DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT
GREEN INFRASTRUCTURE PROGRAM

PRACTICABILITY ASSESSMENT FOR ROCK CREEK GREEN INFRASTRUCTURE

June 2020

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Executive Summary

ES.1 Introduction

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP), also referred to as the DC Clean Rivers Project (DCCR), to control combined sewer overflows (CSOs) to the District of Columbia's (District) waterways. DCCR is comprised of a variety of projects to control CSOs, including pumping station rehabilitations, green infrastructure (GI), and a system of underground storage/conveyance tunnels. DCCR is being implemented in accordance with a first amendment to the Consent Decree (Amended Consent Decree), entered on January 14, 2016, which amends and supersedes the 2005 Consent Decree (Consent Decree) and incorporates GI, in a combination of gray and green solutions to control CSOs while improving the quality of life in the District.

GI can provide environmental, social, and economic benefits not offered by traditional gray infrastructure

GI uses plants, trees, engineered soil mixes, aggregate storage and other measures to mimic natural processes to control stormwater, resulting in cleaned, cooled, and slowed stormwater runoff. These systems promote stormwater detention and infiltration into the soil and include techniques such as pervious pavements, bioretention (rain gardens), rain barrels and downspout disconnections, as well as other technologies. By integrating natural processes into the urban environment, GI provides not only stormwater management, but also supports additional benefits such as local job creation, improved air quality, a cooler city, greener public and private spaces, added bird and pollinator habitat, increased property values, and greenhouse gas mitigation.

ES.2 Amended Consent Decree Requirements

The Amended Consent Decree specifies the projects that must be implement in the Anacostia River, Potomac River, and Rock Creek sewersheds and stipulated deadlines for placing those projects in operation. Figure ES-1 shows the projects required under the Amended Consent Decree.

Because GI had not been implemented on a large scale in an urban setting, the Consent Decree provides for a testing and evaluation process

When the Consent Decree was amended, it was recognized that GI had not been implemented previously on a large scale in an ultra-urban area to provide a high degree of CSO control. As a result, its effectiveness, cost, and practicality were unknown. The Amended Consent Decree therefore provided for DC Water to construct demonstration projects in the Potomac and Rock Creek sewersheds and to evaluate their cost, performance, and other characteristics. Based on that evaluation, the Amended Consent Decree requires DC Water to determine the practicability of GI. If DC Water determined that GI is practicable, then the remaining GI projects would be implemented to control the specified CSOs. If DC Water determined that GI is not practicable, then DC Water would revert to the gray controls. Both the Rock Creek and Potomac sewersheds are required to be evaluated, and separate determinations may be made regarding the practicability of continuing with an all green application within the respective sewershed. This document presents the results of the practicability assessment for GI in the Rock Creek sewershed.

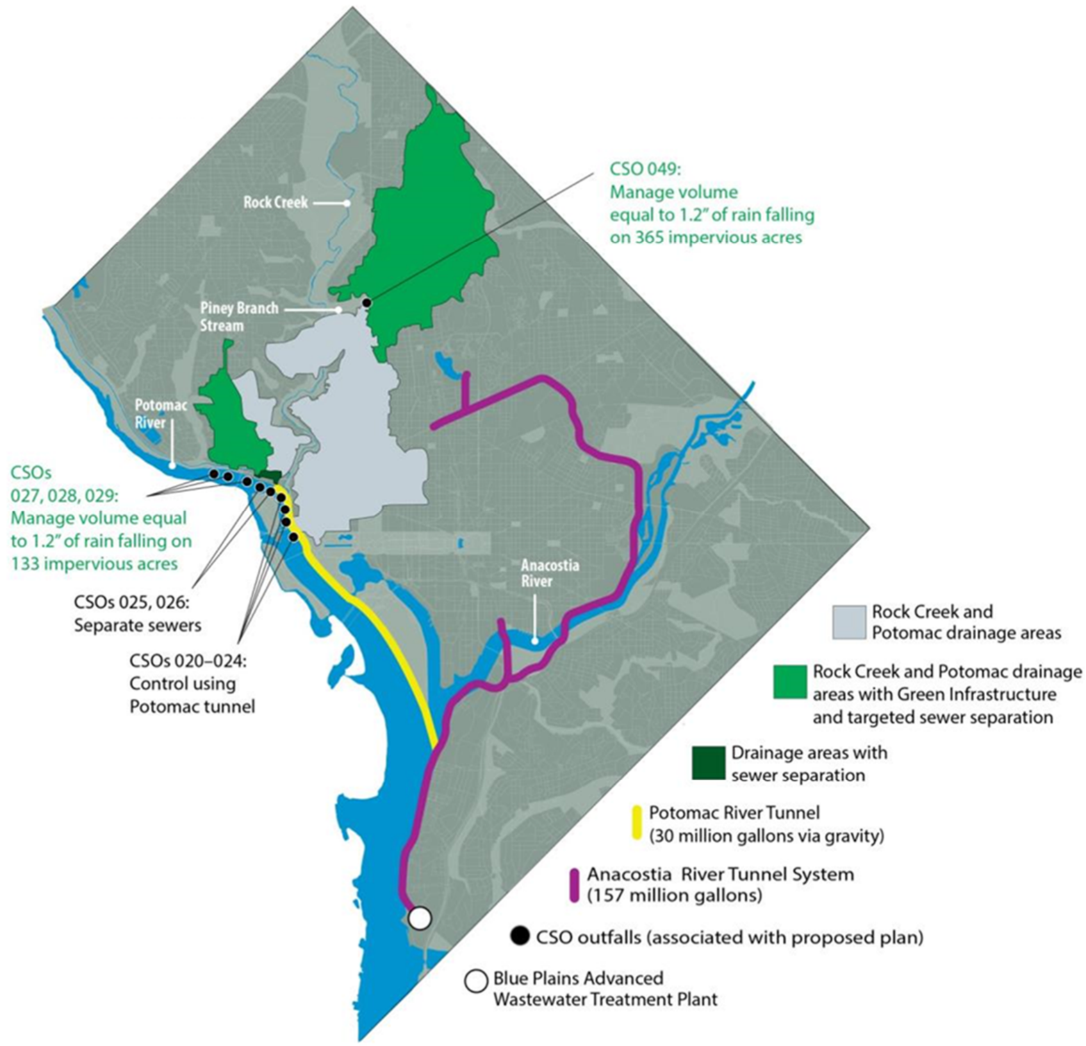


Figure ES-1. Clean Rivers Project

The District applies its stormwater regulations in both the combined and separate stormwater sewersheds. As a result, the Amended Consent Decree allows DC Water to take credit for stormwater controls constructed pursuant to the District's stormwater regulations in the applicable CSO areas. These are stormwater measures that have been implemented due to redevelopment, and paid for by District business owners, residents, and taxpayers. These measures contribute to the overall volume managed in the sewershed, and collectively help to reduce stormwater runoff that contributes to combined sewer overflows from the Rock Creek sewershed at Piney Branch CSO 049.

ES.3 DC Water's Investments to Evaluate Green Infrastructure

DC Water has made major investments to advance the state of GI and to make the evaluation regarding practicability. This includes going above and beyond the minimum requirements of the Consent Decree. Figure ES-2 illustrates the projects and initiatives undertaken that inform and support elements of the practicability assessment. In total these efforts comprise an investment of more than $80M with more than several hundred-thousand person hours of effort.

DC Water has invested more than $80M and several hundred thousand person-hours advancing GI

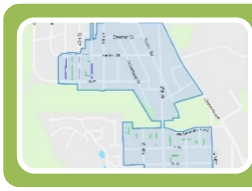
GI projects constructed within both the Rock Creek sewershed and Potomac River sewershed provide the basis for assessing the practicability of future GI implementation in the Rock Creek sewershed to achieve the requirements of the Amended Consent Decree.

Most of the GI control measures planned and implemented by DC Water were constructed in public rights of way (ROW), specifically planter strips, alleys, and roadways. These include bioretention in the planter strip between the curb and the sidewalk, bioretention as curb extensions, subsurface storage, and permeable pavement in alleys and parking lanes. A select number of controls were implemented in small public parks. Additional GI controls were implemented on private properties, specifically downspout disconnections.

While DC Water's experience in the GI arena is vast, not all of these projects can be counted towards the requirements of the Consent Decree. They do however contribute to the depth of institutional knowledge that has informed the conclusions of this Practicability Assessment. Table ES-1 summarizes the GI practices constructed for both Rock Creek Project No. 1 and Potomac River Project No. 1, followed by the number of impervious acres managed in each.

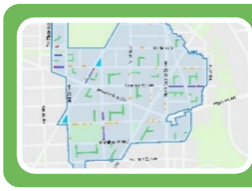
Table ES-1. Summary of GI Projects for CSO Control

Sewershed	Project	Impervious Acres Managed				
		Bioretention	Permeable Pavement	Targeted Sewer Separation	Downspout Disconnect	Total
Rock Creek Project 1	RC-A	3.9	14.9			18.8
	Kennedy Street	1.2	1.5			2.7
	Challenge Parks	1.9				1.9
	AlleyPalooza		3.0			3.0
	Downspout Disconnect				1.0	1.0
	Subtotal Rock Creek	**7.0**	**19.4**	**0.0**	**1.0**	**27.4**
Potomac River Project 1	PR-A	0.3	7.5	67.5		75.3
	AlleyPalooza		0.1			0.1
	Downspout Disconnect				0.2	0.2
	Subtotal Potomac River	**0.3**	**7.6**	**67.5**	**0.2**	**75.6**
Grand Total		**7.3**	**27.0**	**67.5**	**1.2**	**103.0**



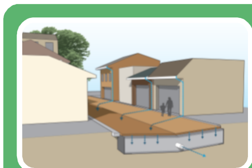
Potomac River Project A

- First large scale GI project for CSO control in Potomac River sewershed
- Manages 75.3 impervious acres
- Consists of a combination of GI in public right of way and targeted sewer separation



Rock Creek Project A

- First large scale GI project for CSO control in the Rock Creek sewershed
- Manages 18.8 impervious acres
- Consists primarily of bioretention, porous pavement in the parking land and permeable alleys



AlleyPalooza Partnership with DDOT

- Constructed under a DDOT contract, consists of 7 permeable alleys in Rock Creek and Potomac River sewersheds managing 3.1 impervious acres
- Utilized inovative standard design details and specifications in combination with a DOEE blanket permit to streamline implementation while lowering costs

Downspout Disconnection

- Program for District Residents to disconnect their home's downspouts from the combined sewer and redirect flow onto landscaped areas
- Manages 1.2 impervious acres in the Rock Creek and Potomac sewersheds
- Over 280 homes have participated to date

GI Challenge - Kennedy Street GI Streetscape

- Showcase GI streetscape located on the 100 block of Kennedy Street NW
- Manages 2.7 impervious acres
- Consists of inovative GI in public right of way, utilizing GI as an amenity through revealed stormwater management and public art elements

GI Challenge - GI Parks Project

- Showcase 2 GI parks projects located along Kansas Avenue NW
- Manages 1.9 impervious acres
- Utilizes GI as an amenity through revealed stormwater management with functional and aesthetic improvements to the parks

DC Water GI Utility Protection Guidelines

- Establishes protocols and protective measures for the design and construction of GI near traditional DC Water sewer and water infrastructure
- Utilized by DC Water, other District agencies and utilities, as well as developers and others engaging in construction of GI in the public right of way

DC Water GI Design Standards

- Development of GI Details and Specifications for CSO control.
- Utilized on Rock Creek Project A and as the basis for work that followed
- Consists of details and specifications for permeable pavement, bioretention, and other common elements of GI.

Figure ES-2. Investments in Support of GI

National Green Infrastructure Certification Program

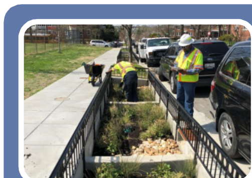
- DC Water partnered with the Water Environment Federation to launch the National Green Infrastructure Ceritfication Program (NGICP) for entry level GI professionals
- Provided nealy $1M in seed capital, recruited 14 other municipalities to join at $50K each

NGICP Training and Workforce Development

- Working with the University of the District of Columbia (UDC) DC water has funded NGICP training for District residents since 2016
- Program has trained over 150 District Residents
- Consists of hands on training, class-time, field work, and job placement assistance

Blanket Permit with District Department of Energy and Environment

- In coordination with DDOT and DOEE utilized a blanket permit approach for implementing standardized permebale alleys in the District
- Approach streamlines the siting, approval, and construction process for permeable alleys



Standardized Designs for Permeable Pavement

- Building off of DCW GI Design Standards, established standardized designs for alley permeable pavement and planter bioretention.
- Approach helped drive down costs and streamline approvals and construction processes

Partner With Local Schools and Universities

- Developed concept plans incorporating GI in the redesign of Georgetown University's Healy Lawn
- Drafted concept plans for GI educational spaces at Washington Latin Public Charter School and Paul Public Charter School

Figure ES-2 (continued). Investments in Support of GI

ES.4 Results of Our Assessments

The Consent Decree provides for assessing the practicability of GI considering constructability, operability, efficacy, public acceptability, and cost per impervious acre treated. Table ES-2 summarizes the results of the assessment and the section below explains the rationale.

Table ES-2. Results of Practicability Assessment

Criteria	Assessment	Basis
Constructability	Good	Projects are constructible with normal construction practices
Public Acceptance	Good	• Survey conducted of homes in project area • Survey results: 64% of residents would like more GI in their neighborhood
Efficacy	Good	• Can be designed and constructed to perform as predicted • Lessons learned can be applied going forward
Operability	Moderate	• Maintenance is simple, but is essential to assure performance • If not maintained adequately, performance can suffer
Cost Effectiveness (Targeted GI)	Good	• Cost can be competitive with gray
Cost Effectiveness (Retrofit Public Space)	Negative	• Costs much higher than gray
Other – Triple Bottom Line and Economic Benefits	Good	• Community and economic benefits substantially higher with Green Infrastructure

- ***Constructability***
  DC Water was able to site, permit, and construct GI practices in public space for Rock Creek Project No. 1. The projects are constructible by conventional construction methods and contractors are available to perform the work. From a constructability standpoint, GI is practicable.

- ***Operability***
  While the DC Water-constructed GI practices do not require active operation, regular maintenance is required to assure adequate performance. Maintenance techniques and equipment are relatively straightforward and can be performed by conventional crews that can be trained on the specifics within reasonable times. From an operability standpoint, GI is practicable.

- ***Efficacy***
  Approximately one year of pre- and post-construction monitoring was conducted, and the collection system model was then run for the average year (1988-1990) to make predictions regarding wet weather flow volume (WWF) reduction. WWF volumes are defined as occurring when predicted flows in the sewer exceed two times average dry weather flow rate. The reduction in WWF volumes were calculated by taking the difference between pre- and post-construction WWF volumes and divided by the number of impervious acres treated at 1.2” to determine the WWF reduction in million gallons per average year per impervious acres treated at 1.2”. Table ES-3 summarizes the results.

Table ES-3. Average Year Predictions Based on Post Construction Monitoring

Sewershed	Imp. Acres treated by GI (% of total)	WWF Volume (mg)		Volume Reduction Normalized per Imp Ac Treated (%)	
		Pre-Construction	Post-Construction	Actual	Predicted
RC-A (After Retrofits)	28.8 %	26.66	22.90	18.68%	30.2%
PR-A	9.1 %	77.73	72.56	6.65%	6.65%

One of the purposes of the initial projects constructed in the Rock Creek and Potomac Basins was to evaluate the effectiveness of GI using adaptive management. This means developing different design and construction methods, learning based on the results and revising subsequent projects using the lessons learned. Rock Creek was the first project constructed and initial data indicated it was underperforming in terms of capture. Retrofits have been implemented in Rock Creek and performance has been improving. This data will continue to be assessed as additional data are collected. The lessons learned on the first Rock Creek project were incorporated into the subsequent Potomac Project. The Potomac monitoring and modeling demonstrate that incorporation of appropriate lessons learned, allows GI to be constructed and to perform as predicted. Knowledge was gained through this process which provides a template for the design of subsequent projects to meet performance objectives. Based on the performance of PR-A and the lessons learned from PR-A and other projects, efficacy of GI is practicable.

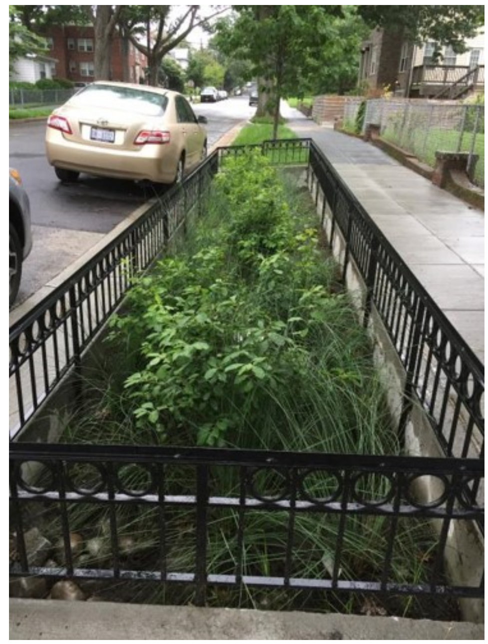
- ***Public Acceptability***
  Rock Creek Project A received a majority of positive feedback and praise from the community:

  - 68% would like a significant amount or quite a bit more of GI in their neighborhood
  - 79% would like a significant amount or quite a bit more of GI in the District
  - 82% felt GI brought a benefit to their neighborhood

- Cleaner rivers/better water quality was rated the most important benefit of GI, with improved infrastructure such as repaved alleys rated the next most important benefit

From a public acceptability standpoint, GI is practicable.

- ***Cost Effectiveness***
The cost to implement GI covers a spectrum from low to high cost. Examples of lower cost GI include open space bioretention and adding GI to an existing capital project. Examples of higher cost GI include those requiring utility relocation, small projects with limited space and small drainage areas and projects requiring significant surface restoration. DC Water's analyses indicate that to manage 365 impervious acres, there is inadequate low-cost GI in the sewershed and that significant amounts of high cost GI would be required.



DC Water compared the cost of all green to all gray to control CSO 049 in Piney Branch in Table ES-4. The cost to construct, operate and maintain an all green option is considerably higher than that of an all gray alternative. Projecting this over a 30-year period, implementing an all green option is approximately 95% more expensive than an all gray option. From a cost effectiveness standpoint, GI is not practicable in the Rock Creek sewershed.

Table ES-4. Cost Effectiveness Analysis (Year 2020 Dollars)

Alt.	Description	Capital Cost ($M)	O&M Cost ($M/yr.)	NPV 30 years ($M)
1	All Gray - 9.5 MG Storage	$ 185	$ 0.28	$ 211
2	All Green – Manage 365 ac to 1.2" retention standard	$ 208	$ 4.41	$ 407

- ***Triple Bottom Line and Economic Benefits***
DC Water prepared an analysis of the co-benefits of GI including air emission reduction, impacts on property values, carbon emission reductions, green jobs benefits and several other factors. The analysis shows that green infrastructure offers significant advantages compared to gray infrastructure in terms of providing these co-benefits. This was a factor in evaluating the recommended path forward for the Authority.

ES.5 Hybrid Plan – the Best of Green and Gray

The Hybrid Plan combined the best features of Green and Gray to achieve same 9.5 million gallons

DC Water has determined that implementation of only GI to control at least 365 acres to the 1.2” Retention Standard in the CSO 049 sewershed is not practicable. This determination is not from a lack of space, but rather due to the considerably higher cost of implementing and maintaining 365 acres of GI as confirmed by the 30-year net present value (NPV) (combining capital costs and long-term operations and maintenance costs) of GI. When compared over 30 years, GI is nearly twice as expensive as the gray alternative of constructing, operating, and maintaining a 9.5 MG storage facility. Ratepayers are making an enormous investment in CSO control and there is significant hardship among many facets of the community. Affordability considerations and DC Water’s fiduciary responsibility to ratepayers dictate that a GI only solution for this CSO is impracticable.

While it is impracticable to control Piney Branch CSO 049 with an all green solution, it is both practicable and advantageous to select the right mix of green and gray controls to maximize benefits. DC Water’s Hybrid Plan selects the best features of both green and gray in an effective and financially responsible manner. The Hybrid Plan provides an equivalent 9.5 million gallons of control and is summarized in Table ES-5.

Table ES-5. Hybrid Plan

Measure	Description	Volume (mg)	Capital Cost ($M)	O&M Cost ($M/yr.)	NPV 30 years ($M)
Targeted GI by DC Water	DC Water has constructed approximately 0.9 mg[1] as part of Project No.1. By focusing on targeted GI and downspout disconnect, DC Water will construct an additional 2.1 mg[1] for grand total of 3 mg[1]	3.0	$ 52	$ 1.34	$ 113
Gray Storage	DC Water will construct a 4.2-million-gallon storage project at the Piney Branch CSO to control this outfall.	4.2	$ 82	$ 0.15	$ 94
Credit District’s Stormwater Controls	DC Water will credit the GI measures constructed by public and private entities in the Piney Branch sewershed pursuant to the District’s stormwater Regulations	2.3	$ -	$ -	$ -
Total		9.5	**$ 133**	**$ 1.49**	**$ 207**

Notes:
1. Units conversions are: 0.9 mg = 27.4 impervious acres @ 1.2”
2.1 mg = 64.0 impervious acres @1.2”
3.0 mg = 92.0 impervious acres @ 1.2”

The Hybrid Plan offers many advantages to District ratepayers and residents and is recommended by DC Water for the following principal reasons:

- ***Best Mix of Green and Gray to Achieve Same 9.5 Million Gallons***
  The hybrid approach achieves the same volume equivalence of 9.5 million gallons of storage as the all gray alternative by integrating the best features of green and gray for an optimized solution.

- ***Maintains DC Water's Commitment to the Success of GI in District of Columbia***
  DC Water's leadership and stewardship in GI will continue under the Hybrid Plan to achieve economic, social, and environmental benefits for District residents.

- ***Equivalent Level of Performance***
  Modeling demonstrates that the Hybrid Plan will achieve the <u>*same degree of CSO control*</u> as the LTCP. There is no change in DC Water's commitment to the degree of CSO control.

- ***Same Technologies as Original Plan***
  The Hybrid Plan uses the same technologies as the LTCP – storage and GI to achieve CSO reductions. There are no unproven or new technologies that may jeopardize CSO performance objectives.

- ***Certain CSO performance***
  The Hybrid Plan includes gray storage which has been proven reliable and effective on the Anacostia in achieving CSO reductions, even during the wettest year on record in the District of Columbia (2018).

- ***Fiscally Responsible***
  The Hybrid Plan is the most cost effective on a capital cost basis and is comparable to gray on a net present worth basis. This maintains DC Water's responsibility to ratepayers who fund the majority of the project.

- ***Same Schedule***
  The Hybrid Plan will be implemented with the same schedule deadline in the Amended Consent Decree – by March 23, 2030.

1 Introduction

1.1 Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP), also referred to as the DC Clean Rivers Project (DCCR), to control combined sewer overflows (CSOs) to the District of Columbia's (District) waterways. DCCR is comprised of a variety of projects to control CSOs, including pumping station rehabilitation, targeted sewer separation, green infrastructure (GI), and a system of underground storage/conveyance tunnels. DCCR is being implemented in accordance with a first amendment to the Consent Decree (Amended Consent Decree), entered on January 14, 2016, which amends and supersedes the 2005 Consent Decree (Consent Decree) and incorporates GI, in a combination of gray and green solutions to control CSOs while improving the quality of life in the District. The Amended Consent Decree requirements are outlined in Section 1.2. The Amended Consent Decree is provided in Appendix A.

The purpose of this document is to comply with the Amended Consent Decree requirement to submit the results of the Rock Creek GI Practicability Assessment. Additionally, the Post Construction Report No. 1 for Rock Creek GI, also required by the Amended Consent Decree, can be found in Appendix B of this report.

1.2 Amended Consent Decree Requirements

The Amended Consent Decree specifies the necessary requirements for projects that DCCR must implement in all three sewersheds (Anacostia River, Potomac River, and Rock Creek) and deadlines for the implementation of these projects. Figure 1-1 shows the projects required under the Amended Consent Decree. In the event DC Water determines that it is not practicable to control the required acres through the use of GI in the Rock Creek or Potomac sewersheds, the Amended Consent Decree currently requires DC Water to construct an all gray alternative. Both the Rock Creek and Potomac sewersheds shall be evaluated, and separate determinations will be made regarding the practicability of continuing with an all green application within the respective sewershed. The Practicability Assessment for GI in the Rock Creek sewershed is made within the body of this report, while the Practicability Assessment for GI in the Potomac River sewershed shall be made under separate cover. The requirements and deadlines of the Amended Consent Decree specific to GI implementation in the Rock Creek and Potomac River sewersheds are described in the following subsections.

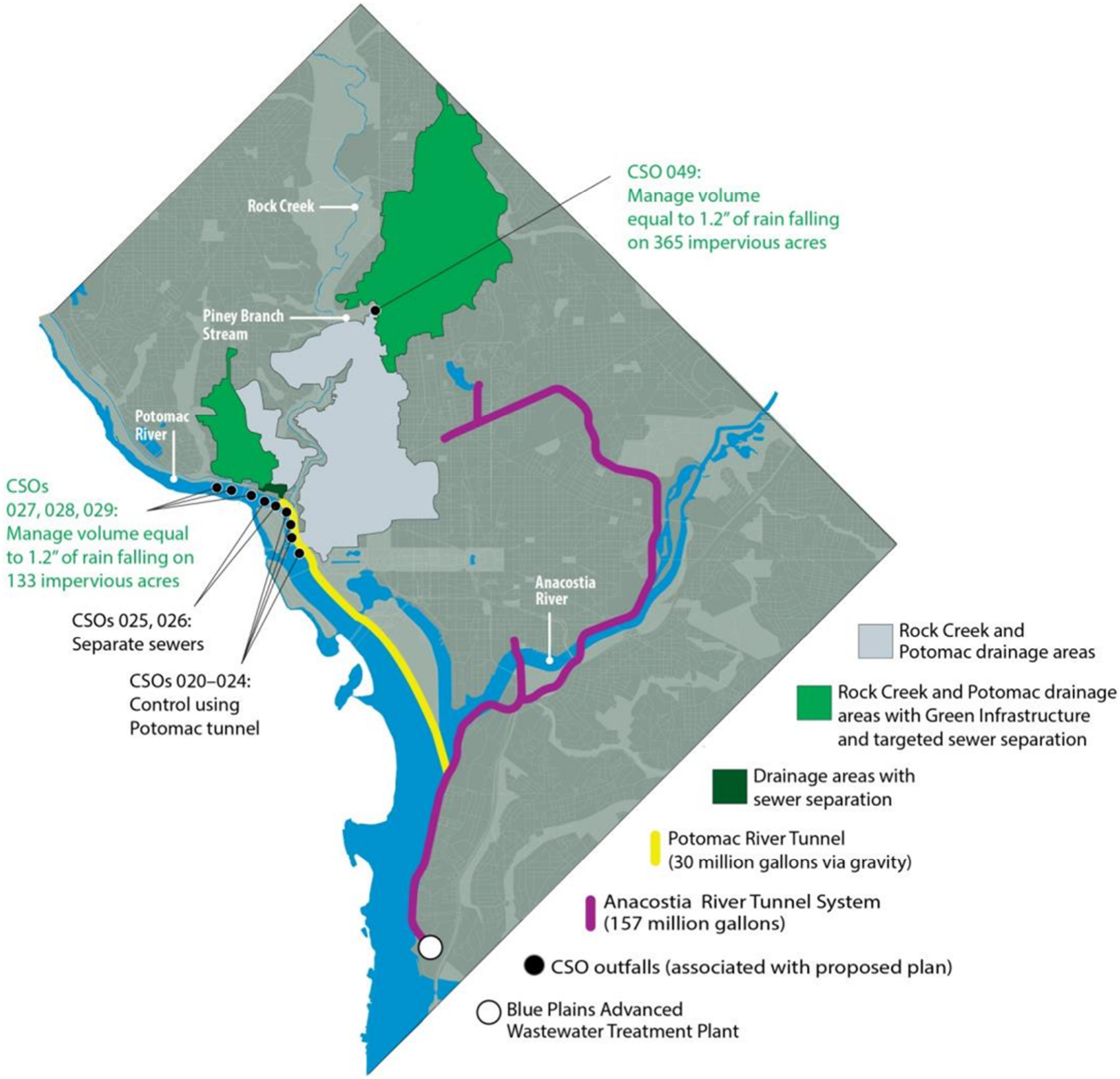


Figure 1-1. Amended Consent Decree Requirements

1.2.1 Rock Creek Sewershed GI Projects

The Amended Consent Decree requires that GI be constructed in the Piney Branch drainage area (CSO 049) within the Rock Creek sewershed to manage the volume of runoff produced by 1.2" of rain falling on 365 impervious acres (30% of the total impervious acres) in the sewershed. Table 1-1 lists the five Rock Creek sewershed projects required to achieve the 365 impervious acres and each project's associated schedule that are part of the Amended Consent Decree.

Table 1-1. Rock Creek Sewershed Projects in Amended Consent Decree

Project No:	Impervious Acres to Control to 1.2" Retention Standard	Date to Award Contract for Construction	Date to Place in Operation
1	20	March 30, 2017	March 30, 2019
2	75	January 23, 2022	January 23, 2024
3	90	March 23, 2025	March 23, 2027
4	90	September 30, 2027	September 30, 2029
5	90	March 23, 2028	March 23, 2030

Appendix F, Section II.D.7 requires that:

> "No later than 15 months following the Place in Operation date for Project 1 above, DC Water shall submit to EPA and the District Post Construction Monitoring Report No.1 for the Rock Creek Sewershed Projects (Rock Creek Report No. 1). In addition to the information required in Subsection II.B above [sic], the report shall contain DC Water's determination of the practicability of controlling at least 365 acres to the 1.2" Retention Standard in the CSO 049 sewershed by the Place in Operation deadline for Project No. 5 above based on its experience with implementing Project No. 1. Such determination shall consider the constructability, operability, efficacy, public acceptability and cost per impervious acre treated of the controls."

In addition to the Practicability Assessment, Appendix F, Section II.B, states:

> "Six months following the completion of the project's post construction monitoring program, DC Water shall submit a Post Construction Report for EPA review and comment. The Post Construction Report shall contain:
>
> 1. A comparison of planned projects under the Project Description and actual implemented projects:
>   a. Costs
>   b. Acreage treated to 1.2" retention standard
>   c. Estimate of run-off control
> 2. Identification of barriers to implementation of projects and steps taken by DC Water and the District to address any identified barriers for this and future projects
> 3. Post Construction Monitoring and Modeling Program results assessing the efficiency of the controls implemented
> 4. Changes proposed for future projects"

1.2.2 Potomac River Sewershed GI Projects

The Amended Consent Decree requires that GI be constructed in the drainage areas for CSOs 027, 028, and 029 within the Potomac River sewershed to manage the volume of runoff produced by 1.2” of rain falling on 133 impervious acres in the sewershed. The number of impervious acres is equivalent to 30% of total impervious acres in the CSOs 027 and 028 sewersheds, and 60% of total impervious acres in the CSO 029 sewershed. Table 1-2 lists the three Potomac River sewershed projects required to achieve the 133 impervious acres and each project’s associated schedule that are part of the Amended Consent Decree.

Table 1-2. Potomac River Sewershed Projects in Amended Consent Decree

Project No	Impervious Acres to Control to 1.2” Retention Standard	Date to Award Contract for Construction	Date to Place in Operation
1	44	June 23, 2017	June 23, 2019
2	46	June 23, 2022	June 23, 2024
3	43	June 23, 2025	June 23, 2027

As with Rock Creek, Appendix F, Section II.C.5 requires submittal of a Practicability Assessment within 15 months of the place in operation date for Potomac Project 1 and a Post Construction Monitoring Report within 6 months after completion of post construction monitoring for Potomac Project No. 1. The Practicability Assessment and Post Construction Report No. 1 for Potomac River Green Infrastructure will be submitted under separate cover.

1.2.3 Definition of 1.2” Retention Standard

As defined in the Amended Consent Decree, Section IV, Page 12, the “1.2” Retention Standard” is “the volume of water runoff produced by 1.2 inches of rain falling on an impervious surface.” To achieve the Amended Consent Decree requirements, GI control measures are to be designed and constructed to collectively manage the required number of impervious acres to the 1.2” Retention Standard. The volume managed by individual GI control measures will be maximized within site constraints. The 1.2” Retention Standard for any particular project will be achieved by managing 1.2” over the project area for the project drainage area. Table 1-3 presents the impervious area treated requirements for each sewershed.

Table 1-3. Impervious Area Treated Requirements

Sewershed	Impervious Area Treated (acres)
CSO 049	365
CSO 027	31
CSO 028	4
CSO 029	98
Total	**498**

2 Basis for Evaluation

This Section provides a summary of the various GI projects constructed within both the Rock Creek sewershed (Rock Creek Project No. 1) and Potomac River sewershed (Potomac River No. 1) under the Amended Consent Decree. DC Water's experience implementing these projects provides the basis for assessing the practicability of future GI implementation in the Rock Creek sewershed to achieve the requirements of the Amended Consent Decree. Assessment of practicability will be discussed in Section 3. Review of the following data is included in the Basis for Evaluation Section:

- Scope of Constructed Projects
- Project Delivery Method
- Basis for Design and Construction Details
- Performance Acceptance Testing
- Improvements After Construction
- Maintenance
- Monitoring and Modeling Program
- Cost
- Public Acceptance
- Other Efforts in Support of GI
- Acres pursuant to District's Stormwater Regulations (MS4)

2.1 Scope of Constructed Projects

Most of the GI control measures planned and implemented by DC Water in the District were constructed in public rights of way (ROW), specifically planter strips, alleys, and roadways. These include bioretention in the planter strip between the curb and the sidewalk, bioretention as curb extensions, subsurface storage, and permeable pavement in alleys and parking lanes. A select number of controls were implemented in small public parks. Additional GI controls were implemented on private properties, specifically downspout disconnections.

Rock Creek Project No. 1 includes the following: Rock Creek Project A (RC-A), Kennedy Street – GI Streetscape, GI Challenge Parks, Green Alley Partnership (AlleyPalooza), and Downspout Disconnections. Potomac River Project No. 1 included the following: Potomac River Project A (PR-A), Targeted Sewer Separation, Green Alley Partnership (AlleyPalooza), and Downspout Disconnections. A synopsis of each of these projects within Rock Creek Project No. 1 and Potomac River Project No. 1 are listed below. Table 2-1 at the end of this subsection summarizes the number of GI practices (including sewer separation) constructed for both Rock Creek Project No. 1 and Potomac River Project No. 1, followed by the number of impervious acres managed in each.

2.1.1 Rock Creek Project A (RC-A)

Rock Creek Project A (RC-A) was the first large scale GI project constructed in the Rock Creek sewershed by DC Water. The project area is mostly residential in nature, mainly comprised of 55 city blocks of row houses predominantly within the Brightwood Park and Manor Park neighborhoods of northwest Washington, DC. The project area is bounded by Oglethorpe Street NW and Gallatin Street NW to the north and south, respectively, and 1st Street NE and 3rd Place NW to the east and west, respectively. Refer to the Rock Creek GI Project A area as shown in Figure 2-1.

An extensive planning effort was undertaken in 2016 to identify and determine the extents of RC-A. This planning effort was summarized in the July 2016 GI Program Plan submitted to EPA. Every block within the CSO 049 sewershed was categorized for GI feasibility using geographic information system (GIS) data and visualization. Opportunities for GI siting as well as constraints were identified. Opportunities included open space in the planting strips for bioretention siting, alleyways that were classified as being in poor to fair condition by DDOT, and locations that would receive sufficient stormwater flow to capture 1.2” of rainfall from the contributing drainage area. Constraints included large trees, density of existing utilities, width of planting strips, steep slopes, and other site conditions that would preclude or drive up the cost of GI implementation. Ultimately, average or typical block conditions were identified, and GI was conceptually sited across the entire CSO 049 sewershed to understand what density was required on a block-by-block level to confirm and understand what a full 365 acres managed by GI build-out would look like. The boundary of RC-A was ultimately delineated as the characteristics of the neighborhood closely matched the typical characteristics that were expected to be encountered through a full program build-out, as well as the density and concentration of GI placement that would ultimately achieve 365 acres managed, again in the full build-out scenario.

Other drivers for determining the extents of the RC-A project area included the location of three sites where GI implementation was already in development through the Green Infrastructure Challenge; the GI Challenge Parks located at Kansas Avenue and 3rd Street NW and Kansas Avenue and 2nd Street NW, respectively, and the Kennedy Street GI Challenge Streetscape, located on the 100 block of Kennedy Street NW. Finally, the subsurface sewer network was overlaid, and a series of distinct monitoring locations were identified so that much of the rainfall within the project boundary could be measured at select points within the sewer network.

As shown in Figure 2-2, the RC-A project consisted of the design and construction of thirty-six (36) planter bioretentions, two (2) curb extension bioretentions, eight (8) parking lane permeable pavements and thirty-one (31) alley permeable pavements implemented through a design-build process. The installed green infrastructure followed DC Water and District design standards, which were customized for site-specific sizing considerations, as well as standardized designs for a portion of the alley facilities (utilizing standard depths and check dam spacing).

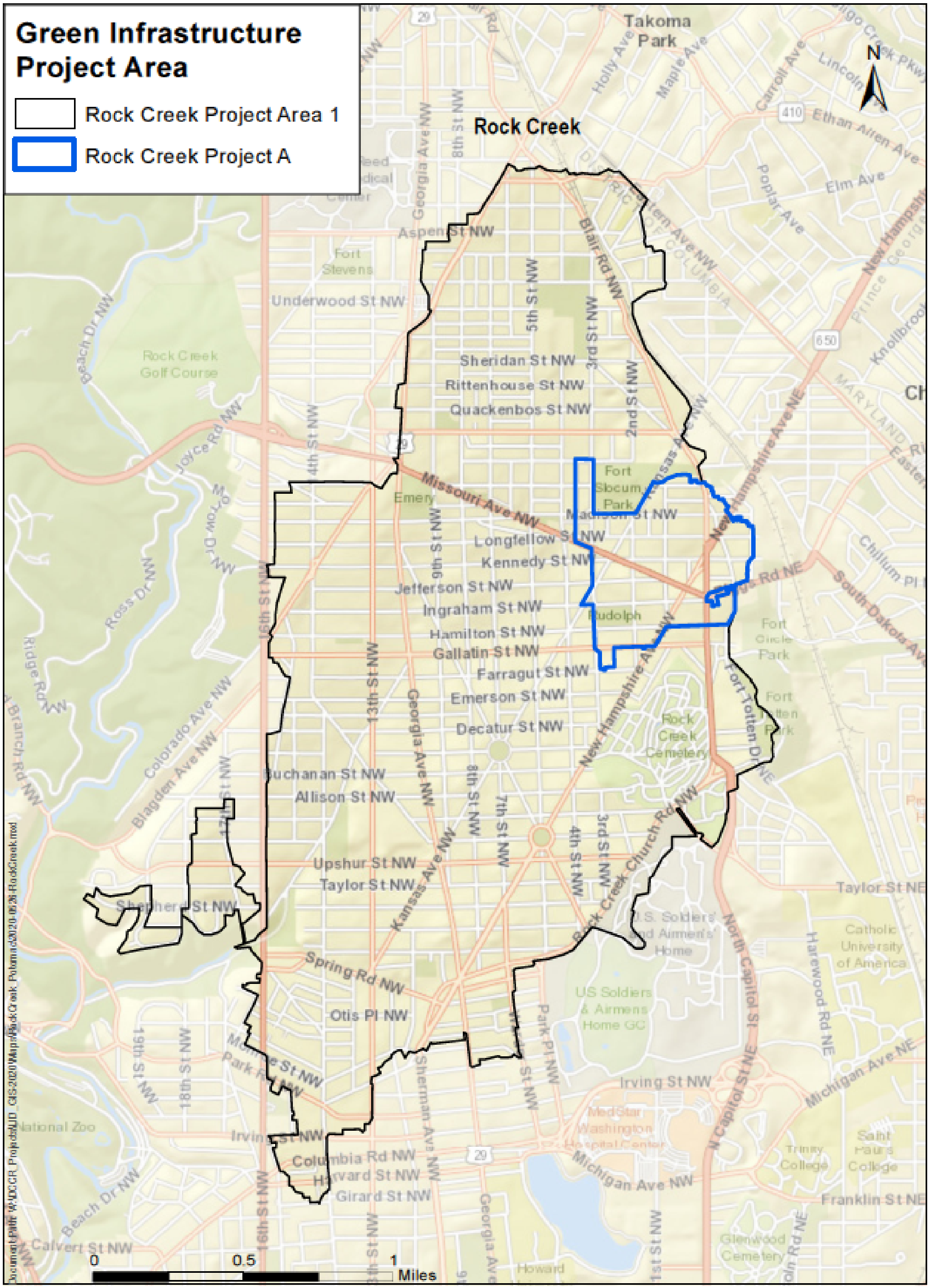


Figure 2-1. Rock Creek Project No. 1 Area and Rock Creek GI Project A

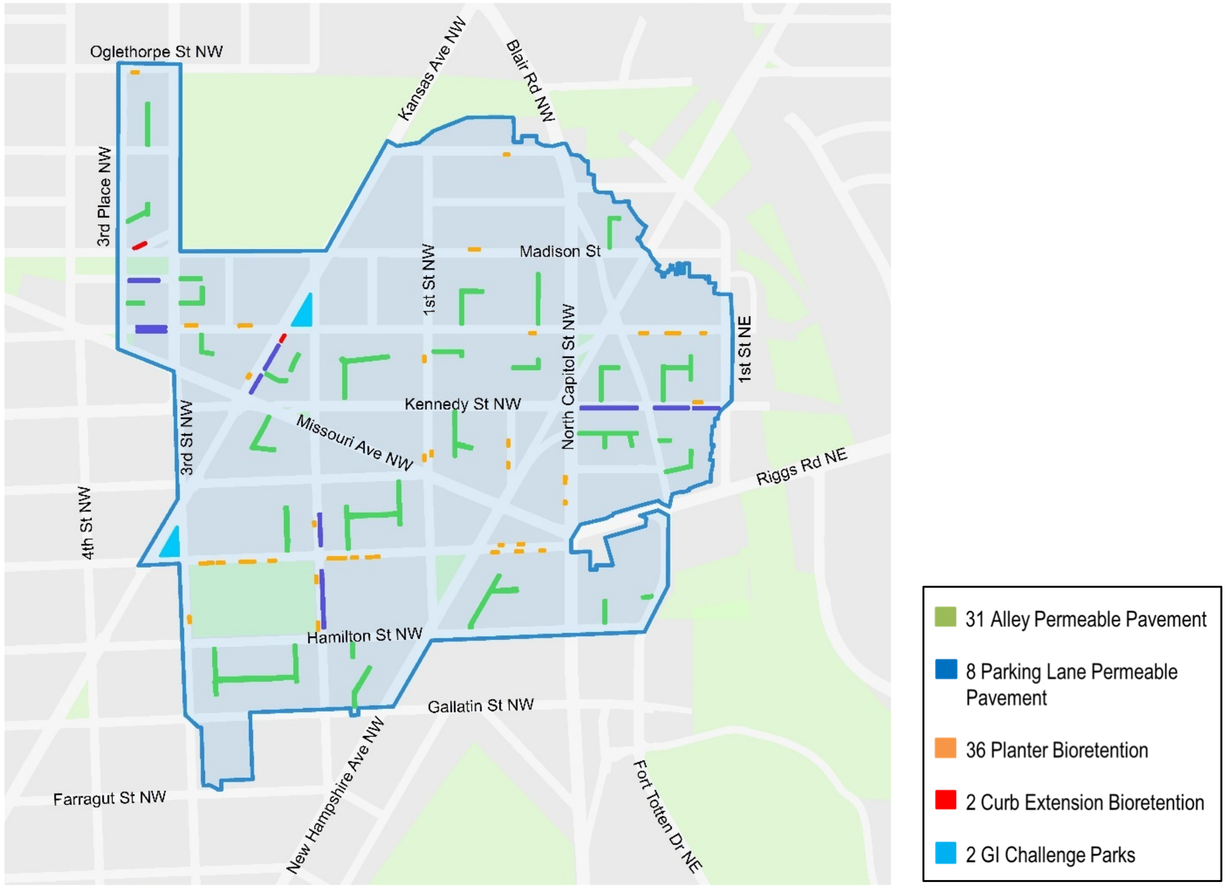


Figure 2-2. Rock Creek Project A (RC-A) GI Practice Locations

2.1.2 Kennedy Street – GI Streetscape (Rock Creek Sewershed)

In April 2013, DC Water launched the GI Challenge Streetscape Project, engaging firms to design innovative, cost effective, replicable, and high performing green infrastructure practices to be implemented on the 100 block of Kennedy Street NW, in the heart of the RC-A project area. Highlights of the design challenge are presented in Appendix C. This project was ultimately made part of the larger Kennedy Street Revitalization Project, a partnership between DC Water, the District of Columbia Mayor's Office, and the District Department of Transportation (DDOT). The GI practices implemented through this project included bioretention (rain gardens), permeable parking lanes, permeable sidewalk pavers, and landscape infiltration gaps. New street trees, traffic calming measures, and stormwater-related educational art were also included in the project. Kennedy Street was implemented utilizing a design-bid-build project delivery method and followed District GI design standards that were customized for site conditions and innovative applications of GI. The Kennedy Street GI Streetscape Project is also referred to as Rock Creek Project B (RC-B) within this report. This showcase project is a frequent stop for groups interested in learning more about DC Water's GI program, as well as a location utilized for in-field training for local residents participating in the National Green Infrastructure Certification Program

(NGICP) training that DC Water runs in partnership with the University of the District of Columbia (Figure 2-3).

Figure 2-3. Kennedy Street Streetscape Project Tour Stop - Bioretention

2.1.3 GI Challenge Parks (Rock Creek Sewershed)

An additional aspect to the Green Infrastructure Challenge, was the GI Challenge Parks Project with highlights presented in Appendix C. The GI Challenge Parks project incorporated the same goals of the Streetscape Challenge of engaging firms to design innovative, cost effective, replicable, and high performing green infrastructure practices, but in this instance focused on implementation of GI in two triangle parks located at Kansas Avenue and 2nd Street NW and Kansas Avenue and 3rd Street NW. The two GI parks were completed in the fall of 2018 under the RC-A contract and showcase a variety of revealed stormwater management practices including bioretention facilities, porous flexible pavement, stone lined swales, as well as natural boulders for creative play, painted paths and steppingstones, pedestrian bridges, and new trees. Figure 2-2 shows the location of the two challenge parks within the Rock Creek sewershed while Figure 2-4 provides a photo of the finished park at 2nd Street NW and Kansas Avenue. Both parks were implemented utilizing a design-bid-build project delivery method and followed District GI design standards that were customized for site conditions and innovative applications of GI.

Figure 2-4. Typical GI Park (photo)

2.1.4 Potomac River Project A (PR-A) (Potomac River Sewershed)

Potomac River Project A (PR-A) was the first large scale GI project constructed in the Potomac River sewershed by DC Water. The project area includes a significant area of the Glover Park and Burleith neighborhoods and is mostly residential in nature, mainly comprised of row houses and some detached homes, with commercial areas along Wisconsin Avenue NW. The southern portion of the Potomac GI area includes Georgetown University and the Georgetown Historic District. Refer to the Potomac River Project A area as shown in Figure 2-5.

A parallel planning effort was conducted (as described above in the RC-A section) for the Potomac sewersheds 027, 028, and 029. This planning effort was summarized in the July 2016 GI Program Plan submitted to EPA. The project extents and block locations for the GI sited in PR-A within the Burleith and Glover Park neighborhoods are generally representative of typical blocks to be encountered in CSOs 028 and 029. CSO 027 corresponds with the Georgetown Historic District and contains conditions unique to that neighborhood. Initially the PR-A project area included a portion of CSO 027, however due to significant pushback from review agencies and representatives of the Historic District, the PR-A project area was reduced to focus on the Glover Park and Burleith neighborhoods in order to meet the required Amended Consent Decree schedule.

As shown in Figure 2-6, this project consisted of the design and construction of five (5) planter bioretentions (Figure 2-7), fifteen (15) parking lane permeable pavements and twenty-three (23) alley permeable pavements through a design-bid-build process. The installed green infrastructure utilized standardized designs for all the bioretention and alley facilities (utilizing standard depths, check dam spacing, etc.).

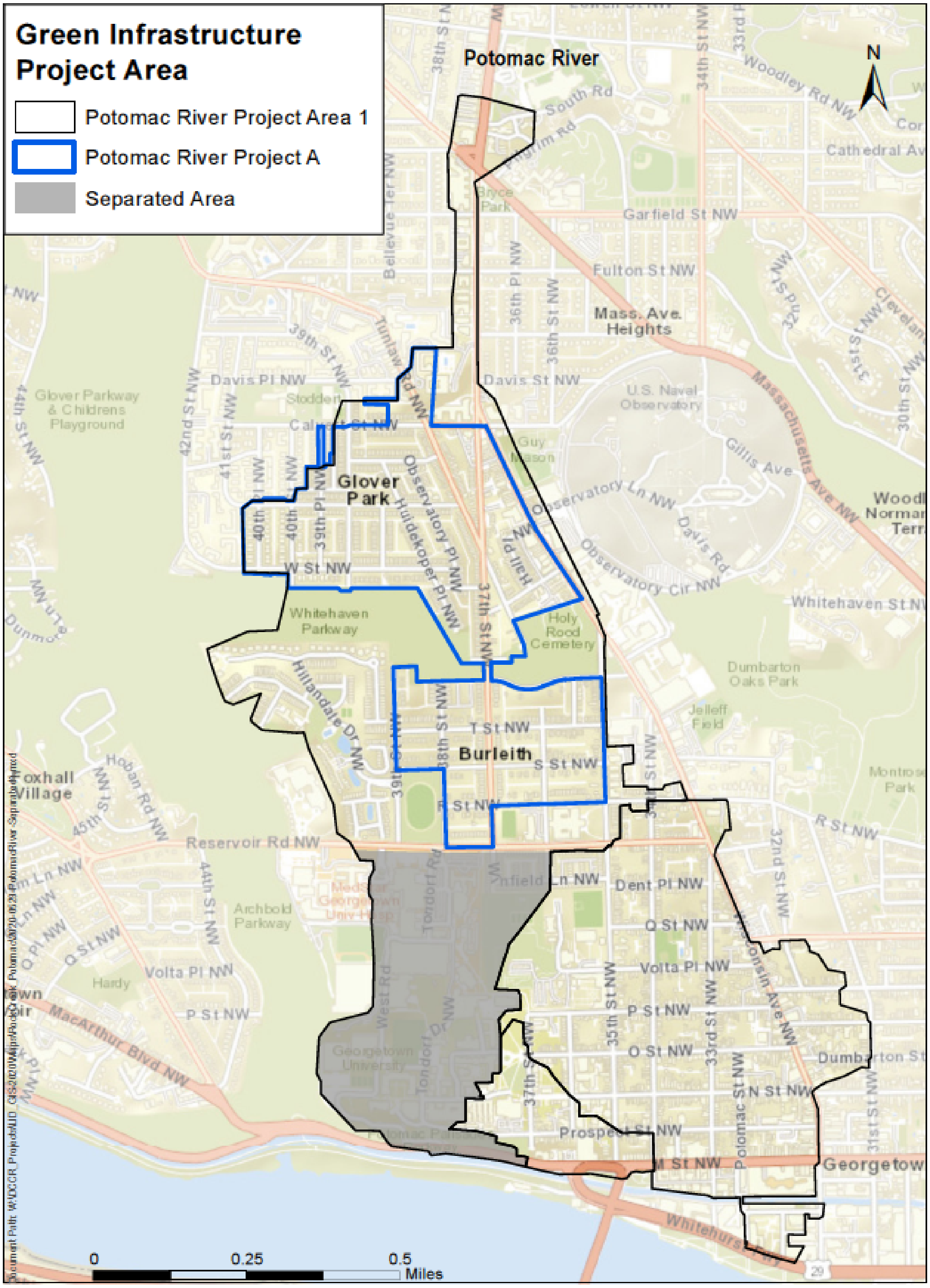


Figure 2-5. Potomac River Project No. 1 Area and Potomac River Project A

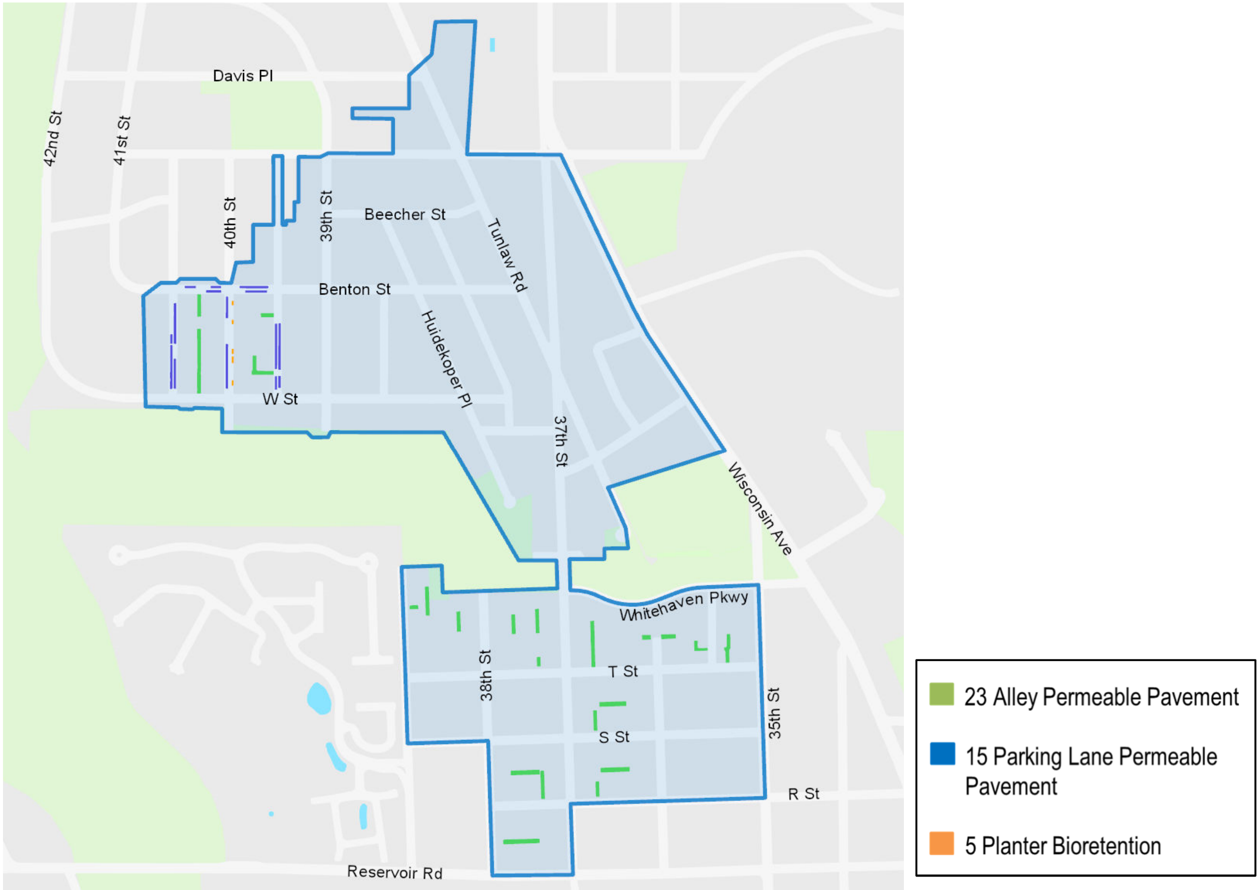


Figure 2-6. Potomac River Project A (PR-A) GI Practice Locations

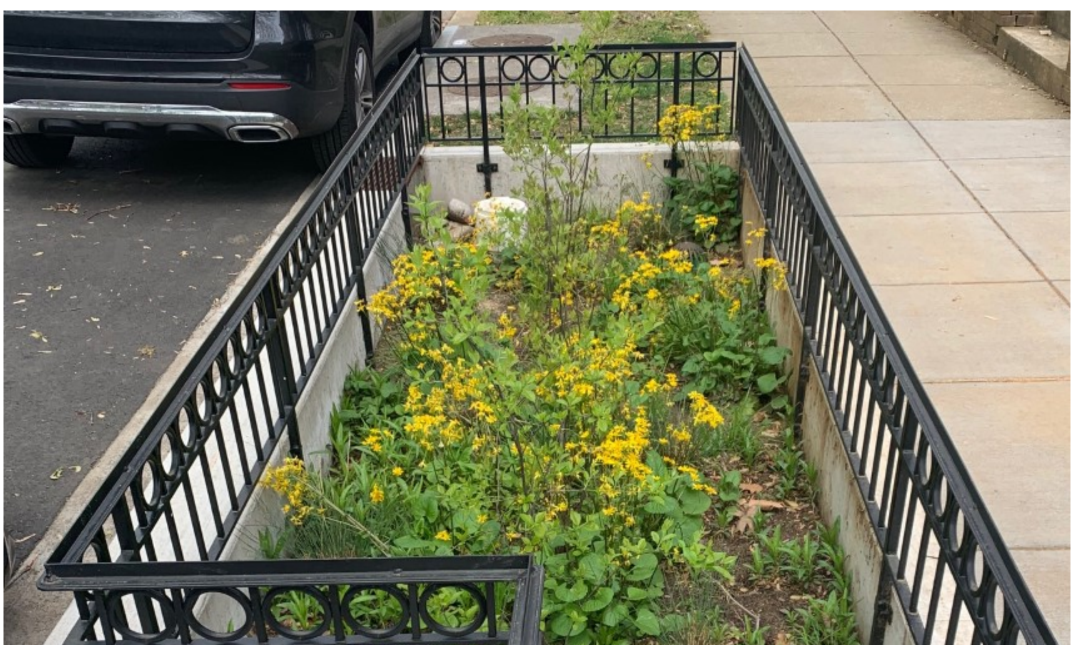


Figure 2-7. Typical Bioretention in Potomac Sewershed (photo)

2.1.5 Targeted Sewer Separation (Potomac River Sewershed)

Targeted sewer separation was planned and implemented on Georgetown University property within the Potomac River CSO 029 sewershed shown in the grey shaded area on Figure 2-5. Preliminary investigations indicated that sewer separation was feasible and appeared to have been partially completed already in small areas throughout the sizable campus. Work was completed in 2018 to formally complete the separation and has eliminated combined sewers from the Georgetown University property. Details on the sewer separation project within the Potomac River sewershed will be made part of the Potomac River Practicability report submitted under separate cover.

2.1.6 Green Alley Partnership (AlleyPalooza) (Rock Creek and Potomac River Sewersheds)

The AlleyPalooza Campaign is a District initiative to focus on alley replacement within the District. DC Water partnered with DDOT to construct permeable pavement alleys within the CSO areas. Figure 2-8 shows a typical alley replacement. The Green Alley Partnership constructed permeable pavement in six (6) alleys within the Rock Creek sewershed and one (1) alley within the Potomac River sewershed. DC Water utilized standard designs for all the permeable alleys (standard depths, check dam spacing, etc.) as well as a blanket permit with the District that lowered cost and expedited implementation.

Figure 2-8. Typical Green Alley Partnership Installation (photo)

2.1.7 Downspout Disconnection (Rock Creek and Potomac Sewersheds)

The first GI project boundaries in both the Rock Creek and Potomac River sewersheds (shown in the Pilot Program Areas in Figure 2-9 and Figure 2-10) contain approximately 4,436 downspouts that were observed during initial project development. Of these downspouts, approximately 36% were already disconnected from the combined sewer system. Another 47% of downspouts could not be feasibly disconnected given the downspout configuration and/or site topography. The remaining downspouts could potentially be disconnected. To date, approximately 13,200 downspouts have been observed in the areas shown in Pilot Program, 2018, and 2019 Project Areas in Figure 2-9 and Figure 2-10. Of these downspouts, approximately 58% were already disconnected from the combined sewer system. Another 27% of downspouts could not be feasibly disconnected given the downspout configuration and/or site topography. The goal was to disconnect as many downspouts as possible, through public outreach with private property owners in order to increase runoff infiltration at the individual residential property, as well as increase the travel time to the nearest combined sewer inlet for any runoff that didn't infiltrate on the resident's property.

The downspout disconnection program is ongoing and is free to participating residents within the CSO GI areas. In addition to disconnecting downspouts, residents may also receive a rain barrel to collect rainwater for irrigating their garden or landscaping. Runoff reduction is achieved by directing rooftop flow into vegetated areas, where a portion of that flow can infiltrate into the ground. Other flow may be directed into a nearby GI practice, or eventually make it into the combined sewer system, albeit at a slower rate and reduced volume than when previously connected directly via the homeowner's downspout and sewer connection. This program has been implemented under contract with Rock Creek Conservancy, a local non-profit. Figure 2-9 and Figure 2-10 show the project areas for both the Rock Creek and Potomac River areas, respectively.

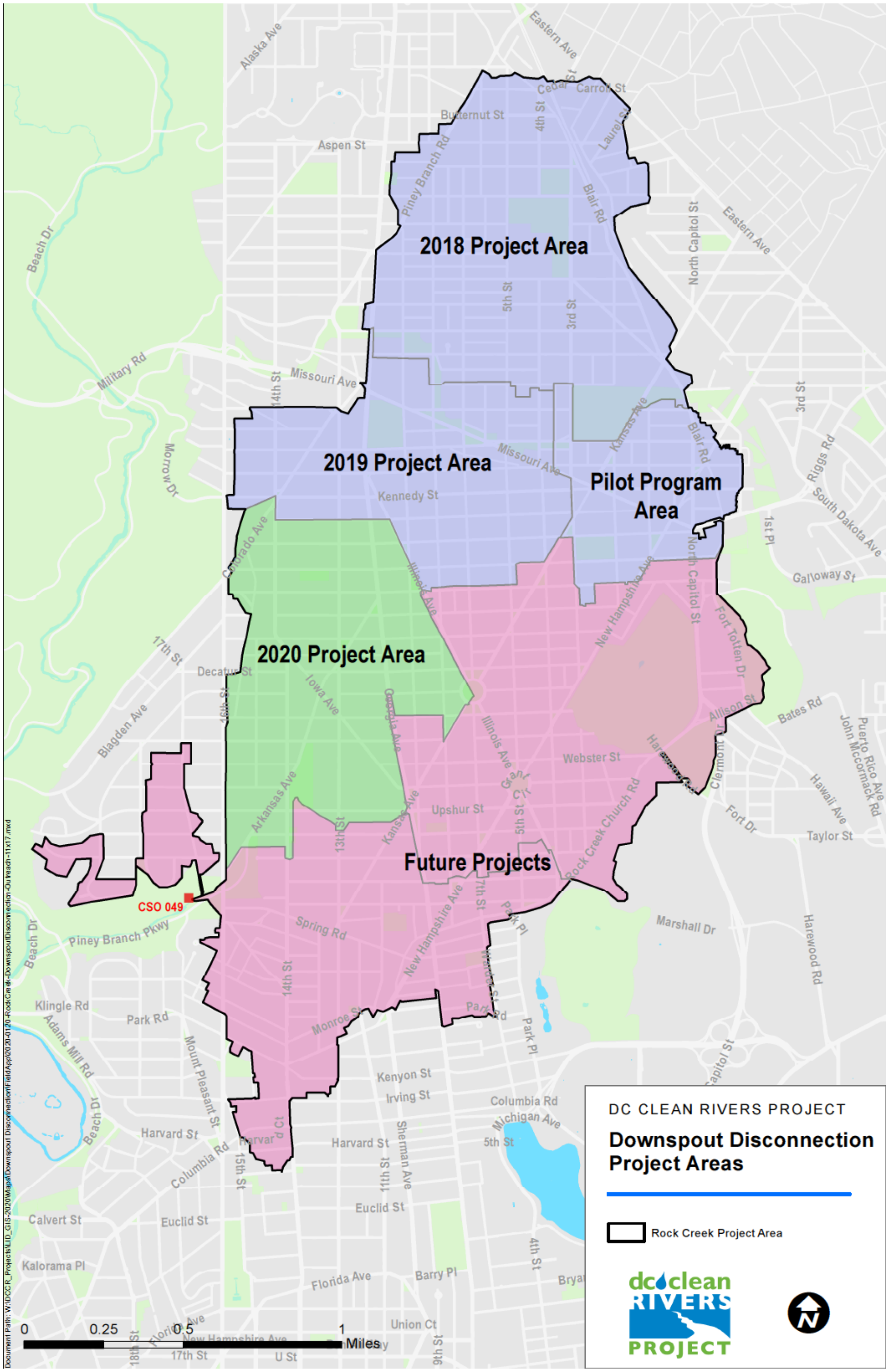


Figure 2-9. Rock Creek Downspout Disconnect Program Locations

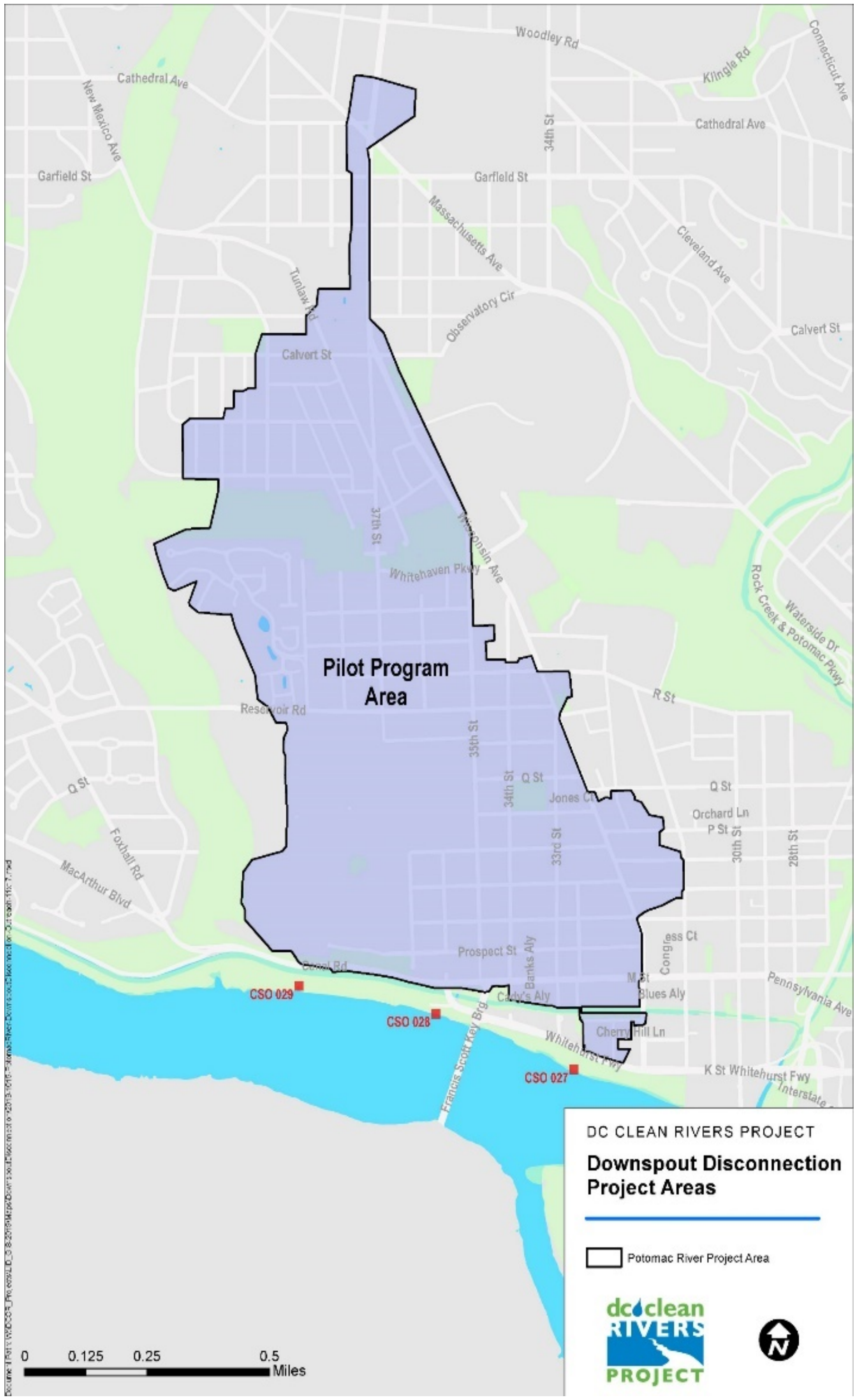


Figure 2-10. Potomac River Downspout Disconnect Program Locations

Table 2-1 below summarizes the number of GI practices (including sewer separation) constructed for both Rock Creek Project No. 1 and Potomac River Project No. 1, followed by the number of impervious acres managed in each.

