommerceStTS

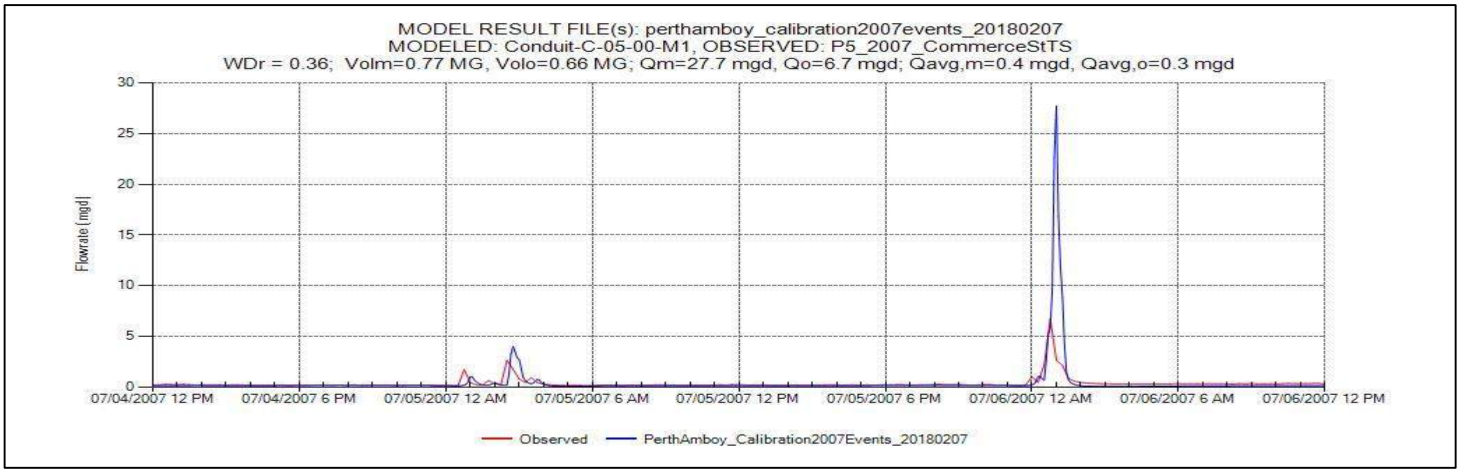


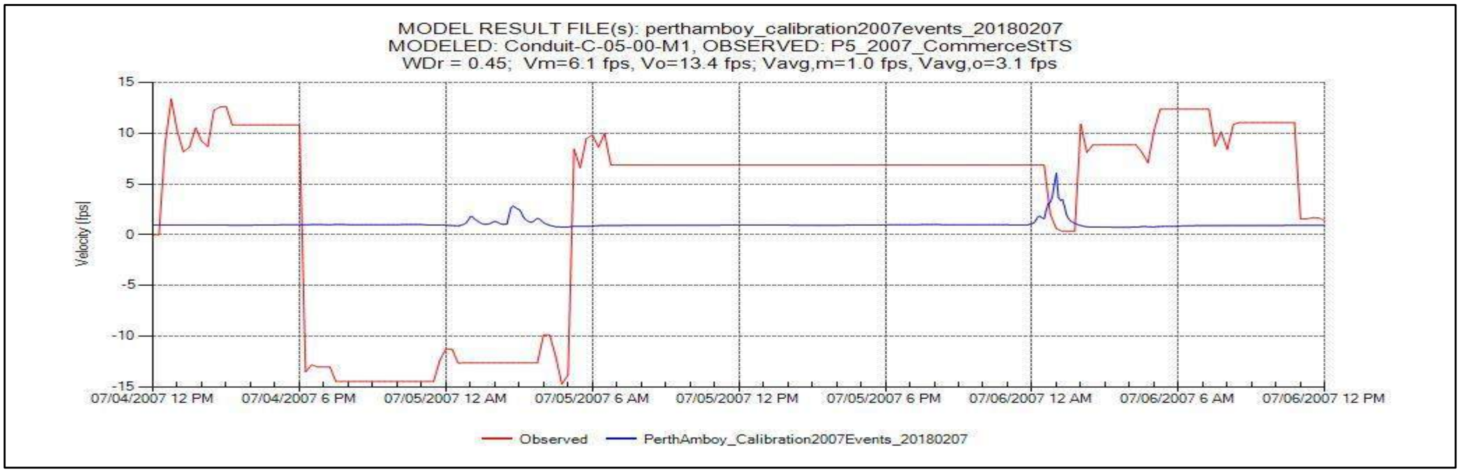




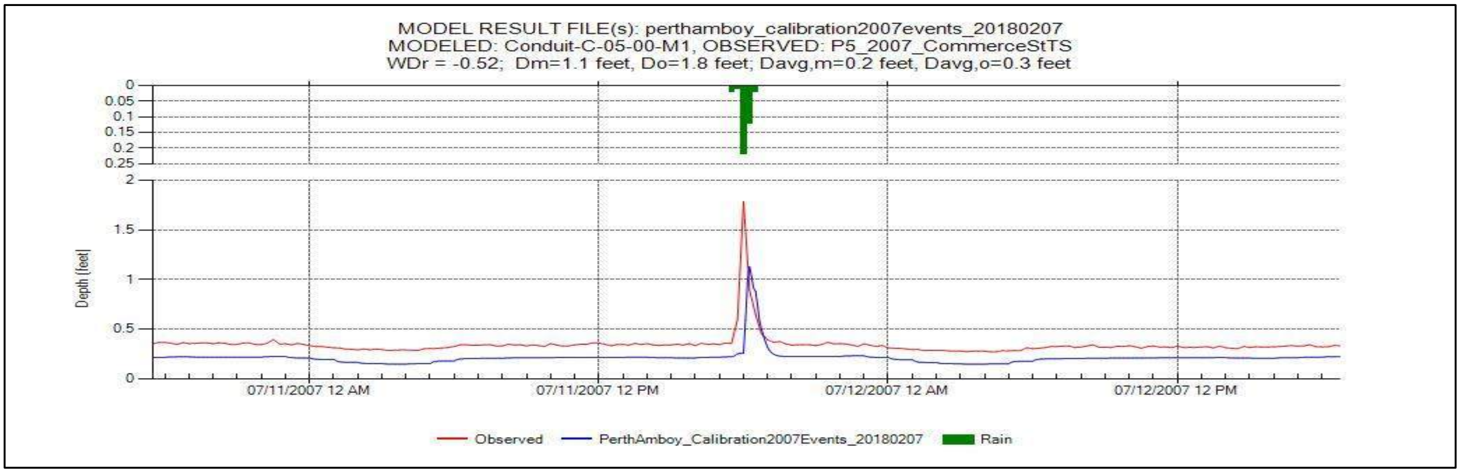
P5_2007_CommerceStTS

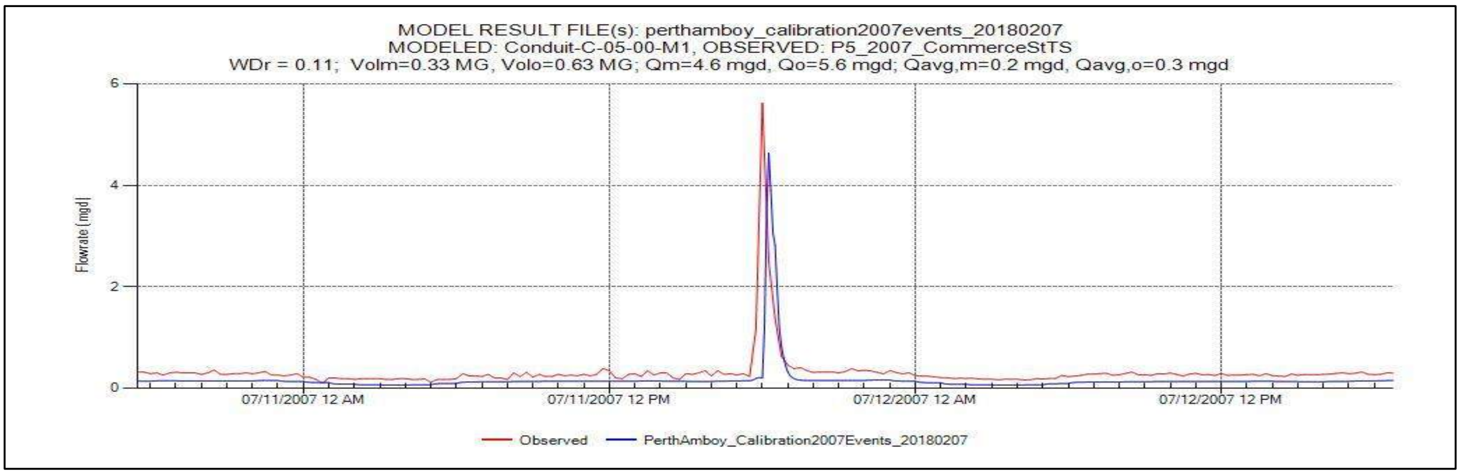


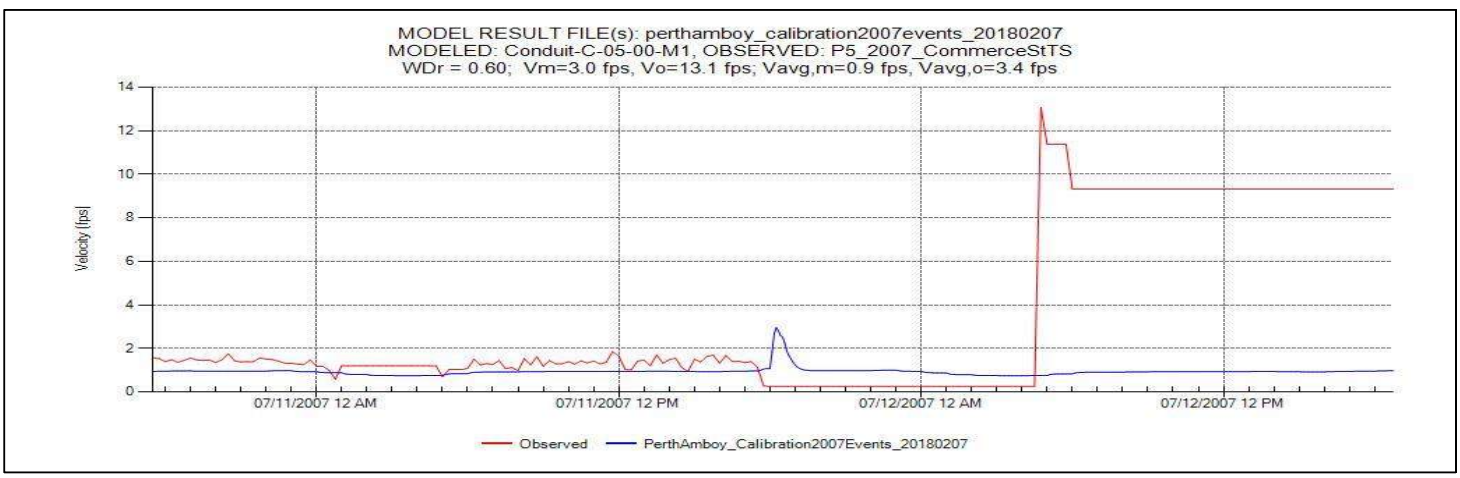




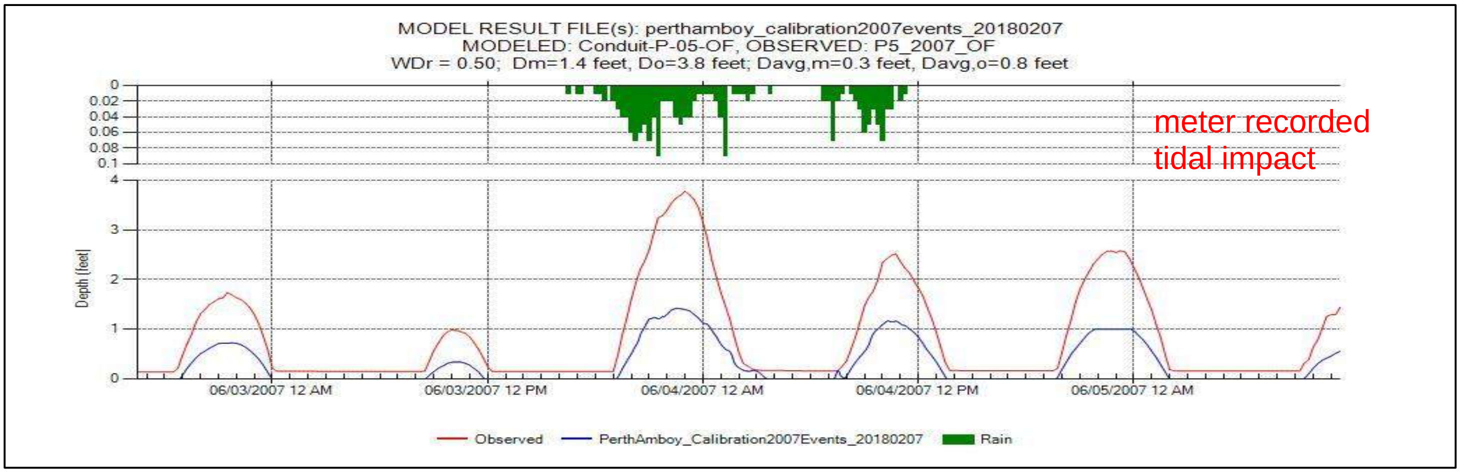
P5_2007_CommerceStTS

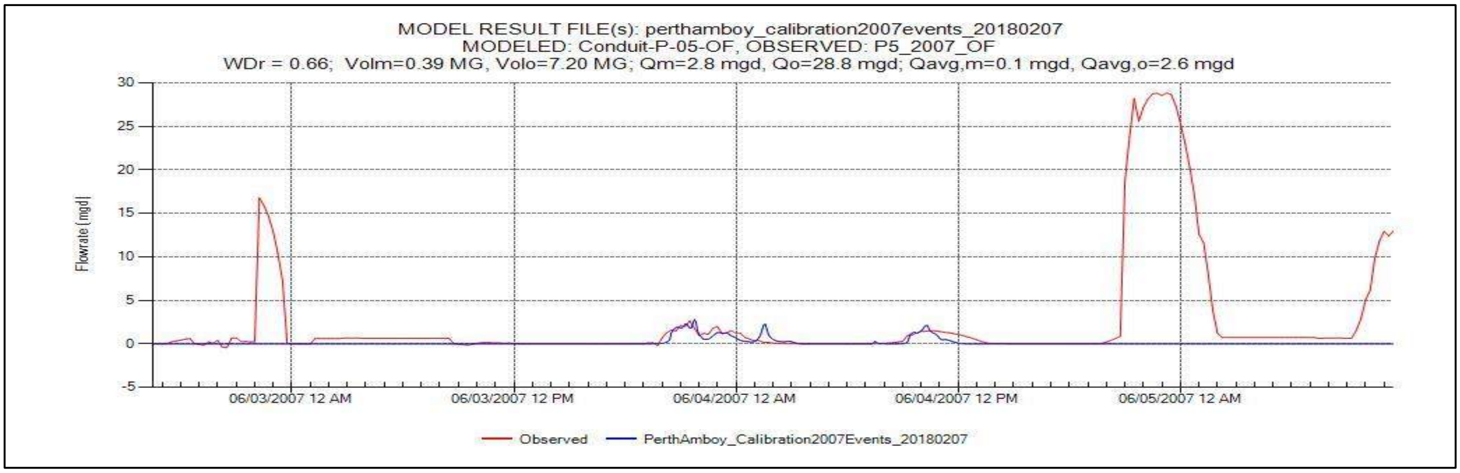


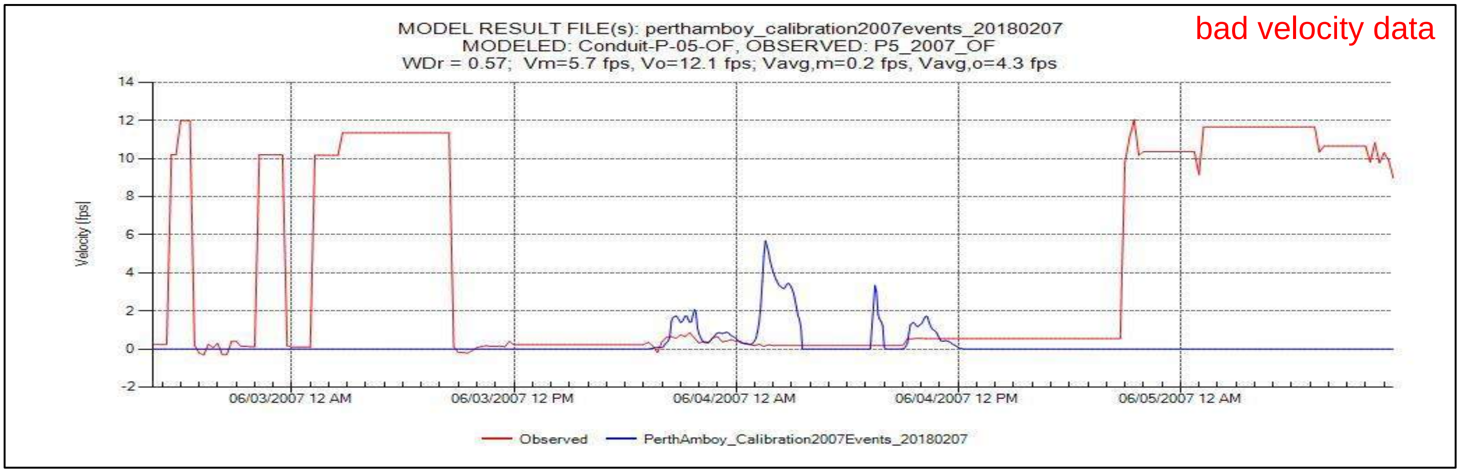




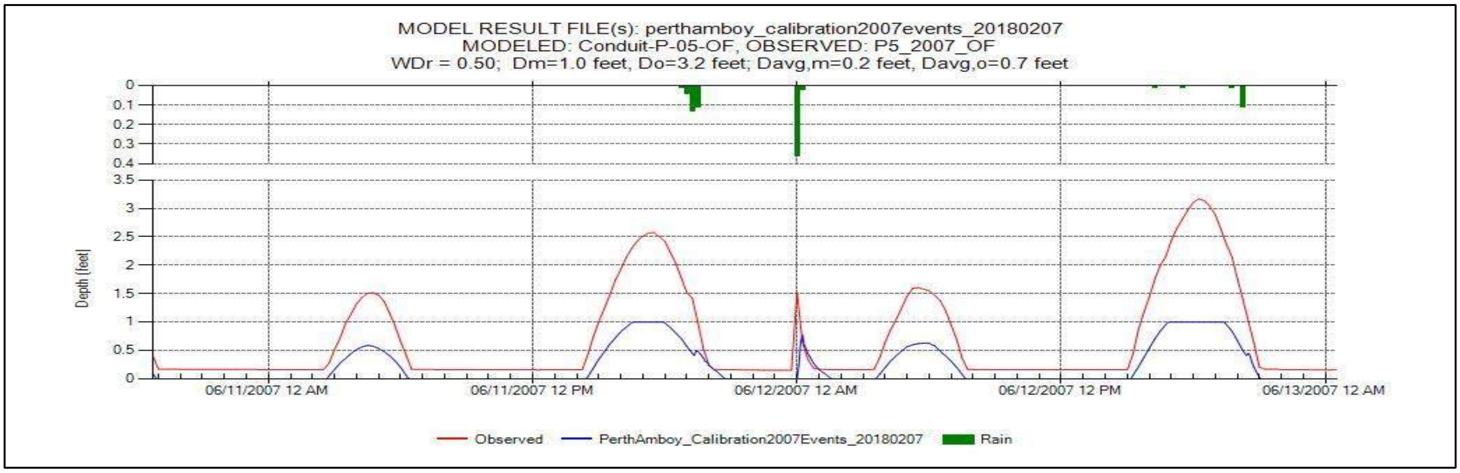
P5_2007_OF

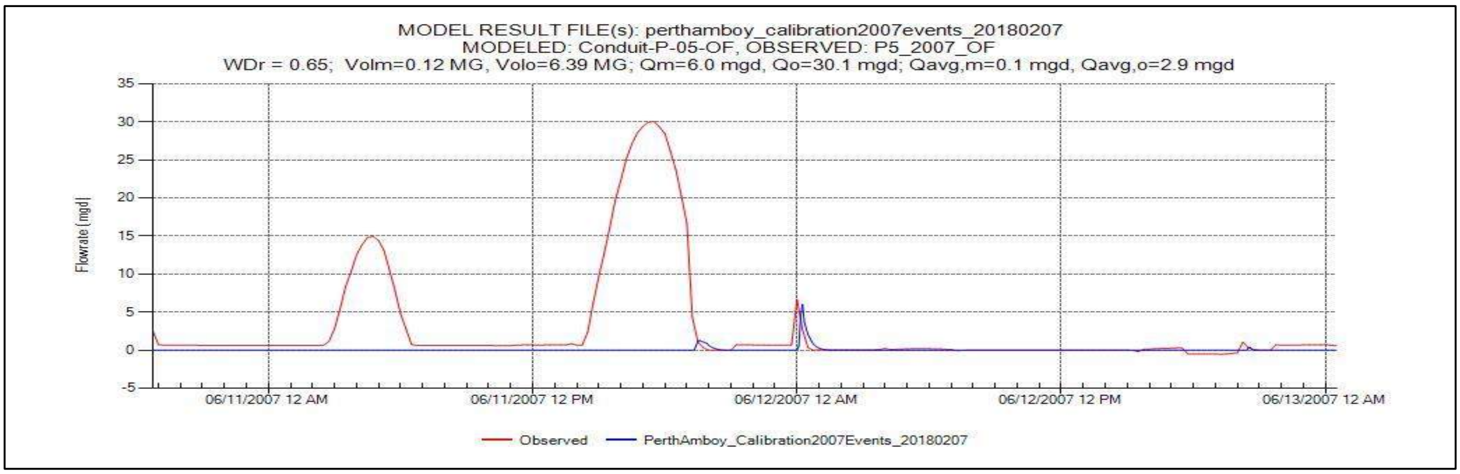

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.50; Dm=1.4 feet, Do=3.8 feet; Davg,m=0.3 feet, Davg,o=0.8 feet
meter recorded tidal impact
Depth (feet)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

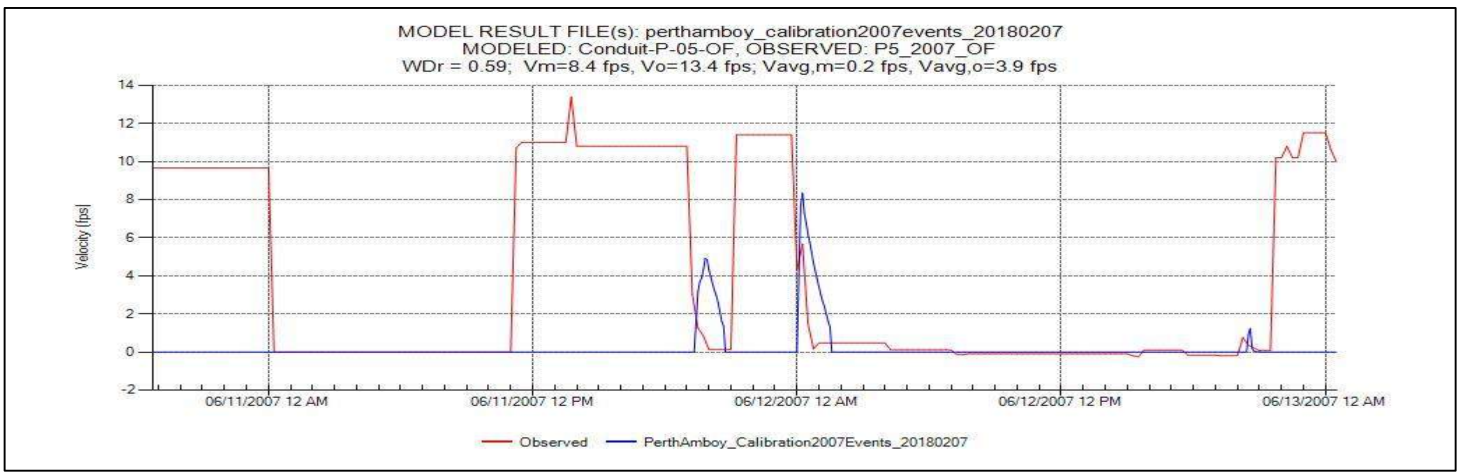

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.66; Volm=0.39 MG, Volo=7.20 MG; Qm=2.8 mgd, Qo=28.8 mgd; Qavg,m=0.1 mgd, Qavg,o=2.6 mgd
Flowrate (mgd)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.57; Vm=5.7 fps, Vo=12.1 fps; Vavg,m=0.2 fps, Vavg,o=4.3 fps
bad velocity data
Velocity (fps)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

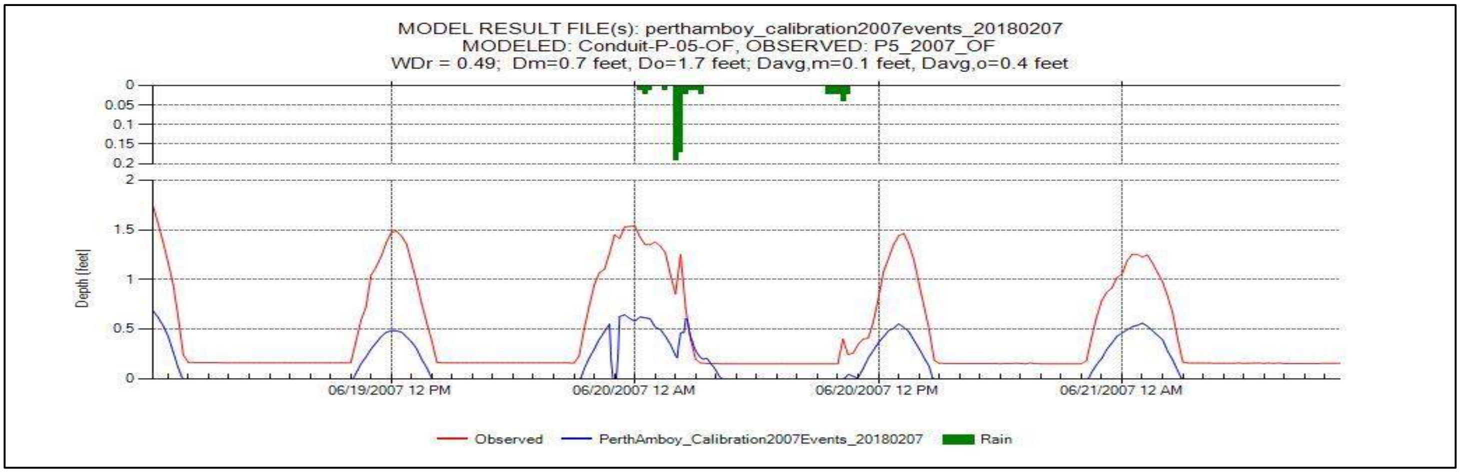
P5_2007_OF

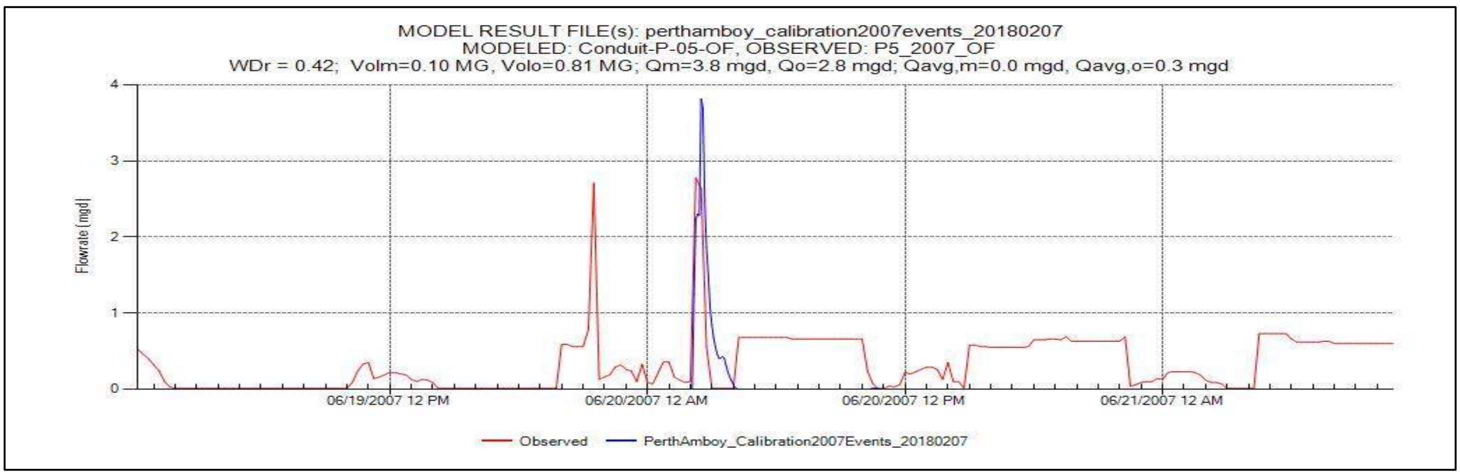

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.50; Dm=1.0 feet, Do=3.2 feet; Davg,m=0.2 feet, Davg,o=0.7 feet
Depth (feet)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

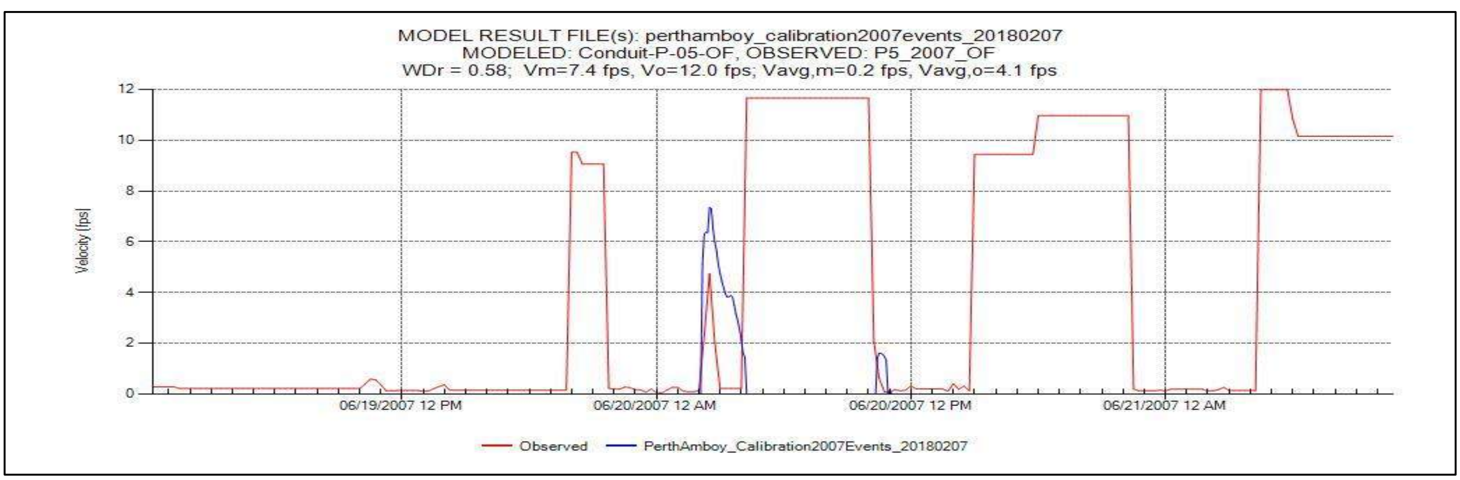

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.65; Volm=0.12 MG, Volo=6.39 MG; Qm=6.0 mgd, Qo=30.1 mgd; Qavg,m=0.1 mgd, Qavg,o=2.9 mgd
Flowrate (mgd)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.59; Vm=8.4 fps, Vo=13.4 fps; Vavg,m=0.2 fps, Vavg,o=3.9 fps
Velocity (fps)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

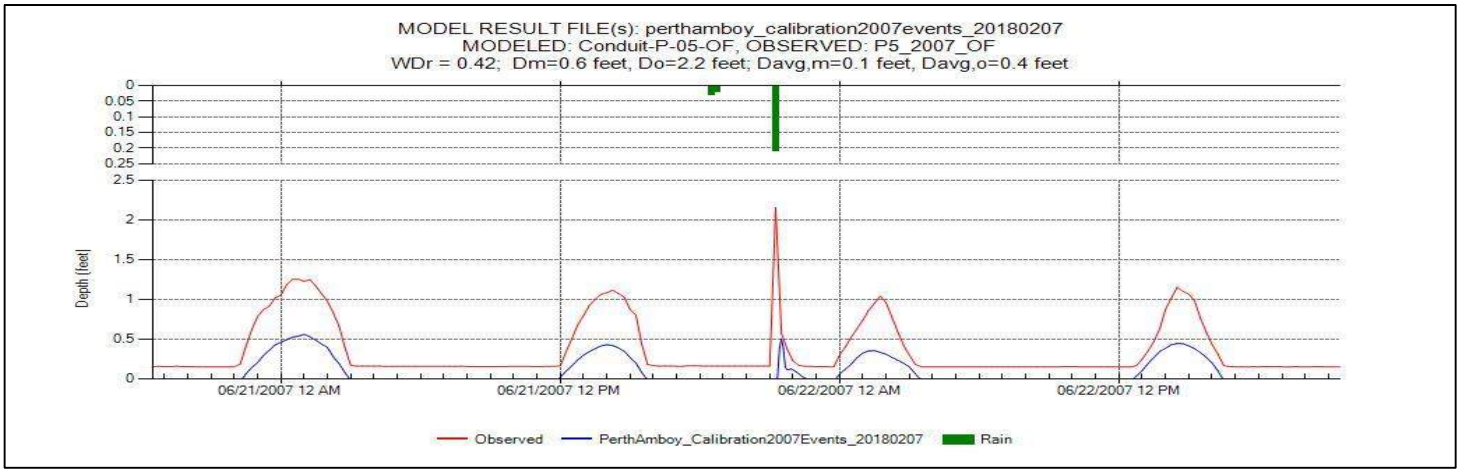
P5_2007_OF

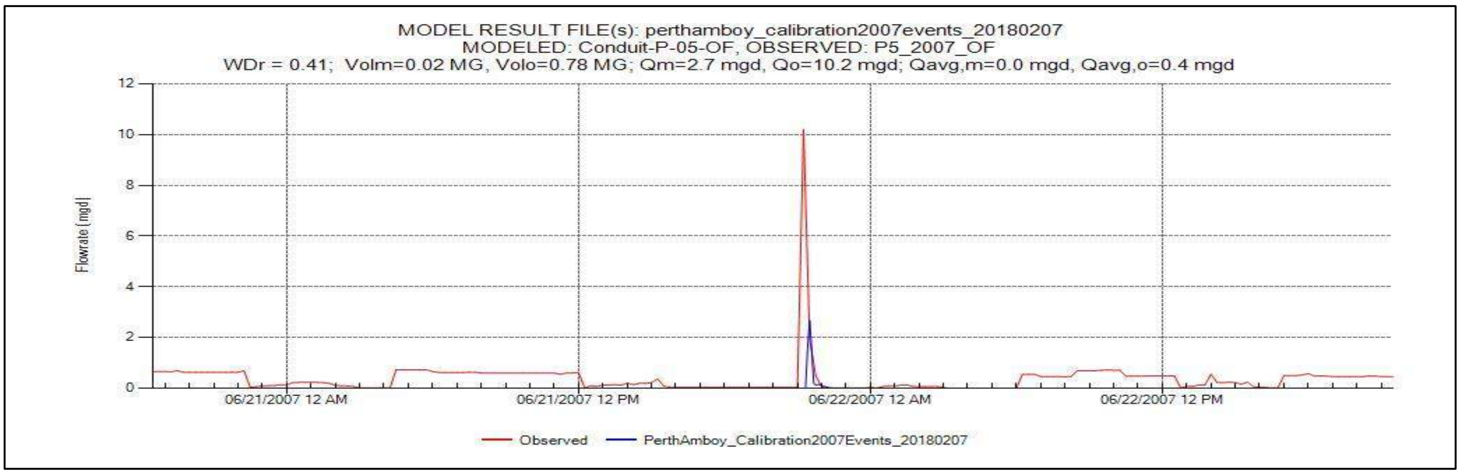

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.49; Dm=0.7 feet, Do=1.7 feet; Davg,m=0.1 feet, Davg,o=0.4 feet
Depth (feet)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

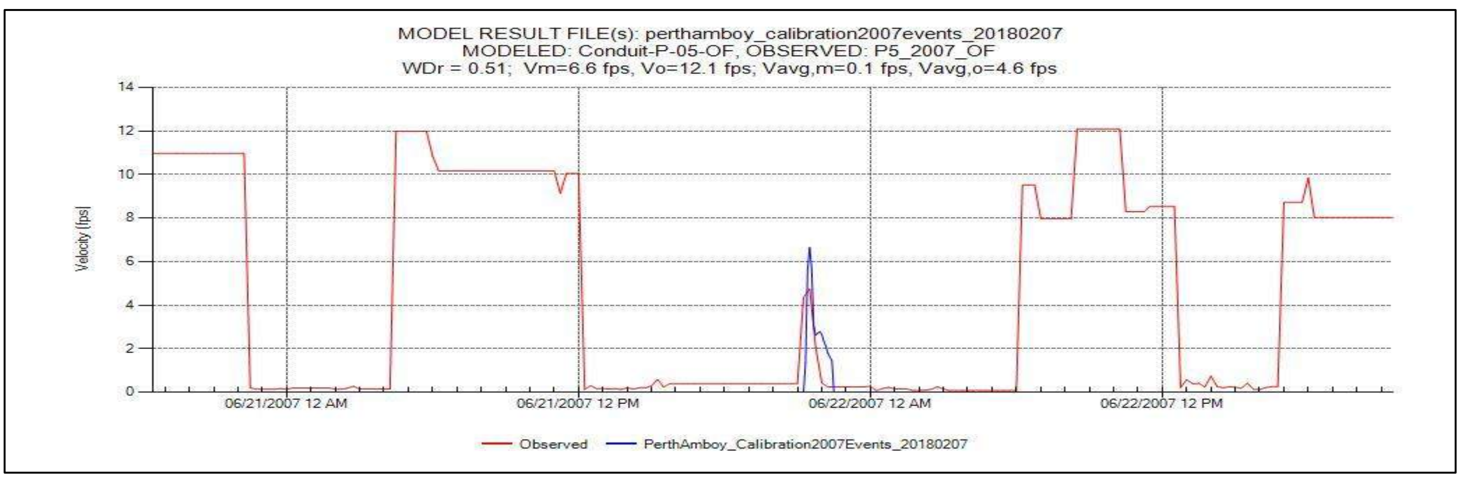

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.42; Volm=0.10 MG, Volo=0.81 MG; Qm=3.8 mgd, Qo=2.8 mgd; Qavg,m=0.0 mgd, Qavg,o=0.3 mgd
Flowrate (mgd)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.58; Vm=7.4 fps, Vo=12.0 fps; Vavg,m=0.2 fps, Vavg,o=4.1 fps
Velocity (fps)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

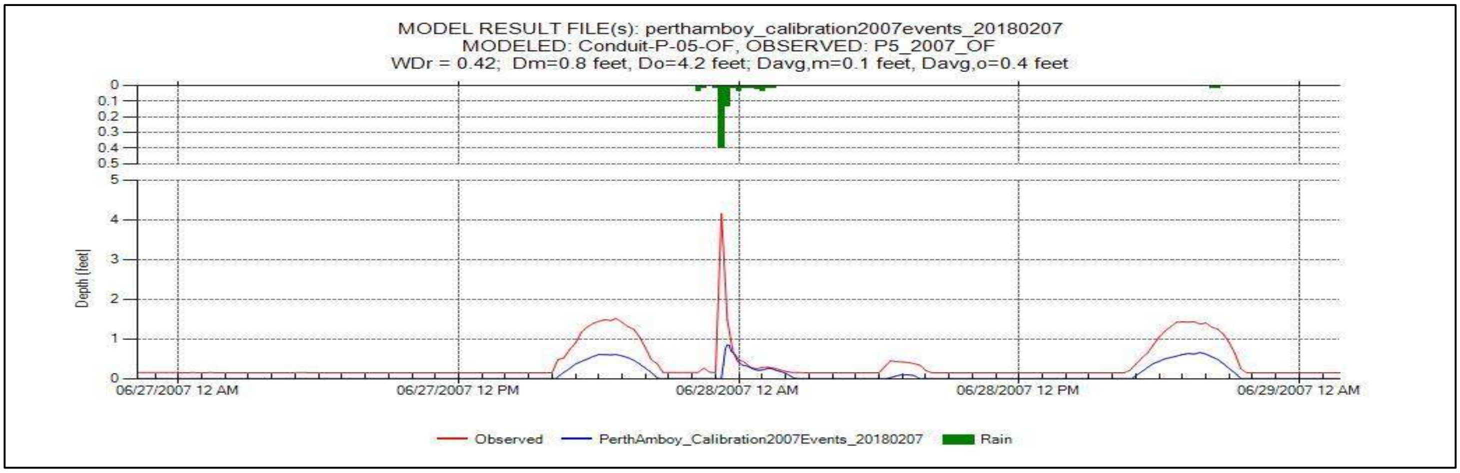
P5_2007_OF

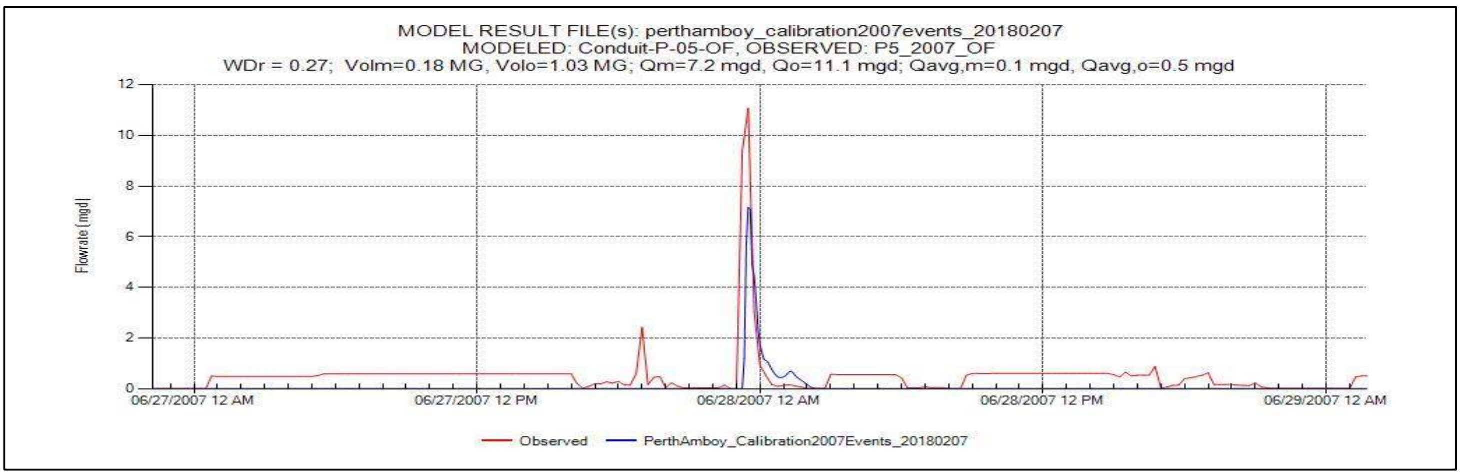

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.42; Dm=0.6 feet, Do=2.2 feet; Davg,m=0.1 feet, Davg,o=0.4 feet
Depth (feet)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

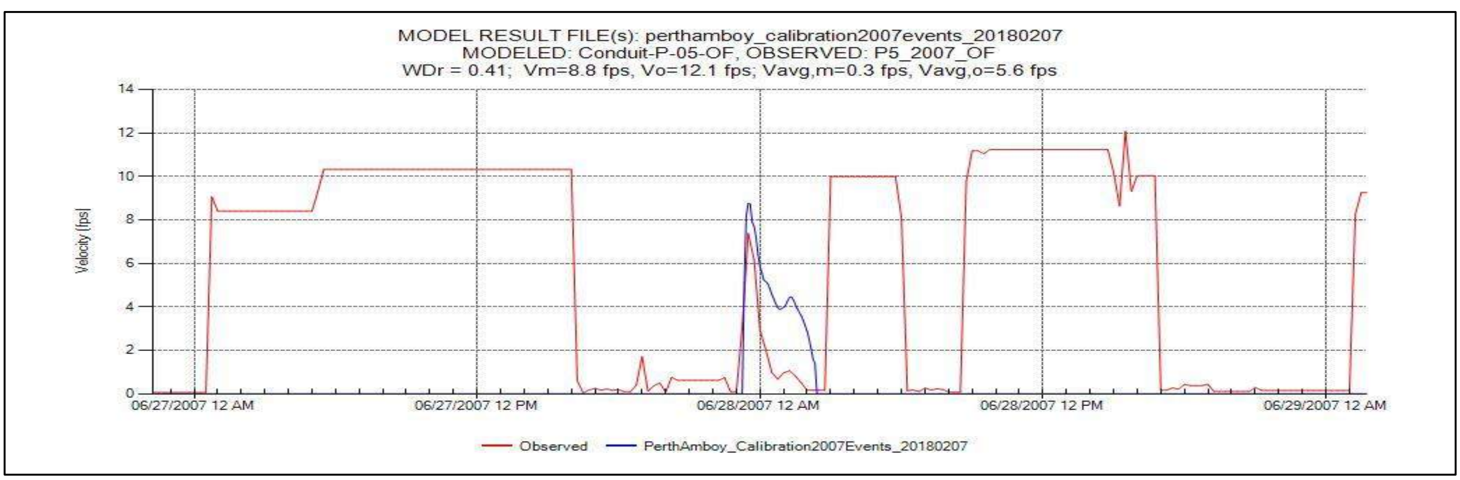

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.41; Volm=0.02 MG, Volo=0.78 MG; Qm=2.7 mgd, Qo=10.2 mgd; Qavg,m=0.0 mgd, Qavg,o=0.4 mgd
Flowrate (mgd)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.51; Vm=6.6 fps, Vo=12.1 fps; Vavg,m=0.1 fps, Vavg,o=4.6 fps
Velocity (fps)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

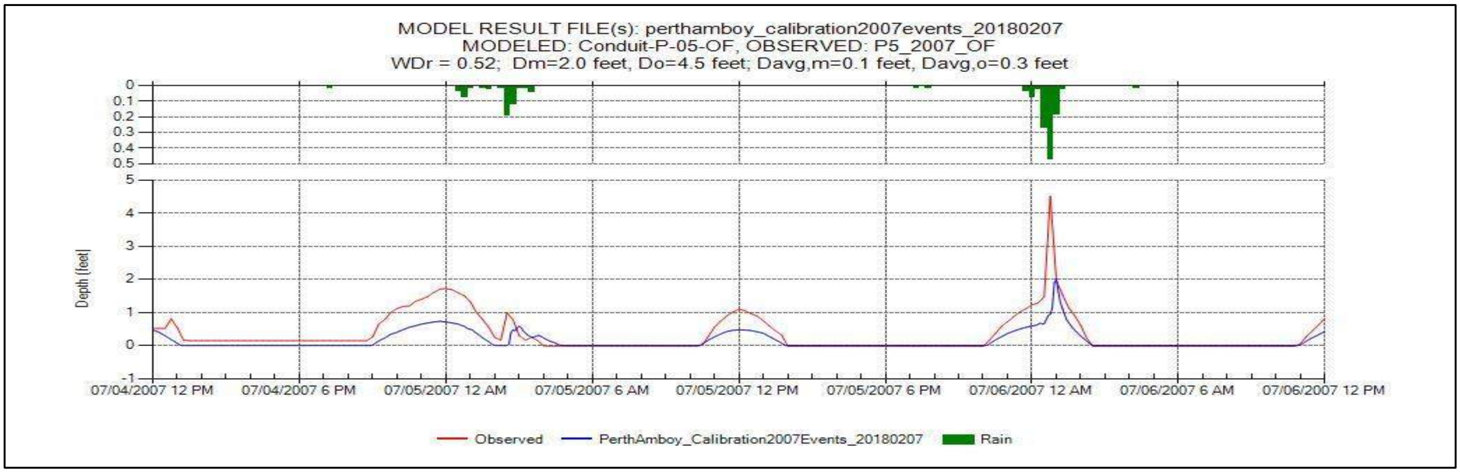
P5_2007_OF

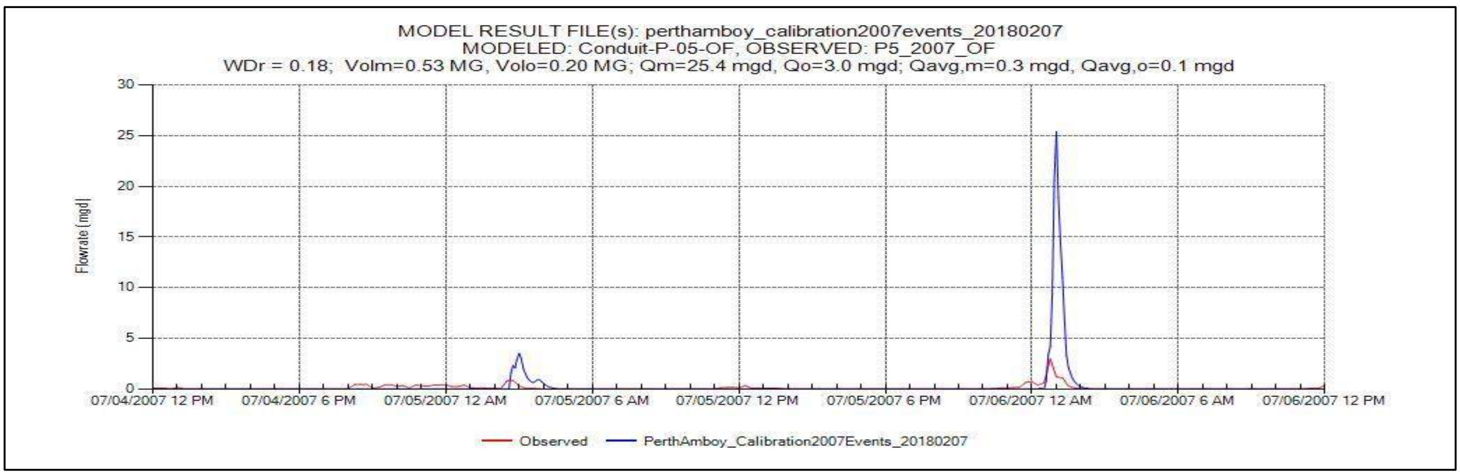

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.42; Dm=0.8 feet, Do=4.2 feet; Davg,m=0.1 feet, Davg,o=0.4 feet
Depth (feet)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

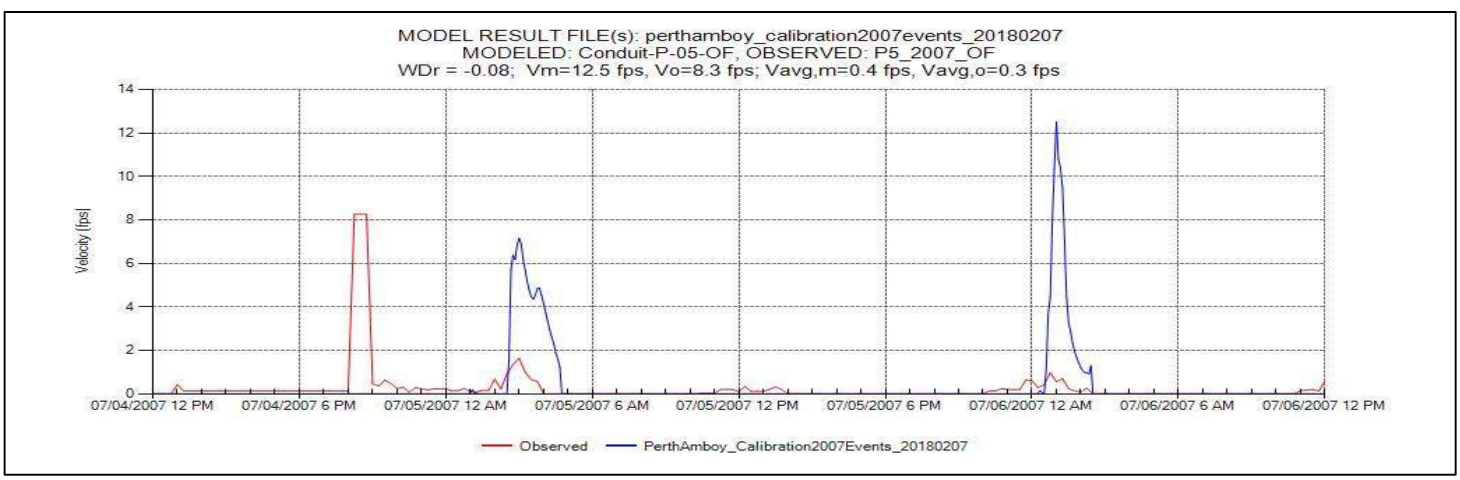

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.27; Volm=0.18 MG, Volo=1.03 MG; Qm=7.2 mgd, Qo=11.1 mgd; Qavg,m=0.1 mgd, Qavg,o=0.5 mgd
Flowrate (mgd)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.41; Vm=8.8 fps, Vo=12.1 fps; Vavg,m=0.3 fps, Vavg,o=5.6 fps
Velocity (fps)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

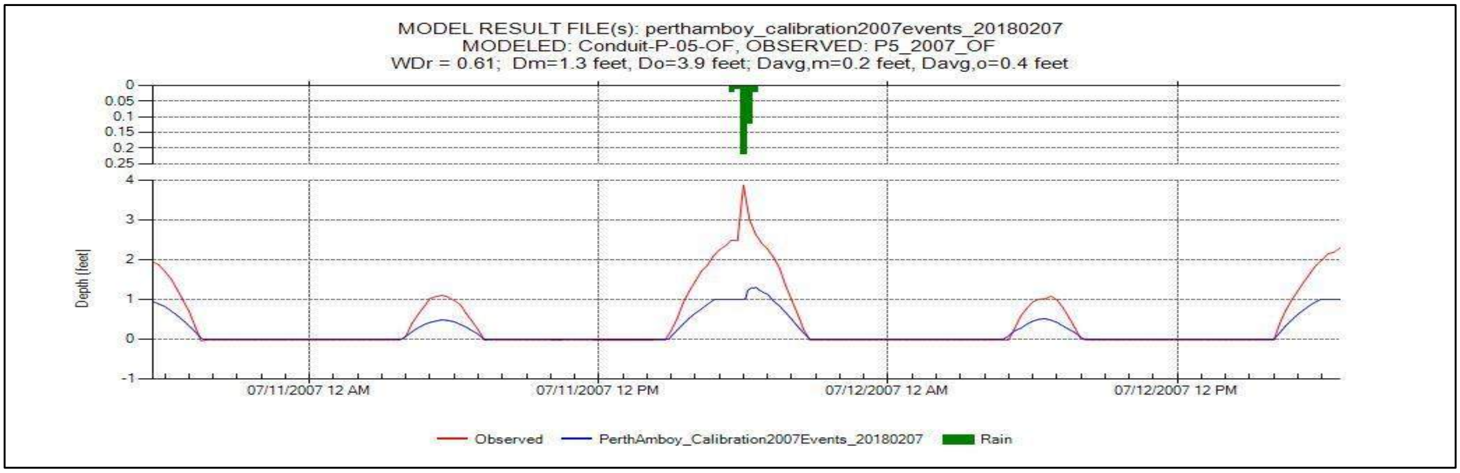
P5_2007_OF

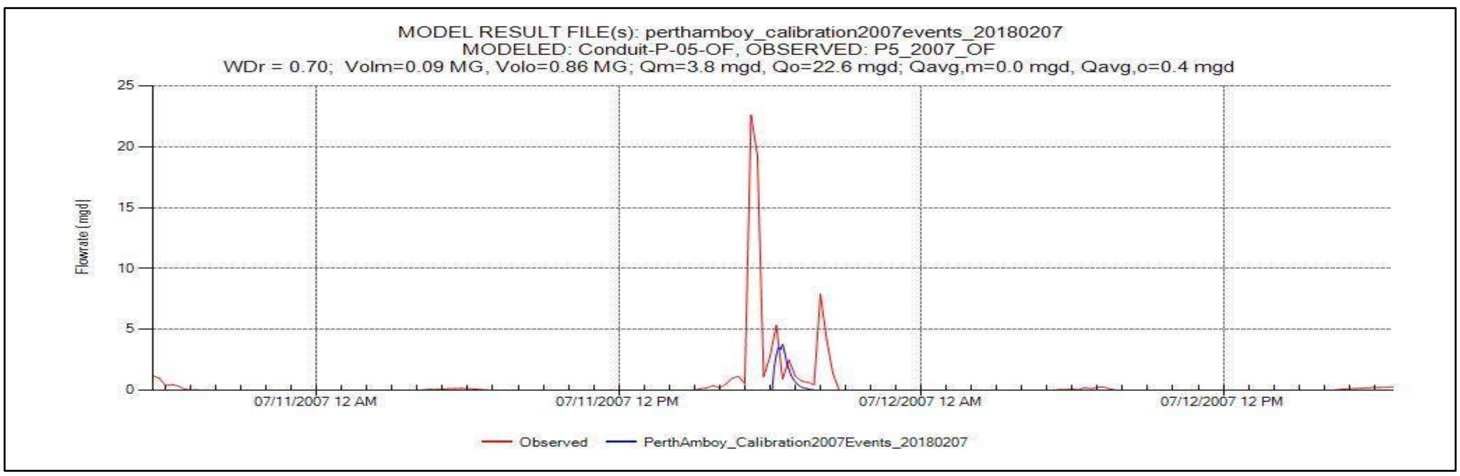

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.52; Dm=2.0 feet, Do=4.5 feet; Davg,m=0.1 feet, Davg,o=0.3 feet
Depth (feet)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

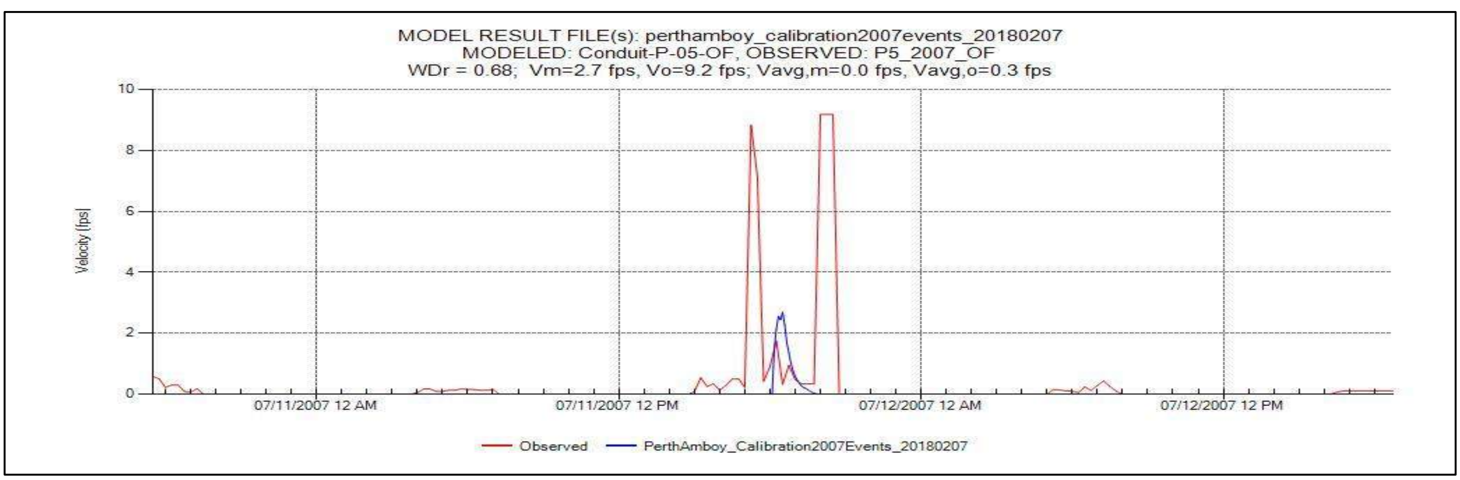

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.18; Volm=0.53 MG, Volo=0.20 MG; Qm=25.4 mgd, Qo=3.0 mgd; Qavg,m=0.3 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = -0.08; Vm=12.5 fps, Vo=8.3 fps; Vavg,m=0.4 fps, Vavg,o=0.3 fps
Velocity (fps)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

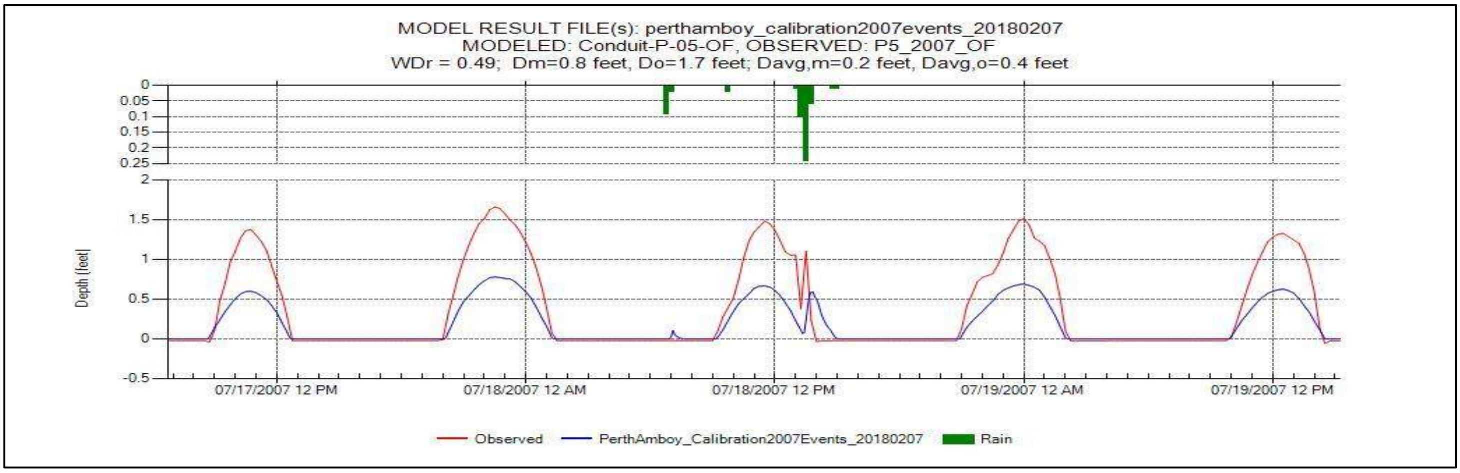
P5_2007_OF

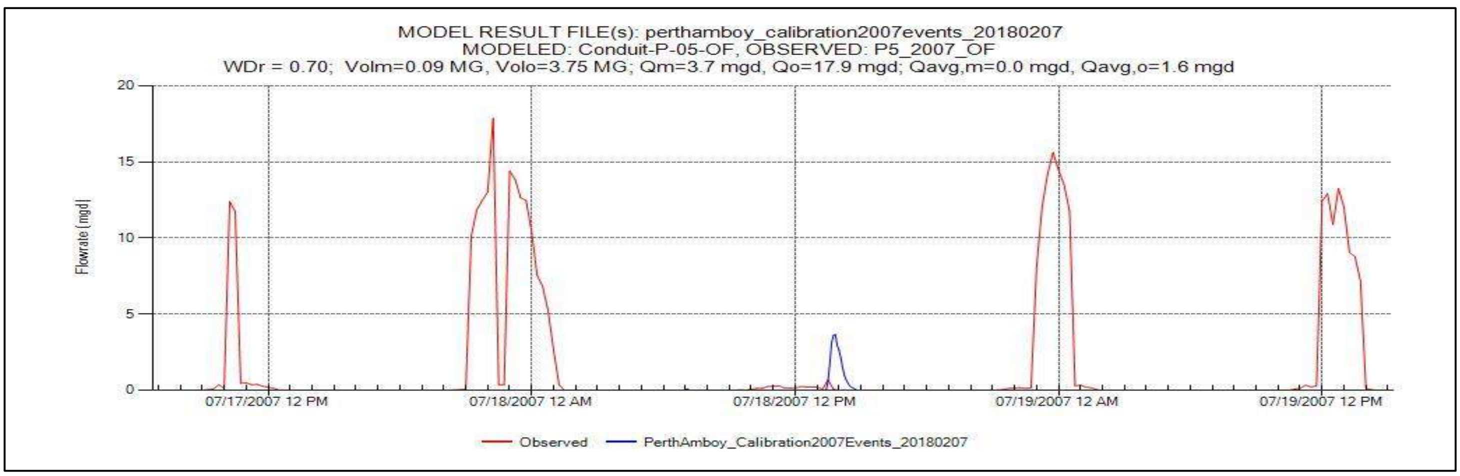

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.61; Dm=1.3 feet, Do=3.9 feet; Davg,m=0.2 feet, Davg,o=0.4 feet
Depth (feet)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

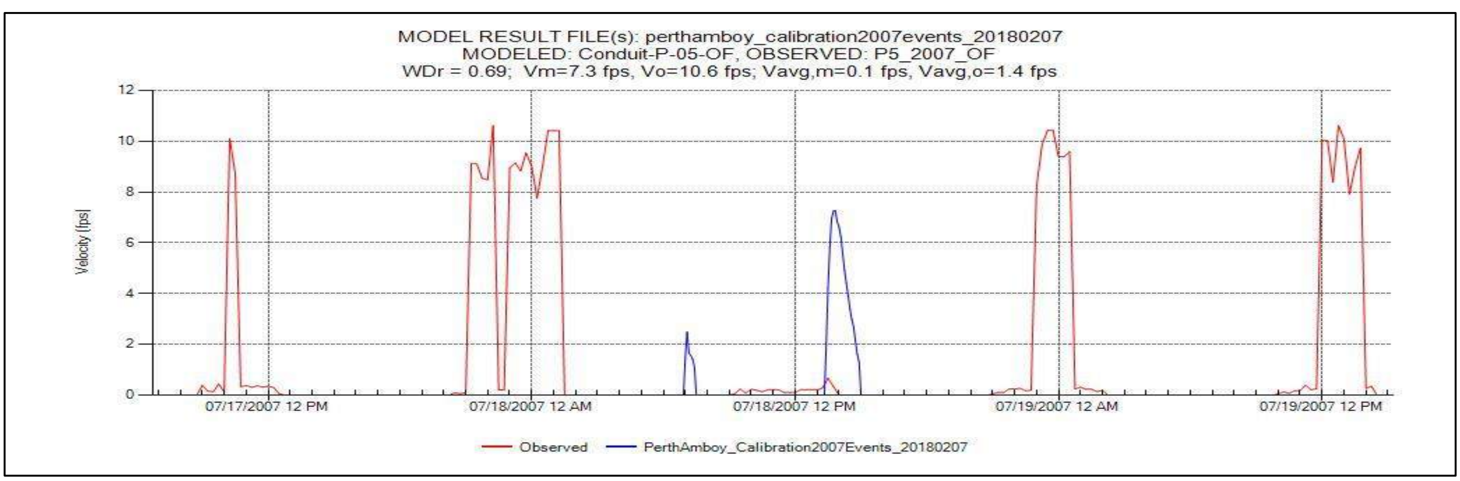

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.70; Volm=0.09 MG, Volo=0.86 MG; Qm=3.8 mgd, Qo=22.6 mgd; Qavg,m=0.0 mgd, Qavg,o=0.4 mgd
Flowrate (mgd)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.68; Vm=2.7 fps, Vo=9.2 fps; Vavg,m=0.0 fps, Vavg,o=0.3 fps
Velocity (fps)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

P5_2007_OF

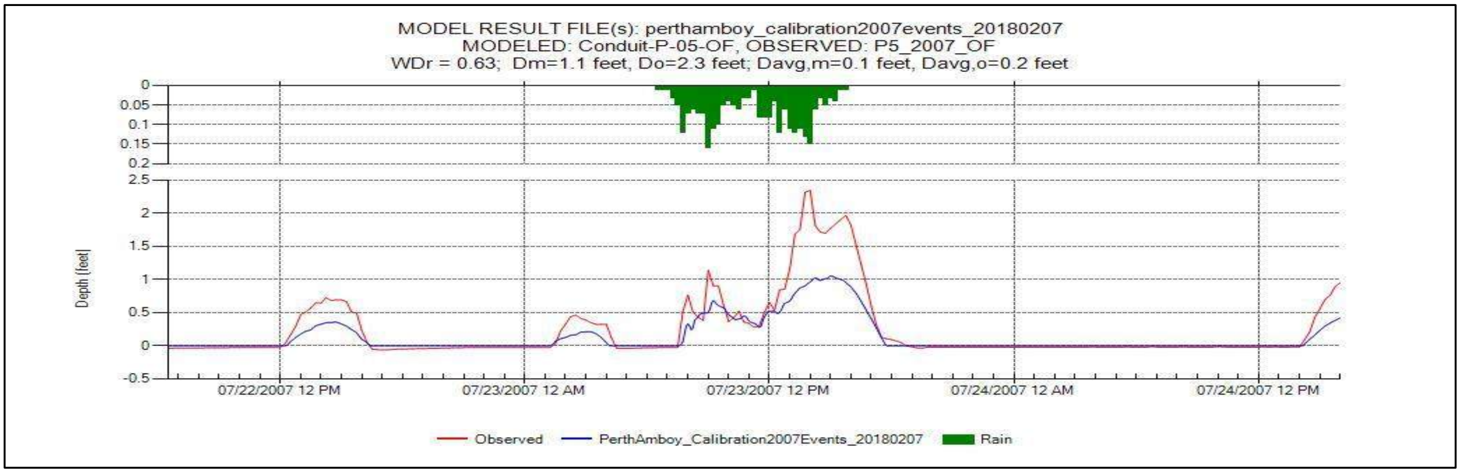

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.49; Dm=0.8 feet, Do=1.7 feet; Davg,m=0.2 feet, Davg,o=0.4 feet
Depth (feet)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

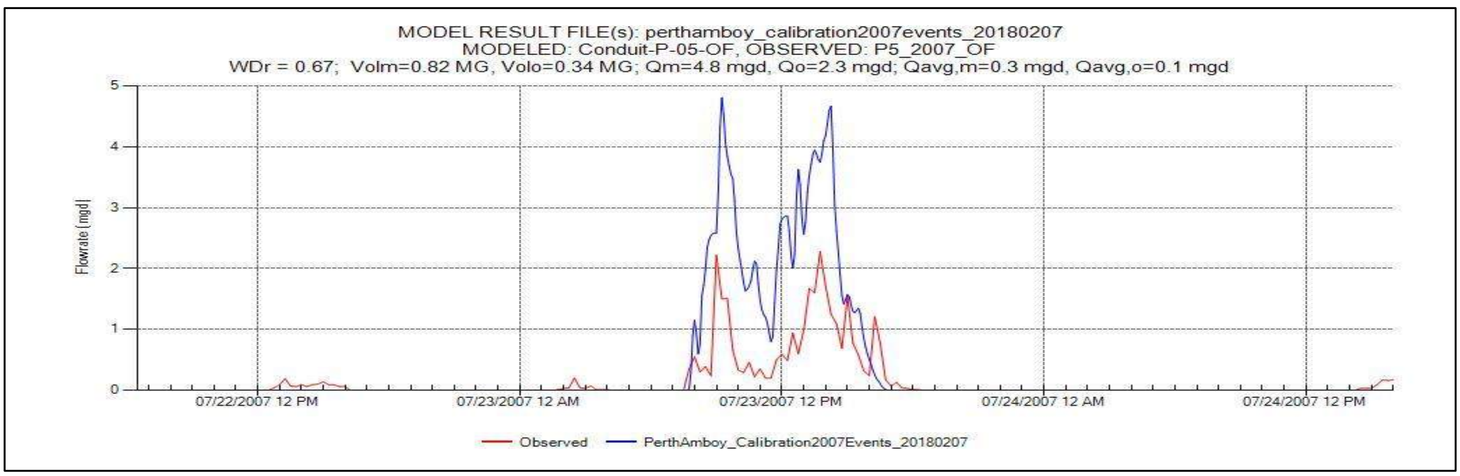

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.70; Volm=0.09 MG, Volo=3.75 MG; Qm=3.7 mgd, Qo=17.9 mgd; Qavg,m=0.0 mgd, Qavg,o=1.6 mgd
Flowrate (mgd)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

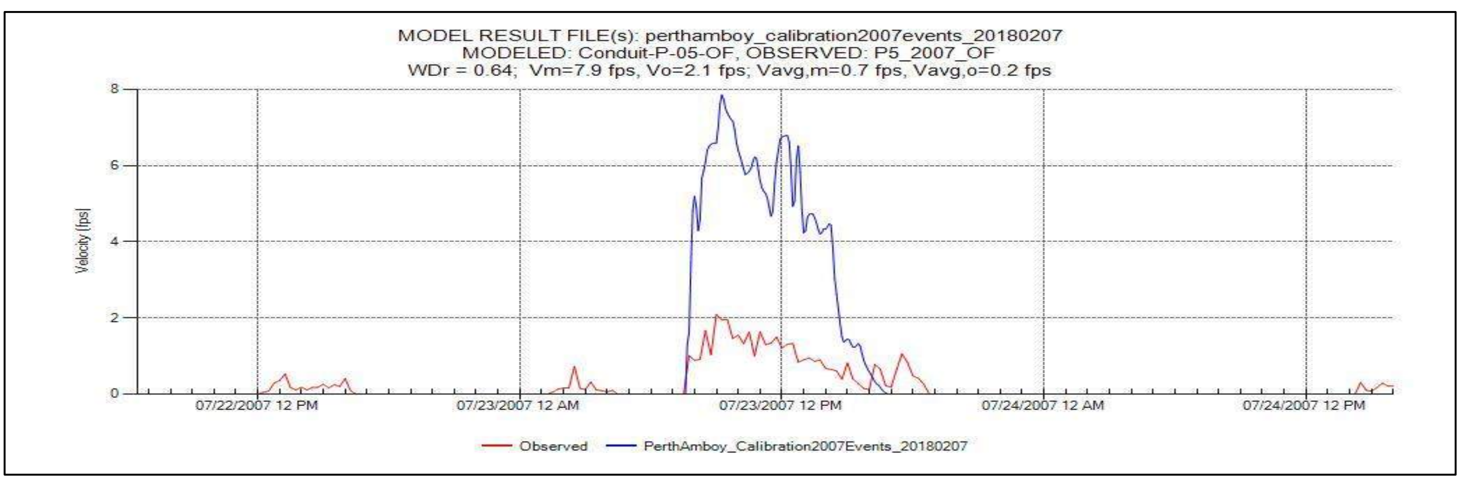

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.69; Vm=7.3 fps, Vo=10.6 fps; Vavg,m=0.1 fps, Vavg,o=1.4 fps
Velocity (fps)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

Simulated Versus Observed Flow at Flow Meter Sites

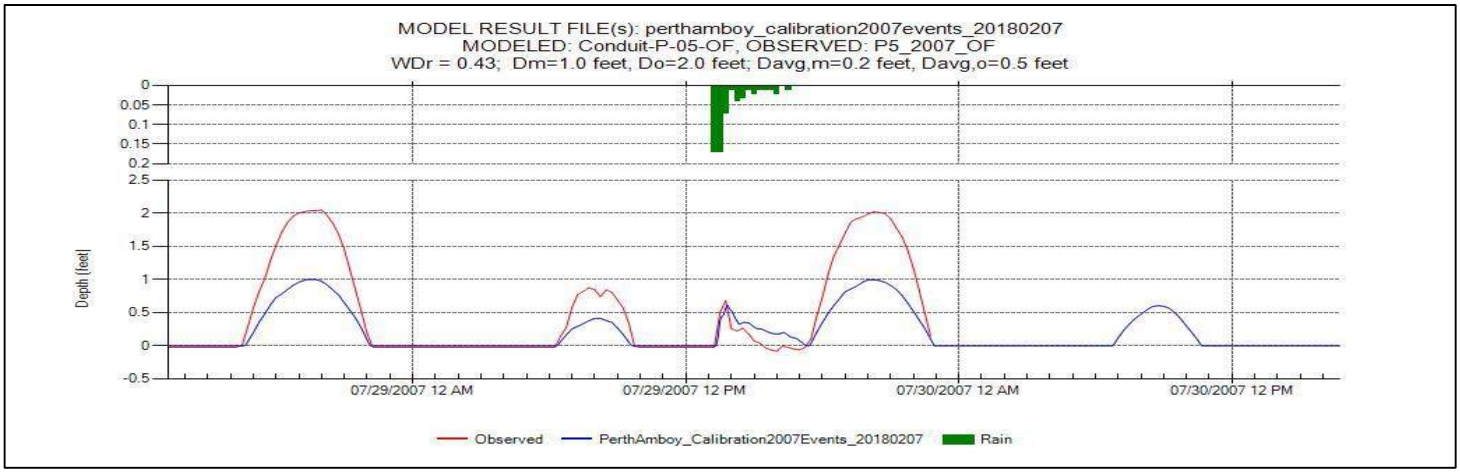
P5_2007_OF

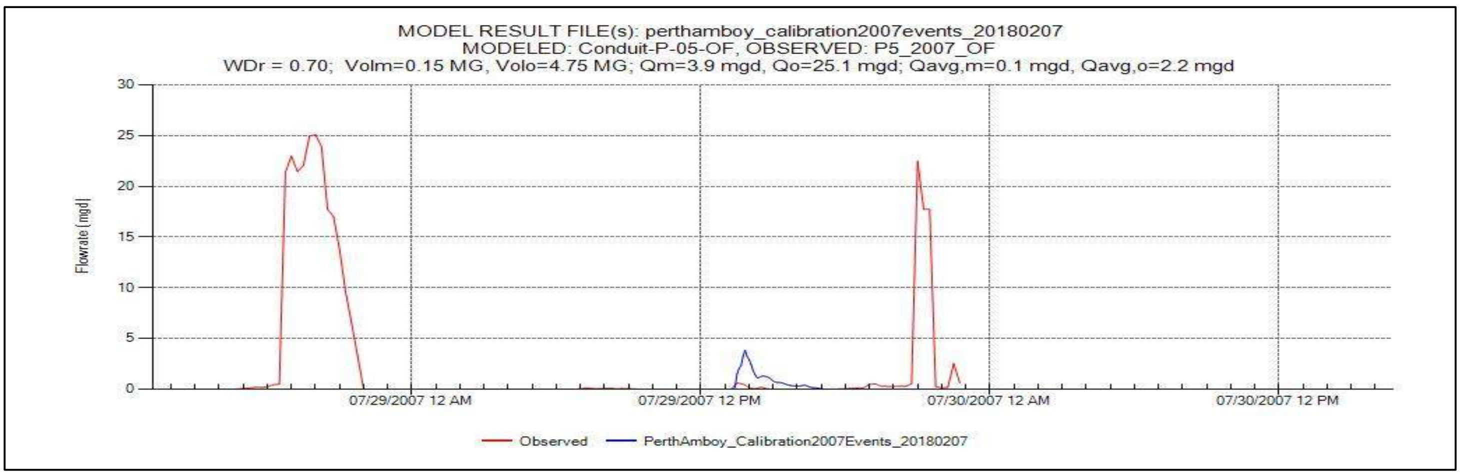


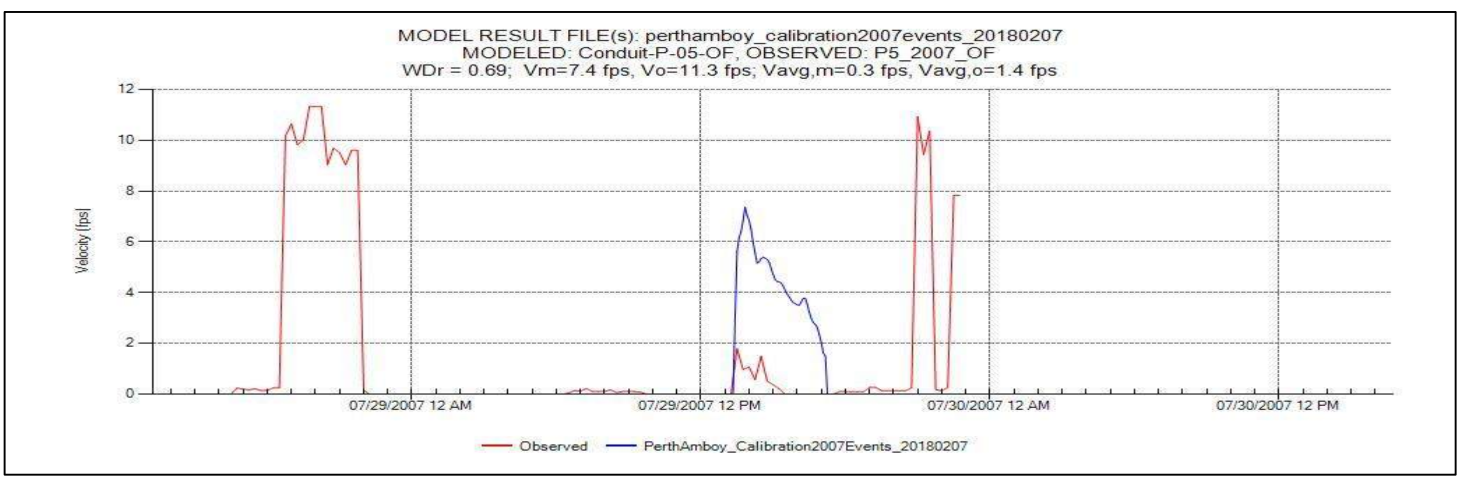




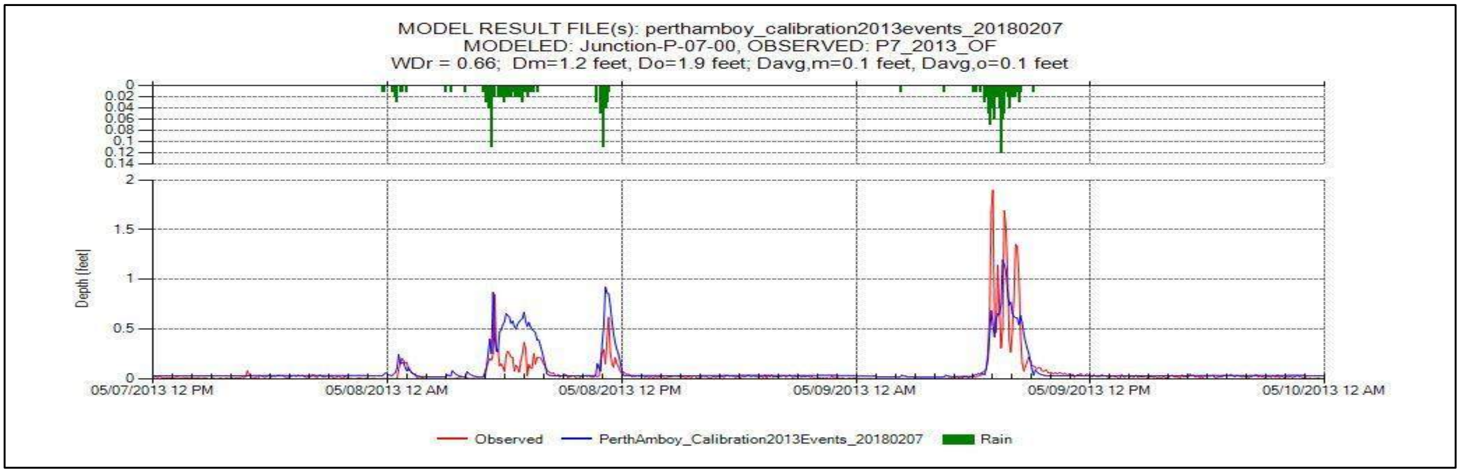
P5_2007_OF

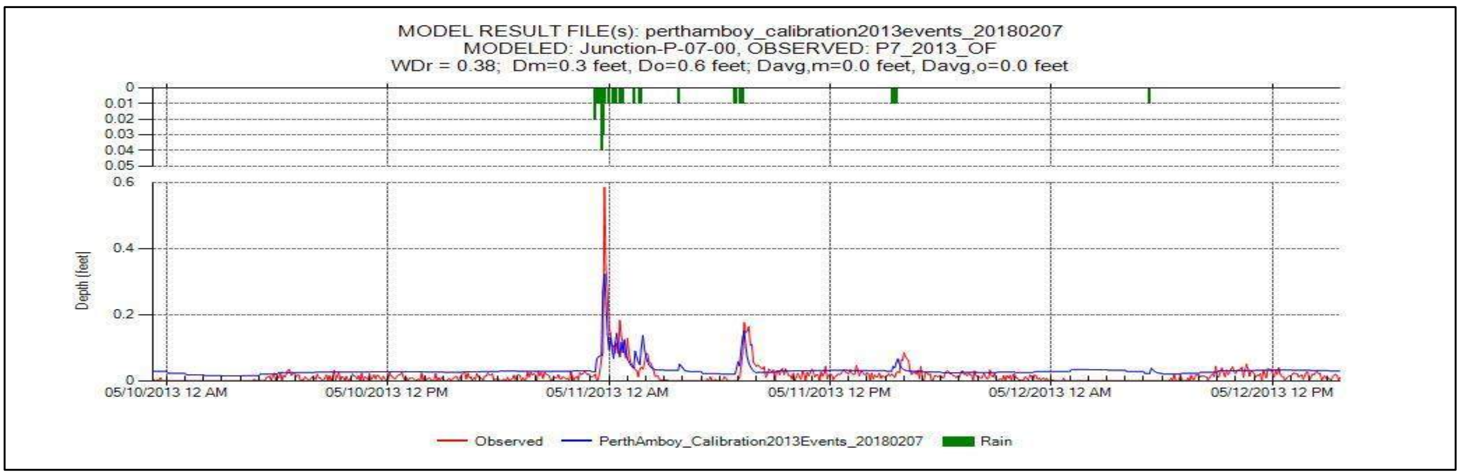

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.43; Dm=1.0 feet, Do=2.0 feet; Davg,m=0.2 feet, Davg,o=0.5 feet
Depth (feet)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

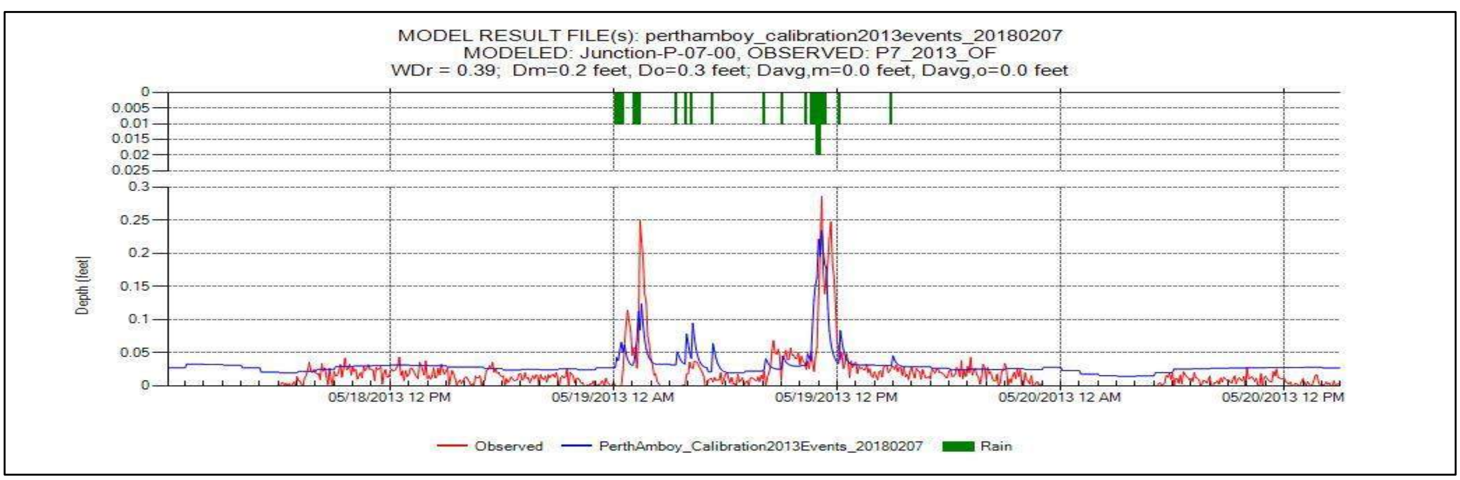

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.70; Volm=0.15 MG, Volo=4.75 MG; Qm=3.9 mgd, Qo=25.1 mgd; Qavg,m=0.1 mgd, Qavg,o=2.2 mgd
Flowrate (mgd)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-05-OF, OBSERVED: P5_2007_OF
WDr = 0.69; Vm=7.4 fps, Vo=11.3 fps; Vavg,m=0.3 fps, Vavg,o=1.4 fps
Velocity (fps)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

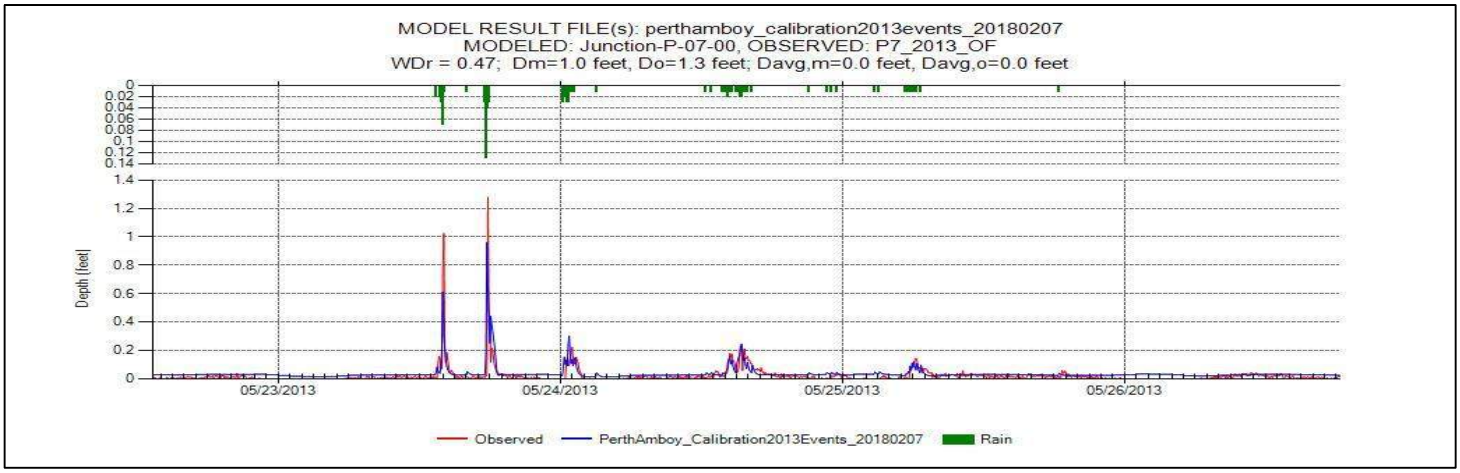
P7_2013_OF

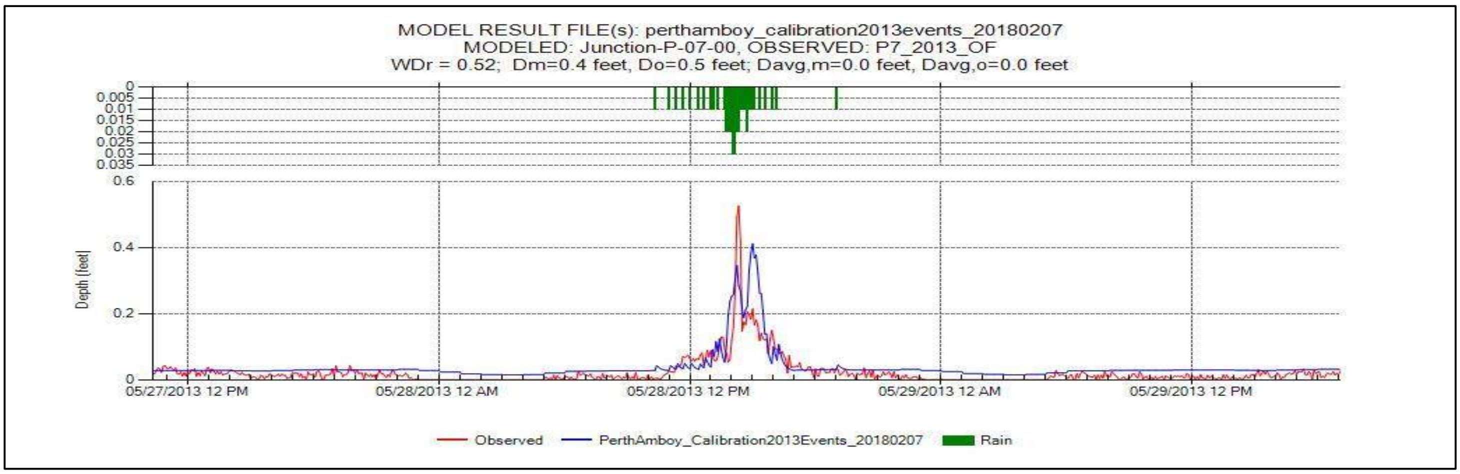

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.66; Dm=1.2 feet, Do=1.9 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
05/07/2013 12 PM
05/08/2013 12 AM
05/08/2013 12 PM
05/09/2013 12 AM
05/09/2013 12 PM
05/10/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

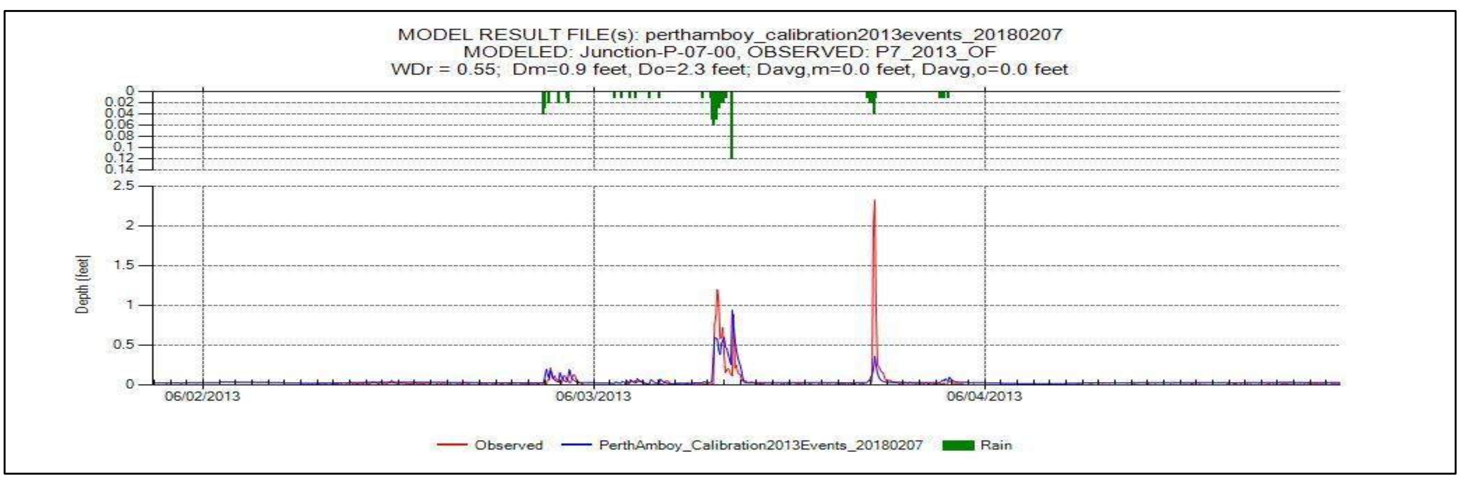

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.38; Dm=0.3 feet, Do=0.6 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/10/2013 12 AM
05/10/2013 12 PM
05/11/2013 12 AM
05/11/2013 12 PM
05/12/2013 12 AM
05/12/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.39; Dm=0.2 feet, Do=0.3 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/18/2013 12 PM
05/19/2013 12 AM
05/19/2013 12 PM
05/20/2013 12 AM
05/20/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

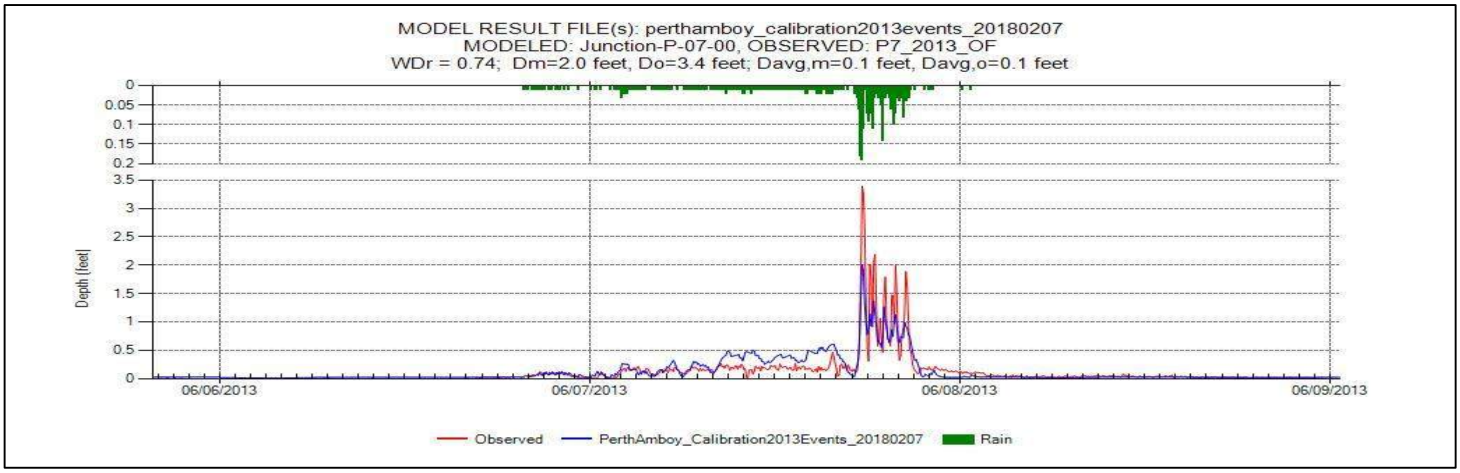
P7_2013_OF

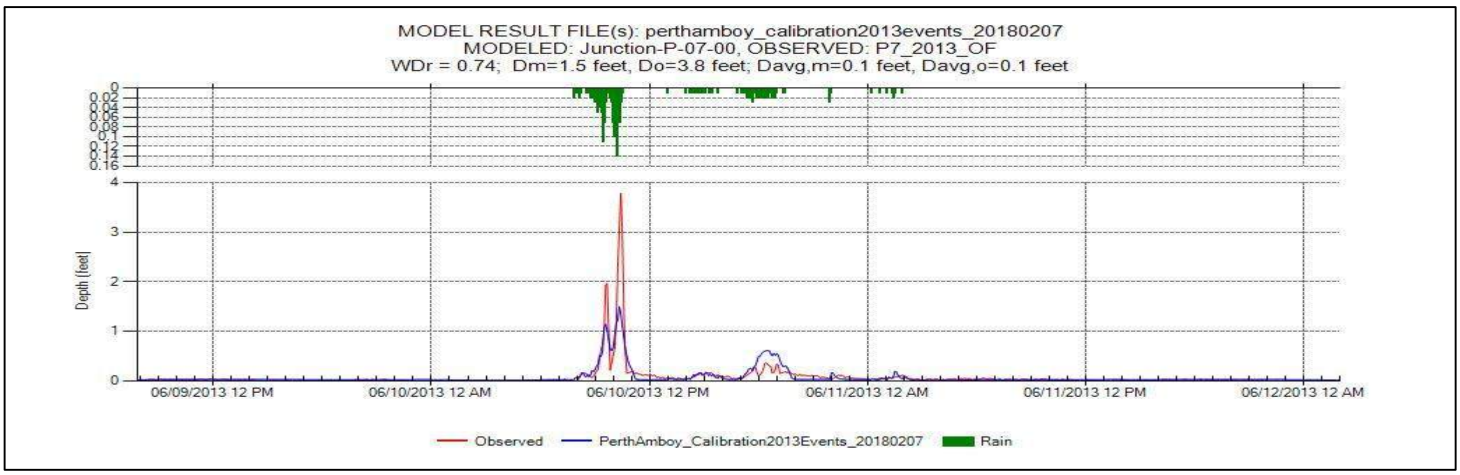

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.47; Dm=1.0 feet, Do=1.3 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/23/2013
05/24/2013
05/25/2013
05/26/2013
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

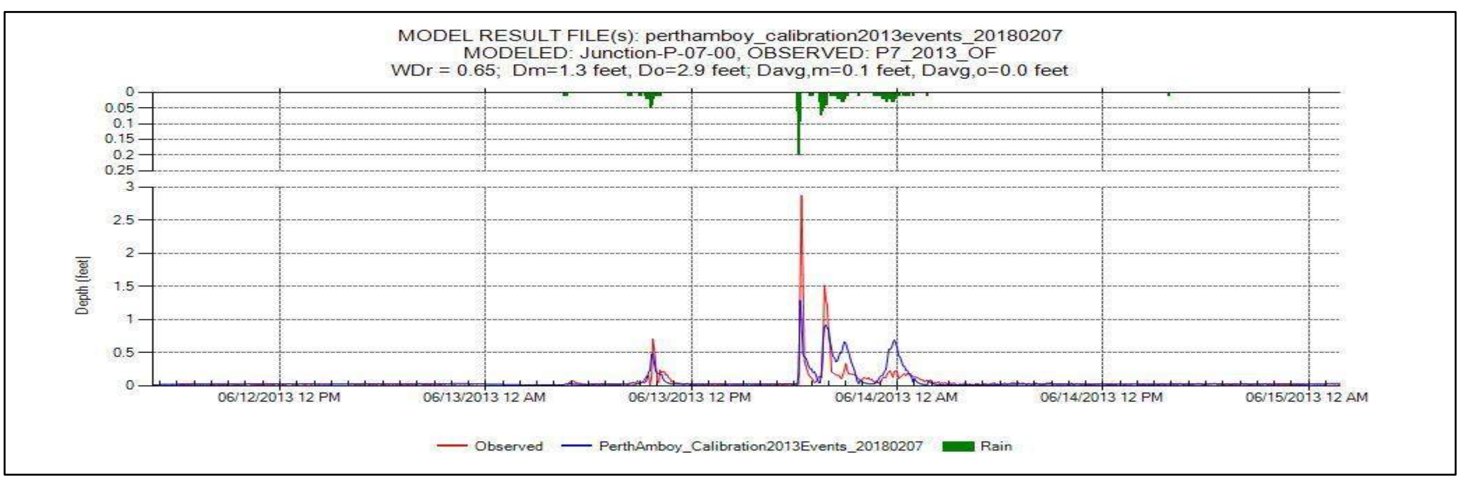

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.52; Dm=0.4 feet, Do=0.5 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/27/2013 12 PM
05/28/2013 12 AM
05/28/2013 12 PM
05/29/2013 12 AM
05/29/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.55; Dm=0.9 feet, Do=2.3 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
06/02/2013
06/03/2013
06/04/2013
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

P7_2013_OF

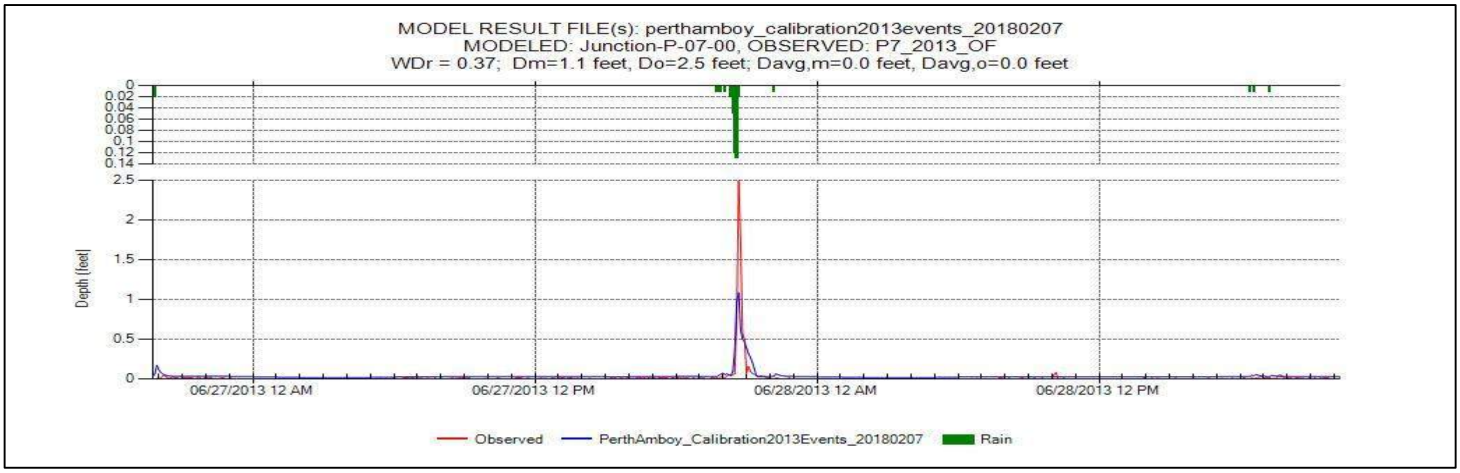

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.74; Dm=2.0 feet, Do=3.4 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
06/06/2013
06/07/2013
06/08/2013
06/09/2013
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

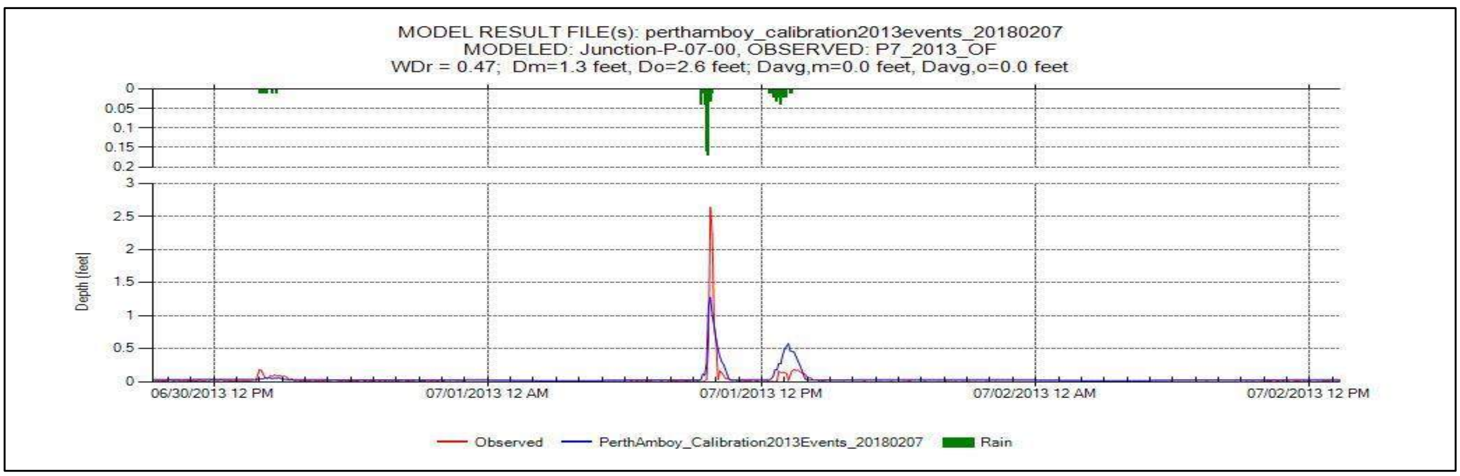

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.74; Dm=1.5 feet, Do=3.8 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
06/09/2013 12 PM
06/10/2013 12 AM
06/10/2013 12 PM
06/11/2013 12 AM
06/11/2013 12 PM
06/12/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

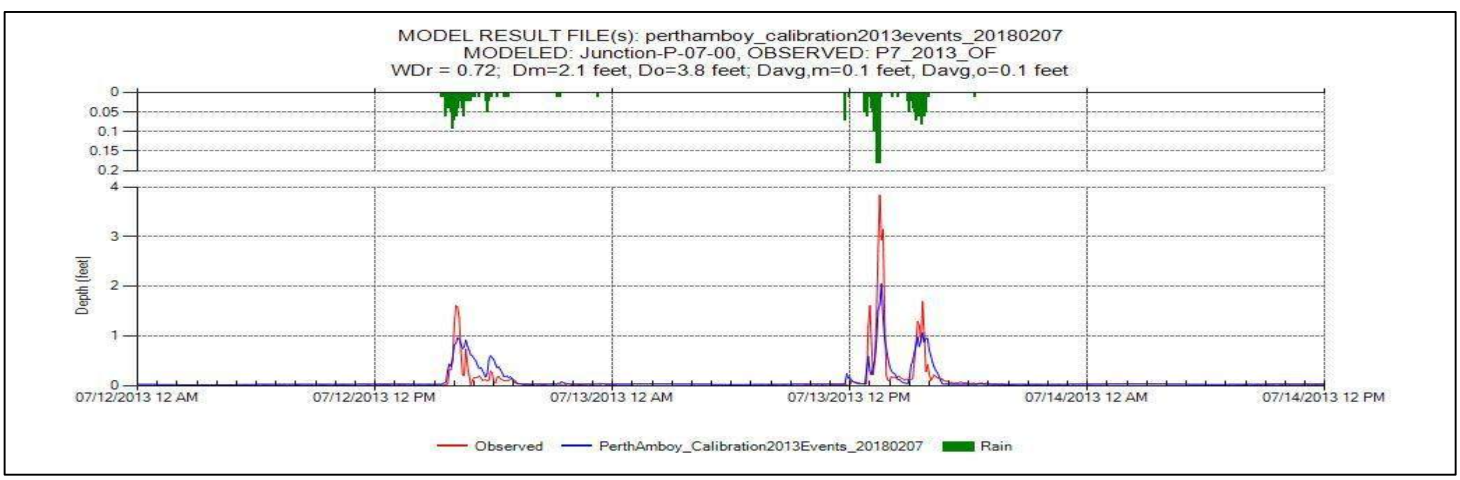

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.65; Dm=1.3 feet, Do=2.9 feet; Davg,m=0.1 feet, Davg,o=0.0 feet
Depth (feet)
06/12/2013 12 PM
06/13/2013 12 AM
06/13/2013 12 PM
06/14/2013 12 AM
06/14/2013 12 PM
06/15/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

Simulated Versus Observed Flow at Flow Meter Sites

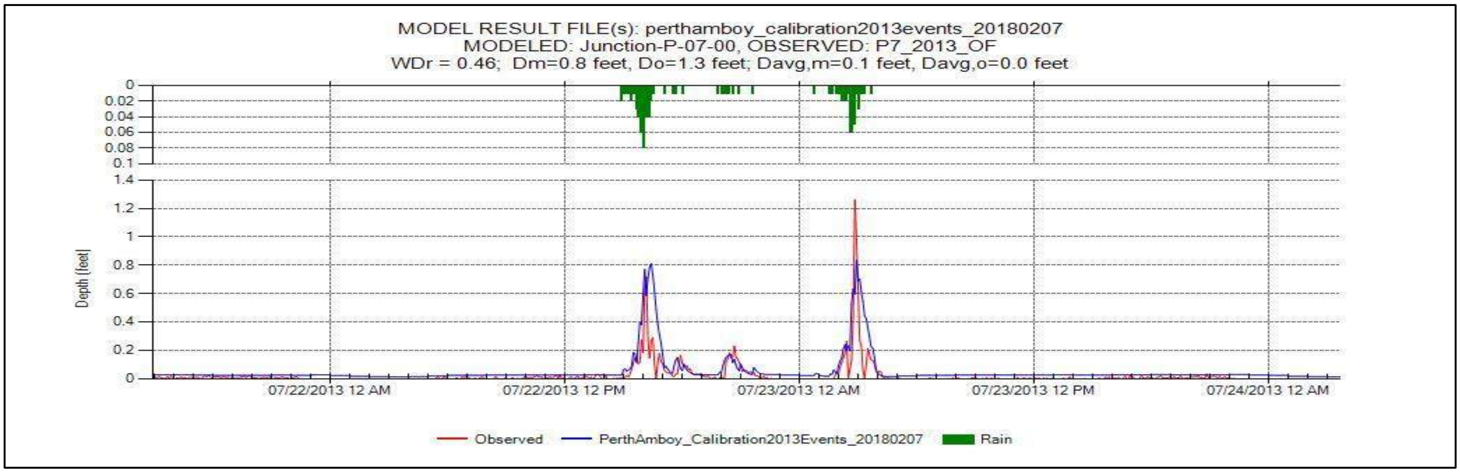
P7_2013_OF

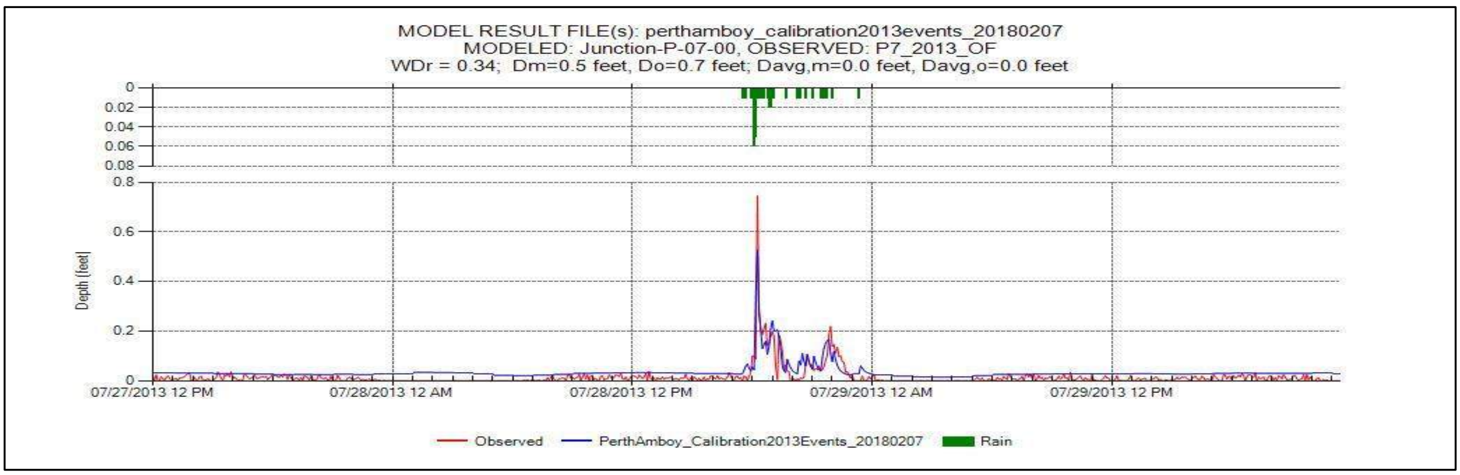


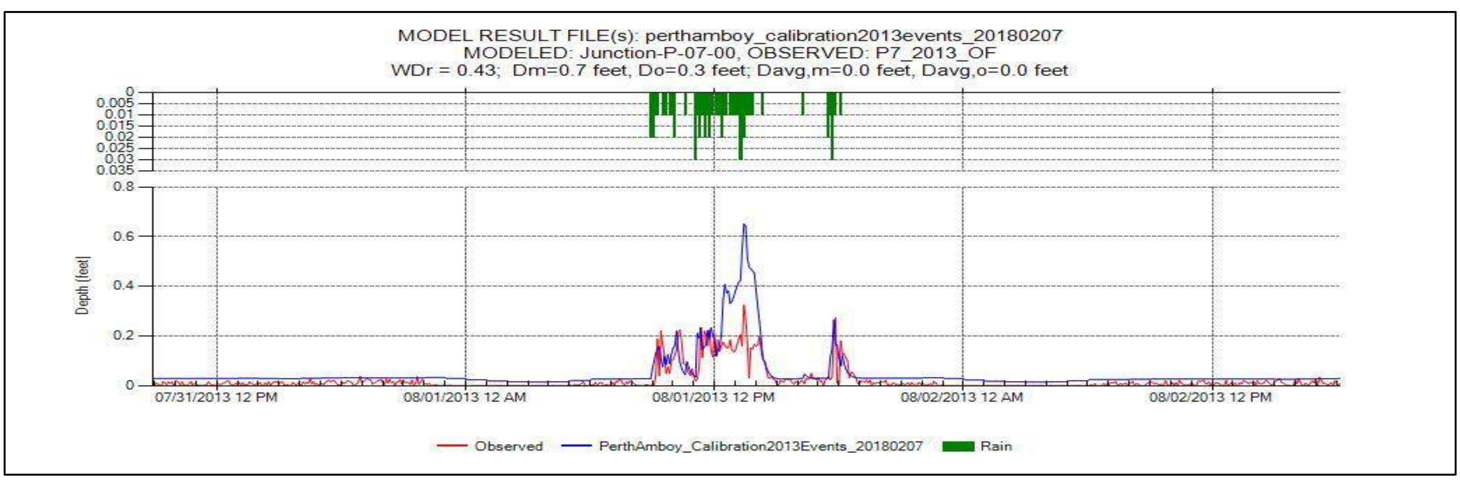




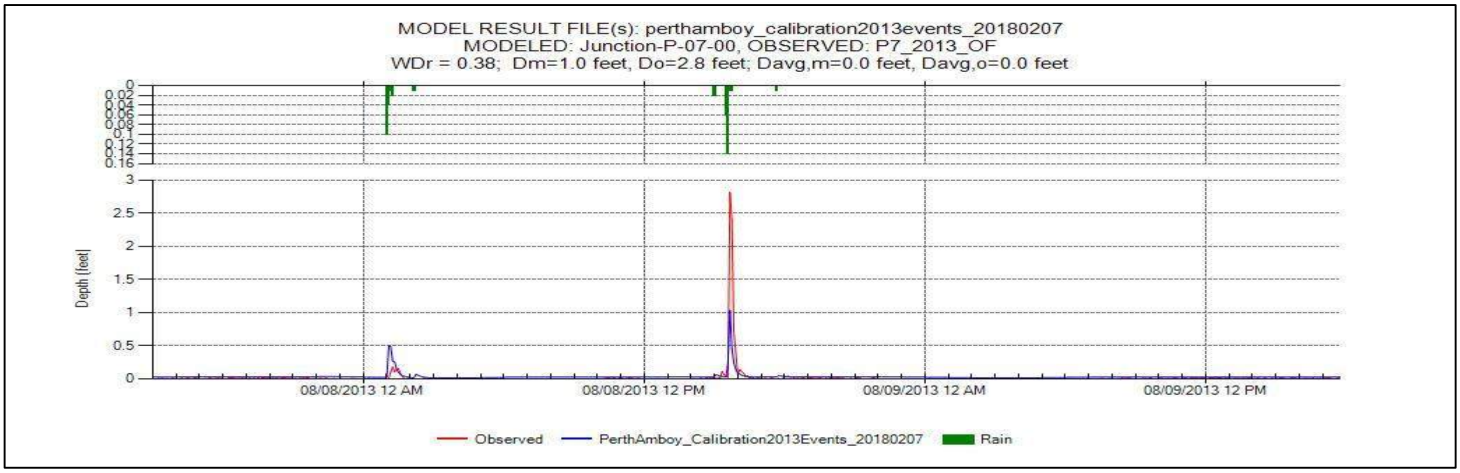
P7_2013_OF

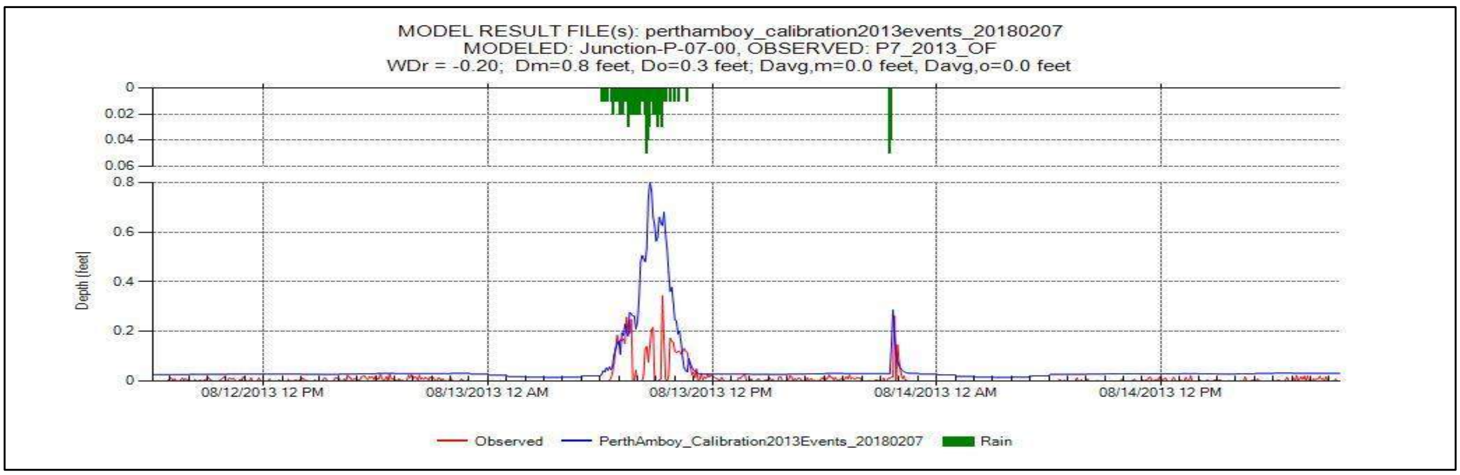

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.46; Dm=0.8 feet, Do=1.3 feet; Davg,m=0.1 feet, Davg,o=0.0 feet
Depth (feet)
07/22/2013 12 AM
07/22/2013 12 PM
07/23/2013 12 AM
07/23/2013 12 PM
07/24/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

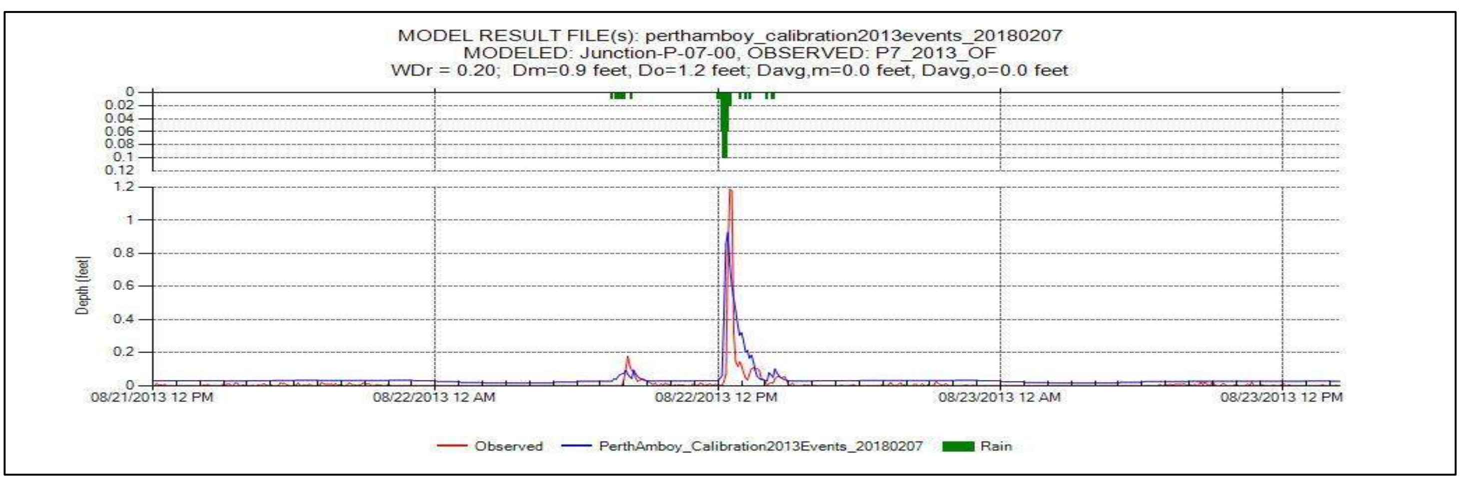

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.34; Dm=0.5 feet, Do=0.7 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
07/27/2013 12 PM
07/28/2013 12 AM
07/28/2013 12 PM
07/29/2013 12 AM
07/29/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.43; Dm=0.7 feet, Do=0.3 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
07/31/2013 12 PM
08/01/2013 12 AM
08/01/2013 12 PM
08/02/2013 12 AM
08/02/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

P7_2013_OF

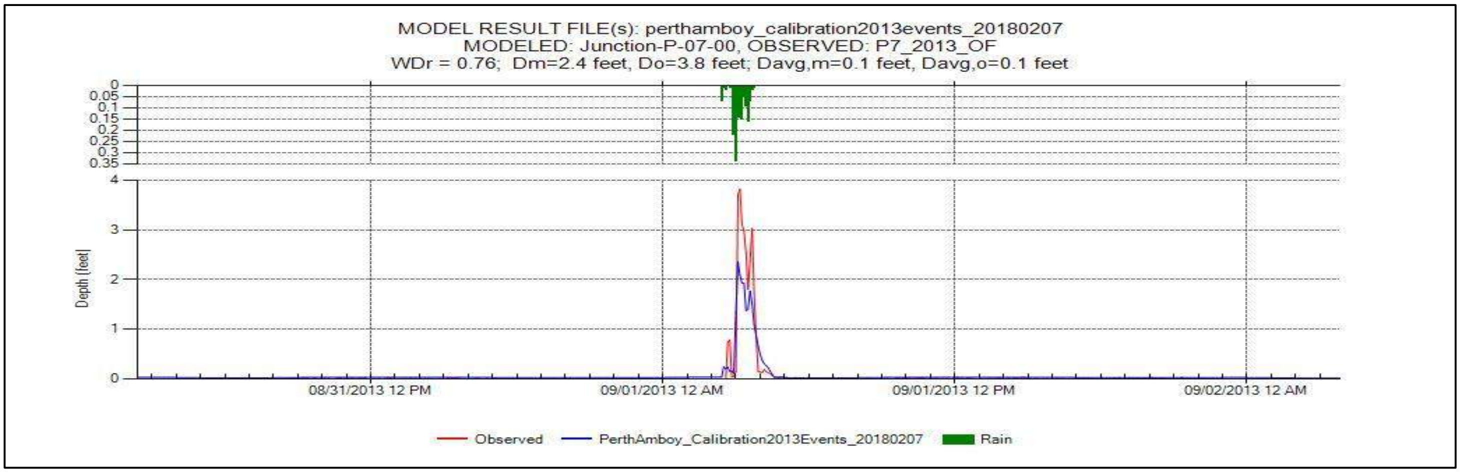

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.38; Dm=1.0 feet, Do=2.8 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
08/08/2013 12 AM
08/08/2013 12 PM
08/09/2013 12 AM
08/09/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

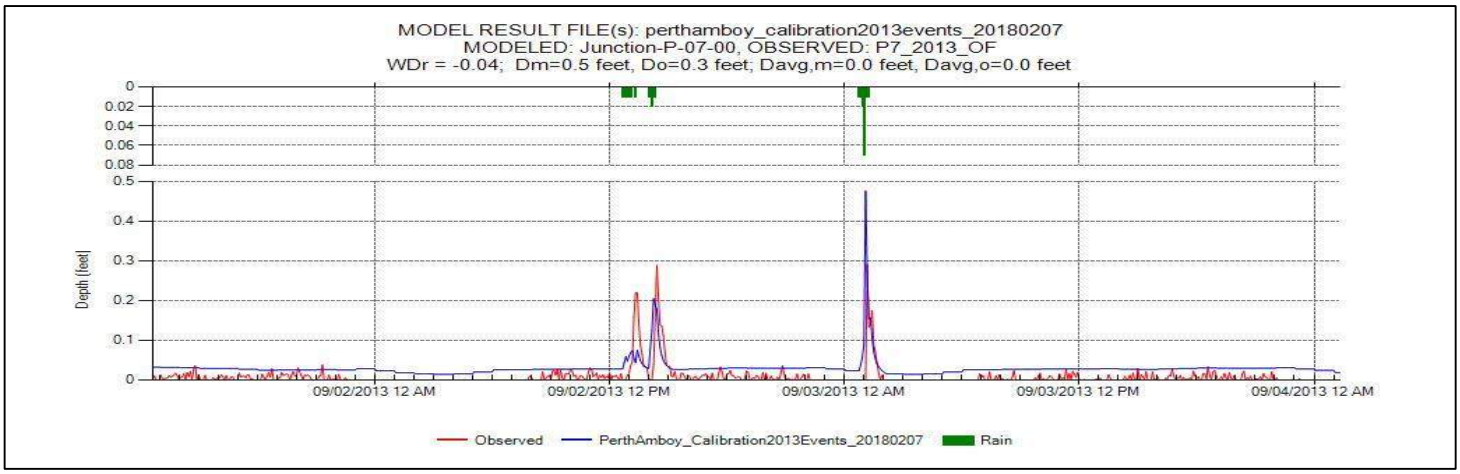

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = -0.20; Dm=0.8 feet, Do=0.3 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
08/12/2013 12 PM
08/13/2013 12 AM
08/13/2013 12 PM
08/14/2013 12 AM
08/14/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

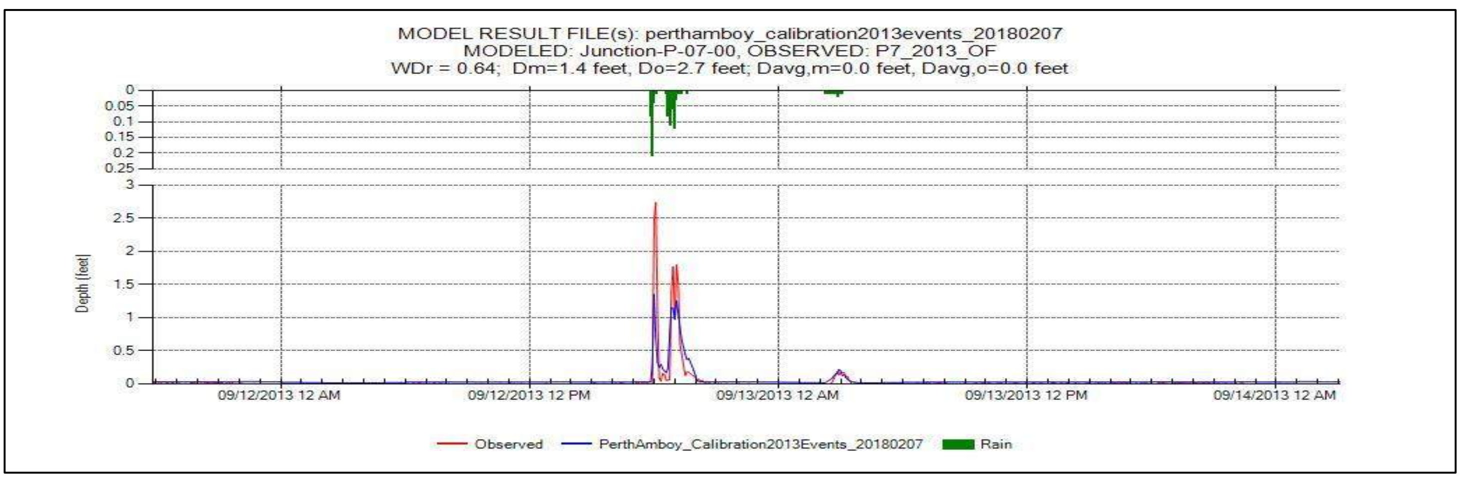

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Junction-P-07-00, OBSERVED: P7_2013_OF
WDr = 0.20; Dm=0.9 feet, Do=1.2 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
08/21/2013 12 PM
08/22/2013 12 AM
08/22/2013 12 PM
08/23/2013 12 AM
08/23/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

Simulated Versus Observed Flow at Flow Meter Sites

P7_2013_OF

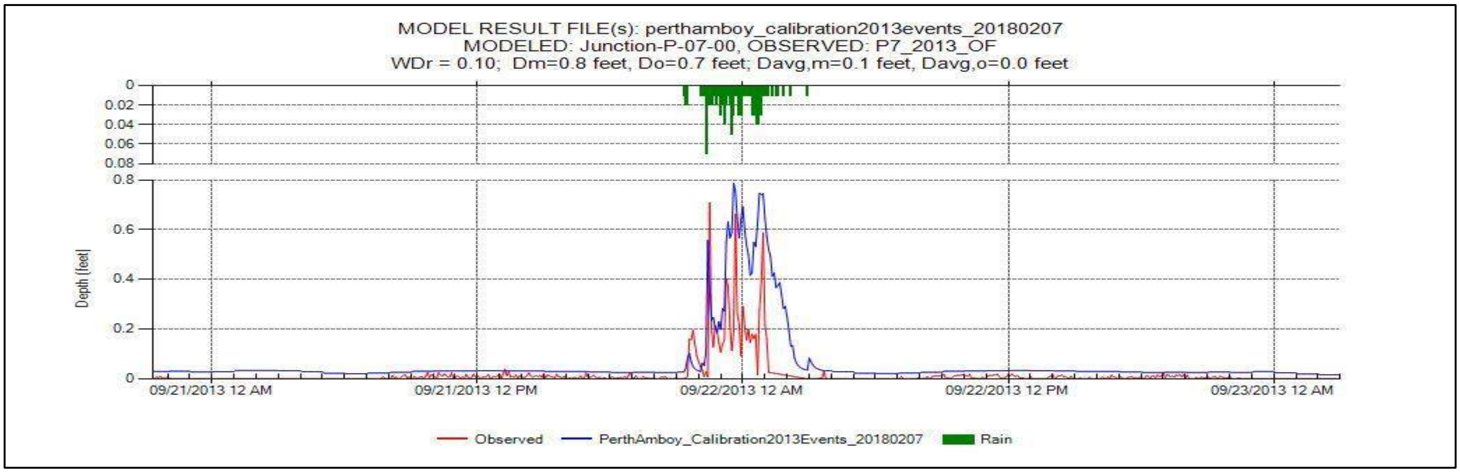




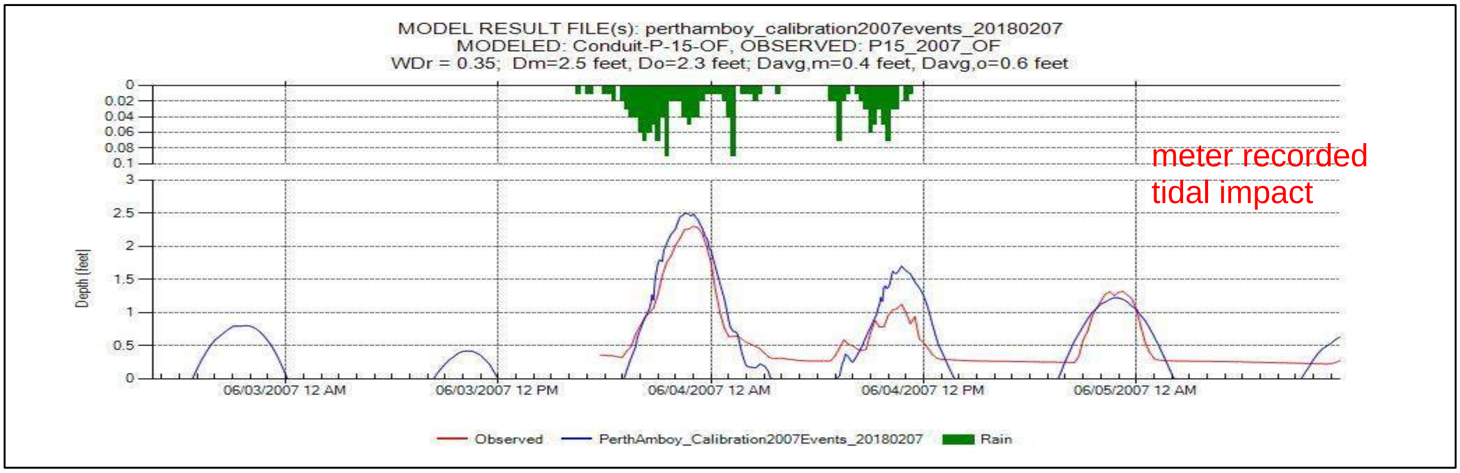


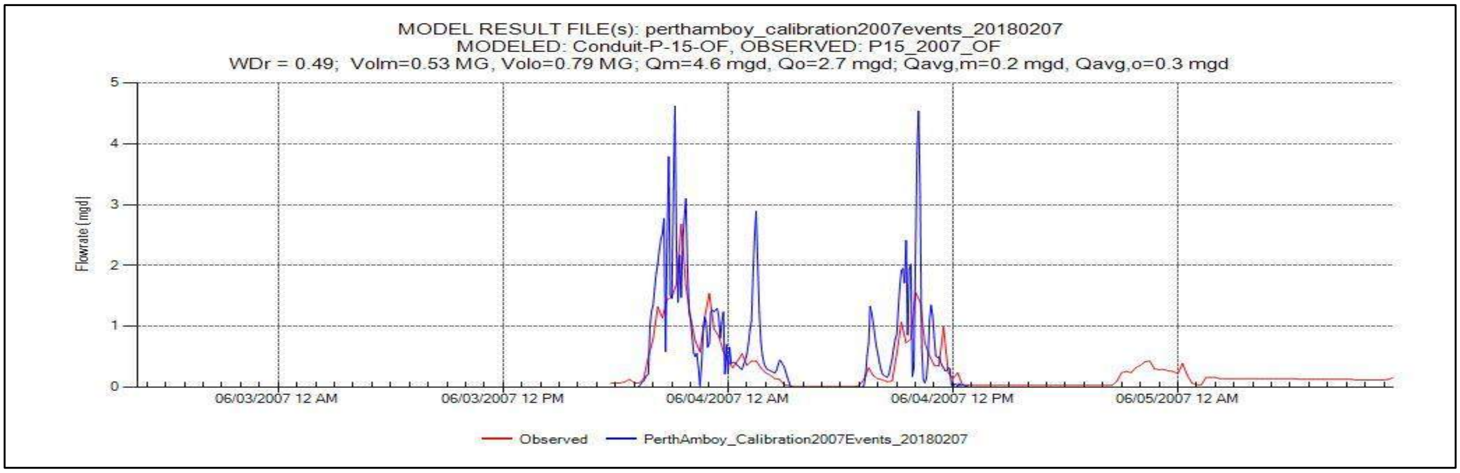
Simulated Versus Observed Flow at Flow Meter Sites

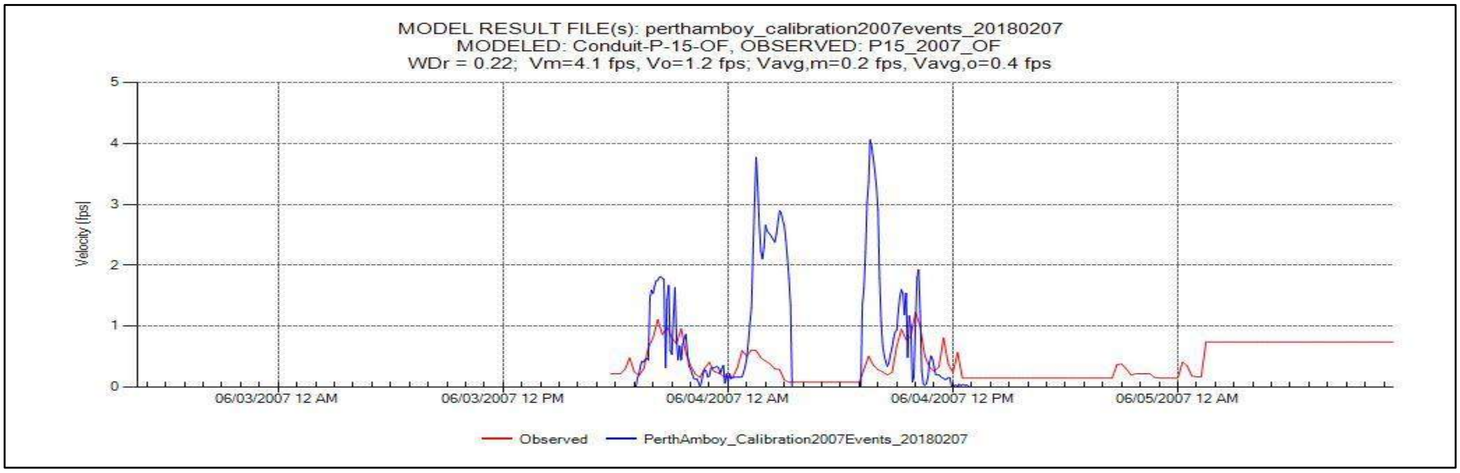
P7_2013_OF



P15_2007_OF

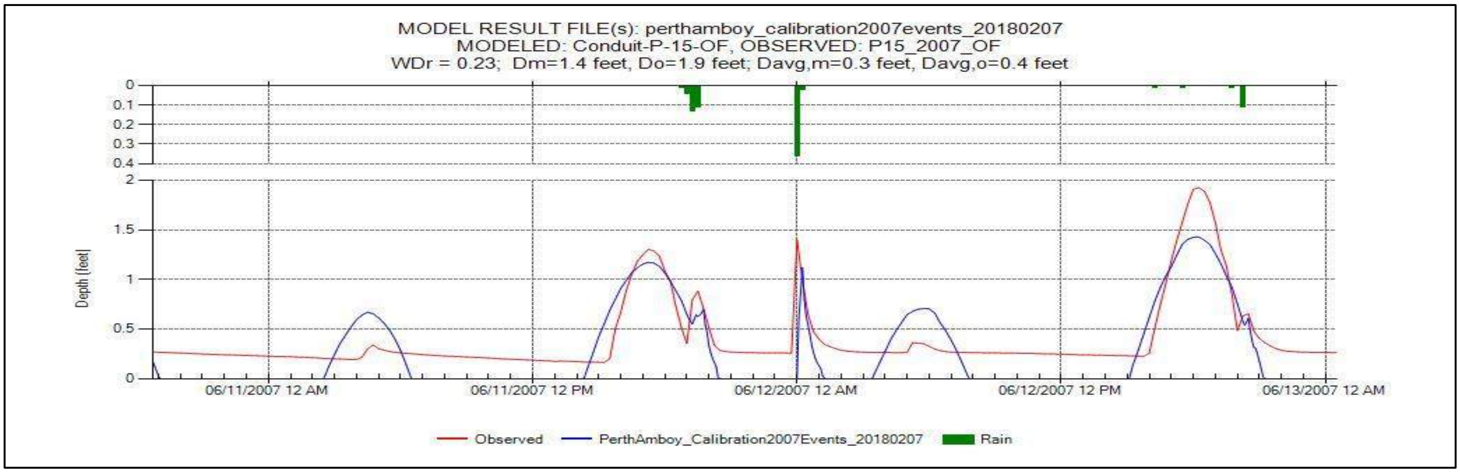

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.35; Dm=2.5 feet, Do=2.3 feet; Davg,m=0.4 feet, Davg,o=0.6 feet
Depth (feet)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
meter recorded
tidal impact
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