Table 2-1. GI Practices Constructed and Impervious Acres Managed by Project

Sewershed	Project	Bioretention	Permeable Pavement	Targeted Sewer Separation	Downspout Disconnect	Total
Number of Projects						
Rock Creek Project 1	RC-A	38	39			77
	Kennedy Street	21	12			33
	Challenge Parks	2				2
	AlleyPalooza		6			6
	Downspout Disconnect				304[1]	304
	Subtotal Rock Creek	**61**	**57**	**0**	**304**	**422**
Potomac River Project 1	PR-A	5	38			43
	AlleyPalooza		1			1
	Downspout Disconnect				58[1]	58
	Subtotal Potomac River	**5**	**39**	**0**	**58**	**102**
	Grand Total	**66**	**96**	**0**	**362**	**524**
Impervious Acres Managed						
Rock Creek Project 1	RC-A	3.9	14.9			18.8
	Kennedy Street	1.2	1.5			2.7
	Challenge Parks	1.9				1.9
	AlleyPalooza		3.0			3.0
	Downspout Disconnect				1.0	1.0
	Subtotal Rock Creek	**7.0**	**19.4**	**0.0**	**1.0**	**27.4**
Potomac River Project 1	PR-A	0.3	7.5	67.5		75.3
	AlleyPalooza		0.1			0.1
	Downspout Disconnect				0.2	0.2
	Subtotal Potomac River	**0.3**	**7.6**	**67.5**	**0.2**	**75.6**
Grand Total		**7.3**	**27.0**	**67.5**	**1.2**	**103.0**

[1] Represents the number of individual downspouts disconnected

2.2 Project Delivery Method

As a point of comparison, DC Water utilized different project delivery methods common to the construction of GI. Table 2-2 below shows the progression of projects and the delivery method utilized for each.

Table 2-2. Project Timeframe and Delivery Method

Project	Timeframe	Delivery Method
Rock Creek Project A (RC-A)	2016	Design-Build
AlleyPalooza	2017	IDIQ
Kennedy Street	2016	Design-Bid-Build
Challenge Parks	2016	Design-Bid-Build
Potomac River Project A (PR-A)	2018	Design-Bid-Build

The Rock Creek Project A used a Design-Build approach. This method allowed DC Water to capitalize on the time saving benefits for this approach. Since a single procurement process was utilized, construction could begin on GI practices as designs were completed. To take advantage of the Design-Build process, the design was split into three construction packages, allowing each to be released for construction at varying times. The Design-Build team utilized custom designs for all the bioretention and parking lane permeable pavement facilities, and initially as well for the alley permeable pavement facilities. Alleys shifted to a standard design as DC Water worked with DDOT and the District Department of the Environment (DOEE) to standardize alley permeable pavement facilities, which were utilized beginning in 2017 for RC-A.

For Kennedy Street, Challenge Parks and Potomac River Project A, DC Water utilized the more traditional Design-Bid-Build process. This provided a greater opportunity for DC Water input and review of the projects. While Kennedy Street and the Challenge Parks utilized a customized design approach, PR-A used standardized designs for all the GI practices.

Since the Green Alley Partnership (AlleyPalooza) was administered by DDOT, DC Water provided funding to DDOT to build permeable pavement alleys within the CSO area. DDOT utilized an indefinite delivery/indefinite quantity (IDIQ) contract that enabled DC Water to know the cost of the GI practice broken down on a unit price basis. This provided a high level of cost detail to DC Water that continued to inform and drive cost reduction strategies for the program.

2.3 Basis for Design and Construction Details

In preparation for program implementation, DCCR began a process of creating GI design standards during the fall of 2014 specifically tailored for CSO control. The DCCR GI Design Standards were first published in 2015 to supplement the current District standards for GI and build upon DC Water's existing GI Utility Protection Guidelines that were released in 2013. District standards, developed by DDOT and DOEE, provided comprehensive guidance for siting, designing, constructing, and maintaining all types of GI, including bioretention, permeable pavement, and impervious surface removal and disconnection. However, these standards were not designed specifically for CSO control, so refinements to the guidelines were necessary to address CSO volume considerations and optimize performance accordingly. Table 2-3 represents DC Water's GI Design parameters used both in RC-A and PR-A designs. A description of how GI practices were optimized for storage and CSO reduction follows the table.

Table 2-3. GI Design Parameters

Description		Rock Creek Project A	Potomac River Project A
Design Guidelines			
Runoff Volume	Minimum	0.8"	0.8"
	Maximum	1.7"	1.7"
Contributing Drainage Area (CDA)	Bioretentions	No. min	10%
	Permeable Pavements	3:1	10:1
Underdrains	All Facility Types	As required	Yes
Planter Bioretention			
Facility Length (ft.)	Minimum	10 ft.	10 ft.
	Maximum	35 ft.	No maximum
	Increments	1 ft	1 ft
Facility Width (ft.)	Minimum	2.5 ft	2.5 ft
	Maximum	Not to exceed existing	Not to exceed existing
Curb Extension Bioretention			
Facility Length (ft.)	Minimum	20 ft.	10 ft.
	Maximum	Limited to replace 1 parking space (20 feet) per street within block.	No impacts to parking
	Increments	1.0 ft.	0.5 ft
Facility Width in roadway (ft.)	Minimum	4 ft.; intervals of 1 ft.	4 ft.; intervals of 1 ft.
	Maximum	8 ft.	8 ft.
Sidewalk Storage (Planter/Curb Extension)			
Facility Length (ft.)	Criteria	Based on adjacent facility and site constraints	Based on adjacent facility and site constraints
Facility Width (ft.)	Minimum	1.25 ft.	1.25 ft.
	Maximum	Based on site constraints	Based on site constraints
Alley Permeable Pavement			
Facility Length (ft.)	Minimum	40 ft.	No minimum
	Maximum	Based on site constraints	Based on site constraints
Facility Width (ft.)	Minimum	3 ft.	3 ft.
	Maximum	Match existing alley	Match existing alley
Parking Lane Permeable Pavement			
Facility Length (ft.)	Minimum	40 ft.	No minimum
	Maximum	Based on site constraints	Based on site constraints
Facility Width (ft.)	Minimum	No minimum	No minimum
	Maximum	Match existing parking lane	Match existing parking lane

2.3.1 Standard Design Elements

The primary GI control measures that were made part of the DC Water GI Program include the following:

- **Bioretention facilities** are depressed, landscaped basins that allow stormwater to collect and infiltrate through plants and soils to an aggregate storage layer for temporary storage. These control measures may allow infiltration of water into the surrounding soil. In cases where infiltration is not feasible, underdrains can slowly release flow back into the sewer system.

- **Permeable pavement facilities** replace impervious, traditional paving surfaces with materials that provide the necessary structural support for vehicles and pedestrians while allowing rainfall to infiltrate into the underlying aggregate storage layer for temporary storage. Like bioretention, these control measures may allow groundwater recharge through infiltration but where infiltration is not feasible, underdrains can slowly release flow back into the sewer system.

Standard design elements for each of these facility types were developed to provide uniformity across the GI practices, allowing for a more streamlined design and construction process. Some of these elements included underdrain configuration, check dam spacing, and storage layer depth as shown in Figure 2-11 and Figure 2-12 on the following page.

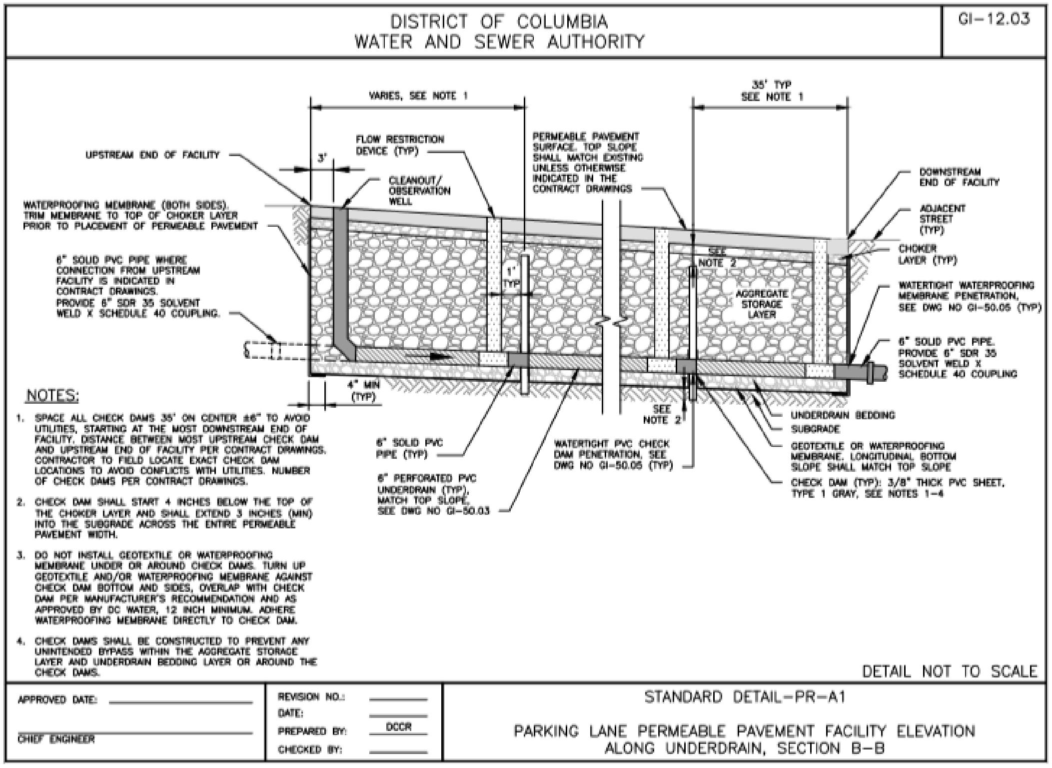


Figure 2-11. Typical Permeable Pavement Section

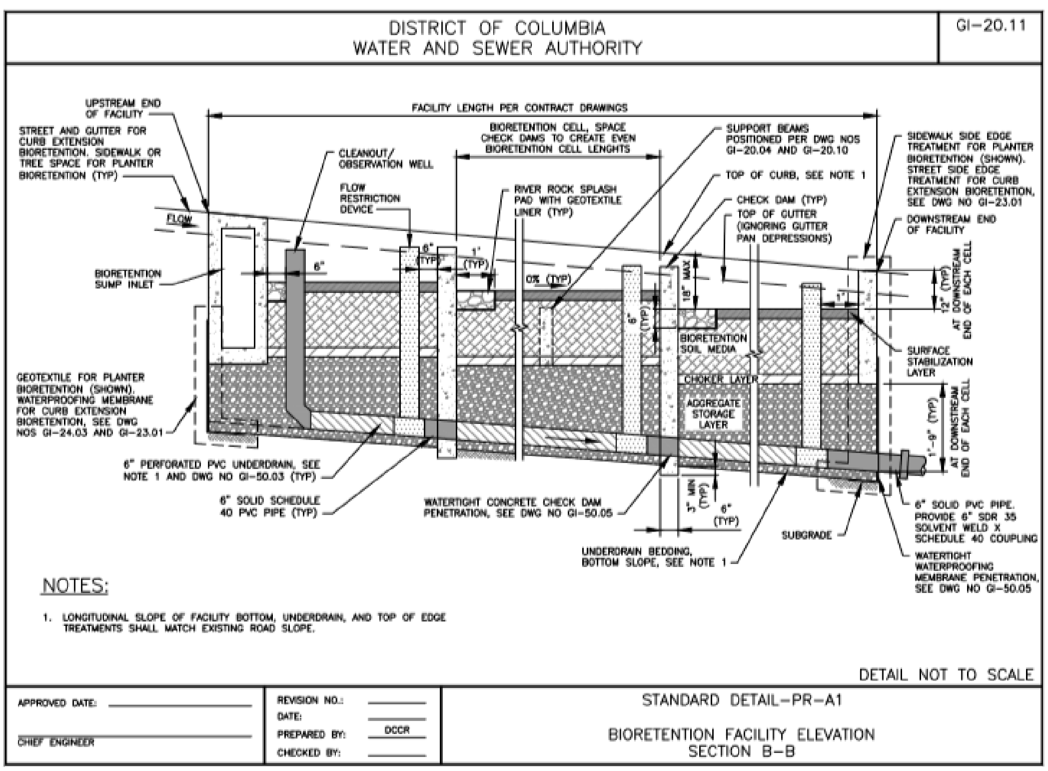


Figure 2-12. Typical Bioretention Section

2.3.2 CSO Volume Control Design Elements

Key criteria for the development of the DCCR GI standards included optimized volume capture, cost effectiveness, delivery of triple bottom line benefits, long-term performance, and ease of maintenance. Most specifically, two key elements were included in the DCCR standard GI details to maximize CSO volume control. These were the addition of Enhanced Infiltration Risers (EIR) within bioretention facilities and Flow Restriction Devices (FRD) in all GI practices.

Enhanced Infiltration Risers were designed to deliver stormwater directly to the storage layer of the bioretention when the rate of water entering the GI practice was greater than the soil media could infiltrate. Since stormwater volume capture is the main driver in DC Water's GI program to reduce CSOs, the EIRs were installed just above the ponding elevation to increase the volume of water captured both at the surface to promote treatment, and within each cell of the facility by providing an alternative means of water reaching open storage capacity in the aggregate layer. The addition of the EIR also reduces the bypassing of flows during larger storm events, helping to maximize the bioretention's performance. A detail of the EIR is shown in Figure 2-13.

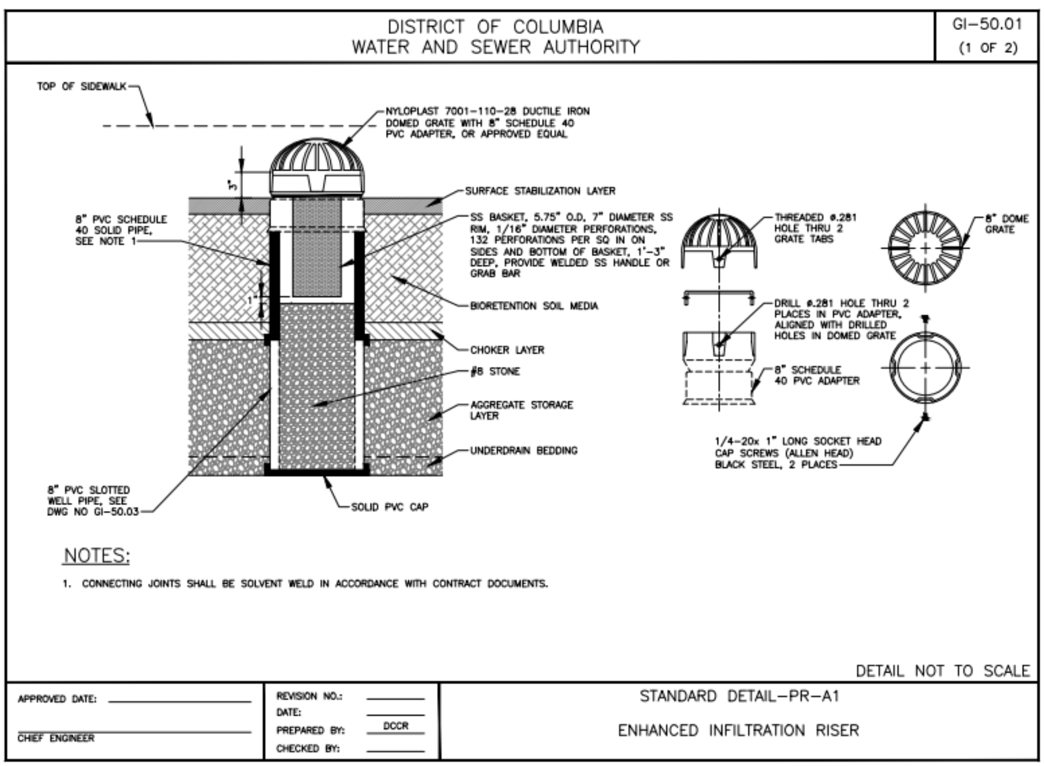


Figure 2-13. Enhanced Infiltration Riser Standard Detail

Flow Restriction Devices are designed to restrict flow between cells separated by a check dam within a facility and/or through the GI practice underdrain system before stormwater reenters the Combined Sewer System (CSS) and better utilize more of the GI storage volume during a typical storm. The FRD utilized a flapper style gate (shown in Figure 2-14) fitted with an orifice sized to retain water within the GI practice with a target of 48-hours per the design guidance. For bioretention facilities, the FRD access riser sits above the ponding elevation and is fitted with a solid PVC cap. In permeable pavement facilities, the FRD access riser sits below the finished surface and is protected with a solid cast iron cover. A detail of an FRD found in a bioretention is shown in Figure 2-15. A full copy of the DCCR GI design details are provided in Appendix D.

Figure 2-14. Flow Restriction Device – Flapper Style

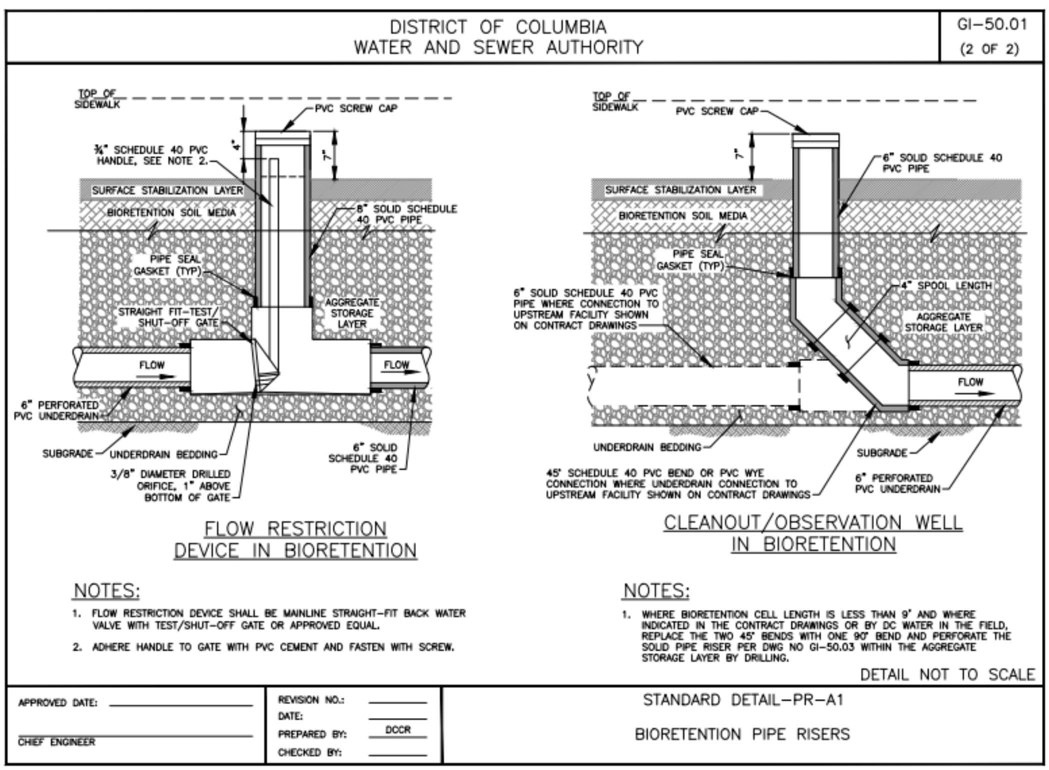


Figure 2-15. Flow Restriction Device Standard Detail

2.4 Performance Acceptance Testing

As part of the construction contracts, GI practices were tested to determine if the requirements of the design specifications were met. Each facility underwent two specific tests to determine compliance prior to acceptance by DC Water.

The first test was to verify the surface infiltration rate. For bioretention facilities, an infiltration rate of no less than 1" per hour (in/hour) was required through the soil media. The bioretention surface was flooded up to the enhanced infiltration riser elevation. Water levels were recorded every fifteen (15) minutes until the water level within the bioretention ponding layer reached zero (the surface of the bioretention). The infiltration rate of the facility was then calculated using the following formula.

$$\boldsymbol{Infiltration\ Rate}\ \left(\frac{\boldsymbol{in}}{\boldsymbol{hr}}\right) = \frac{\boldsymbol{Total\ Water\ Elevation\ Change}\ (\boldsymbol{in})}{\boldsymbol{Total\ Drawdown\ Time}\ (\boldsymbol{hr})}$$

For permeable pavement facilities (both parking lane and alley) a minimum surface infiltration rate of sixty (60") inches per hour was required. A ring test following ASTM C1701 standards was conducted to determine the infiltration rate. The surface infiltration rate of the facility was calculated using the following formula.

$$\boldsymbol{Infiltration\ Rate}\ \left(\frac{\boldsymbol{in}}{\boldsymbol{hr}}\right) = \frac{\boldsymbol{K}(\boldsymbol{constant}) * \boldsymbol{M}(\boldsymbol{mass\ of\ water})}{\boldsymbol{D}^2(\boldsymbol{in}) * \boldsymbol{t}(\boldsymbol{sec})}$$

The second test was to verify that the facilities held water while also draining in no more than 48 hours through a flood test. Each facility was filled and monitored over a 48-hour period to ensure the water retained in the facility either infiltrated into the subsurface soils or was released back into the CSS via the underdrain system.

Prior to final acceptance by DC Water, each facility was required to pass these performance tests.

2.5 Improvements Made After Construction (Retrofits)

To improve the stormwater capture of the GI practices, DC Water made several retrofits to each facility shortly after completion of the RC-A, PR-A, and Green Alley Partnership (AlleyPalooza) projects. Within a few months of operation, it was observed, as well as detected in the metering data, that GI practices were releasing water back into the CSS at a higher rate than what was noted during the performance testing and specified in the design. The seal on the flapper style gates (Figure 2-14 above) began to fail, allowing higher volumes of water to be released faster than the target drawdown rate of 48-hours. To correct this issue, the FRD flapper gates in all GI practices were replaced with either a mechanical plug (Figure 2-16) or a straight fit gate (Figure 2-17), both with orifices. Mechanical plugs were installed in the most downstream end of the facility, while the straight fit gates were installed in all the upstream cells. This permits maintenance crews to easily remove the gates when flushing the underdrain systems, where the most downstream cell is used as a sump to collect the sediment to be pumped out. This retrofit allows water to be retained longer within the facility to reach the target drawdown time of 48-hours per the design guidance.

Figure 2-16. Flow Restriction Device - Mechanical Plug

Figure 2-17. Flow Restriction Device - Straight Fit Gate

In addition, during high intensity storm events, stormwater runoff was observed to be flowing down the center of the permeable pavement alley and out of the drainage area when adequate storage was still available in the subsurface. To increase the volume of water entering each cell of the facility, FRD access solid cast iron lid covers within Alley Permeable Pavement facilities of the RC-A, PR-A, and AlleyPalooza projects were replaced with slotted cast iron grate covers, and a stainless-steel filter basket inserted into the riser pipe to protect the facility from sedimentation and debris. This modification has increased the volume of water reaching the aggregate storage, similar to the EIRs in the bioretention practices, and thereby reduced the bypassing of flows during larger storm events.

2.6 Maintenance

DC Water is responsible for maintaining the GI control measures in accordance with DC Water's National Pollutant Discharge Elimination System (NPDES) Permit. For GI control measures in the public ROW, access for inspection, maintenance and monitoring is included in the annual blanket permit from DDOT for maintenance and access to water and sewer lines and manholes. Maintenance of GI control measures in the public ROW is coordinated among DDOT, Department of Public Works (DPW) and DC Water, but ultimately falls on DC Water to perform.

DC Water's established maintenance goals related to the performance, safety and aesthetics of the GI measures are as follows:

- Ensure GI function and performance to meet DC Water's water quality goals and Amended Consent Decree requirements;
- Ensure public and maintenance crew safety;
- Ensure original GI project aesthetic goal(s); and
- Ensure public use of the ROW, preservation of public infrastructure, protection of public and private properties, and minimization of nuisance conditions.

2.6.1 Maintenance Activities and Frequency

In Table 2-4 on the following page, a selection of typical maintenance activities is summarized for each of the project's bioretention and permeable pavement practices. Maintenance crews submit monthly reports indicating work performed, and if corrective actions are necessary. Verification inspections are performed monthly by DC Water asset management staff to confirm maintenance activities required that period were performed to the degree and frequency necessary to achieve the CSO control performance objectives. Inspection and maintenance measures and frequencies continue to be adjusted through an adaptive management approach based on ongoing experience observing and maintaining the GI practices.

Table 2-4. Typical Maintenance Activities for Permeable Pavement and Bioretention

Project/Facility Type	Frequency	Maintenance Activities
Kennedy Street - Streetscape Bioretentions	Monthly	Trash, weed, leaves, debris, and dead plant removal. Inspect for erosion. Check for missing signs. Remove sediment. Inspect cleanout, underdrains, and dry well grate inlets and note any standing water.
Kennedy Street - Streetscape Pervious Pavement	Monthly	Removal of trash, leaves, sediment, and debris. Inspect, remove by hand, vacuum, and sweep between pavers. Replace void filler aggregate as needed.
	Annually	Inspect the surface and underdrain system by flushing to verify flow and exfiltration. Repair any damaged or displaced pavers.
Rock Creek Project A (RCA) Bioretentions	Monthly	Trash, weed, leaves, debris, and dead plant removal. Inspect for erosion. Check for missing signs. Remove sediment. Inspect cleanout, underdrains, and dry well grate inlets and note any standing water.
	Quarterly	Inspection of system for hydraulic function, mitigation of clogging. Replace gravel or river rock in eroded areas.
	Annually	Trim grasses and perennials, prune shrubs.
Rock Creek Project A (RCA) Pervious Pavement	Monthly	Vacuum sweeping and remove debris from enhanced infiltration baskets. Inspection and removal of trash, leaves, sediment, and weeds.
	Quarterly	Inspect structures for blockages and sediment and inspection and correction of settlement or heaving.
	Annually	Inspect the surface and underdrain system by flushing to verify flow and exfiltration. Repair any damaged or displaced pavers.
GI Challenge Parks	Monthly	Trash, weed, leaves, debris, and dead plant removal. Inspect and remove debris and sediment from all structures. Treat vegetation for any disease and pest problems. Turf area mowing and watering vegetation frequency is variable.
	Quarterly	Inspect and replace mulch or river rock in eroded areas.
	Bi-Annually	Inspection of system for hydraulic function, mitigation of clogging.
	Annuallly	Trim grasses and perennials, prune shrubs.
Green Alley Partnership (AlleyPalooza) Pervious Pavement	Monthly	Removal of trash, leaves, sediment, and debris. Inspect, remove by hand, vacuum, and sweep between pavers. Replace void filler aggregate as needed.
	Quarterly	Inspection of system for water flow and removal of any clogging. Inspect cleanouts, observation wells, and underdrains for blockages. Inspection and corrrection of settlement and heaving.
	Bi-Annually	Inspection and removal of leaves and weeds.
	Annually	Inspection and cleanout of system piping.

Table 2-4. Typical Maintenance Activities for Permeable Pavement and Bioretention (cont.)

Project/Facility Type	Frequency	Maintenance Activities
Potomac River Project A-1 (PRA-1) Bioretentions	Monthly	Inspect flow restriction devices, enhanced infiltration baskets, cleanouts, and ponding areas for standing water. Removal of trash, leaves, weeds, debris, dead plants, and sediment. Inspect and remove all sediment and blockages from inlet/outlet structures.
	Quarterly	Inspection of system for hydraulic function, mitigation of clogging. Replace gravel or river rock in eroded areas.
	Annually	Trim grasses and perennials, prune shrubs.
Potomac River Project A-1 (PRA-1) Pervious Pavement	Monthly	Inspect flow restriction devices, cleanouts, and enhanced infiltration baskets. Vacuum sweep pavement and inspect system for flow for any heaving or settlement in pavement.
	Quarterly	Inspection of system for water flow and removal of any clogging. Inspect cleanouts, observation wells, and underdrains for blockages. Inspection and corrrection of settlement and heaving.
	Bi-Annually	Inspection and removal of leaves and weeds.
	Annually	Inspection and cleanout of system piping.

2.6.2 Initial Warranty and Maintenance Periods

As part of the construction contracts, the contractor was obligated to maintain completed facilities through the duration of the contract until the facilities were turned over to DC Water at contract Final Completion. For the RC-A project only, the Contractor was responsible for a contractually obligated 1-year initial maintenance period after substantial completion. For all other GI projects, DC Water took over maintenance responsibilities following final acceptance and completion. Currently all GI maintenance is being performed under contract.

DC Water continues to evaluate potential changes to the maintenance program such as optimizing contract requirements and maintenance frequencies based on accumulated field observations and experience. In addition, DC Water is considering the option of self-performing GI maintenance with internal DC Water maintenance crews. Considerations such as costs, availability of necessary labor and experience, job creation, public outreach, and legal requirements will be carefully reviewed prior to any substantial changes to the current approach.

2.7 Monitoring and Modeling Program

This Section describes the monitoring and modeling programs for various project areas constructed by DC Water to evaluate the effectiveness of GI in the District. A brief modeling background and terminology is explained here for informational purpose.

A SWMM model developed by integrating DC Water's InfoWorks model elements is used for modeling the green infrastructure (GI). The model represents GI practices by combining all practices of a given practice type (alley permeable pavement, parking lane permeable pavement, bioretention practices) into one single practice per type per model subshed. A schematic of this "lumped practice" modeling approach is shown in Figure 2-18. The red block in the figure represents lumped GI.

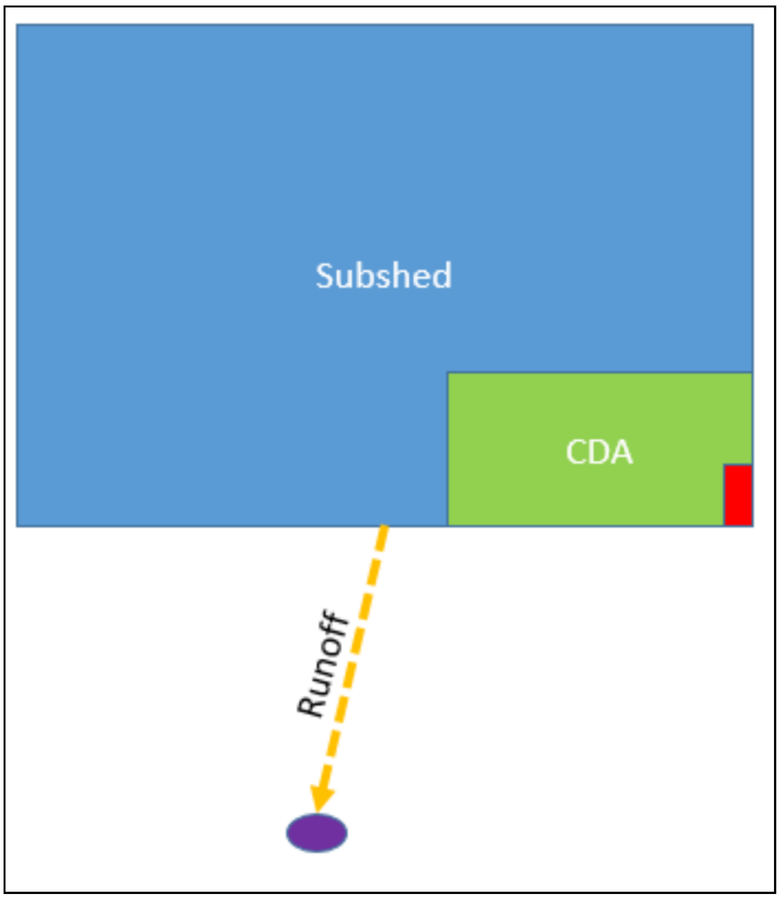


Figure 2-18. Lumped Practice Modeling Approach

A model calibration is an iterative process to adjust the model parameters until a reasonable match is achieved in the wet weather volume and peaks between model predictions and observed metered data. In a 1-to-1 plot between model prediction and metered data under an ideal scenario, the model predictions will perfectly match the metered data and all events would line up along the 1- l line with the R-squared value 1.00.

2.7.1 RC-A Monitoring and Modeling Program

DC Water performed pre-construction monitoring, which commenced in January 2016, for 12 months prior to construction of Rock Creek GI Project A. By March 23, 2019, DC Water completed the design and construction of the first Rock Creek GI project, at which point post-construction monitoring was conducted for 12 months to evaluate the effectiveness of GI in meeting the Amended Consent Decree requirements. This section provides an overview of the monitoring program, model calibration methodology and calibration results. A detailed model documentation report along with the calibrations plots is provided as Appendix E.

The RC-A model was developed, updated, and calibrated over the following timeline:

- The original pre-construction model was calibrated for the period of 03/1/2016 to 6/2/2016. Additional pre-construction monitoring data were collected until 1/22/2017 and used to further improve the calibration.
- As part of post construction modeling, installed GI practices were added to the model and GI parameters were calibrated using post-construction sewer monitoring data using data from 3/1/2019 to 7/18/2019. To assess the performance of GI, the collection system elements and model parameters unrelated to GI are kept unchanged from the pre-construction calibrated model. Adjustments during this calibration were only limited to the GI parameters.
- The calibrated post-construction model was then used to simulate the LTCP forecast period of 1988-1990 and compared with the performance predictions.
- Additional GI parameter calibration was conducted that incorporated practice-specific water level data. Initial practice-specific data for four practices was later supplemented by data from an additional 73 practices, although this expanded data set has captured a limited number of events as of the end of March 2020. The adjusted model based on the practice-level data was applied to the LTCP forecast period of 1988-1990.

Table 2-5 below provides an overview of all monitoring and modeling timeframes.

The sewershed monitoring locations are tabulated in Table 2-6 and shown in Figure 2-19. The two major outlets from RC-A that were monitored by meters 049-1 and 049-2 during both pre- and post-construction periods are used for model calibration purposes. The 049-1 metered area consists of 117 acres (86% of the total RC-A area) and is 39% impervious. The 049-2 metered area consists of 19 acres (14% of the total RC-A area) and is 45% impervious.

Table 2-5. RC-A Monitoring Schedule

Monitoring Type	Timeframe	Model Description	Total Rainfall (in)
Rainfall Monitoring	1/22/16 – 3/22/20	For Pre-Construction Period: 1/22/16 - 1/22/17 For Post-Construction Period: 3/1/19 - 3/22/20	
Pre-Construction Monitoring - Sewershed	1/22/16 - 1/22/17	Model Period: 3/1/16 to 6/2/16	26.7
Post-Construction Monitoring – Sewershed	3/1/19 - 3/22/19	Calibration Period: 3/1/19 – 7/18/19 Retrofits Period (Data not used): 11/1/19-11/30/19 Field Corrective Actions: 12/1/19-1/31/20	41.0
Post-Construction Monitoring – GI Practice	4/19/19 - 3/22/20	Calibration Period: 4/19/19 – 3/31/20 GI model parameter adjustments based on in-practice water level monitoring data for 4 practices Calibration Period: 3/12/20 – 3/22/20 GI model parameter adjustments based on in-practice water level monitoring data for 73 practices	41.0

Table 2-6. RC-A Flow Meters

Meter	Purpose / Usage	Drainage Area (ac)	Monitored during Pre-construction	Monitored during Post-construction
RC-A 049-1	Quantify total stormwater reduction from RC-A	117	YES	YES
RC-A 049-2	Quantify total stormwater reduction from RC-A	19	YES	YES
RC-A 049-3	Monitor runoff from a specific group of GI practices (*)	0.9	YES	YES
RC-A 049-4	Monitor runoff from a specific group of GI practices (*)	1.2	YES	YES

(*) Meter not used for this study due to data quality issues and insufficient drainage area size

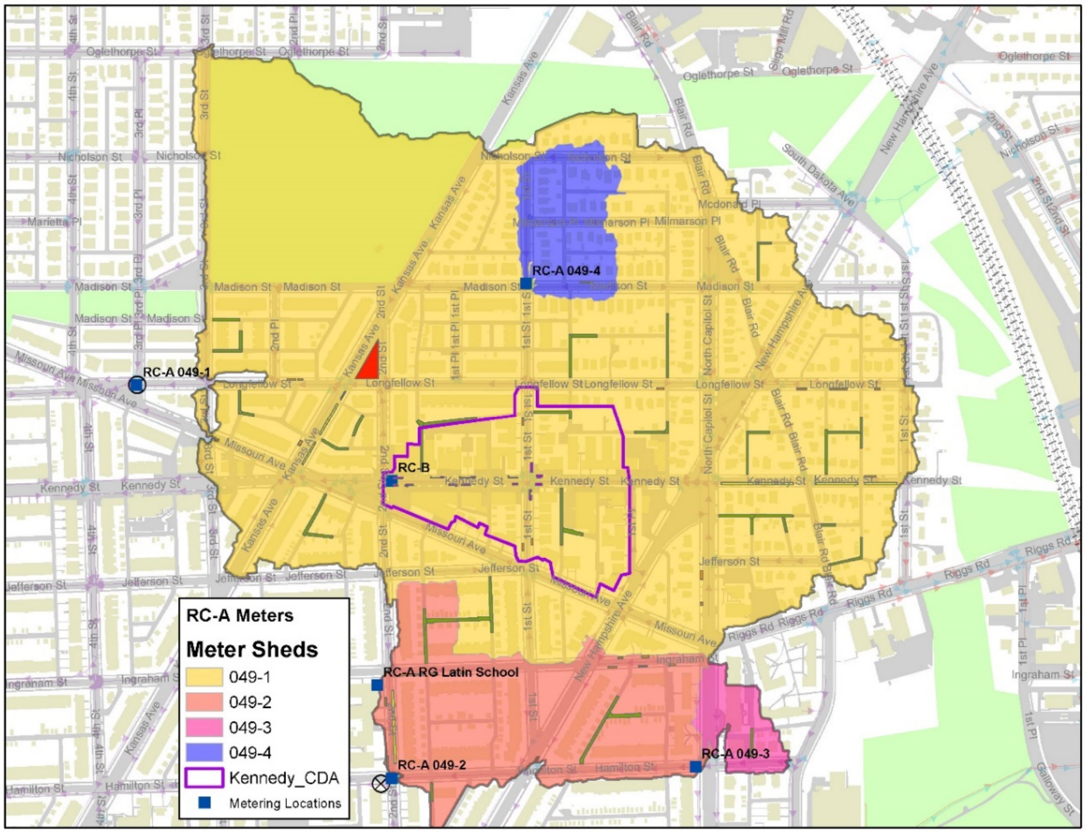


Figure 2-19. RC-A Monitoring Locations

2.7.2 RC-B Control Basin

This section provides an overview of the Kennedy Street Green Infrastructure Streetscape project, which is referred as RC-B. As shown in Figure 2-19, the contributing drainage area for RC-B green infrastructure falls within the footprint of RC-A.

The evaluation of the RC-B GI performance is data driven without the use of a SWMM model. Since no two storms are the same based on storm characteristics such as depth, duration and intensity, the GI performance assessment using two rain events with similar depths that occurred during pre- and post- construction monitoring phases only provides performance indication. To increase the confidence in this assessment, a control basin methodology was employed. This methodology uses a second (control) sewershed to normalize the impact of different weather and system conditions on the sewershed in the study area by assuming that collection system is unchanged during the pre-construction versus post-construction monitoring periods. The control basin for this study is RC-A 049-3 (0.9 acres, 69% impervious) which is located approximately 1,500 ft away from the RC-B project. The rationale for selecting this sewershed is summarized as follows:

- Proximity to the GI Streetscape project site (1,500 ft) increases the likelihood to receive the same weather input.
- Reasonably similar percentage of impervious areas and condition of the collection system.

Table 2-7 provides an overview of the timeframes for pre- and post-construction monitoring efforts.

Table 2-7. RC-B Monitoring Schedule

Monitoring Type	Timeframe	Total Rainfall (in)	No. of Rainfall Events
Rainfall Monitoring	8/25/15 – 3/13/20		
Pre-Construction Flow Monitoring	8/25/15 - 10/1/16	44.1	78
Post-Construction Flow Monitoring	3/14/19 - 3/13/20	38.9	71

The sewershed monitoring location is tabulated in Table 2-8 and shown in Figure 2-19. The metered area consists of 16 acres and is 60% impervious.

Table 2-8. RC-B Flow Meters

Meter	Purpose / Usage	Drainage Area (ac)	Monitored during Pre-Construction	Monitored during Post-Construction
RC-B	Monitor runoff from a specific group of GI practices	16	YES	YES

2.7.3 PR-A Monitoring and Modeling Program

This section provides an overview of the PR-A monitoring program. A detailed model documentation report along with the calibration plots are provided as Appendix F.

The Table 2-9 provides an overview of all monitoring and modeling timeframes for pre- and post-construction monitoring efforts.

Table 2-9. PR-A Monitoring Schedule

Monitoring Type	Timeframe	Model Description	Total Rainfall (in)
Rainfall Monitoring	2/5/16 – 3/26/20	For Pre-Construction Period: 2/5/16 - 2/4/17 For Post-Construction Period: 4/16/19 - 3/26/20	
Pre-Construction Monitoring - Sewershed	2/5/16 - 2/4/17	Entire monitoring period served as calibration period	28.3
Post-Construction Monitoring – Sewershed	4/16/19 - 3/26/20	Entire monitoring period served as calibration period	35.4
Post-Construction Monitoring – GI Practice	11/14/19 - 3/26/20	Comparison of modeled WLs with practice-specific WL data.	13.05

The sewershed monitoring locations are tabulated in Table 2-10 and shown in Figure 2-20. There are two outlets from PR-A, with interconnections between them, that were monitored by meters 029-5 and 029-6 during both pre- and post-construction periods. Those two meters' flows were summed for model calibration. There are also two upstream meters with interconnections, 029-1 and 029-2, which were also summed for calibration. The combined 029-1 and 029-2 area covers 33 acres and is 50% impervious. The combined 029-5 and 029-6 area (overall PR-A area) consists of 190 acres and is 46% impervious. The installed green infrastructure practices consist mostly of pervious pavers, with only a few bioretention cells. About 40% of the GI practices are concentrated in the 029-1 and 029-2 meter sheds, with the remainder in the 029-5 and 029-6 meter sheds.

Table 2-10. PR-A Flow Meters

Meter	Purpose / Usage	Drainage Area (ac)	Pre-Construction	Post-Construction
PR-A 029-1	Quantify runoff from a specific group of GI practices	33.4	YES	YES
PR-A 029-2	Quantify runoff from a specific group of GI practices		YES	YES
PR-A 029-3	Quantify runoff from a specific area (*, **)	22.7	YES	YES
PR-A 029-4	Quantify runoff from a specific area (*, **)	40.5	YES	YES
PR-A 029-5	Quantify total flows in PR-A area	190.0	YES	YES
PR-A 029-6	Quantify total flows in PR-A area		YES	YES

(*) Internal Meter, not used for this study due to inconsistencies in flows from pre- to post-construction periods, as well as absence of GI practices within these meter sheds

(**) Meter not used for this study due to overlapping drainage area size or data quality issues

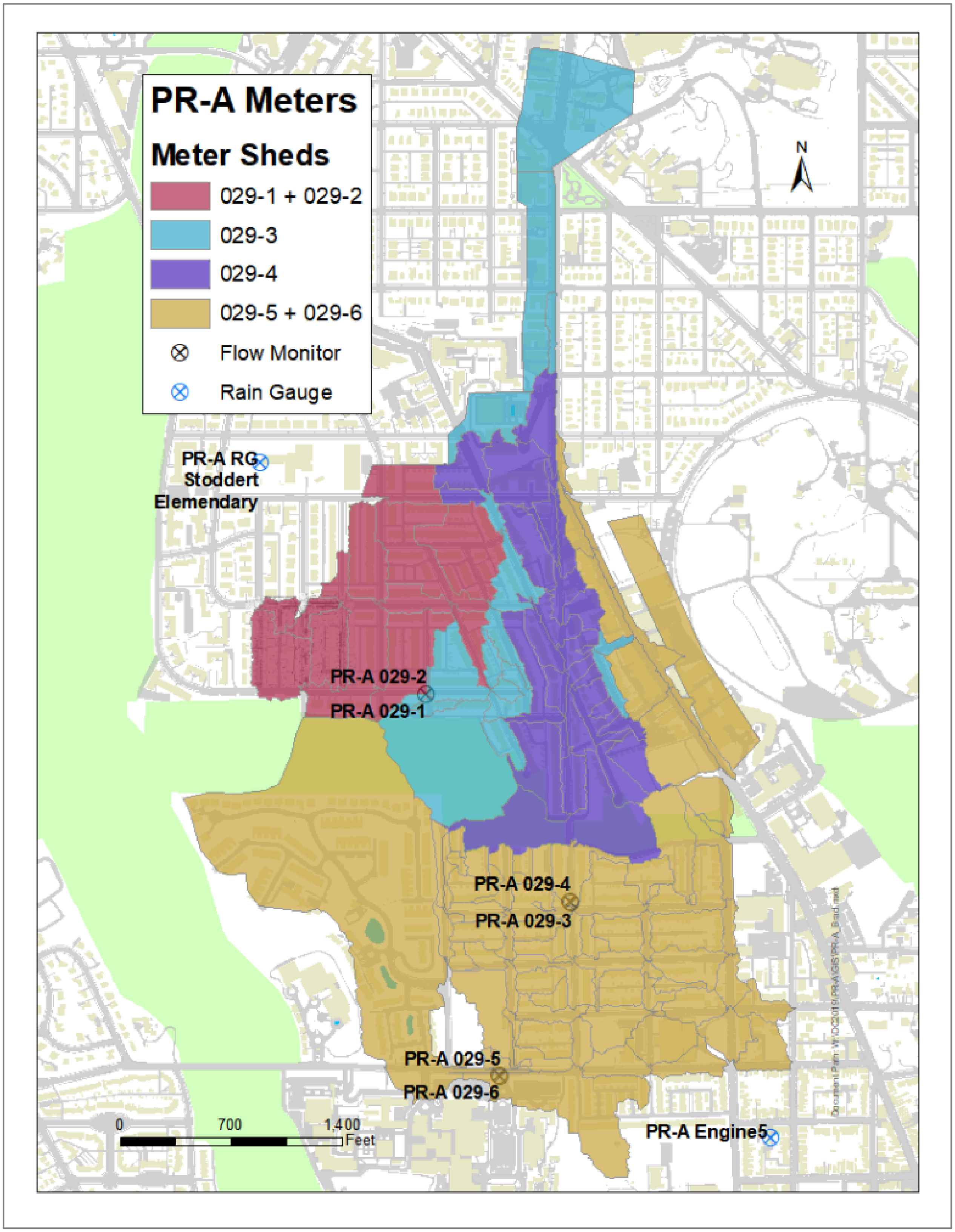


Figure 2-20. PR-A Monitoring Locations

2.8 Cost Data

Table 2-11 below presents the cost data for each of the projects described above. It should be noted that the cost listed in Table 2-11 for Green Alley Partnership (AlleyPalooza) and Downspout Disconnect projects represent the combined total for GI practices built in both the Rock Creek and Potomac River sewersheds.

Table 2-11. Project Cost Data

Project	Construction Cost (M)	Capital Cost (M)	Acres Managed	Construction Cost per Acre Managed	Capital Cost per Acre Managed
Rock Creek Project A (RC-A)	$ 16.85	$ 21.91	18.8	$ 896,300	$ 1,165,200
AlleyPalooza	$ 1.67	$ 2.00	3.1	$ 538,700	$ 646,500
Kennedy Street	$ 2.15	$ 2.79	2.7	$ 794,800	$ 1,033,300
Challenge Parks	$ 1.58	$ 2.06	1.9	$ 833,500	$ 1,083,500
Potomac River Project A-1 (PRA-1)	$ 5.22	$ 6.79	7.9[1]	$ 660,800	$ 859,000
Downspout Disconnect	$ 0.57	$ 0.68	1.2	$ 475,000	$ 570,000

[1] Target Sewer Separation excluded

Through implementation of each project and lessons learned, DC Water has been able to realize cost savings from one project to another. As described above, some of the cost saving measures implemented between projects included design standardization and contract methodology.

For the maintenance contract described in Section 2.6, DC Water received multiple bids to conduct the work required. The cost per acre per year for the maintenance of the RC-A GI practices are shown in Table 2-12.

Table 2-12. RC-A Maintenance Costs ($/ac/yr)

	Bidder 1	Bidder 2	Bidder 3
Rock Creek Project A (RC-A)	$16,100.96	$14,768.09	$22,999.73

2.9 Public Acceptance

Below is a summary of the community's concerns, positive feedback, and survey responses (Appendix G) received from residents regarding DC Water's GI Program.

DC Water's GI Program constructed over 150 GI practices throughout multiple neighborhoods in the District. Approximately 2,000 homes are located near GI practices constructed by DC Water as part of Rock Creek Project A, Potomac River Project A, Kennedy Street, GI Challenge Parks, and the Green Alley Partnership. During these projects, DC Water received a total of 187 inquiries from the community. Table 2-13 summarizes the inquiries received regarding the construction of GI in resident neighborhoods and does not include comments received based on the post-construction survey described in Section 2.9.4 below.

Table 2-13. Community Inquiries on GI through Construction

Category	Number of Residents	% of Project Area (2,029 Homes)
General/Schedule	40	2.0%
Access	11	0.5%
Trash Collection	25	1.2%
Parking	60	3.0%
Noise/Debris	9	0.4%
Construction of GI/Lack of GI	6	0.3%
Damage Claims	36	1.8%
Total	**187**	**9.2%**

DC Water received inquiries from 9% of the homes located near GI sites; highlighting the fact that the outreach efforts surrounding the GI program was successful in communicating the project as well as mitigating construction impacts to the community. Concerns (general inquiries and schedule, access, and trash collection) made up 41% of the received inquiries while complaints (loss of parking, noise/debris, either not wanting the GI constructed near their home or not having GI constructed near their home, and damage claims) made up 59% of the inquiries received. The following sections provides further details on the concerns and complaints expressed as well as the resolutions DC Water completed.

2.9.1 Construction Concerns

The concerns that were received were categorized in the following categories: general inquiries and schedule, access, and trash collection.

Residents had many questions about the construction schedule or more details on the project such as the aesthetics of the permeable pavers and types of plants for the bioretention facilities. One resident was planning to repave her driveway and wanted to know if the bioretention facility would impact her renovation. Residents wanted to understand how long construction would occur near their homes. The DC Water team would call, email, or meet with residents to answer their questions, explain the extents of the work, and remind residents that all the work was occurring in the public space.

Many residents had concerns about access when they received the notice about upcoming construction, with handicap access and access for elderly as the top concerns. Other residents needed access for deliveries, other contractors, and movers. DC Water worked with everyone to determine the best solution which included setting up temporary disability parking spots, providing disability parking permits, moving equipment and materials to allow access, and even helped with carrying in groceries.

For many residents in the project area, trash is collected from the alleys. When alleys were closed for GI construction, trash was collected from the front of homes. Some residents expressed concern over the ability to move the bins as well as concern that their trash collection would be missed. DC Water assisted in moving bins for residents. DC Water also worked closely with the District's Department of Public Works (DPW) to redeploy trash crews when a pick-up was missed. In certain instances, the construction crews would remove and haul away trash themselves to prevent residents from having to wait for DPW to return. The construction crews also temporarily labeled bins to ensure the correct bin was returned to its owner.

2.9.2 Construction Complaints

The complaints that were received were categorized in the following categories: loss of parking, noise/debris, not wanting the GI constructed near their home and damage claims.

Most complaints occurred during active construction and revolved around a lack of parking and access to parking within alleys. DC Water understood the inconvenience of alley closures, preventing parking and access to the back of homes during construction, and helped mitigate concerns by assisting residents with obtaining temporary street parking permits while their alley was closed. DC Water also coordinated with a local grocery store to provide free resident access to parking spaces in the store's garage. In total, DC Water assisted over 50 residents with obtaining alternative parking solutions. Additionally, DC Water worked closely with the contractor to phase the work to minimize the amount and duration of parking impacts. The contractor opened access to completed alley sections as soon as possible to provide access to back-of-home parking. To ensure better communication regarding alley closures, additional notification flyers were developed to:

- Let residents know more precisely when construction would start in the back of their individual home,
- Let residents know when the work behind their individual home was complete so they could start parking again in the back of their home,
- Let residents know when trash collection would resume in the back of their home.

DC Water experienced a few cases where residents returned home from a long work trip or vacation away to discover that their vehicle was stuck in the back of their home within a closed alley. DC Water worked with these residents and the construction crews to identify how to access their vehicles as quickly as possible. In some instances, the construction crews would build a temporary bridge over the excavations to allow for the cars to be moved.

In general, complaints and issues encountered were typical of any infrastructure construction activities that occur in the proximity of residential housing. For example, there were a few instances when residents complained about noise, specifically that the construction began before the permitted 7am construction start hour. In these cases, the Construction Management Team immediately informed the contractor to stop work and to discuss the importance of adhering to the permitted construction work hours. Annoyance vibration was noted by a few residents, in response DC Water worked with the contractor to modify their means and methods to reduce annoyance vibrations during demolition and construction. A few complaints regarding construction debris were also received. For example, one resident notified the team that trash from a GI construction site blew into her yard during a storm. A staff member was deployed to remove the trash. Similarly, another resident alerted the team that construction materials were left in the neighborhood. The construction crews were sent to retrieve the materials.

Many residents inquired as to the reasons GI was or was not constructed near their home. Some residents did not want GI due to the inconvenience of construction or distrust of public works projects, while others were disappointed to not have GI constructed on their block. To help residents understand why their neighborhood may have or have not received GI, the outreach coordinator would explain the general selection criteria which includes:

- Ability to meet the stormwater management requirements (cost effectiveness, slope, amount of stormwater reaching the facility)
- Utility conflicts
- Condition of pavement
- Coordination with other construction projects

Damage claims were also received. These ranged from concern over potential damage that could occur, perceived damage, and damage determined to be caused by GI construction. Damage claims included minor damage to retaining walls, driveways, and flooding. DC Water offered a claims process if a property owner believed that construction activities undertaken by the project damaged their property. The resident could call the 24/7 project telephone hotline or DC Water to initiate the claims process. A brief description of that process follows:

- A member of the contractor team would first visit the property and confirm the details, but not determine liability.
- Following the site visit, the claim would be handed over to DC Water’s insurance company. Communication with the property owner would then continue between the resident and DC Water’s insurance carrier and assigned adjuster.
- The claim would receive a claim number and an adjuster would visit the property to observe the alleged damage.
- The project team would follow the claim so that DC Water and the homeowner would be aware of the status and outcome of each claim.

A total of 36 damage claims were received related to the GI construction. Of these damage claims, 25 were repaired by the contractor or payments were made to the homeowner by DC Water’s insurance company. Nine of the damage claims were determined to be false claims or conditions that existed prior to construction. With over 2000 homes located near GI practices constructed by DC Water as part of Rock Creek Project A, Potomac River Project A1, and the Green Alley Partnership; the percentage of actual damage at 1% is low given the scope and extents of the project.

As described above, in most cases, DC Water was able to respond to and resolve complaints.

2.9.3 Positive Feedback

Although many residents were initially concerned about the disruptions caused by construction, the GI projects received many positive comments from the community. Residents complimented the aesthetics of the finished product and how helpful and responsive the outreach team was in answering questions and providing assistance. Several noted that their experience communicating with DC Water's GI team was far better than their experience with other local utilities. Below are a few examples of the feedback provided by residents located near DC Water GI practices.

- *"I would complement them on how nice the finished alleys look and how helpful the supervisors were. Amanda Zander has been very responsive to my queries and has helped me write two web posts explaining the work. She and a colleague also tabled at two BCA picnics."*
  ~Ann Carper, resident, Potomac River sewershed, August 2019

- *"You guys did the best job! I'm very impressed and I love the alley. The Clean Rivers project did a great job! The Public Outreach Coordinator and Project Manager came by my house to review the project with me beforehand. During the project, I needed help and they were responsive and helpful. I was definitely impressed. Thank you!"*
  ~Stacey Proctor, resident, Potomac River sewershed, February 2019

- *"DC Water's projects have enhanced the neighborhood with flowers and planter strips in place of pooling water. The permeable pavement in the alley behind my house lets the water through instead of ponding. It was also a bonus to have the work completed so quickly."*
  ~Patricia Roberts, resident, Rock Creek sewershed, March 2019

- *"It looks really nice, there has been a ton of work completed since then. We are very happy the results and the assistance provided with parking during construction."*
  ~Emily Howe, resident, Rock Creek sewershed, March 2019

- *"I just want to thank you for all of your help during the construction across the street from me to enable me to park my car in front of the house. Without your help I couldn't have done it. I truly appreciate your kindness in helping me with my groceries that day also. Believe me your kindness will never be forgotten."*
  ~Denise Bond, resident, Rock Creek sewershed, December 2018

- *"I am writing to commend Ms. Amanda Zander for her excellence in coordinating and distributing much-needed parking permits to our household with the commencement of significant work to be done in the alley behind our home. The attached letter reiterates the message in this email for your and her records.*

  We would have been in dire straits without them, and although Ms. Zander is responsible for a number of high priority items, she nonetheless also prioritized minimizing headaches in the *community where the work is currently still underway. She responded immediately to our desperation with calm foresight, a simple plan of action, and expedient response.*

Her professionalism represented DC Water with distinction and quality service to DC residents. I am thankful and impressed. I believe Ms. Zander's skillful management of a potentially stressful set of interactions qualify her for a promotion and pay raise, and hope you will agree.

Thank you Ms. Zander, from all of us at 37th Street!"

~Jee Kim, resident, Potomac River sewershed, January 2019

2.9.4 Survey

To gather additional post-construction input from the community, DC Water developed a GI Survey. This survey was mailed to each of the 2029 homes located near GI practices constructed by DC Water as part of RC-A, PR-A, and AlleyPalooza. Surveys were completed and returned via mail, email, or online through Survey Monkey.

Two-hundred and six (206) residents responded to the survey. Most of the survey responses provided appreciation for GI and support for future GI Construction. Specifically:

- 68% would like a significant amount or quite a bit more of GI in their neighborhood
- 79% would like a significant amount or quite a bit more of GI in the District
- Green alleys rated highest in types of GI preferred (only slightly higher, residents chose a mix of all technologies including bioretention, green parks, green roofs, rain barrels, and green streetscapes)
- 82% felt GI brought a benefit to their neighborhood
- Cleaner rivers/better water quality was rated the most important benefit of GI, with improved infrastructure such as repaved alleys rated the next most important benefit
- 85% agreed or slightly agreed that the benefit of GI outweighed the disruption of construction

The survey helped to gauge the ways in which residents prefer to be informed of construction projects. Mailers and door flyers were the most preferred methods over other methods such as meetings, websites, word-of-mouth, and listservs and social media forums such as NextDoor. Although outreach for GI included a variety of methods, the preferred methods correlated well with DC Water's actual outreach efforts, which relied heavily on mailers and door flyers to provide information about the GI projects.

2.10 Other Efforts in Support of GI

2.10.1 GI Utility Protection Guidelines

The DC Water Green Infrastructure Utility Protection Guidelines (Guidelines) provide guidance on the design and construction of GI adjacent or connected to DC Water utilities. The Guidelines are intended to provide reasonable protections for traditional DC Water sewer and water assets, and provide siting and design guidance for the following types of GI practices: street tree planting, tree and tree box filters; bioretention and bioswales; permeable pavements and pavers; alleys with bioretention; and underdrains adjacent to catch basins. DC Water utilities adjacent to, crossing, or connected to these GI practices include water mains, sewers, water services, sewer laterals, water meters, shutoff valves and valve boxes, cleanouts, hydrants, and other structures.

The development of these Guidelines included consultation with other agencies including DDOT, analysis of similar guidelines in other localities and a review of local regulations (including District of Columbia Municipal Separate Storm Sewer System permit) The specific requirements were developed and published in July 2013 with a copy included in Appendix H, reflect the due diligence performed as part of the development process. The Guidelines are used by designers working in public space for various District Agencies, other Utilities, and by private developers and property owners implementing GI in and around public space.

2.10.2 Coordination with DDOT's Green Book

The Sustainable DC Plan (http://www.sustainabledc.org/) adopted in 2013, sets long-range goals for making the District the greenest city in the nation. The plan calls for increasing green infrastructure in the public right-of-way (ROW) and taking actions to improve the health of the city’s waterways.

The District Stormwater regulations require stormwater volume retention on all major construction projects. Both public and private projects constructing in the ROW are required to retain stormwater to the maximum extent practicable. Designers must examine all uses of public space and place stormwater management where space and use allow.

DDOT is installing Green Infrastructure as part of construction projects and in retrofit projects to reduce stormwater runoff in more areas of the city. Green Street and Green Alley projects utilize GI techniques and may be constructed where watershed and infrastructure improvements are prioritized.

Some of the DDOT Green Infrastructure practices for streets include bioretention, street trees, landscape areas, permeable pavement, and removing unnecessary paving. When implemented, GI creates living green streets that capture, store, and infiltrate stormwater to treat it as a resource and improve the urban environment.

In 2014, DDOT released the GI Standards which included technical drawings, specifications, design manual, plant list, and maintenance schedules, and can be found here: https://ddot.dc.gov/publication/ddot-green-infrastructure-standards-2014

During the development of the DDOT GI standards, DC Water provided extensive comments on multiple iterations of the Standards that considered the (then) future construction of DC Water's GI program. The feedback from DC Water focused on making sure that the Standards would not be in conflict with DC Water’s goals and could instead complement and support them as DC Water moved forward with its GI program for CSO control.

2.10.3 National Green Infrastructure Certification Program (NGICP)

DC Water recognized early on that green infrastructure not only helps to beautify neighborhoods, support natural habitats, enhance public space, and clean District rivers, GI also helps create and sustain long-term local green jobs. Not only has DC Water committed with the District of Columbia to have 51% of new jobs created through the Green Infrastructure Program be filled by District residents, but in 2016, through a partnership with the Water Environment Federation (WEF) and 14 cities and towns across the country, DC Water lead the creation of the National Green Infrastructure Certification Program (NGICP). (https://ngicp.org/)

DC Water and WEF in concert with the other NGICP partners set a national standard for GI entry level construction, inspection, and maintenance workers. A curriculum was developed to train individuals and provide the necessary skills for the creation of a proficient green workforce and establish a career path for skilled green infrastructure workers. Since inception in 2016, a total of 605 individuals have become NGICP certified.

Since 2016, DC Water has been working in partnership with the University of the District of Columbia (UDC) to fund NGICP training and workforce development in the District. The program has included a blend of soft skills, technical studies focused on the NGICP curriculum, and a variety of field and hands on learning experiences. 150 District residents have completed the training, with 66 District residents passing the exam and receiving the NGICP credential. As part of the workforce development component, DC Water staff through DC WaterWorks, has assisted in placing graduates in jobs on DC Water GI projects, and other organizations and firms working within the GI arena. Job placement numbers have fluctuated over time, but at its high point over the course of the program to-date, over 30 individuals were working in GI related jobs including many on DC Water projects.

As the use of green infrastructure for stormwater management grows nationwide, holding this certification will provide a unique opportunity for the participants to pursue a successful career path here in the District and beyond. Additional information on the NGICP program is provided in Appendix I.

2.10.4 Standard Alley Design and Blanket Permit

As mentioned above, in 2013, the District of Columbia adopted the “Sustainable DC Plan” which set long-range goals for making the District the greenest city in the nation and to take actions to improve the water quality in Rock Creek, and Potomac and Anacostia Rivers. To relieve pressure on the stormwater infrastructure, the plan calls for DC to increase the use of GI along the District’s public rights-of-way and build 25 miles of green alleys by 2032.

In coordination with the Mayor’s Office, DDOT initiated a six-year, $175 million program called AlleyPalooza in 2014. The program’s goal is to provide targeted and expedited alley maintenance and restoration services for the residents of the District. Due to the extensive need for alley repairs across the District, DDOT prioritizes alley improvement projects based on the number of resident service requests and an alley condition rating. Each year DDOT uses the alley prioritization process to select eight alley rehabilitation projects in each of the District's eight wards for a total of 64 AlleyPalooza projects per year.

In addition to AlleyPalooza, DDOT is installing GI as part of construction projects and in retrofit projects to reduce the quantity and improve the quality of stormwater within the District. DDOT's green alley projects are constructed where watershed improvements and infrastructure rehabilitation are prioritized in the District's right-of-way. Because DCCR's and DDOT's programs have a significant focus on alley work, there existed an opportunity to utilize a standard approach to green alley permitting, design, and construction to achieve common goals while reducing total cost to District residents and ratepayers.

In 2017, DC Water developed standard alley permeable pavement (APP) details and specifications. The standard APP design details were developed based on DDOT's Standard GI Details with sufficient updates to specify dimensions and elements of the design that were not otherwise provided in DDOT's green book details. The specifications and standard APP details are provided as part of Appendix D. As part of the implementation, a blanket permit was negotiated with DOEE and DDOT referencing and allowing the standardized approach and associated standardized details and specifications. This approach significantly streamlined the siting, design, permitting, and construction processes. Instead of an alley taking months to site, design, permit, and begin construction, this highly efficient method allowed DC Water to identify a permeable alley and be mobilized and starting construction in a matter of weeks. This efficiency throughout the process helped to drive down costs significantly.

2.10.5 Partnerships with Schools

Throughout the course of the GI program, DC Clean Rivers staff worked with several schools on conceptual plans for GI, provided tours to various school groups, and supported other school initiatives such as "family fun day" types of public events. Examples of design and conceptual planning work follow in this section.

2.10.5.1 Washington Latin Public Charter School

DC Clean Rivers staff began working with Washington Latin Public Charter School in 2013, as part of the planning and groundwork for the future of the GI program and the first large-scale Rock Creek project. Initially the school was envisioned as part of a "hub and spoke" approach that identified locations for GI that provided multiple functions (improving parks, school grounds, recreation centers and the like) that would serve as "hubs" with GI in the public right-of-way serving as "green corridor spokes". At the time, Washington Latin had an underutilized bioretention site, and an opportunity for a school garden that was a prime candidate for irrigation derived from rainwater harvesting from the school's rooftop. Through multiple meetings and conversations with the school, concept plans were developed (see Figure 2-21), which included a cistern, terraced vegetable gardens, and enhancements to the bioretention area including additional plantings and outdoor classroom space. Ultimately due to funding and timing DC Water did not advance the conceptual designs to final designs, however the school went on to implement many of the elements contained in the plans.

Figure 2-21. Washington Latin PCS Concept Design

2.10.5.2 Paul Public Charter School

Located in Northwest DC, Paul Public Charter School was also envisioned to function as a green infrastructure "hub". In 2013 as-built plans for the school were obtained, and every corner of the school property studied for GI implementation. Multiple sites on the property were considered, but here again, timing was not ideal as the school shortly thereafter began a process for a major renovation/addition that expanded across many of the ideal GI locations. Ultimately concept plans were developed that identified and disconnected interior roof drains at the front of the school and directed that flow into a pair of bioretention facilities flanking the school entrance stairs (see Figure 2-22). This location was initially considered to be included in Rock Creek Project A, but ultimately was identified as a location for consideration under a later project as it fell outside of the contiguous RC-A project area.

Figure 2-22. Paul PCS Concept Rendering

2.10.5.3 Georgetown University

DC Clean Rivers staff worked with non-technical Georgetown University students and staff to mentor and provide technical guidance for their 2014 submission to EPA for the "Campus Rainworks Challenge" (Figure 2-23). For 2014 there were sixty-four submissions for the Rainworks Challenge, including multiple submissions with technical teams of engineering and landscape architecture students. Two entries were awarded first place, two second place, and two received an honorable mention (one of which was the submission from the non-technical Georgetown University team).

From EPA's website:

> *The design focuses on retrofitting areas around Lauinger Library, an iconic building on the university's main quadrangle that receives an estimated 1 million visitors per year. The site comprises a significant portion of the sewershed and currently contains underutilized space, impermeable surfaces, and inefficient drainage. To mitigate stormwater runoff draining into the combined sewer, the team identified three mini-sites around the library to implement green infrastructure practices. The sites together have the potential to manage 22,050 gallons of rainwater during a 1.2" storm. The team's design also improves community space on campus and provides opportunities for public education about sustainable stormwater infrastructure.*
>
> (https://www.epa.gov/green-infrastructure/2014-campus-rainworks-challenge-winners#georgetown)

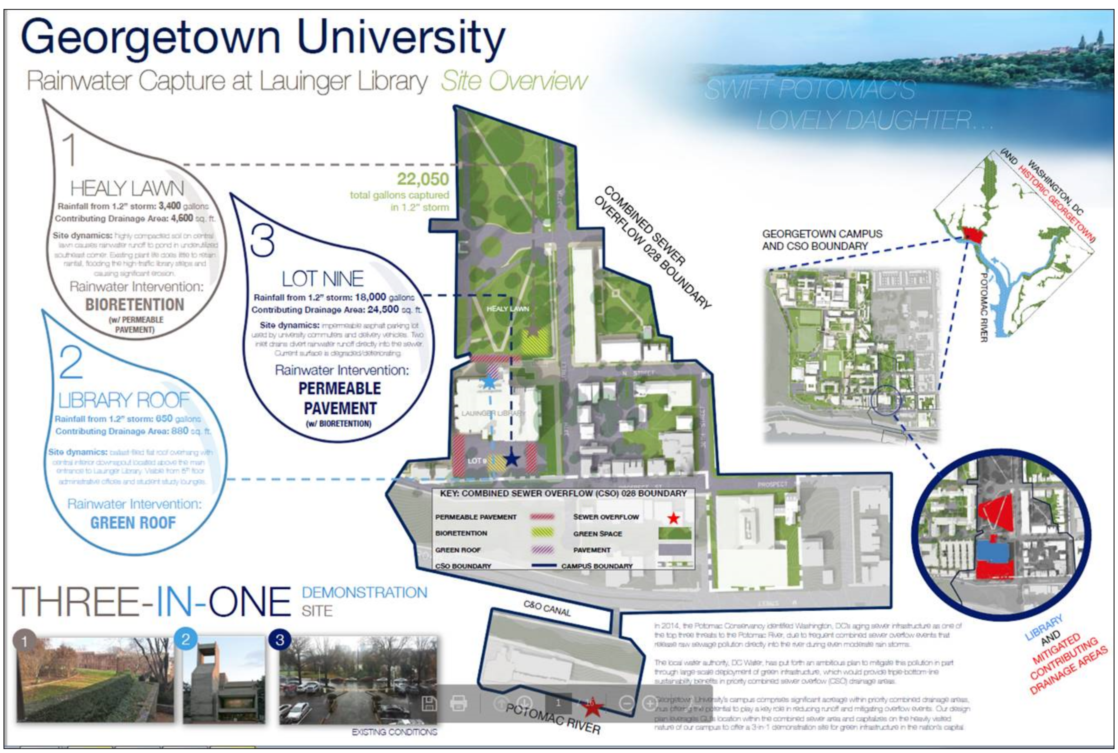


Figure 2-23. Georgetown University Rainwater Capture Site Overview

This initial work with Georgetown University led to additional conversations and technical investigations for GI retrofit of Healy Lawn, the iconic open space on the eastern side of campus, as well as the parking lot behind Lauinger Library. The University was in the process of updating their master plan, and several areas of Healy Lawn needed redesign that also offered opportunities for GI retrofit. The parking lot behind Lauinger Library had poor circulation and drainage issues that also represented an opportunity for GI. Ultimately given timing, the scope of work involved, and long-term campus development considerations, the work did not progress beyond the early concept stage.

2.11 Acres Pursuant to District's Stormwater Regulations

Appendix F, Section II.E of the Amended Consent Decree allows DC Water to take credit for other controlled acres. The decree states that within the GI areas "Controlled acres from the implementation of the District's MS4 Permit and Stormwater Regulations will be credited against DC Water's obligations to control acres." These are stormwater measures that have been implemented due to redevelopment within the sewershed, and paid for by District business owners, residents and taxpayers. These measures contribute to the overall volume managed in the sewershed, and collectively help to reduce stormwater runoff that contributes to combined sewer overflows at Piney Branch CSO 049. The following criteria must be met to allow these acres to be credited towards the acres noted in
Table 1-1:

"1. They are located in the CSO areas targeted for GI implementation by DC Water; and

2. The design of the control measures and their level of control has been verified by DC Water to achieve the 1.2" retention standard or any portion thereof. Where green infrastructure installation by any party do not meet the full 1.2" design criterion and are counted towards meeting the requirements of this consent decree, DC Water may proportionally credit the control achieved; and

3. DC Water, the District or a private party has assumed operation and maintenance responsibilities in a legally binding document of as part of its statutory or regulatory authority."

2.11.1 DOEE MS4 Database

DOEE has responsibility for administering the District's stormwater program and activities required in the District's National Pollutant Discharge Elimination System (NPDES) Permit – more commonly referred to as a Municipal Separate Storm Sewer System (or MS4) Permit. DOEE created a stormwater database, giving them the ability to track, evaluate, and report on details of GI installations throughout the District, including those in the Combined Sewer Areas where they also apply the MS4 requirements. The database contains such information as Best Management Practice (BMP) type, installation date, contributing drainage area, and storage and retention volumes. In addition, the database indicates if the BMP is regulated under the MS4 permit or not. Regulated BMPs are listed as a "Yes" in the database under the "Major Regulated Activity" field.

2.11.2 DOEE Requirements

To ensure compliance with the stormwater requirements of the District, DOEE mandated that stormwater facilities installed after approximately 1999 have a legally binding covenant, which is filed with the record of deeds of the property, requiring the stormwater practices to exist and to be maintained. Facilities regulated under this provision are listed in the database as such under the “Major Regulated Activity” field. This indicates that a covenant is on file with DOEE which coveys with the property anytime it is bought or sold. In addition, DOEE inspects each facility approximately every three years to confirm the property owner is maintaining the facilities.

2.11.3 MS4 Credit

DC Water reviewed the stormwater practices in DOEE’s database and used the following criteria to identify practices to credit:

- Practices must be in the Piney Branch sewershed. DC Water overlaid the latitude/longitude coordinates for the practices in DOEE’s database on the GIS sewershed boundaries to identify practices within the sewershed. Figure 2-20 shows the location of the practices.
- Only practices constructed after 2002 were eligible. Since the monitoring for the LTCP occurred in 2002 to determine the volume to be managed at CSO 049, BMPs installed prior to that period would already have been accounted for in the monitoring data. Therefore, only BMPs listed in the DOEE database after 2002 were considered eligible for inclusion.
- Only practices identified as constructed pursuant to a “Major Regulated Activity” were eligible. This is because Major Regulated Activities are required to have covenants that convey with the property.
- Only practices that had a quantified storage volume in the database were eligible. Practices with no storage volume such as trees and Bayscaping were considered ineligible to be conservative in the accounting.
- Forty-three potentially eligible practices were identified as constructed between 2003 and 2012. DC Water performed a review of property records to confirm the presence of covenants in the property records. The review determined that:
    - Fourteen practices are owned by the Government agencies such as the District or Federal Government, and the stormwater regulations do not require covenants for government agencies.
    - Twenty-nine practices are owned by private entities, and covenants were located for 27 practices. Covenants were not found for two practices. Because of this, DC Water has elected to not credit the two private practices where covenants could not be located in the property records.
- DC Water reviewed the sizing of practices in the database. The volume of practices that exceeded the predicted runoff from the drainage area tributary to the practice for a 3.5” rainfall was excluded. This is because a 3.5” rainfall is the largest storm in the average year period (1988, 1989 and 1990) used as the basis for CSO planning.

Based on upon the above criteria, Table 2-14 through Table 2-16 summarize the practices while Figure 2-24. Georgetown University Rainwater Capture Site Overview depicts their location. The full list of practices is included in Appendix J.

Table 2-14. Major Regulated Activity BMPs

Period	# Practices	Storage Vol. (MG)
After 2002 (after LTCP monitoring)	244	2.32

Table 2-15. Major Regulated Stormwater Practice by Type (after 2002)

	# Practices	Storage Vol. (M)
Bioretention	56	0.64
Filtering	15	0.10
Green Roofs	34	0.15
Infiltration	33	0.11
Permeable Pavement	68	0.76
Storage	16	0.36
Other	22	0.20
Total	**244**	**2.32**

Table 2-15 above summarizes the distribution of MS4 major regulated DOEE BMPs with storage by practice type, while Table 2-16 summarizes by installation year. BMPs that do not have a storage component such as tree plantings, are not accounted for in the impervious acres managed.

Table 2-16. Major Regulated Stormwater Practices by Year (after 2002)

Year	# Practices	Storage Vol. (MG)	Year	# Practices	Storage Vol. (MG)
2003	1	0.04	2012	8	0.07
2004	4	0.17	2013	2	0.03
2005	4	0.04	2014	11	0.15
2006	2	0.03	2015	47	0.63
2007	5	0.02	2016	23	0.06
2008	4	0.03	2017	12	0.02
2009	6	0.22	2018	59	0.15
2010	4	0.03	2019	43	0.45
2011	5	0.18	2020	4	0.01
			Totals	**244**	**2.32**

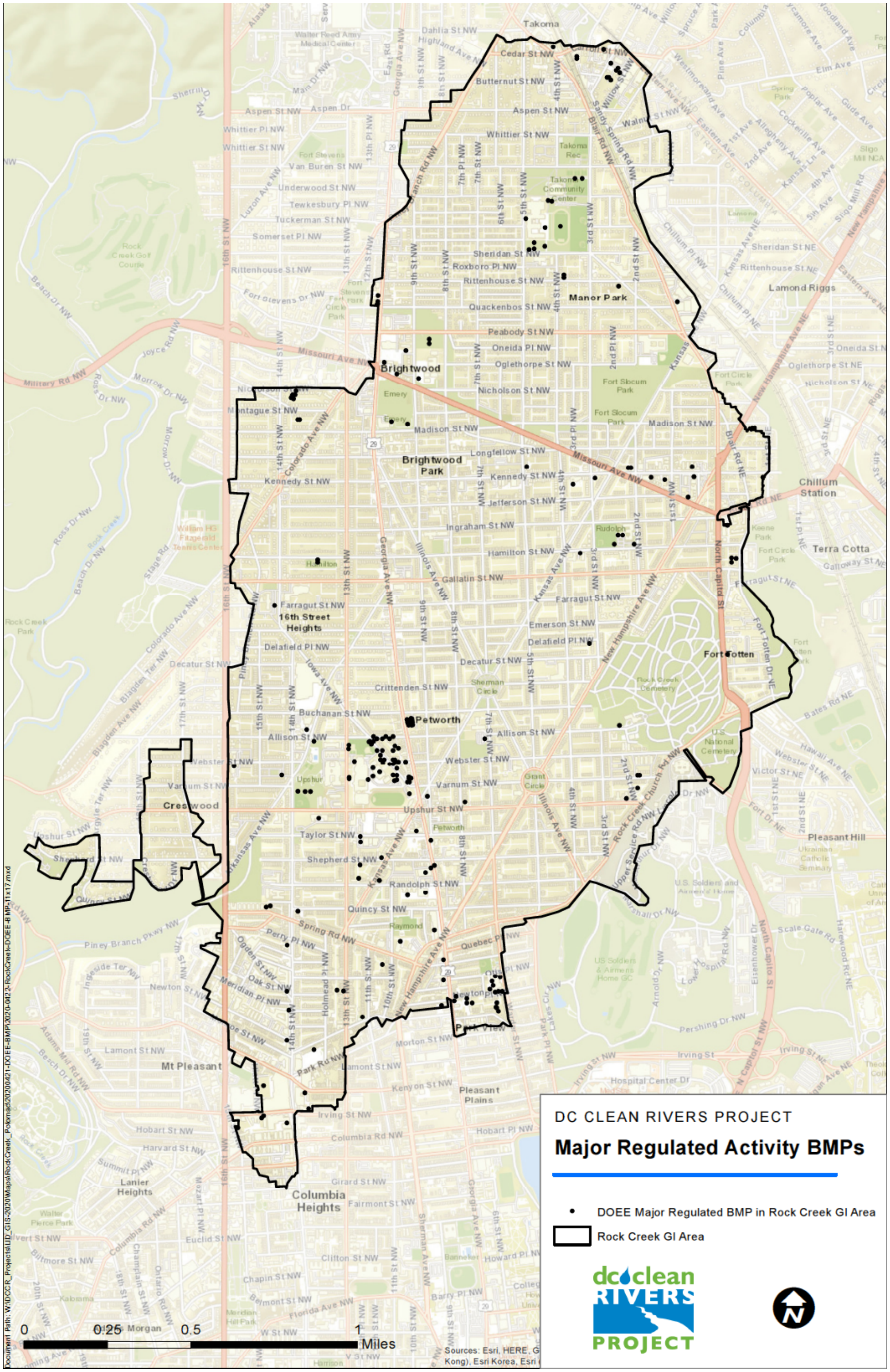


Figure 2-24. Georgetown University Rainwater Capture Site Overview

3 Assessment

In accordance with the Amended Consent Decree, this section provides a practicability assessment of the first GI project in the CSO 049 sewershed. In performing the assessment, DC Water considered the lessons learned for all the GI constructed in the Rock Creek and Potomac sewersheds. The following items were considered in the assessment:

- Constructability
- Operability
- Efficacy
- Public Acceptability
- Cost Effectiveness

3.1 Constructability

Rock Creek Project A (RC-A) is located along the eastern edge of the Rock Creek GI Area and comprises a project boundary of approximately 163 acres as shown in Figure 2-1. This project area was selected for its feasibility of design and construction and the availability of monitoring locations. Most importantly, the RC-A project area was selected because it is representative of the entire Rock Creek sewershed. As demonstrated in the July 2016 GI Program Plan submitted to EPA, there is enough public space within the sewershed to manage 1.2” of runoff from 365 impervious acres utilizing GI.

The GI practices implemented within the RC-A project boundary were sited based on existing condition constraints, such as utilities, structures, topography, land use, and vegetation. In addition, the practices were sited as a distribution and concentration representative of a full 365-acre build out. In addition to RC-A, DC Water has implemented other work within CSO 049 including alleys constructed as part of Green Alley Partnership (AlleyPalooza), Downspout Disconnection on private property, as well as the GI Challenge Parks and Kennedy Street-GI Streetscape. In sum, DC Water was able to site, permit and construct GI practices that exceed the number of acres required to be managed under the Consent Decree for Project No. 1 as shown in Table 1-1.

From a constructability standpoint, GI is practicable in the Rock Creek Sewershed.

3.2 Operability

Effective operation and maintenance are essential to the success of GI. DC Water maintains the inventory of GI practices they own, including those GI practices brought on during Rock Creek Project No. 1.

While the DC Water-constructed GI practices do not require an active operator, ongoing and extensive GI Maintenance is conducted on a monthly and quarterly basis to maximize performance of each of the GI practices. Monthly maintenance for all bioretention facilities involves weed, sediment, and debris removal, inspection of cleanout and underdrain structures, and inspection for erosion. Monthly maintenance for all pervious pavement facilities involves vacuuming with regenerative air sweepers, inspections of flow restriction devices and observation wells for standing water, clogging and blockages.

Additional quarterly maintenance of bioretentions includes removal of weeds, trash, and debris and inspection of all structures and vegetation and includes the flushing of underdrains if required. Quarterly maintenance for the pervious pavement involves inspection of the system for clogging, blockages, debris and sediment, intensive joint cleaning using compressed air, and inspection of the correction of settlement or heaving as well as the flushing of underdrains if required.

Reporting and photo logging for each maintenance visit is performed and reported back to DC Water's Asset Management group. As the inventory of GI practices owned and operated by DC Water grows, DC Water will have a significant annual resource demand beyond what is currently allocated.

From an operability standpoint, GI is practicable in the Rock Creek Sewershed.

3.3 Efficacy

To determine the efficacy of GI, DC Water monitored and modeled the sewershed both pre- and post-construction to see if there was a reduction in wet weather flow (WWF), and if that reduction matched the predicted reduction based on the number of impervious acres treated by GI. The WWF volumes presented in this Section are defined as occurring when predicted flows in the sewer are exceeding two times average dry weather flow rate. The reduction in WWF volumes per average year were calculated by taking the difference between pre- and post-construction volumes divided by the number of impervious acres treated at 1.2" to determine the WWF reduction in million gallons per average year per impervious acres treated at 1.2". Due to the nature of the sewersheds and the applicability of flow monitoring installations, this section focuses on the RC-A, RC-B, and PR-A project areas.

3.3.1 RC-A Pre-Construction Monitoring - Sewershed

A detailed post-construction monitoring report for RC-A is provided as Appendix E. In addition, a complete set of event hydrographs, monthly plots and rainfall events tabulations are included in the modeling report prepared for RC-A. The calibration and monitoring results are explained as follows.

For pre-construction monitoring, Figure 3-1 and Figure 3-2 show 1-to-1 plots for wet weather event volumes and peak flows for pre-construction monitoring calibration. Overall modeled predictions match event volumes well for meters 049-1 and 049-2 combined with the regression close to the 1-to-1 line and an R-squared value of 0.85. The overall wet weather volume match is acceptable with a difference of only 7%. P Peak flow response is more variable in the 1-to-1 plots; more variability with peak flows than with volumes is typical for collection system modeling, and reflects the difficulty in precisely quantifying the actual flow paths and peak flow response by the collection system due to potential issues such as flow bypassing the inlets or uneven road surfaces. The hydrograph comparisons for individual events show a great variability in metered sewer response for rainfall events of similar size.

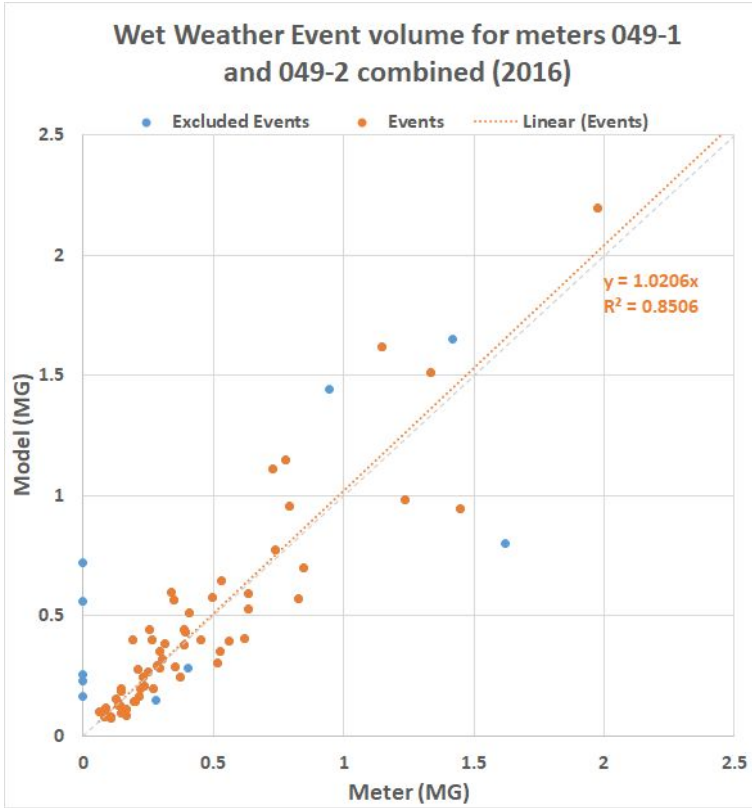


Figure 3-1. RC-A Pre-Construction Event Volumes, 049-1 and 049-2 Combined

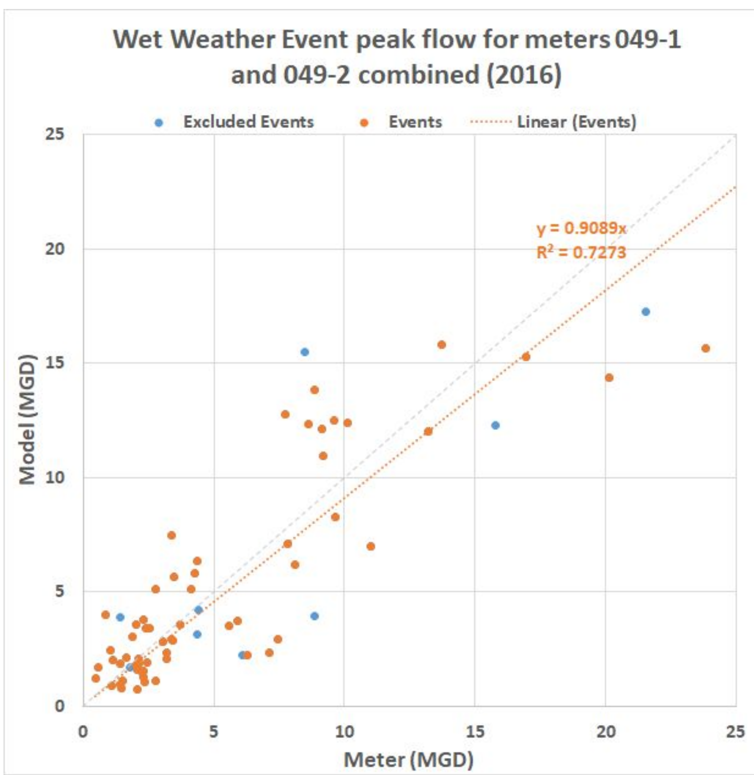


Figure 3-2. RC-A Pre-Construction Event Peak Flows, 049-1 and 049-2 Combined

3.3.2 RC-A Post-Construction Monitoring - Sewershed

For Post -construction monitoring using sewershed flow monitoring data, Figure 3-3 and Figure 3-4 show 1-to-1 plots for wet weather event volumes and peak flows for the combined flows from metering locations 049-1 and 049-2. Timeframes in the figures correspond to various stages of practice rehabilitation and in-practice monitoring as described below.

- 3/1/19 – 10/31/19: Period before practice retrofits
- 12/1/19 – 1/31/20: Period of ongoing practice retrofits
- 2/1/20 – 03/31/20: Period after practice retrofits completed

Overall modeled predictions match event volumes well for meters 049-1 and 049-2 combined, with the regression close to the 1-to-1 line and an R-squared value of 0.94 for the calibration timeframe (3/1/2019 – 7/18/2019). The overall wet weather volume match is acceptable with a difference of only 8%. Peak flow response is more variable in the 1-to-1 plots. The hydrograph comparisons for individual events show a great variability in metered sewer response for rainfall events of similar size.

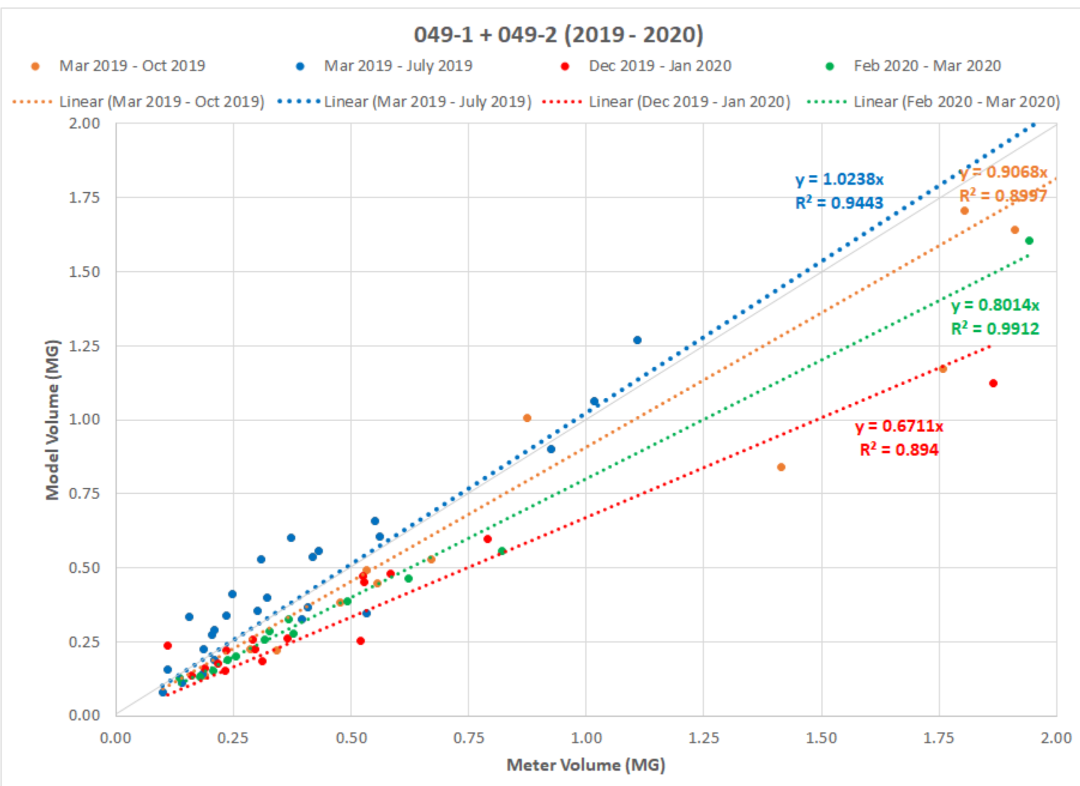


Figure 3-3. Post-Construction Event Volumes, 049-1 and 049-2 Combined

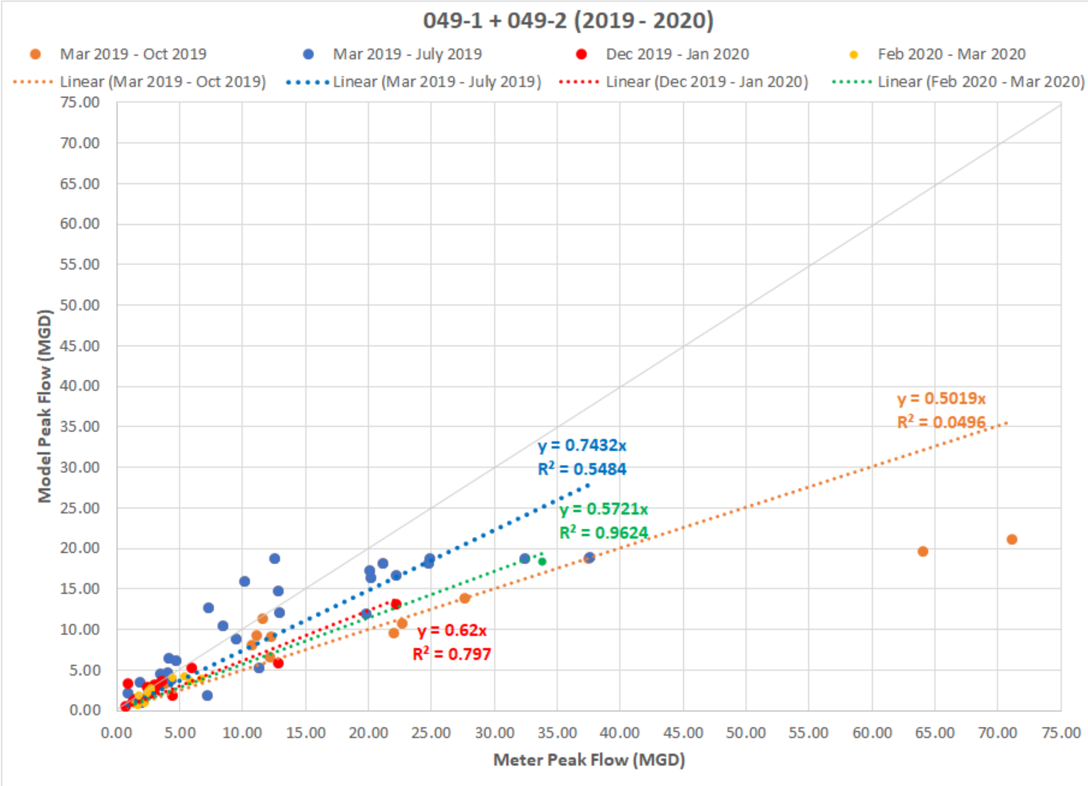


Figure 3-4. Post-Construction Event Peak Flows, 049-1 and 049-2 Combined

3.3.3 RC-A Post-Construction Monitoring - GI Practice Level

GI performance assessment using the practice level data for various timeframes associated with the practice rehabilitations is discussed here. Practice level monitoring started with four GI practices (PBR-3503, APP-3608, APP-4105, PPP-4211) on 4/19/2019. Table 3-1 summarizes the maximum water levels observed in each of the practice-level monitoring wells for the retrofit time frames. Highlighted cells mark the maximum observed water level for each monitored cell over all time periods.

Table 3-1. Maximum Observed Practice Water Levels

Practice ID	Type	Maximum Water Level (in) Pre-retrofit 3/1/19 – 10/31/19	Retrofits (ongoing) 12/1/19 – 1/31/20	Post-retrofit (completed) 2/1/20 – 3/31/20
3503-A01	PBR	1.03	**1.04**	0.91
3503-A02	PBR	**1.55**	0.83	1.42
3503-A03	PBR	**6.14**	1.24	1.04
3503-A04	PBR	**4.56**	0.82	1.09
3608-A01	APP	0.65	8.99	**25.38**
3608-A02	APP	0.82	**25.85**	25.43
3608-A03	APP	0.89	**29.34**	25.56
3608-A04	APP	24.38	14.64	**23.71**
3608-A05	APP	1.51	30.01	**30.56**
3608-A06	APP	5.64	31.37	**32.72**
3608-A07	APP	29.52	15.78	**32.1**
3608-A08	APP	12.19	21.77	**44.03**
4105-A01	APP	1.49	1.25	**23.5**
4105-A02	APP	1.69	0.72	**33.54**
4105-A03	APP	11.1	1.03	**43.21**
4105-A04	APP	14.38	1.13	**45.98**
4211-A01	PPP	**1.09**	0.8	0.92
4211-A02	PPP	**1.26**	1.06	0.91
4211-A03	PPP	**1.54**	1	0.79
4211-A04	PPP	**11.03**	1.48	1.22
4211-A05	PPP	**5.68**	0.77	1.73
4211-A06	PPP	**9.7**	1.26	1.22
4211-A07	PPP	**0.98**	0.65	0.49
4211-A08	PPP	**8**	1.84	3.13
4211-A09	PPP	**13.37**	0.85	2.28
4211-A10	PPP	**6.67**	0.98	0
4211-A11	PPP	**10.87**	0.97	2.81
4211-A12	PPP	**8.7**	1.21	4.31

The observed practice water levels show that one (APP-3608) practice out of the monitored practices benefited from the 12/1/19 – 1/31/20 retrofits. Upon completion of all practice retrofits, practice APP-4105 also showed a significant increase of the observed maximum water levels.

Beginning on 3/13/2020, the in-practice monitoring was extended to include all RC-A GI practices. Modeled water levels from the sewershed model for the first GI project is compared with the averaged water level observations for each practice type and re-calibrated the GI parameters in the model for the timeframe of 3/13/20 – 3/22/20 (three wet weather events).

Figure 3-5 shows 1-to-1 plot for wet weather event volumes for the combined flows from metering locations 049-1 and 049-2.

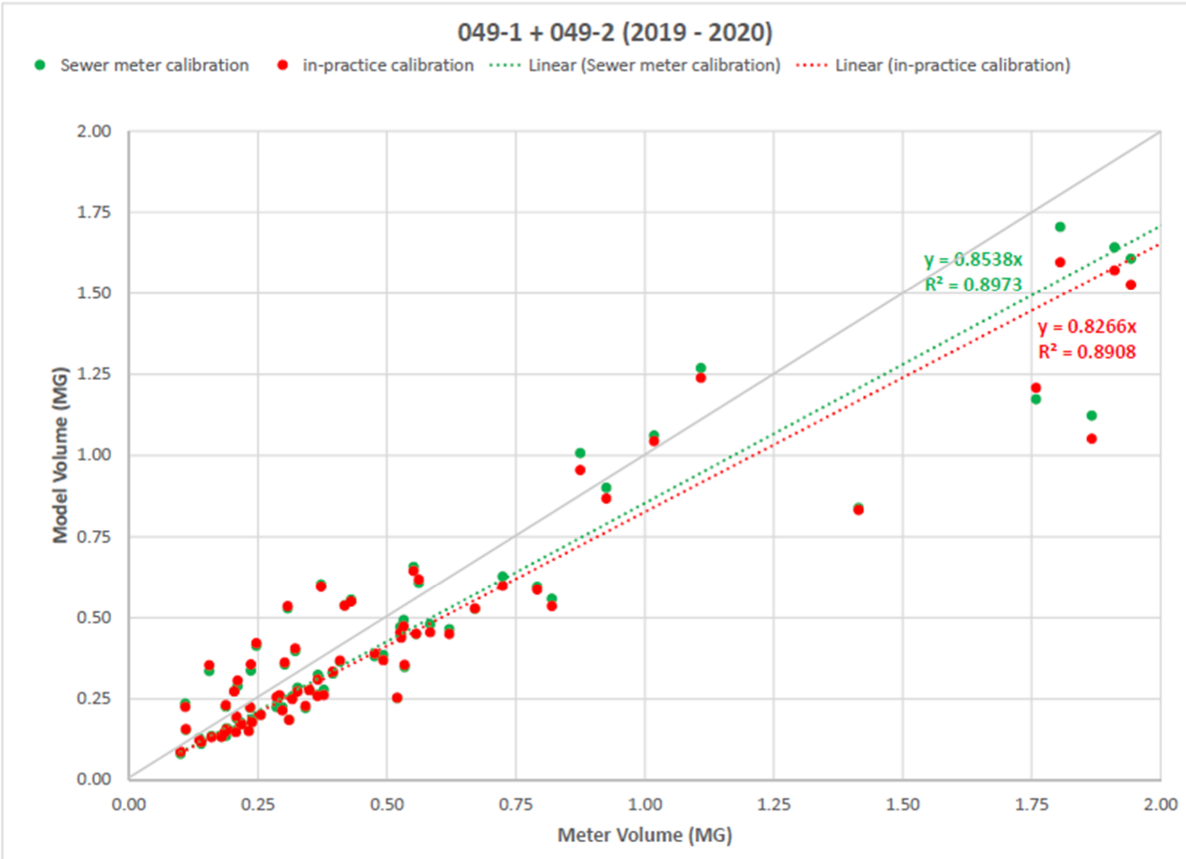


Figure 3-5. Post-Construction Event Volumes, 049-1 and 049-2 Combined

3.3.4 RC-B Control Basin

Using the control basin methodology, paired wet weather event volumes between RC-B and RC-A 049-3 sewersheds is plotted in Figure 3-6 for both monitoring phases. These wet weather responses from both sewersheds refer to similar weather input and antecedent conditions. The difference in the slopes of the two regression lines is statistically significant, suggesting that RC-B is effectively reducing the overall volume of stormwater runoff from the collection system.

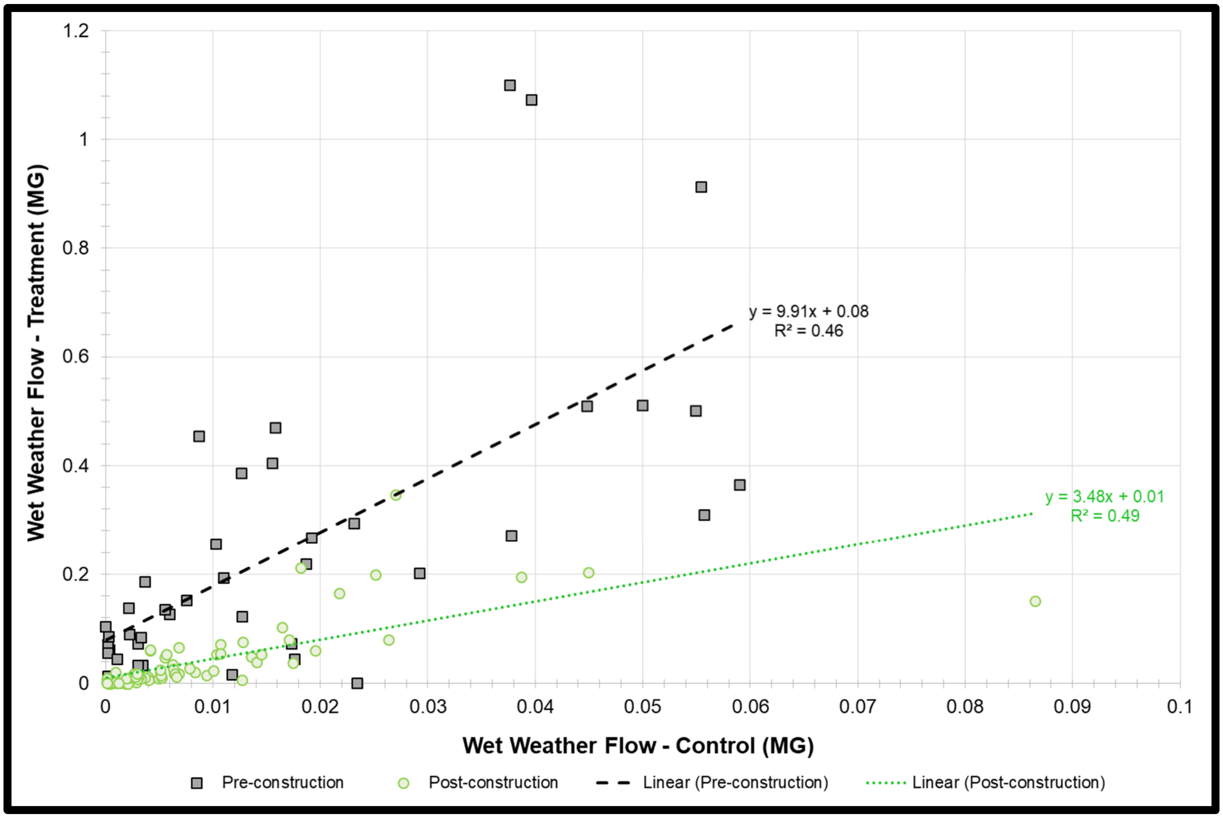


Figure 3-6. RC-B Performance Evaluation – Control Basin Methodology

3.3.5 PR-A Pre-Construction Monitoring - Sewershed

A complete set of event hydrographs, monthly plots and rainfall events tabulations is included in the modeling report prepared for PR-A, provided as Appendix F. The calibration and monitoring results are explained as follows.

Figure 3-7 through Figure 3-10 are 1-to-1 volume and peak flow plots for the combined 029-1 + 029-2 meter locations and 029-5 + 029-6 meter locations, comparing metered flows versus modeled predictions. Modeled predictions match event volumes well for both 029-1 + 029-2 and 029-5 + 029-6 locations. Peak flow response is more variable, with the model generally predicting somewhat higher peak flows, but with significant variability from event to event.

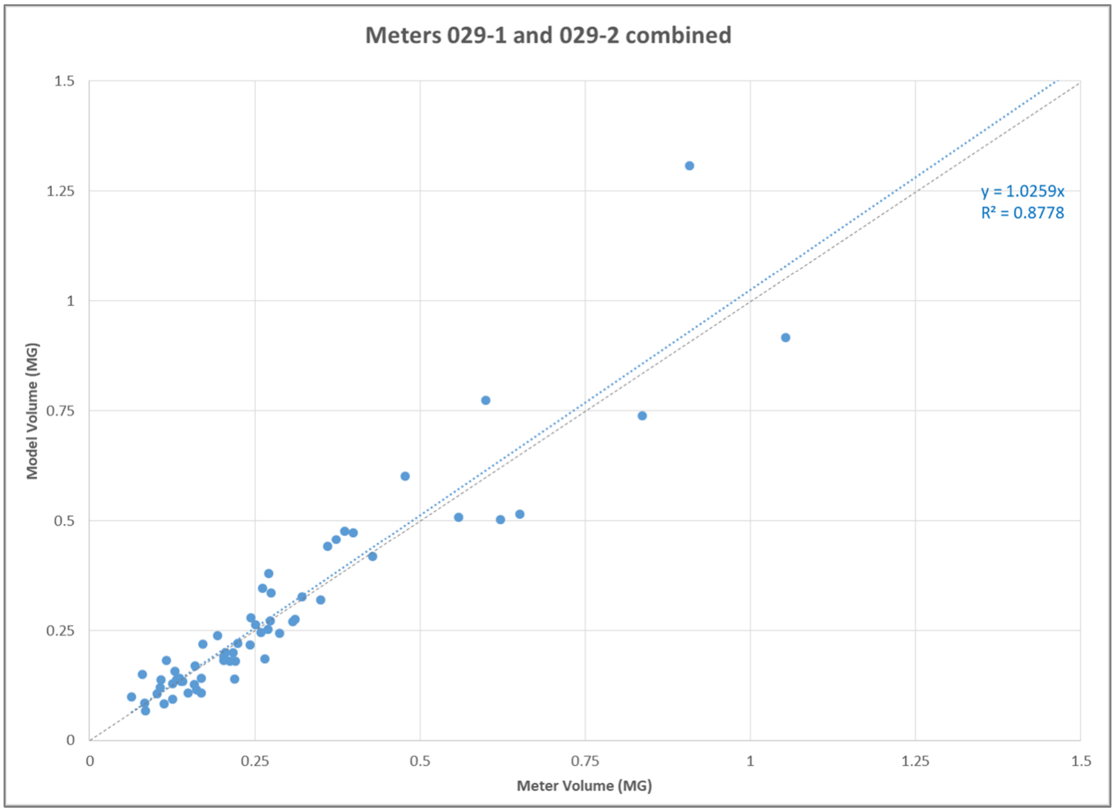


Figure 3-7. PR-A Pre-Construction Event Volumes, 029-1 + 029-2

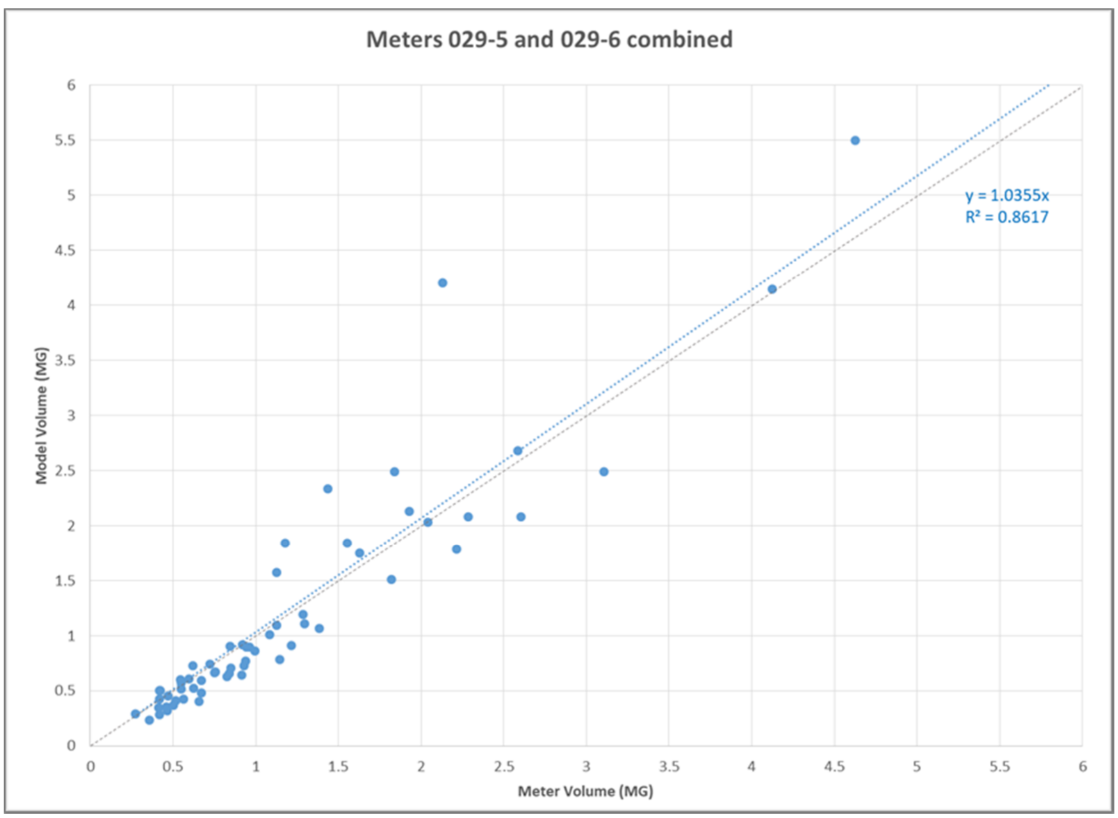


Figure 3-8. PR-A Pre-Construction Event Volumes, 029-5 + 029-6

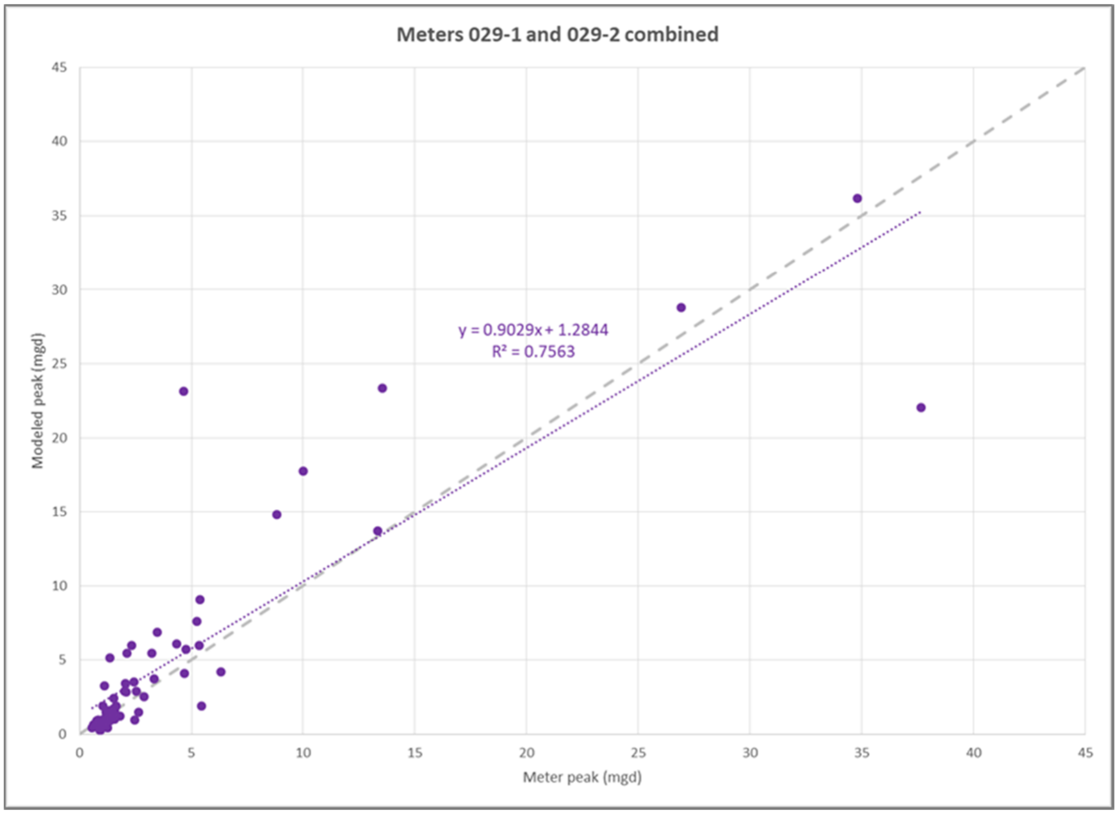


Figure 3-9. PR-A Pre-Construction Event Peak Flows, 029-1 + 029-2

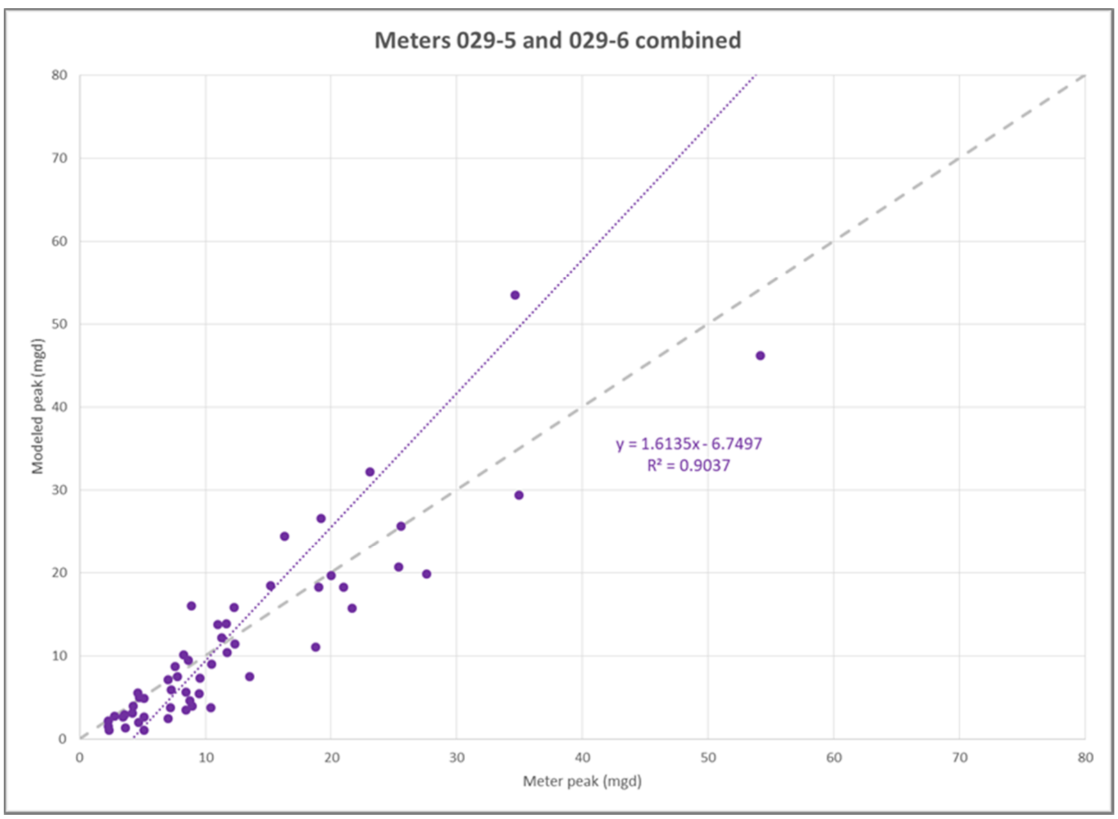


Figure 3-10. PR-A Pre-Construction Event Peak Flows, 029-5 + 029-6

3.3.6 PR-A Post-Construction Monitoring - Sewershed

Figure 3-11 through Figure 3-14 are 1-to-1 volume and peak flow plots for the combined 029-1 + 029-2 meter locations and 029-5 + 029-6 meter locations, comparing metered flows versus modeled predictions.

For 029-1 + 029-2, over the entire calibration period, the model under-predicts volumes by 3%. For 029-5 + 029-6, there is an overall over-prediction of volumes by 22%. Considering the difficulty in metering near a CSS regulator (029-5 meter), and that the performance in the smaller 029-1 + 029-2 subshed (in which GI practices were highly concentrated) was very close to the observed values, the PR-A post-construction model was considered to be calibrated.

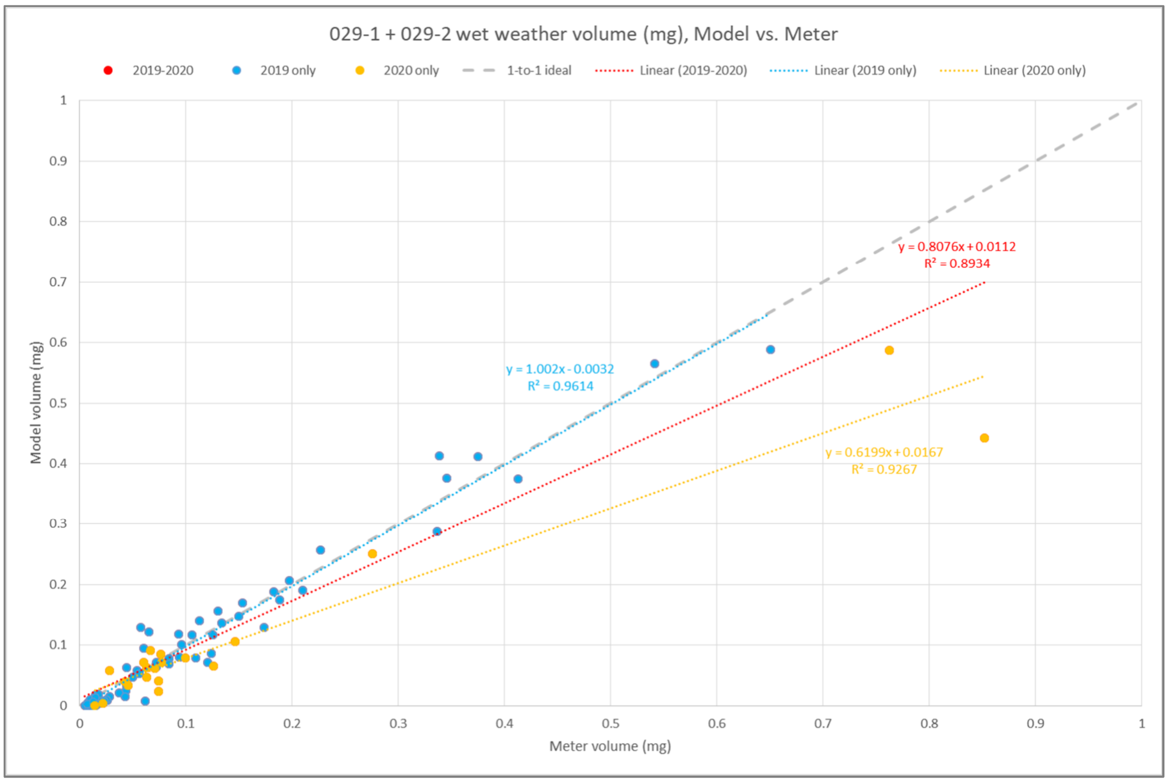


Figure 3-11. PR-A Post-Construction Event Volumes, 029-1 + 029-2

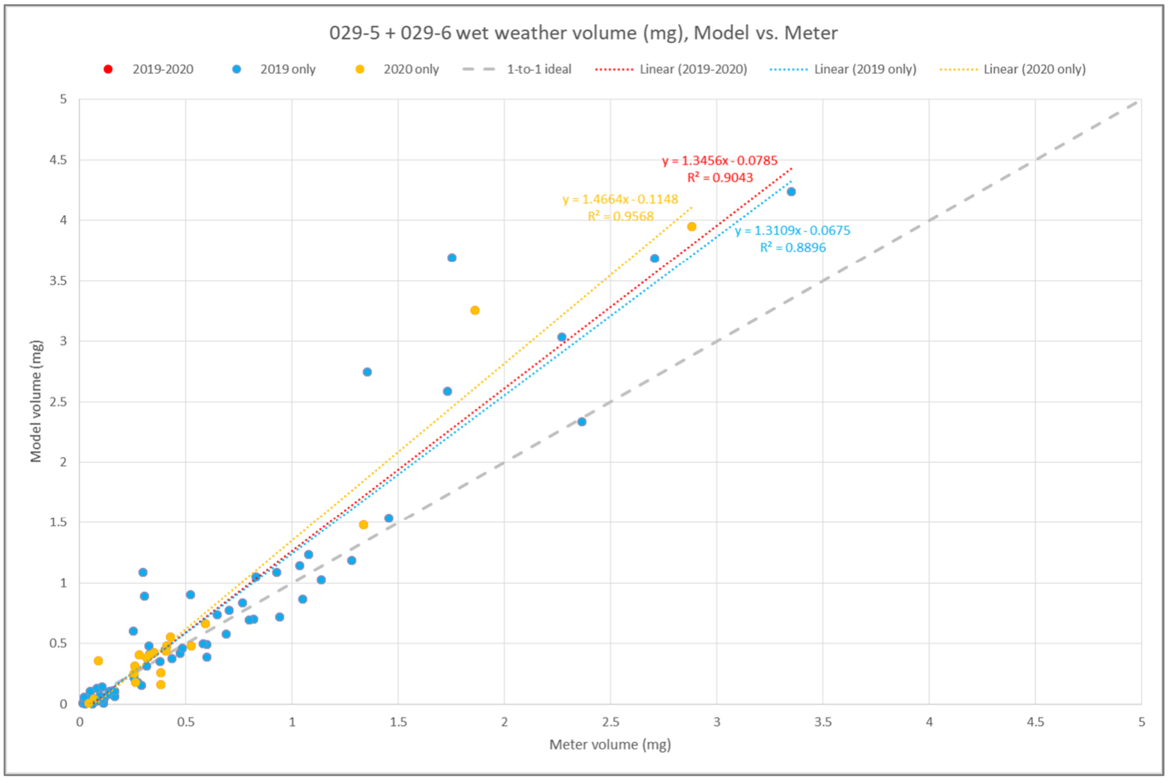


Figure 3-12. PR-A Post-Construction Event Volumes, 029-5 + 029-6

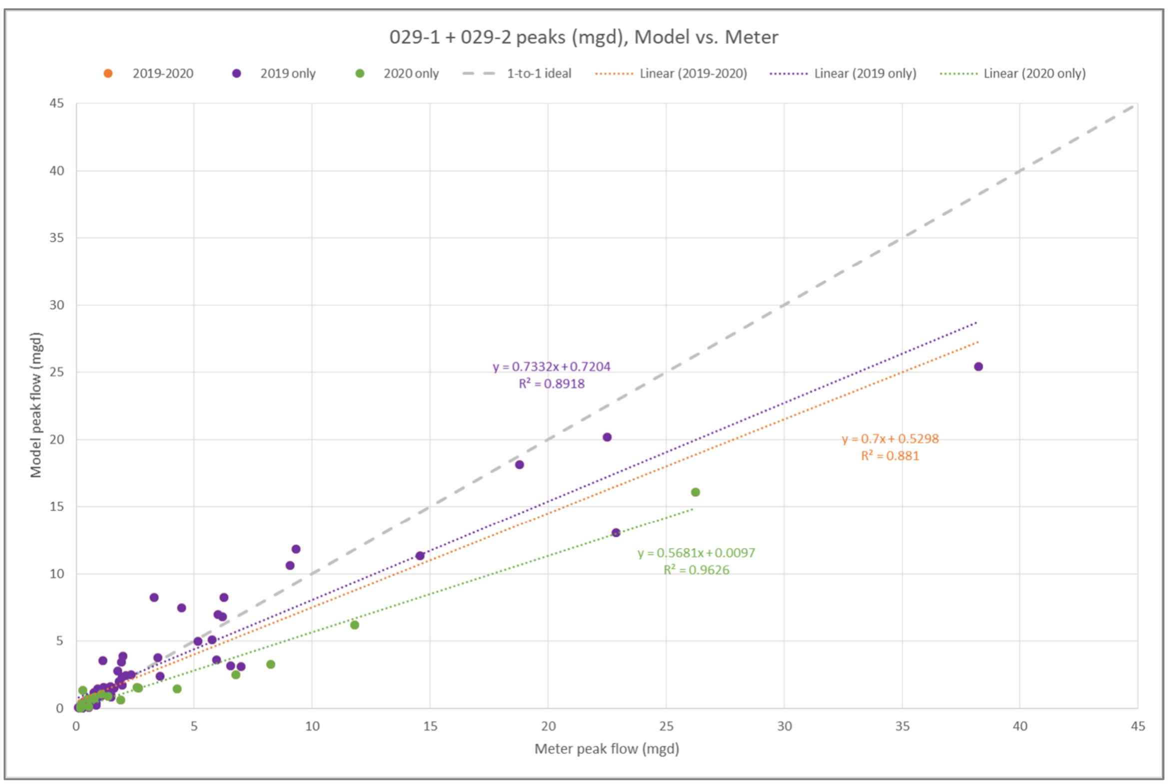


Figure 3-13. PR-A Post-Construction Event Peak Flows, 092-1 + 029-2

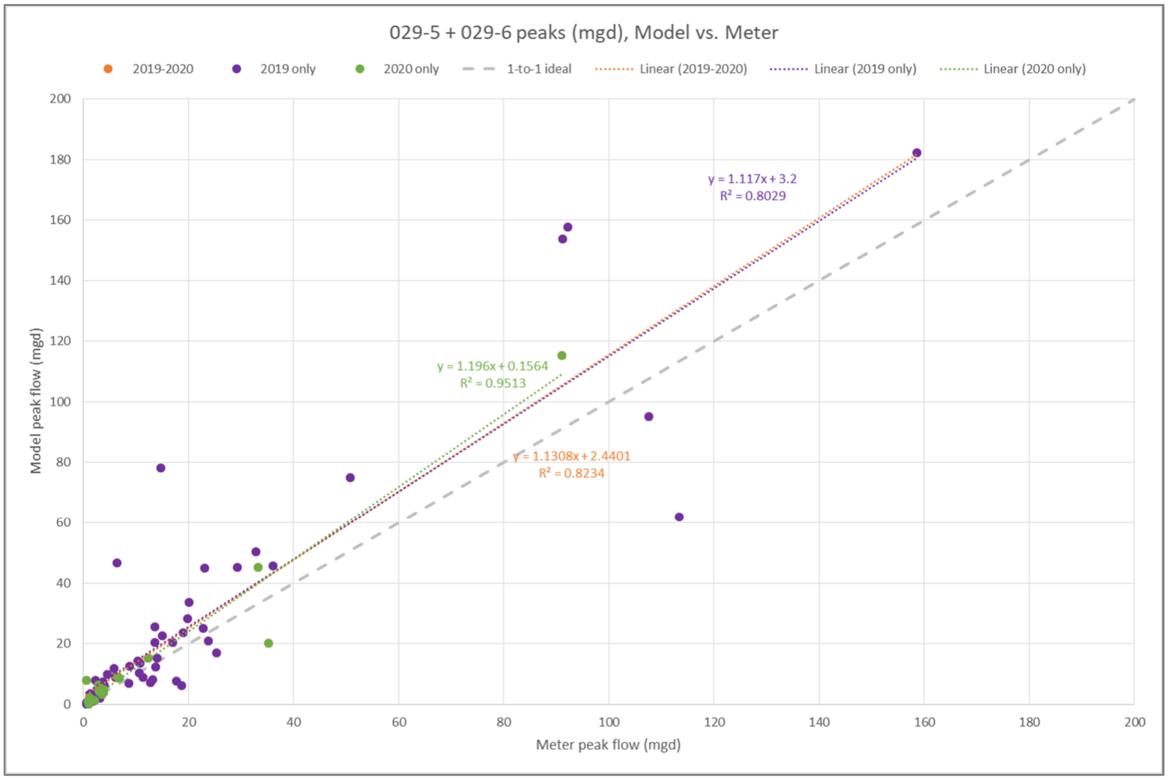


Figure 3-14. PR-A Post-Construction Event Peak Flows, 029-5 + 029-6

3.3.7 Post-Construction Model Results Summary

Results from the post construction model calibration and the LTCP forecast period of 1988-1990 are presented in Table 3-2 below. Wet weather flow (WWF) volumes are defined as occurring when predicted flows in the sewer are exceeding two times average dry weather flow rate. The reduction in WWF volumes per average year were calculated by taking the difference between pre- and post-construction WWF volumes and divided by the number of impervious acres treated at 1.2” to determine the WWF reduction in million gallons per average year per impervious acres treated at 1.2”.

For PR-A, there were no predictions made on WWF reductions prior to the construction, as there were with RC-A. As the predictions from post-construction model using as-built GI matched the observed meter data to an acceptable degree without major calibration and since the as-built GI did not deviate significantly from the designed GI, it is assumed that actual modeled volume reduction and expected volume reduction are same for the period 1988-1990.

Table 3-2. Post-Construction Monitoring Results

Sewershed	Impervious Acres treated by GI (% of total)	WWF volume – Pre-Construction (MG)	WWF volume – Post Construction (MG)	Predicted Volume Reduction Using Monitoring Data, Normalized to Impervious Acres Treated (%)	Predicted Volume Reduction Before Construction, Normalized to Impervious Acres Treated (%)
2019 -2020 Rainfall Conditions					
RC-A (After Retrofits) (2020 Rainfall)	28.8 %	31.49	27.10	18.46%	N/A
PR-A (2019 -2020 Rainfall)	9.1 %	81.98	77.24	5.78%	N/A
Average Year Rainfall Conditions (1988, 1989, 1990)					
RC-A (After Retrofits)	28.8 %	26.66	22.90	18.68%	30.2%
PR-A	9.1 %	77.73	72.56	6.65%	6.65%

One of the purposes of the initial projects constructed in the Rock Creek and Potomac Basins was to evaluate the effectiveness of GI using adaptive management. This means developing different design and construction methods, learning based on the results and revising subsequent projects using the lessons learned. Rock Creek was the first project constructed and initial data indicated it was underperforming in terms of capture. Retrofits have been implemented in Rock Creek and performance has been improving. This data will continue to be assessed as additional data are collected. The lessons learned on the first Rock Creek project were incorporated into the subsequent Potomac Project. The Potomac monitoring and modeling demonstrate that incorporation of appropriate lessons learned allows GI to be constructed and to perform as predicted. Knowledge was gained through this process which provides a template for the design of subsequent projects to meet performance objectives. This was the goal of the initial projects in Rock Creek and Potomac River sewersheds and has been successfully achieved.