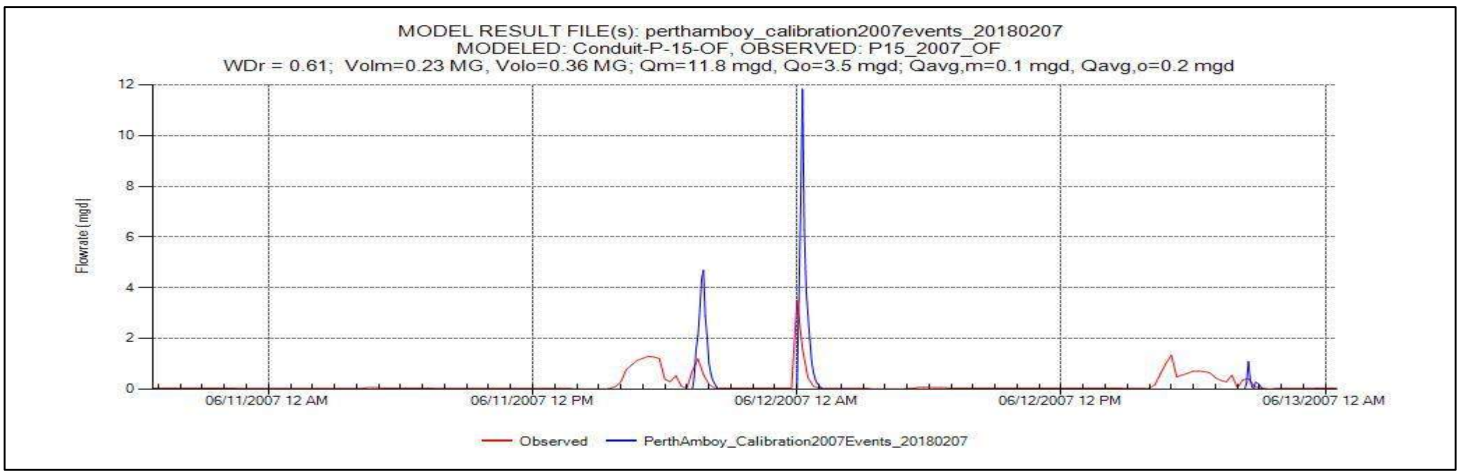

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.49; Volm=0.53 MG, Volo=0.79 MG; Qm=4.6 mgd, Qo=2.7 mgd; Qavg,m=0.2 mgd, Qavg,o=0.3 mgd
Flowrate (mgd)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

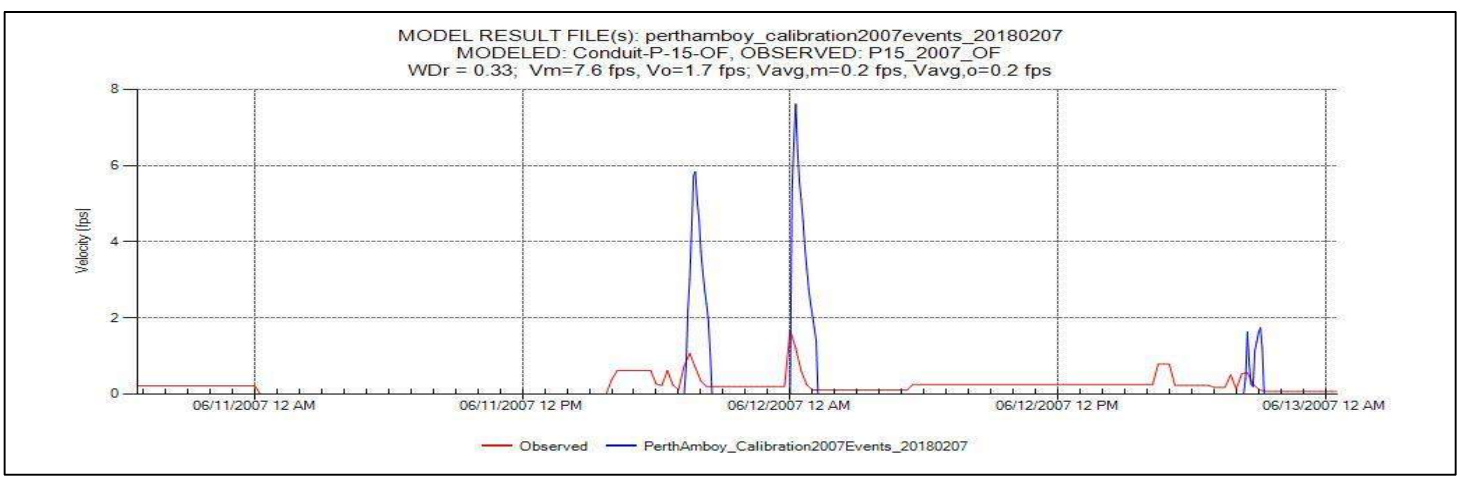

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.22; Vm=4.1 fps, Vo=1.2 fps; Vavg,m=0.2 fps, Vavg,o=0.4 fps
Velocity (fps)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

Simulated Versus Observed Flow at Flow Meter Sites

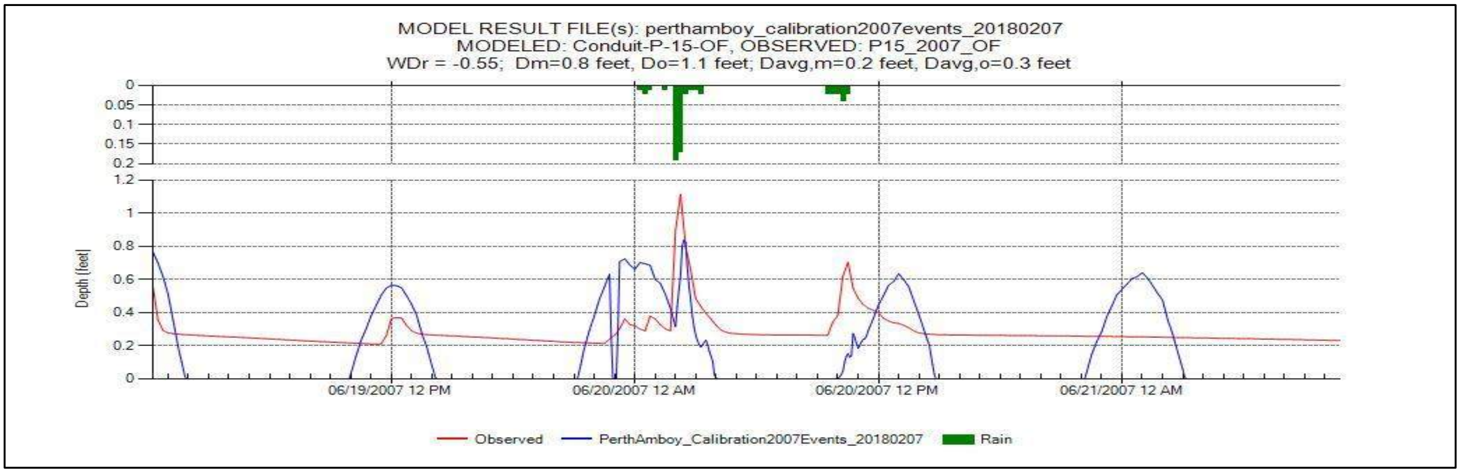
P15_2007_OF

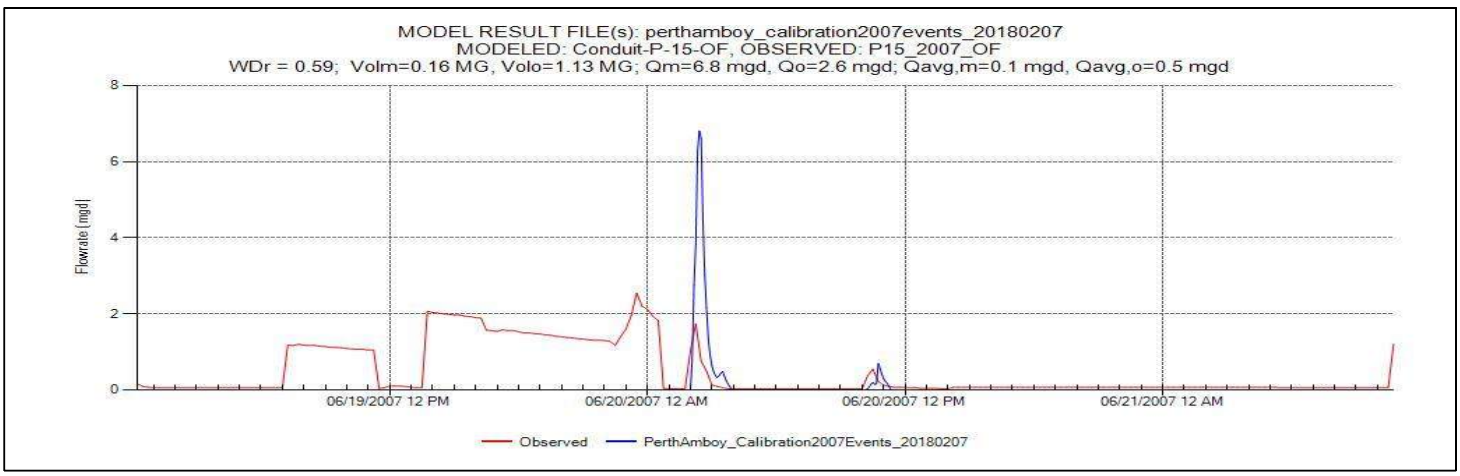


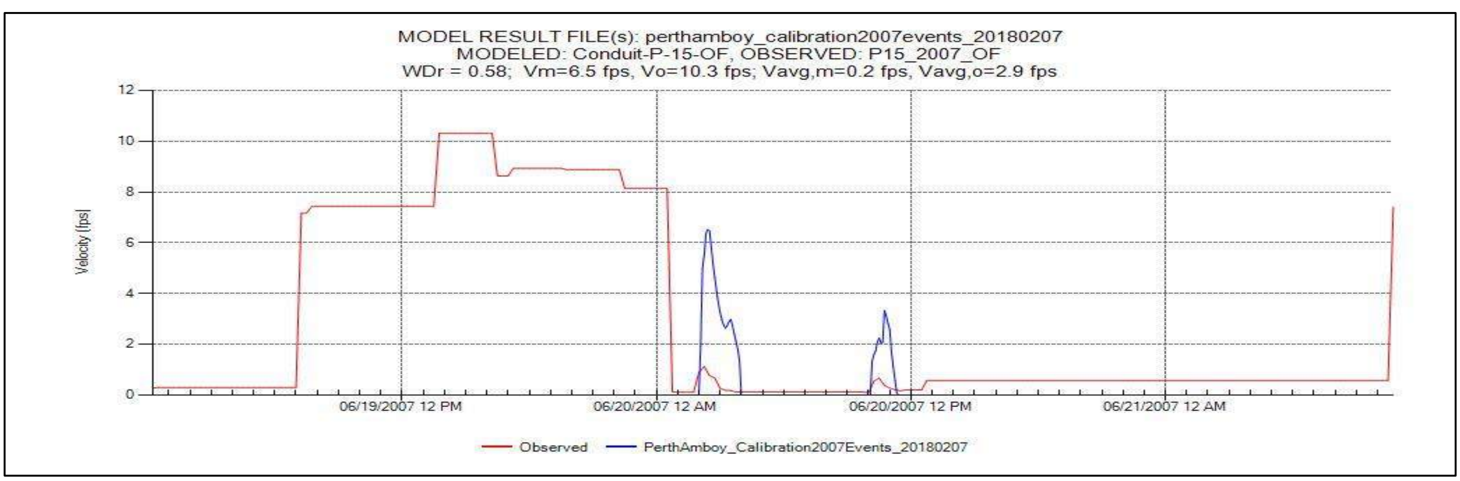




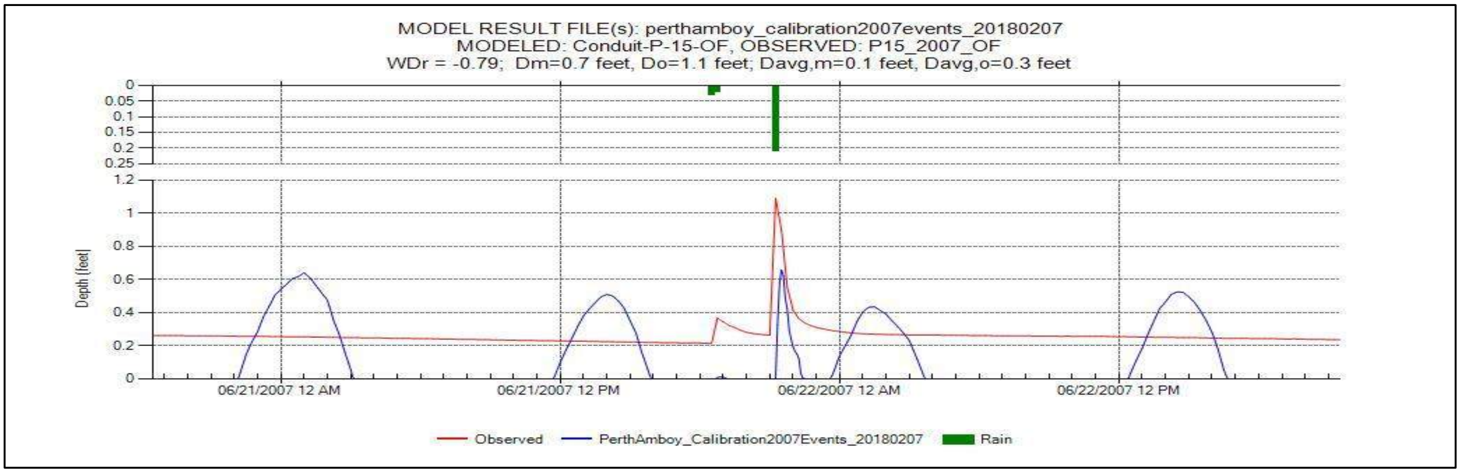
P15_2007_OF

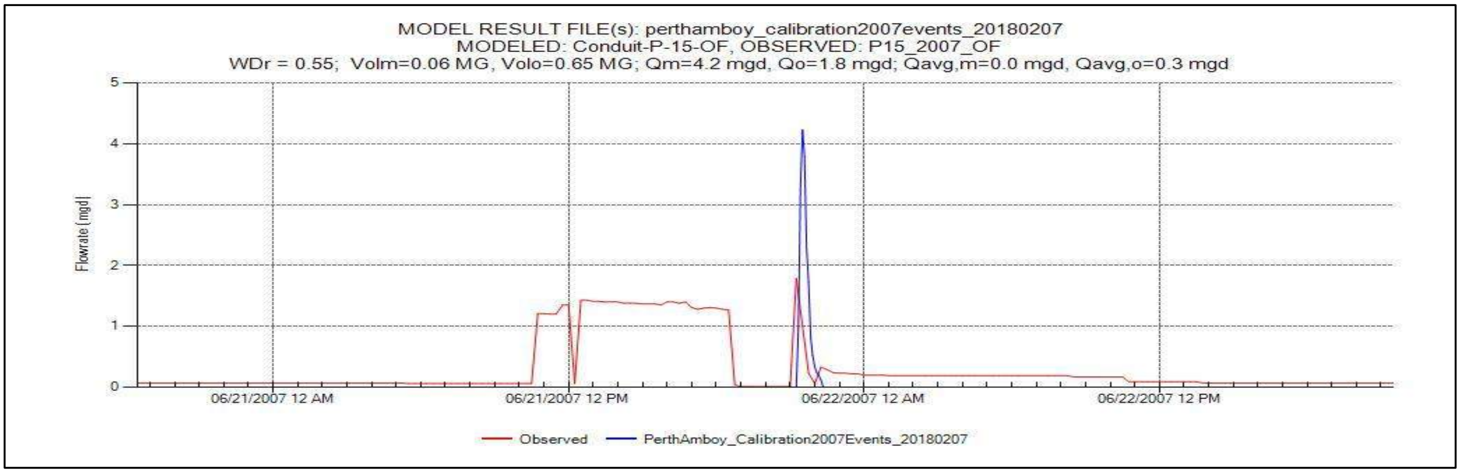

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = -0.55; Dm=0.8 feet, Do=1.1 feet; Davg,m=0.2 feet, Davg,o=0.3 feet
Depth (feet)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

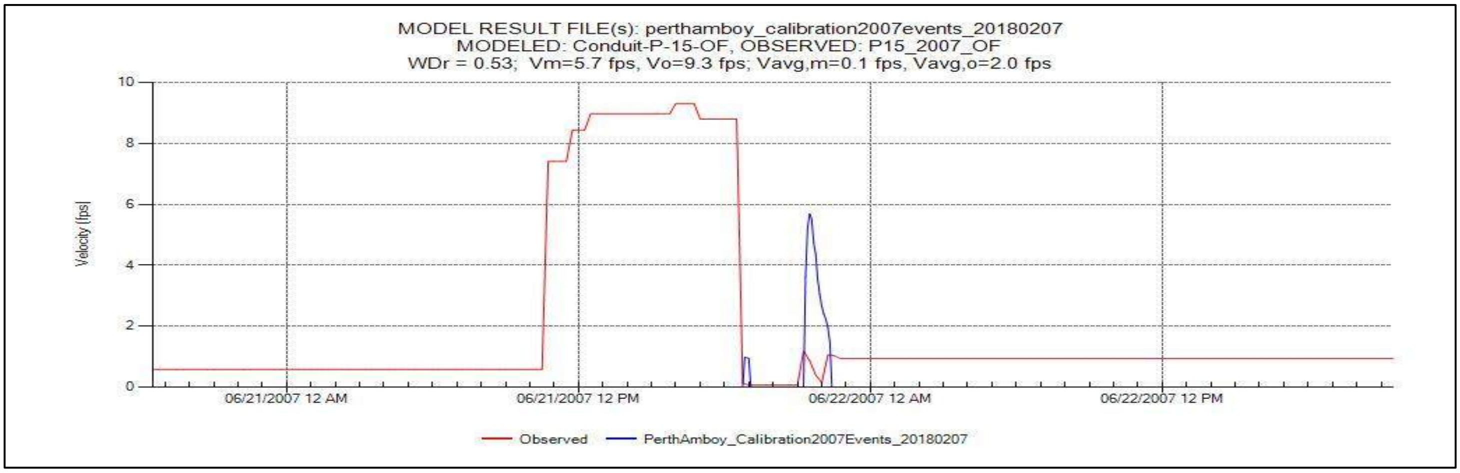

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.59; Volm=0.16 MG, Volo=1.13 MG; Qm=6.8 mgd, Qo=2.6 mgd; Qavg,m=0.1 mgd, Qavg,o=0.5 mgd
Flowrate (mgd)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.58; Vm=6.5 fps, Vo=10.3 fps; Vavg,m=0.2 fps, Vavg,o=2.9 fps
Velocity (fps)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

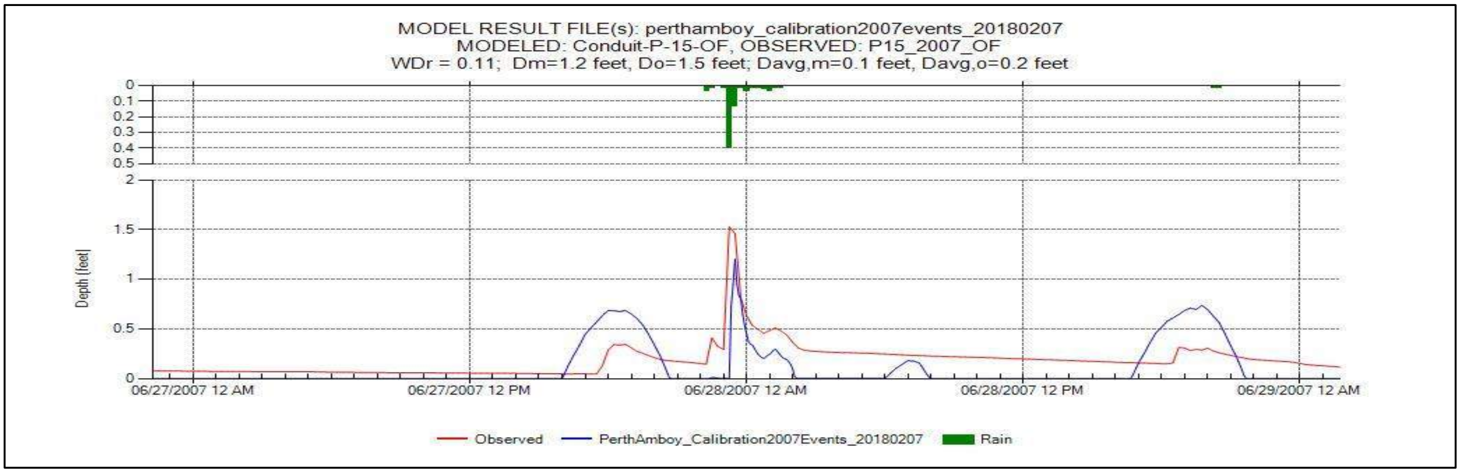
P15_2007_OF

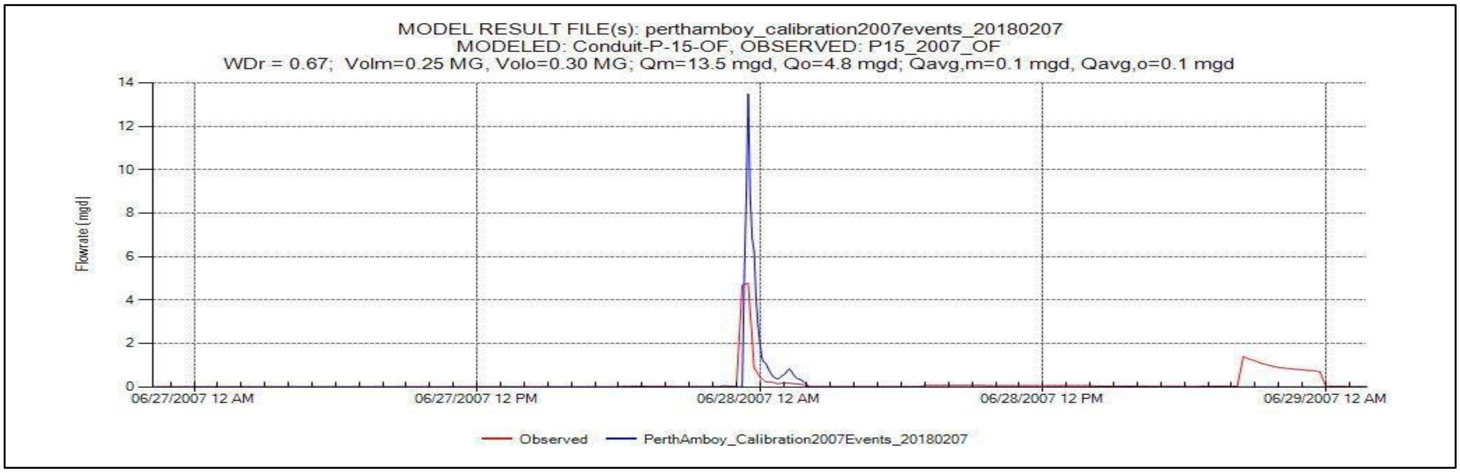

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = -0.79; Dm=0.7 feet, Do=1.1 feet; Davg,m=0.1 feet, Davg,o=0.3 feet
Depth (feet)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

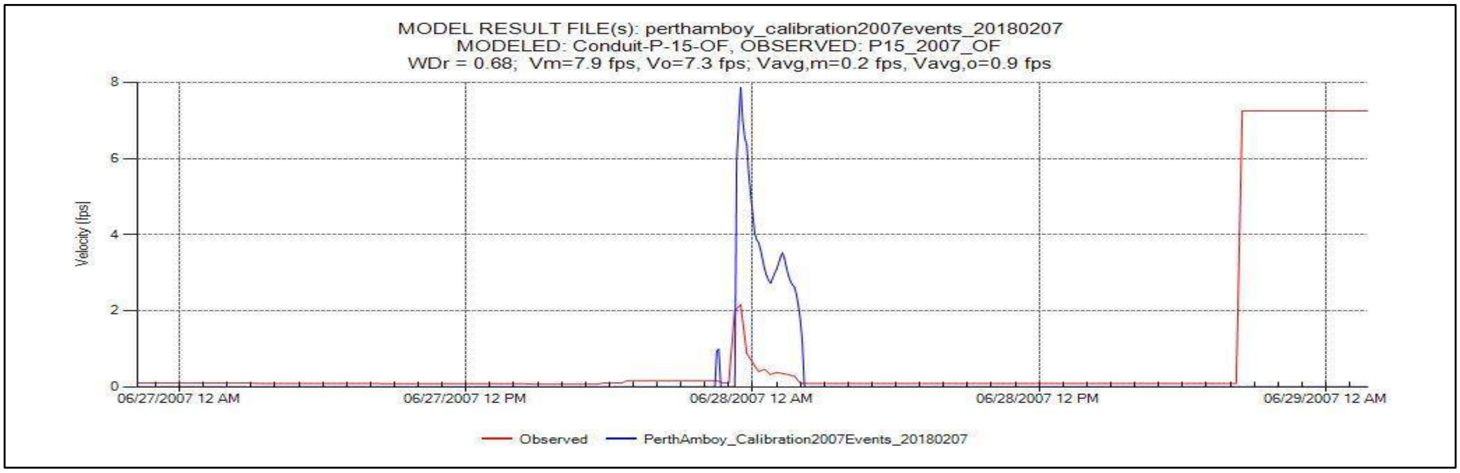

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.55; Volm=0.06 MG, Volo=0.65 MG; Qm=4.2 mgd, Qo=1.8 mgd; Qavg,m=0.0 mgd, Qavg,o=0.3 mgd
Flowrate (mgd)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.53; Vm=5.7 fps, Vo=9.3 fps; Vavg,m=0.1 fps, Vavg,o=2.0 fps
Velocity (fps)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

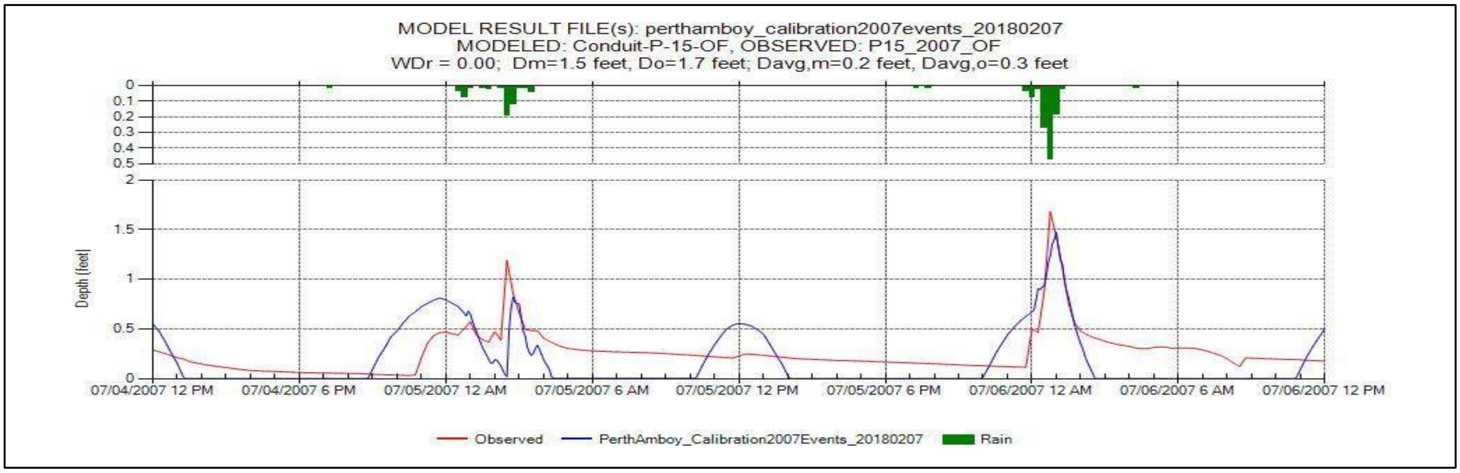
P15_2007_OF

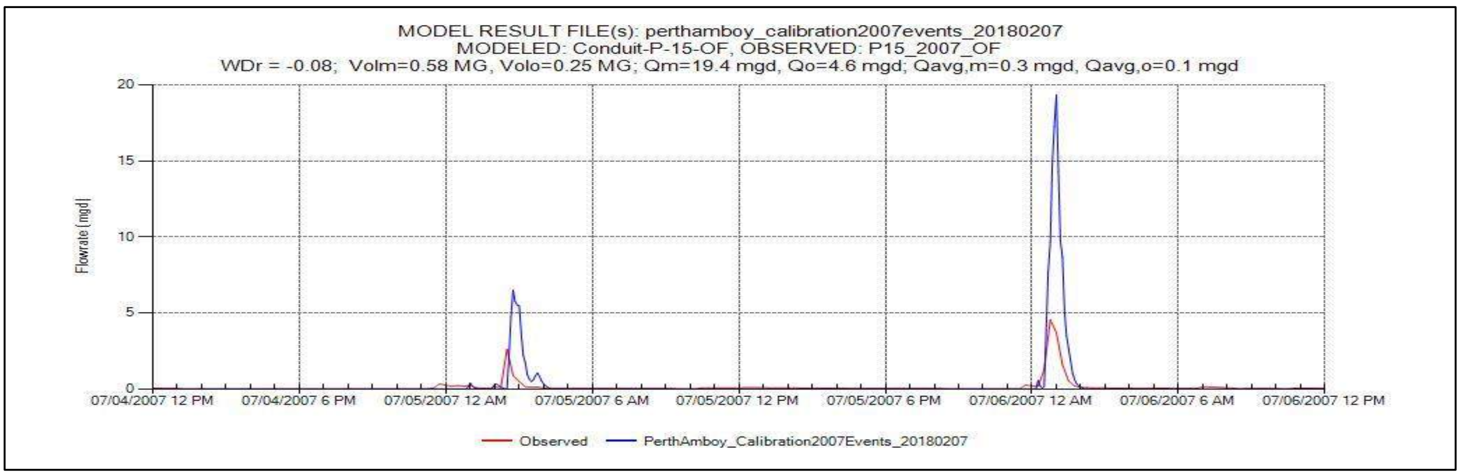

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.11; Dm=1.2 feet, Do=1.5 feet; Davg,m=0.1 feet, Davg,o=0.2 feet
Depth (feet)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

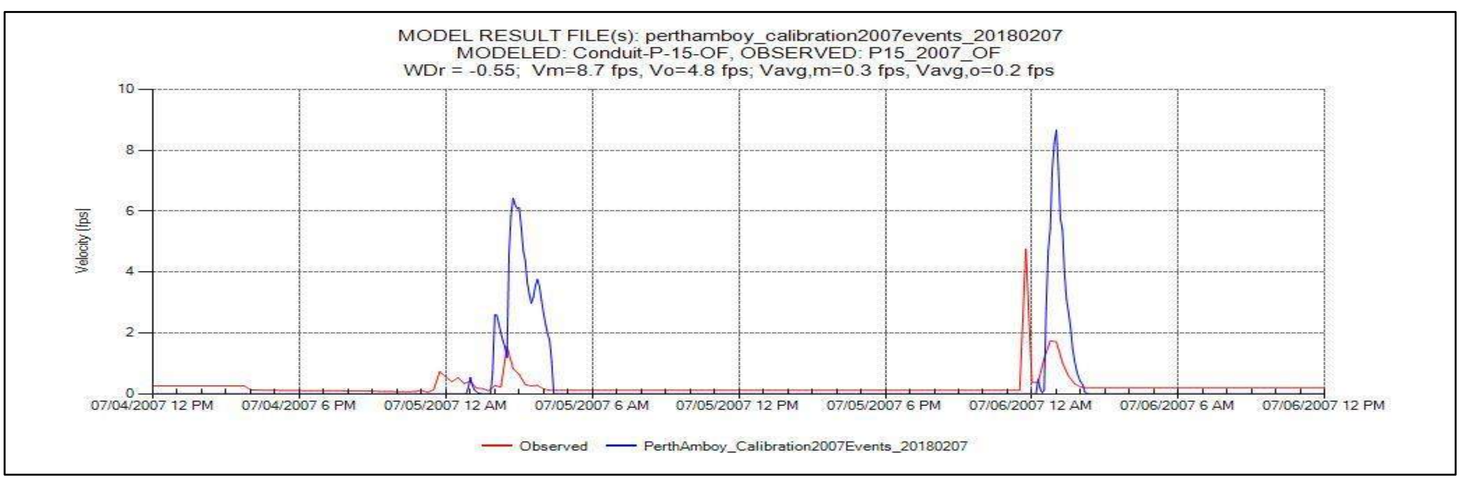

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.67; Volm=0.25 MG, Volo=0.30 MG; Qm=13.5 mgd, Qo=4.8 mgd; Qavg,m=0.1 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.68; Vm=7.9 fps, Vo=7.3 fps; Vavg,m=0.2 fps, Vavg,o=0.9 fps
Velocity (fps)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

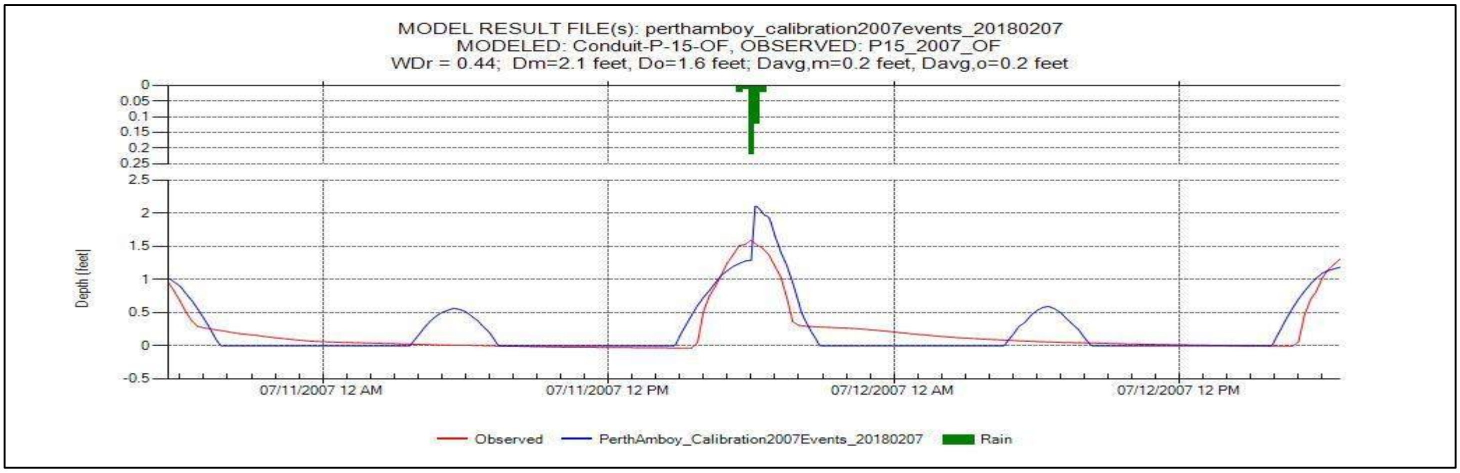
P15_2007_OF

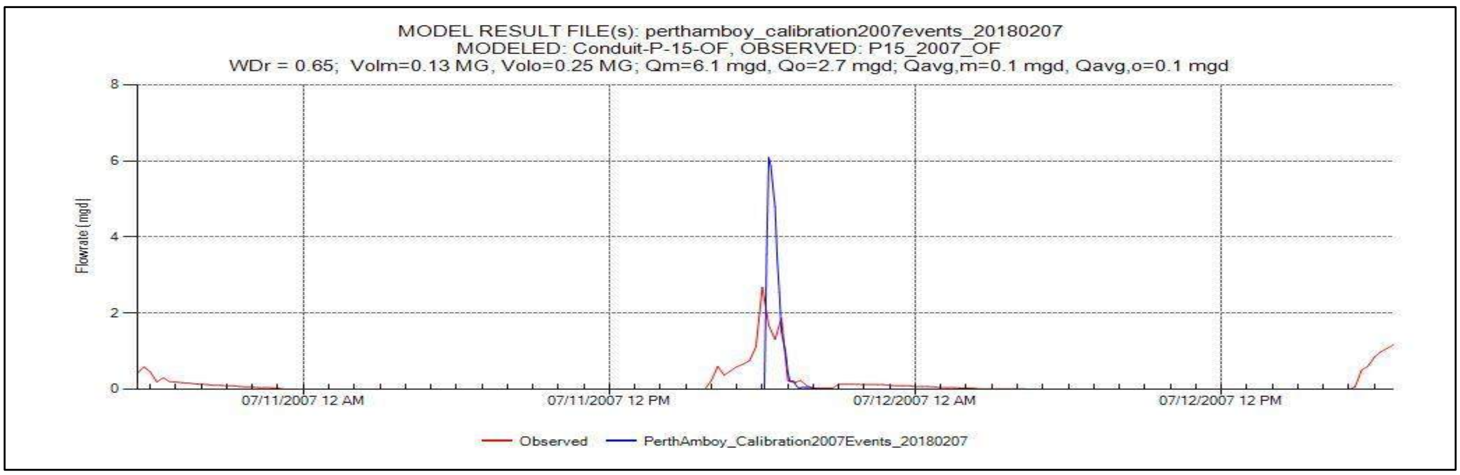

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.00; Dm=1.5 feet, Do=1.7 feet; Davg,m=0.2 feet, Davg,o=0.3 feet
Depth (feet)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

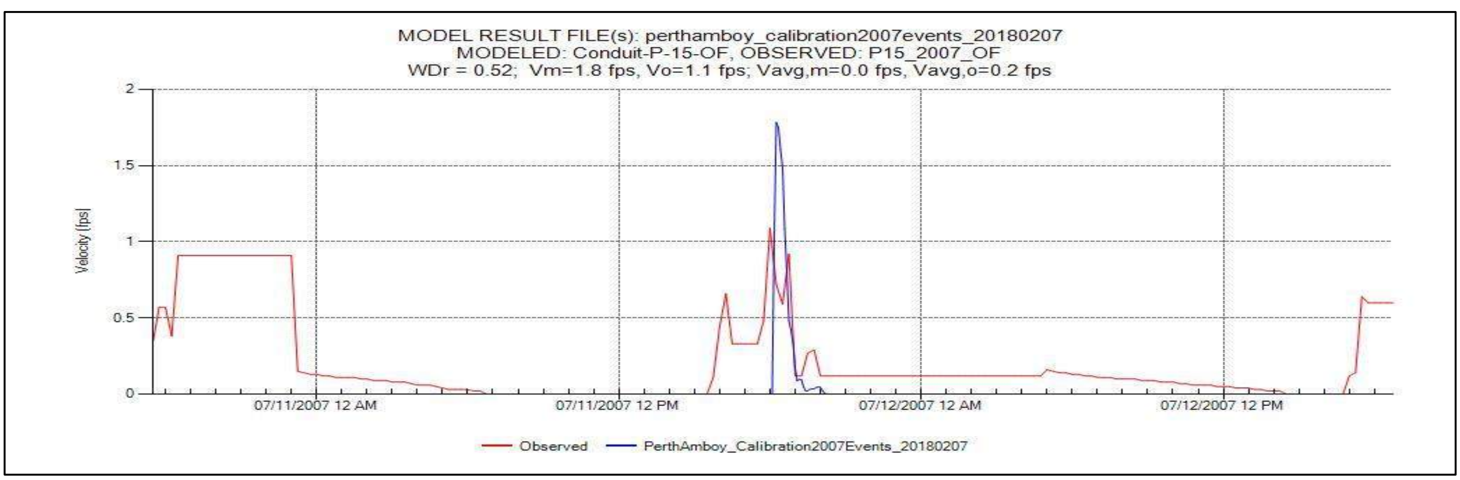

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = -0.08; Volm=0.58 MG, Volo=0.25 MG; Qm=19.4 mgd, Qo=4.6 mgd; Qavg,m=0.3 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = -0.55; Vm=8.7 fps, Vo=4.8 fps; Vavg,m=0.3 fps, Vavg,o=0.2 fps
Velocity (fps)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

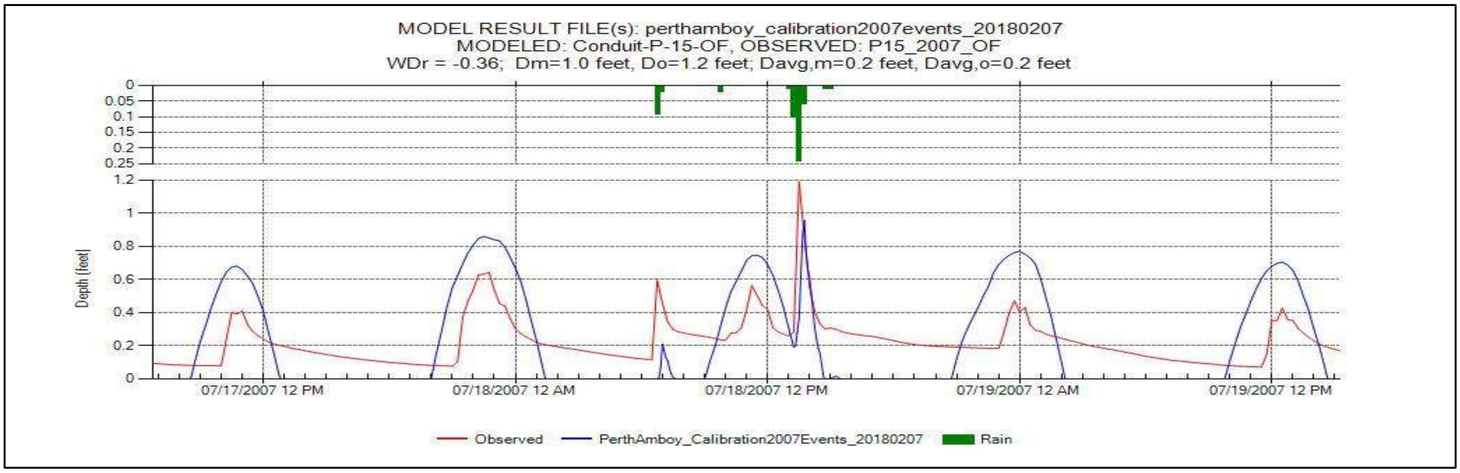
P15_2007_OF

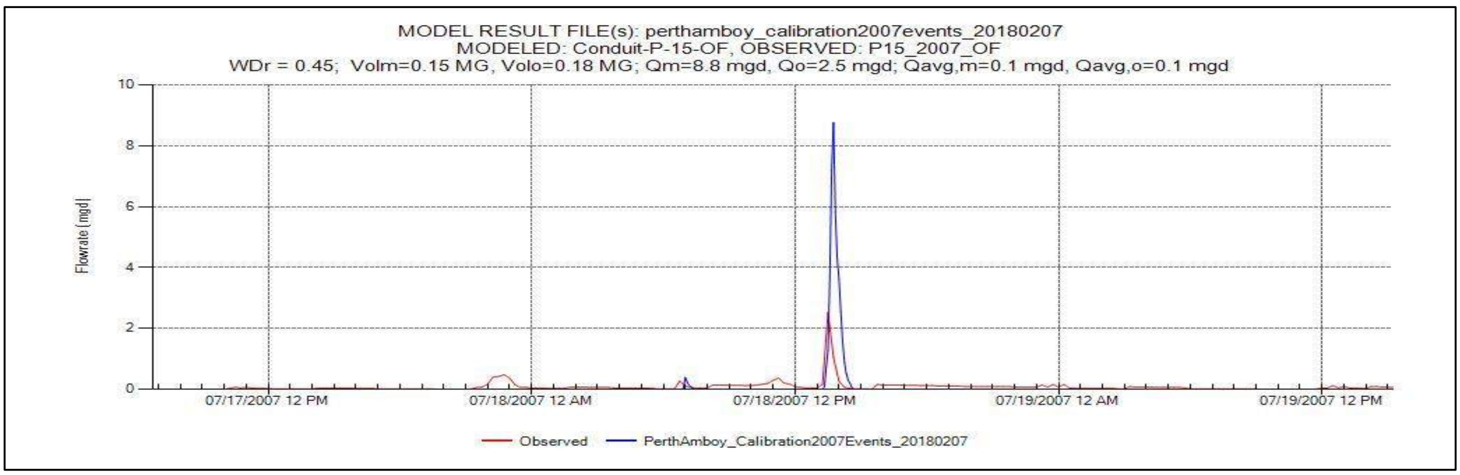

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.44; Dm=2.1 feet, Do=1.6 feet; Davg,m=0.2 feet, Davg,o=0.2 feet
Depth (feet)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

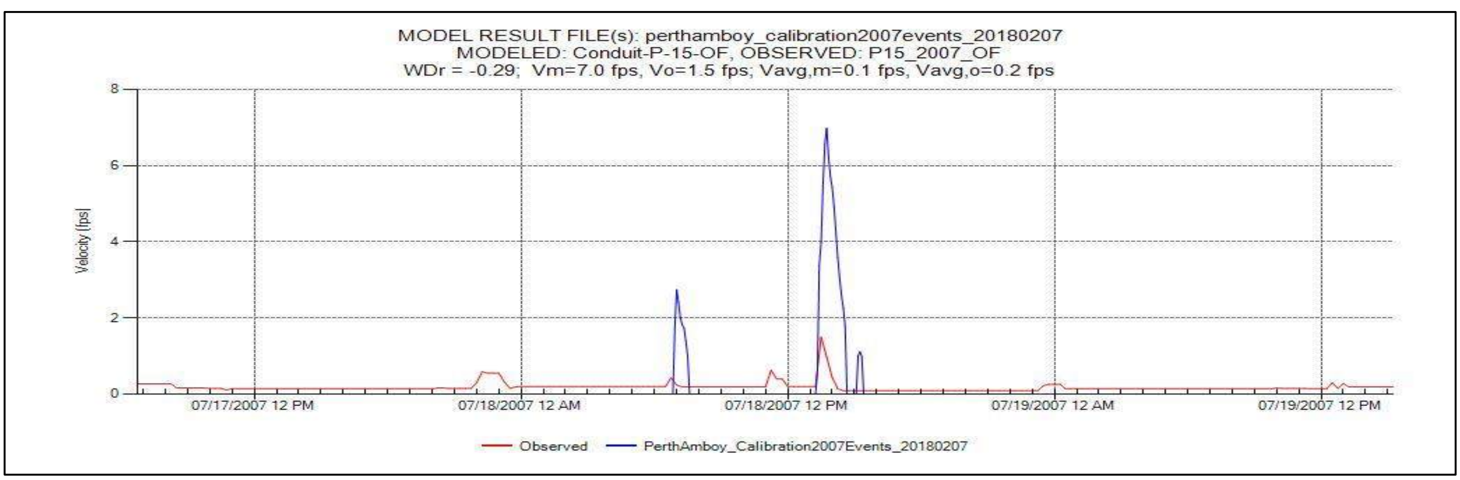

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.65; Volm=0.13 MG, Volo=0.25 MG; Qm=6.1 mgd, Qo=2.7 mgd; Qavg,m=0.1 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.52; Vm=1.8 fps, Vo=1.1 fps; Vavg,m=0.0 fps, Vavg,o=0.2 fps
Velocity (fps)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

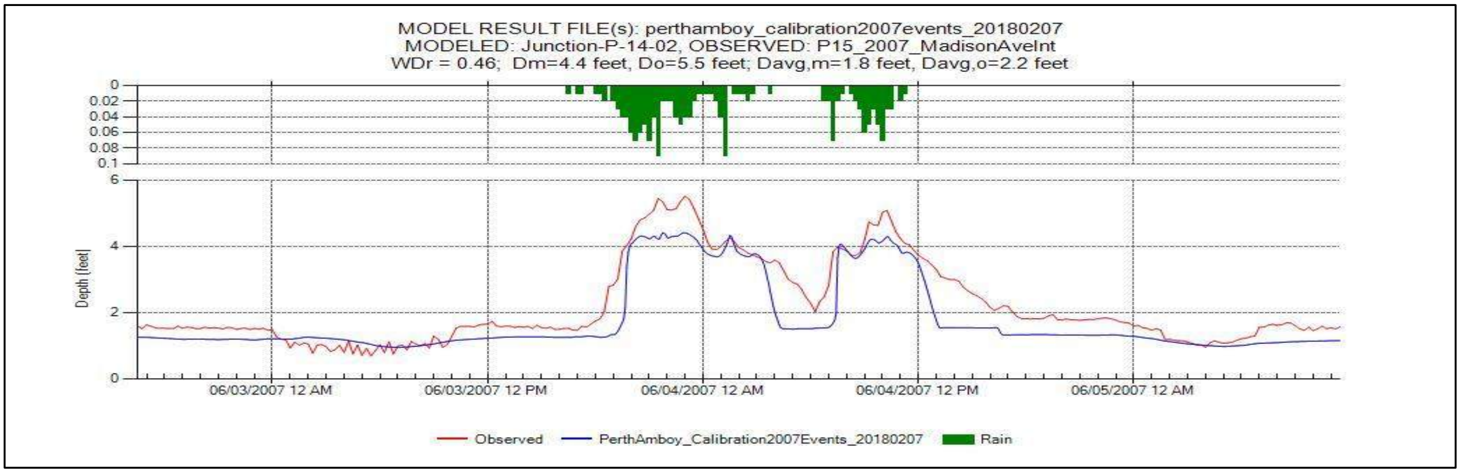
P15_2007_OF

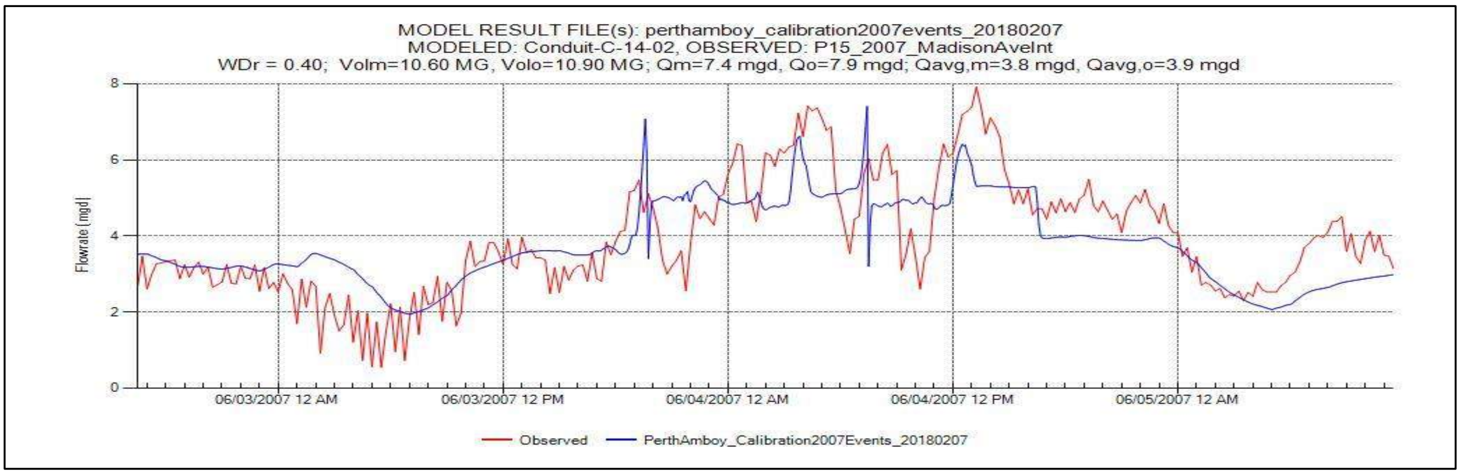

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = -0.36; Dm=1.0 feet, Do=1.2 feet; Davg,m=0.2 feet, Davg,o=0.2 feet
Depth (feet)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

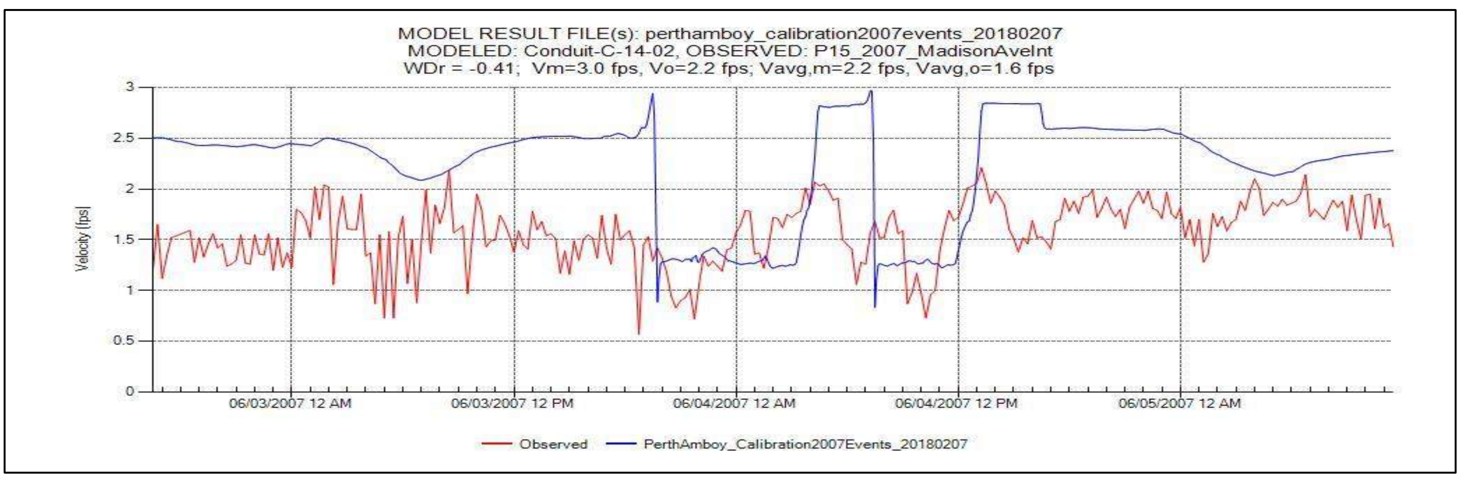

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = 0.45; Volm=0.15 MG, Volo=0.18 MG; Qm=8.8 mgd, Qo=2.5 mgd; Qavg,m=0.1 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-P-15-OF, OBSERVED: P15_2007_OF
WDr = -0.29; Vm=7.0 fps, Vo=1.5 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

P15_2007_MadisonAveInt

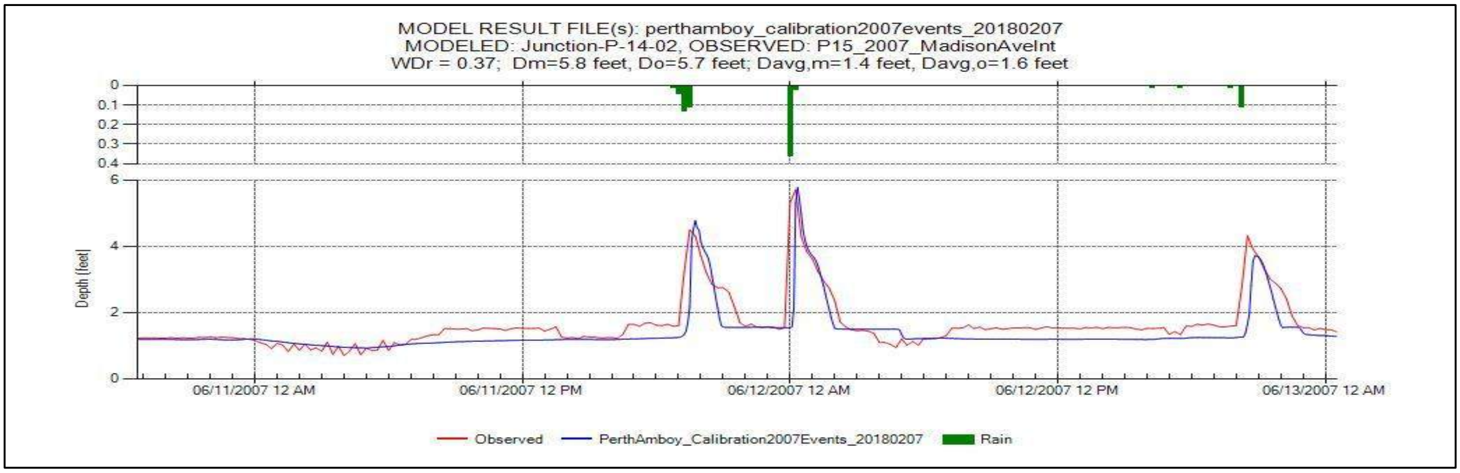


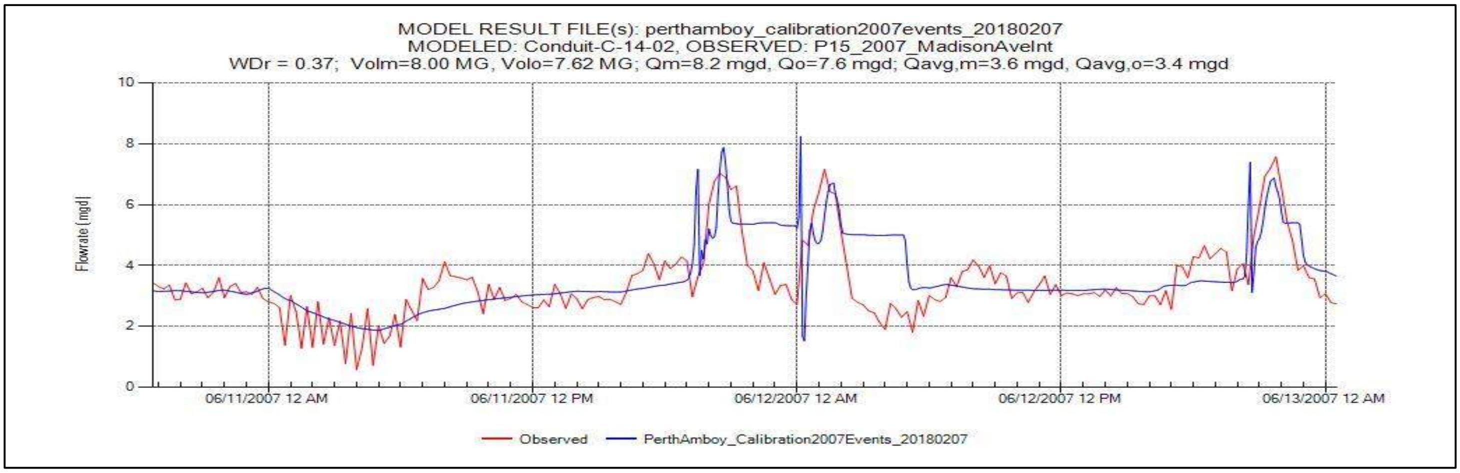


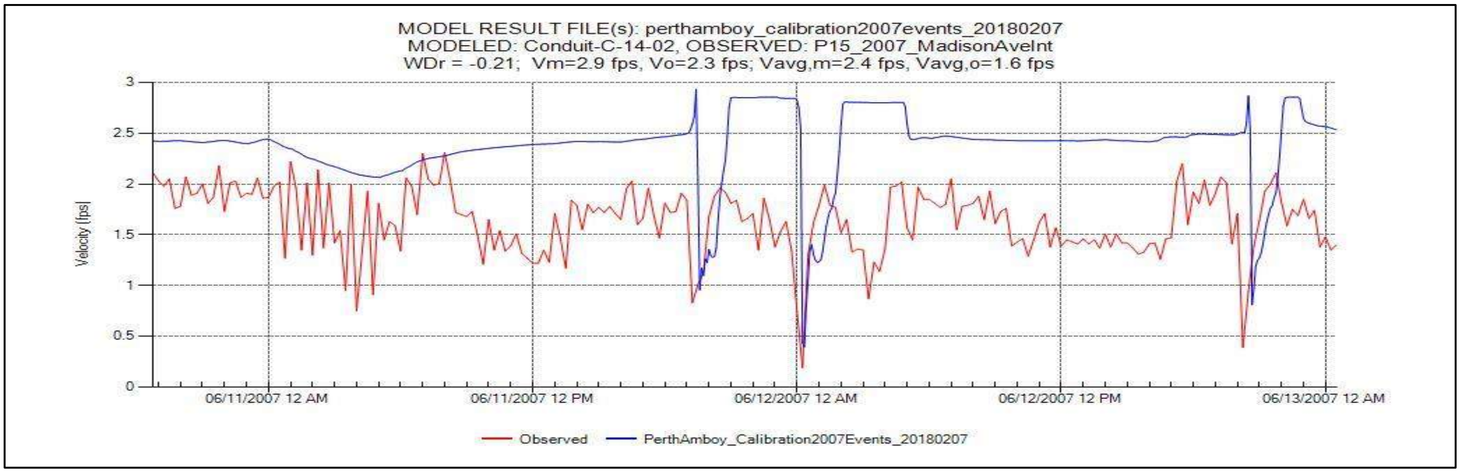


Simulated Versus Observed Flow at Flow Meter Sites

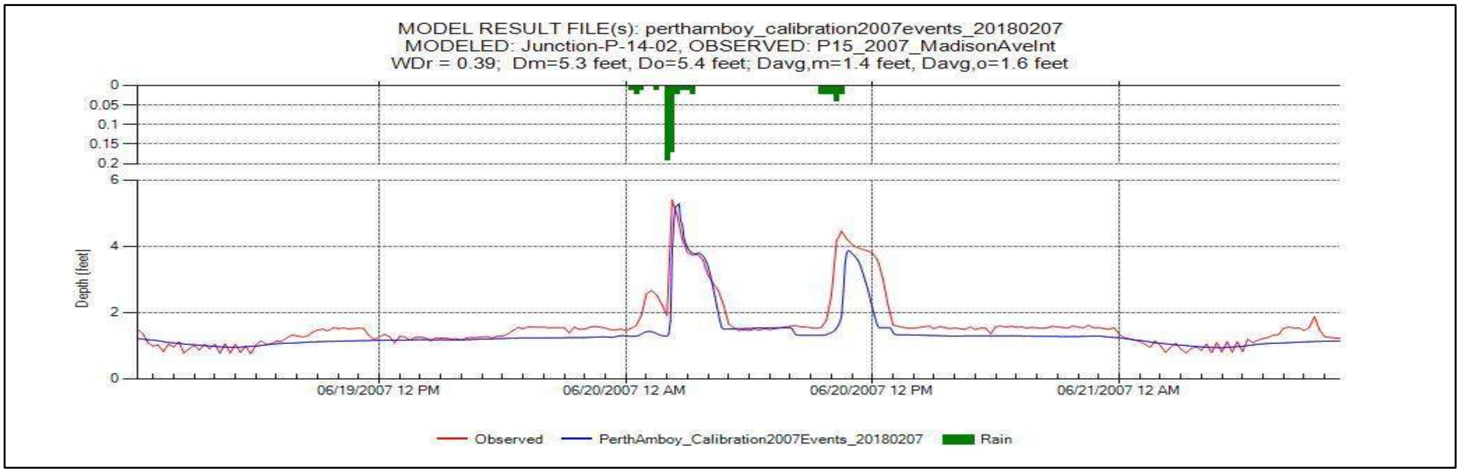
P15_2007_MadisonAveInt

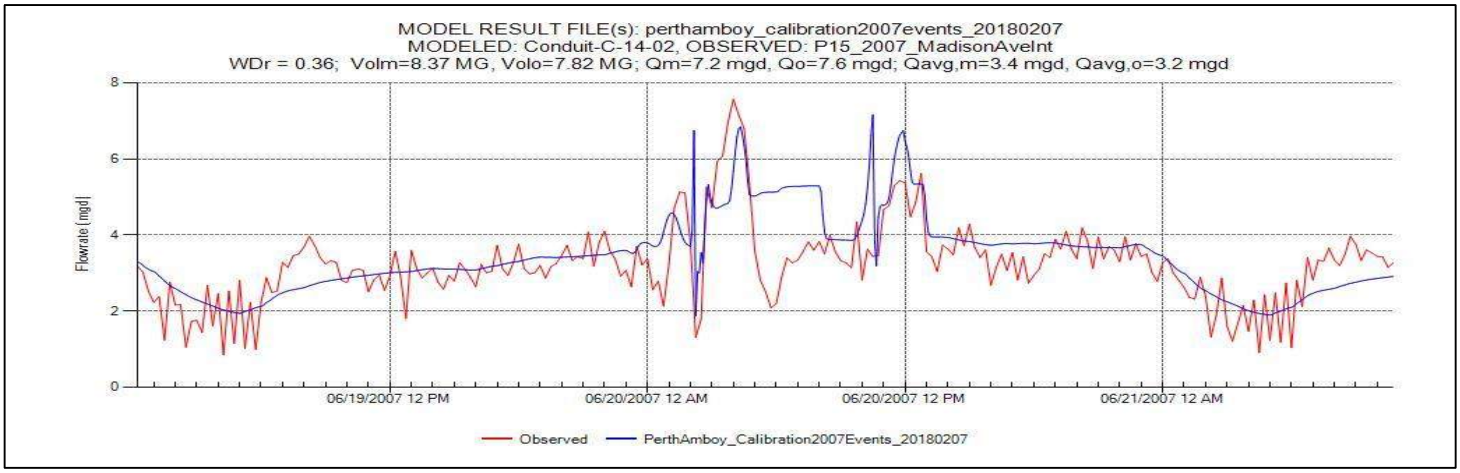


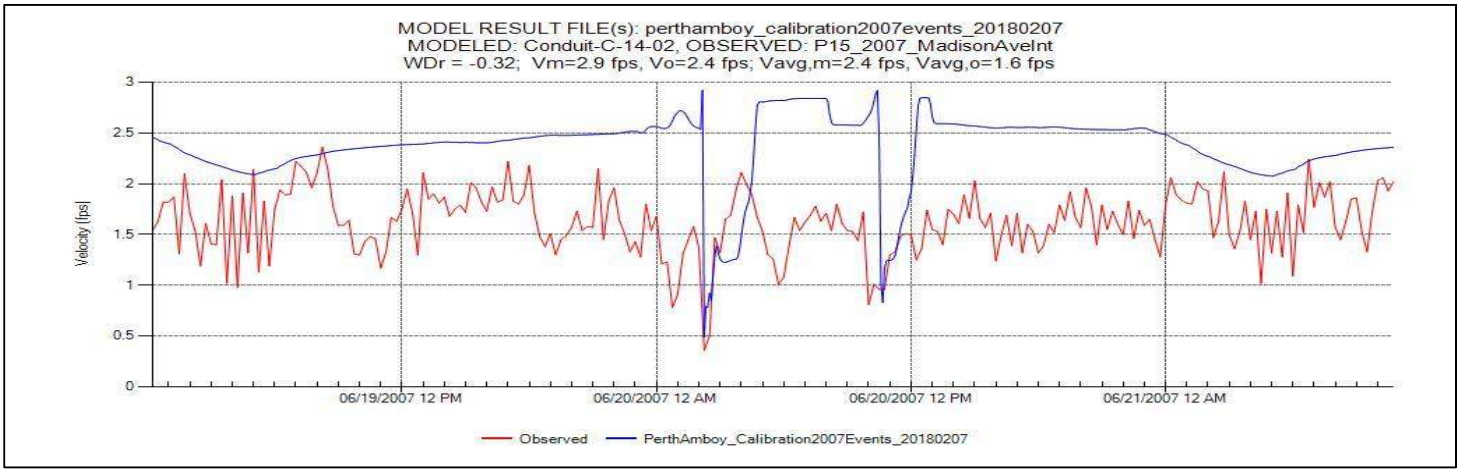




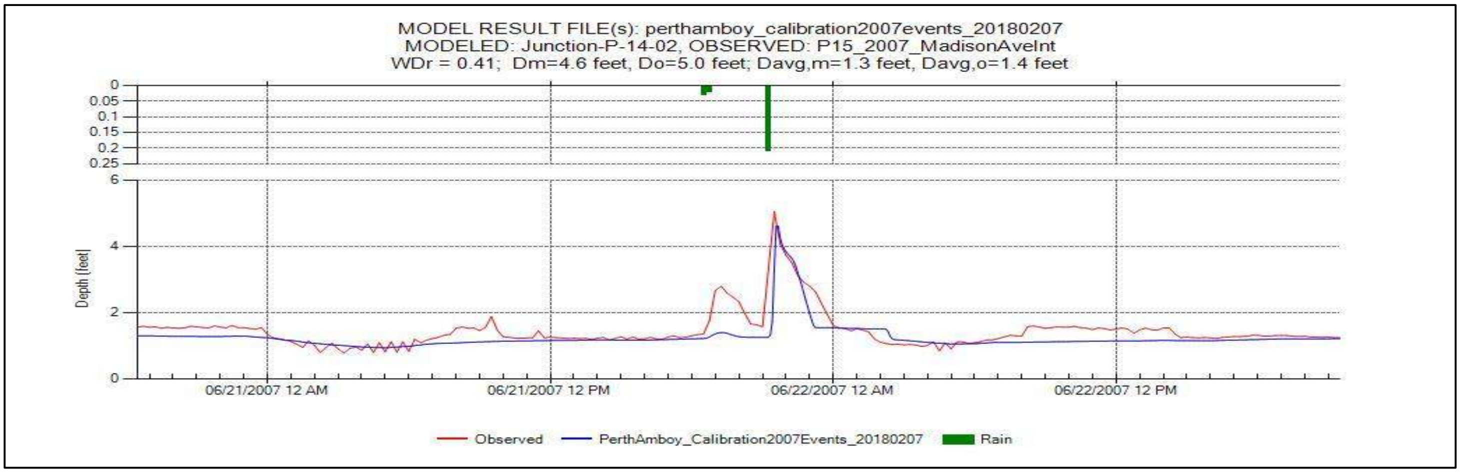
P15_2007_MadisonAveInt

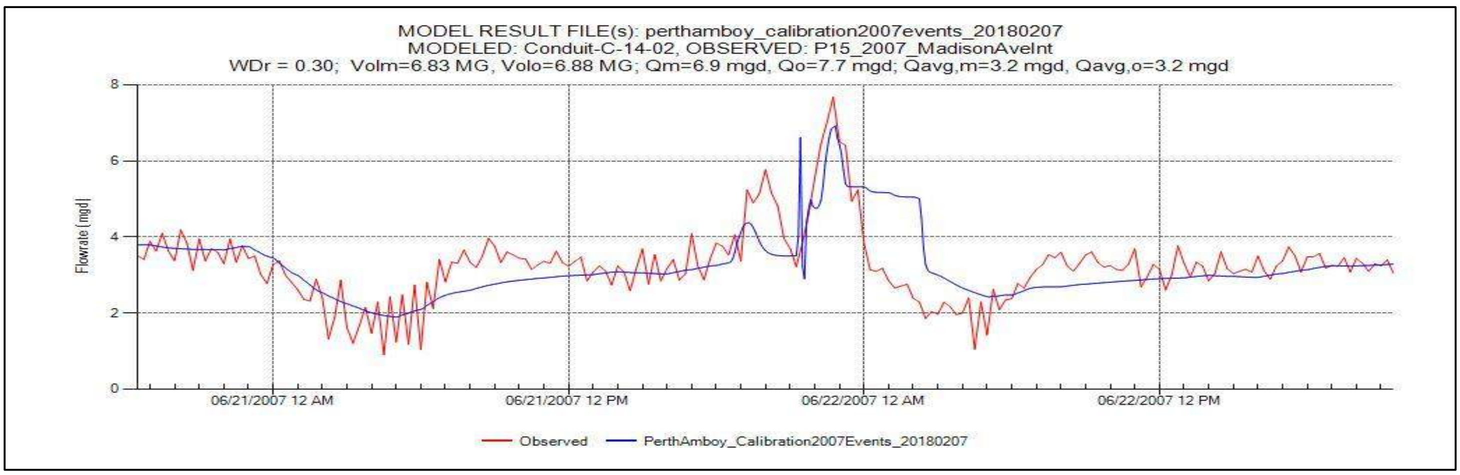


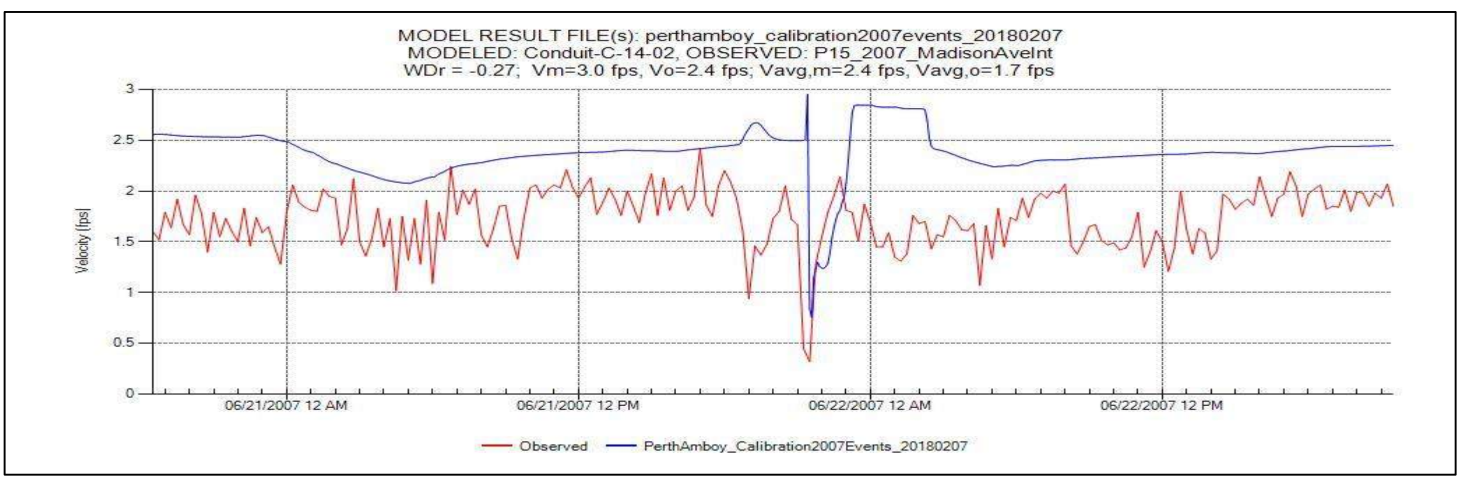




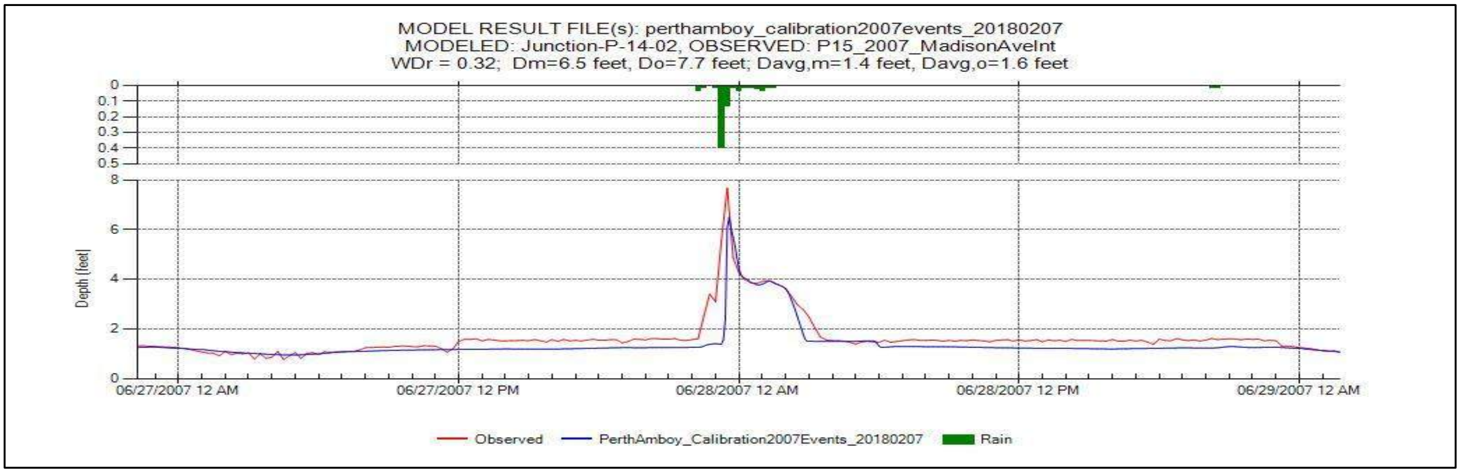
P15_2007_MadisonAveInt

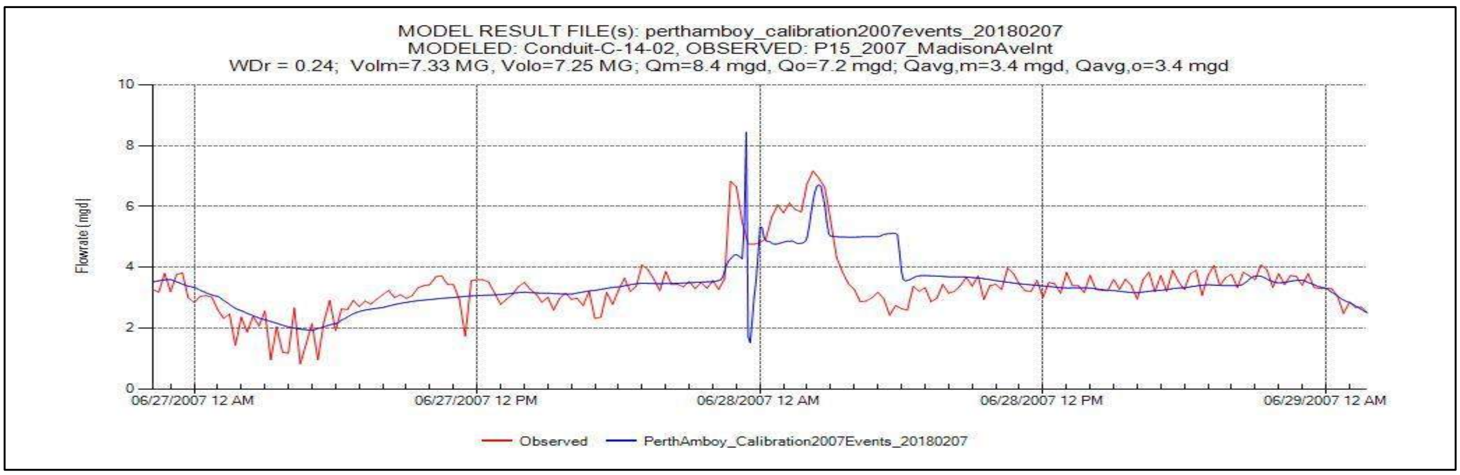


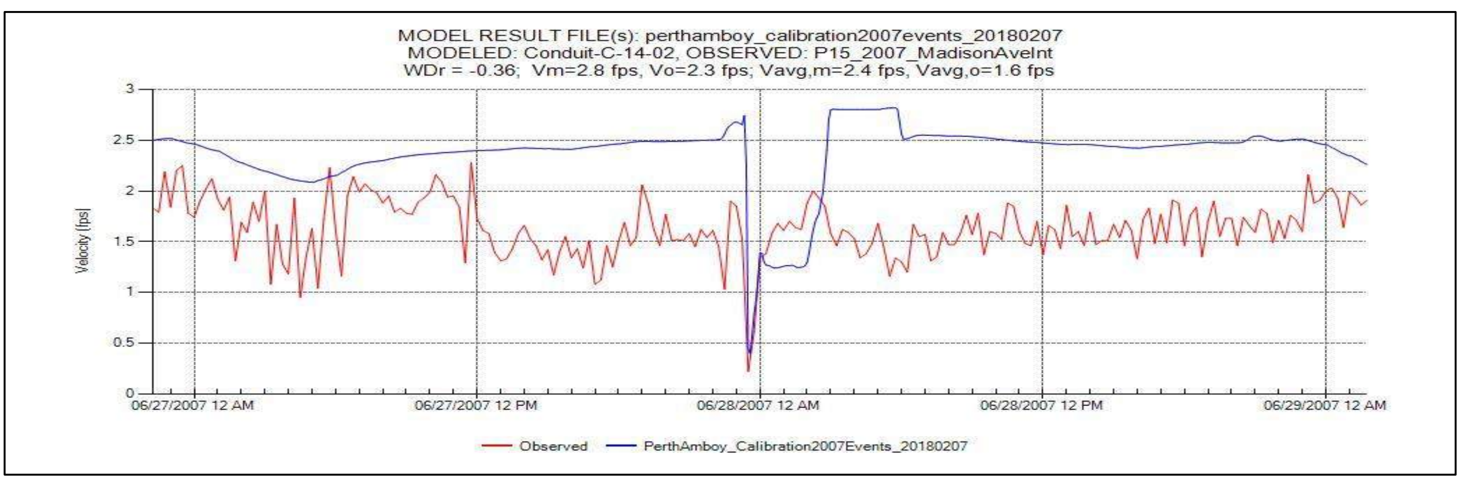




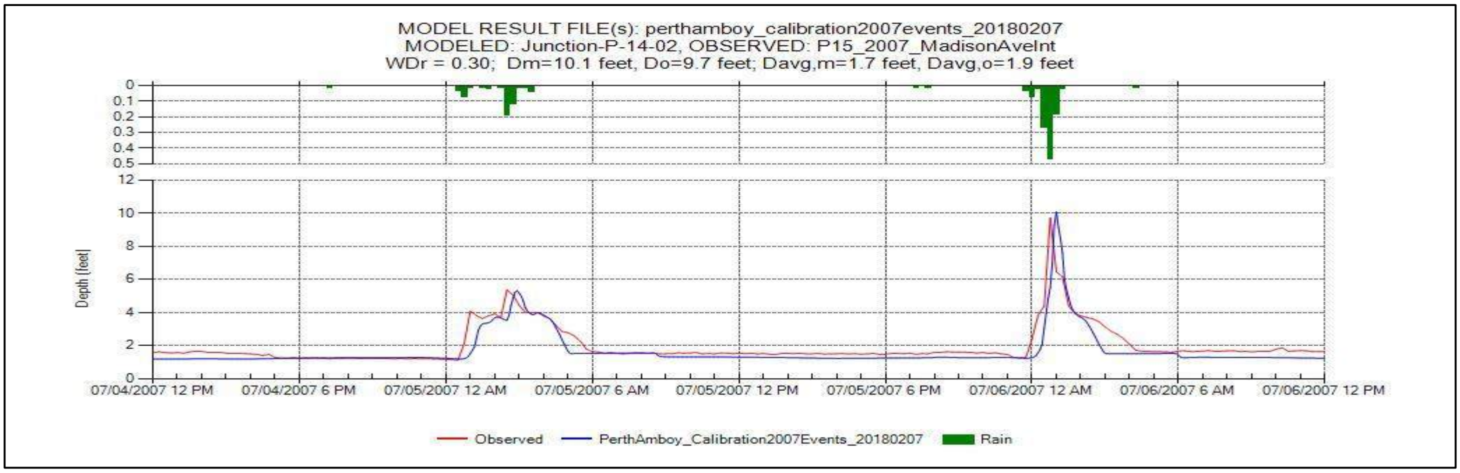
P15_2007_MadisonAveInt

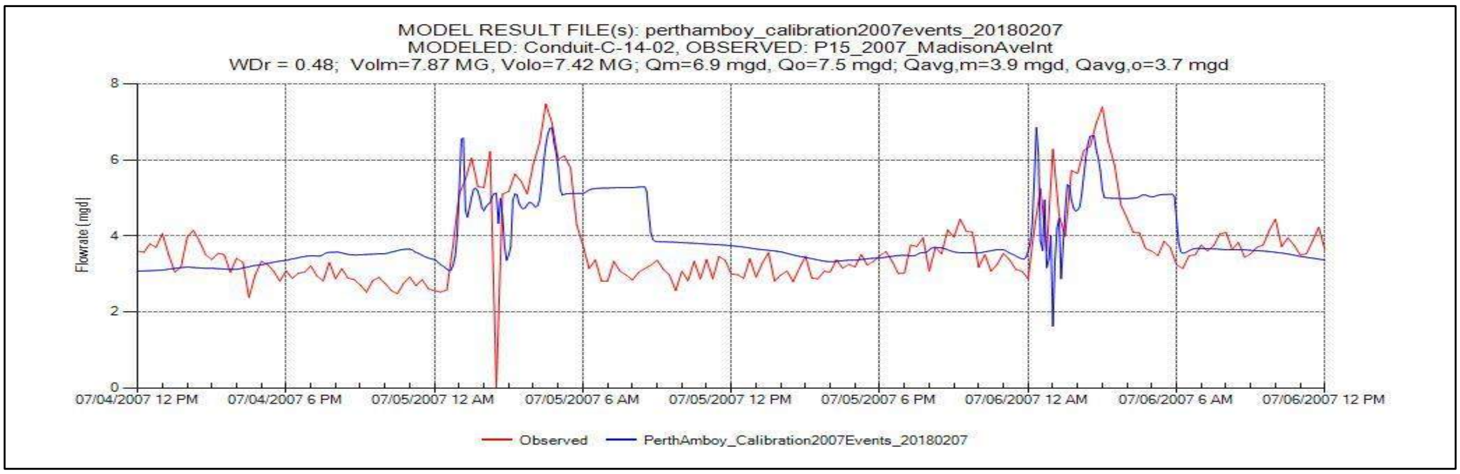


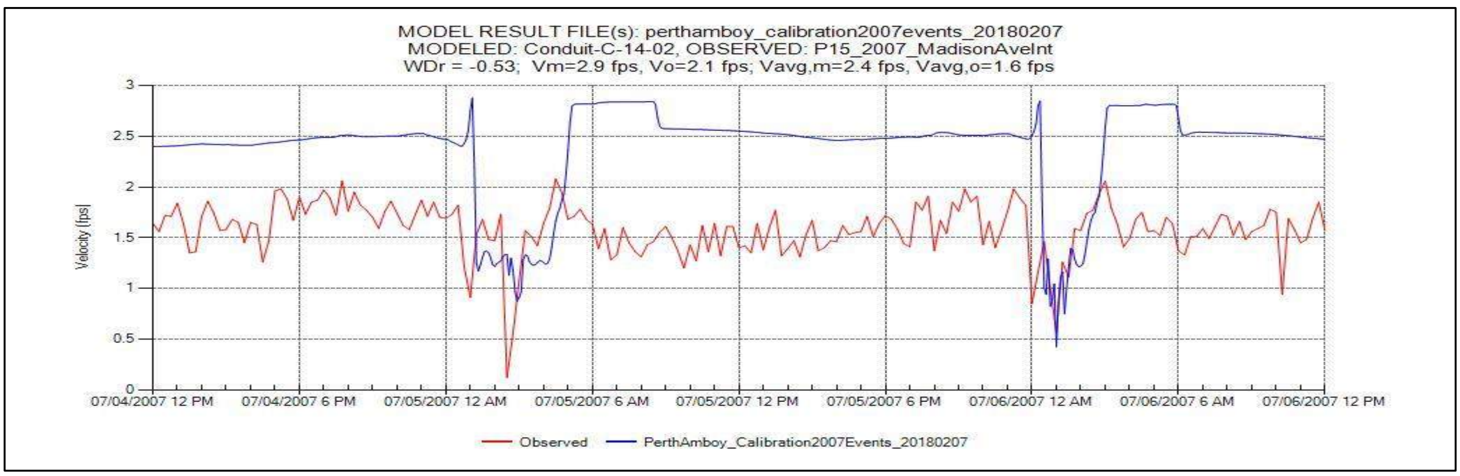




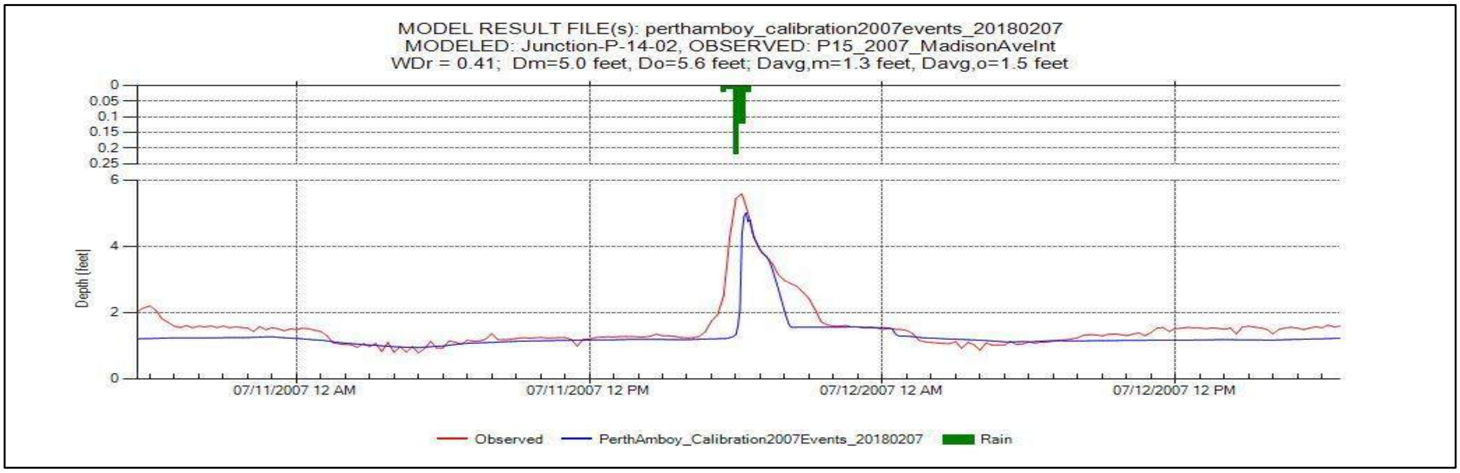
P15_2007_MadisonAveInt

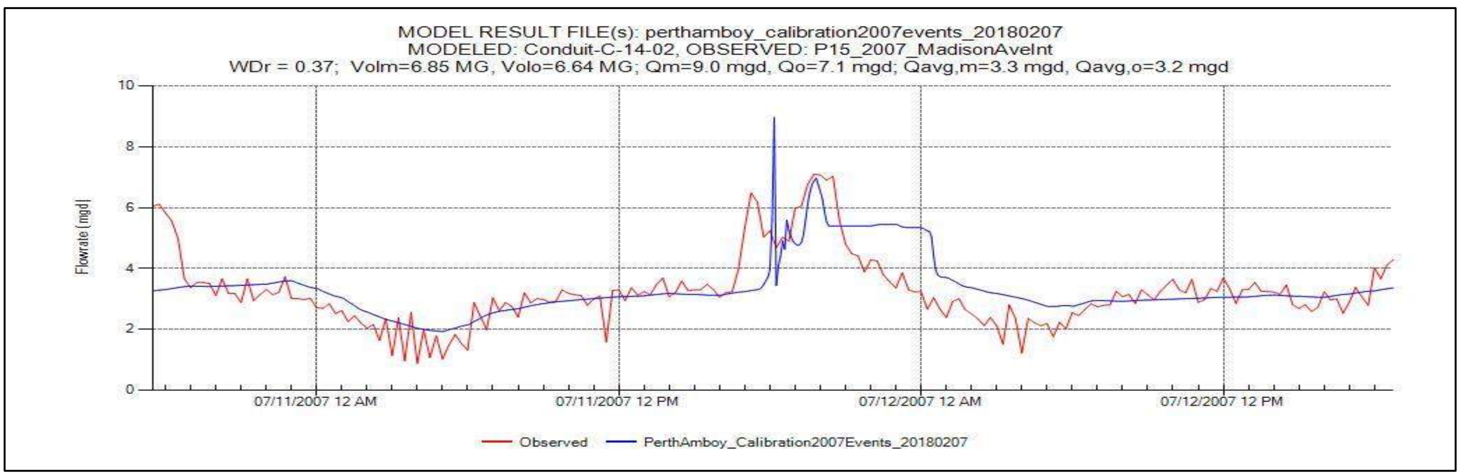


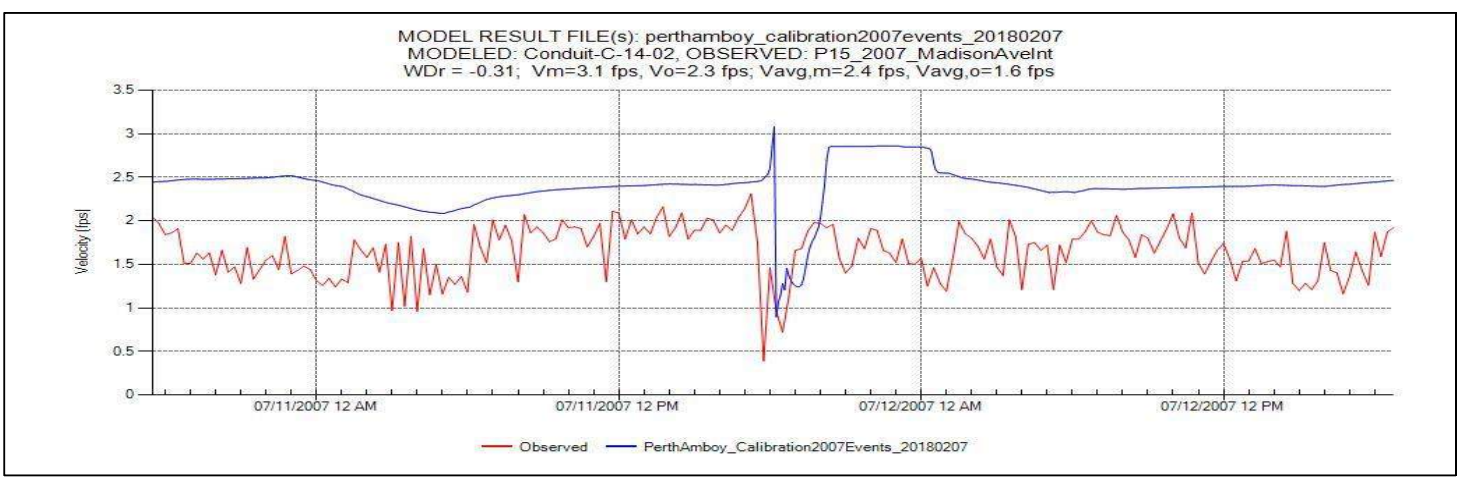




P15_2007_MadisonAveInt







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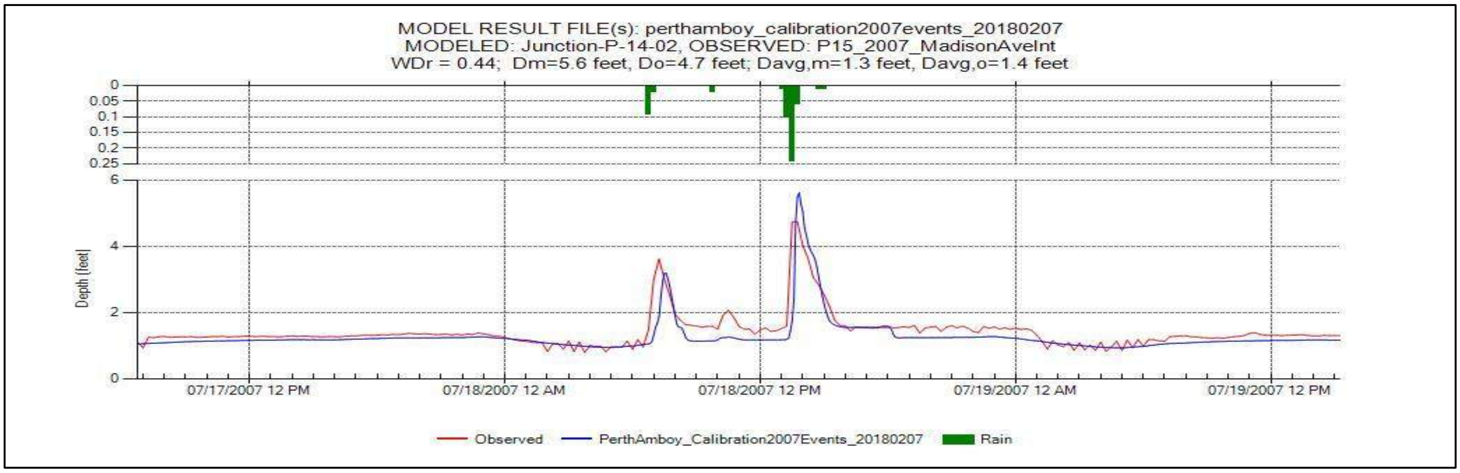

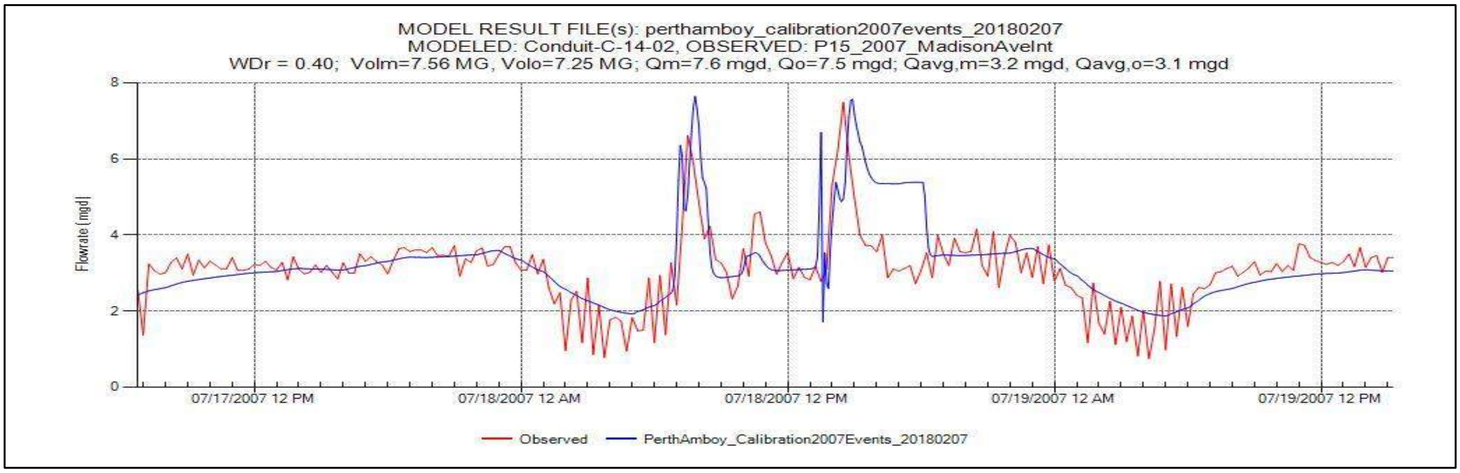

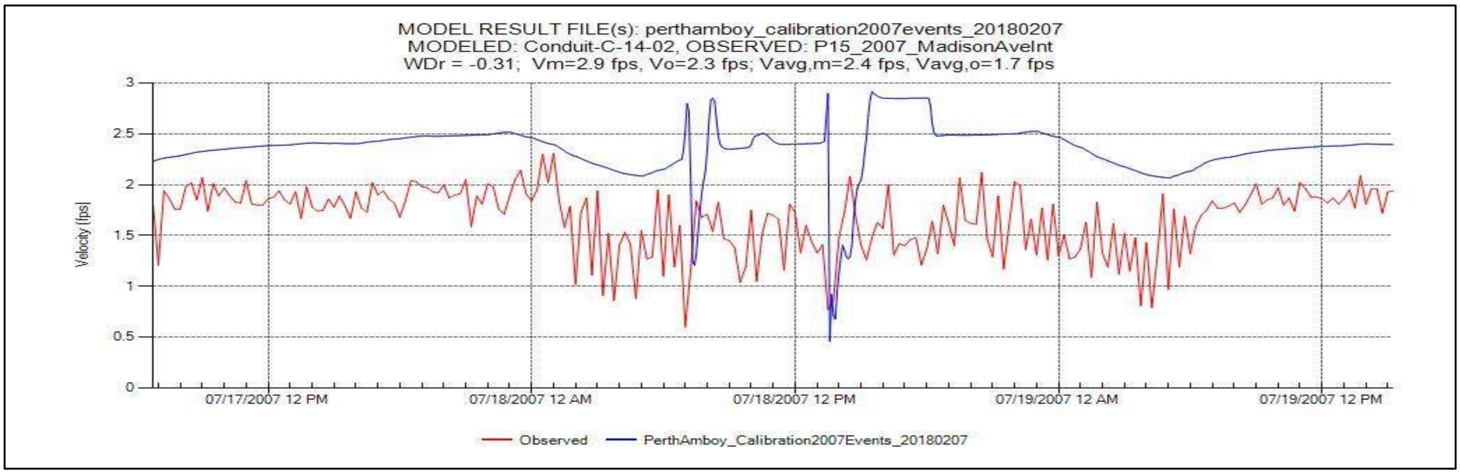

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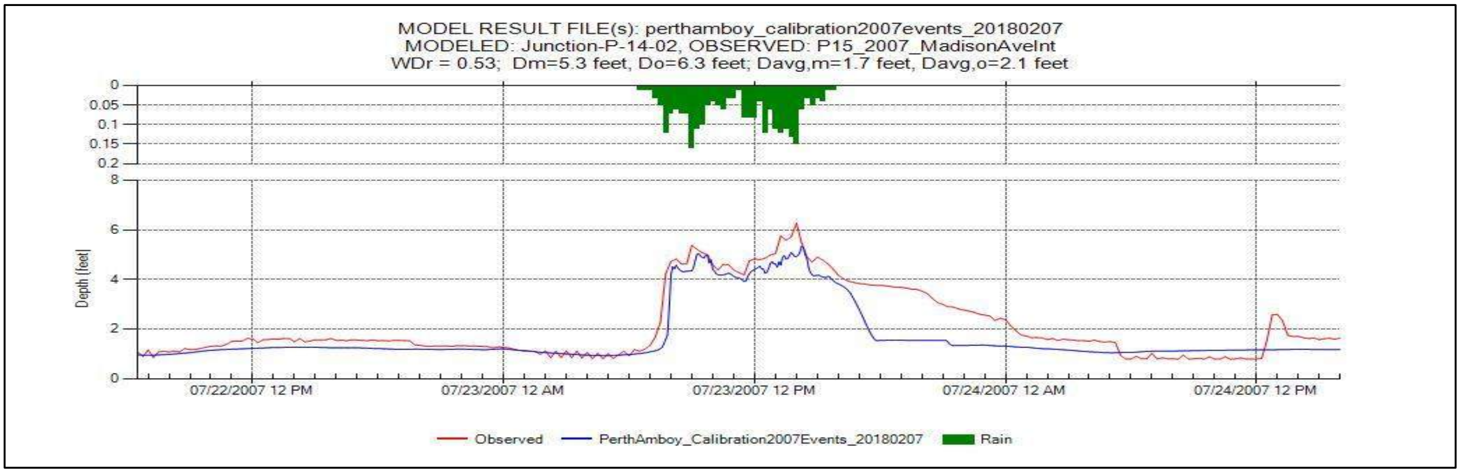
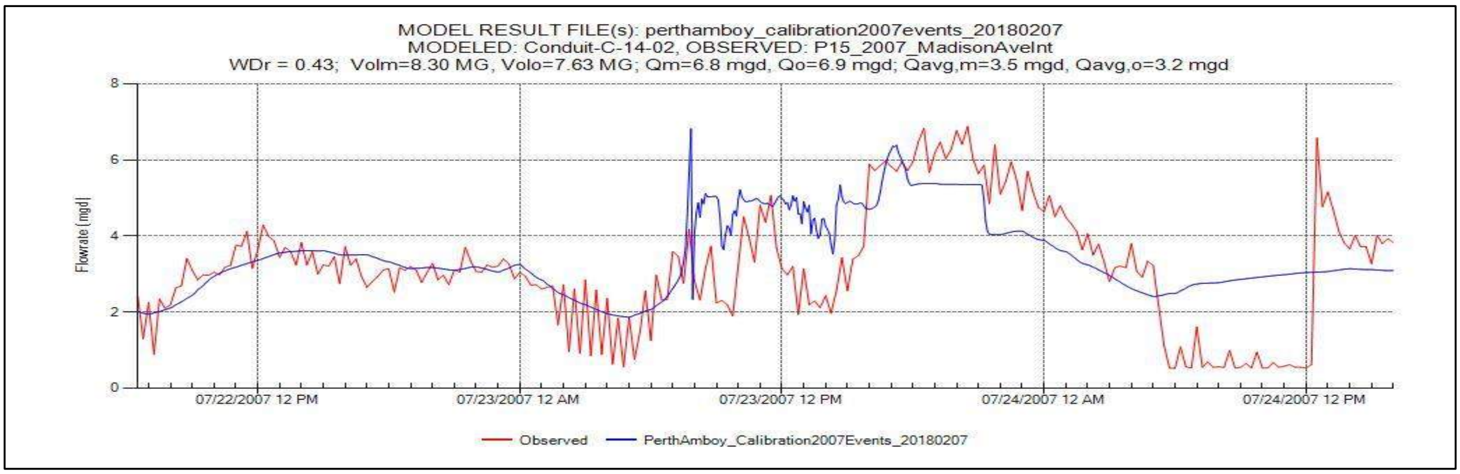
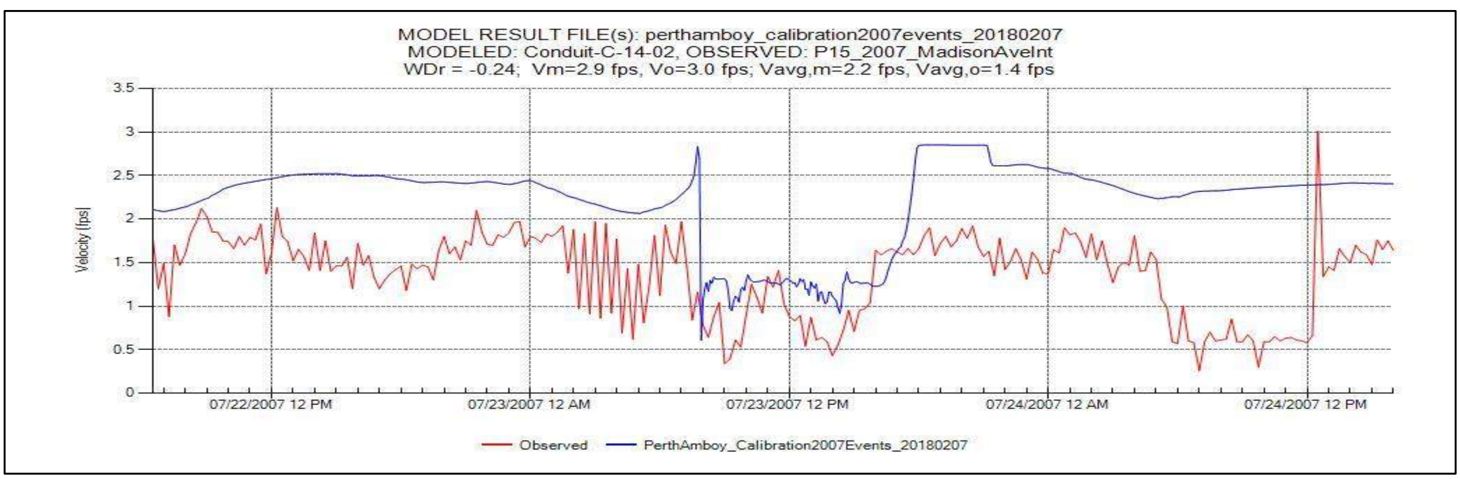
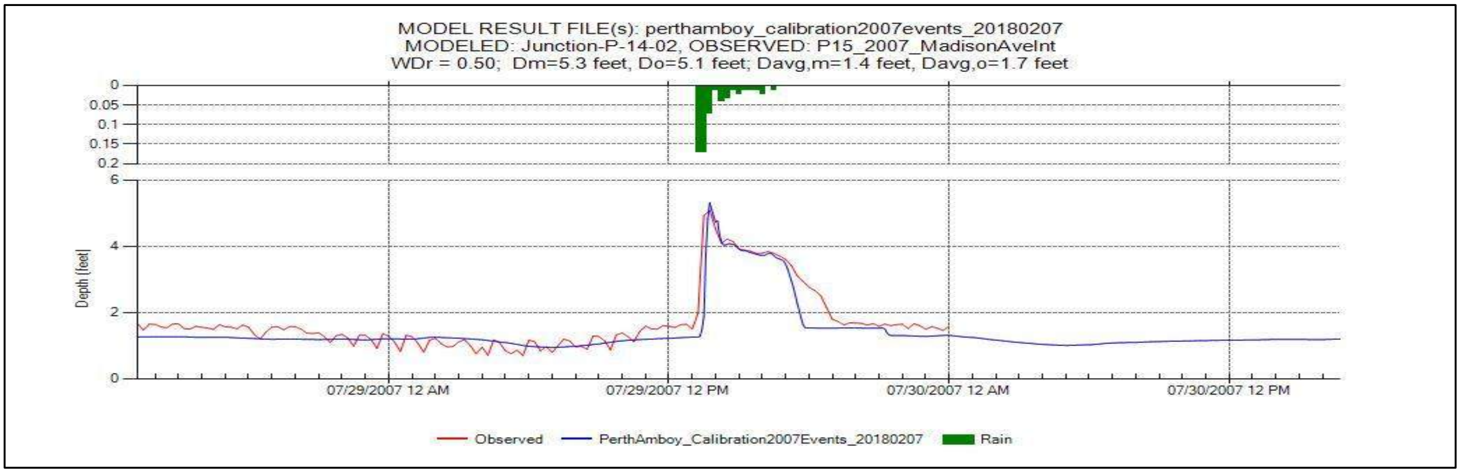


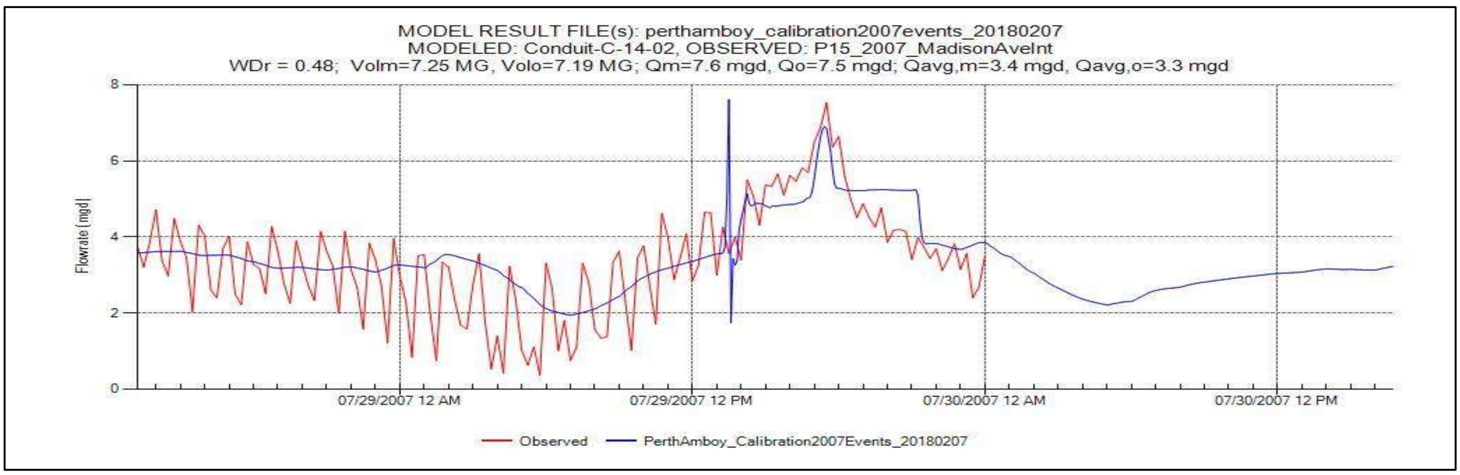


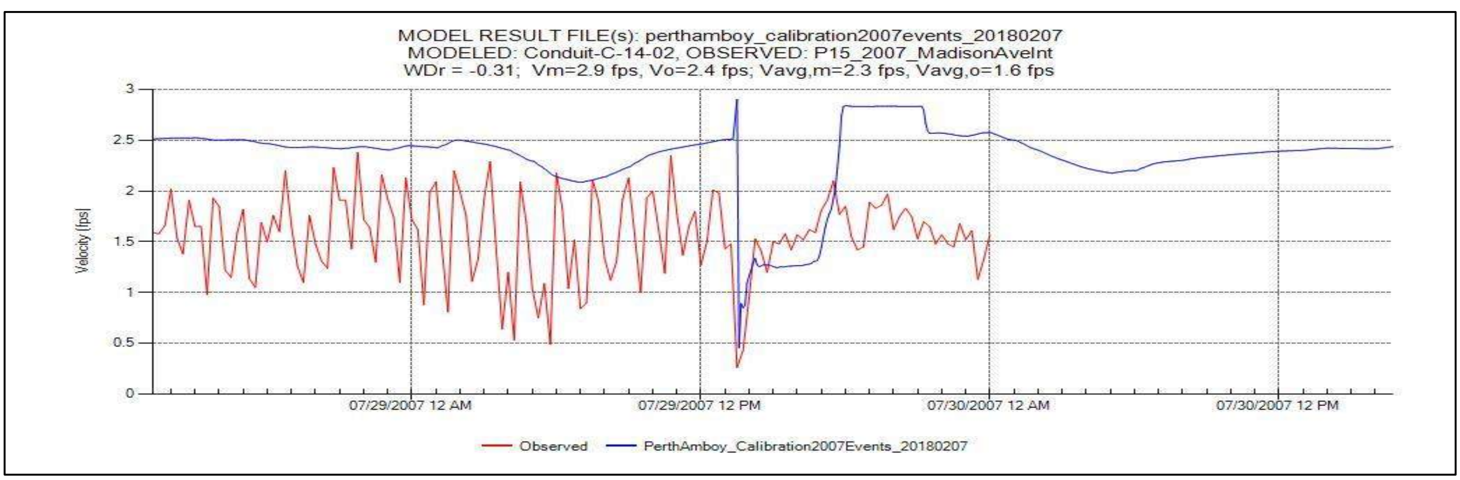


Simulated Versus Observed Flow at Flow Meter Sites

P15_2007_MadisonAveInt



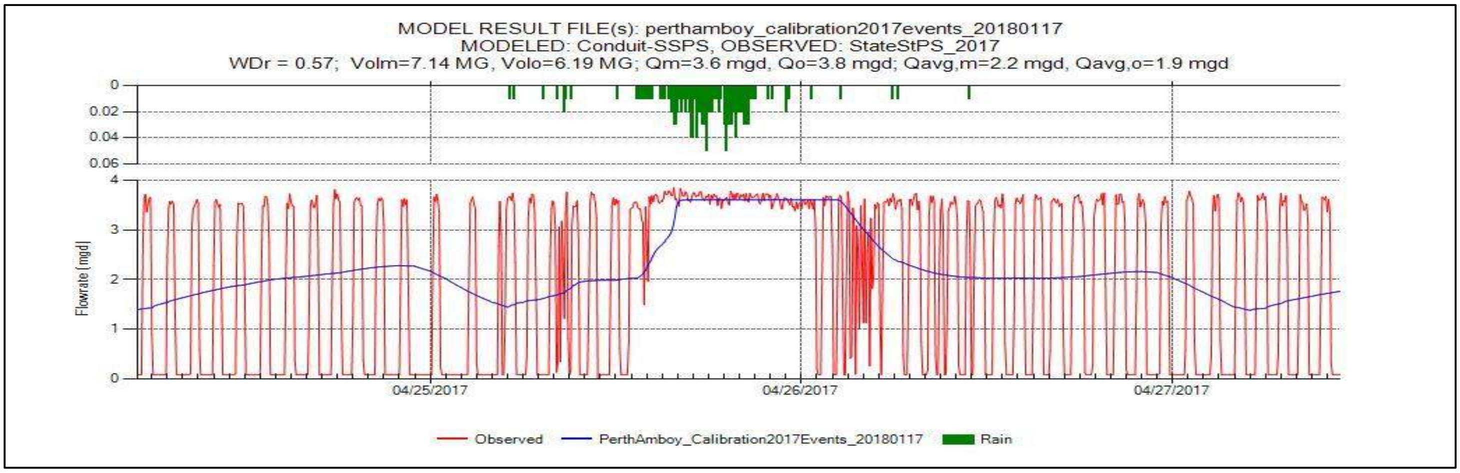


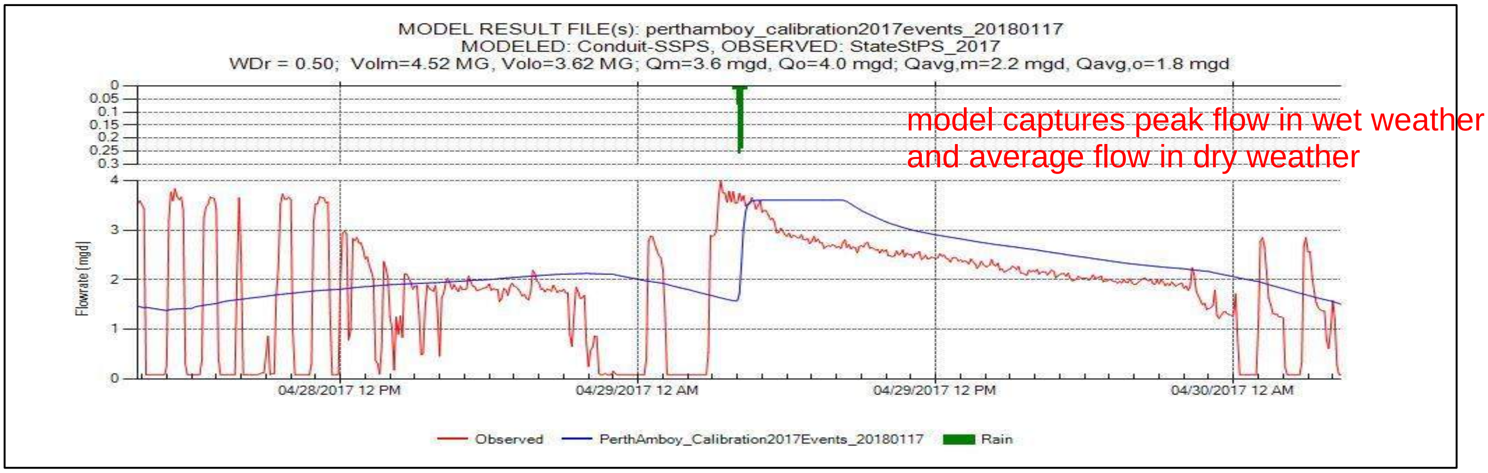


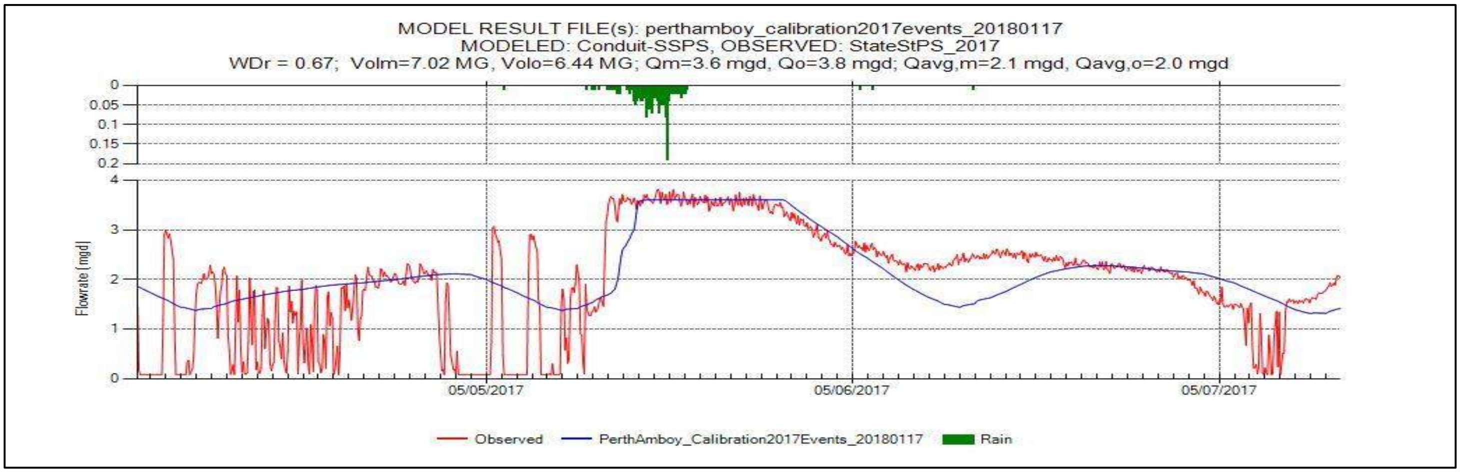
Time Series Plots:
Pump Stations

Simulated Versus Observed Flow at Flow Meter Sites

StateStPS_2017

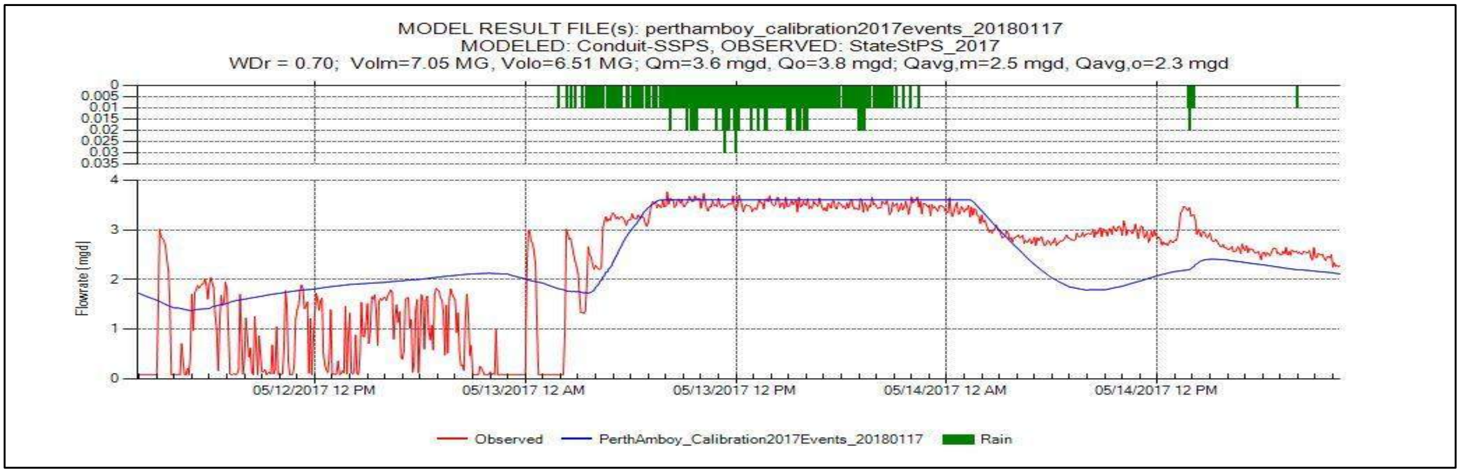


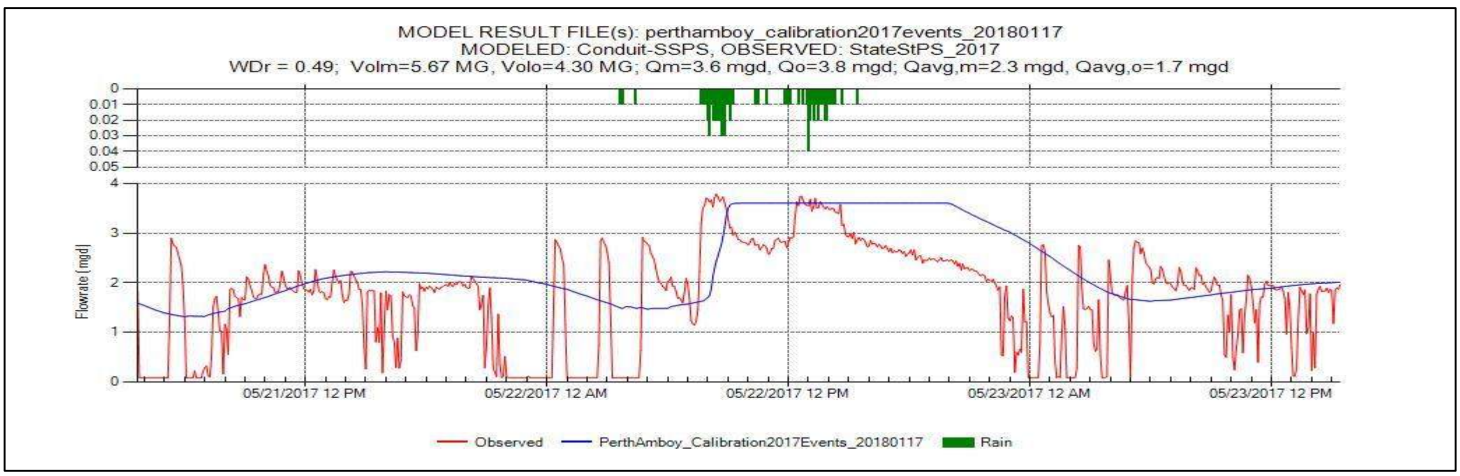


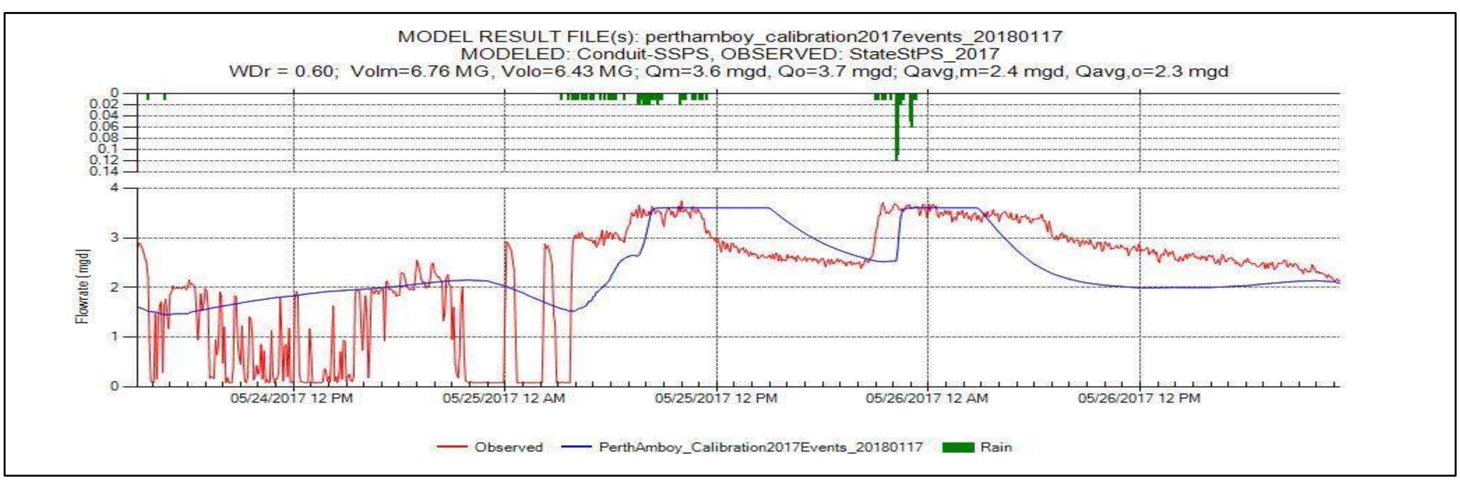


Simulated Versus Observed Flow at Flow Meter Sites

StateStPS_2017

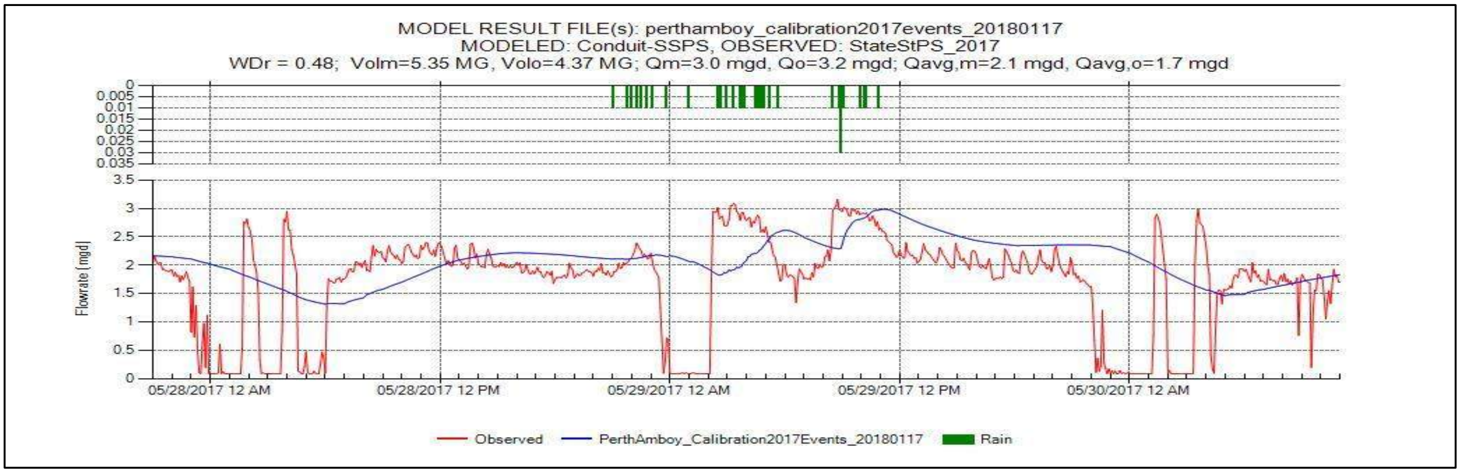


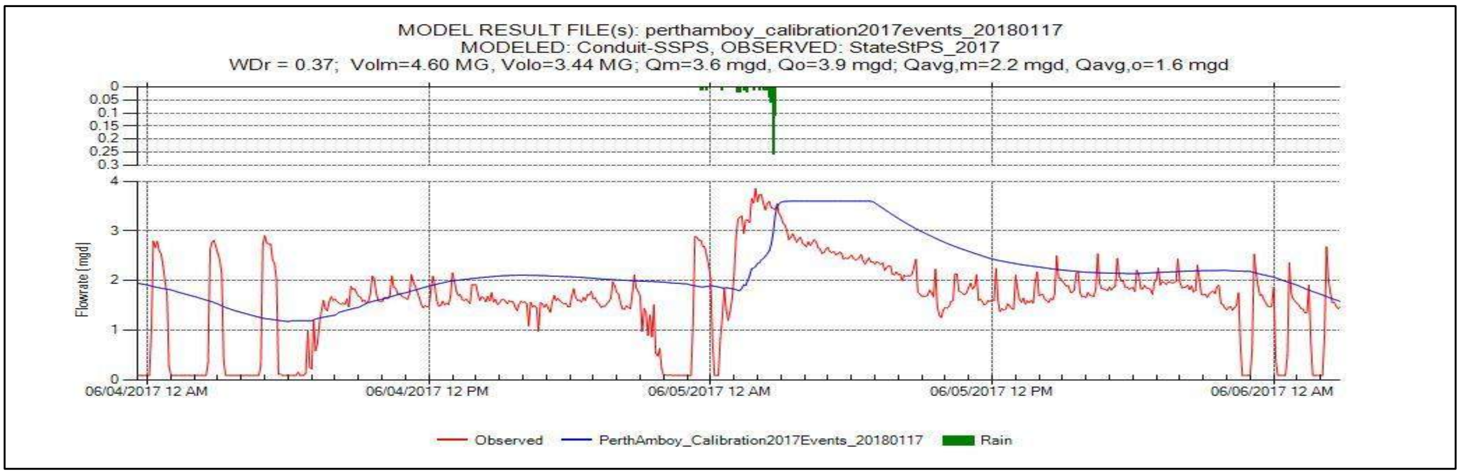


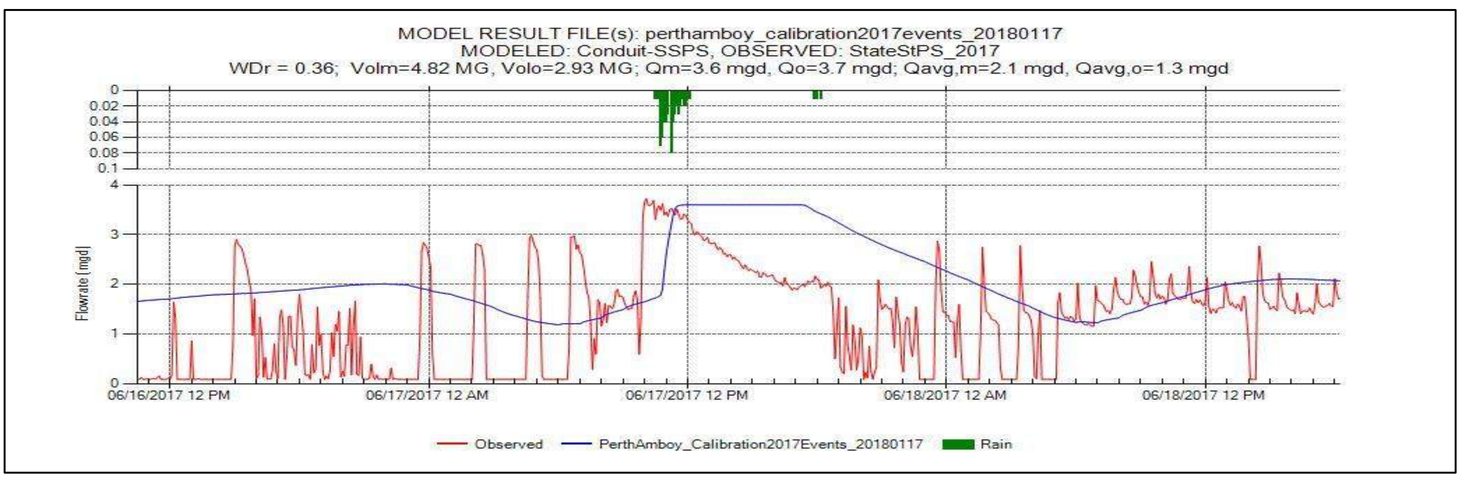


Simulated Versus Observed Flow at Flow Meter Sites

StateStPS_2017

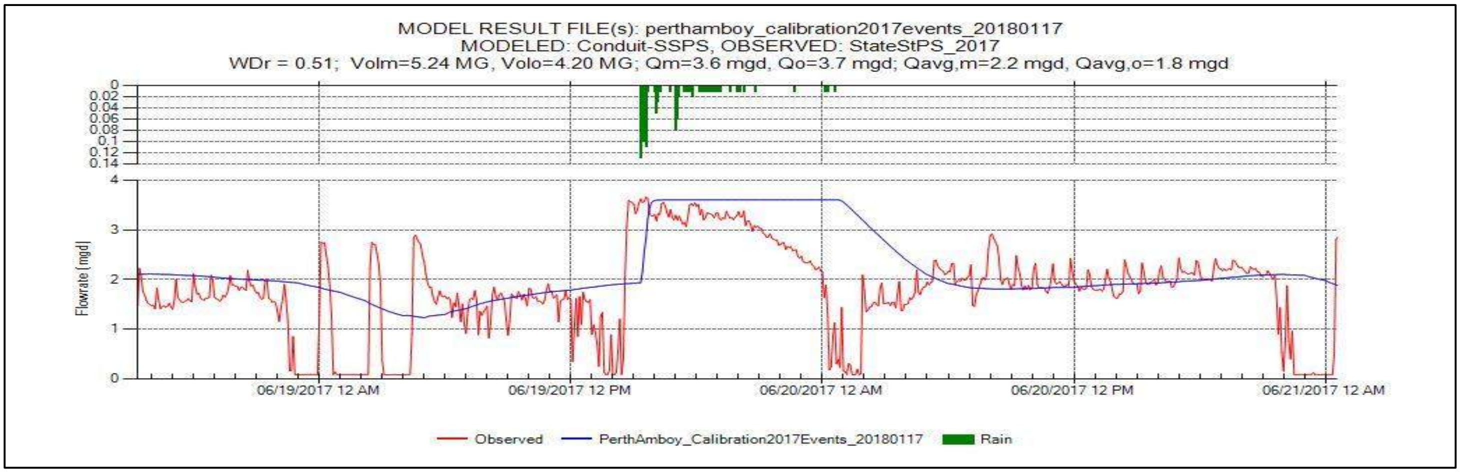


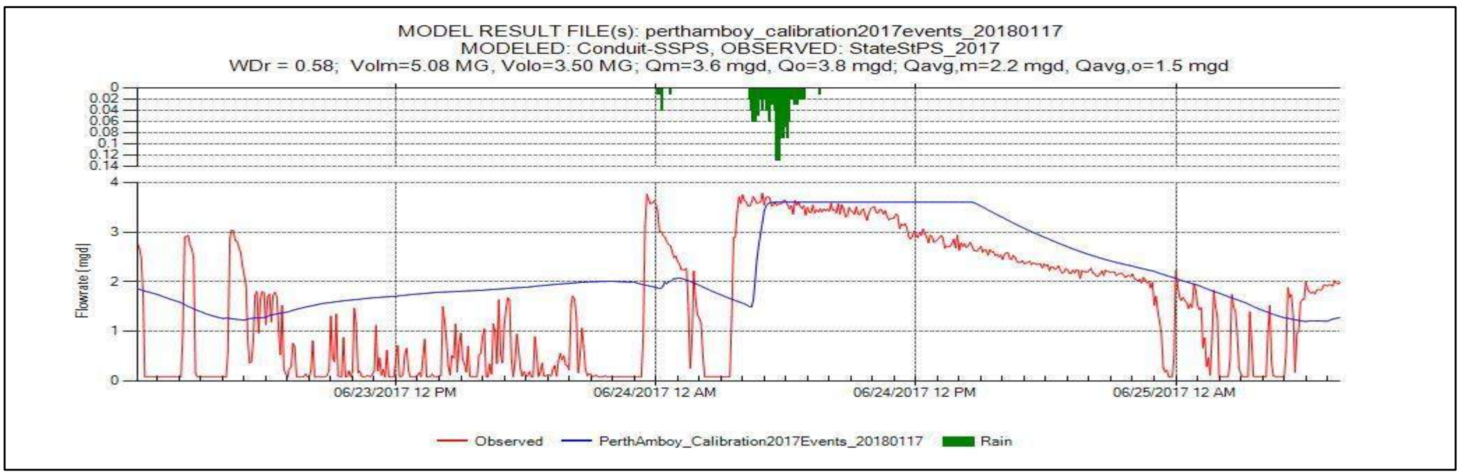


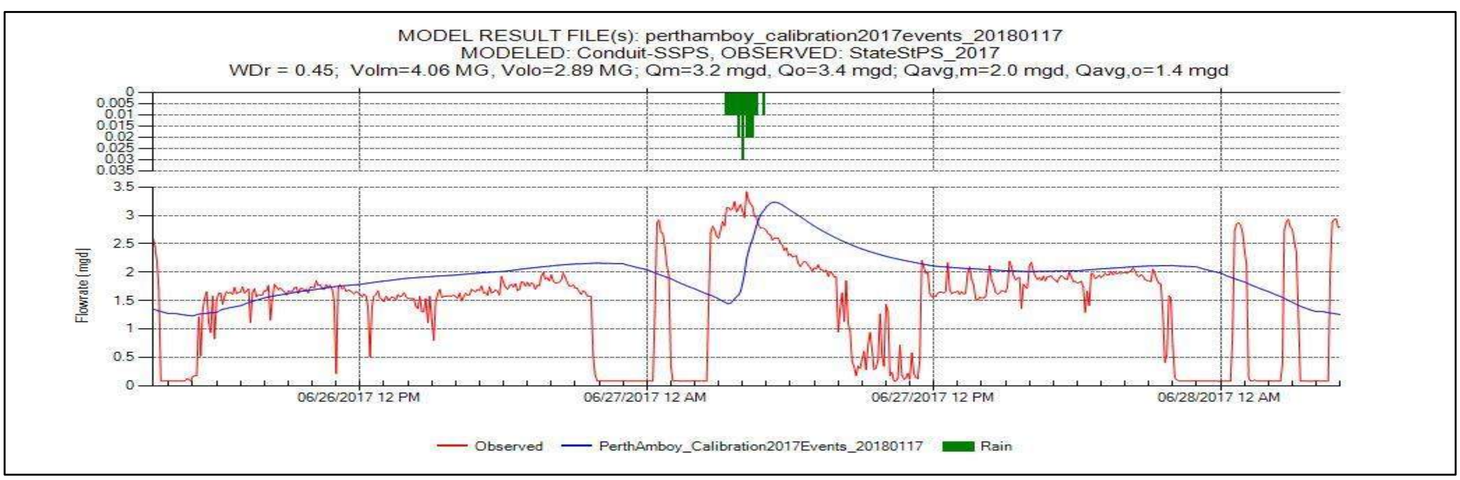


Simulated Versus Observed Flow at Flow Meter Sites

StateStPS_2017

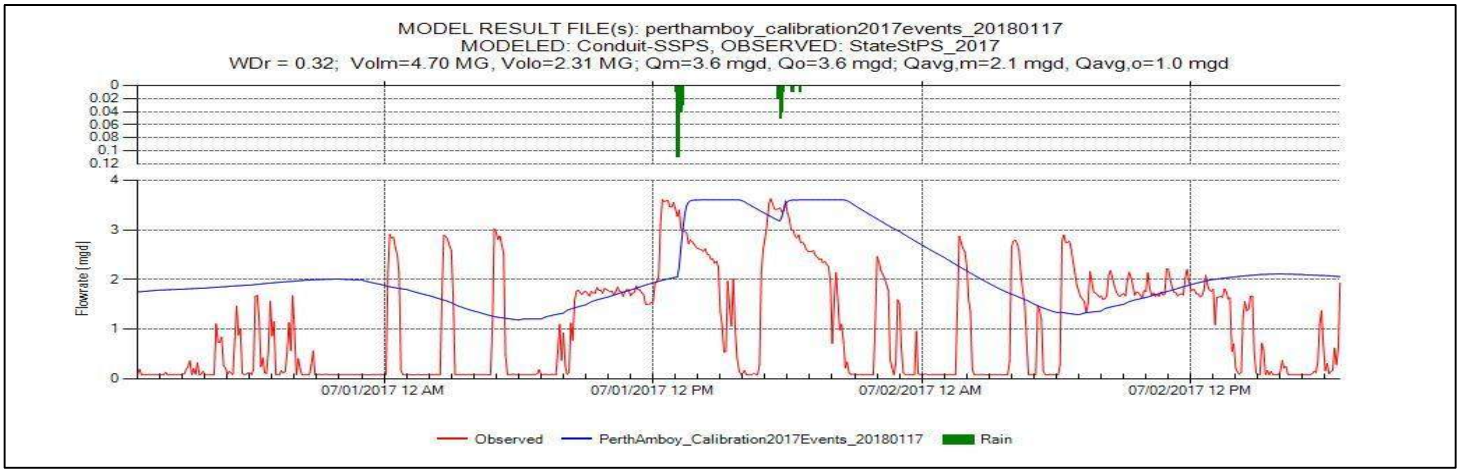


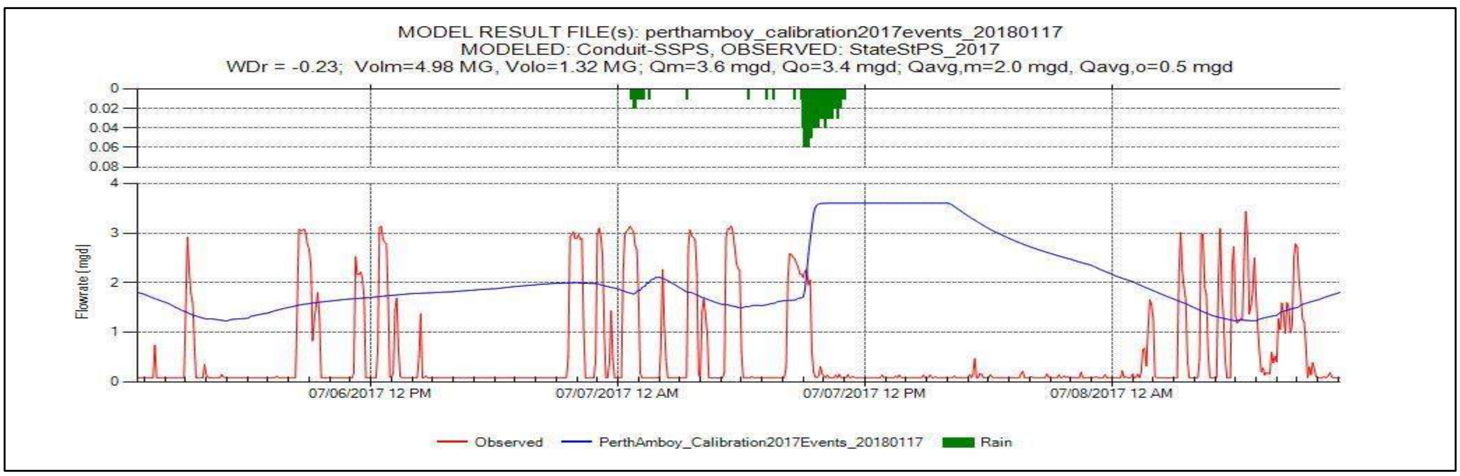


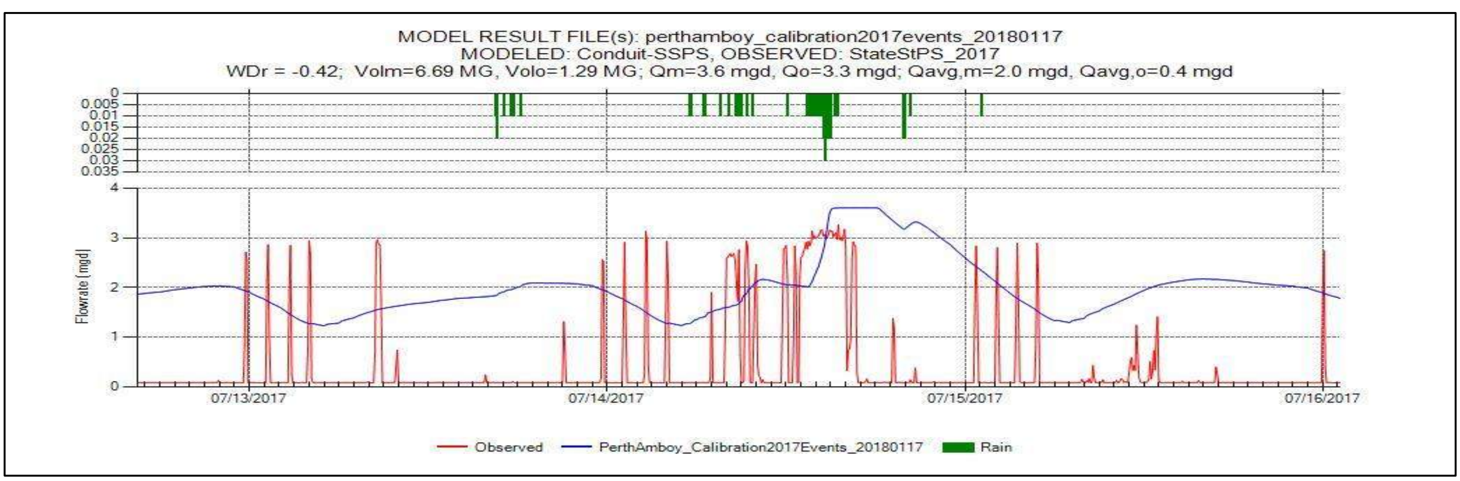


Simulated Versus Observed Flow at Flow Meter Sites

StateStPS_2017

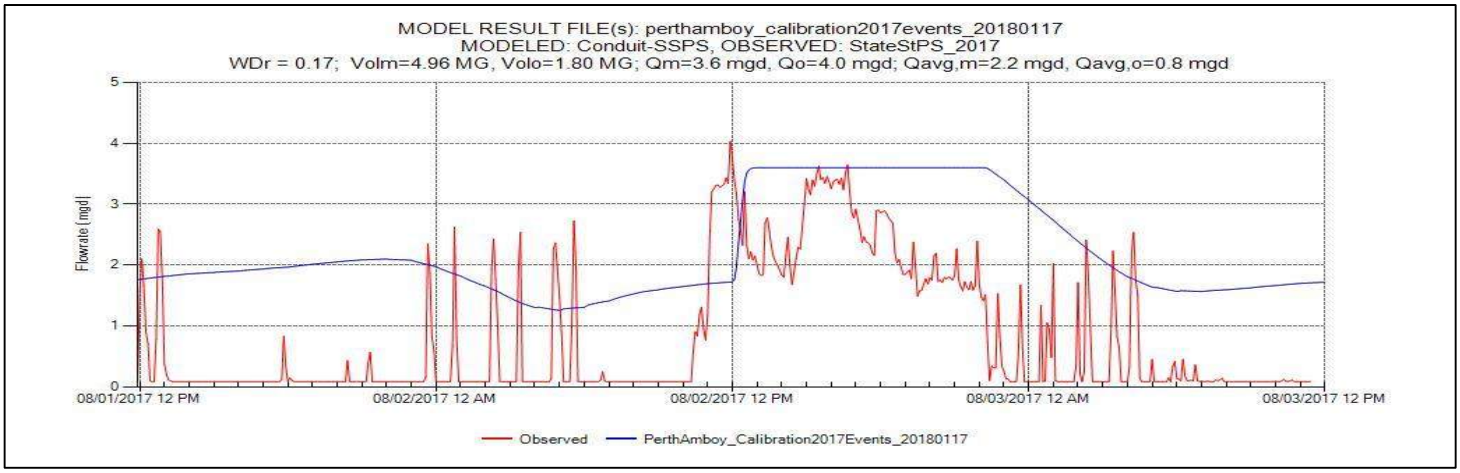






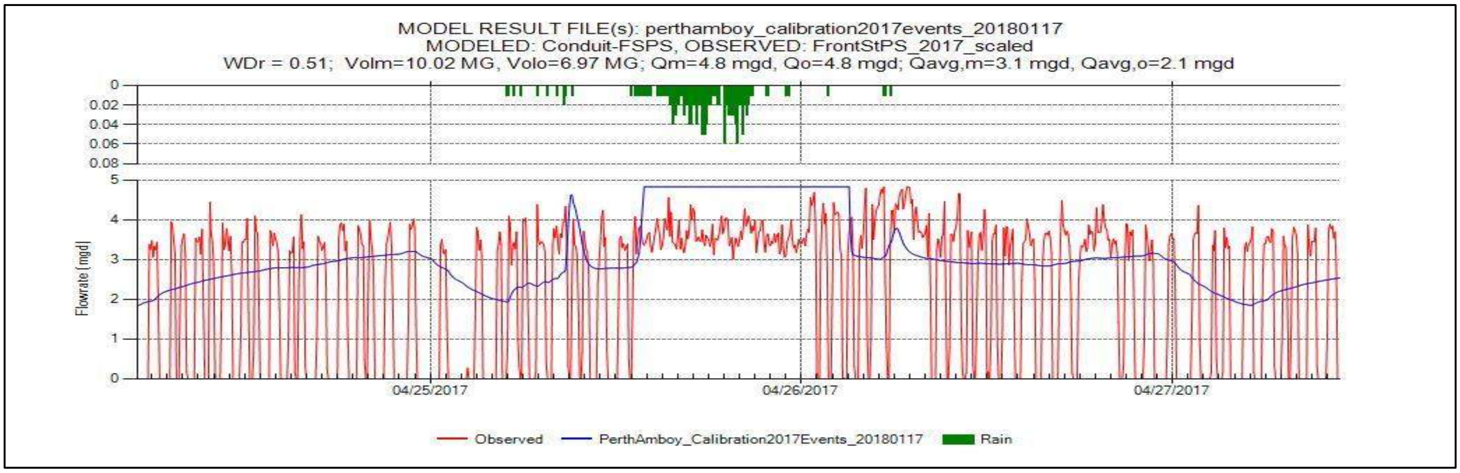
Simulated Versus Observed Flow at Flow Meter Sites