Based on the performance of PR-A, and the lessons learned from PR-A and other projects following RC-A, efficacy of GI in the Rock Creek Sewershed is practicable.

3.3.8 Modeling to Predict Rock Creek Gray Storage Required

DC Water performed an evaluation of the magnitude of gray storage required to provide the degree of CSO control in the LTCP for varying levels of GI implementation.

Note that the original LTCP was developed by DC Water from 1999-2002. During the preparation of the LTCP, flow monitoring was performed at the Piney Branch outfall during 1999-2000. That flow monitoring was used to develop, calibrate, and validate the collection system model which was ultimately used to determine the size of the storage facility included in the original LTCP, which was 9.5 MG. Since the development of the LTCP, several changes have occurred in the sewershed:

- Pursuant to the requirements of the LTCP Consent Decree, DC Water raised the weir at the diversion structure (Structure 70) for the Piney Branch CSO outfall. The purpose of the weir raising was to increase the capture of combined sewage by increasing the height of the weir. The weir was raised as high as practicable given the capacity of the downstream interceptors, without causing upstream flooding due to restriction of the Piney Branch outlet due to the weir raising.
- Since the original monitoring conducted at the outfall from 1999-2000, natural economic development has occurred in the sewershed. The District's stormwater regulations require mitigation of runoff for development and redevelopment that exceeds certain thresholds. As part of this redevelopment, stormwater controls constructed in the Piney Branch sewershed since 2002 have a storage volume of 2.3 MG.
- Rock Creek Project 1 and its associated projects comprising approximately 27 impervious acres was placed in operation on March 15, 2019. These practices were constructed over the previous 2 years and the net effect of these practices appear in the monitoring data collected.

DC Water used the monitoring data collected since 2018 to calibrate the collection system model to the measured performance of the outfall. The model was then applied in the average year (1988, 1989 and 1990) to predict the magnitude of CSOs and the amount of storage required to provide the degree of CSO control in the LTCP. Appendix K provides a summary of the monitoring and modeling analysis.

Based on the foregoing, Table 3-3 provides the minimum gray storage volumes that are required to provide the degree of CSO control of one remaining overflow's per average year of rainfall. The minimum storage volumes are based on model output and do not include a safety factor. DC Water normally includes a safety factor in its designs to account for uncertainties in rainfall measurement, monitoring, modeling, construction, climate change and other factors. The Piney Branch Outfall is difficult to monitor given the complicated hydraulics at the outfall, the limited space to install equipment in non-varying flow conditions. While typical safety factors have been in the range of 1.2, we have selected a safety factor of 1.4 for this analysis to account for the more challenging hydraulic conditions at the outfall.

Table 3-3. Piney Branch Minimum Gray Storage Volumes

Green Infrastructure Implemented by DC Water (acres)	Minimum Storage Volume (MG)	Safety Factor	Final Volume (MG)
0	2.76	1.4	3.9
50	2.40	1.4	3.4
100	2.08	1.4	2.9
150	1.85	1.4	2.6

3.4 Public Acceptability

Rock Creek Project A received a majority of positive feedback and praise from the community. In general:

- 68% would like a significant amount or quite a bit more of GI in their neighborhood
- 79% would like a significant amount or quite a bit more of GI in the District
- Green alleys rated highest in types of GI preferred (only slightly higher, residents chose a mix of all technologies including bioretention, green parks, green roofs, rain barrels, and green streetscapes)
- 82% felt GI brought a benefit to their neighborhood
- Cleaner rivers/better water quality was rated the most important benefit of GI, with improved infrastructure such as repaved alleys rated the next most important benefit
- 85% agreed or slightly agreed that the benefit of GI outweighed the disruption of construction

It is therefore inferred that District residents favorably support GI and understand the benefits it brings to their neighborhoods. Therefore, from a public acceptability standpoint, GI is practicable in the Rock Creek Sewershed.

3.5 Cost Effectiveness

DC Water evaluated the cost effectiveness of the two Alternatives written into the terms of the Amended Consent Decree to manage CSOs at the Piney Branch outfall:

- Alternative 1 (All Gray) — Construct at least a nine and one-half (9.5) million gallon Rock Creek Storage Facility, which shall store combined sewer flow from the Piney Branch Outfall; or
- Alternative 2 (All Green) — Control at least 365 acres to the 1.2” Retention Standard in the CSO 049 sewershed.

3.5.1 Basis for Assessment of Alternatives 1 and 2

As DC Water’s Green Infrastructure program matures, cost saving strategies have been able to be implemented from project to project. As shown in Table 3-4, the Rock Creek Project A cost was approximately 36% higher per acre managed than the Potomac River Project A, while the AlleyPalooza project shows additional cost reductions. Some of the cost saving measures implemented between projects included design standardization (Section 2.3.1) and contract methodology (Section 2.2).

Table 3-4. RC-A, PR-A and AlleyPalooza Cost Comparison

Project	Acres Managed	Construction Cost per Acre Managed	Capital Cost per Acre Managed
Rock Creek Project A (RC-A)	18.8	$ 896,300	$ 1,165,200
Potomac River Project A (PR-A)	7.9[1]	$ 660,800	$ 859,000
AlleyPalooza	3.1	$ 538,700	$ 646,500

[1] Targeted Sewer Separation excluded

Table 3-5 presents the predicted construction and capital cost per gal of stormwater of the facilities types presented in the two alternatives above. Cost projections for CSO Storage and Downspout Disconnect are based on actual bids received from previous projects, while costs for GI is based on installation of GI with an average construction cost per acre of $600,000 which is approximate to the costs experienced by DC Water on PR-A and AlleyPalooza.

Table 3-5. Construction and Capital Cost Assumptions

Facility Type	Units	Year 2020 Dollars		
		Construction Cost	Capital Cost Markup	Capital Cost
CSO Storage	$/gal	$ 15.00	30%	$ 19.50
Green Infrastructure	$/gal	$ 18.40	30%	$ 23.90
Downspout Disconnect	$/gal	$ 12.30	20%	$ 14.75

Table 3-6 and Table 3-7 on the following page, present the projected Operation and Maintenance (O&M) cost and rehabilitation costing assumptions.

Table 3-6. Operation and Maintenance Cost Assumptions

Facility Type	Units	Year 2020 Dollars	Basis
CSO Storage	$/yr.	$ 280,000 to $ 120,000	• Based on DPO & DWT costs for Anacostia River Tunnel • Includes cost of complete treatment at Blue Plains
Green Infrastructure	$/ac/yr.	$ 15,000	• Range of bids on GI maintenance contract was $12,000-$18,000/ac/yr.
Downspout Disconnect	-	$ -	Assumed zero

Operation and Maintenance cost shown in Table 3-6 above, for the CSO Storage is based on a 9.5 MG facility, while the cost for O&M of GI is on a per acre basis. Operation and Maintenance on the full 365 acres of GI per year would therefore be estimated at $5.48M.

Table 3-7. Rehabilitation Cost Assumptions (over 30 years)[1]

Facility Type	Subcategory	Cost Basis
CSO Storage	Pumping & Mechanical	• Every 10 years, rehab = 15% of escalated capital cost
	Structure	• Every 10 years, rehab = 1.0% of escalated capital cost
GI-Bioretention	Bioretention Soil Media layer	• Every 10 years, rehab = 5% of escalated capital cost
	Bioretention Soil Media, choker layer and plants replaced every 20 years	• Every 20 years, rehab = 15% of escalated capital cost
GI-Permeable Pavement	Resurface permeable asphalt in parking lane, replace choker layer	• Every 20 years, rehab = 15% of escalated capital cost
	Reset permeable pavers in alleys to address rutting	• Every 15 years, rehab = 15% of escalated capital cost
	Replace alley pavers and choker layer every 30 years	• Every 30 years, rehab = 25% of escalated capital cost
Downspout Disconnect		• Assume zero cost

[1] Based on literature review, District experience, and best practices

3.5.2 Assessment of Alternatives 1 and 2

DC Water compared the Net Present Value of these two alternatives presented in the consent decree. Table 3-8 shows the NPV of both all gray option (9.5 MG storage) and all green option (365 acres).

Table 3-8. Net Present Value of Alternatives 1 and 2

Description	Capital Cost ($M)	O&M Cost ($M/yr.)	NPV 30 years ($M)
Alternative 1 All Gray - 9.5 MG Storage	$ 185	$ 0.28	$ 211
Alternative 2 All Green - 365 ac of GI	$ 208	$ 4.41	$ 407

As shown in Table 3-8 above, the cost to construct, operate and maintain an all green option is considerably higher than that of an all gray alternative. Projecting this over a 30-year period, implementing an all green option is 94.7% more expensive than an all gray option.

Despite the cost saving measures that have been achieved from project to project, costs for a full 365-acre buildout (including operations and maintenance) within the Rock Creek Sewershed is cost prohibitive.

From a cost effectiveness standpoint, GI is not practicable in the Rock Creek sewershed.

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4 Evaluation of New Alternative (Hybrid)

DC Water looked at a third alternative not presented in the Amended Consent Decree to provide the equivalent volume at the 1.2" storm of Alternative 1 as a matter of comparison:

- Alternative 3 (Hybrid) Gray infrastructure storage capacity of 4.2 MG; 3.0 MG managed through GI (including downspout disconnections); and credit of 2.3 MG managed from the existing DOEE Stormwater Program.

The same basis for Alternatives 1 and 2 presented in Section 3.5.1 were used in sizing the mix of projects presented in Alternative 3 above.

4.1 Assessment of Alternative 3

The gray/green hybrid (Alternative 3) presented in Table 4-1 represents a gray/green approach that DC Water believes provides the best of each solution at a cost competitive alternative to the all gray Alternative 1, which was found to be significantly less expensive than the all green Alternative 2. While this approach is not one of the current solutions presented in the current Consent Decree, the individual components are allowed.

Table 4-1. Net Present Value of Alternative 3

Description	Capital Cost ($M)	O&M Cost ($M/yr.)	NPV 30 years ($M)	Volume of Controls (MG)
Hybrid - Gray / Green				
Green Infrastructure	$ 52	$ 1.34	$ 113	3.0
Gray Storage	$ 82	$ 0.15	$ 94	4.2
Credit from DOEE MS4s	$ -	$ -	$ -	2.3
Total	**$ 133**	**$ 1.49**	**$ 207**	**9.5**

The hybrid alternative presented in Table 4-1 above has a lower capital cost and NPV than the all gray alternative. This was an important consideration when developing the mix of projects for this alternative. Since DC Water is unable to control the number of homes that will participate in the downspout disconnect program or forecast the number of new BMPs to be installed in the sewershed, a conservative approach was taken. It was assumed that no new acres would be realized under each of these categories. Therefore, DC Water looked at a variety of CSO storage sizes compared to the volume controlled by GI and determined that a 4.2 MG storage facility coupled with 3.0 MG of GI, presented a cost effective alternative to the all gray option.

4.2 CSO Performance

The hybrid gray/green controls will provide a degree of CSO control equivalent to the gray controls in the LTCP as summarized in Table 4-2 below. In addition, the hybrid approach will have a higher socio-economic benefit to the District as presented in Sections 4.3 and 4.4, especially in the communities served by GI.

Table 4-2. Piney Branch Predicted CSO Overflows in Average Year

Parameter	Before LTCP	LTCP	Hybrid Controls
No. of Overflows (#/avg yr.)	25	1	1
Overflow Volume (MG/avg yr.)	39.73	1.41	1.41
% reduction from Before LTCP	-	96%	96%

4.3 Economic Impact Analysis

Corona Environmental Consulting (Corona) evaluated the economic impacts and triple bottom line (TBL) benefits associated with three CSO control alternatives for the Rock Creek sewershed. This Section summarized their findings, with their full report included in Appendix L. Three alternatives, each designed to manage 9.5 MG of stormwater runoff using various stormwater management practices were used in the evaluation. The alternatives evaluated for the economic impact analysis differ slightly from the alternatives discussed earlier. The alternatives during this analysis consisted of the following components:

- Alternative 1: (All Gray) — Gray infrastructure storage capacity of 9.5 MG; no GI; no downspout disconnections; and no DOEE MS4 credits.
- Alternative 2: (All Green) — Full green infrastructure build-out of 365 acres was not analyzed as it was determined this alternative was unaffordable. (This Alternative is not included in the Corona Report found in Appendix L. Alternative 2 described in Appendix L is Alternative 3a of this Section.)
- Alternative 3a: (Hybrid) — Gray infrastructure storage capacity of 4.2 MG; GI (including downspout disconnections) to manage 3.0 MG (70% through permeable pavement practices and 30% through bioretention practices (supported by planning and internal GIS analysis)); and credit of 2.3 MG managed from DOEE MS4 areas. (This is labeled as Alternative 2 in the Corona Report found in Appendix L.)

- Alternative 3b: (Hybrid) Gray infrastructure storage capacity of 4.2 MG; GI (including downspout disconnections) to manage 3.0 MG (50% through permeable pavement practices and 50% through bioretention practices (supported by planning and internal GIS analysis)); and credit of 2.3 MG managed from DOEE MS4 areas. (This is labeled as Alternative 3 in the Corona Report found in Appendix L.)

An IMPLAN model was developed to evaluate the economic impacts associated with DC Water's investments in alternative CSO controls. IMPLAN is an economic impact model that uses actual dollar amounts of all business transactions occurring in a local economy (as reported each year by businesses and government agencies).

Overall, given the same level of spending (or household savings), the hybrid alternatives results in a greater economic impact in the District compared to the gray alternative. This is primarily due to the increased utilization of local resources associated with GI, as well as the increase in local employment generated. Alternative 3b would result in the largest economic impact, supporting an estimated 2,016 jobs between 2022 and 2060, which includes direct, indirect, and induced employment. This compares to an estimated 1,885 jobs between 2026 and 2060 under Alternative 1 (includes O&M that begins after construction is complete). A higher percentage of the jobs under the hybrid alternatives would also likely be filled by unemployed/underemployed local residents, resulting in a larger net gain in employment rather than a transfer of employment. Table 4-3 summarizes the total direct, indirect, and induced effects for employment, labor income, total value added, and economic output under the gray and hybrid alternatives.

Table 4-3. Summary of Economic Impacts

Impact type	Alternative 1 – Gray	Alternative 3a – Hybrid	Alternative 3b – Hybrid
Employment (jobs)	1,885	1,960	2,016
Labor income ($M, 2019 USD)	$16.18	$17.27	$16.85
Total value added ($M, 2019 USD)	$134.46	$158.15	$159.38
Economic output ($M, 2019 USD)	$272.94	$277.37	$276.34

4.4 Triple Bottom Line Assessment of GI Co-Benefits

Corona Environmental Consulting evaluated the triple bottom line (TBL) co-benefits associated with the two green hybrid alternatives described above for the Rock Creek sewershed. The gray alternative, and the gray components of the hybrid alternatives were not considered, as the gray components do not provide significant co-benefits. The all green alternative (Alternative 2) was not considered, as this alternative was found to be unaffordable early on.

Table 4-4 presents the summary of present value of co-benefit estimates for Alternatives 3a and 3b, as well as for the Rock Creek demonstration project (RC-A, completed in 2019) and reflects the costs associated with the GI components of the hybrid alternatives only. Costs associated with the gray infrastructure components of the hybrid alternatives, as well as downspout disconnection, are not included in the table.

Table 4-4. Present Value of Co-Benefits Compared to Costs, (2019 USD)

	Present Value of Benefits	Present Value of Costs (GI only)	Benefits Compared to Costs
Alternative 3a - Hybrid Green/Gray	$17,306,499	$68,103,754	0.25
Alternative 3b – Hybrid Green/Gray	$25,868,510	$67,819,680	0.38
Rock Creek A - Demonstration	$7,484,357	$ --	--

The present value benefits shown in Table 4-4 above are larger for Alternative 3b than for Alternative 3a for several reasons. First, the property value increases are much greater under Alternative 3b because the analysis assumes that permeable pavement installations do not result in property value increases. Second, there are greater green job benefits in Alternative 3b compared to Alternative 3a because a greater proportion of bioretention requires more labor. Finally, there is greater recreation improvement benefit because Alternative 3b is assumed to improve additional open space than Alternative 3a. Figure 4-1 shows the distribution of benefits for Alternative 3a; Figure 4-2 shows the distribution of benefits for Alternative 3b. Benefits for the Rock Creek A demonstration project are shown for comparison in Figure 4-3.

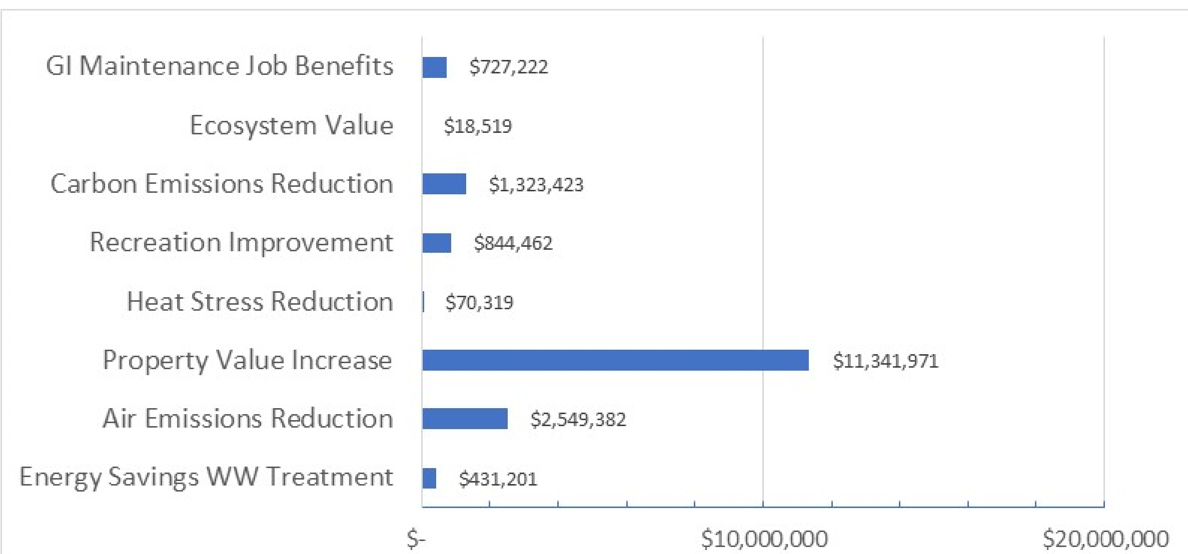

Figure 4-1. Distribution of Co-Benefit Present Values for Alternative 3a - Hybrid

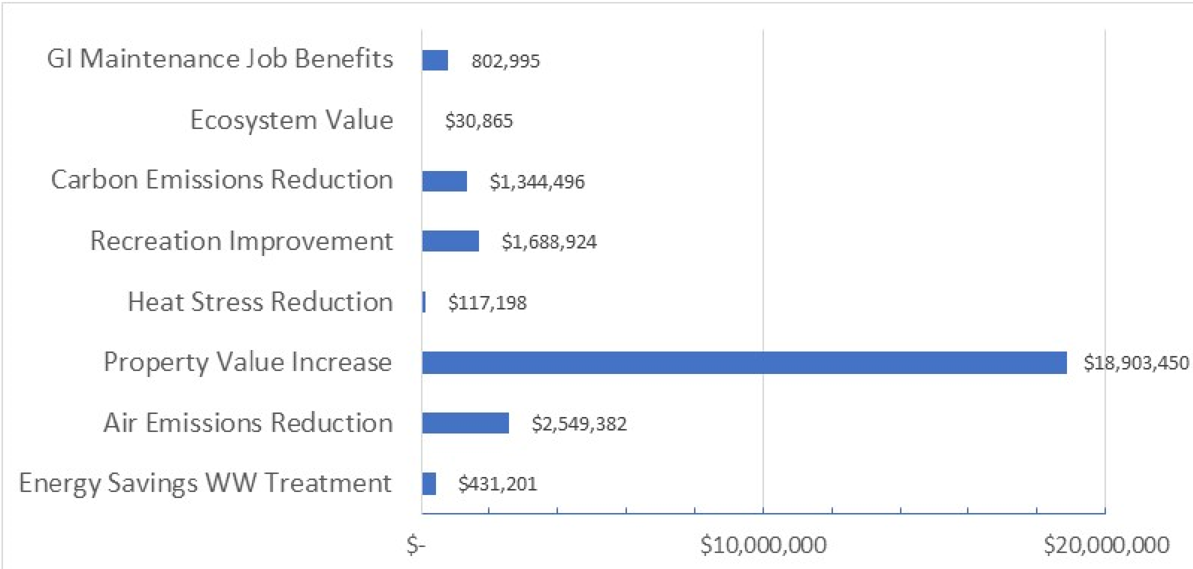

Figure 4-2. Distribution of Co-Benefit Present Value for Alternative 3b – Hybrid

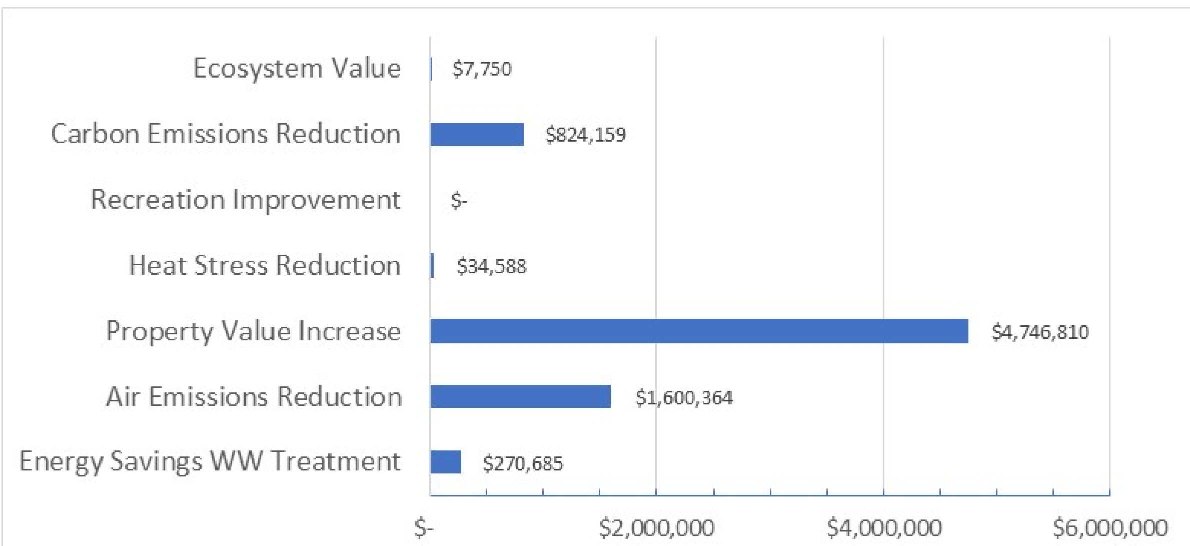

Figure 4-3. Distribution of Co-Benefit Present Values for RC-A

The present value of costs for each scenario including the gray scenarios is shown in Table 4-5. The table reports capital and O&M values for both the Gray and Green aspects of each scenario, when applicable, and the sum of capital and O&M. Downspout disconnection (DD) costs are reported separately for each scenario and are included in the total.

Table 4-5. Present Value Costs of Alternatives ($M 2019 USD)

	Gray Infrastructure Component			GI Components (Permeable Pavement and Bioretention)			DD[a]	Total
Alternative	Capital	O&M	Total	Capital	O&M	Total		
Alt 1 Gray	147.2	11.9	159.0					159.0
Alt 3a Hybrid	65.2	5.67	70.9	43.4	24.7	68.1	0.81	139.8
Alt 3b Hybrid	65.2	5.67	70.9	43.4	24.4	67.8	0.81	139.5

5 Practicability Determination and Recommendation

5.1 Summary of Assessment

Table 5-1 provides a summary of the Assessment required under the Amended Consent Decree as described in Section 3 as well as the Evaluation of New Alternative (Hybrid) presented in Section 4.1.

Table 5-1. Summary of Assessment

Item	**Alternatives**				
	No. 1 All Gray	**No. 2 All Green**		**No. 3 Hybrid Green and Gray**	
Components	9.5 MG storage facility	Manage 365 imp ac to 1.2” standard by: • RC-A Project: • AlleyPalooza • Kennedy St. • Challenge Parks • Downspout • DOEE MS4 Credit • Manage @ 1.2” new ac **Total**	 18.8 ac 3.0 ac 2.7 ac 1.9 ac 1.3 ac 71.0 ac 266.3 ac **365.0 ac**	Provide 9.5 MG storage by: • Gray storage: • GI • DOEE MS4 Credit **Total**	 4.2 MG 3.0 MG 2.3 MG **9.5 MG**
CSO Reduction	Meets LTCP objectives	Meets LTCP objectives		Meets LTCP objectives	
Constructability	Practicable	Practicable		Practicable	
Operability	Practicable	Practicable		Practicable	
Efficacy	Practicable	Practicable		Practicable	
Public Acceptability	Practicable	Practicable		Practicable	
Cost	Practicable	Not Practicable		Practicable	
Capital ($M)	$185	$206		$133	
O&M ($M/yr.)	$0.28	$4.41		$1.49	
NPV 30 yrs. ($M)	$211	$407		$207	
Triple Bottom Line				**Alt. 3a**	**Alt. 3b**
Monetized TBL Benefits ($M)	NA	Not Calculated		$17.3	$25.9
Economic Output	$272.94	Not Calculated		$277.37	$276.34

5.2 Conclusion and Recommendation

DC Water has determined that due to the cost to implement, operate and maintain, it is not practicable to control at least 365 acres to the 1.2” Retention Standard in the CSO 049 sewershed with the all green alternative (Alternative 2). DC Water has concluded that the preferred alternative in controlling CSOs at outfall 049, is through the implementation of the hybrid alternative (Alternative 3). This alternative, when compared to an all gray solution (Alternative 1), offers a cost savings from the capital cost side, and a cost competitive approach to all gray when a 30-year NPV is considered. Additionally, the recommended hybrid alternative (Alternative 3) provides an equivalent level of performance as compared to 9.5 MG of all gray storage, while realizing triple bottom line and economic benefits in the District beyond what would be realized through an all gray approach. Finally, the hybrid approach continues to support and advance DC Water’s commitment to the success of green infrastructure in the District of Columbia and beyond.

If approved by EPA, a modification to the Amended Consent Decree will be required.

Appendix A

Amended Consent Decree

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UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

ANACOSTIA WATERSHED SOCIETY, et al., **Plaintiffs,** **v.** **DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY, and THE DISTRICT OF COLUMBIA,** **Defendants,** **and** **THE UNITED STATES OF AMERICA,** **Plaintiff,** **v.** **DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY, et al., and THE DISTRICT OF COLUMBIA,** **Defendants.**	)	**Consolidated** **Civil Action No. 1:00CV00183TFH**

FIRST AMENDMENT TO CONSENT DECREE

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WHEREAS, on February 2, 2000, the Plaintiffs, Anacostia Watershed Society, Kingman Park Civic Association, American Canoe Association, Friends of the Earth, Sierra Club, and Mary Stuart Bick Ferguson ("Citizen Plaintiffs") filed an action, Civil Action No. 1:00CV00183TFH, against the District of Columbia Water and Sewer Authority (hereinafter "DC Water") and its then General Manager, Jerry Johnson, pursuant to Sections 309(b) and (d) and 505 of the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 and the Water Quality Act of 1987 ("Clean Water Act" or "the Act"), 33 U.S.C. §§1319(b) and (d), and 1365;

WHEREAS, on December 20, 2002, Plaintiff, the United States of America, on behalf of the United States Environmental Protection Agency ("EPA"), filed a Complaint against DC Water and the District of Columbia ("District"), which case was consolidated with the pending matter against DC Water for the alleged violations of the Clean Water Act;

WHEREAS, the Complaints alleged that DC Water violated the Clean Water Act, 33 U.S.C. §§1251 et seq., by failing to comply with the District of Columbia Water Quality Standards, effluent limitations and other conditions established in the National Pollutant Discharge Elimination System ("NPDES") Permit No. DC0021199 issued to DC Water by EPA under Section 402 of the Act, 33 U.S.C. §1342, and by failing to properly manage, operate and maintain all collection, pumping facilities, treatment and/or combined sewer overflow ("CSO") control facilities or combined sewer systems ("CSS") owned and/or operated by DC Water;

WHEREAS, the United States further asserted, inter alia, a claim against the District of Columbia pursuant to Section 309(e) of the Act, 33 U.S.C. §1319(e), and Fed. R. Civ. P. 19(a);

WHEREAS, the United States, the Citizen Plaintiffs, and DC Water have resolved the claims for alleged violations of the Nine Minimum Controls and for the performance of certain projects in a partial consent decree, entered by the Court on October 10, 2003 ("Partial Consent Decree");

WHEREAS, in that Partial Consent Decree, DC Water agreed to pay a civil penalty and to perform Supplemental Environmental Projects and a Citizen Community Project;

WHEREAS, on April 26, 2004, Plaintiffs and Defendants entered into a stipulation which provided in essence that Defendants would not contest their liability for certain claims; that Plaintiff United States waived its claims for any additional civil penalties and dismissed with prejudice its claims under Count Three of its Complaint; and that Citizen Plaintiffs also waived their claims for civil penalties;

WHEREAS, DC Water submitted a draft Long Term Control Plan to EPA in June, 2001. Thereafter, DC Water finalized the Long Term Control Plan in July 2002 ("LTCP") and submitted it to EPA in August, 2002;

WHEREAS, DC Water provided for public participation in development of the Long Term Control Plan through public hearings at various locations throughout the District of Columbia, stakeholder meetings, and other means;

WHEREAS, the recommended control plan in Section 13 of the LTCP provides for, inter alia, three or more underground storage tunnels to hold up to 193 million gallons of the combined wastewater and stormwater during wet weather and to thereby reduce CSOs significantly;

WHEREAS, the Parties and the Citizen Plaintiffs stipulated and agreed and on September 22, 2004, the Court ordered, that issues pertaining to the scope of Section 402(q) of the Clean Water Act, 33 U.S.C. § 1342(q), including whether the measures proposed in DC Water's August, 2002 LTCP conform to the water quality standards of the District of Columbia, would not be addressed in this consolidated action, but rather EPA agreed to address such issues outside the context of this lawsuit in, inter alia, the modification of DC Water's NPDES permit that was pending at that time;

WHEREAS, EPA is the permitting agency and noticed an NPDES Permit containing Phase II conditions for public comment on March 18, 2004. EPA issued the final version of the Permit on December 14, 2004. The Fact Sheet to the final permit states that EPA has determined that, "based upon current information, including but not limited to documentation in the LTCP and the District of Columbia Department of Health's analysis and interpretation of its water quality standards, DC Water has demonstrated, pursuant to Section II.C.4.b of the 1994 CSO Policy, that the CSO control program will not preclude the attainment of water quality standards or the receiving waters' designated uses or contribute to their impairment." The Fact Sheet further provides that this determination is subject to post-construction monitoring adequate to verify compliance with water quality standards, in accordance with Section II.C.4.b and II.C.9 of the 1994 CSO Policy;

WHEREAS, because DC Water is unable to comply with the water quality based CSO effluent limits in the Phase II conditions of its NPDES Permit until such time as it has completed implementation of the CSO controls in its LTCP, the Parties entered into a consent decree, entered by the Court on March 23, 2005 ("2005 Consent Decree"), to establish a judicially enforceable schedule for implementation of the CSO controls in the LTCP;

WHEREAS, in a March 19, 2008 ruling on a permit appeal, the EPA Environmental Appeals Board ruled that District of Columbia water quality standards required that any compliance schedules for attainment of effluent limits for total nitrogen ("Total Nitrogen Limit") and phosphorus must be included in DC Water's NPDES Permit;

WHEREAS, on August 31, 2010, EPA re-issued DC Water's NPDES permit. The re-issued permit requires DC Water to design, construct and Place in Operation (as defined below) the facilities needed for DC Water to attain the Total Nitrogen Limit in the re-issued NPDES permit, and sets forth a schedule for DC Water to place such facilities into operation and to attain compliance with the Total Nitrogen Limit;

WHEREAS, in 2008, DC Water prepared a first revision to its LTCP which is called "DC Water's Total Nitrogen Removal/Wet Weather Plan" ("TN/Wet Weather Plan"). The TN/Wet Weather Plan sets forth DC Water's proposal and schedule to attain the Nitrogen Limit and related limits for phosphorus in its NPDES Permit, to satisfy its wet weather treatment obligations, and to optimize operations at Blue Plains (as defined below). On September 23, 2008, DC Water submitted to EPA the Anacostia River Facility Plan summary report and detailed implementation schedule ("Summary Report"). The Summary Report, which was approved by EPA on July 27, 2010, provides plans for implementing the wet weather aspects of the TN/Wet Weather Plan. The Summary Report is attached as **Appendix D** to this First Amendment to Consent Decree ("Consent Decree");

WHEREAS, the plans for reconfiguring and enlarging the Anacostia River tunnels and related facilities have been expanded upon by DC Water in accordance with the Summary Report, and these facilities are now under design and construction;

WHEREAS, DC Water has also completed a number of additional CSO control projects since the Partial Consent Decree was entered, including, but not limited to, projects to separate combined sewers in the Anacostia and the Rock Creek sewersheds, rehabilitate the Main & O, East Side, and Poplar Point Pumping Stations, improve regulators, eliminate outfalls, and install Green Infrastructure at multiple sites throughout the District;

WHEREAS, the 2005 Consent Decree calls for DC Water to control CSOs in the Potomac River and Rock Creek sewersheds by implementing Gray CSO Controls, including storage tunnels in each sewershed with combined storage capacities of 67.5 million gallons in the aggregate, rehabilitation of the existing Potomac Pumping Station, constructing a new Potomac Tunnel dewatering pumping station, and CSO outfall diversion, consolidation, and separation;

WHEREAS, in 2013, DC Water prepared and submitted to EPA a second revision to its LTCP which proposed substituting Green/Gray CSO Controls in the Potomac sewershed and Green CSO Controls in the Rock Creek sewershed for the corresponding Gray CSO Controls proposed in the LTCP. The new controls proposed in the second revision to the LTCP are summarized and depicted in **Appendix E** to this Consent Decree. The analyses submitted by DC Water in support of the second revision to the LTCP demonstrated that these Green/Gray CSO Controls and Green CSO Controls are projected to provide a degree of control equivalent to the Gray Controls in the LTCP. Following EPA's response to the second revision to the LTCP, DC Water filed a request to modify the affected CSO controls and deadlines pursuant to Section VII of the 2005 Consent Decree (Modifications to Selected CSO Controls and Schedules).

WHEREAS, as required by Section XXII of the 2005 Consent Decree (Modification), DC Water conducted a public participation process prior to submitting its modification request. The public participation process also included the proposed amendments to incorporate the reconfigured and enlarged Anacostia tunnels and related facilities according to the Summary Report and the more efficient designs for the Anacostia River Selected CSO Controls;

WHEREAS, the Parties have agreed to enter into this Consent Decree to reflect the above-described changes to the Selected CSO Controls and Schedules;

WHEREAS, DC Water contends that, pursuant to Section 202 of its enabling legislation, which provides, with certain exceptions not applicable here, that DC Water is subject to all laws applicable to offices, agencies, departments, and instrumentalities of the District government, DC Water is subject to the requirements of the Anti-Deficiency Act, 31 U.S.C. §§1341 et seq., to the same extent as other agencies of the District of Columbia;

WHEREAS, the Parties agree, without adjudication of facts or law, that settlement of this matter in accordance with the terms of this Consent Decree is in the public interest, and have agreed to entry of this Consent Decree without trial of any issues, and the Parties hereby stipulate that, in order to resolve the claims for alleged violations of water quality standards stated in the Complaint of the United States, and to provide for compliance with the water quality-based effluent CSO limits in DC Water's modified NPDES permit, this Consent Decree should be entered;

WHEREAS, the Court, upon consideration of the judicial record before it and review of this Consent Decree, also finds that settlement of this matter and entry of this Consent Decree is fair and in the public interest and will address the underlying causes of the violations. The Court also finds that it should exercise continuing jurisdiction over this matter to resolve disputes and, should the need arise, to modify the obligations in this Consent Decree;

AND WHEREAS, settlement and entry of this Consent Decree does not constitute an admission of liability by DC Water or the District of Columbia;

NOW THEREFORE, before taking any testimony, and without any adjudication of any fact or law, it is hereby ORDERED, ADJUDGED, and DECREED as follows:

I. JURISDICTION AND VENUE

1. This Court has jurisdiction over the subject matter of this action, and over the Parties hereto, pursuant to Sections 309 and 505 of the Clean Water Act, 33 U.S.C. §§ 1319, 1365, and 28 U.S.C. §§ 1331, 1345, 1355, and 1367. Venue is proper in the District of Columbia

pursuant to Section 309 of the Clean Water Act, 33 U.S.C. § 1319, and 28 U.S.C. §§ 1391 and 1395(a).

II. APPLICATION AND SCOPE

2. The provisions of this Consent Decree shall apply to and be binding upon the Parties to this action, and their agents, employees, successors and assigns, as well as to all persons acting under the direction and/or control of DC Water, including but not limited to third party firms, corporations, consultants, and contractors.

3. DC Water shall provide a copy of this Consent Decree to any consultant and contractor selected or retained to perform any activity required by this Consent Decree upon selecting or retaining such consultant or contractor.

4. No later than thirty (30) days prior to transfer of any ownership interest, operation, management, or other control of the CSS (as defined below), DC Water shall give written notice and provide a copy of this Consent Decree to any such transferee or successor in interest. DC Water shall require, as a condition of any such sale or transfer, that the purchaser or transferee agree in writing to be bound by this Consent Decree and submit to the jurisdiction of this Court for its enforcement. DC Water shall also notify, in writing, EPA Region III, the United States Attorney for the District of Columbia, and the United States Department of Justice, in accordance with Section XXI (Form of Notice), of any such planned transfer at least thirty (30) days prior to the transfer.

III. OBJECTIVES

5. It is the express purpose of the Parties in entering this Consent Decree to further the objectives of the Act, as enunciated at Section 101 of the Act, 33 U.S.C. § 1251. All plans, reports, construction, and other obligations in this Consent Decree or resulting from the activities required by this Consent Decree shall have the objective of achieving full compliance with the

Clean Water Act, all applicable Federal and local regulations, and the terms and conditions of DC Water's NPDES Permit, and to meet the objectives of the 1994 CSO Policy (as defined below).

IV. DEFINITIONS

6. Unless otherwise defined herein, the terms used in this Consent Decree shall have the meaning given to those terms in the Clean Water Act, 33 U.S.C. §§ 1251 et seq., the regulations promulgated thereunder, and EPA's 1994 CSO Policy.

7. The following terms used in this Consent Decree shall be defined as follows:

"Blue Plains" means the District of Columbia advanced wastewater treatment plant at Blue Plains.

"Collection System" means both the separate sanitary sewer and combined sewer systems within the District of Columbia.

"Combined Sewer Collection System" or "CSS" means the pipelines, pumping stations, treatment facilities and appurtenances in the District of Columbia which are designed to convey wastewaters and stormwater through a single pipe system to combined sewer overflow outfalls and/or treatment works. It includes the CSS and CSO facilities described in the NMC Report (as defined below), as well as any future additions or modifications required by this Consent Decree and the Partial Consent Decree.

"Combined Sewer Overflow" or "CSO" means a discharge from the CSS at a CSO outfall designated in the Permit.

"2005 Consent Decree" means the consent decree entered by the Court in this action on March 23, 2005.

"Consent Decree" or "Decree" means this First Amendment to Consent Decree, which amends and supersedes the 2005 Consent Decree.

"Consolidation" or "Outfall Consolidation" means elimination of a permitted CSO outfall by routing the discharge so that it is joined with one or more other permitted CSO outfall(s), or by connecting it with a storage/conveyance tunnel. Consolidation of outfalls does not reduce the volume of the overflow but does allow its location to be changed.

"Contract Award" or "Award Contract" means the date on which a contract is signed by both DC Water and the other party to the contract.

"Construction" means the act of building a facility.

"1994 CSO Policy" means EPA's April 19, 1994 CSO Control Policy, published at 59 Fed. Reg. 18,688, and incorporated into the Clean Water Act pursuant to the Wet Weather Water Quality Act, Section 402(q) of the Clean Water Act, 33 U.S.C. § 1342(q).

"DC Water" means the District of Columbia Water and Sewer Authority and any successors thereto.

"Detailed Design" means the final stage of preparing contract documents to be used to receive bids for construction of a facility.

"District" means the Government of the District of Columbia.

"Effective Date of the First Amendment to the Consent Decree" means the date on which this First Amendment to Consent Decree is approved and entered by the Court.

"Enhanced Clarification Facility" or "ECF" means those facilities at Blue Plains which are to replace the excess flow treatment facilities at Blue Plains. The ECF includes a combination of process units located on the end of the Blue Plains Tunnel ("BPT"), designed to empty the BPT and distribute flow from the BPT. Flows treated in and distributed from the ECF will be discharged as a CSO Bypass from Outfall 001 and/or Outfall 002 as provided in the NPDES Permit. Disinfection by chlorination will be followed by de-chlorination.

"Facility Plan" or "Facility Planning" means preparing an engineering study to develop additional definition of the Selected CSO Controls as may be necessary for preliminary design. Examples of Facility Planning activities include, but are not limited to, planning level geotechnical investigations, developing proposed alignments for the tunnels, identifying land acquisition and required approvals, establishing bases for design, establishing system hydraulics, siting shafts, regulators and pumping stations, and other elements needed to define the function and interaction of the Selected CSO Controls in the LTCP.

"Final Nitrogen Limit" means a limit on the discharge of total nitrogen from Blue Plains as specified in the NPDES Permit.

"Gray CSO Controls" means structural facilities, including but not limited to combined sewer separation, pumping stations, pipelines and conveyance and treatment facilities to control CSO discharges.

"Green CSO Controls" means the use of Green Infrastructure to control CSO discharges.

"Green/Gray CSO Controls" means the use of combinations of Green Infrastructure and Gray CSO Controls.

"Green Infrastructure" or "GI" means both LID and LIDR.

"Long Term Control Plan" or "LTCP" means the plan for controlling CSOs from DC Water's CSS that was prepared by DC Water pursuant to the 1994 CSO Policy and submitted to EPA as a final report in August, 2002, and all supplements thereto.

"Low Impact Development" or "LID" means design and techniques that store, infiltrate, evaporate and detain runoff, including, but not limited to, practices that mimic predevelopment site hydrology as identified in the District's stormwater management regulations and guidebook and in "Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer

Overflow (CSO) Control", U.S. Environmental Protection Agency, March 2014, Publication # 832-R-14-001.

"Low Impact Development Retrofit" or "LIDR" means the modification of an existing site to accomplish LID goals. In this Decree, LIDR refers to both LID and LIDR.

"MGD" means million gallons per day.

"NMC Report" means the report entitled District of Columbia Water and Sewer Authority, EPMC III-Sewer System, "Combined Sewer System Nine Minimum Controls Summary Report", Draft, July 1999 (Engineering Program Management Consultant III, Greeley and Hansen, Program Manager).

"NPDES Permit" means National Pollutant Discharge Elimination System ("NPDES") permit number DC0021199 issued to DC Water pursuant to Section 402 of the Clean Water Act, 33 U.S.C. § 1342, and any future, extended, modified or reissued permit.

"Partial Consent Decree" means the Consent Decree in this consolidated action entered by this Court on October 10, 2003, resolving, inter alia, Plaintiffs' claim for failure to implement Nine Minimum Controls.

"Parties" means the United States of America, DC Water and the District of Columbia.

"Person" means an individual, corporation, partnership, association, State, municipality, commission, or political subdivision of a State, or any interstate body.

"Place in Operation" means to achieve steady state operation and to operate consistently in such a way as to accomplish the intended function, even though all construction close-out activities (such as completion of a punchlist and resolution of contract disputes or close-outs) may not yet be completed.

"Required Approvals" means approvals and/or permits required from agencies of the

District of Columbia government (other than DC Water itself), the federal government or any other governmental or private entity or person.

"Selected CSO Controls" or "Selected Controls" means the controls and projects that are comprised by the recommended control plan in Section 13 of the LTCP as subsequently modified and enumerated in Section VI (Selected CSO Controls and Schedules).

"Separation" or "Sewer Separation" means separation of sewers carrying stormwater and sanitary wastes, so that stormwater and sanitary wastewater each are conveyed through a separate system of pipes. For those portions of the CSS that are separated pursuant to this Decree or that were separated pursuant to the 2005 Consent Decree, the permitted CSO outfall may remain as a discharge point but shall discharge only stormwater after its separation. For Sewer Separation, in areas targeted for Green Infrastructure, the area managed by sewer separation may be accounted for as achieving the 1.2" retention standard for that area.

"Settling Defendants" means DC Water and the District of Columbia.

"Summary Report" means the Anacostia River Facility Plan summary report and detailed implementation schedule submitted by DC Water to EPA on September 23, 2008, and approved by EPA on July 27, 2010.

"The 1.2" Retention Standard" means the volume of water runoff produced by 1.2 inches of rain falling on an impervious surface.

V. OVERVIEW

A. Selected CSO Controls from the LTCP

8. The LTCP provides for control of CSO discharges to the Anacostia River, the Potomac River, and to Rock Creek and its Piney Branch tributary ("receiving waters"). The Selected CSO Controls comprise a system of underground storage tunnels and pumping stations designed to reduce CSO discharges to the receiving waters and to convey stored combined flow

to Blue Plains for treatment. Other elements of the LTCP include LIDR, Sewer Separation, Outfall Consolidation, CSO monitoring, public notification, intercepting sewers, regulator improvements and improvements to excess flow treatment facilities at Blue Plains.

B. Total Nitrogen/Wet Weather Plan-Related Changes to the Selected CSO Controls for the Anacostia Sewershed

9. The Summary Report **(Appendix D)** embodies certain changes to the Selected CSO Controls that implement the wet weather aspects of DC Water's TN/ Wet Weather Plan. Those changes, which are herein memorialized, include the use of enhanced clarification for treatment of certain wet weather flows consistent with the terms and conditions of DC Water's NPDES Permit, design and construction of a tunnel from the Main and O Street Pumping Station site to Blue Plains (the "Blue Plains Tunnel"), a 225 mgd Blue Plains Tunnel Dewatering Pumping Station, a 225 mgd Enhanced Clarification Facility ("ECF") to provide high-rate treatment of certain wet weather flows at Blue Plains, and other modifications to the Selected CSO Controls derived from the facility planning work summarized in the Summary Report.

C. Green/Gray CSO Control-Related Changes to the Selected CSO Controls and Schedules for the Potomac and Rock Creek Sewershed.

10. This Consent Decree also incorporates changes to the Selected CSO Controls and related schedules to incorporate substitution of Green/Gray CSO Controls in the Potomac sewershed and Green CSO Controls in the Rock Creek sewersheds as set forth in the second revision to the LTCP and summarized at Appendix E.

11. **Green/Gray CSO Controls for the Potomac Sewershed.** The Green/Gray CSO Controls in the Potomac sewershed are designed to take advantage of and build upon the additional conveyance and treatment capacity provided by the Blue Plains Tunnel, the Blue Plains Tunnel Dewatering Pumping Station, and the ECF. For Outfalls 025, 026, 027, 028 and 029, DC Water will implement a combination of targeted Sewer Separation and Green

Infrastructure for these outfalls. For Outfalls 020, 021, 022 and 024, DC Water will reduce the capacity of the Potomac Tunnel from 58 million gallons to 30 million gallons. Accordingly, the Green/Gray CSO Controls for the Potomac sewershed incorporated in this Consent Decree include substituting a smaller Potomac tunnel for the larger tunnel in the Selected CSO Controls from the LTCP, connecting the Potomac Tunnel to the Blue Plains Tunnel, the Green Infrastructure Program in **Appendix F** to this Decree, and targeted Sewer Separation. Because the Potomac and Anacostia Tunnel Systems will be interconnected, the total system storage available will not be less than 187 million gallons. The analyses submitted by DC Water in support of the second revision to the LTCP demonstrate that these Green/Gray CSO Controls and Green CSO Controls are projected to provide a degree of control equivalent to the Gray Controls in the LTCP.

12. **Green/Gray CSO Controls for the Rock Creek Sewershed.** DC Water will substitute Green Infrastructure for the Piney Branch Storage Tunnel. Accordingly, the Green CSO Controls for the Rock Creek sewershed incorporated in this Consent Decree include substituting the Green Infrastructure Program in **Appendix F** to this Decree for the Piney Branch Storage Tunnel.

VI. SELECTED CSO CONTROLS AND SCHEDULES

DC Water agrees to and is ordered to implement the following Selected CSO Controls, which shall be operated in accordance with the NPDES Permit and shall have the minimum elements and capacities set forth below. Nothing herein shall be deemed to supersede the NPDES Permit and, in the event of a conflict, the NPDES Permit shall control.

A. Anacostia River Projects

DC Water shall plan, design, and Place in Operation the following projects to control CSO discharges to the Anacostia River, at any time up to, but no later than, the schedules set forth below, and thereafter operate them.

13. DC Water commenced work required under the Facility Plan for the Anacostia River Projects on April 4, 2005. On September 18, 2008 DC Water submitted the Summary Report to EPA pursuant to Section X of the 2005 Consent Decree (EPA Approval of Plans and Submissions). EPA approved the Summary Report and detailed implementation schedule on July 10, 2010. Except for the milestones in this subsection VI.A (Anacostia River Projects), the deadlines in the detailed implementation schedule approved on July 10, 2010, shall serve to track and report progress, but shall not be enforceable obligations of this Consent Decree.

14. **Rehabilitation of Main, "O" Street, and Eastside Pumping Stations.** DC Water has certified that these projects have been completed pursuant to the requirements of the Partial Consent Decree.

15. **Separate Fort Stanton Drainage Area (Outfall 006).** On April 1, 2010, DC Water certified that it had separated the combined sewer area tributary to CSO Outfall 006 on the east side of the Anacostia River, eliminating it as a CSO outfall.

16. **Storage/Conveyance Tunnel from Blue Plains to CSO 019.** DC Water shall construct a Storage/Conveyance Tunnel from Blue Plains to CSO 019 which shall store and convey combined sewer flow from the Main and O Street Pumping Station site and other CSOs along the Anacostia River in accordance with DC Water's NPDES Permit. This tunnel will be designed and operated to provide CSO storage and conveyance for CSO Outfalls 005, 007, 009, 010, 011, 011a, 012, 013, 014, 015, 016, 017, 018, and 019 on the Anacostia River. The storage capacity of the tunnel shall be at least 105 million gallons. The location of the tunnel shall be finalized during final design but its approximate location is depicted in the Summary Report. After the tunnel and its appurtenances are Placed in Operation, discharges to the Northeast

Boundary Facility may be discontinued and the Facility may be abandoned or demolished in accordance with applicable law. After the tunnel is Placed in Operation, in the event of weather causing the tunnel to be used for storage, DC Water shall dewater the tunnel to the CSS as soon as practicable, but in no event longer than 59 hours from the end of the last rainfall event, and shall convey the contents of the tunnel to Blue Plains for treatment in accordance with its NPDES permit. DC Water shall plan, design, construct, and Place in Operation the tunnel at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: Completed

b. Award Contract for Construction: Completed

c. Place in Operation: March 23, 2018

17. **Poplar Point Pumping Station.** Under the Partial Consent Decree, DC Water is required to make certain interim improvements to the existing Poplar Point Pumping Station. In addition, DC Water shall replace the existing Poplar Point Pumping Station with a new pumping station, which shall have a firm pumping capacity of not less than 45 MGD. DC Water shall design, construct and Place in Operation the new pumping station at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: Completed

b. Award Contract for Construction: Completed

c. Place in Operation: March 23, 2018

18. **Northeast Boundary Storage/Conveyance Tunnels.** DC Water shall construct: (1) a Storage/Conveyance Tunnel generally in the Northeast Boundary area, and (2) a Branch Tunnel from the Storage/Conveyance Tunnel in the area of First Street NW and Rhode Island Avenue. The purpose of these tunnels is to provide additional storage and conveyance for

combined sewer flow and to relieve street and basement flooding in the Northeast Boundary area. The tunnels shall capture and store the combined sewer flow, in accordance with DC Water's NPDES permit. After the tunnels are Placed in Operation, in the event of wet weather causing the tunnels to be used for storage, DC Water shall dewater the tunnels to the CSS as soon as practicable, but in no event longer than 59 hours from the end of the last rainfall event, and shall convey the contents of the tunnels to Blue Plains for treatment in accordance with DC Water's NPDES permit. The sum of the storage capacities of the Storage/Conveyance Tunnel from Blue Plains to CSO 019 and the Northeast Boundary Storage/Conveyance Tunnels shall be at least 157 million gallons. The locations of the tunnels will be finalized during final design but their approximate locations are depicted in the Summary Report. DC Water shall design, construct and Place in Operation the tunnels at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: January 2, 2016

b. Award Contract for Construction: March 23, 2020

c. Place in Operation: March 23, 2025

19. **M Street (CSO 016 and CSO 017) and 018 Diversion Sewers.** DC Water shall consolidate and direct all combined sewer flow from Outfalls 016, 017 and 018 in the vicinity of the Anacostia Marina to the Storage/Conveyance Tunnel from Blue Plains to CSO 019 by way of diversion sewers, thus eliminating Outfalls 016, 017 and 018 except in those rare cases where use of those outfalls is required to isolate the tunnels or their appurtenances for service or repair. DC Water shall consolidate these outfalls at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: Completed

b. Award Contract for Construction: Completed

c. Place in Operation: March 23, 2018

B. Potomac River Projects

DC Water shall plan, design, construct, and Place in Operation the following projects on the Potomac River to control CSO discharges to that river, at any time up to, but no later than, the schedules set forth below, and thereafter to operate them.

20. DC Water shall start the Facility Plan for the Potomac Storage Tunnel and the Potomac Tunnel Dewatering Pumping Station no later than January 1, 2017. No later than December 31, 2018, DC Water shall submit to EPA pursuant to Section X (EPA Approval of Plans and Submissions) a summary report and detailed implementation schedule for the Potomac Storage Tunnel. That detailed implementation schedule shall set forth anticipated completion dates for stages of work and shall include appropriate deadlines for filing all applications for all permits that DC Water knows will be necessary, and dates for notices to proceed with work and construction starts. Except for the milestones in this subsection VI.B (Potomac River Projects), the deadlines in the detailed implementation schedule that is submitted no later than December 31, 2018, shall serve to track and report progress and shall not be enforceable obligations of this Consent Decree.

21. **Rehabilitation of the Existing Potomac Pumping Station**. The existing Potomac Pumping Station is being rehabilitated pursuant to the Partial Consent Decree in this consolidated action.

22. **Potomac Storage Tunnel.** DC Water shall construct a Potomac Storage/Conveyance Tunnel which shall store combined sewer flow from CSO Outfalls 020, 021, 022, and 024 in accordance with DC Water's NPDES Permit. The storage capacity of the tunnel will be at least thirty (30) million gallons. The location of the tunnel will be finalized

during facility planning and design but its approximate location is depicted in **Appendix E** to this Decree. The tunnel will be dewatered by gravity to the Blue Plains Tunnel. After the tunnel is Placed in Operation, in the event of wet weather causing the tunnel to be used for storage, DC Water shall dewater the tunnel as soon as practicable, but in no event longer than 59 hours, and will convey the contents of the tunnel to Blue Plains for treatment in accordance with DC Water's NPDES permit. DC Water will design, construct and Place into Operation the tunnel at any time up to, but no later than, the following schedule:

a. Award Contract for Design: July 1, 2021

b. Award Contract for Construction: September 30, 2023

c. Place in Operation: March 23, 2030

23. **CSO Outfall Separation.** DC Water shall separate the CSS tributary to CSO Outfalls 025 and 026 and eliminate them as CSO outfalls at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: March 23, 2019

b. Award Contract for Construction: March 23, 2021

c. Place in Operation: March 23, 2023

24. **Environmental Impact Statement for the Potomac Storage Tunnel.** DC Water has certified that it has awarded a contract for preparation of the Environmental Impact Statement ("EIS") required by the National Park Service for the Potomac Storage Tunnel. DC Water shall proceed to complete preparation of the EIS in accordance with the requirements of the National Environmental Policy Act and applicable National Park Service regulations.

25. **Green Infrastructure Program.** DC Water shall implement the Green Infrastructure Program for the Potomac sewershed in accordance with the requirements and

schedules in **Appendix F** to this Decree.

C. Rock Creek Projects

26. **Green Infrastructure Program.** DC Water shall implement the Green Infrastructure Program for the Rock Creek sewershed in accordance with the requirements and schedules in **Appendix F** to this Decree.

27. **CSO Outfall Separation.** DC Water has certified pursuant to the Partial Consent Decree that it has separated the Luzon Valley CSS tributary to CSO Outfall 059. DC Water has also certified that it has separated the combined sewer areas tributary to CSO outfalls 031, 037, 053 and 058, and that the separation has eliminated them as CSO outfalls.

28. **Monitoring at CSO Outfalls 033, 036, 047 and 057.** DC Water represents that it has conducted hydraulic monitoring at CSO Outfalls 033, 036, 047 and 057 to obtain data to further characterize the overflows on Rock Creek, including their frequency and volume. DC Water submitted its monitoring data to EPA on April 15, 2005, and EPA approved the data on November 23, 2005. Subsequently, DC Water submitted its plan for controlling CSOs 033, 036, 047 and 057 on May 19, 2006 in a report titled *Control Plan: Rock Creek CSO Outfall Nos. 033. 036, 047 and 057*, Final, May 2006 ("Control Plan"). EPA approved the Control Plan on October 4, 2007. The Control Plan calls for diversion structure improvements and sewer construction to control CSOs 033, 036, and 057. Based on the monitoring, the Control Plan determined that CSO 047 was not predicted to overflow in the average year and that no additional controls were required. The location, sizing, and extent of improvements were finalized during final design. DC Water shall plan, design, construct, and Place in Operation the measures in the Control Plan at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: Completed

b. Award Contract for Construction: Completed

c. Place in Operation: Completed

29. **Piney Branch Diversion Structure Improvements.** DC Water shall modify diversion Structure No. 70 at Piney Branch to improve diversions to the interceptor system at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: March 23, 2016

b. Award Contract for Construction: March 23, 2018

c. Place in Operation: March 23, 2020

D. Blue Plains Wastewater Treatment Plant Projects

DC Water shall plan, design, construct, Place in Operation and operate the following projects at Blue Plains, at any time up to, but no later than, the schedules set forth below.

30. **Blue Plains Tunnel Dewatering Pumping Station ("TDPS") and Enhanced Clarification Facility ("ECF").** The locations of the ECF and TDPS will be finalized during the final design. Their approximate location is depicted in the Summary Report. DC Water shall design, construct, and Place in Operation the TDPS and ECF at Blue Plains at any time up to, but no later than, the following schedule:

a. Award Contract for Detailed Design: Completed

b. Award Contract for Construction: Completed

c. Place in Operation: March 23, 2018

E. Public Notification

31. A visual notification system shall be installed as part of the construction of the tunnel storage projects for the Anacostia River, the Potomac River and for Rock Creek. The system shall be installed at a minimum of three locations on each receiving water at public access locations. The system shall be designed to notify the public of the occurrence of overflows based on flow monitoring at representative CSO outfalls on each receiving water. The

system shall comprise a series of colored lights, flags or pendants that shall operate as follows:

a. Color A shall be displayed as long as flow is detected from the representative outfall;

b. Color B shall be displayed for 24 hours after flow is no longer detected from the representative outfall;

c. When operational, the visual notification system shall be described and explained on DC Water's web site.

32. DC Water shall finalize the details of the public notification system (e.g., selection of representative outfalls, locations, warning devices, and colors) during Facility Planning for each receiving water. DC Water shall submit its plan with the final details to EPA for approval pursuant to Section X (EPA Approval of Plans and Submissions).

VII. MODIFICATIONS TO SELECTED CSO CONTROLS AND SCHEDULES

33. DC Water agrees that the original 20 year implementation schedule and the work set forth in Section VI of the 2005 Consent Decree (Selected CSO Controls and Schedules) remain feasible and equitable, based on current information, assumptions and financial and other projections. Some of the information originally available to DC Water and its original assumptions and projections are set forth in, inter alia, the LTCP appended at **Appendix A**. DC Water's original financial assumptions and projections for the 20 year implementation schedule are set forth in, inter alia, **Appendix B**.

34. The Parties recognize that the information currently available to DC Water as well as DC Water's current assumptions and projections may change during implementation of the Selected CSO Controls. The schedule and/or the Selected CSO Controls in Section VI (Selected CSO Controls and Schedules) may be modified based on a significant change in the information currently available to DC Water, or in DC Water's current assumptions or

projections, whether or not such change is anticipated, that renders the Consent Decree no longer feasible and equitable. Unless the Parties otherwise agree, a request for modification shall not relieve DC Water of its obligations pursuant to Section VI (Selected CSO Controls and Schedules) and DC Water shall continue with implementation of the Selected CSO Controls until the request for modification is either agreed to by the Parties, approved by the Court, or ruled on by the Court under Section XXII (Modification). Any dispute as to whether or not implementation of the Selected CSO Controls should continue during the pendency of the modification request shall not be subject to judicial review or to dispute resolution.

35. The United States on behalf of EPA has accepted the Selected CSO Controls and the 20 year schedule. **Appendices A, B, D and E** are not stipulations, however, and the United States reserves its right to disagree with or to contest particular statements or facts contained therein. In the event that DC Water seeks a modification to extend the schedule based upon a significant increase in costs or other changes in financial circumstances, DC Water shall provide to EPA an update of the information contained in **Appendix B** and, at EPA's request, an update of the key financial variables listed at **Appendix C**.

36. The failure of DC Water and/or the District to seek, approve, or enact timely and adequate rate changes or to obtain bond or other financing to implement the work according to the schedule contained herein based on current information, assumptions and projections shall not constitute a significant change in circumstances under this Section nor shall such failure by itself justify any change in or reassessment of the interim milestones or the 20 year schedule in this Decree.

37. **Grant Funding.** The schedules contained herein assume no federal appropriations, grants, or funding from sources other than DC Water for performance of the

work described in Section VI (Selected CSO Controls and Schedules). In the event that DC Water receives grant funding from federal or other sources for such work, it shall report to EPA in writing the source, amount, and timing of any such grant funding when it learns that it will be appropriated or otherwise received. DC Water has the option but is not required to accelerate the schedule contained in Section VI (Selected CSO Controls and Schedules) based on grant funding.

38. Modifications made pursuant to this Section shall follow the procedures set forth in Section XXII (Modification).

39. In the event that DC Water, after consultation with the District, requests a modification to the schedule or to the Selected CSO Controls, and the United States does not agree to the proposed modification, DC Water and/or the District may invoke the dispute resolution procedures of Section XIV (Dispute Resolution).

40. If DC Water, after consultation with the District, requests a modification because it has decided that it needs to rebid a contract to construct a project, and if DC Water has made best efforts to communicate with the appropriate personnel at EPA Region 3 to obtain a response to a request for modification and has promptly responded to any requests for information from EPA Region 3 related to the requested modification, but EPA does not act on the request for modification within sixty (60) days after receiving the modification request, DC Water may initiate informal dispute resolution and issue a notice of the dispute under the dispute resolution procedures. For all other requests for modification, if DC Water has made best efforts to communicate with the appropriate personnel at EPA Region 3 to obtain a response to a request for modification, and has promptly responded to any requests for information from EPA Region 3 related to the requested modification, but EPA does not act on the request for modification

within one hundred twenty (120) days after receiving the modification request, DC Water may initiate informal dispute resolution and issue a notice of the dispute under the dispute resolution procedures.

41. Compliance with the terms of this Decree is not conditioned upon the receipt of federal or state grant funds and DC Water's failure to comply is not excused by the lack of federal or state grant funds, or by the processing of any applications for the same, subject solely to a force majeure event due to the Anti-Deficiency Act provisions in Section XIII (Force Majeure).

VIII. CONTROL SYSTEM COMPLIANCE AND POST-CONSTRUCTION MONITORING

A. Individual Construction Project Certification.

42. Within sixty (60) days of Placing in Operation each project required under Section VI (Selected CSO Controls and Schedules), DC Water shall certify under Section XX (Certification of Submissions) that such project has been designed, constructed and will be operated in accordance with the terms of this Consent Decree and its NPDES permit.

B. Post-construction monitoring.

43. When the Selected Controls set forth in Section VI (Selected CSO Controls and Schedules) have been Placed in Operation, DC Water shall comply with the post-construction monitoring program set forth in its NPDES permit.

44. Following the Effective Date of the First Amendment to the Consent Decree, DC Water shall include with its next application for NPDES permit renewal proposed revisions to the post-construction monitoring program to reflect the modifications to the Selected CSO Controls for the Potomac River and Rock Creek.

IX. LOW IMPACT DEVELOPMENT RETROFIT

45. DC Water shall promote LIDR in the District of Columbia by performing projects as set forth in this Section. Such projects shall constitute additional work that DC Water agrees to perform in addition to the injunctive relief set forth in Section VI (Selected CSO Controls and Schedules).

46. As set forth in the LTCP, DC Water shall incorporate LIDR techniques into new construction or reconstruction on DC Water facilities for demonstration projects up to a total expenditure of $3 million and shall maintain the LIDR projects for at least five (5) years after each project is Placed into Operation. DC Water shall monitor such projects to obtain data regarding the effectiveness of LIDR in reducing run-off reaching combined sewers and surface waters. These LIDR projects shall be in addition to those constructed as a Supplemental Environmental Project or financed as a Citizen Environmental Project pursuant to the Partial Consent Decree.

47. DC Water submitted a plan to EPA for approval and a schedule for implementing and monitoring LIDR on its own property, which plan and schedule have been approved by EPA. DC Water Placed in Operation all LIDR projects by March 18, 2014. DC Water shall monitor the LIDR projects for twelve (12) months after Placing in Operation all LIDR facilities.

X. EPA APPROVAL OF PLANS AND SUBMISSIONS

48. After review of any plan, report, or other item that is required to be submitted pursuant to this Consent Decree (with the exception of requests for modification pursuant to Section VII (Modifications to Selected CSO Controls and Schedules)), EPA shall in writing: (a) approve the submission; (b) approve the submission upon specified conditions; (c) approve part of the submission and disapprove the remainder; or (d) disapprove the submission.

49. If the submission is approved, DC Water shall take all actions required by the plan, report, or other item, as approved. If the submission is conditionally approved or approved

only in part, DC Water shall, upon written direction of EPA, take all actions required by the approved plan, report, or other item that EPA determines are technically severable from any disapproved portions, subject to DC Water's right to dispute only the specified conditions or the disapproved portions, under Section XIV (Dispute Resolution).

50. If the submission is disapproved in whole or in part, DC Water shall, within 45 days or such other time as the Parties agree in writing, correct all deficiencies and resubmit the plan, report, or other item, or disapproved portion thereof, for approval. Any Stipulated Penalties applicable to the original submission, as provided in Section XII (Stipulated Penalties), shall accrue during the 45-day period or other specified period, but shall not be payable unless the resubmission is untimely or is disapproved in whole or in part; provided that, if the original submission was so deficient as to constitute a material breach of DC Water's obligations under this Decree, the Stipulated Penalties applicable to the original submission shall be due and payable notwithstanding any subsequent resubmission.