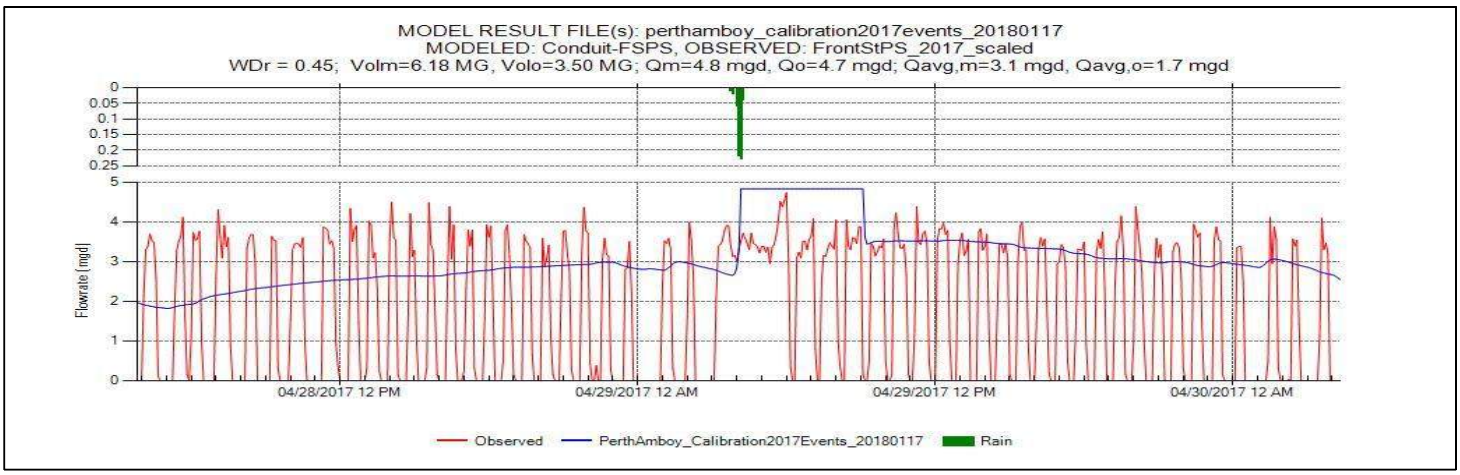
StateStPS_2017

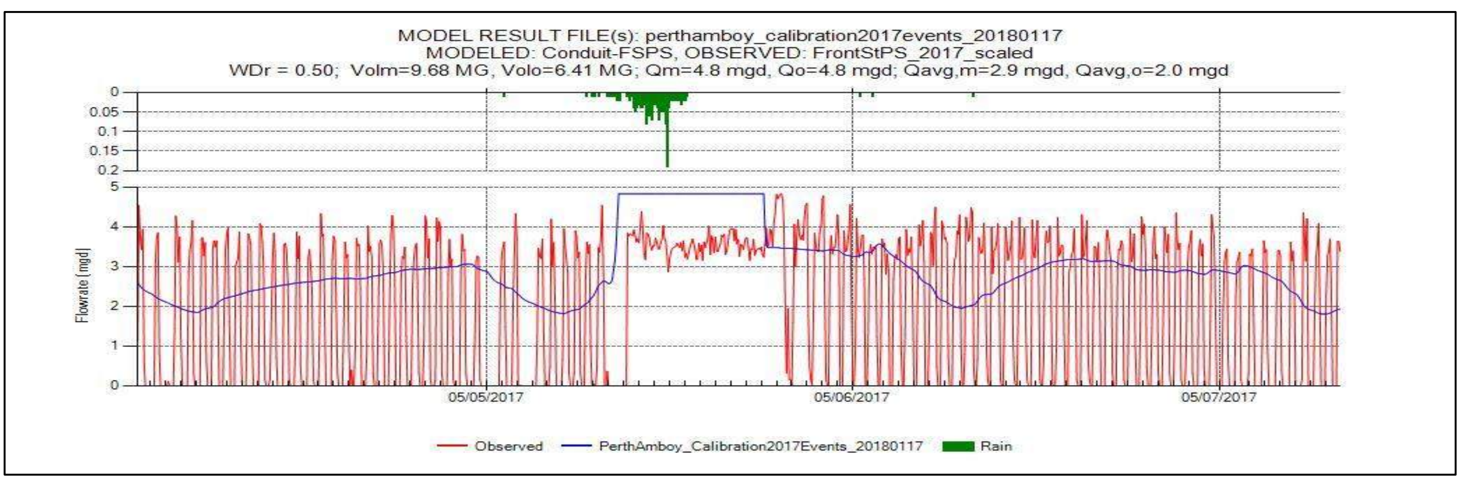


Simulated Versus Observed Flow at Flow Meter Sites

FrontStPS-2017

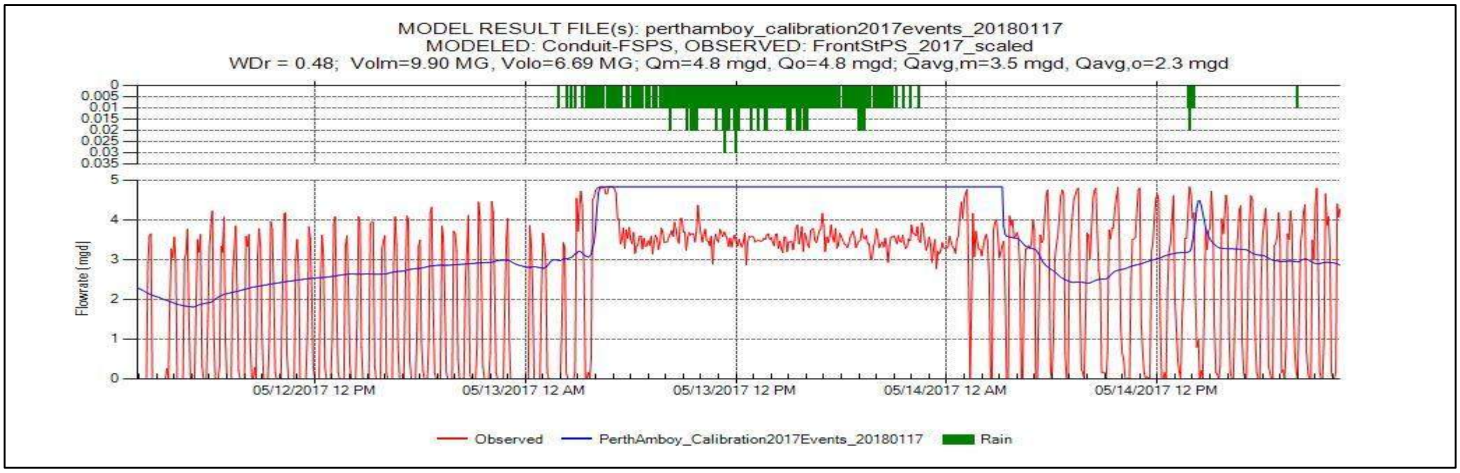


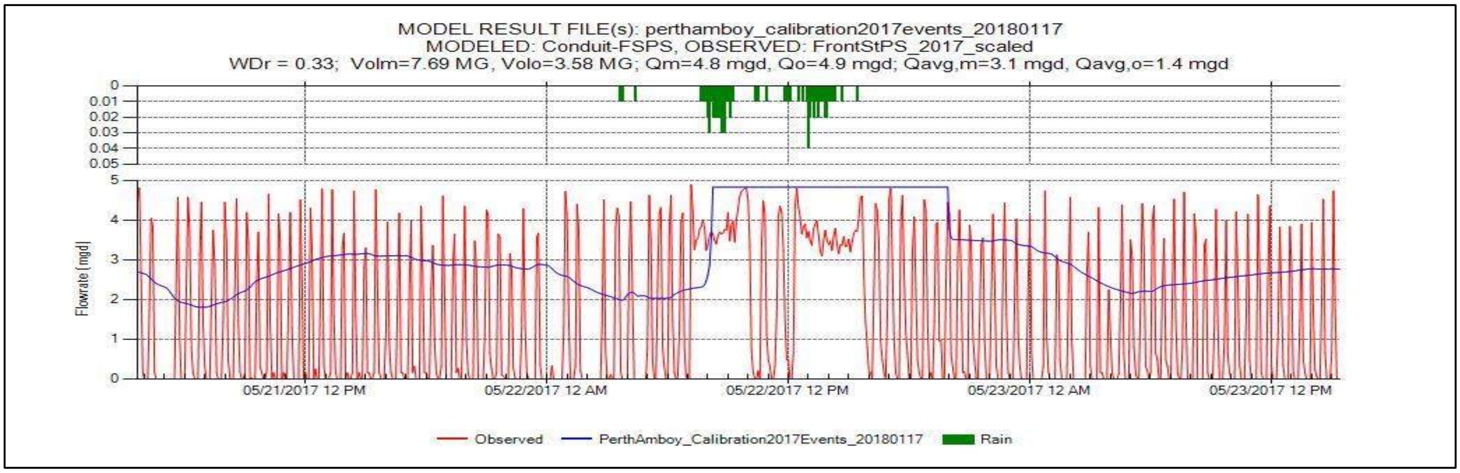


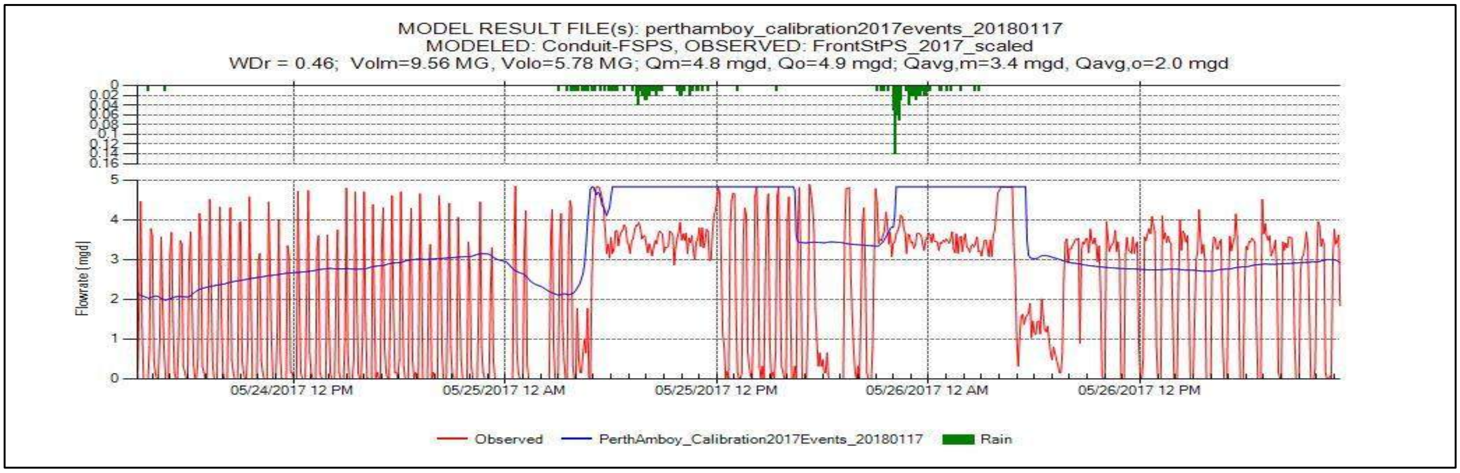


Simulated Versus Observed Flow at Flow Meter Sites

FrontStPS-2017

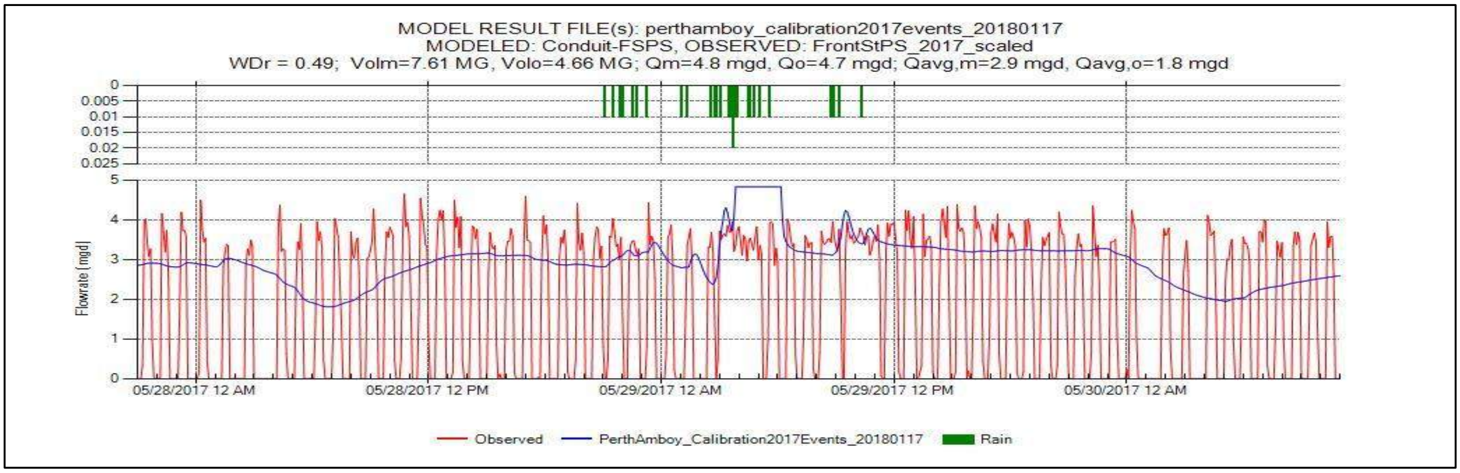


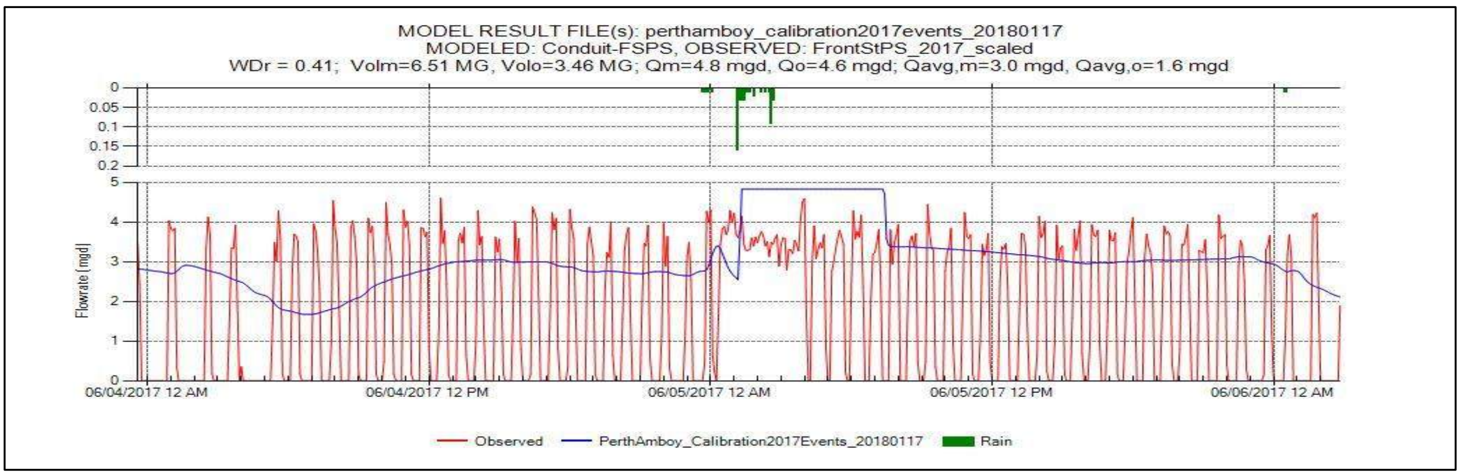


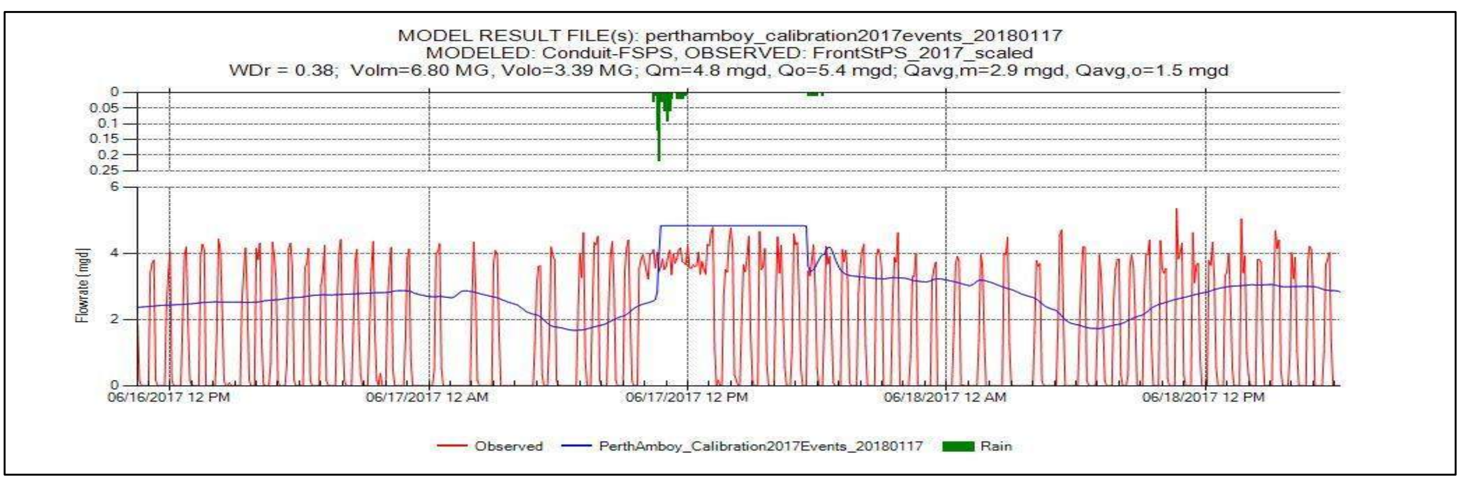


Simulated Versus Observed Flow at Flow Meter Sites

FrontStPS-2017

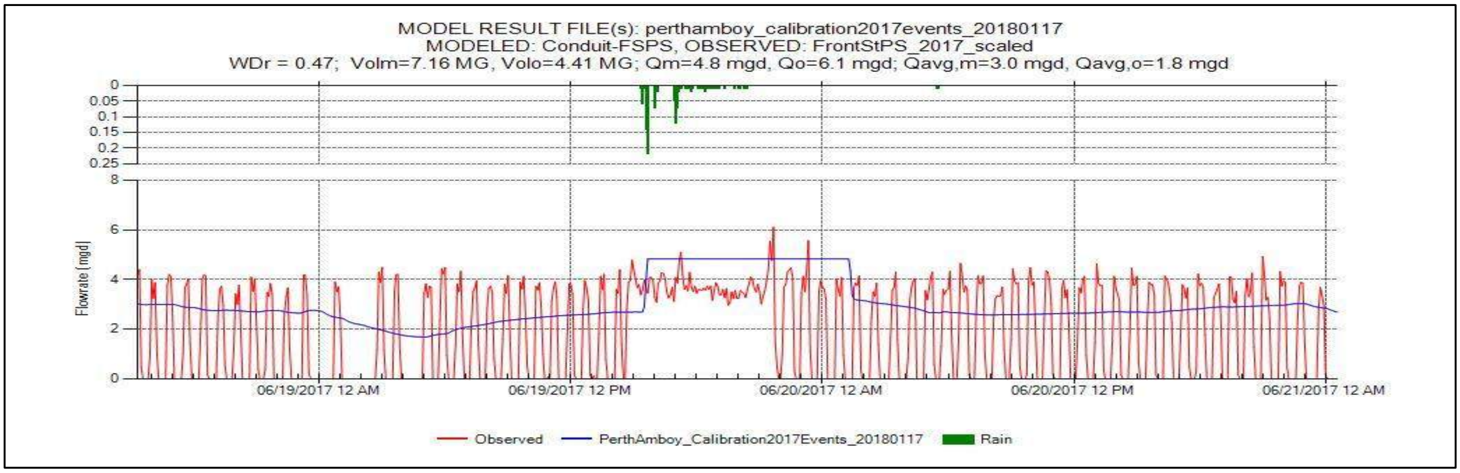


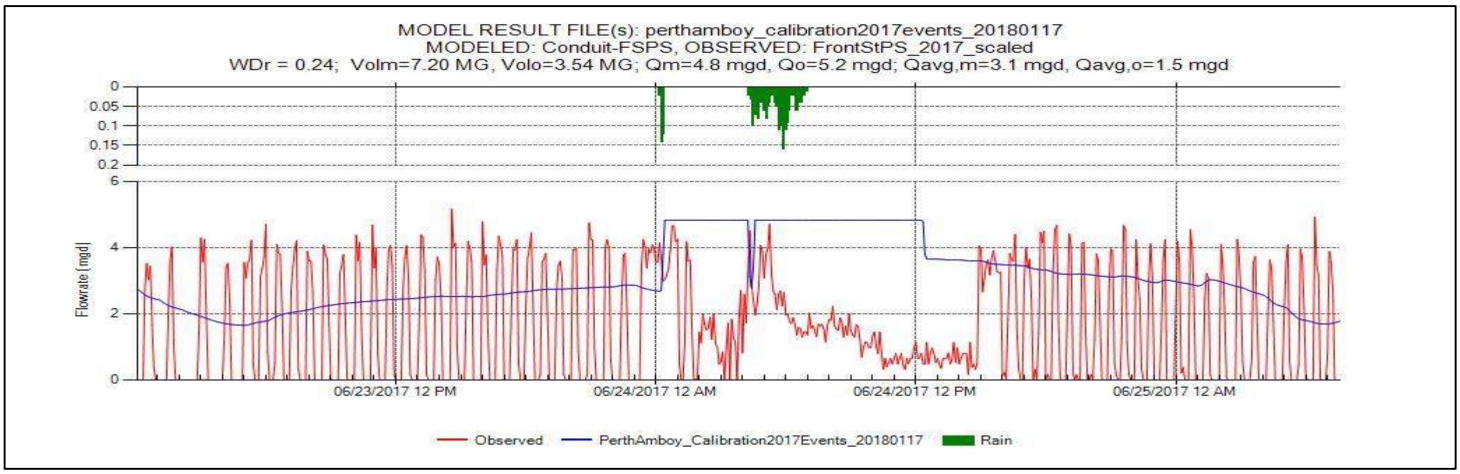


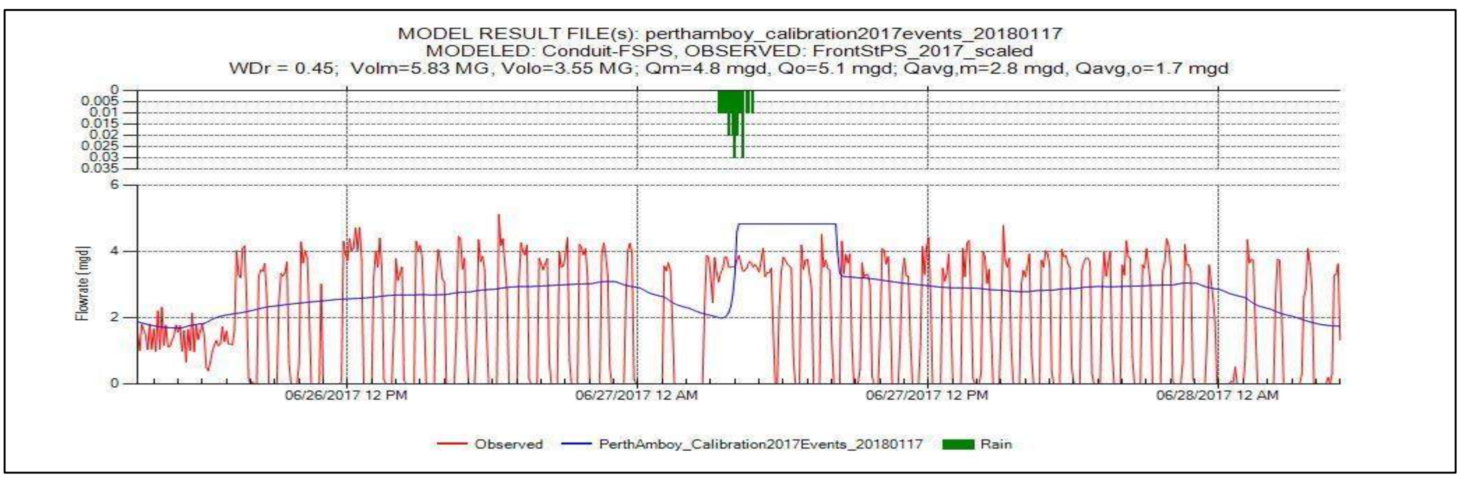


Simulated Versus Observed Flow at Flow Meter Sites

FrontStPS-2017

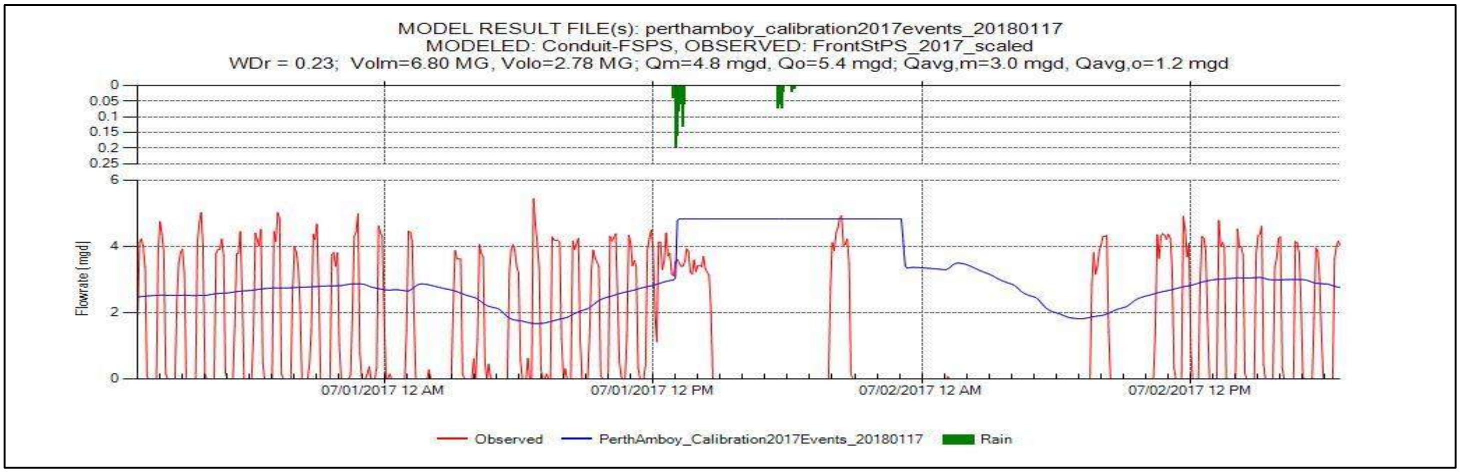


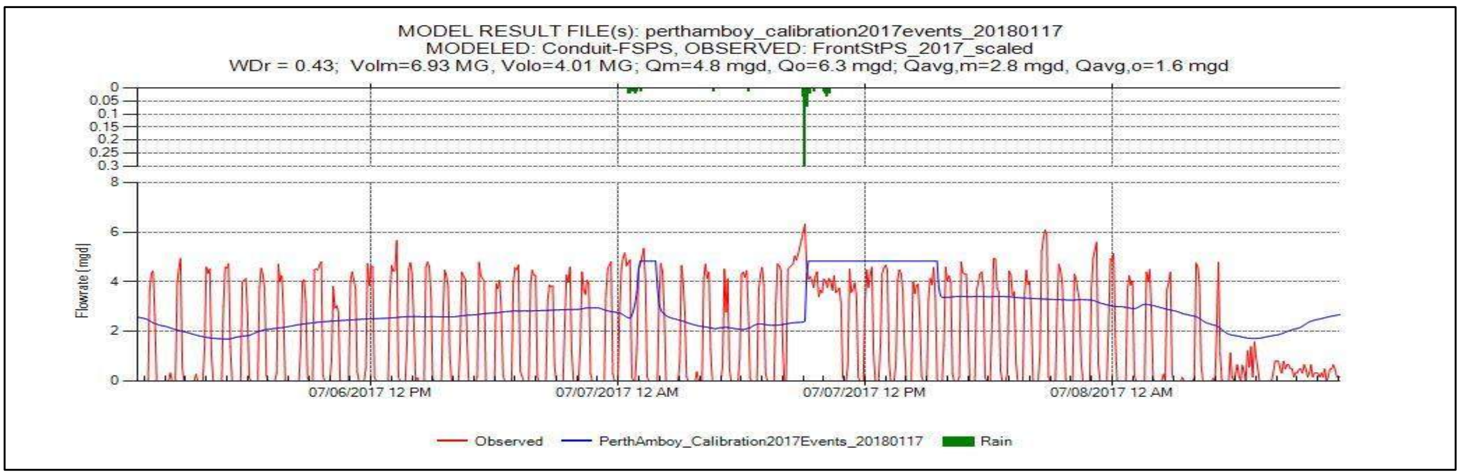


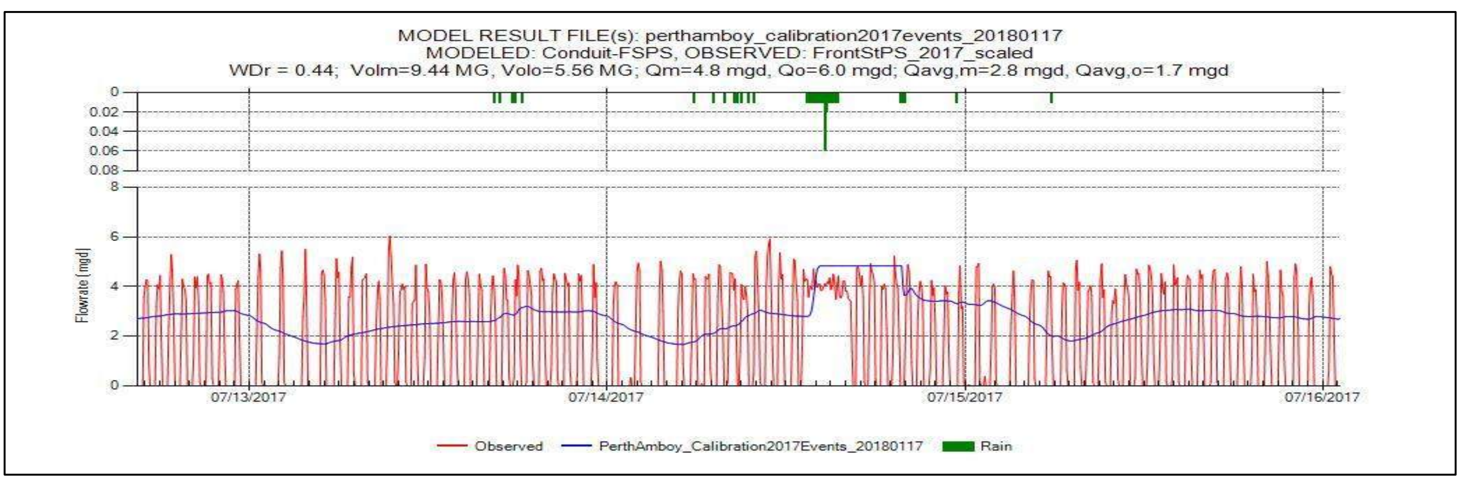


Simulated Versus Observed Flow at Flow Meter Sites

FrontStPS-2017

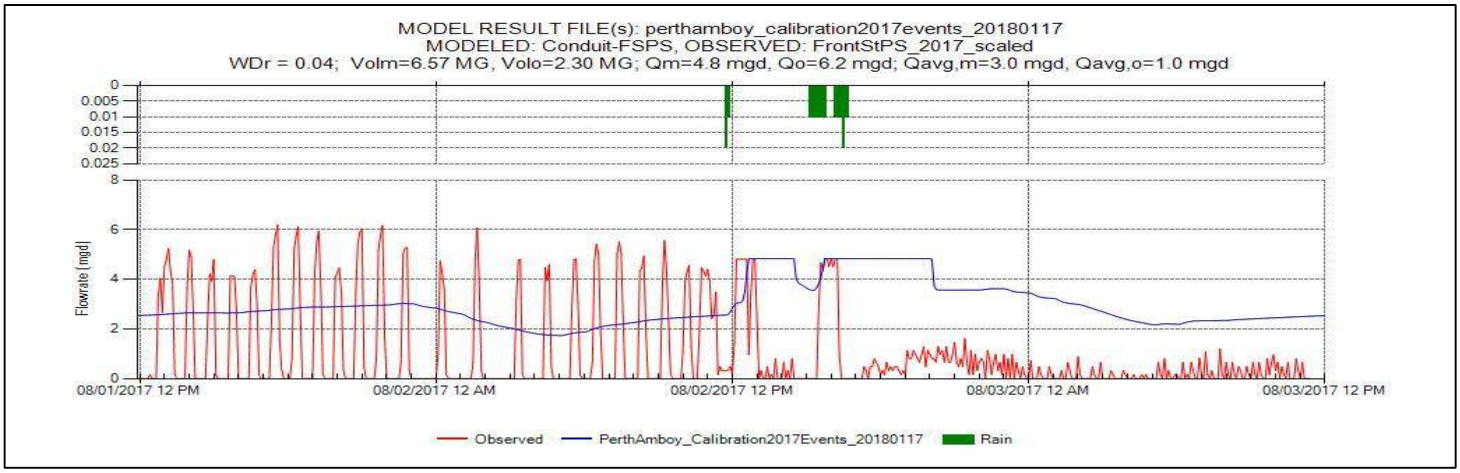






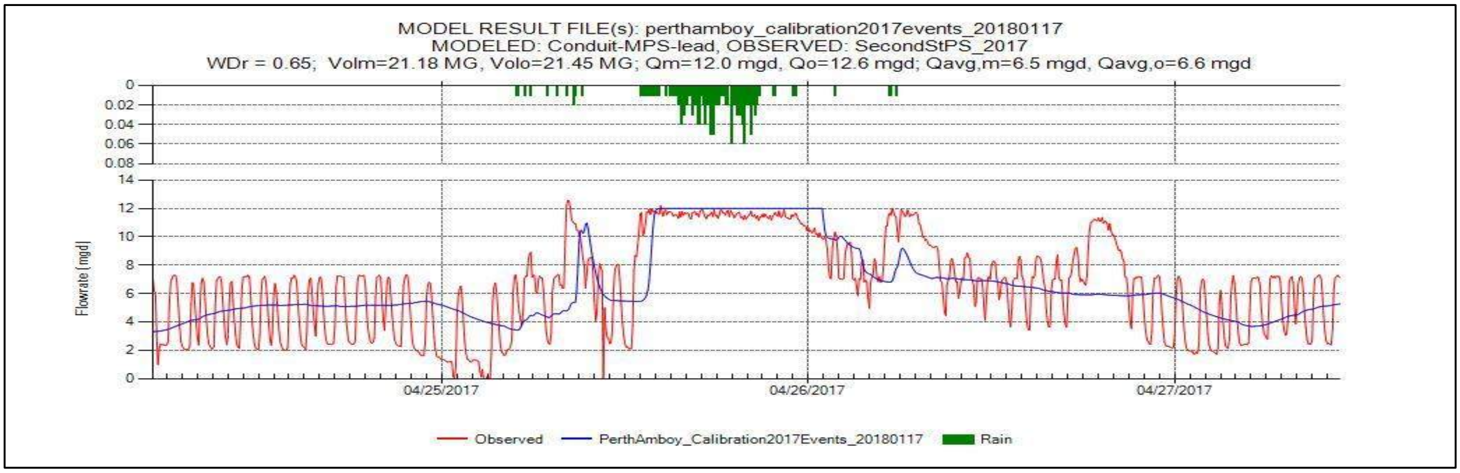
Simulated Versus Observed Flow at Flow Meter Sites

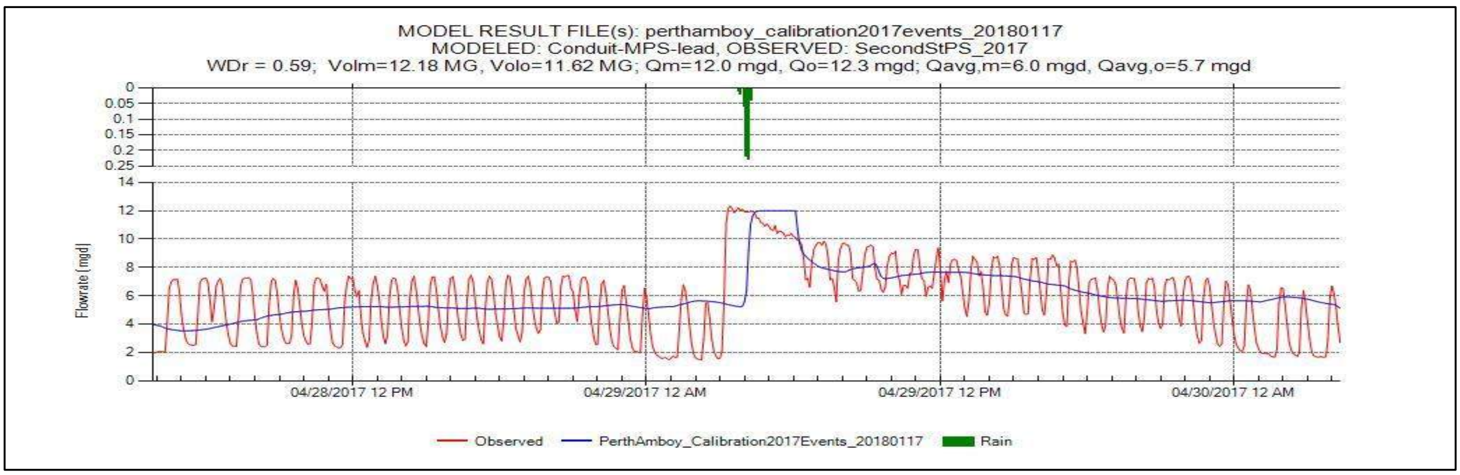
FrontStPS-2017

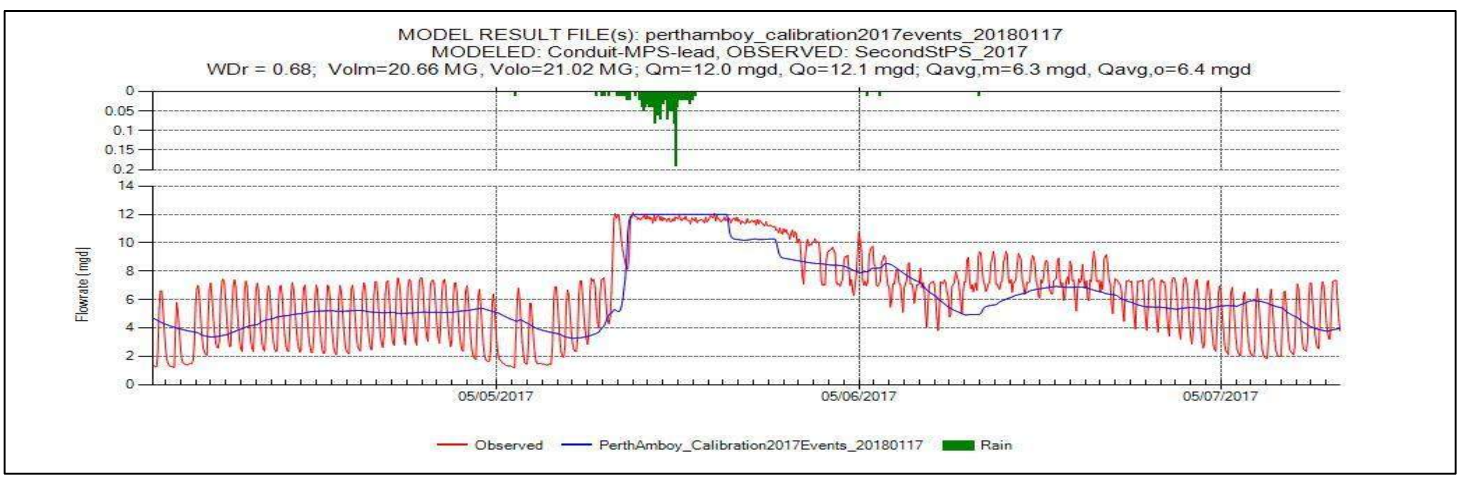


Simulated Versus Observed Flow at Flow Meter Sites

SecondStPS-20170425

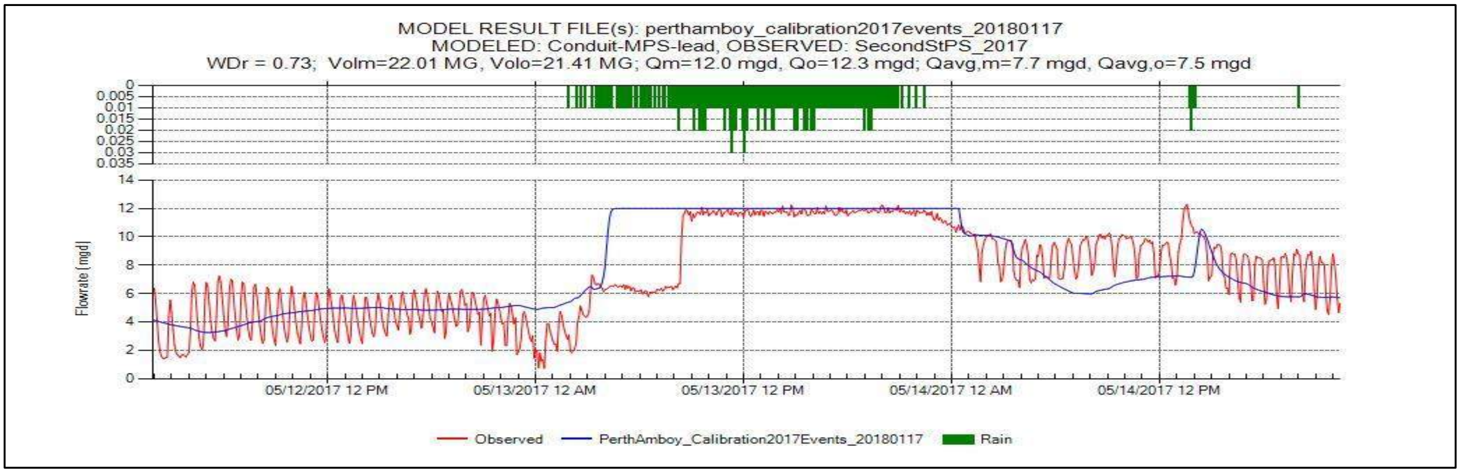


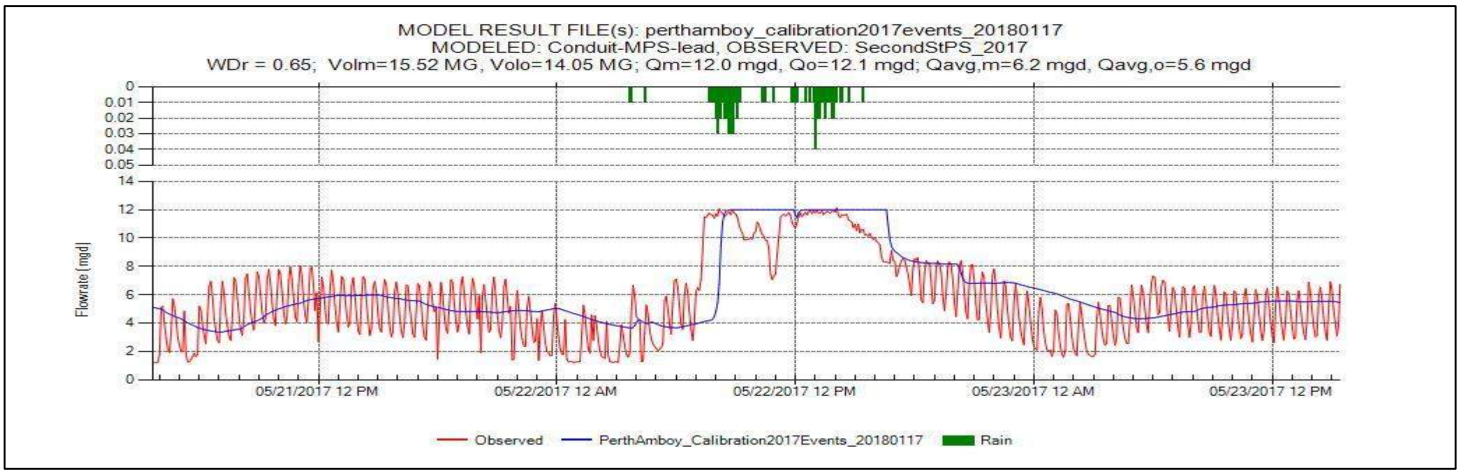


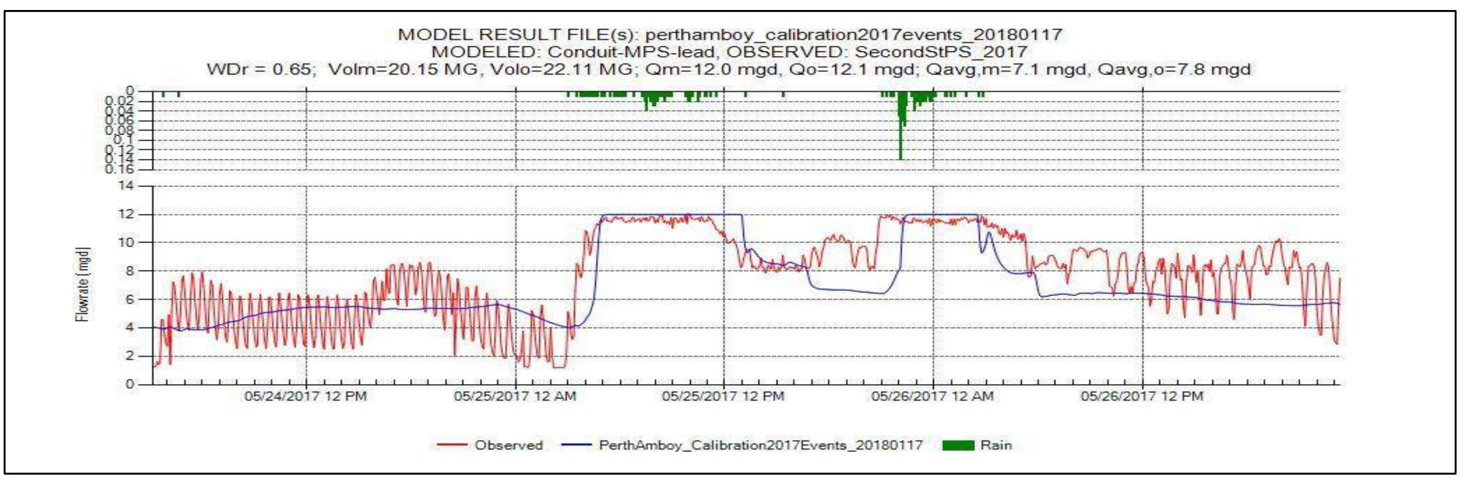


Simulated Versus Observed Flow at Flow Meter Sites

SecondStPS-20170513

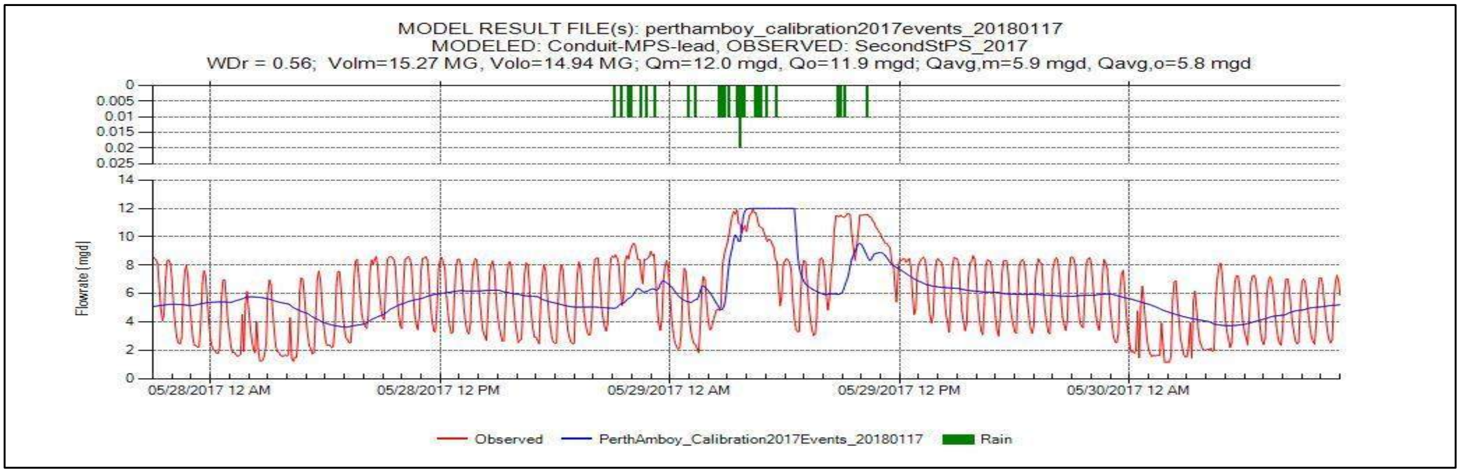


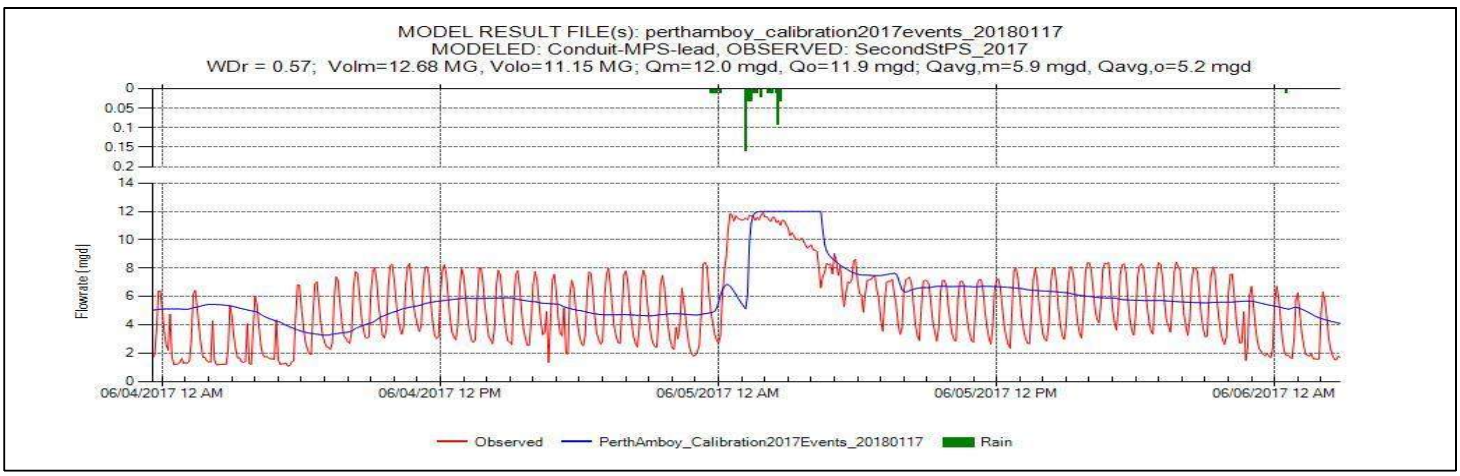


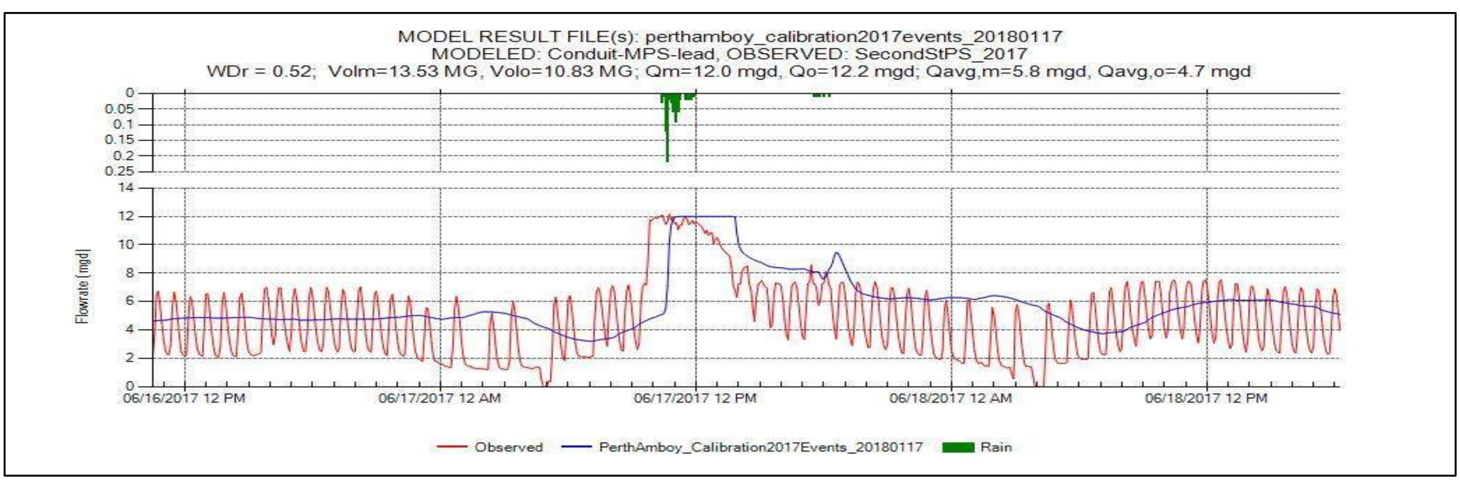


Simulated Versus Observed Flow at Flow Meter Sites

SecondStPS-20170528

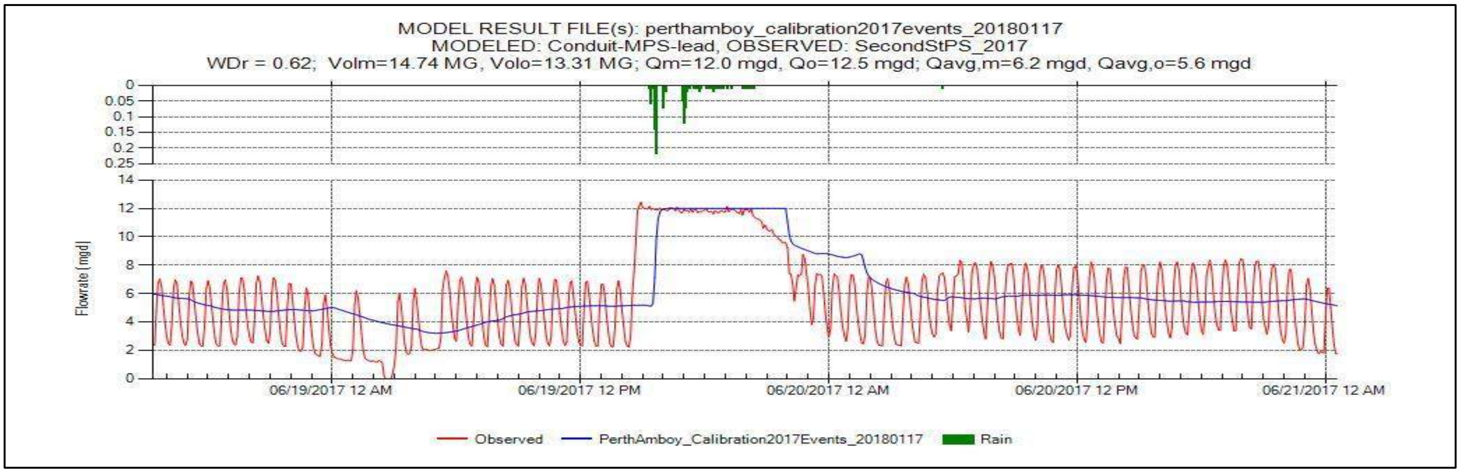


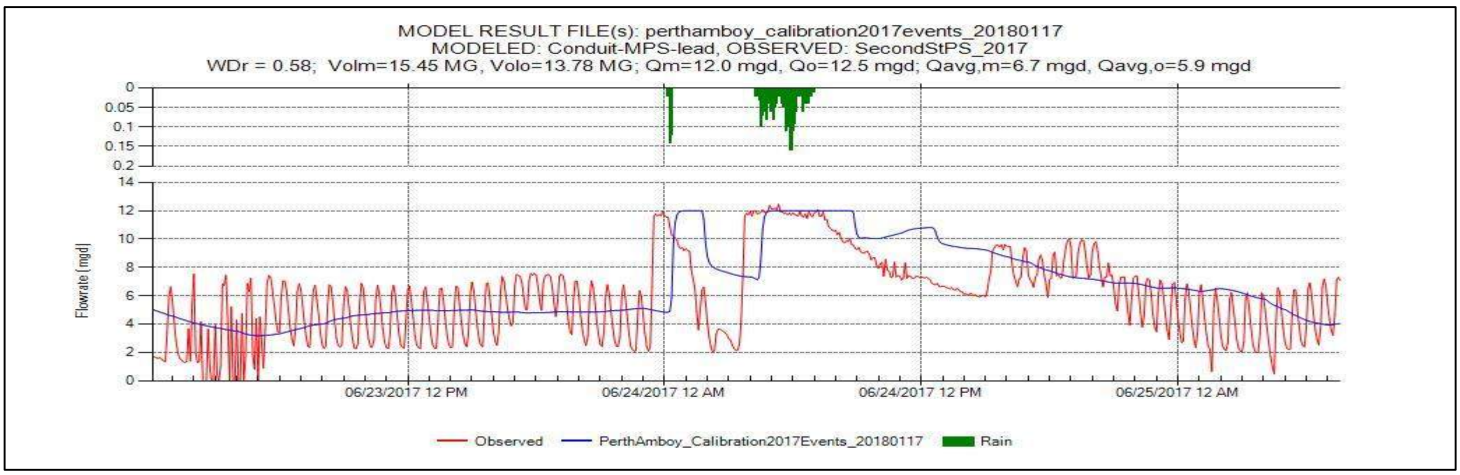


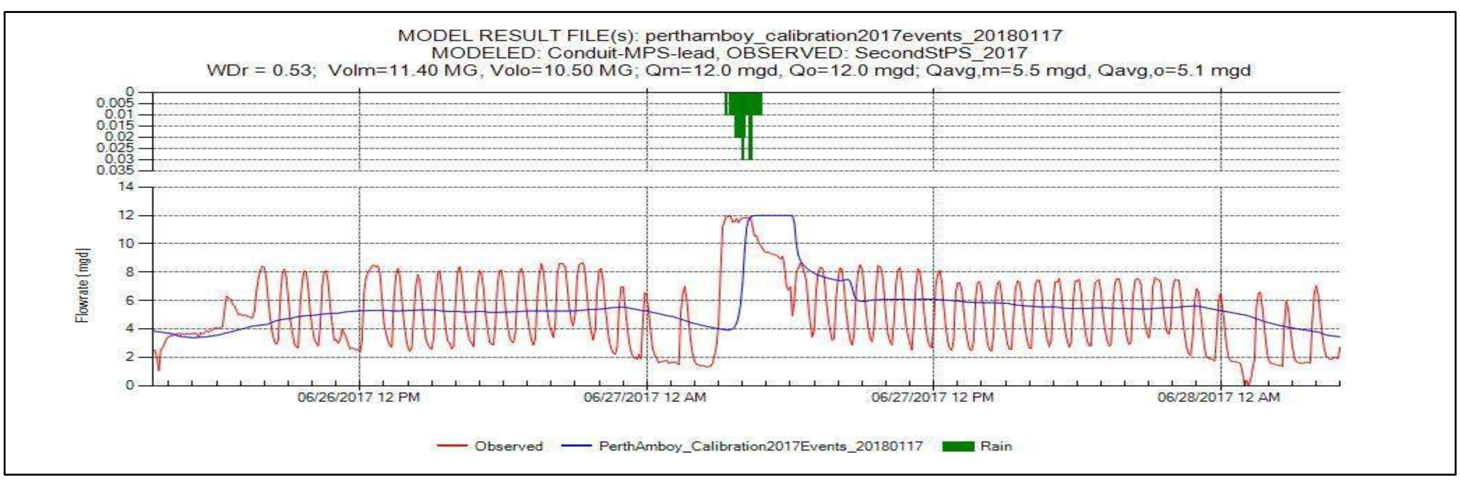


Simulated Versus Observed Flow at Flow Meter Sites

SecondStPS-20170619







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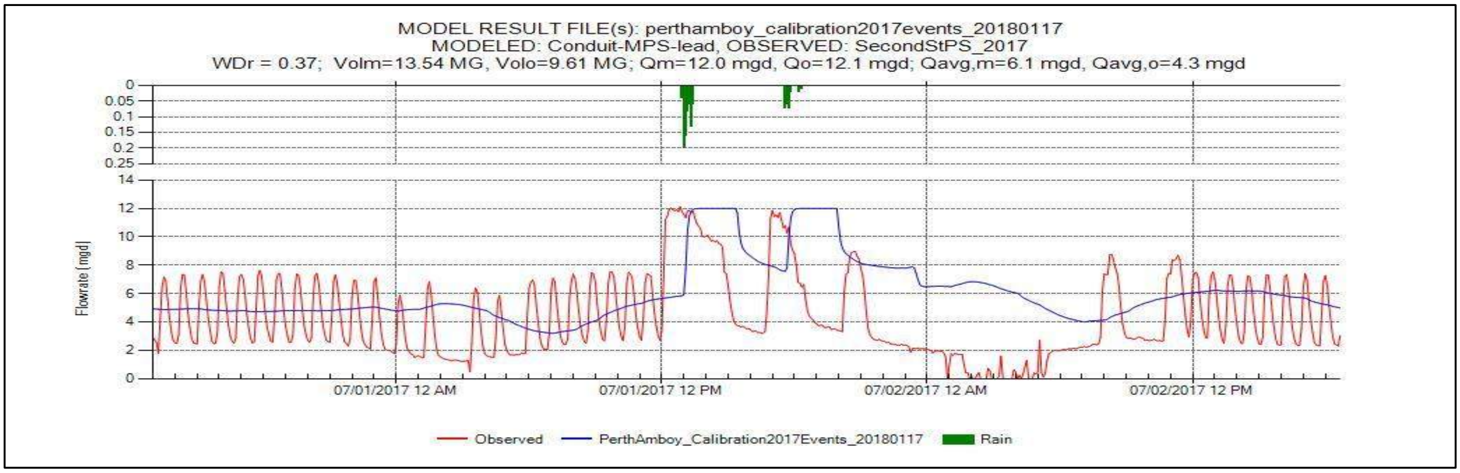
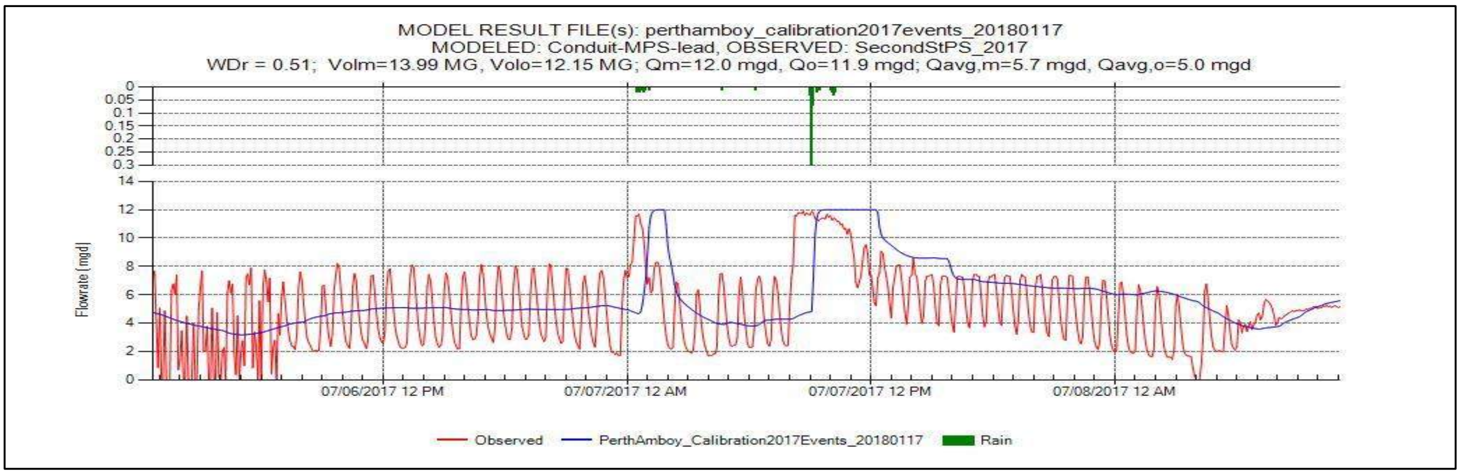
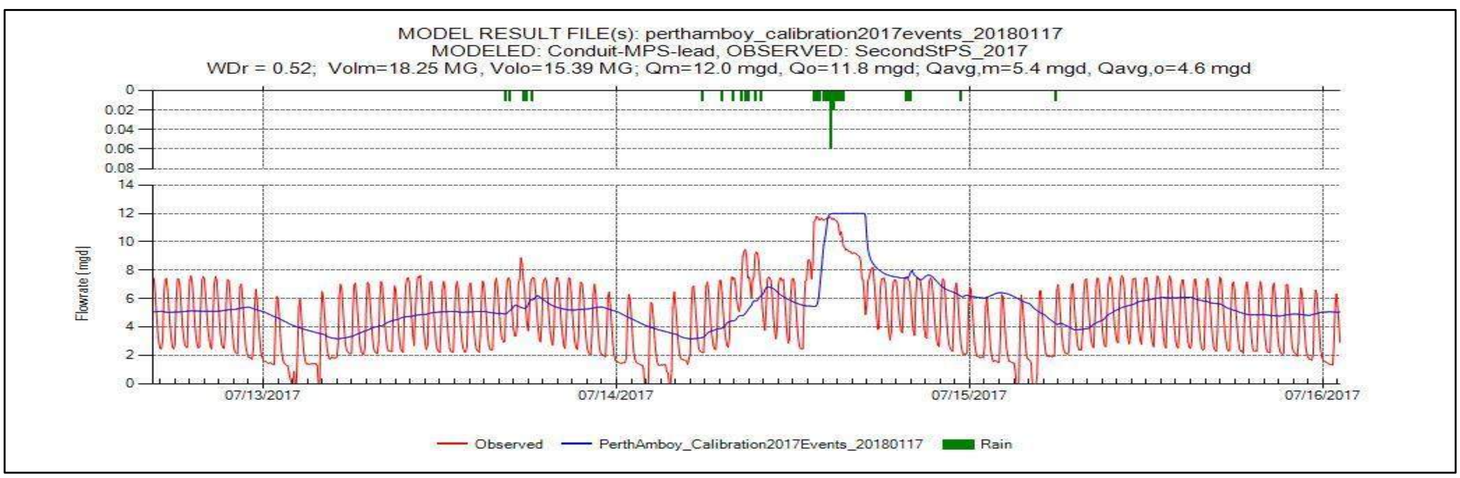
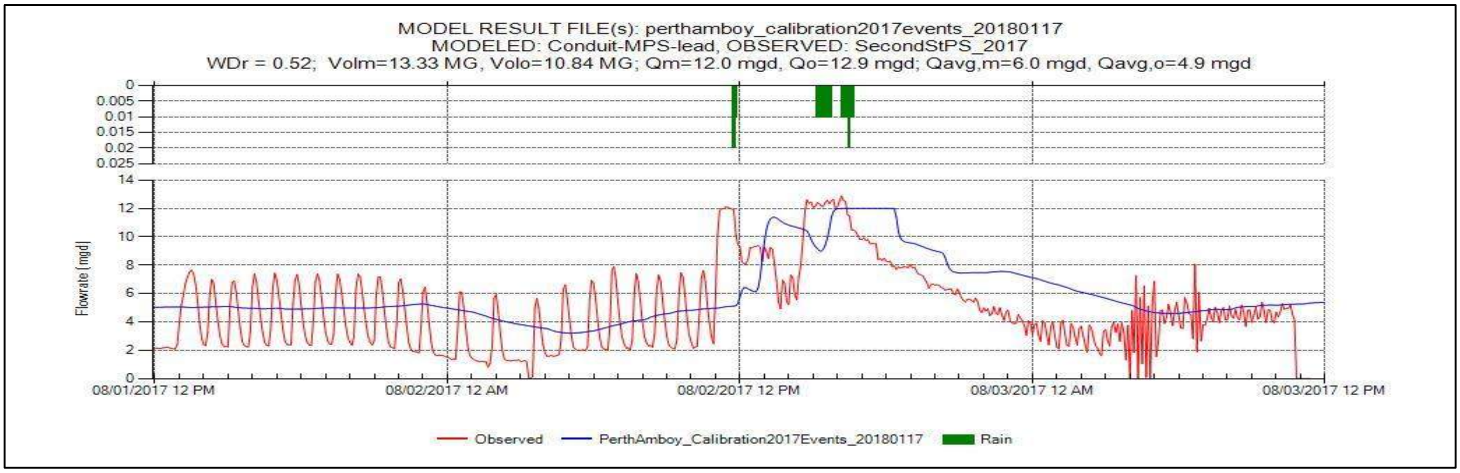






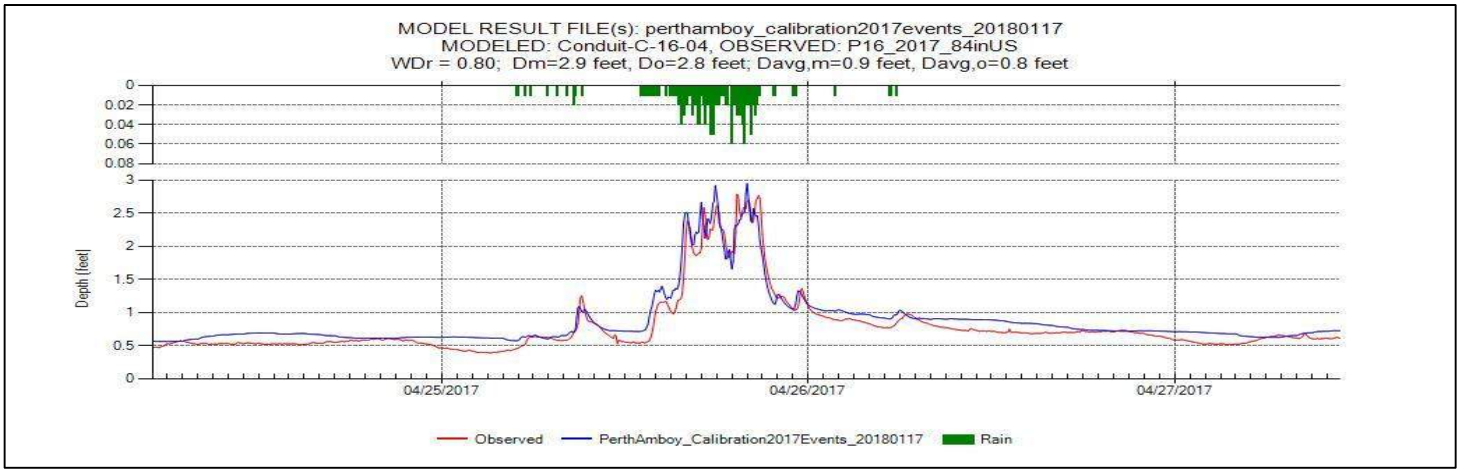
Simulated Versus Observed Flow at Flow Meter Sites

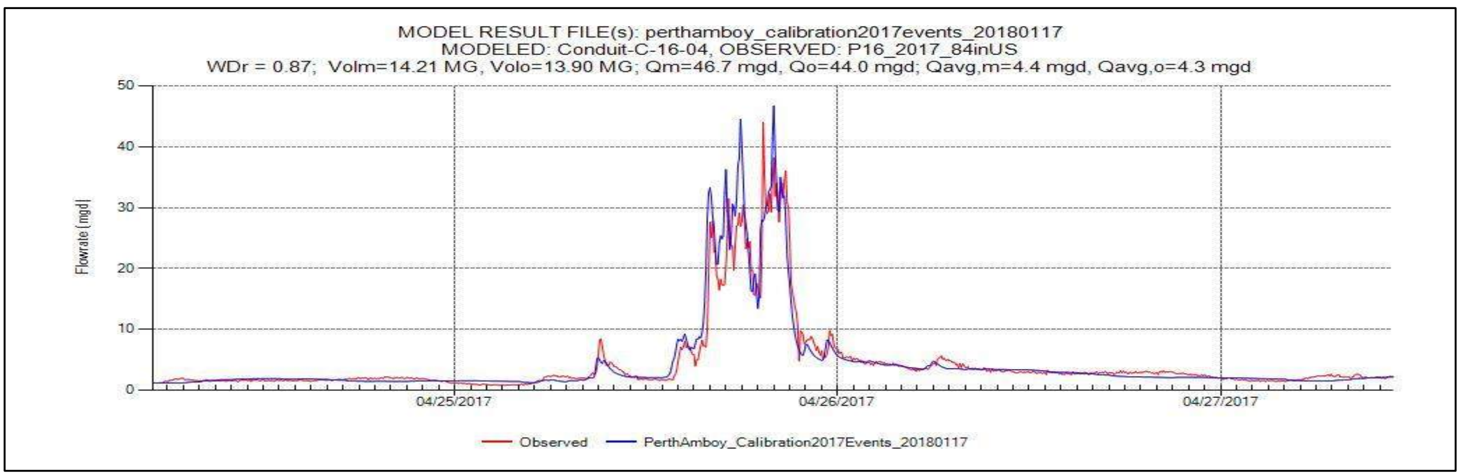
SecondStPS-20170802

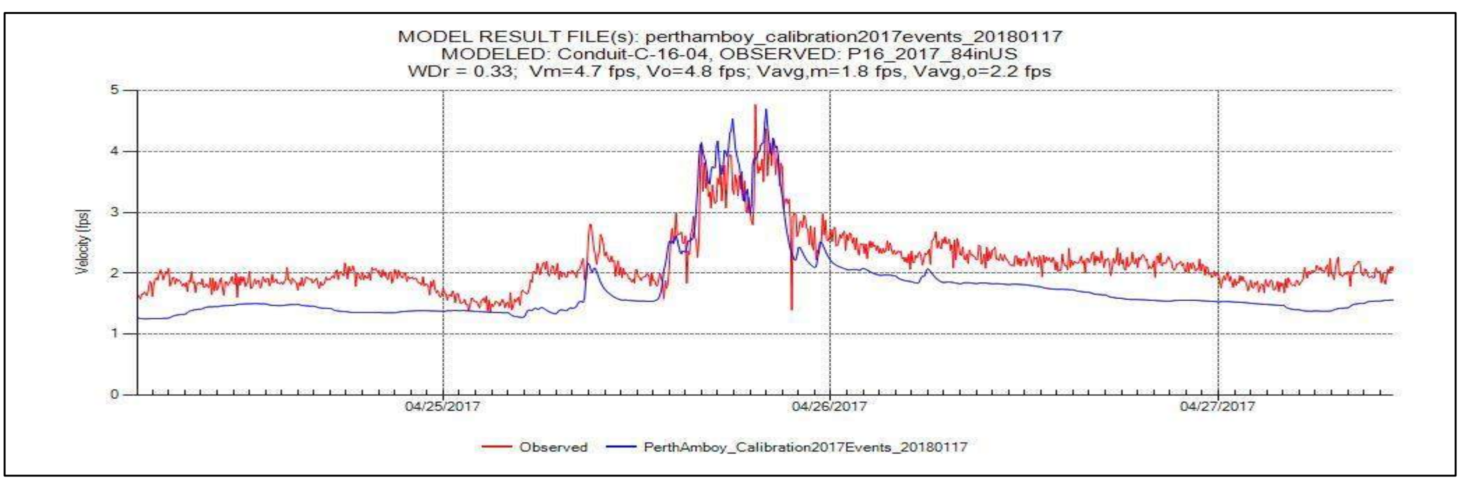


Time Series Plots:
Westside Interceptor

P16_2017_84inUS







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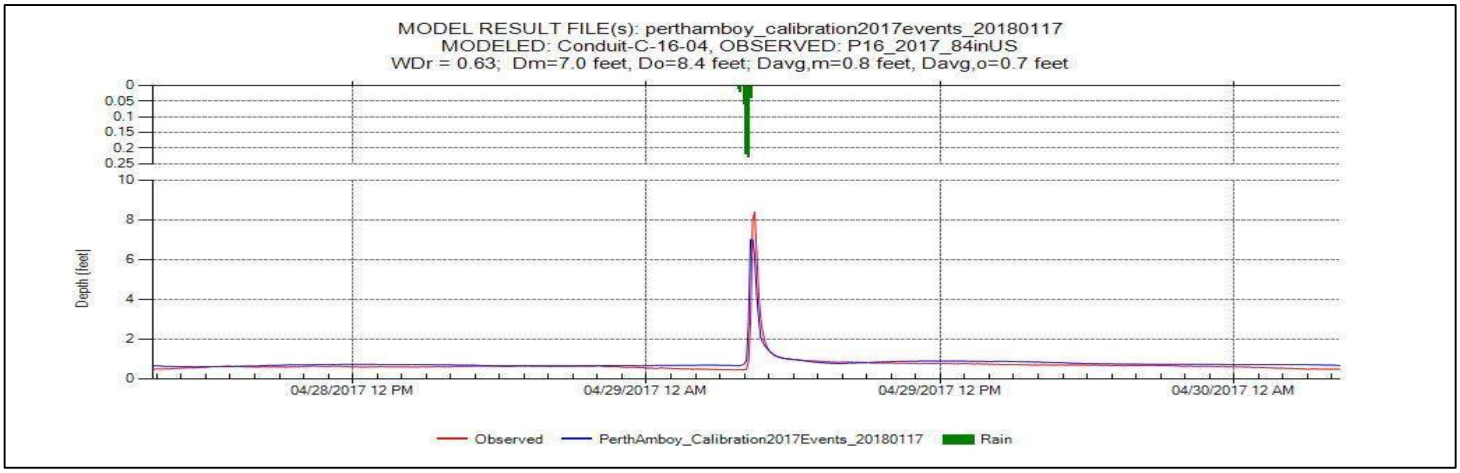
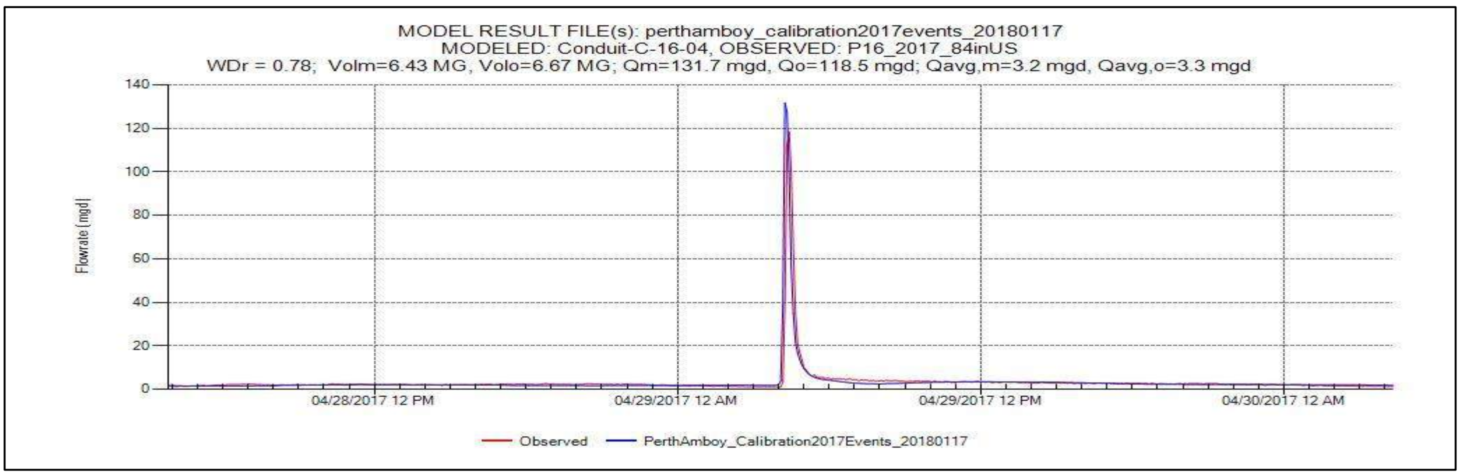
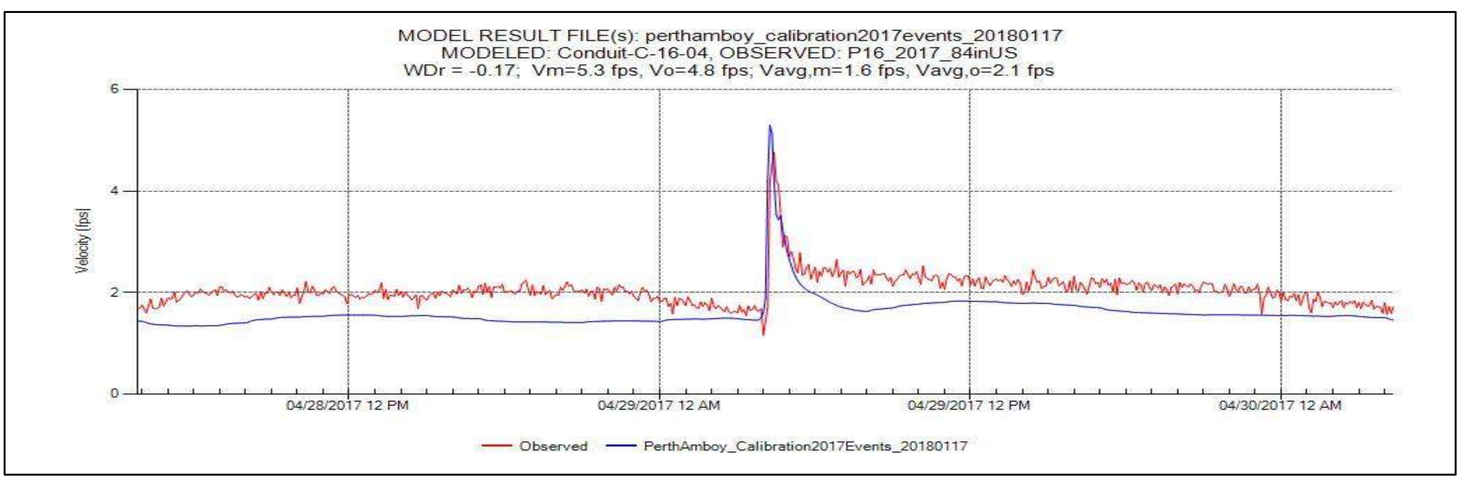
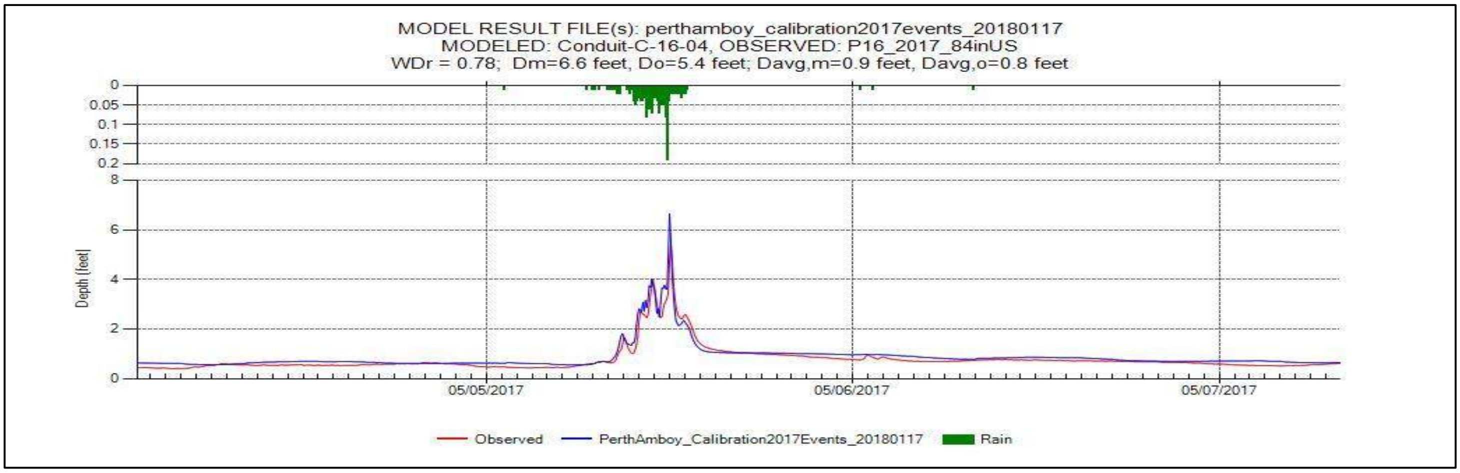


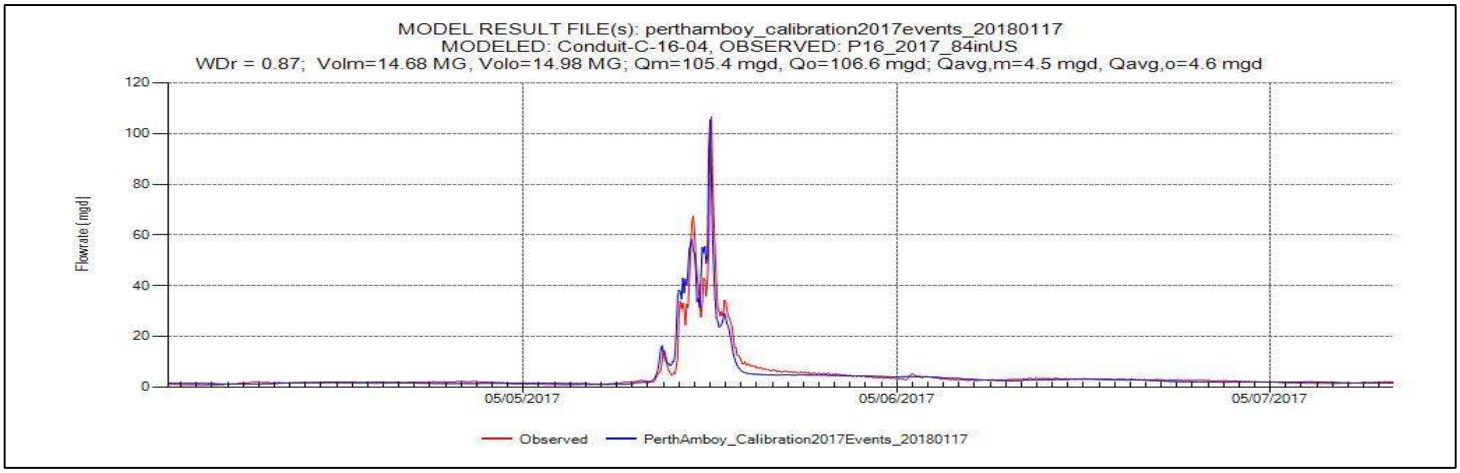


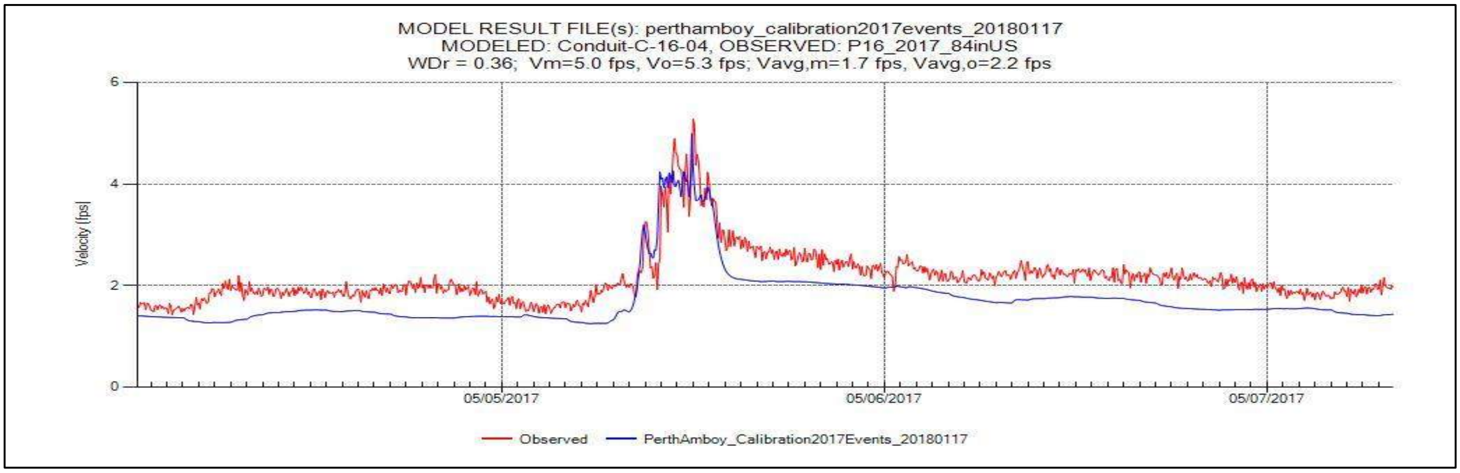


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS







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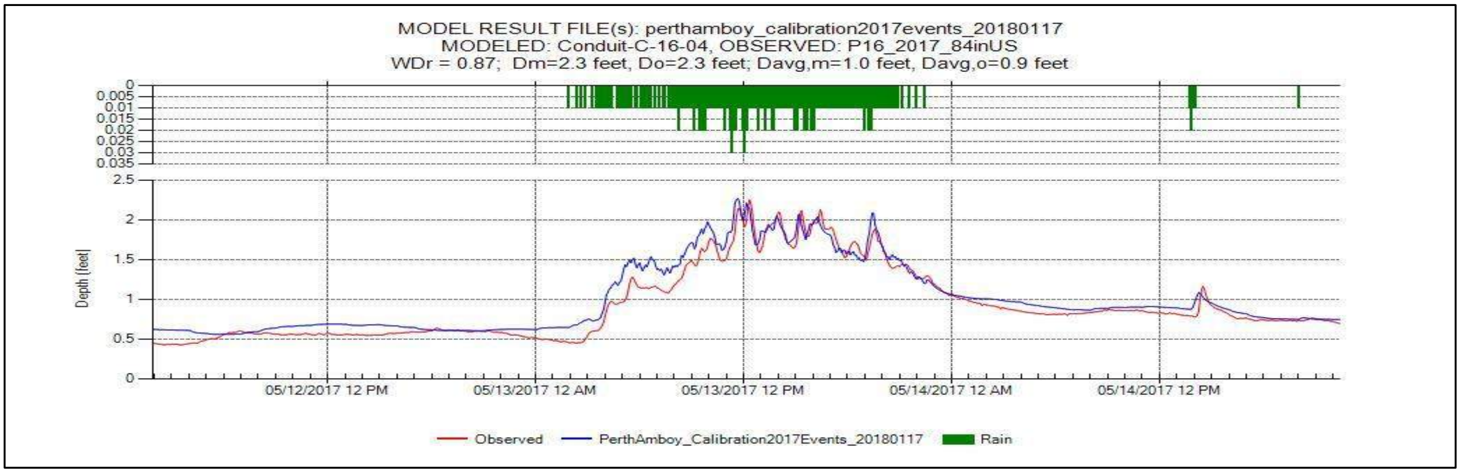
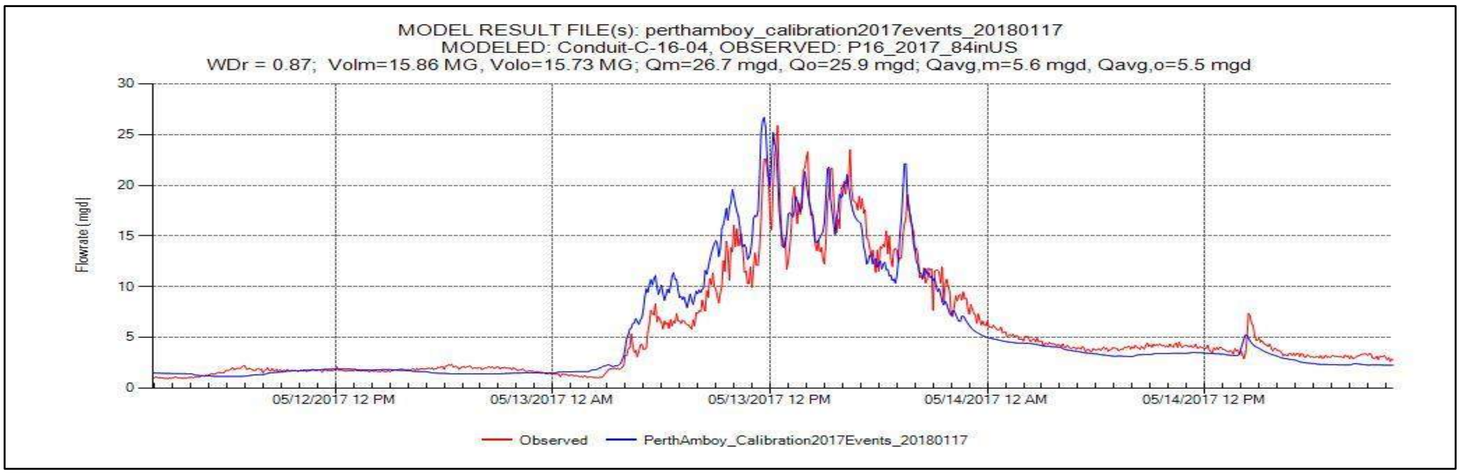
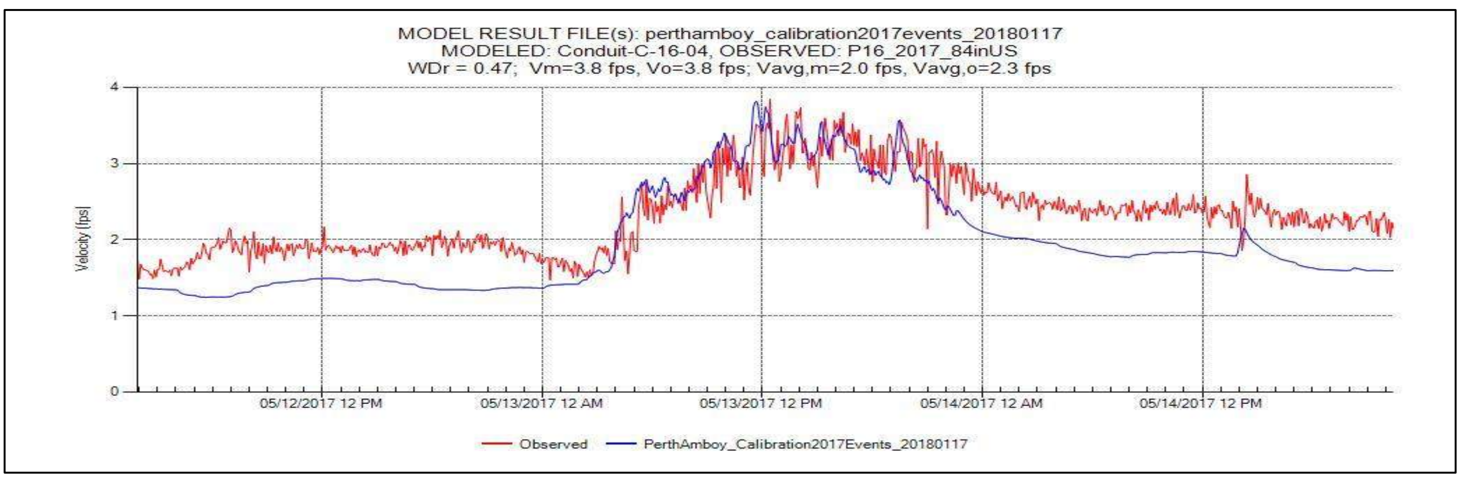
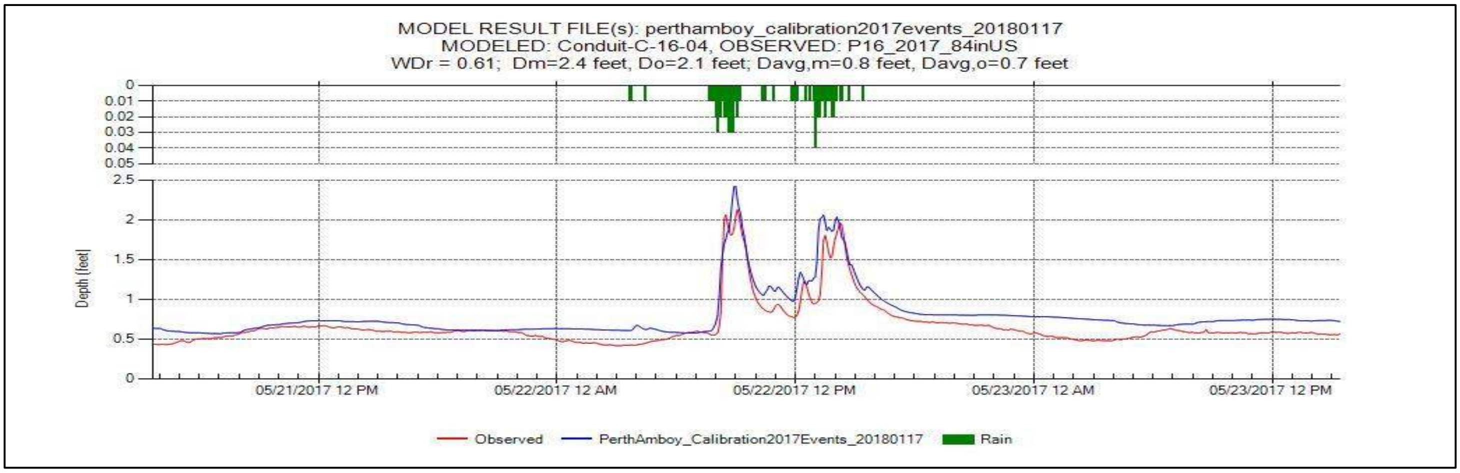
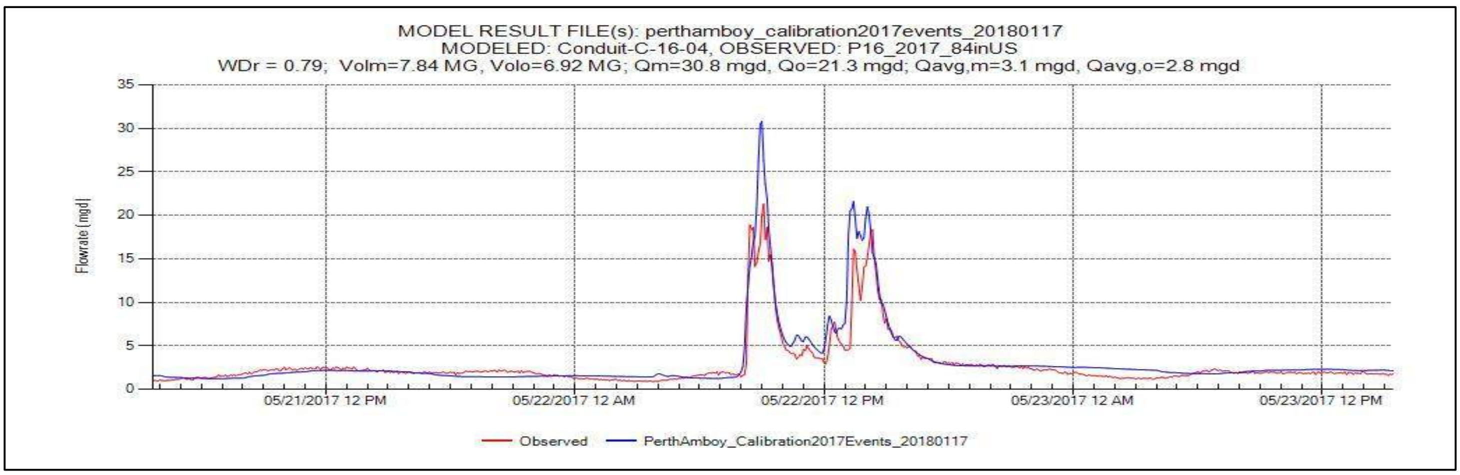


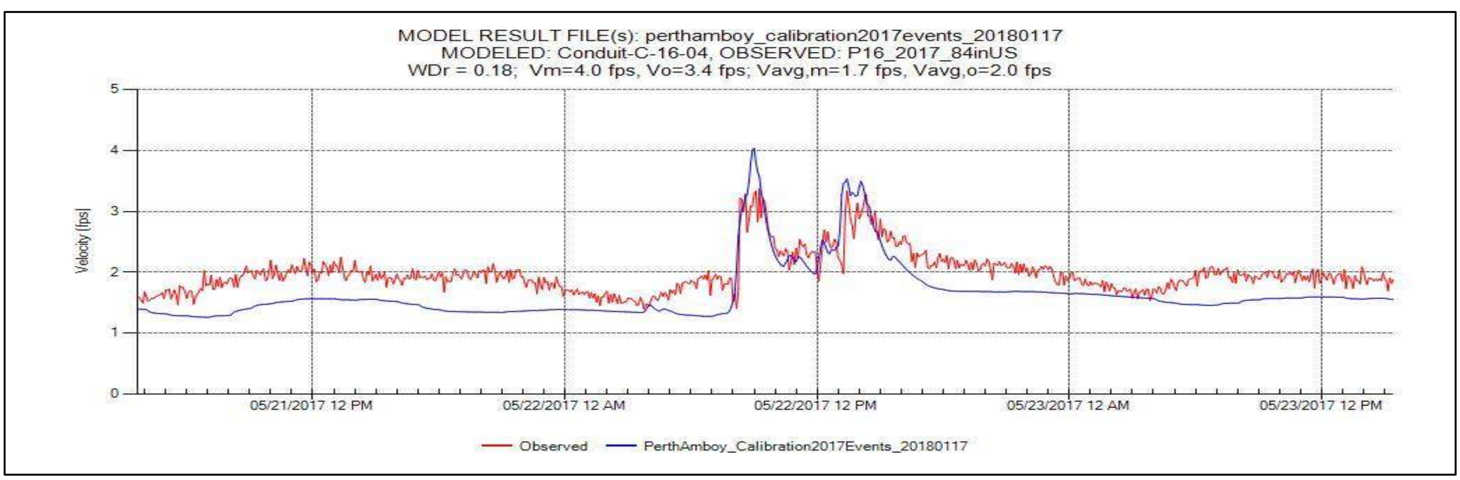




P16_2017_84inUS

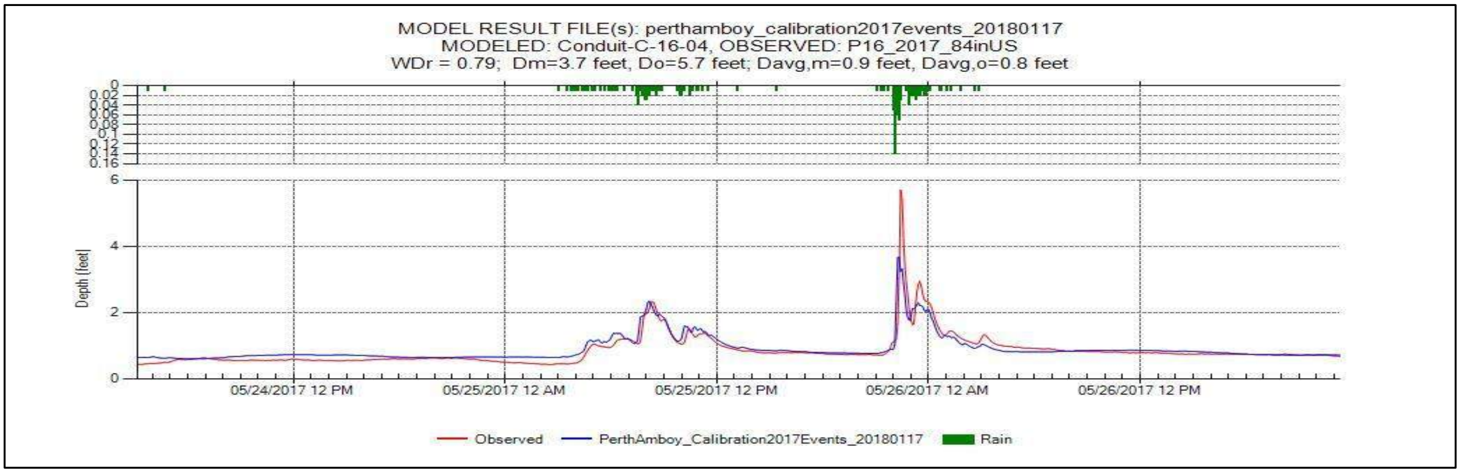


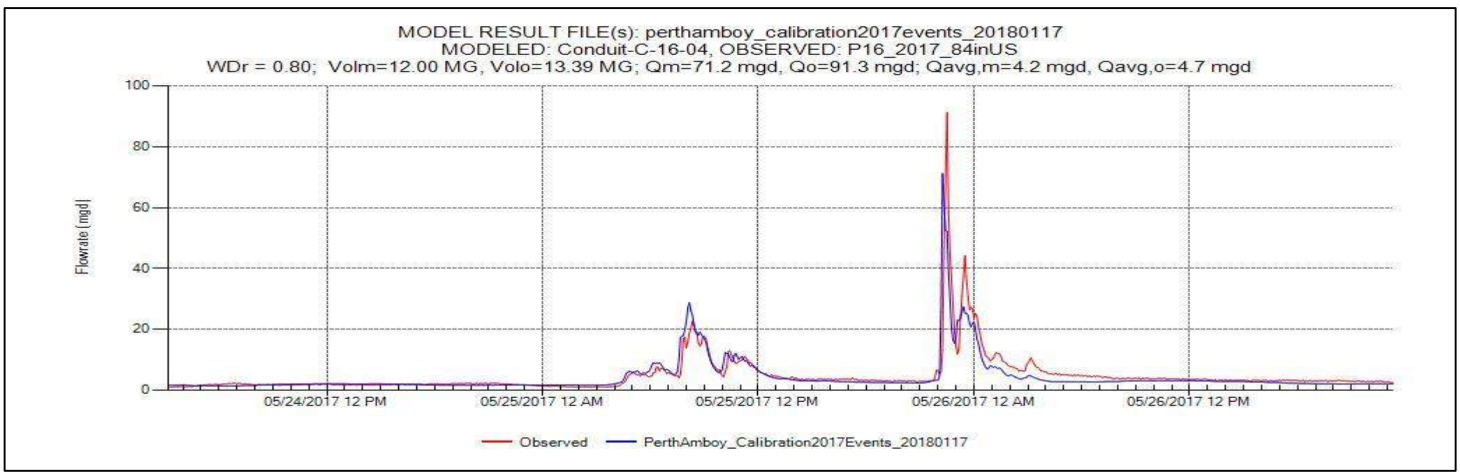


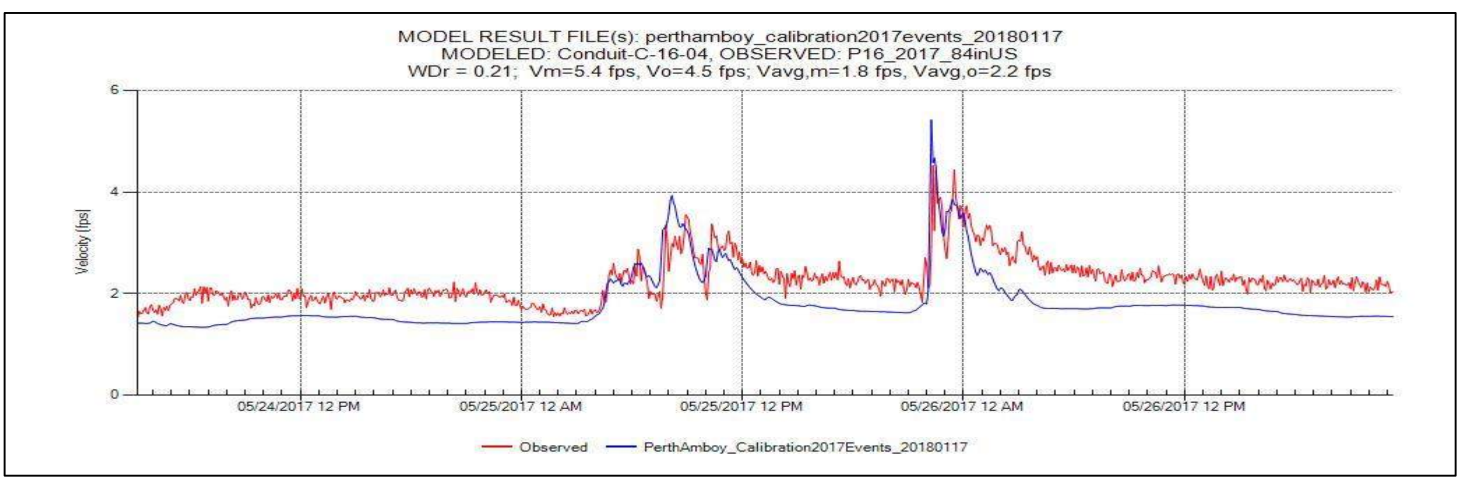


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS

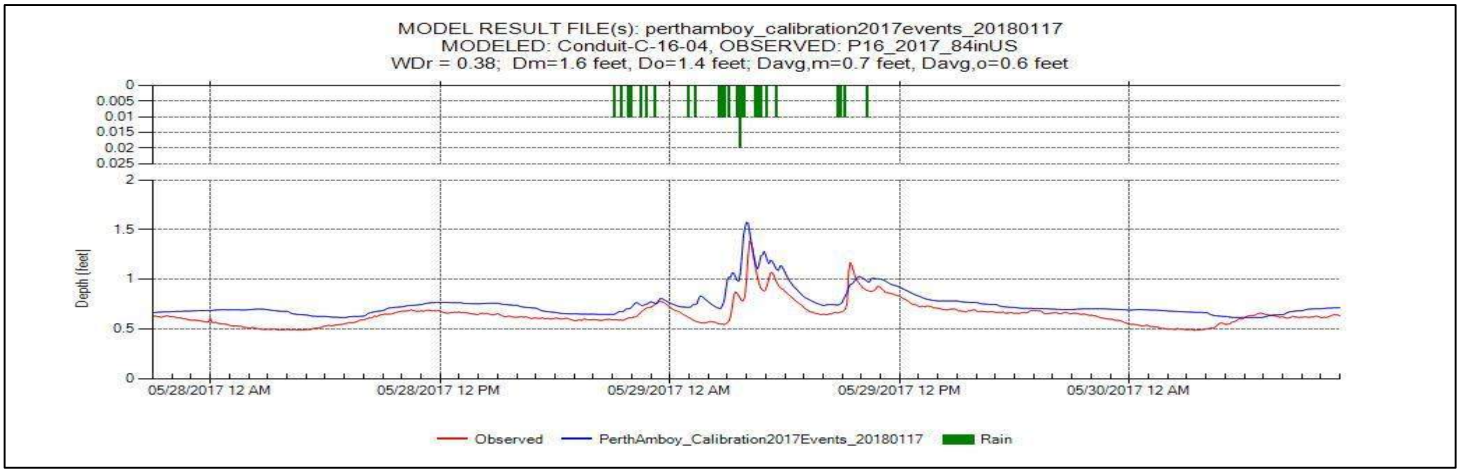


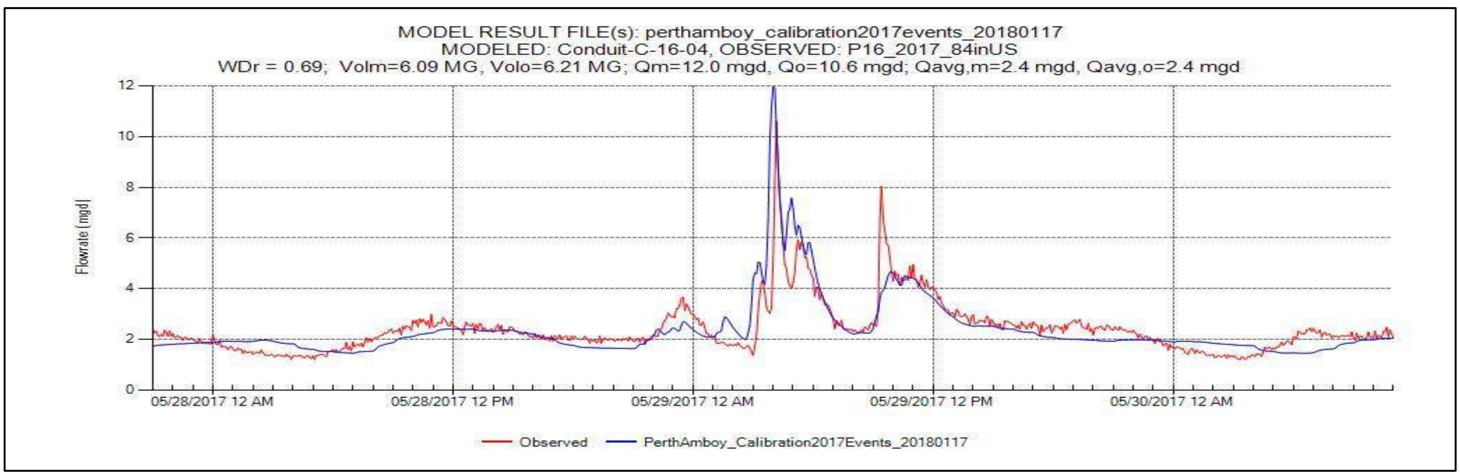


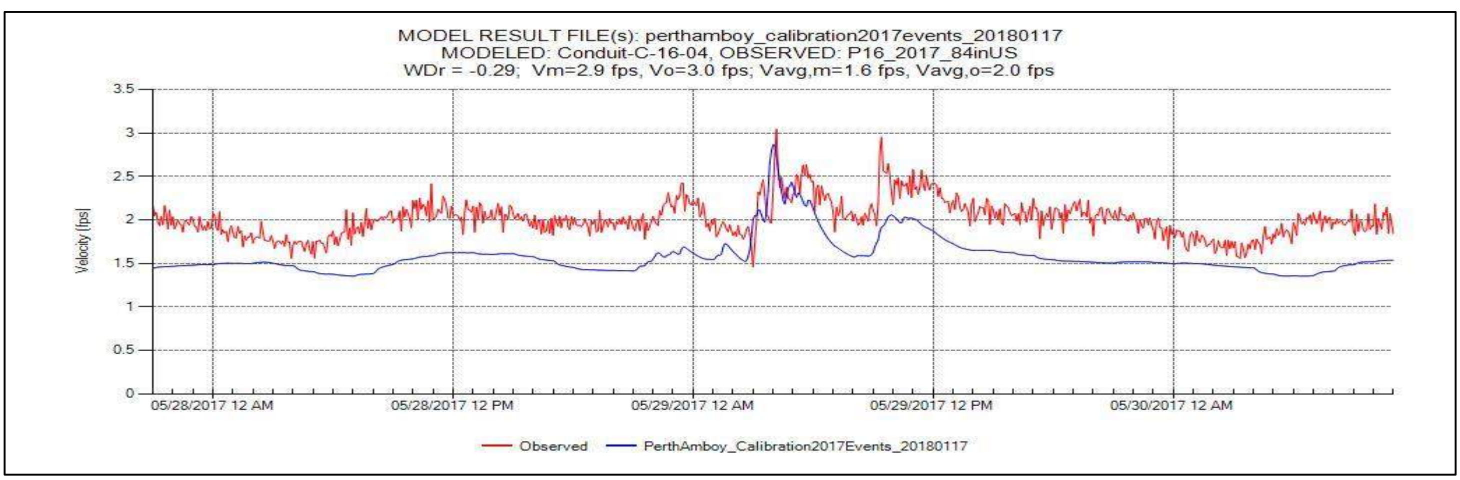


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS

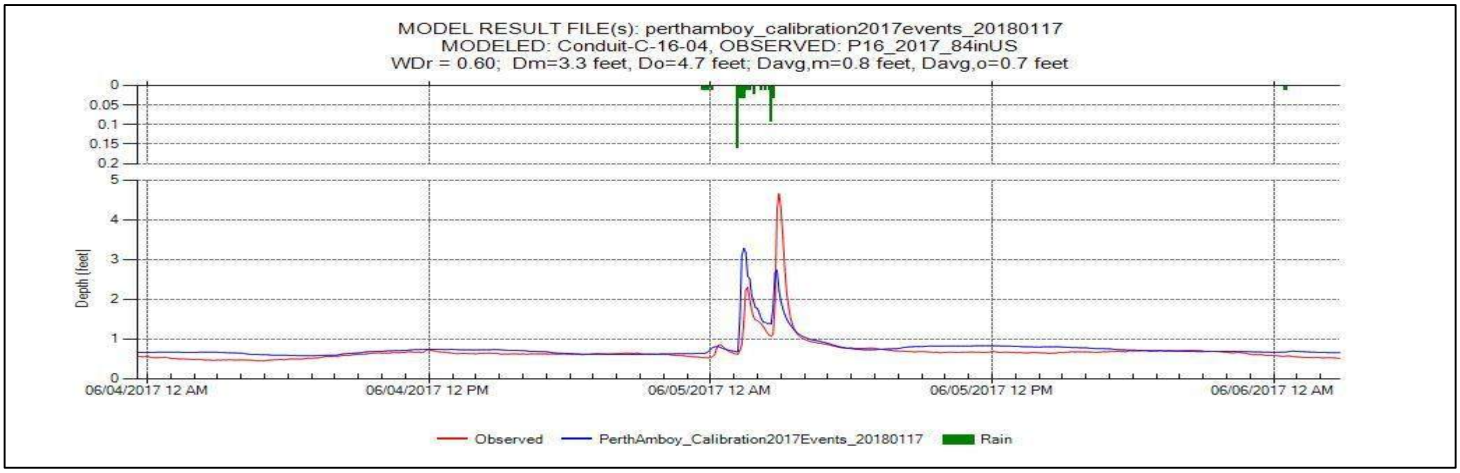


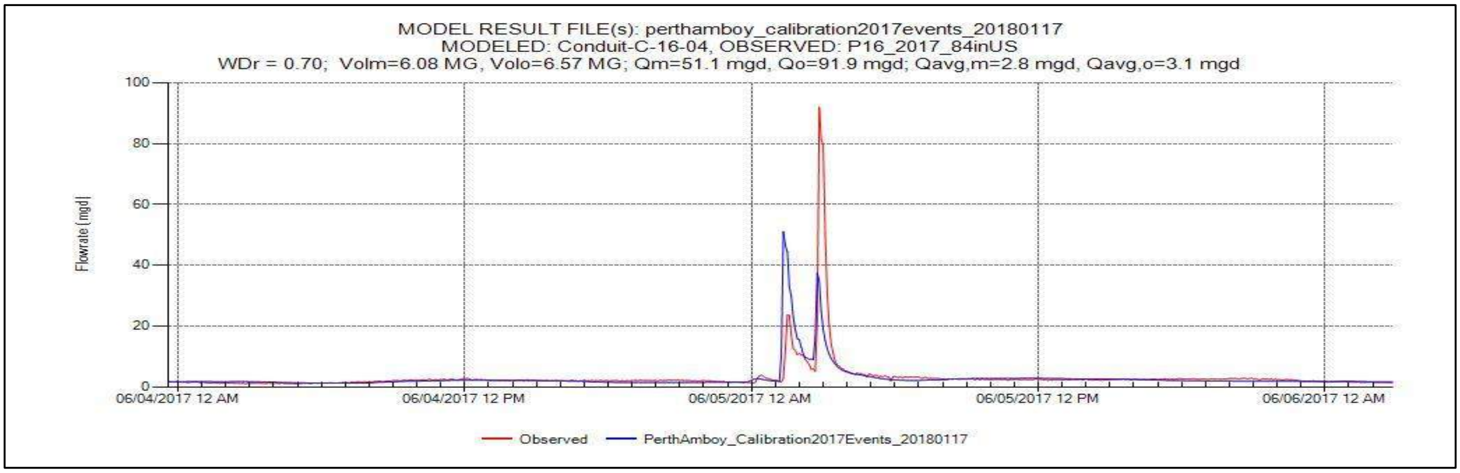


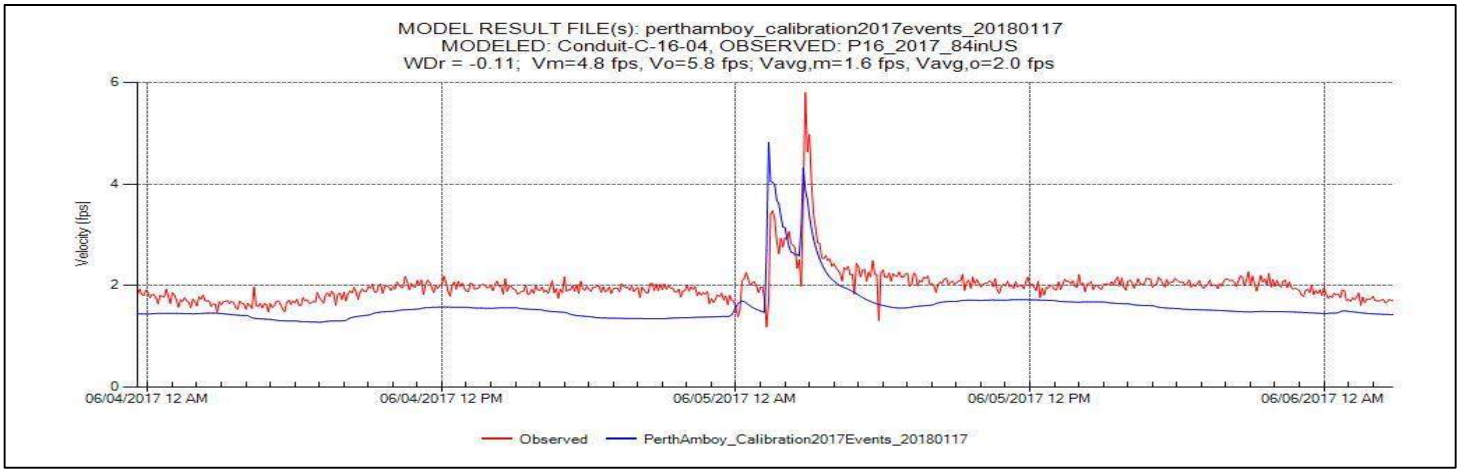


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS

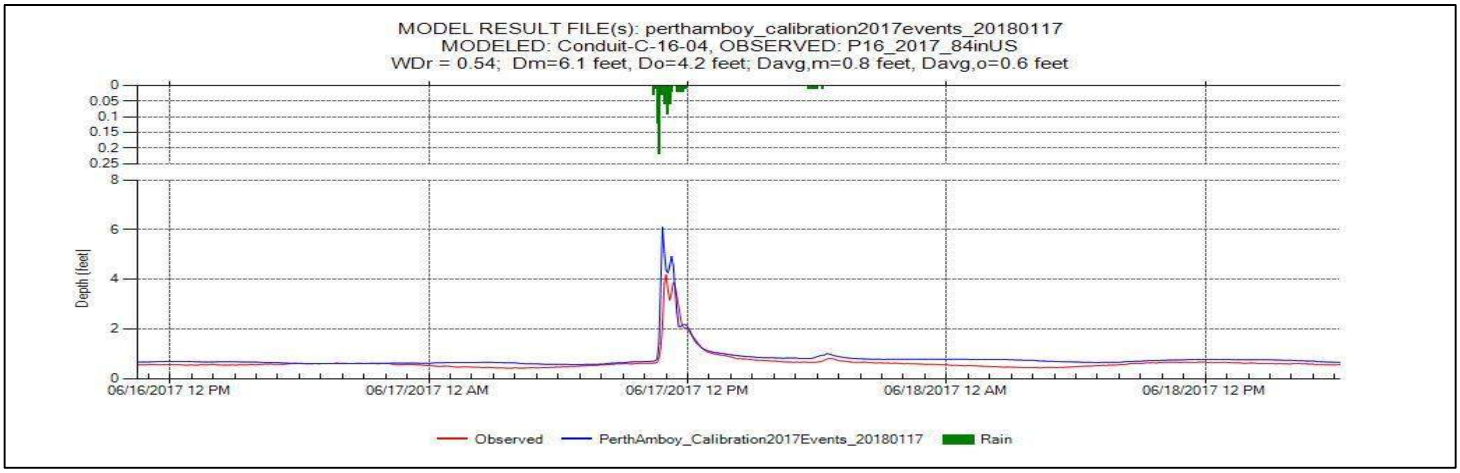


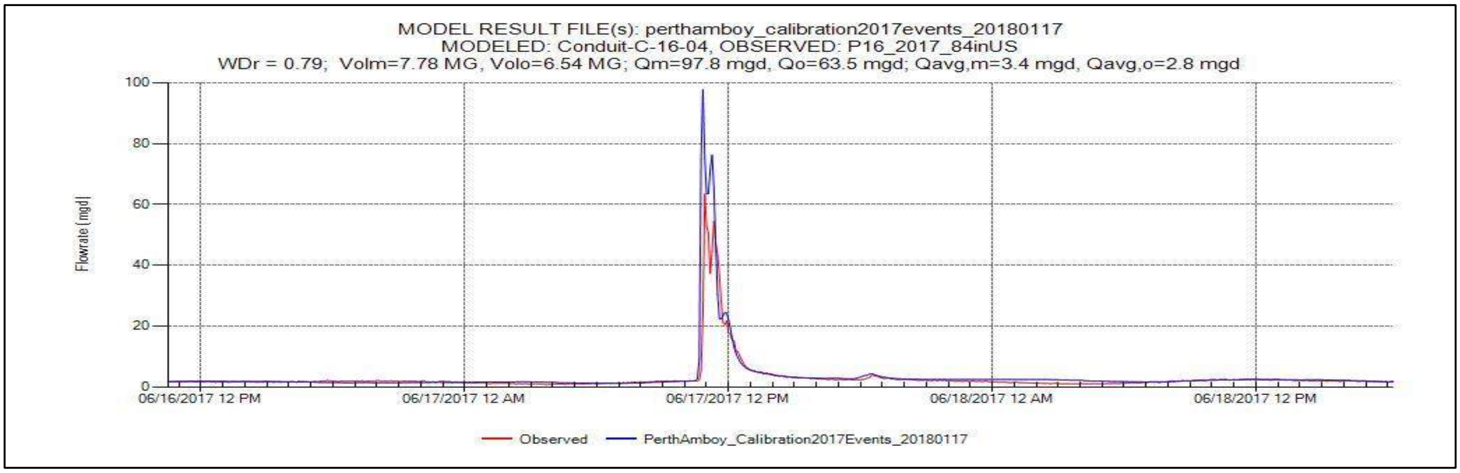


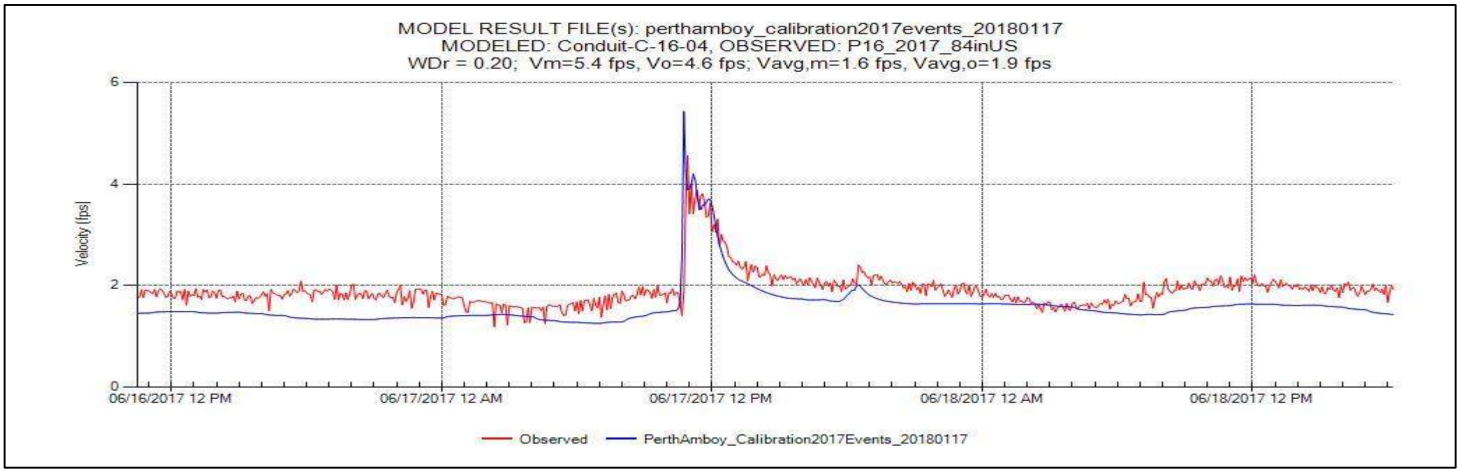


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS

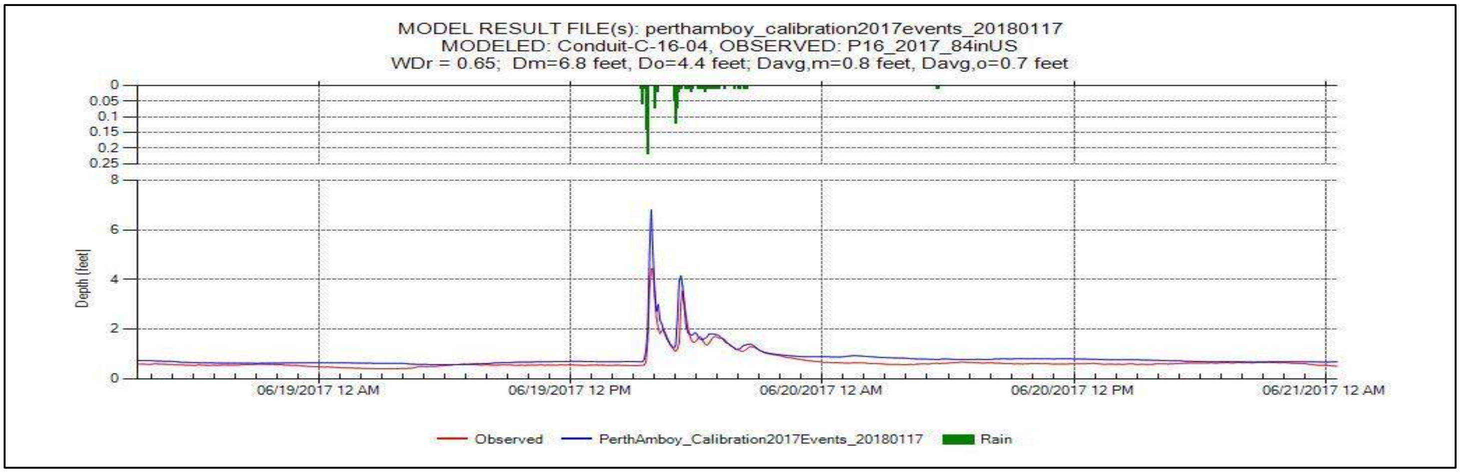


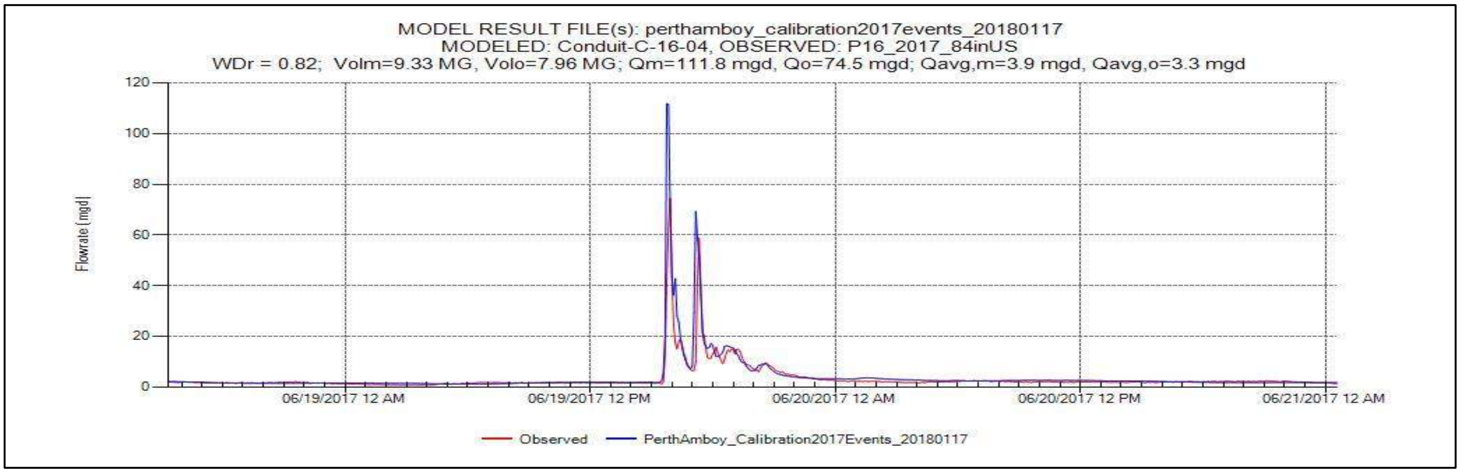


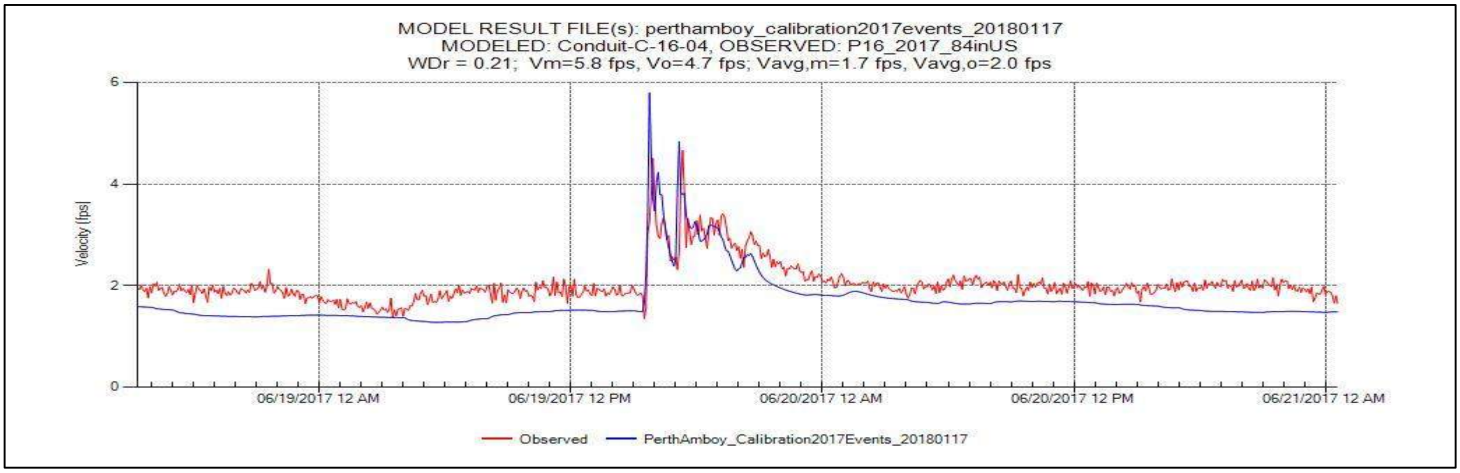


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS







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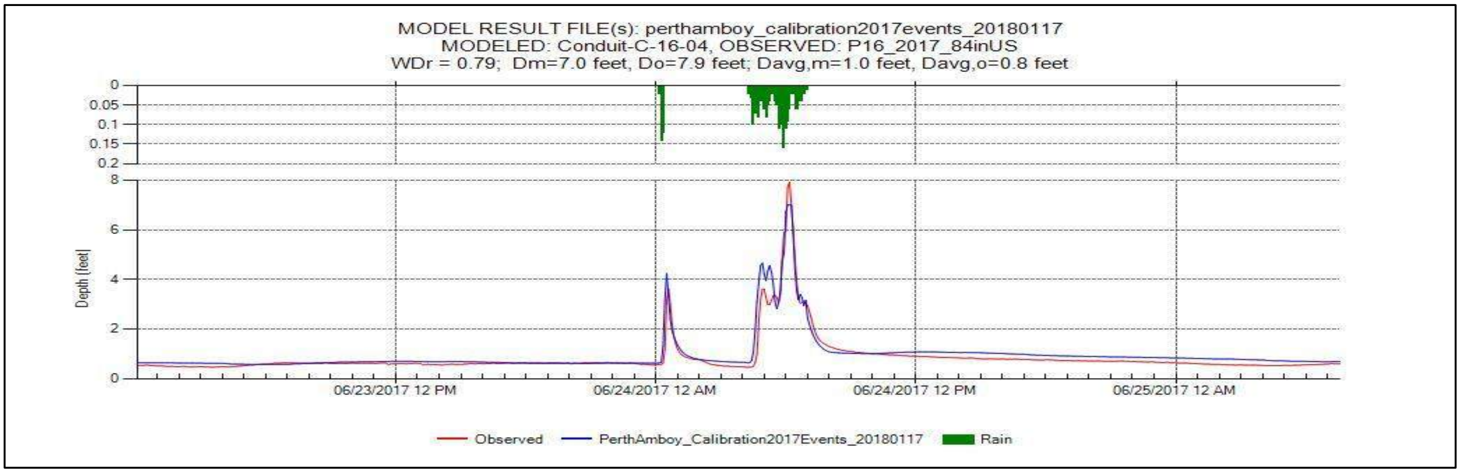
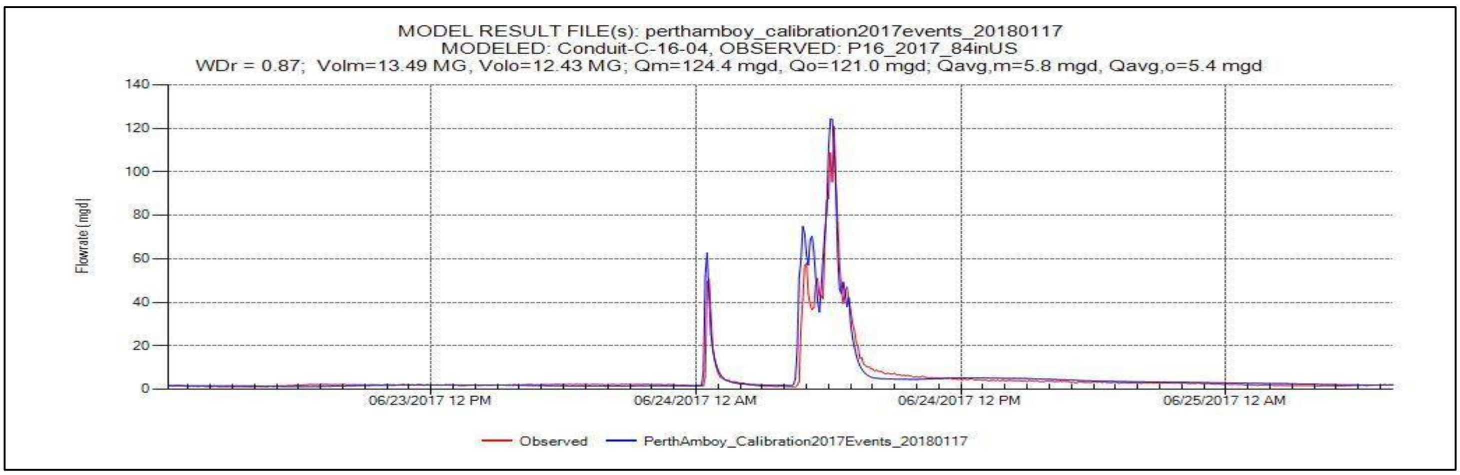
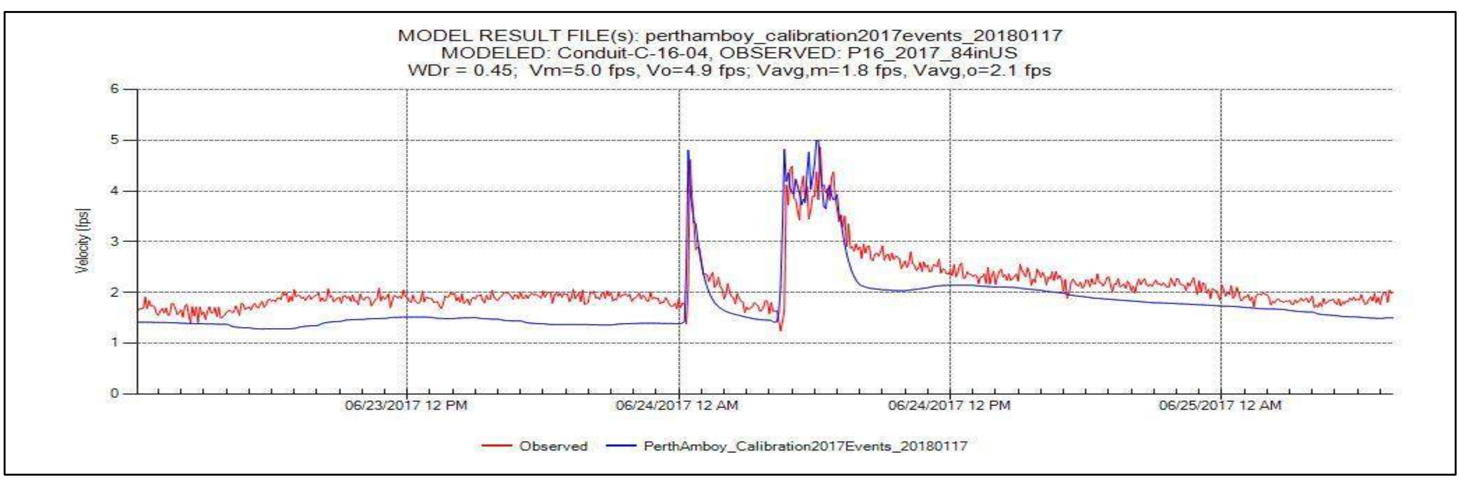
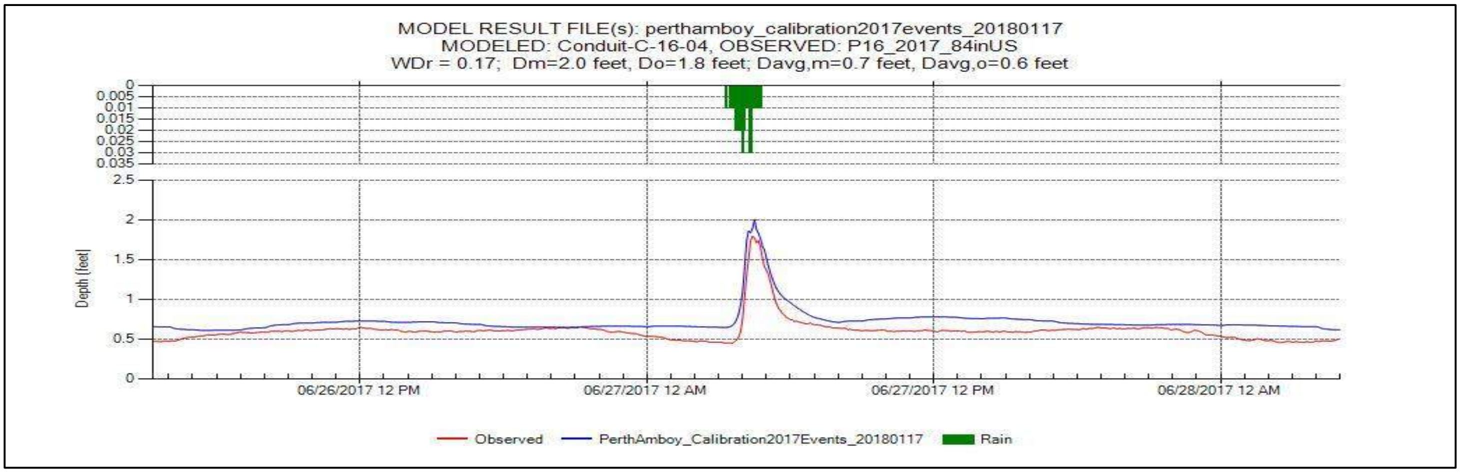


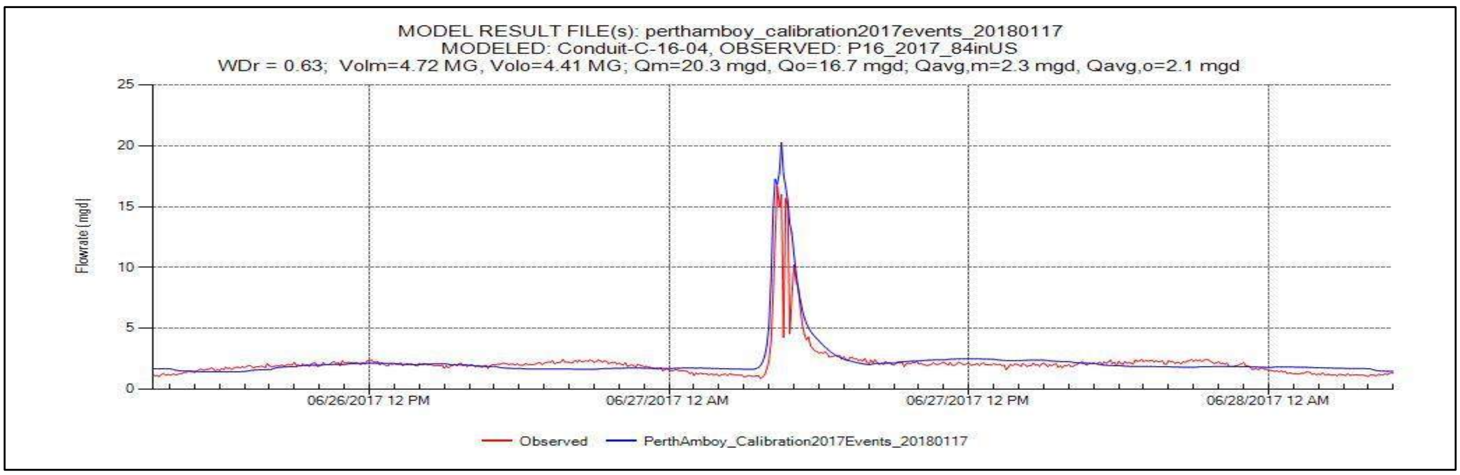


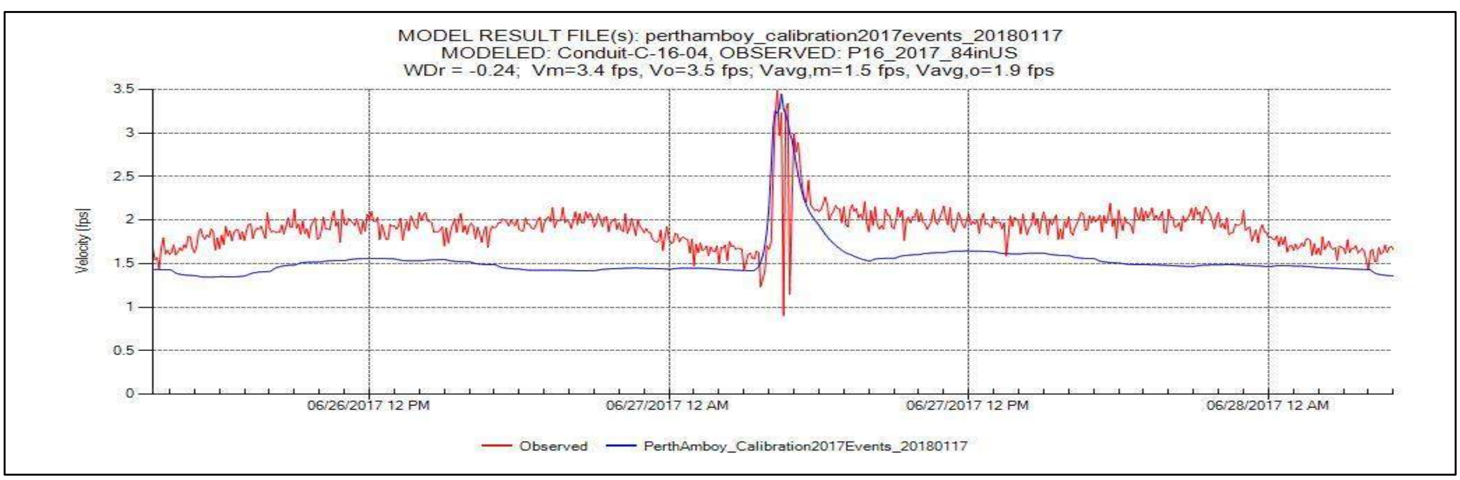


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS







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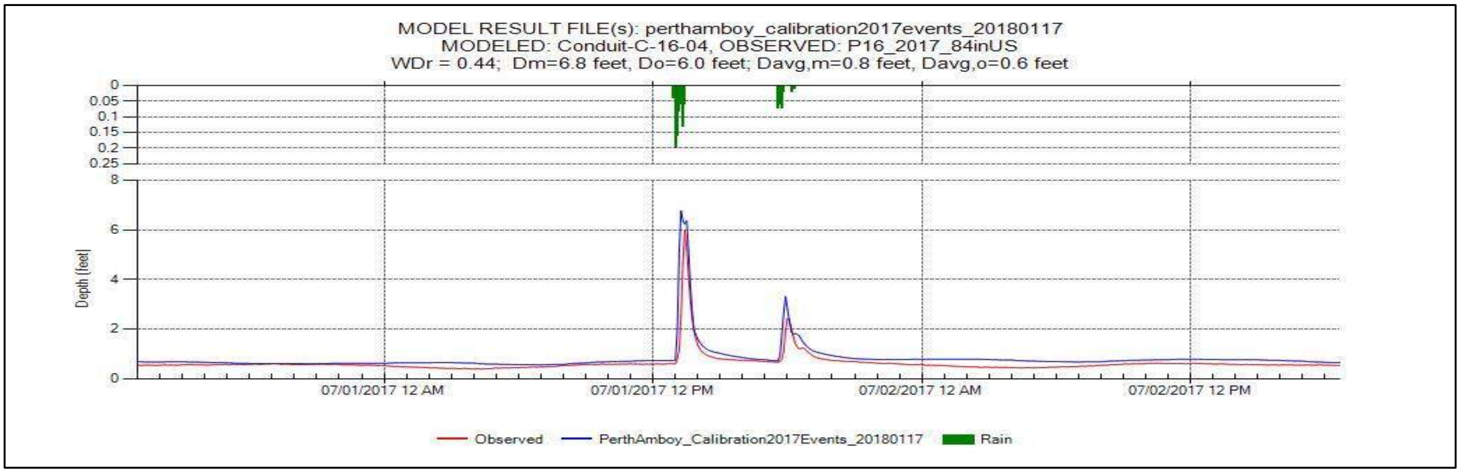
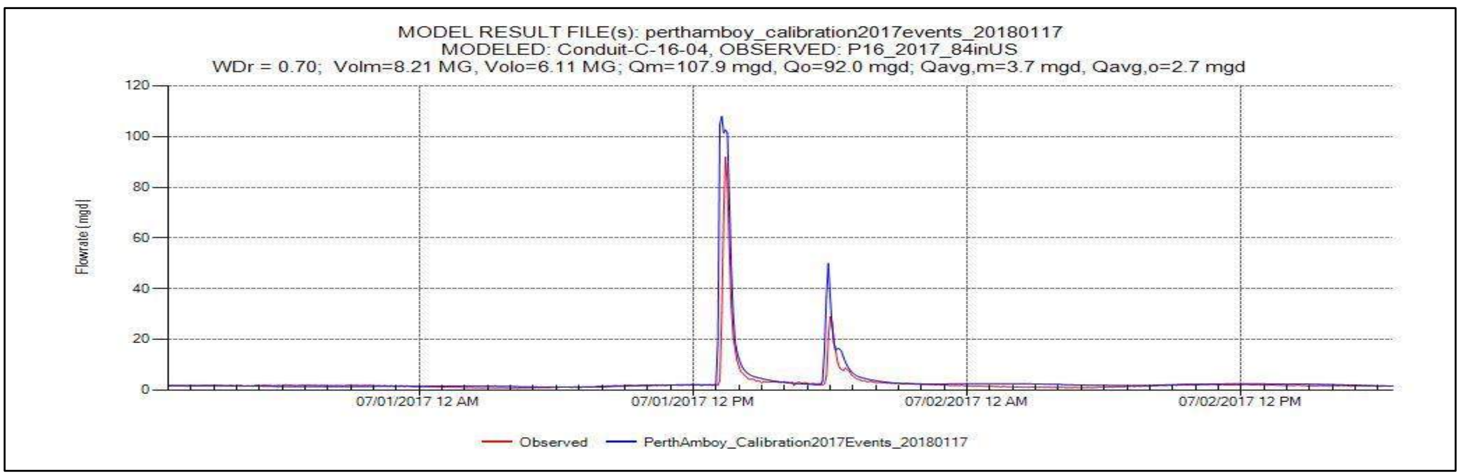
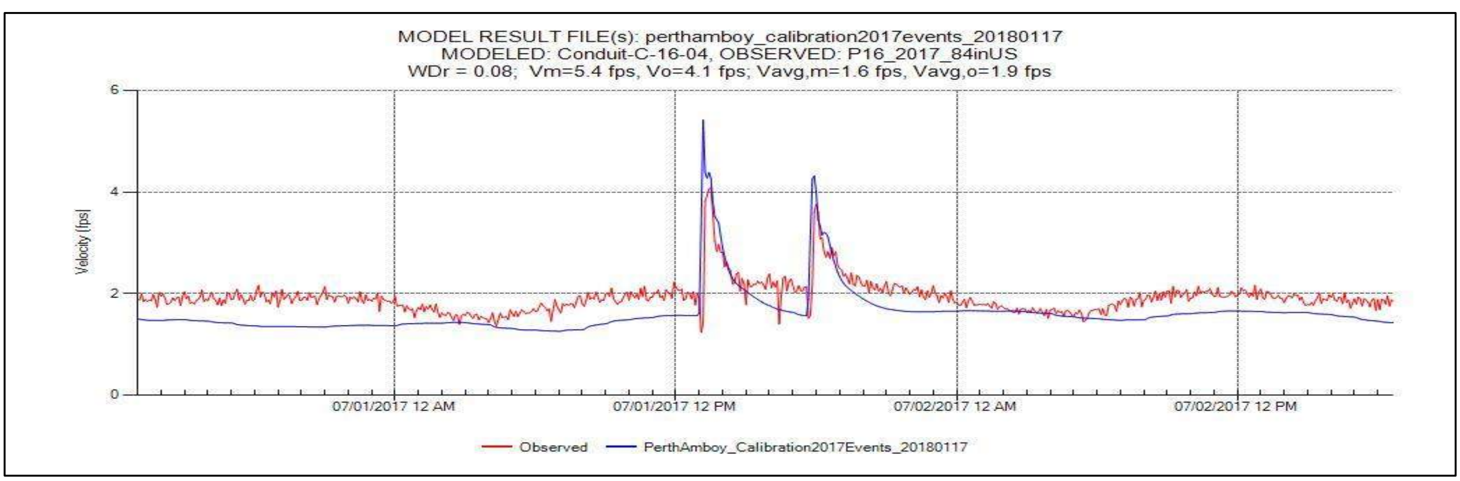
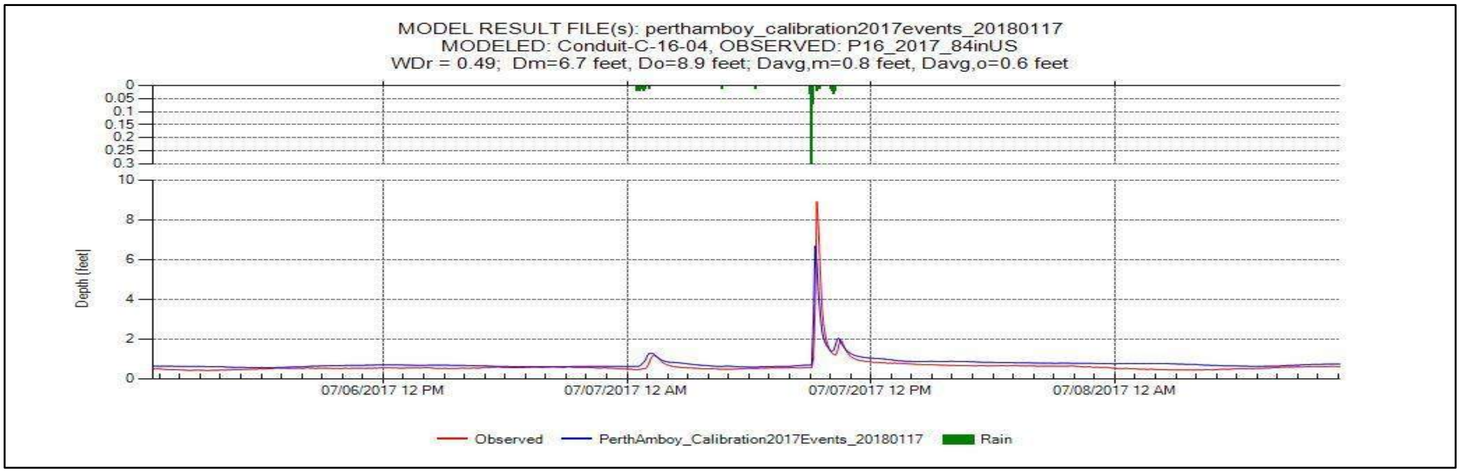


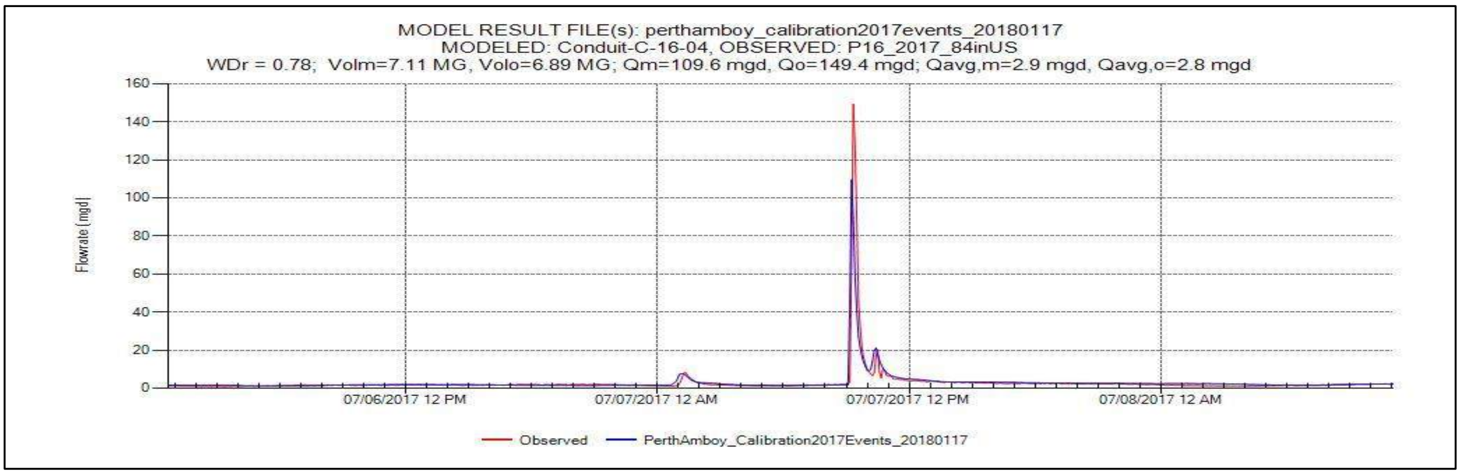


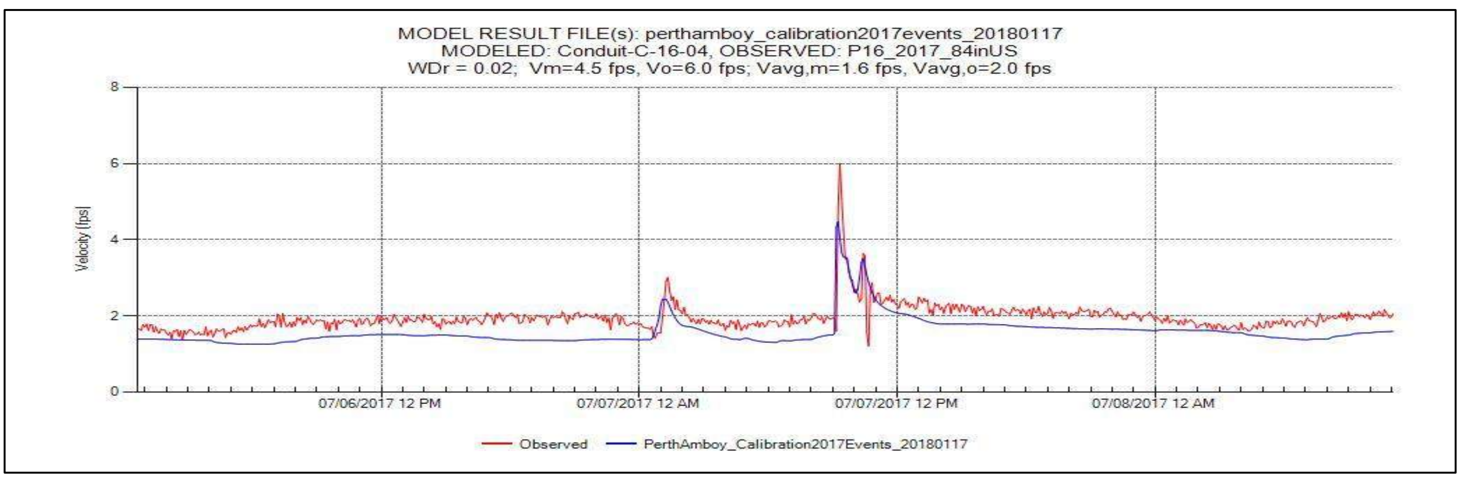


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS







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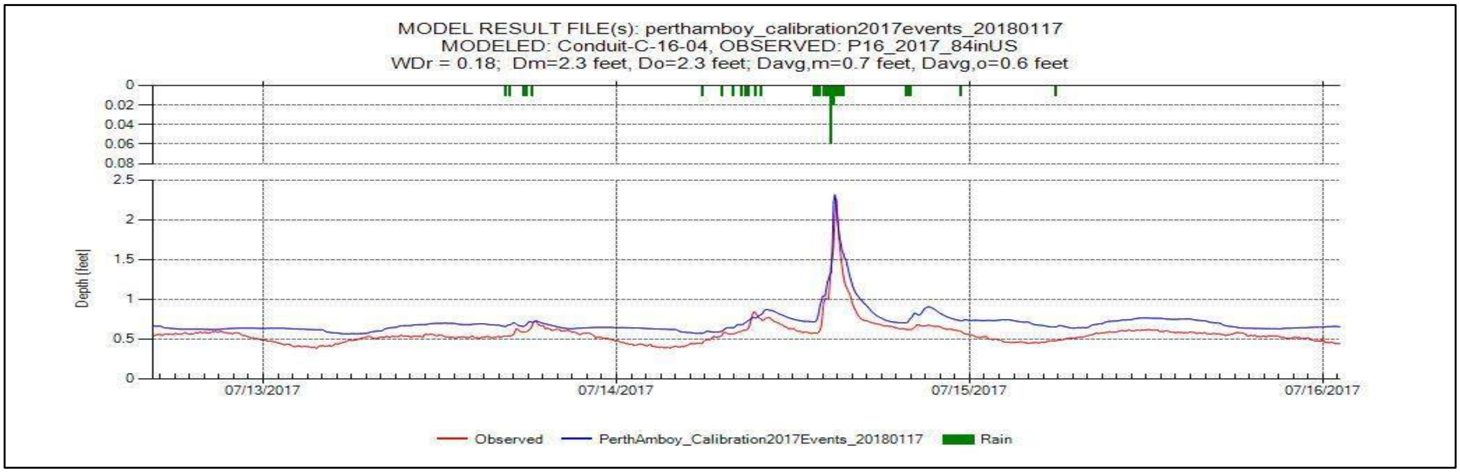
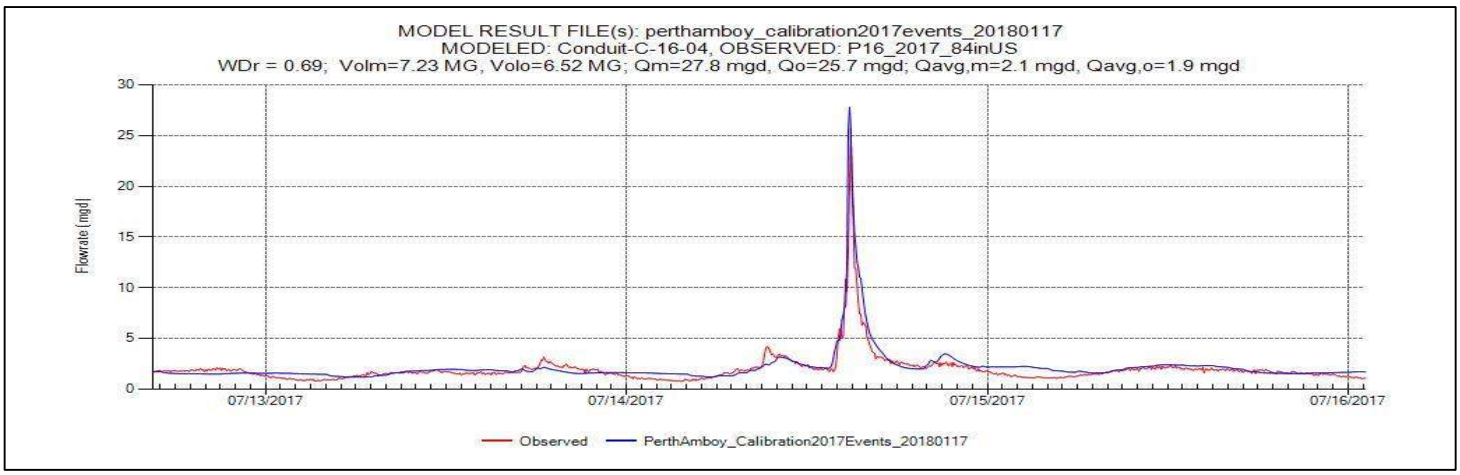
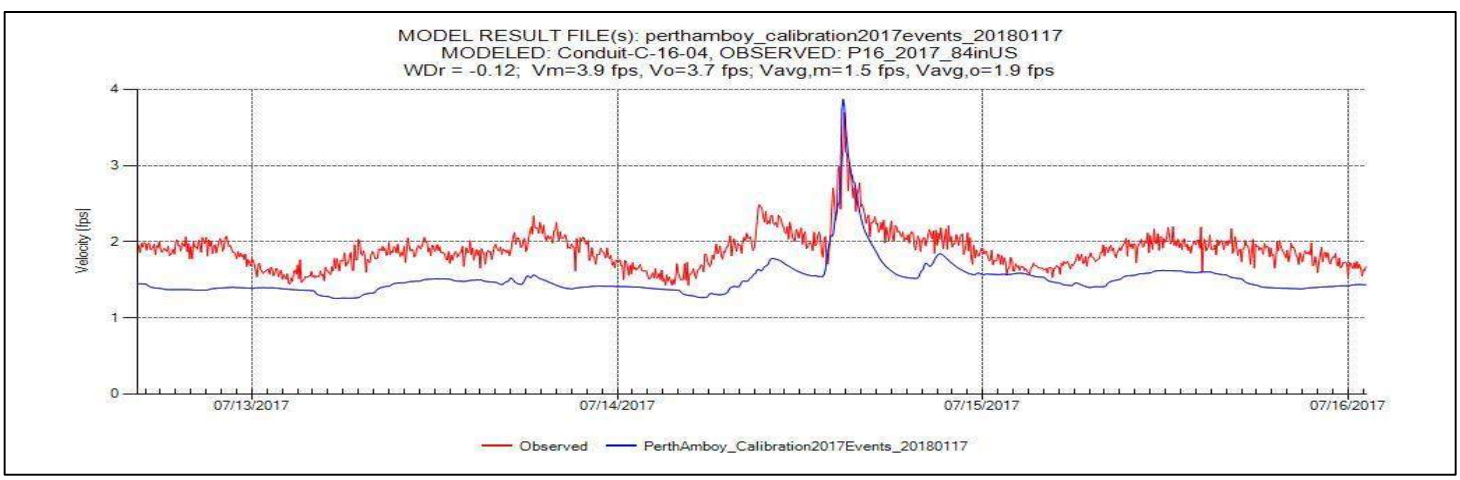
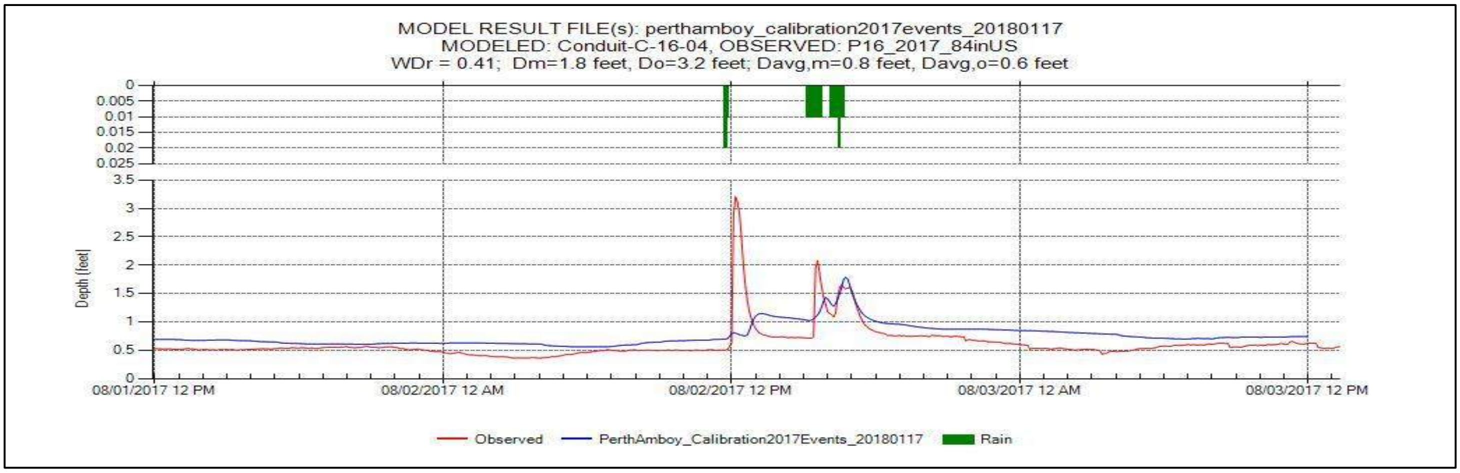


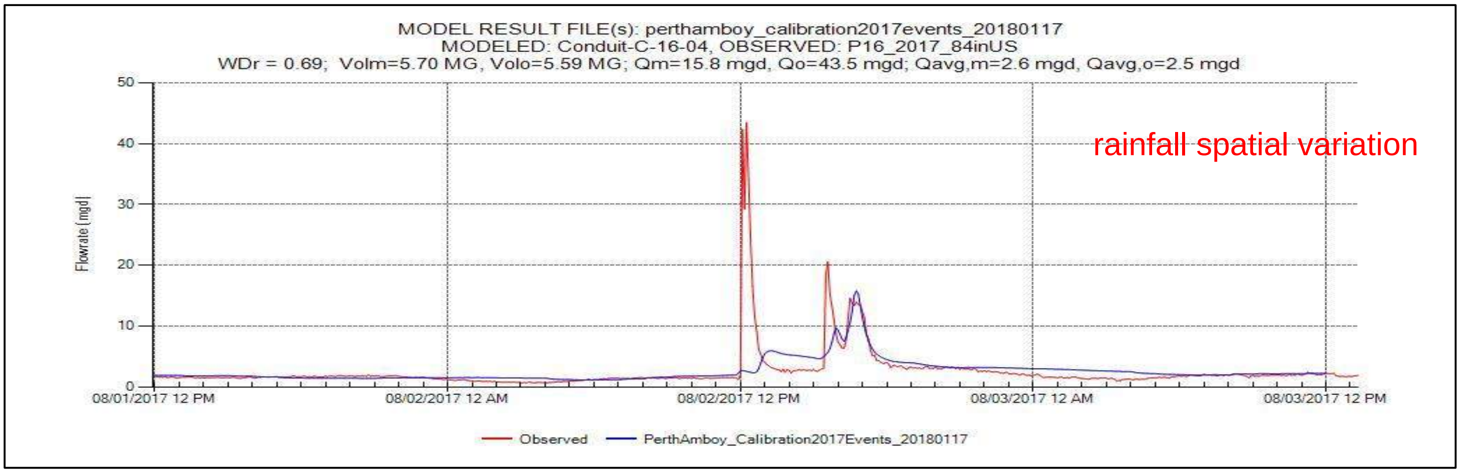


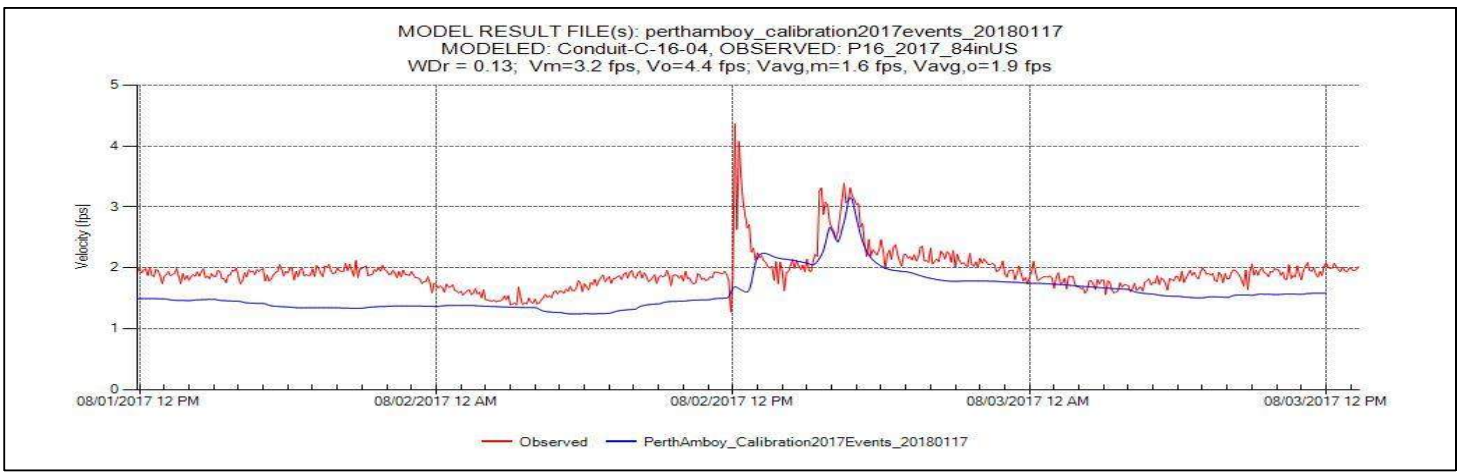


Simulated Versus Observed Flow at Flow Meter Sites

P16_2017_84inUS







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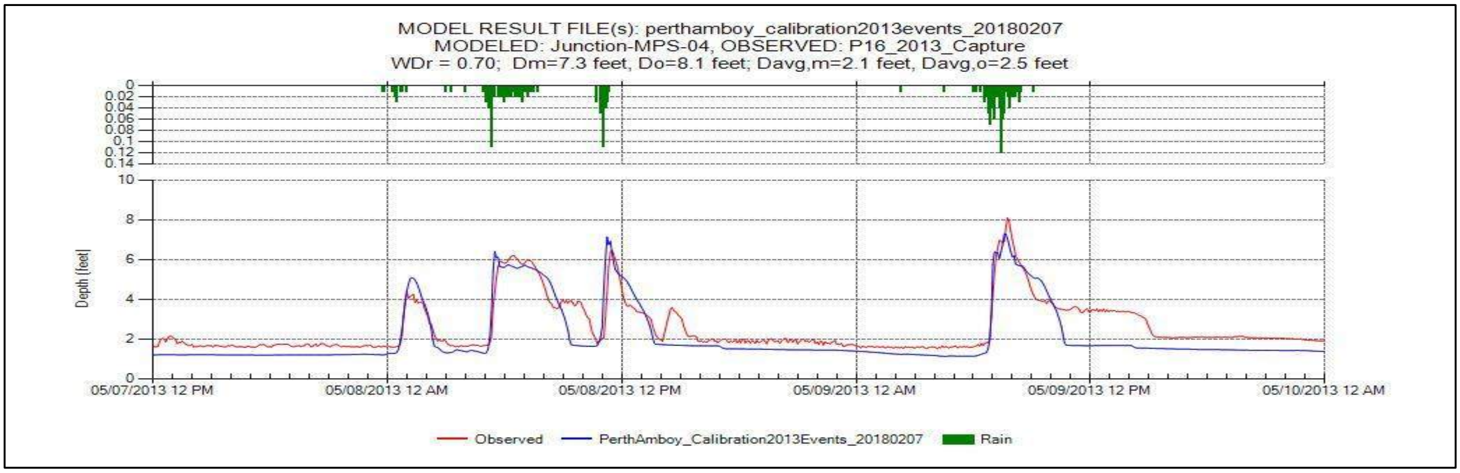

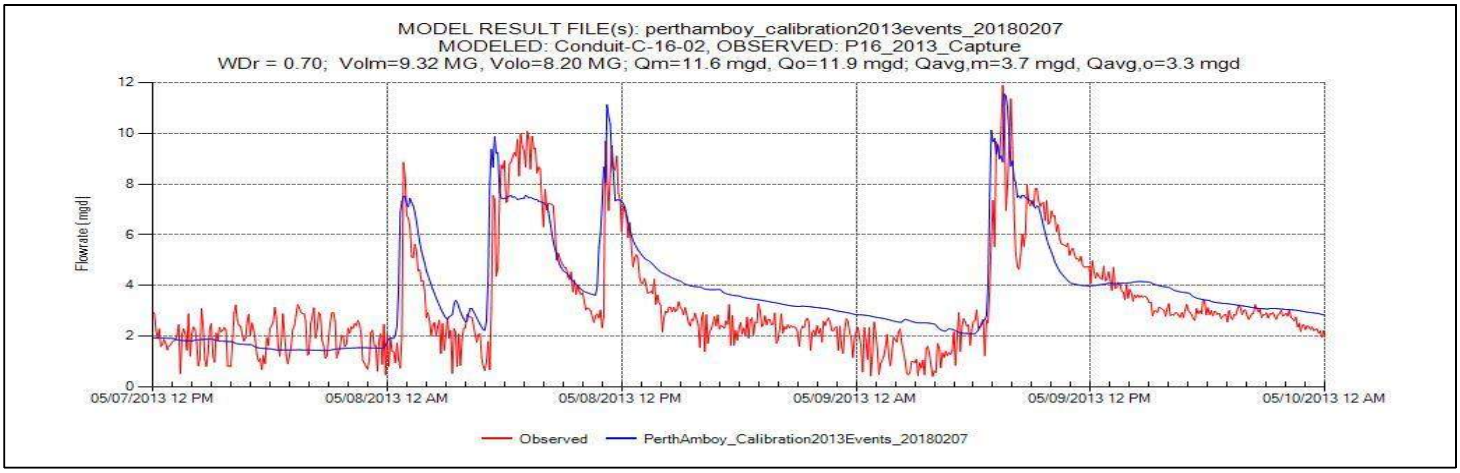

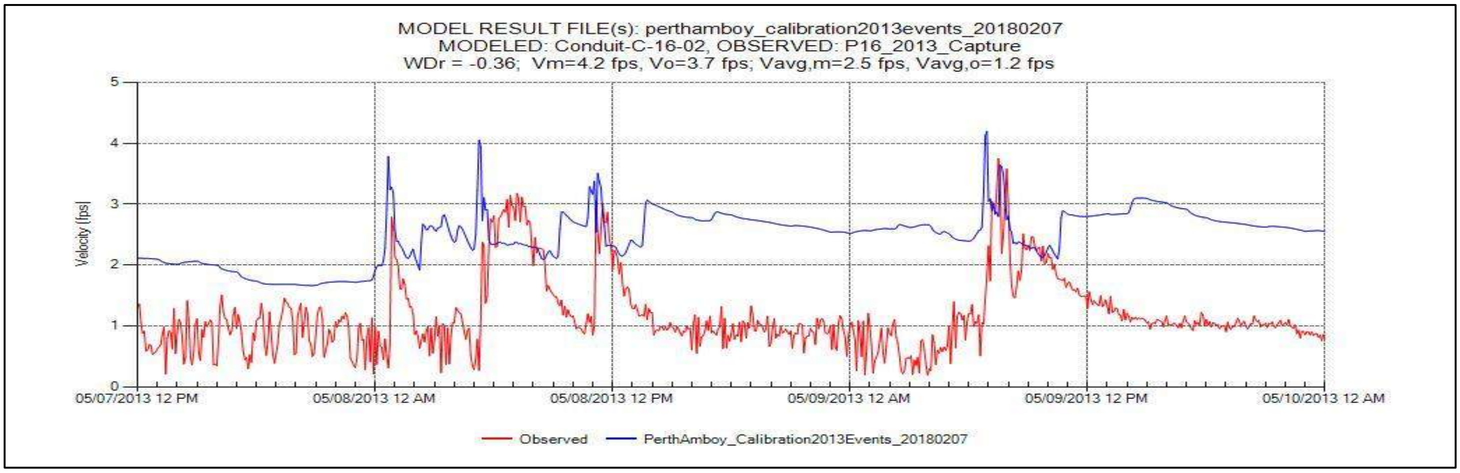

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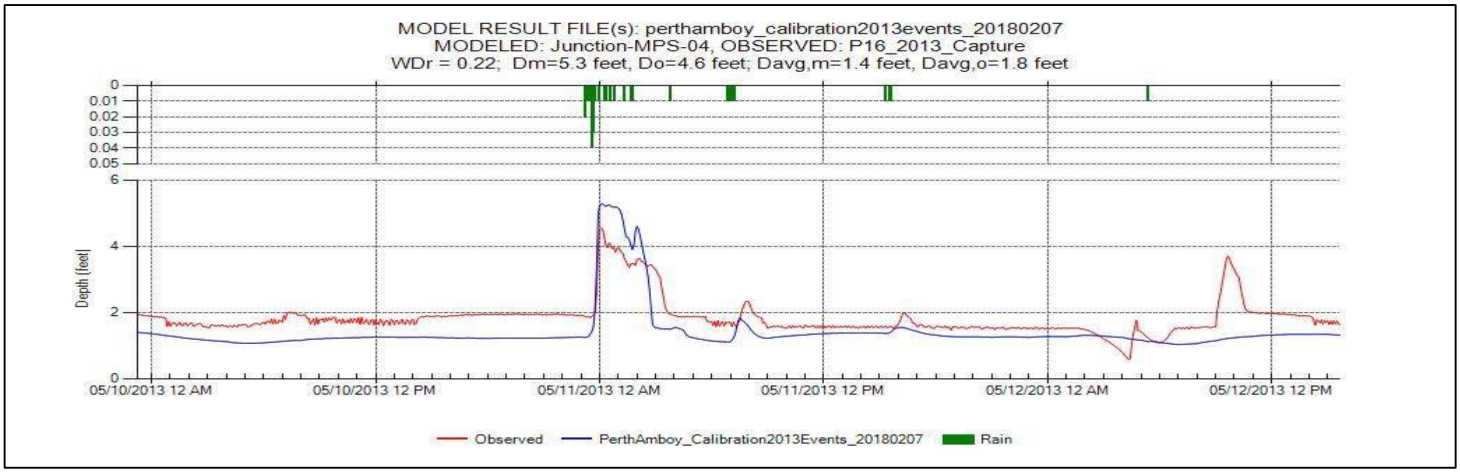
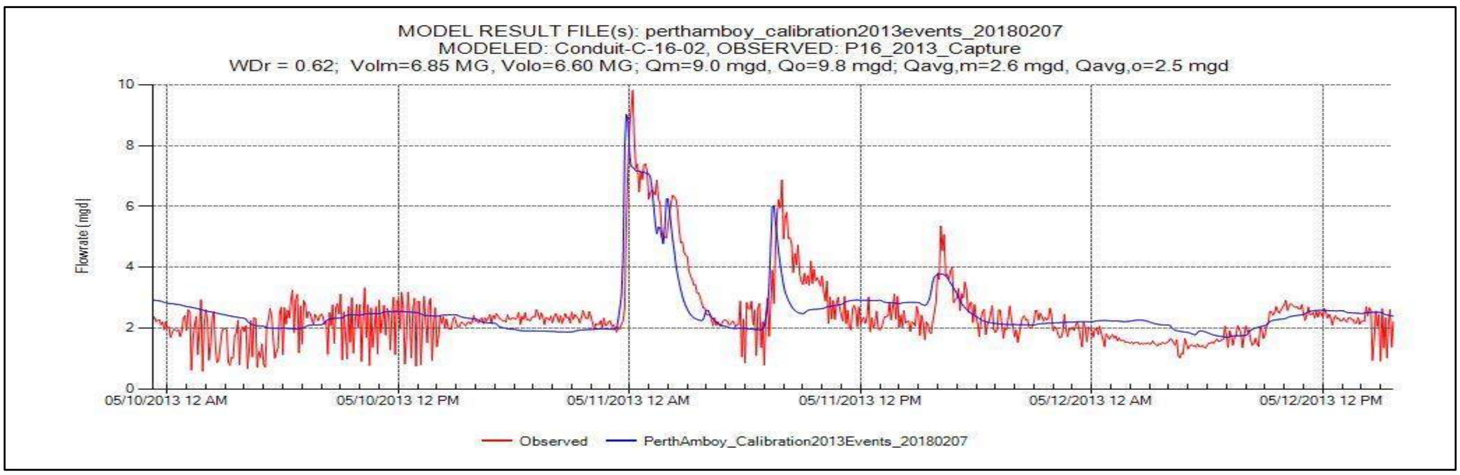
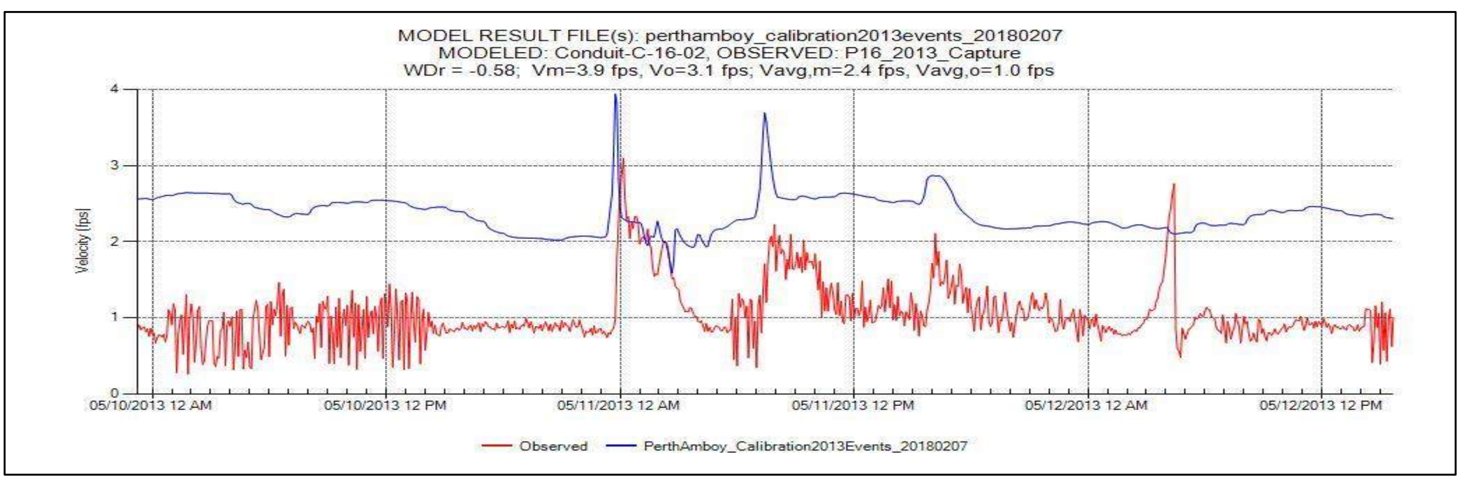
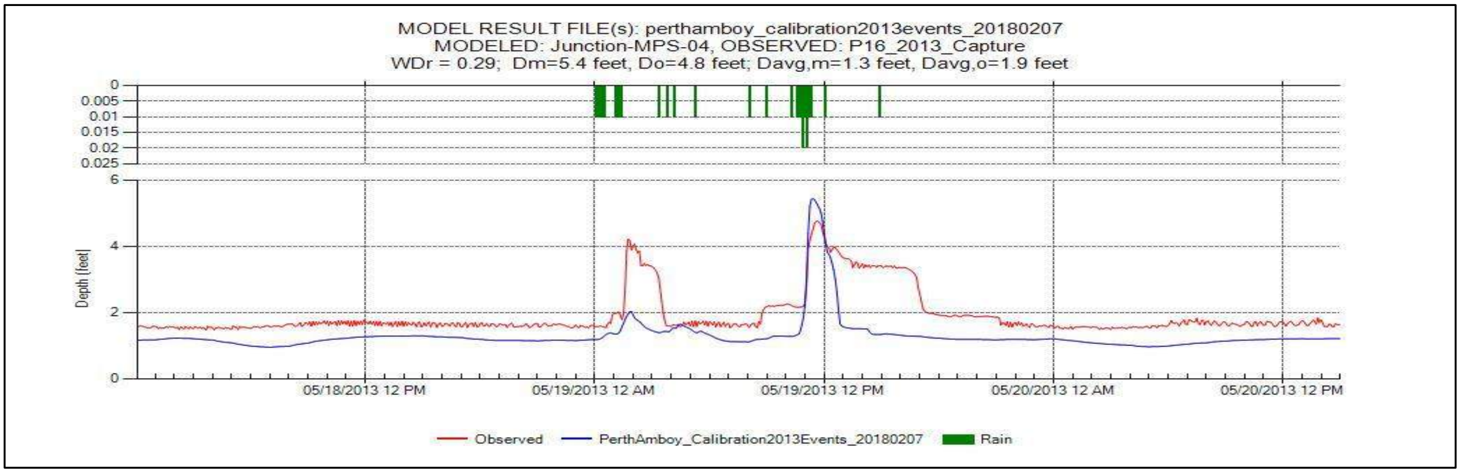


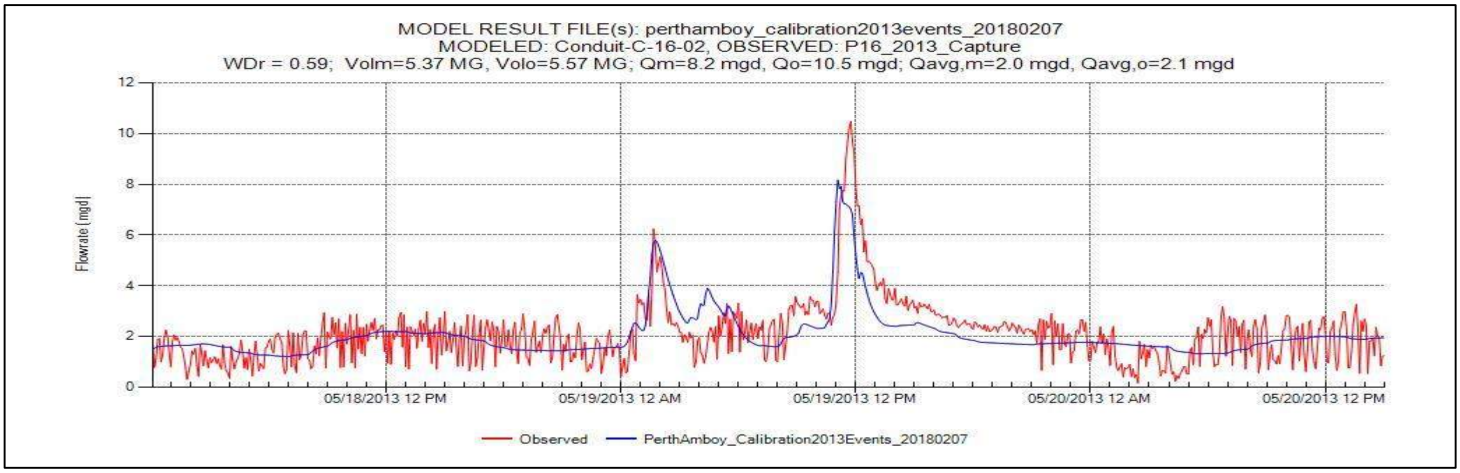


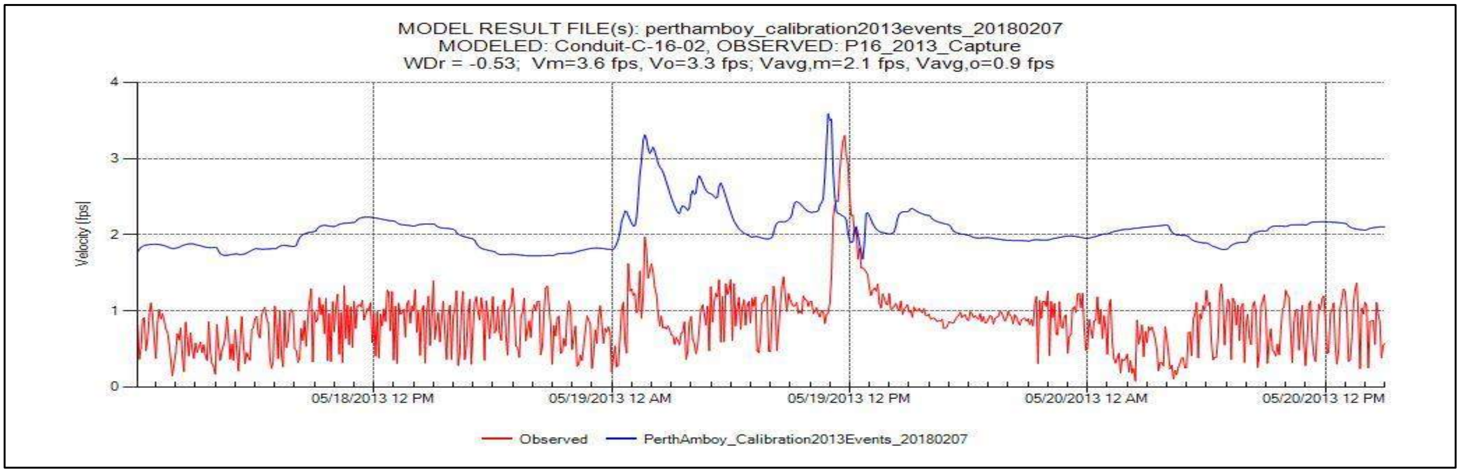


Simulated Versus Observed Flow at Flow Meter Sites

P16_2013_Capture







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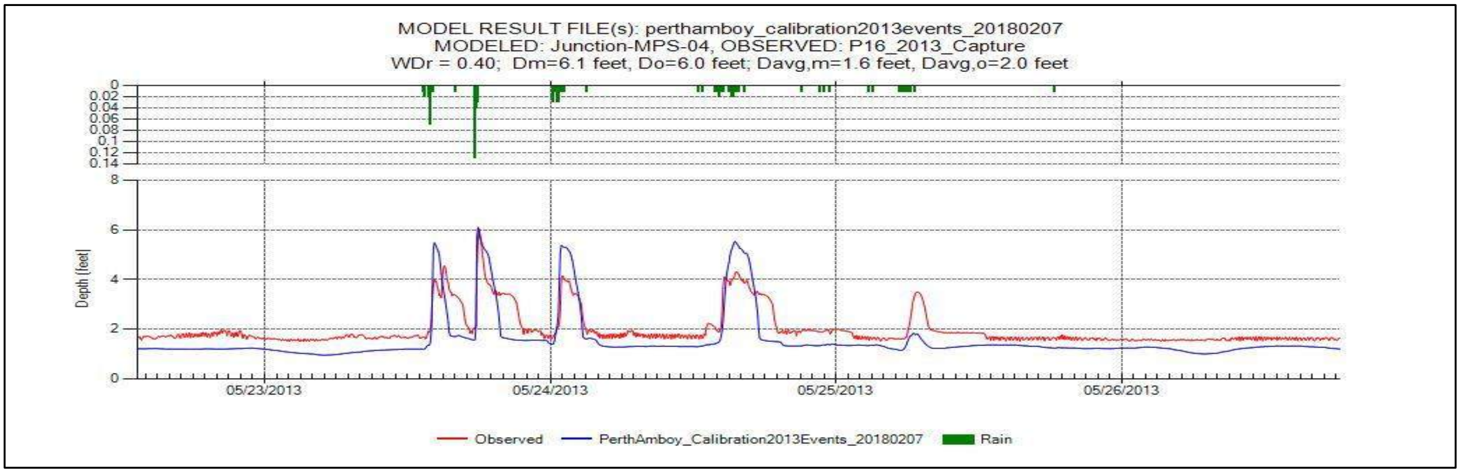

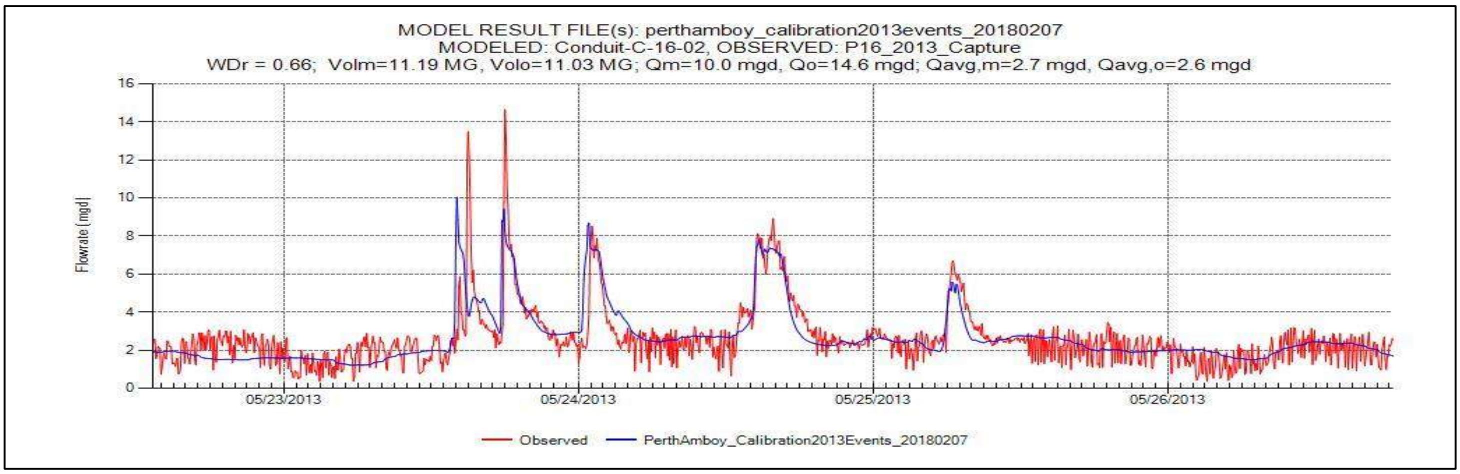

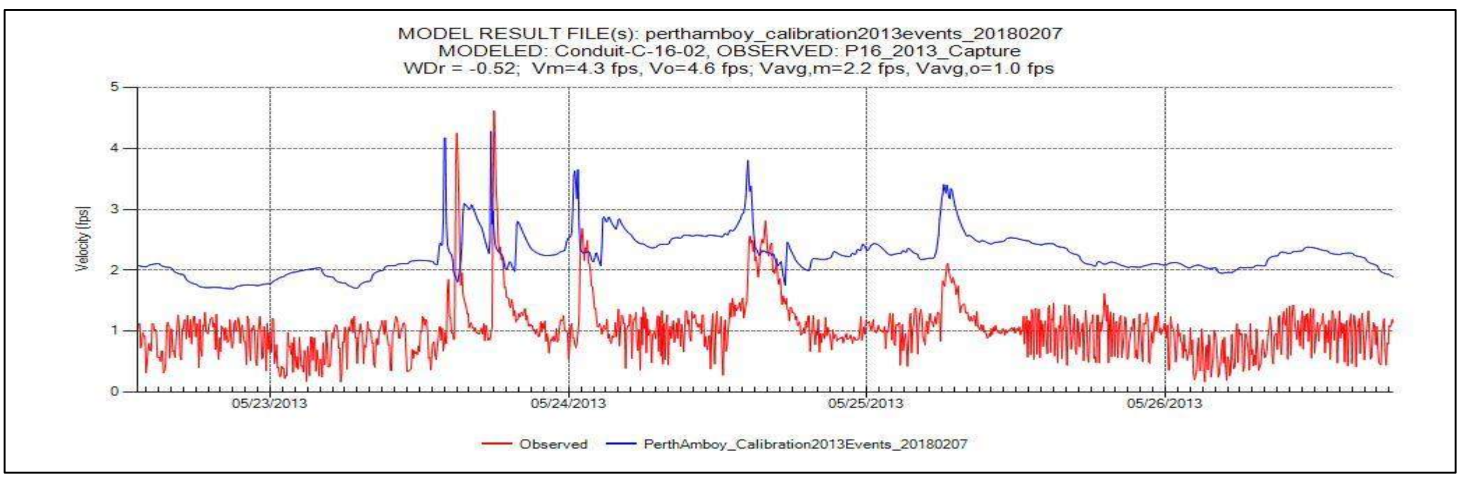

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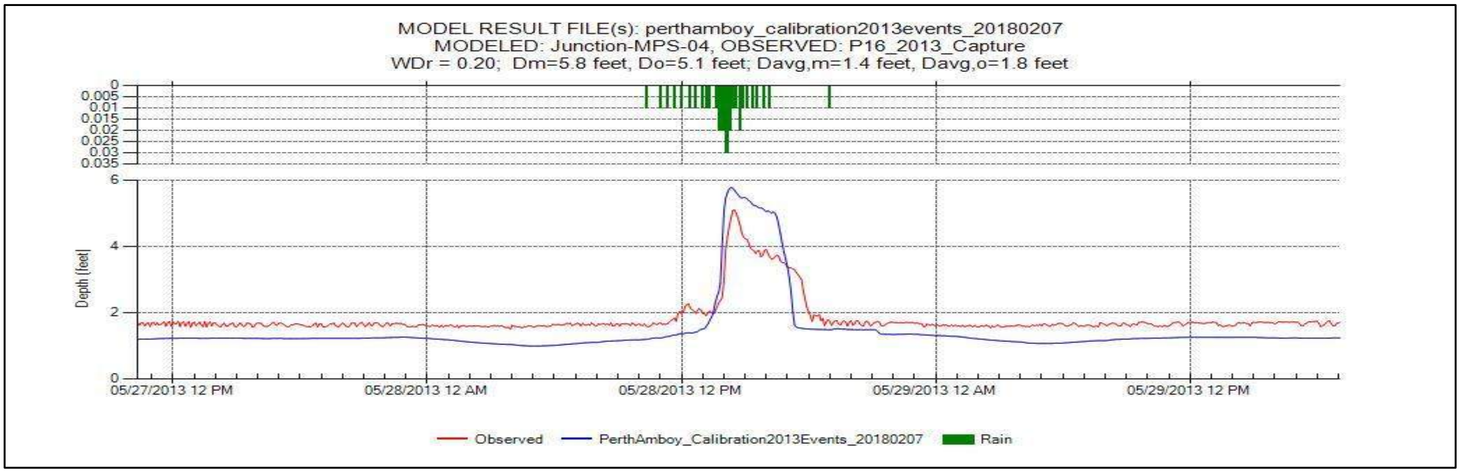
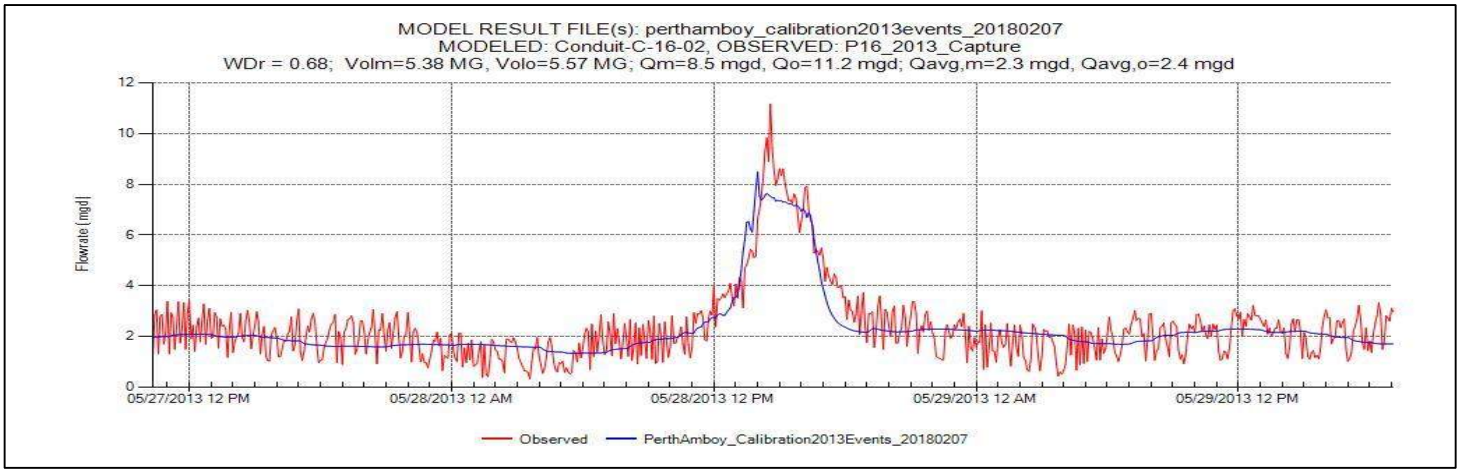
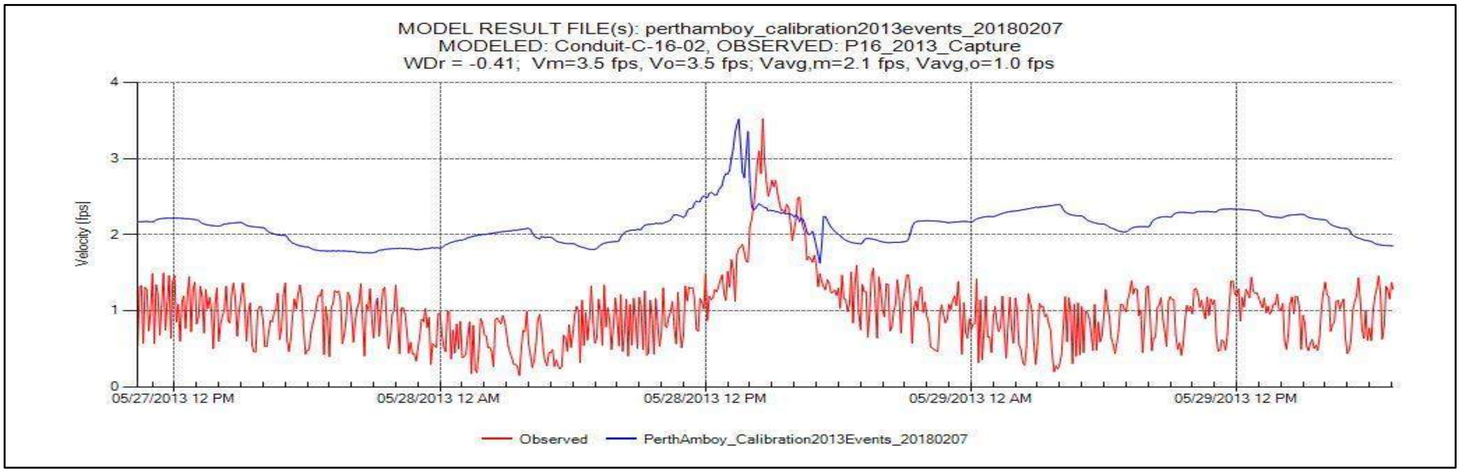
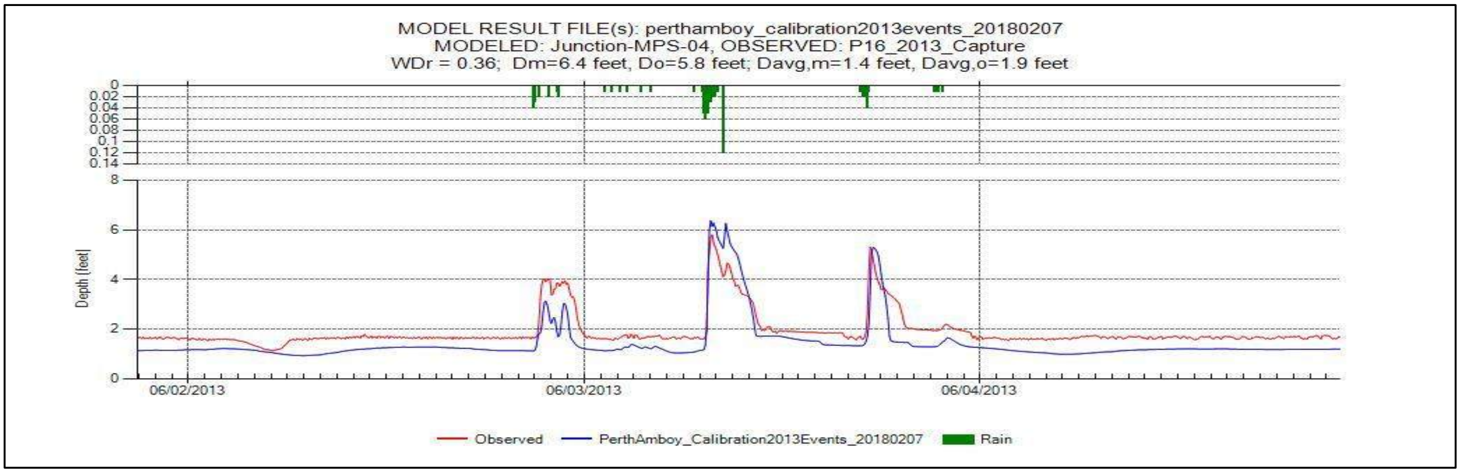


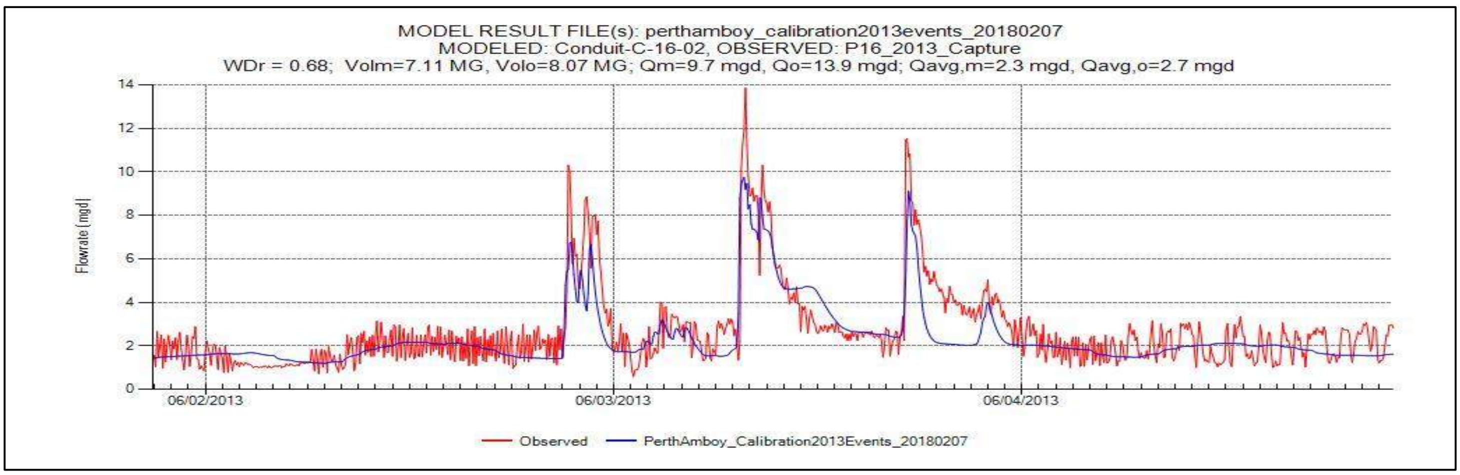


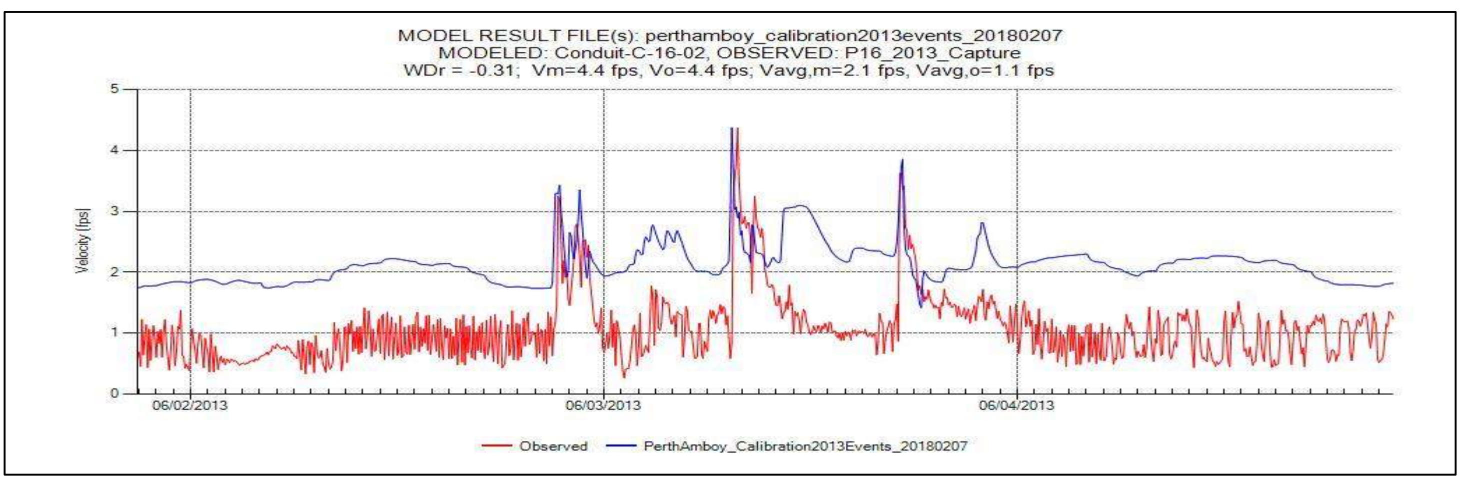


Simulated Versus Observed Flow at Flow Meter Sites

P16_2013_Capture







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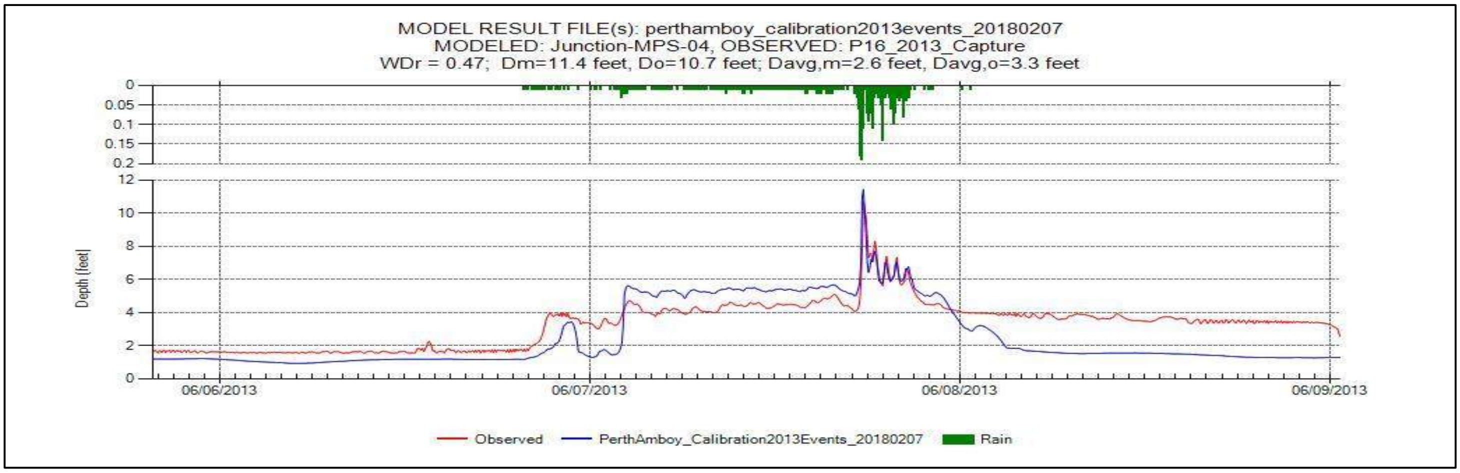

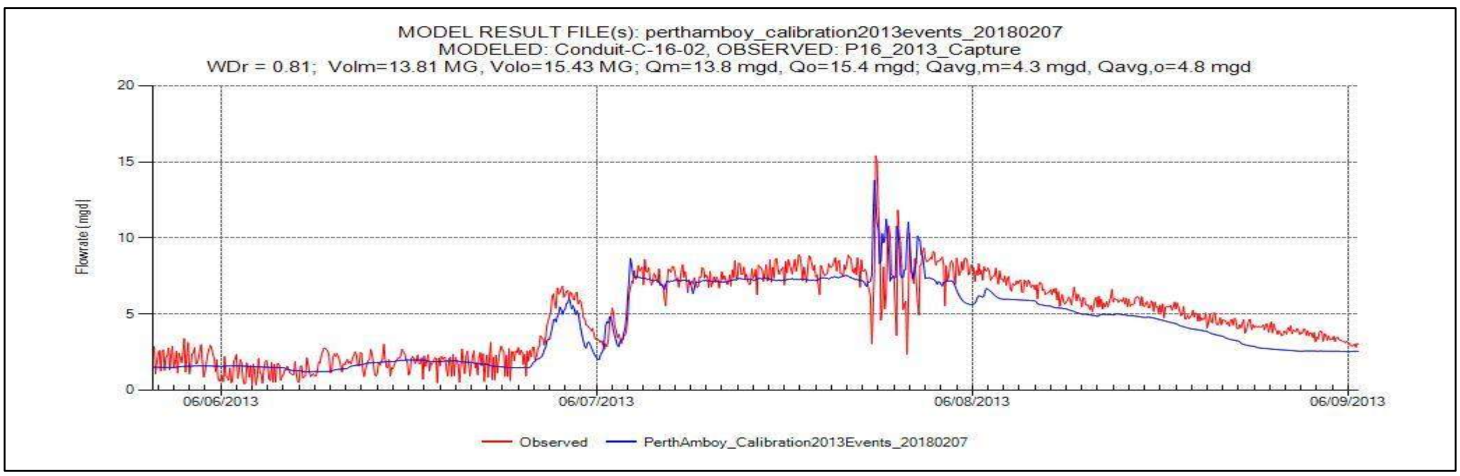

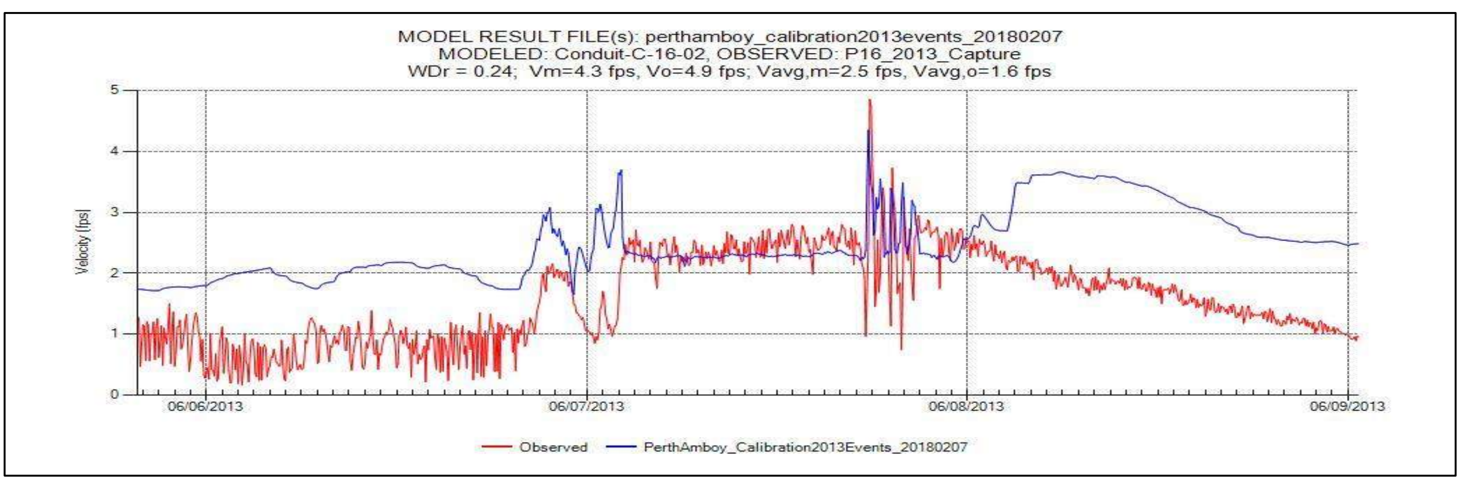

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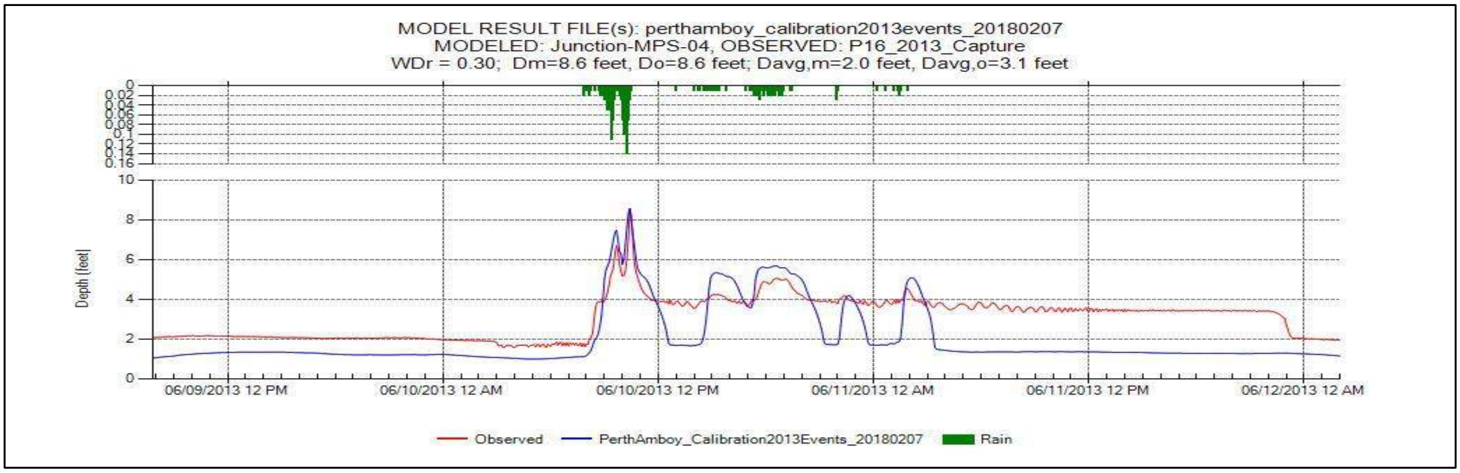
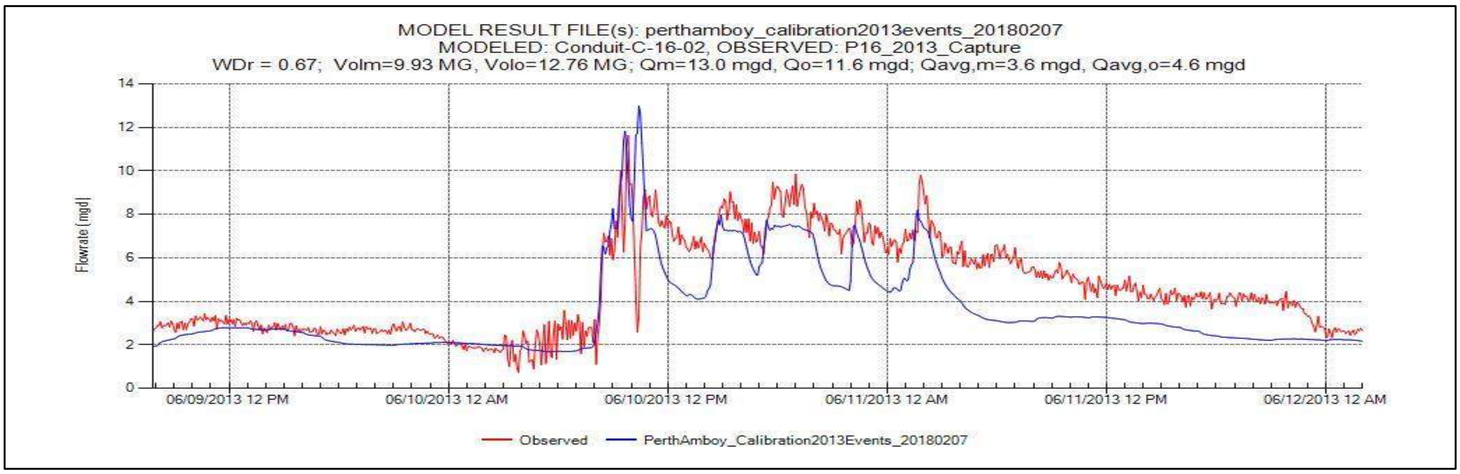
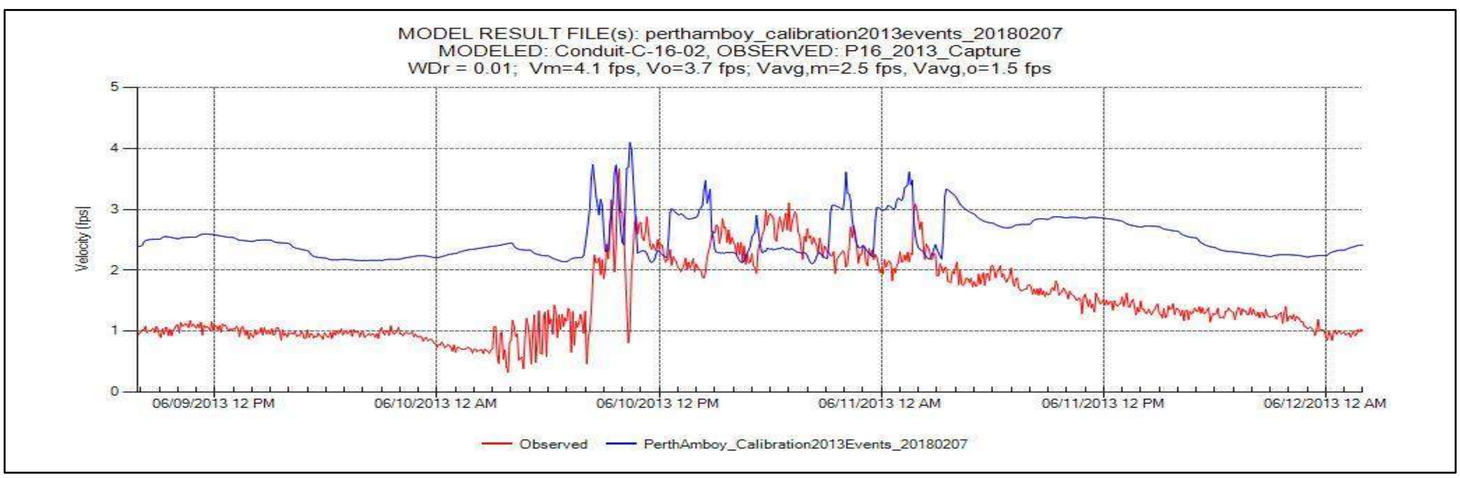
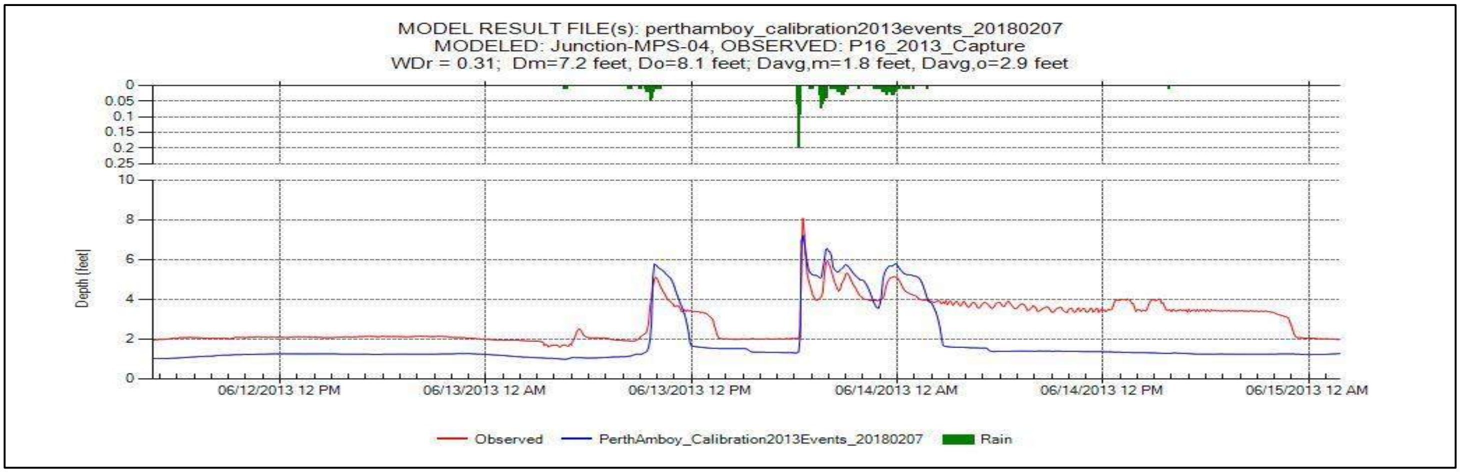


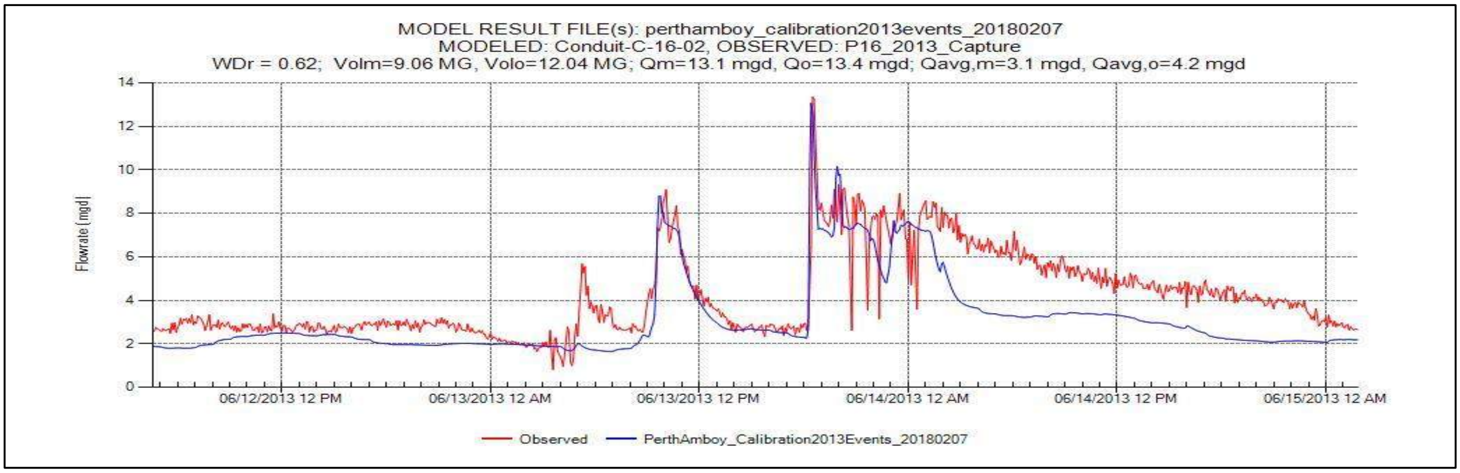


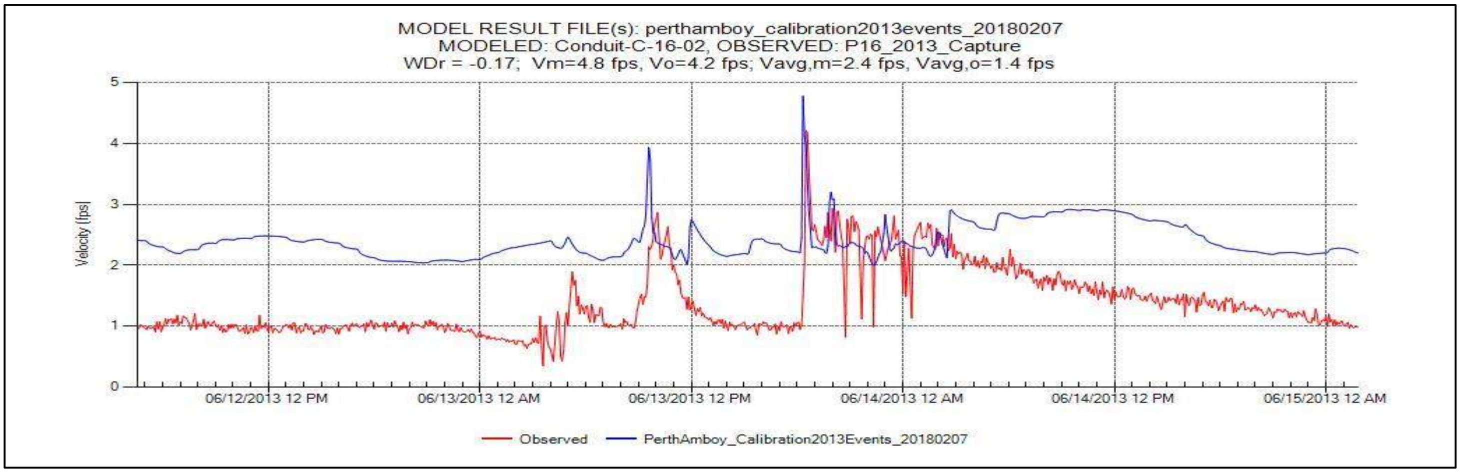


Simulated Versus Observed Flow at Flow Meter Sites

P16_2013_Capture







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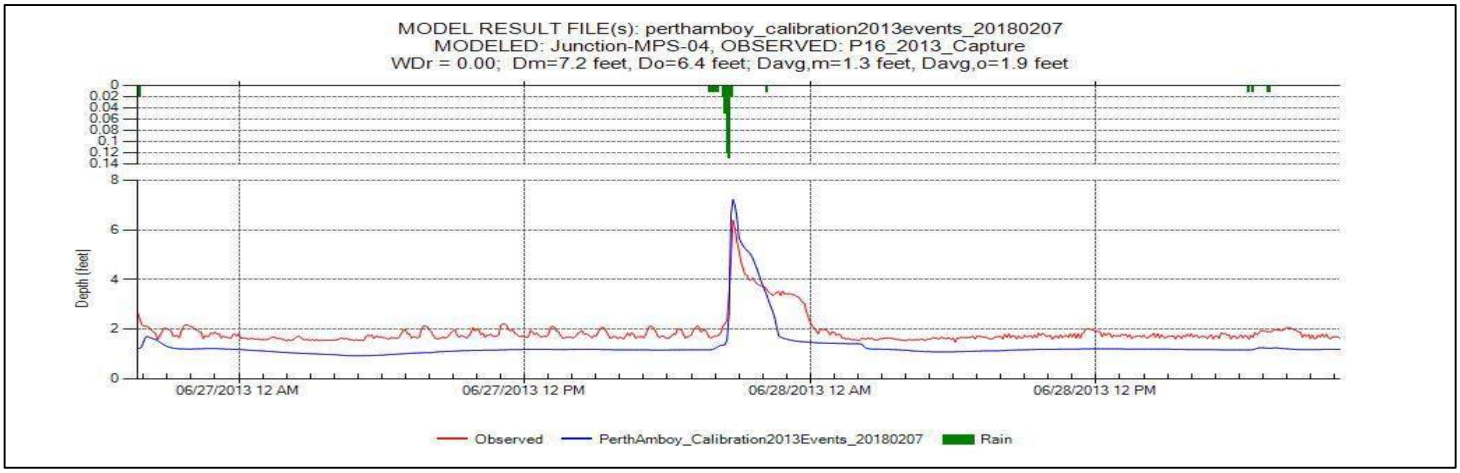
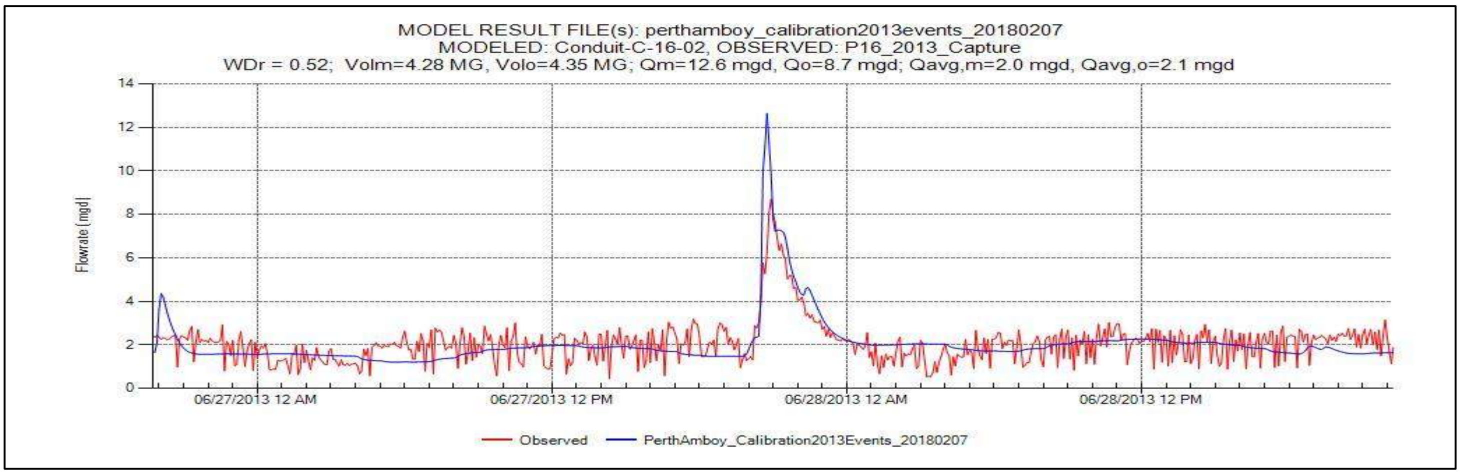
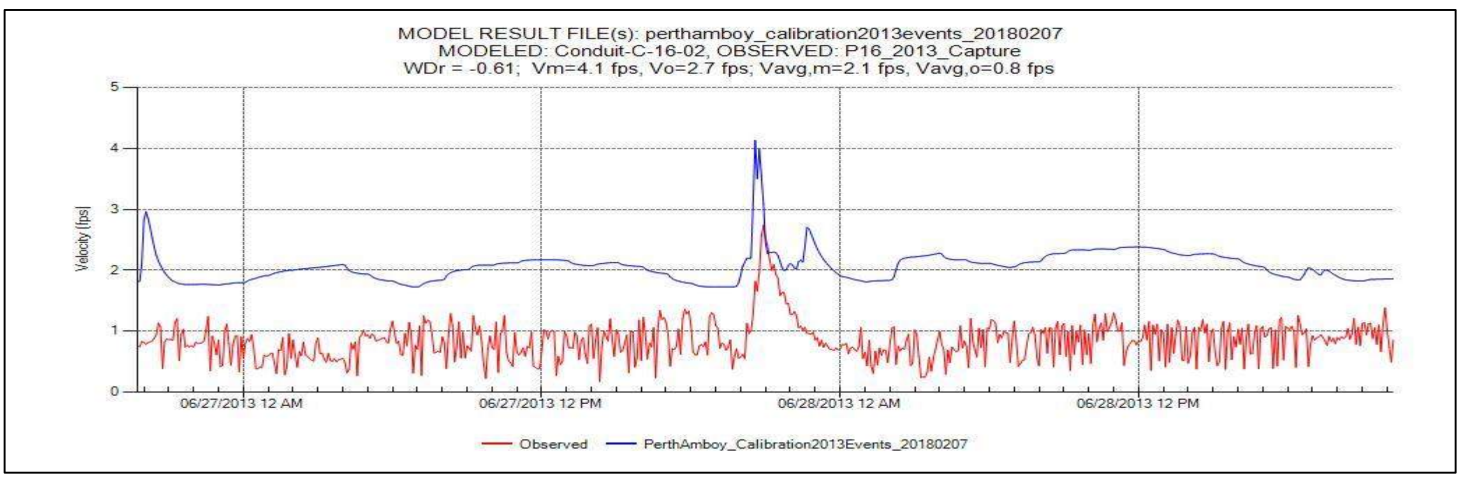
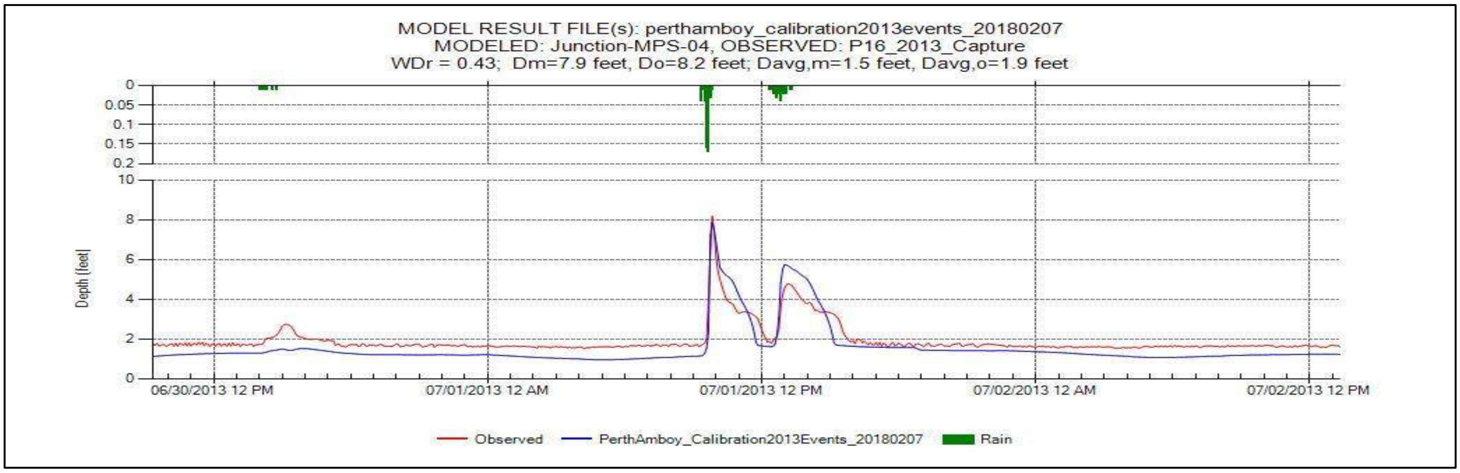


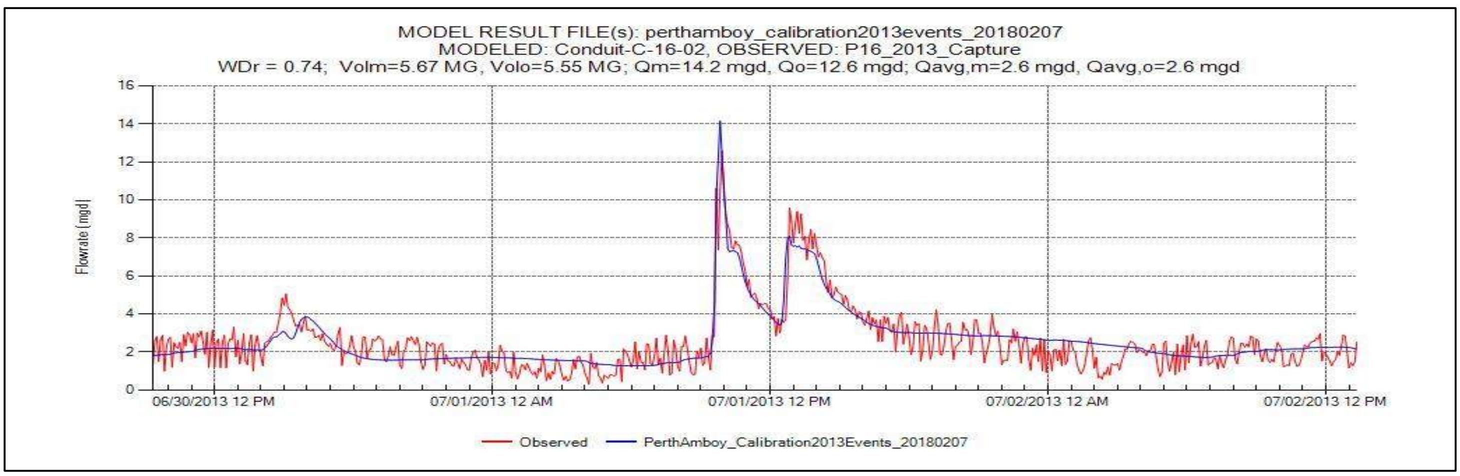


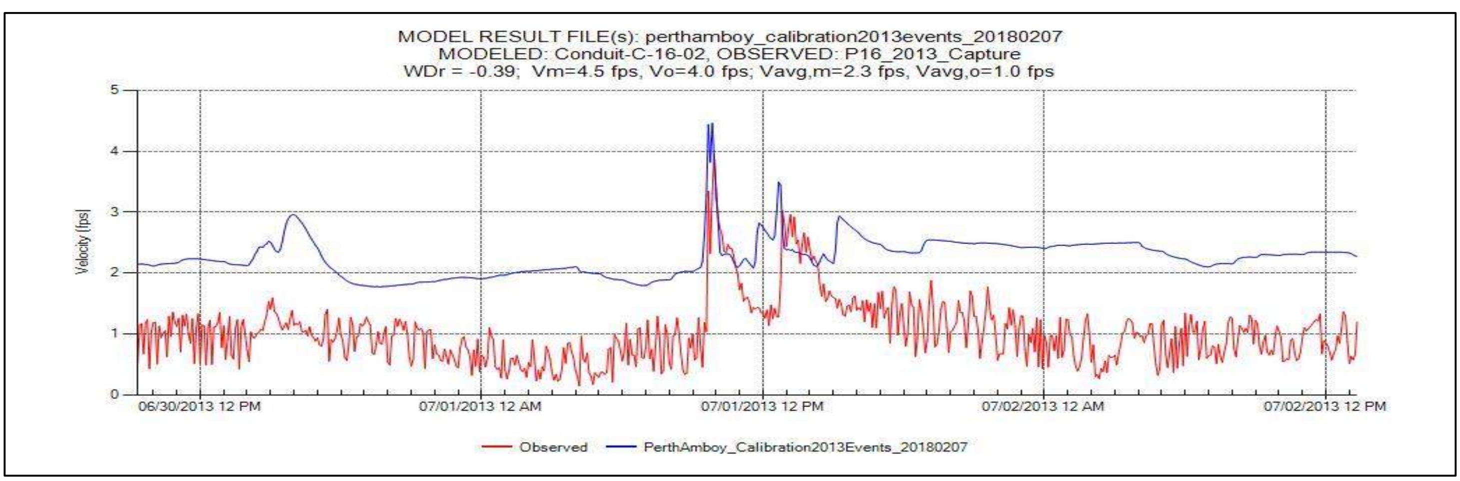


Simulated Versus Observed Flow at Flow Meter Sites

P16_2013_Capture







Simulated Versus Observed Flow at Flow Meter Sites

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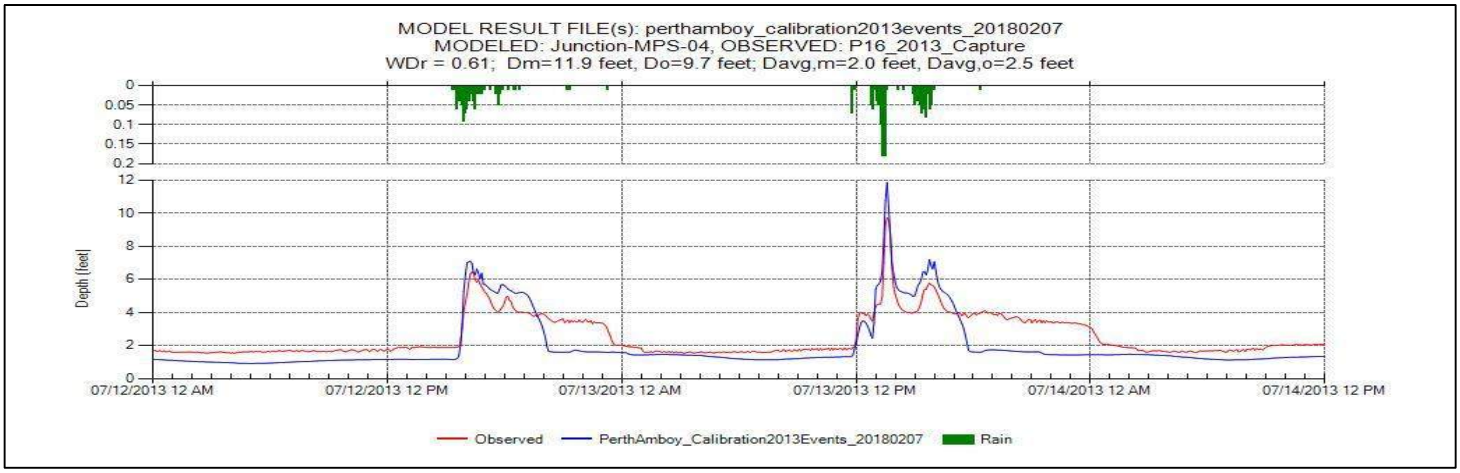
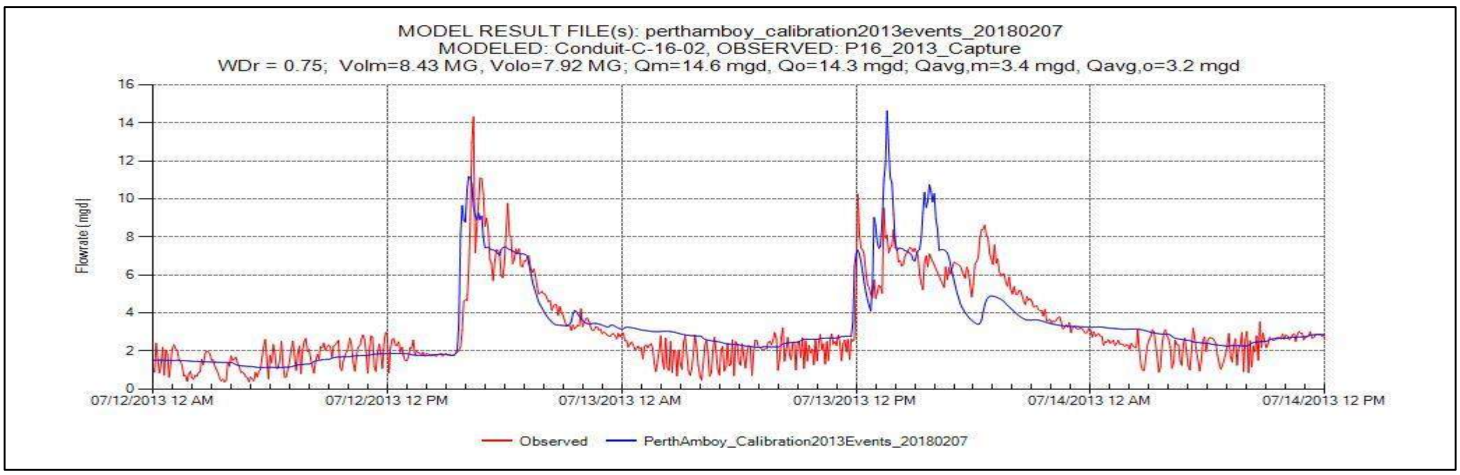
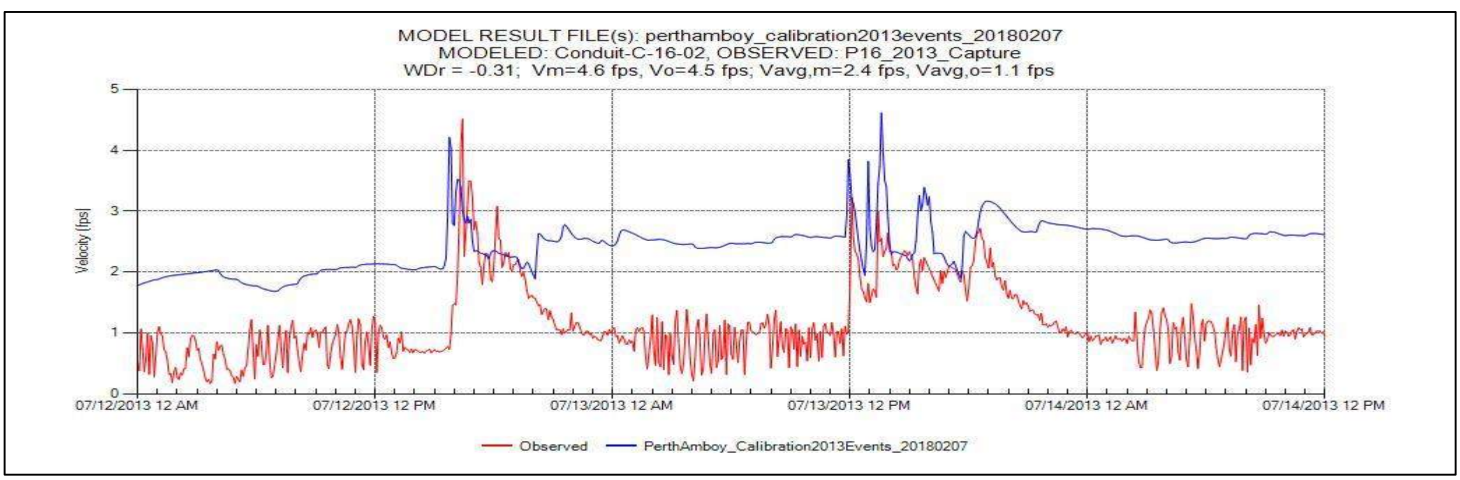
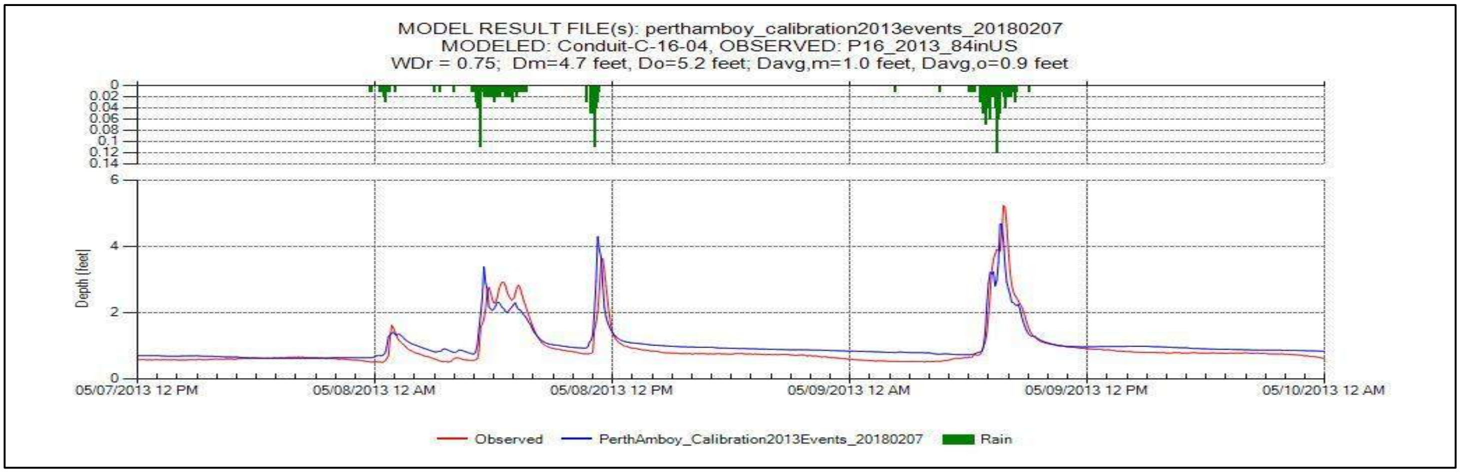
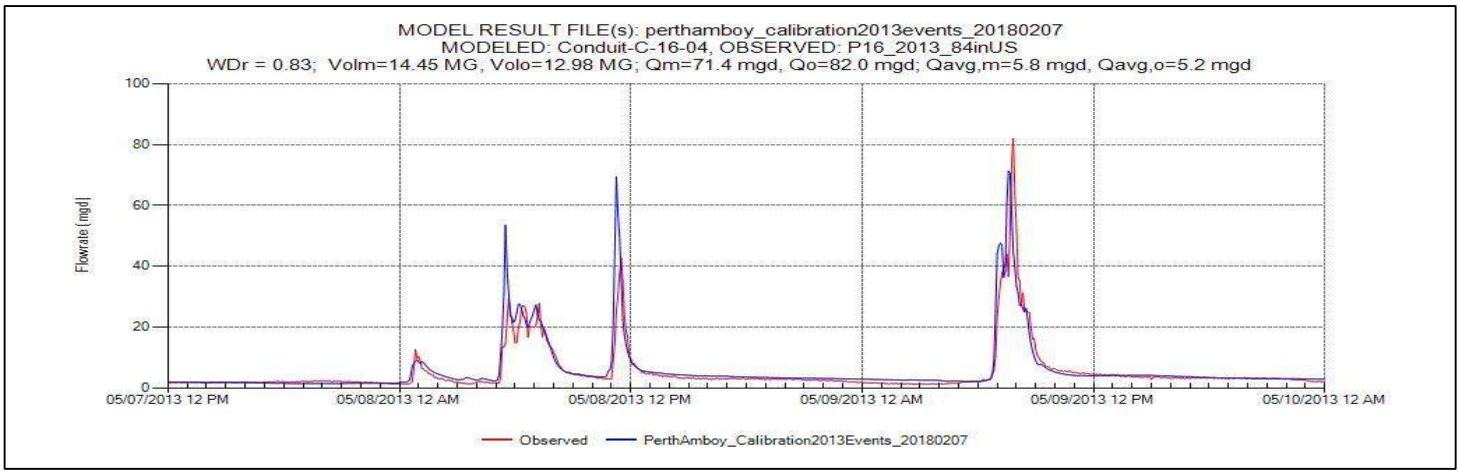