51. If a resubmitted plan, report, or other item, or portion thereof, is disapproved in whole or in part, EPA may again require DC Water to correct any deficiencies, in accordance with the preceding Paragraphs of this Section, subject to DC Water's right to invoke Dispute Resolution and the right of EPA to seek Stipulated Penalties, as provided in the preceding Paragraphs of this Section.

XI. REPORTING

52. Progress reports are to be provided at quarterly intervals for all milestone events one year or longer in duration. Each progress report shall summarize the status and progress of work required for completion of the next milestone and the impact of any delays on completion of said milestone, and shall be submitted on the 28th day of the month following each calendar quarter.

53. Beginning with the first CSO Quarterly Report due after the Effective Date of the First Amendment to the Consent Decree, and for every calendar quarter thereafter until this Consent Decree terminates in accordance with Section XXVI (Termination), DC Water shall submit written status reports to U.S. EPA, certified pursuant to Section XX (Certification of Submissions), and post them on the DC Water website. In each report, DC Water shall provide the following:

a. a statement setting forth the deadlines and other terms that DC Water is required by this Consent Decree to meet since the date of the last quarterly statement, whether and to what extent DC Water has met these requirements, and the reasons for any noncompliance;

b. a statement tracking DC Water's progress against the detailed implementation schedules required to be submitted under Section VI (Selected CSO Controls and Schedules) upon the completion of Facility Planning for each receiving water, whether there have been any delays, the reasons for the delays, and the actions DC Water is taking or intends to take to overcome the delays.

c. a general description of the work completed within the three-month period, and a projection of work to be performed pursuant to this Consent Decree during the next three-month period. Notification to U.S. EPA of any anticipated delay shall not, by itself, excuse the delay.

XII. STIPULATED PENALTIES

54. DC Water shall be liable for stipulated penalties for the failure to satisfactorily achieve any deadline for the start of Facility Planning, submission of a detailed implementation schedule and summary report on Facility Planning, Award of Contract for Detailed Design and the Award of Contract for Construction in Section VI (Selected CSO Controls and Schedules), as

follows:

Period of Noncompliance	Penalty Per Day Per Violation
1^{st} to 30^{th} Day	$ 500
31^{st} to 59^{th} Day	$ 1,000
60^{th} day until submitted	$ 1,500

55. DC Water shall be liable for stipulated penalties for the failure to satisfactorily Place in Operation any of the required projects by the final deadline set forth for that project in the schedules in Section VI (Selected CSO Controls and Schedules), as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1^{st} to 30^{th} Day	$ 1,000
31^{st} to 59^{th} Day	$ 2,000
After 60 Days	$ 5,000

56. DC Water shall be liable for stipulated penalties for each failure to properly perform the CSO monitoring required in its NPDES Permit after the Selected Controls are Placed in Operation, as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1^{st} to 30^{th} Day	$ 1,000
31^{st} to 59^{th} Day	$ 2,000
60^{th} day until submitted	$ 2,500

57. DC Water shall be liable for stipulated penalties for failure to timely submit any progress or completion report required in Section XI (Reporting) , as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1^{st} to 30^{th} Day	$ 500
31^{st} to 59^{th} Day	$ 1,000
60^{th} day until submitted	$ 2,000

58. Other Violations: If DC Water fails to comply with a requirement or provision of this Decree not expressly listed above, it shall be liable for stipulated penalties as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1^{st} to 30^{th} Day	$ 500
31^{st} to 59^{th} Day	$ 1,000
60^{th} day until submitted	$ 2,000

59. General Provisions. Stipulated civil penalties shall automatically begin to accrue on the first day DC Water fails to meet any of the schedules required by this Consent Decree or to satisfy any obligation or requirement of this Consent Decree and shall continue to accrue each day until DC Water achieves compliance with such schedule, obligation or requirement; provided, however, that if DC Water submits an appropriately documented request for modification under Section XXII (Modification) 180 days prior to an affected deadline or compliance date, and EPA does not act on such request for modification prior to the deadline or compliance date, stipulated penalties shall not accrue for DC Water's failure to satisfy the deadline or compliance date until EPA's approval or disapproval. This provision shall not apply if DC Water does not have a reasonable basis to make the request for modification or if the request is made for purposes of delay. In the event EPA approves or disapproves DC Water's request for modification after passage of the affected deadline or compliance date, stipulated penalties shall begin to accrue from the time EPA acts on the request for modification.

60. Failure to Meet Award of Construction Contract Deadlines Due to Rebidding. If DC Water elects to rebid a construction contract for a project described in Section VI (Selected CSO Controls and Schedules), it may request a modification under Section VII (Modifications to Selected CSO Controls and Schedules). In the alternative, DC Water may rebid and elect to have any stipulated penalties for failure to meet the Award of Construction Contract deadline due and owing but to defer their payment. If DC Water meets its deadline for Placing in Operation the specific project for which penalties were deferred, stipulated penalties for failure to meet the deadline for Award of Construction Contract will be excused. If DC Water fails to meet the deadline for Placing in Operation the specific project for which penalties were deferred, stipulated penalties for the failure to meet both the Award of Construction Contract and the

Placing in Operation deadlines will be due and payable on demand by the United States. When DC Water elects a deferral of stipulated penalties for failure to meet an Award of Construction deadline due to rebidding a project, it shall give written notice to EPA that it intends to rebid the project and to defer stipulated penalties. When it awards the contract for construction of that project, DC Water shall so notify EPA and advise it in writing of the amount of stipulated penalties accrued pursuant to Section XII (Stipulated Penalties) that are due and owing but deferred.

61. Stipulated civil penalties shall be paid within thirty (30) days of the date of a demand for payment of stipulated civil penalties for any non-compliance with any of the schedules of performance or requirements set forth in this Consent Decree.

62. In the event that a stipulated penalty is not paid according to the instructions in a written demand from the United States, the stipulated civil penalty shall be payable with interest from the original due date to the date of payment, at the statutory judgment rate set forth at 28 U.S.C. § 1961(a).

63. Stipulated civil penalties shall be paid electronically or by submitting a certified or cashier's check payable to "Treasurer, the United States of America", and tendered to the United States Attorney for the District of Columbia. Simultaneously, DC Water shall send copies of the certified or cashier's check, together with a letter describing the basis for the penalties, to Chief, Environmental Enforcement Section, United States Department of Justice, Post Office Box 7611, Ben Franklin Station, Washington, D.C. 20044, and to Section Chief, Compliance and Enforcement Branch, Water Protection Division, US EPA Region 3, 1650 Arch Street, Philadelphia, PA 19103. The transmittal letter shall reference the caption, the civil action number, and DOJ Number 90-5-1-1-07137.

64. Payment of stipulated civil penalties as set forth above shall be in addition to any other rights or remedies which may be available to the United States or its agencies by reason of DC Water's failure to comply with the requirements of this Consent Decree and all applicable Federal, state or local laws, regulations, wastewater discharge permit(s) and all other applicable permits. Where a violation of this Consent Decree is also a violation of such laws, regulations, or permits, DC Water shall be allowed a credit, in the amount of any Stipulated Penalties paid, as a set-off against any statutory penalties imposed for such violation.

65. If DC Water invokes dispute resolution and the Court resolves the dispute against DC Water, stipulated penalties which have accrued during the pendency of the dispute shall be payable, as set forth herein, upon resolution of the dispute; provided, however, that in the event that the Director of the Water Protection Division requires more than sixty (60) days to issue a final agency decision concerning the dispute, DC Water shall be liable only for sixty (60) days of stipulated penalties for the period from submission of the final Statements of Position or written Reply until issuance of the final agency decision, as set forth in Section XIV (Dispute Resolution). Stipulated penalties shall begin to accrue again upon issuance of the final agency decision.

XIII. FORCE MAJEURE

66. "Force Majeure" for the purposes of this Consent Decree is defined as an event arising from causes beyond the control of DC Water or the control of any entity controlled by DC Water, including its consultants and contractors, which delays or prevents the performance of any obligation under this Consent Decree. Nothing in this Section is intended to relieve DC Water of its duty to use due diligence to complete the requirements of this Consent Decree in a timely manner or of DC Water's obligation to meet all discharge limitations and other obligations contained in DC Water's NPDES Permit. Unanticipated or increased costs or

changed financial circumstances are not Force Majeure events, except as provided in Paragraph 68 (Anti-Deficiency Act Events) below, although in certain instances they may constitute the basis for a request for modification pursuant to Section VII (Modifications to Selected CSO Controls and Schedules).

67. **Permitting:** Failure to apply for a required permit or approval, or to provide in a timely manner all information required to obtain a permit or approval necessary to meet the requirements of this Consent Decree, are not Force Majeure events. However, failure of a permitting authority to issue a necessary permit in a timely fashion is an event of Force Majeure where the failure of the permitting authority to act is beyond the control of DC Water and DC Water demonstrates that it has taken all steps available to it to obtain the necessary permit, including but not limited to:

a. Promptly providing reasonably known permitting authorities with copies of this Consent Decree, when lodged, as well as briefing each such authority, both orally and with written materials if necessary, on the projects and schedules contained therein in order to coordinate permitting submittals and approvals;

b. submitting a complete permit application within two (2) months of the date identified in the detailed implementation schedule to apply for permits that are known to be required, and in a prompt fashion for those permits not known to be required or previously identified in the schedule;

c. responding to requests for additional information by the permitting authority in a timely fashion;

d. making regular inquiry, approximately every 45 days, both verbally and in writing, with the permitting authority after initial or supplemental permit filings, to determine the status of the permit application;

e. seeking relief from higher management officials within the permitting authority where permit processing delays threaten to cause noncompliance with any deadline in this decree;

f. accepting lawful permit terms and conditions; and

g. prosecuting appeals of any unlawful terms and conditions imposed by the permitting authority in an expeditious fashion.

68. **Anti-Deficiency Act Events**: Nothing in this Decree shall be construed to require an expenditure, obligation or contract in violation of the Anti-Deficiency Act, 31 U.S.C. §§ 1341 et seq. Where an expenditure, obligation or contract is subject to the Anti-Deficiency Act, DC Water's obligations shall be subject to the availability of appropriated funds. In such case, DC Water must identify the portion of its budget related to implementation of this Consent Decree that is comprised of appropriated or other funds, and demonstrate why the unavailability of those appropriated or other funds will delay specific obligations.

69. To the extent made necessary by lack of appropriated funds, DC Water may obtain deferral of compliance with an obligation of this Consent Decree until its next annual budget cycle if, within sixty (60) days after DC Water knew or should have known of the event described in Paragraph 70 below, it provides in writing to EPA Region III a statement which shows the following:

a. That it included in its annual budget, which accompanies the District of Columbia budget submitted to the President for transmission to the Congress pursuant to Section 446 of the District of Columbia Home Rule Act, D.C. Code Sec. 1-204.46 (2001), sufficient money to carry out such objective;

b. That it made diligent efforts to obtain Congressional enactment of that part of the budget act;

c. That it expressly identified in the annual fiscal year adopted budget prepared for Congressional use such obligation (not necessarily to include reference to this Decree as such) together with the amount of money tied to performing such obligation; and

d. That Congress acted expressly to eliminate such amount of money or to reduce it below the level necessary to perform the obligation, or that Congress made an across the board reduction in DC Water's appropriation as shown in DC Water's adopted budget without expressly saving such obligation and the across the board reduction, as applied proportionately to the amount of money shown in the adopted budget for such obligation, left an insufficient amount to carry out that obligation.

70. **General Requirements:** When circumstances are occurring or have occurred which may delay the completion of any requirement of this Consent Decree, whether or not due to a Force Majeure event, DC Water shall so notify EPA, in writing, within fifteen (15) days after DC Water knew, or should have known, of the delay or anticipated delay. The notice shall describe in detail the basis for DC Water's contention that it experienced a Force Majeure delay, the anticipated length of the delay, the precise cause or causes of the delay, the measures taken or to be taken to prevent or minimize the delay, and the timetable by which those measures will be implemented. Failure to so notify the United States shall constitute a waiver of any claim of Force Majeure as to the event in question.

71. If the United States finds that a delay in performance is, or was, caused by a Force Majeure event, it shall extend the time for performance, in writing, for a period to compensate for the delay resulting from such event and stipulated penalties shall not be due for

such period. In proceedings on any dispute regarding a delay in performance, the dispute resolution provisions of Section XIV (Dispute Resolution) shall apply and DC Water shall have the burden of proving that the delay is, or was, caused by a Force Majeure event, and that the amount of additional time requested is necessary to compensate for that event.

72. Compliance with a requirement of this Consent Decree shall not by itself constitute compliance with any other requirement. An extension of one compliance date based on a particular event shall not automatically extend another compliance date or dates. DC Water shall make an individual showing of proof regarding the cause of each delayed incremental step or other requirement for which an extension is sought. DC Water may petition for the extension of more than one compliance date in a single request.

XIV. DISPUTE RESOLUTION

73. This Court shall retain jurisdiction for the purpose of adjudicating, in the manner provided by this Section, all disputes between DC Water and the United States that may arise under the provisions of this Consent Decree. Unless otherwise expressly provided in this Consent Decree, the dispute resolution procedures of this Section shall be the exclusive mechanism to resolve disputes arising under or with respect to this Consent Decree. However, the procedures set forth in this Section shall not apply to actions by the United States to enforce obligations of DC Water that have not been disputed in accordance with this Section.

74. Permit actions pursuant to 40 C.F.R. Part 124, including issuance, denials, and modifications, shall not be subject to this Consent Decree, but rather shall continue to be handled through the administrative and judicial procedures set forth in those regulations.

75. Any dispute which arises under or with respect to this Consent Decree shall in the first instance be the subject of informal negotiations between DC Water and the United States. Notice of the dispute shall be transmitted no later than fourteen (14) days from the date of

the circumstances giving rise to the dispute. The period for informal negotiations shall not exceed twenty (20) days from the date of receipt of the original notice of the dispute, unless DC Water and the United States otherwise agree in writing to extend that period.

76. If the informal negotiations are unsuccessful, the position of the United States shall control unless, within twenty (20) days after the conclusion of the informal negotiation period, DC Water invokes the formal dispute resolution procedures of this Section by serving on the United States a written Statement of Position on the matter in dispute, which shall set forth the nature of the dispute with a proposal for its resolution as well as any factual data, analysis or opinion supporting that position and any supporting documentation (including the Long Term Control Plan or portions thereof) relied upon.

77. Within thirty (30) days of the receipt of a Statement of Position, pursuant to this Section, the United States may serve on DC Water its own Statement of Position, which may include an alternate proposal for resolution of the dispute as well as any factual data, analysis, or opinion supporting that position and all supporting documentation (including the Long Term Control Plan or portions thereof) relied upon by the United States. Within 15 days after receipt of such Statement, DC Water may serve on the United States a written Reply.

78. Matters Accorded Record Review: With the exception of modification requests pursuant to Section VII (Modifications to Selected CSO Controls and Schedules), this Paragraph shall pertain to disputes subject to the procedures of this Section that concern the adequacy or nature of the work to be performed under Section VI (Selected CSO Controls and Schedules), or other matters that are accorded review on the administrative record under applicable principles of administrative law. For matters subject to this Paragraph, DC Water shall have the burden of showing that the position of the United States is arbitrary and capricious or otherwise not in

accordance with applicable law or this Consent Decree. Plaintiff shall compile an administrative record, which shall consist of the Statements of Position and supporting documentation relied upon (including the LTCP or portions thereof that the parties incorporated into their Statements) and other documents considered and relied upon by EPA in arriving at its final administrative decision. Where appropriate, EPA may allow DC Water, the District of Columbia, Citizen Plaintiffs, and/or other members of the public to make supplemental submissions. The Director of the Water Protection Division shall issue a written final administrative decision resolving the dispute based on the administrative record. Stipulated penalties for the period from submission of the final Statement of Position or written Reply until issuance of the final administrative decision shall accrue for no more than sixty (60) days, even if EPA issues the final administrative decision after more than 60 days. The final administrative decision shall be effective in ten (10) days, unless DC Water moves for judicial review within ten (10) days of its receipt of the final agency decision.

79. Modification Requests: In the case of requests for modification of the Selected CSO Controls and/or schedules pursuant to Section VII (Modifications to Selected CSO Controls and Schedules), DC Water shall bear the burden of demonstrating that the requested modification should be approved in accordance with Section VII (Modifications to Selected CSO Controls and Schedules). EPA's final decision shall be binding on DC Water, unless within twenty (20) days of its receipt DC Water submits a modification request to the Court. If the Director of the Water Protection Division does not issue a final decision on a request for modification within one hundred twenty (120) days from the date that DC Water submits its Reply to the United States' Statement of Position, DC Water may elect to move in Court to modify the Consent Decree.

80. Other Matters: In the case of other matters not subject to Paragraphs 78 and 79

above, DC Water shall have the burden to demonstrate that its actions or positions were taken in accordance with the terms, conditions, requirements and objectives of this Consent Decree and the Clean Water Act. The Director of the Water Protection Division will issue a final decision resolving the dispute which will be binding on DC Water, unless within twenty (20) days of its receipt DC Water serves on the United States a motion for judicial review of the decision setting forth the matter in dispute, the efforts made to resolve it, the relief requested, and the schedule, if any, within which the dispute must be resolved to ensure orderly implementation of this Consent Decree. Stipulated penalties for the period from submission of the final Statement of Position or written Reply until issuance of the final administrative decision shall accrue for no more than sixty (60) days, even if EPA issues the final administrative decision after more than 60 days.

81. Where the dispute arises from DC Water's request for modification of the Selected CSO Controls and/or schedules pursuant to Section VII (Modifications to Selected CSO Controls and Schedules), the matter shall not be subject to the principles of record review in Paragraph 78. For other matters, if DC Water and the United States disagree as to whether the dispute should proceed under the principles of record review or not, DC Water shall follow the procedures determined by EPA to be applicable. Upon appeal, the Court shall determine which procedures are applicable in accordance with the standards set forth in this Section.

82. Submission of any matter to the Court for resolution shall not extend or stay any of the deadlines set forth in this Consent Decree unless the Parties agree to such extension in writing or the Court grants an order extending such deadline(s). Stipulated penalties with respect to the disputed matter shall continue to accrue but payment shall be stayed pending resolution of the dispute as provided in this Section. Notwithstanding the stay of payment, stipulated penalties shall accrue from the first day of noncompliance with any applicable provision of this Consent

Decree. In the event that DC Water does not prevail on the disputed issue, stipulated penalties shall be assessed and paid as provided in Section XII (Stipulated Penalties).

XV. RIGHT OF ENTRY

83. Commencing upon the date of lodging of this Consent Decree, U.S. EPA and its representatives, contractors, consultants, and attorneys shall have the right of entry into and upon the premises of DC Water at all reasonable times, upon proper presentation of credentials, for the purposes of:

a. Monitoring the progress of activities required by this Consent Decree;

b. Verifying any data or information required to be submitted pursuant to this Consent Decree;

c. Obtaining samples and, upon request, splits of any samples taken by DC Water or its consultants. Upon request, DC Water will be provided with splits of all samples taken by the United States;

d. Inspecting and evaluating the CSO System;

e. Inspecting and reviewing any record required to be kept under the provisions of this Consent Decree or any NPDES Permit and the Clean Water Act; and

f. Otherwise assessing DC Water's compliance with this Consent Decree.

84. This Section XV (Right of Entry) in no way limits or affects any right of entry and inspection, or any other right otherwise held by the United States, U.S. EPA and any other governmental entity, pursuant to applicable federal or state laws, regulations.

85. DC Water reserves the right to request the laboratory analytical results of samples taken from the CSS by the United States during the term of this Consent Decree, and any non-privileged reports prepared using such results.

XVI. NOT A PERMIT/COMPLIANCE WITH OTHER STATUTES/REGULATIONS

86. This Consent Decree is not and shall not be interpreted to be a permit or modification of any existing permit issued pursuant to Section 402 of the Act, 33 U.S.C. § 1342. This Consent Decree does not relieve DC Water of any obligation to apply for, obtain and comply with the requirements of any new or existing NPDES permit or to comply with any federal, state or local laws or regulations, including, but not limited to its obligations to obtain a permit for its wastewater treatment and collection system or facilities and to comply with the requirements of any NPDES permit or with any other applicable federal or state law or regulation. Any new permit, or modification of existing permits, must be complied with in accordance with federal and state laws and regulations.

XVII. FAILURE OF COMPLIANCE

87. The United States does not, by its consent to the entry of this Consent Decree, warrant or aver in any manner that DC Water's complete compliance with this Consent Decree will result in compliance with the provisions of the Clean Water Act, 33 U.S.C. §§ 1251 et seq., or with DC Water's NPDES permit. Notwithstanding EPA's review or approval of any Scope of Work, report, or plans and specifications, pursuant to this Consent Decree, DC Water shall remain solely responsible for any non-compliance with the terms of this Consent Decree, all applicable permits, the Clean Water Act, and regulations promulgated thereunder. The pendency or outcome of any proceeding concerning issuance, reissuance, or modification of any permit shall neither affect nor postpone DC Water's duties and obligations as set forth in this Consent Decree.

XVIII. EFFECT OF DECREE AND NON-WAIVER PROVISIONS

88. The Parties agree that this Consent Decree resolves the civil claims for violation of water quality standards and for long-term injunctive relief (Claim One) alleged in the Complaint filed by the United States through the date of lodging of this Decree.

89. The Consent Decree in no way affects or relieves Settling Defendants of any responsibility to comply with any federal, state, or local law or regulation.

90. The Parties agree that DC Water is responsible for achieving and maintaining complete compliance with all applicable federal and state laws, regulations, and permits, and that compliance with this Consent Decree shall be no defense to any actions commenced pursuant to said laws, regulations, or permits.

91. The United States reserves the right to file a civil action for statutory penalties or injunctive relief against DC Water for any violations of the Clean Water Act by DC Water which occur after the date of lodging of this Consent Decree and any such violations occurring prior to that date that are not specifically alleged as Claims for Relief in the Complaints.

92. This Consent Decree does not limit or affect the rights of DC Water, the District of Columbia, or the United States as against any third parties which are not parties to this Consent Decree.

93. The Parties reserve any and all legal and equitable remedies available to enforce the provisions of this Consent Decree. This Consent Decree shall not limit any authority of EPA under any applicable statute, including the authority to seek information from DC Water or to seek access to the property of DC Water, nor shall anything in this Consent Decree be construed to limit the authority of the United States to undertake any action against any person, including DC Water, in response to conditions that may present an imminent and substantial endangerment to the environment or the public health or welfare.

94. Obligations of DC Water under the provisions of this Consent Decree to perform duties scheduled to occur after the date of lodging, but prior to the Effective Date of the First Amendment to the Consent Decree, shall be legally enforceable from the date of lodging of this

Consent Decree. Liability for stipulated penalties, if applicable, shall accrue for violation of such obligations as of the date of violation and payment of such stipulated penalties may be demanded by the United States upon or after the Effective Date of the First Amendment to the Consent Decree.

95. The United States reserves the right to file a criminal action for statutory penalties or other criminal relief against DC Water for any violations by DC Water of the Clean Water Act or other applicable federal statutes.

96. It is the intent of the Parties hereto that the clauses hereof are severable, and should any clause(s) be declared by a court of competent jurisdiction to be invalid and unenforceable, the remaining clauses shall remain in full force and effect.

97. The United States reserves all remedies available to it for violations of Federal, State and local law.

XIX. <u>COSTS OF SUIT</u>

98. The Parties shall bear their own costs and attorney's fees with respect to this action and to matters related to this Consent Decree.

XX. <u>CERTIFICATION OF SUBMISSIONS</u>

99. DC Water shall maintain copies of any underlying research and data in its possession, custody or control for any and all documents, scope of work, reports, plans and specifications, or permits submitted to EPA pursuant to this Consent Decree for a period of five (5) years, except that DC Water shall not be required to maintain copies of drafts of documents, scope of work, reports, plans and specifications, reports or permits. DC Water shall require any independent contractor implementing this Consent Decree to also retain such materials for a period of five (5) years. DC Water shall submit such supporting documents to EPA upon request. DC Water shall also submit to EPA upon request any other documents that relate to or discuss

the operation, maintenance, repair, or construction of the CSO system (or any portion thereof), or that relate to or discuss the number, frequency, volume, quality or environmental impact of CSO discharges. In all notices, documents or reports submitted to EPA pursuant to this Consent Decree, a senior management official of DC Water shall sign and certify such notices, documents and reports as follows:

> 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 ensure 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 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.

XXI. FORM OF NOTICE

100. Unless otherwise specified within the terms of this Consent Decree, all reports, notices, or any other written communications required to be submitted under this Consent Decree shall be sent to the respective parties at the following addresses:

As to the United States:

Department of Justice

Chief, Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
Post Office Box 7611, Ben Franklin Station
Washington, DC 20044
Reference DOJ Case No. 90-5-1-1-07137

United States Attorney
District of Columbia
Judiciary Center
555 Fifth Street NW
Washington, DC 20530

EPA

Director
Water Enforcement Division
Office of Regulatory Enforcement
U.S. Environmental Protection Agency
OECA-ORE-WED
Ariel Rios Building
12th and Pennsylvania Ave, NW
Mail Code 2243A
Washington, DC 20004

Chief
NPDES Branch (3WP42)
Water Protection Division
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

Yvette Roundtree (3RC20)
Office of Regional Counsel
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

As to DC Water:

George S. Hawkins or his successor
General Manager
District of Columbia Water and Sewer Authority
5000 Overlook Avenue, SW
Washington, D.C. 20032

Deputy General Manager/Chief Enginner
District of Columbia Water and Sewer Authority
5000 Overlook Avenue, SW
Washington, D.C. 20032

As to the District:

The Attorney General of District of Columbia
One Judiciary Square
441 Fourth Street NW
Suite 600 South
Washington, DC 20001

XXII. MODIFICATION

101. This Consent Decree contains the entire agreement of the Parties and shall not be modified by any prior oral or written agreement, representation or understanding. Prior drafts of this Consent Decree shall not be used in any action involving the interpretation or enforcement of this Consent Decree.

102. The non-material terms of this Consent Decree may be modified by a subsequent written agreement signed by all the Parties. If all the Parties agree to a material modification in writing, they may apply to the Court for approval thereof. If the Parties do not reach agreement on such material modification, the request for modification shall be subject to the dispute resolution procedures of this Decree. All material modifications shall be in writing and approved by the Court before they will be deemed effective.

103. In the event DC Water requests a material modification to the Selected CSO Controls and/or the schedule set forth in Section VI (Selected CSO Controls and Schedules), DC Water shall arrange for additional public participation prior to submitting the modification request to the United States. DC Water shall initially consult with EPA concerning the modification and the scope of public participation to be obtained by DC Water prior to submission of a formal request for modification from DC Water to EPA.

a. The proposed modification package shall be submitted to EPA and shall contain the following:

i. the basis for the modification and the supporting technical and regulatory justification (including if applicable the LTCP or pertinent portions thereof);

ii. any changes to the Selected CSO Controls and/or to the schedule in Section VI (Selected CSO Controls and Schedules), along with any supporting data;

iii. a demonstration of material compliance with any applicable requirements of the 1994 CSO Policy; and

iv. a demonstration that public participation has occurred.

b. If the United States, after consultation with the District of Columbia, agrees to the modification, the proposed changes to the Selected CSO Controls and/or the schedules shall be executed by appropriate officials on behalf of the United States, the District of Columbia, and DC Water and lodged with the Court for a period of public comment prior to entry. If the United States does not agree to the proposed modification, the matter shall be subject to the procedures of Section XIV (Dispute Resolution).

XXIII. PUBLIC COMMENT

104. The parties agree and acknowledge that final approval by the United States and entry of this Consent Decree is subject to the requirements of 28 C.F.R. § 50.7, which provides for notice of the lodging of this Consent Decree in the Federal Register, an opportunity for public comment, and consideration by the United States of any comments. This Paragraph does not create any rights exercisable by the Settling Defendants, and Settling Defendants shall not withdraw their consent to this Consent Decree between lodging and entry of this Consent Decree and hereby consents to entry of this Decree without further notice.

105. All information and documents submitted by Settling Defendants to U.S. EPA pursuant to this Consent shall be subject to public inspection, unless identified and supported as confidential by DC Water in accordance with 40 C.F.R. Part 2.

XXIV. CONTINUING JURISDICTION OF THE COURT

106. The Court shall retain jurisdiction to enforce the terms and conditions of this Consent Decree and to resolve disputes arising hereunder as may be necessary or appropriate for the construction, modification or execution of this Consent Decree.

XXV. APPENDICES

Appendix A is the Long Term Control Plan and its Appendices.

Appendix B contains DC Water's financial assumptions and projections that it sets forth as its basis for the 20 year implementation schedule in this Consent Decree.

Appendix C contains a list of key financial variables to be updated in the event of a request for modification due to changed financial circumstances pursuant to Section VII of the 2005 Consent Decree (Modifications to Selected CSO Controls and Schedules).

Appendix D contains the TN/Wet Weather Plan Summary Report.

Appendix E contains the Summary of Gray/Green and Green CSO Controls for the Potomac and Rock Creek Sewersheds.

Appendix F contains the Green Infrastructure Program for the Potomac and Rock Creek Sewersheds.

XXVI. TERMINATION

107. This Consent Decree shall terminate upon motion of the United States to the Court after each of the following has occurred:

a. DC Water has Placed in Operation all of the construction projects required under Section VI (Selected CSO Controls and Schedules);

b. DC Water has demonstrated that it has achieved and maintained compliance with the water quality based CSO numerical effluent limitations and the performance standards requiring that the Selected CSO Controls be implemented, operated and maintained as described in DC Water's NPDES Permit for two years after the Selected CSO Controls are Placed in Operation;

c. DC Water has satisfactorily implemented its LIDR projects and programs as required by Section IX (Low Impact Development Retrofit);

d. DC Water has paid all stipulated penalties and any other monetary obligations due hereunder, and no penalties or other monetary obligations due hereunder are outstanding or owed to the United States; and

e. DC Water has certified completion to the United States, and the United States has not contested DC Water's completion or compliance.

108. The Consent Decree shall not terminate if, within 90 days of certification by DC Water to the United States of compliance pursuant to this Section, the United States asserts in writing that full compliance has not been achieved, or seeks further specific information in order to evaluate DC Water's certification. If the United States disputes DC Water's full compliance, this Consent Decree shall remain in effect pending resolution of the dispute by the parties or the Court.

109. Notwithstanding Paragraph 108 above, if DC Water submits a certification to the United States that it has completed all the requirements in Paragraph 107 above, and the United States does not respond on or before 90 days, DC Water may file a motion to the Court seeking termination of this Consent Decree.

XXVII. <u>SIGNATORIES</u>

110. The Assistant Attorney General on behalf of the United States and the undersigned representatives of the Settling Defendants certify that they are fully authorized to enter into the terms and conditions of this Consent Decree and to execute and legally bind such party to this document.

Entered this 14th day of January, 2016

Thomas F. Hogan

~~Chief~~ Judge, United States District Court

THE UNDERSIGNED PARTIES enter into this First Amendment to Consent Decree in the matter of *Anacostia Watershed Society, et al., v. District of Columbia Water and Sewer Authority and the District of Columbia; and United States of America v. District of Columbia Water and Sewer Authority and the District of Columbia*

FOR THE UNITED STATES OF AMERICA:

4/22/15
Dated

JOHN C. CRUDEN
Assistant Attorney General
Environment and Natural Resources Division
U.S. Department of Justice

3/27/15
Dated

MARCELLO MOLLO
Senior Attorney
Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
P.O. Box 7611, Ben Franklin Station
Washington, D.C. 20044
601 D Street NW
Washington, D.C. 20004

THE UNDERSIGNED PARTIES enter into this First Amendment to Consent Decree in the matter of *Anacostia Watershed Society, et al., v. District of Columbia Water and Sewer Authority and the District of Columbia; and United States of America v. District of Columbia Water and Sewer Authority and the District of Columbia*

[RESERVED]

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FOR THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY:

5/8/15
Dated

SHAWN M. GARVIN
Regional Administrator
U.S. EPA Region III

4/20/15
Dated

MARY COE
Acting Regional Counsel
U.S. EPA Region III

4/21/15
Dated

YVETTE ROUNDTREE
Senior Assistant Regional Counsel
U.S. EPA Region III
1650 Arch Street
Philadelphia, PA 19103

THE UNDERSIGNED PARTIES enter into this First Amendment to Consent Decree in the matter of *Anacostia Watershed Society, et al., v. District of Columbia Water and Sewer Authority and the District of Columbia; and United States of America v. District of Columbia Water and Sewer Authority and the District of Columbia*

FOR THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY:

4/7/15
Dated

SUSAN SHINKMAN
Director
Office of Civil Enforcement
Office of Enforcement and Compliance Assurance

4-7-15
Dated

MARK POLLINS
Director, Water Enforcement Division
Office of Civil Enforcement
Office of Enforcement and Compliance Assurance

4. 7. 15
Dated

SUSHILA NANDA
Senior Attorney Advisor
Office of Civil Enforcement
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

THE UNDERSIGNED PARTIES enter into this First Amendment to Consent Decree in the matter of *Anacostia Watershed Society, et al., v. District of Columbia Water and Sewer Authority and the District of Columbia; and United States of America v. District of Columbia Water and Sewer Authority and the District of Columbia*

FOR THE DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY:

12/18/14
Dated

GEORGE S. HAWKINS
General Manager
District of Columbia Water and Sewer Authority

12/18/14
Dated

RANDY E. HAYMAN
~~General Counsel~~
District of Columbia Water and Sewer Authority
5000 Overlook Avenue, S.W.
Washington, D.C. 20032

Dec. 18, 2014
Dated

DAVID E. EVANS
McGuireWoods LLP
One James Center
901 East Cary Street
Richmond, Virginia 23219
Counsel to District of Columbia Water and Sewer Authority

THE UNDERSIGNED PARTIES enter into this First Amendment to Consent Decree in the matter of *Anacostia Watershed Society, et al., v. District of Columbia Water and Sewer Authority and the District of Columbia; and United States of America v. District of Columbia Water and Sewer Authority and the District of Columbia*

FOR THE DISTRICT OF COLUMBIA:

3/24/15
Dated

RASHAD M. YOUNG
City Administrator
District of Columbia
John A. Wilson Building
1350 Pennsylvania Avenue, NW
Washington, DC 20004

KARL A. RACINE
Attorney General for the District of Columbia

3/24/15
Dated

By: Ellen A. Efros /tmr
Ellen A. Efros
Deputy Attorney General
Public Interest Division
441 4th Street, NW, Suite 6 South
Washington, DC 20001

APPENDIX B

APPENDIX B

Table 1, attached, presents WASA's financial projections for the impact on sewer rates of the 20-year LTCP implementation schedule as specified in the consent decree. Descriptions of the heading columns in Table 1 are presented below:

Column No.	Heading	Description
1	Year No.	Sequential count of number of years starting in 2004
2	Calendar year	Calendar year starting in 2004
3	Capital 2001 Dollars ($M)	Estimated capital costs for the CSO LTCP expressed in constant year 2001 dollars
4	Capital Actual Dollars ($M)	The estimated capital costs for the CSO LTCP expressed in the year of expenditure dollars using 3% per year to escalate the 2001 value estimate.
5	OM 2001 Dollars ($M)	Estimated operating and maintenance costs for the CSO LTCP expressed in constant year 2001 dollars.
6	OM Actual Dollars ($M)	The estimated operating and maintenance costs for the CSO LTCP expressed in the year of expenditure dollars using 3% per year to escalate the 2001 value estimate.
7	Total 2001 Dollars ($M)	The addition of CSO Costs/OM/2001 Dollars ($M) and CSO Costs/Capital/2001 Dollars ($M).
8	Total Actual Dollars ($M)	The addition of CSO Costs/OM/Actual Dollars ($M) and CSO Costs/Capital/Actual Dollars ($M).
9	Capital Costs Financed ($M)	The amount of actual capital costs that are debt financed.
10	Capital Costs PAYGO ($M)	The amount of actual capital costs that are paid from current year revenues on a pay-as-you-go-basis.
11	Debt Service ($M)	Estimated annual debt service on capital costs that are financed using 30 year term and borrowing costs of 7%.
12	O&M ($M)	Same as Column 6, OM Actual Dollars ($M)
13	Total Rate Requirements	The addition of PAYGO, Debt Service, O&M costs.
14	Other WASA Wastewater Costs Paid by DC Ratepayers	Operating and capital costs for wastewater services that are funded by retail ratepayers before the addition of CSO LTCP costs.
15	Typical Residential Bill Without CSO LTCP	Estimated annual residential wastewater bill before addition of the CSO LTCP costs.
16	Bill Increase Without CSO LTCP	Estimated annual change in residential wastewater bill before addition of CSO LTCP costs.
17	Typical Residential Bill Without CSO LTCP	Estimated annual residential wastewater bill after addition of the CSO LTCP costs.
18	Bill Increase Without CSO LTCP	Estimated annual change in residential wastewater bill after addition of CSO LTCP costs.
19	MHI	Estimated median household income (MHI) using 3% annual growth rate
20	% of MHI	Estimated residential bill as a percent of MHI.
21	Lower 20%	Household income of the most affluent household of the lower 20th percentile of households in the District.
22	% of Lower 20%	Estimated residential bill as a percent of the household income for the most affluent household of the lower 20th percentile of households in the District.

The financial projections are based on certain assumptions, which include, but are not limited to the following:

1. Billed water use is projected to decrease at 1% per year. Residential bill estimates are based on average consumption of 100 ccf per year.

2. Customers are assessed a charge for water and wastewater services based on water consumption. With the exception of certain federal government customers located outside of the District, all customers pay the same rate, regardless of account class, meter size, or size of service connection. The analysis assumes this practice will continue.

3. The analysis assumes a revenue collection rate of 97.7% of billed amounts.

4. Median Household Income in the District of Columbia is projected to increase at 3% per year. The most affluent of the lower 20th percentile of households in the District have a household income in 2004 dollars of $19,669 and this is projected to increase at the rate of inflation, which is assumed to be 3% per year.

5. Projections take into account discounts to low-income customers under the Authority's customer assistance program. The Authority's program covers 6,000 low-income customers and provides discounts of approximately $500,000 each year. Each eligible participant receives an exemption for water service charges in the amount of 4 ccf per month.

6. The financial analysis assumes an all-in borrowing cost assumption of 7 percent including cost of issuance (including bond insurance premiums, premiums for debt service reserve facility and fees and expenses related to bond issuance; approximately 2% on the Authority's 2003 revenue bond issue). The analysis assumes a debt coverage ratio of 1.40 x Term of Debt. The financial analysis utilizes fixed rate financing with a term of 30 years.

7. CSO operating and maintenance and capital costs are escalated at a rate of 3% per year from 2001 cost estimates to the year of expenditure. Non CSO-related wastewater operating and capital costs are projected to increase at approximately 5 percent per year reflecting impacts of inflation and reinvestment in capital facilities.

Table 1
25-Year LTCP Financial Projections

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		CSO Costs						CSO LTCP Financing					Other WASA Wastewater Costs			Effect on Users					
		Capital		O/M		Total															
Year No.	Calendar Year	2001 Dollars ($M)	Actual Dollars ($M)	2001 Dollars ($M)	Actual Dollars ($M)	2001 Dollars ($M)	Actual Dollars ($M)	Capital Costs Financed ($M)	Capital Costs PAYGO ($M)	Debt Service ($M)	O & M ($M)	Total Annual Rate Requirements ($M)	Other WASA WW Costs Paid by DC Ratepayers ($M)	Typical Residential Bill w/o CSO LTCP	Bill Increase without CSO LTCP	Typical Residential Bill with CSO LTCP	Bill Increase with CSO LTCP	MHI	% of MHI	Lower 20%	% of Lower 20%
1	2004	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 120.47	$ 297		$ 297		$ 40,616	0.7%	$ 19,660	1.5%
2	2005	$ 4.07	$ 4.68	$ 0.04	$ 0.04	$ 4.11	$ 4.82	$ 3.86	$ 0.16	$ 0.31	$ 0.04	$ 0.50	$ 126.53	$ 310	5%	$ 311	5%	$ 41,834	0.7%	$ 20,259	1.5%
3	2006	$ 4.46	$ 5.17	$ 0.08	$ 0.09	$ 4.54	$ 5.26	$ 1.88	$ 0.29	$ 0.46	$ 0.09	$ 0.84	$ 132.60	$ 323	4%	$ 325	4%	$ 43,089	0.8%	$ 20,867	1.6%
4	2007	$ 12.61	$ 15.06	$ 0.19	$ 0.22	$ 12.80	$ 15.28	$ 7.63	$ 0.67	$ 1.09	$ 0.22	$ 1.99	$ 139.87	$ 344	6%	$ 348	7%	$ 44,382	0.8%	$ 21,493	1.6%
5	2008	$ 13.45	$ 16.54	$ 0.31	$ 0.37	$ 13.76	$ 16.92	$ 5.36	$ 0.97	$ 1.53	$ 0.37	$ 2.87	$ 149.23	$ 369	8%	$ 376	8%	$ 45,713	0.8%	$ 22,138	1.7%
6	2009	$ 15.23	$ 19.29	$ 0.45	$ 0.56	$ 15.68	$ 19.85	$ 14.74	$ 1.23	$ 2.71	$ 0.56	$ 4.50	$ 158.08	$ 397	8%	$ 408	8%	$ 47,085	0.9%	$ 22,802	1.8%
7	2010	$ 12.67	$ 16.52	$ 0.57	$ 0.72	$ 13.23	$ 17.24	$ 14.91	$ 1.62	$ 3.92	$ 0.72	$ 6.26	$ 166.47	$ 424	7%	$ 439	8%	$ 48,497	0.9%	$ 23,486	1.9%
8	2011	$ 55.90	$ 76.12	$ 1.07	$ 1.40	$ 56.97	$ 78.52	$ 71.13	$ 3.99	$ 8.65	$ 1.40	$ 15.04	$ 173.07	$ 440	4%	$ 477	8%	$ 49,952	1.0%	$ 24,190	2.0%
9	2012	$ 60.19	$ 83.32	$ 1.62	$ 2.18	$ 61.81	$ 85.49	$ 76.77	$ 6.54	$ 16.83	$ 2.18	$ 24.56	$ 179.02	$ 459	4%	$ 520	9%	$ 51,461	1.0%	$ 24,916	2.1%
10	2013	$ 60.96	$ 86.91	$ 2.17	$ 3.01	$ 63.13	$ 89.92	$ 77.78	$ 9.14	$ 22.10	$ 3.01	$ 34.24	$ 177.46	$ 460	0%	$ 545	5%	$ 52,994	1.0%	$ 25,664	2.1%
11	2014	$ 53.55	$ 78.64	$ 2.66	$ 3.79	$ 56.21	$ 82.43	$ 67.28	$ 11.38	$ 27.52	$ 3.79	$ 42.89	$ 184.34	$ 482	5%	$ 589	8%	$ 54,584	1.1%	$ 26,434	2.2%
12	2015	$ 57.05	$ 86.29	$ 3.17	$ 4.68	$ 60.22	$ 90.98	$ 72.80	$ 13.79	$ 33.37	$ 4.68	$ 51.82	$ 191.51	$ 505	5%	$ 637	8%	$ 56,221	1.1%	$ 27,227	2.3%
13	2016	$ 61.13	$ 95.24	$ 3.73	$ 5.64	$ 64.86	$ 100.88	$ 78.82	$ 16.42	$ 39.72	$ 5.64	$ 61.77	$ 198.96	$ 530	5%	$ 688	8%	$ 57,908	1.2%	$ 28,043	2.5%
14	2017	$ 63.43	$ 101.79	$ 4.30	$ 6.71	$ 67.73	$ 108.49	$ 82.82	$ 19.17	$ 46.38	$ 6.71	$ 72.25	$ 206.69	$ 556	5%	$ 743	8%	$ 59,645	1.2%	$ 28,885	2.6%
15	2018	$ 69.02	$ 114.07	$ 4.93	$ 7.91	$ 73.95	$ 121.98	$ 91.84	$ 22.23	$ 53.78	$ 7.91	$ 83.92	$ 214.73	$ 582	5%	$ 802	8%	$ 61,435	1.3%	$ 29,751	2.7%
16	2019	$ 66.99	$ 114.04	$ 5.54	$ 9.15	$ 72.52	$ 123.19	$ 88.85	$ 25.19	$ 60.94	$ 9.15	$ 95.28	$ 223.09	$ 611	5%	$ 863	8%	$ 63,278	1.4%	$ 30,644	2.8%
17	2020	$ 70.36	$ 123.37	$ 6.18	$ 10.51	$ 76.53	$ 133.88	$ 95.02	$ 28.36	$ 68.59	$ 10.51	$ 107.46	$ 231.78	$ 640	5%	$ 928	8%	$ 65,176	1.4%	$ 31,563	2.9%
18	2021	$ 116.31	$ 210.07	$ 7.23	$ 12.68	$ 123.54	$ 222.75	$ 176.86	$ 34.21	$ 82.77	$ 12.68	$ 129.65	$ 240.78	$ 671	5%	$ 1,021	10%	$ 67,131	1.5%	$ 32,510	3.1%
19	2022	$ 125.00	$ 232.54	$ 8.36	$ 15.11	$ 133.37	$ 247.65	$ 191.94	$ 40.60	$ 98.23	$ 15.11	$ 153.94	$ 250.14	$ 704	5%	$ 1,124	10%	$ 69,145	1.6%	$ 33,485	3.4%
20	2023	$ 107.76	$ 206.48	$ 9.34	$ 17.38	$ 117.10	$ 223.85	$ 180.63	$ 45.95	$ 111.17	$ 17.38	$ 174.50	$ 259.88	$ 738	5%	$ 1,219	8%	$ 71,220	1.7%	$ 34,490	3.5%
21	2024	$ 108.12	$ 213.39	$ 10.32	$ 19.78	$ 118.44	$ 233.17	$ 162.04	$ 51.35	$ 124.23	$ 19.78	$ 195.35	$ 269.99	$ 774	5%	$ 1,318	8%	$ 73,366	1.8%	$ 35,525	3.7%
22	2025	$ -	$ -	$ 10.32	$ 20.37	$ 10.32	$ 20.37	$ -	$ -	$ 124.23	$ 20.37	$ 144.60	$ 280.50	$ 812	5%	$ 1,218	-8%	$ 75,567	1.6%	$ 36,590	3.3%
23	2026	$ -	$ -	$ 10.32	$ 20.98	$ 10.32	$ 20.98	$ -	$ -	$ 124.23	$ 20.98	$ 145.21	$ 291.42	$ 851	5%	$ 1,264	4%	$ 77,824	1.6%	$ 37,688	3.4%
24	2027	$ -	$ -	$ 10.32	$ 21.61	$ 10.32	$ 21.61	$ -	$ -	$ 124.23	$ 21.61	$ 145.84	$ 302.77	$ 893	5%	$ 1,311	4%	$ 80,158	1.6%	$ 38,819	3.4%
25	2028	$ -	$ -	$ 10.32	$ 22.26	$ 10.32	$ 22.26	$ -	$ -	$ 124.23	$ 22.26	$ 146.49	$ 314.56	$ 936	5%	$ 1,361	4%	$ 82,563	1.6%	$ 39,983	3.4%
26	2029	$ -	$ -	$ 10.32	$ 22.93	$ 10.32	$ 22.93	$ -	$ -	$ 124.23	$ 22.93	$ 147.16	$ 326.81	$ 982	5%	$ 1,413	4%	$ 85,040	1.7%	$ 41,183	3.4%
27	2030	$ -	$ -	$ 10.32	$ 23.61	$ 10.32	$ 23.61	$ -	$ -	$ 124.23	$ 23.61	$ 147.84	$ 339.53	$ 1,030	5%	$ 1,467	4%	$ 87,591	1.7%	$ 42,418	3.5%
28	2031	$ -	$ -	$ 10.32	$ 24.32	$ 10.32	$ 24.32	$ -	$ -	$ 124.23	$ 24.32	$ 148.55	$ 352.78	$ 1,080	5%	$ 1,524	4%	$ 90,219	1.7%	$ 43,691	3.5%
29	2032	$ -	$ -	$ 10.32	$ 25.05	$ 10.32	$ 25.05	$ -	$ -	$ 124.23	$ 25.05	$ 149.28	$ 366.50	$ 1,133	5%	$ 1,583	4%	$ 92,925	1.7%	$ 45,001	3.5%
30	2033	$ -	$ -	$ 10.32	$ 25.80	$ 10.32	$ 25.80	$ -	$ -	$ 124.23	$ 25.80	$ 150.03	$ 380.78	$ 1,188	5%	$ 1,645	4%	$ 95,713	1.7%	$ 46,351	3.5%
31	2034	$ -	$ -	$ 10.32	$ 26.58	$ 10.32	$ 26.58	$ -	$ -	$ 124.23	$ 26.58	$ 150.81	$ 395.62	$ 1,246	5%	$ 1,710	4%	$ 98,585	1.7%	$ 47,742	3.6%
32	2035	$ -	$ -	$ 10.32	$ 27.37	$ 10.32	$ 27.37	$ -	$ -	$ 123.92	$ 27.37	$ 151.29	$ 411.04	$ 1,307	5%	$ 1,777	4%	$ 101,542	1.8%	$ 49,174	3.6%
33	2036	$ -	$ -	$ 10.32	$ 28.20	$ 10.32	$ 28.20	$ -	$ -	$ 123.77	$ 28.20	$ 151.96	$ 427.06	$ 1,371	5%	$ 1,848	4%	$ 104,588	1.8%	$ 50,650	3.6%
34	2037	$ -	$ -	$ 10.32	$ 29.04	$ 10.32	$ 29.04	$ -	$ -	$ 123.13	$ 29.04	$ 152.18	$ 443.70	$ 1,438	5%	$ 1,921	4%	$ 107,726	1.8%	$ 52,169	3.7%
35	2038	$ -	$ -	$ 10.32	$ 29.91	$ 10.32	$ 29.91	$ -	$ -	$ 122.70	$ 29.91	$ 152.62	$ 461.00	$ 1,509	5%	$ 1,997	4%	$ 110,958	1.8%	$ 53,734	3.7%
	Total	$ 1,138.24	$ 1,898.43	$ 216.78	$ 468.93	$ 1,356.60	$ 2,368.36	$ 1,641.56	$ 333.22	$ 2,540.89	$ 468.93	$ 3,343.34	[redacted]								

J:\1162\Litigation\Financial Impacts\[20 YR CSO LTCP Case V10292004 scenario 1.xls]Vertical Table

APPENDIX C

APPENDIX C
Certain Financial Information to Perform Financial Analysis
Pursuant to Section VII

In the event that WASA seeks a modification of the Schedule pursuant to Section VII of the Consent Decree due to cost overruns or changed financial circumstances, WASA shall update its financial information. Information that may be relevant includes the following list or categories of information, and WASA agrees to provide such information in the event the United States requests it. Nothing in this Appendix in any way limits or narrows the United States' right to obtain or request other information in order to review and respond to WASA's request for a modification.

1. DC population, current and projected

2. Number of households, current and projected
   - Single-family residence
   - Multi-family buildings

3. Median household income

4. Wastewater billings and volume billed for past three years, broken out for all user classes

5. Wastewater revenues and expenditures for past three years.

6. WASA financial statements for past three years.

7. Prospectuses issued within the past three years.

8. Rate studies prepared within the past three years related to wastewater or stormwater programs.

9. Per household wastewater metering fee and ROW fee

10. Average per household volume billed for
    - Single-family residence
    - Multi-family residence

11. Current baseline revenues and expenditures.

12. LTCP costs
    - Capital costs incurred to date
    - Capital costs projected by year
    - Additional operations and maintenance costs projected by year
    - Costs to date financed with grants (amount and interest rate by year)
    - Costs to date financed with low interest, non-market loans (amount and interest rate by

year)

13. Projected costs other than those required by this consent decree that should be considered in addition to baseline costs. Identify and project by year.
- Costs necessary to comply with regulations or other legal requirements.
- Projected sewer system assessment and rehabilitation costs
- Other increases that would cause total annual expenditures to rise at a rate greater than inflation

14. Debt coverage ratio

15. Bond interest rate and term

16. Rate of inflation

17. PAYGO assumption

18. Current wastewater rate per ccf for single-family residential customers.

19. History of rate adjustments or rate recovery approach during the past five years. Identify the current basis for recovery of LTCP costs and any expected changes in the basis for the recovery of these costs. If rates are recovered through other than the wastewater rate, identify the mechanism, and the amount of costs born by each user class.

20. Projection over twenty years estimating per household impact of LTCP.

21. Current programs to provide relief to low-income residents.

22. Other documentation or analysis that EPA and/or WASA deems relevant for the particular circumstances.

APPENDIX D

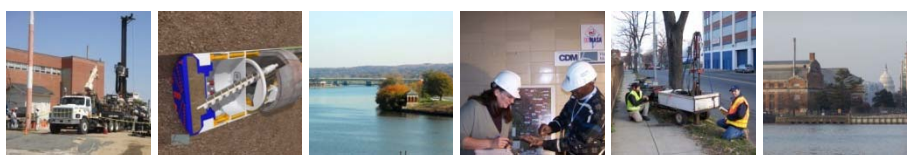
DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY

LONG TERM CSO CONTROL PLAN

ANACOSTIA RIVER PROJECTS

DOCUMENT II-3:5-FI

FACILITY PLAN



SUMMARY REPORT AND DETAILED IMPLEMENTATION SCHEDULE

SEPTEMBER 23, 2008

CDM/HMM, A JOINT VENTURE – FACILITY PLAN, DCFA #399-WSA

GREELEY AND HANSEN LLC - OPERATIONAL PLAN, EPMC-III

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Summary Report and Detailed Implementation Schedule

This report is a summary of findings and recommendations based on the Facility Plan developed for the District of Columbia Water and Sewer Authority's (Authority or WASA) Anacostia River Projects which are part of WASA's Long Term Control Plan for Combined Sewer Overflows. It has been prepared to satisfy the requirement for the Authority to submit to the United States Environmental Protection Agency (EPA), no later than September 23, 2008, a summary report and detailed implementation schedule for the Anacostia River Projects as described at Section VI, paragraph A.9. of the Consent Decree entered into by the Authority, the United States and the District of Columbia, effective March 23, 2005. Detailed information regarding the Facility Plan for the Anacostia River Projects, is provided in Document II-3:4 FD, Facility Plan, which includes a main document volume and four Appendix volumes of supporting and reference information.

When completed, the Anacostia River Projects are expected to reduce the average year volume of combined sewer overflows to the Anacostia River by 98 percent, and number of overflows from 82 to 2 in the average year.

1. Background and Introduction

Communities with combined sewer systems are required to prepare long term plans for control of combined sewer overflows (CSOs) in accordance with the CSO Policy at Section 402 (q) of the Clean Water Act. The Authority, after extensive stakeholder and public participation, completed its Long Term Control Plan (LTCP) for the District's combined sewer system in July 2002. The LTCP provides for control of CSOs to the Anacostia River, Rock Creek and Potomac River and was submitted for approval to the District Department of Health (DOH) and EPA.

The LTCP was approved by DOH on August 28, 2003, and on December 16, 2004 EPA reissued the Authority's National Pollutant Discharge Elimination System (NPDES) permit to include the CSO control provisions of the DOH approved LTCP. Subsequently, the Authority, the District of Columbia and the United States entered into a Consent Decree to implement the LTCP. The Consent Decree includes the schedule for the facilities included in the LTCP and was entered by the Federal Court on March 23, 2005.

Projects to control CSOs to the Anacostia River are at the top of the court ordered schedule, and the Authority is required to prepare a Facility Plan for these projects. The Facility Plan for the Anacostia River CSOs comprises engineering studies to advance the LTCP conceptual plan to a level sufficient to proceed into detailed design and construction.

The Consent Decree schedule for the Anacostia River Projects, including milestone dates, is summarized in Table 1.

Table 1
Anacostia River Projects
Consent Decree Milestone Dates
(not later than dates)

Project	Award Contract for Design	Award Contract for Construction	Place in Operation
Anacostia River Projects Facility Plan	Sep 23, 2005	n/a	Sep 23, 2008 (1)
Storage/Conveyance Tunnel From Poplar Point to Northeast Boundary	Mar 23, 2009	Mar 23, 2012	Mar 23, 2018
Anacostia Outfall Consolidation	Mar 23, 2013	Mar 23, 2016	Mar 23, 2018
Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer	Mar 23, 2015	Mar 23, 2018	Mar 23, 2025
Northeast Boundary Side Tunnels	Mar 23, 2019	Mar 23, 2022	Mar 23, 2025
Poplar Point Pumping Station	Mar 23, 2012	Mar 23, 2015	Mar 23, 2018
Separate Fort Stanton Drainage Area (Outfall 006)	Mar 23, 2006	Mar 23, 2008	Mar 23, 2010
Fort Stanton Interceptor	Mar 23, 2013	Mar 23, 2016	Mar 23, 2018

(1) Requires WASA to submit a summary report and detailed implementation schedule to EPA.

There are fourteen existing CSO outfalls along the Anacostia River as shown on Figure 1. Under the LTCP, the area tributary to Outfall 006 is being separated. That project is under construction and scheduled to be placed in operation by March 23, 2010. The remainder of the CSOs, shown on Figure 1, are included in the facilities that comprise the Facility Plan for the Anacostia River Projects (ARP) program. The ARP program comprises a tunnels system together with diversion and overflow facilities to capture, store and convey combined sewer flow. In addition to providing CSO control, the tunnels system is designed to control chronic surface flooding on the combined sewer system in the Northeast Boundary Area. The chronic surface flooding is the result of a lack of adequate capacity in the existing Northeast Boundary Trunk Sewer. The tunnels system, CSO locations and the Northeast Boundary areas prone to surface flooding are shown on Figure 2.

Figure 1: Locations of Combined Sewer Overflows along the Anacostia River

As shown on Figure 2, the tunnels system extends from the Authority's Blue Plains Advanced Wastewater Treatment Plant (Blue Plains or BPAWWTP), along the Potomac and Anacostia Rivers and into the Northeast Boundary Area. Existing CSOs will be conveyed into the tunnels system through a system of diversion sewers and drop shafts. Similar diversion facilities will be used to provide relief for the existing Northeast Boundary Trunk Sewer. Flow captured in the tunnels will be treated at Blue Plains. Flows in excess of the tunnels storage capacity and Blue Plains treatment capacity will overflow to the Potomac and Anacostia Rivers at locations shown on Figure 2.

Figure 2: Location of Tunnels System Relative to CSOs and Flooding Areas

The tunnels system shown on Figure 2, is a result of the following:

- The LTCP approved by DOH on August 28, 2003, which provided for the tunnel's system to terminate at its south end on Poplar Point and;
- Supplement No.1 to the LTCP, which comprises the Blue Plains Total Nitrogen Removal/Wet Weather Plan submitted to EPA on October 12, 2007. This plan provides for modifying the LTCP Consent Decree to blend the new nitrogen limit for Blue Plains and wet weather treatment. The principal provisions of the plan include the addition of enhanced nitrogen removal (ENR) at Blue Plains and extension of the tunnels system from Poplar Point to Blue Plains, including tunnel dewatering and enhanced clarification facilities at the tunnels system terminus.

2. Project Scope & Description of Facilities

Principal facilities included in the Anacostia River Projects are shown on Figure 3 and include approximately 12.9 miles of tunnels, 17 shafts for conveyance of flows into the tunnels system, overflow structures, air venting and management, and maintenance and inspection access. In addition to the underground works, diversion chambers and sewers will be constructed to capture and divert flows from the existing combined sewer system into drop shafts that will convey the flows to the tunnels system. The tunnels will be constructed using pressurized-face soft ground tunnel boring machines (TBMs). The tunnels and shafts will be constructed at depths to invert between 70 and 200 below existing ground elevation.

The principal elements that comprise the ARP are described briefly as follows:

- Blue Plains Tunnel (BPT) –The BPT follows an alignment that starts at Blue Plains, traverses west of Interstate 295 along the Potomac River through Bolling Air Force Base (BAFB) and the Anacostia Naval Annex, then crosses under the Anacostia River north of the existing WASA Main Outfall Sewers (which extend from WASA's Main Pumping Station to Poplar Point), and terminates in the north yard area of WASA's Main Pumping Station. The BPT will have an inside diameter of 23 feet and a permanent lining of precast concrete segments connected by bolts and gaskets. This lining system will be used for all tunnel reaches on the ARP for bored tunnels. Shafts located along the BPT include a dewatering pumping station shaft at Blue Plains; a tunnel overflow shaft within BAFB downstream of a new connection to the Potomac Outfall Sewers; a combination drop and junction shaft with the Anacostia River Tunnel near Poplar Point; and a drop shaft at WASA's Main Pumping Station.
- Anacostia River Tunnel (ART) – The ART begins at the junction shaft with the BPT at a location approximately 750 feet south of the existing Poplar Point Pumping Station. It then traverses under the Washington Metropolitan Area Transit Authority (WMATA) Green Line at Poplar Point, follows Anacostia Park to a point east of the 11th Street Bridges where it crosses the Anacostia River, and then follows the north (west) shore of the river from Water Street to an interface with the Northeast Boundary Tunnel immediately north of the planned CSO 019 facilities. The ART is planned to be constructed from the CSO 019 area southward to the junction shaft with the BPT, with all

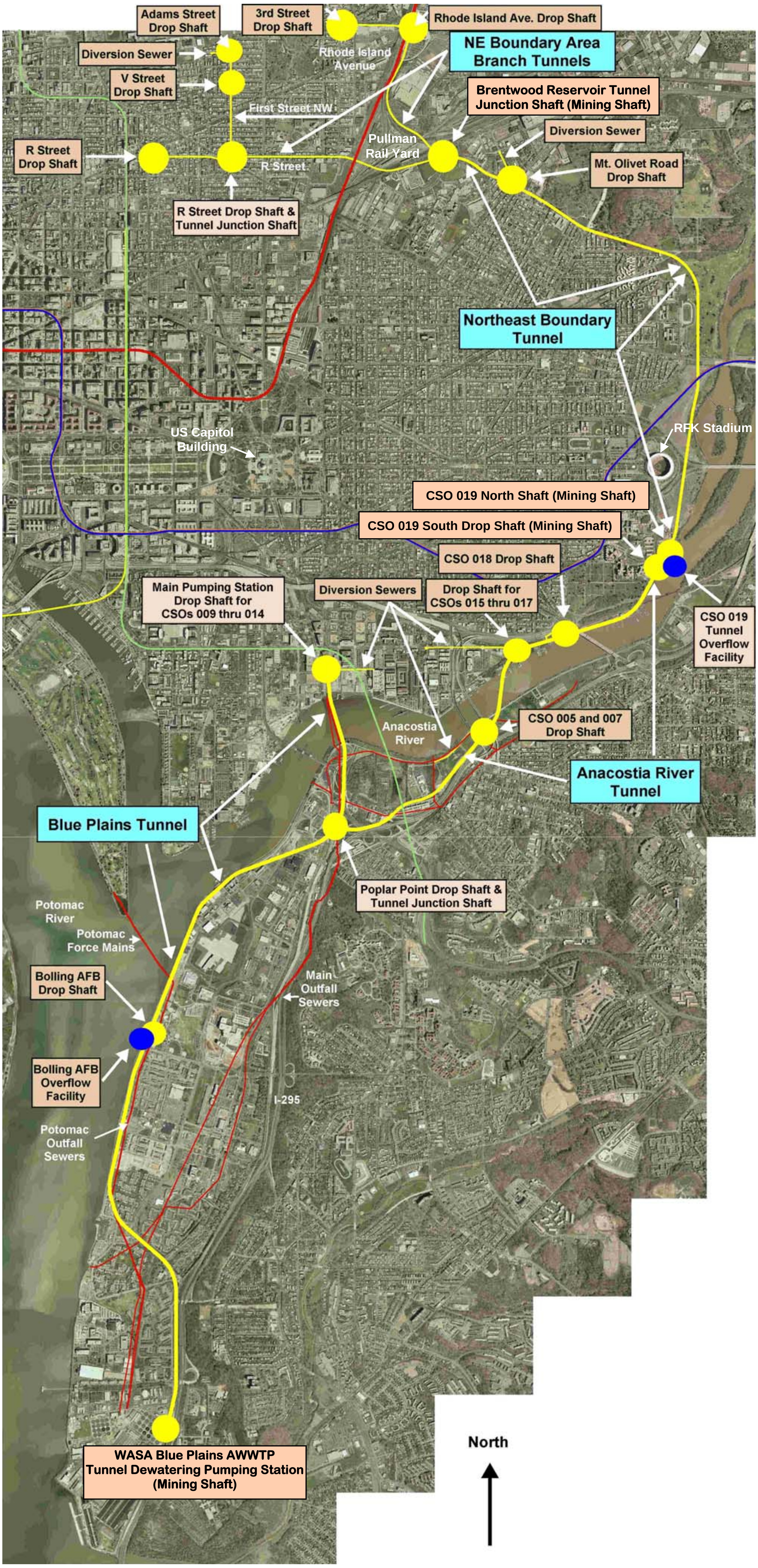


Figure 3: Principal Anacostia River Projects Facilities

tunnel construction staging from the south parking lot area of RFK Stadium. Flows from CSOs 005 and 007 on the south side of the river will be captured in a new diversion sewer and conveyed into the tunnel at a drop shaft located between the approach roadways for the 11th Street Bridges. Flows from CSOs 015, 016 and 017 on the north (west) side of the river also will be captured in a new diversion sewer and conveyed to a drop shaft located at the intersection of Water Street SE and M Street SE. Flows from CSO 018 on the north (west) side of the river will be conveyed to a drop shaft somewhat to the east along M Street near Barney Circle. At the CSO 019 area, a drop shaft will accept flows from the existing Northeast Boundary Trunk Sewer above CSO 019. In addition, the drop shaft will serve as a tunnel overflow shaft, and a second tunnel overflow shaft will also be constructed. The CSO 019 area is the limit of the first phase of facilities construction and facilities system operation. The Consent Decree requires the new ARP facilities from Blue Plains to the CSO 019 area to be placed in operation by March 23, 2018.

- Northeast Boundary Tunnel (NEBT) – The NEBT will be excavated north from the CSO 019 area under the RFK Stadium parking lots along the Anacostia River, Langston Golf Course and under the National Arboretum. It will then continue west along Mount Olivet Road NE and terminate at WASA’s Brentwood Reservoir site adjacent to New York Avenue. Since the ART will be operating while the NEBT is under construction, a temporary isolation plug or physical separation (bulkhead) between the ART and NEBT tunnels must be in place to provide for the safety of the workers constructing the NEBT. This separating plug or bulkhead will be constructed by the ART construction contractor. Along the NEBT there will be a drop shaft near the intersection of Mount Olivet Road NE and West Virginia Avenue NE to receive flows from this flooding area. The tunnel terminus at the Brentwood Reservoir will be at a shaft for extraction of the TBM. This shaft will also serve as a junction shaft for connecting the Northeast Boundary Area branch tunnels to the NEBT, and as the mining shaft for the R Street and Rhode Island Avenue branch tunnels.

- Northeast Boundary Area Branch Tunnels – Three branch tunnels will convey flows from flooding areas west of the Pullman Rail Yard: the R Street Branch Tunnel (RSBT), the Rhode Island Avenue Branch Tunnel (RIBT), and the First Street NW Branch Tunnel (FSNWBT). These tunnels have been planned with inside diameters of 12 feet. Drop shafts are planned at the upstream ends of the respective tunnels. The RSBT and FSNWBT will join at an intermediate, combination drop and junction shaft. As for other drop shafts, these will connect to the existing combined sewer system via diversion chambers and sewers.