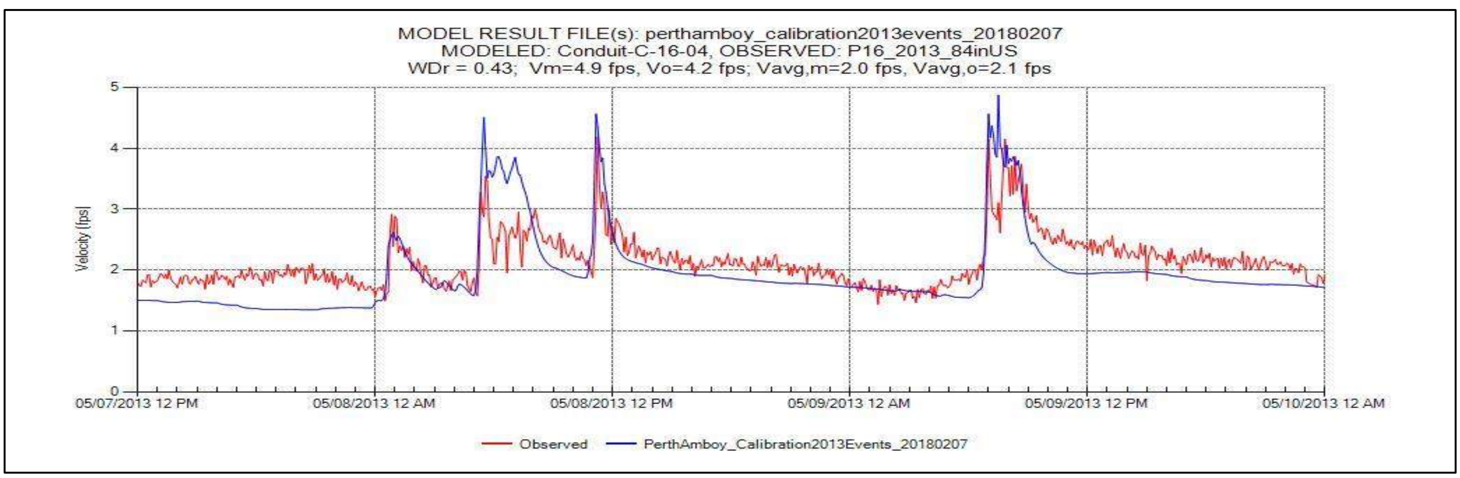




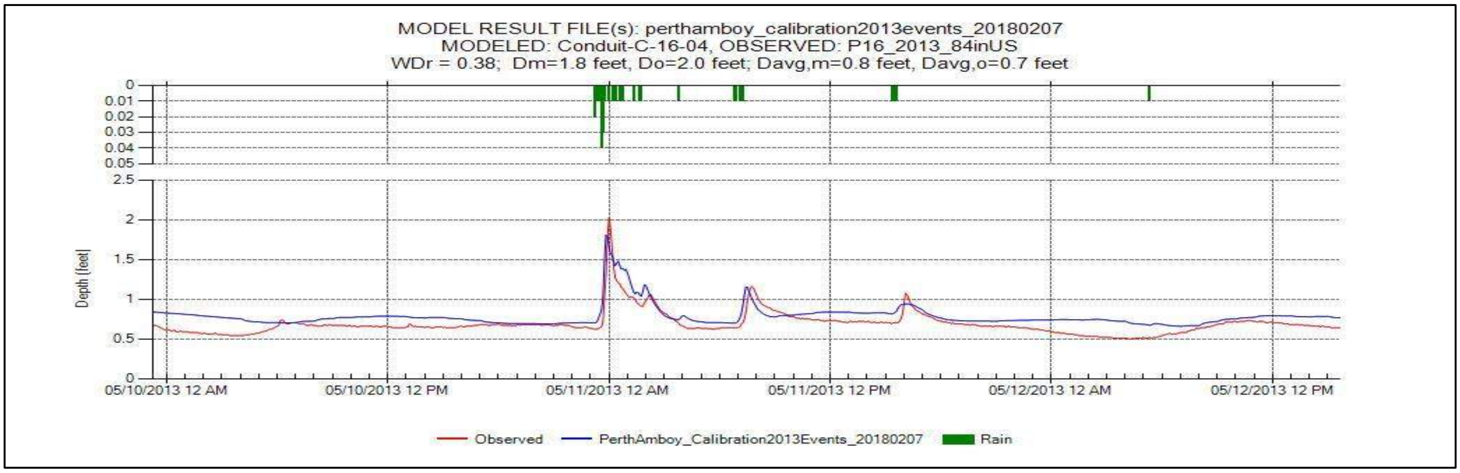
P16_2013_84inUS

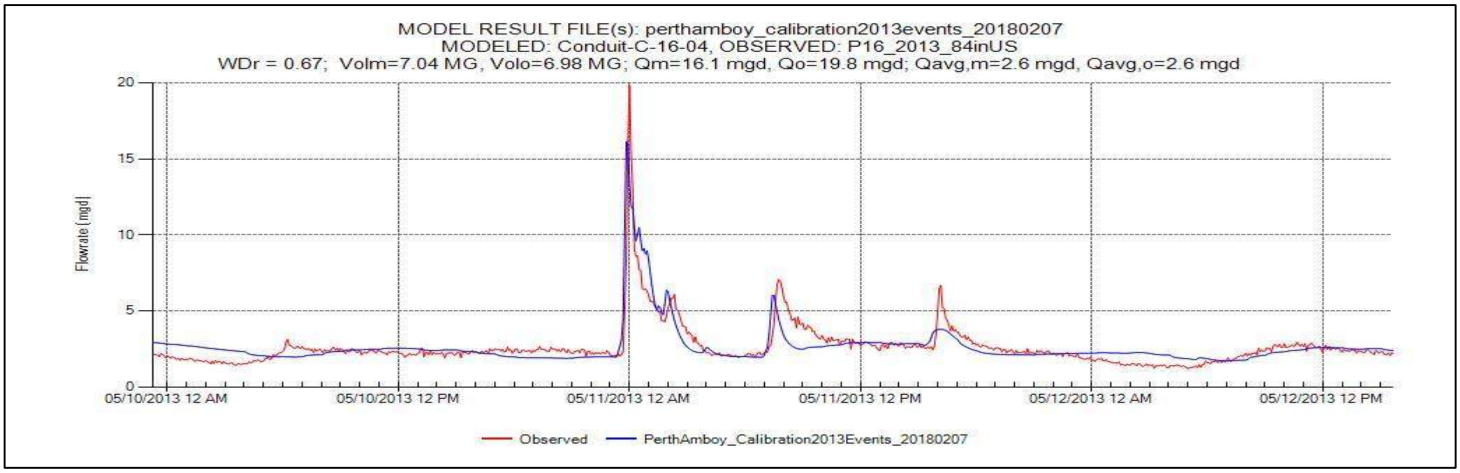


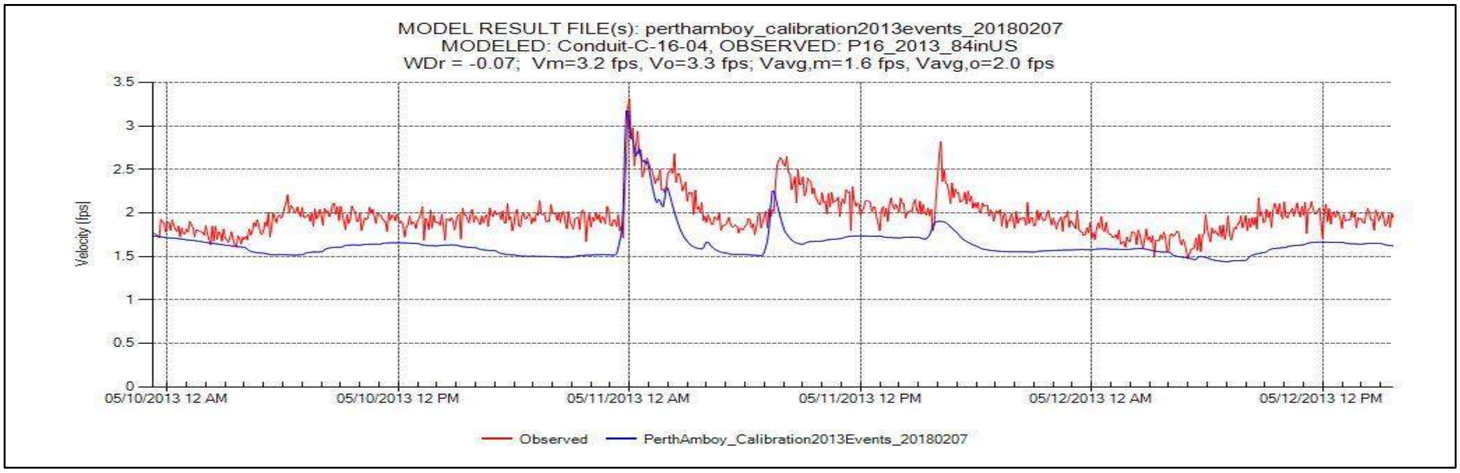




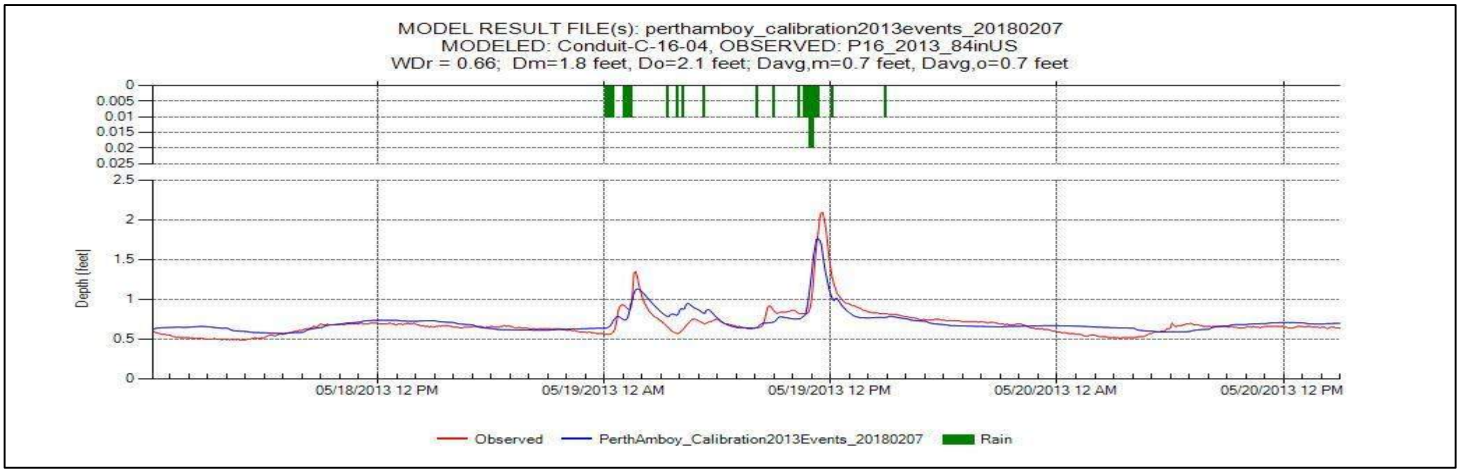
P16_2013_84inUS

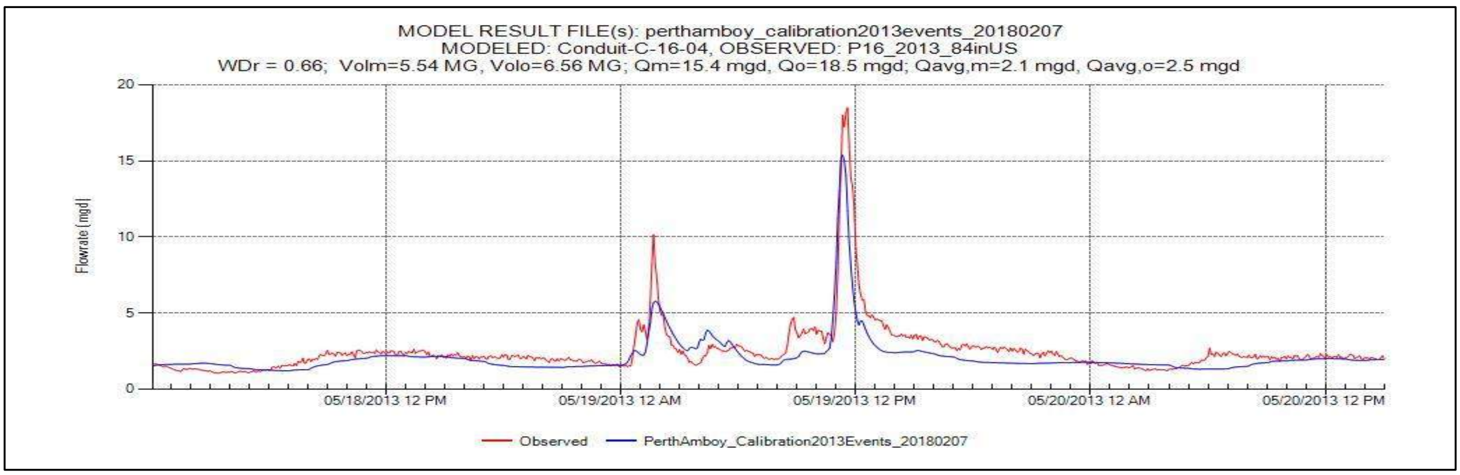


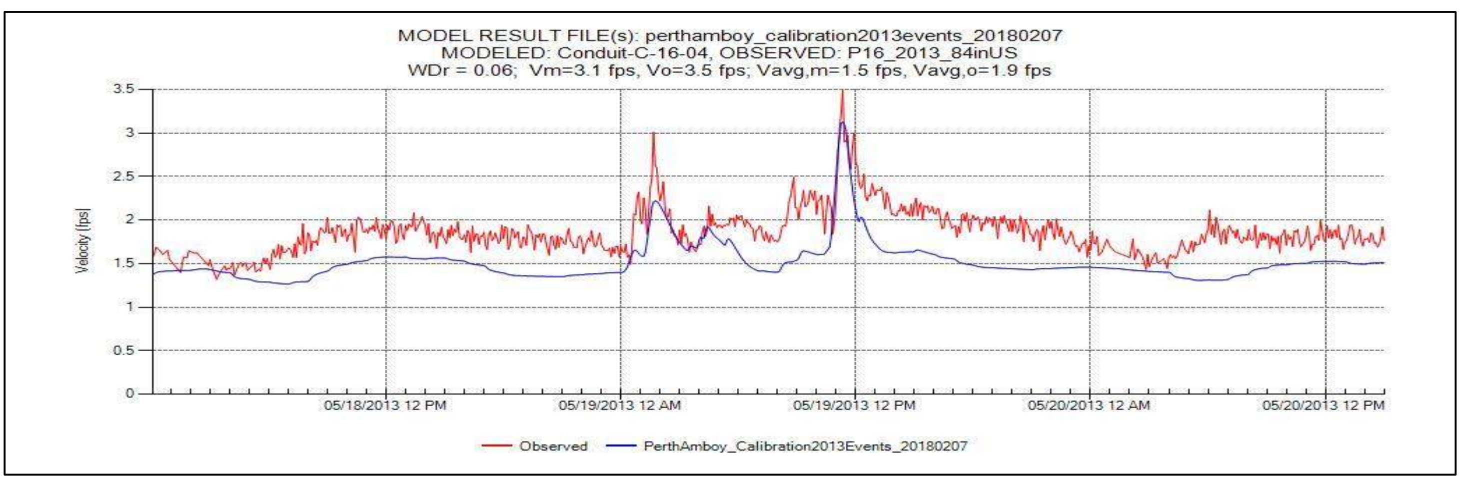




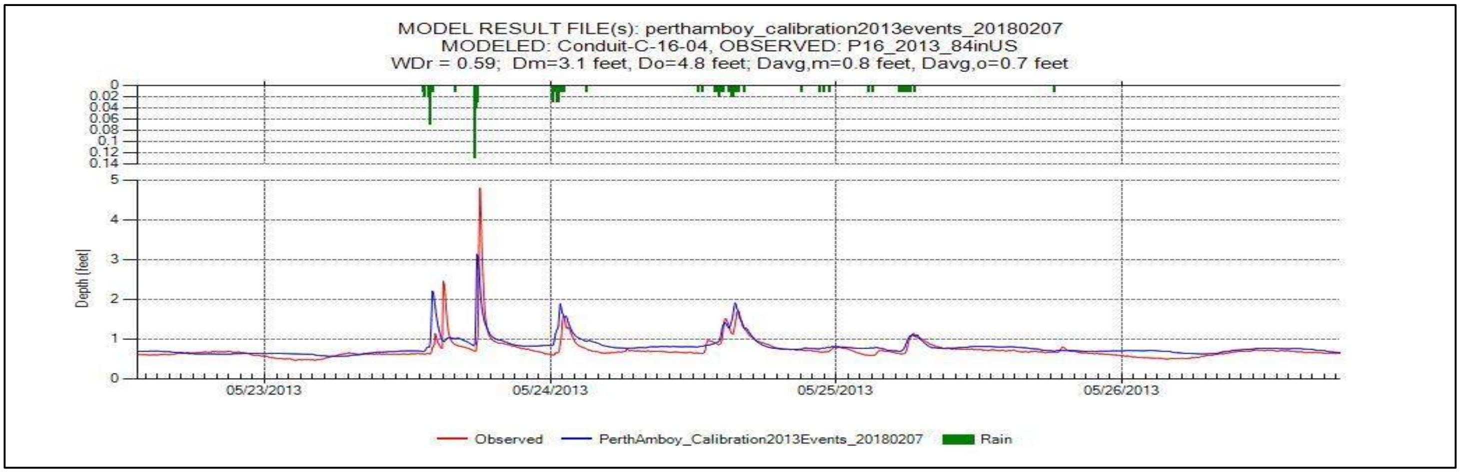
P16_2013_84inUS

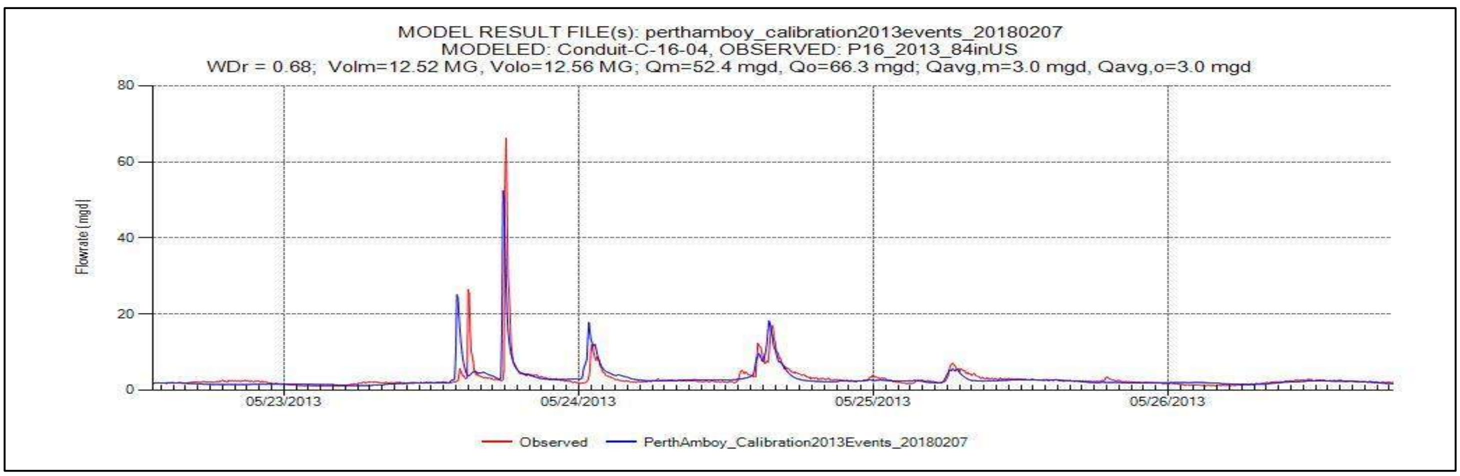


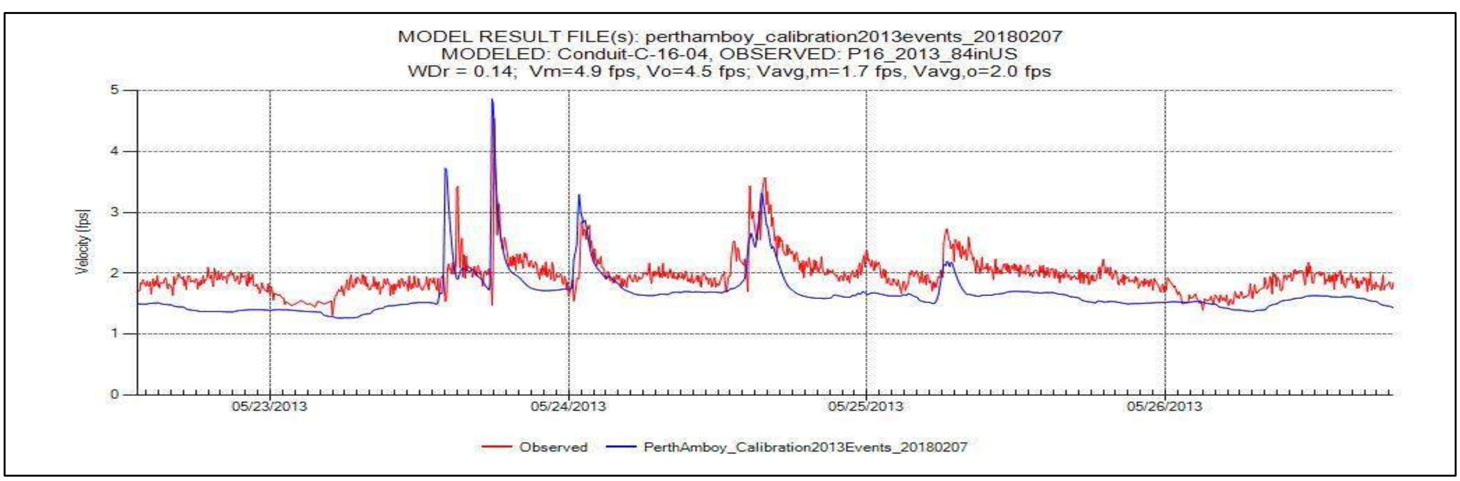




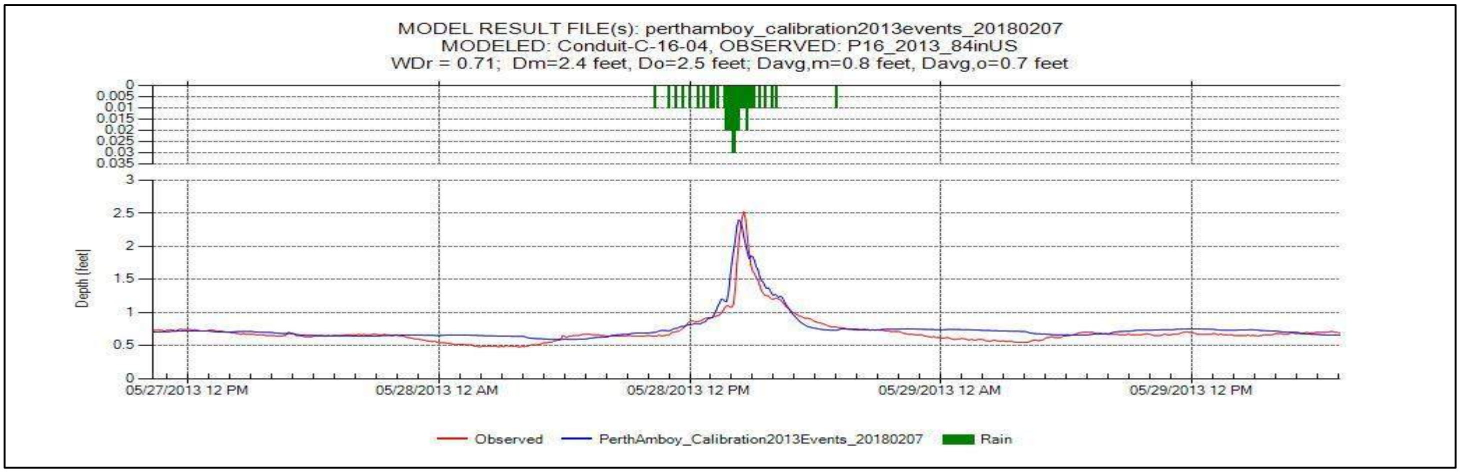
P16_2013_84inUS

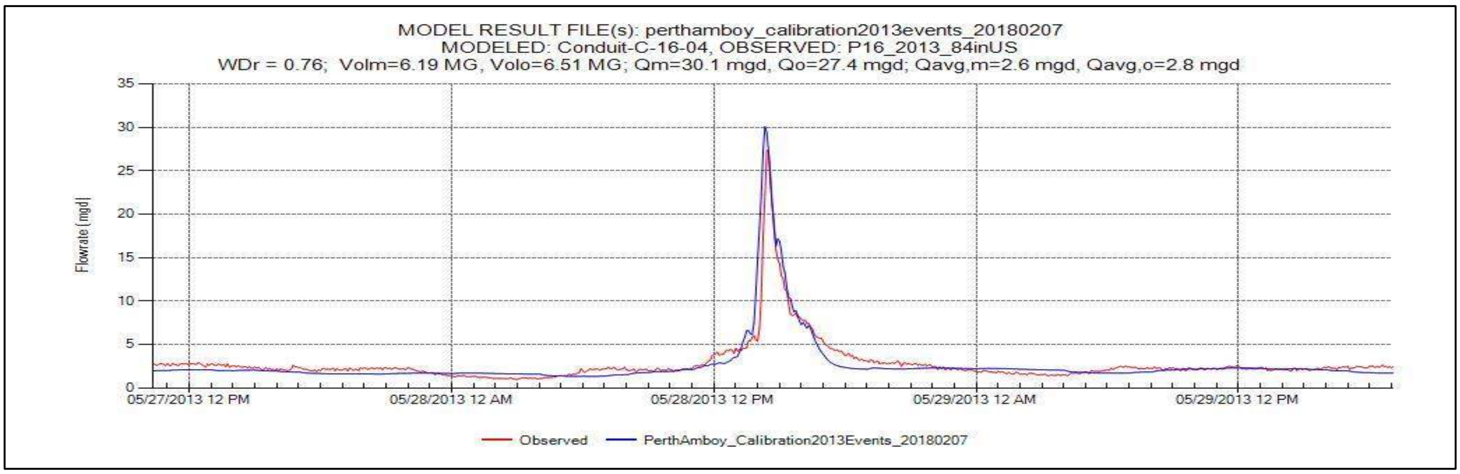


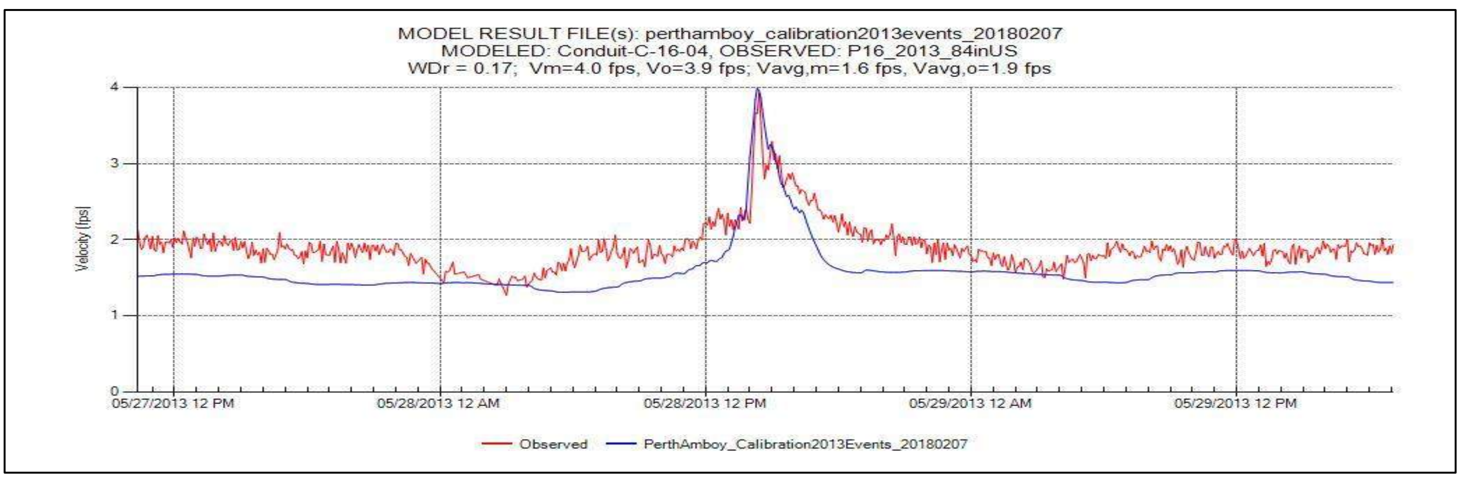




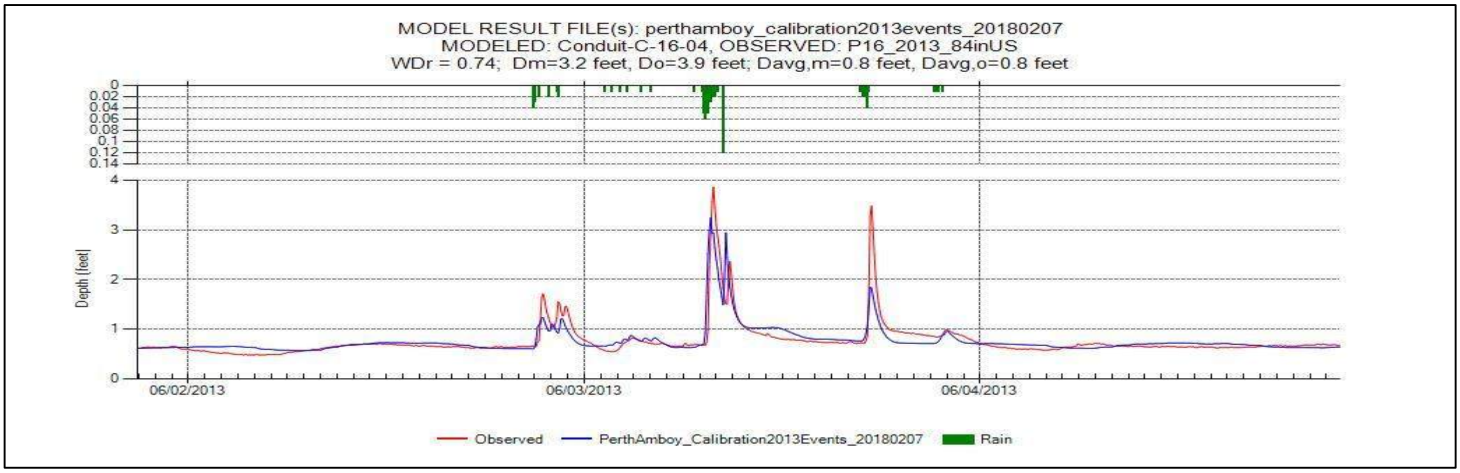
P16_2013_84inUS

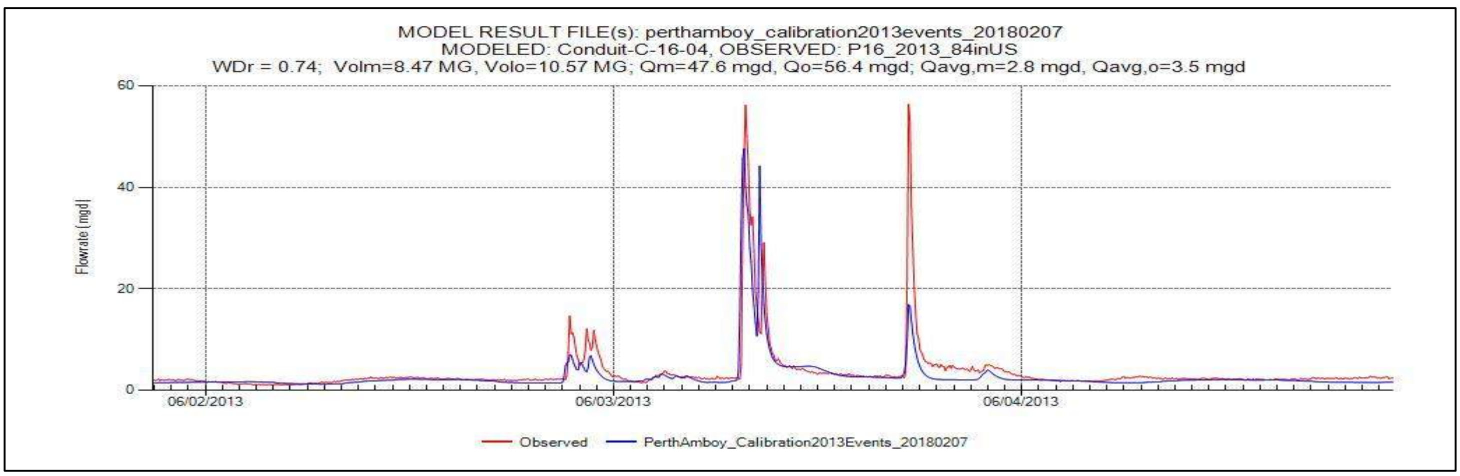


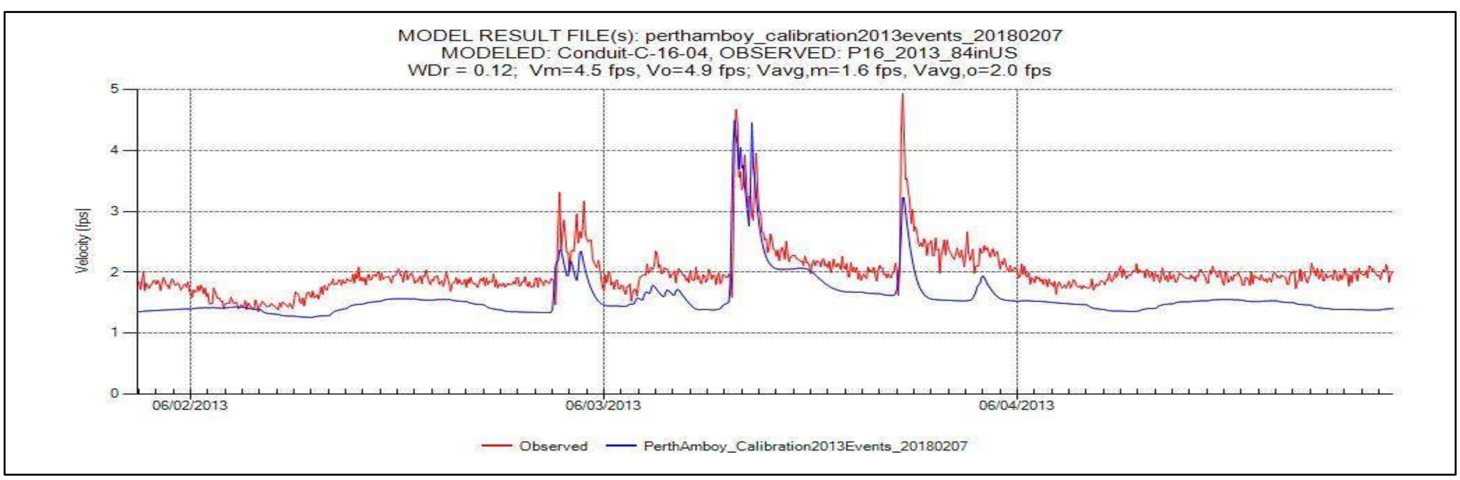




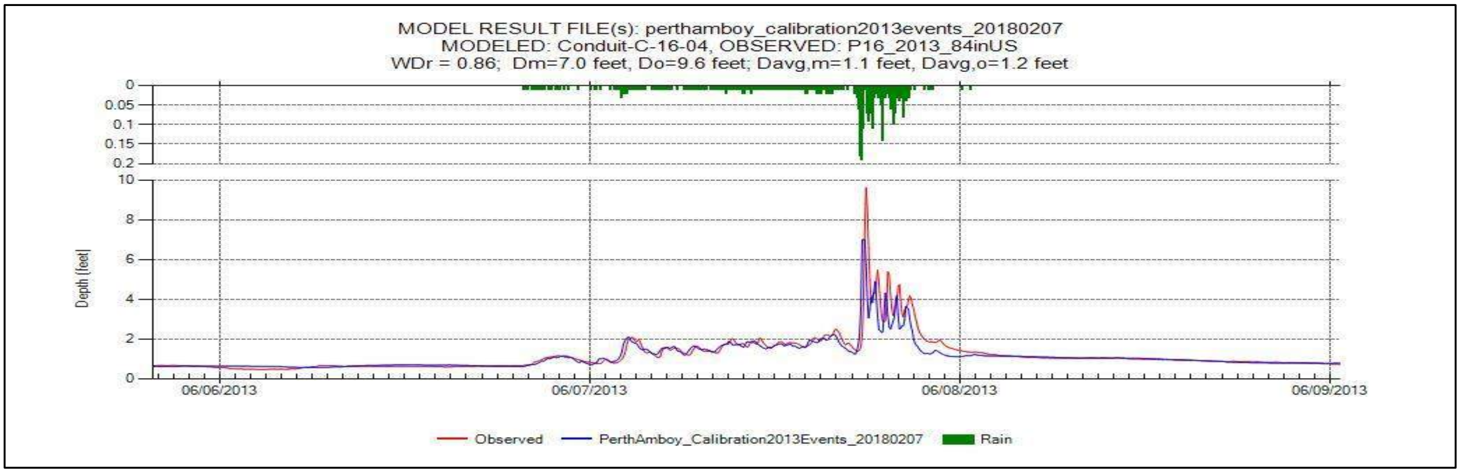
P16_2013_84inUS

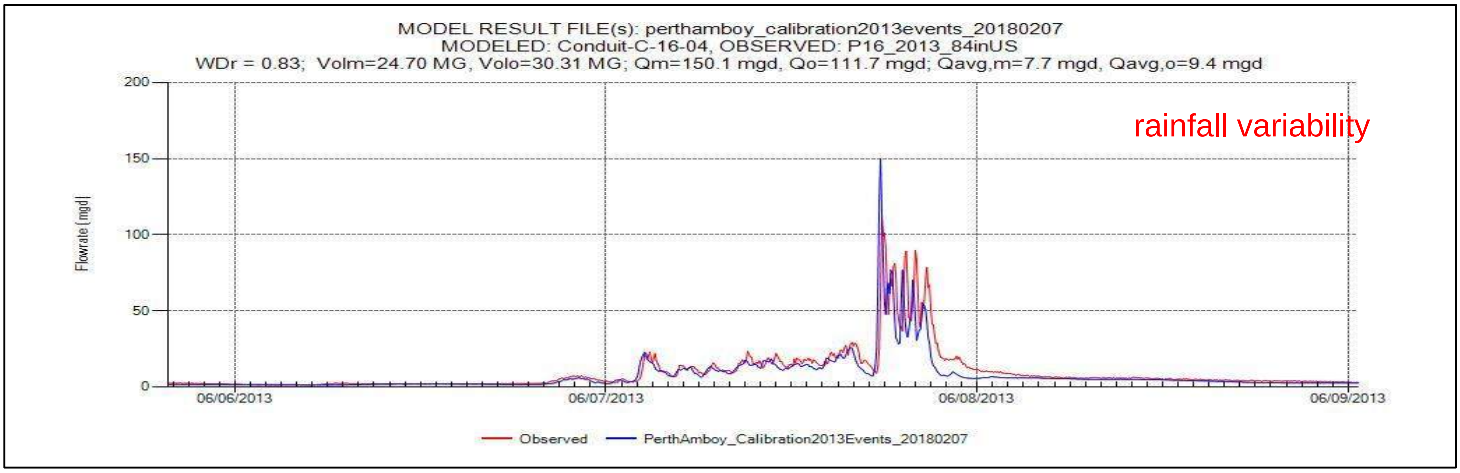


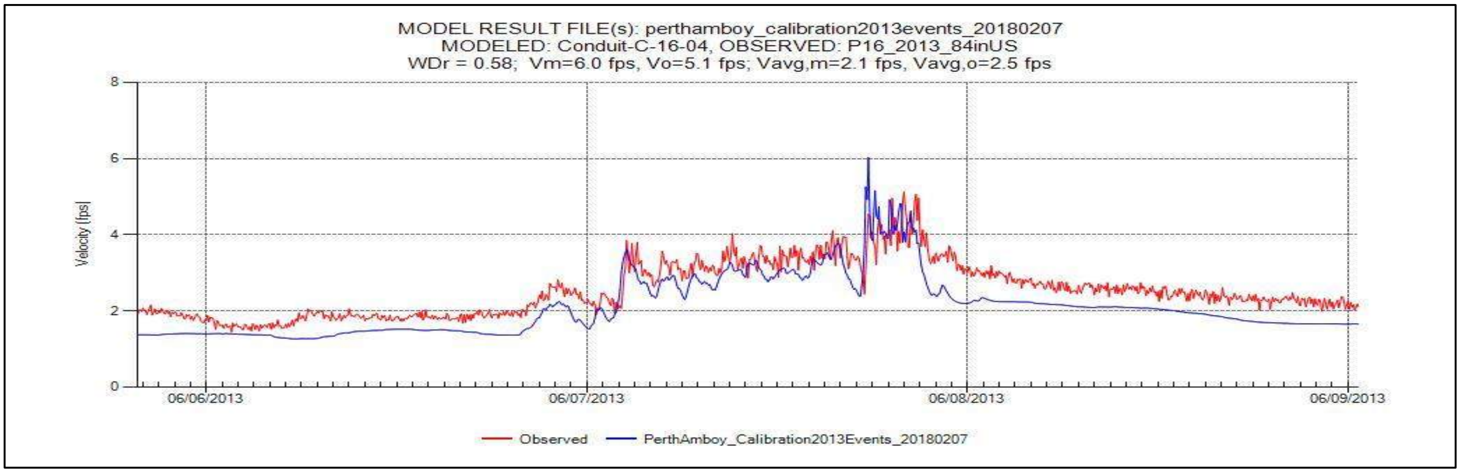




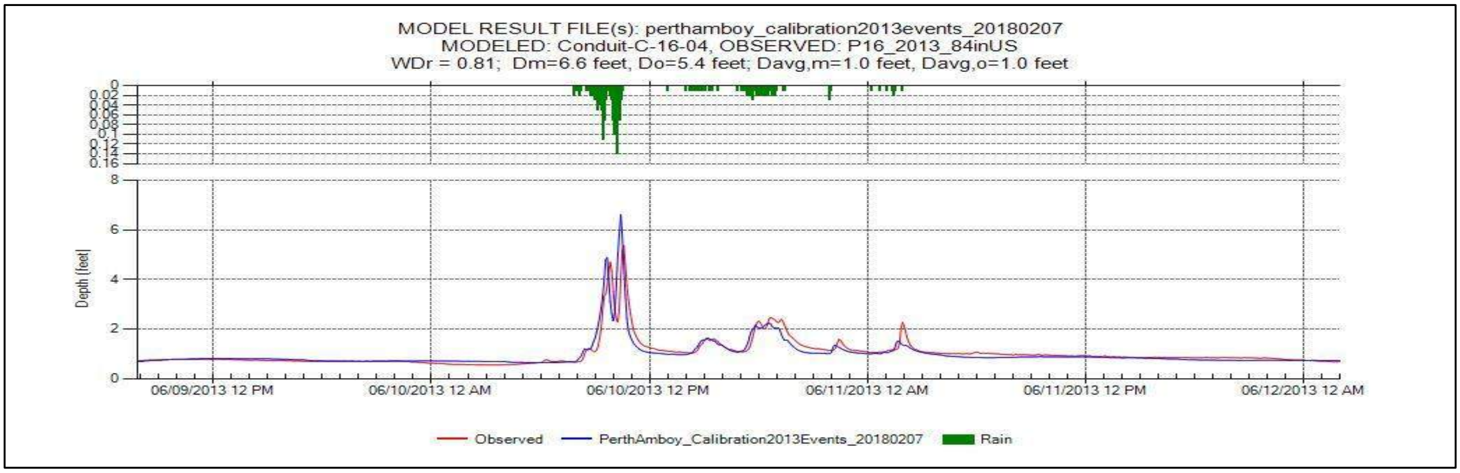
P16_2013_84inUS

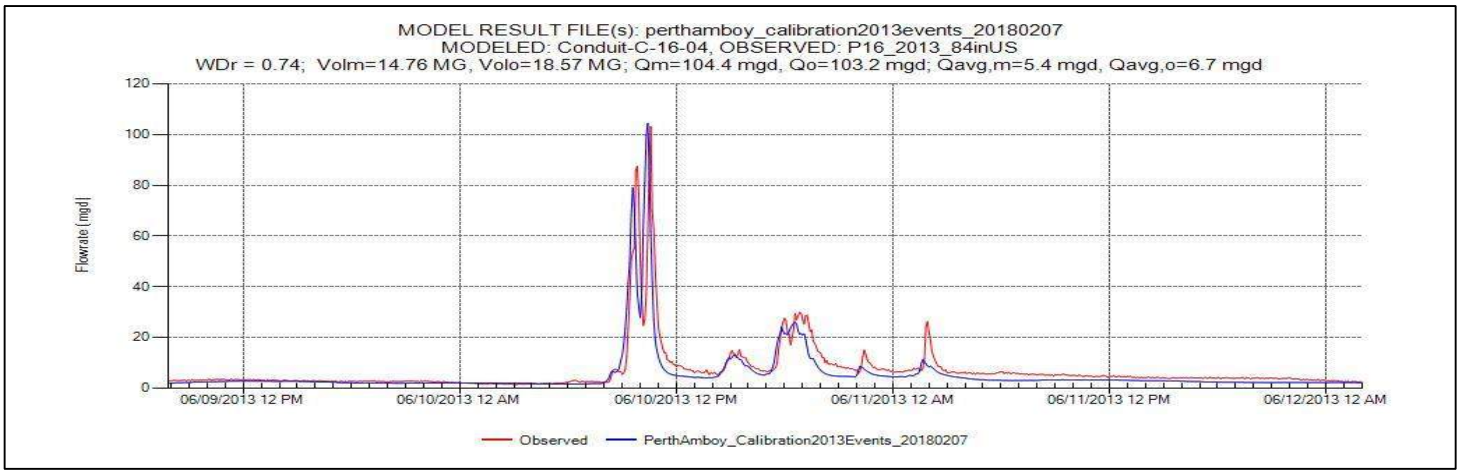


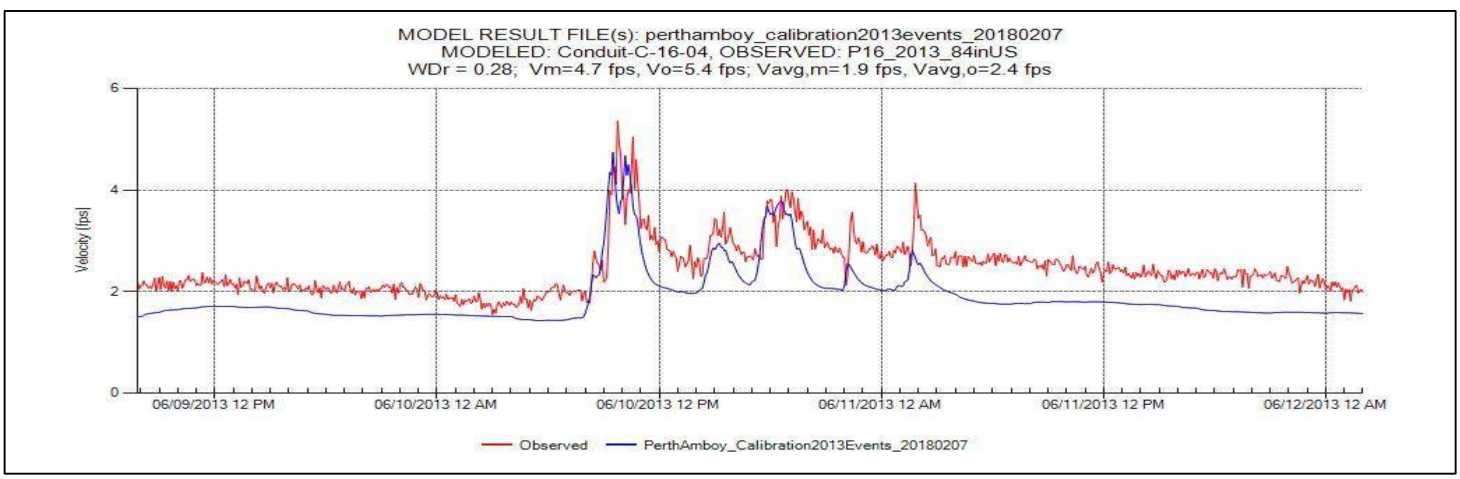




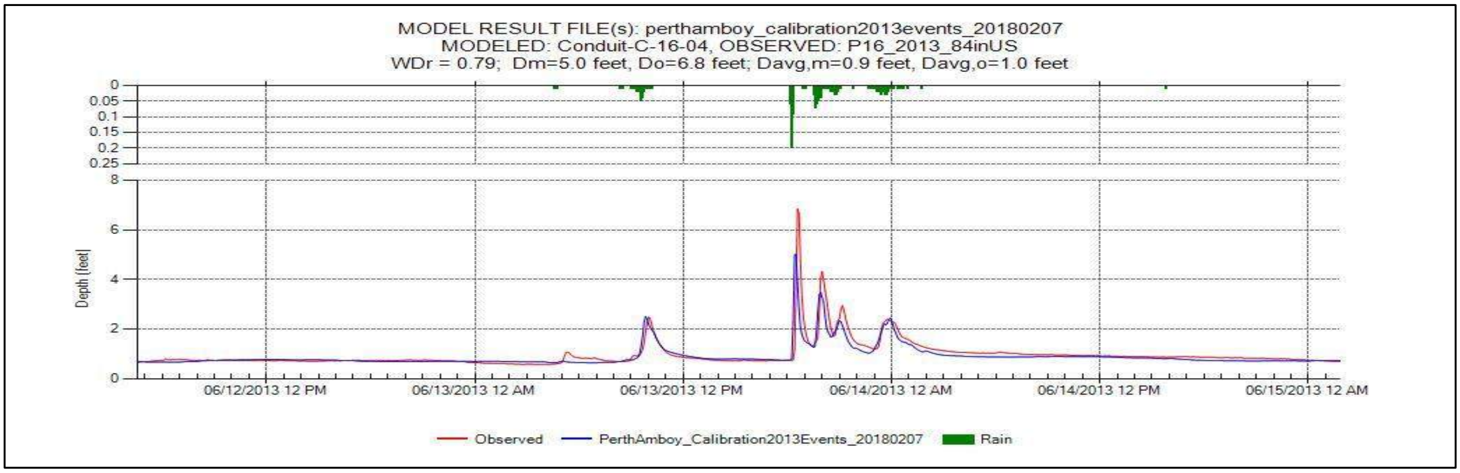
P16_2013_84inUS

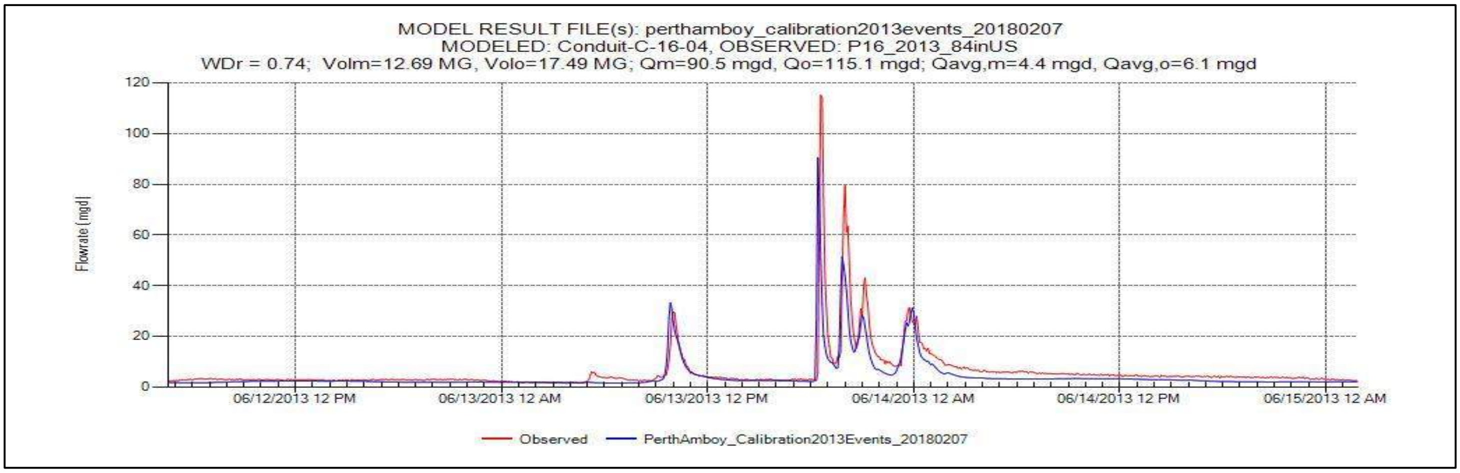


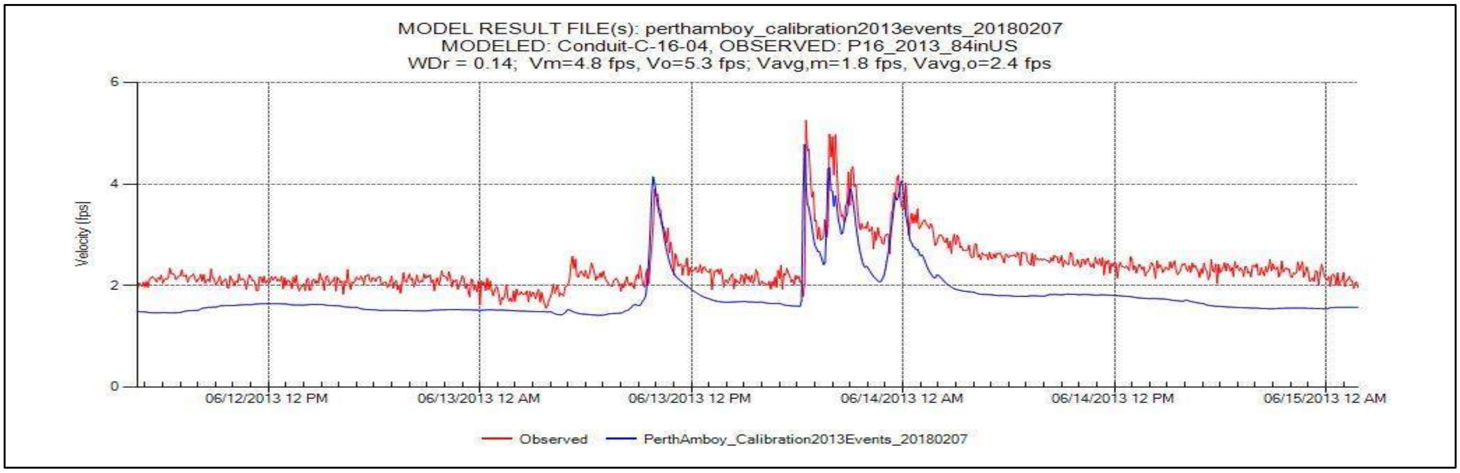




P16_2013_84inUS







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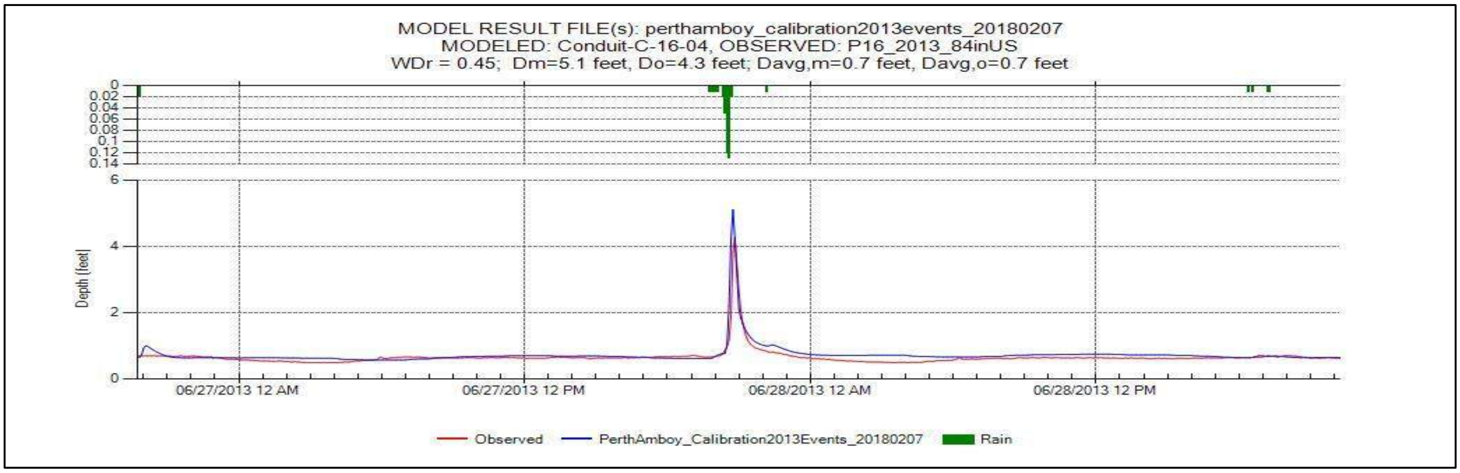
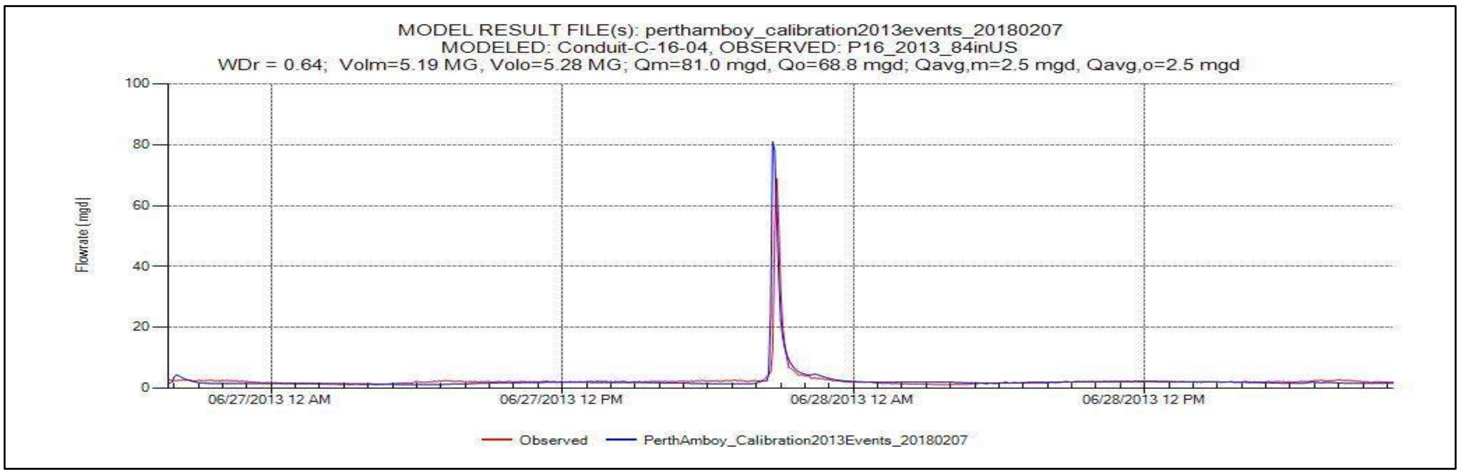
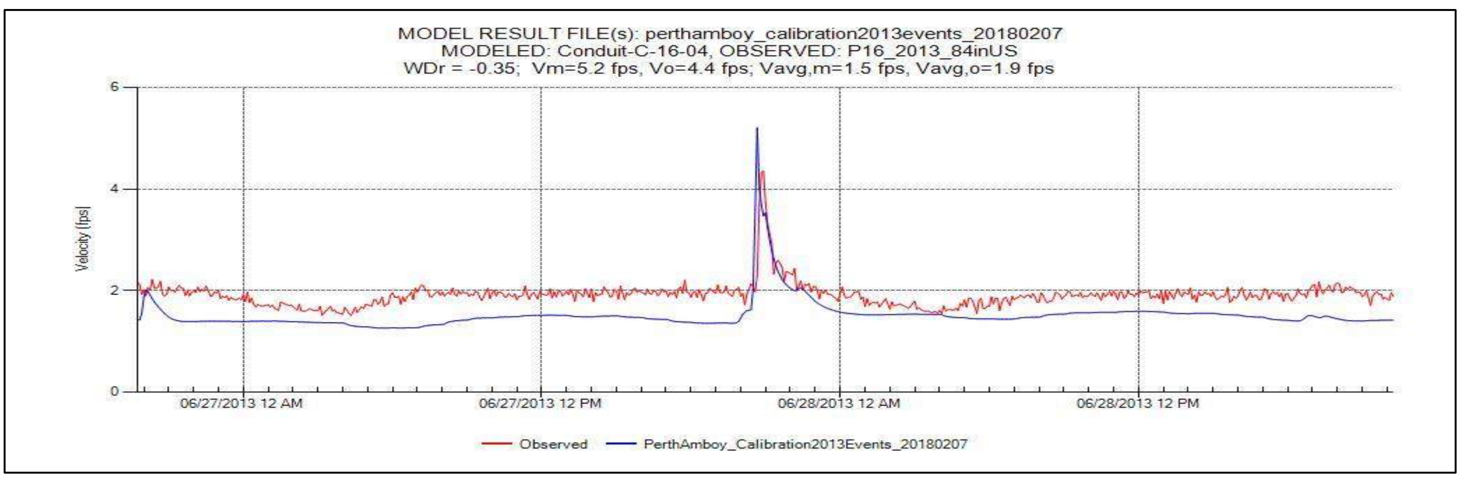
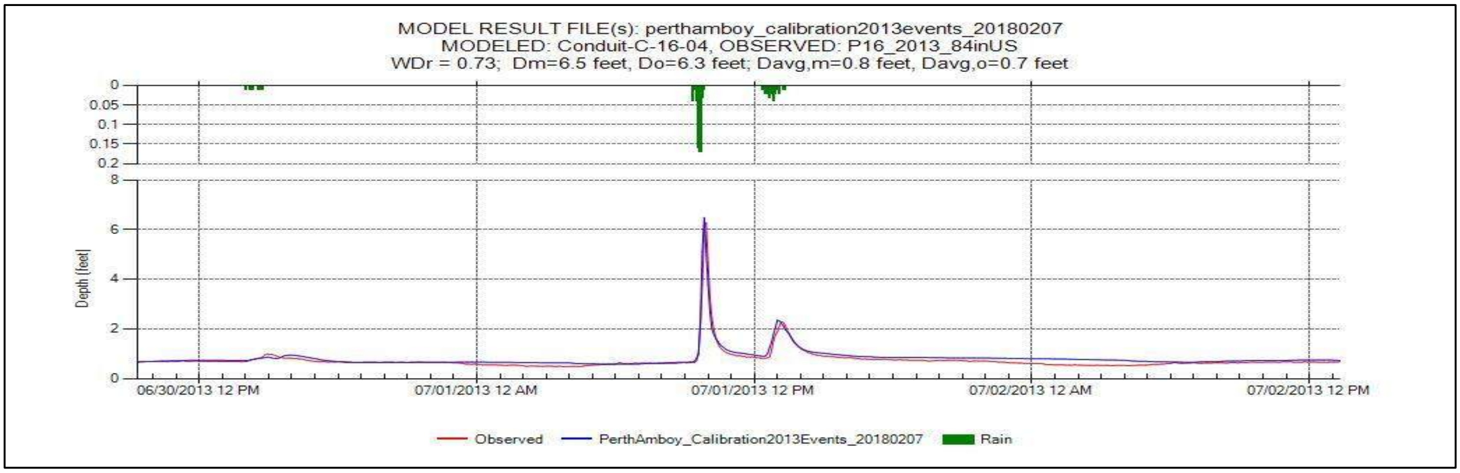
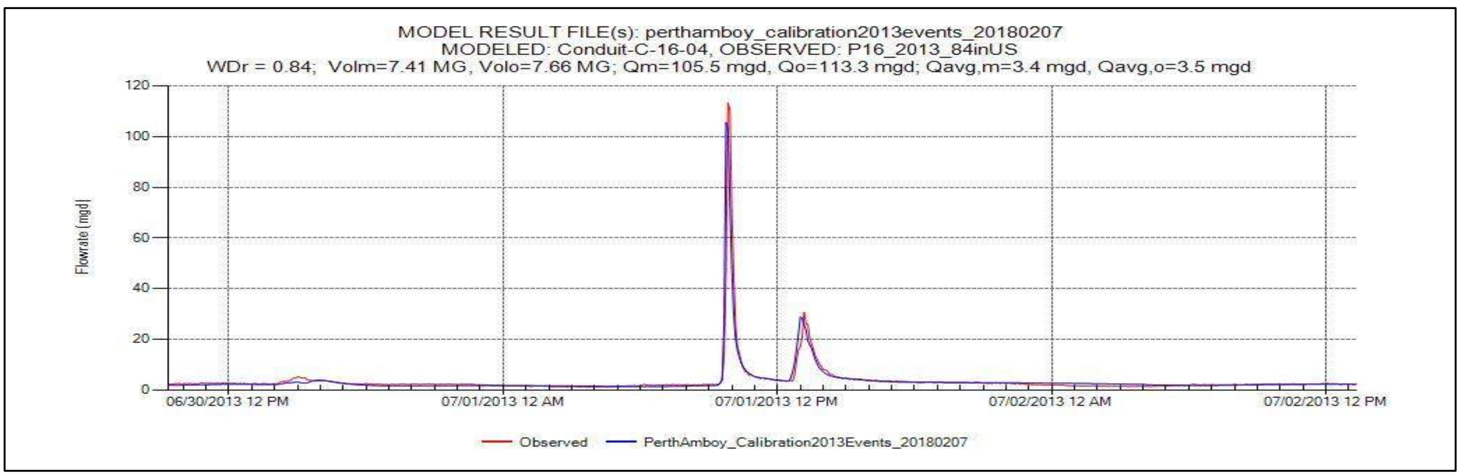


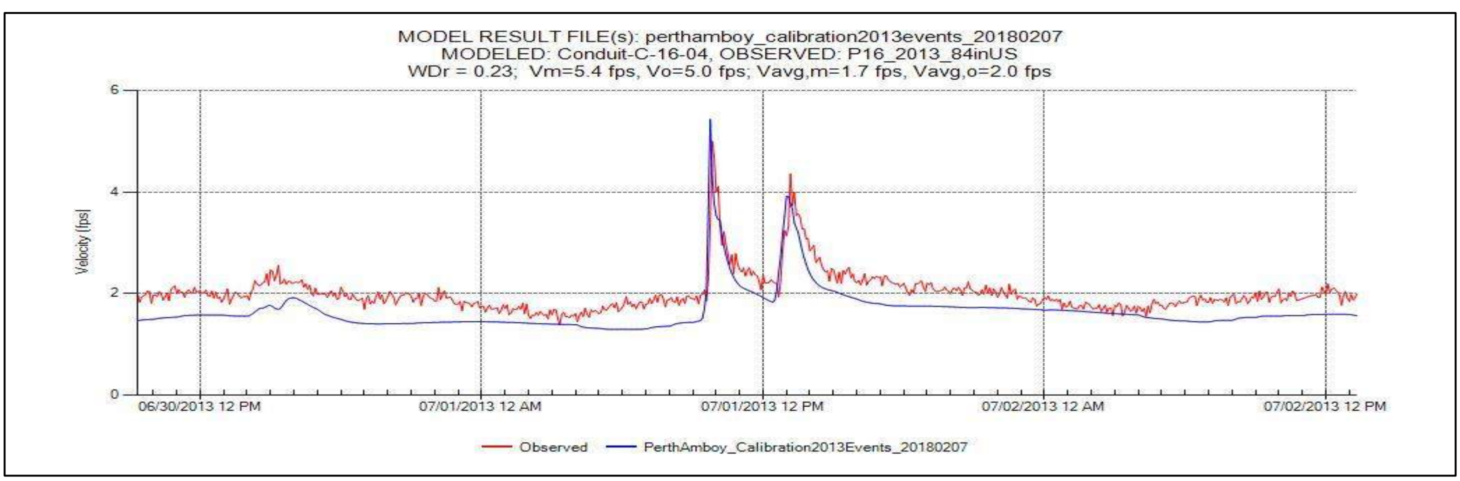




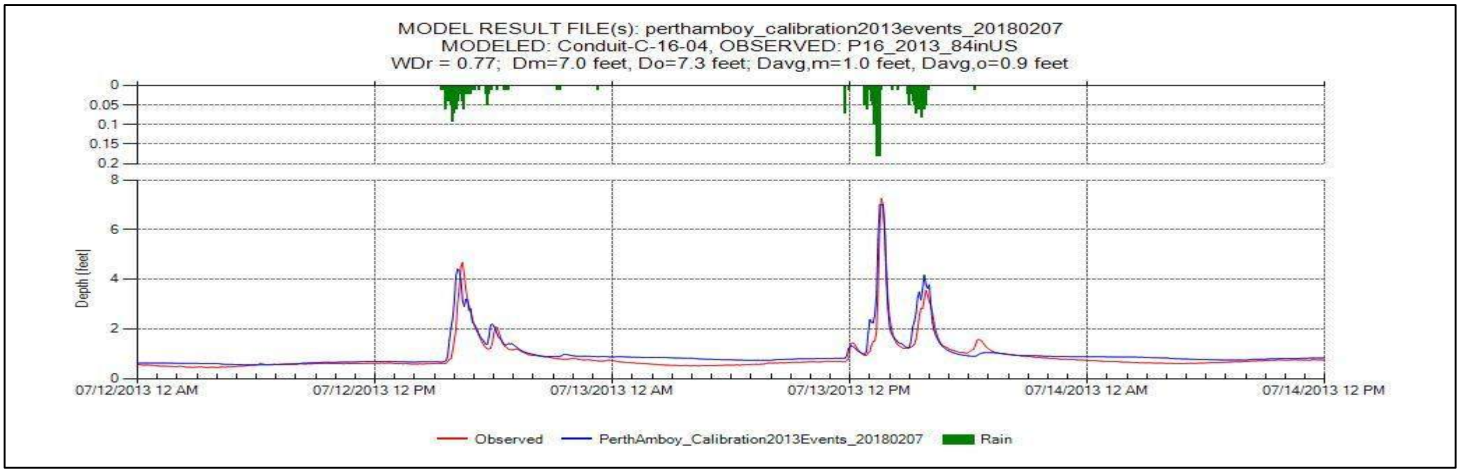
P16_2013_84inUS

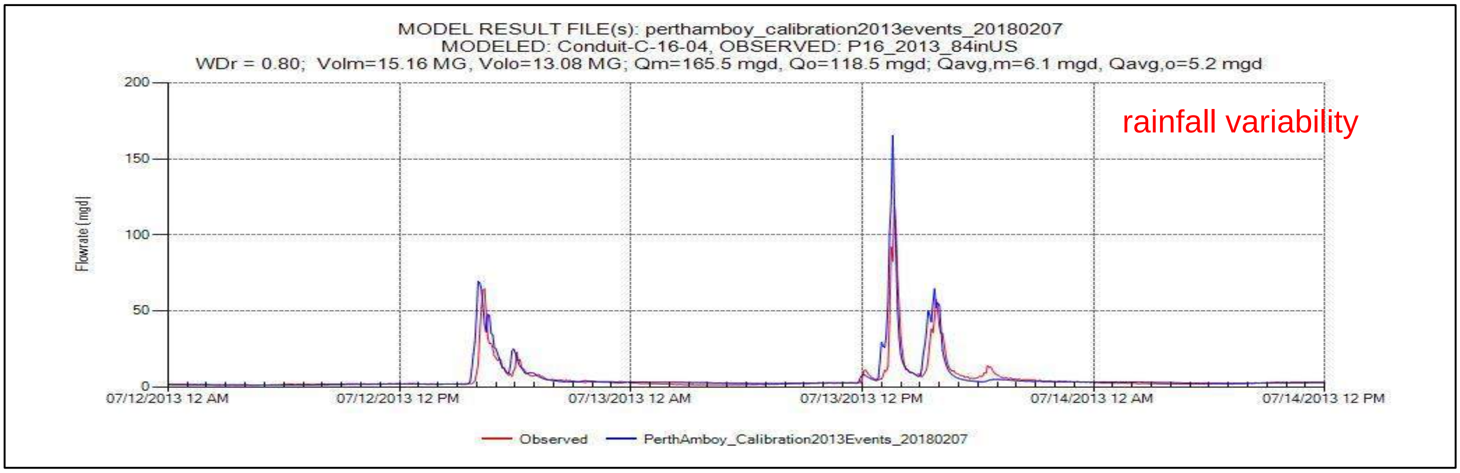


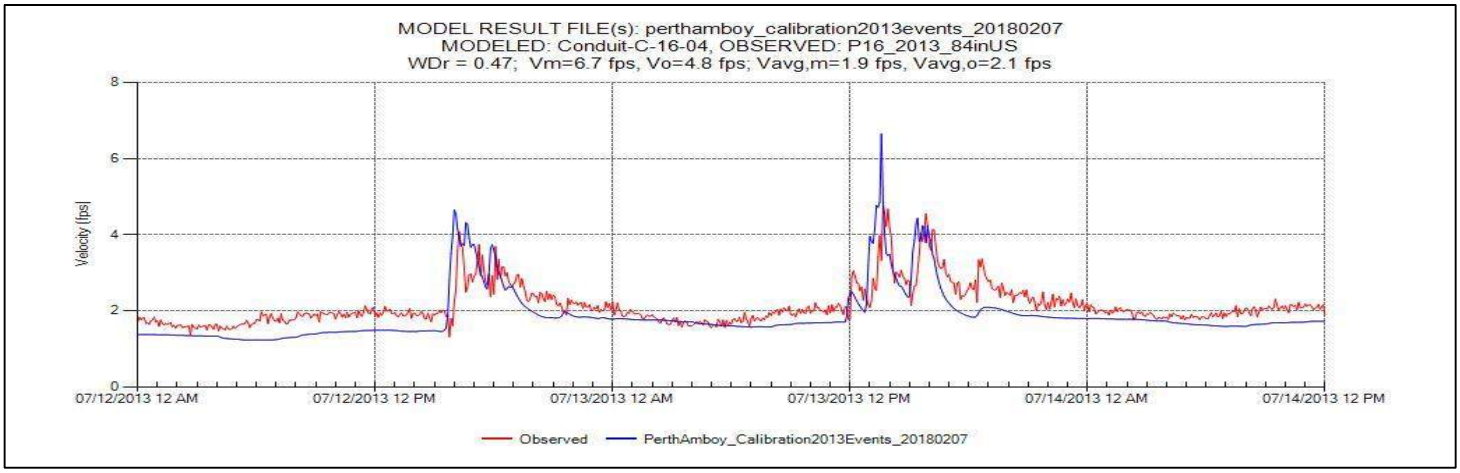




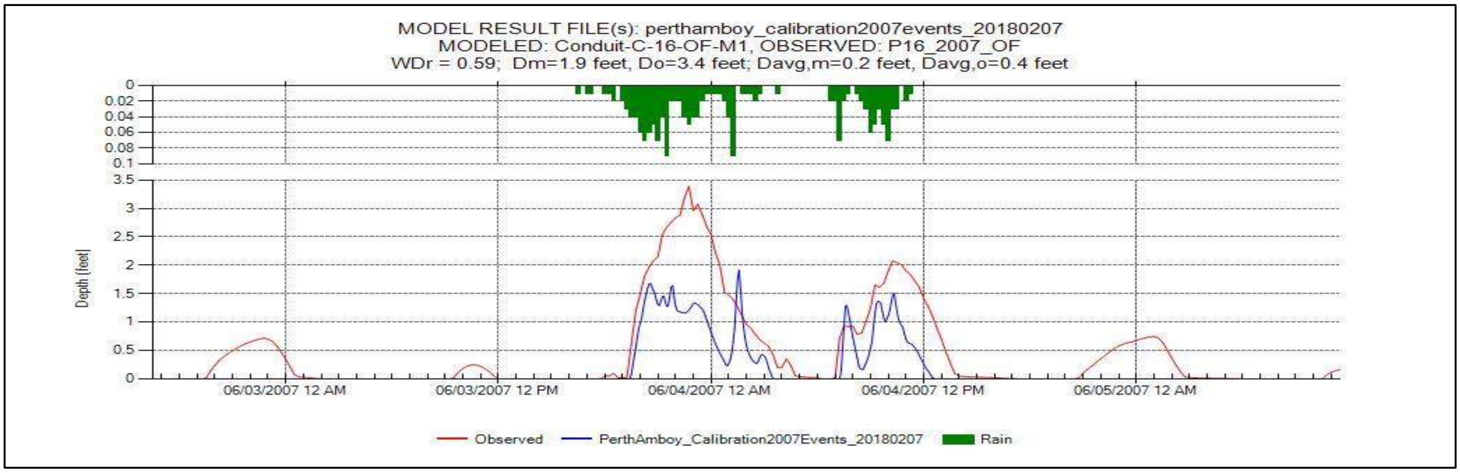
P16_2013_84inUS

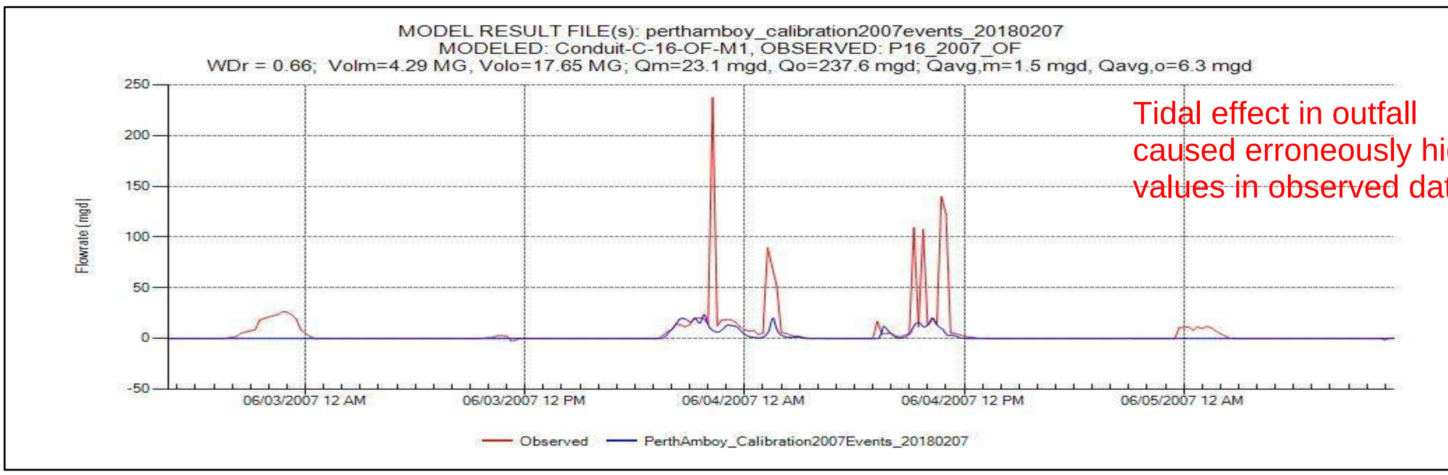


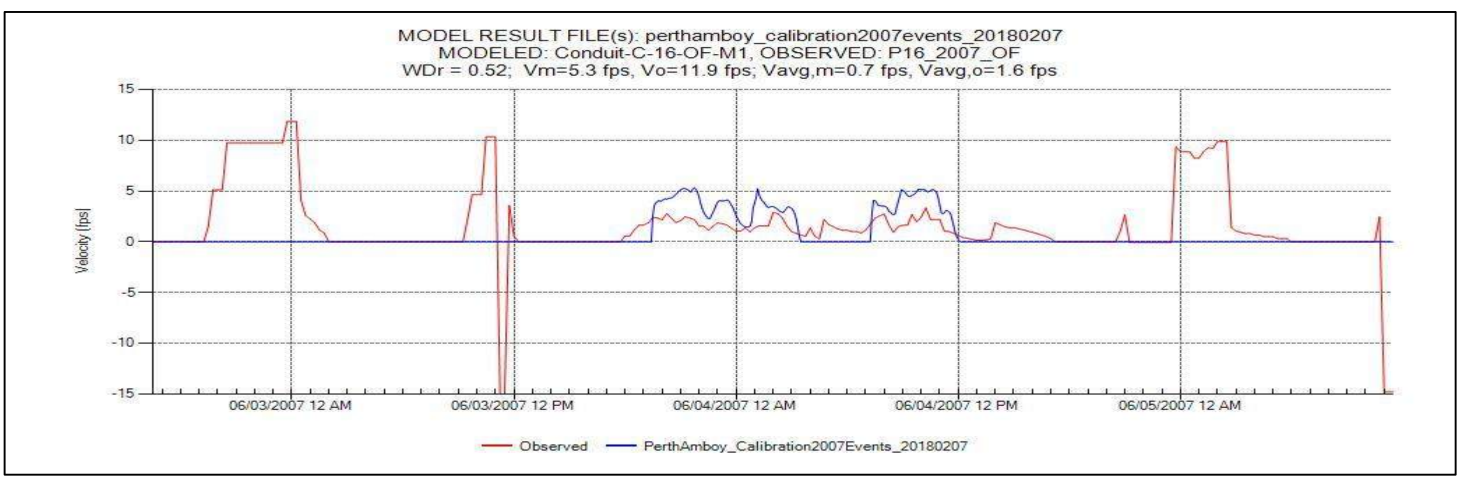




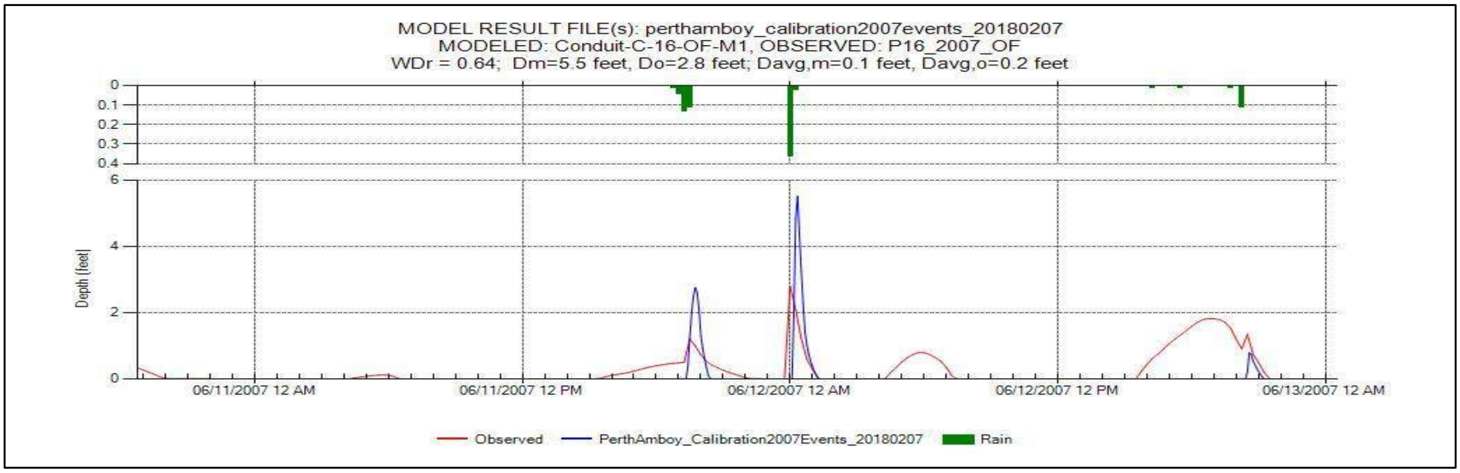
P16_2007_OF

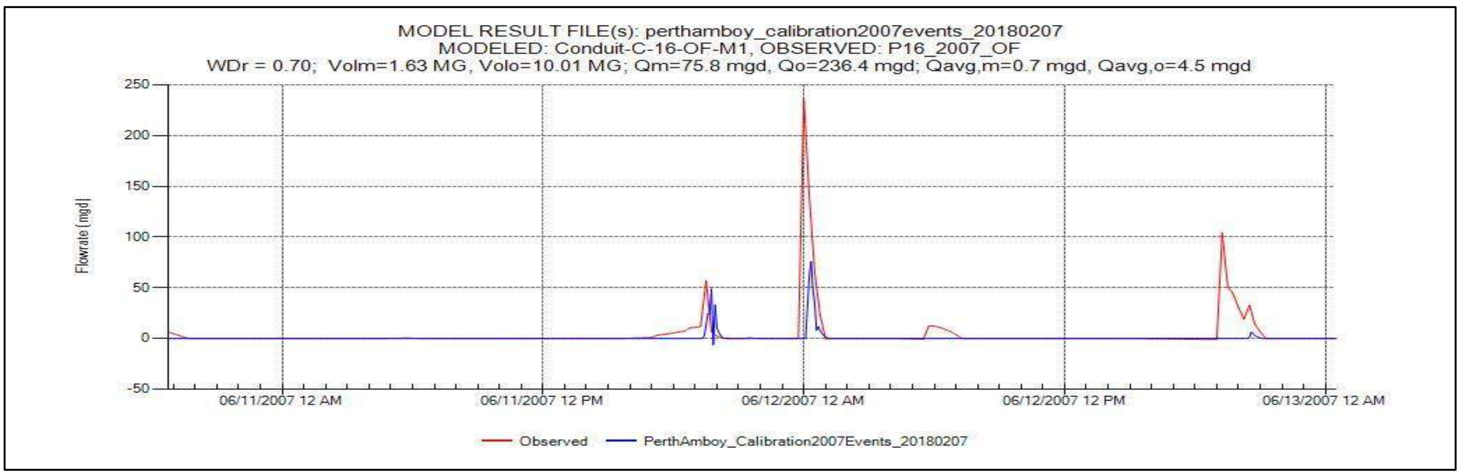

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.59; Dm=1.9 feet, Do=3.4 feet; Davg,m=0.2 feet, Davg,o=0.4 feet
Depth (feet)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

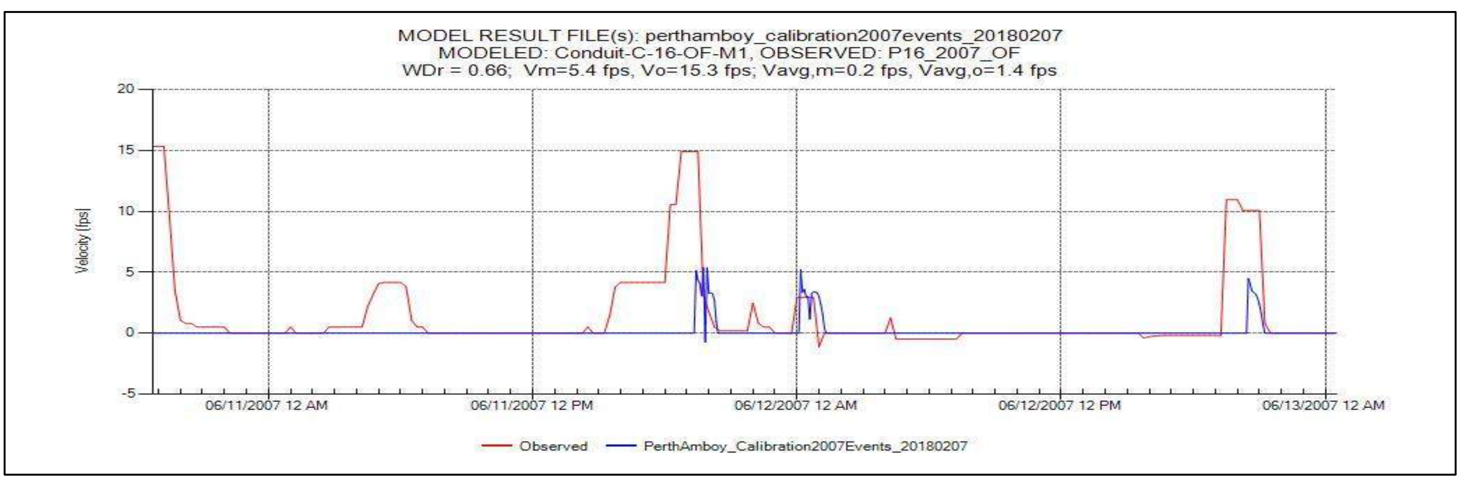

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.66; Volm=4.29 MG, Volo=17.65 MG; Qm=23.1 mgd, Qo=237.6 mgd; Qavg,m=1.5 mgd, Qavg,o=6.3 mgd
Tidal effect in outfall caused erroneously high values in observed data
Flowrate (mgd)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.52; Vm=5.3 fps, Vo=11.9 fps; Vavg,m=0.7 fps, Vavg,o=1.6 fps
Velocity (fps)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

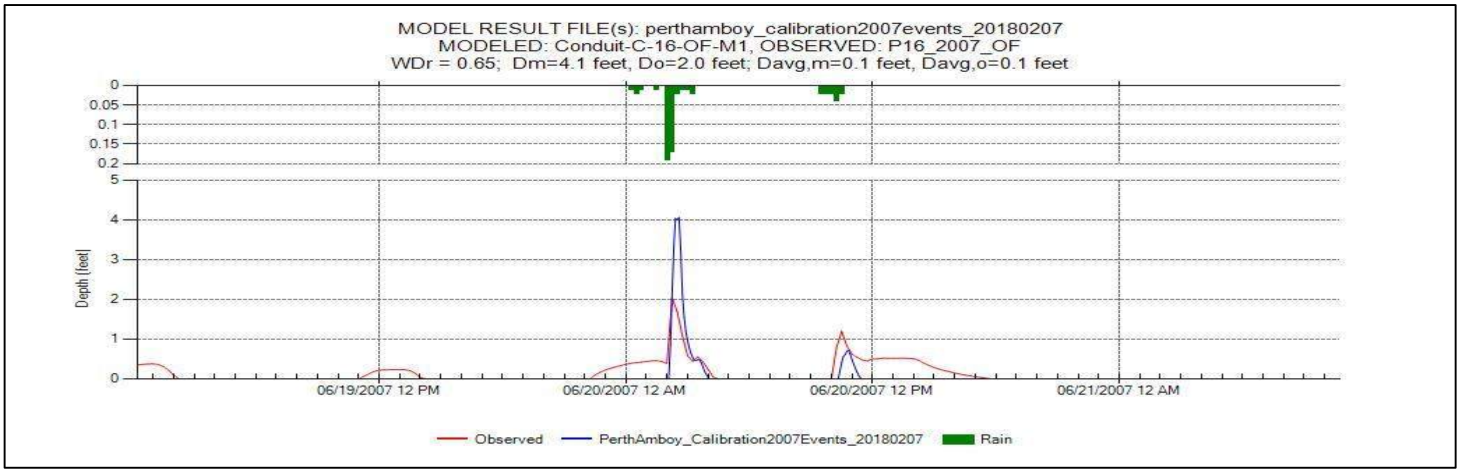
P16_2007_OF

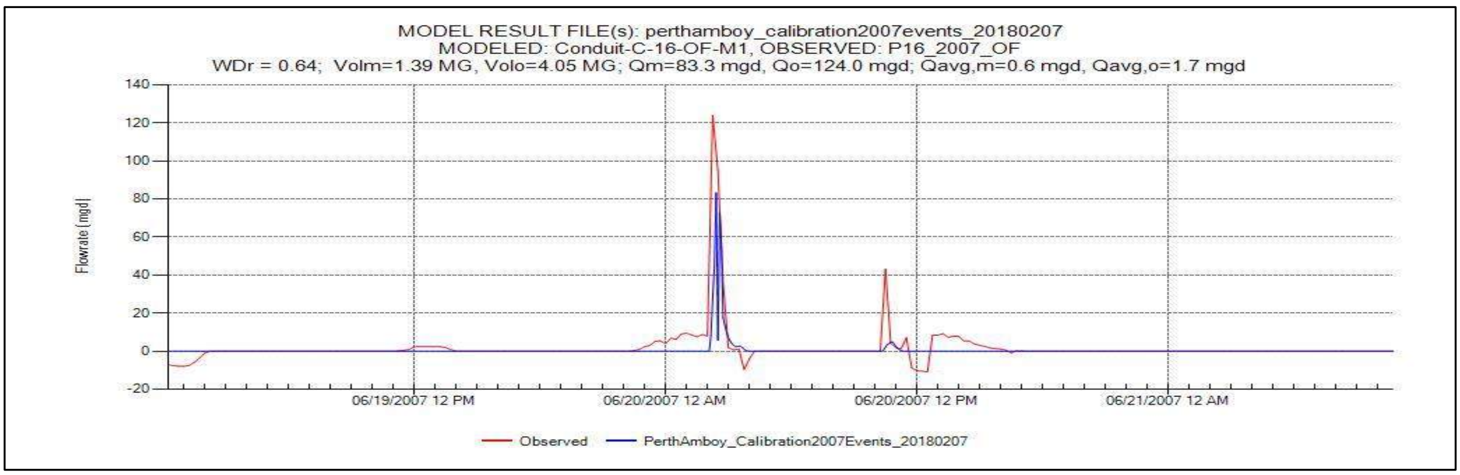

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.64; Dm=5.5 feet, Do=2.8 feet; Davg,m=0.1 feet, Davg,o=0.2 feet
Depth (feet)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

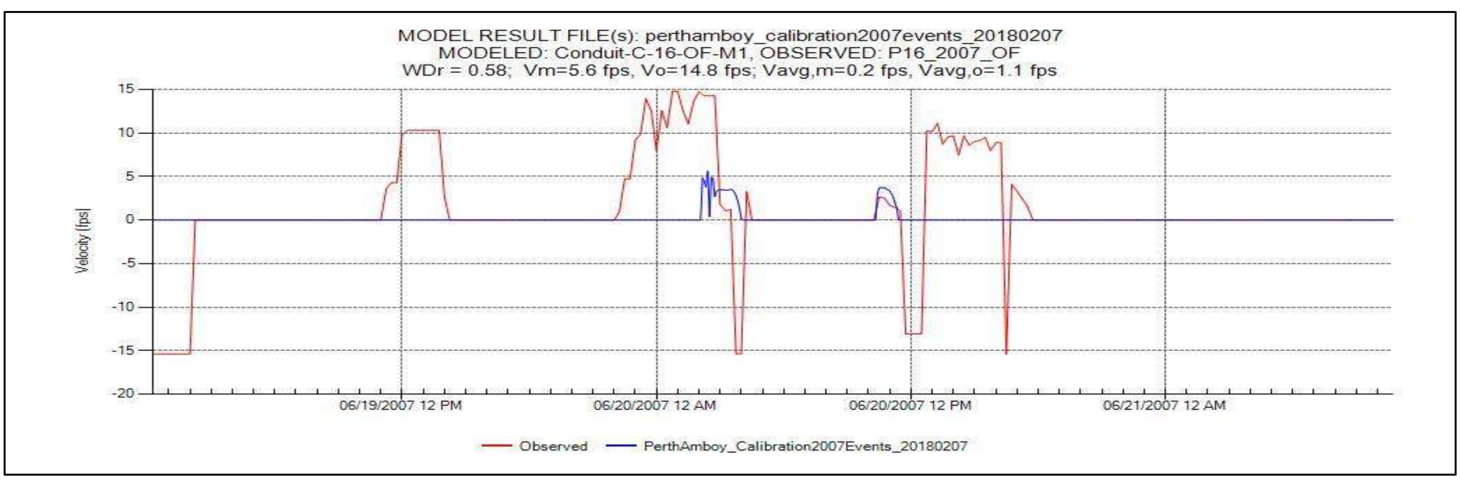

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.70; Volm=1.63 MG, Volo=10.01 MG; Qm=75.8 mgd, Qo=236.4 mgd; Qavg,m=0.7 mgd, Qavg,o=4.5 mgd
Flowrate (mgd)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.66; Vm=5.4 fps, Vo=15.3 fps; Vavg,m=0.2 fps, Vavg,o=1.4 fps
Velocity (fps)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

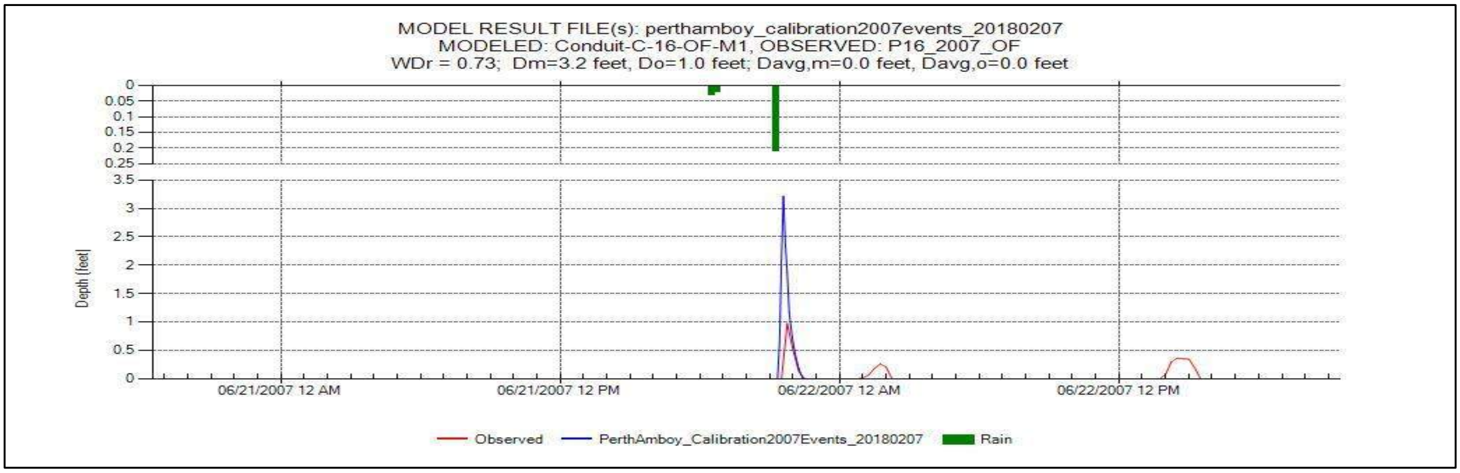
P16_2007_OF

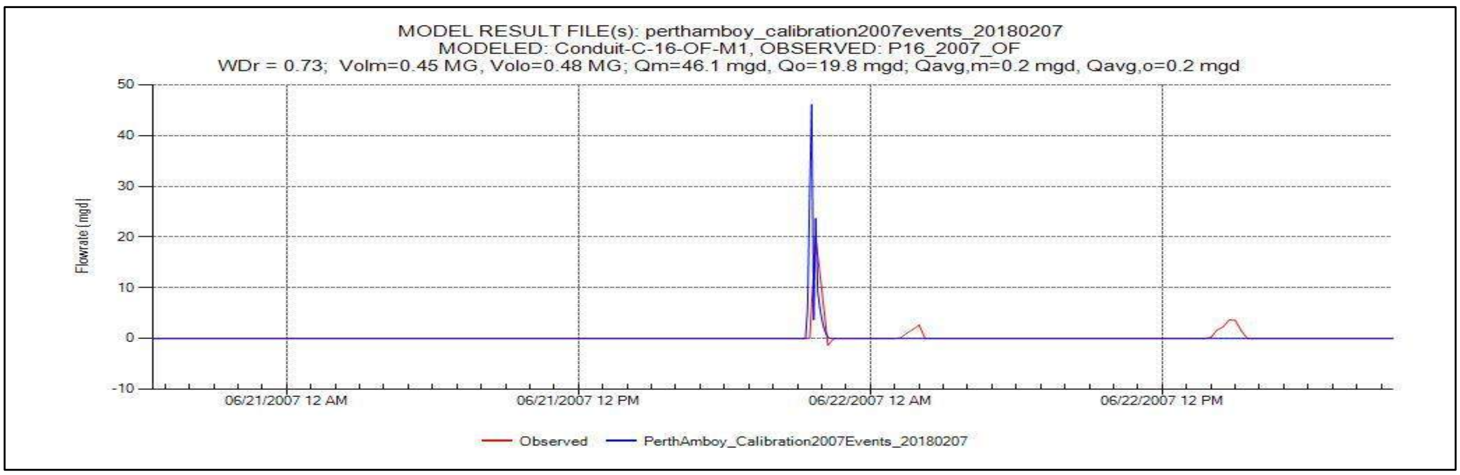

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.65; Dm=4.1 feet, Do=2.0 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

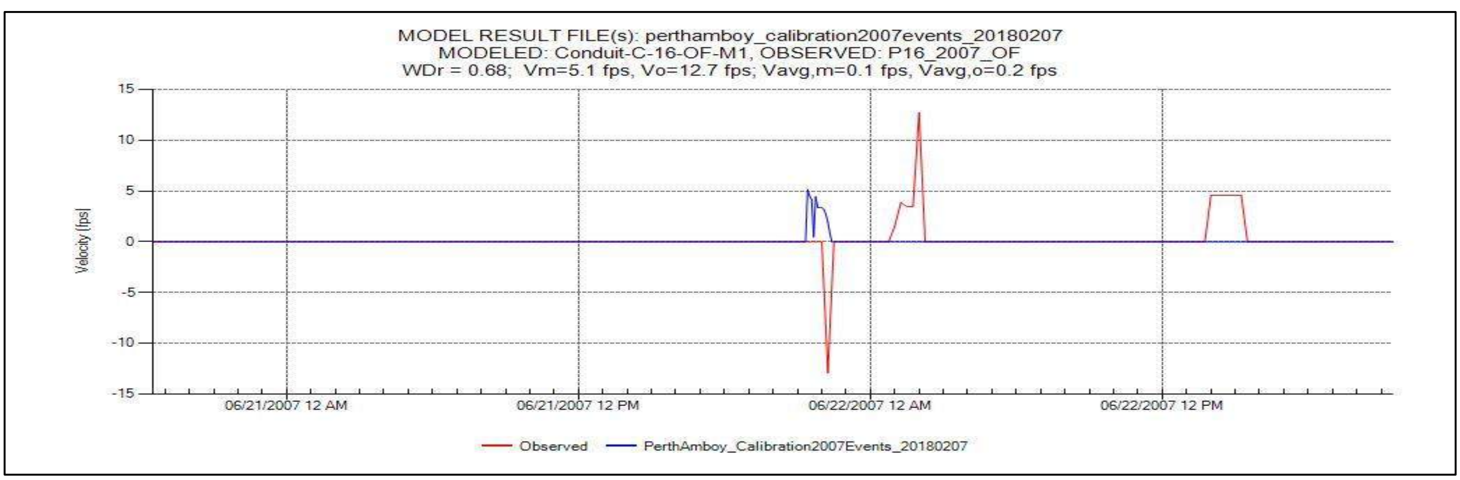

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.64; Volm=1.39 MG, Volo=4.05 MG; Qm=83.3 mgd, Qo=124.0 mgd; Qavg,m=0.6 mgd, Qavg,o=1.7 mgd
Flowrate (mgd)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.58; Vm=5.6 fps, Vo=14.8 fps; Vavg,m=0.2 fps, Vavg,o=1.1 fps
Velocity (fps)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

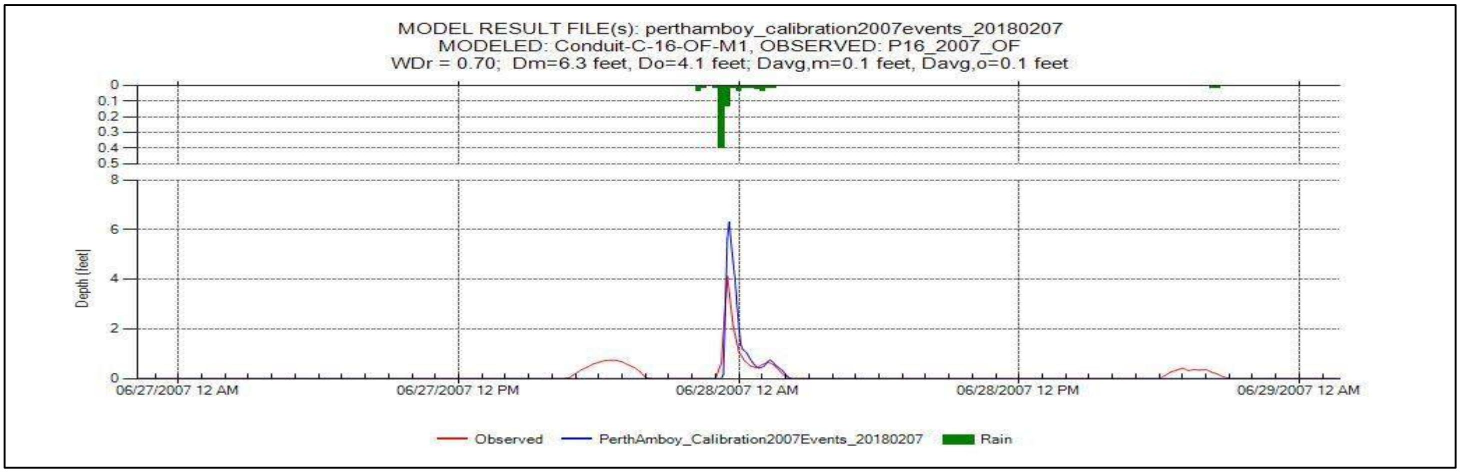
P16_2007_OF

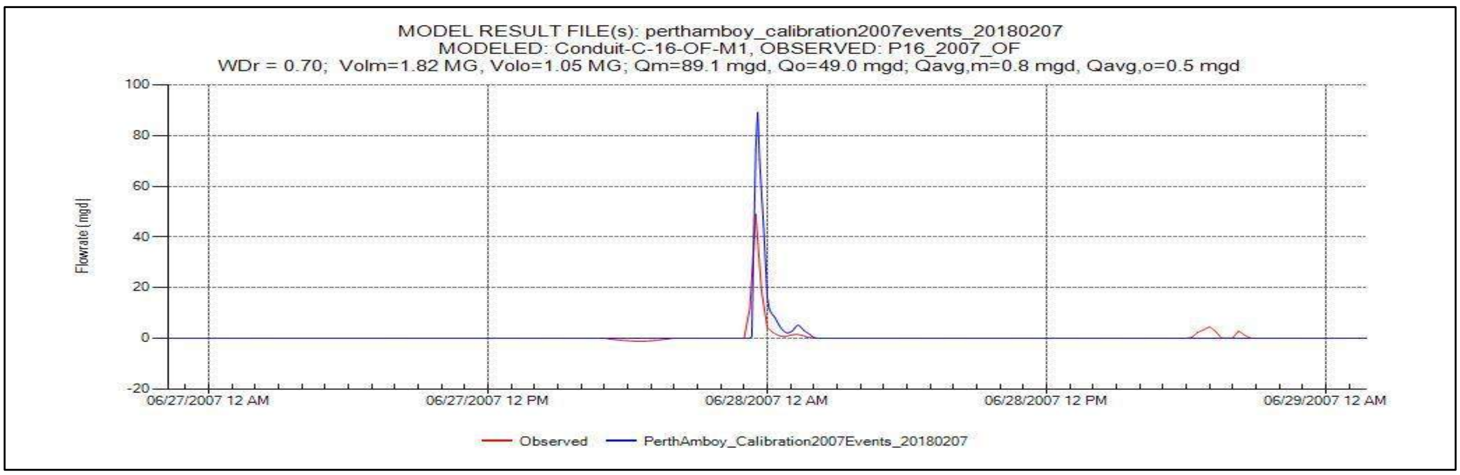

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.73; Dm=3.2 feet, Do=1.0 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

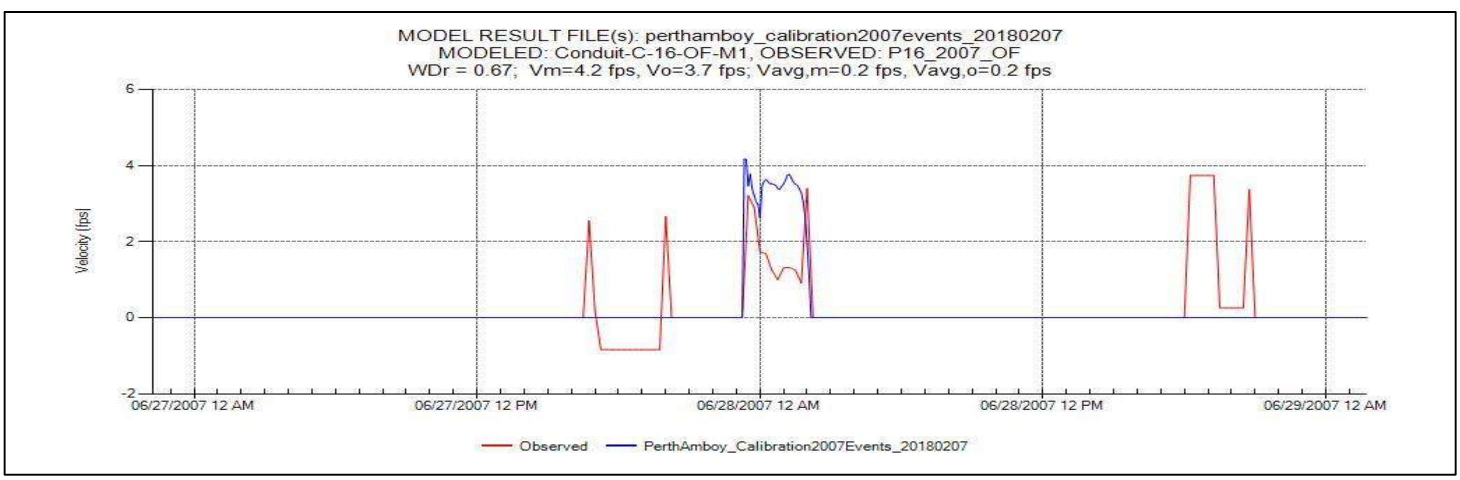

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.73; Volm=0.45 MG, Volo=0.48 MG; Qm=46.1 mgd, Qo=19.8 mgd; Qavg,m=0.2 mgd, Qavg,o=0.2 mgd
Flowrate (mgd)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.68; Vm=5.1 fps, Vo=12.7 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

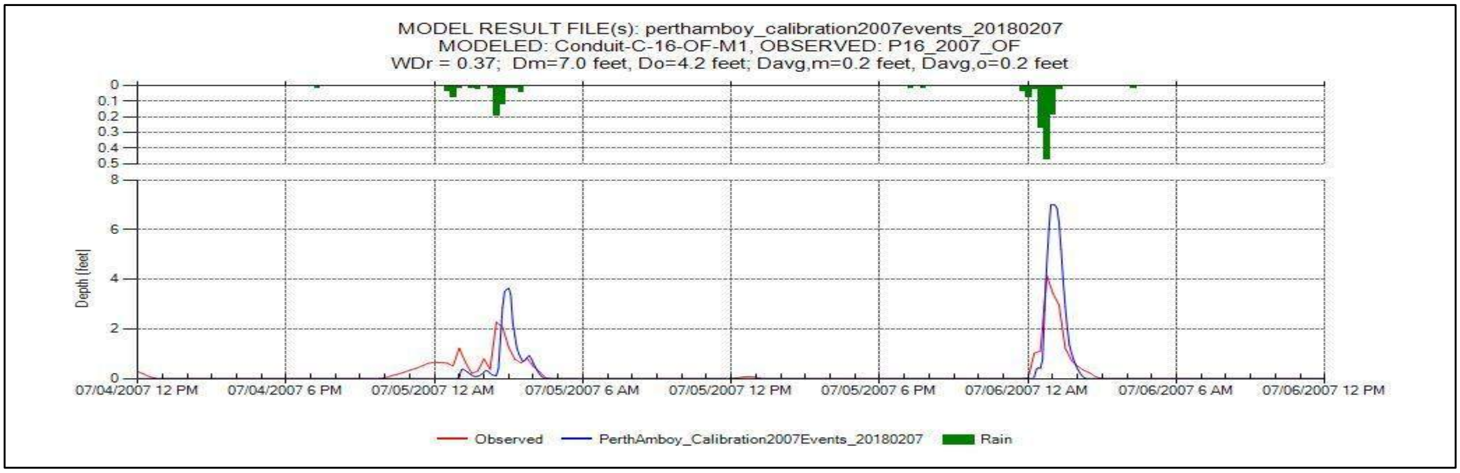
P16_2007_OF

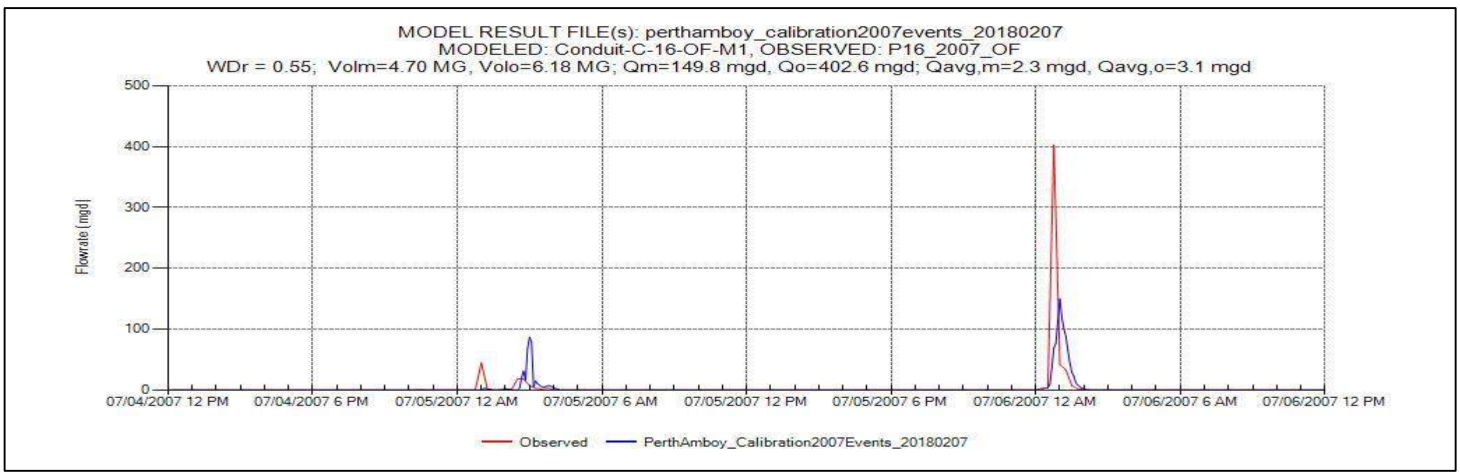

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.70; Dm=6.3 feet, Do=4.1 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

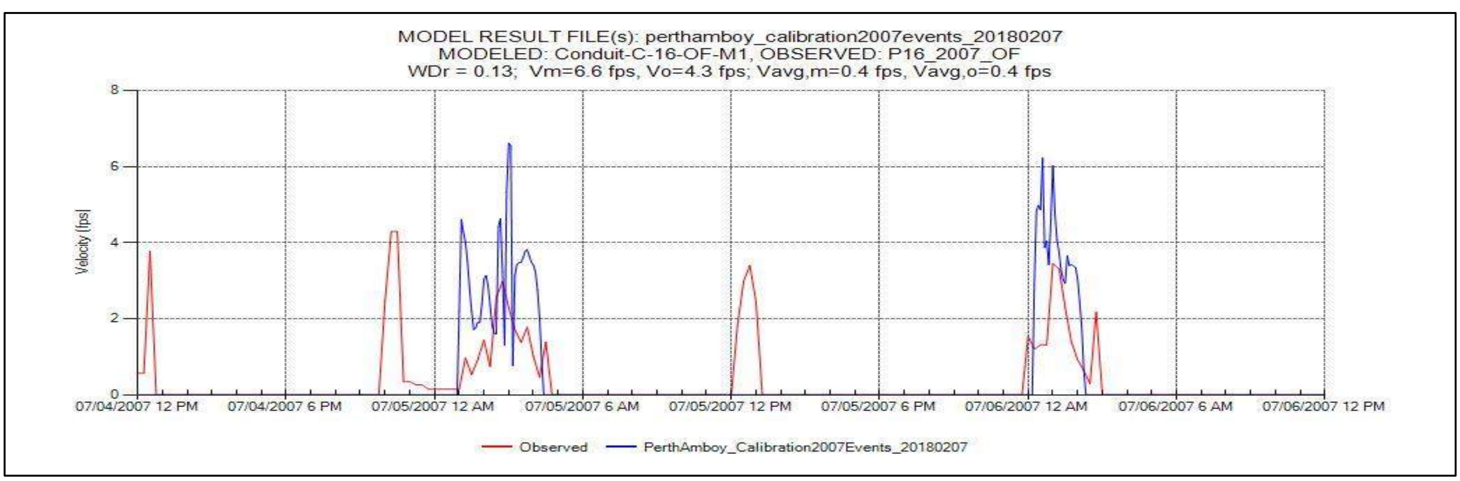

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.70; Volm=1.82 MG, Volo=1.05 MG; Qm=89.1 mgd, Qo=49.0 mgd; Qavg,m=0.8 mgd, Qavg,o=0.5 mgd
Flowrate (mgd)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.67; Vm=4.2 fps, Vo=3.7 fps; Vavg,m=0.2 fps, Vavg,o=0.2 fps
Velocity (fps)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

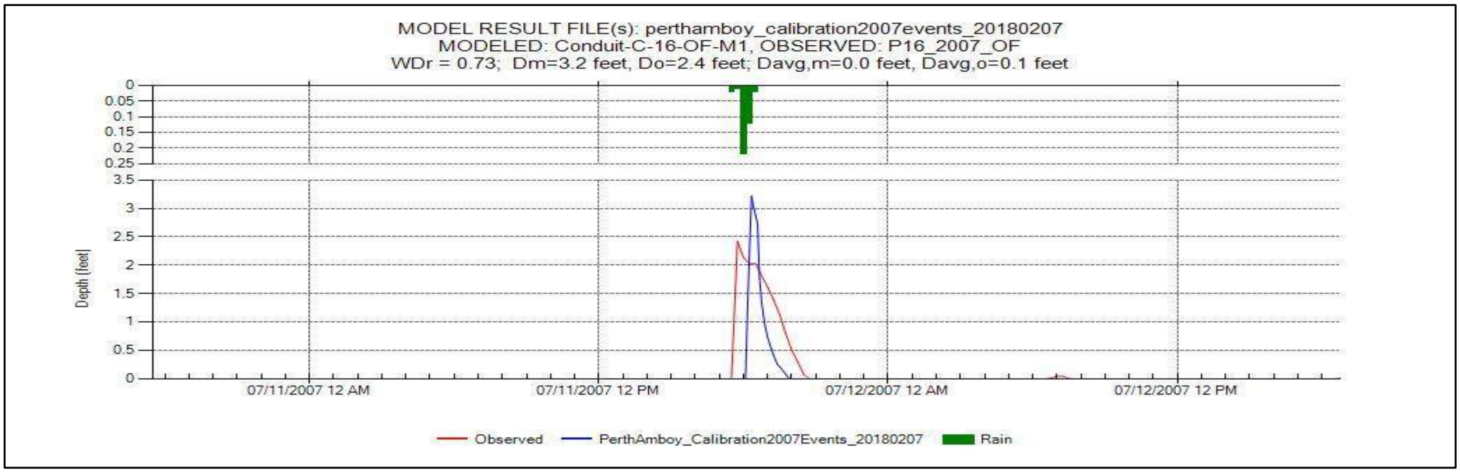
P16_2007_OF

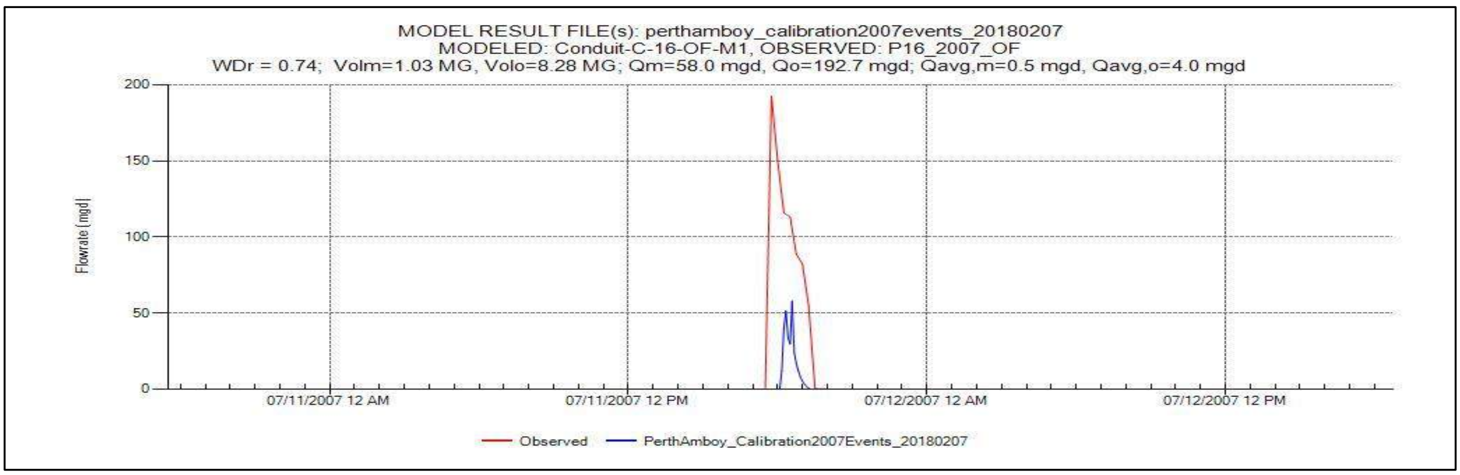

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.37; Dm=7.0 feet, Do=4.2 feet; Davg,m=0.2 feet, Davg,o=0.2 feet
Depth (feet)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

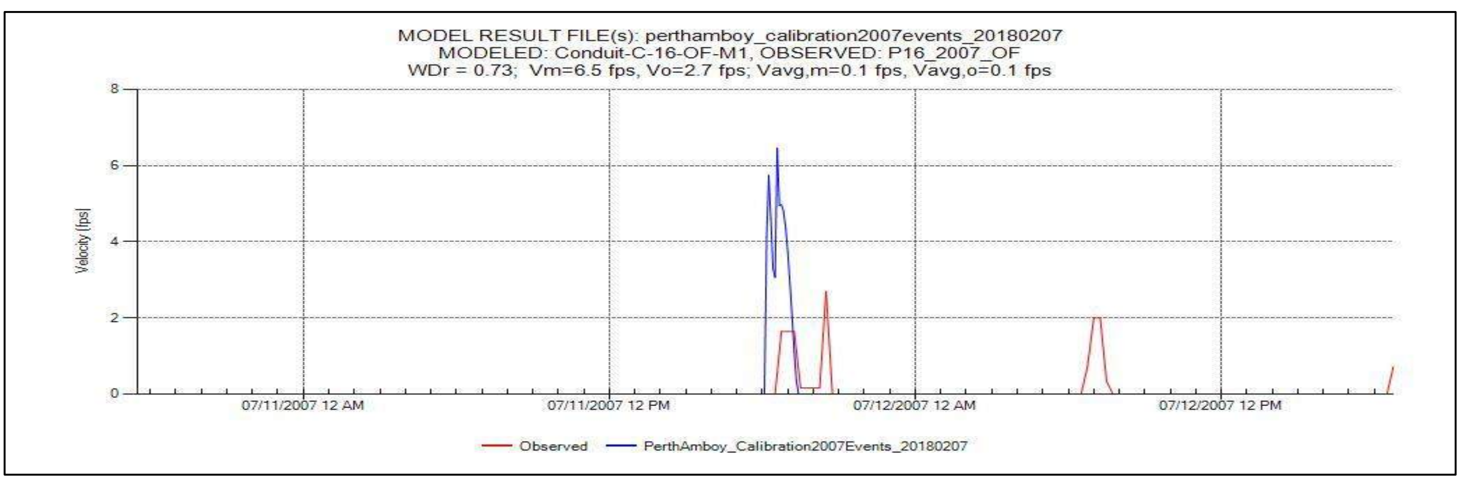

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.55; Volm=4.70 MG, Volo=6.18 MG; Qm=149.8 mgd, Qo=402.6 mgd; Qavg,m=2.3 mgd, Qavg,o=3.1 mgd
Flowrate (mgd)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.13; Vm=6.6 fps, Vo=4.3 fps; Vavg,m=0.4 fps, Vavg,o=0.4 fps
Velocity (fps)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

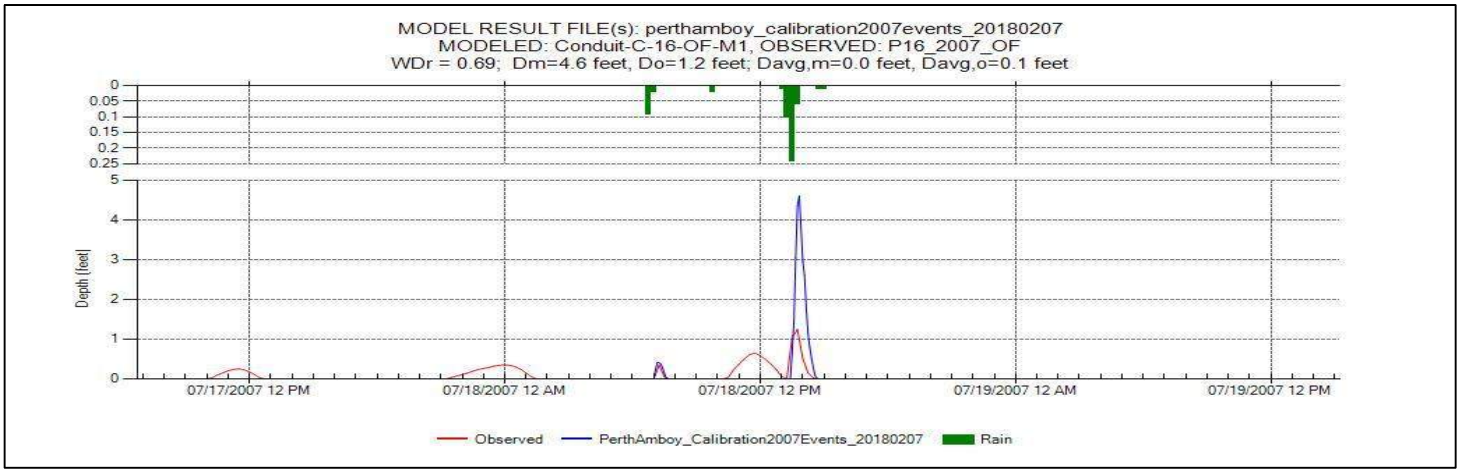
P16_2007_OF

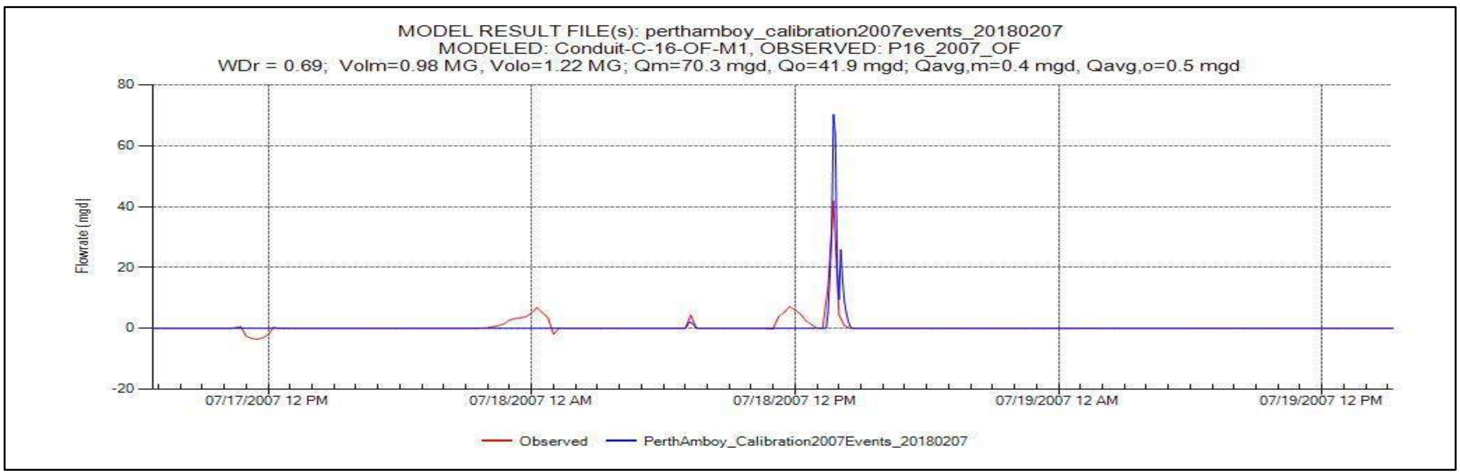

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.73; Dm=3.2 feet, Do=2.4 feet; Davg,m=0.0 feet, Davg,o=0.1 feet
Depth (feet)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

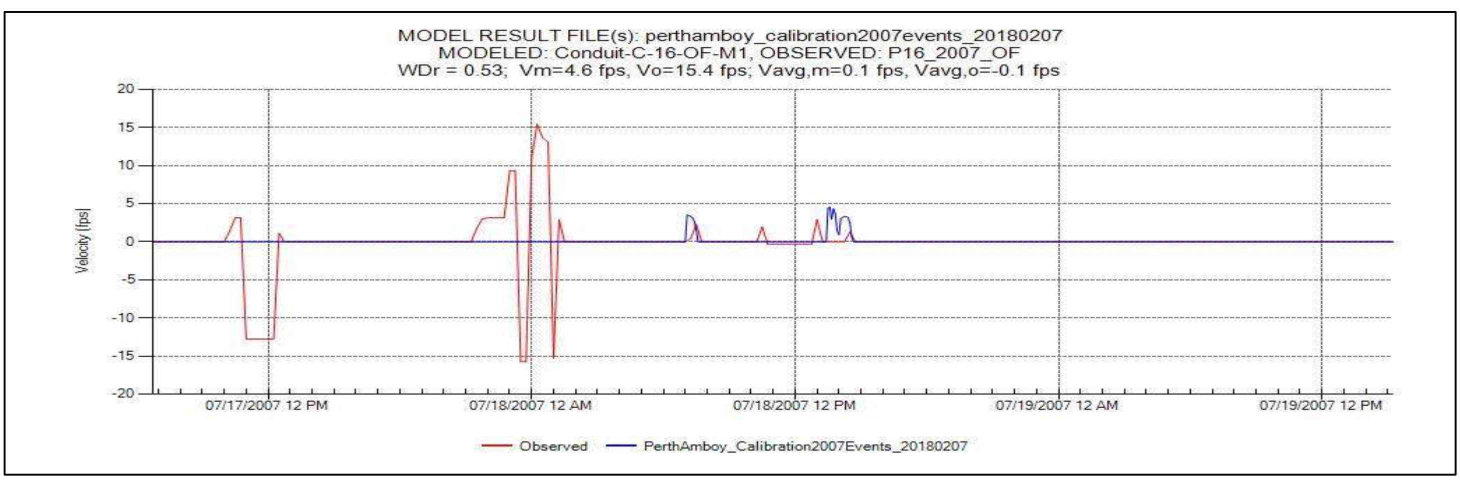

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.74; Volm=1.03 MG, Volo=8.28 MG; Qm=58.0 mgd, Qo=192.7 mgd; Qavg,m=0.5 mgd, Qavg,o=4.0 mgd
Flowrate (mgd)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.73; Vm=6.5 fps, Vo=2.7 fps; Vavg,m=0.1 fps, Vavg,o=0.1 fps
Velocity (fps)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

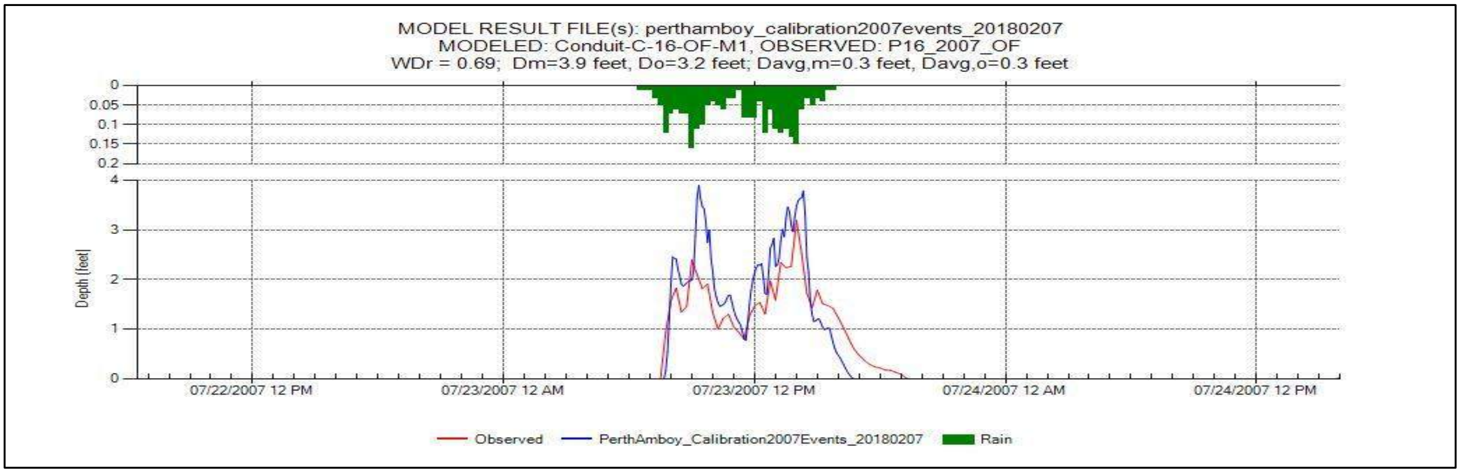
P16_2007_OF

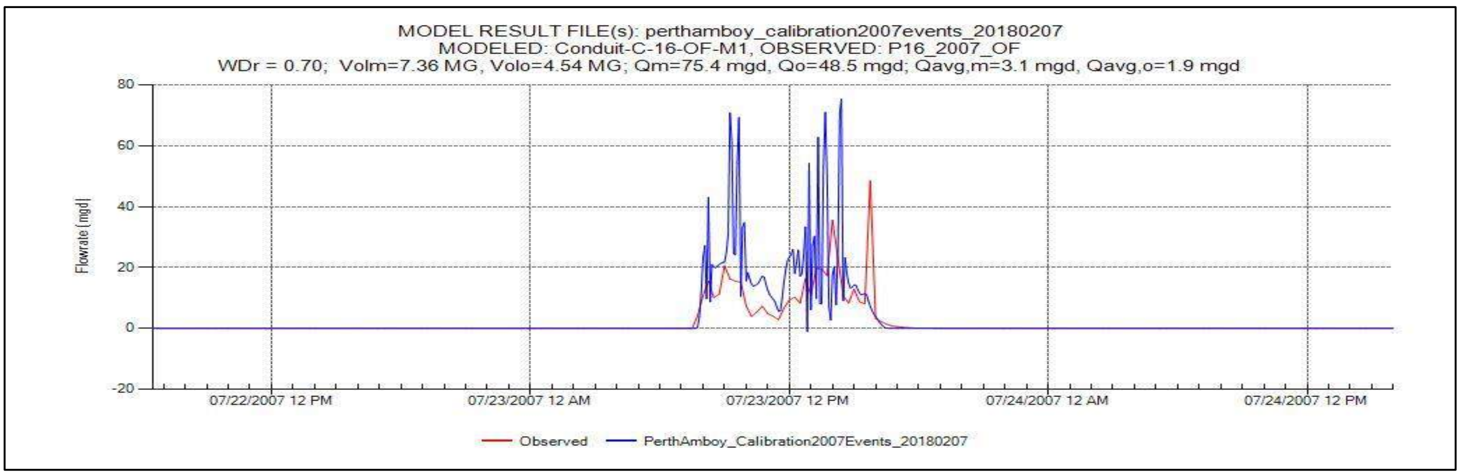

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.69; Dm=4.6 feet, Do=1.2 feet; Davg,m=0.0 feet, Davg,o=0.1 feet
Depth (feet)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

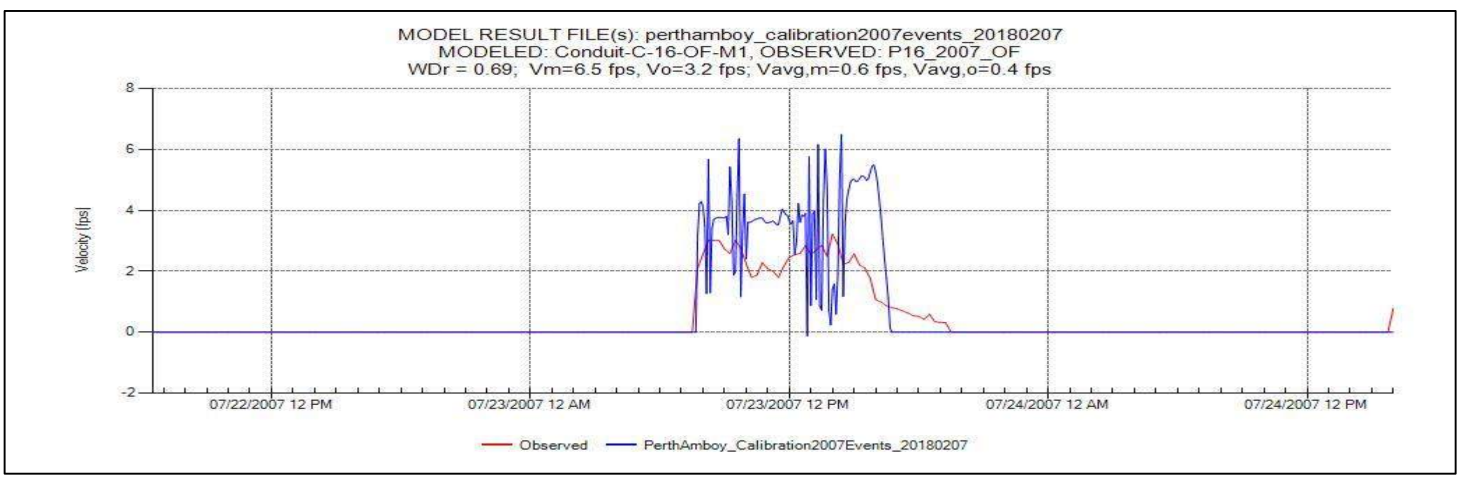

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.69; Volm=0.98 MG, Volo=1.22 MG; Qm=70.3 mgd, Qo=41.9 mgd; Qavg,m=0.4 mgd, Qavg,o=0.5 mgd
Flowrate (mgd)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.53; Vm=4.6 fps, Vo=15.4 fps; Vavg,m=0.1 fps, Vavg,o=-0.1 fps
Velocity (fps)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

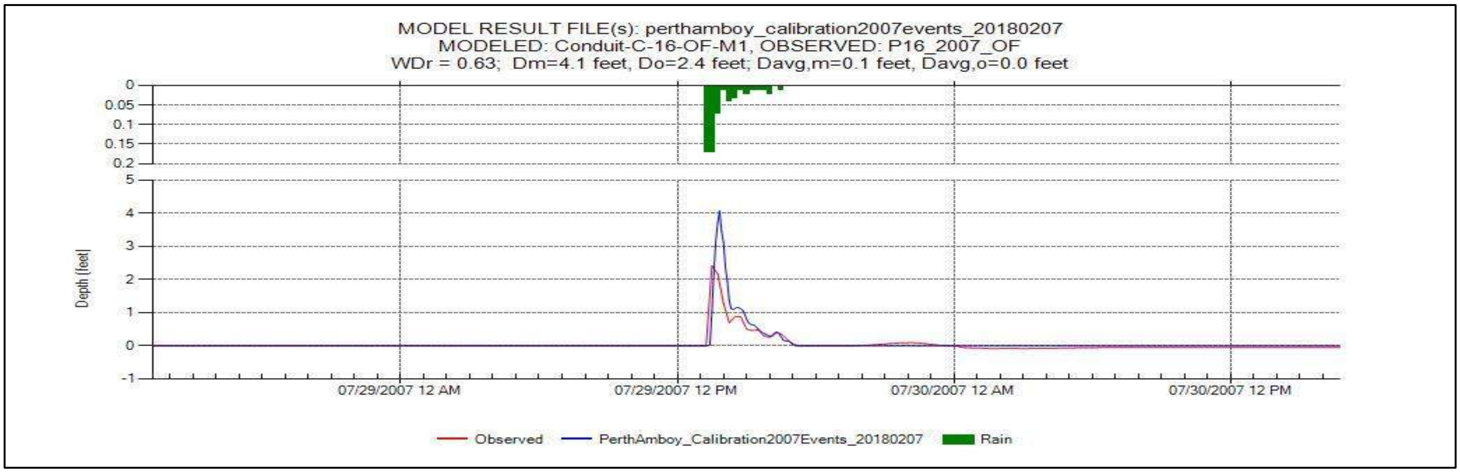
P16_2007_OF

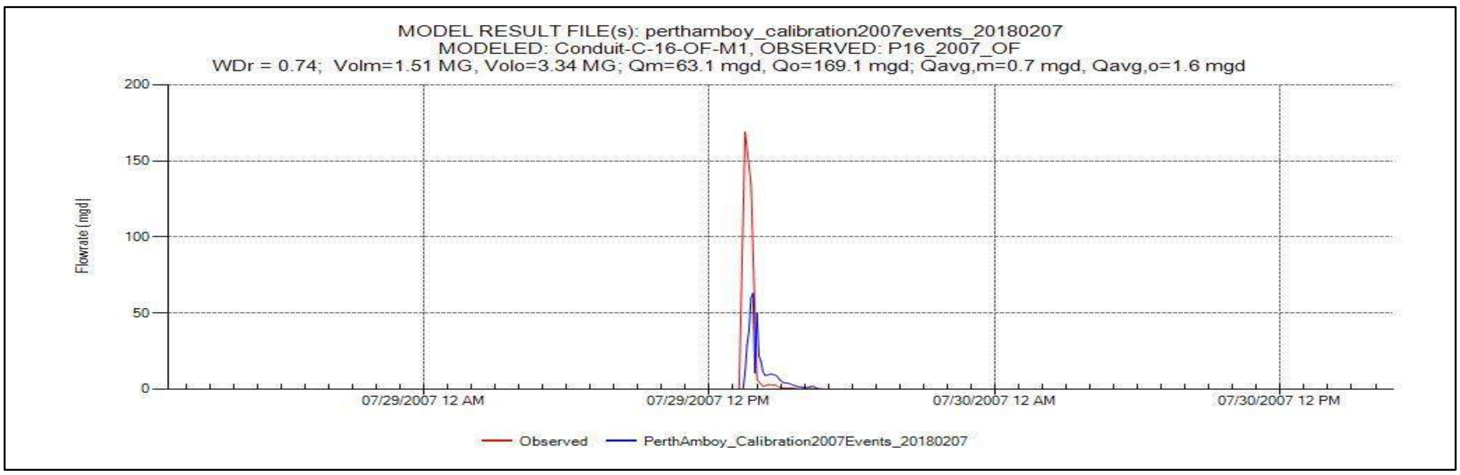

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.69; Dm=3.9 feet, Do=3.2 feet; Davg,m=0.3 feet, Davg,o=0.3 feet
Depth (feet)
07/22/2007 12 PM
07/23/2007 12 AM
07/23/2007 12 PM
07/24/2007 12 AM
07/24/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

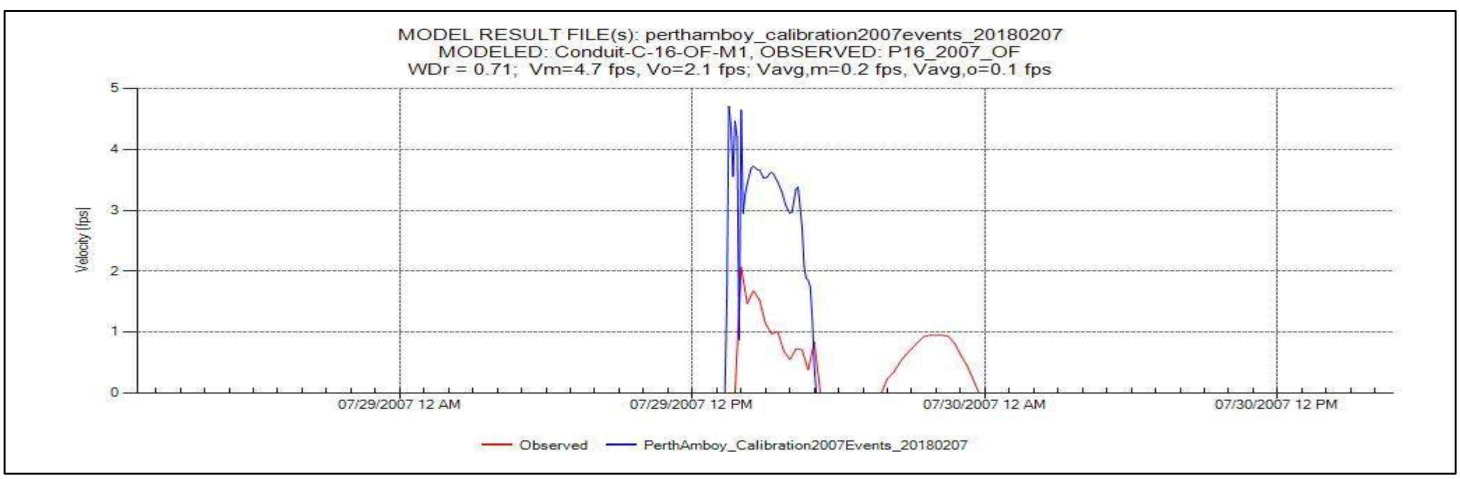

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.70; Volm=7.36 MG, Volo=4.54 MG; Qm=75.4 mgd, Qo=48.5 mgd; Qavg,m=3.1 mgd, Qavg,o=1.9 mgd
Flowrate (mgd)
07/22/2007 12 PM
07/23/2007 12 AM
07/23/2007 12 PM
07/24/2007 12 AM
07/24/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.69; Vm=6.5 fps, Vo=3.2 fps; Vavg,m=0.6 fps, Vavg,o=0.4 fps
Velocity (fps)
07/22/2007 12 PM
07/23/2007 12 AM
07/23/2007 12 PM
07/24/2007 12 AM
07/24/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

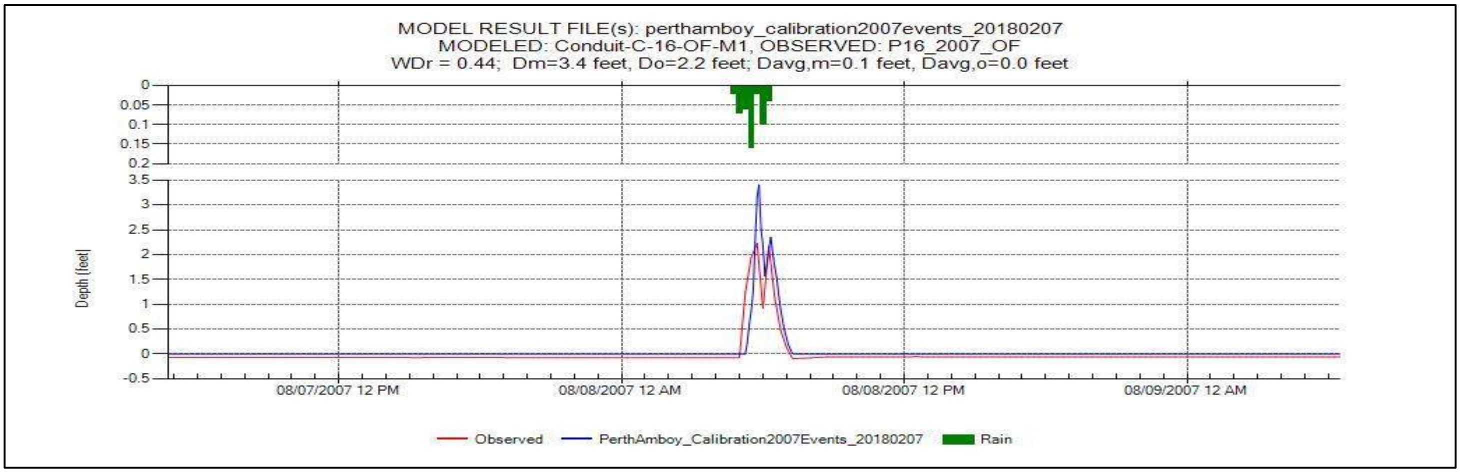
P16_2007_OF

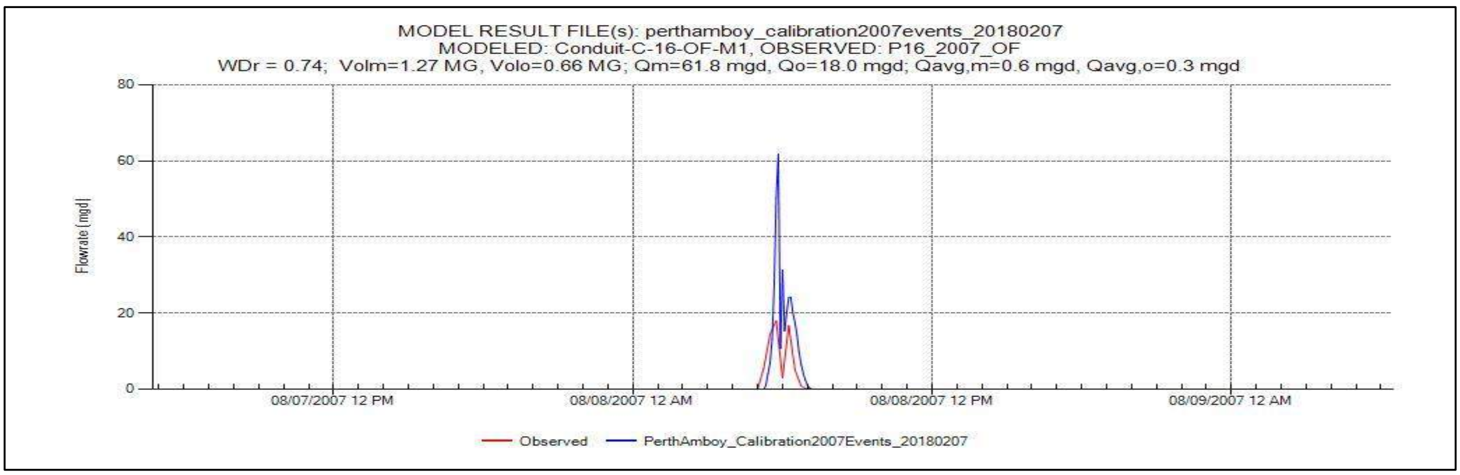

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.63; Dm=4.1 feet, Do=2.4 feet; Davg,m=0.1 feet, Davg,o=0.0 feet
Depth (feet)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

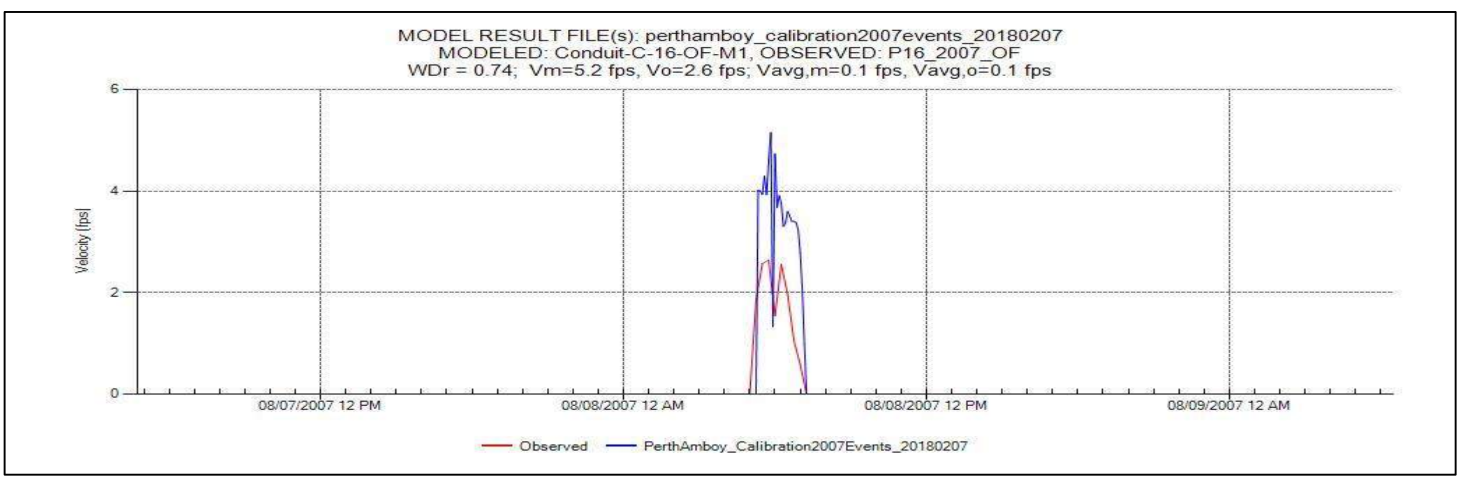

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.74; Volm=1.51 MG, Volo=3.34 MG; Qm=63.1 mgd, Qo=169.1 mgd; Qavg,m=0.7 mgd, Qavg,o=1.6 mgd
Flowrate (mgd)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.71; Vm=4.7 fps, Vo=2.1 fps; Vavg,m=0.2 fps, Vavg,o=0.1 fps
Velocity (fps)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

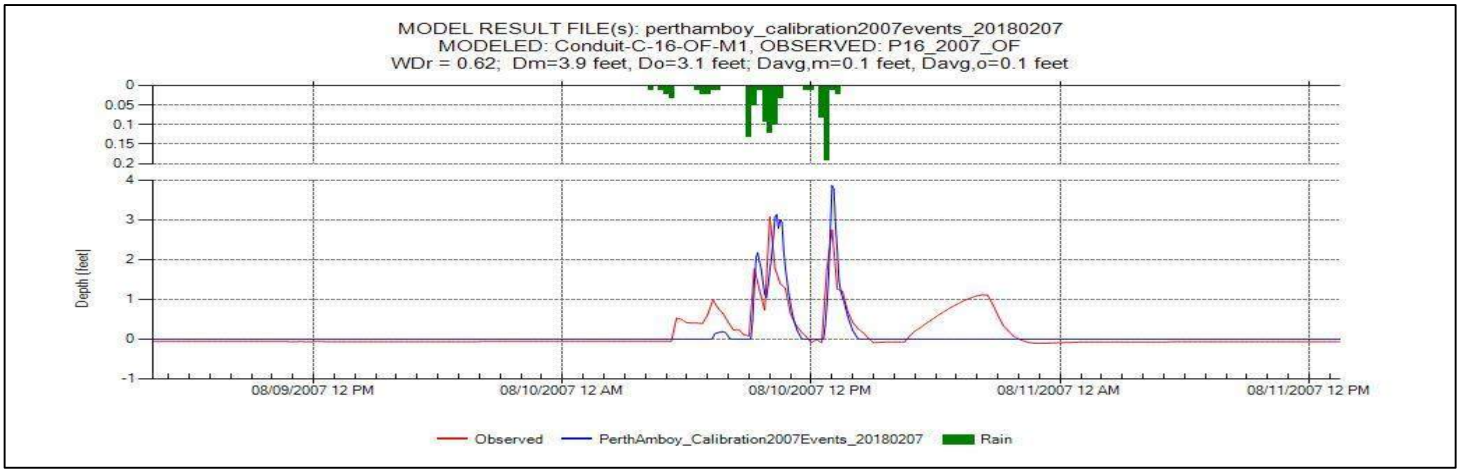
P16_2007_OF

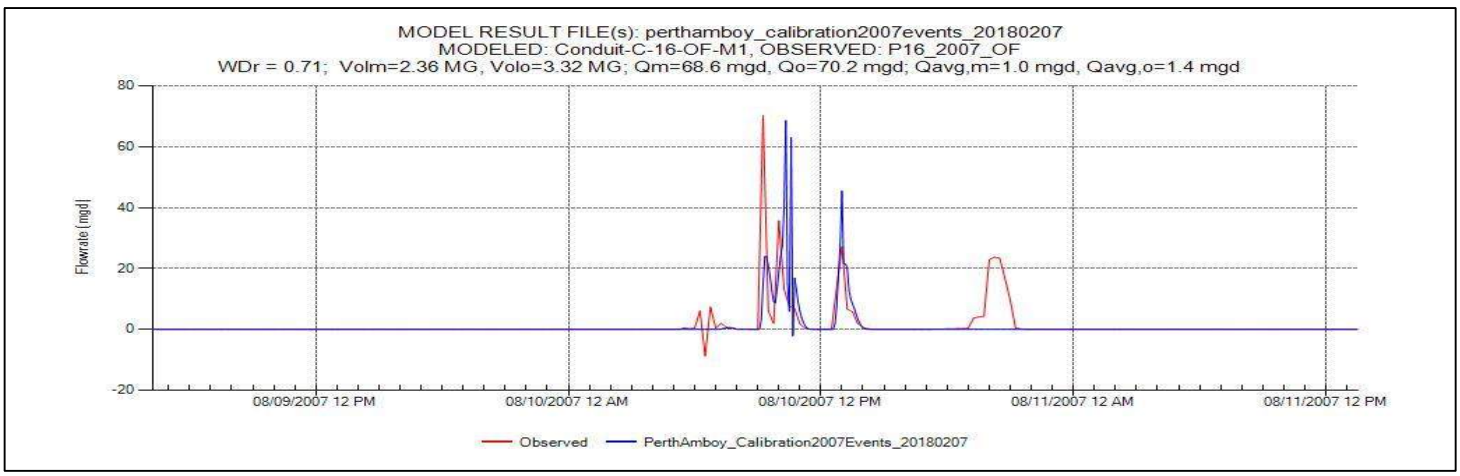

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.44; Dm=3.4 feet, Do=2.2 feet; Davg,m=0.1 feet, Davg,o=0.0 feet
Depth (feet)
08/07/2007 12 PM
08/08/2007 12 AM
08/08/2007 12 PM
08/09/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

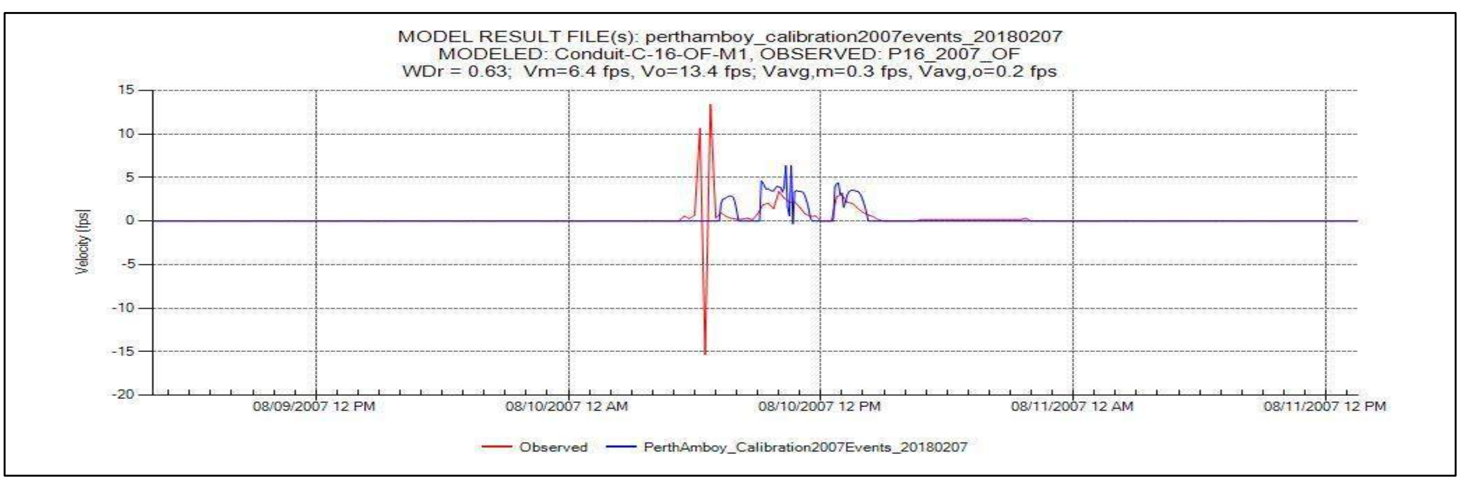

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.74; Volm=1.27 MG, Volo=0.66 MG; Qm=61.8 mgd, Qo=18.0 mgd; Qavg,m=0.6 mgd, Qavg,o=0.3 mgd
Flowrate (mgd)
08/07/2007 12 PM
08/08/2007 12 AM
08/08/2007 12 PM
08/09/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.74; Vm=5.2 fps, Vo=2.6 fps; Vavg,m=0.1 fps, Vavg,o=0.1 fps
Velocity (fps)
08/07/2007 12 PM
08/08/2007 12 AM
08/08/2007 12 PM
08/09/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

P16_2007_OF

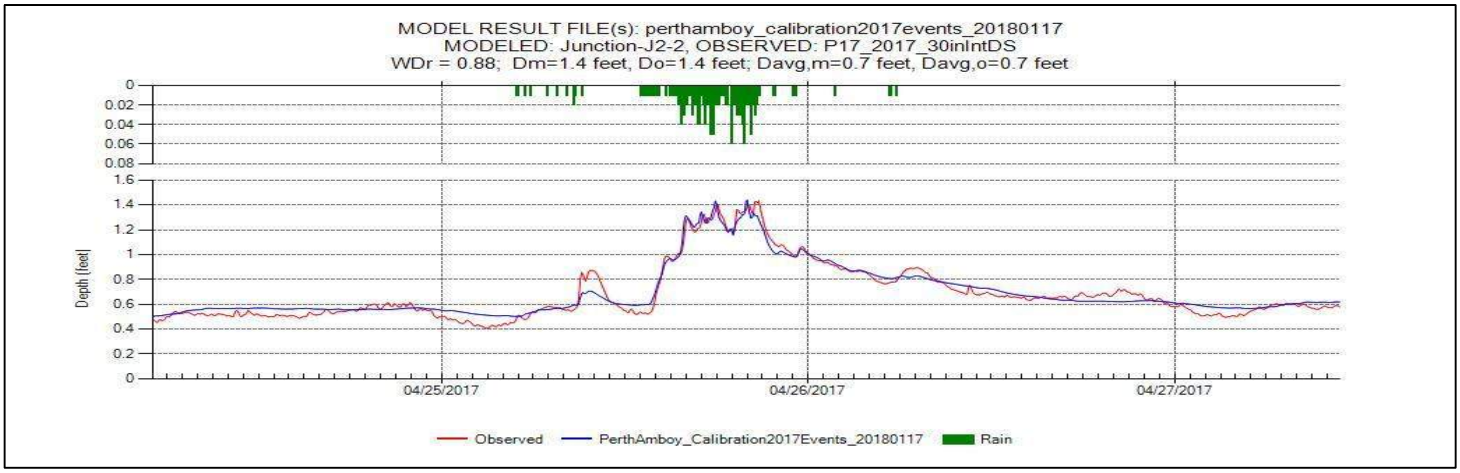

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.62; Dm=3.9 feet, Do=3.1 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
08/09/2007 12 PM
08/10/2007 12 AM
08/10/2007 12 PM
08/11/2007 12 AM
08/11/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

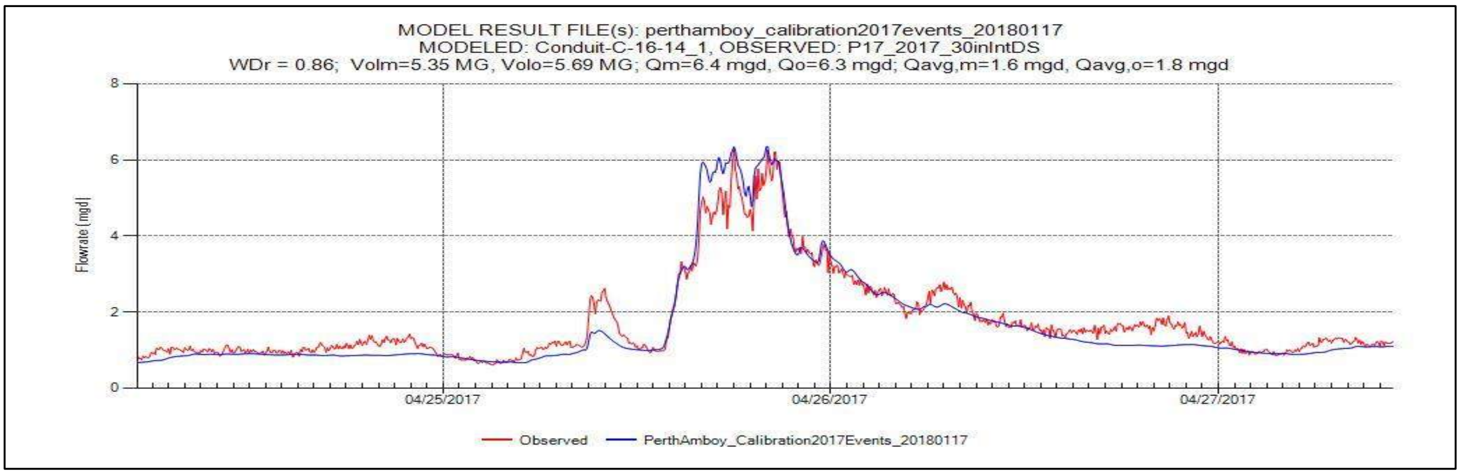

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.71; Volm=2.36 MG, Volo=3.32 MG; Qm=68.6 mgd, Qo=70.2 mgd; Qavg,m=1.0 mgd, Qavg,o=1.4 mgd
Flowrate (mgd)
08/09/2007 12 PM
08/10/2007 12 AM
08/10/2007 12 PM
08/11/2007 12 AM
08/11/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

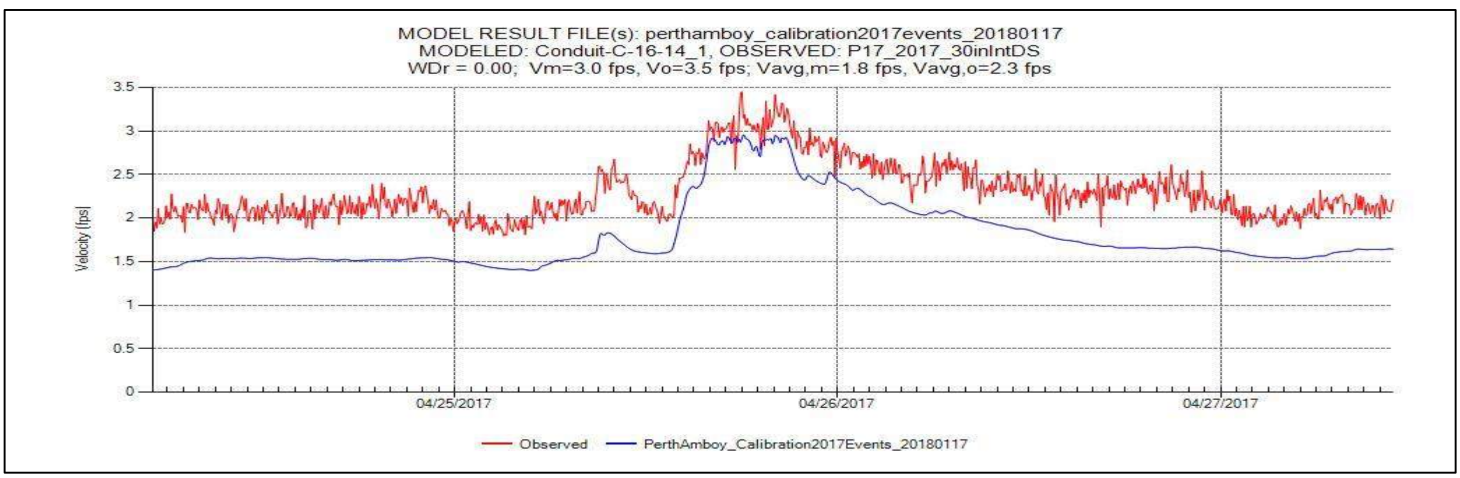

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-16-OF-M1, OBSERVED: P16_2007_OF
WDr = 0.63; Vm=6.4 fps, Vo=13.4 fps; Vavg,m=0.3 fps, Vavg,o=0.2 fps
Velocity (fps)
08/09/2007 12 PM
08/10/2007 12 AM
08/10/2007 12 PM
08/11/2007 12 AM
08/11/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

Simulated Versus Observed Flow at Flow Meter Sites

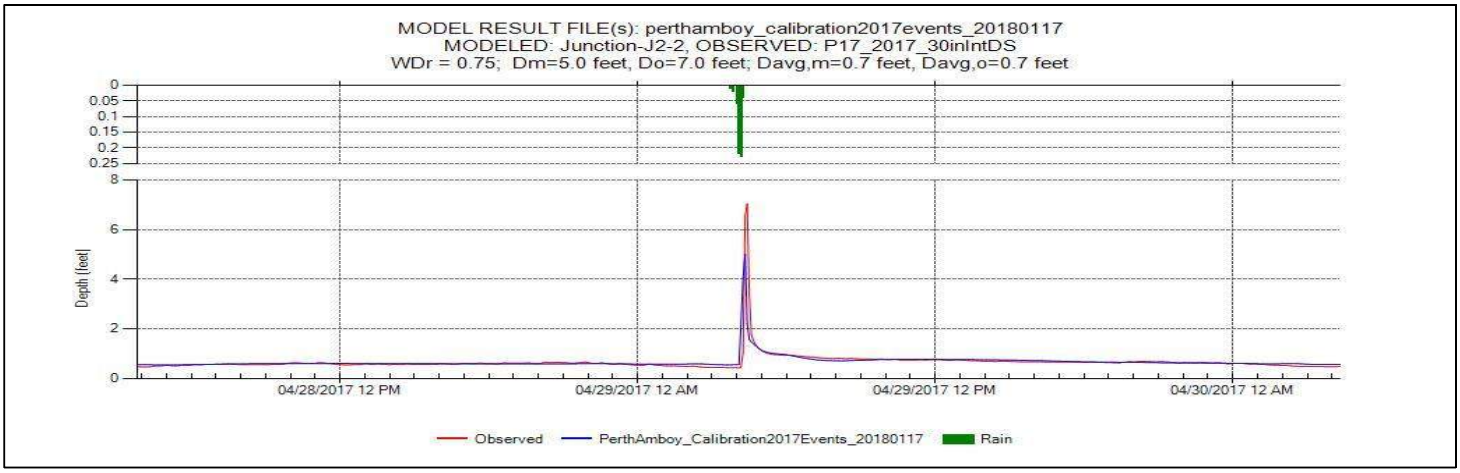
P17_2017_30inIntDS

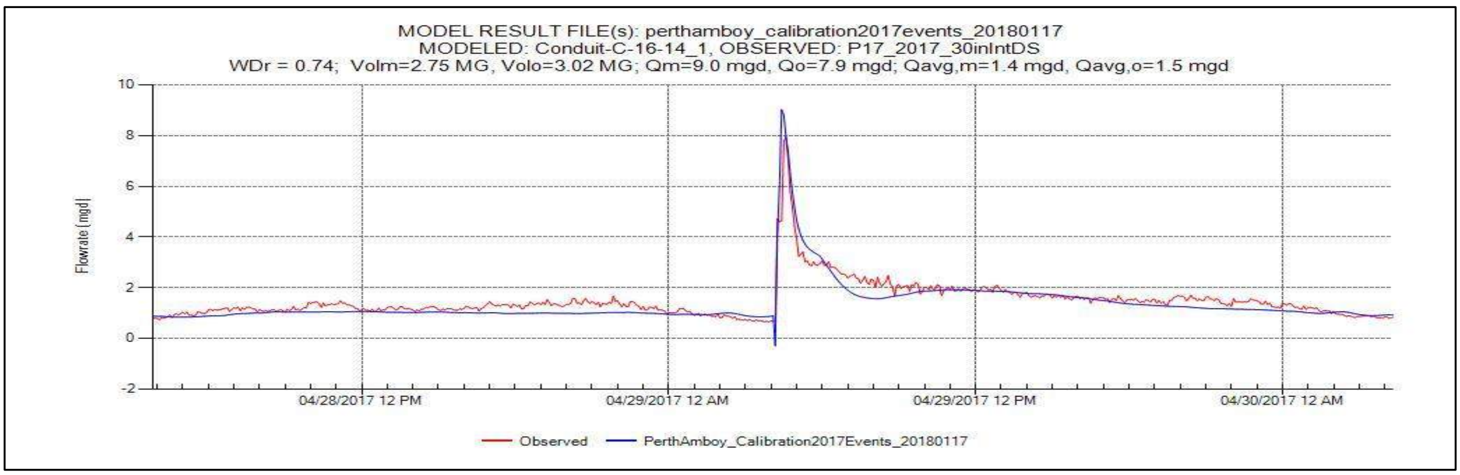


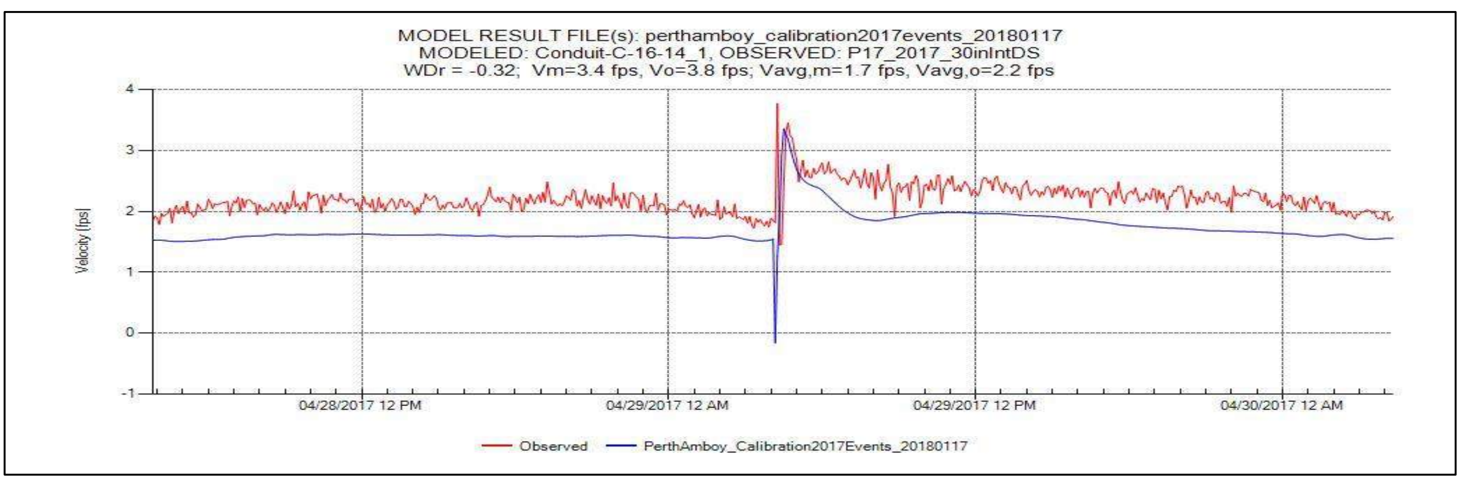




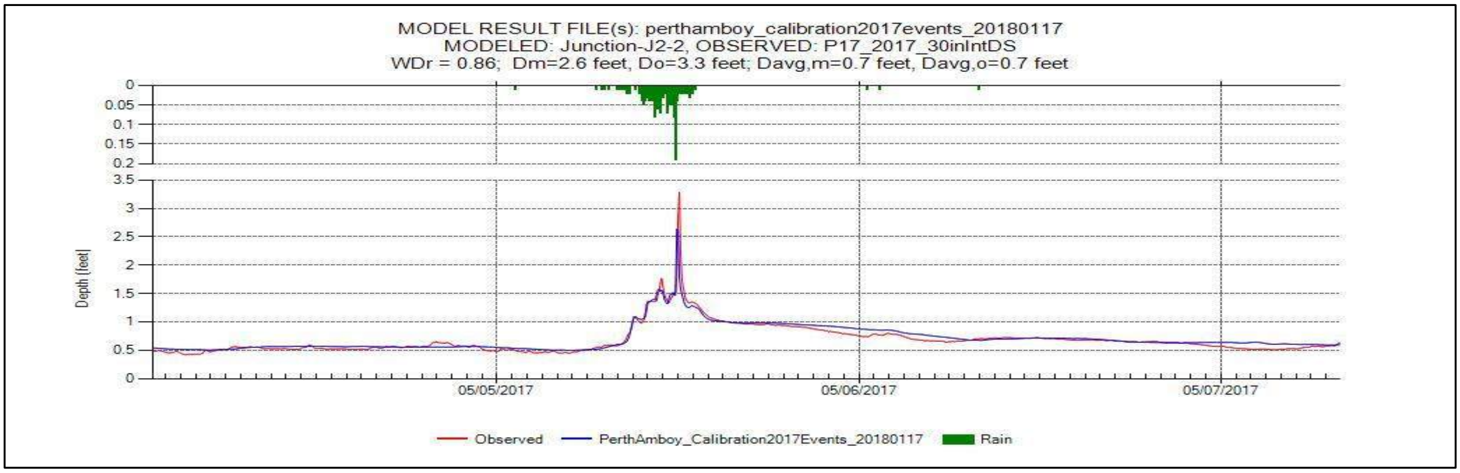
P17_2017_30inIntDS

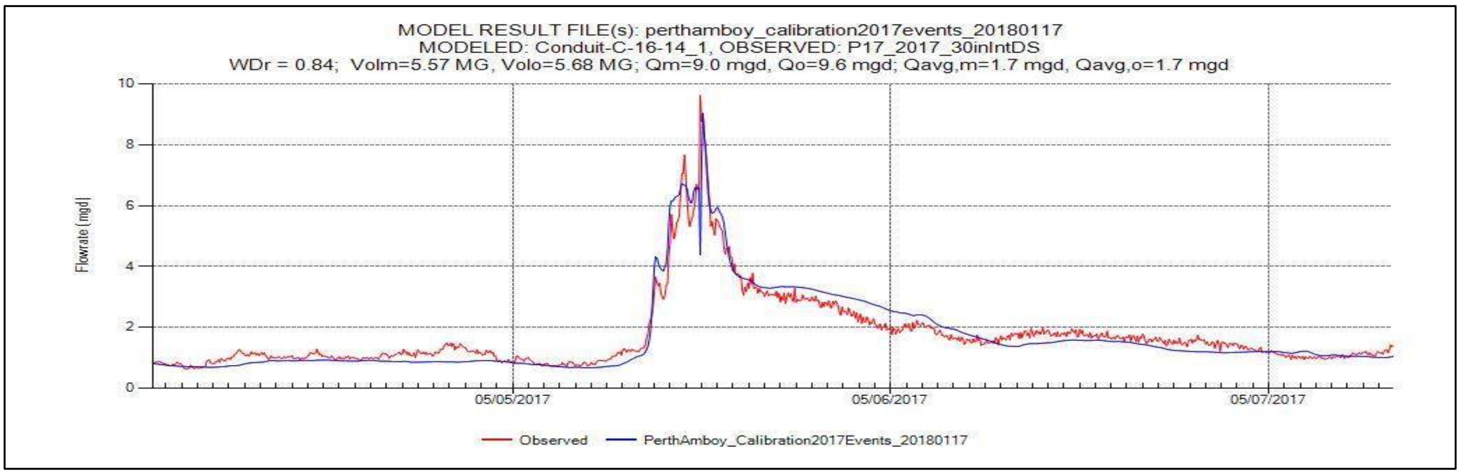


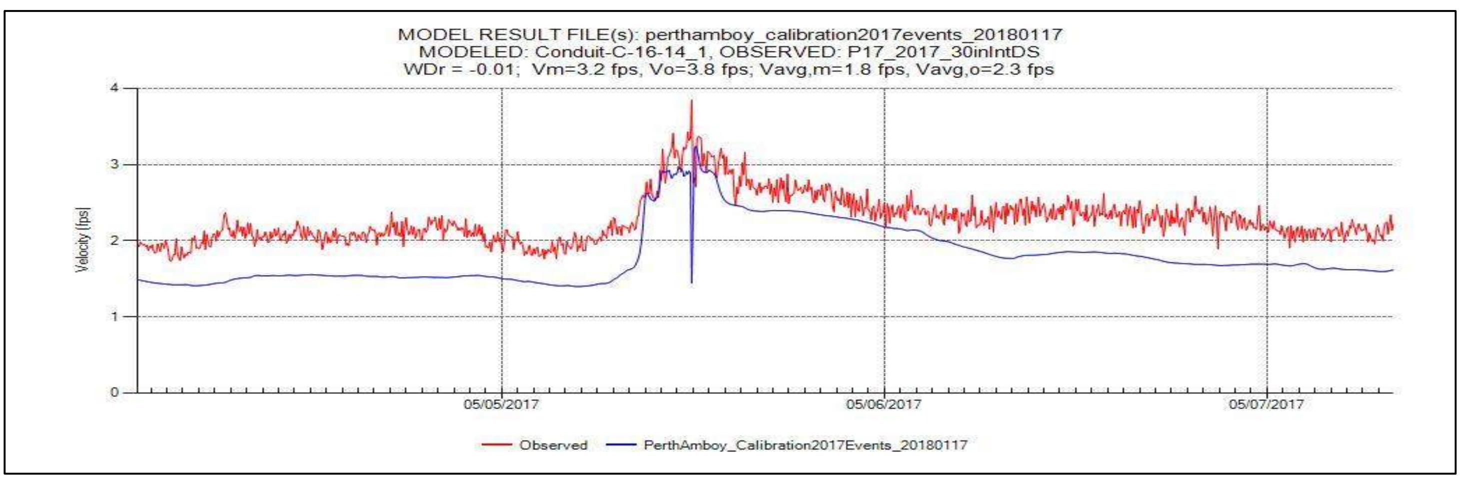




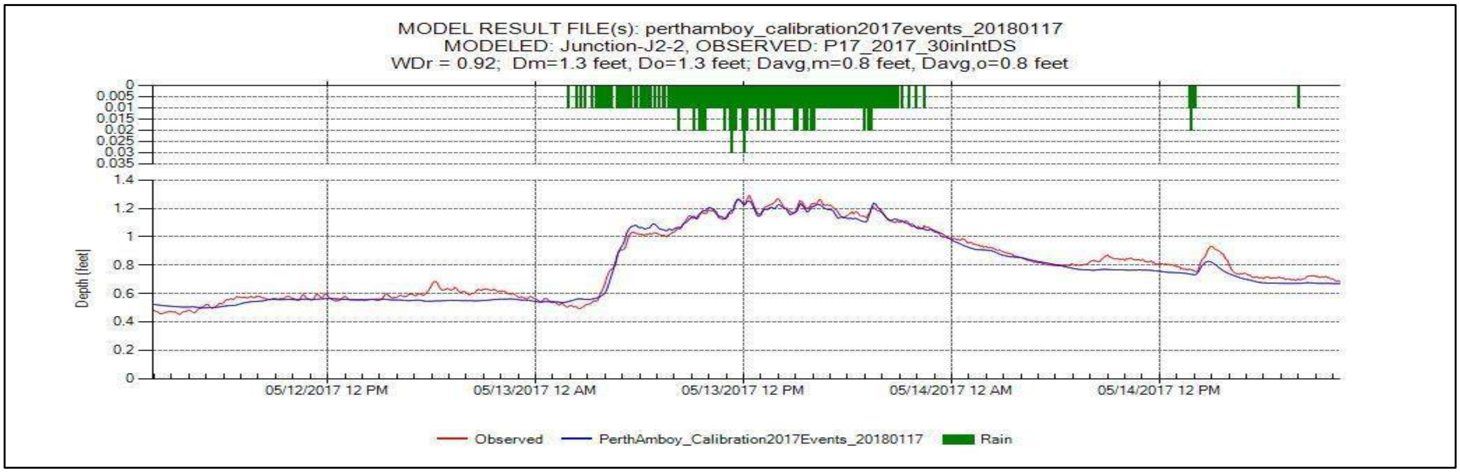
P17_2017_30inIntDS

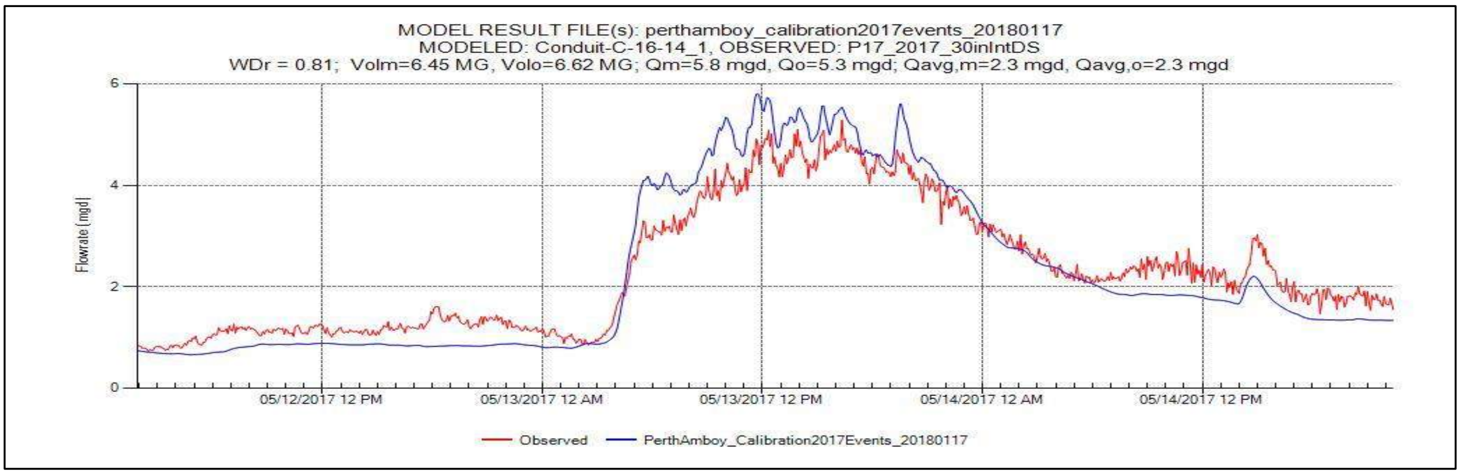


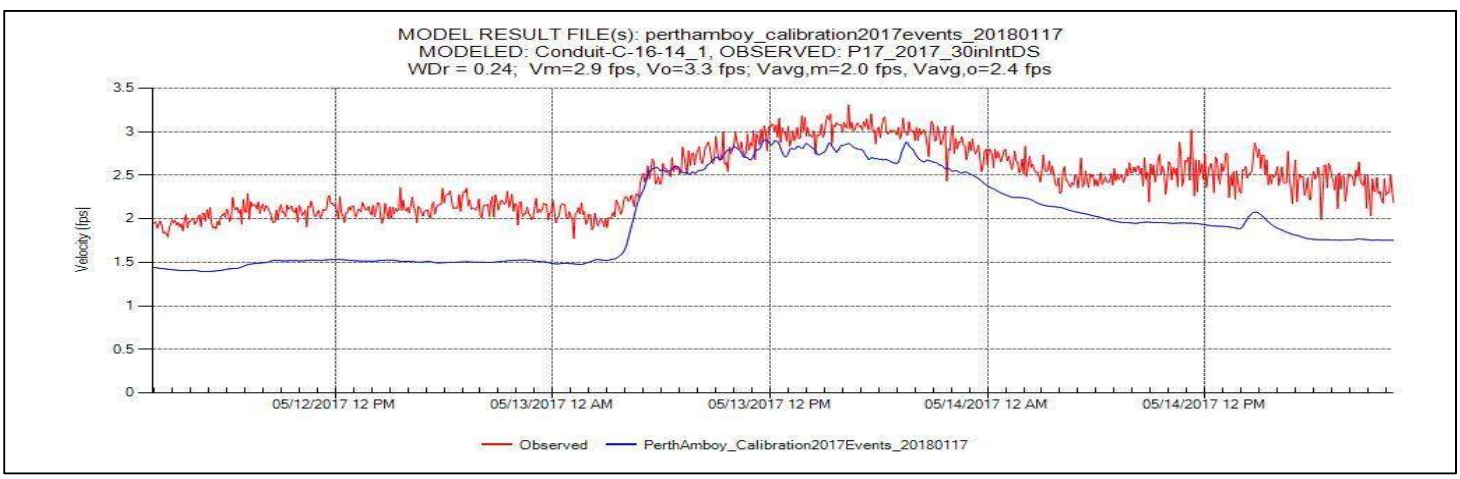




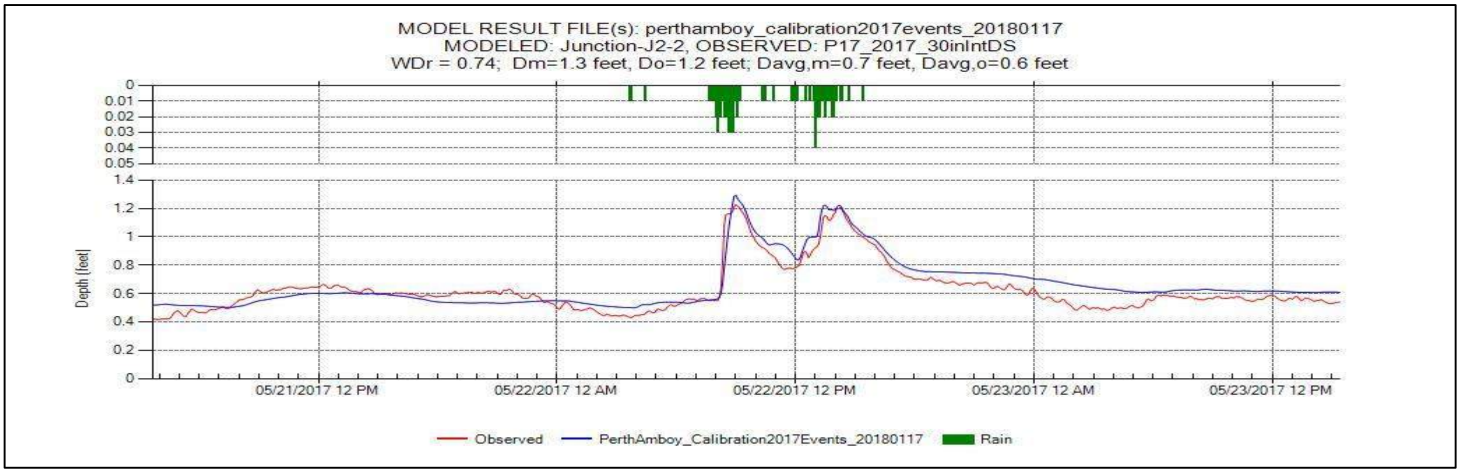
P17_2017_30inIntDS

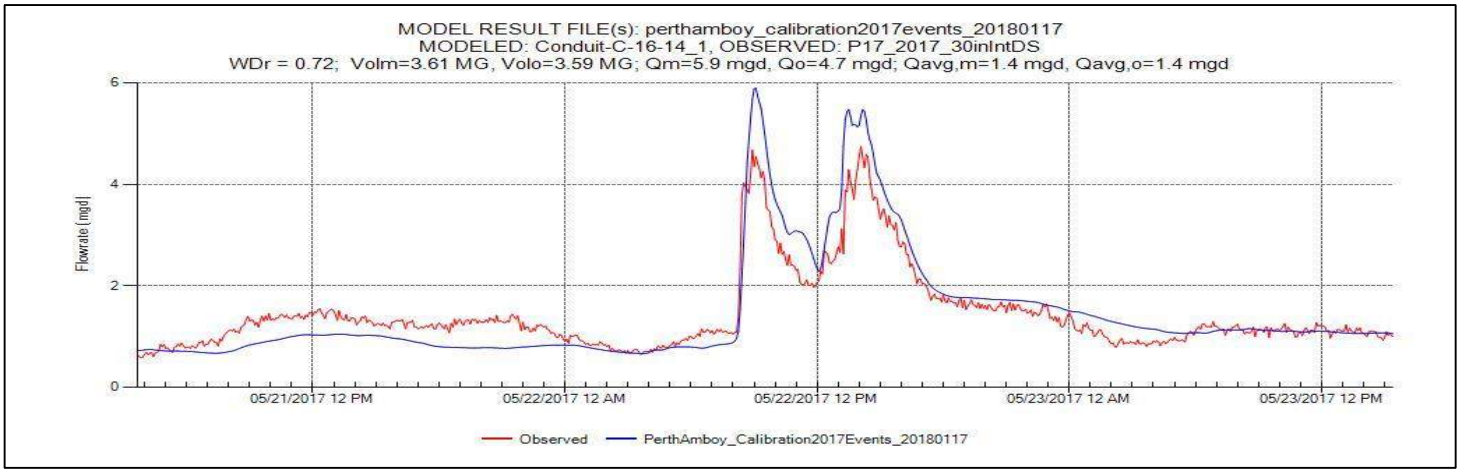


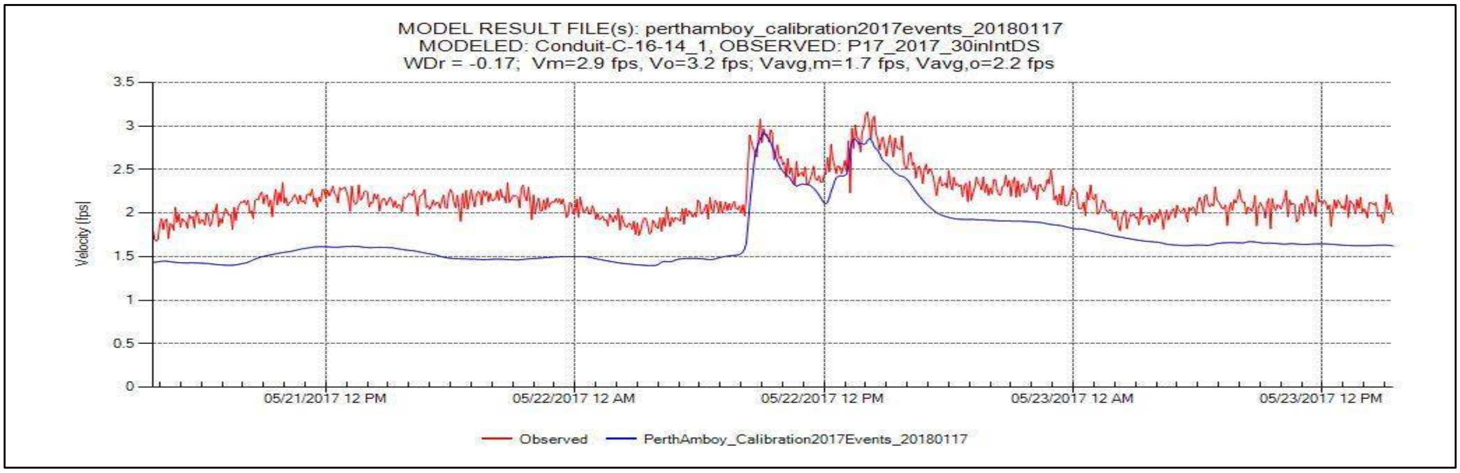




P17_2017_30inIntDS

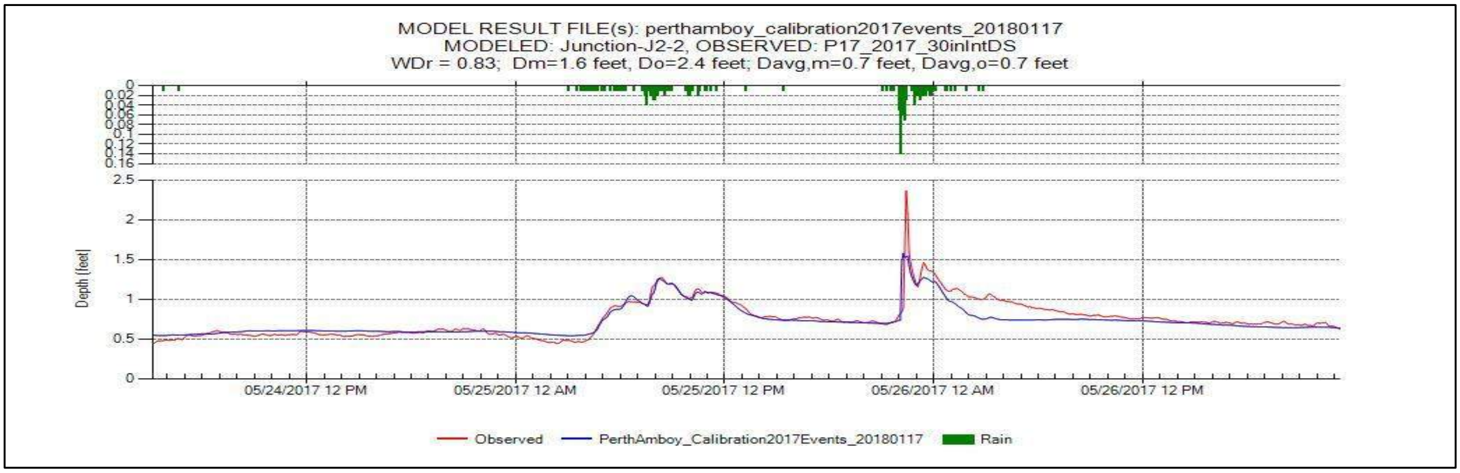


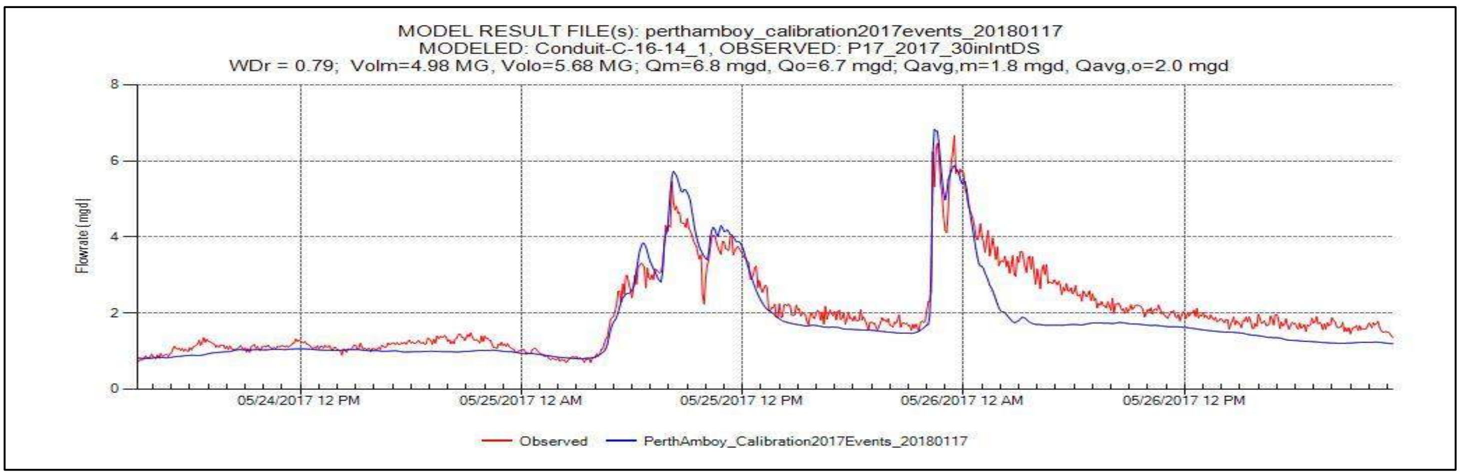


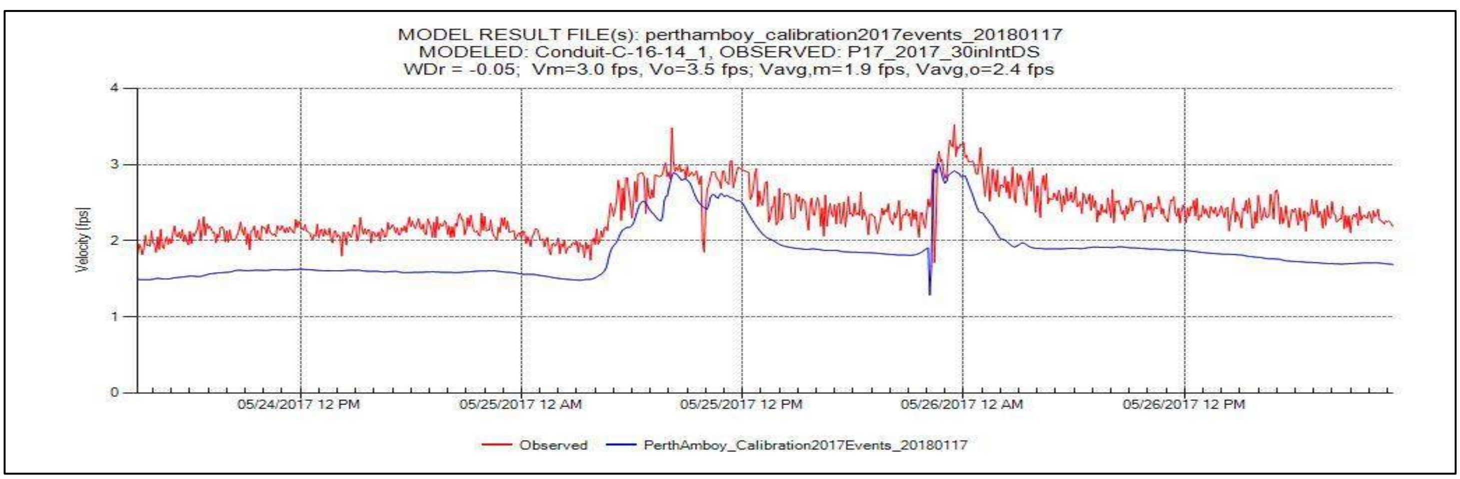


Simulated Versus Observed Flow at Flow Meter Sites

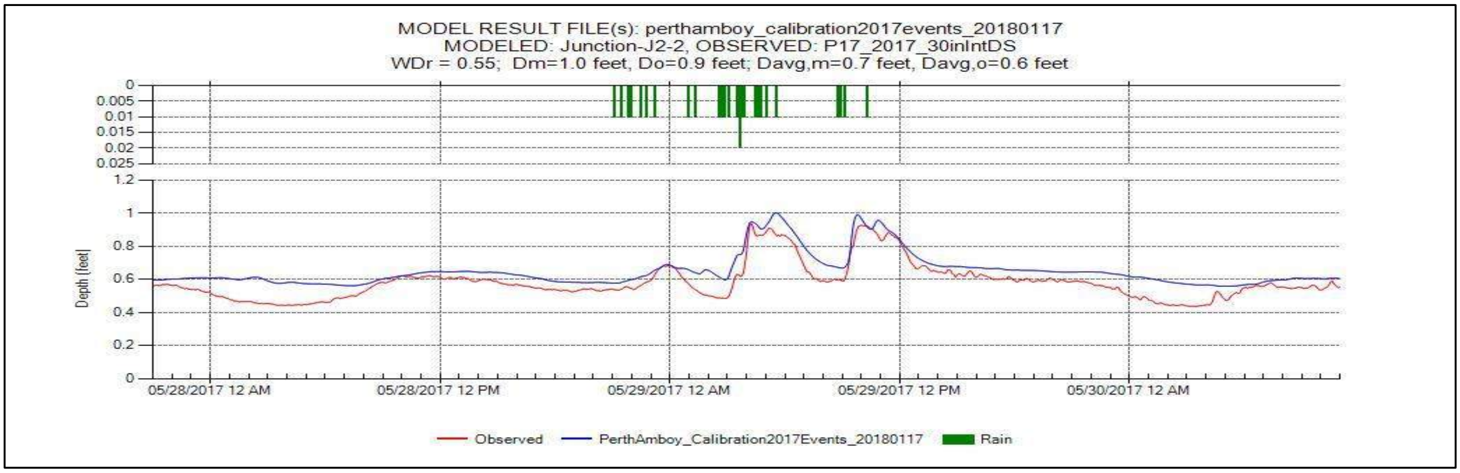
P17_2017_30inIntDS

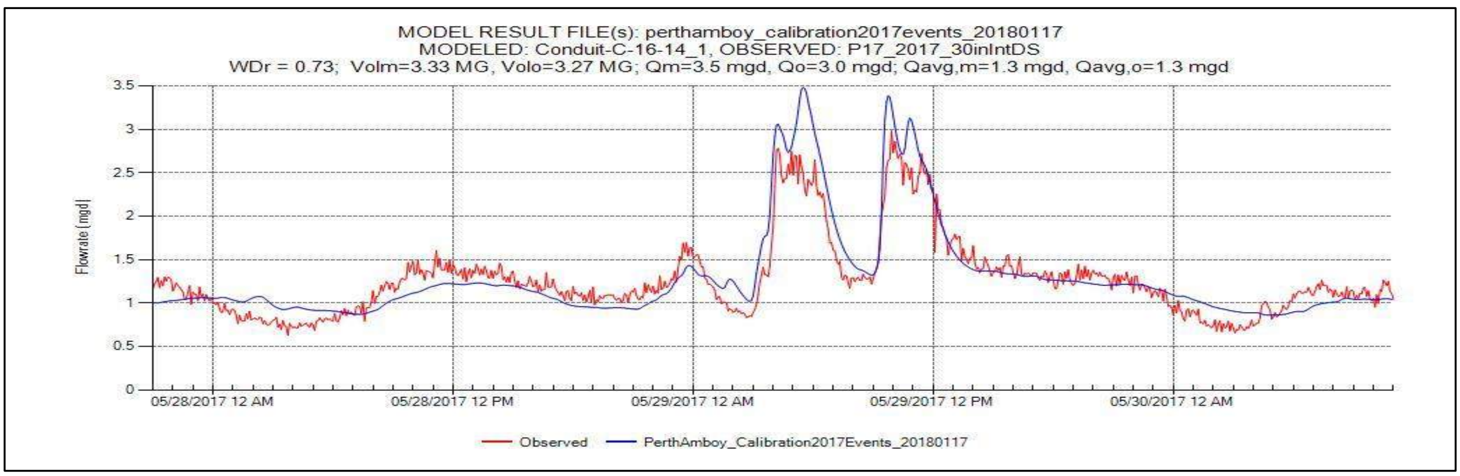


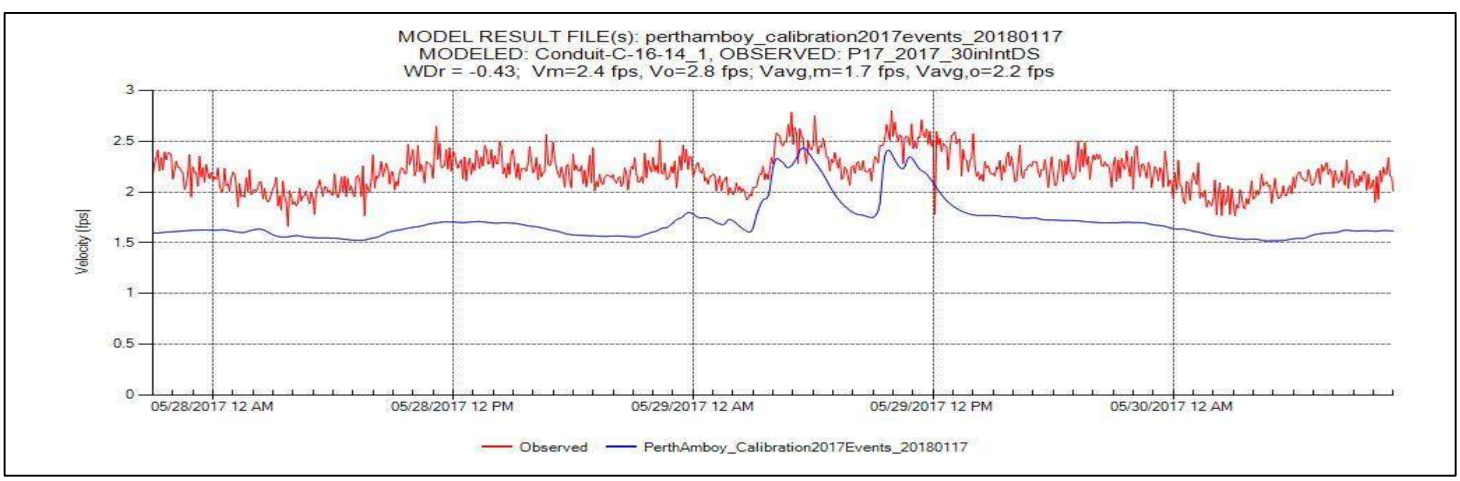




P17_2017_30inIntDS







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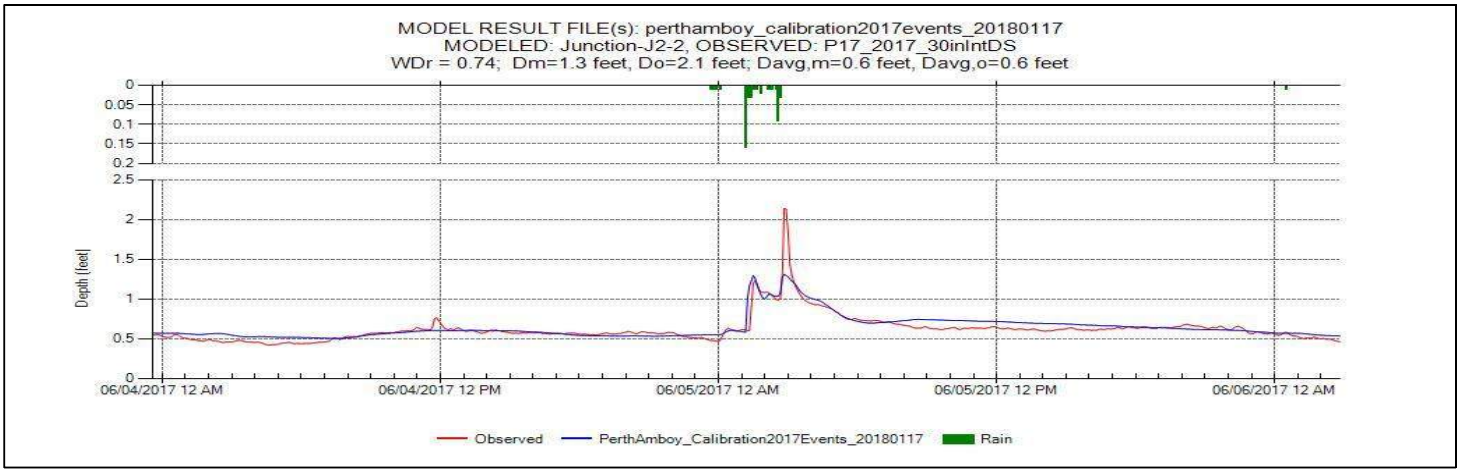

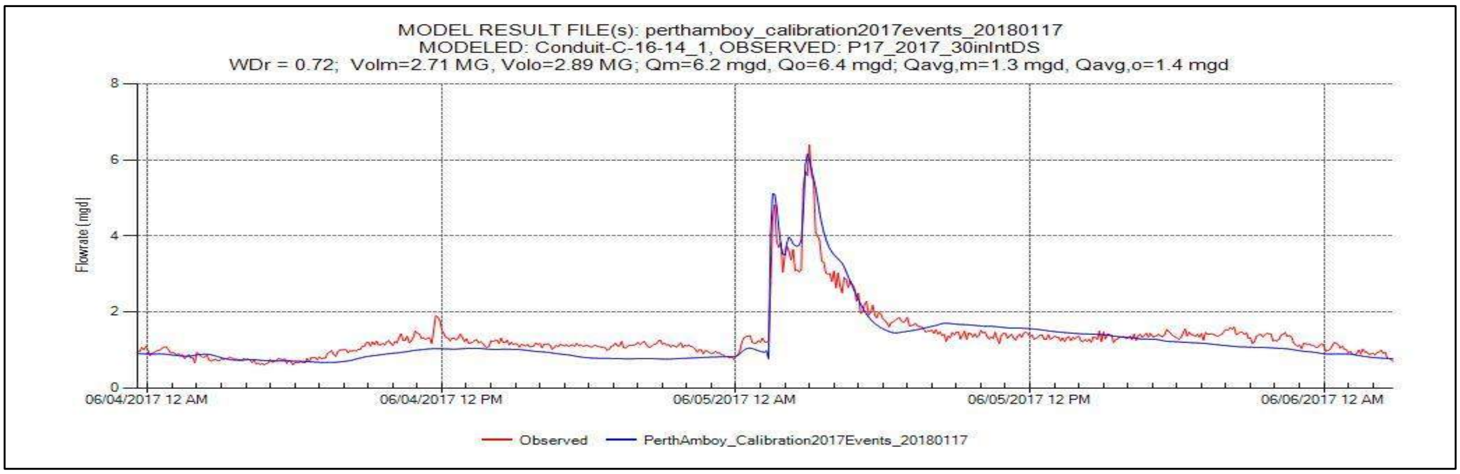

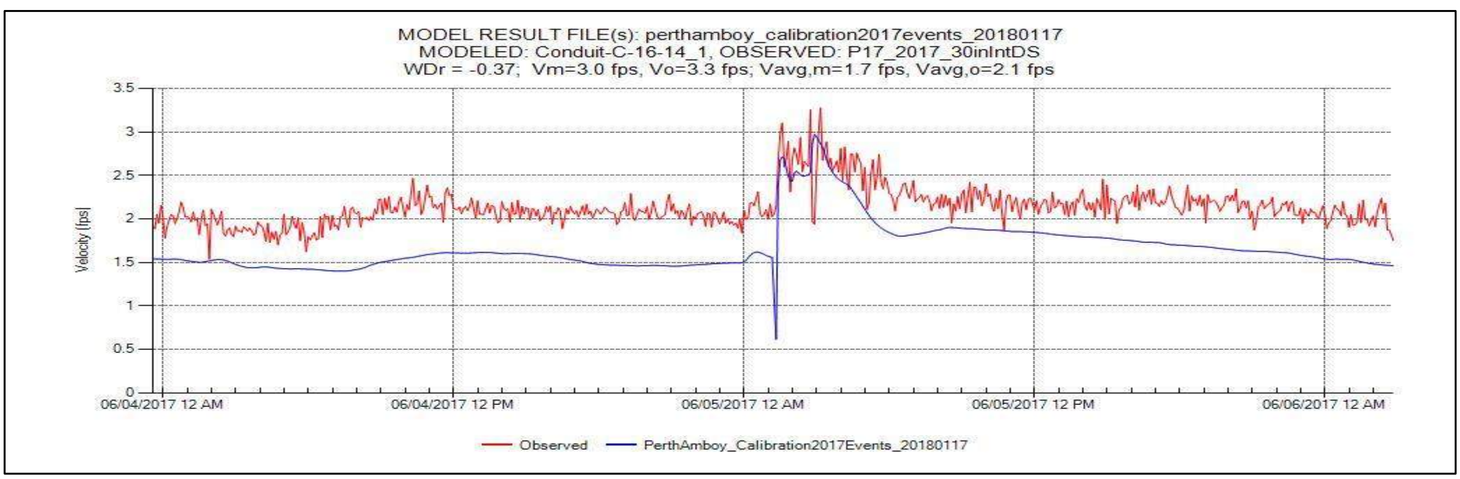

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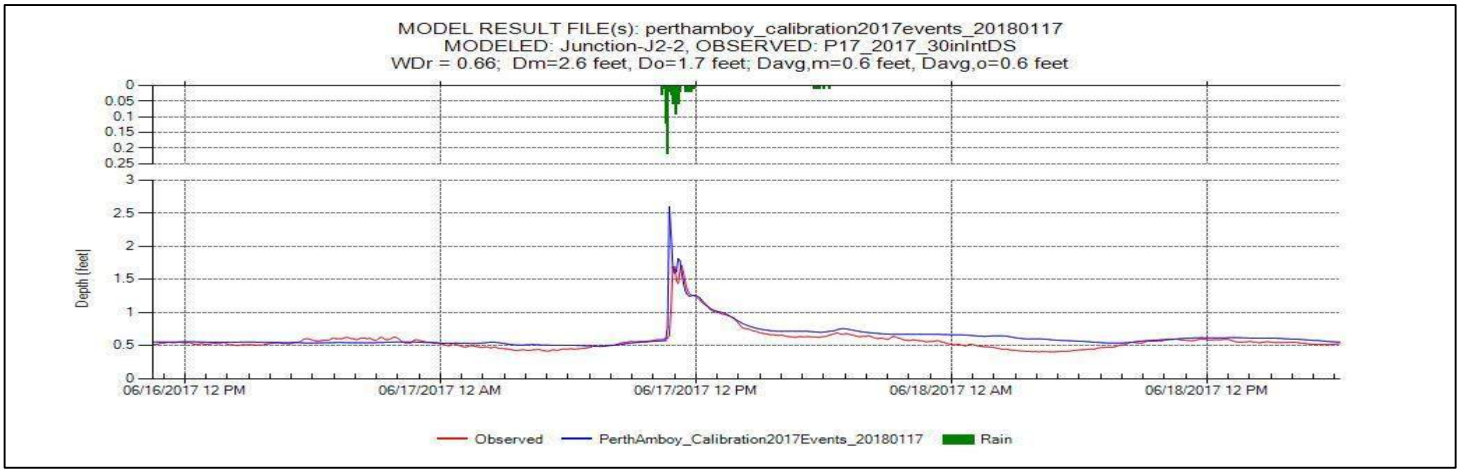

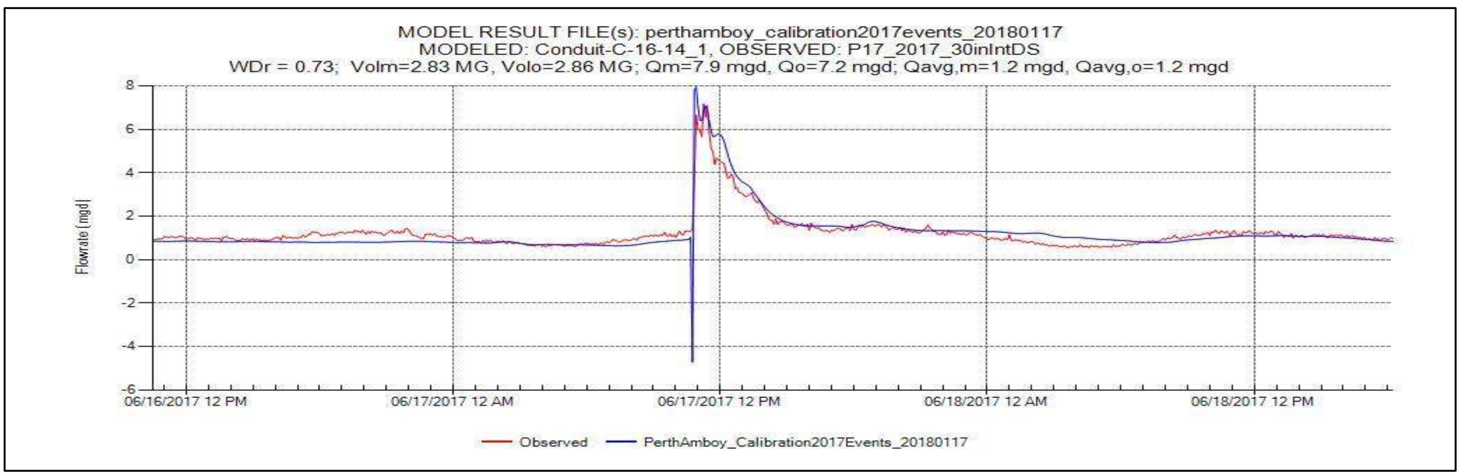

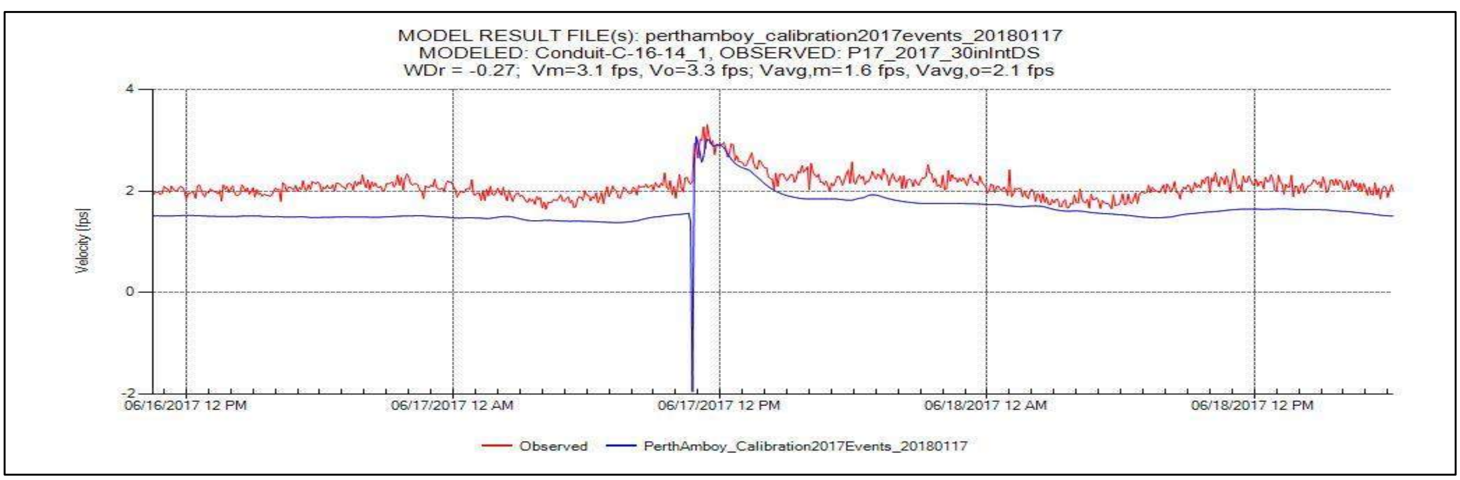

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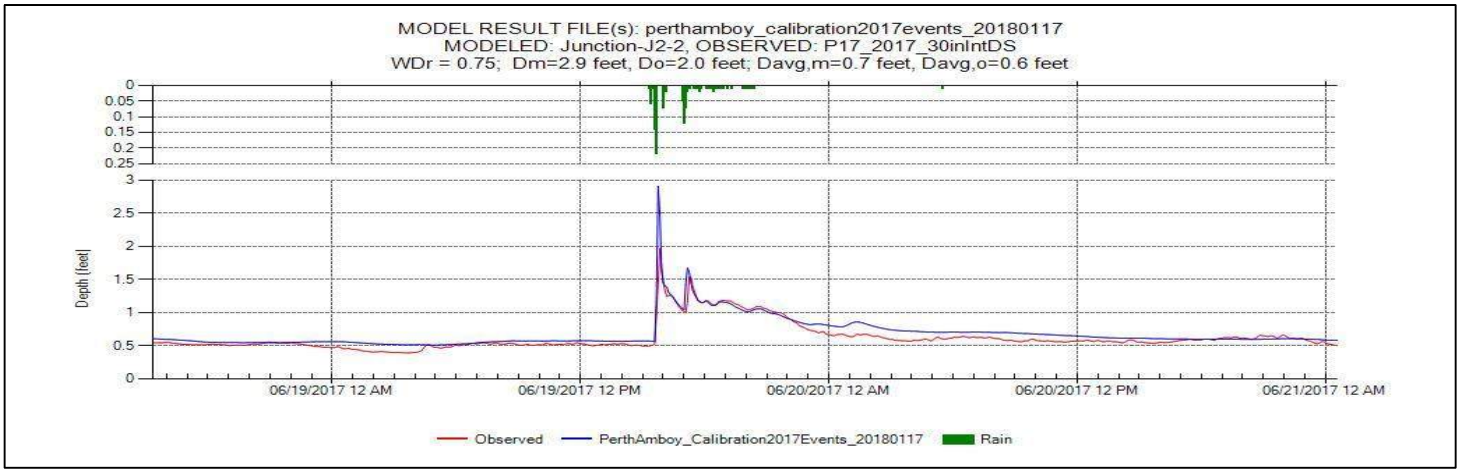

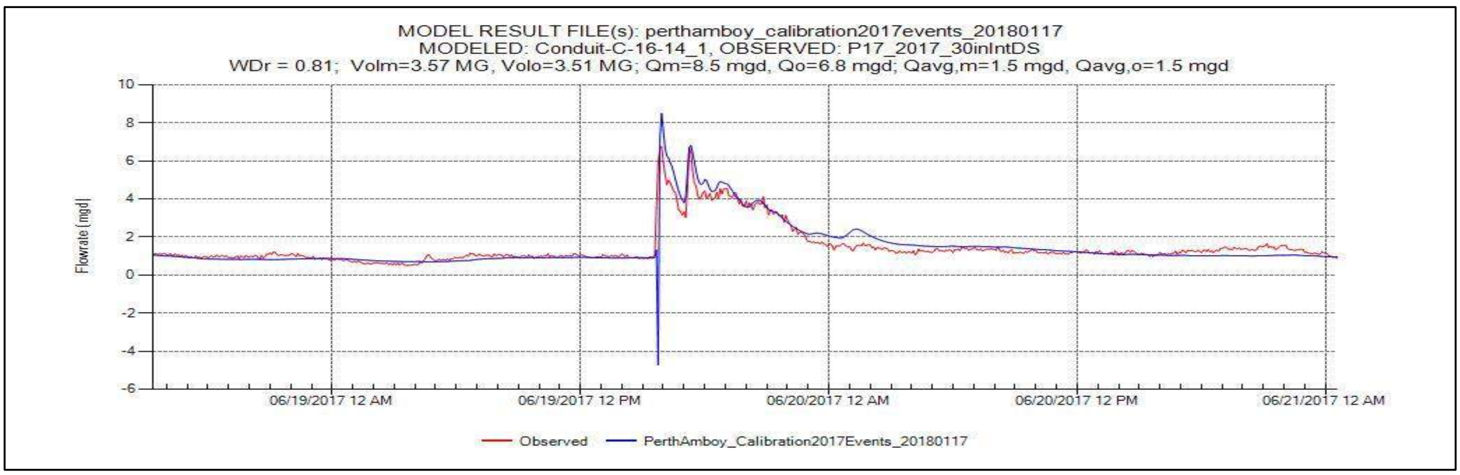

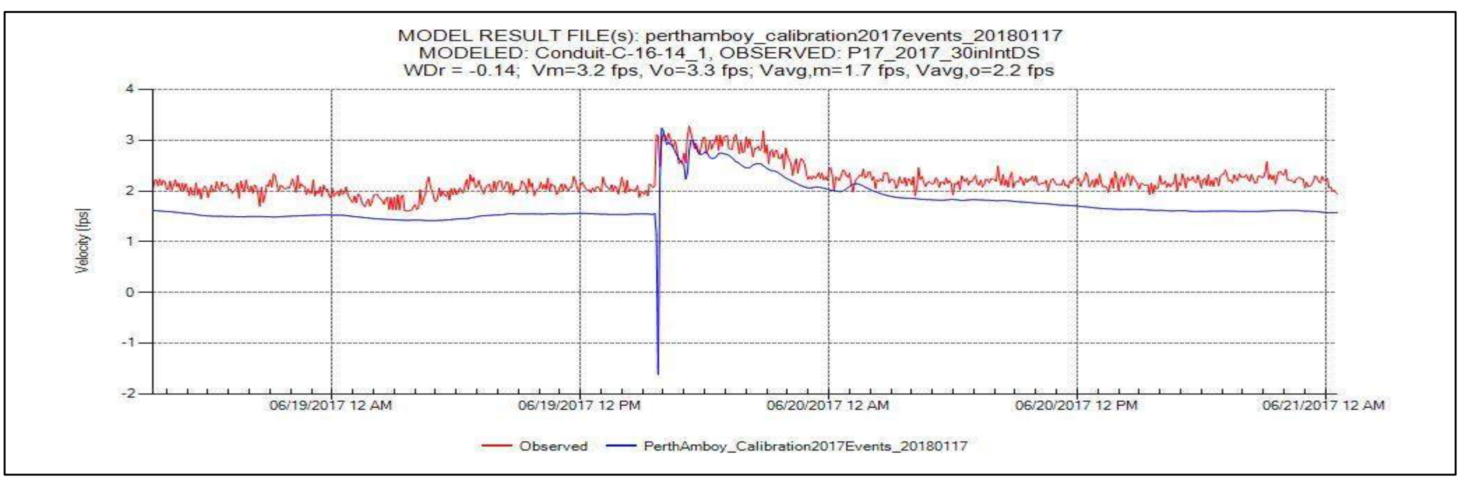

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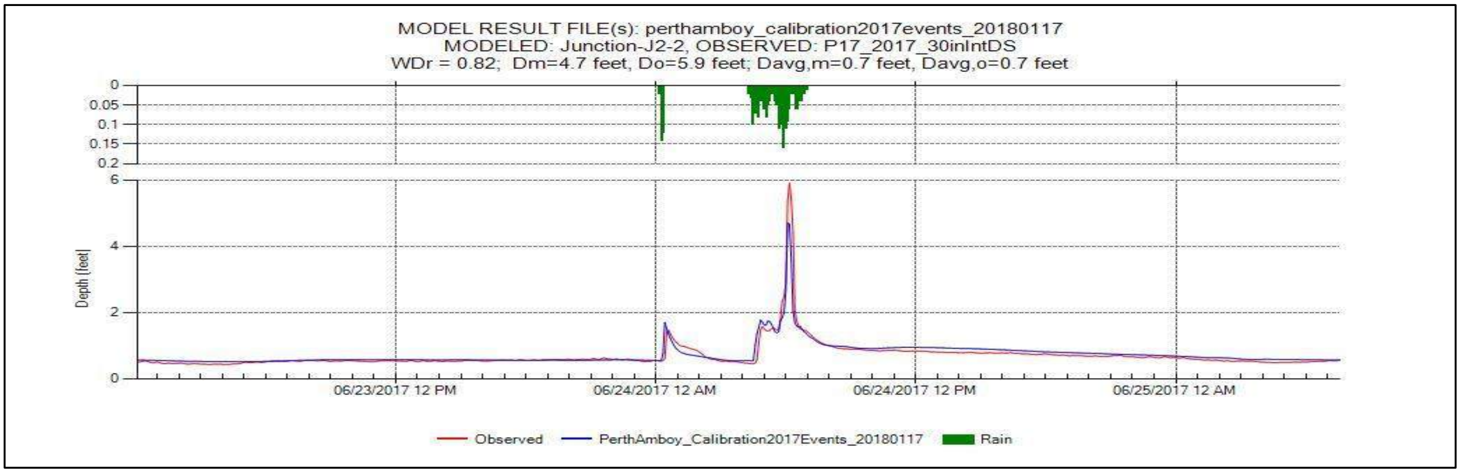
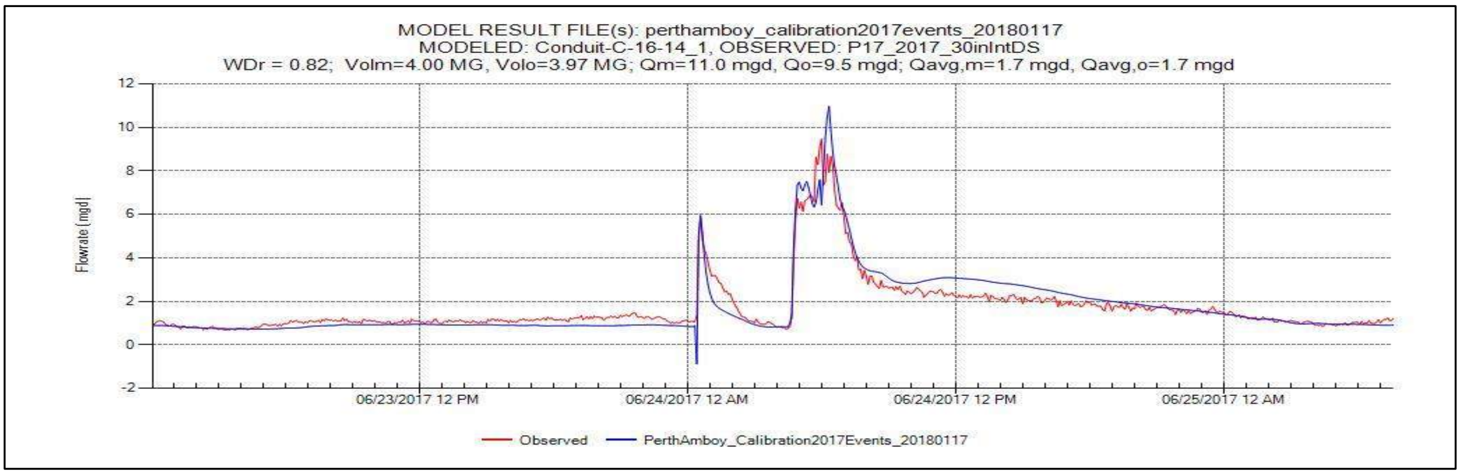
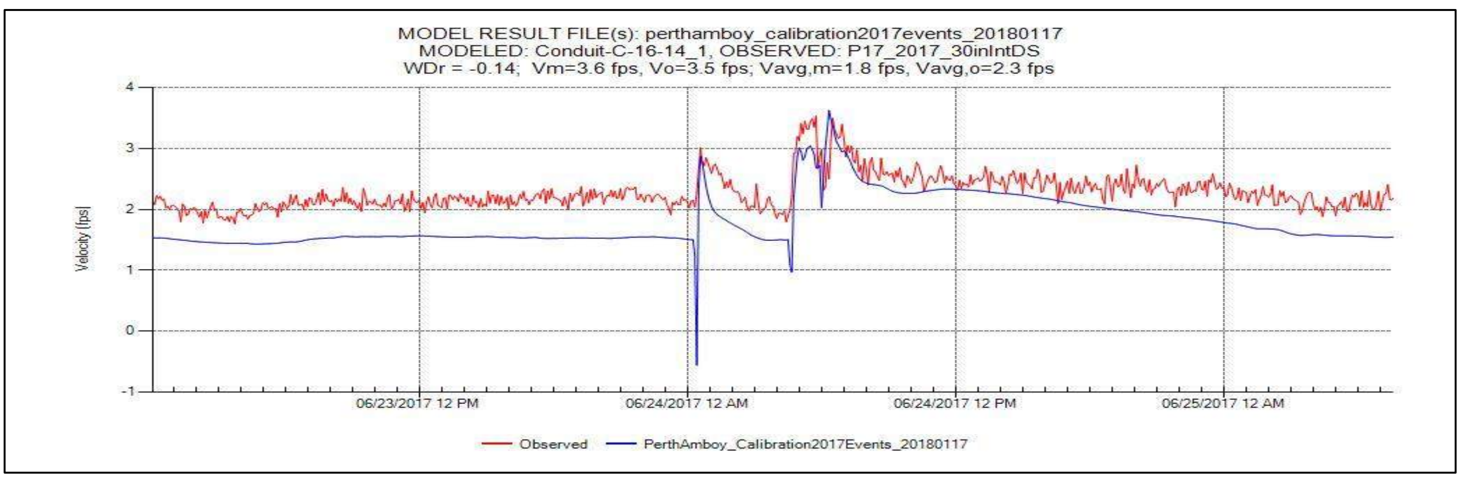
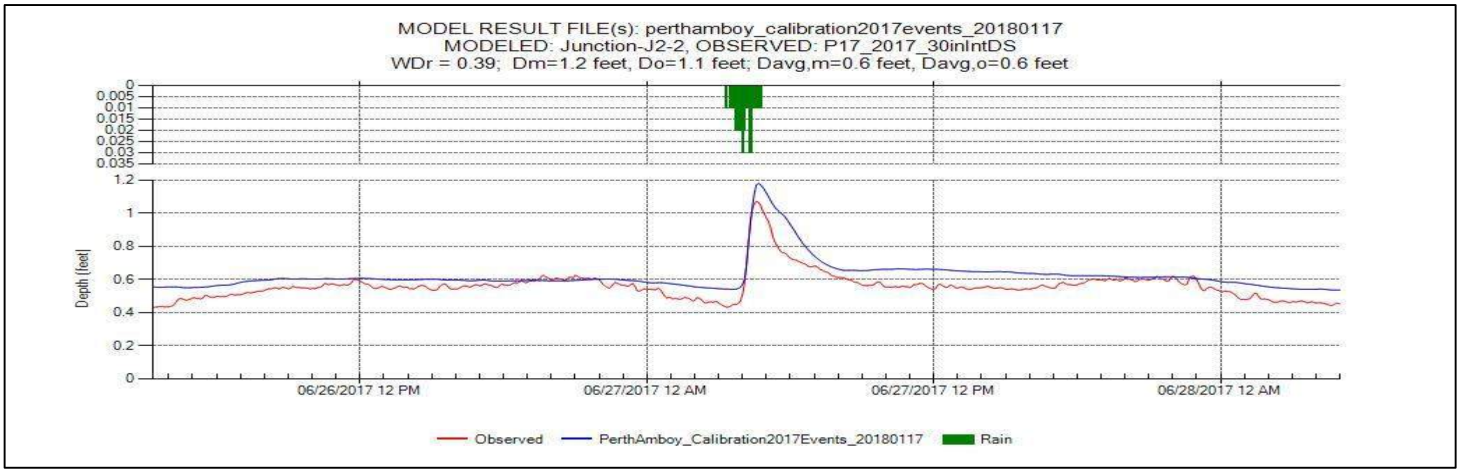


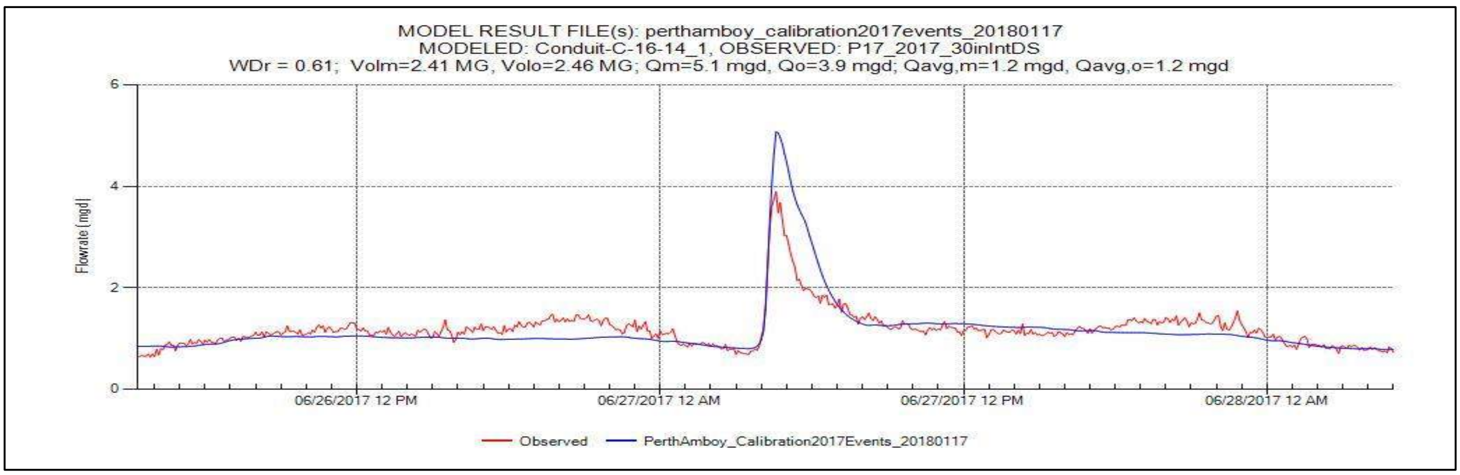


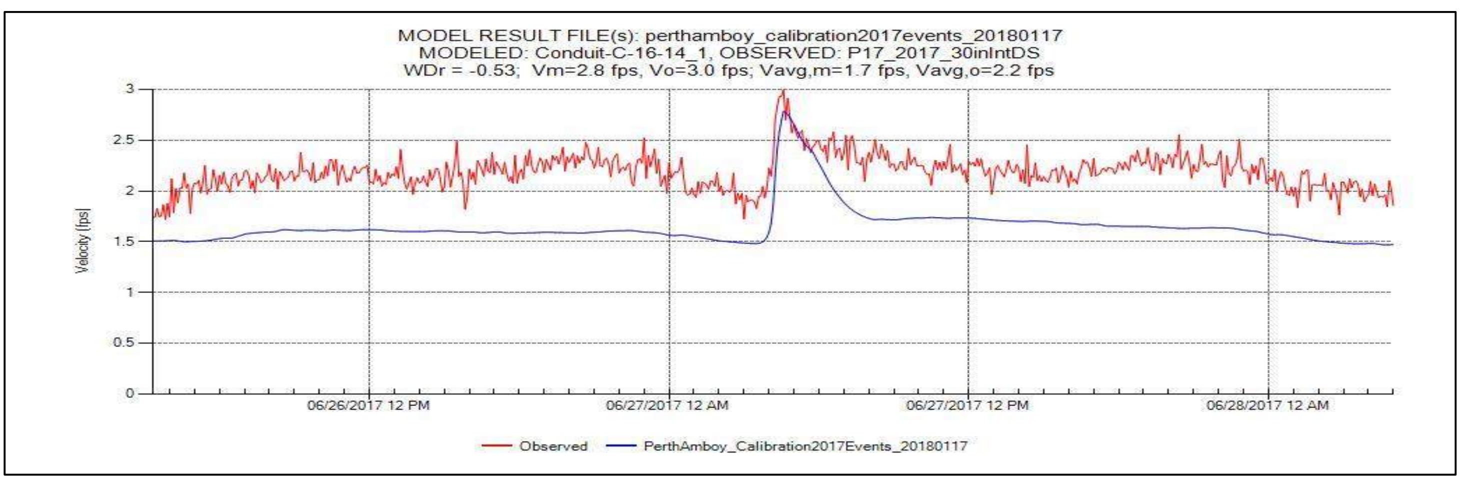


Simulated Versus Observed Flow at Flow Meter Sites

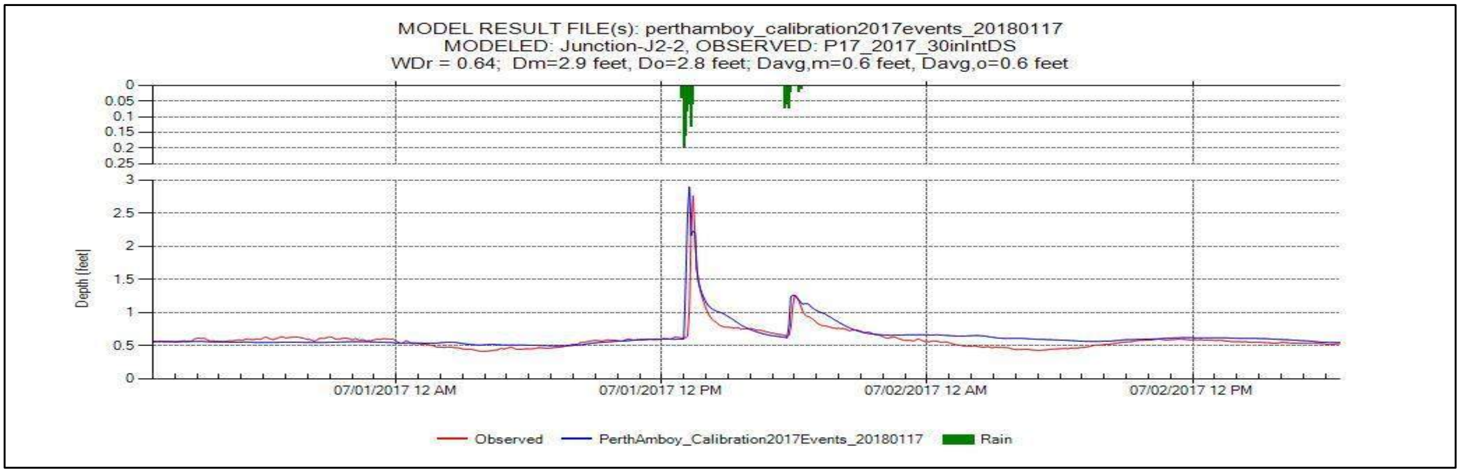
P17_2017_30inIntDS

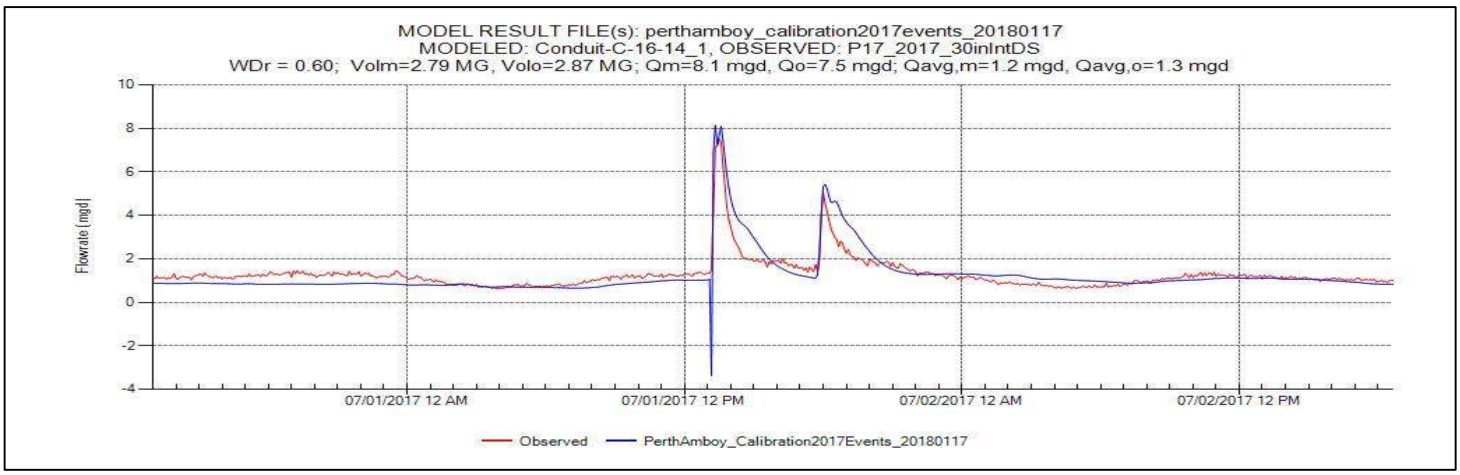


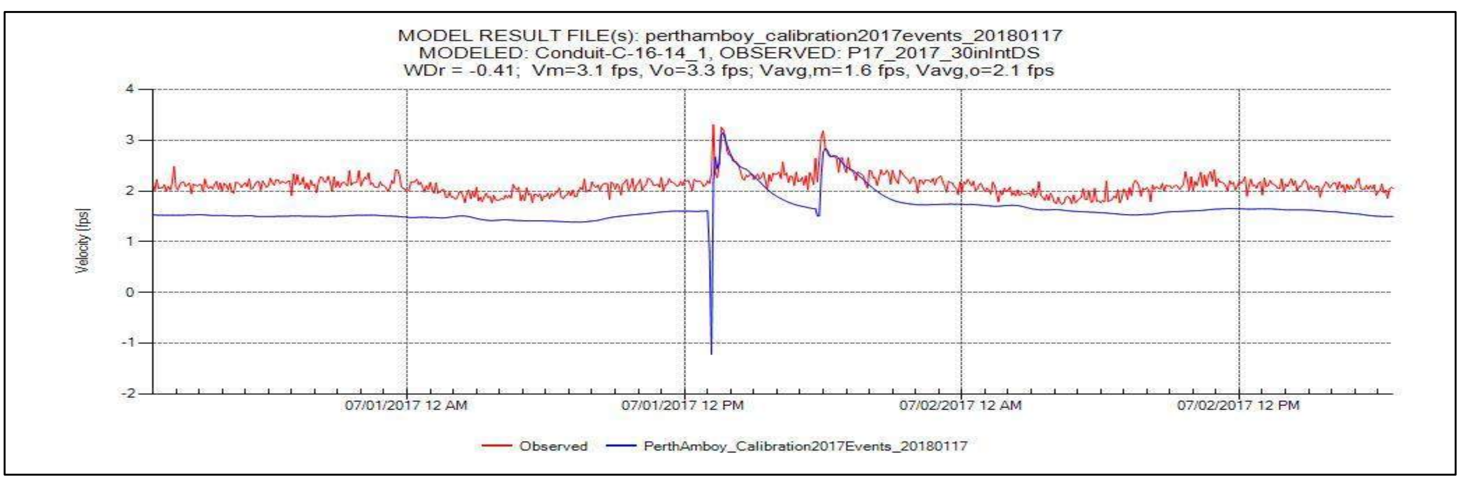




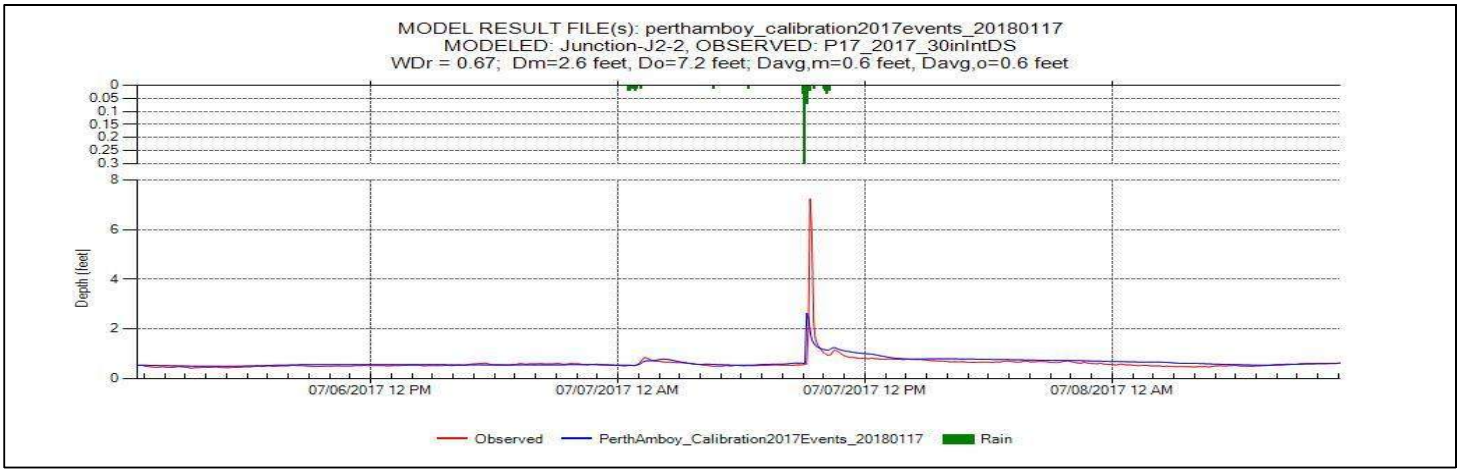
P17_2017_30inIntDS

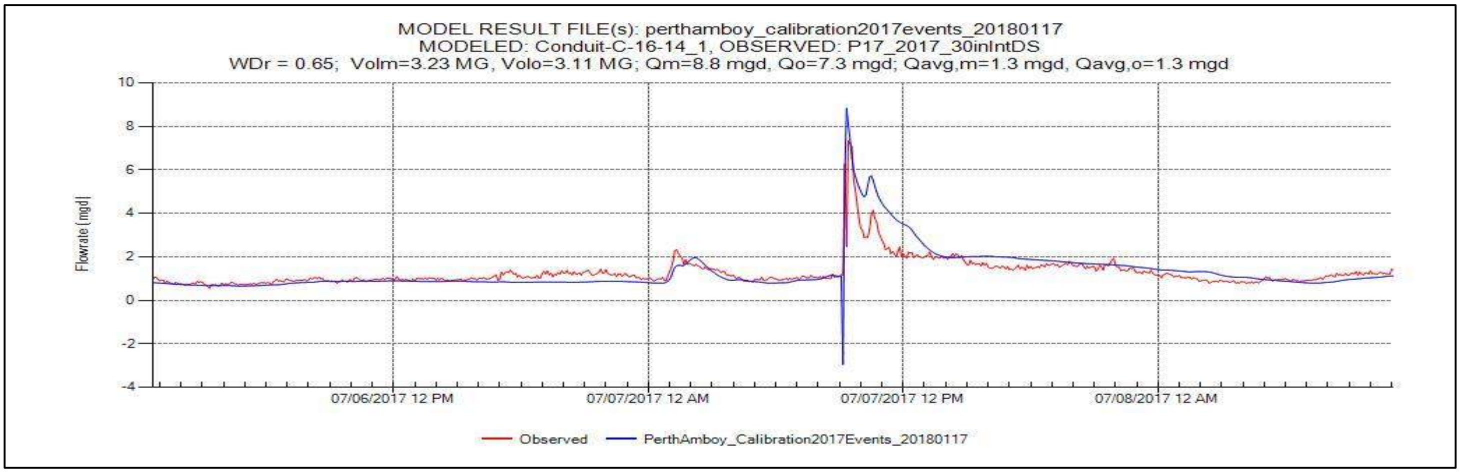


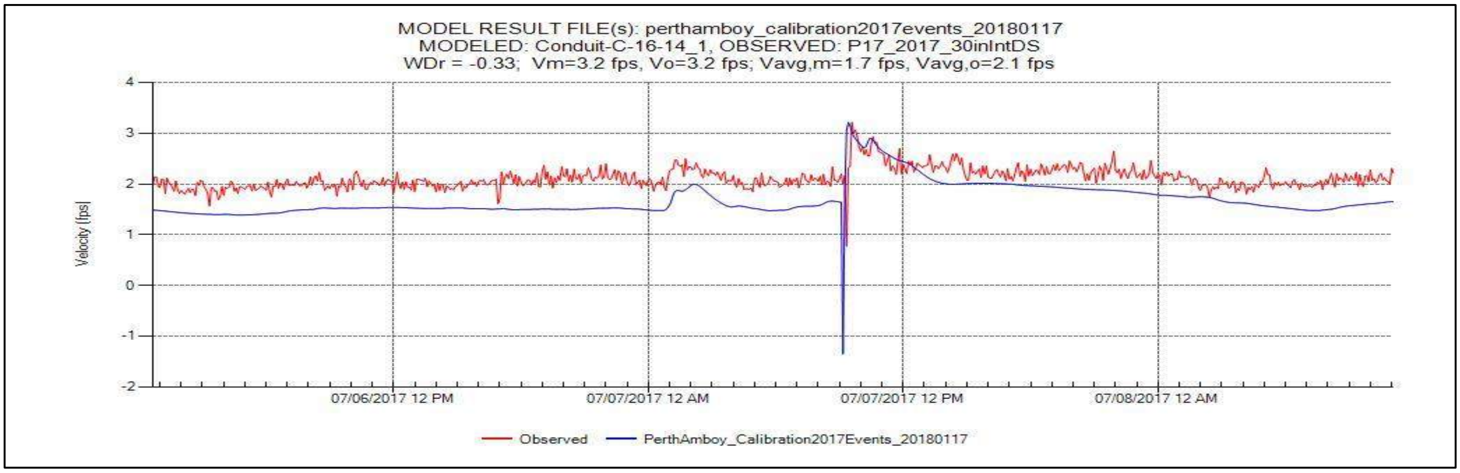




P17_2017_30inIntDS

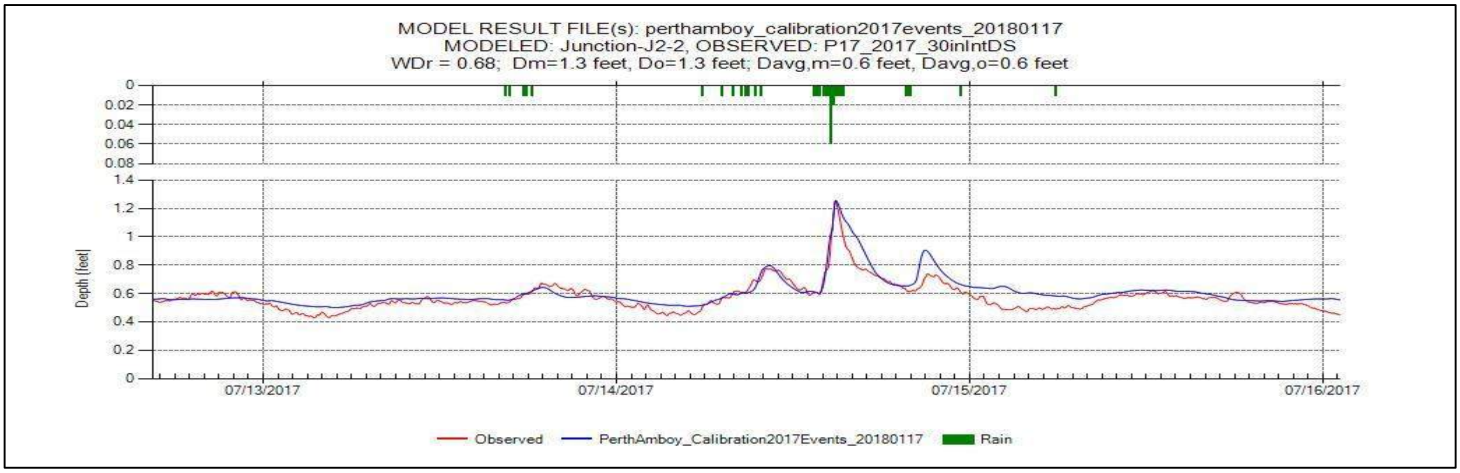


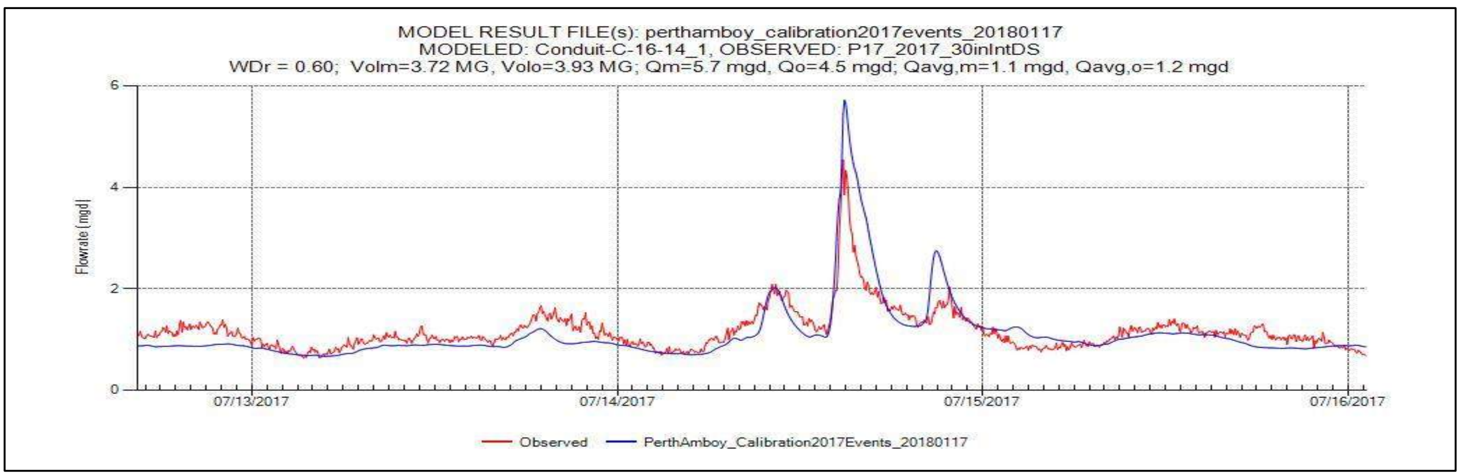


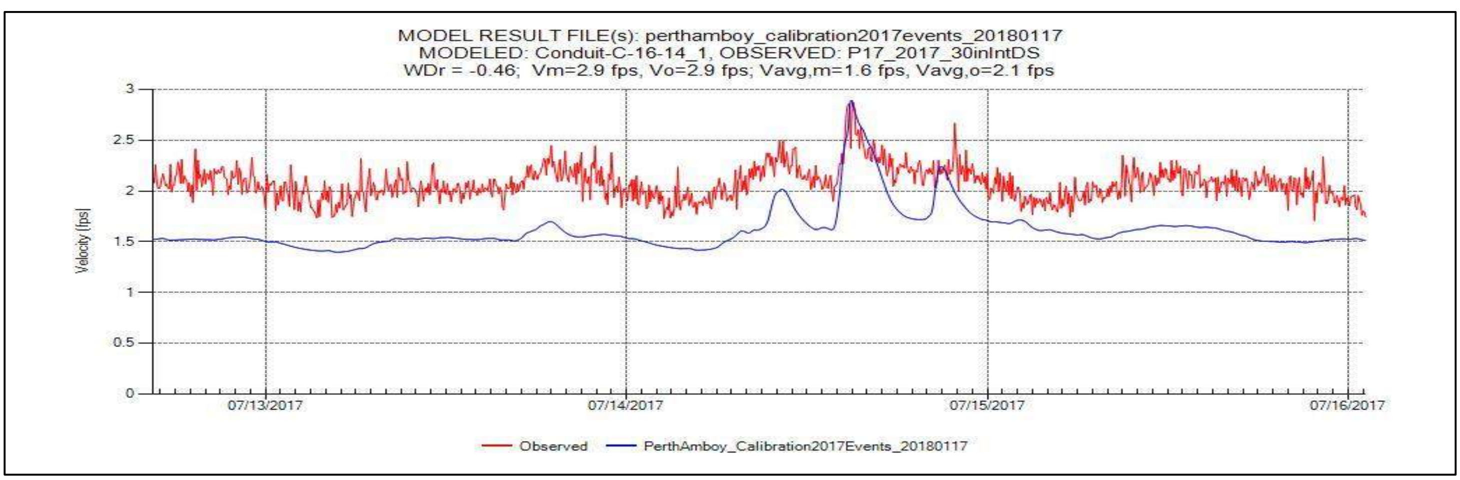


Simulated Versus Observed Flow at Flow Meter Sites

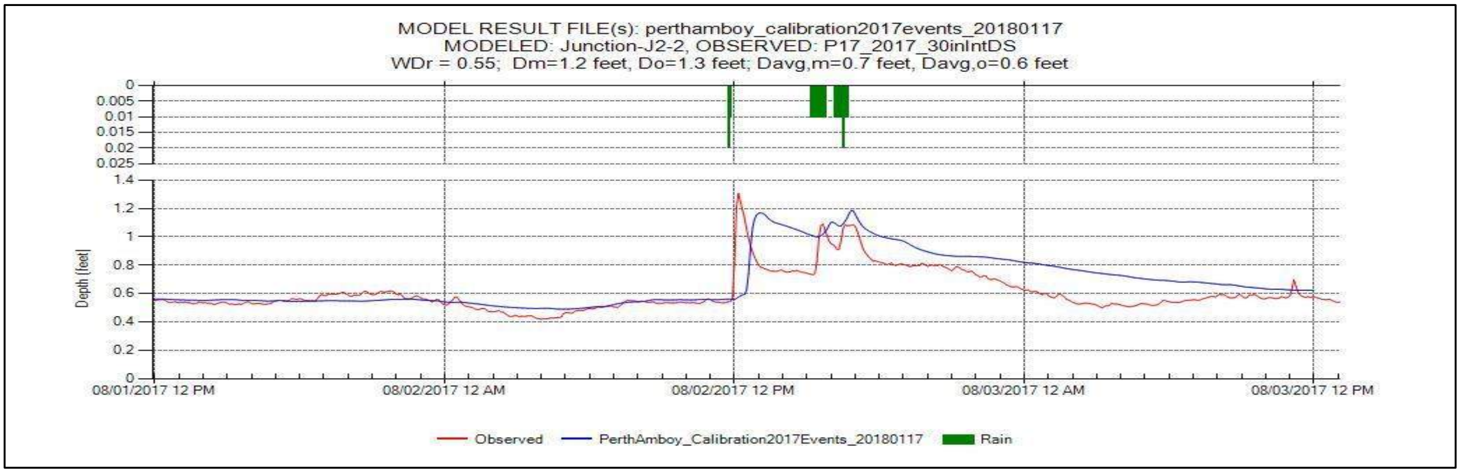
P17_2017_30inIntDS

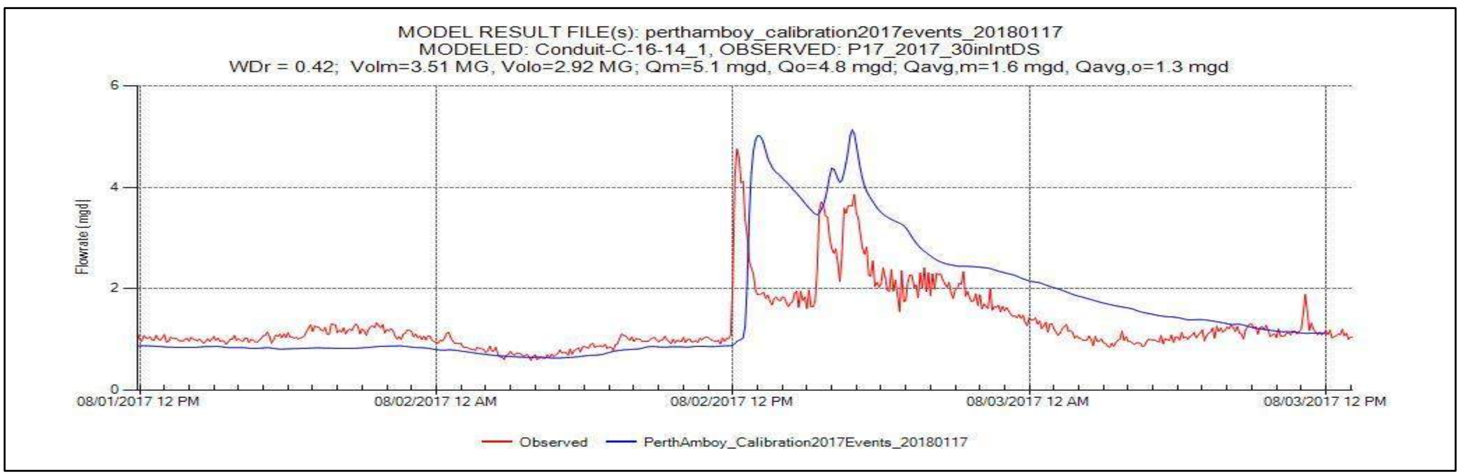


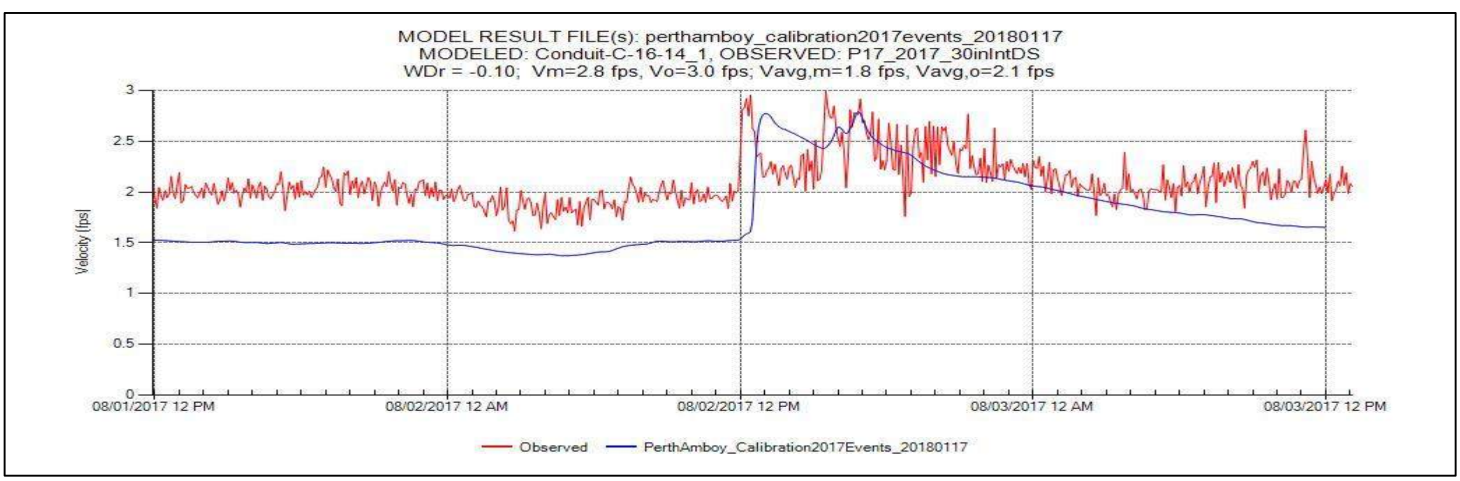




P17_2017_30inIntDS

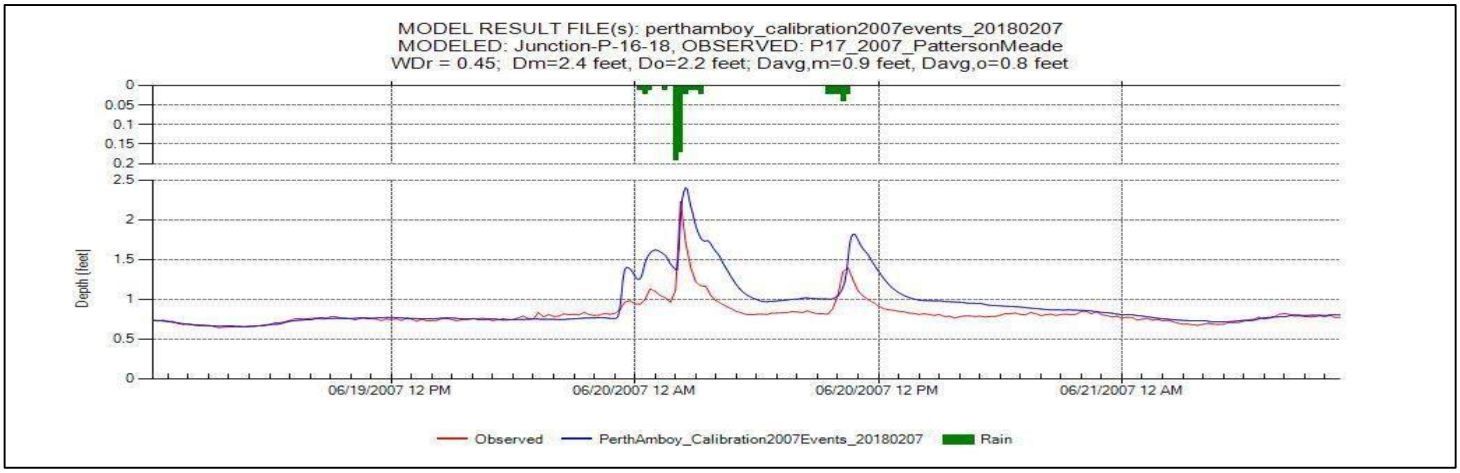


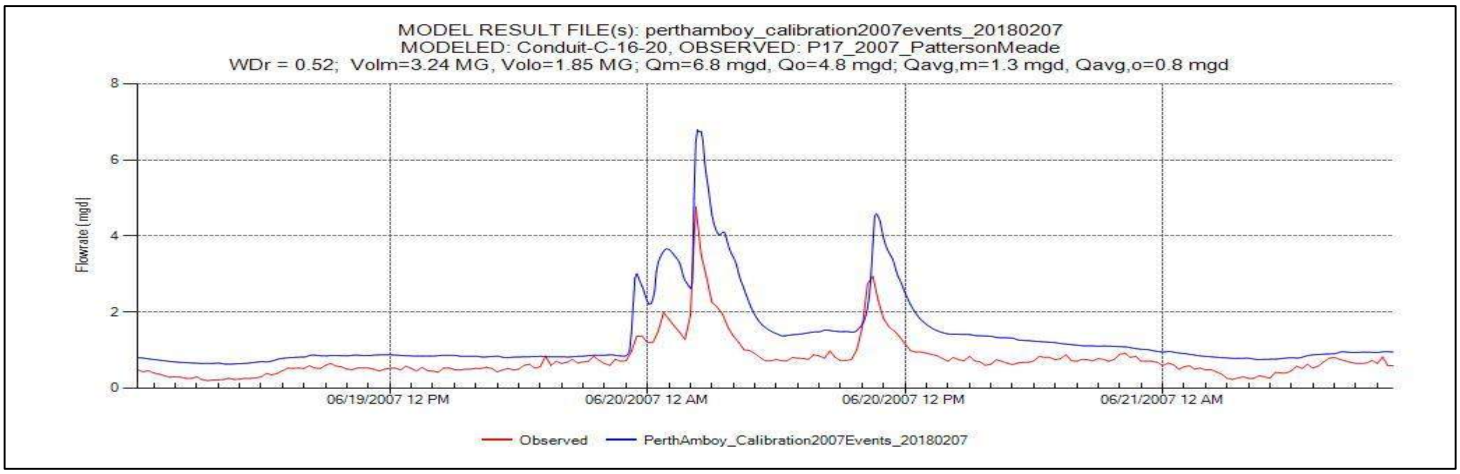


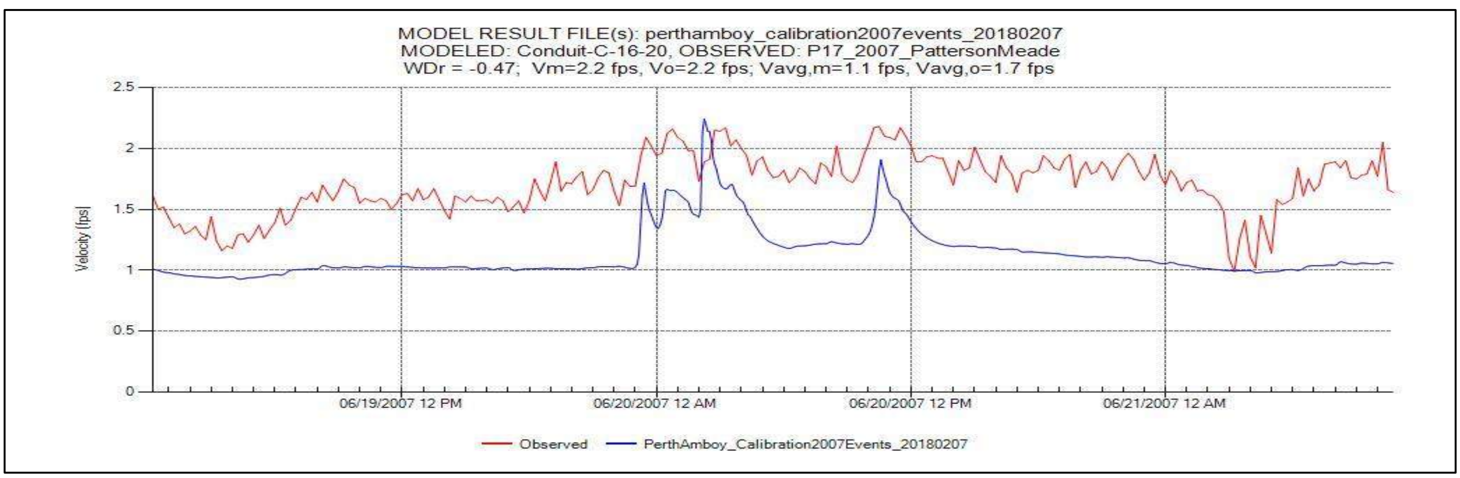


Simulated Versus Observed Flow at Flow Meter Sites

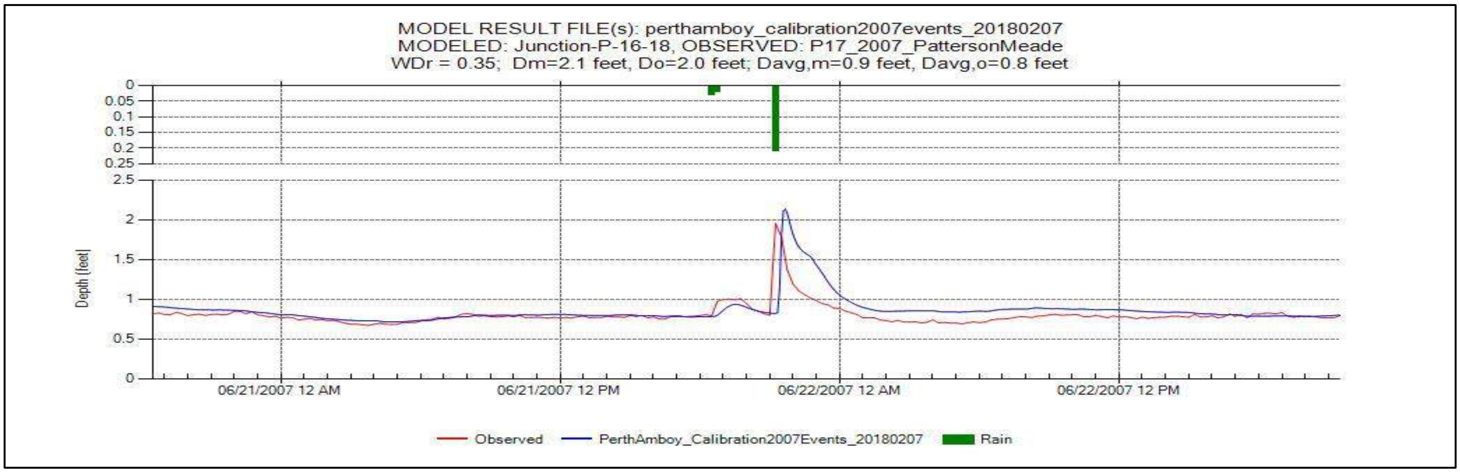
P17_2007_PattersonMeade

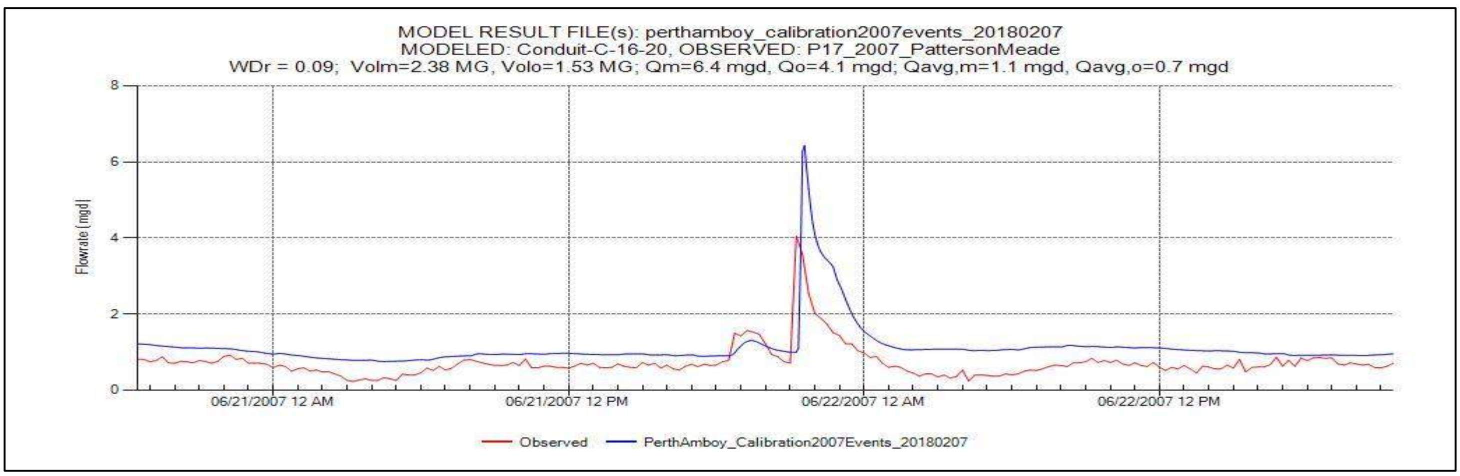


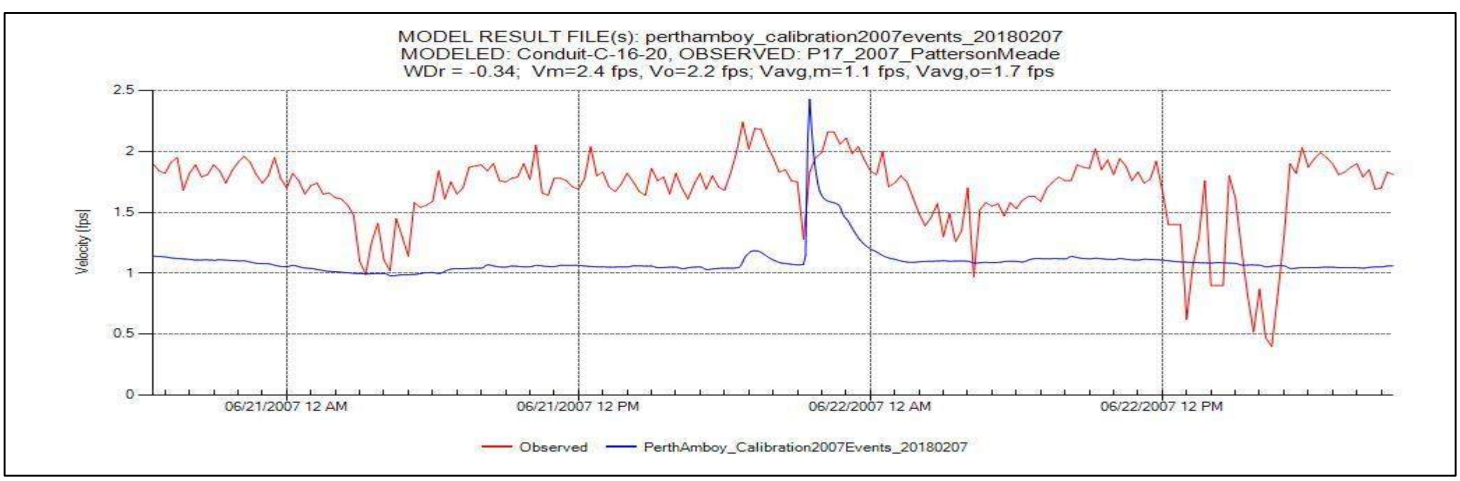




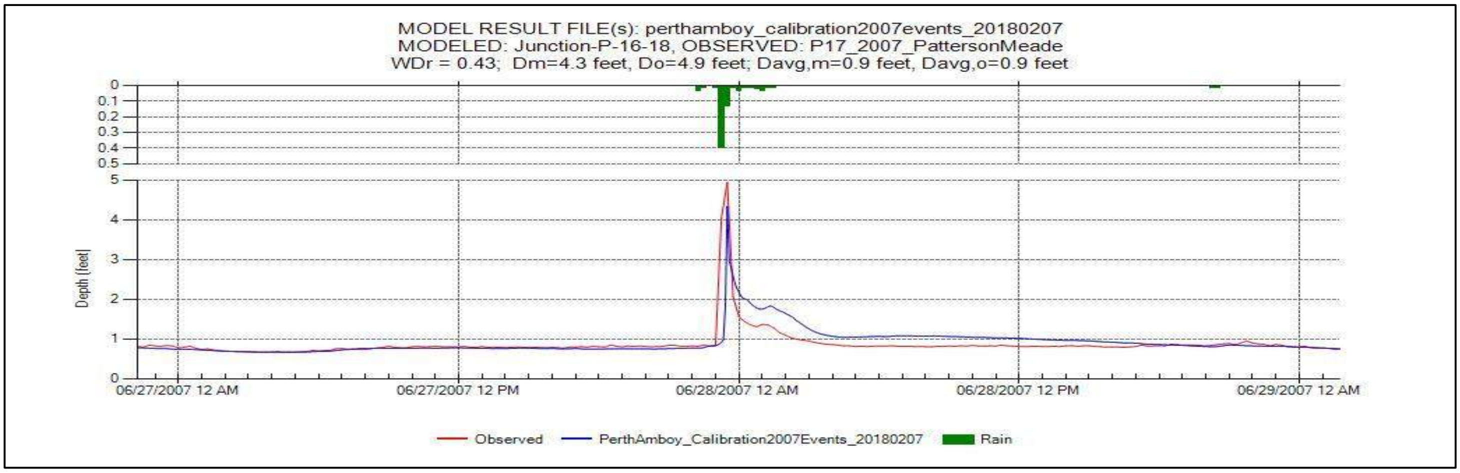
P17_2007_PattersonMeade

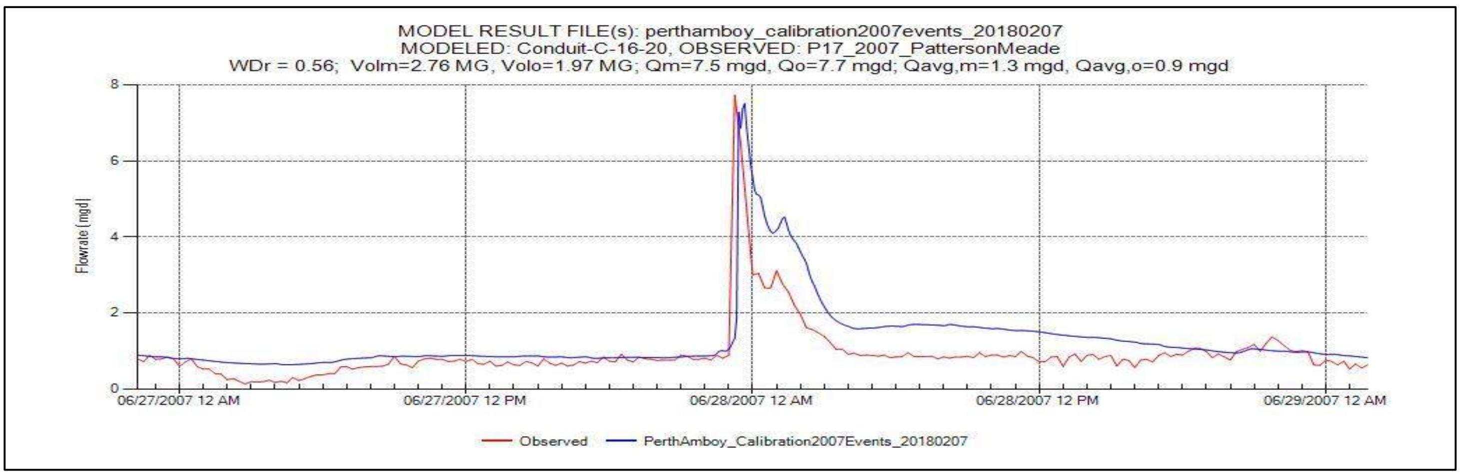


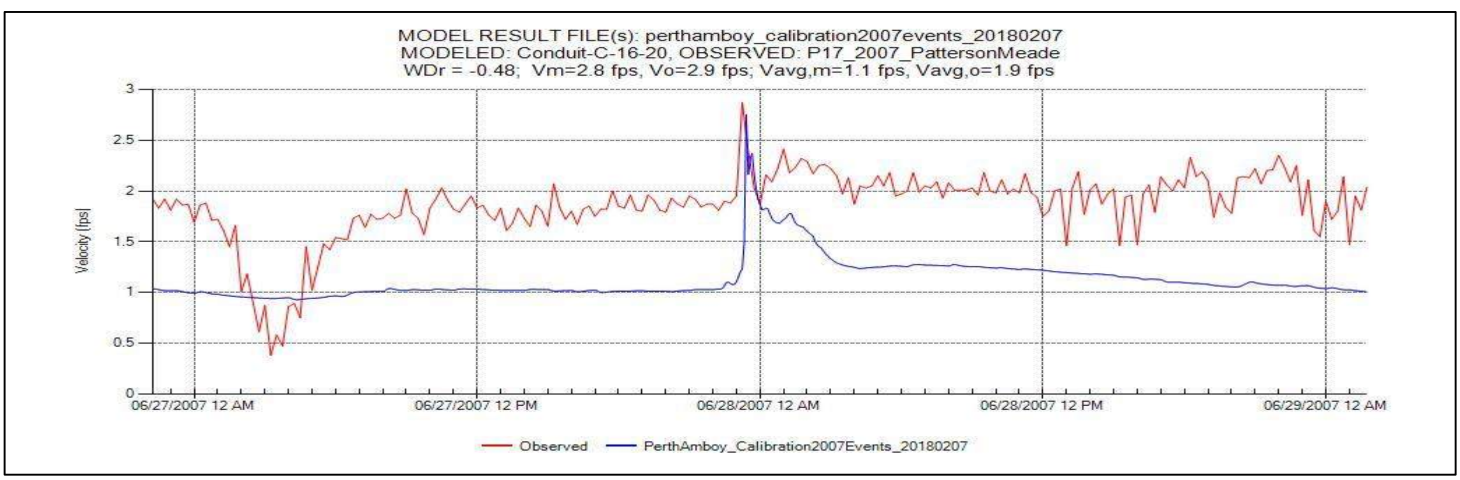




P17_2007_PattersonMeade







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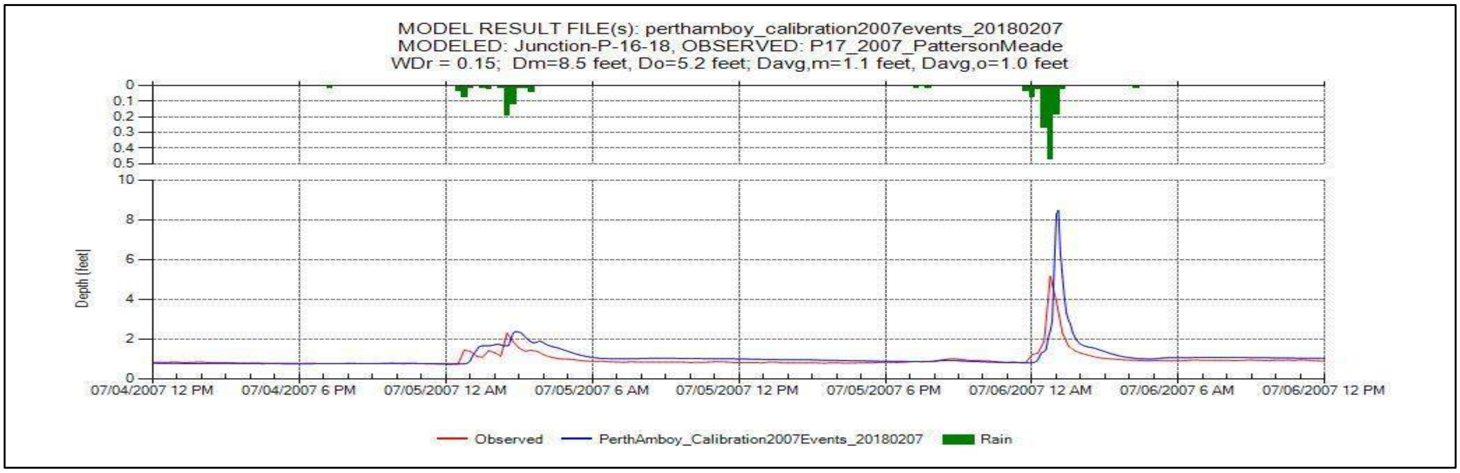

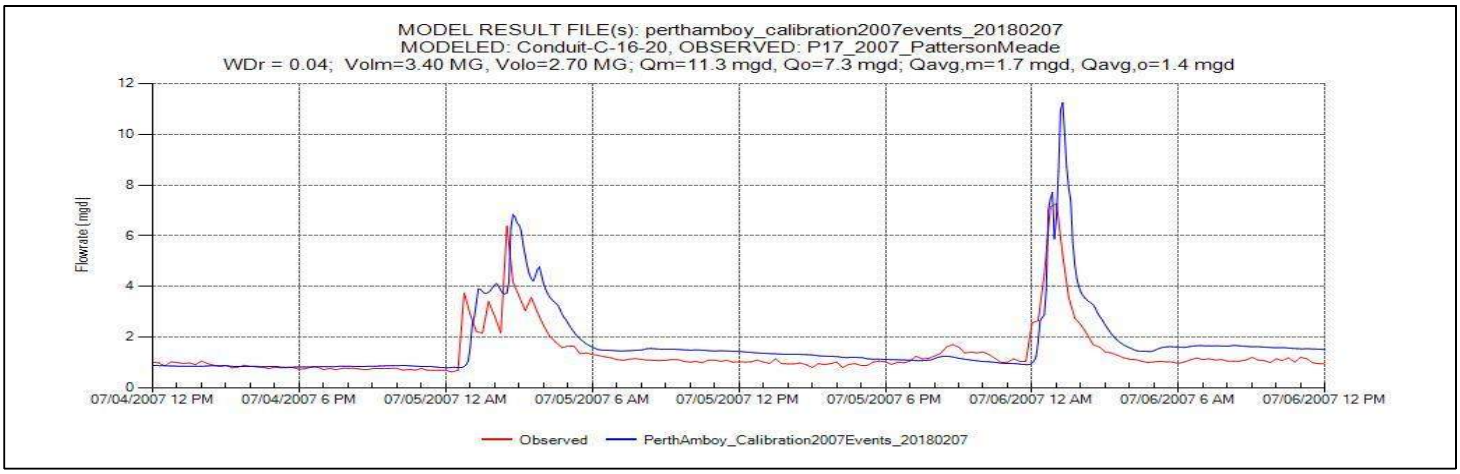

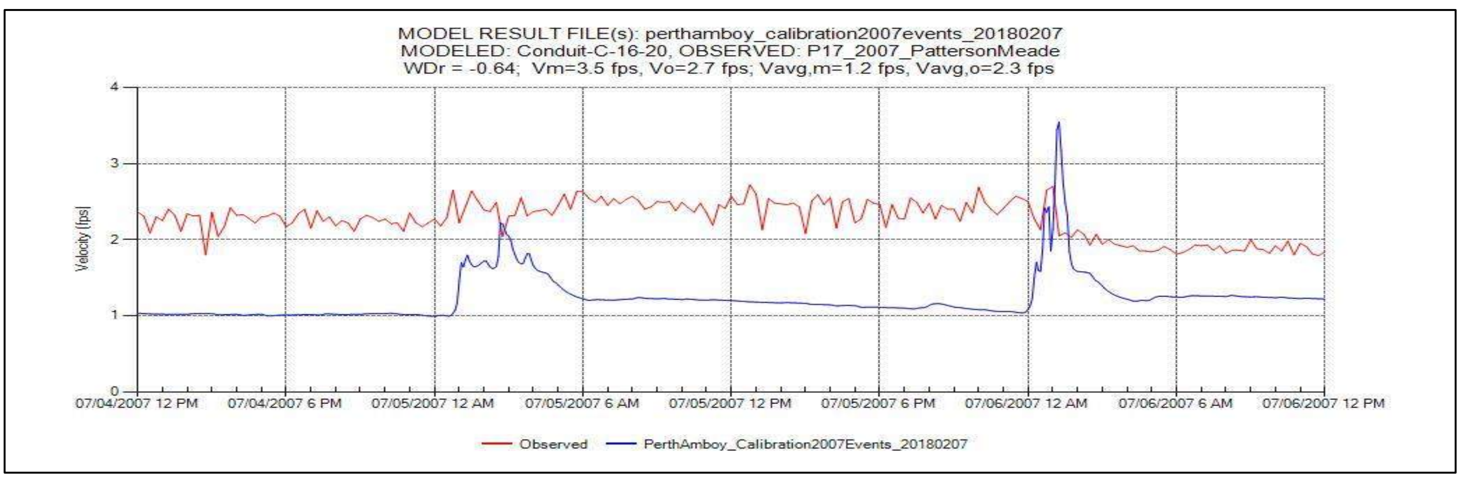

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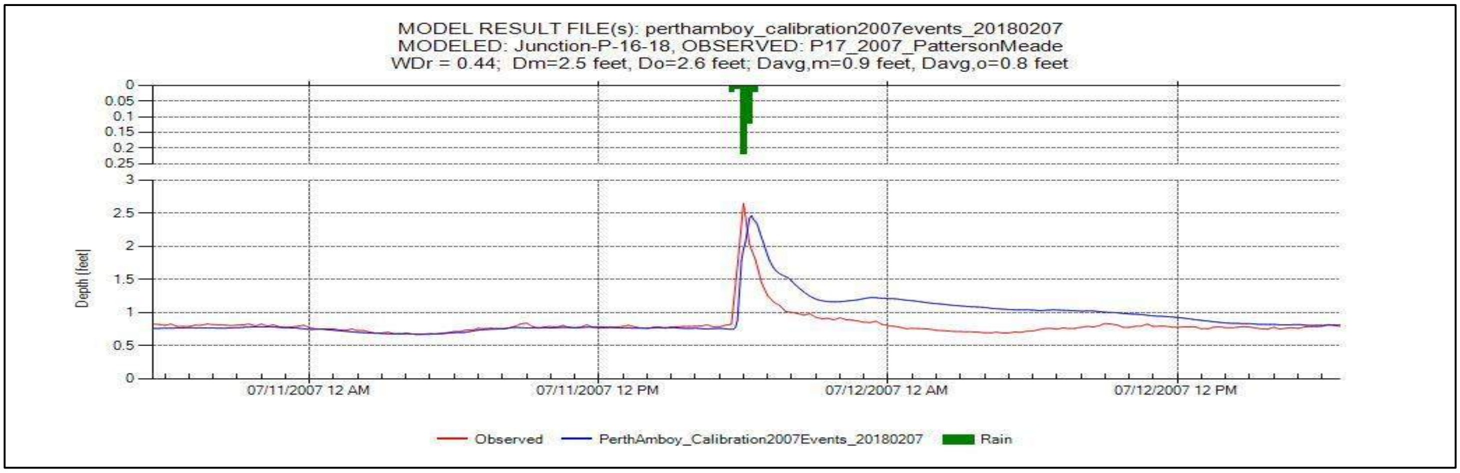
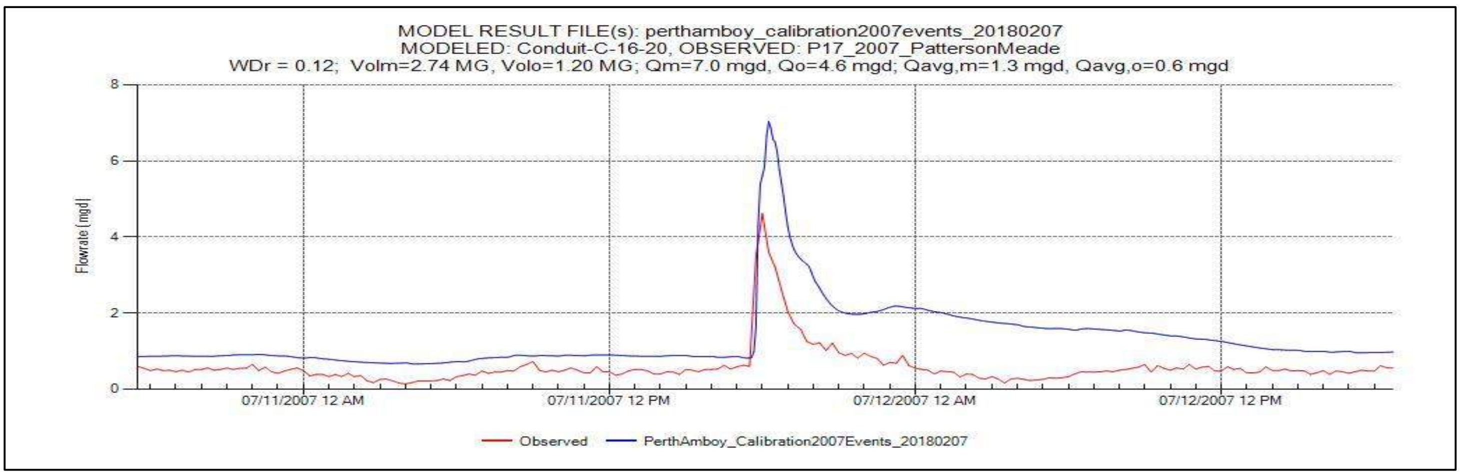
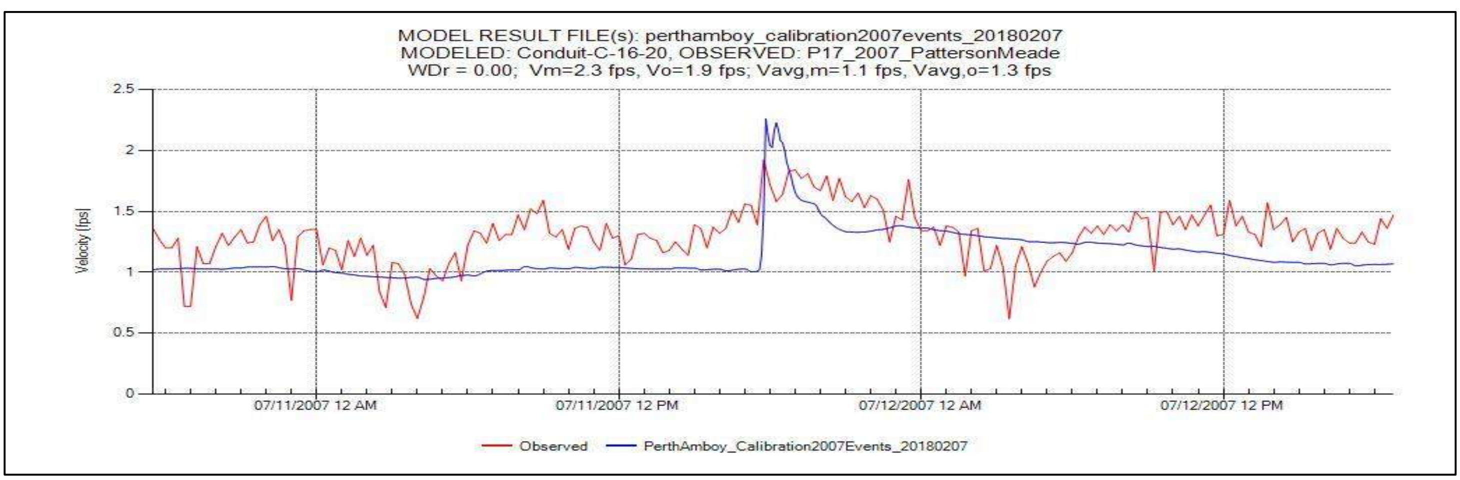
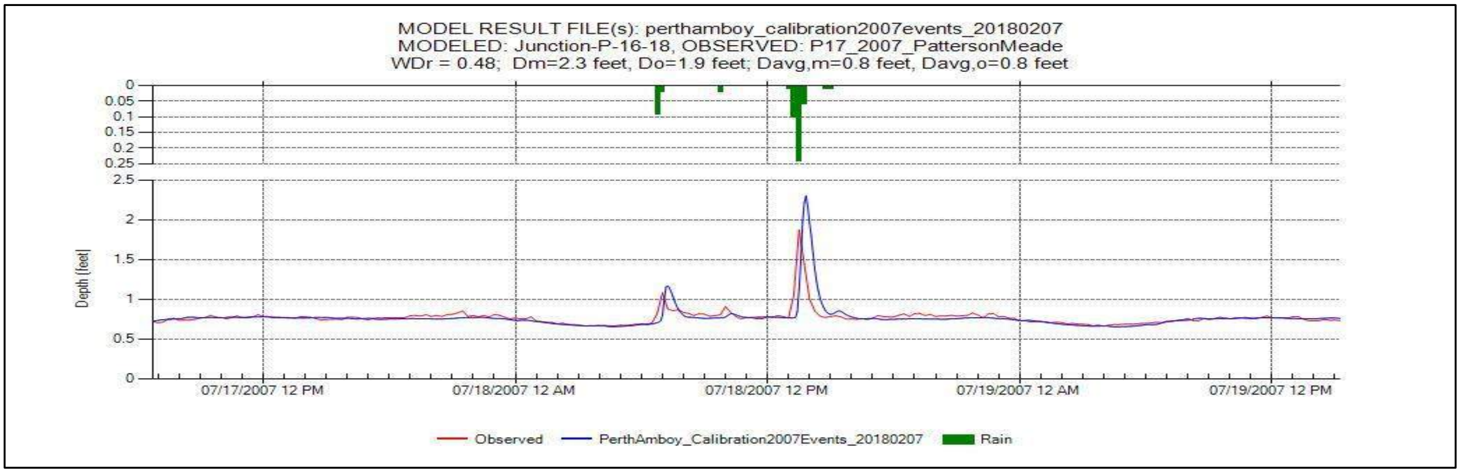
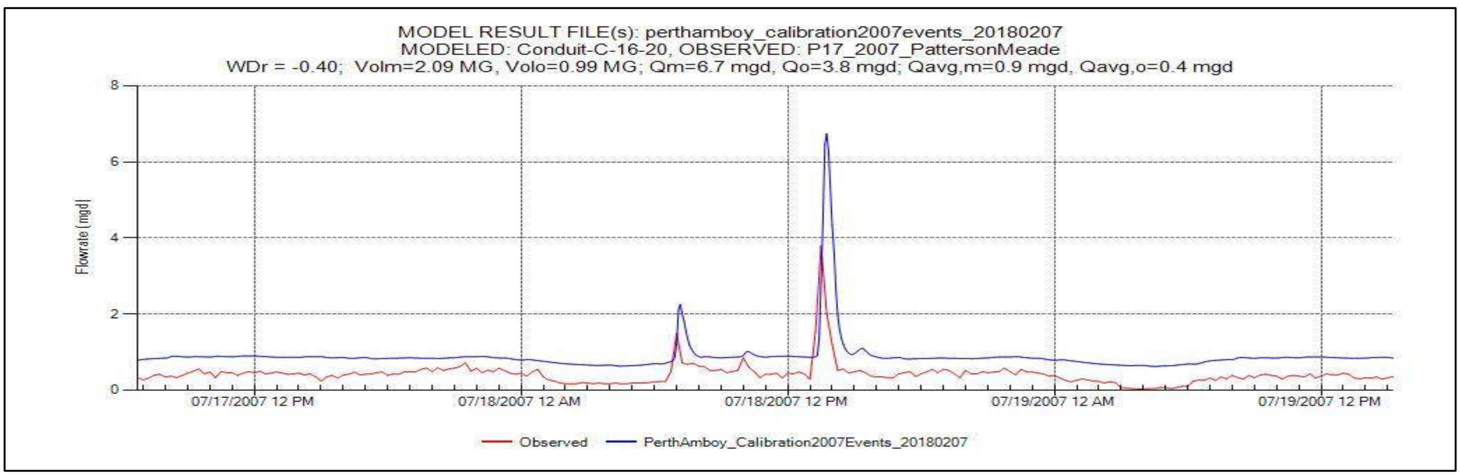