  Diversion Chambers and Sewers – In order to capture and convey flows from the existing combined sewer system to the respective drop shaft facilities, diversion chambers will be constructed at the points of diversion, and diversion sewers will be constructed from those points to the nearest drop shafts. These will involve surface construction at the diversion points and potentially at intermediate locations along the diversion sewer alignments, depending on the construction technology applied. Microtunneling and pipe-jacking applications are being considered for construction of diversion sewers, depending on the feasibility of the respective technologies with respect to the site conditions. The most significant diversion sewer alignments include:

- Tingey Street SE, connecting to drop shaft facilities at the Main Pumping Station
- M Street SE and Water Street SE areas, connecting to drop shaft facilities along Water Street SE and M Street SE
- Mount Olivet Road neighborhood area diversions
- Northeast Boundary Area diversions connecting to the branch tunnels described above

3. Project Setting

Facilities to be constructed and operated will be located in a variety of settings ranging from open space and public lands to well developed residential and commercial neighborhoods. Several areas are also being planned to undergo substantial development and infrastructure improvements prior to and during construction of the ARP facilities. Therefore, the siting of facilities and planning for construction and facilities operations has involved a substantial degree of coordination and collaboration with numerous government agencies, citizen groups and neighborhoods, military commands, railroad entities, utility companies and other interested parties. Planning has been designed to minimize disturbance to neighborhoods as well as physical and construction staging interfaces with planned property development and major infrastructure projects.

The storage and conveyance tunnels are predominantly located in soil strata, and therefore soft ground tunneling technologies will be employed. Tunnel construction will be performed by Tunnel Boring Machines (TBMs) that will be driven from mining shafts at locations shown on Figure 3. The majority of tunnel construction activities will be concentrated at the mining shaft locations. Consequently, the mining shaft areas require substantial staging areas for material handling, construction logistics, and utility support. The recommended plan is based on the use of two sites for the majority of tunnel construction: WASA's Blue Plains site for construction of the BPT to Main Pumping Station and the southern parking lot area of RFK Stadium for construction of the ART to its junction with the BPT; and the NEBT to its terminal shaft at Brentwood Reservoir in the vicinity of New York Avenue NE. The Brentwood Reservoir site will also be a construction work site for mining and construction of approximately 2.6 miles of the branch tunnels.

Improvements in tunneling technology during the past couple of decades will result in fewer impacts on the surrounding neighborhoods and environment than in the past and provides the ability to construct tunnels within more variable and difficult ground conditions than in the past. However, the minimization of risks associated with the ARP tunnels program is a key consideration as for any other underground construction program. Such risks could involve, but are not limited to:

- Ability to perform the work under varying or adverse geological conditions
- Protection of structures and utilities from settlement or other adverse impacts
- Encountering unknown subsurface obstructions that impede tunnel advance

- Major mechanical failures of the TBM that may require construction of an unplanned access from the surface or extensive ground improvement to rescue and repair the TBM

These risks are particularly important considerations for the design and construction of soft ground tunnels compared to tunnels constructed in intact rock, as has been the case for many CSO tunnels that have been constructed prior to the introduction of modern soft-ground tunneling technology.

In consideration of the risks above, as well as in the interest of minimizing the need to acquire private property or easements, the tunnel alignments have been located to be predominantly in open land within public space and to not pass directly below existing surface structures. These public lands include D.C. streets and properties occupied by WASA, development land, park land, BAFB, the Anacostia Naval Annex, the RFK Stadium site, and the National Arboretum. Rights are required for construction and operation of the tunnels underneath private properties, including CSX and WMATA properties at five locations and several small privately owned parcels for subsurface easements along the tunnels alignments. Easements for small privately owned parcels along sections of the alignments are required because of the minimum turning radii needed for the TBMs to facilitate excavation and construction of the pre-cast concrete tunnel lining.

To avoid subsurface obstructions and to protect structures and utilities from settlement-induced damage, the Facility Plan development included a limited subsurface geotechnical exploration program to investigate geological conditions along the planned tunnel alignments and research of the major infrastructure and structures in proximity to the alignments. The alignment of the ART is greatly influenced by avoidance of past, present, and future bridge piers and piles while maintaining a minimum radius of curvature for tunnel construction. Protection and avoidance of damage to WMATA transit structures is also a consideration. The tunnel alignments cross under the subsurface Green Line just west of Anacostia Station, the aerial section of the Blue Line in the northern parking area of RFK Stadium, and the surface Red Line track south and north of the Rhode Island Avenue Station. Additionally, the Tingey Street Diversion Sewer will cross above the WMATA Green Line. Traversal of the Bolling AFB and Anacostia Naval Annex also include consideration of not only protection of existing structures and infrastructure, but also security considerations during construction and systems operations.

For the branch tunnels west and north of the NEBT terminus shaft, the local area along the tunnel alignments is predominantly residential with some commercial properties and small public parks. Tunnels in this area will be primarily to provide conveyance of storm flows rather than provide storage during a storm event. Consequently, they are planned to be smaller than the main storage / conveyance tunnels, which lessens the potential for surface or structural settlement. At the currently planned diameters, these tunnels will be constructed using the same methodology as the main storage / conveyance tunnels. If it is determined, as the design proceeds, that these can be smaller tunnels, alternative tunnel construction technologies may be applied, such as pipe jacking or micro-tunneling. The determination of the appropriate technology will likely occur during the design phase of the program based on a more extensive site characterization and geotechnical investigation program.

Coordination with other planned development and infrastructure projects also had a significant influence on the siting of the facilities. The Principal projects include those shown on Figure 4 and are:

- The planned development of residential and commercial properties and public lands at Poplar Point and the planned replacement of the South Capitol Street Bridge with associated modifications to the I-295 interchange in this area.
- The planned development of Diamond Teague Park, currently under construction, located along the north bank of the Anacostia River immediately to the south and east of Nationals Stadium and to the south and west of WASA's O Street Pumping Station.

Figure 4: Principal Planned Development and Infrastructure Projects in ARP Area

- On the north (west) shore of the Anacostia River, planned property development at the Southeast Federal Center near WASA's Main Pumping Station, Maritime Plaza and Boathouse Row developments near Water Street, and the Hill East development project near CSO 019 have to be considered relative to the siting of facilities.
- Another major infrastructure project that impacts the design and construction of facilities on both sides of the Anacostia River is the replacement of the 11th Street Bridges by the District Department of Transportation (DDOT). Coordination is required for diversion chambers and sewers as well as the drop shaft facility for CSO 005 and CSO 007.
- In the Northeast Boundary Area, extensive development has been accomplished near New York and Florida Avenues, with more planned to be completed over the next 20+ years while the ARP is under design and construction. Much of this development will be accomplished under the District's NoMA project (North of Massachusetts Avenue).

4. Investigation and Evaluation of Alternatives

During development of the recommended plan, a number of alternatives and variations of alternatives for the configuration of facilities were investigated and evaluated in an organized and systematic manner. The major alternative alignment corridors which were investigated are presented on Figure 5. These alternatives were evaluated relative to their ability to achieve the required system hydraulic operational performance, as well as their respective programmatic profiles (e.g., estimated cost, schedule, risks, real estate needs, permitting, and degree of required coordination with other agencies and projects and community impacts, if any).

Overall, 12 alternative tunnel horizontal alignments, with some associated variations for localized conditions, were investigated for the tunnels between Poplar Point and the Northeast Boundary Area. For the BPT, three alternative alignments were investigated to varying degrees.

Alternative configurations were also investigated for construction and operation of deaeration facilities and drop shafts. Where such facilities have been constructed in rock as part of CSO storage and conveyance systems in major cities such as Milwaukee and Atlanta, deaeration facilities were constructed in horizontal chambers at the terminus of tunnel segments or adjacent to the tunnel with a small-diameter connecting tunnel or adit between the drop shaft and the tunnel. In those cases, the deaeration chambers were also typically of similar or larger cross-section than the tunnel. For the soil conditions anticipated for the ARP, construction of that same type of configuration could prove difficult and risky. Accordingly, an alternative configuration for locating the deaeration facility within a construction shaft in line with the tunnel has been developed for the ARP program. For this configuration, flows will enter the drop shaft through a tangential approach ramp and vortex generator, which is typical for many CSO facilities. However, at the base of the drop shaft the flow would transition to a circular channel to allow deaeration of the flow before the flow enters the tunnels system.

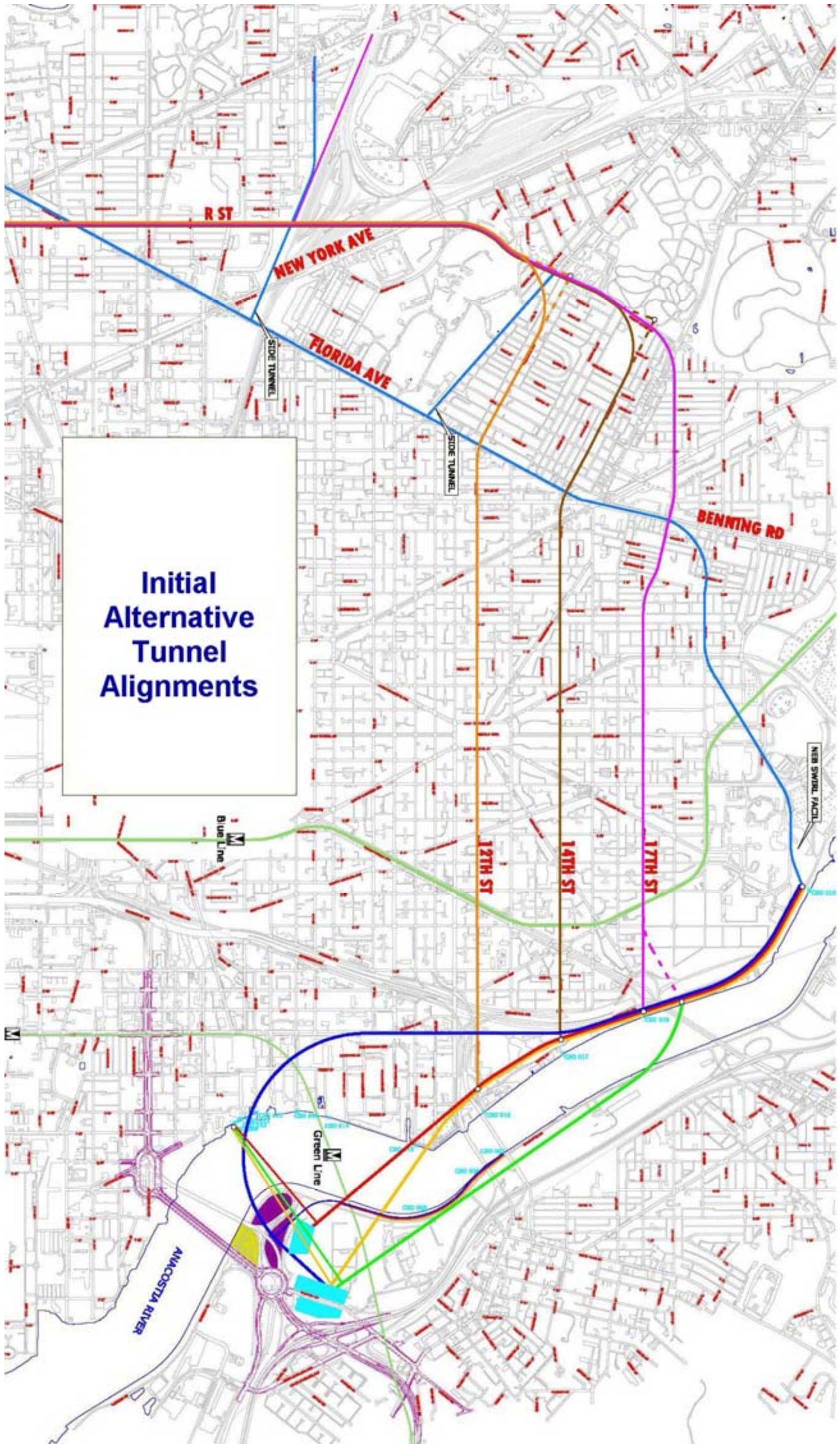


Figure 5: Alternative Tunnel Alignment Corridors

5. Recommended Implementation Schedule for Anacostia River Projects

The Facility Plan documents provide an expanded description of the facilities to be designed, constructed and placed in operation for the Anacostia River Projects, together with an associated schedule, estimated costs and other program related activities and issues.

The implementation schedule for the ARP has been developed to provide for construction through a number of individual contracts or contract divisions based on principal consideration as follows:

- Limit the value of construction contracts to the availability of bonding capacity and contractor resources in the tunneling industry.
- Separate work by degree of risk, contractor specialty and availability of local resources. Basically, this means separating the deep tunnel work from the near surface work such as diversion structures and sewers.
- Sequencing and interfacing requirements for the individual contract divisions
- Ability to meet and exceed goals for MBE/WBE participation.
- Timeframes required for the various construction activities such as time for procurement and delivery of the large tunnel boring machines and anticipated tunnel mining rates.

Construction contract divisions developed for implementation of the ARP are summarized in Table 2 and shown on Figure 6.

A comparison between the projects developed in the Facility Plan and those in the Consent Decree is summarized in Table 3. This comparison relates compliance dates for the Consent Decree projects to the Facility Plan Contract Divisions.

A detailed implementation schedule for the Facility Plan Contract Divisions is shown on Figure 7. Also shown on Figure 7 are the proposed projects and milestone dates for a modification of the Consent Decree that reflects facility planning. Additionally, the schedule shows permitting timeframes related to the proposed construction. The modified Consent Decree projects milestones match the milestones for the projects in the existing Consent Decree.

Principal features included in the detailed implementation schedule shown on Figure 7 are summarized as follows:

- An 18-month period from award of construction contract, for manufacture, delivery, assembly and start-up of a TBM. This means that actual tunnel mining starts 18 months after construction contract award.
- Tunnels shafts construction starts upon award of construction contract.
- Tunnels mining derived from the available geotechnical information and other experience has been based on an average rate of 40 feet per day.

- Contract Divisions C, E, F and G, which interface with Contract Division H, the Anacostia River Tunnel, will be completed to a "Ready to be Placed in Operation" stage before the Division H contract is awarded.
- The construction contract award date for Contract Division K, the Northeast Boundary Branch Tunnels, occurs on the "Place in Operation" date for Contract Division H, the Anacostia River Tunnel.
- The construction contract award date for Contract Division J, the Northeast Boundary Tunnel occurs at a point when there should be sufficient time for Contract Division K to vacate the Brentwood shaft site, which is the recovery shaft for Contract Division J.
- Contract Division H, Anacostia River Tunnel has the responsibility for activating connections, constructed under other contracts, to place the system between Blue Plains and CSO 019 in operation.
- Contract Division J, Northeast Boundary Tunnel has the responsibility for activating connections, constructed under other contracts, to place the system between CSO 019 and the Northeast Boundary area in operation.

Table 2
Construction Contract Divisions for Anacostia River Projects

CONTRACT DIVISION	DESCRIPTION
A	Blue Plains Tunnel and Main Outfall Sewers Diversion
B	Tingey Street Diversion Sewer for CSOs 013 and 014
C	CSO 019 Overflows and Diversion Structures
D	Bolling AFB Overflow and Potomac Outfall Sewer Diversion
E	M Street Diversion Sewer for CSOs 015, 016, and 017
F	CSO 018 Diversion Sewer
G	CSO 005 and 007 Diversion Sewer
H	Anacostia River Tunnel
I	Main Pumping Station Diversions
J	Northeast Boundary Tunnel
K	Northeast Boundary Branch Tunnels
L	Northeast Boundary Diversions
M	Mt. Olivet Road Diversions
Y	Blue Plains Tunnel Dewatering Pumping Station and Enhanced Clarification Facility
Z	Poplar Point Pumping Station Replacement

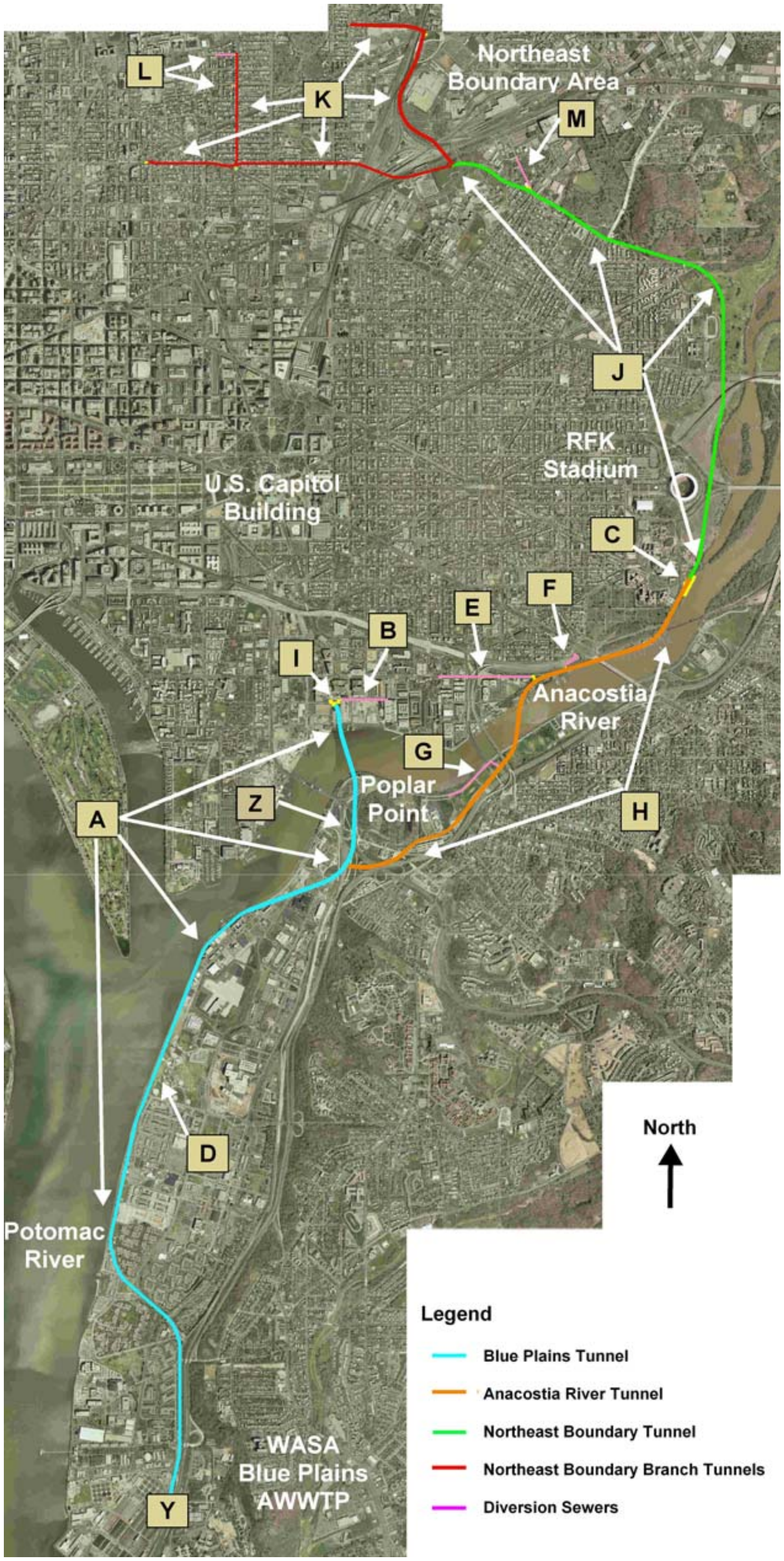
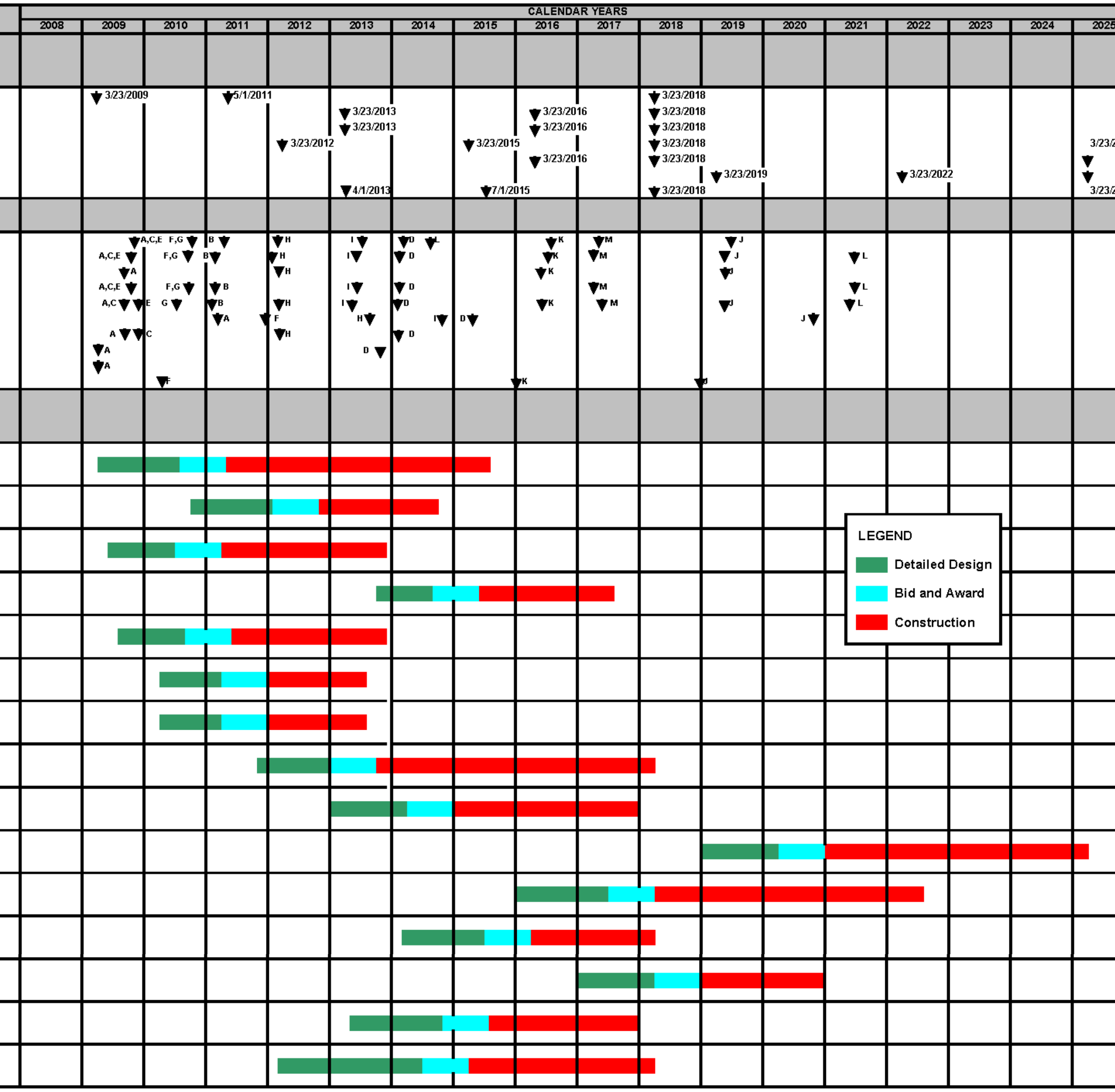


Figure 6: Locations of Contract Divisions

Table 3
Anacostia River Projects
Comparison of Facility Plan and Consent Decree Projects

FACILITY PLAN CONTRACT DIVISION	FACILITY PLAN PROJECT	MATCHING CONSENT DECREE PROJECT	CONSENT DECREE COMPLIANCE DATES RELATED TO FACILITY PLAN PROJECT
A	Blue Plains Tunnel and Main Outfall Sewers Diversion	Storage/Conveyance Tunnel from Poplar Point to Northeast Boundary	Contract Division A award dates for detailed design and contract for construction to be used to determine compliance for Consent Decree project dates
E F	M Street Diversion Sewer for CSOs 015, 016, and 017 CSO 018 Diversion Sewer	Anacostia Outfall Consolidation	Contract Divisions E and F award dates for detailed design and contract for construction to be used to determine compliance for Consent Decree project dates
H	Anacostia River Tunnel	Storage/Conveyance Tunnel from Poplar Point to Northeast Boundary	Contract Division H Place in Operation Date to be used to determine compliance for Consent Decree project date
G	CSO 005 and 007 Diversion Sewer	Fort Stanton Interceptor	Contract Division G replaces function of Consent Decree project; Fort Stanton Interceptor to be deleted.
Z	Poplar Point Pumping Station Replacement	Poplar Point Pumping Station	Contract Division Z has same compliance dates as Consent Decree project
J	Northeast Boundary Tunnel	Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer	Contract Division J Place in Operation date to be used to determine compliance for Consent Decree projects date
K	Northeast Boundary Branch Tunnels	Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer	Contract Division K award dates for detailed design and contract for construction to be used to determine compliance for Consent Decree project dates
K	Northeast Boundary Branch Tunnels	Northeast Boundary Side Tunnels	Contract Division K award dates for detailed design and contract for construction and Place in Operation date to be used to determine compliance for Consent Decree project dates
Y	Blue Plains Tunnel Dewatering Pumping Station and Enhanced Clarification Facility (ECF)	Poplar Point Pumping Station and Excess Flow Improvements	Contract Division Y Place in Operation date to be used to determine compliance for Consent Decree project date; ECF replaces Excess Flow Improvements

	FACILITY PLAN PROJECTS RELATED TO MODIFIED CONSENT DECREE PROJECTS AND ASSOCIATED MODIFIED CONSENT DECREE MILESTONES (1)	Award Contract for Detailed Design	Award Contract for Construction	Place in Operation	
	Storage/Conveyance Tunnel from Blue Plains to CSO 019	*March 23, 2009*	*May 1, 2011*	*March 23, 2018*	
	M Street Diversion Sewer and CSO 018 Diversion Sewer	*March 23, 2013*	*March 23, 2016*	*March 23, 2018*	
	CSO 005 and 007 Diversion Sewer	*March 23, 2013*	*March 23, 2016*	*March 23, 2018*	
	Poplar Point Pumping Station Replacement	*March 23, 2012*	*March 23, 2015*	*March 23, 2018*	
	Northeast Boundary Storage/Conveyance Tunnel	*March 23, 2016*	*March 23, 2018*	*March 23, 2025*	
	Northeast Boundary Branch Tunnels	*March 23, 2019*	*March 23, 2022*	*March 23, 2025*	
	Blue Plains Tunnel Dewatering Pumping Station and Enhanced Clarification Facilities	*April 1, 2013*	*July 1, 2014*	*March 23, 2018*	
	GENERAL TIME FRAMES FOR PERMIT APPLICATIONS BY CONTRACT DIVISION				
	DC Water and Sewer Authority	*2 months prior to 60% design*			
	Department of Consumer & Regulatory Affairs	*3 months prior to 60% design*			
	Department of Health, DC Fire & Emergency Medical Services	*30% design*			
	DC Department of Environment	*3 months prior to 60% design*			
	DC Department of Public Works	*30% design*			
	DC Department of Parks & Recreation	*2 months prior to Construction NTP*			
	US Army Corps of Engineers	*30% design*			
	Bolling AFB (DOD), Department of the Air Force	*Design NTP*			
	US Navy	*Design NTP*			
	CSX Corporation	*Design NTP*			
CONTRACT DIVISION	DESCRIPTION	AWARD CONTRACT FOR DETAILED DESIGN	AWARD CONTRACT FOR CONSTRUCTION	READY TO BE PLACED IN OPERATION (2)	PLACE IN OPERATION
A	*Blue Plains Tunnel and Main Outfall Sewers Diversion*	*March 23, 2009*	*May 1, 2011*	*July 1, 2015*	*(3)*
B	*Tingey Street Diversion Sewer for CSOs 013 and 014*	*October 1, 2010*	*October 1, 2012*	*October 1, 2014*	*(3)*
C	*CSO 019 Overflows and Diversion Structure*	*June 1, 2009*	*March 1, 2011*	*November 1, 2013*	*(3)*
D	*Bolling AFB Overflow and Potomac Outfall Sewer Diversion*	*October 1, 2013*	*July 1, 2015*	*July 1, 2017*	*(3)*
E	*M Street Diversion Sewer for CSOs 015, 016, and 017*	*August 1, 2009*	*May 1, 2011*	*November 1, 2013*	*(3)*
F	*CSO 018 Diversion Sewer*	*April 1, 2010*	*January 2, 2012*	*July 1, 2013*	*(3)*
G	*CSO 005 and 007 Diversion Sewer*	*April 1, 2010*	*January 2, 2012*	*July 1, 2013*	*(3)*
H	*Anacostia River Tunnel*	*November 1, 2011*	*November 1, 2013*	*March 23, 2018*	*March 23, 2018*
I	*Main Pumping Station Diversions*	*January 2, 2013*	*January 2, 2015*	*December 31, 2017*	*(3)*
J	*Northeast Boundary Tunnel*	*January 2, 2019*	*January 2, 2021*	*March 23, 2025*	*March 23, 2025*
K	*Northeast Boundary Branch Tunnels*	*January 2, 2016*	*March 23, 2018*	*July 1, 2022*	*(4)*
L	*Northeast Boundary Diversions*	*March 23, 2014*	*March 23, 2016*	*March 23, 2018*	*(4)*
M	*Mt. Olivet Road Diversions*	*January 2, 2017*	*January 2, 2019*	*December 31, 2020*	*(4)*
Y	*Blue Plains Tunnel Dewatering Pumping Station and Enhanced Clarification Facility (ECF)*	*April 1, 2013*	*July 1, 2015*	*December 31, 2017*	*(3)*
Z	*Poplar Point Pumping Station Replacement*	*March 23, 2012*	*March 23, 2015*	*March 23, 2018*	*March 23, 2018*



Note:
1 See Table 3 for comparison of Facility Plan and Consent Decree Projects
2 Means that facilities included in contract can be placed in operation when a subsequent contract is placed in operation.
3 Will be placed in operation when Contract Division H is placed in operation.
4 Will be placed in operation when Contract Division J is placed in operation.

Figure 7: Anacostia River Projects Detailed Facility Plan Contract Divisions Implementation Schedule

6. Program Implementation

The Authority and its consultants have developed the Facility Plan and implementation schedule. This work has been frequently reviewed by the Authority's Project Review Board (PRB). The PRB is comprised of nine individuals with a high level of experience and expertise in planning, engineering, construction and management of projects of similar type and scope to those in the ARP program. The Project Review Board has endorsed the Facility Plan and contributed suggestions and recommendations for its implementation.

The following subsections describe findings to-date regarding issues and other factors associated with the implementation of the Anacostia River Projects together with discussion of various aspects that are pertinent to its successful and timely completion.

Operational Plan and Hydraulic Design

The following criteria were selected by WASA for the operational plan and hydraulic design of the Anacostia River Projects.

- Comply with the LTCP Consent Decree, as modified to accommodate the Total Nitrogen Removal / Wet Weather (TN/WW) Plan.
- Reduce CSO overflows on the Anacostia River to the level identified in the approved LTCP: two CSO overflows and 54 million gallons (mg) of overflow per average year.
- Provide flood relief to the Northeast Boundary (NEB) Drainage Area up to a 6-hour 15-year design storm.
- Provide solids and floatables control for remaining overflows.
- Consolidate CSO's 016, 017 and 018 in the Anacostia Marina area such that all overflows are either stored in the tunnel or conveyed by the tunnel for overflow at another location.
- Configure the system to operate passively by gravity, without use of active operation gates or other such controls.
- Configure the system to prevent flooding of basements and flooding to grade. Where existing conditions in the collection system cause these conditions, arrange the tunnel system to improve hydraulic performance to the extent practicable.

The hydraulic design of the tunnels system was performed using the model prepared to develop the LTCP: the Danish Hydraulic Institute's MOUSE Model. The model was updated to reflect changes to the collection system since the development of the LTCP. The following summarizes key elements of the hydraulic design and operational plan:

- <u>System operation:</u> The tunnels system is designed to fill by gravity. If storms produce volumes that exceed the capacity of the system, the tunnels system has been configured to overflow to the receiving waters by gravity. The only facility that requires active operation during storms is the tunnel dewatering pumping station. The facilities that control diversions into and overflows from the tunnel typically comprise weirs, orifices and other static hydraulic controls.

- Extent of Northeast Boundary Flooding Protection: The tunnels system is designed to provide flooding protection to the Northeast Boundary area up to a 15-year, 6-hour design storm. It has been determined that most existing trunk and local street sewers in the drainage area do not have adequate capacity to convey the design storm. This is not unexpected since the sewers were constructed prior to the adoption of the 15-year storm as the bases for design. Since most of the existing sewers in the Northeast Boundary area do not have the capacity to convey the design storm, evaluations were made to determine the extent of flooding relief that would be provided by the ARP. These evaluations showed that it was cost prohibitive to bring all sewers in the Northeast Boundary area up to the 15-year design standard. Instead, the following design criteria were adopted for the program:
  - Provide flooding relief for the Northeast Boundary Trunk Sewer from it's outlet at CSO 019 to 1st Street NW
  - Provide relief to the following chronic flood areas and to the trunk sewers serving the areas listed below that are located between the Northeast Boundary Trunk Sewer and the flood areas:
    - Area 1 - Rhode Island Avenue N.E. between 4th and 6th Streets
    - Area 2 - West Virginia Avenue N.E. near Mt. Olivet Road
    - Area 3 - P Street and 1st Street N.W.
    - Area 5 - Rhode Island Avenue N.W., near 6th and R Streets
    - Area 6 – Thomas and Flagler Streets, NW
  - Size the tunnel and its appurtenances so they are large enough to accommodate future relief in the Northeast Boundary Area.

  These criteria will provide relief for the identified flooding in the drainage area up to the design storm. In addition, the tunnel is sized large enough to allow future relief of other sub-sewer sheds in the Northeast Boundary area if relief is required in other areas in the future.

- Storage Volume: The tunnels system is designed to provide 157 million gallons of storage at a tunnel fill elevation of -24.0 (DC DPW Datum).

- Tunnel Overflow Facilities: Tunnel overflow facilities have been sited at Bolling Air Force Base (BAFB) and at CSO 019 which serves the Northeast Boundary area. After the tunnel is full, the BAFB overflow facility will typically convey flow from CSOs 005, 007, 009, and 011 through 018, while the overflow facility at CS0 019 will provide relief for the Northeast Boundary area combined sewer flow and relief flow for the flood prone locations in the Northeast Boundary area.

- Tunnel Dewatering Pumping Station – In accordance with the TN/WW Plan, the facility will have an installed firm capacity of 225 mgd. To provide for future expansion, the facility will be designed to be expandable.

- Other Aspects: Analyses have been conducted during the facility planning regarding odor control, venting, hydraulic transients, access, isolation of the tunnel, monitoring and keeping the tunnel clean. These are described in detail in the Facility Plan document.

Risk Management and Construction Planning

Underground construction for shafts and tunnels is a highly specialized field with inherent risks. Design and construction efforts and activities should, therefore, progress in concert with an appropriate risk management program. Section 8 of the Facility Plan discusses the risk management efforts accomplished to date and outlines a risk management program considered as part of facility planning efforts. Figure 8 below illustrates the relationship between the implementation elements of the projects and the risk management program as suggested in the Facility Plan.

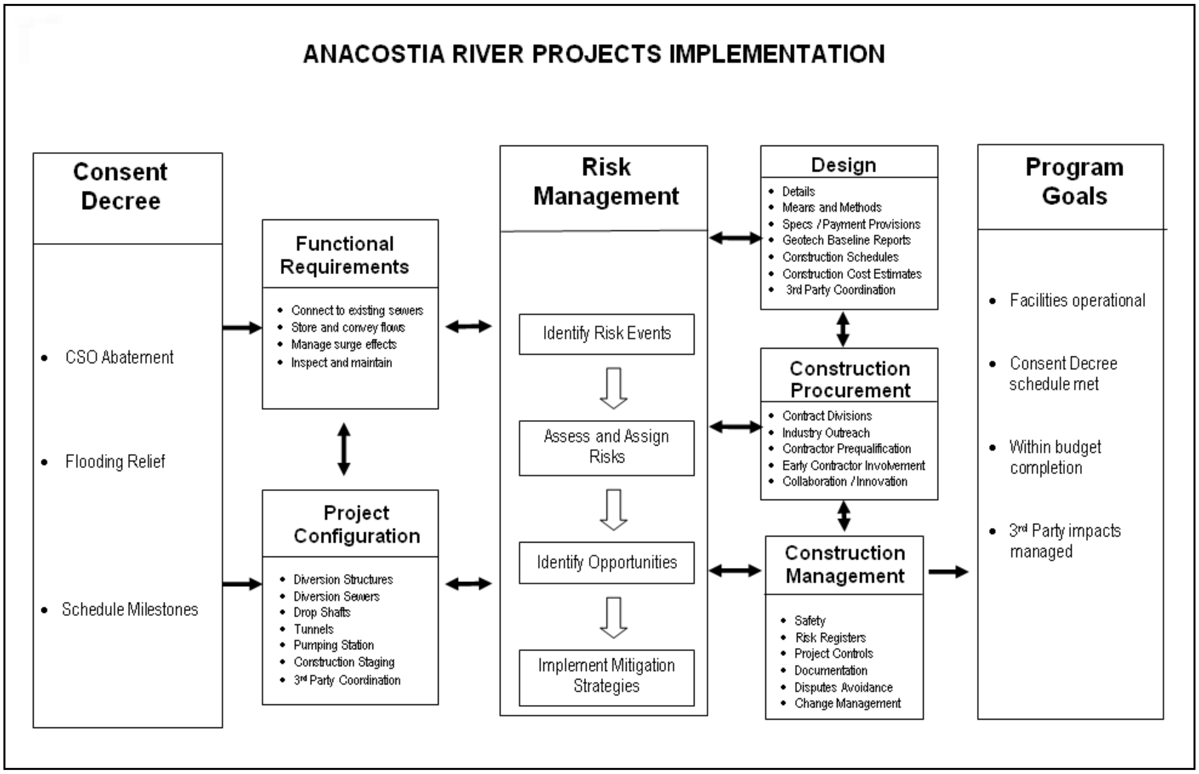


Figure 8: Program Implementation and Risk Management

The general risk management considerations diagrammed in Figure 8 will be evaluated further to develop a comprehensive approach in the future phases of the ARP implantation.

Additionally, the risk management program will need to include provisions to mitigate construction impacts on areas and neighborhoods during construction. Such provisions include by may not be limited to impacts to residences and businesses, traffic routes, noise, dust, utilities and other public concerns. The design and construction phases of the ARP program will, therefore, include outreach elements to accommodate public and institutional needs

Geotechnical Investigations

Planning level geotechnical investigations have been made for the development of the Facility Plan. Most of these investigations have been completed, but some will continue through the end of 2008. Data from the latter investigations will be included in subsequent phases of project implementation. The geotechnical investigations have included research of existing information; geophysical surveys; borings by conventional rotary and sonic drilling methods; field instrumentation and testing programs; laboratory testing of recovered soil and rock samples; and groundwater monitoring. The Facility Plan includes a Preliminary Geotechnical Data Report as Appendix Volume III.

Figure 9 shows the locations of borings and geophysical surveys performed as part of the Facility Plan development. Figure 10 presents a general composite of the geological profile of the currently anticipated ground conditions along the tunnels alignments. Geotechnical investigations during design will provide more detailed information regarding the conditions which may be expected at specific shaft and structure locations as well as along the diversion sewers and tunnels alignments.

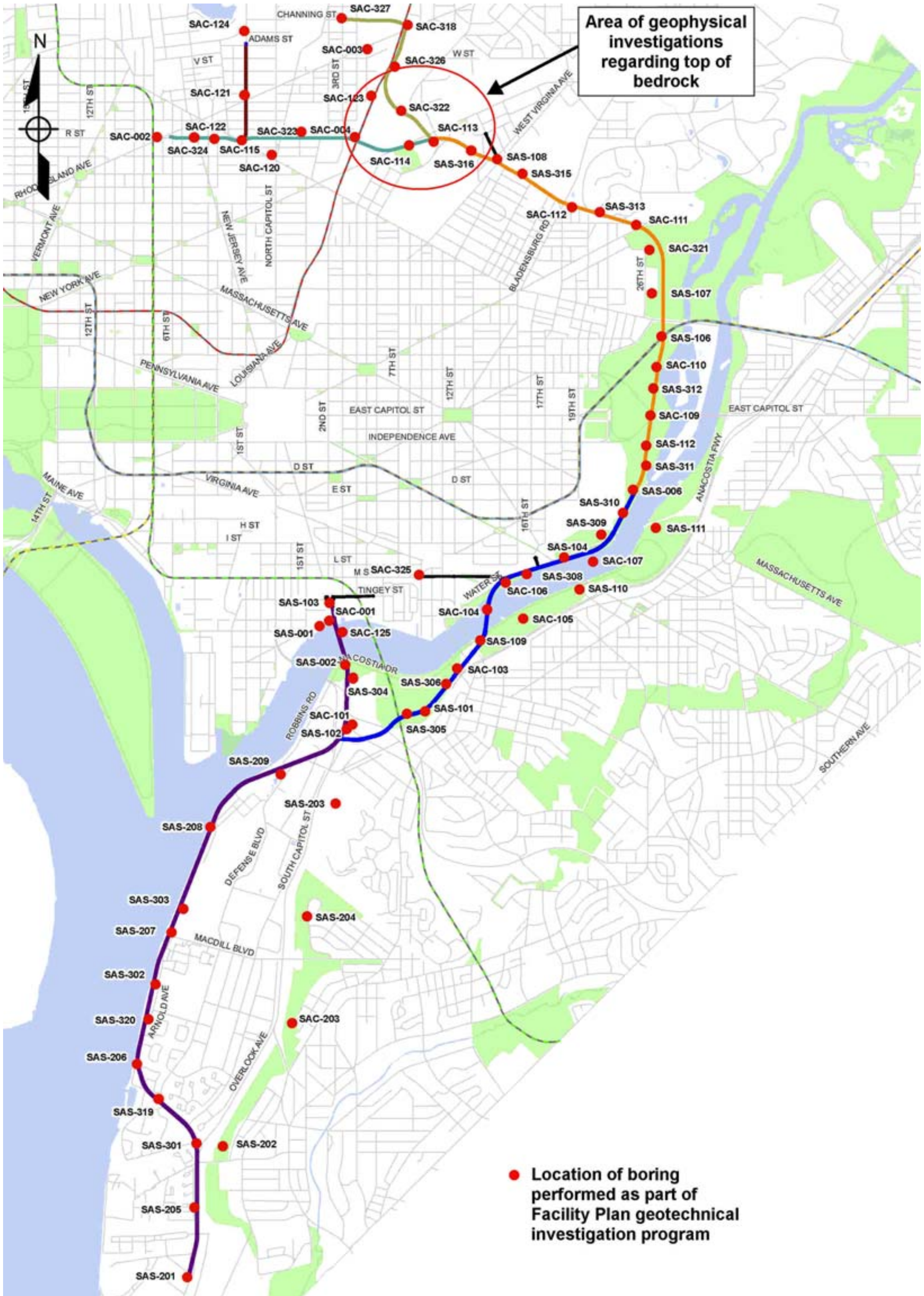
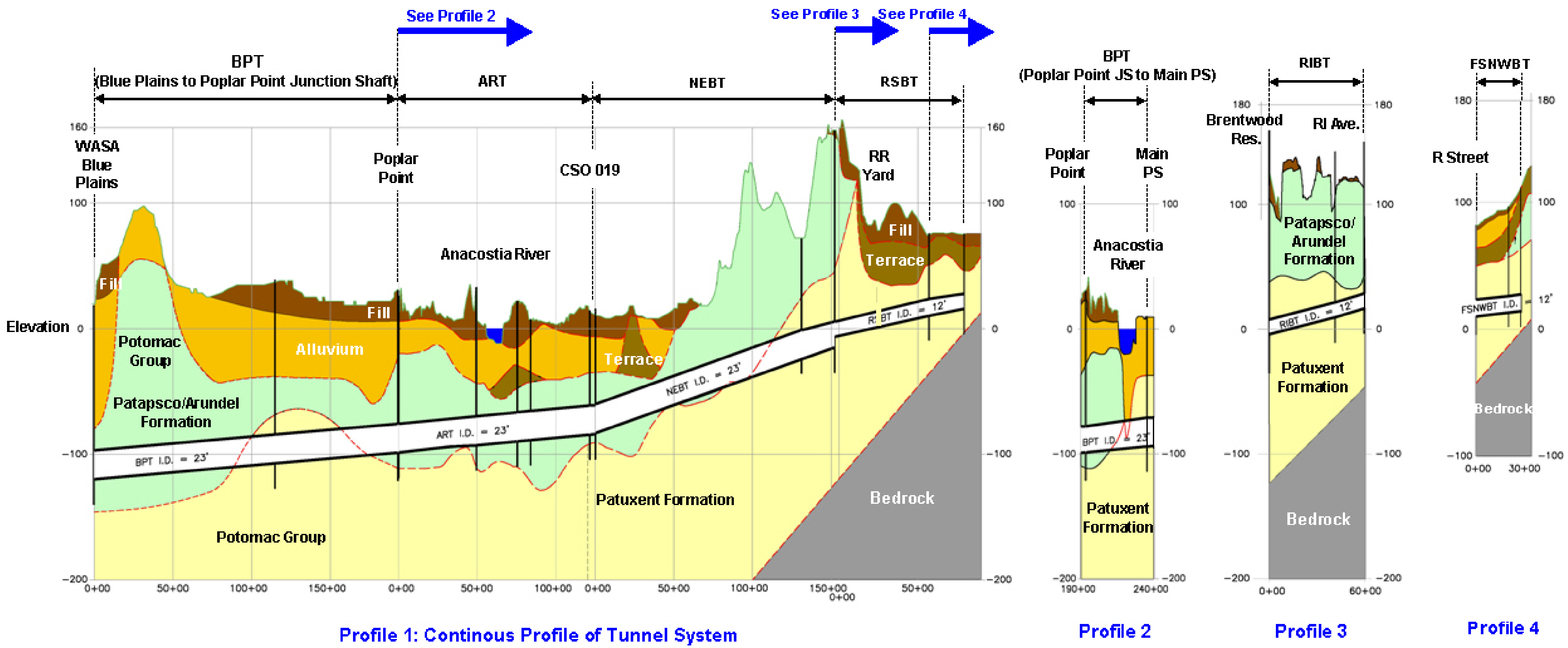


Figure 9: Locations of Borings and Geophysical Survey



TUNNELS:

BPT = Blue Plains Tunnel
ART = Anacostia River Tunnel
NEBT = Northeast Boundary Tunnel
RSBT = R Street Branch Tunnel
RIBT = Rhode Island Branch Tunnel
FSNWBT = First Street NW Branch Tunnel

Figure 10: Summary Geologic Profiles

Project Permitting

The Consent Decree includes requirements relative to acquisition of permits and approvals associated with the ARP. These requirements include identification of the permits required for the ARP as well as the timing for submittals applications. Table 4 identifies the agencies and organizations that will require some type of permit or approval for construction of the facilities defined for the project. The detailed implementation schedule shown on Figure 7 also includes a graphical summary of the permits process timeline.

The permitting agencies and organizations presented in Table 4 have been divided into the following categories:

- Utility agencies
- District of Columbia (D.C.) agencies
- Regional agencies
- Federal agencies, including applicable military commands
- Private organizations/property owners

The permit requirements vary among the different agencies. Section 11 of the Facility Plan identifies, to the extent identified as being applicable, all of the agencies that will have jurisdiction over the planned alignments, and appurtenant facilities sites, and it outlines the requirements and procedures for obtaining a permit from each respective agency. Section 14 of the Facility Plan provides additional information relative to those agencies and other entities that will require on-going coordination beyond the formal permitting process throughout the design and construction periods.

Land Acquisition and Approvals

Section 12 of the Facility Plan provides a detailed listing of the property acquisitions, easements and agreements required for the project. The scope of the respective property acquisitions relative to the planned facilities and tunnels alignments are also shown on several figures included within Section 12. The evaluations of alternative tunnel alignments were based on locations that would minimize impacts on private property owners and establish the locations of tunnels corridors in public owned areas. Approximately 10 percent of the tunnels alignments and facilities defined in the Facility Plan are located on privately owned locations.

A summary of property owners identified on Figures 12-1 through 12-23 of the Facility Plan is presented in Table 5. More than 90 percent of the tunnels length is located below land owned by the United States Government and controlled by the military (Bolling Air Force Base and Anacostia Naval Annex) or the National Park Service, or below the public right-of-way. Various railroad companies, including CSX Railroad and WMATA own or control the land above approximately 6 percent of the tunnels length and private entities own the land above approximately 3 percent of the tunnels length.

Table 4, Sheet 1 of 3
Project Permitting and Submittal Deadline Requirements
Based on Information Available During Facility Planning

Contract Division Designation and Major Components	Agency/Organization																											
	Utilities					DC Agencies										Federal Agencies									Other Agencies/Private			
	Potomac Electric Power Company		Washington Gas Company	Telephone (Comcast/Verizon)	DC Water and Sewer Authority	District Department of Transportation	DC Office of Planning	Department of Consumer & Regulatory Affairs	Department of Health / D.C. Fire & Emergency Medical Services	District Department of Environment	Navy Research Laboratory	Deputy Mayor for Planning and Economic Development	Various Advisory Neighborhood Commissions	DC Department of Public Works	DC Department of Parks & Recreation	National Mall and Memorial Parks	U.S. Army Corps of Engineers	Department of the Interior (Marinas)	National Park Service - East	Bolling AFB (DoD) or Department of the Air Force	U.S. Navy	National Arboretum	National Capitol Planning Commission	U.S. Coast Guard (Sector Baltimore)	Washington Metropolitan Area Transit Authority	CSX Corporation	Private Property Owners	U.S. Postal Service
	Request for New Service	Utility Relocation Review	Utility Relocation Request	Utility Relocation Request	Construction Site Permit	Maintenance of Traffic Schemes	Document Review	Public Space Application/PSMA-WOSE/Others	Tunnel Ventilation/Other Permit Approvals through DCRA & DDOT	ESC/SMP/NPDES	Property Access	Site Acquisition	Letter Notification	Site Layout Permit	Tree Protection Permit	RFK Stadium Access	404 Permit (s)	Document Review	Site Acquisition /Document Review	Document Review/Site Access Permit	Document Review/Site Access Permit	Document Review	Document Review	River Crossing	Real Estate Application	Document Review/Right of Entry Permit	Letter of Notification	Document Review
A BPT, BPTDS, BAFB-DS, PP-JS (excavation & support), MPS-DS, MOS-DC, and approach channel	At 30% design	At 30% design	—	—	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	At 30% design	3 mo. prior to 60% design	At NTP for design	At NTP for design	At 30% design	At 30% design	—	—	2 mo. Prior to 30%	—	2 mo. prior to 30% design	At NTP design	At NTP design	—	3 mo. prior to 60% design	At NTP design	—	—	—	—
B CSO 013-DC, CSO 014-DC and microtunnel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	—	—	—	—	—	—	—	—	3 mo. prior to 60% design	—	—	—	—	—
C CSO 019-S, CSO 019-N, CSO 019-JC-2 and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	—	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	2 mo. prior to const. NTP	At 30% design	—	—	2 mo. prior to 30% design	—	—	—	3 mo. prior to 60% design	—	—	—	—	—
D BAFB-OF, BPOS-DC and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	30% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	—	At 30% design	At 30% design	2 mo. prior to const. NTP	—	At 30% design	—	2 mo. prior to 30% design	At NTP design	—	—	3 mo. prior to 60% design	At NTP design	—	—	—	—
E CSO 015-DC, CSO 016-DC, CSO 017-DC, microtunnel and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	2 mo. prior to const. NTP	—	—	At 30% design	—	—	—	—	3 mo. prior to 60% design	—	—	—	—	—

Table 4, Sheet 2 of 3
Project Permitting and Submittal Deadline Requirements
Based on Information Available During Facility Planning

Contract Division Designation and Major Components	Agency/Organization: Utilities					DC Agencies										Federal Agencies									Other Agencies/Private			
	Potomac Electric Power Company		Washington Gas Company	Telephone (Comcast/Verizon)	DC Water and Sewer Authority	District Department of Transportation	DC Office of Planning	Department of Consumer & Regulatory Affairs	Department of Health / D.C. Fire & Emergency Medical Services	District Department of Environment	Navy Research Laboratory	Deputy Mayor for Planning and Economic Development	Various Advisory Neighborhood Commissions	DC Department of Public Works	DC Department of Parks & Recreation	National Mall and Memorial Parks	U.S. Army Corps of Engineers	Department of the Interior (Marinas)	National Park Service - East	Bolling AFB (DoD) or Department of the Air Force	U.S. Navy	National Arboretum	National Capital Planning Commission	U.S. Coast Guard (Sector Baltimore)	Washington Metropolitan Area Transit Authority	CSX Corporation	Private Property Owners	U.S. Postal Service
	Request for New Service	Utility Relocation Review	Utility Relocation Request	Utility Relocation Request	Construction Site Permit	Maintenance of Traffic Schemes	Document Review	Public Space Application/PSMA-WOSE/Others	Tunnel Ventilation/Other Permit Approvals through DCRA & DDOT	ESC/SMP/NPDES	Property Access	Site Acquisition	Letter Notification	Site Layout Permit	Tree Protection Permit	RFK Stadium Access	404 Permit (s)	Document Review	Site Acquisition /Document Review	Document Review/Site Access Permit	Document Review/Site Access Permit	Document Review	Document Review	River Crossing	Real Estate Application	Document Review/Right of Entry Permit	Letter of Notification	Document Review
A BPT, BPTDS, BAFB-DS, PP-JS (excavation & support), MPS-DS, MOS-DC, and approach channel	At 30% design	At 30% design	—	—	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	At 30% design	3 mo. prior to 60% design	At NTP for design	At NTP for design	At 30% design	At 30% design	—	—	2 mo. Prior to 30%	—	2 mo. prior to 30% design	At NTP design	At NTP design	—	3 mo. prior to 60% design	At NTP design	—	—	—	—
B CSO 013-DC, CSO 014-DC and microtunnel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	—	—	—	—	—	—	—	—	3 mo. prior to 60% design	—	—	—	—	—
C CSO 019-S, CSO 019-N, CSO 019-JC-2 and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	—	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	2 mo. prior to const. NTP	At 30% design	—	—	2 mo. prior to 30% design	—	—	—	3 mo. prior to 60% design	—	—	—	—	—
D BAFB-OF, BPOS-DC and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	30% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	—	At 30% design	At 30% design	2 mo. prior to const. NTP	—	At 30% design	—	2 mo. prior to 30% design	At NTP design	—	—	3 mo. prior to 60% design	At NTP design	—	—	—	—
E CSO 015-DC, CSO 016-DC, CSO 017-DC, microtunnel and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	2 mo. prior to const. NTP	—	—	At 30% design	—	—	—	—	3 mo. prior to 60% design	—	—	—	—	—

Table 4, Sheet 3 of 3
Project Permitting and Submittal Deadline Requirements
Based on Information Available During Facility Planning

Contract Division Designation and Major Components	Agency/Organization																											
	Utilities					DC Agencies										Federal Agencies									Other Agencies/Private			
	Potomac Electric Power Company		Washington Gas Company	Telephone (Comcast/Verizon)	DC Water and Sewer Authority	District Department of Transportation	DC Office of Planning	Department of Consumer & Regulatory Affairs	Department of Health / D.C. Fire & Emergency Medical Services	District Department of Environment	Navy Research Laboratory	Deputy Mayor for Planning and Economic Development	Various Advisory Neighborhood Commissions	DC Department of Public Works	DC Department of Parks & Recreation	National Mall and Memorial Parks	U.S. Army Corps of Engineers	Department of the Interior (Marinas)	National Park Service - East	Bolling AFB (DoD) or Department of the Air Force	U.S. Navy	National Arboretum	National Capital Planning Commission	U.S. Coast Guard (Sector Baltimore)	Washington Metropolitan Area Transit Authority	CSX Corporation	Private Property Owners	U.S. Postal Service
	Request for New Service	Utility Relocation Review	Utility Relocation Request	Utility Relocation Request	Construction Site Permit	Maintenance of Traffic Schemes	Document Review	Public Space Application/PSMA-WOSE/Others	Tunnel Ventilation/Other Permit Approvals through DCRA & DDOT	ESC/SMP/NPDES	Property Access	Site Acquisition	Letter Notification	Site Layout Permit	Tree Protection Permit	RFK Stadium Access	404 Permit (s)	Document Review	Site Acquisition /Document Review	Document Review/Site Access Permit	Document Review/Site Access Permit	Document Review	Document Review	River Crossing	Real Estate Application	Document Review/Right of Entry Permit	Letter of Notification	Document Review
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B CSO 013-DC, CSO 014-DC and microtunnel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	—	—	—	—	—	—	—	—	3 mo. prior to 60% design	—	—	—	—	—
C CSO 019-S, CSO 019-N, CSO 019-JC-2 and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	—	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	2 mo. prior to const. NTP	At 30% design	—	—	2 mo. prior to 30% design	—	—	—	3 mo. prior to 60% design	—	—	—	—	—
D BAFB-OF, BPOS-DC and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	30% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	—	At 30% design	At 30% design	2 mo. prior to const. NTP	—	At 30% design	—	2 mo. prior to 30% design	At NTP design	—	—	3 mo. prior to 60% design	At NTP design	—	—	—	—
E CSO 015-DC, CSO 016-DC, CSO 017-DC, microtunnel and approach channel	At 60% design	At 30% design	2 mo. prior to 60% design	At 30% design	2 mo. prior to 60% design	At 60% design	At NTP design	3 mo. prior to 60% design	—	3 mo. prior to 60% design	—	At NTP for design	At 30% design	At 30% design	2 mo. prior to const. NTP	—	—	At 30% design	—	—	—	—	3 mo. prior to 60% design	—	—	—	—	—

Table 5
Summary of Property Owners along the Proposed Tunnels System Alignments

Property Owners	Approximate Length of Tunnel (Ft)	% of Total Length
Public Right-of-Way	20,775	32.9%
National Park Service (USA)	18,260	28.9%
Military (BAFB and Navy)	15,390	24.4%
Railroad Entities	4,025	6.4%
US Army Corps of Engineers (USA)	2,300	3.6%
Private Property	1,915	3.0%
USA (other)	1,725	2.7%
National Arboretum (USDA)	1,660	2.6%
District of Columbia	1,370	2.2%
WASA controlled (owned by DC and/or USA)	510	0.8%
PEPCO	105	0.2%
Total	**68,035**	**100%**

Public Notification

A visual CSO notification system has been installed and is in operation on the Anacostia River as shown on Figure 11. Under the Consent Decree, at least three additional systems are required. Because extensive redevelopment planning and new bridge construction planning is underway all along the Anacostia River in the area of all the CSO outfalls, it is not practicable, at this time, to finalize the details of the public notification system. For example, some of the redevelopment plans are considering new public access to the river, but the locations and other details are only conceptual. In view of the circumstance associated with the redevelopment and bridge construction, the Authority proposes to include the visual notification systems under Contract Division H, Anacostia River Tunnel, which is scheduled for award of design by November 1, 2011.

Figure 11: CSO Warning Lights on Anacostia River

Other ARP Implementation Factors

The ARP have been developed at this stage to a level sufficient to proceed to detailed design and construction. However, uncertainties remain, and these uncertainties could impact the design and schedule of the facilities included in the Facility Plan. In addition to uncertainties discussed under project setting, risk management and construction planning, geotechnical information, permitting and land acquisition, there are those criteria, standards, regulations, laws, guidelines and assumptions upon which the ARP and schedule are based. The following list includes, but may not be limited to, factors for which changes from the bases upon which the Facility Plan has been prepared, could require changes to the ARP and the implementation schedule:

- Those items listed in subsection 13.7 of the LTCP, Final Report, July 2002
- EPA's approval and approval conditions of the Authority's Blue Plains Total Nitrogen Removal/Wet Weather Plan, LTCP Supplement No. 1, Final, October 2007
- The terms and conditions related to nitrogen removal and the combined sewer system in the proposed and final reissued NPDES permit for Blue Plains
- The terms and conditions in a modified Consent Decree necessary to incorporate LTCP Supplement No. 1 and the Facility Plan
- Actions, decision, conditions and delays created, caused or contributed by third parties that impact the design and schedule bases of the ARP included in the Facility Plan. Third parties include, but may not be limited to, the parties to the Consent Decree, other than the Authority, and all their branches, departments and agencies; utility agencies, transportation agencies, the affected public, special interest groups, suppliers, and contractors.

APPENDIX E

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

APPENDIX E

SUMMARY OF GREEN/GRAY AND GREEN CONTROLS FOR THE POTOMAC AND ROCK CREEK SEWERSHEDS

December 2014

Prepared for:

Prepared by:

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Blue Plains Advanced Wastewater Treatment Plant
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1 Introduction

1.1 Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP or DC Clean Rivers Project, DCCR) to control combined sewer overflows (CSOs) to the District's waterways. The DCCR is comprised of a variety of projects including pumping station rehabilitations, targeted sewer separation, green infrastructure (GI) at DC Water facilities and a system of underground storage/conveyance tunnels to control CSOs. The DCCR is being implemented in accordance with a Consent Decree (LTCP Decree) signed by DC Water, the District, and the U.S Government, that specifies the schedule for implementation. Projects on the Anacostia River are first in the schedule and DC Water is implementing those projects in accordance with the Decree.

Unlike single-purpose gray infrastructure which uses tanks, tunnels and pipes to store and convey CSO, GI uses vegetation and soil to manage stormwater where it falls. GI has the ability to reduce stormwater and CSOs, and provide multiple environmental, social and economic benefits. Examples of these benefits include improved air quality, reduced heat island effects, improved property values and creation of local jobs. In addition, GI consists of many small projects which can be brought on line as soon as individual projects are completed. In contrast, gray CSO projects can typically only be brought on line when all the elements are completed. Because of this, GI projects can provide earlier CSO reduction than all-gray projects.

Based on an assessment of the sewersheds, DC Water is proposing hybrid CSO controls for the Potomac and Rock Creek as follows:

- In Rock Creek, construct GI instead of the Piney Branch tunnel to control the Piney Branch CSO
- On the Potomac, construct a hybrid green and gray control system for the Potomac River CSOs

This document provides a summary of the green/gray and green controls for the Potomac and Rock Creek sewersheds.

DC Water has public noticed a detailed summary of the analysis supporting the green and green/gray controls in the following document: *Long Term Control Plan Modification for Green Infrastructure*, January 2014, DC Water.

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2 Collection System Modeling

This section describes the use of DC Water's hydrologic and hydraulic model to predict sewer system response to the proposed green and green/gray CSO controls. This section presents a brief background on the models employed followed by discussions of the model development and the model application.

2.1 Background

Hydrologic and hydraulic models are computer simulation tools used by planners and engineers to evaluate rainfall and runoff relationships in urban areas. The hydrologic model simulates the major components of the hydrologic cycle; that is, the physical processes of rainfall, evapotranspiration, storage, and runoff. The response of urban neighborhoods to rainfall is determined by the relative degree of imperviousness of surface features (e.g., rooftops, parking lots, roads, etc.) and the infiltration capabilities of the soils. The hydraulic model simulates the movement of runoff and sewer flows through the below-ground network of pipes and other infrastructure that make up the sewer system. Flow through the sewer system is determined by the capacity of pipes, pumps, and other hydraulic control structures, and by backwater conditions.

Hydrologic and hydraulic models are calibrated based on observed rainfall and flow data. The model parameters (e.g., infiltration rate, slope, roughness coefficient, etc.) are adjusted in calibration to an optimal point where the ability of the model to simulate the volume and timing of runoff events is maximized. Independent validation of models is done by gauging the ability of the model to simulate a separate group of rainfall/runoff events without adjustment of the model parameters. Model calibration and validation provide confidence in the ability of the models to "predict" the response of the system under a variety of conditions. This is particularly true when the calibration and validation data sets include a wide variety of rainfall and flow conditions.

Identifying a dataset that represents average rainfall conditions for use in the hydrologic model is a fundamental first step in model development. As part of the evaluation of the original LTCP, DC Water analyzed over 50 years of hourly rainfall data at Ronald Reagan National Airport to identify an average rainfall period. The years from 1988 to 1990 were selected as the average rainfall period. This period was chosen because annual precipitation from these three years represent dryer conditions, wetter conditions, and average conditions compared to the long term average for the District. Table 2-1 compares the rainfall for these three years to the long term average.

Table 2-1. Annual Average Rainfall Conditions in the District

Statistic	1988	1989	1990	1988-1990 Avg	Long Term Avg[1]
Annual Rainfall (inches)	31.74	50.32	40.84	40.97	38.95
No. Events > 0.05 inches[2]	61	79	74	71	74
Average Storm Duration (hours)[2]	9.6	11.2	9.6	10.1	9.9
Average Maximum Intensity (in/hr)	0.15	0.18	0.15	0.16	0.15
Maximum Intensity (in/hr)	1.32	1.31	1.25	1.29	1.30
Percentile[3]	14th	90th	68th	68th	--

Notes: 1. Ronald Reagan National Airport hourly data, 1949-1998

2. Individual events separated by a minimum of 6 hours with no rain.

3. Percentile is based on total annual rainfall.

DC Water has used the MIKE URBAN Model and its predecessor (the MOUSE Model) for all of its hydrologic and hydraulic analyses dating back to 1998. Both models are products of DHI, formerly the Danish Hydraulic Institute (www.dhigroup.com).The models were applied to support a wide range of projects and studies including development of the original LTCP for the combined sewer system (CSS). The MOUSE Model incorporating both hydrologic and hydraulic modeling capabilities was selected by DC Water in 1998 to support development of the LTCP. MOUSE was chosen at the time because it had the capability to directly simulate Real Time Control (RTC) operations, a feature that was not then available in the widely-used Storm Water Management Model (SWMM).

During model development, sewersheds for both the CSS and the municipal separate storm sewer system (MS4) in the District were delineated based on sewer maps and topography. Hydrology parameters in the hydrologic model (e.g., pervious vs. impervious, infiltration, etc.) were based on available soil, land use, and zoning maps. Hydraulic controls (e.g., regulators, pump stations, outfalls, inflatable dams, etc.) were based on drawings, pump curves, operations documents, and other studies.

Model calibration and validation was based on rainfall and flow records in the CSS collected during 1999-2000. This included 24 rainfall events for model calibration and another 20 rainfall events for model validation. Several rain gages in the District and observed rainfall at DC National Airport were used to drive the hydrologic model. The hydrologic model was calibrated ahead of the hydraulic model. Overall, the emphasis of calibration and validation was placed on developing a mass balance of flow at Blue Plains, and a reasonable representation of the frequency and volume of CSO discharges.

Since the original model was developed to support the LTCP, a number of software upgrades and model improvements have been made. DHI upgraded the MOUSE model engine to the current incarnation of MIKE URBAN in 2003. The upgrade to MIKE URBAN improved the model application in several ways. It was able to be applied in a continuous simulation mode, a very important consideration where long multiple year simulations are required. MIKE URBAN also included GIS-based software. This made it easier to use GIS data sets for impervious surfaces (e.g., roads, sidewalks, parking lots, etc.) and soils more spatially and directly. In addition, DC Water had its sewer maps (i.e., counter maps) digitized and developed as a geodatabase that could be directly linked to MIKE URBAN. The result of this update was a much improved representation of surface conditions across the CSS in the hydrologic model. In addition, the pipe network in the hydraulic model was based on better information on pipe slopes, diameters, roughness, and other relevant characteristics. New and more robust flow data from suburban jurisdictions and from the District's separate sewer system were also integrated into the model boundary conditions. Figures 2-1 and 2-2 provide a visual representation of the model elements and the land cover for Potomac and Piney Branch sewersheds, respectively.