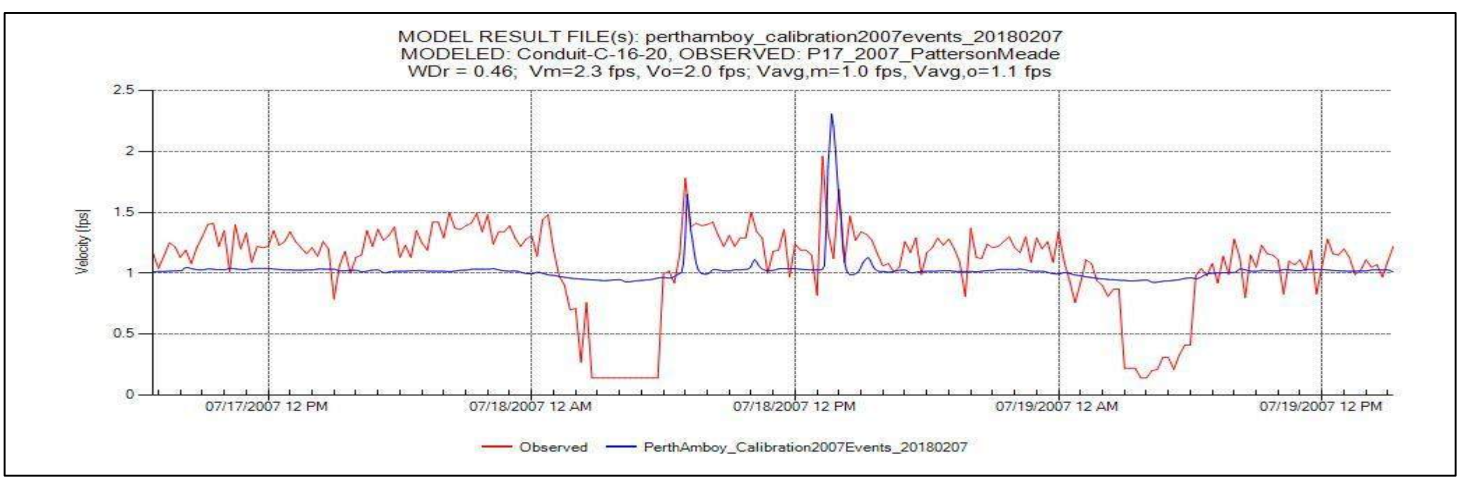




P17_2007_PattersonMeade

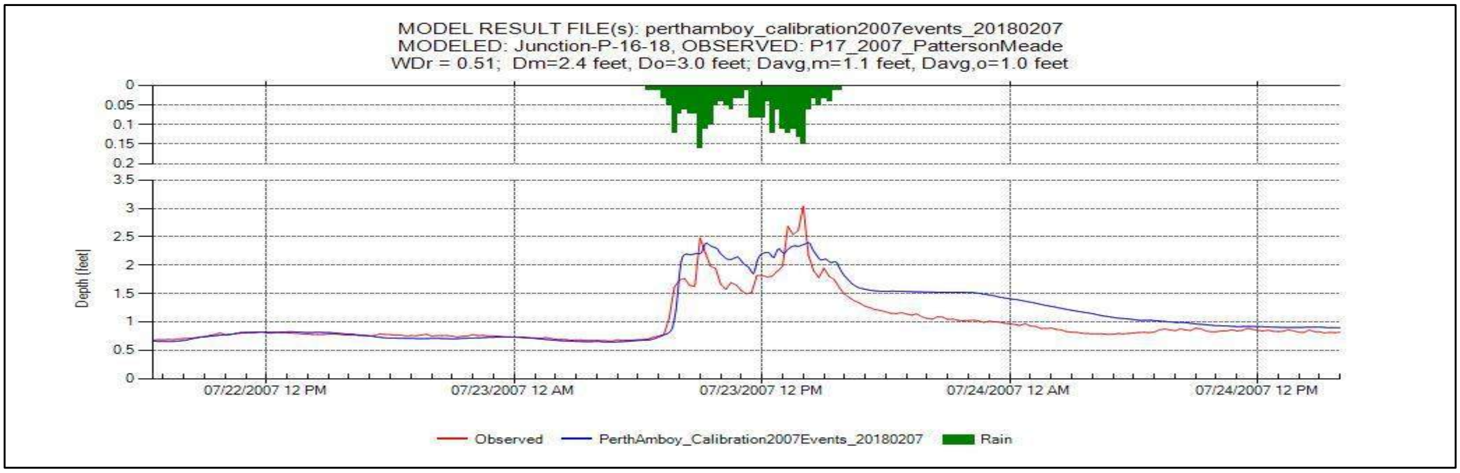


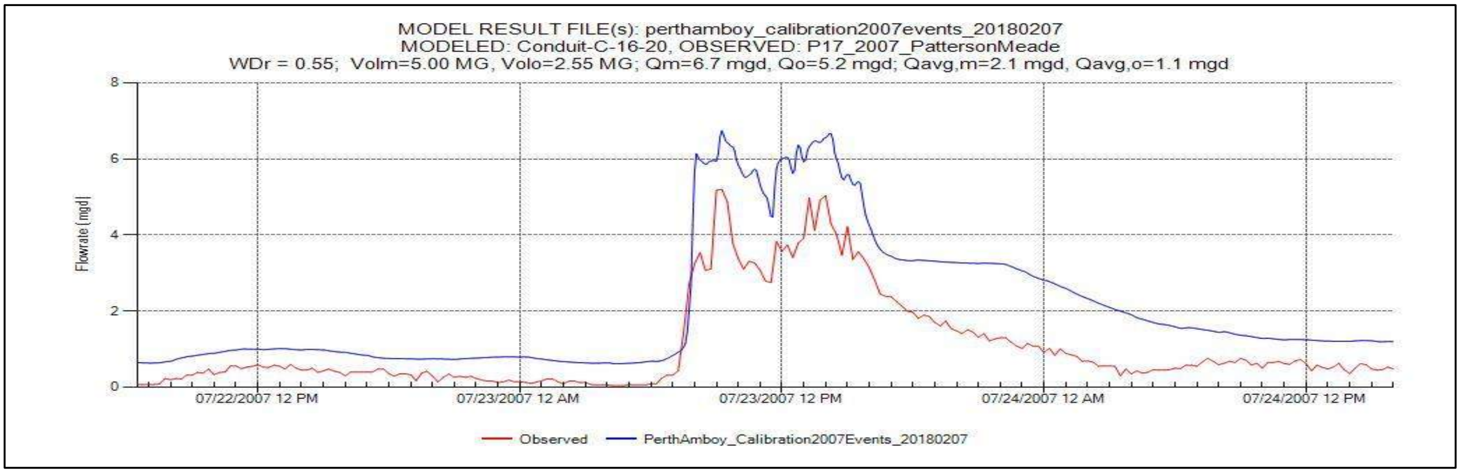


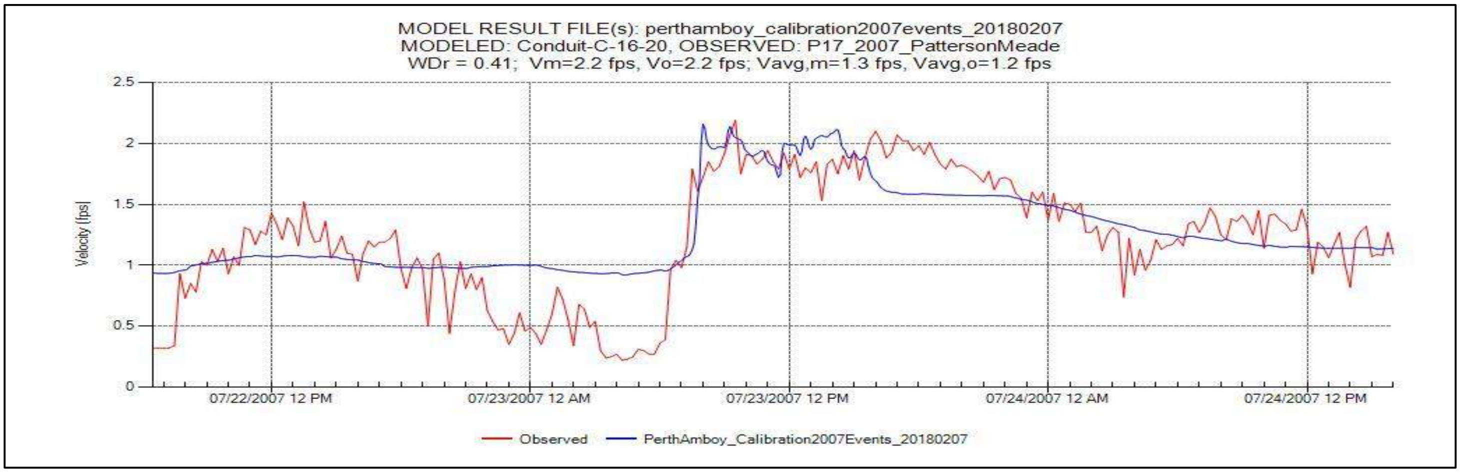


Simulated Versus Observed Flow at Flow Meter Sites

P17_2007_PattersonMeade

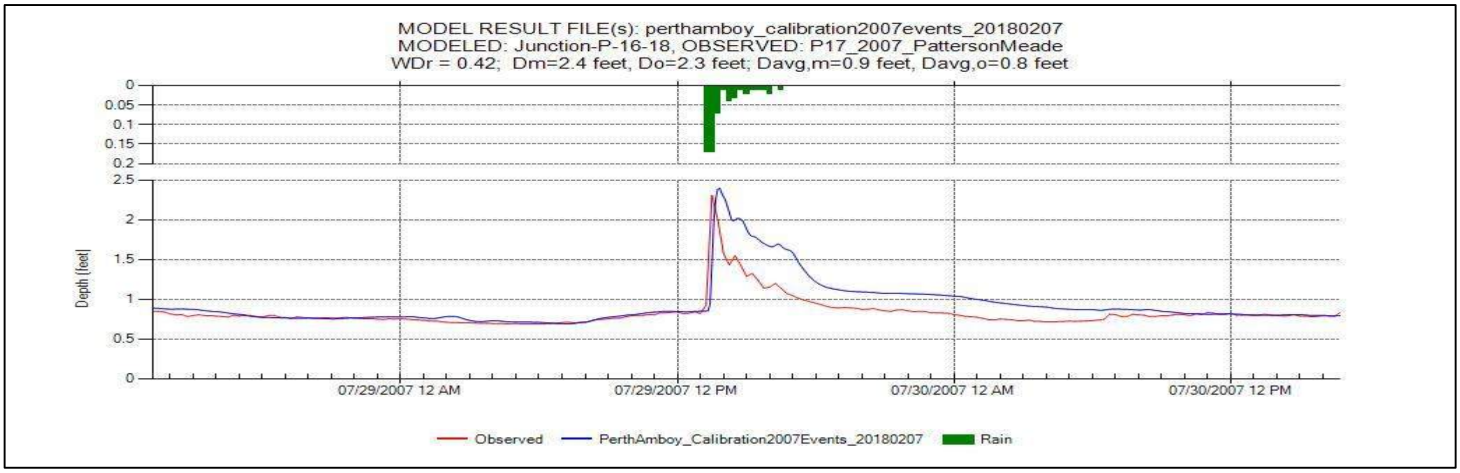


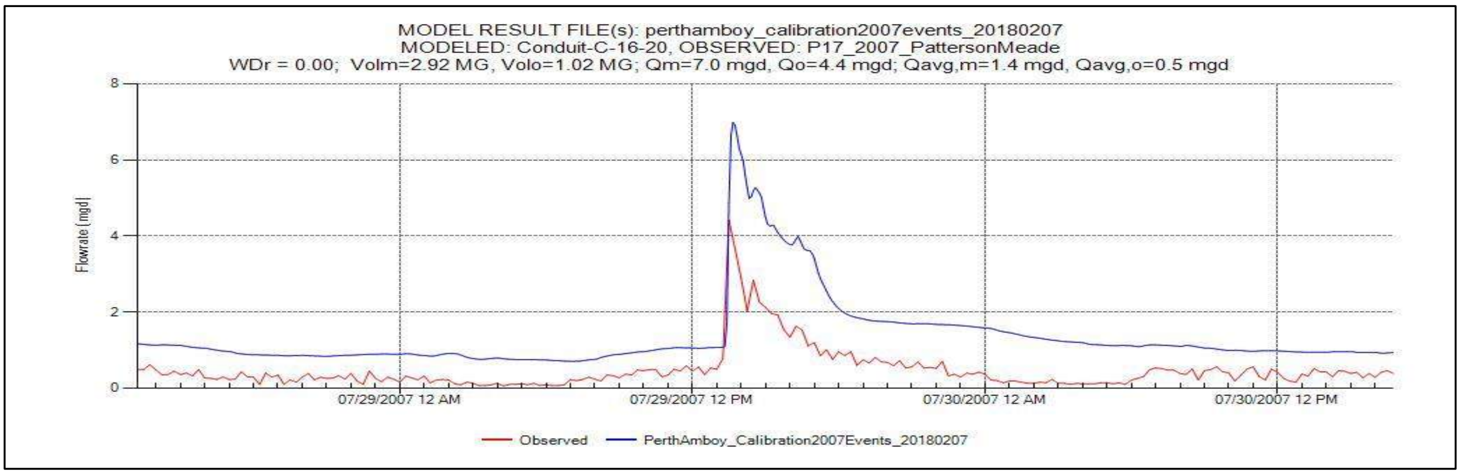


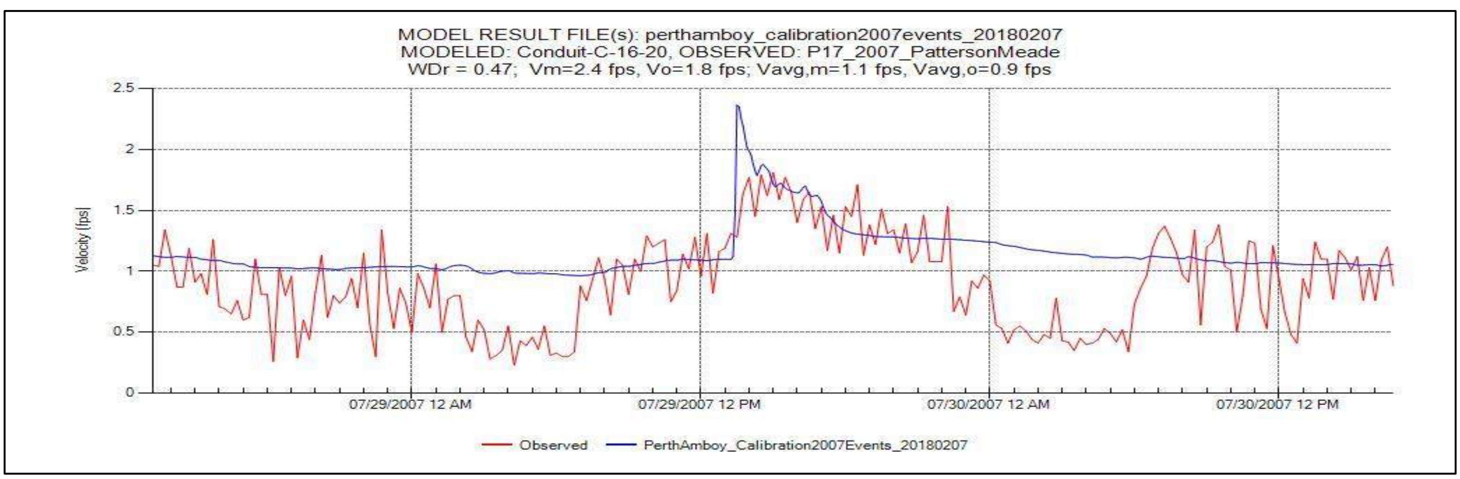


Simulated Versus Observed Flow at Flow Meter Sites

P17_2007_PattersonMeade







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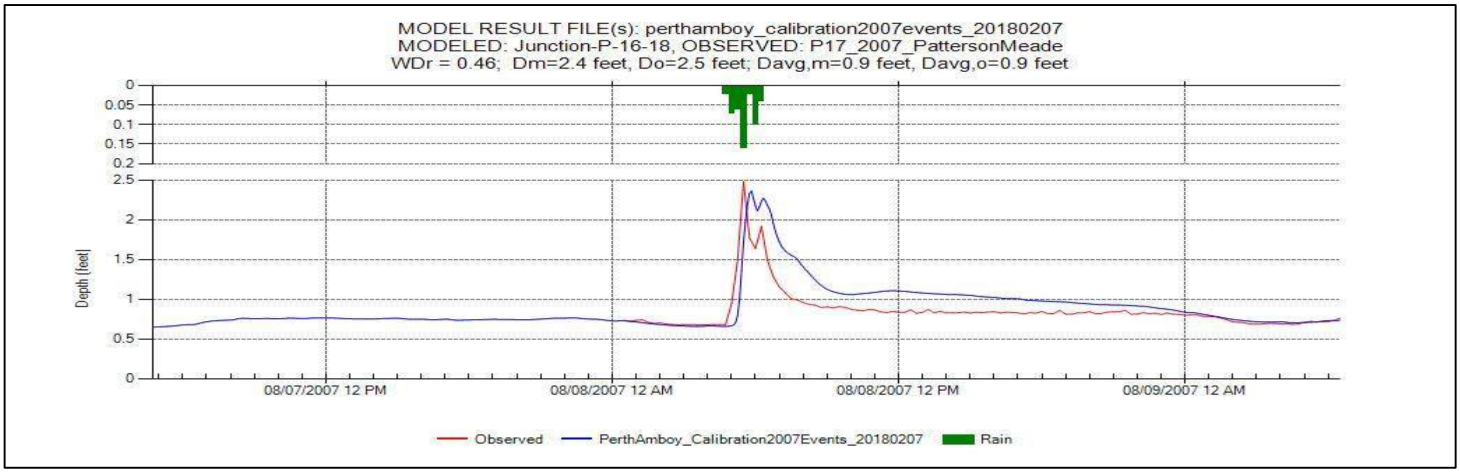

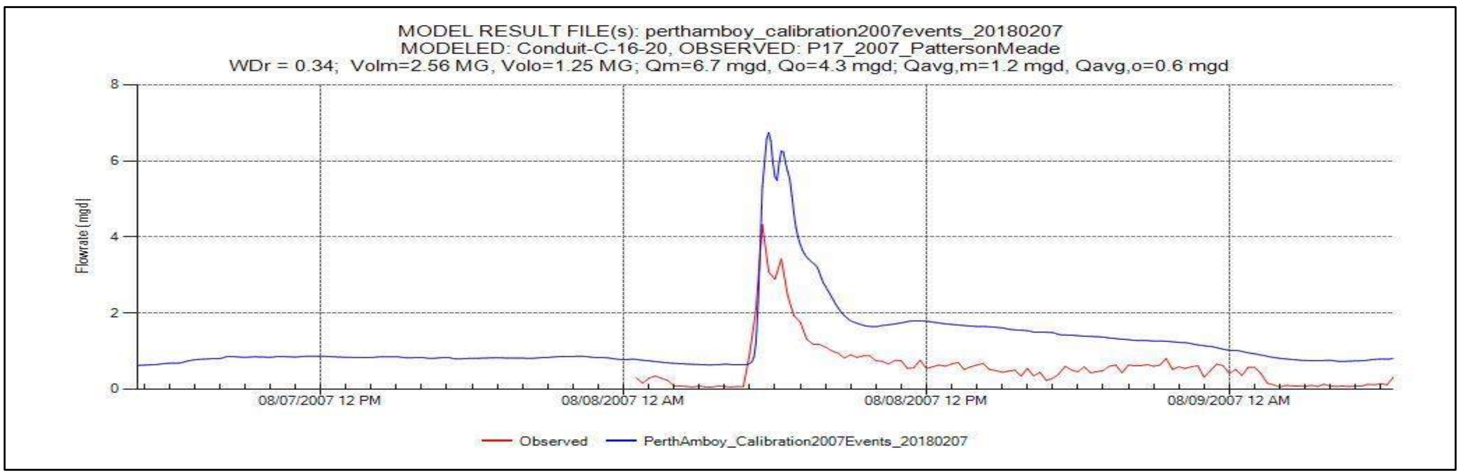

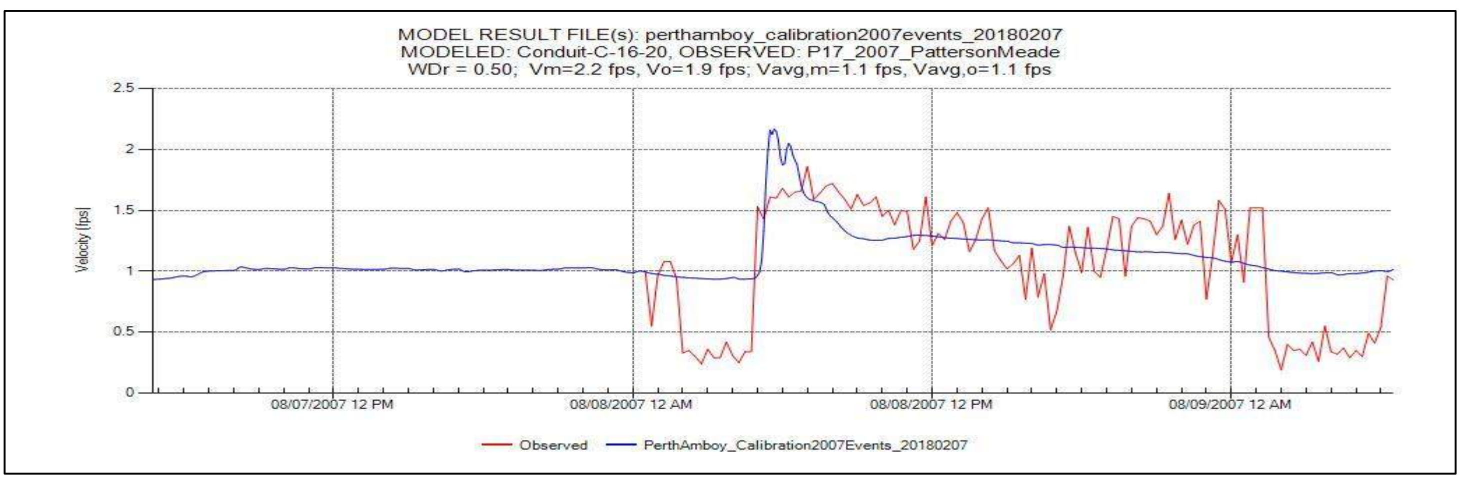

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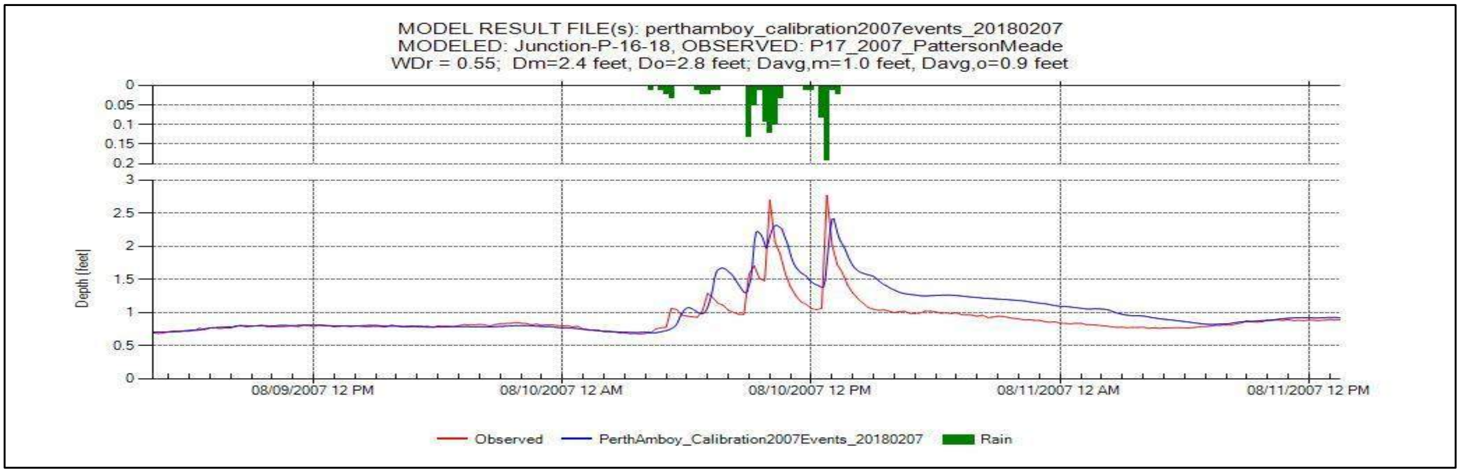
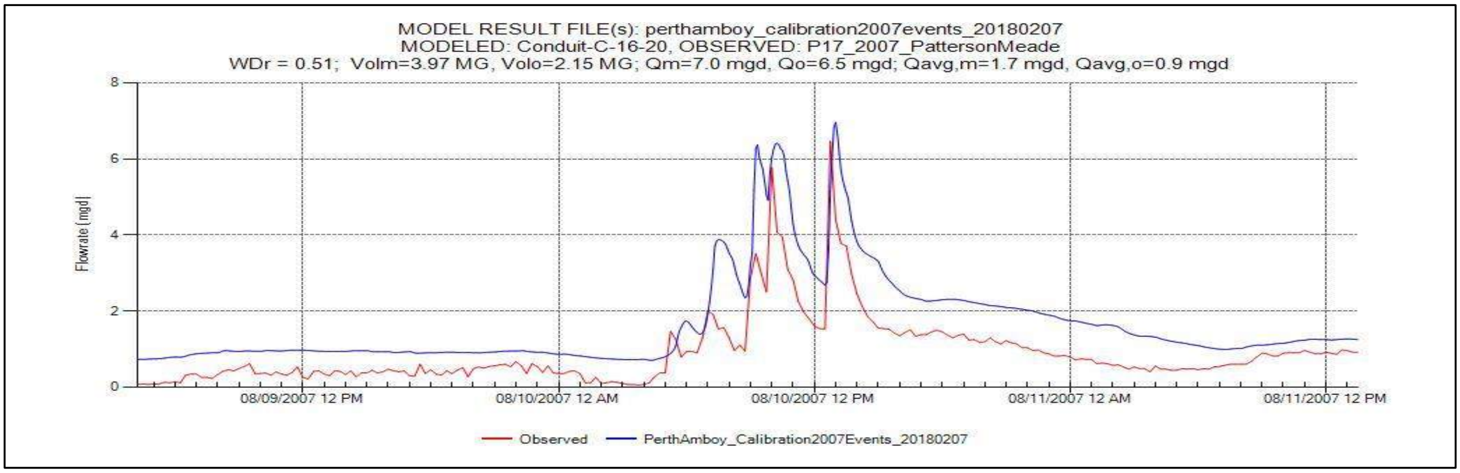
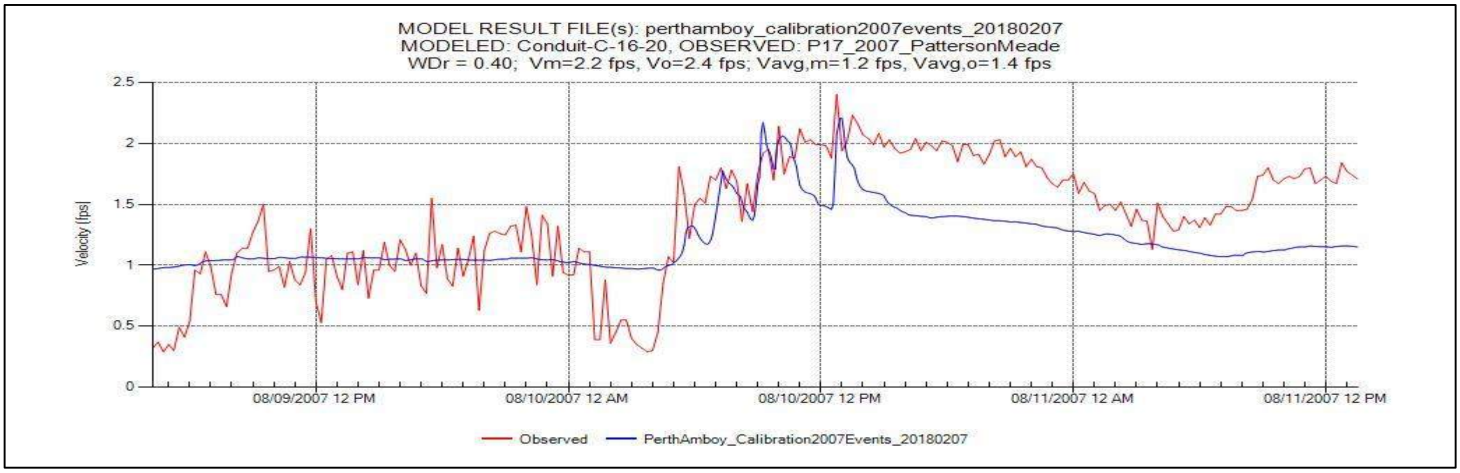
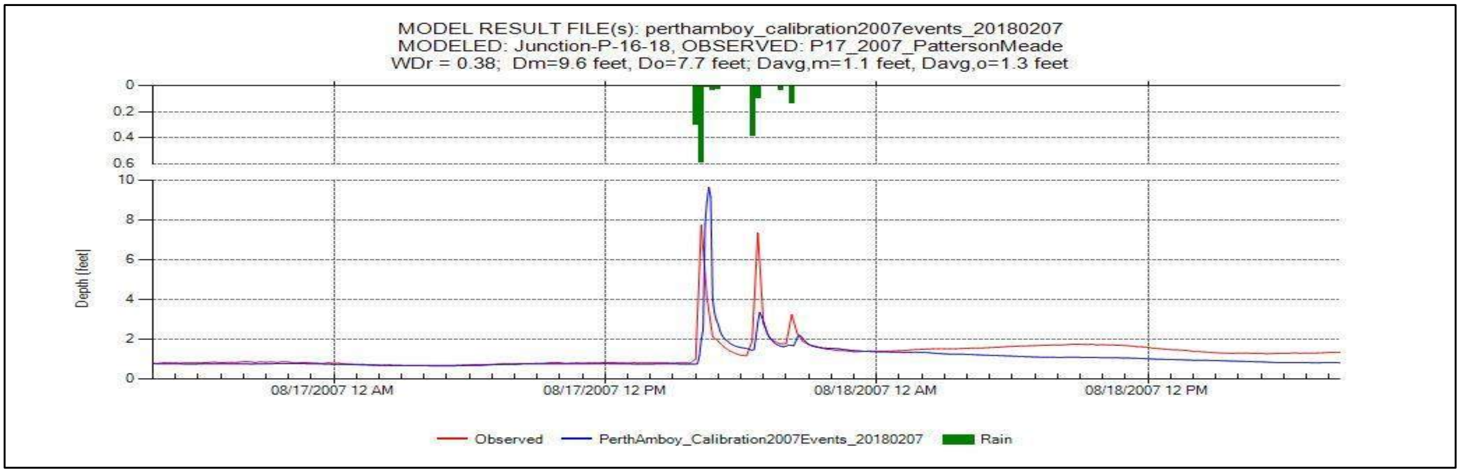


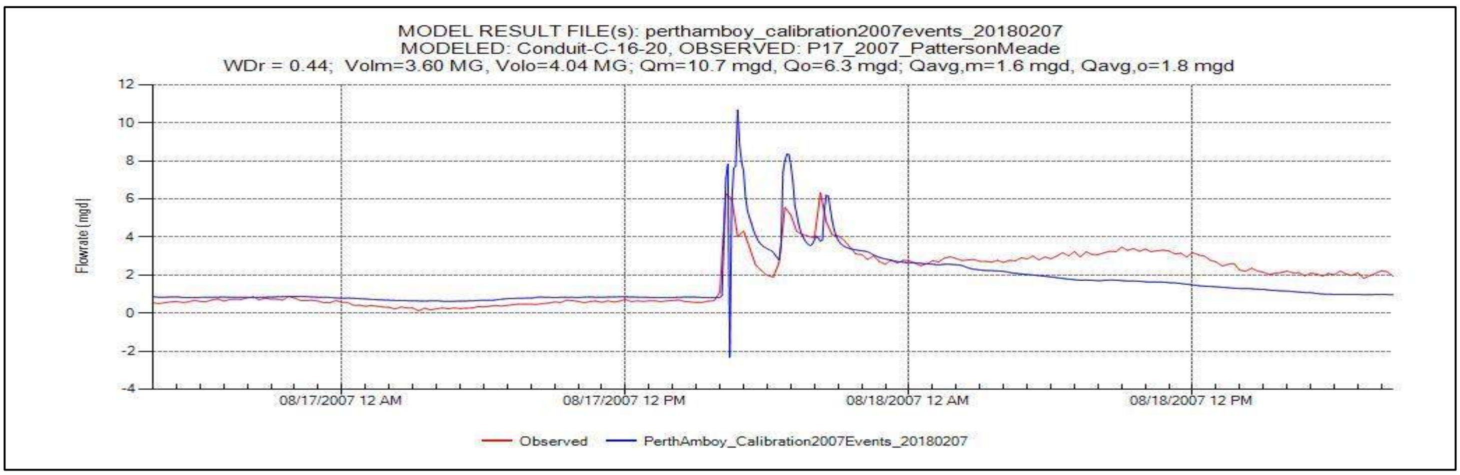


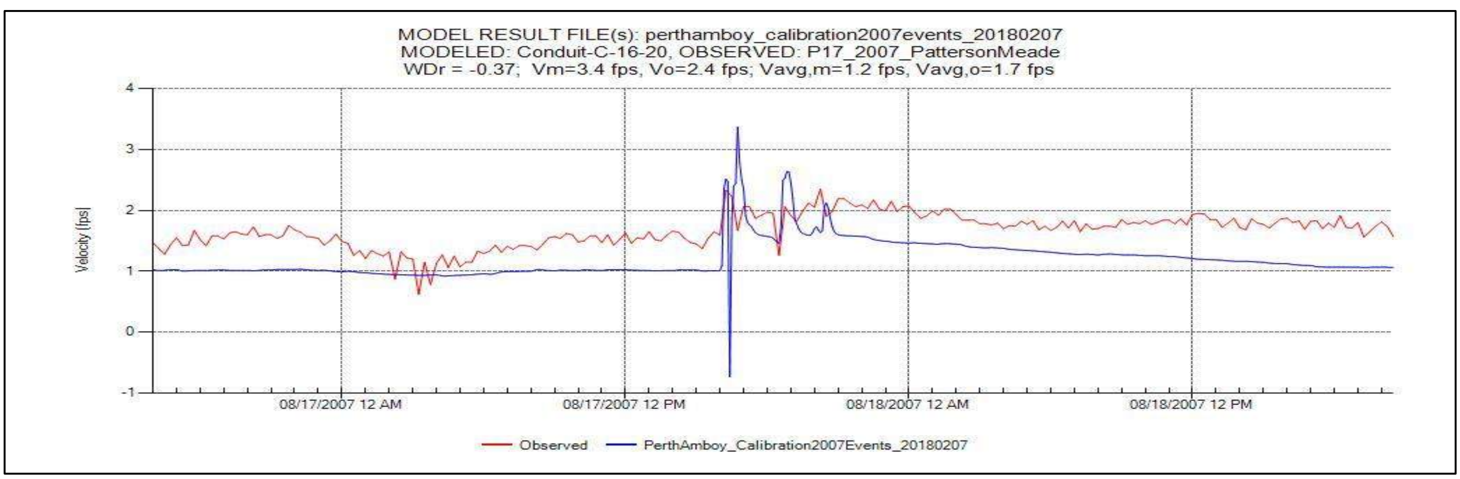


Simulated Versus Observed Flow at Flow Meter Sites

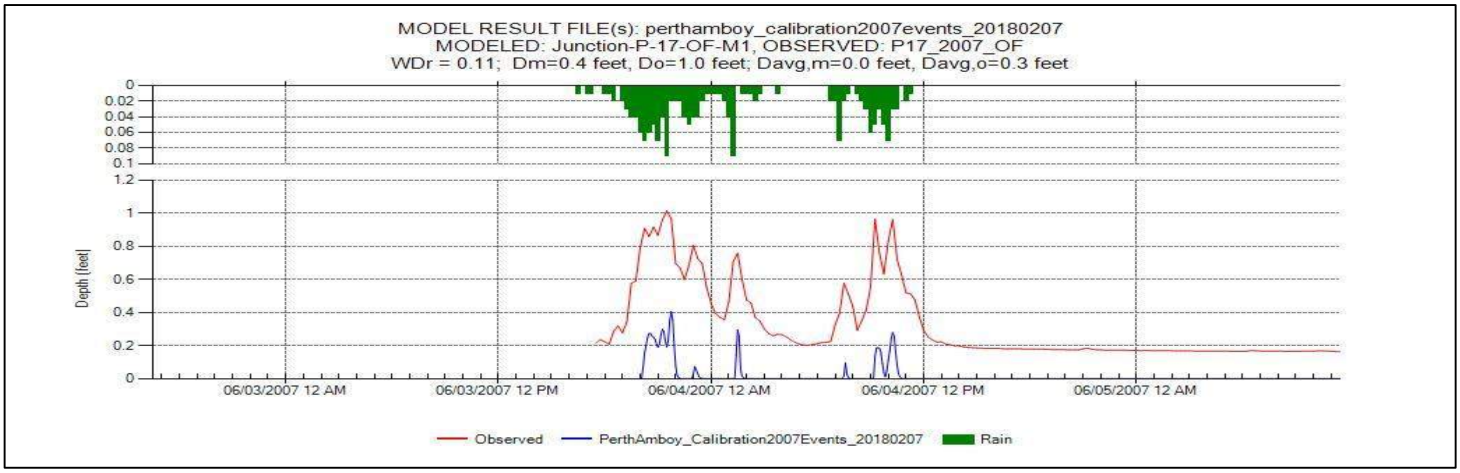
P17_2007_PattersonMeade

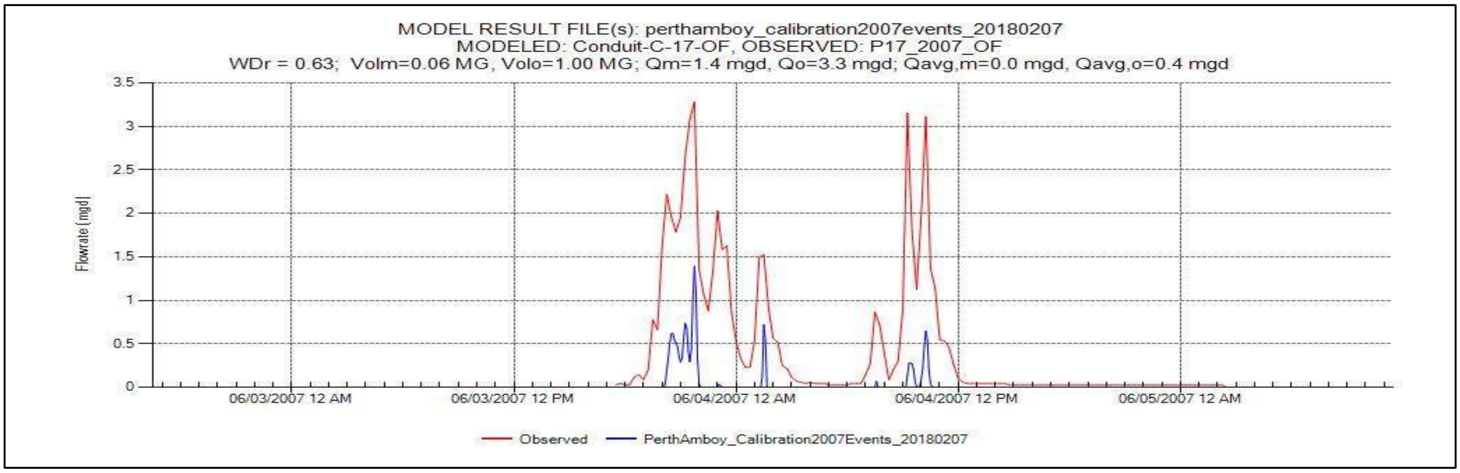


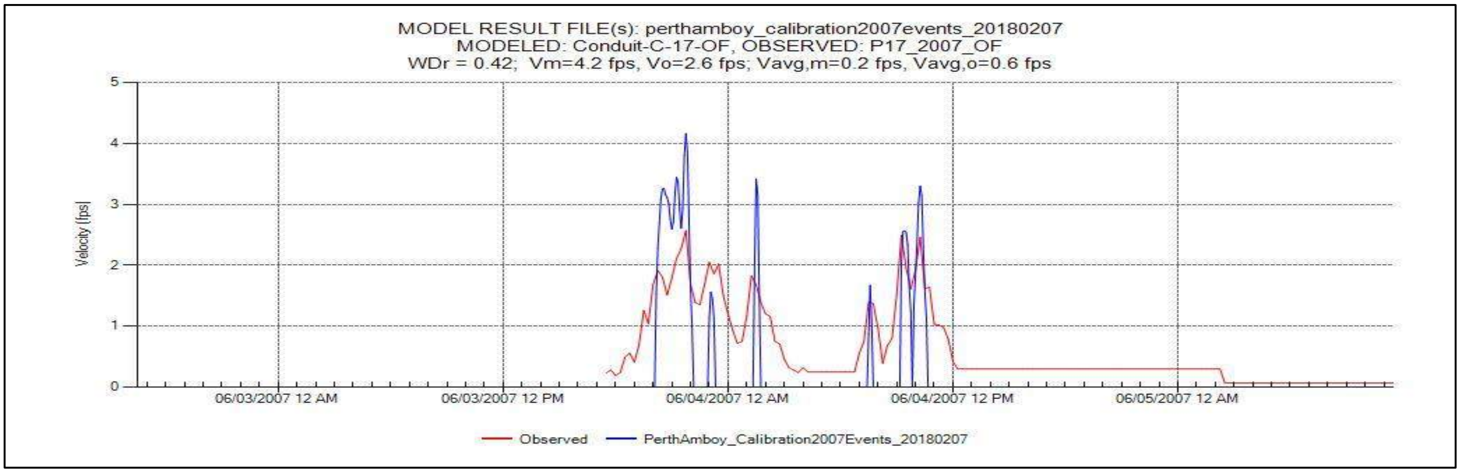




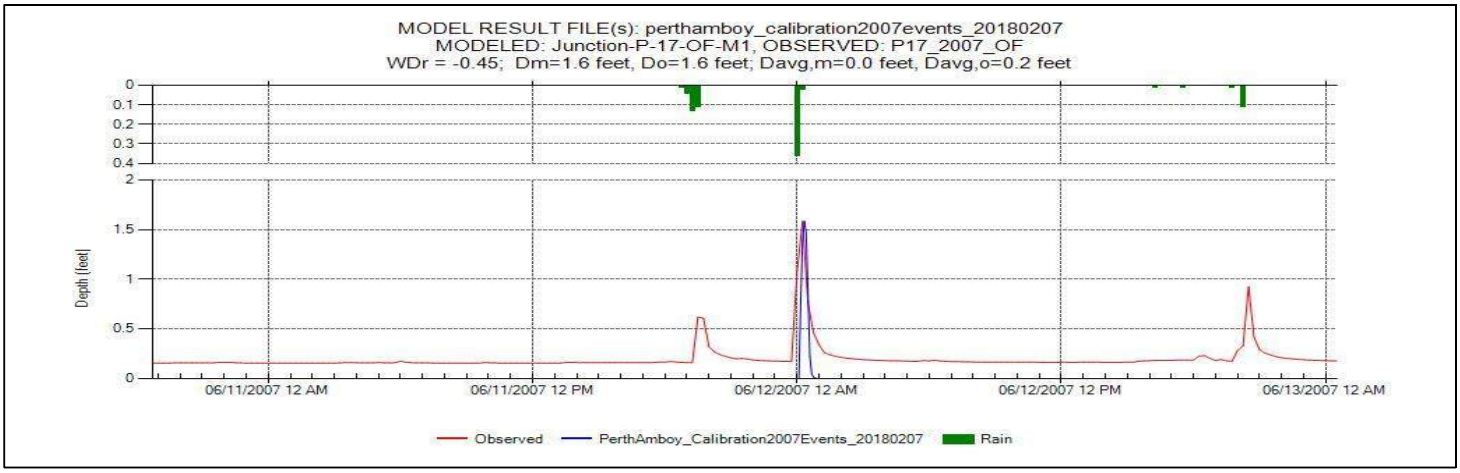
P17_2007_OF

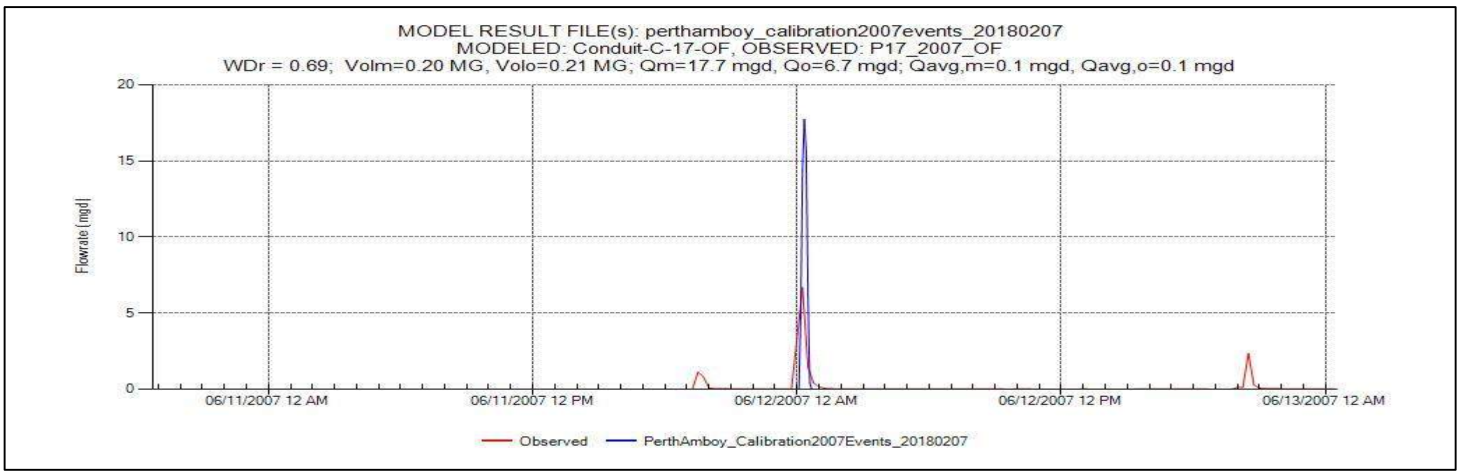

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = 0.11; Dm=0.4 feet, Do=1.0 feet; Davg,m=0.0 feet, Davg,o=0.3 feet
Depth (feet)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

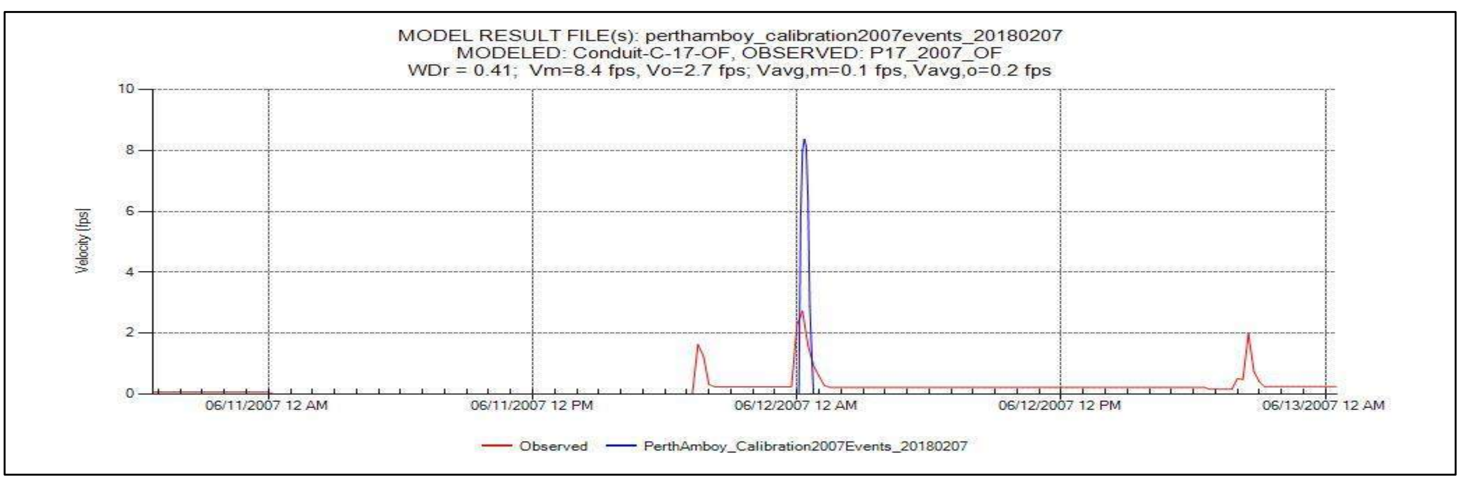

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.63; Volm=0.06 MG, Volo=1.00 MG; Qm=1.4 mgd, Qo=3.3 mgd; Qavg,m=0.0 mgd, Qavg,o=0.4 mgd
Flowrate (mgd)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.42; Vm=4.2 fps, Vo=2.6 fps; Vavg,m=0.2 fps, Vavg,o=0.6 fps
Velocity (fps)
06/03/2007 12 AM
06/03/2007 12 PM
06/04/2007 12 AM
06/04/2007 12 PM
06/05/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

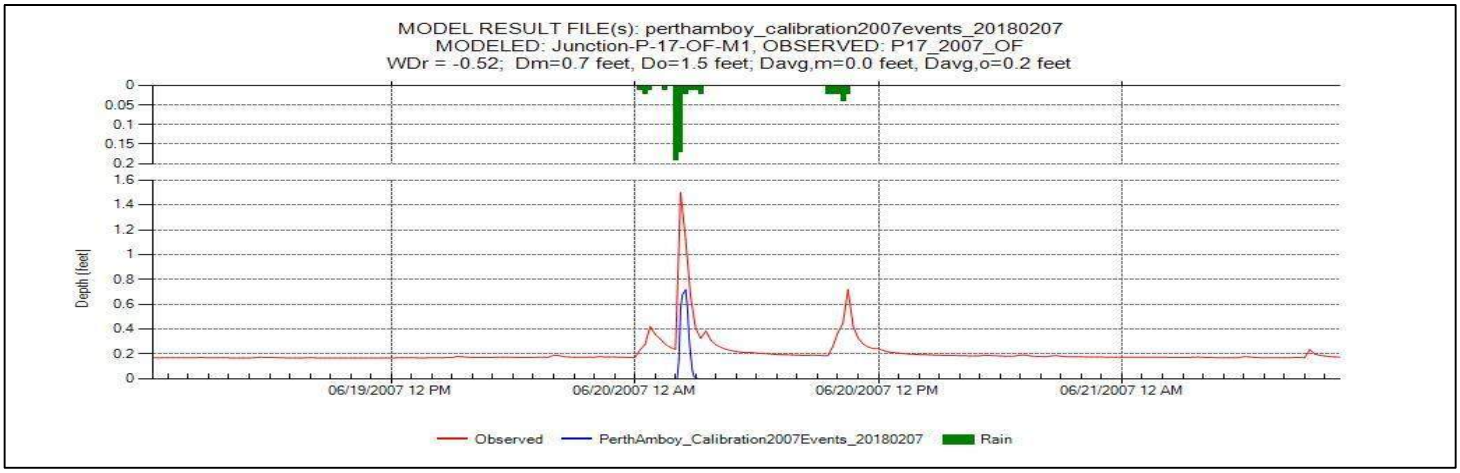
P17_2007_OF


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.45; Dm=1.6 feet, Do=1.6 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

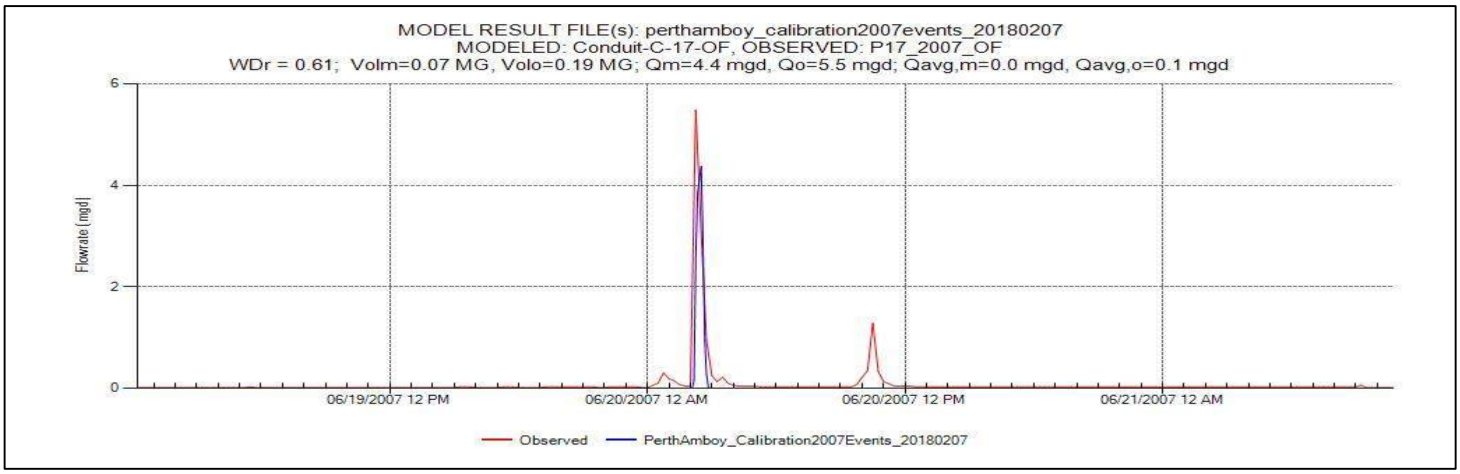

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.69; Volm=0.20 MG, Volo=0.21 MG; Qm=17.7 mgd, Qo=6.7 mgd; Qavg,m=0.1 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.41; Vm=8.4 fps, Vo=2.7 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
06/11/2007 12 AM
06/11/2007 12 PM
06/12/2007 12 AM
06/12/2007 12 PM
06/13/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

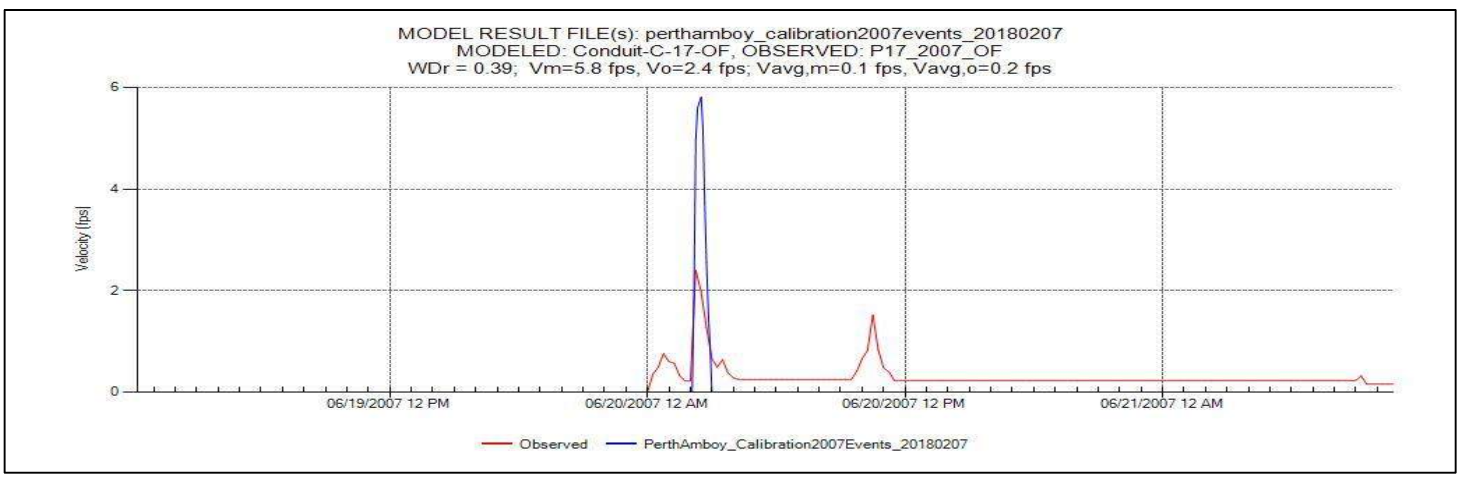
P17_2007_OF



MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.52; Dm=0.7 feet, Do=1.5 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

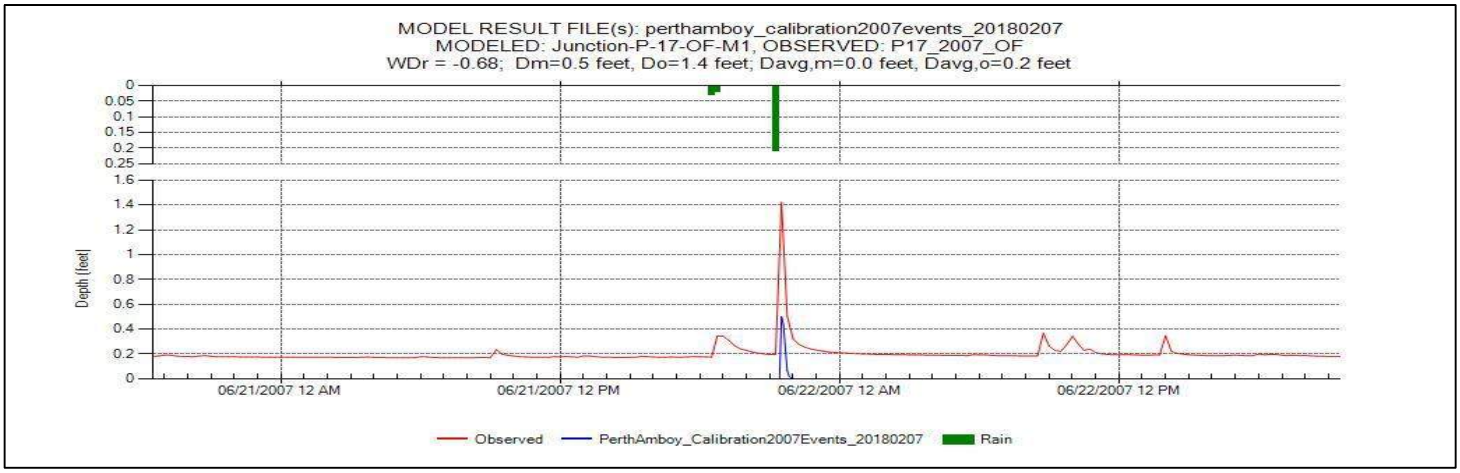


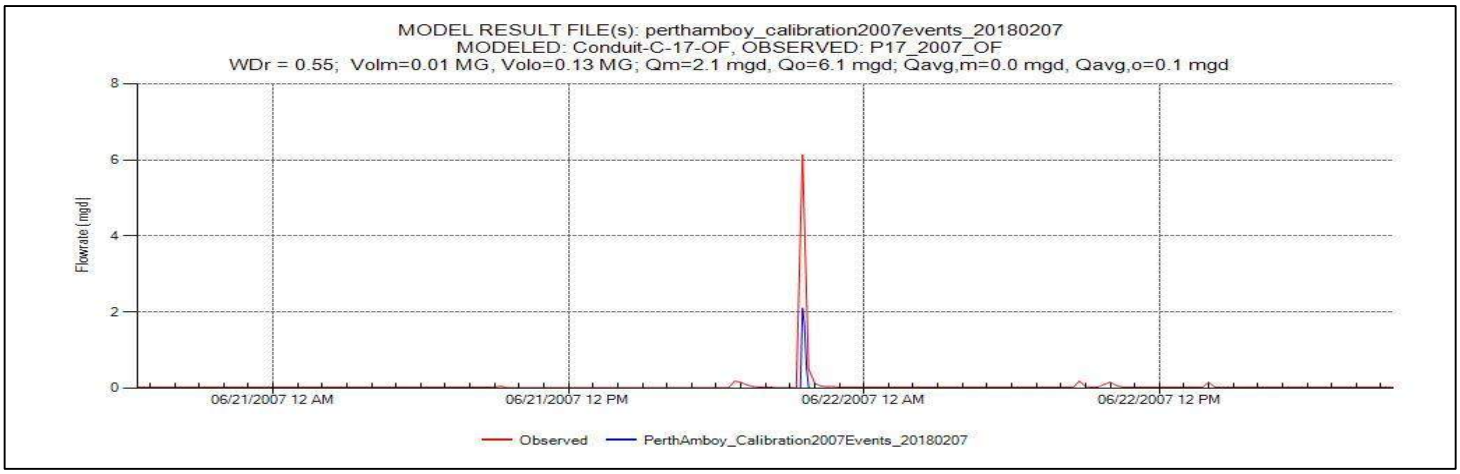
MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.61; Volm=0.07 MG, Volo=0.19 MG; Qm=4.4 mgd, Qo=5.5 mgd; Qavg,m=0.0 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

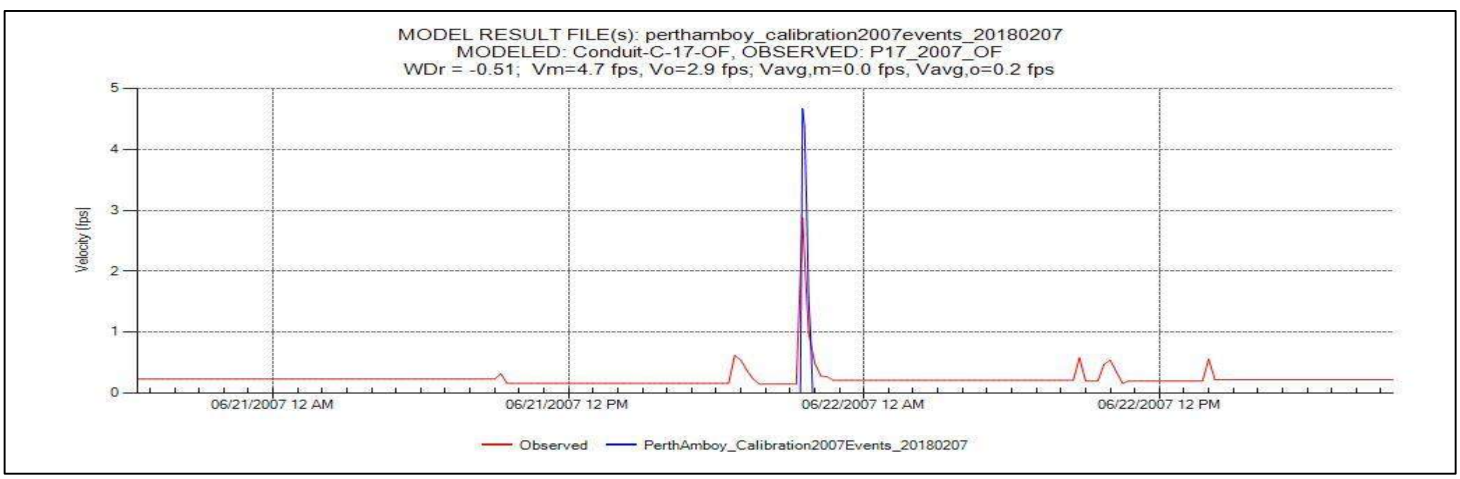


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.39; Vm=5.8 fps, Vo=2.4 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
06/19/2007 12 PM
06/20/2007 12 AM
06/20/2007 12 PM
06/21/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

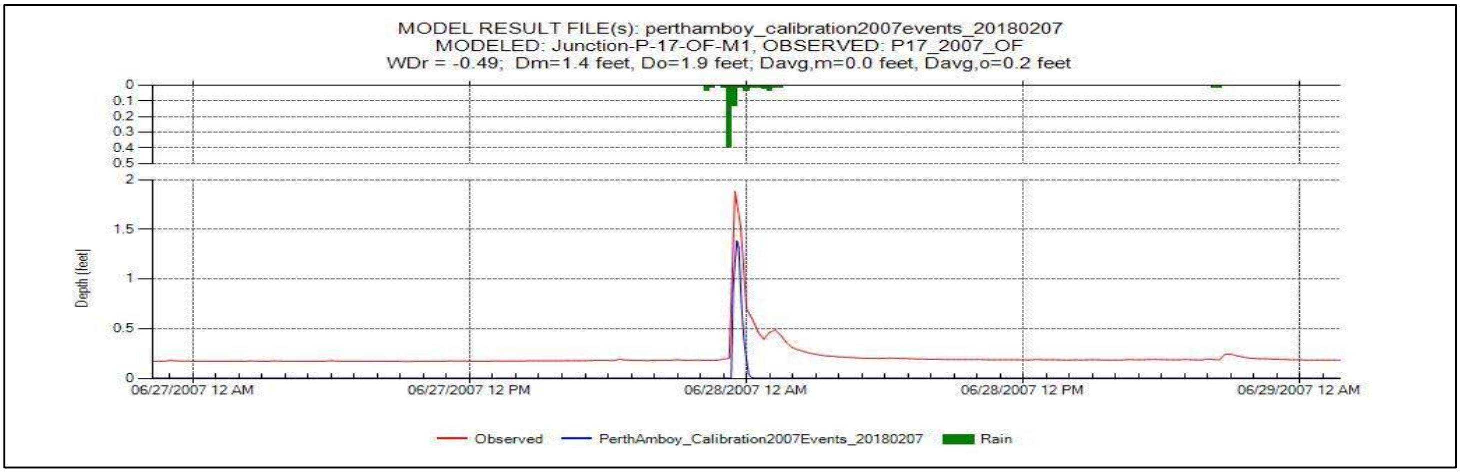
P17_2007_OF

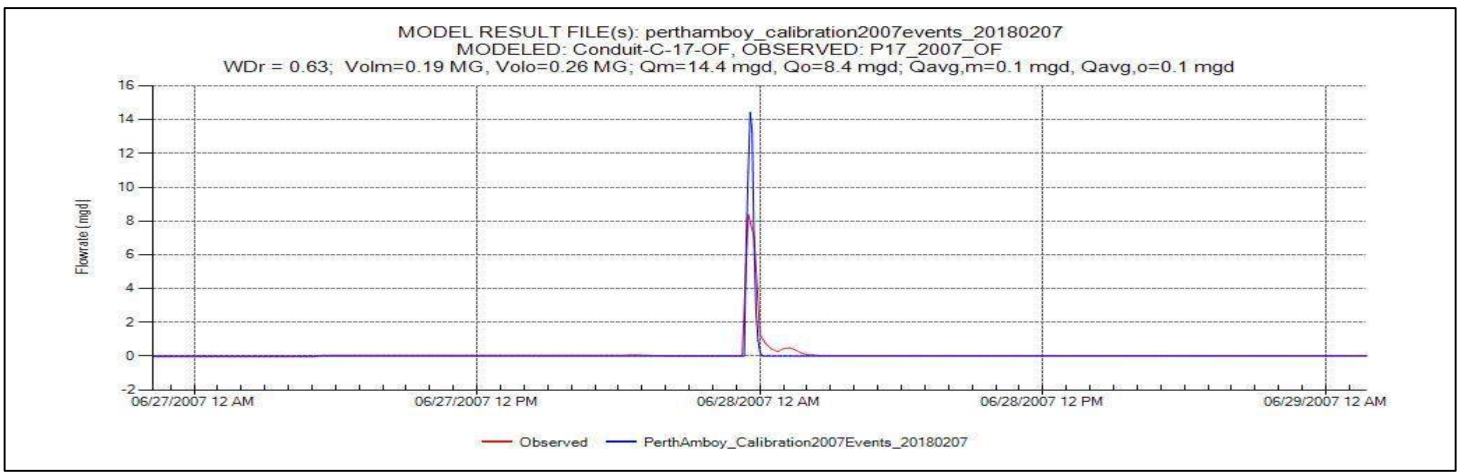

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.68; Dm=0.5 feet, Do=1.4 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

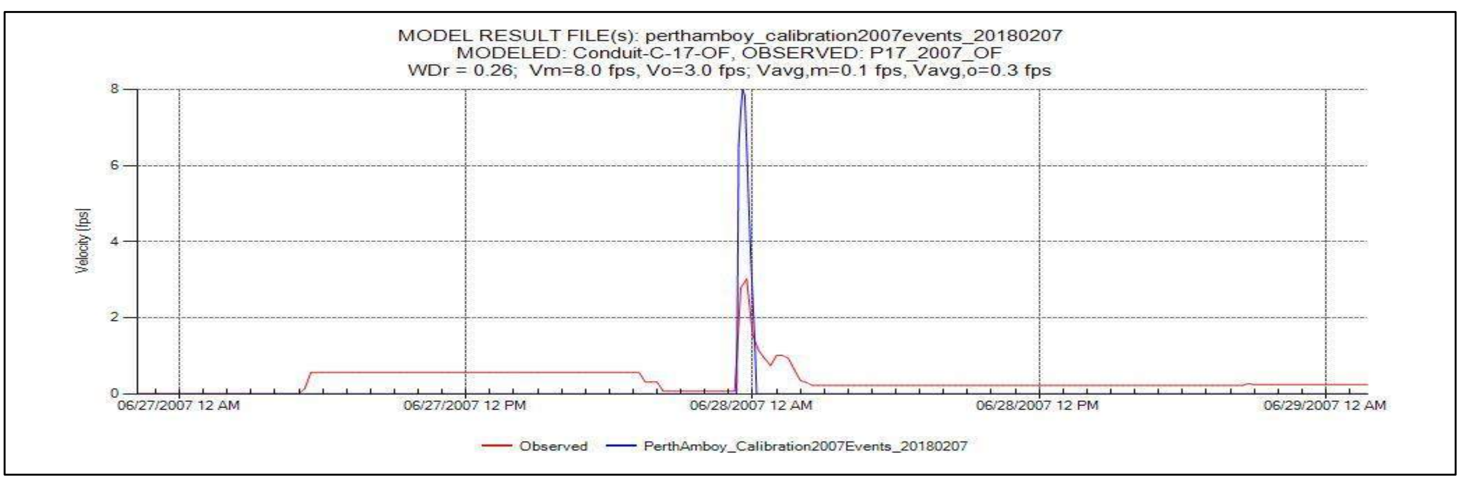

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.55; Volm=0.01 MG, Volo=0.13 MG; Qm=2.1 mgd, Qo=6.1 mgd; Qavg,m=0.0 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = -0.51; Vm=4.7 fps, Vo=2.9 fps; Vavg,m=0.0 fps, Vavg,o=0.2 fps
Velocity (fps)
06/21/2007 12 AM
06/21/2007 12 PM
06/22/2007 12 AM
06/22/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

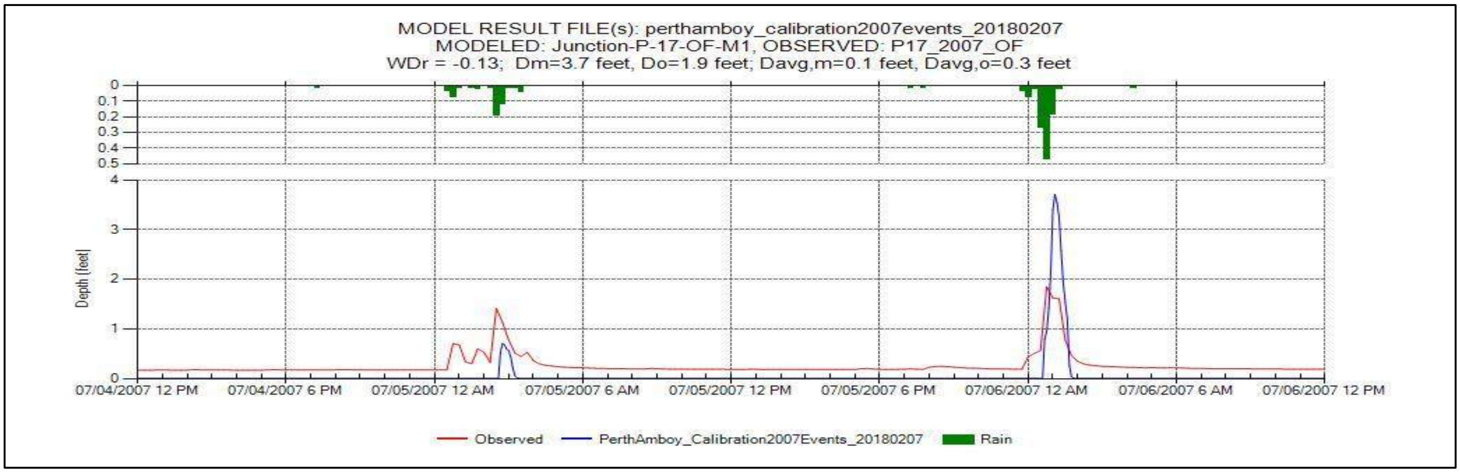
P17_2007_OF

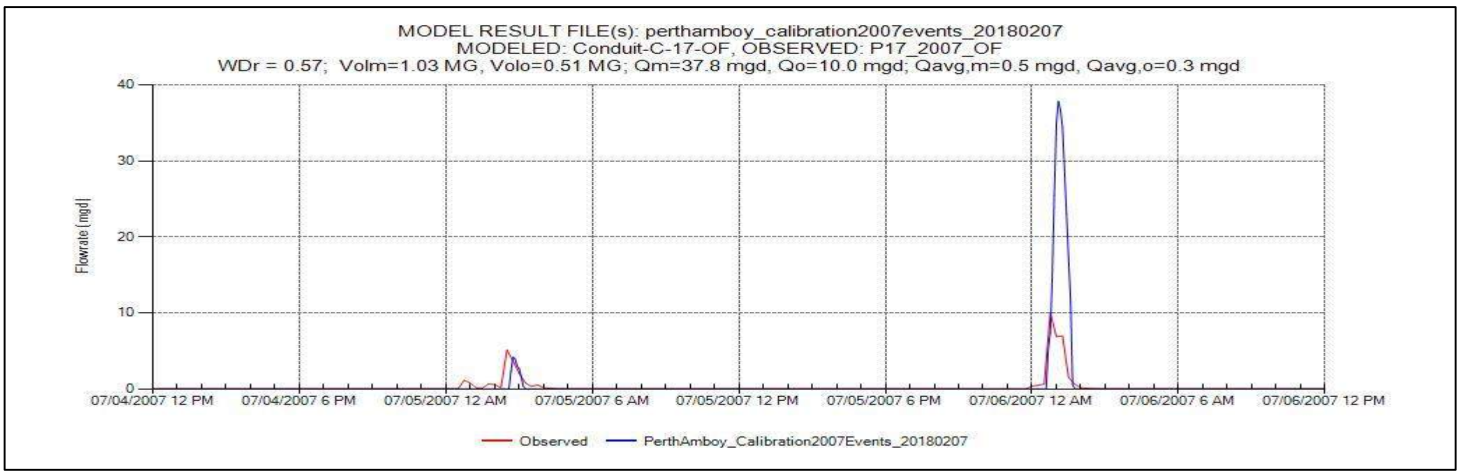

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.49; Dm=1.4 feet, Do=1.9 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

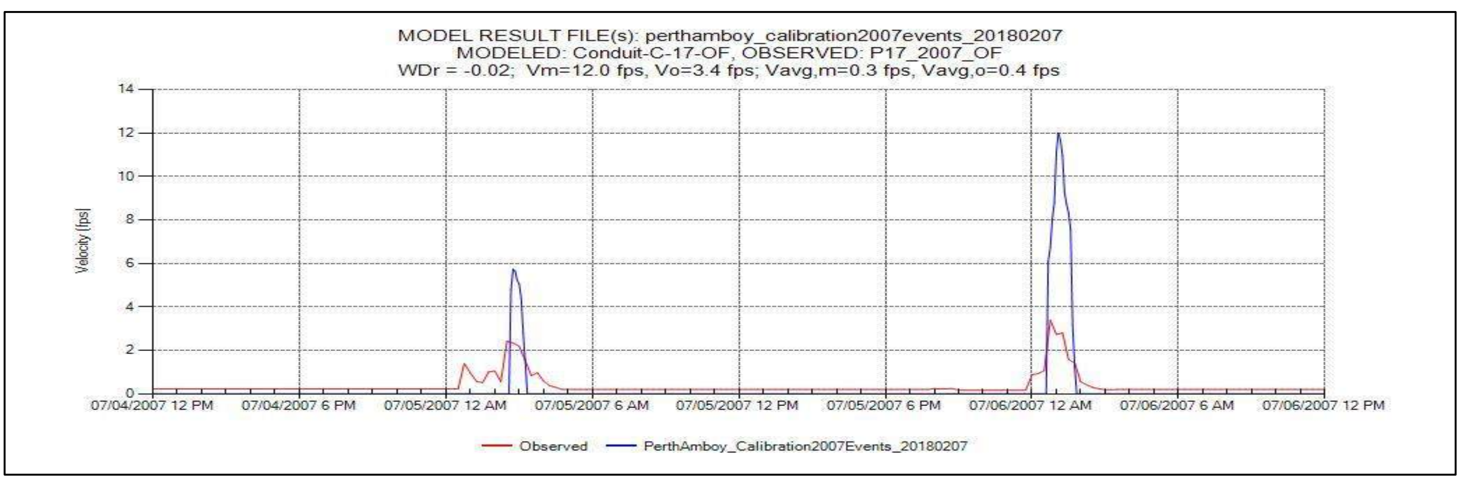

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.63; Volm=0.19 MG, Volo=0.26 MG; Qm=14.4 mgd, Qo=8.4 mgd; Qavg,m=0.1 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.26; Vm=8.0 fps, Vo=3.0 fps; Vavg,m=0.1 fps, Vavg,o=0.3 fps
Velocity (fps)
06/27/2007 12 AM
06/27/2007 12 PM
06/28/2007 12 AM
06/28/2007 12 PM
06/29/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

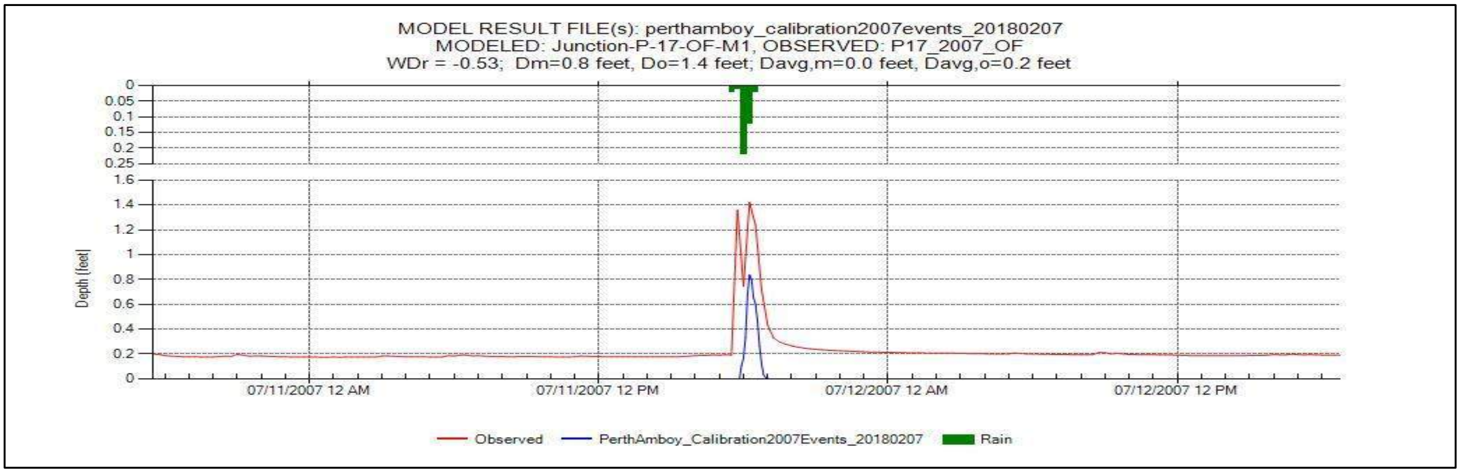
P17_2007_OF

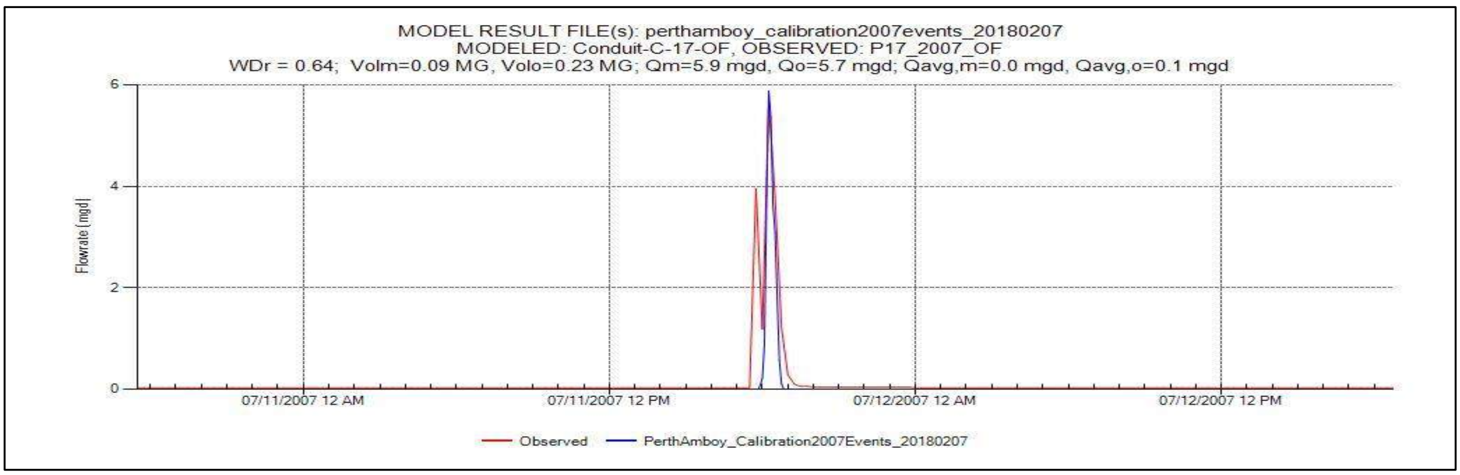

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.13; Dm=3.7 feet, Do=1.9 feet; Davg,m=0.1 feet, Davg,o=0.3 feet
Depth (feet)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

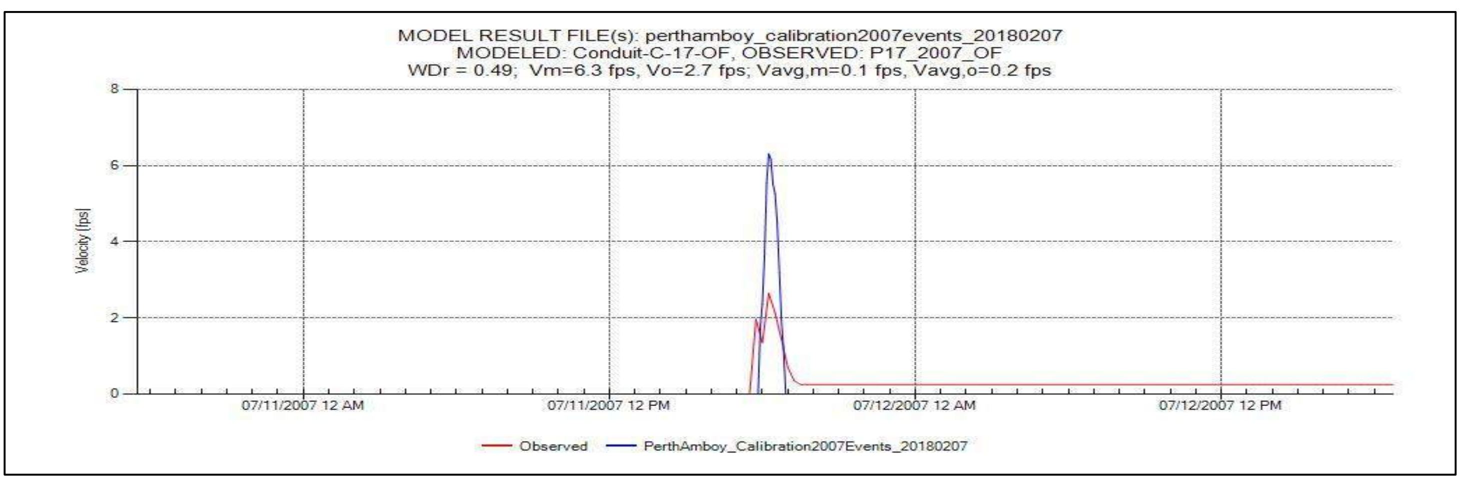

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.57; Volm=1.03 MG, Volo=0.51 MG; Qm=37.8 mgd, Qo=10.0 mgd; Qavg,m=0.5 mgd, Qavg,o=0.3 mgd
Flowrate (mgd)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = -0.02; Vm=12.0 fps, Vo=3.4 fps; Vavg,m=0.3 fps, Vavg,o=0.4 fps
Velocity (fps)
07/04/2007 12 PM
07/04/2007 6 PM
07/05/2007 12 AM
07/05/2007 6 AM
07/05/2007 12 PM
07/05/2007 6 PM
07/06/2007 12 AM
07/06/2007 6 AM
07/06/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

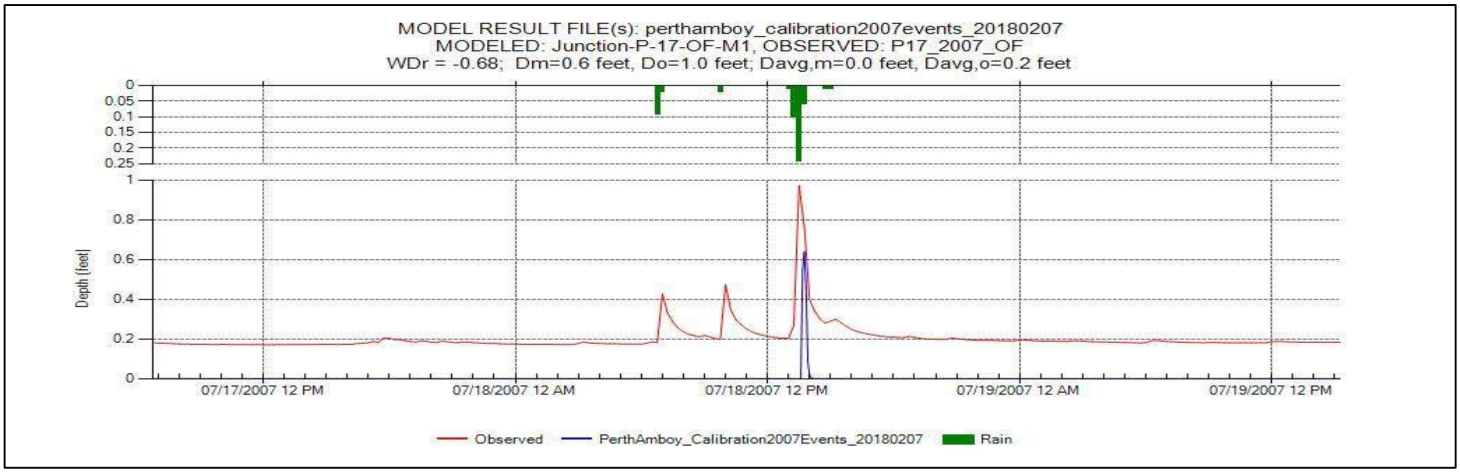
P17_2007_OF

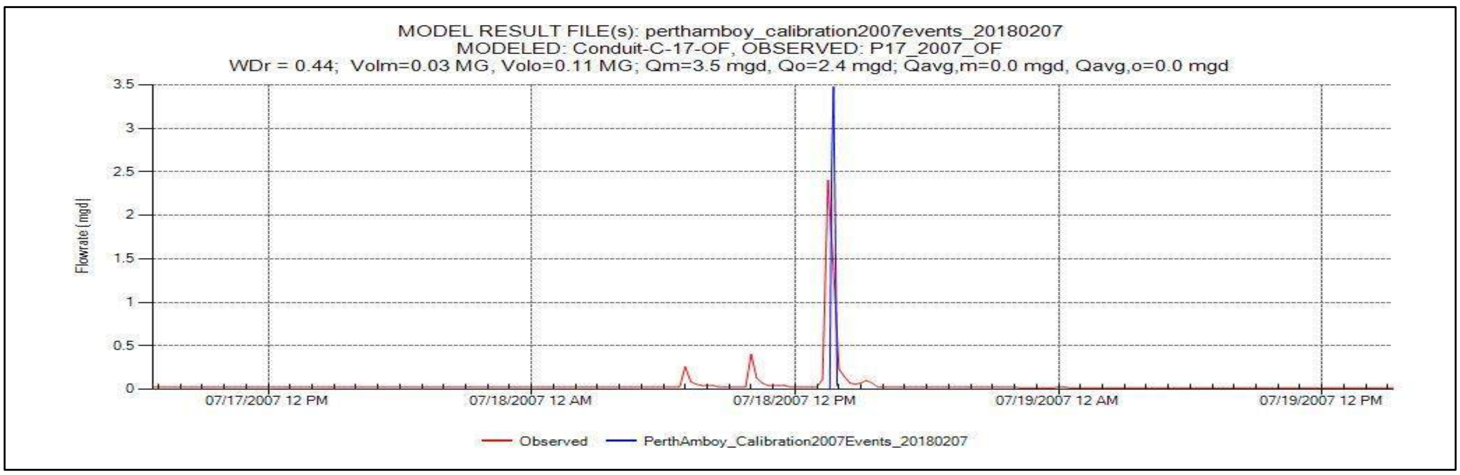

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.53; Dm=0.8 feet, Do=1.4 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

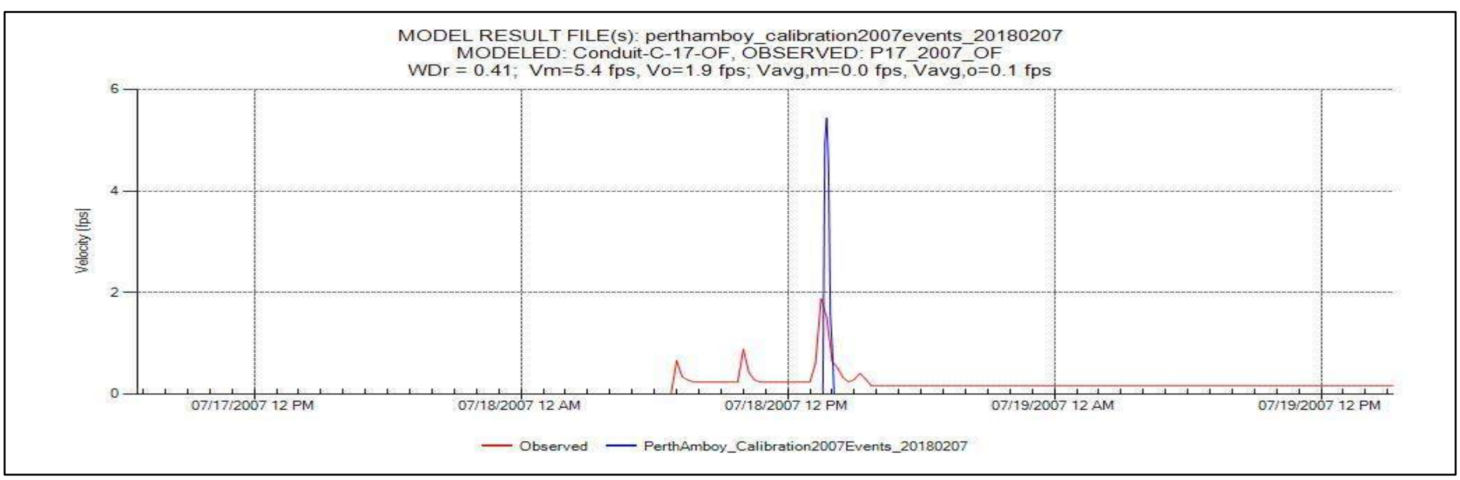

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.64; Volm=0.09 MG, Volo=0.23 MG; Qm=5.9 mgd, Qo=5.7 mgd; Qavg,m=0.0 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.49; Vm=6.3 fps, Vo=2.7 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
07/11/2007 12 AM
07/11/2007 12 PM
07/12/2007 12 AM
07/12/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

P17_2007_OF

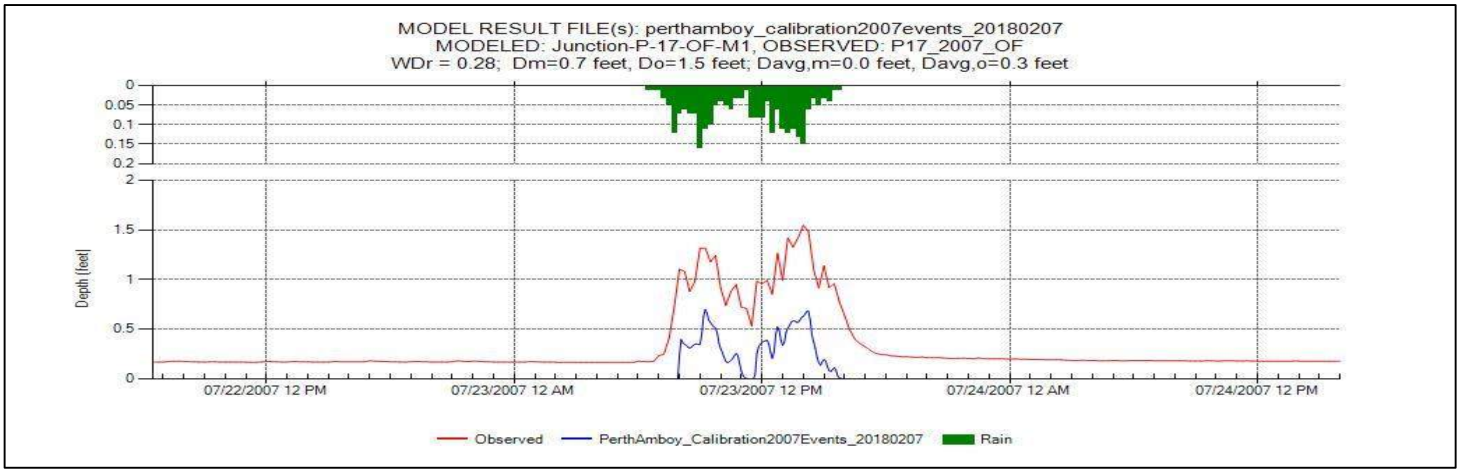

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.68; Dm=0.6 feet, Do=1.0 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

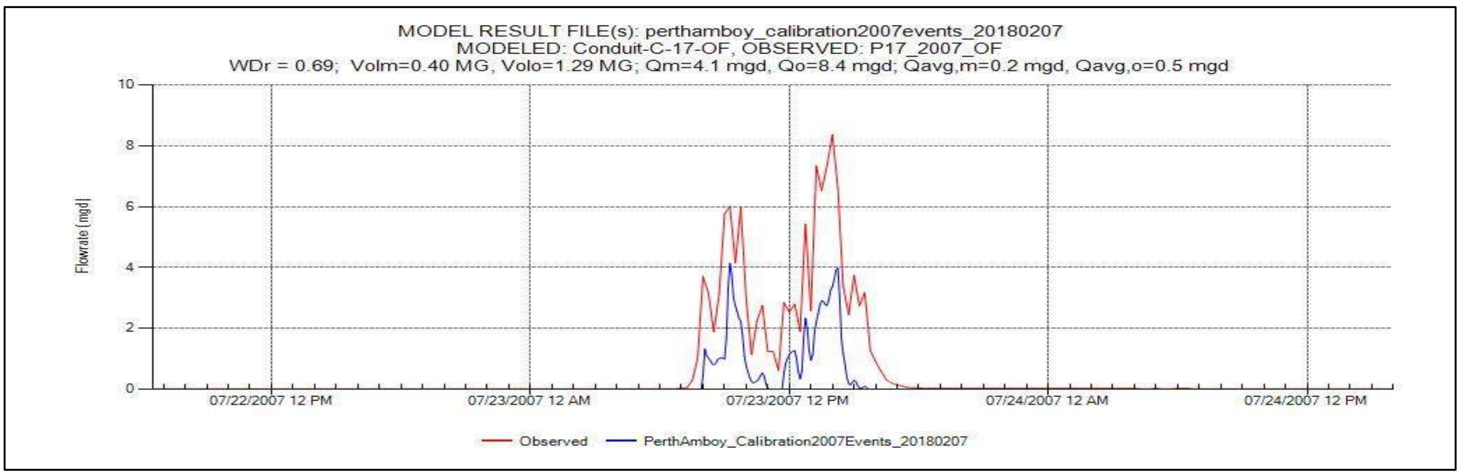

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.44; Volm=0.03 MG, Volo=0.11 MG; Qm=3.5 mgd, Qo=2.4 mgd; Qavg,m=0.0 mgd, Qavg,o=0.0 mgd
Flowrate (mgd)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

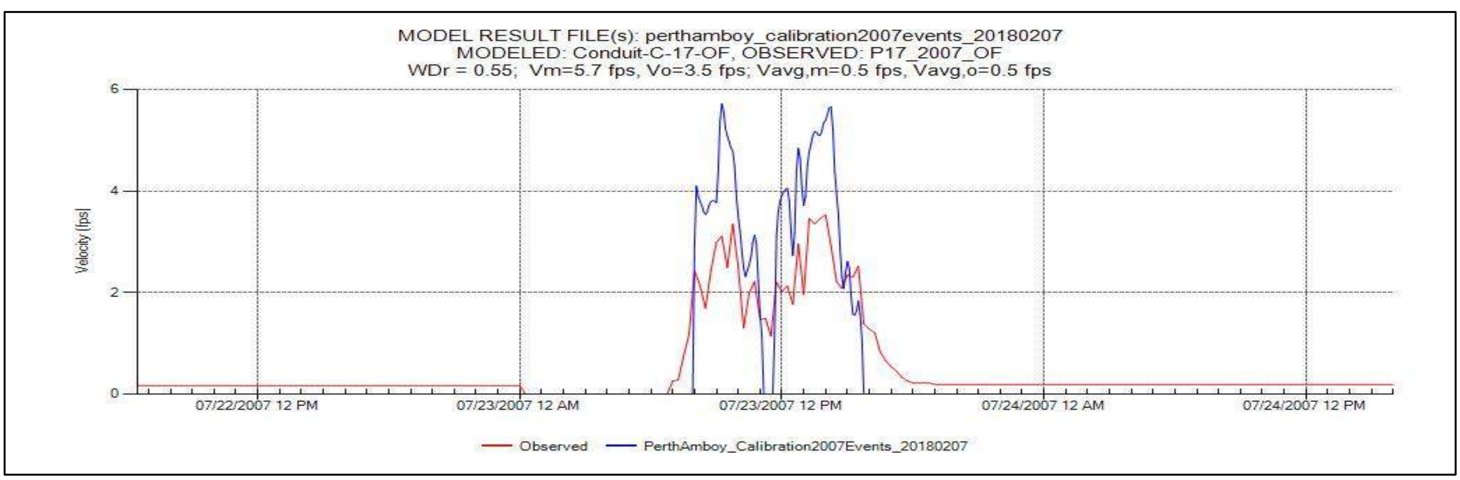

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.41; Vm=5.4 fps, Vo=1.9 fps; Vavg,m=0.0 fps, Vavg,o=0.1 fps
Velocity (fps)
07/17/2007 12 PM
07/18/2007 12 AM
07/18/2007 12 PM
07/19/2007 12 AM
07/19/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

Simulated Versus Observed Flow at Flow Meter Sites

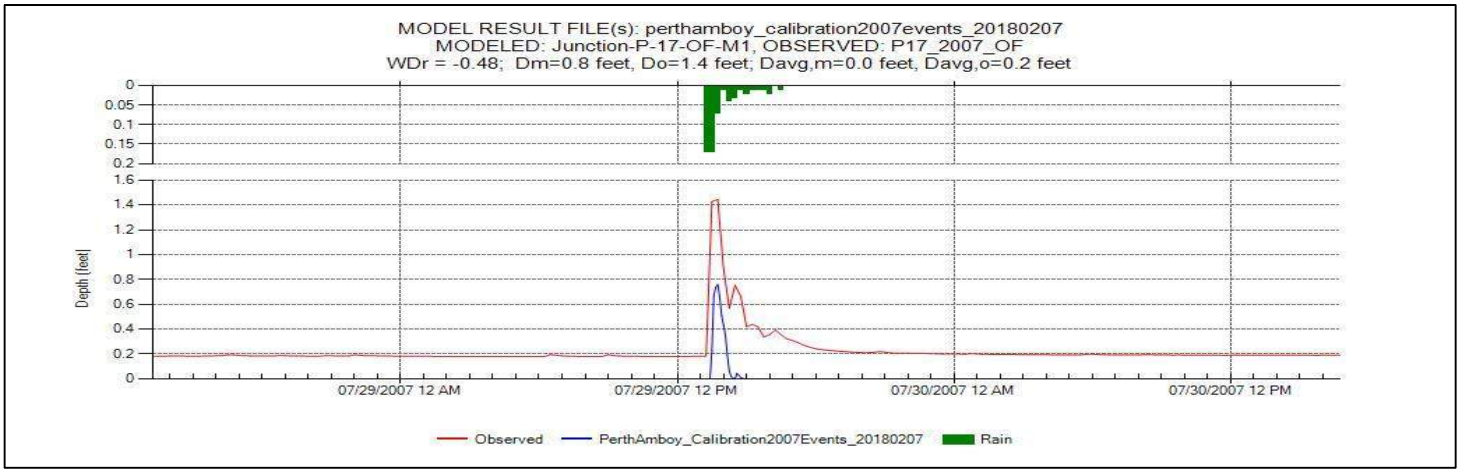
P17_2007_OF

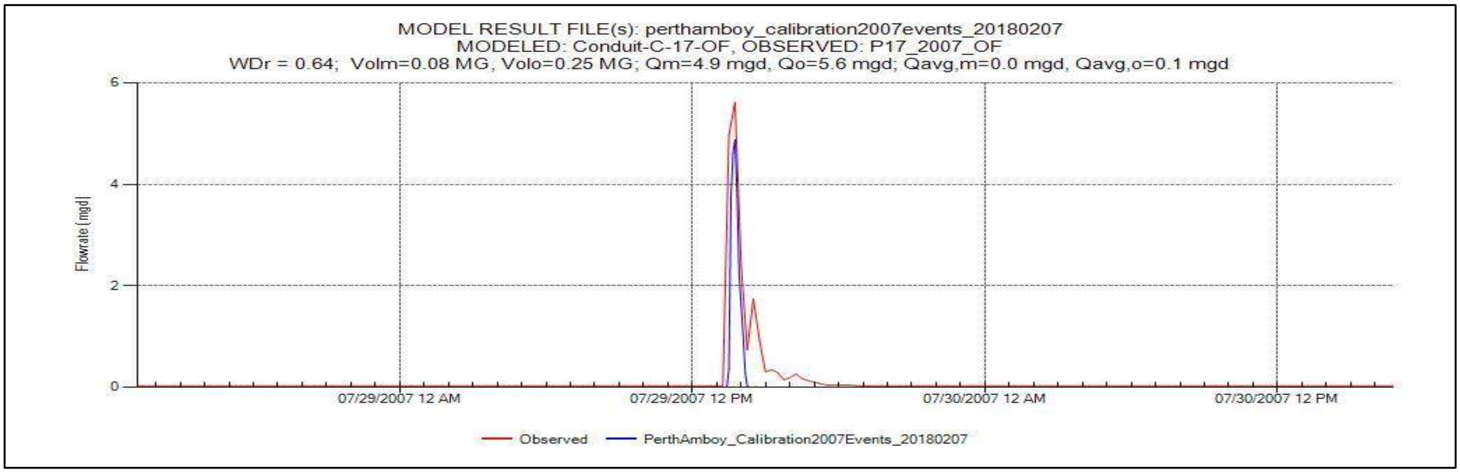


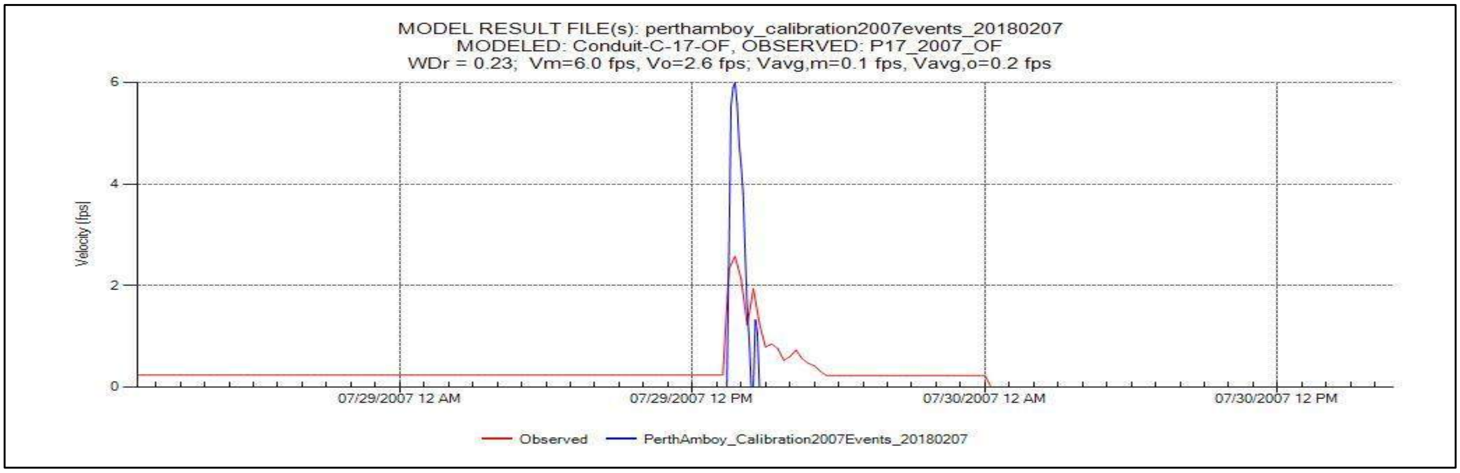




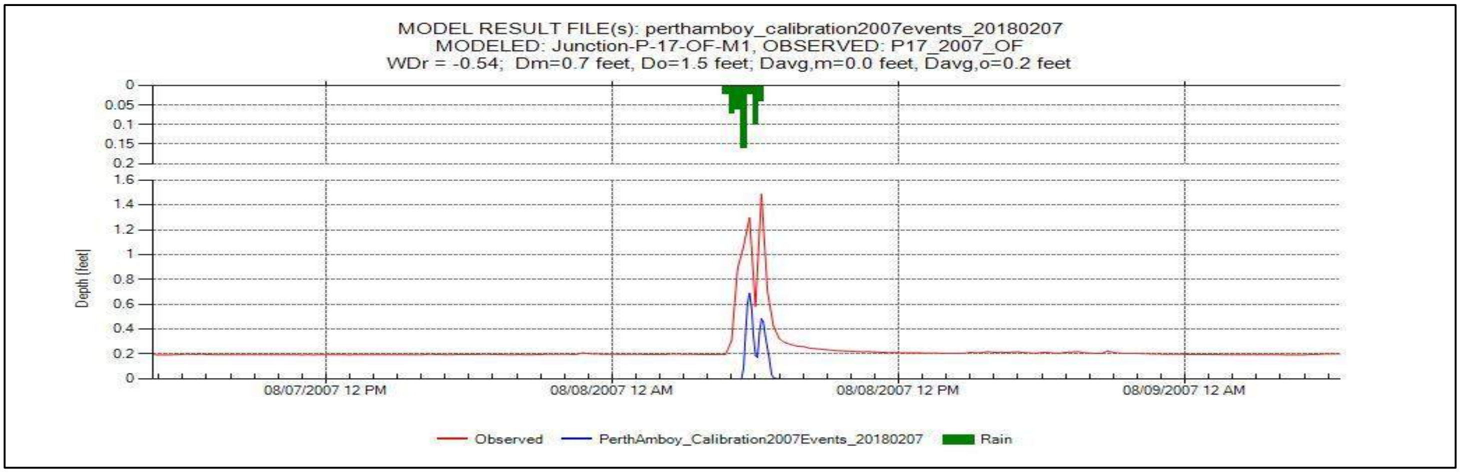
P17_2007_OF

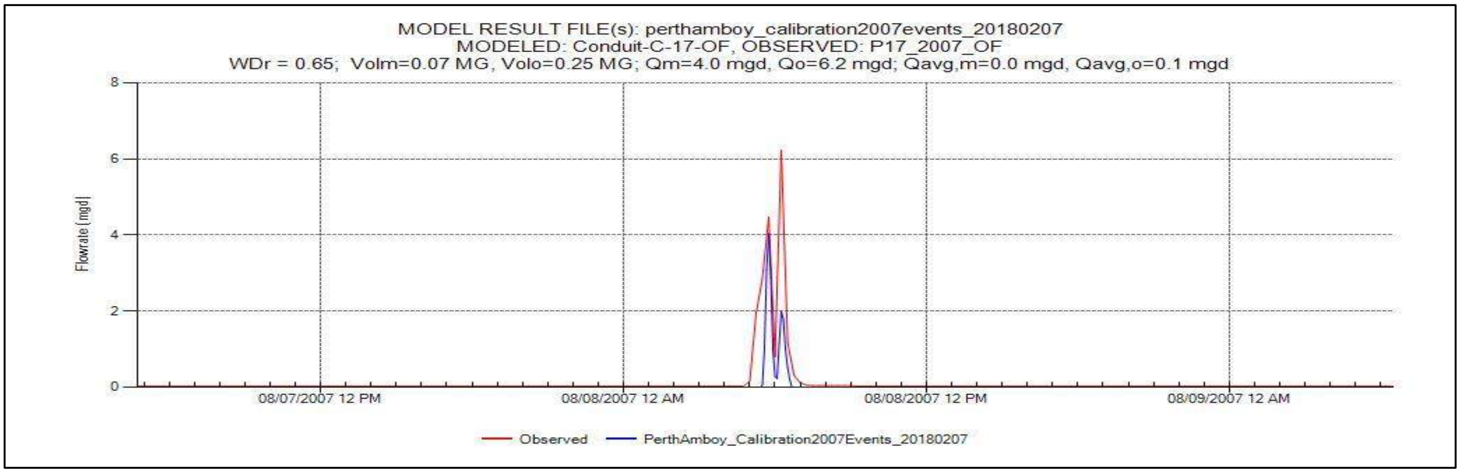

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.48; Dm=0.8 feet, Do=1.4 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

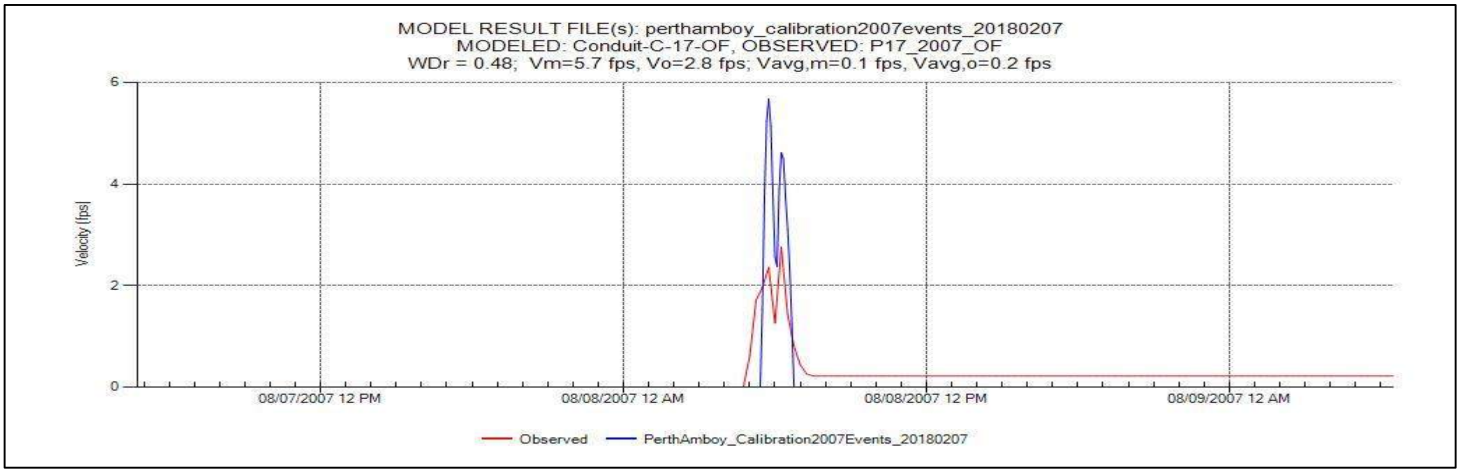

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.64; Volm=0.08 MG, Volo=0.25 MG; Qm=4.9 mgd, Qo=5.6 mgd; Qavg,m=0.0 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.23; Vm=6.0 fps, Vo=2.6 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
07/29/2007 12 AM
07/29/2007 12 PM
07/30/2007 12 AM
07/30/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

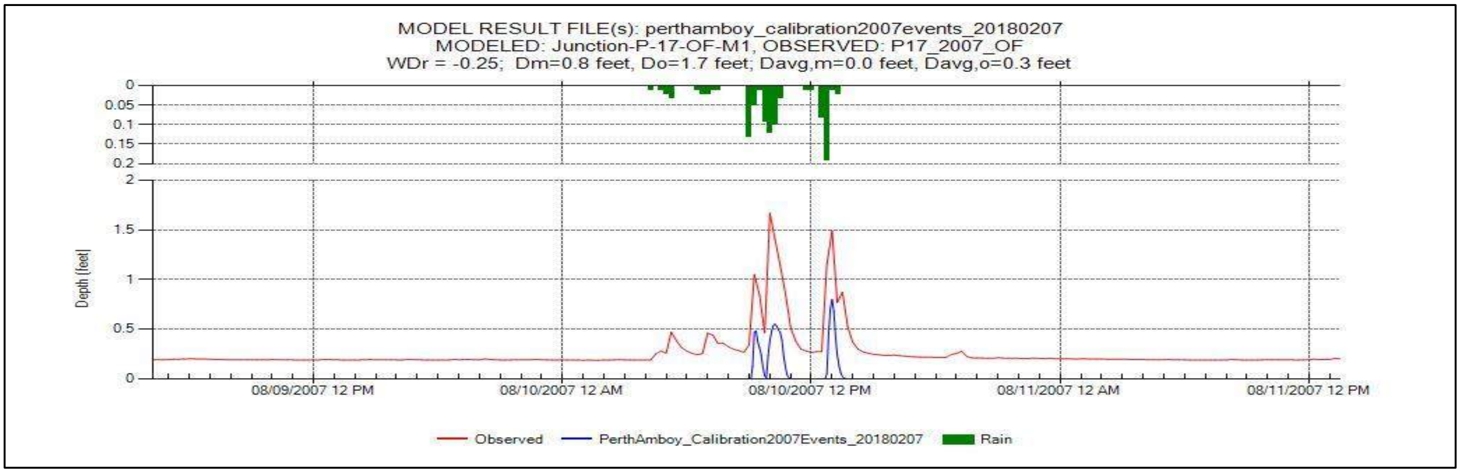
P17_2007_OF

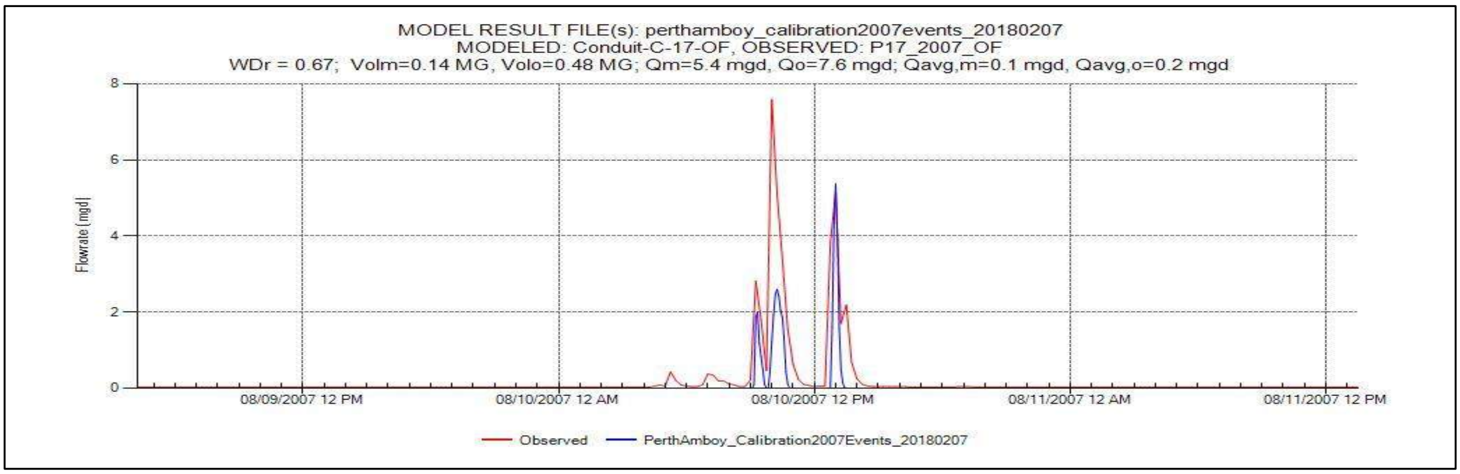

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.54; Dm=0.7 feet, Do=1.5 feet; Davg,m=0.0 feet, Davg,o=0.2 feet
Depth (feet)
08/07/2007 12 PM
08/08/2007 12 AM
08/08/2007 12 PM
08/09/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

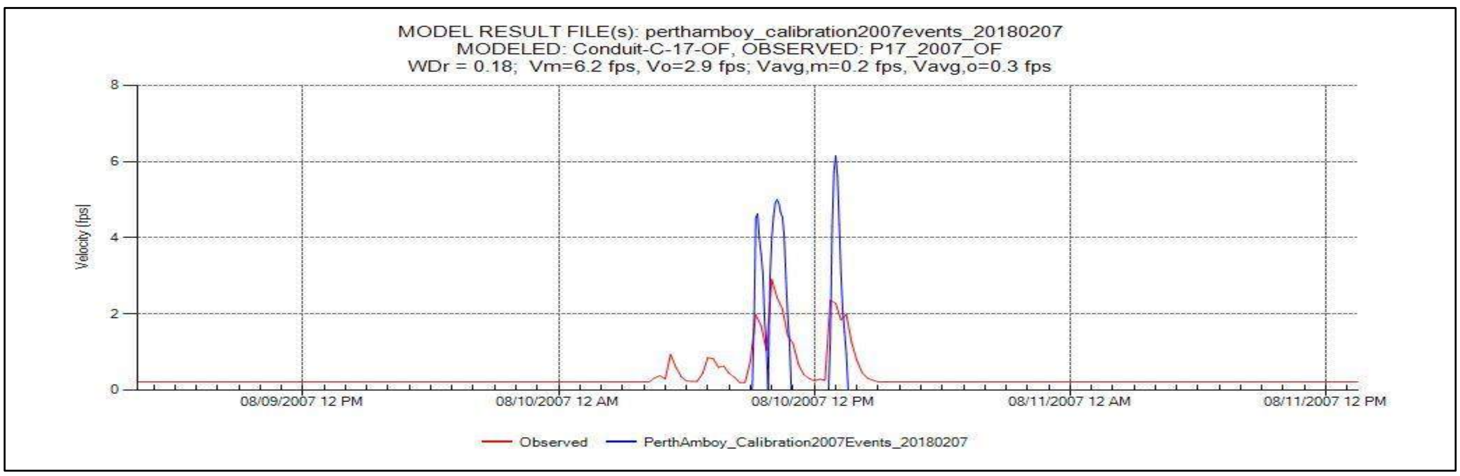

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.65; Volm=0.07 MG, Volo=0.25 MG; Qm=4.0 mgd, Qo=6.2 mgd; Qavg,m=0.0 mgd, Qavg,o=0.1 mgd
Flowrate (mgd)
08/07/2007 12 PM
08/08/2007 12 AM
08/08/2007 12 PM
08/09/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.48; Vm=5.7 fps, Vo=2.8 fps; Vavg,m=0.1 fps, Vavg,o=0.2 fps
Velocity (fps)
08/07/2007 12 PM
08/08/2007 12 AM
08/08/2007 12 PM
08/09/2007 12 AM
Observed
PerthAmboy_Calibration2007Events_20180207

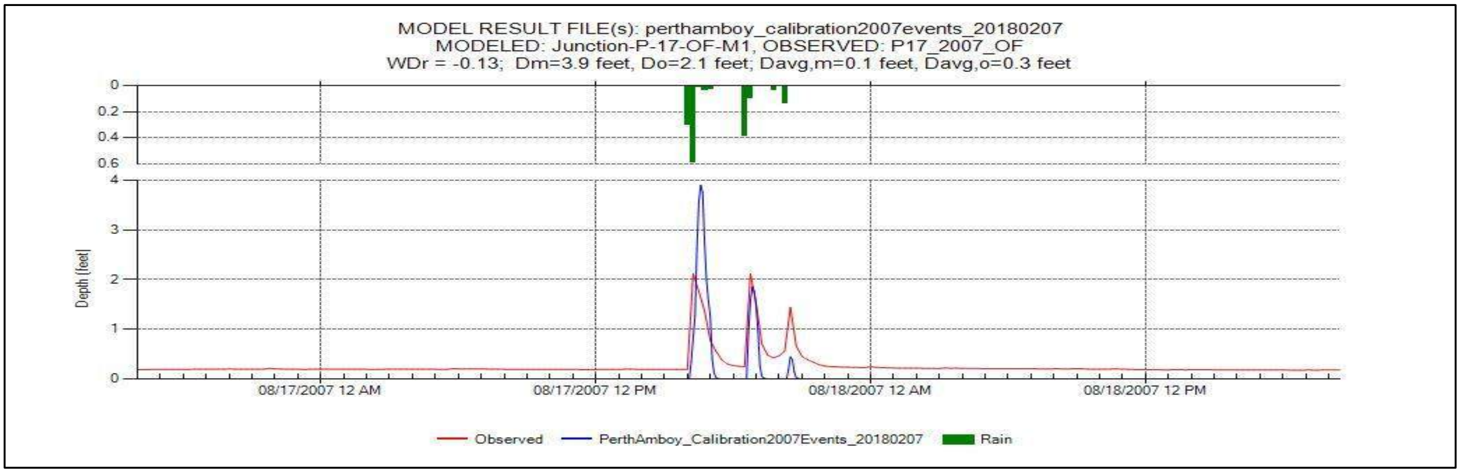
P17_2007_OF

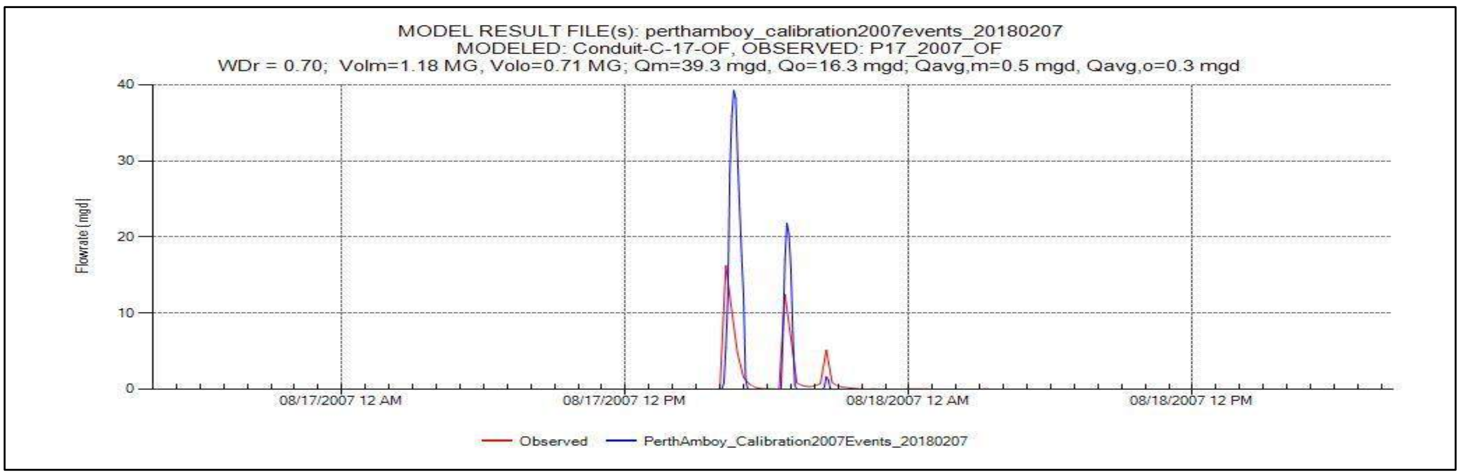

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.25; Dm=0.8 feet, Do=1.7 feet; Davg,m=0.0 feet, Davg,o=0.3 feet
Depth (feet)
08/09/2007 12 PM
08/10/2007 12 AM
08/10/2007 12 PM
08/11/2007 12 AM
08/11/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

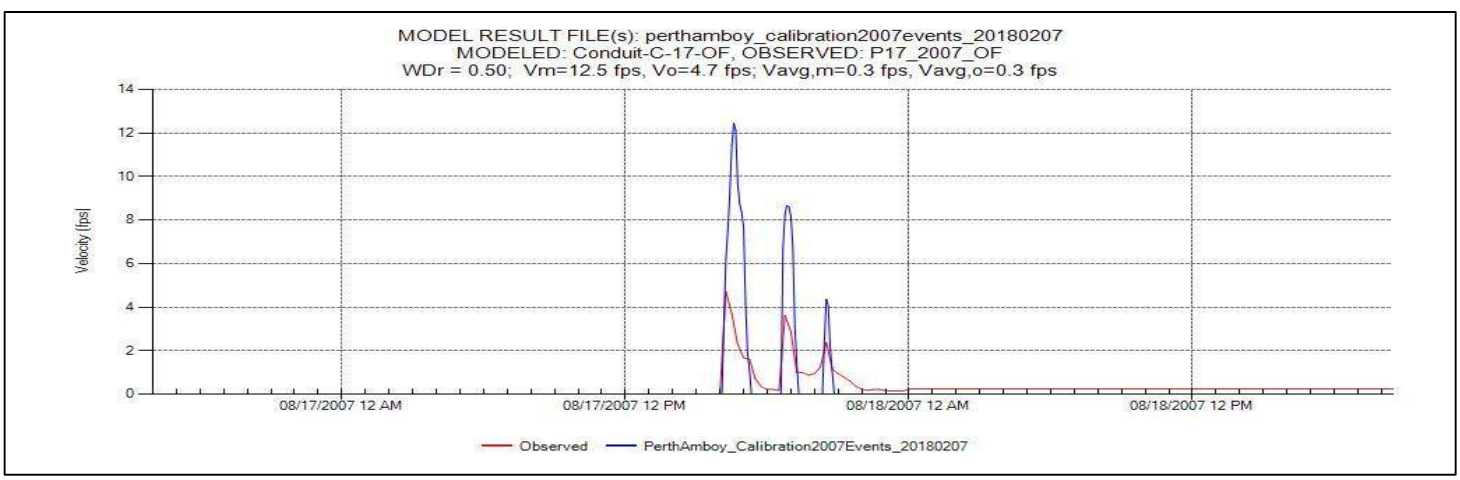

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.67; Volm=0.14 MG, Volo=0.48 MG; Qm=5.4 mgd, Qo=7.6 mgd; Qavg,m=0.1 mgd, Qavg,o=0.2 mgd
Flowrate (mgd)
08/09/2007 12 PM
08/10/2007 12 AM
08/10/2007 12 PM
08/11/2007 12 AM
08/11/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207


MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.18; Vm=6.2 fps, Vo=2.9 fps; Vavg,m=0.2 fps, Vavg,o=0.3 fps
Velocity (fps)
08/09/2007 12 PM
08/10/2007 12 AM
08/10/2007 12 PM
08/11/2007 12 AM
08/11/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

P17_2007_OF

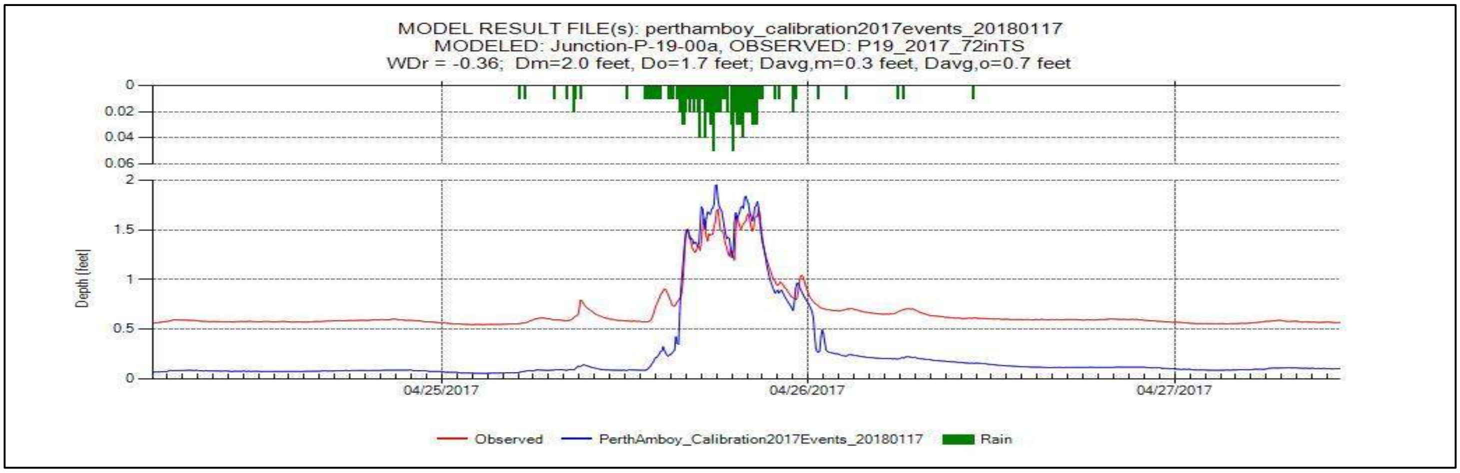

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Junction-P-17-OF-M1, OBSERVED: P17_2007_OF
WDr = -0.13; Dm=3.9 feet, Do=2.1 feet; Davg,m=0.1 feet, Davg,o=0.3 feet
Depth (feet)
08/17/2007 12 AM
08/17/2007 12 PM
08/18/2007 12 AM
08/18/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207
Rain

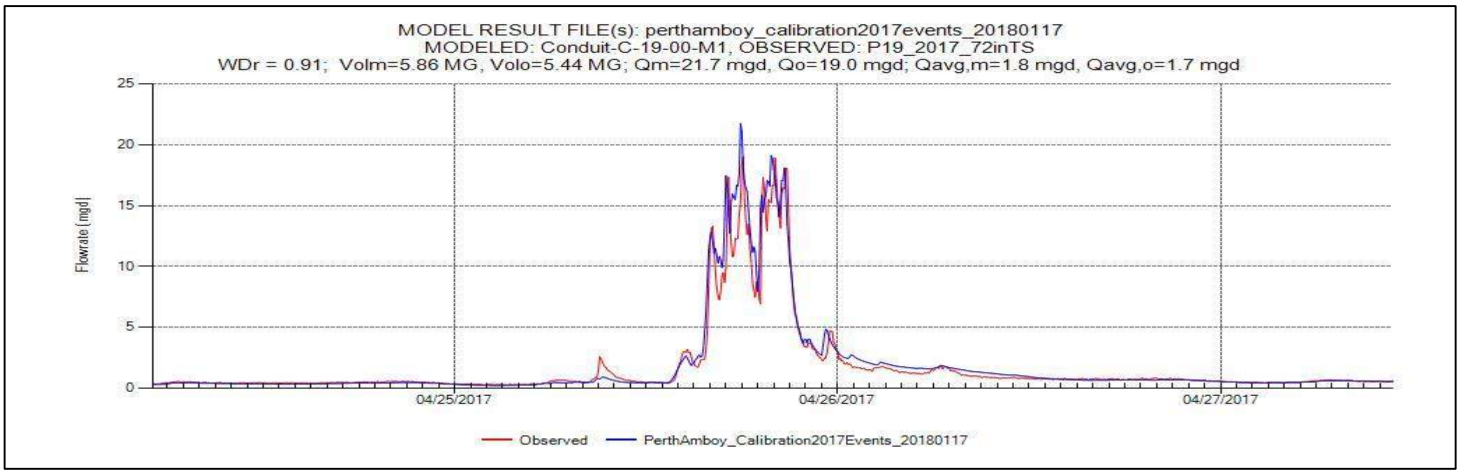

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.70; Volm=1.18 MG, Volo=0.71 MG; Qm=39.3 mgd, Qo=16.3 mgd; Qavg,m=0.5 mgd, Qavg,o=0.3 mgd
Flowrate (mgd)
08/17/2007 12 AM
08/17/2007 12 PM
08/18/2007 12 AM
08/18/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

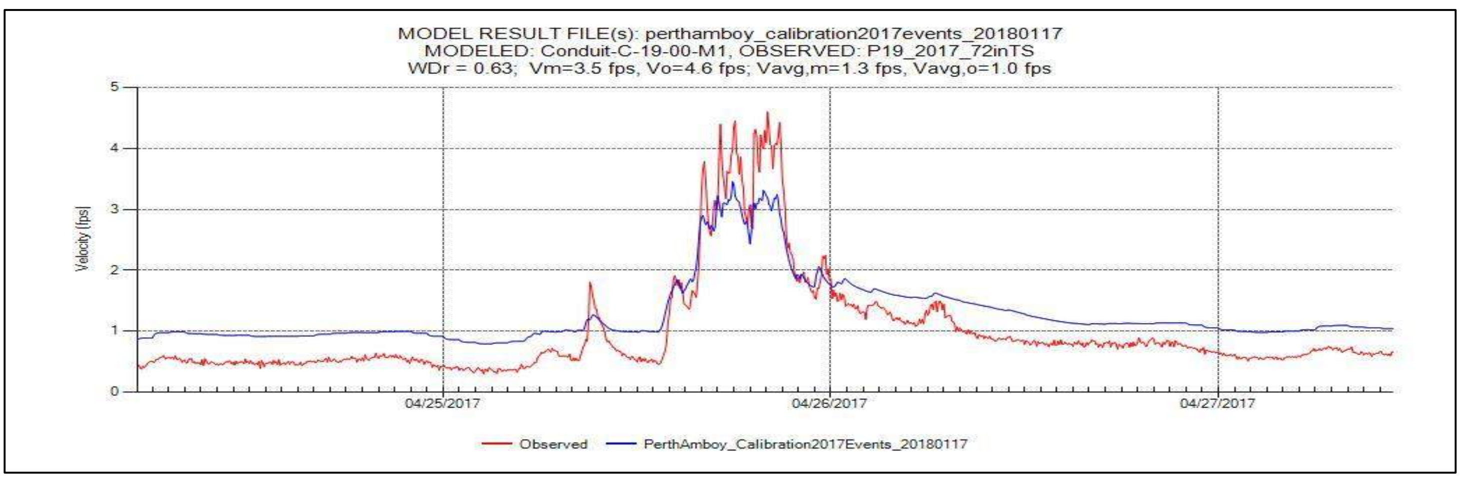

MODEL RESULT FILE(s): perthamboy_calibration2007events_20180207
MODELED: Conduit-C-17-OF, OBSERVED: P17_2007_OF
WDr = 0.50; Vm=12.5 fps, Vo=4.7 fps; Vavg,m=0.3 fps, Vavg,o=0.3 fps
Velocity (fps)
08/17/2007 12 AM
08/17/2007 12 PM
08/18/2007 12 AM
08/18/2007 12 PM
Observed
PerthAmboy_Calibration2007Events_20180207