MIKE URBAN was recalibrated during the period 2005-2006 based on metered flow data for the collection system and Blue Plains. This flow data was supplemented with point rainfall data at National Airport and other District of Columbia stations, with radar rainfall estimates on a square kilometer basis available for some key rainfall events.

Since this recalibration, the MIKE URBAN model has continued to be employed in a number of capacities for DC Water. The model has been used for emergency operations planning, Inter Municipal Agreement (IMA) negotiations, multi-jurisdictional use facilities planning and cost allocation, the Anacostia Facilities Plan, the updated LTCP/Total Nitrogen-Wet Weather Plan, the Federal Triangle and other flood studies, and quarterly NPDES reporting of CSO estimates.

For DC Water's analysis of green infrastructure potential, a suite of modeling software packages (including MIKE URBAN and SWMM5) was evaluated to identify the best modeling tool to utilize. The results of this evaluation are presented in Technical Memorandum No. 2, Approach to Hydrologic and Hydraulic Modeling. This evaluation resulted in the selection of EPA's SWMM5 runoff application to perform the hydrologic evaluation and paired with the existing MIKE URBAN hydraulic model. EPA SWMM5 features options for explicit characterization and simulation of specific GI practices that the MIKE URBAN hydrologic model does not.

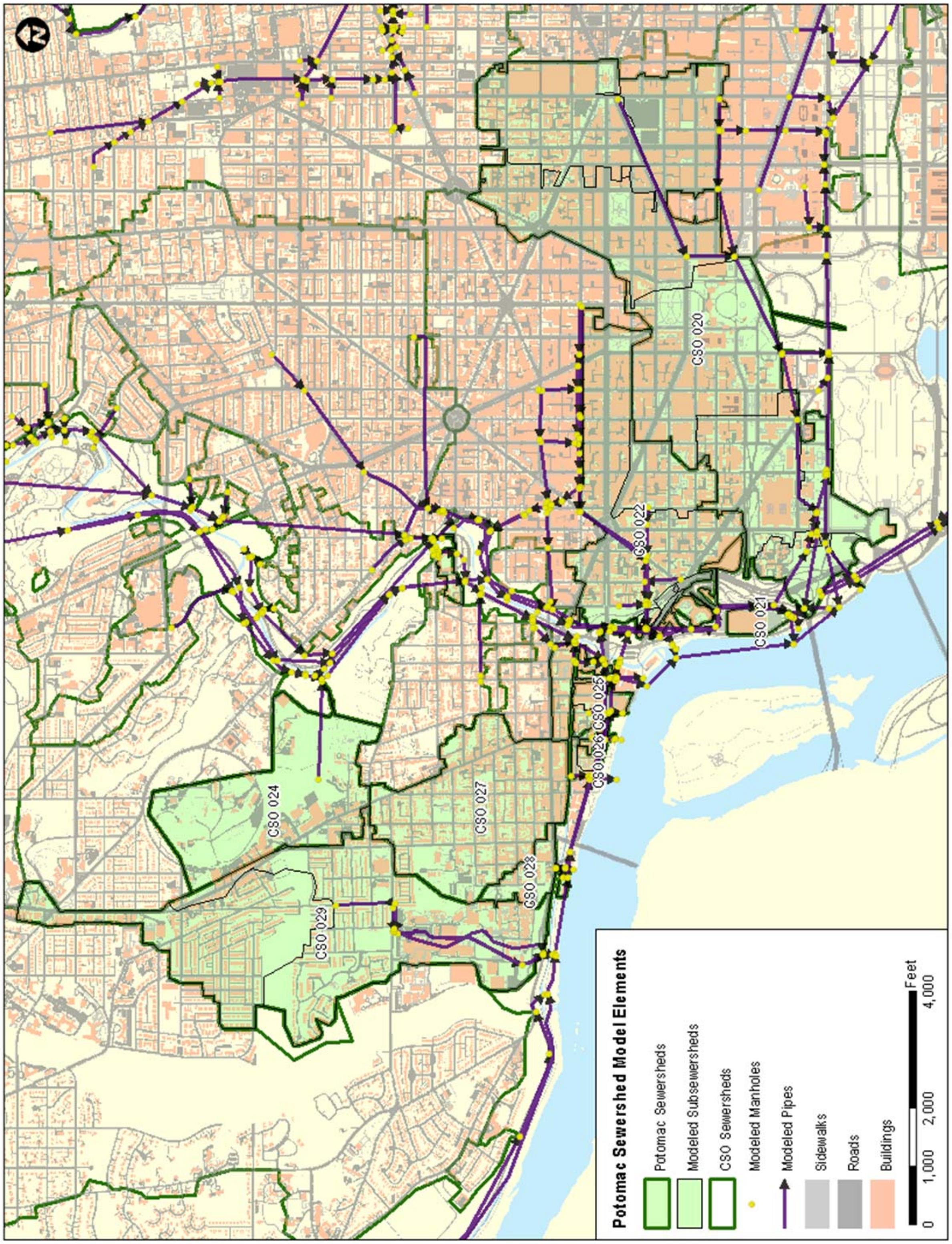

Figure 2-1. Potomac Sewershed Model Elements

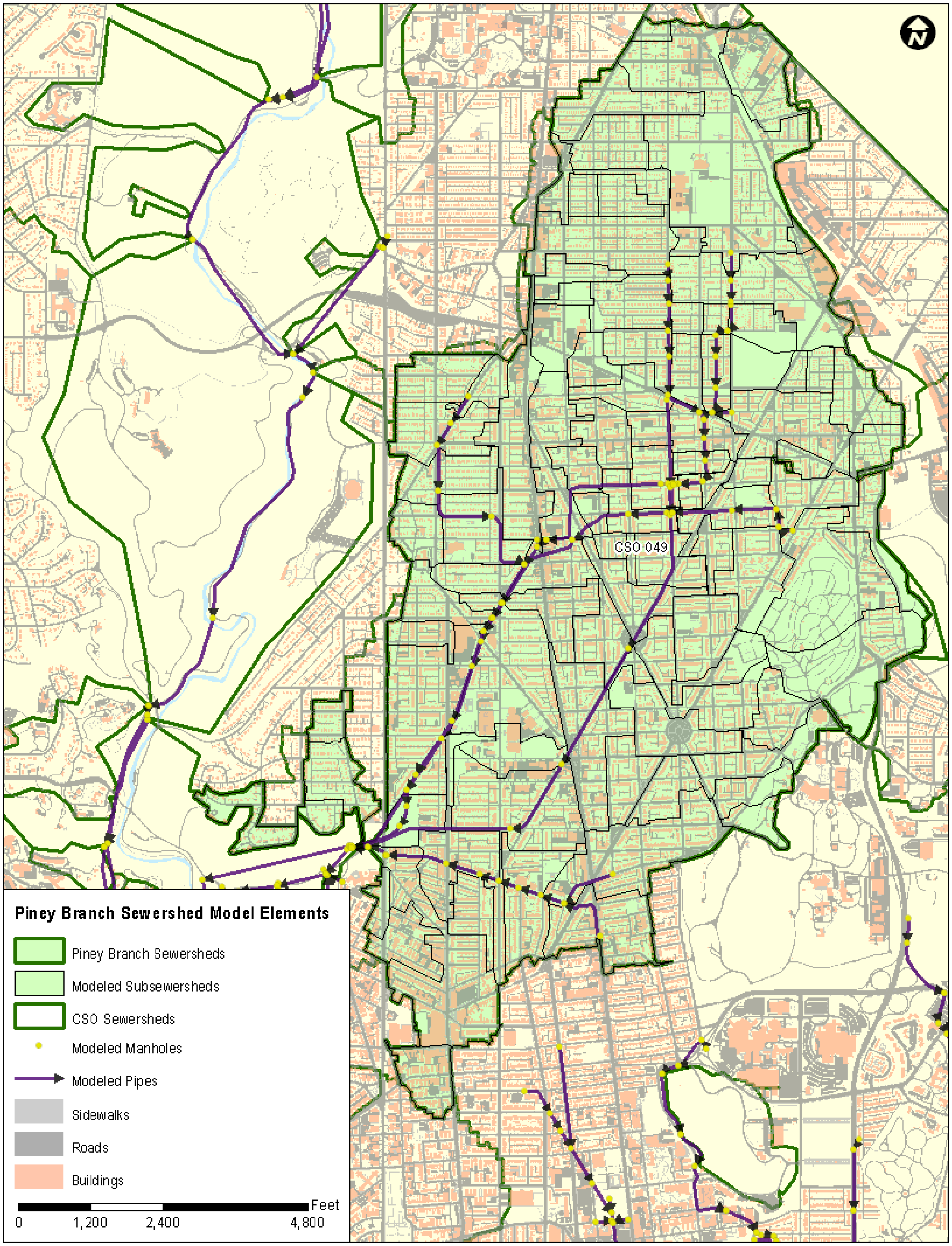

Figure 2-2. Piney Branch Sewershed Model Elements

2.2 Model Development

For this GI screening analysis, the SWMM5 hydrologic model was used for runoff simulation and the existing hydraulic portion of the MIKE URBAN model was used to model flow through the collection system. The SWMM5 runoff model was developed based on the runoff portion of the MIKE URBAN model as described below, and results were compared to the MIKE URBAN model to ensure consistency with previous model runs.

Historically, the purpose of the MIKE URBAN model was to predict combined sewer volumes and overflows entering receiving waters from the DC Water combined sewer service area. Developing a model for GI simulation requires finer subsewershed, pipe, and manhole resolution than previously existed in the MIKE URBAN runoff model. To accommodate this, the Piney Branch sewershed was redelineated to a higher resolution of 101 geographically separate model subsewersheds. Potomac model subsewersheds were deemed to be of sufficient resolution that finer delineations were unnecessary. There are 138 modeled subsewersheds throughout the Piney Branch and Potomac sewersheds with a median area of 19 acres. Ninety percent (90%) of the modeled subsewersheds are less than 140 acres.

Existing runoff parameters from MIKE URBAN were converted to SWMM5 runoff parameters. Parameters were copied when the exact analog to the MIKE URBAN parameter existed in SWMM5. Other parameters were converted to match as closely to the parameters in MIKE URBAN and then checked for consistency. Horton infiltration parameters were updated based on NRCS SSURGO soil data for the model area.

In order to effectively model water loss within GI practices, evapotranspiration (ET) was refined so that it could be applied to GI practices and the model in general. In MIKE URBAN, ET was applied only to water in storage, which was a representation of green infrastructure practice storage. SWMM5 does not have an option to apply ET solely to a practice; instead it is applied to the model as a whole. ET for SWMM5 was based on daily temperatures and climate at the Ronald Reagan Washington National Airport using a modified Thornwaite approach. Of the several accepted methods that could be used to approximate ET, this approach provided results most similar to the MIKE URBAN runoff model.

The models were run for the 1988-1990 period for validation. Time series output from both SWMM5 and MIKE URBAN runoff models was used as an input to the MIKE URBAN hydraulic model. Several metrics were used to compare the two models and insure the SWMM5 model was consistent with the MIKE URBAN runoff model including runoff volume, overflow volume, and frequency of CSO overflows.

2.3 Model Application

GI practices are represented in SWMM5 as “LID controls” (Low Impact Development). LID controls were used in the model for the Piney Branch and Potomac River areas of the combined sewer area. SWMM5 is a lumped parameter model that assumes uniformity across a single modeled sewershed. This means that LID controls were designed to represent the total of all GI practices contained within the modeled sewershed instead of representing each GI practice separately. This is common practice in a lumped parameter model.

GI practices are grouped into the four following LID control categories based on their general design and purpose:

- Rain Barrels
- Cisterns
- Bioretention
- Porous Pavement

Each type of LID control treats runoff from a specific area and drainage areas do not overlap. In SWMM5, each of the contributing areas to the four types of LID control is simulated as a separate subcatchment. Each type of impervious cover exists throughout the Potomac and Rock Creek sewersheds leading to a generally uniform distribution of LID controls. The modeling analysis focused on aggregate area of each impervious cover type without regard to public or private ownership. For scenarios that examine a high level of GI control, it is possible that opportunities for private GI implementation could be limited. In these cases, it is assumed that opportunities exist on public-owned property to compensate for the lack of opportunity on private property, and runoff passes through public property before entering the collection system.

In SWMM5, runoff from the surface to be treated by an LID control is routed to the control before entering the hydraulic model (MIKE URBAN). For example, if the scenario calls for 30% GI treatment, 30% of the contributing area from the variety of types of impervious surfaces is routed to LID controls identified for the specific type of impervious surface. Runoff not entering a LID control flows directly to the hydraulic model. Figure 2-3 shows the modeling framework used by SWMM5 to route flow to LID controls.

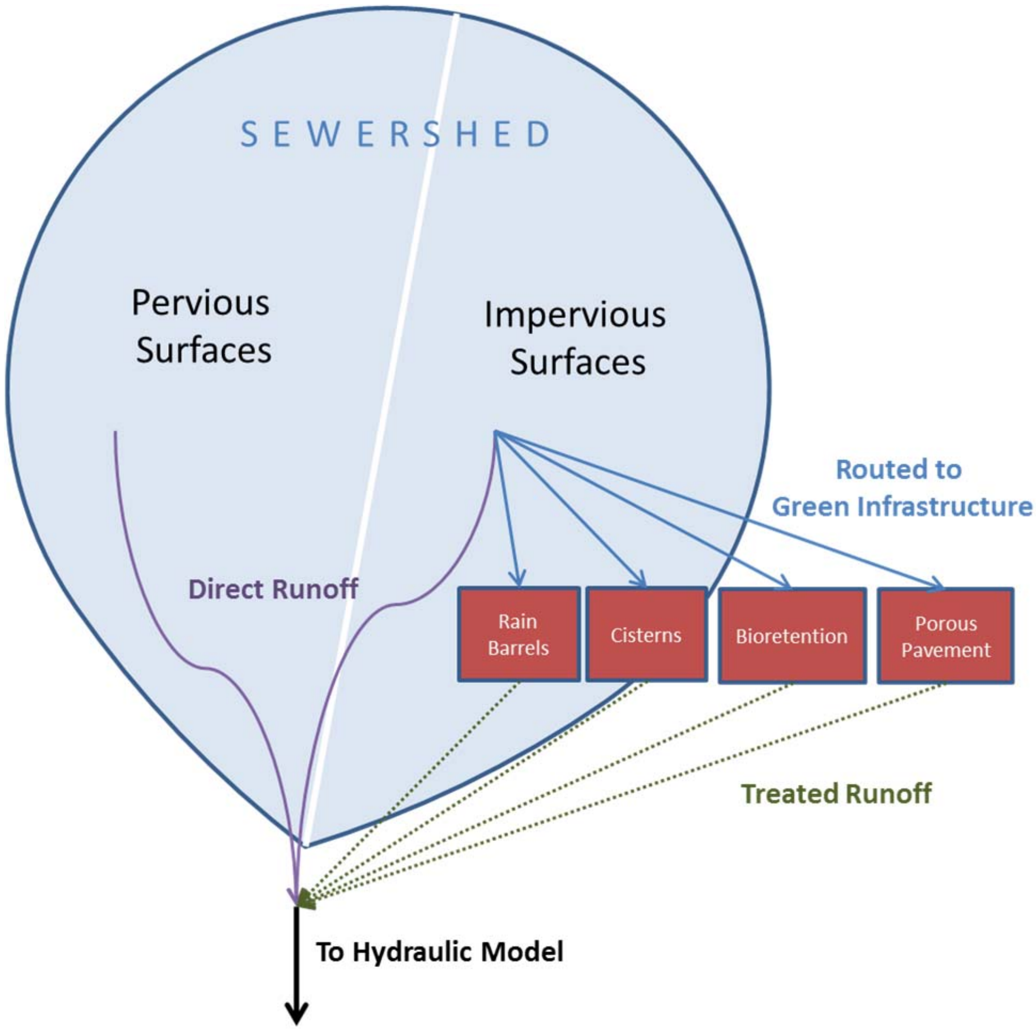

Figure 2-3: SWMM5 LID Control Routing

SWMM5 represents LID controls as shown in Figure 2-4. All LID controls use the same framework, with runoff entering the LID through the surface layer and passing to other layers or out of the LID practice through ET, overflow, underdrain, or infiltration based on parameters defined for each LID practice.

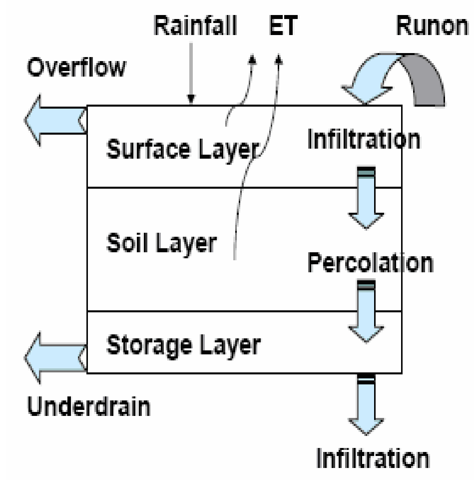

Figure 2-4. SWMM5 LID Control Representation

Each LID control is sized to completely contain the runoff volume produced from a 1.2 inch storm over the area treated. Other LID control parameters are determined based on accepted literature values for the types of LID controls and design guidelines used in the Concept Plan (see Technical Memorandum No. 3). Table 2-2 shows the LID control parameters used in the SWMM5 runoff model. Bioretention cell and porous pavement parameters for infiltration and underdrains varied due to site-specific soil conditions and infiltration potential across the modeled area.

Infiltration from each of the LID controls into the underlying soil is assumed to occur at a rate equal to the Horton method minimum infiltration rate for the subsewershed within which it is contained. This is a conservative assumption and accounts for probable soil compaction under the LID control.

Each LID control has a simulated underdrain. The underdrain diameter and height from the bottom of the control are optimized to allow the control to drain or infiltrate within 48 hours of the end of the storm and allow the water surface elevation in the control to remain below the surface of the practice. Rain barrels and cisterns do not have infiltration and the underdrains are simulated at the bottom of the control. Underdrain outflow from rain barrels is assumed to drain to the surface of the subshed where the rain barrel is located. Underdrain outflow from the other practices is assumed to flow directly into the collection system.

Table 2-2. SWMM5 LID Practice Parameters

Parameter	Units	Rain Barrel	Cistern	Bioretention Cell	Porous Pavement
Surface					
Storage depth	in			6	0.1
Surface slope	%			0	1.9
Soil/Pavement					
Thickness	in			24	6
Porosity	frac			0.3	0.2
Field Capacity	frac			0.105	0.105
Wilting Point	frac			0.047	0.047
Conductivity	in/hr			1.18	100
Conductivity Slope				7	7
Suction Head	in			1.4	1.4
Storage					
Height	in	36	36	18	36
Void Ratio				0.67	0.67
Infiltration	in/hr			Varies	Varies
Clogging Factor				0	0
Drain					
Drain Coef.	in/hr	0.25	0.25	Varies	Varies
Drain Exponent		0.5	0.5	0.5	0.5
Drain Offset	in	0	0	Varies	Varies
Drain Delay	hr	0	0		

Various implementation scenarios were simulated to evaluate the expected runoff reduction and resulting tunnel size resulting from implementing various distributions of LID practices described above. The specific scenarios, the modeling approach, and the modeling results are presented in Section 5.

3 Green and Green/Gray Controls for Piney Branch and Potomac River

DC Water is proposing to modify its LTCP to change the CSO control plan for Piney Branch and the Potomac River. The proposed control plan includes green and green/gray controls. Each control technology will be used where it is the most appropriate. The hybrid green/gray controls are predicted to provide a degree of CSO control equivalent to the gray controls in the LTCP. The hybrid approach will have a higher socio economic benefit to the District, especially in the communities served by GI. Figure 3-1 at the end of this section summarizes the proposed controls as compared to the LTCP.

3.1 Green Controls for Piney Branch

3.1.1 Scope

Piney Branch
30% GI Implementation
Total Sewershed area = 2,329 acres
Impervious area = 1,215 acres
GI @ 30% of Impervious Area = 365 acres

GI will treat approximately 30% (or 365 acres) of the impervious area in the Piney Branch drainage area, providing control for CSO 049. GI will be sized to provide a retention capacity equivalent to 1.2” of rain falling on an impervious surface. GI projects may include bioretention practices (bioretention cells, bioswales, vegetated filter strips, and tree box filters), rooftop collection practices (green roofs, blue roofs, downspout disconnection, rain barrels, and cisterns), permeable pavement, and large-volume underground storage. These facilities will be constructed in both public and privately-owned spaces. In addition to GI, targeted sewer separation may be utilized to offload storm water from the combined sewer system.

In addition to GI, the weir height of the existing diversion structure serving CSO 049 will be raised to increase the capture of combined sewage. The resulting captured sewage will be diverted to the existing East Rock Creek Diversion Sewer for conveyance to Blue Plains for treatment This control structure modification is not predicted to increase overflow frequency or volume at other downstream CSOs in the Rock Creek sewershed.

3.1.2 Predicted Performance

Hydraulic modeling predictions indicate that GI implementation and modifications to Structure 70 will eliminate the need to construct 9.5 MG of tunnel storage included in the LTCP. The GI program is predicted to provide a degree of CSO control equivalent to the gray controls in the LTCP, as summarized in Table 3-1.

Predicted water quality is summarized in Table 3-2 and the GI controls are predicted to provide a degree of water quality performance in the receiving water equivalent to the gray controls in the LTCP.

Green and Green/Gray Controls

Table 3-1
Piney Branch Predicted CSO Overflows in Average Year

Parameter	Before LTCP[1]	LTCP	Green Controls[2]
No. of Overflows (#/avg yr)	25	1	1
Overflow Volume (mg/avg yr)	39.73	1.41	<1
% reduction from Before LTCP	--	96%	96% or greater

Table 3-2
Predicted Water Quality in
Rock Creek after Piney Branch (Segment 17) in Average Year

Parameter	Before LTCP[1]	LTCP	Green Controls[2]
# Months Fecal Geomean>200 (all loads)	12	12	12
# Months Fecal Geomean>200 (CSO only)	0	0	0
# Days Fecal>200 (all loads)	335	335	335
# Days Fecal>200 (CSO Only)	24	1	1
# Days Fecal>200 (all loads) May - Sept	135	135	135
# Days Fecal>200 (CSO Only) May - Sept	15	1	1
# Months E. Coli Geomean>126 (all loads)	12	12	12
# Months E. Coli Geomean>126 (CSO only)	0	0	0
# Days E. Coli>126 (all loads)	365	365	365
# Days E. Coli>126 (CSO Only)	24	1	1
# Days E. Coli>126 (all loads) May - Sept	153	153	153
# Days E. Coli>126 (CSO Only) May - Sept	15	1	0
# Days D.O.< 5 mg/L (all loads)	0	0	0
# Days D.O.< 5 mg/L (CSO Only)	0	0	0

Notes for Tables 3-1 and 3-2:

1. Results shown for Before LTCP are without Phase1 Controls in place (i.e. without inflatable dams, pumping station rehabilitations and Northeast Boundary Swirl Facility in operation).
2. At the low levels of CSO overflows projected herein, model accuracy is highly dependent on many variables such as the accuracy of rainfall data, information on the drainage area and other factors. Further, additional overflows will occur for rain events which exceed or are not represented in the average year. The model predictions contained herein do not change the level of CSO control determined to be adequate to meet water quality standards which was included by DC Water in its LTCP, and subsequently approved by EPA and the D.C. Department of the Environment.

3.2 Green/Gray Controls for Potomac River

3.2.1 Scope

DC Water will construct the following controls for the Potomac River CSOs:

- **Potomac Tunnel (CSOs 020 – 024)**
  The Potomac Storage Tunnel will capture CSOs 020 through 024. These outfalls serve the major interceptors draining Rock Creek and the large downtown areas in the Potomac sewershed. Given the large overflow volume produced by these outfalls and the highly urbanized nature of the sewershed, DC Water will construct gray infrastructure to control these CSOs. The tunnel in the LTCP was a 58 million gallon (mg) facility with a tunnel dewatering pumping station at the low end. After rain events, the pumping station would bleed captured flow via the existing system to Blue Plains for treatment. The large size of the tunnel was driven, in part, by the inability to completely dewatering the tunnel during back-to-back rain events.

  As part of this modification, DC Water is proposing to construct a gravity tunnel from CSO 024 all the way to interconnect with the Blue Plains Tunnel on the Anacostia System. The total volume of the Potomac Tunnel will be 30 mg and the tunnel will be emptied by gravity. This configuration will create one interconnected tunnel system. The advantages of this system include:

  - The Potomac and Anacostia Tunnel Systems will be interconnected, with a total system storage volume of 187 mg (30 mg for the Potomac + 157 mg for the Anacostia River Tunnel System). Since rainfall has both geographic and temporal variability, the interconnection of the tunnel system improves the ability of the system to provide CSO control. As an example, intense rain events in one part of the District can utilize the tunnel system volume as needed to control overflows. This, combined with the sewer separation and GI, allows the 30 mg Potomac Tunnel to provide a degree of control equivalent to the gray controls in the LTCP.

  - The gravity tunnel does not require construction of a new pumping station in the National Mall area. This preserves space for other higher value use. In addition, it reduces the need operation and maintenance associated with a complex mechanical system. Elimination of the pumping station also improves reliability and redundancy since the gravity tunnel does not require electrical power or other mechanical equipment to function.

  - The gravity tunnel improves the reliability and operability of the existing sewer system. The system will be configured such that if Potomac Pumping Station loses power, then normal sanitary flows in the system will drop into the tunnel by gravity for conveyance to Blue Plains thereby preventing a dry weather overflow. Further, if Potomac Pumping Station or the Potomac Force Mains experience equipment failures or need to be worked on for repair or maintenance, the gravity tunnel can be used as a backup to convey flows to Blue Plains for treatment.

- The gravity Potomac Tunnel is more environmentally responsible because it eliminates the need for an energy intensive pumping station.

- **Separation of Combined Sewers (CSOs 025 – 026)**
  The drainage areas for CSO 025 (17 acres) and CSO 026 (3 acres) are very small and, therefore, it is practical to separate the tributary combined sewers. Separation will result in the elimination of combined sewer overflows from these sewersheds.

- **Green Infrastructure (CSOs 027 – 029)**
  GI will provide CSO control in these outlying sewersheds. GI will treat 30% of impervious areas in the CSO 027 and 028 sewersheds, and 60% of impervious areas in the CSO 029 sewershed, for a total of 133 impervious acres. GI will be sized to provide capture equivalent to 1.2” of rain falling on an impervious surface. GI projects may include bioretention practices (bioretention cells, bioswales, vegetated filter strips, and tree box filters), rooftop collection practices (green roofs, blue roofs, downspout disconnection, rain barrels, and cisterns), permeable pavement, and large-volume underground storage. In addition to GI, targeted sewer separation may be utilized to offload storm water from the combined sewer system. Diversion structures within the CSO 027, 028, and 029 sewersheds will be modified to increase diversion capacities. The diversion structure improvements coupled with the GI are predicted to provide a degree of CSO control comparable to the LTCP.

CSO 025 Separation
Sewershed = 17 acres

CSO 026 Separation
Sewershed = 3 acres

CSO 027 30% GI Implementation
Sewershed = 164 acres
Impervious = 104 acres
30% GI = 31 acres

CSO 028 30% GI Implementation
Sewershed = 21 acres
Impervious = 13 acres
30% GI = 4 acres

CSO 029 60% GI Implementation
Sewershed = 330 acres
Impervious = 164 acres
60% GI = 98 acres

3.2.2 Predicted Performance

Hydraulic modeling predictions indicate that the hybrid green/gray controls are predicted to provide a degree of CSO control equivalent to the gray controls in the LTCP. Predicted CSOs are summarized in Table 3-3. Predicted water quality is summarized in Table 3-4 and the data show that the GI controls are predicted to provide a degree of water quality performance in the receiving water equivalent to the gray controls in the LTCP.

Green and Green/Gray Controls

Table 3-3
Potomac River Predicted CSO Overflows (Average Year)

Parameter	Before LTCP[1]	LTCP	Green/Gray Controls[2]
No. of Overflows (#/avg yr)	74	4	4
Overflow Volume (mg/avg yr)	953	79	59
% reduction from Before LTCP	--	92%	92% or greater

Table 3-4
Potomac River Predicted Water Quality
Memorial Bridge (Segment 6) in Average Year

Parameter	Before LTCP[1]	LTCP	Green/Gray Controls[2]
# Months Fecal Geomean>200 (all loads)	3	1	1
# Months Fecal Geomean>200 (CSO only)	0	0	0
# Days Fecal>200 (all loads)	142	109	109
# Days Fecal>200 (CSO Only)	57	6	3
# Days Fecal>200 (all loads) May - Sept	64	44	44
# Days Fecal>200 (CSO Only) May - Sept	33	4	1
# Months E. Coli Geomean>126 (all loads)	2	0	0
# Months E. Coli Geomean>126 (CSO only)	0	0	0
# Days E. Coli>126 (all loads)	118	77	74
# Days E. Coli>126 (CSO Only)	60	6	3
# Days E. Coli>126 (all loads) May - Sept	57	36	30
# Days E. Coli>126 (CSO Only) May - Sept	35	5	1
# days D.O.< 5 mg/L (all loads)	0	0	0
# days D.O.< 5 mg/L (CSO Only)	0	0	0

Notes for Tables 3-3 and 3-4:

1. Results shown for Before LTCP are without Phase1 Controls in place (i.e. without inflatable dams, pumping station rehabilitations and Northeast Boundary Swirl Facility in operation).
2. At the low levels of CSO overflows projected herein, model accuracy is highly dependent on many variables such as the accuracy of rainfall data, information on the drainage area and other factors. Further, additional overflows will occur for rain events which exceed or are not represented in the average year. The model predictions contained herein do not change the level of CSO control determined to be adequate to meet water quality standards which was included by DC Water in its LTCP, and subsequently approved by EPA and the D.C. Department of the Environment.

Green and Green/Gray Controls

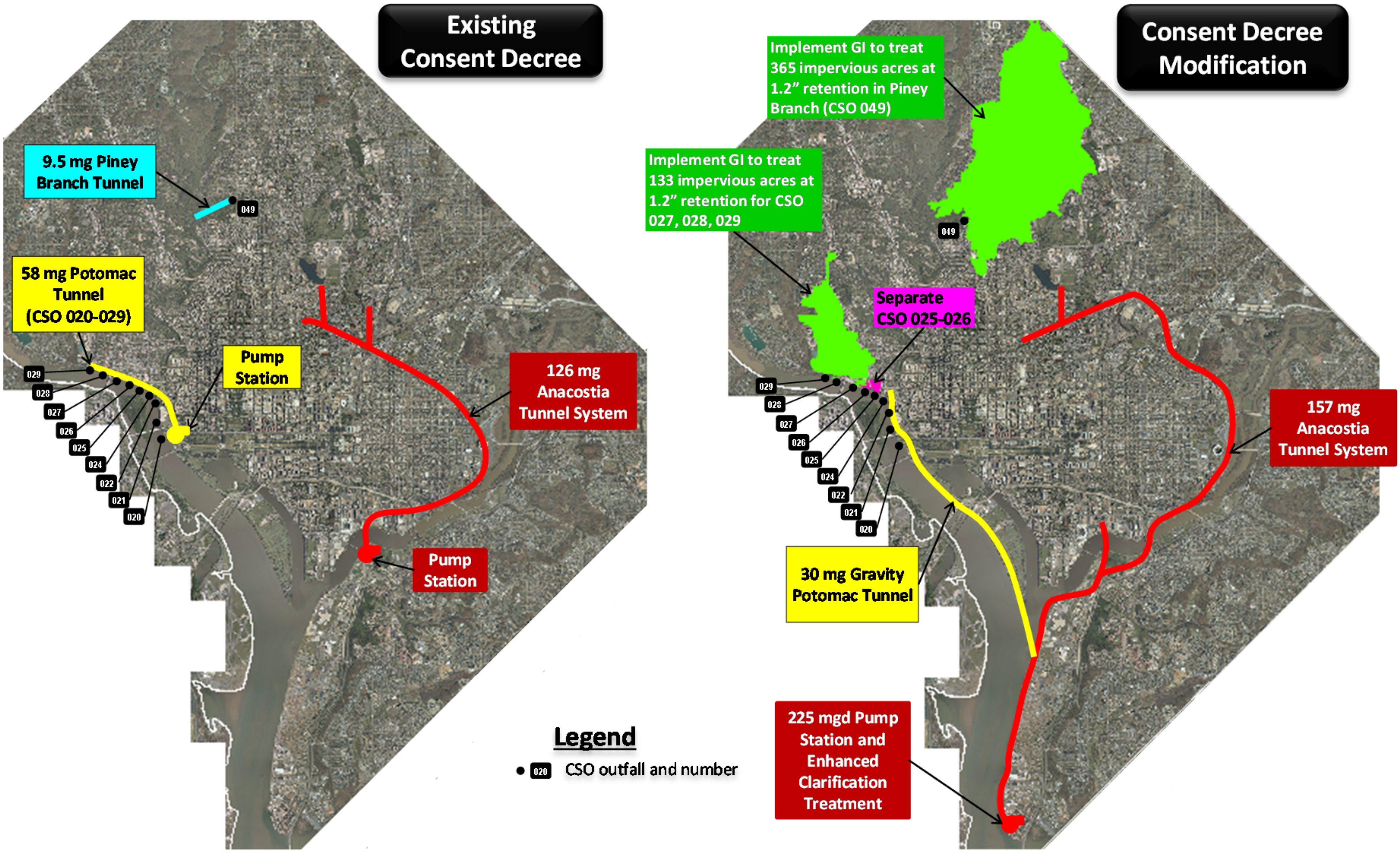

Figure 3-1: Green and Green/Gray Controls

APPENDIX F

APPENDIX F
GREEN INFRASTRUCTURE PROGRAM FOR THE POTOMAC AND ROCK CREEK SEWERSHEDS

I. Green Infrastructure Program Plan

Within 12 months after the Effective Date of the First Amendment to the Consent Decree, DC Water shall submit to EPA for approval pursuant to Section X (EPA Approval of Plans and Submissions) of this Consent Decree a Green Infrastructure Program Plan (the "GI Program Plan"). The GI Program Plan shall include the information described in subsections A, B, and C below:

A. **Green Infrastructure Control Measures**.

1. Identification and description of the GI control measures (including any targeted sewer separation projects) that DC Water intends to install (or have the District or other entities install on its behalf), the approximate locations of the sites for the measures, and the estimated cost to implement the measures.

2. The conceptual project location identifications and descriptions, and cost estimates for the measures that DC Water intends to install (or have the District or other entities install on its behalf), which shall correspond to the individual GI Projects set forth in the schedule in Section II of this Appendix F.

3. An estimate of the number of acres of land projected to be effectively retrofitted with GI in the Potomac and Rock Creek sewersheds prior to 2030 pursuant to the District's MS4 permit and storm water regulations.

B. **Preservation and Maintenance of Constructed Green Infrastructure Projects**. A plan to (1) preserve and maintain the GI control measures installed pursuant to the GI Program Plan and (2) ensure that future site or land use changes do not result in the loss of the runoff reduction benefits of the GI control measures installed pursuant to the GI Program Plan, unless that loss is compensated for by other controls in the same CSO drainage area.

C. **Public Outreach**. A plan to engage property owners in the Potomac and Rock Creek sewersheds and interested stakeholders to promote and facilitate installation of GI on private property and to ensure public input into the site selection process and concept design for the control measures that DC Water proposes to install as part of the GI Program Plan.

II. DC Water Implementation Schedule

DC Water shall construct and Place in Operation the GI control measures assigned to it and set forth in the GI Program Plan developed pursuant to Section I of this Appendix F in accordance with the following schedule.

A. Six months prior to the award contract for construction for each of the projects listed in this section, DC Water shall submit a Project Description to EPA for review and comment. The Project Description shall contain:

1. An identification of the CSO areas where the projects are to be implemented

2. The types of GI control that are to be employed and the rational for their use

3. The approximate location of the controls

4. The estimated acreage that will be controlled to a 1.2” retention standard

5. A schedule for implementation of the controls

6. The estimated cost for each type of control to be employed

7. The total cost for the Project

8. Post Construction Monitoring and Modeling Program for this project to demonstrate the capture efficiency of the controls to be implemented

B. Six months following the completion of a project’s post construction monitoring program, DC Water shall submit a Post Construction report for EPA review and comment. The Post Construction Report shall contain:

1. A comparison of planned projects under the Project Description and actual implemented projects:

   (a) Costs

   (b) Acreage treated to 1.2” retention standard

   (c) Estimate of run-off control.

2. Identification of barriers to implementation of projects and steps taken by DC Water and the District to address any identified barriers for this and future projects

3. Post Construction Monitoring and Modeling Program results assessing the efficiency of the controls implemented

4. Changes proposed for future projects

C. Potomac Sewershed Projects: In accordance with the following schedule, construct GI, including targeted sewer separation, in the CSO 027, 028 and 029 sewersheds designed to:

1. Project No. 1: Control 44 acres to the 1.2” Retention Standard

   (a) Award Contract for Construction: June 23, 2017

   (b) Place in Operation: June 23, 2019

2. Project No. 2: Control 46 acres to the 1.2” Retention Standard

   (a) Award Contract for Construction: June 23, 2022

   (b) Place in Operation: June 23, 2024

3. Project No. 3: Control 43 acres to the 1.2” Retention Standard

   (a) Award Contract for Construction: June 23, 2025

   (b) Place in Operation: June 23, 2027

4. Controlled acres placed in operation in excess of those specified for a given project in this paragraph II.C may be credited against the acres required to be controlled on subsequent projects.

5. No later than 15 months following the Place in Operation date for Project No. 1 above, DC Water shall submit to EPA and the District Post Construction Monitoring Report No. 1 for the Potomac Sewershed Projects (Potomac Report No. 1). In addition to the information required in Subsection II.B above, the report shall contain DC Water’s determination of the practicability of controlling at least 133 acres to the 1.2” Retention Standard in the CSO 027, 028 and 029 sewersheds by the Place in Operation deadline for Project No. 3 above based on its experience with implementing Project No. 1. Such determination shall consider the constructability, operability, efficacy, public acceptability and cost per impervious acre treated of the controls.

6. EPA shall either approve or disapprove of the determination required by Paragraph 5 above. If EPA fails to either approve or disapprove the determination within 180-days following receipt of Potomac Report No. 1, any subsequent deadline that is dependent upon such approval or disapproval shall be extended by the number of calendar days beyond the 180-day period that EPA uses to approve or disapprove the determination.

The process for approving or disapproving the determination shall be governed by Paragraph 39 of the Consent Decree.

7. In the event DC Water determines that it is not practicable to control at least 133 acres to the 1.2” Retention Standard in the CSO 027, 028 and 029 sewersheds by the Place in Operation deadline for Project No. 3 above and such determination is approved by EPA, DC Water shall:

(a) Plan, design, and construct the Potomac River Storage/Conveyance Tunnel with a total storage volume of not less than 40 million gallons, at any time up to, but no later than the following schedule

(i) Award Contract for Detailed Design: Three (3) months after EPA approval

(ii) Award Contract for Construction: Two (2) years and six (6) months after EPA approval

(iii) Place in Operation: Nine (9) years after EPA approval

(b) Be relieved of its obligation to implement Project Nos. 2 and 3 above; and

(c) Operate and maintain the GI constructed in Project No. 1 in accordance with its NPDES Permit.

D. Rock Creek Sewershed Projects: In accordance with the following schedule, construct GI, including targeted sewer separation, in the CSO 049 (Piney Branch) sewershed designed to:

1. Project No. 1: Control 20 acres to the 1.2” Retention Standard

(a) Award Contract for Construction: March 30, 2017

(b) Place in Operation: March 30, 2019

2. Project No. 2: Control 75 acres to the 1.2” Retention Standard

(a) Award Contract for Construction: January 23, 2022

(b) Place in Operation: January 23, 2024

3. Project No. 3: Control 90 acres to the 1.2” Retention Standard

(a) Award Contract for Construction: March 23, 2025

(b) Place in Operation: March 23, 2027

4. Project No. 4: Control 90 acres to the 1.2” Retention Standard

   (a) Award Contract for Construction: September 30, 2027

   (b) Place in Operation: September 30, 2029

5. Project No. 5: Control 90 acres to the 1.2” Retention Standard

   (a) Award Contract for Construction: March 23, 2028

   (b) Place in Operation: March 23, 2030

6. Controlled acres placed in operation in excess of those specified for a given project in this paragraph II.D. may be credited against the acres required to be controlled on subsequent projects.

7. No later than 15 months following the Place in Operation date for Project No. 1 above, DC Water shall submit to EPA and the District Post Construction Monitoring Report No. 1 for the Rock Creek Sewershed Projects (Rock Creek Report No. 1). In addition to the information required in Subsection II.B above, the report shall contain DC Water’s determination of the practicability of controlling at least 365 acres to the 1.2” Retention Standard in the CSO 049 sewershed by the Place in Operation deadline for Project No. 5 above based on its experience with implementing Project No. 1. Such determination shall consider the constructability, operability, efficacy, public acceptability and cost per impervious acre treated of the controls.

8. EPA shall either approve or disapprove of the determination required by Paragraph 7 above. If EPA fails to either approve or disapprove the determination within 180-days following receipt of Rock Creek Report No. 1, any subsequent deadline that is dependent upon such approval or disapproval shall be extended by the number of calendar days beyond the 180-day period that EPA uses to approve or disapprove the determination. The process for approving or disapproving the determination shall be governed by Paragraph 39 of the Consent Decree.

9. In the event DC Water determines that it is not practicable to control at least 365 acres to the 1.2” Retention Standard in the CSO 049 sewershed by the Place in Operation deadline for Project No. 5 above and such determination is approved by EPA, DC Water shall:

   (a) Construct a Rock Creek Storage Facility the (Facility), which shall store combined sewer flow from the Piney Branch Outfall, CSO 049, in accordance with DC Water’s NPES Permit. The storage capacity of the Facility will be at least nine and one-half (9.5) million gallons. After the Facility is Placed in Operation, in the event of wet weather causing the facility to be used for storage, DC Water shall dewater the Facility to the CSS as soon as practicable, but in no event longer than 59 hours, and shall convey the contents of the Facility to Blue Plains for treatment in accordance with DC Water's NPDES permit. The location of the Facility will be finalized during Facility Planning and design, but it will be between CSO 049 and Rock Creek and its approximate location is depicted in Page ES-9 of Appendix A to this Decree;

(b) Plan, design, construct and Place in Operation the Facility at any time up to, but no later than the following schedule:

(i) Award Contract for Detailed Design: Three (3) years six (6) months after EPA approval

(ii) Award Contract for Construction: Five (5) years six (6) months after EPA approval

(iii) Place in Operation: Nine (9) years after EPA Approval

(c) Be relieved of its obligation to implement Project Nos. 2, 3, 4 and 5 above; and

(d) Operate and maintain the GI constructed in Project No. 1 in accordance with its NPDES Permit.

E. **Credit for Other Controlled Acres**. Controlled acres from the implementation of the District's MS4 Permit and Stormwater Regulations will be credited against DC Water's obligations to control acres in paragraphs II.C. and II.D. if:

1. They are located in the CSO areas targeted for GI implementation by DC Water; and

2. The design of the control measures and their level of control has been verified by DC Water to achieve the 1.2" retention standard or any portion thereof. Where green infrastructure installations by any party do not meet the full 1.2" design criterion and are counted towards meeting the requirements of this consent decree, DC Water may proportionally credit the control achieved; and

3. DC Water, the District or a private party has assumed operation and maintenance responsibilities in a legally binding document or as part of its statutory or regulatory authority.

F. **DC Water Commitments to Coordinate with the District.** The commitments of DC Water in coordinating with the District are:

1. DC Water shall consult with the District's Program Coordinator and relevant District agencies in selecting planned GI projects proposed for District property or rights of way to ensure coordination with District infrastructure policies and priorities;

2. DC Water shall submit draft GI construction staging packages identifying facilities to be constructed, including preliminary engineering plans and specifications, staging areas, estimated construction durations, work hours and traffic management plans for review by the District and shall do so sufficiently in advance of construction of the various GI contract divisions in order to allow adequate time for the District to review the packages, for the District and DC Water to resolve any issues, and for the District to issue the permits before the expected start date of construction;

3. DC Water shall prepare 30%, 60%, 90% and 100% documents each for RFP and design for District review and comment prepared in accordance with terms agreed to by the District and DC Water;

4. DC Water shall submit a maintenance and monitoring plan, including the funding methodology, for each GI Project to the District agencies having jurisdiction.

5. DC Water shall submit applications for public space, construction, and any other necessary permits for each project or facility;

6. DC Water shall submit the documents required by this section sufficiently in advance of construction in order to allow adequate time for the District to review the document, for the District and DC Water to resolve any issues, and for the District to issue the permits or other legal authority before the expected start date of construction of the project.

7. DC Water shall work with the District to coordinate and align capital projects and expenditures, where feasible and practical, to allow implementation of the GI projects in a manner that enables the efficient use of resources and minimizes costs to the taxpayers and rate-payers.

8. DC Water shall assure that GI credited towards meeting DC Water's obligations to control acres in paragraphs II.C. and II.D is inspected no less than once every three years and that any deficiencies are corrected.

III. District of Columbia Government Commitments

A. The commitments of the District in support of the GI Projects are:

1. The District agrees to provide the public space necessary for DC Water to construct GI to control 365 acres to the 1.2" Retention Standard in the CSO 049 sewershed and 133 acres to the 1.2" Retention Standard in the

CSO 027, 028 and 029 sewersheds, less any acres controlled from implementation of the District's MS4 Permit and Stormwater Regulation. The District and DC Water will establish procedures for identifying GI locations, technologies, and issuance of permits for construction, operation and maintenance and other matters in a Memorandum of Understanding. The Memorandum of Understanding will be executed within 24 months of the Effective Date of the First Amendment to Consent Decree.

2. The District will appoint an executive-level District official as the District's Program Coordinator within 6 months of Effective Date of the First Amendment to the Consent Decree. The Coordinator will be charged with coordinating and expediting the work of the relevant District offices, departments and agencies;

3. After submission by DC Water of each construction staging package, the District shall review the proposed construction staging areas, construction durations, maintenance of traffic, parking mitigation, work hours and facilities to be constructed, and work with DC Water to resolve any concerns and issue approval letters identifying the conditions that must be met in order to obtain permits for construction;

4. The District shall issue permits for construction within thirty (30) business days of submittal of a complete application package prepared in accordance with an approval letter;

5. After submission and review of the maintenance and monitoring plan for a GI Project submitted by DC Water, the District shall issue permits or other legal authority to DC Water in advance of the completion of construction of the GI Projects allowing access for the maintenance and monitoring of the project; unless, as part of the maintenance and monitoring plan submitted by DC Water and approved by the District, the District or private party will be responsible for the maintenance and monitoring of the project.

6. The District shall revise its storm water policies regarding in-lieu fees to include the following:

   (a) In-lieu fees paid by regulated projects in the CSO 027, 028, 029 and 049 sewersheds will be used to fund construction of GI in those sewersheds; and

   (b) In-lieu fees paid by regulated projects in combined sewersheds will not be used to fund projects in combined sewersheds controlled by the Gray CSO Controls required by this Consent Decree.

7. The District shall submit a report to EPA for review and comment no later than March 1, 2016 identifying impediments to implementation of the GI Projects and identifying proposed changes to the regulations, codes, standards, guidelines and policies by reviewing the following items at a minimum:

   (a) Storm water regulations and policies; including a review of the practicability of incentivizing storm water retention credits (SRCs) to maximize water quality benefits;

   (b) District Department of Transportation ("DDOT") Design and Engineering Manual;

   (c) Zoning regulations;

   (d) Plumbing and Building Codes;

   (e) DDOT Urban Forestry Guidelines;

   (f) DDOT Green Infrastructure Standards; and

   (g) DC Water Utility Protection Guidelines.

8. The District shall take the following actions with respect to the proposed amendments to the regulations, codes, standards and guidelines included in the reports described in paragraphs above:

   (a) For statutory amendments, the District shall submit to the Council by no later than March 1, 2017, proposed legislation to enact the statutory amendments;

   (b) For regulatory amendments that require Council approval, the District shall publish a notice of proposed rulemaking by March 1, 2017, and shall submit to the Council by no later than January 1, 2018, a proposed resolution to approve the final rules;

   (c) For regulatory amendments that require Zoning Commission approval, the District shall submit proposed zoning language to the Zoning Commission for its approval by no later than March 1, 2017;

   (d) For regulatory amendments that do not require Council or Zoning Commission approval, the District shall issue a notice of proposed rulemaking by March 1, 2017;

   (e) For statutory amendments and for regulatory amendments that require Council approval, the District shall take such actions as are necessary to obtain the Council's approval of the proposed legislation by March 1, 2018;

(f) For regulatory amendments that require Zoning Commission approval, the District shall take such actions as are necessary to obtain the Zoning Commission's adoption of the regulatory amendments by March 1, 2018; and

(g) For regulatory amendments that do not require Council or Zoning Commission approval, the District shall issue a notice of final rulemaking no later than March 1, 2018.

B. Anti-Deficiency Act Events: Nothing in this Decree shall be construed to require an expenditure, obligation or contract in violation of the Anti-Deficiency Act, 31 U.S.C. §§ 1341 et seq. Where an expenditure, obligation or contract is subject to the Anti-Deficiency Act, the District's obligations shall be subject to the availability of appropriated funds.

IV. Additional Coordination between DC Water and District

DC Water and the District will work together to coordinate and align capital projects and expenditures, where feasible and practical, to allow implementation of the GI Projects in a manner that enables the efficient use of resources and minimizes costs to the taxpayers and rate-payers. As part of this process, the District and DC Water will identify capital projects in the sewersheds for CSO 027, 028, 029 and 049 that are projected to be completed during the subsequent three (3) years and that provide an opportunity to include more than $200,000 of green infrastructure in excess of that required by District law. DC Water may request the District to incorporate in one or more of these projects GI in excess of that required by District law. The District agrees to grant such requests if DC Water agrees to fund the incremental design, construction, monitoring and maintenance costs of GI implemented by the District in excess of GI required by District law, the amount of such funding is agreed to by the District and DC Water, and the proposed GI is consistent with the District's current and potential future program for the project. Such excess GI will be credited to the acres required to be controlled in Subsections II.C and II.D of this Appendix F.

V. Reporting

A. Following EPA's approval of the GI Program Plan, DC Water shall report on the status of implementation of the GI Program Plan in each Quarterly Report required by Section XI (Reporting) of this Decree. The reports shall describe the status (i.e., in design, in procurement, under construction, or completed) of the control measure projects identified in the Plan. As part of the First Quarterly Report of each calendar year, DC Water shall include the following information for the prior calendar year:

1. Total acres of impervious area treated by GI installed and by sewer separation since the Effective Date of the First Amendment to the Consent Decree in the sewersheds for CSO 027, 028, 029 in the Potomac and CSO 049 (Piney Branch);

2. Acres of impervious area treated by GI pursuant to the District's MS4 permit and Stormwater Regulations installed since the Effective Date of the First Amendment to the Consent Decree in the sewersheds for CSO 027, 028, 029 in the Potomac and CSO 049 (Piney Branch); and the numbers of such acres credited in accordance with Section II.C of this Appendix F;

3. The activities the District and DC Water have taken to coordinate and align capital projects to minimize costs associated with implementation of the GI Projects by DC Water.

Appendix B

Rock Creek GI Project No. 1: Post Construction Report

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT
GREEN INFRASTRUCTURE PROGRAM

ROCK CREEK GI PROJECT NO. 1
POST CONSTRUCTION REPORT

June 2020

Prepared for:

dc water is life

Prepared by:

dc clean RIVERS PROJECT
RESTORING OUR RIVERS
PROTECTING OUR DISTRICT

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 20032

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1 Introduction

1.1 Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP), also referred to as the DC Clean Rivers Project (DCCR), to control combined sewer overflows (CSOs) to the District of Columbia's (District) waterways. DCCR is comprised of a variety of projects to control CSOs, including pumping station rehabilitations, green infrastructure (GI), and a system of underground storage/conveyance tunnels. DCCR is being implemented in accordance with a first amendment to the Consent Decree (Amended Consent Decree), entered on January 14, 2016, which amends and supersedes the 2005 Consent Decree (Consent Decree) and incorporates GI, in a combination of gray and green solutions to control CSOs while improving the quality of life in the District.

The purpose of this document is to demonstrate compliance with the Amended Consent Decree requirement as stated in the Amended Consent Decree's Appendix F, Section II.B which states "Six months following the completion of the project's post construction monitoring program, DC Water shall submit a Post Construction report for EPA review and comment."

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2 Post Construction Report for Rock Creek Project No. 1

The Amended Consent Decree's Appendix F, Section II.B, states: "Six months following the completion of the project's post construction monitoring program, DC Water shall submit a Post Construction report for EPA review and comment. The Post Construction Report shall contain:

1. A comparison of planned projects under the Project Description and actual implemented projects:
    a. Costs
    b. Acreage treated to 1.2" retention standard
    c. Estimate of run-off control.
2. Identification of barriers to implementation of projects and steps taken by DC Water and the District to address any identified barriers for this and future projects
3. Post construction Monitoring and Modeling Program results assessing the efficiency of the controls implemented
4. Changes proposed for future projects"

This Section addresses this requirement of the Amended Consent Decree.

2.1 Comparison of Costs – Planned vs. Actual

Rock Creek Project No. 1 includes the following: Rock Creek Project A (RC-A), Kennedy Street – GI Streetscape, GI Challenge Parks, Green Alley Partnership (AlleyPalooza), and Downspout Disconnections. Table 2-1 compares the total project cost for Rock Creek Project No. 1 as estimated in the Project Description (2016) to the actual project cost after construction.

Table 2-1. Cost Comparison Planned vs. Implemented

Rock Creek Project No. 1	Cost
Planned Project Cost (in 2015 capital costs)	\$20 - \$30 million
Implemented Project Costs (actual)	\$16.85 million[1]
	\$2.15 million[2]
	\$1.58 million[3]
	\$1.67 million[4]
	\$0.49 million[5]
Total Implemented Project Costs:	**\$22.74 million**

Note:
1. Rock Creek Project A (RC-A)
2. Kennedy Street – Streetscape
3. GI Challenge Parks
4. Green Alley Partnership (AlleyPalooza)
5. Downspout Disconnect

2.2 Comparison of Acreage Treated to 1.2" Retention Standard and Estimate of Run-off Control

The first Rock Creek GI project under the Amended Consent Decree was required to manage 1.2" of stormwater runoff from at least 20 impervious acres. Under Rock Creek Project No. 1, 27.4 acres were built. Table 2-2 shows the breakdown of acres per project.

Table 2-2. Practices Constructed and Impervious Acres Managed by Project

Sewershed	Project	Bioretention	Permeable Pavement	Targeted Sewer Separation	Downspout Disconnect	Total
Number of Projects						
Rock Creek Project 1	RC-A	38	39			77
	Kennedy Street	21	12			33
	Challenge Parks	2				2
	AlleyPalooza		6			6
	Downspout Disconnect				304[1]	304
	Total	**61**	**57**	**0**	**304**	**422**
Impervious Acres Managed						
Rock Creek Project 1	RC-A	3.9	14.9			18.8
	Kennedy Street	1.2	1.5			2.7
	Challenge Parks	1.9				1.9
	AlleyPalooza		3.0			3.0
	Downspout Disconnect				1.0	1.0
	Total	**7.0**	**19.4**	**0.0**	**1.0**	**27.4**

[1] Represents the number of individual downspouts disconnected

2.3 Barriers to Implementation

There were no barriers that prevented implementation of the control measures outlined in the Rock Creek GI Project No. 1 Project Description submitted to EPA in July 2016.

2.4 Pre-Construction Monitoring - Sewershed

For pre-construction monitoring, Figure 2-1 and Figure 2-2 show 1-to-1 plots for wet weather event volumes and peak flows for pre-construction monitoring calibration. A complete set of event hydrographs, monthly plots and rainfall events tabulations are included in Appendix A.

Overall modeled predictions match event volumes well for meters 049-1 and 049-2 combined with the regression close to the 1-to-1 line and an R-squared value of 0.85. The overall wet weather volume match is acceptable with a difference of only 7%. Peak flow response is more variable in the 1-to-1 plots. The hydrograph comparisons for individual events show a great variability in metered sewer response for rainfall events of similar size.

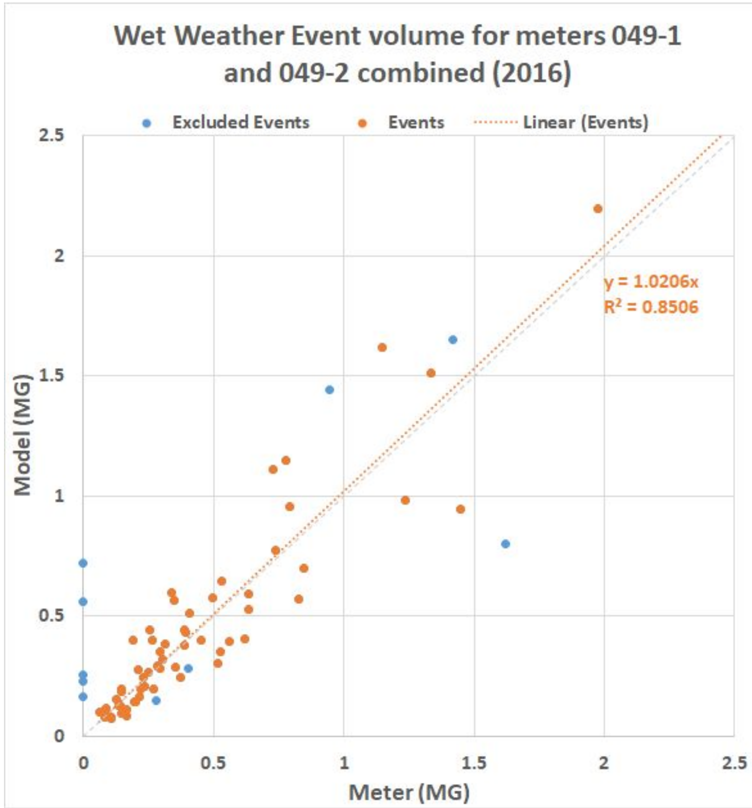

Figure 2-1. RC-A Pre-Construction Event Volumes, 049-1 and 049-2 Combined

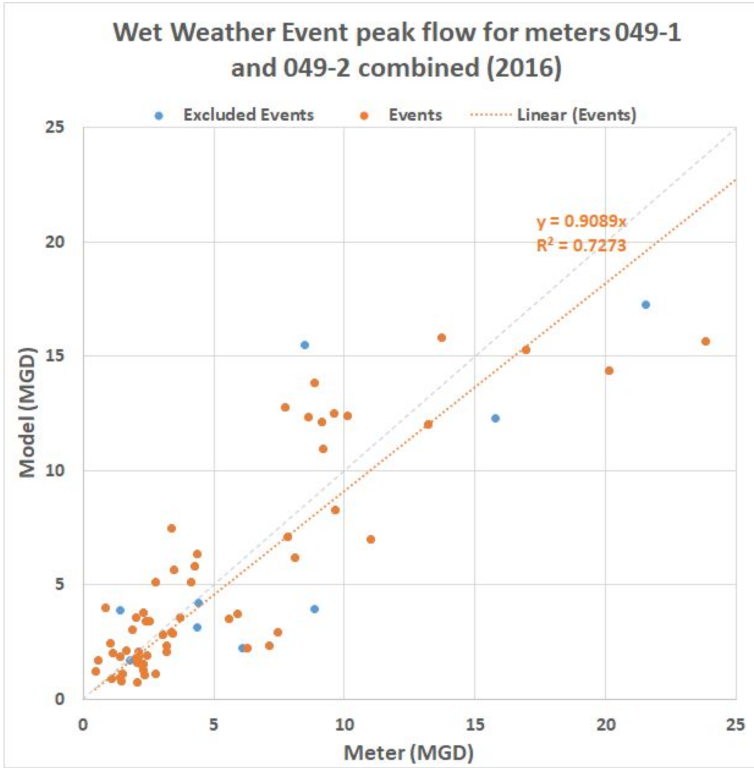

Figure 2-2. RC-A Pre-Construction Event Peak Flows, 049-1 and 049-2 Combined

2.5 Post-Construction Monitoring - Sewershed

For post-construction monitoring using sewershed flow monitoring data, Figure 2-3 and Figure 2-4 show 1-to-1 plots for wet weather event volumes and peak flows for the combined flows from metering locations 049-1 and 049-2. A complete set of event hydrographs, monthly plots and rainfall events tabulations is included in Appendix A.

Overall modeled predictions match event volumes well for meters 049-1 and 049-2 combined, with the regression close to the 1-to-1 line and an R-squared value of 0.94 for the calibration timeframe (3/1/2019 – 7/18/2019). The overall wet weather volume match is acceptable with a difference of only 8%. Peak flow response is more variable in the 1-to-1 plots. The hydrograph comparisons for individual events show a great variability in metered sewer response for rainfall events of similar size.

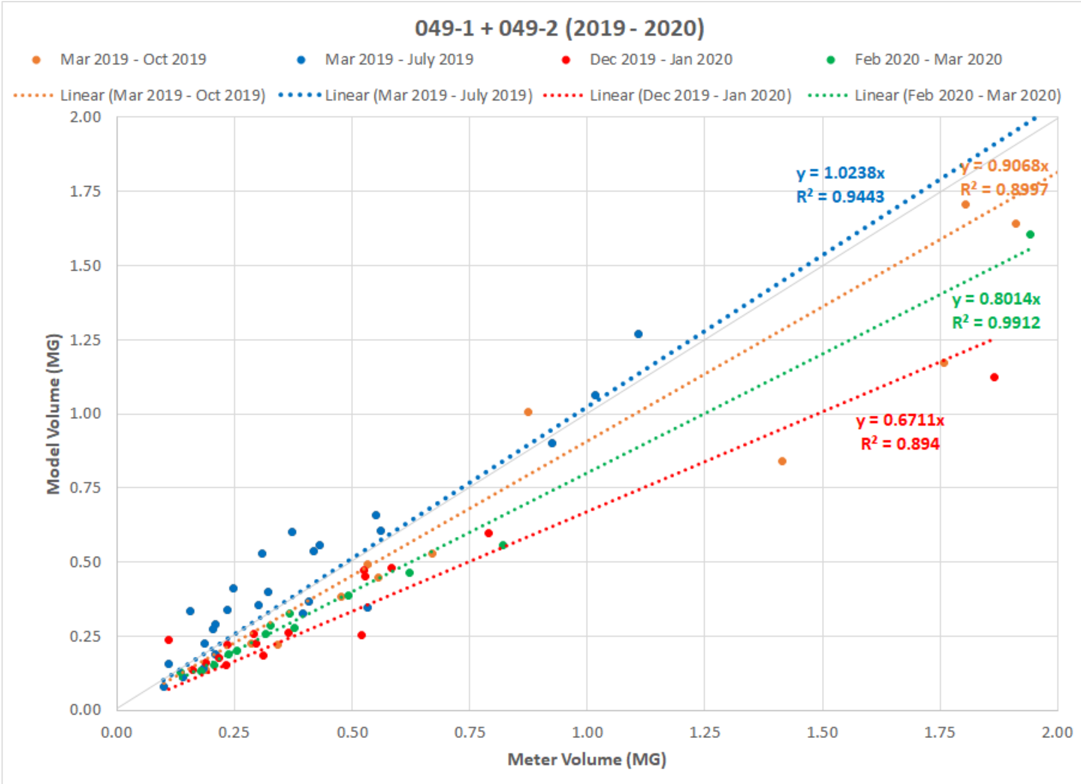

Figure 2-3. Post-Construction Event Volumes, 049-1 and 049-2 Combined

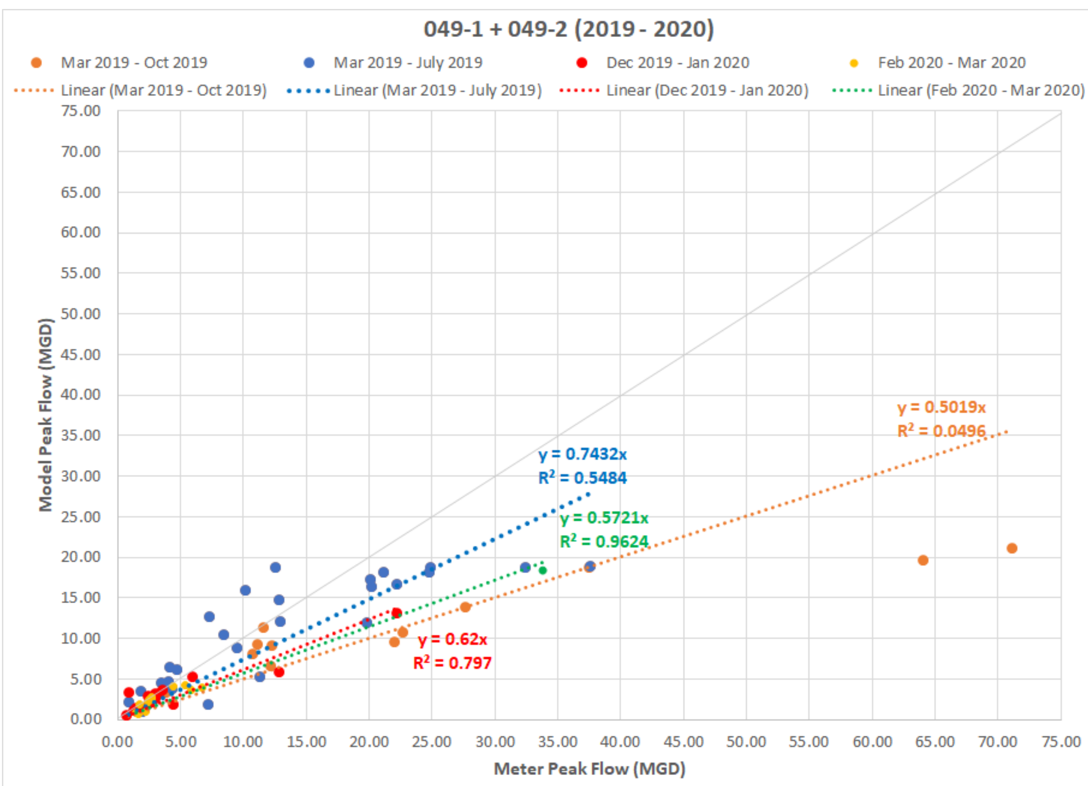

Figure 2-4. Post-Construction Event Peak Flows, 049-1 and 049-2 Combined

2.6 Post-Construction Monitoring - GI Practice-Level

The post-construction model was calibrated using sewershed monitoring data from meters 049-1 and 049-2 for the timeframe 3/1/2019 – 7/18/2019. Modeled water levels for the GI (lumped) practices were compared with the observed in-practice water levels. GI model parameters were adjusted using this data to better match the observed in-practice water levels. The following adjustments were made:

- Re-calibration of model for all practice types (APP, PPP, PBR) using data from the four observed practices for the timeframe of 1/25/20 - 2/29/20 (five wet weather events). Data from the three of the four observed practices (3503-PBR, 3608-APP, 4211-PPP) was used to calibrate the water levels in the corresponding "lumped" model practices. The adjusted model parameters were then applied to all practices of that model type.