Simulated Versus Observed Flow at Flow Meter Sites

P19_2017_72inTS

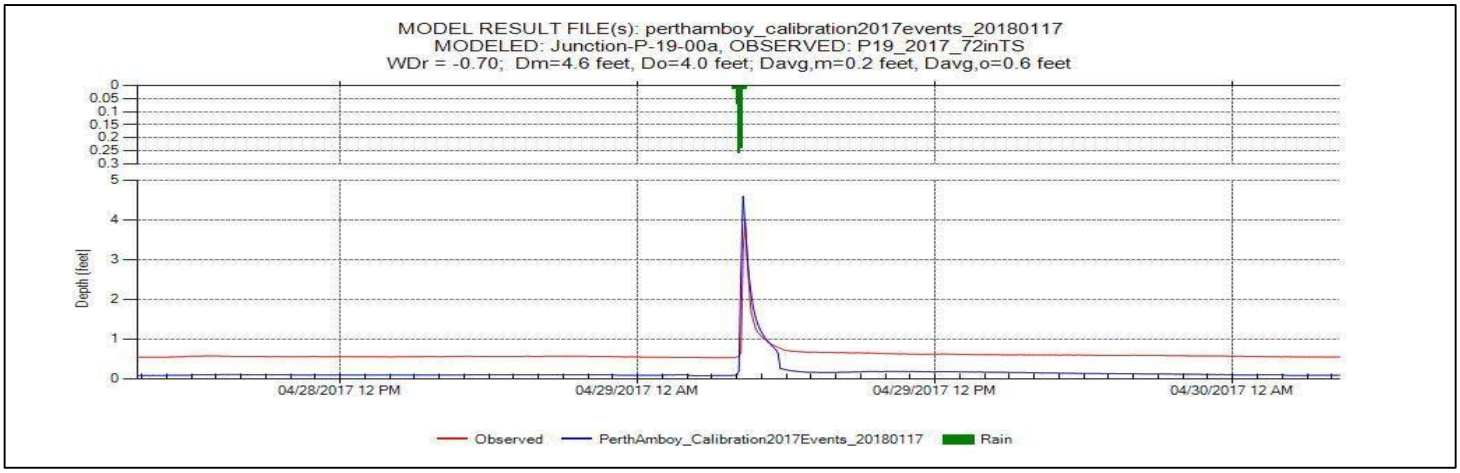


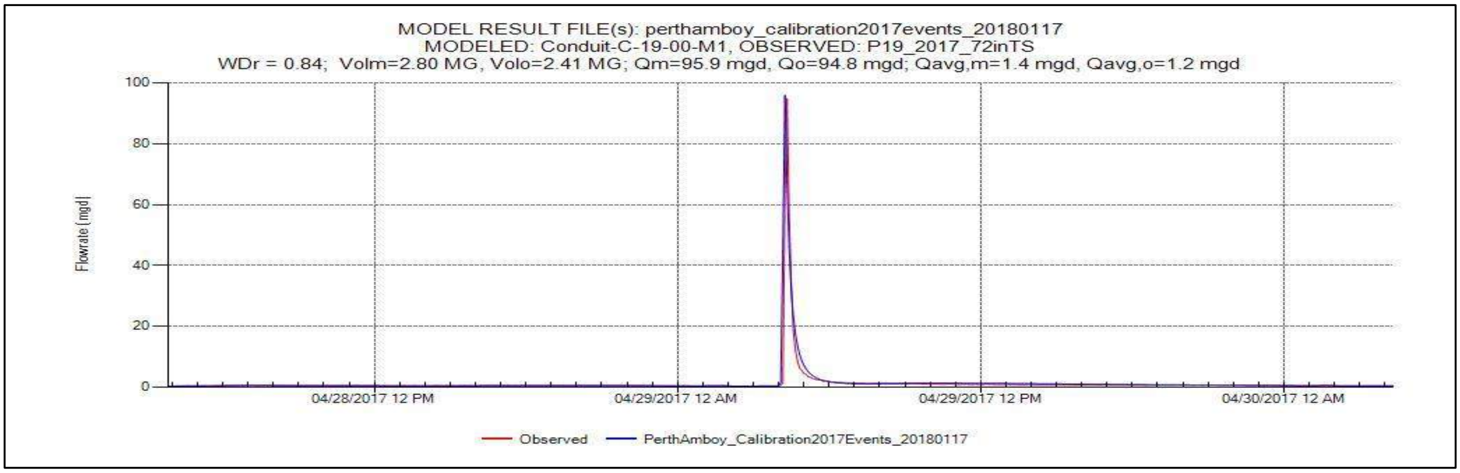


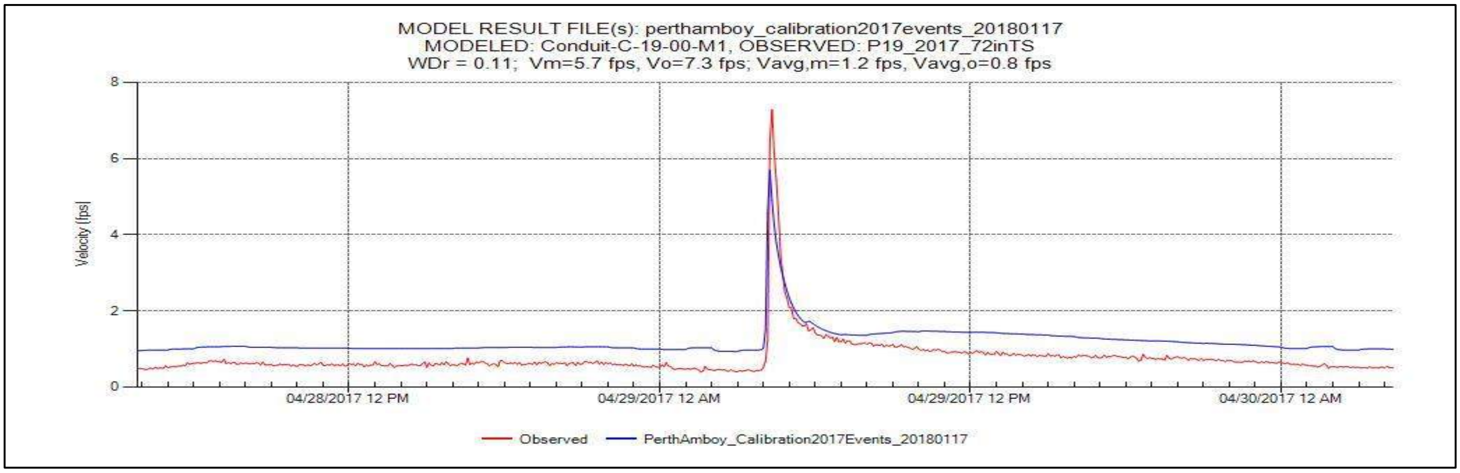


Simulated Versus Observed Flow at Flow Meter Sites

P19_2017_72inTS

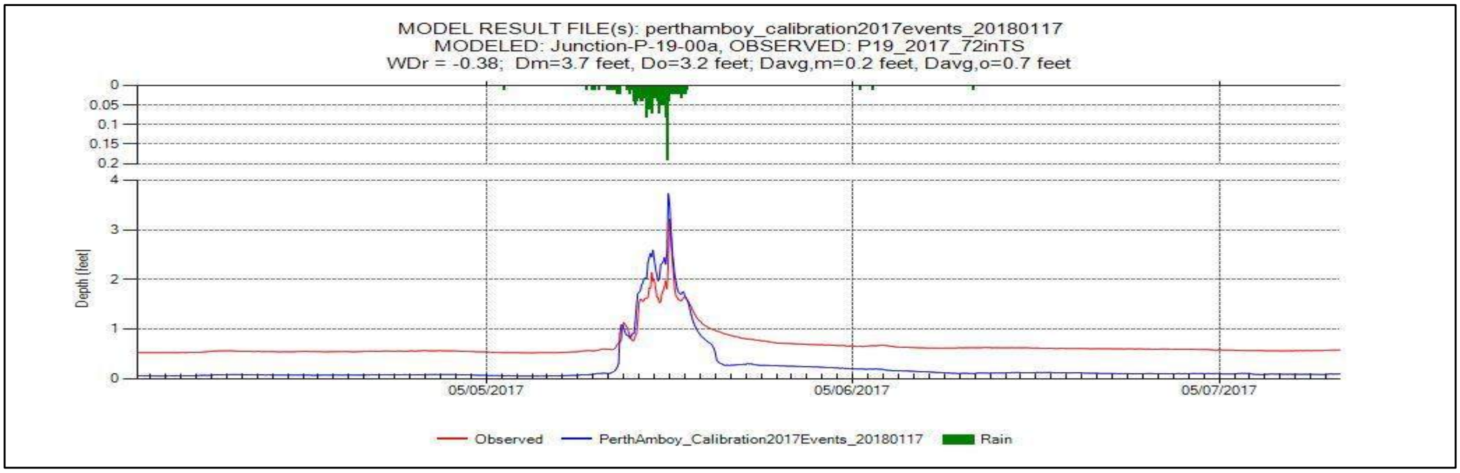


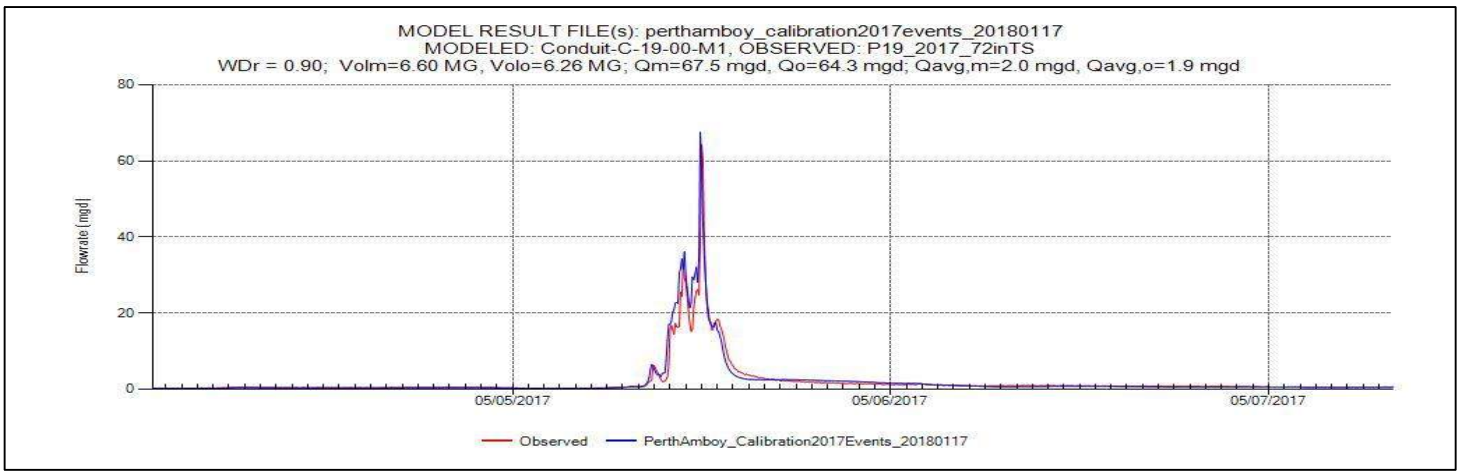


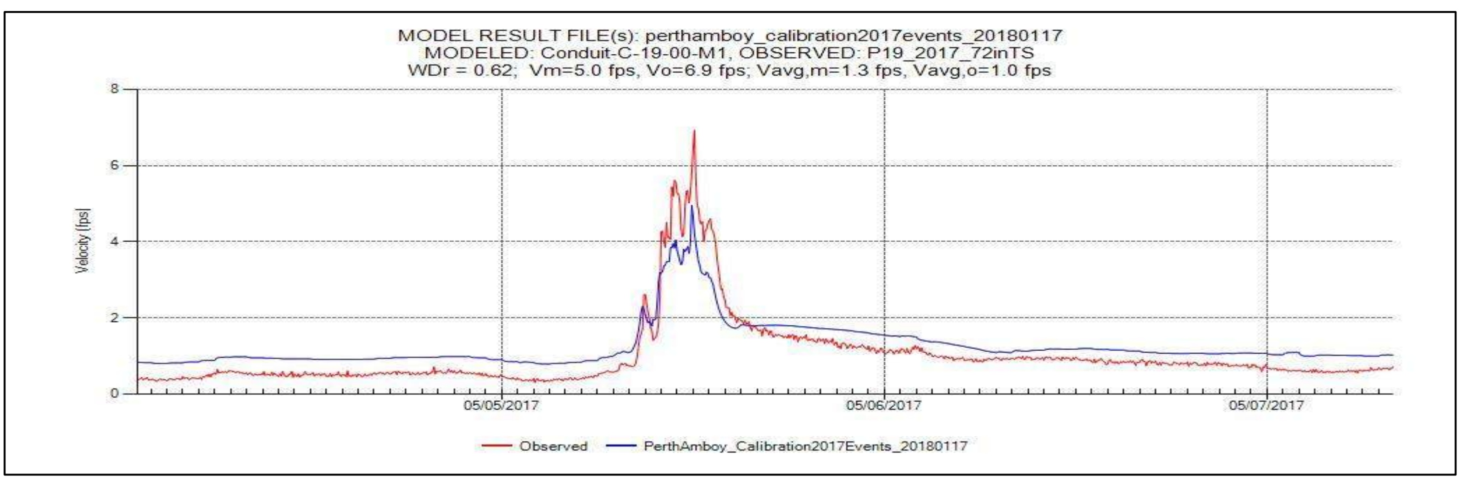


Simulated Versus Observed Flow at Flow Meter Sites

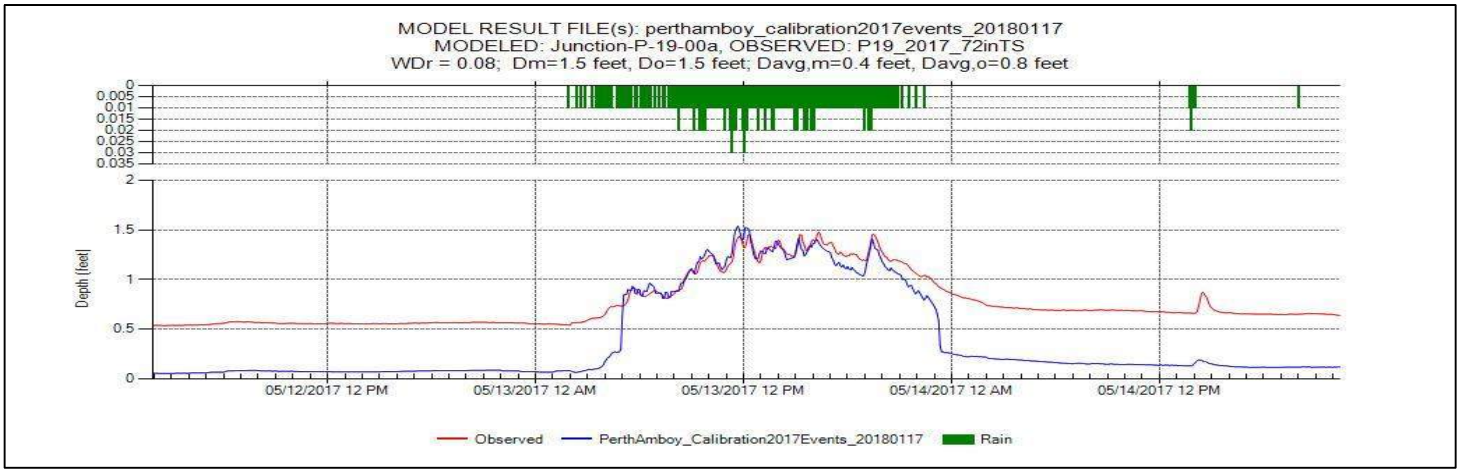
P19_2017_72inTS

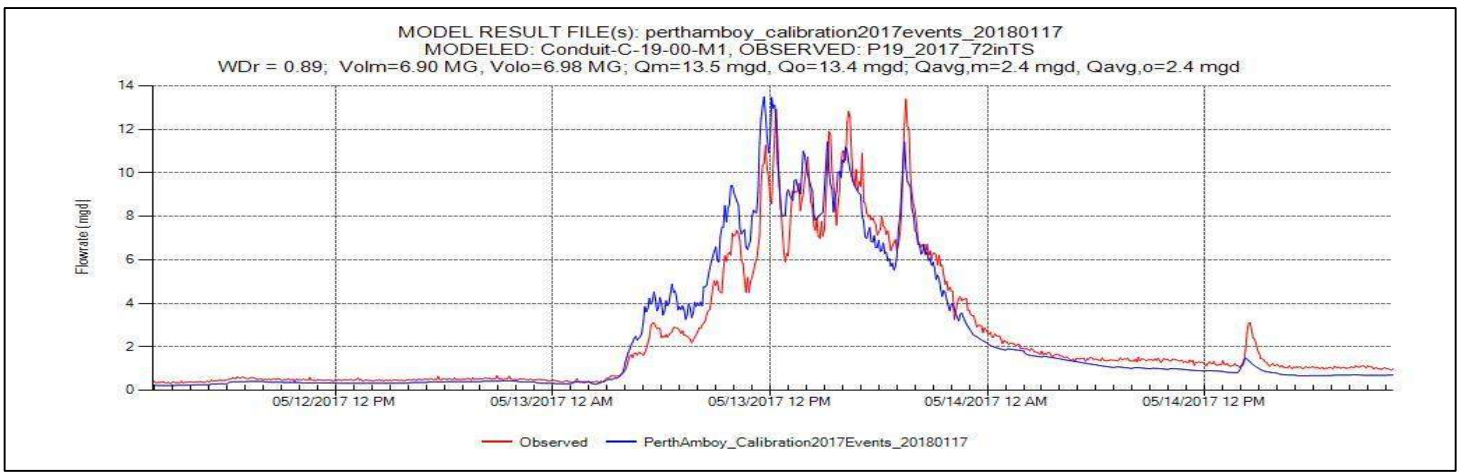


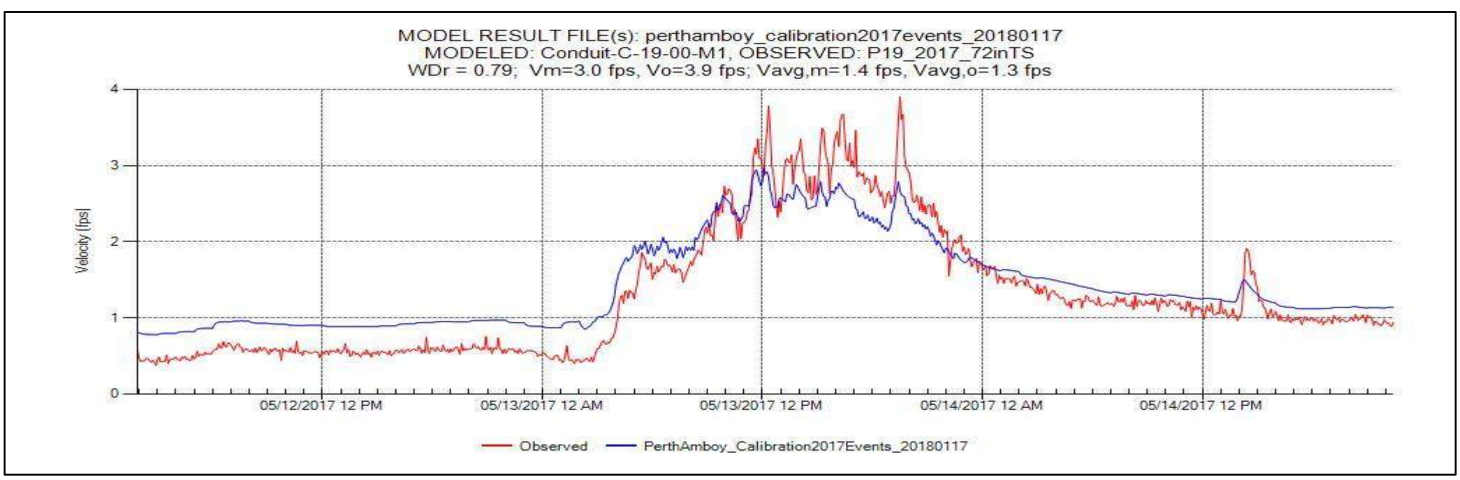




P19_2017_72inTS

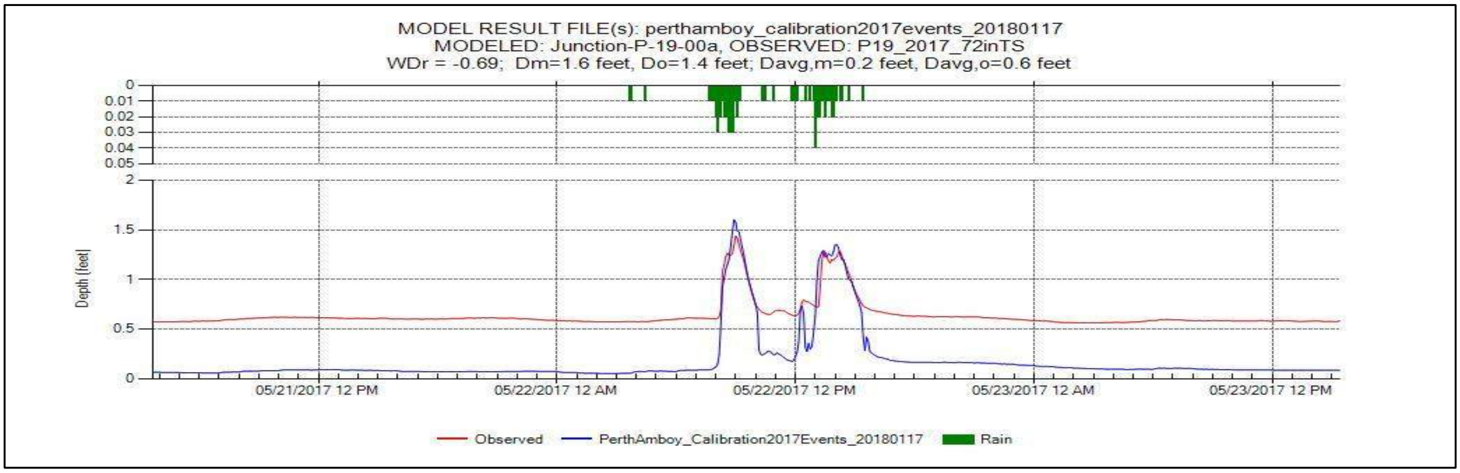


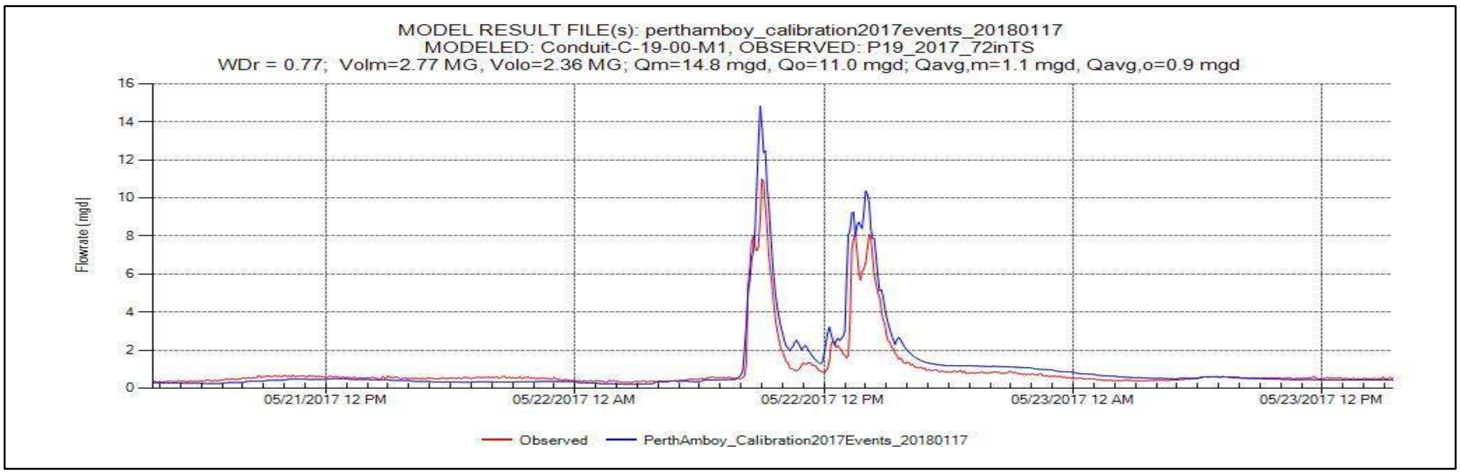


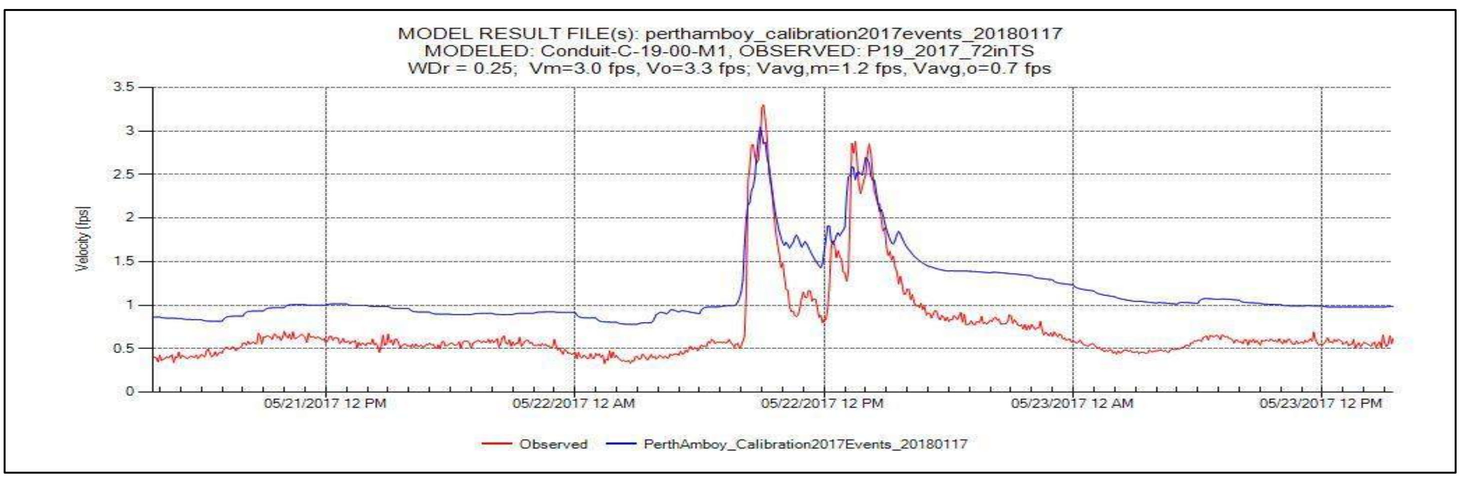


Simulated Versus Observed Flow at Flow Meter Sites

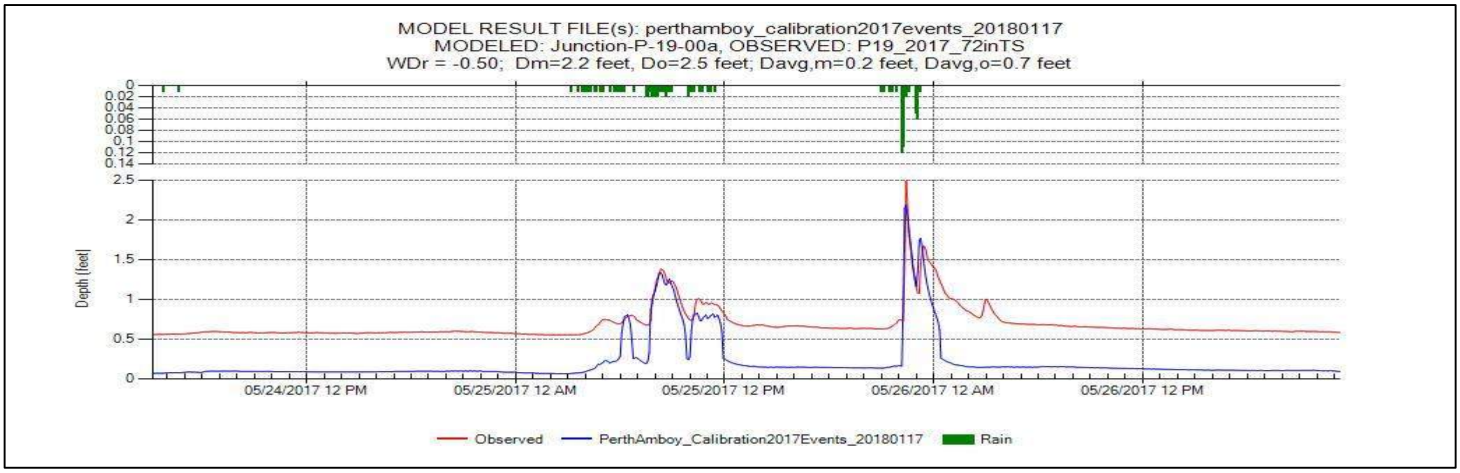
P19_2017_72inTS

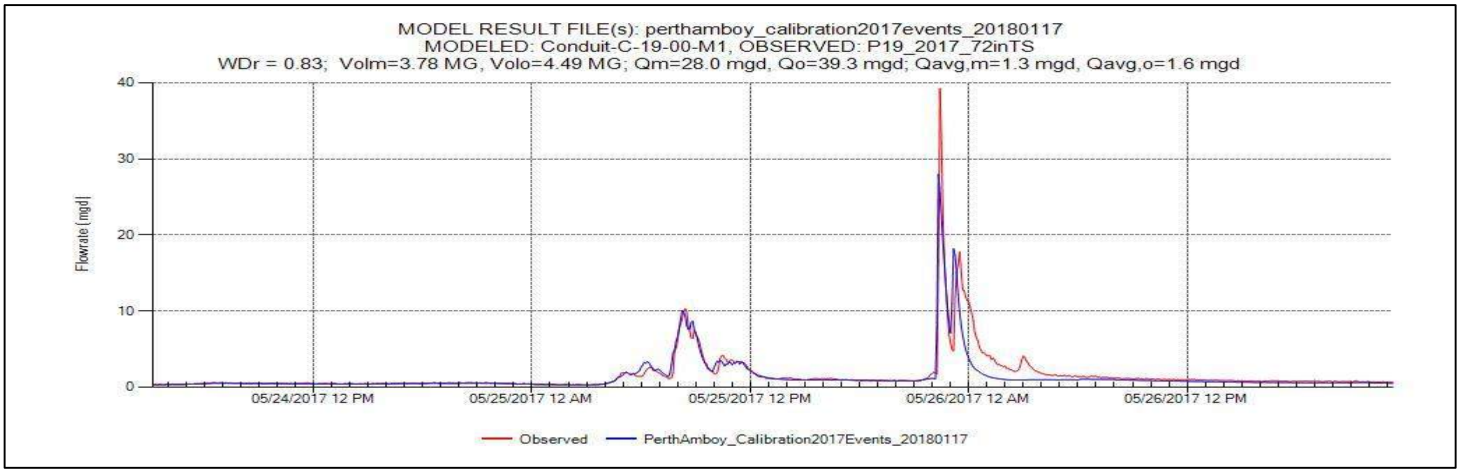


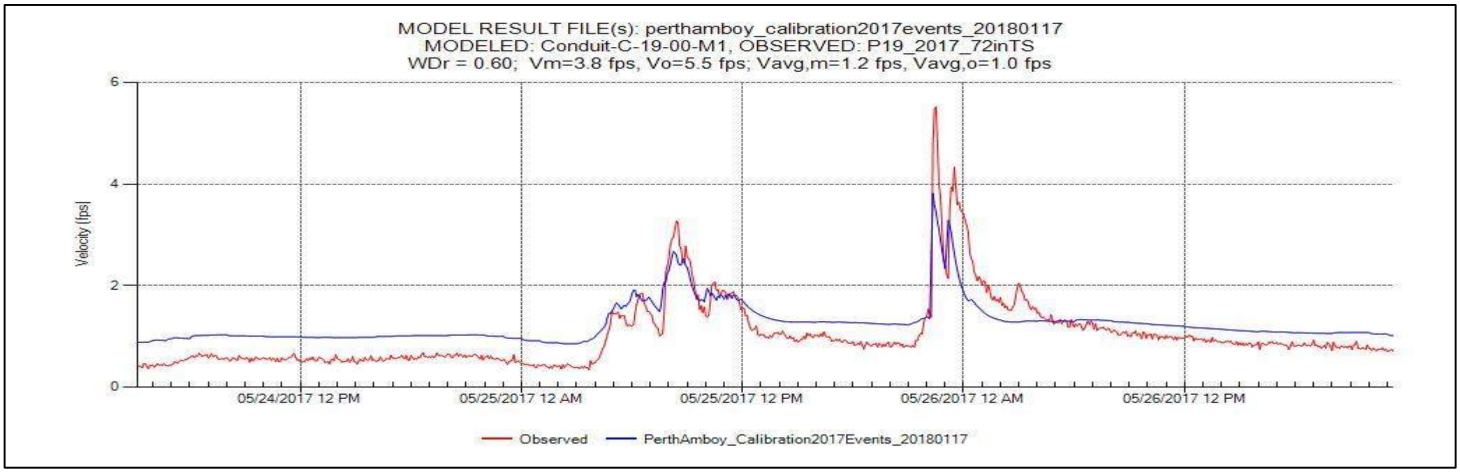




P19_2017_72inTS

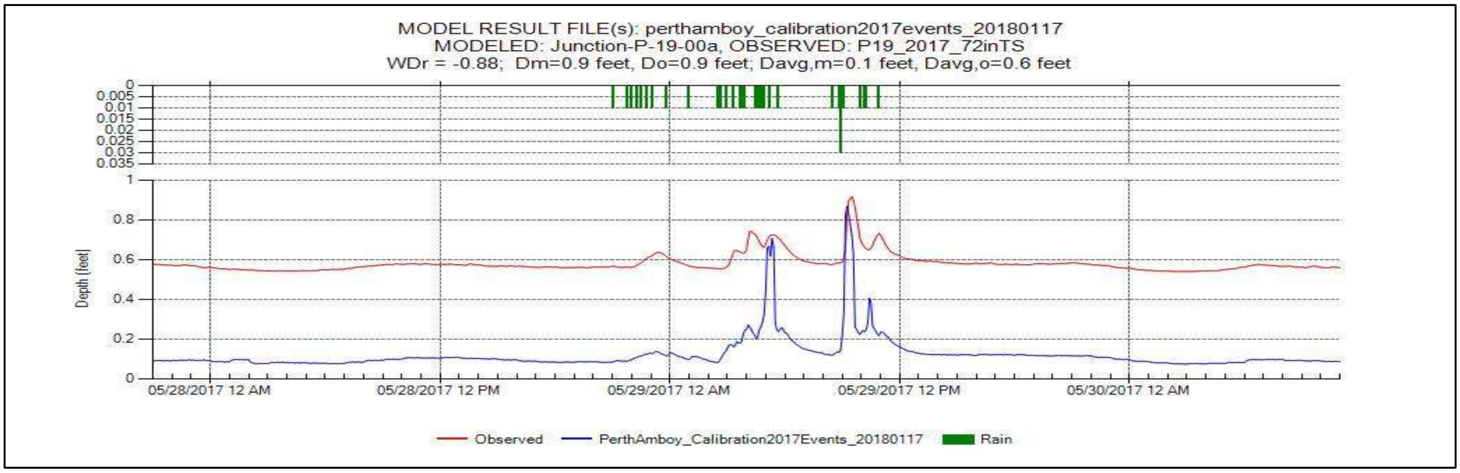


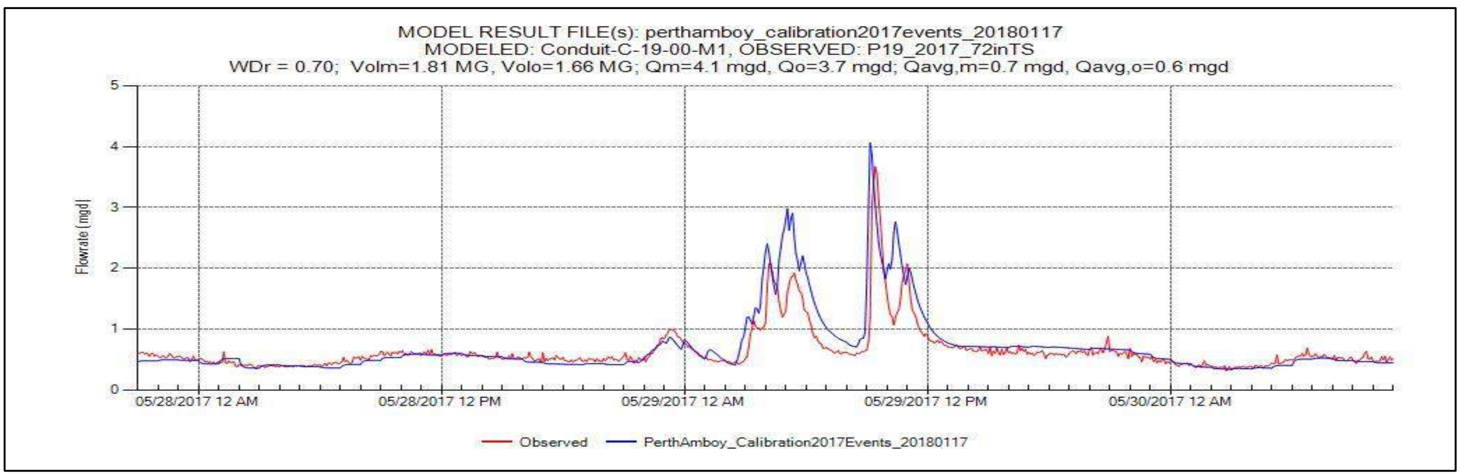


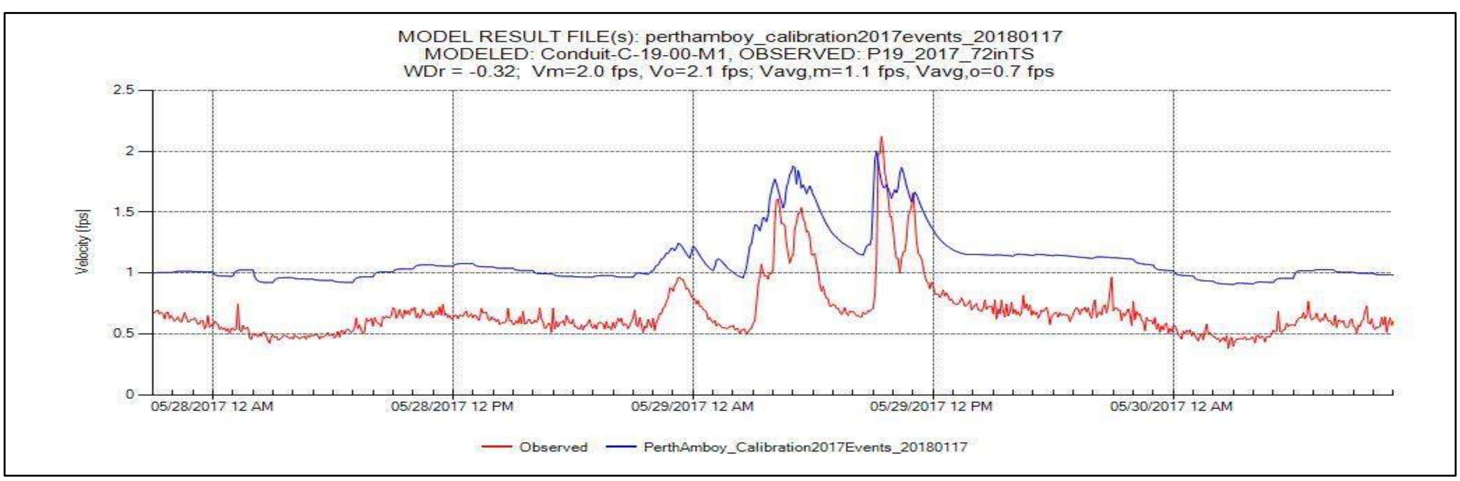


Simulated Versus Observed Flow at Flow Meter Sites

P19_2017_72inTS







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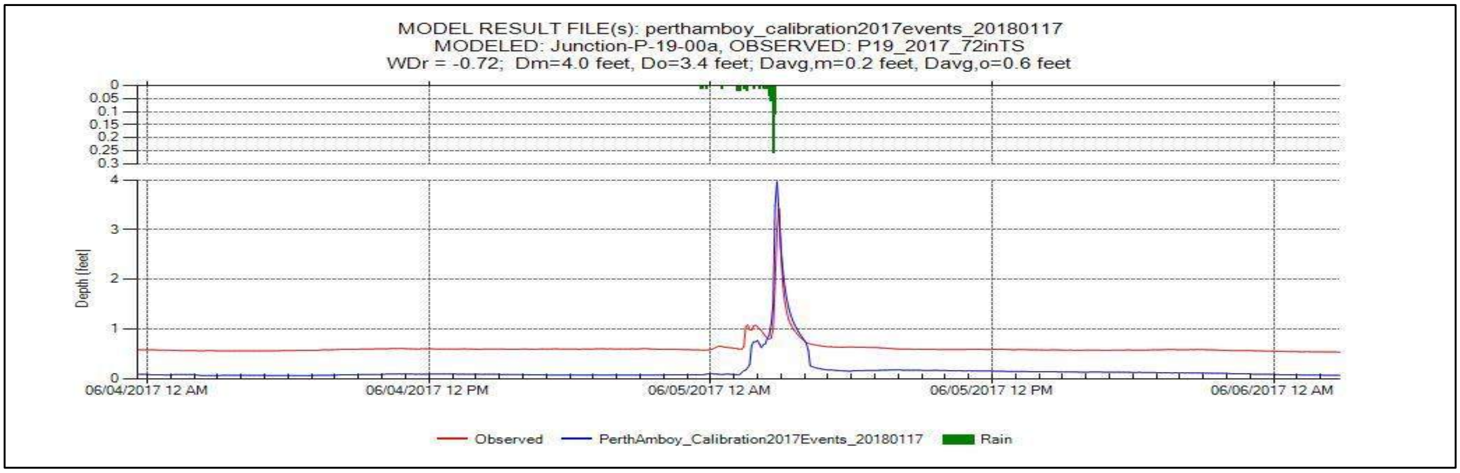
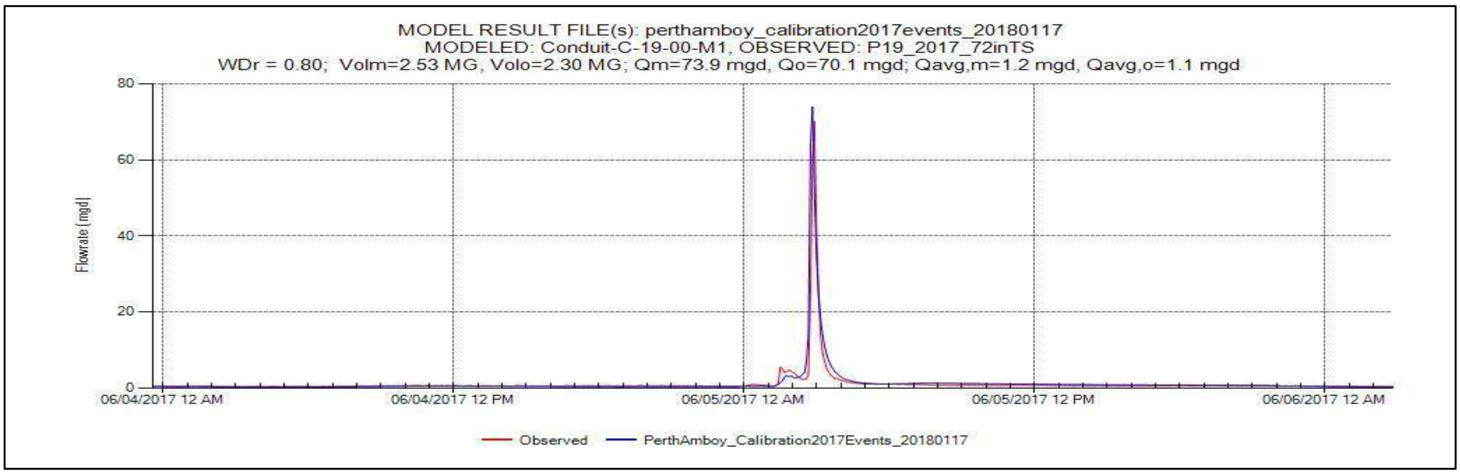
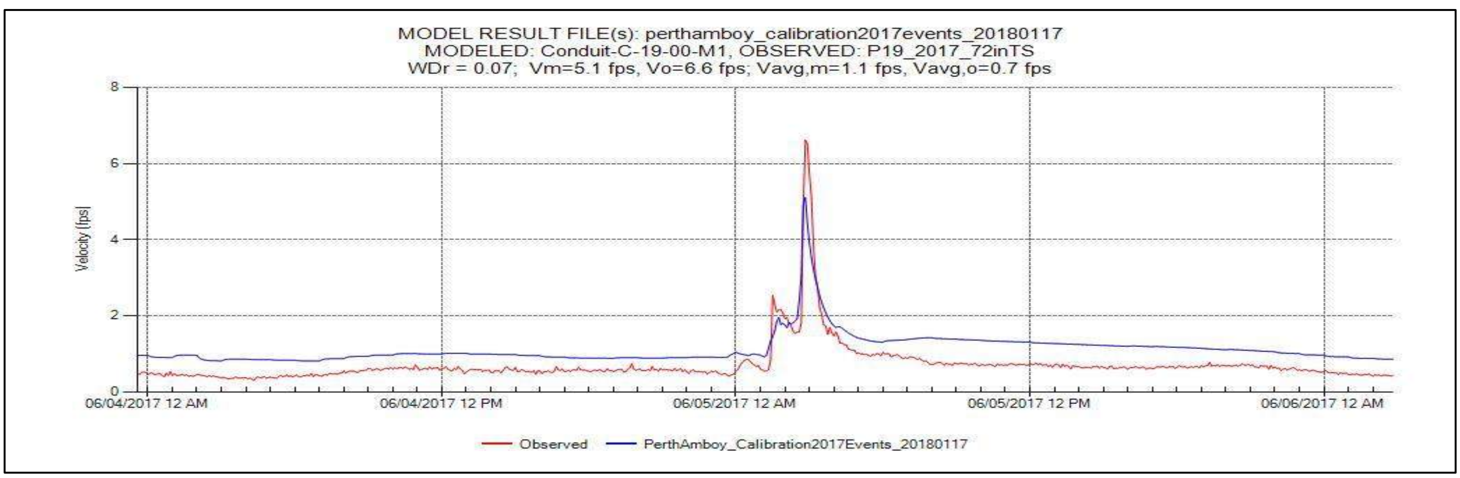
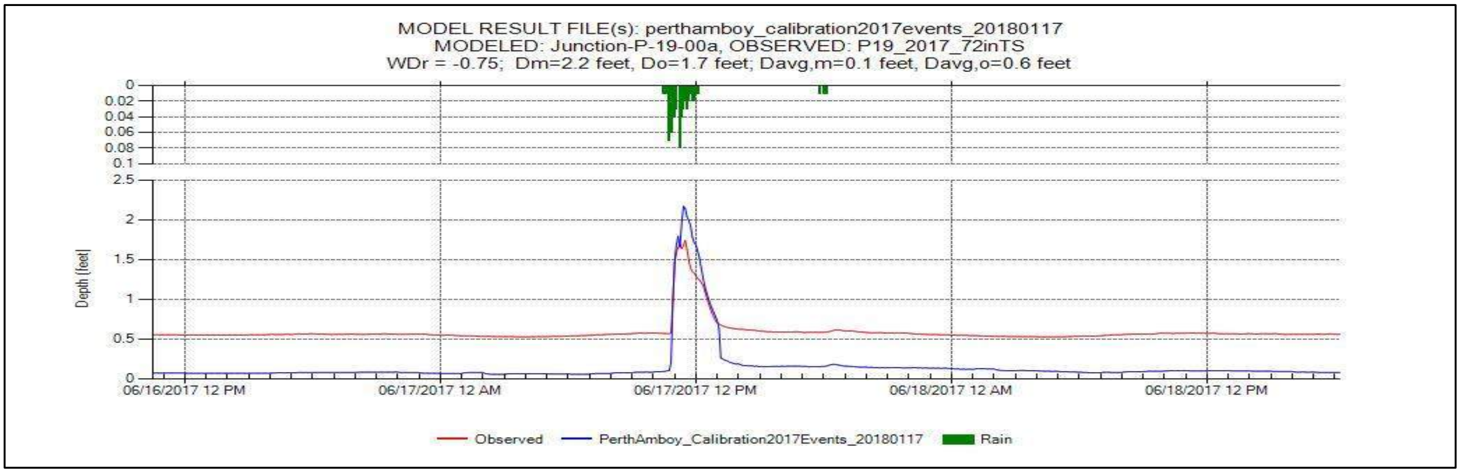


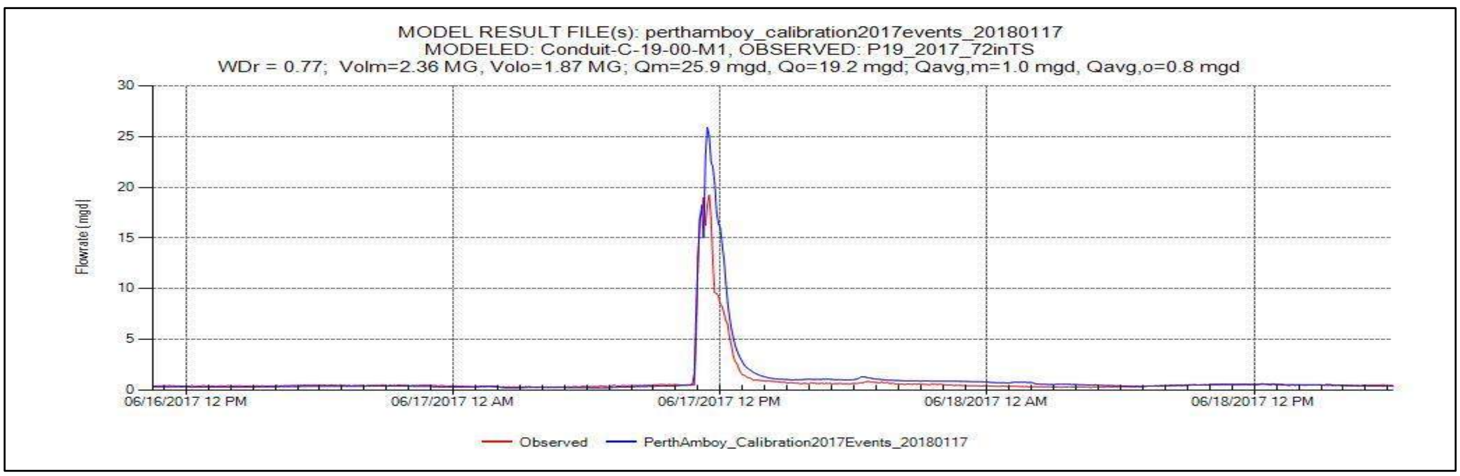


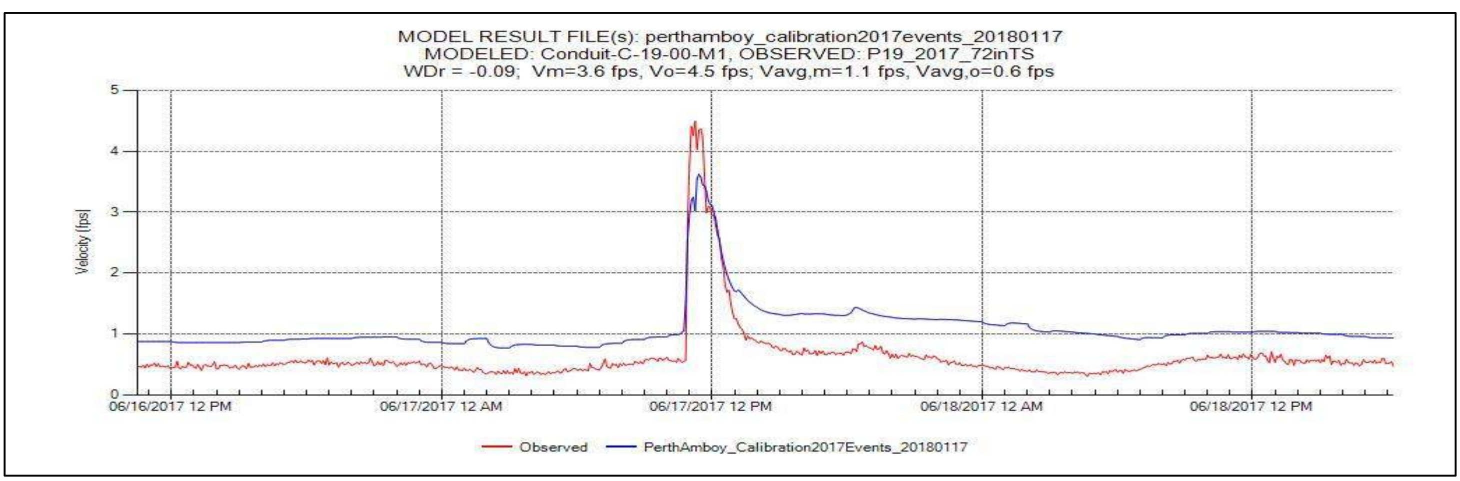


Simulated Versus Observed Flow at Flow Meter Sites

P19_2017_72inTS

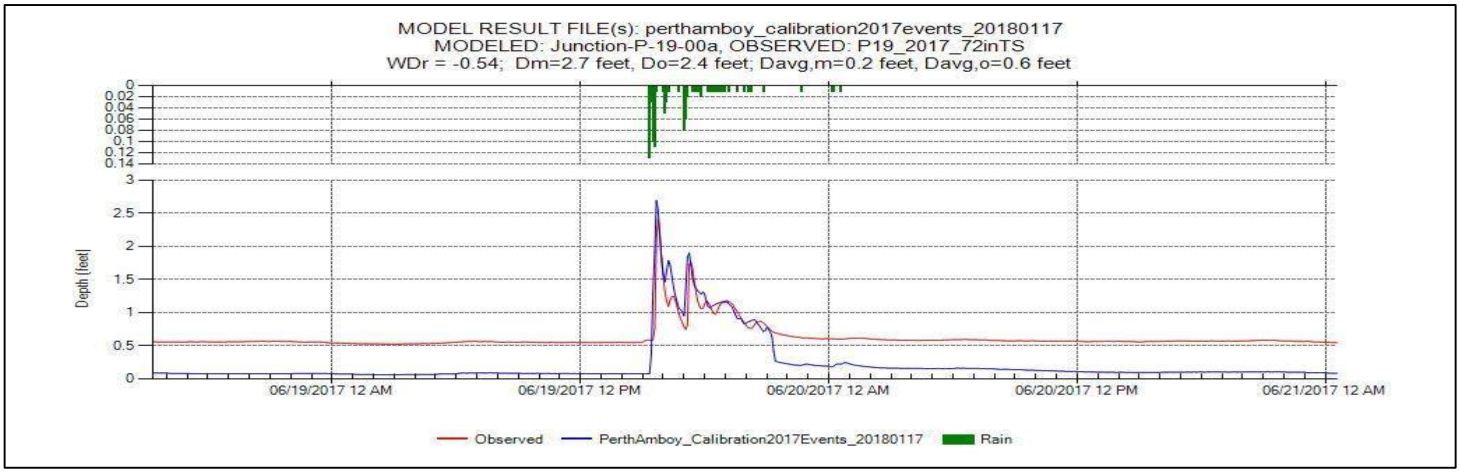


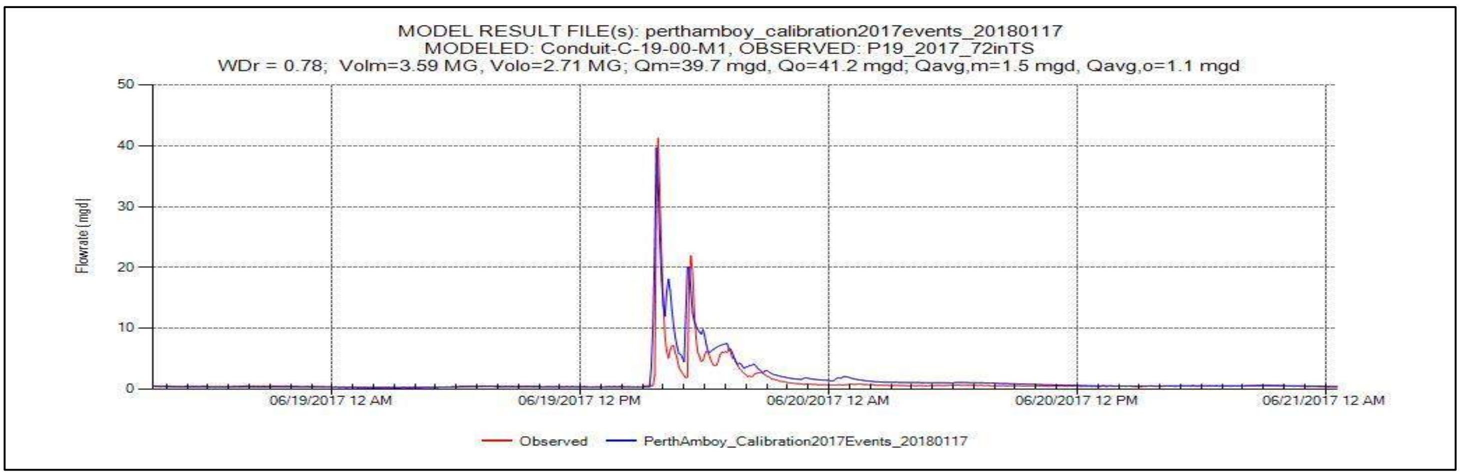


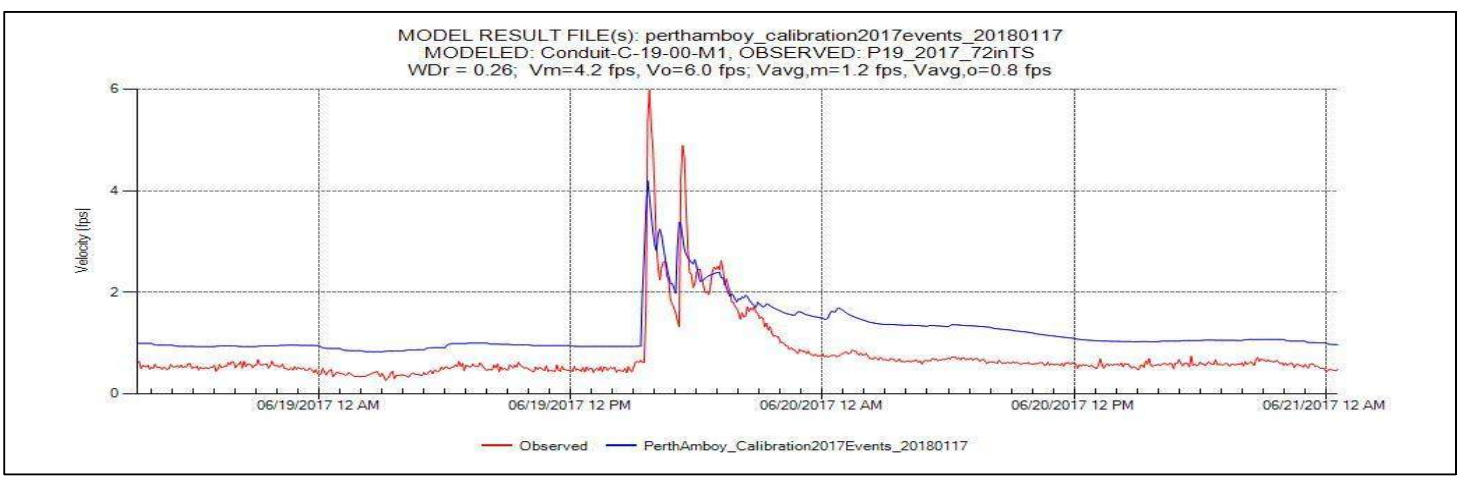


Simulated Versus Observed Flow at Flow Meter Sites

P19_2017_72inTS

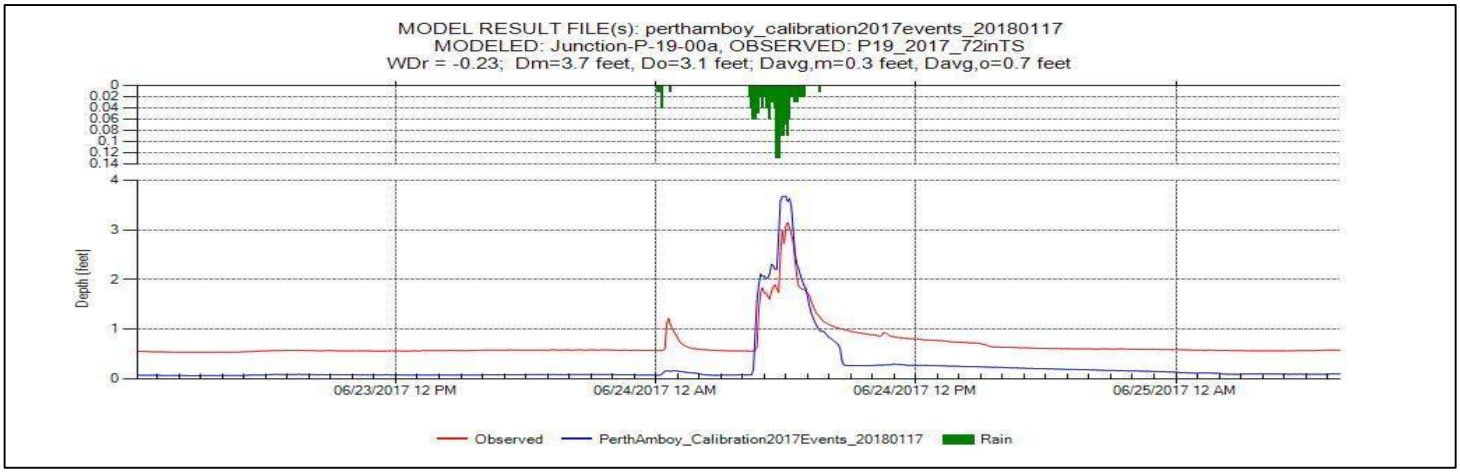


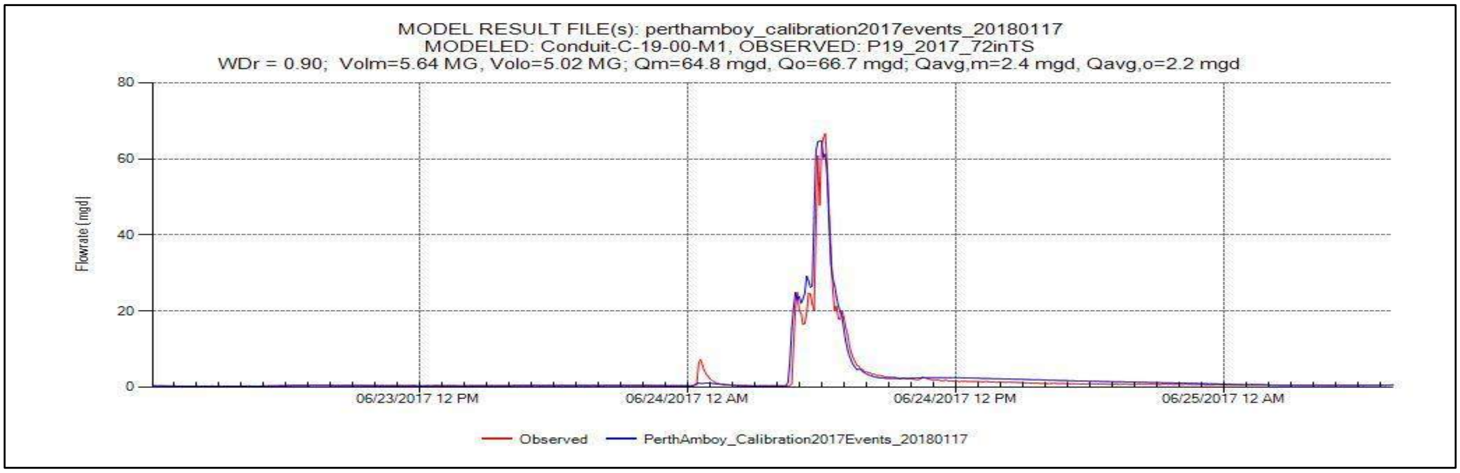


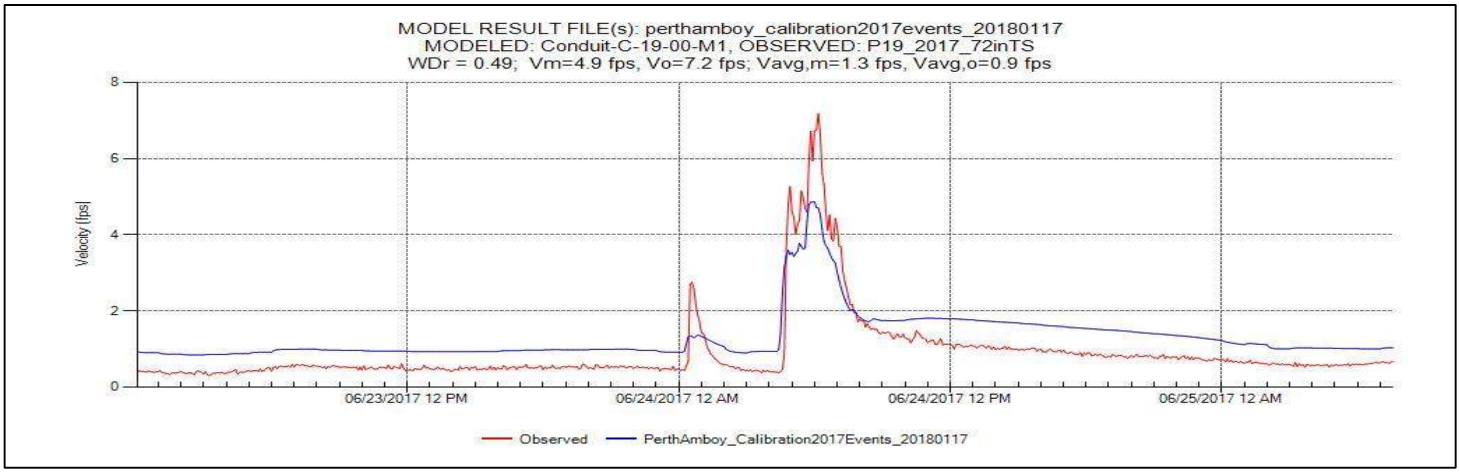


Simulated Versus Observed Flow at Flow Meter Sites

P19_2017_72inTS







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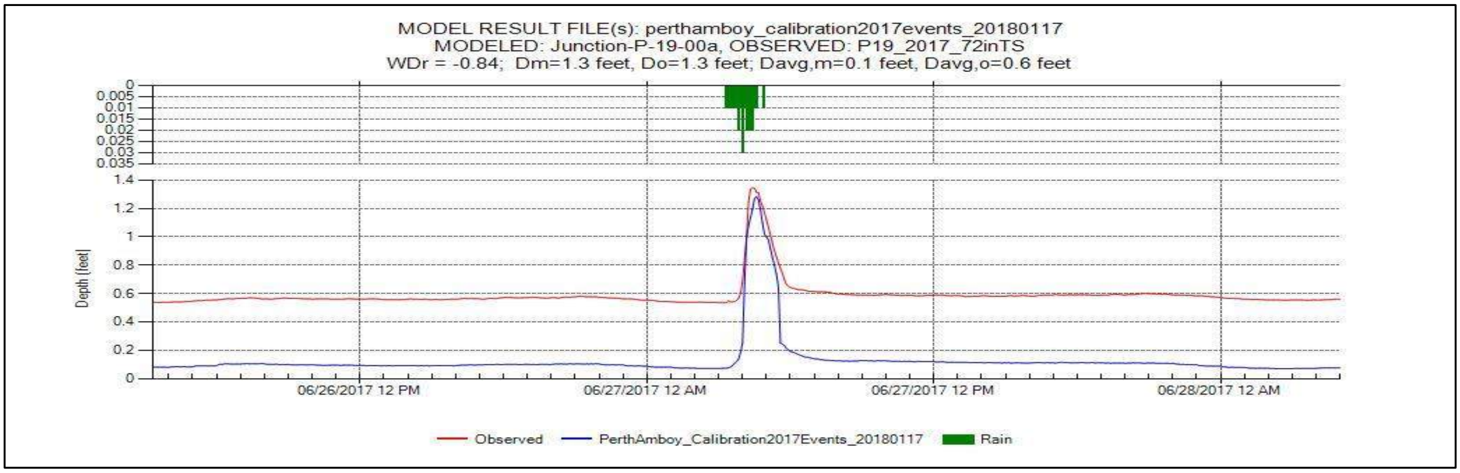
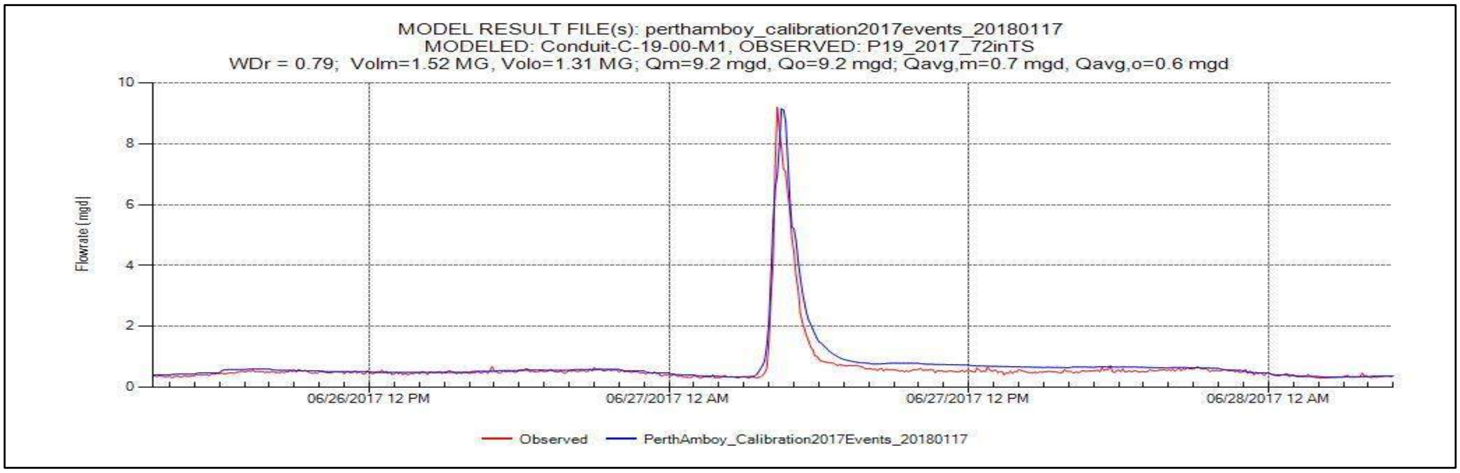
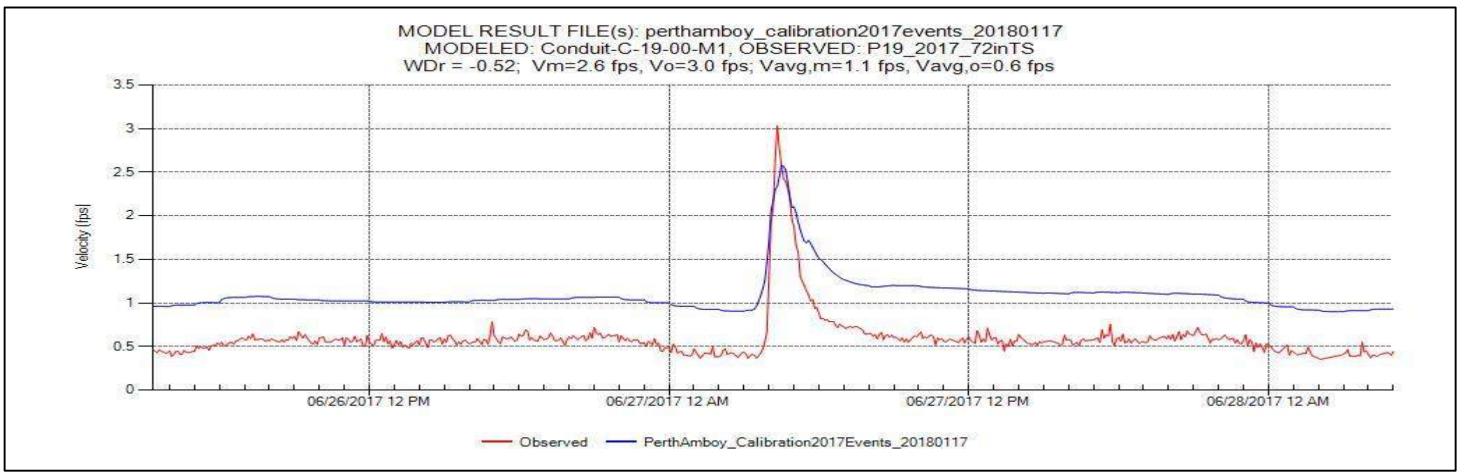
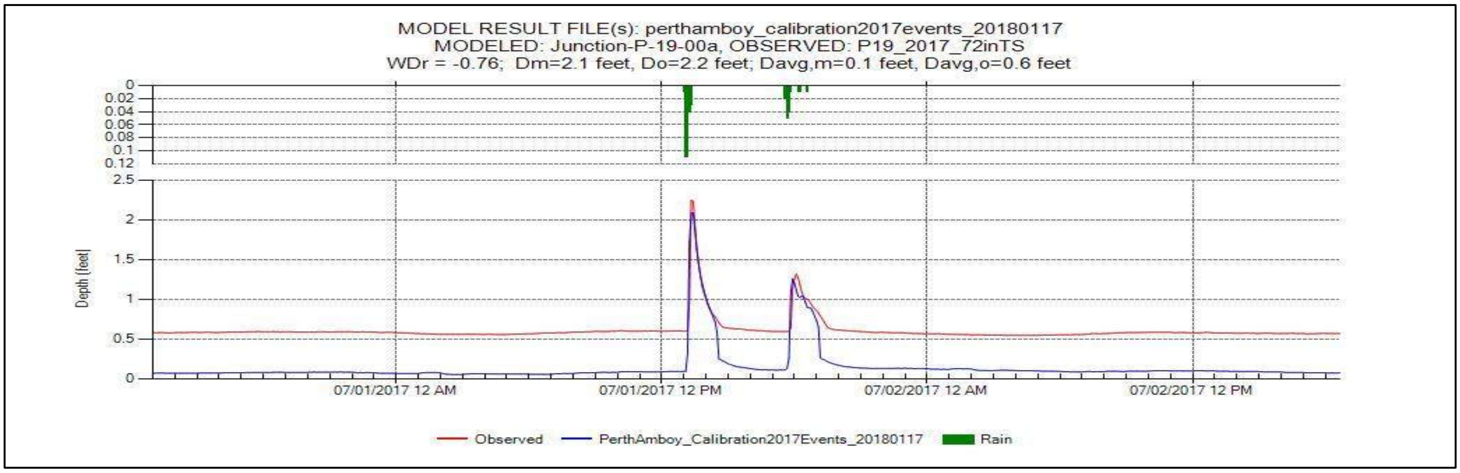


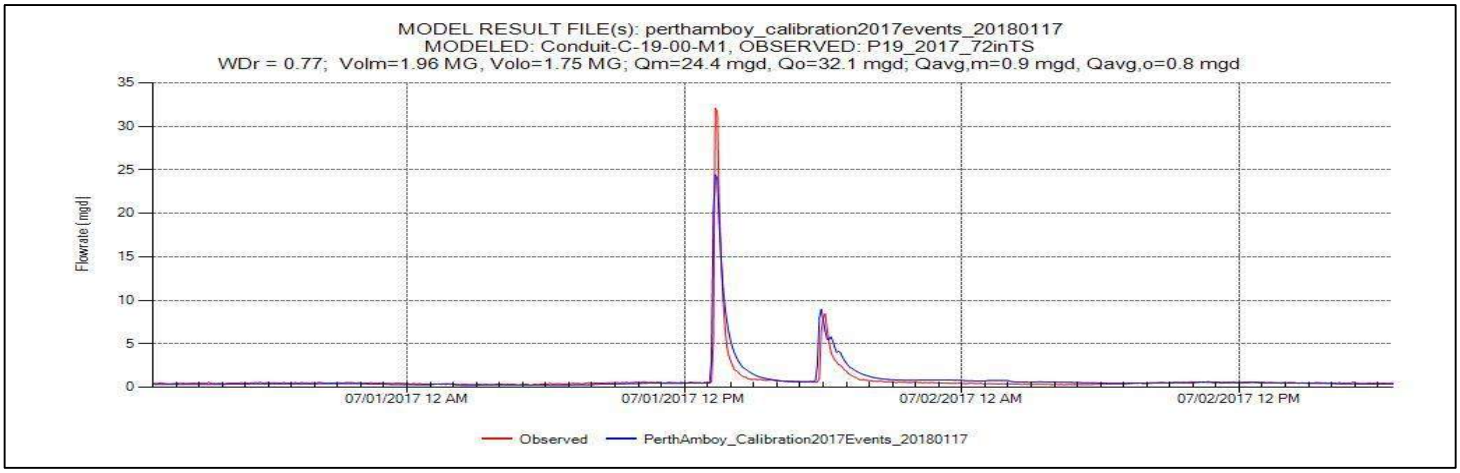


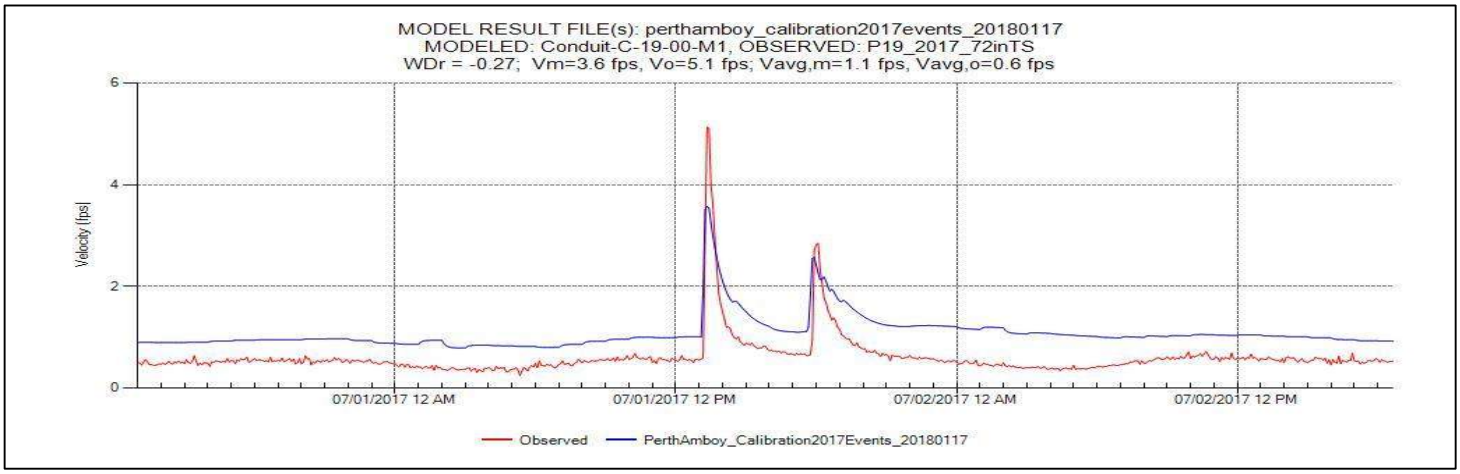


Simulated Versus Observed Flow at Flow Meter Sites

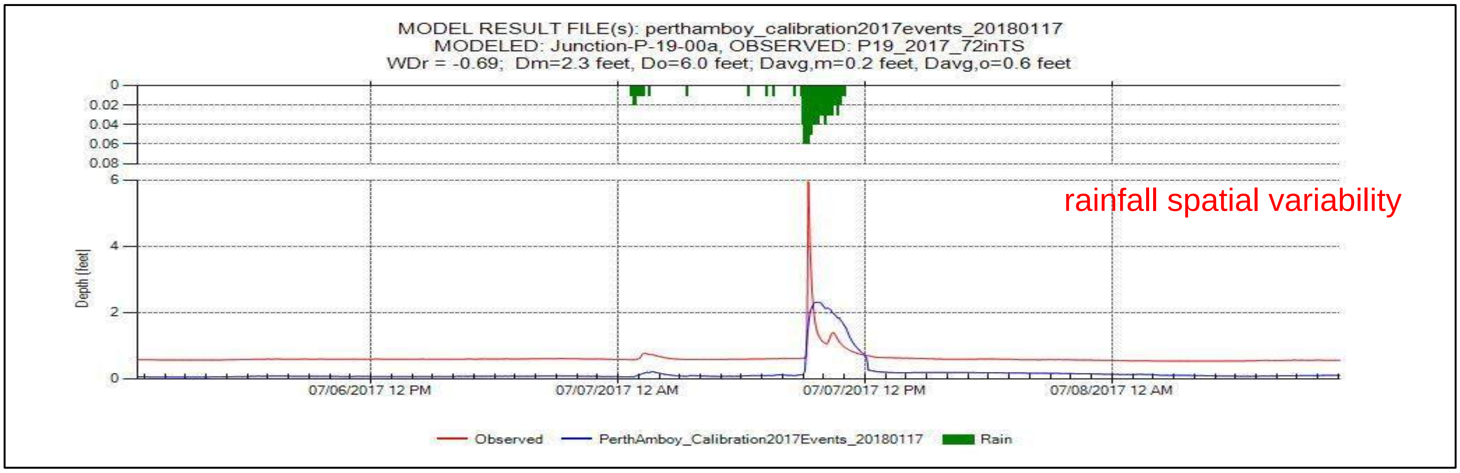
P19_2017_72inTS

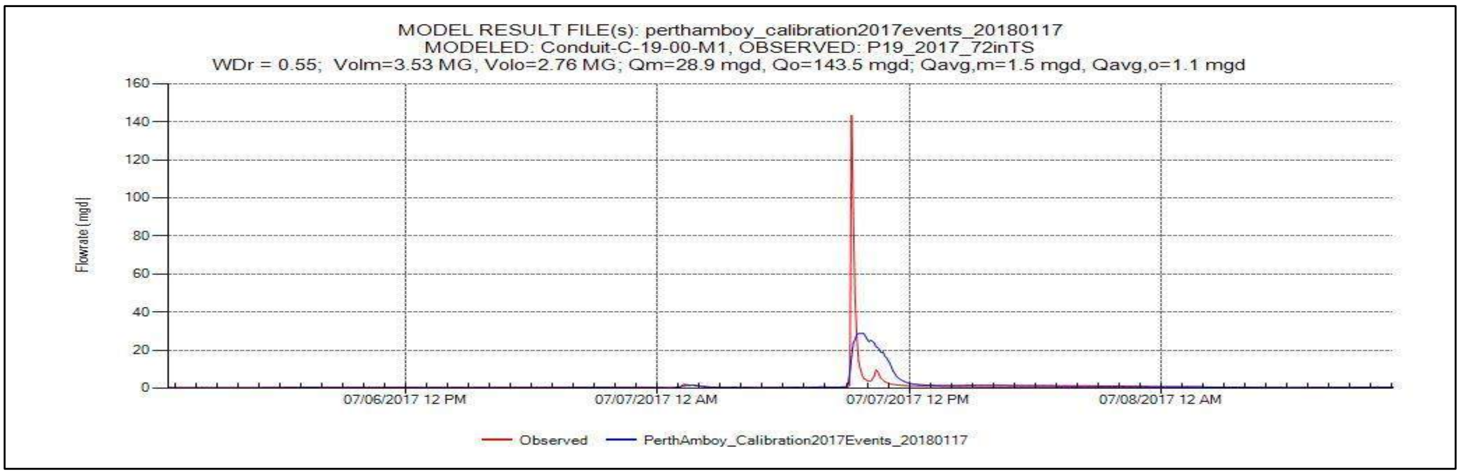


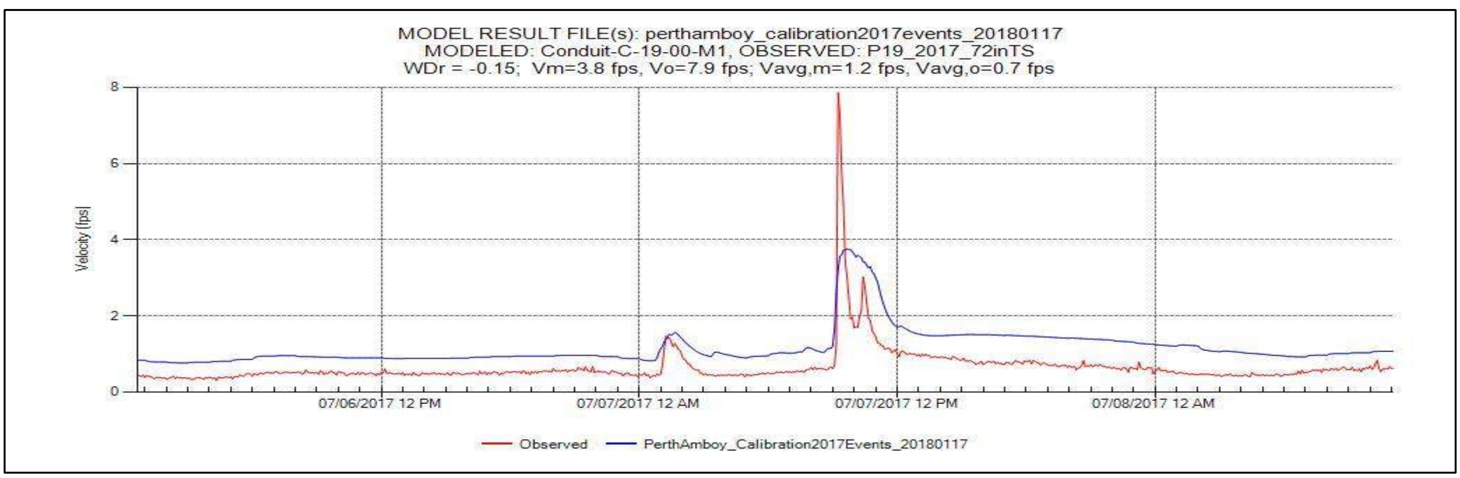




P19_2017_72inTS

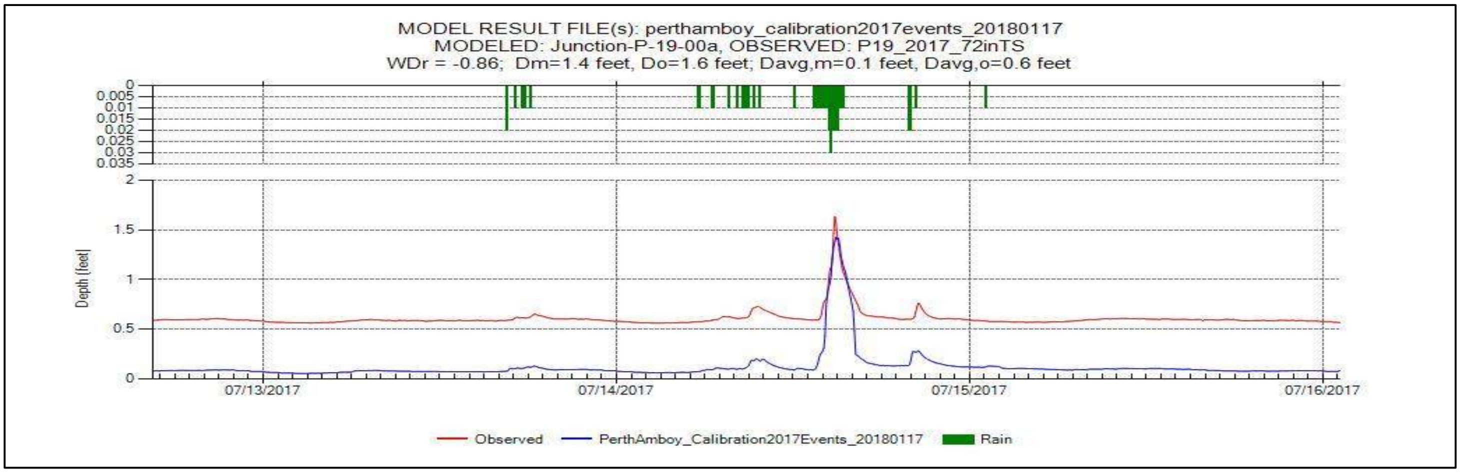


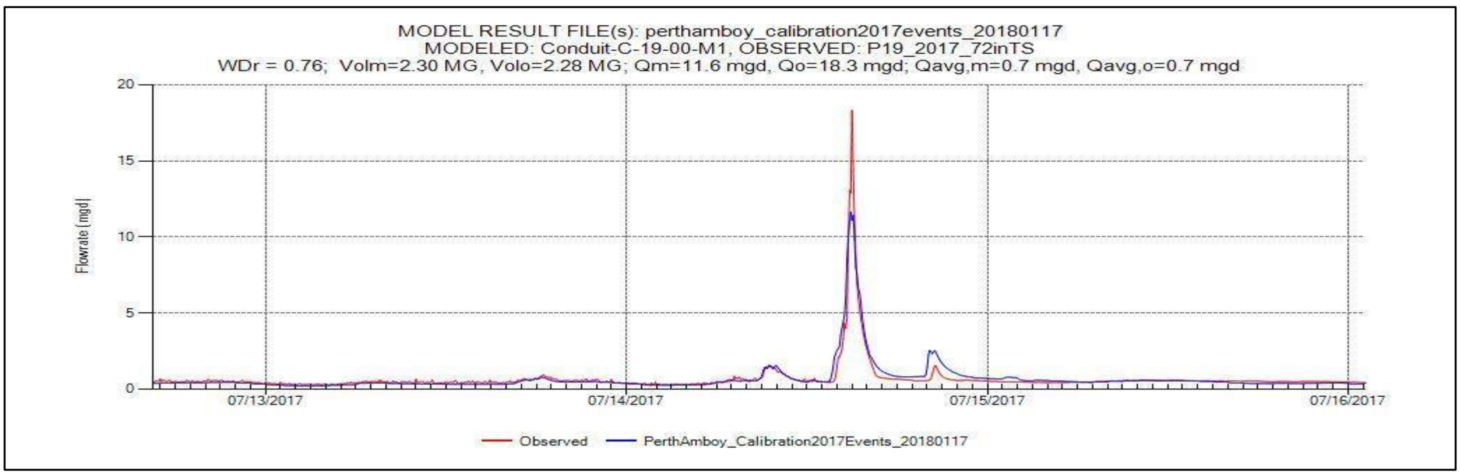


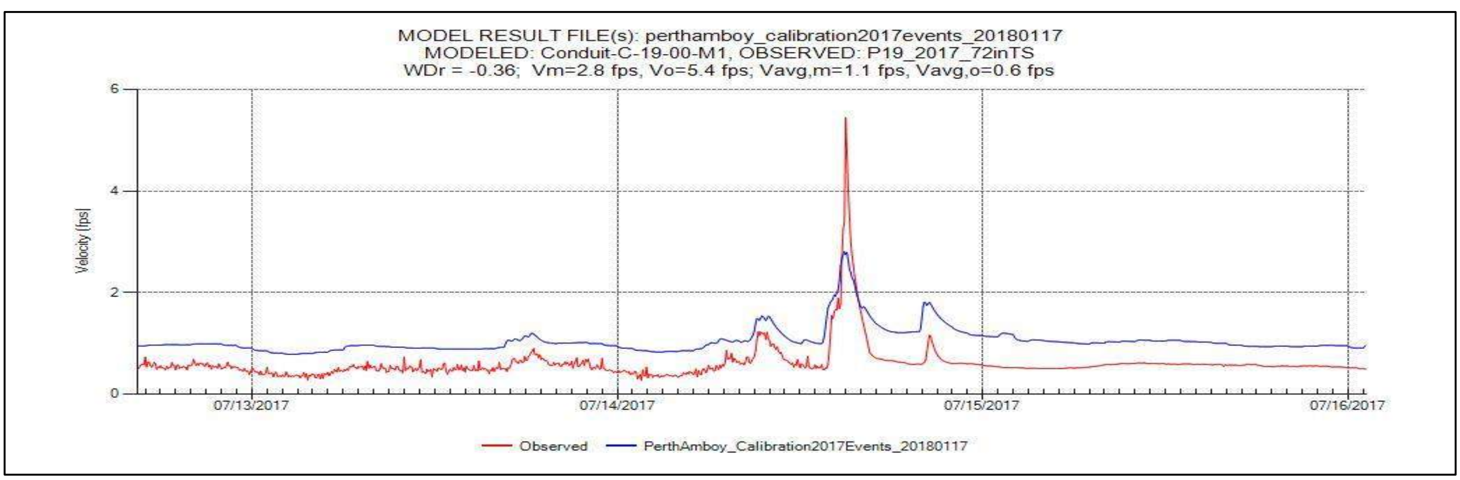


Simulated Versus Observed Flow at Flow Meter Sites

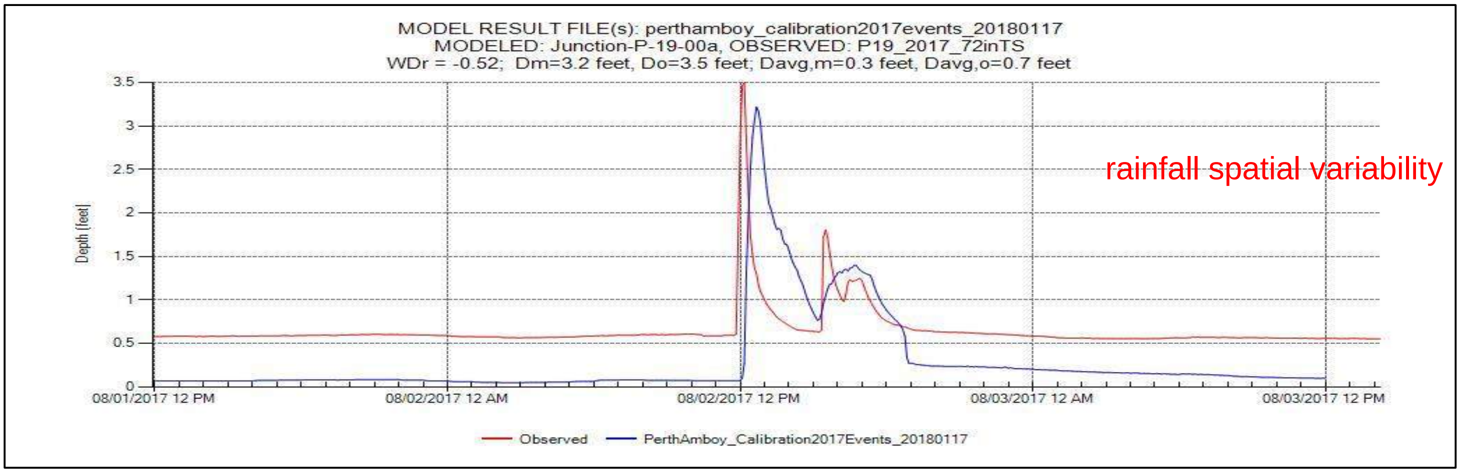
P19_2017_72inTS

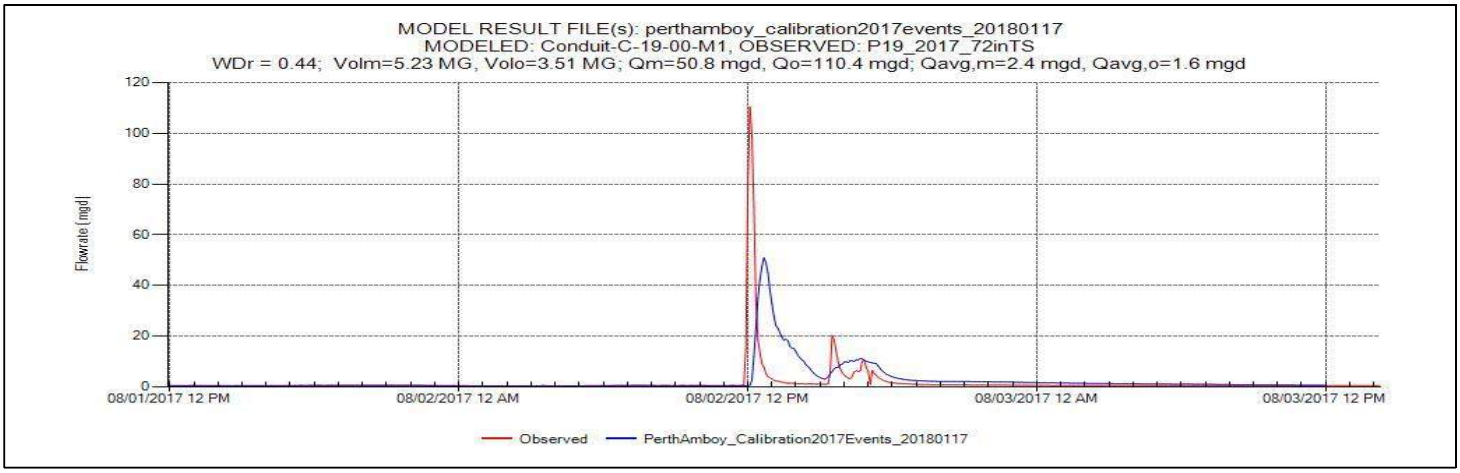


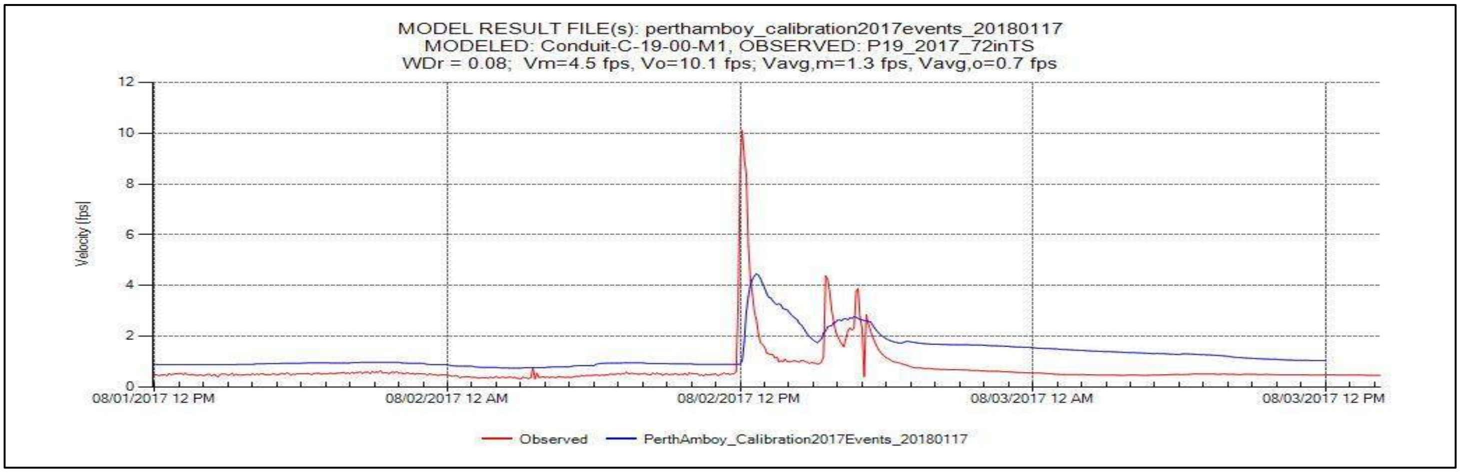




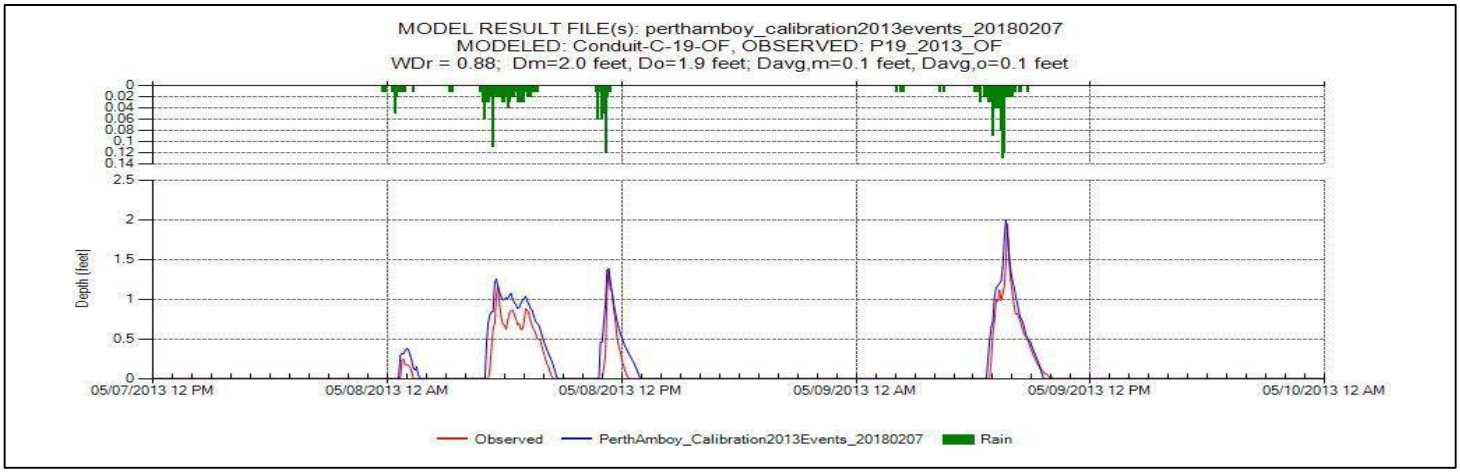
P19_2017_72inTS

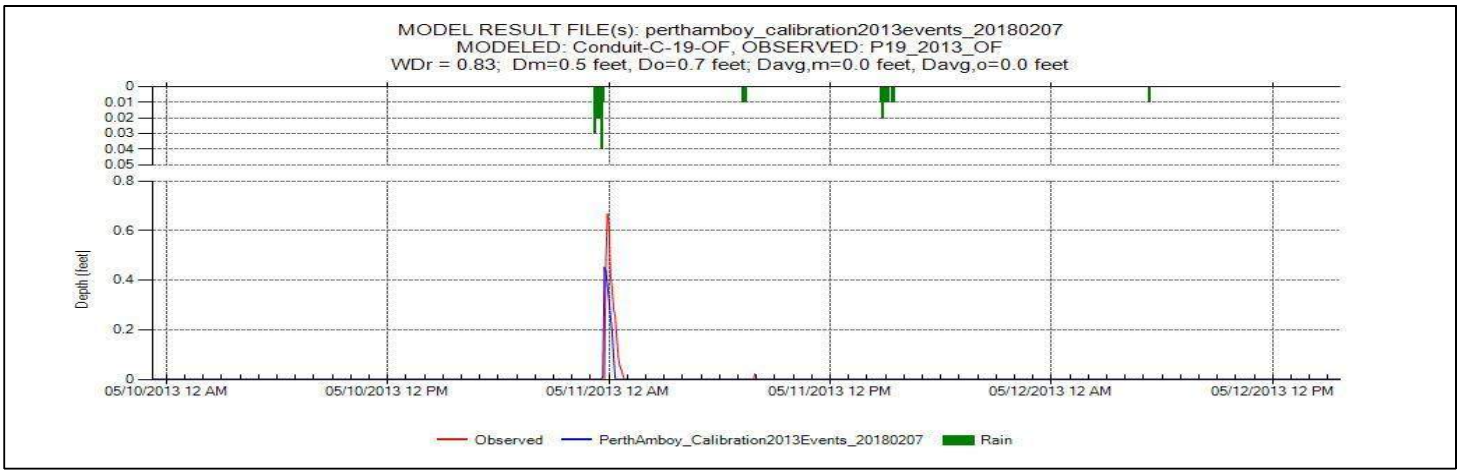


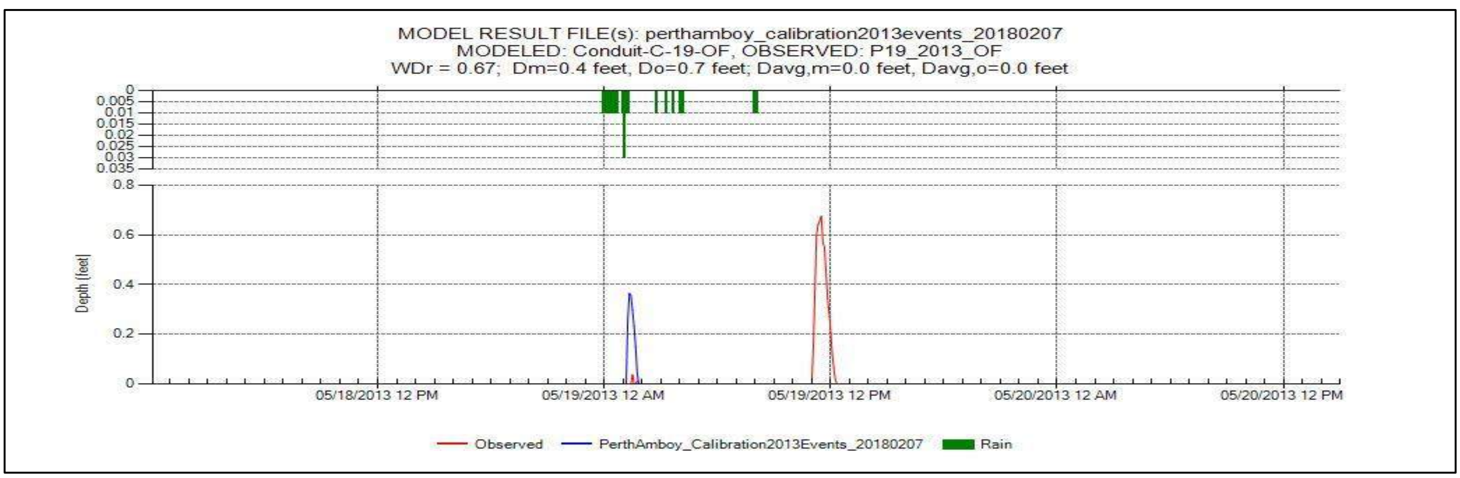




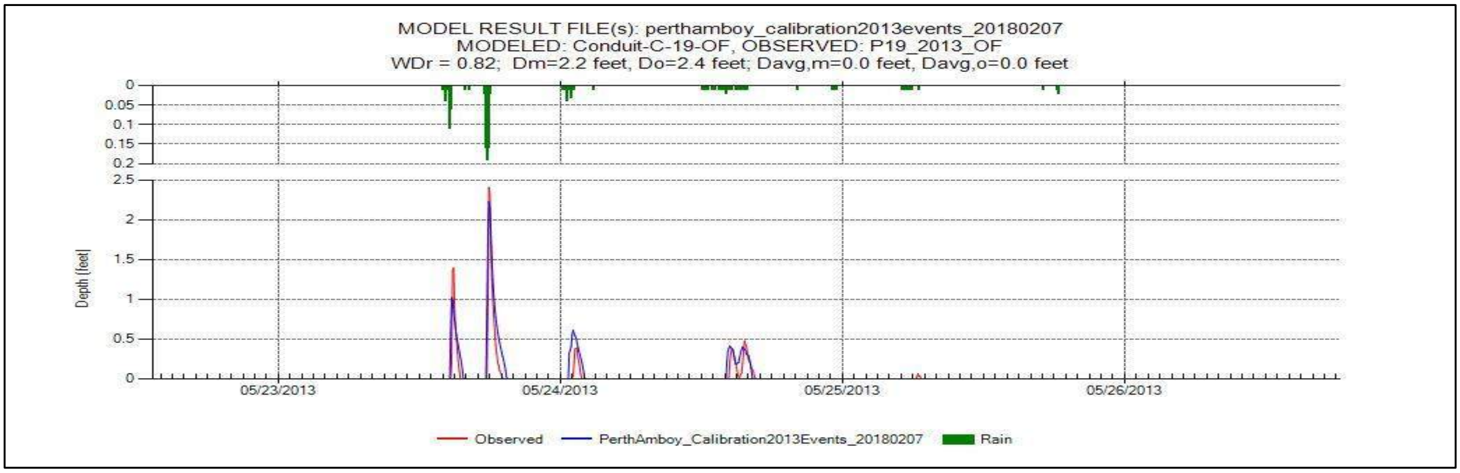
P19_2013_OF

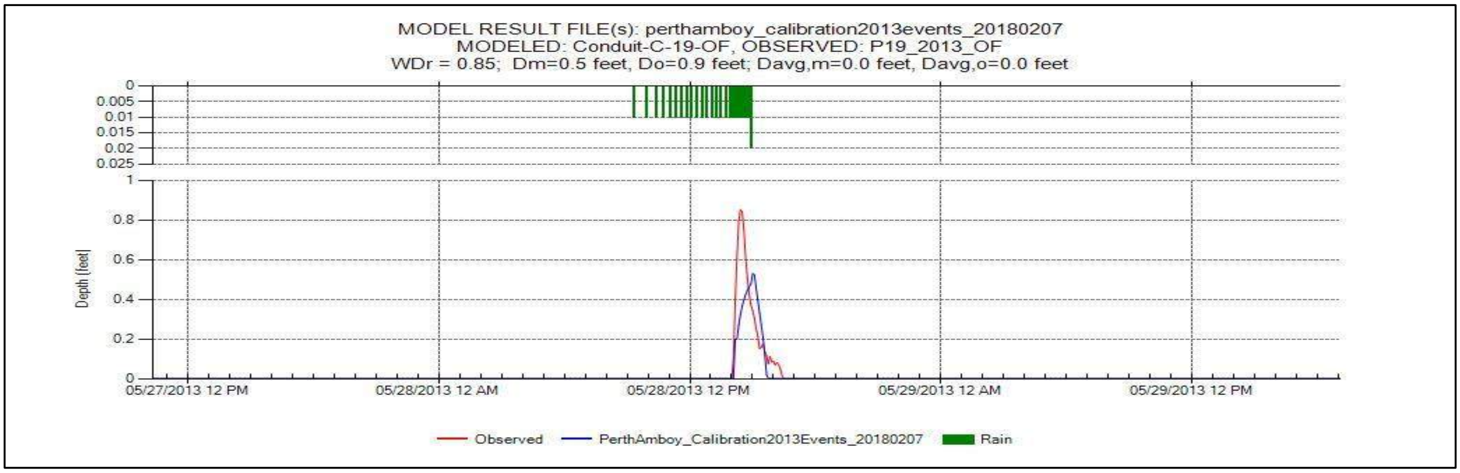

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.88; Dm=2.0 feet, Do=1.9 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
05/07/2013 12 PM
05/08/2013 12 AM
05/08/2013 12 PM
05/09/2013 12 AM
05/09/2013 12 PM
05/10/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

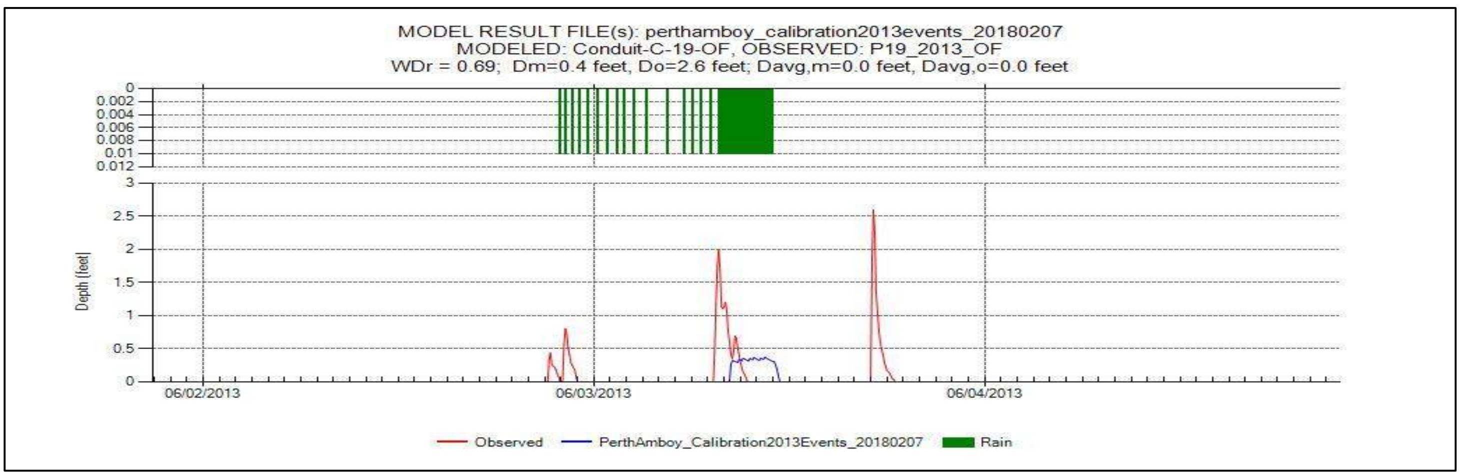

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.83; Dm=0.5 feet, Do=0.7 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/10/2013 12 AM
05/10/2013 12 PM
05/11/2013 12 AM
05/11/2013 12 PM
05/12/2013 12 AM
05/12/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.67; Dm=0.4 feet, Do=0.7 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/18/2013 12 PM
05/19/2013 12 AM
05/19/2013 12 PM
05/20/2013 12 AM
05/20/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

P19_2013_OF

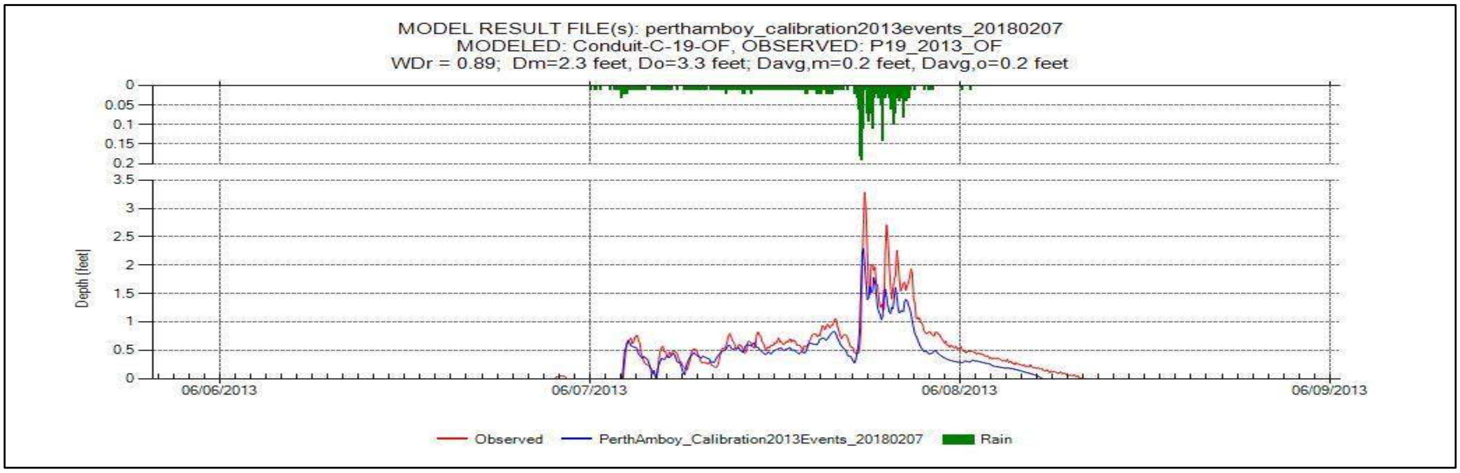

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.82; Dm=2.2 feet, Do=2.4 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/23/2013
05/24/2013
05/25/2013
05/26/2013
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

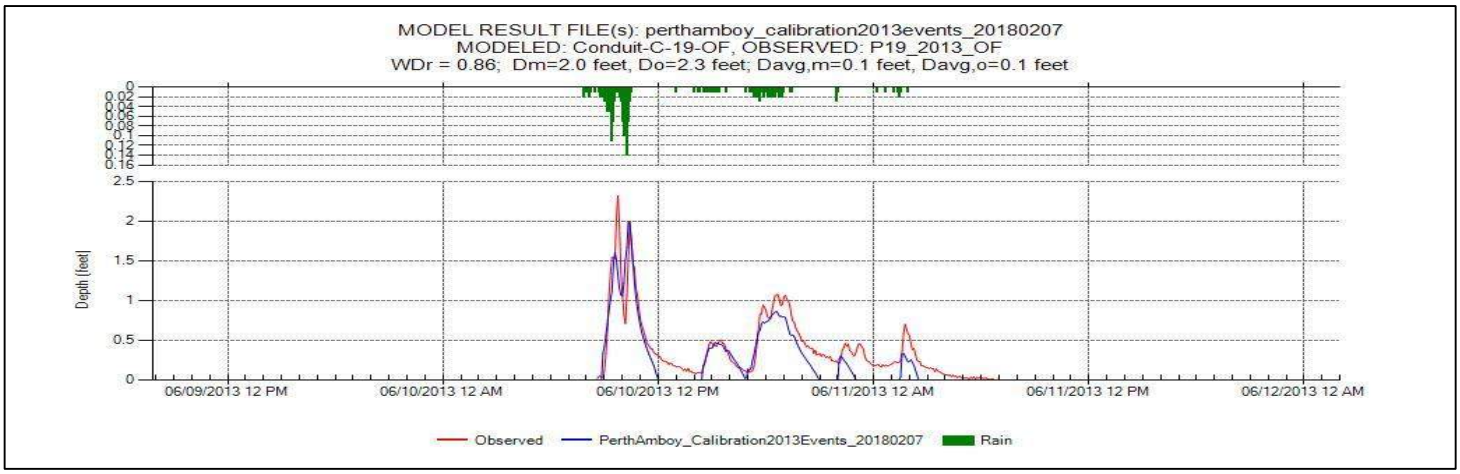

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.85; Dm=0.5 feet, Do=0.9 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
05/27/2013 12 PM
05/28/2013 12 AM
05/28/2013 12 PM
05/29/2013 12 AM
05/29/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

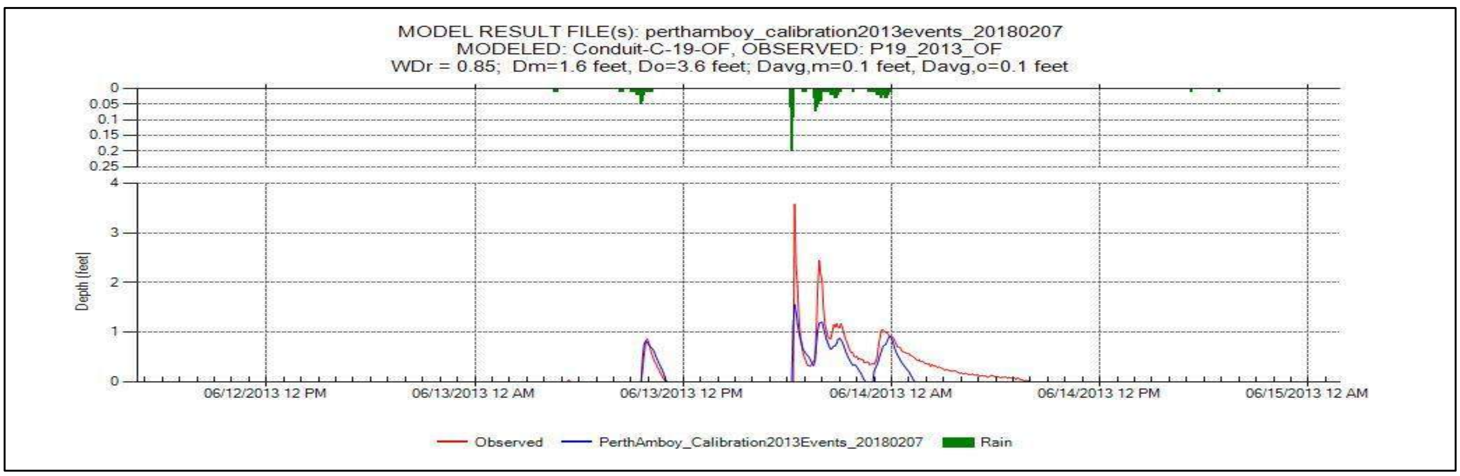

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.69; Dm=0.4 feet, Do=2.6 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
06/02/2013
06/03/2013
06/04/2013
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

Simulated Versus Observed Flow at Flow Meter Sites

P19_2013_OF

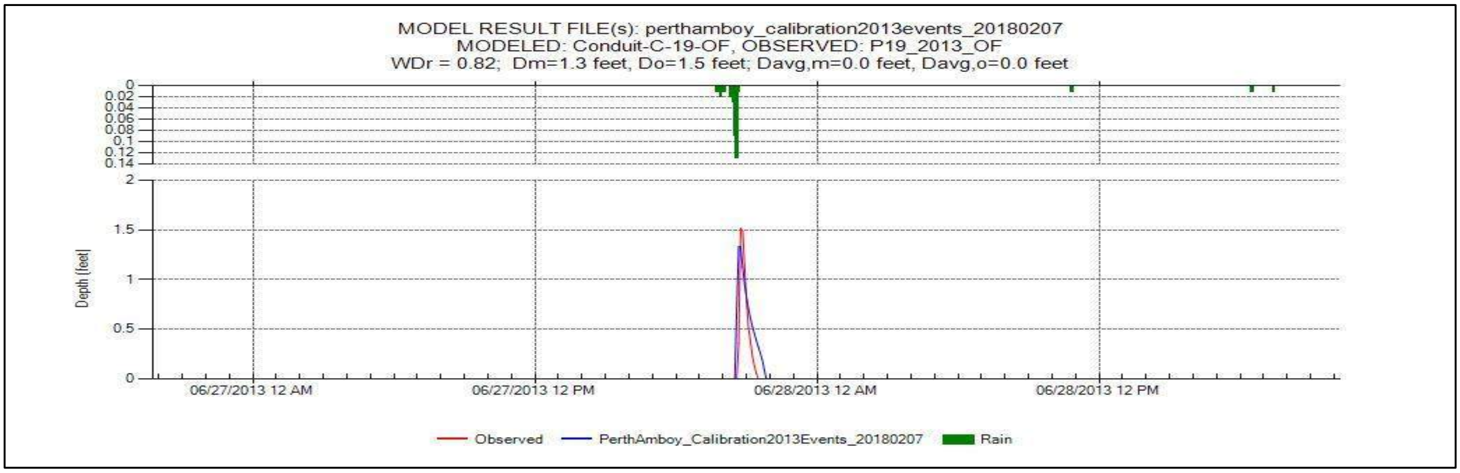


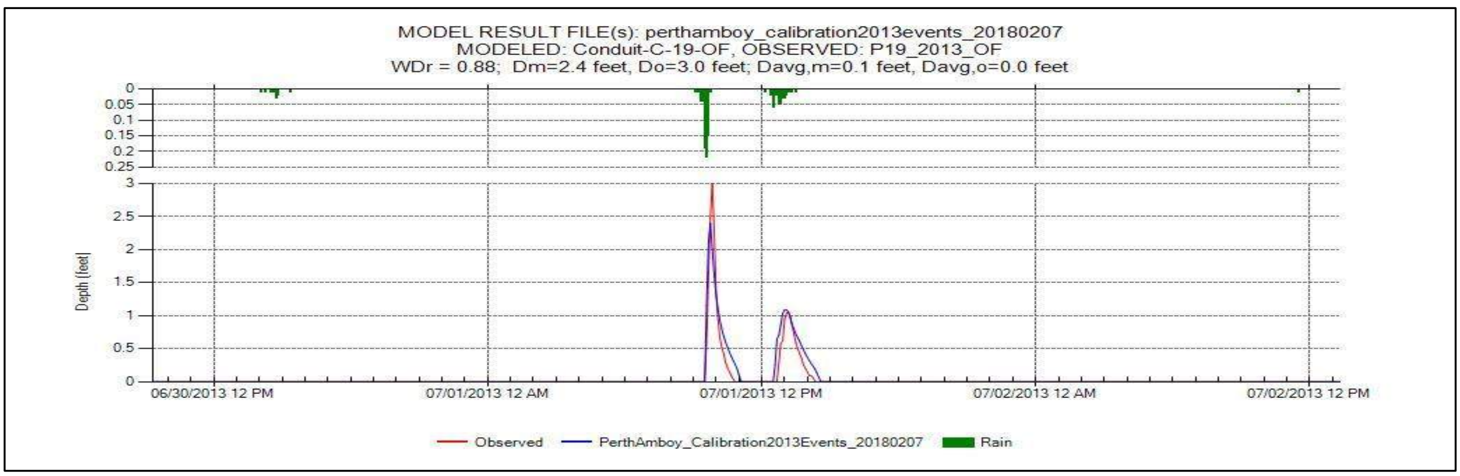


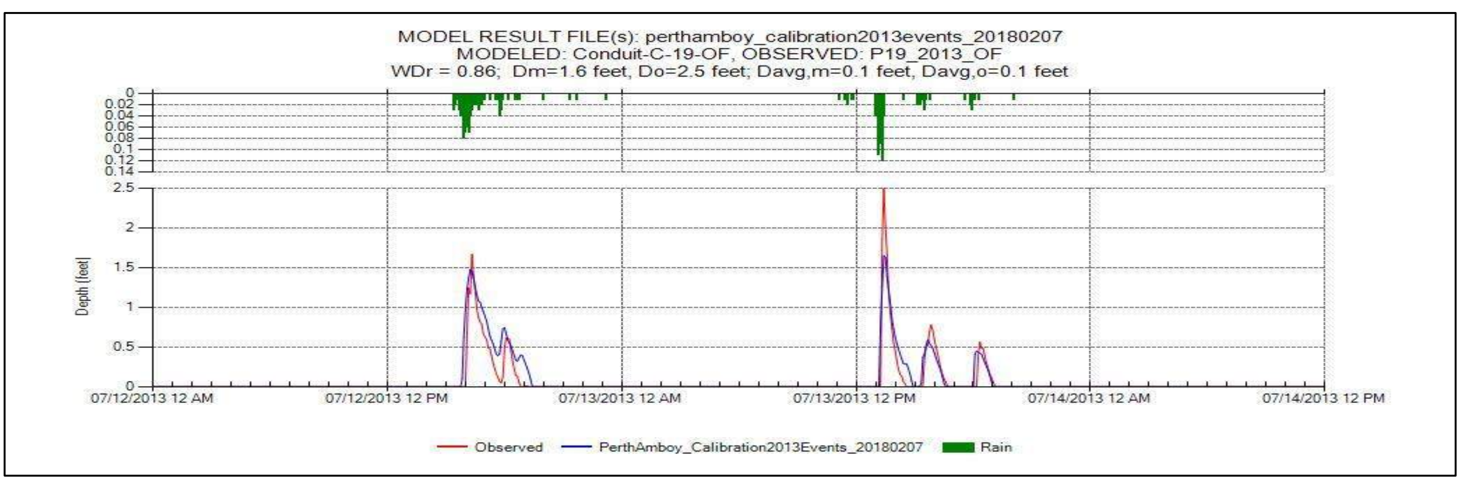


Simulated Versus Observed Flow at Flow Meter Sites

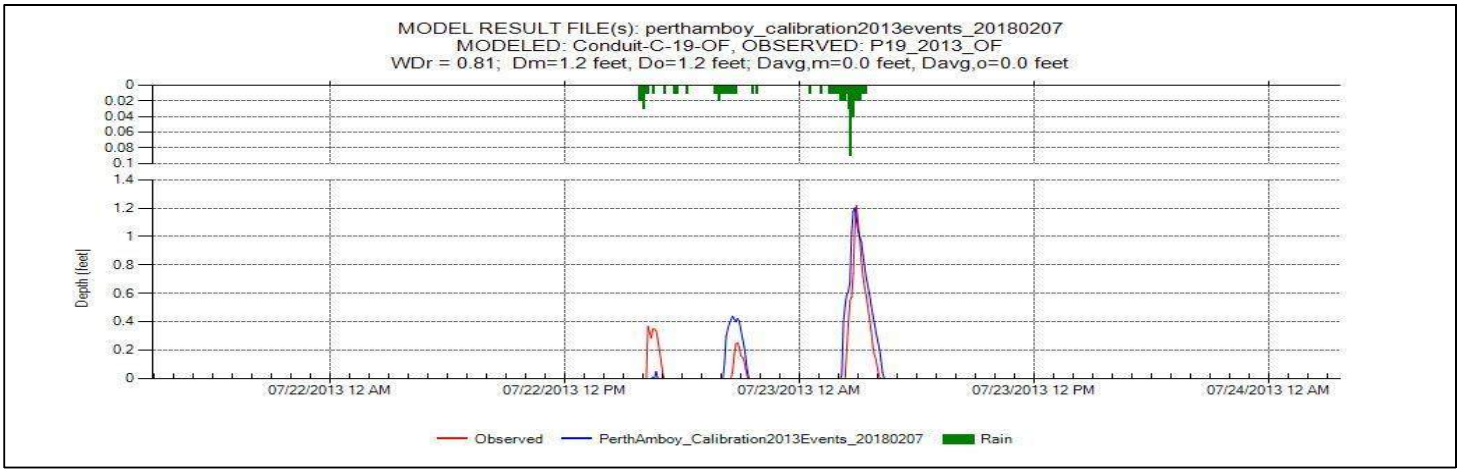
P19_2013_OF

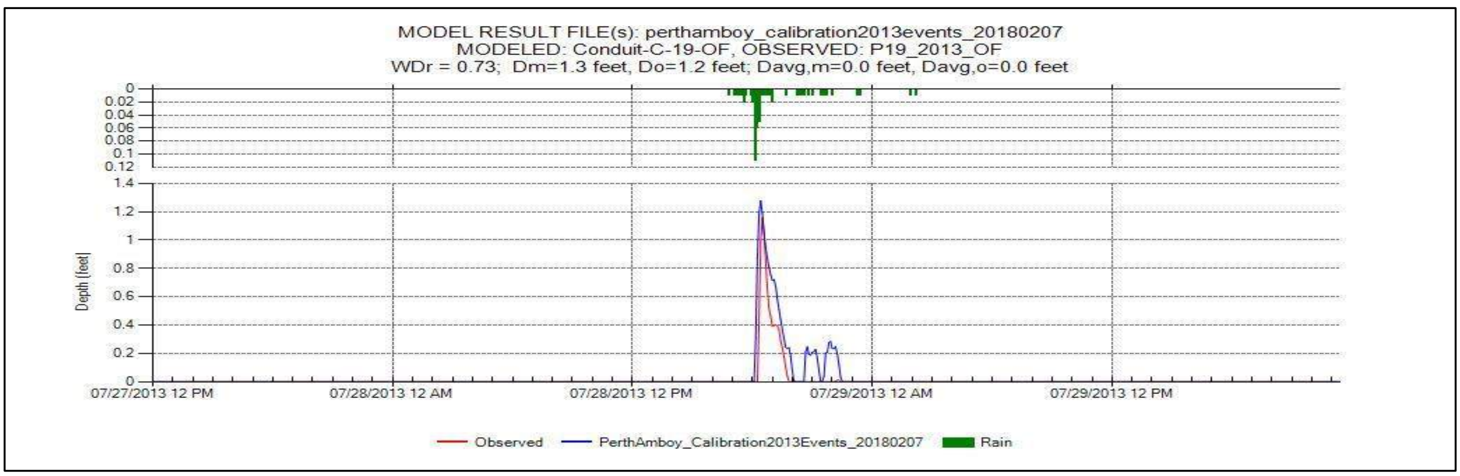


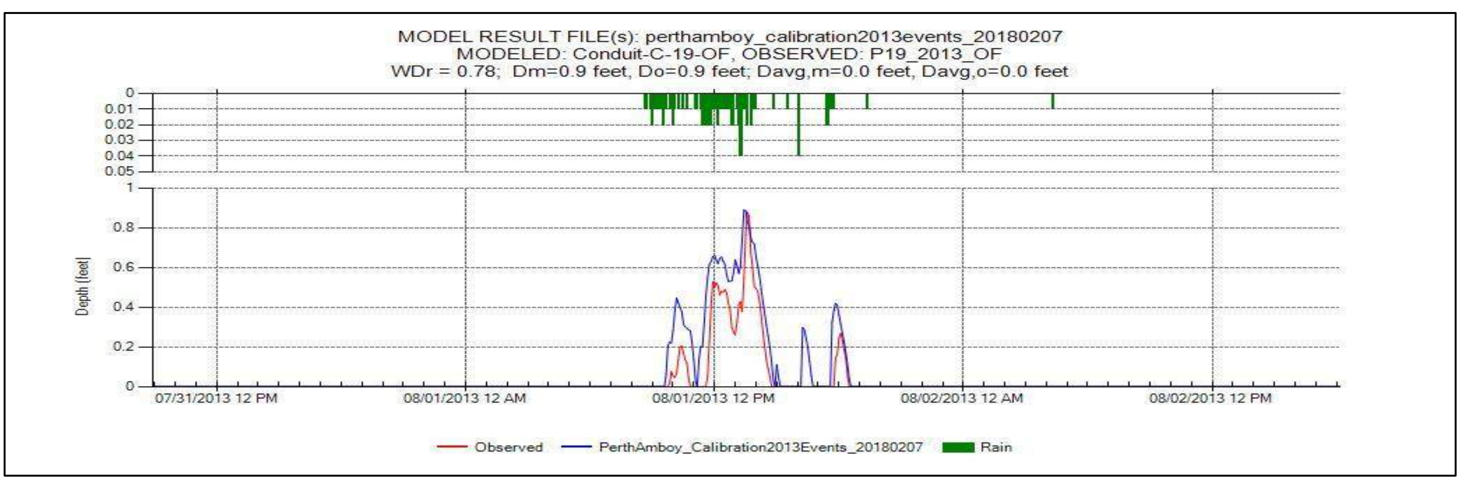




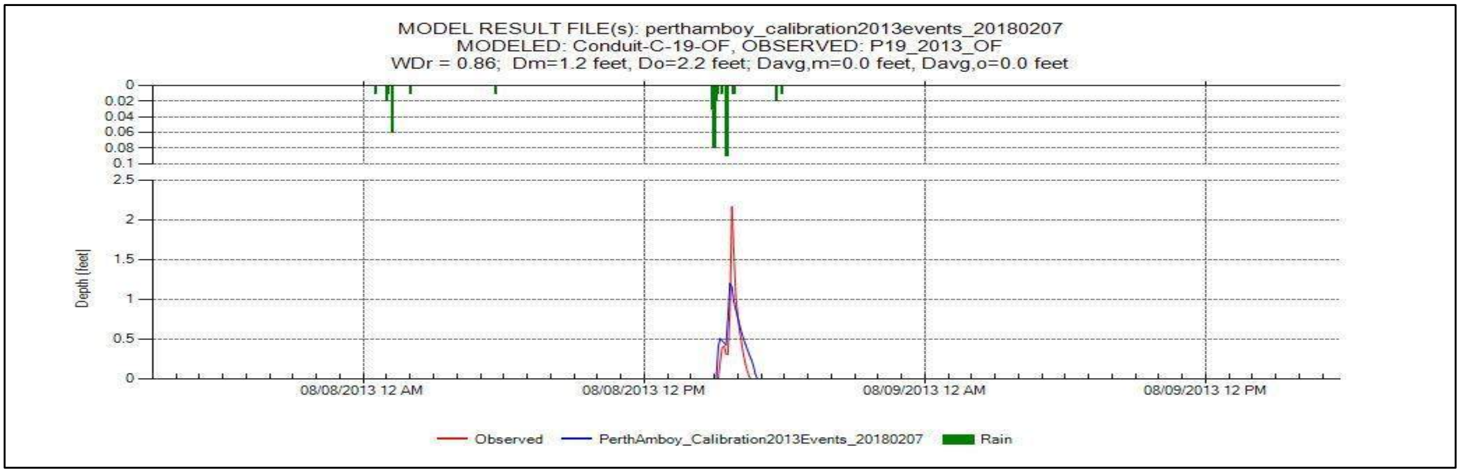
P19_2013_OF

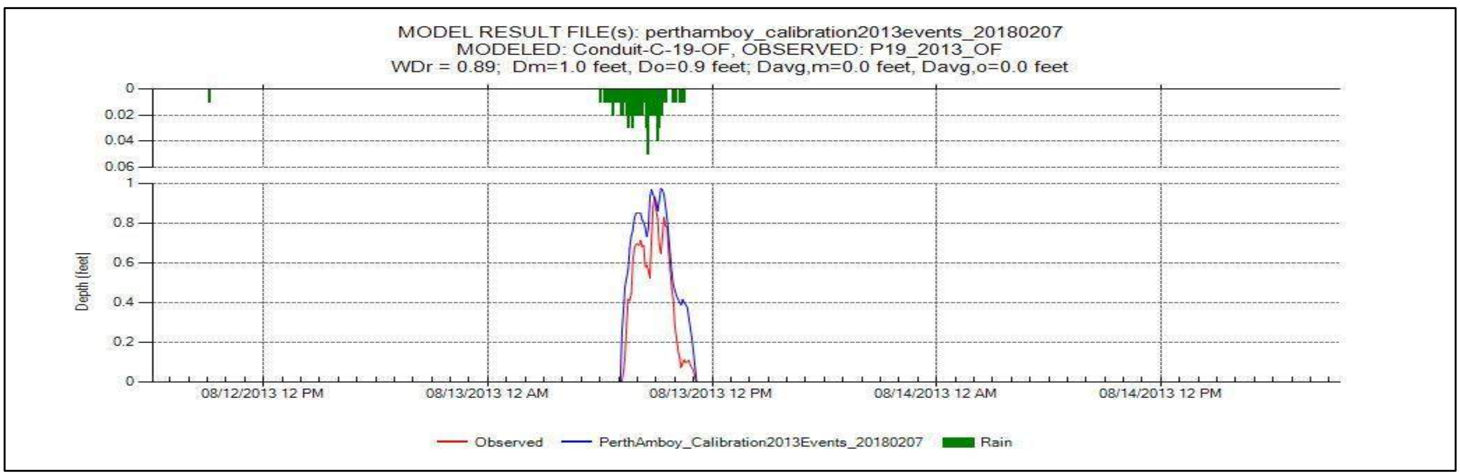

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.81; Dm=1.2 feet, Do=1.2 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
07/22/2013 12 AM
07/22/2013 12 PM
07/23/2013 12 AM
07/23/2013 12 PM
07/24/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

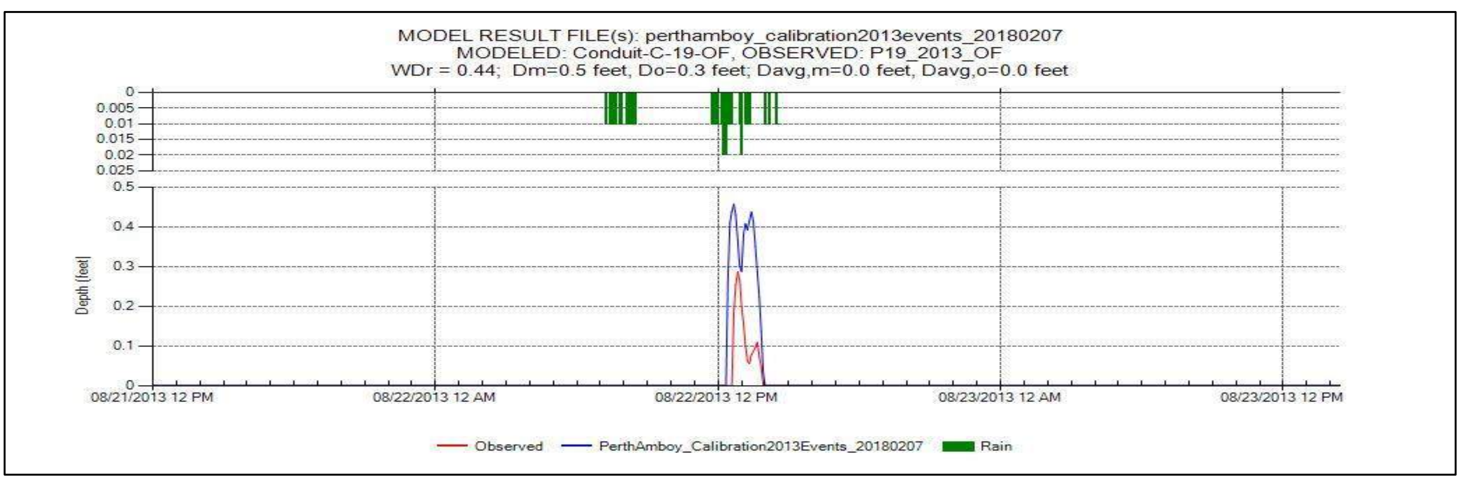

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.73; Dm=1.3 feet, Do=1.2 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
07/27/2013 12 PM
07/28/2013 12 AM
07/28/2013 12 PM
07/29/2013 12 AM
07/29/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.78; Dm=0.9 feet, Do=0.9 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
07/31/2013 12 PM
08/01/2013 12 AM
08/01/2013 12 PM
08/02/2013 12 AM
08/02/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

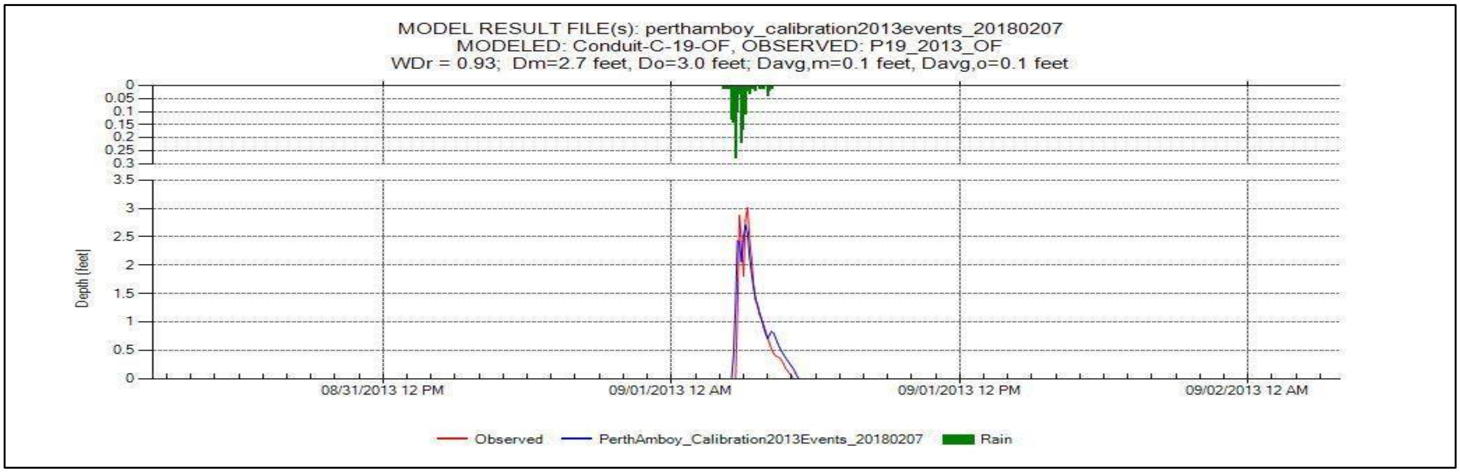
P19_2013_OF

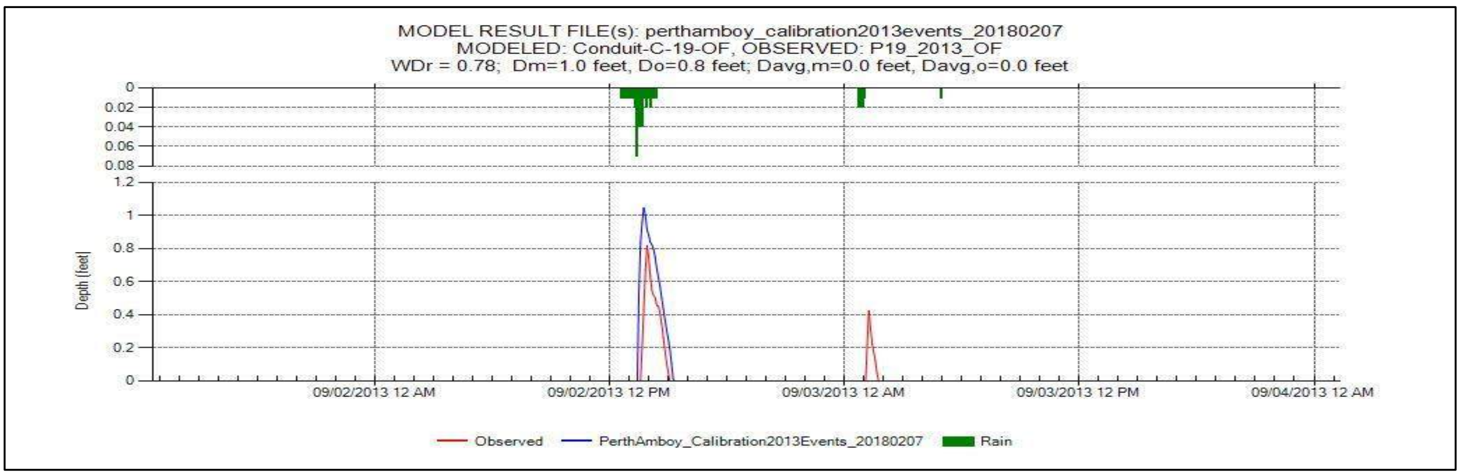

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.86; Dm=1.2 feet, Do=2.2 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
08/08/2013 12 AM
08/08/2013 12 PM
08/09/2013 12 AM
08/09/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

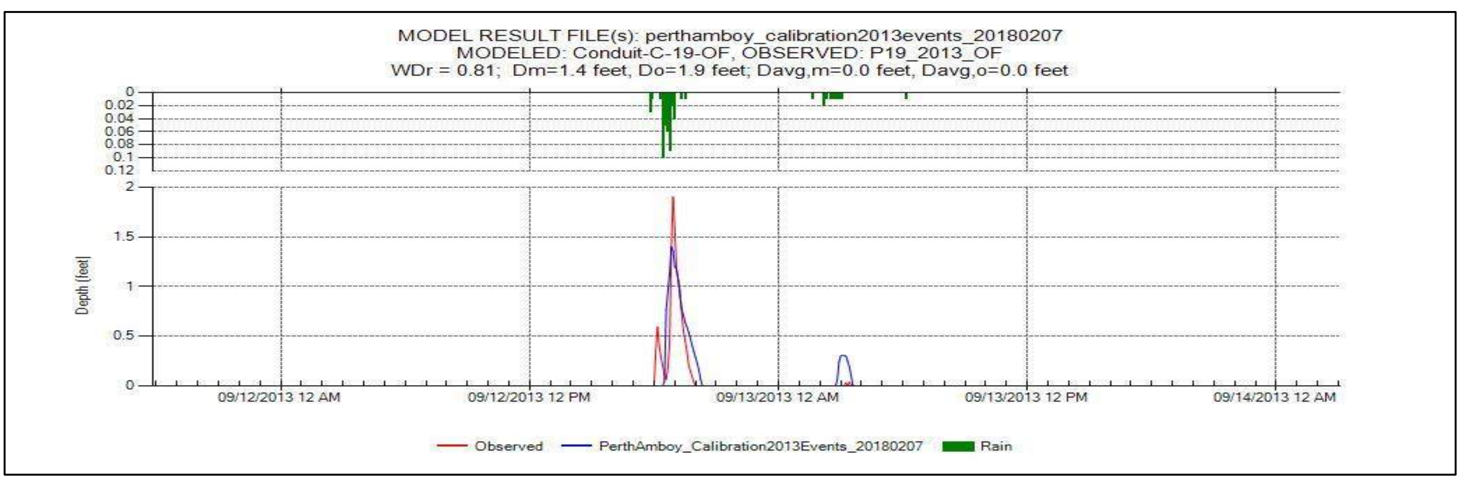

MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.89; Dm=1.0 feet, Do=0.9 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
08/12/2013 12 PM
08/13/2013 12 AM
08/13/2013 12 PM
08/14/2013 12 AM
08/14/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.44; Dm=0.5 feet, Do=0.3 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
08/21/2013 12 PM
08/22/2013 12 AM
08/22/2013 12 PM
08/23/2013 12 AM
08/23/2013 12 PM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

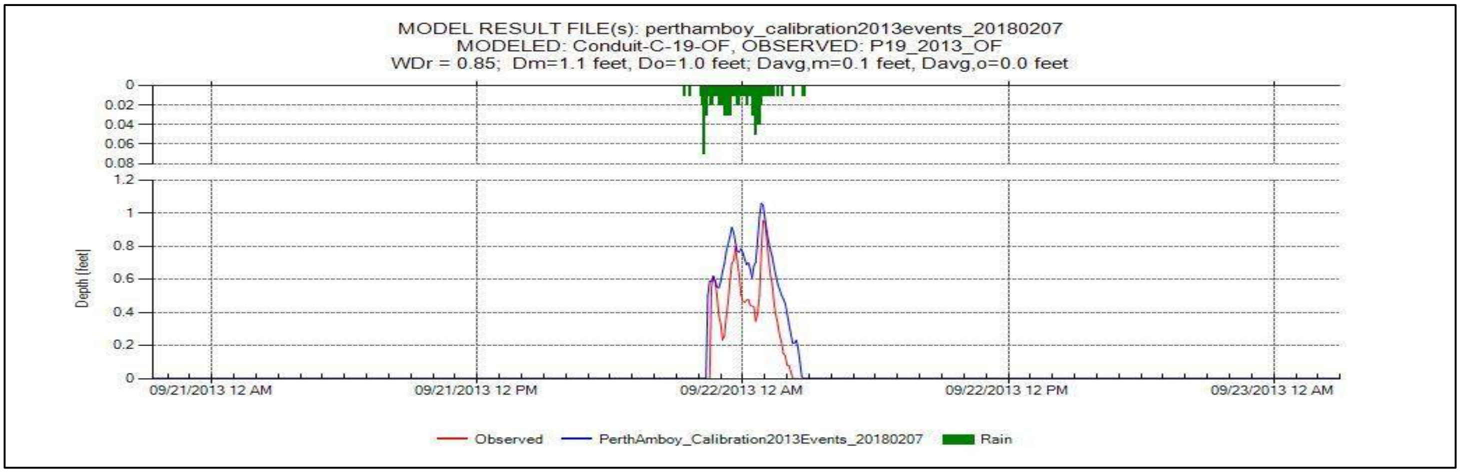
P19_2013_OF


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.93; Dm=2.7 feet, Do=3.0 feet; Davg,m=0.1 feet, Davg,o=0.1 feet
Depth (feet)
08/31/2013 12 PM
09/01/2013 12 AM
09/01/2013 12 PM
09/02/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.78; Dm=1.0 feet, Do=0.8 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
09/02/2013 12 AM
09/02/2013 12 PM
09/03/2013 12 AM
09/03/2013 12 PM
09/04/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.81; Dm=1.4 feet, Do=1.9 feet; Davg,m=0.0 feet, Davg,o=0.0 feet
Depth (feet)
09/12/2013 12 AM
09/12/2013 12 PM
09/13/2013 12 AM
09/13/2013 12 PM
09/14/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

P19_2013_OF


MODEL RESULT FILE(s): perthamboy_calibration2013events_20180207
MODELED: Conduit-C-19-OF, OBSERVED: P19_2013_OF
WDr = 0.85; Dm=1.1 feet, Do=1.0 feet; Davg,m=0.1 feet, Davg,o=0.0 feet
Depth (feet)
09/21/2013 12 AM
09/21/2013 12 PM
09/22/2013 12 AM
09/22/2013 12 PM
09/23/2013 12 AM
Observed
PerthAmboy_Calibration2013Events_20180207
Rain

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