- Re-calibration for all model practices using data from all 73 observed practices for the timeframe of 3/13/20 – 3/22/20 (three wet weather events). Averaged water level observations for each practice type were compared to the average modeled water levels for each practice type.

Figure 2-5 show 1-to-1 plot for wet weather event volumes for the combined flows from metering locations 049-1 and 049-2. A complete set of event hydrographs, monthly plots and rainfall events tabulations are included in Appendix A.

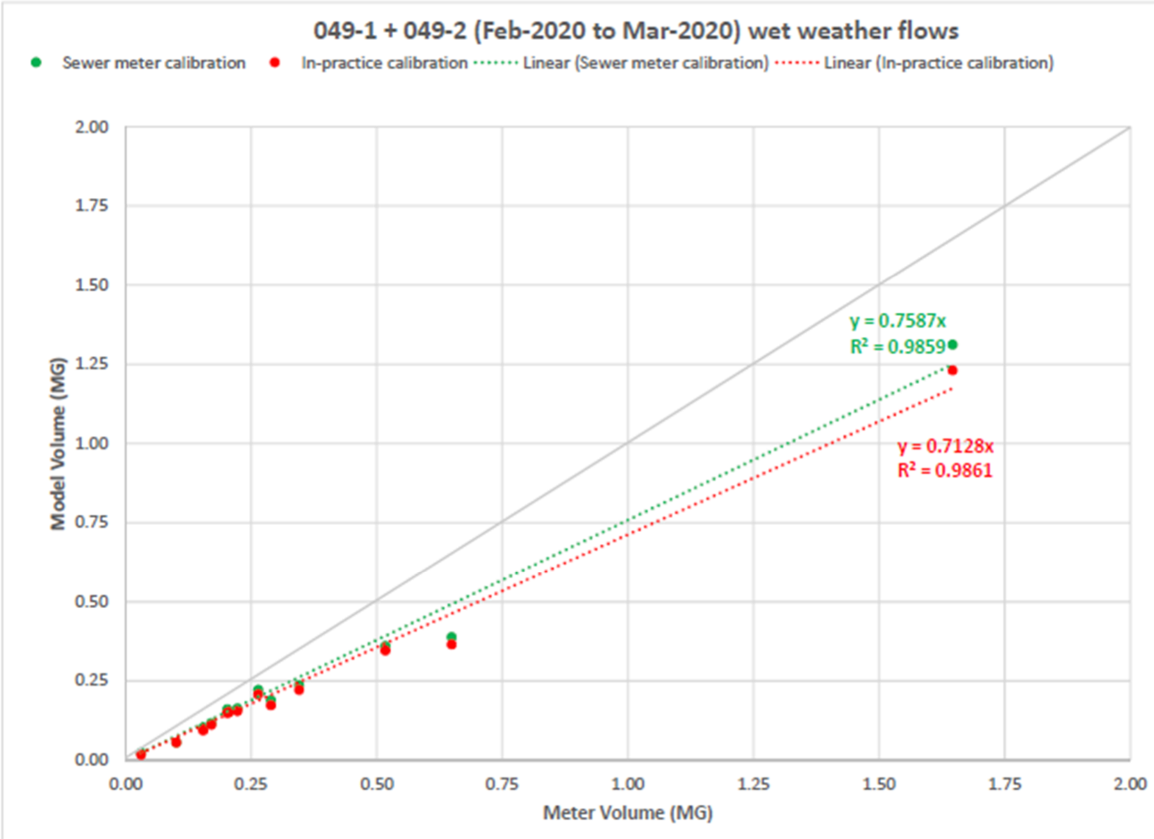

Figure 2-5. Post-Construction Event Volumes, 049-1 and 049-2 Combined

The modeling of the RC-A green infrastructure reflects the sewer meter flow data and the practice-specific water level data. The RC-A model has been calibrated to fit the data from these two types of data sources in addition to accounting for the retrofit periods that occurred during the post-construction monitoring period. Most recent monitoring period (beginning February 2020) that reflect retrofits and practice-level monitoring for all practices is of shorter duration, and the calibration of the model to those periods relies on fewer events.

The results presented in Table 2-3 are based on the in-practice level data using a methodology for modeling, in which the wet weather flow volumes are defined as occurring when predicted flows in the sewer are exceeding two times average dry weather flow rate. The reduction in WWF volumes per average year were calculated by taking the difference between pre- and post-construction WWF volumes divided by the number of impervious acres treated at 1.2” to determine the WWF reduction in million gallons per average year per impervious acres treated at 1.2”.

Table 2-3. Post Construction Monitoring Results

Sewershed	Impervious Acres treated by GI (% of total)	WWF volume Normalized to Impervious Acres Treated – Pre-construction	WWF volume Normalized to Impervious Acres Treated – Post Construction	Volume Reduction (%)
2019 Rainfall Conditions				
Rock Creek Project A (After Retrofits)	28.8 %	31.49	27.10	18.46%
Average Year Rainfall Conditions (1988, 1989, 1990)				
Rock Creek Project A (After Retrofits)	28.8 %	26.66	22.90	18.68%

2.7 Changes for Future Projects

Since a determination of practicability for controlling at least 365 acres to the 1.2” Retention Standard in the CSO 049 sewershed by the Place in Operation deadline for Project No. 5 (March 23, 2030) is being undertaken concurrently, please refer to the Practicability Assessment for Rock Creek Green Infrastructure Report dated June 2020 for changes in future projects in this sewershed.

Appendix A

Model Documentation:
Green Infrastructure Modeling for RC-A Area

(this appendix can be found as Appendix E of the
Rock Creek Practicability Report dated June 2020)

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Appendix C

GI Challenge Projects

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PUBLIC MEETING

Green Infrastructure Challenge

Thursday, July 9, 6 - 8 pm

(Open house format)

Roots Public Charter School, Multi-Purpose Room

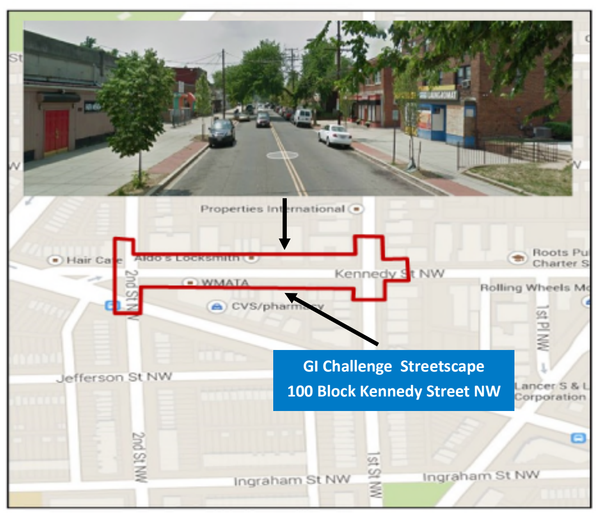
15 Kennedy Street NW, Washington DC, 20011

DC Water will hold a public meeting to present the final concept plans of two upcoming Green Infrastructure projects to be constructed as par t of the DC Clean Rivers Project:

Kansas Avenue Green Infrastructure Parks

Kansas Avenue and 3rd Street NW
&
Kansas Avenue and 2nd Street NW

Kennedy Street Green Infrastructure



100 Block of Kennedy Street NW

For more information, please contact Lilia Ledezma at (202) 787-4496

by email at lilia.ledezma@dcwater.com

Or visit the project website at dcwater.com/greenchallenge

District of Columbia Water and Sewer Authority
George S. Hawkins, General Manager

Briefing on:

Green Infrastructure Challenge Projects

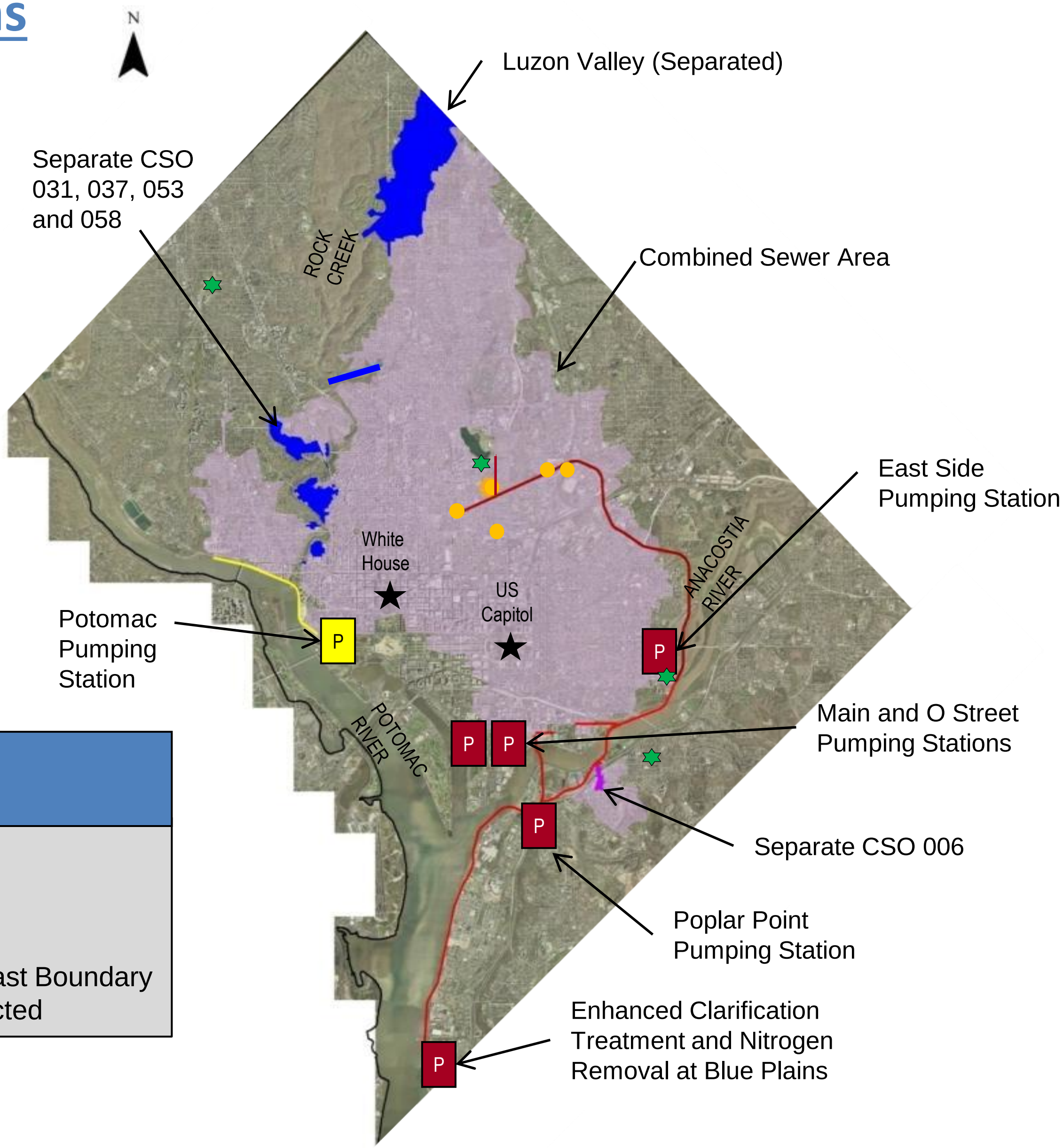
Briefing for:

ANC 4D

May 19, 2015

DCWATER.COM

DC Clean Rivers Project and Nitrogen Removal Programs – Prior to Modification

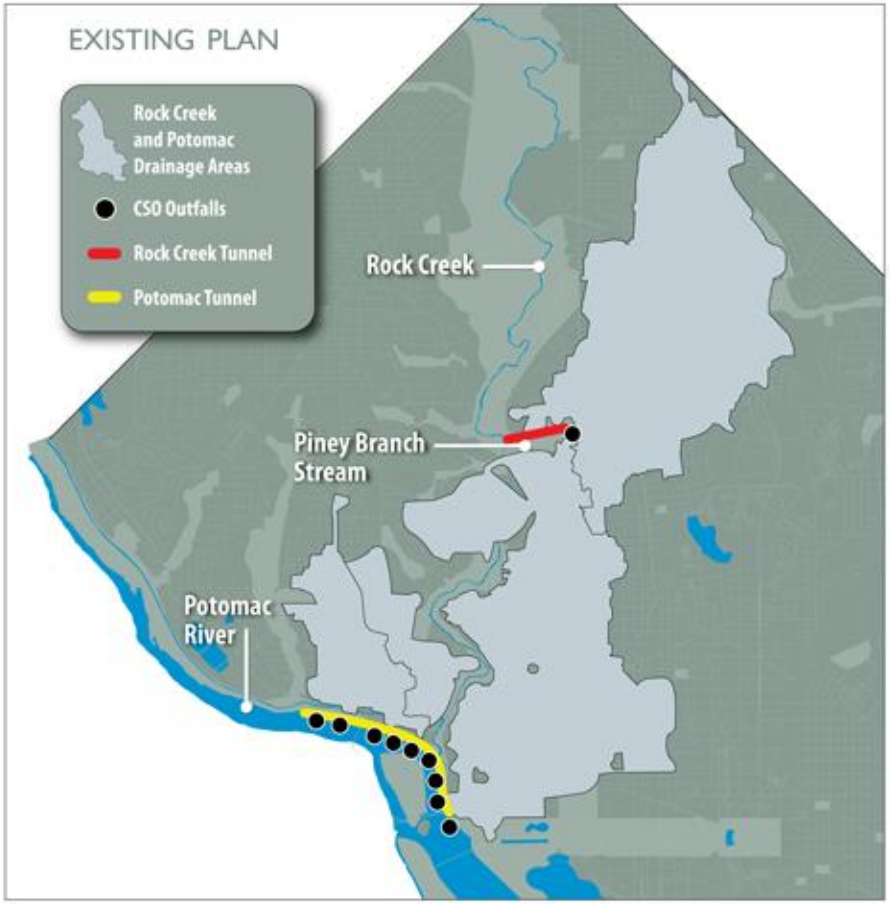


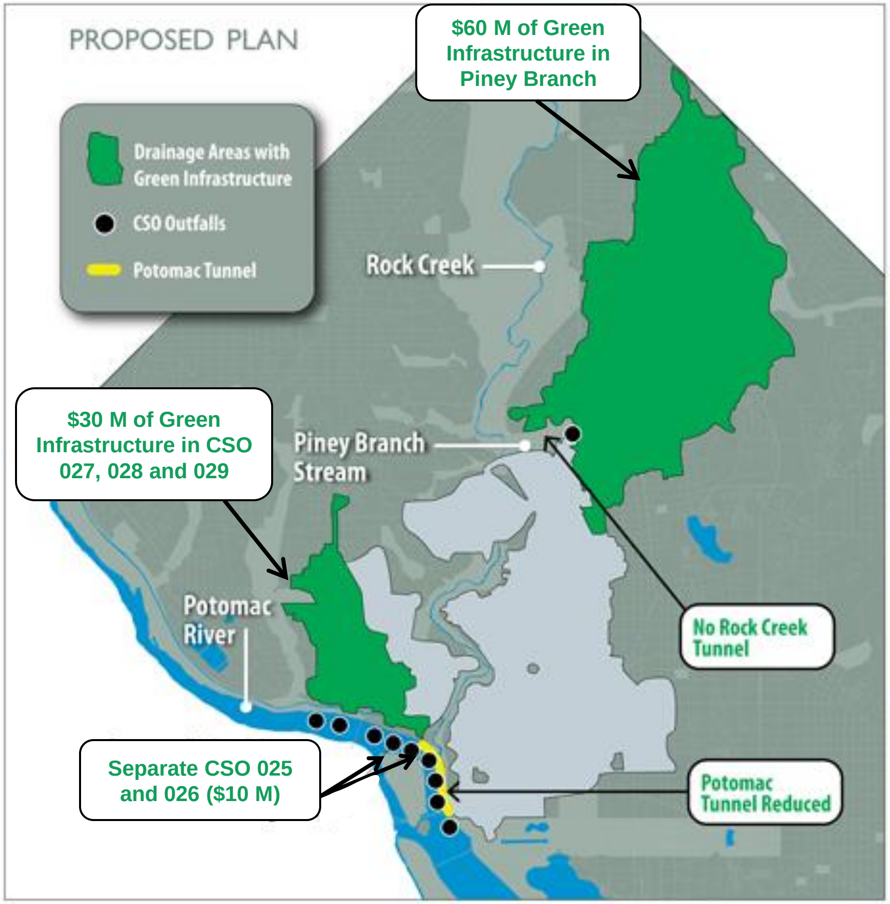
LEGEND

- Anacostia River Tunnel System
- Potomac River Tunnel
- Piney Branch Tunnel
- P Pumping Station Rehabilitation
- Known Flood Area
- Green Infrastructure (by DC Water)

DC CLEAN RIVERS PROJECT AND NITROGEN REMOVAL PROGRAMS
• DC Clean Rivers Project: \$2.6 Billion • Nitrogen Removal: \$950 Million • Total > \$ 3.5 Billion • 20 yr implementation (2005 – 2025) • 96% reduction in CSOs & flood relief in Northeast Boundary • Approx 1 million lbs/yr nitrogen reduction predicted

Background:
DC Clean Rivers Proposed Green Infrastructure Plan





dc clean RIVERS PROJECT

GI Challenge
Goals

- Challenge Goals
  - Proposing practical and implementable solutions that can be constructed
  - Demonstrating performance in capturing stormwater runoff volume
  - Retrofitting the urban environment and utilizing stormwater as a site amenity
  - Advancing innovative technologies
  - Demonstrating cost effective solutions

GI Challenge Design Phase Summary

- Two Planning Phase Winning Designs Selected for Final Design
- Categories for this Phase Include:
  - **Kansas Avenue Green Infrastructure Parks Project**
    - Designs for 2 GI Parks
    - Selected Team: CH2M
  - **Kennedy Street Green Infrastructure Streetscape Project**
    - Design for 1 GI Streetscape
    - Selected Team: Nitsch Engineering
- Streetscape project to be bid and constructed with DDOT Kennedy Street Project







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GI Challenge Design Phase
GI Parks Project Description

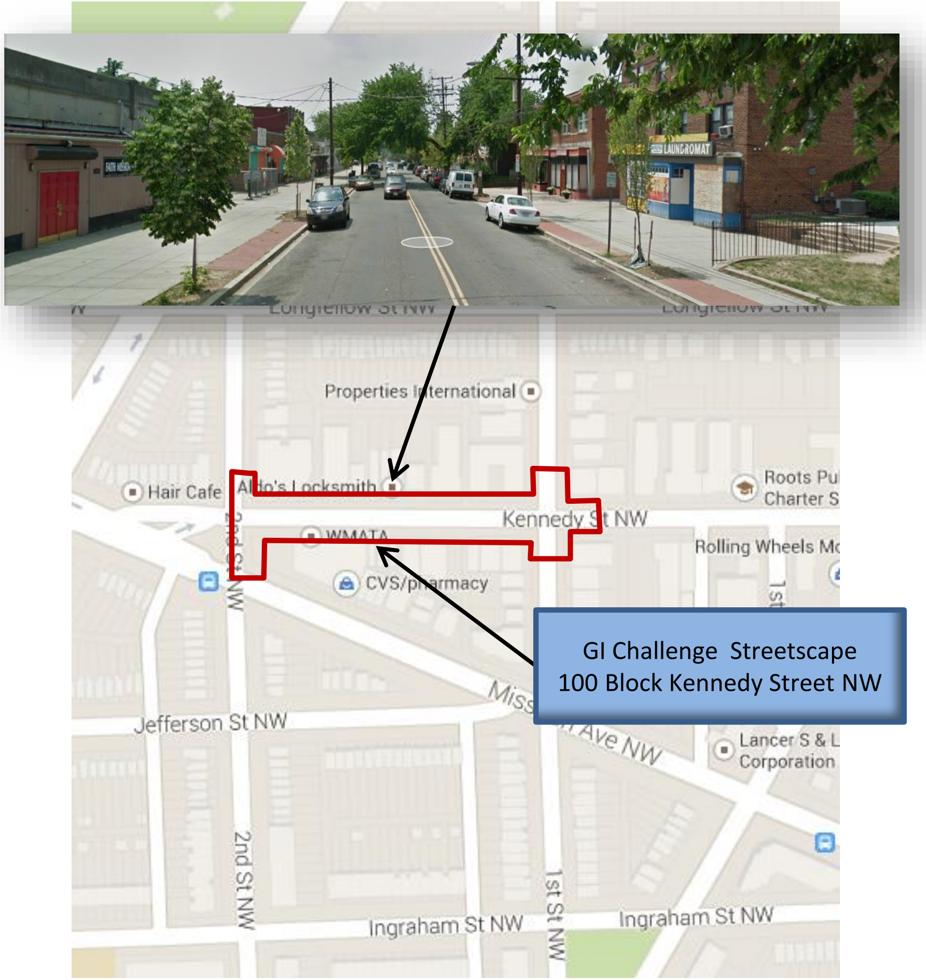
Kansas Avenue NW Green Infrastructure Parks Project:

- Park 1:
  - Approx 150' L x 90' W. Bounded by Ingraham Street NW, Kansas Avenue NW, and 3rd Street NW
  - Brightwood Park Neighborhood
  - Existing Site Conditions:
    - Mix of shade and ornamental trees
    - Sidewalks on all sides
    - Adjacent to Washington Latin PCS
    - Surrounded by row houses
- Park 2:
  - Approx 170' L x 90' W. Bounded By Longfellow Street NW, Kansas Avenue NW, and 2nd Street NW
  - Brightwood Park Neighborhood
  - Existing Site Conditions:
    - Small, recently planted trees and turf
    - Sidewalks on all sides
    - Adjacent to Fort Slocum Park
    - Surrounded by row houses

GI Challenge Design Phase
GI Streetscape Description

Kennedy Street Green Infrastructure Streetscape Project:

- Bounded by 1st Street NW and Missouri Avenue NW
  - Approximately 800' long with a right-of-way width of 60'
  - Primarily commercial site
  - Brightwood Park neighborhood
  - Characterized by broad sidewalks, a mix of recently planted trees and mature trees, and underutilized commercial properties
  - Design to be closely coordinated with DDOT work on Kennedy Street.



GI Challenge Design Phase
Anticipated Schedule

Task	Date – GI Parks	Date – GI Streetscape
1. Public Outreach Meeting # 1	May 28, 2015	May 28, 2015
2. Public Outreach Meeting # 2	July 2015 (TBD)	July 2015 (TBD)
5. Public Outreach Meeting #3 (~ 90% Design)	December 2015	N/A
7. Construction	TBD (pending LTCP Modification)	w/ DDOT Kennedy Street Project October 2015 – Spring 2016 (Anticipated)

GI Challenge Design Phase
Next Steps

Next Steps:

- First Public Outreach Meeting May 28, 2015 from 6:00 pm – 8:00 pm
  - Roots PCS, 15 Kennedy Street, NW Washington, DC 20011
  - Goal: Solicit and incorporate feedback from the public in design process
- Second Public Outreach Meeting July, 2015
  - Date/Location TBD







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QUESTIONS AND ANSWERS

Kennedy Street Green Infrastructure Streetscape Briefing for DDOT

May 14, 2015

Project Team

Project Team:

DC Clean Rivers

Nitsch Engineering (PM, Lead Engineer)

Urban Rain | Design (Lead Landscape Architect)

Warner Larson Landscape Architects (Landscape Architect)

EBA Engineering (Survey, Geotech, Estimating)

McKissack & McKissack (Permitting)

Stacy Levy (Environmental Artist)

Tina Boyd & Associates (Public Outreach)

BACKGROUND

GI Challenge Design Phase
Goals

- Challenge Goals
  - Proposing practical and implementable solutions that can be constructed
  - Demonstrating performance in capturing stormwater runoff volume
  - Retrofitting the urban environment and utilizing stormwater as a site amenity
  - Advancing innovative technologies
  - Demonstrating cost effective solutions

GI Challenge Design Phase Summary

- Two Planning Phase Winning Designs Selected for Final Design and Construction
- Categories for this Phase Include:
  - **Kansas Avenue Green Infrastructure Parks Project :**
    - Designs for 2 GI Parks
    - Selected Team: CH2M HILL
  - **Kennedy Street Green Infrastructure Streetscape Project :**
    - Design for 1 GI Streetscape
    - Selected Teams: Nitsch Engineering
- Park Project Anticipated to be Executed Under a Design-Bid-Build Project Delivery or Similar
- Streetscape Project to be bid and constructed with DDOT Kennedy Street Project






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Evaluation Panel

- Evaluation Panel consisted of members from
  - DC Water
  - District Department of the Environment
  - District Department of Transportation
  - District Office of Planning
  - District Department of Public Works
  - Other industry experts

GI Challenge Design Phase
GI Parks Project Description

Kansas Avenue NW Green Infrastructure Parks Project:

- Park 1:
  - Approx 150’ L x 90’ W. Bounded by Ingraham Street NW, Kansas Avenue NW, and 3rd Street NW
  - Brightwood Park Neighborhood
  - Existing Site Conditions:
    - Mix of shade and ornamental trees
    - Sidewalks on all sides
    - Adjacent to Washington Latin PCS
    - Surrounded by row houses
- Park 2:
  - Approx 170’ L x 90’ W. Bounded By Longfellow Street NW, Kansas Avenue NW, and 2nd Street NW
  - Brightwood Park Neighborhood
  - Existing Site Conditions:
    - Small, recently planted trees and turf
    - Sidewalks on all sides
    - Adjacent to Fort Slocum Park
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dc clean RIVERS PROJECT

GI Challenge Design Phase
GI Streetscape Description

Kennedy Street Green Infrastructure Streetscape Project:

- Bounded by First Street NW and Missouri Avenue NW
    - Approximately 800' long with a right-of-way width of 60'
    - Primarily commercial site
    - Brightwood Park neighborhood
    - Characterized by broad sidewalks, a mix of recently planted trees and mature trees, and underutilized commercial properties
    - Design and construction to be closely coordinated with DDOT work on Kennedy Street.

GI Challenge Design Phase
Designer's Scope of Work

Designer's Scope of Work:

- Assisting DC Water with public engagement and design refinement.
- Integrating revealed stormwater management processes that facilitate public engagement and education.
- Organizing, managing and otherwise providing the engineering, landscape architecture, and other design services necessary to prepare contract documents, suitable for obtaining bids for the construction of the project.
- Obtaining necessary permits and approvals.
- Engineering services during bidding.
- Services during construction, including responses to requests for information, review of shop drawings, etc.

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GI Challenge Design Phase
Anticipated Schedule

Kansas Avenue Green Infrastructure Parks Project:

Task	Date
1. Public Outreach Meeting # 1	May 28, 2015
2. Public Outreach Meeting # 2	July, 2015
3. 50% Design Complete	August 2015
4. 90% Design Complete	December 2015
5. Public Outreach Meeting #3 (Review 90% Design)	December 2015
6. 100% Design	March 2016
7. Begin Construction	TBD – per CD Mod
8. Complete Construction	TBD – per CD Mod

Kennedy Street Green Infrastructure Streetscape Project:

Task	Date
1. Public Outreach Meeting # 1	May 28, 2015
2. DDOT Bid Submission	June 15, 2015
3. Public Outreach Meeting # 2	July, 2015
5. 50% Design Complete	July 2015
6. 90% Design Complete	August 2015
7. Public Outreach Meeting #3 (Review 90% Design)	August 2015
8. 100% Design	September 2015
9. Begin Construction (Under DDOT Streetscape work)	October 2015
10. Complete Construction	Spring 2016

EXISTING CONDITIONS

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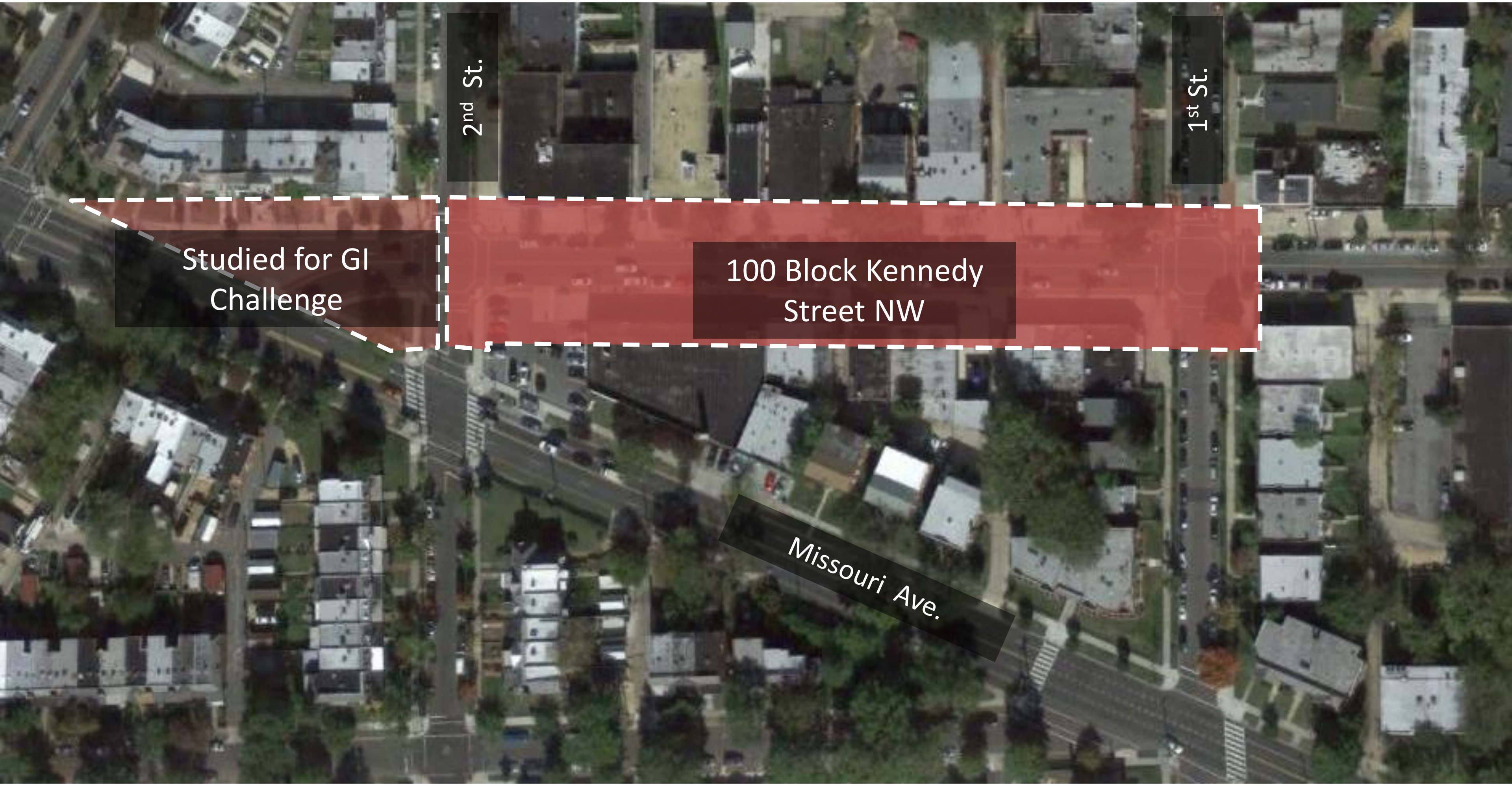
Project Site



Project Site


Vegetation
Thin, Inconsistent
Tree Canopy

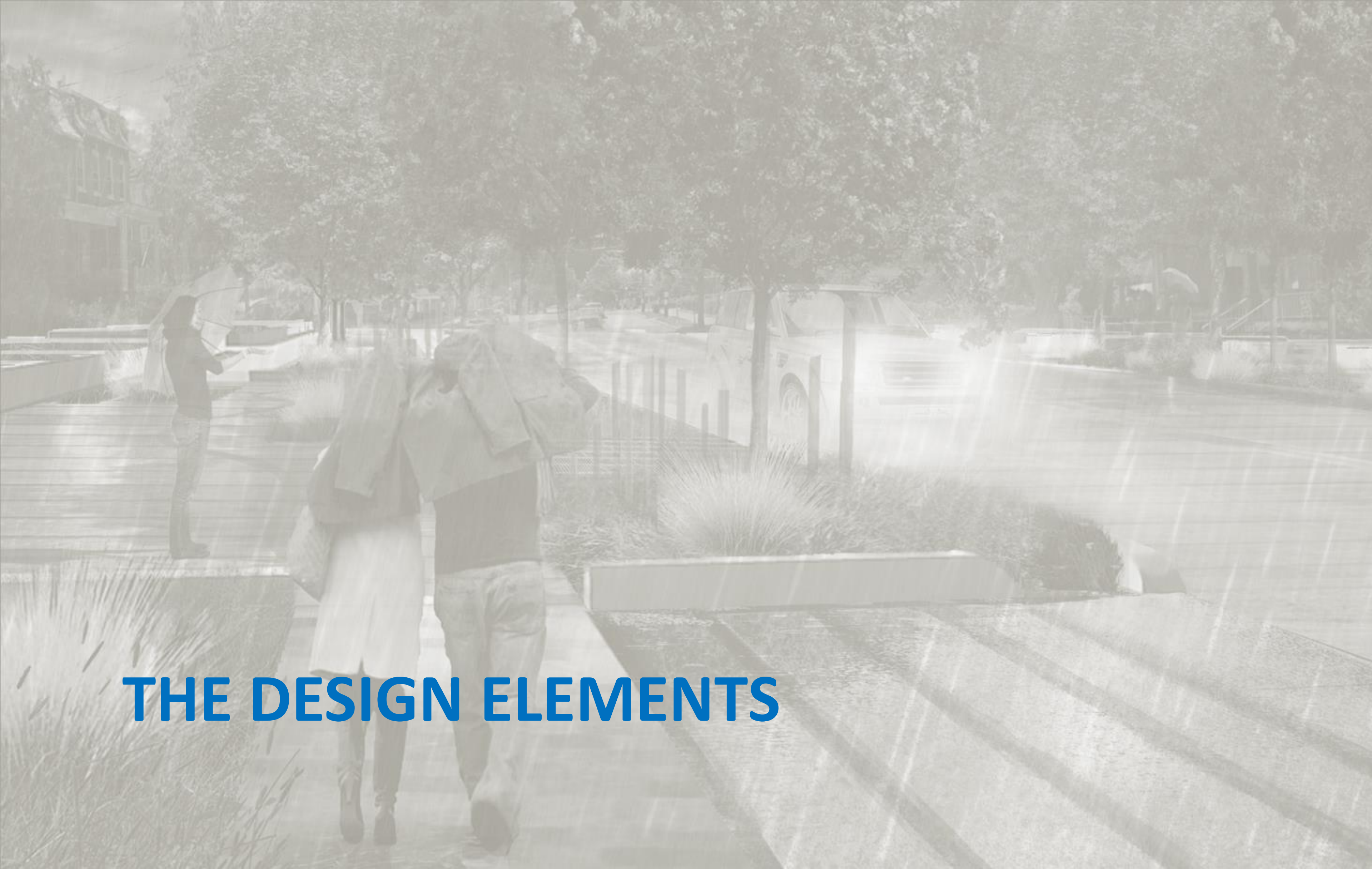

Wide Sidewalks
Lack of Programming,
Street Furniture, and Other
Pedestrian Amenities


Function
Streetscape Does Not Inspire, Educate, or Improve Health of Community
Lack of Street Identity


Mobility
Street is dominated
by vehicular use and speed

Lack of people use and
gathering space


Public R.O.W
Private Sidewalk



THE DESIGN ELEMENTS





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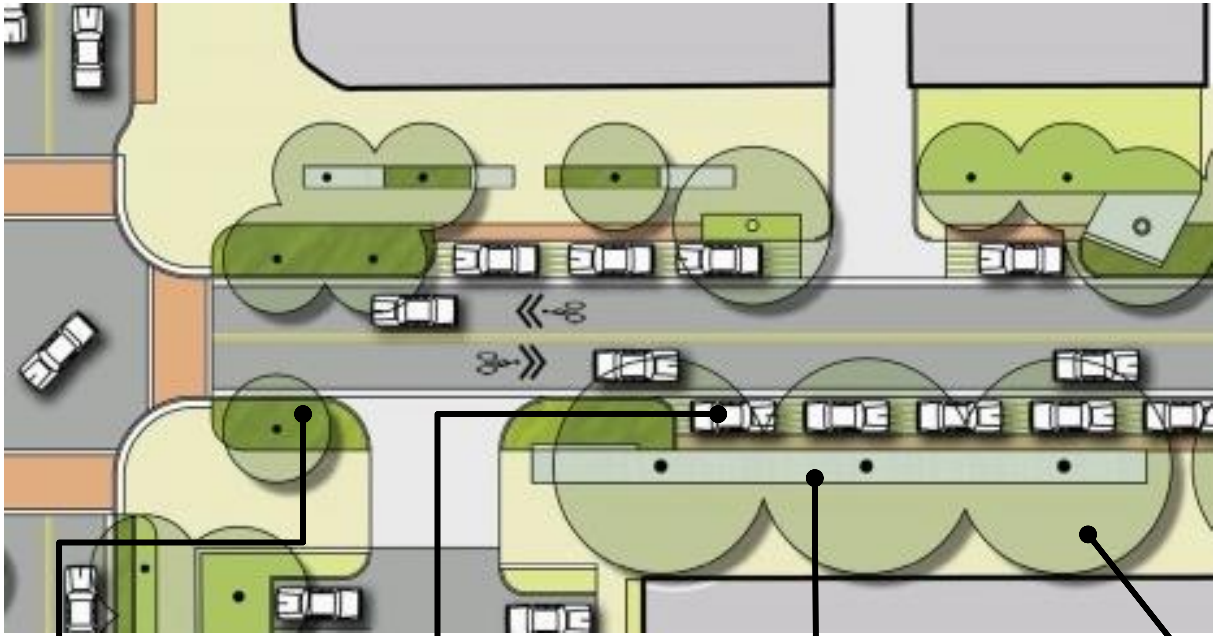
Multi-Layer Design Approach



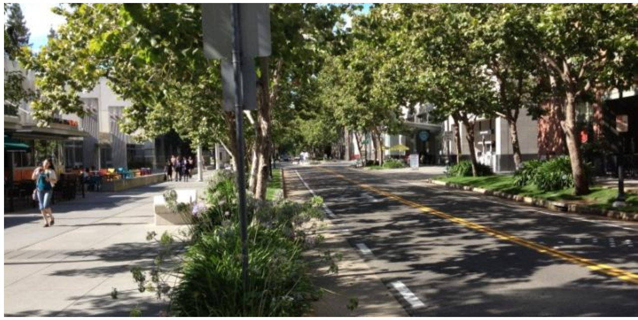
Bioretention Curb Extensions

Permeable Parking Lane

Walkable Recessed Landscapes

Enhanced Tree Canopy

Street Tree Canopy



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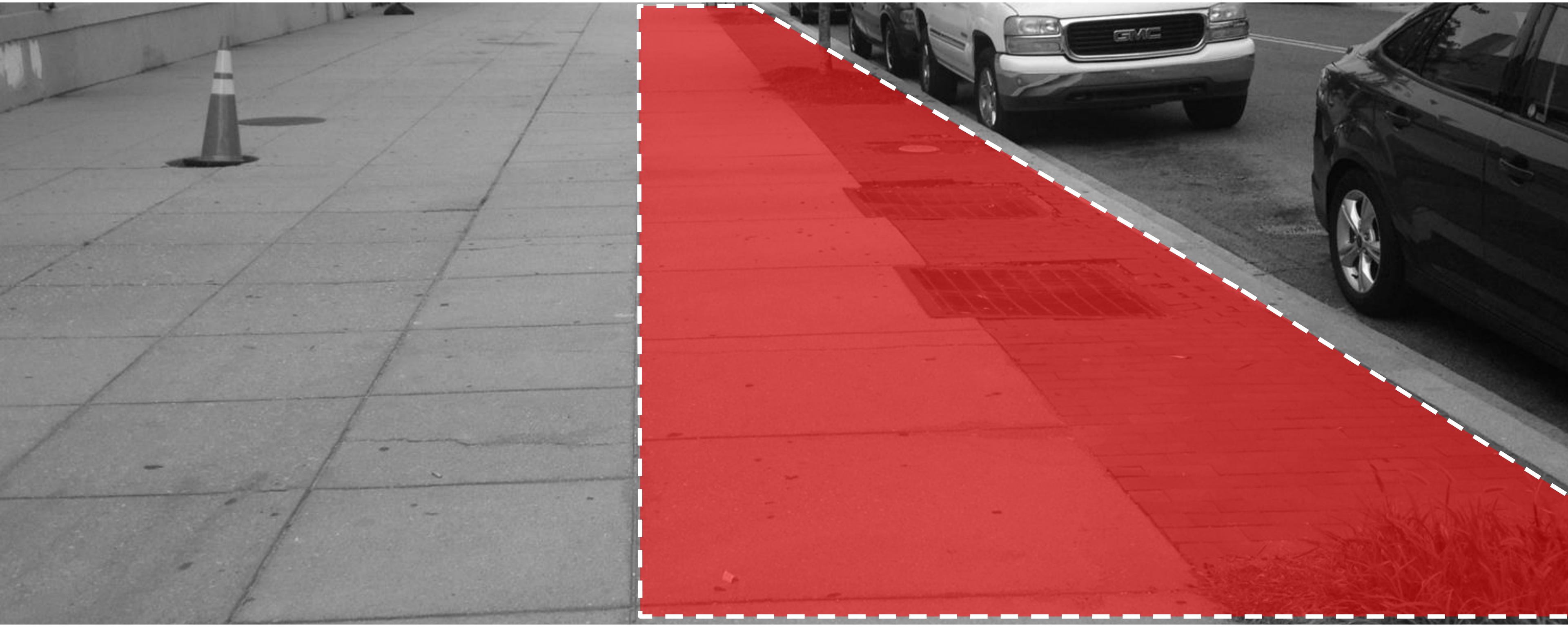
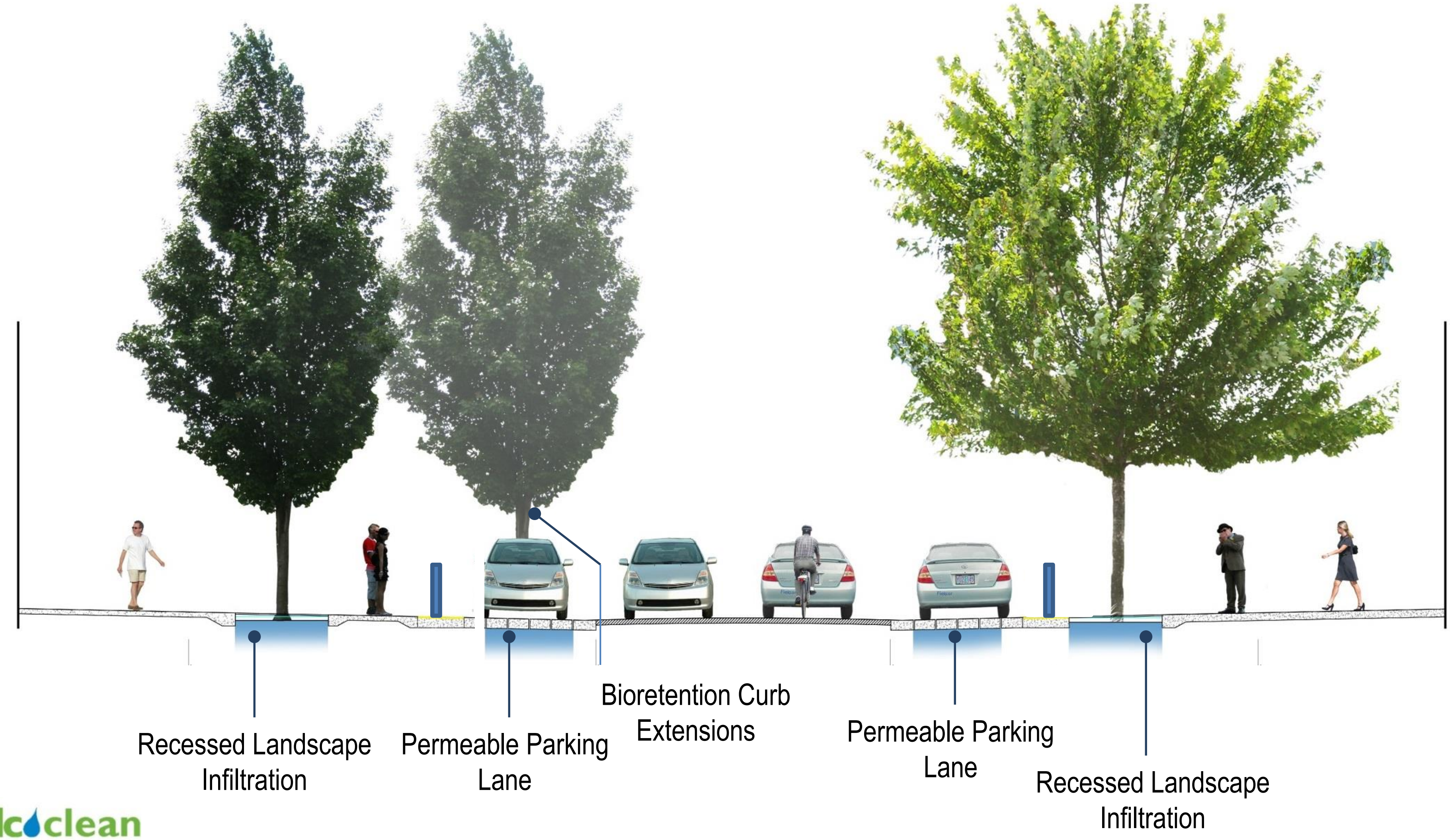
Permeable Parking Lane

Bioretention Curb Extensions

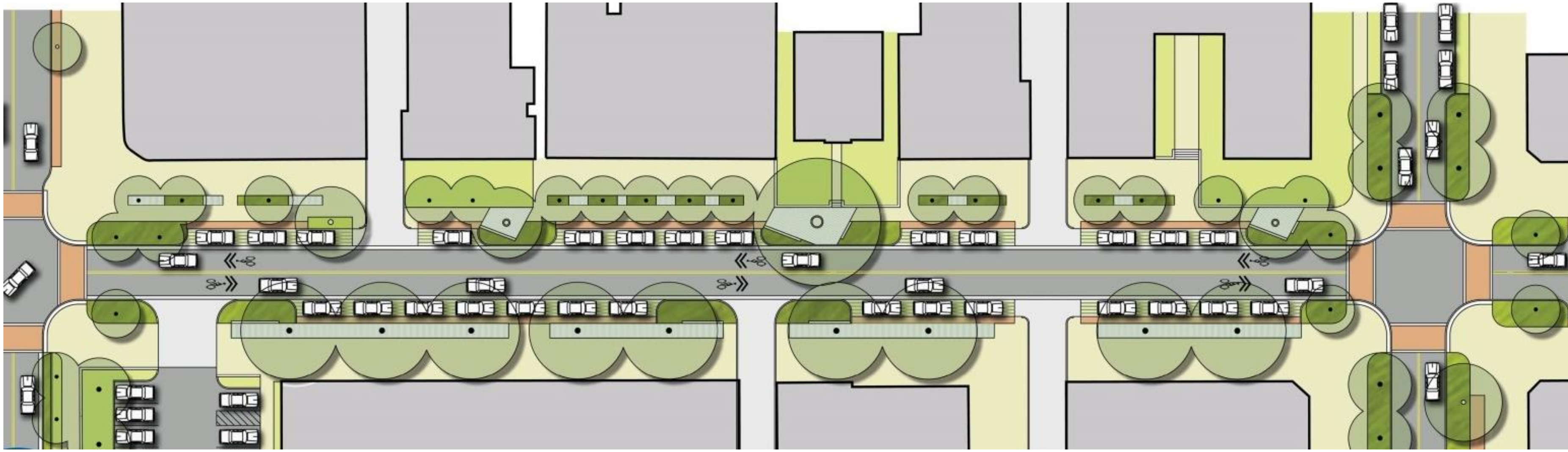
Walkable Recessed Landscape



Cross Section

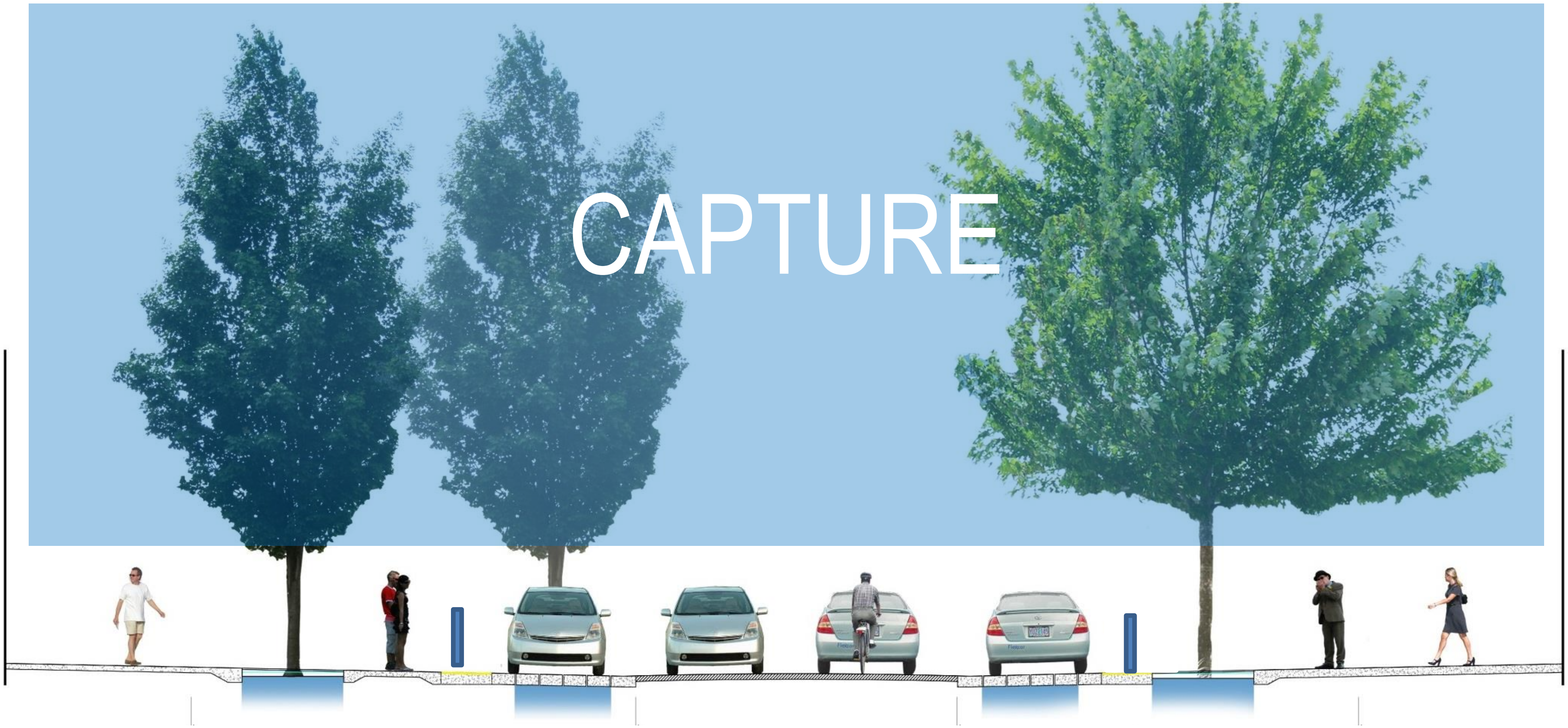


High Performance Stormwater Management



Vertical Capture

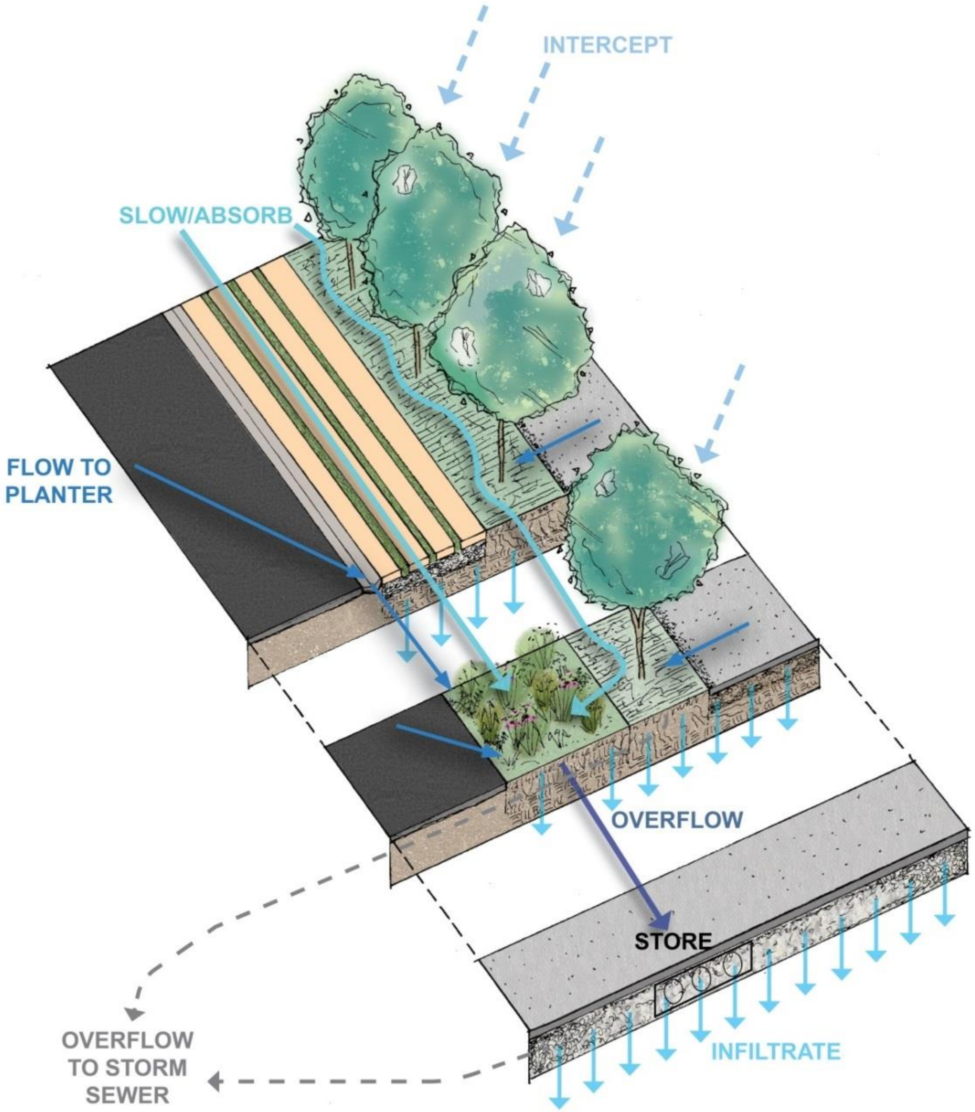
CAPTURE



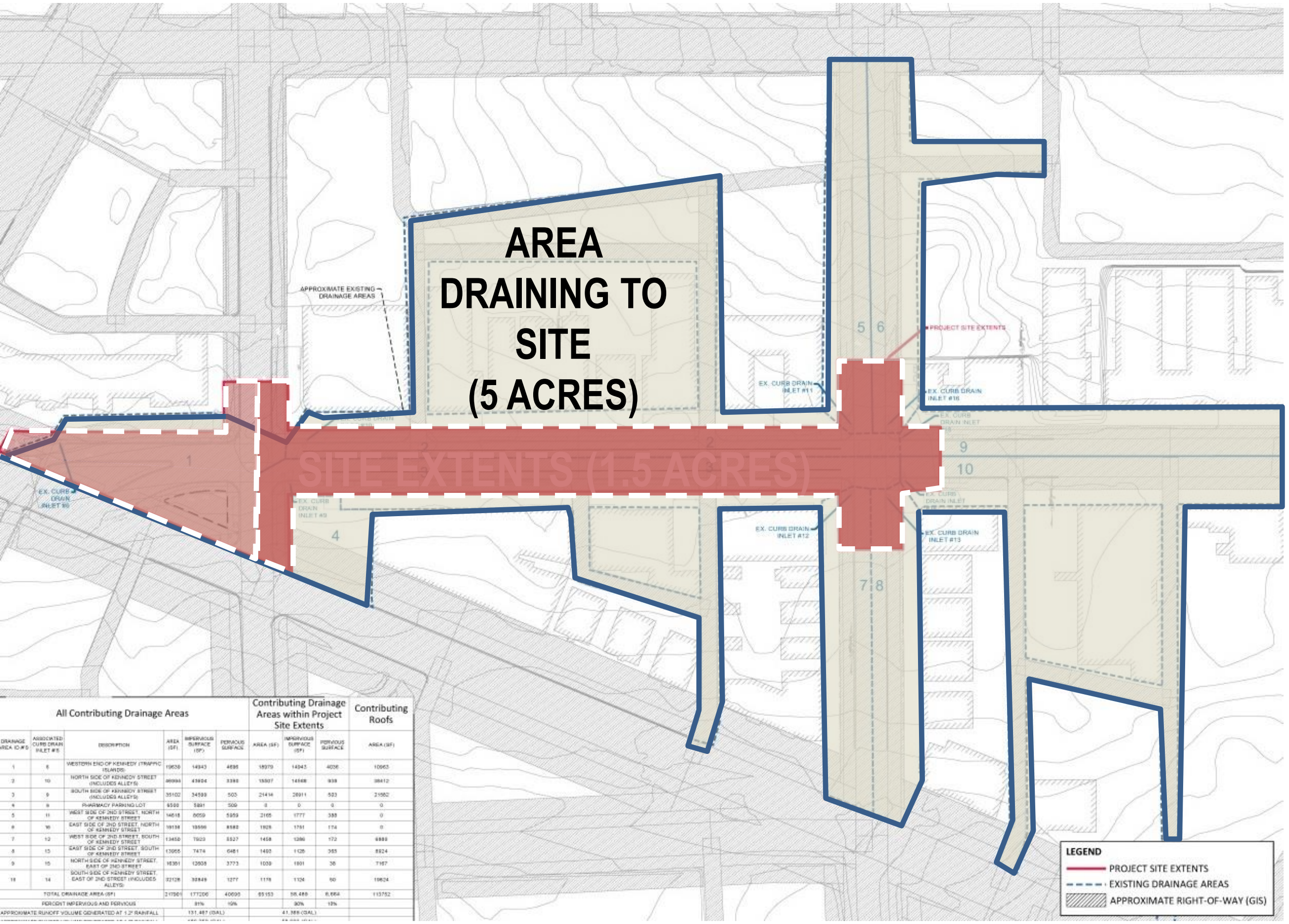
Ground Surface Absorption

VOLUME & TIME

An Integrated Treatment Train

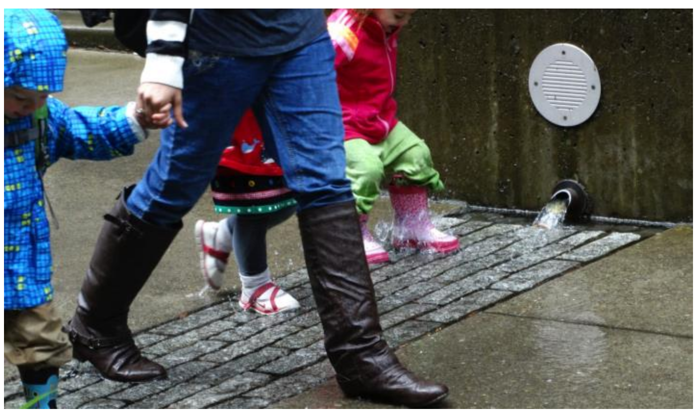


Beyond the Project Boundary



Sidewalk Placemaking

Interpretive Public Art




1 HOUR


Green Catalyst

DISCUSSION

Topics of concern we've heard so far…

- Accessibility and Safety
  - ADA
  - Bicycle, pedestrian, and vehicular zones
- Curbless, "w" cross section
  - Safety (vehicles entering pedestrian zone)
  - Flooding/Conveyance (15-year storm)
- R.O.W vs. Private Sidewalk
  - Location of GI (within ROW)
  - Location of public art (sidewalks, crosswalks)
  - Sidewalk minimum width (8')
- Walkable Grates
  - Gap width (1/2" max.)
  - Accessibility
  - Safety
  - Performance
  - Access and Maintenance
- LIG (landscape infiltration gaps)
  - Parking lane (not suitable)
  - Planting strip and pedestrian zone
- Street Trees
  - Protection of existing trees
  - Removal of unhealthy trees
  - Enhancement of canopy
  - Emphasis on soil volume
- Decking over existing 36" Elm root zone
  - Accessibility
  - Alternate application
- Bioretention curb extensions
  - Turning radii
  - Curb ramps
  - Unprotected drops and tripping hazards

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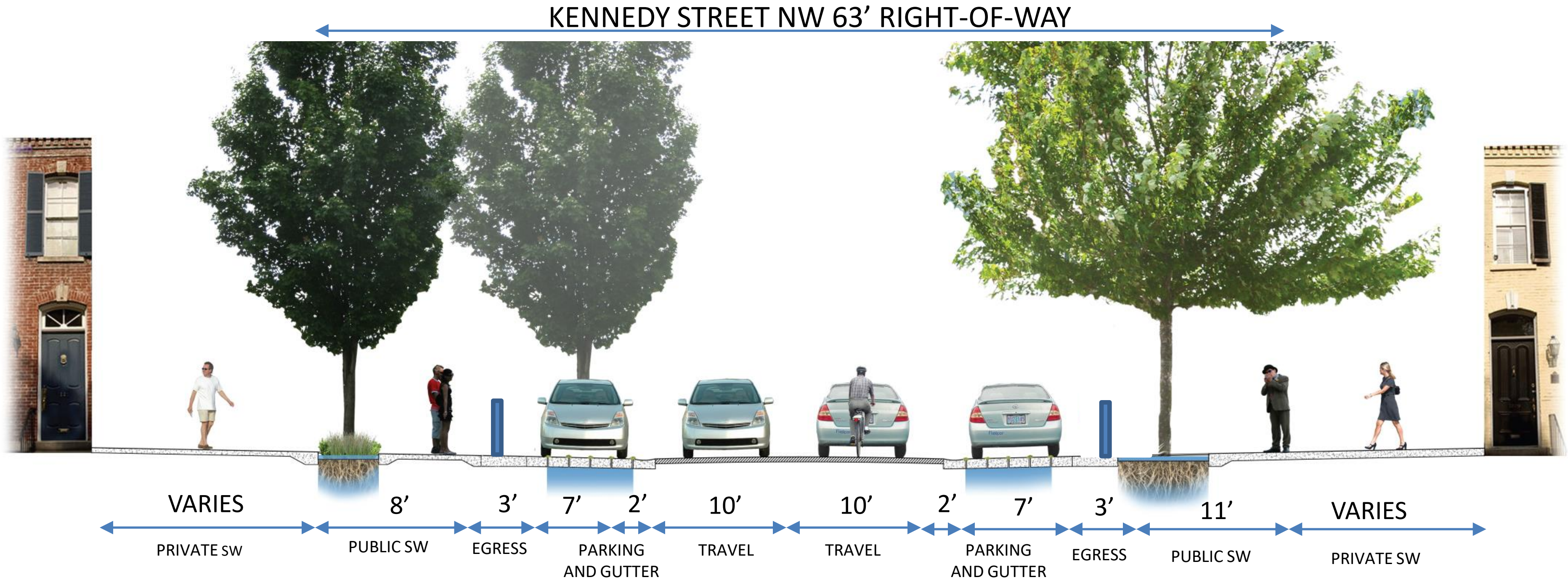
Curbless "w" Cross Section



Notes:

Existing vehicular zone (curb to curb) is 36'

Proposed vehicular zone is 38' (aligns with DDOT guidelines)

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Curbless "w" Cross Section, Drainage

Cambridge, MA

Ashville, NC

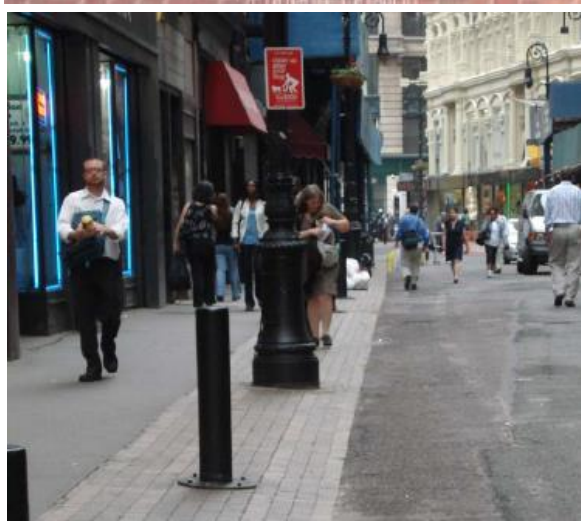
British Columbia

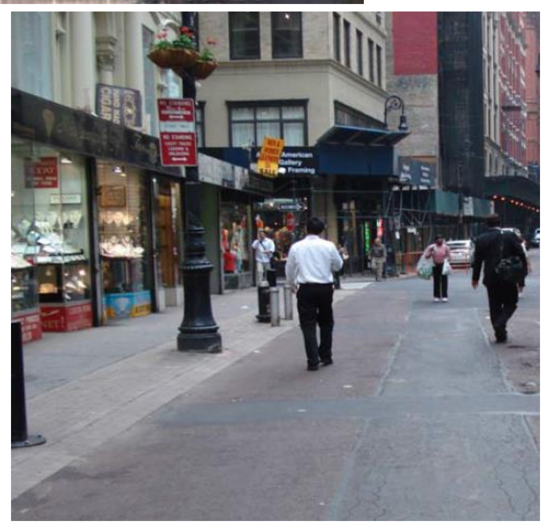
Cleveland

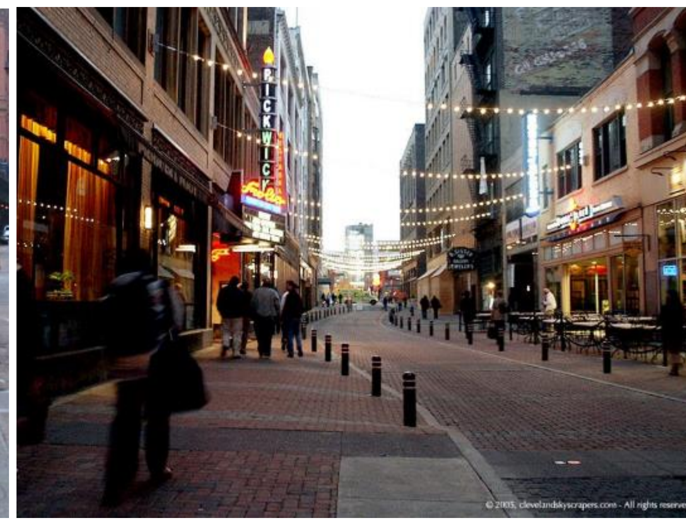
Shared Space, Safety

Eugene, OR

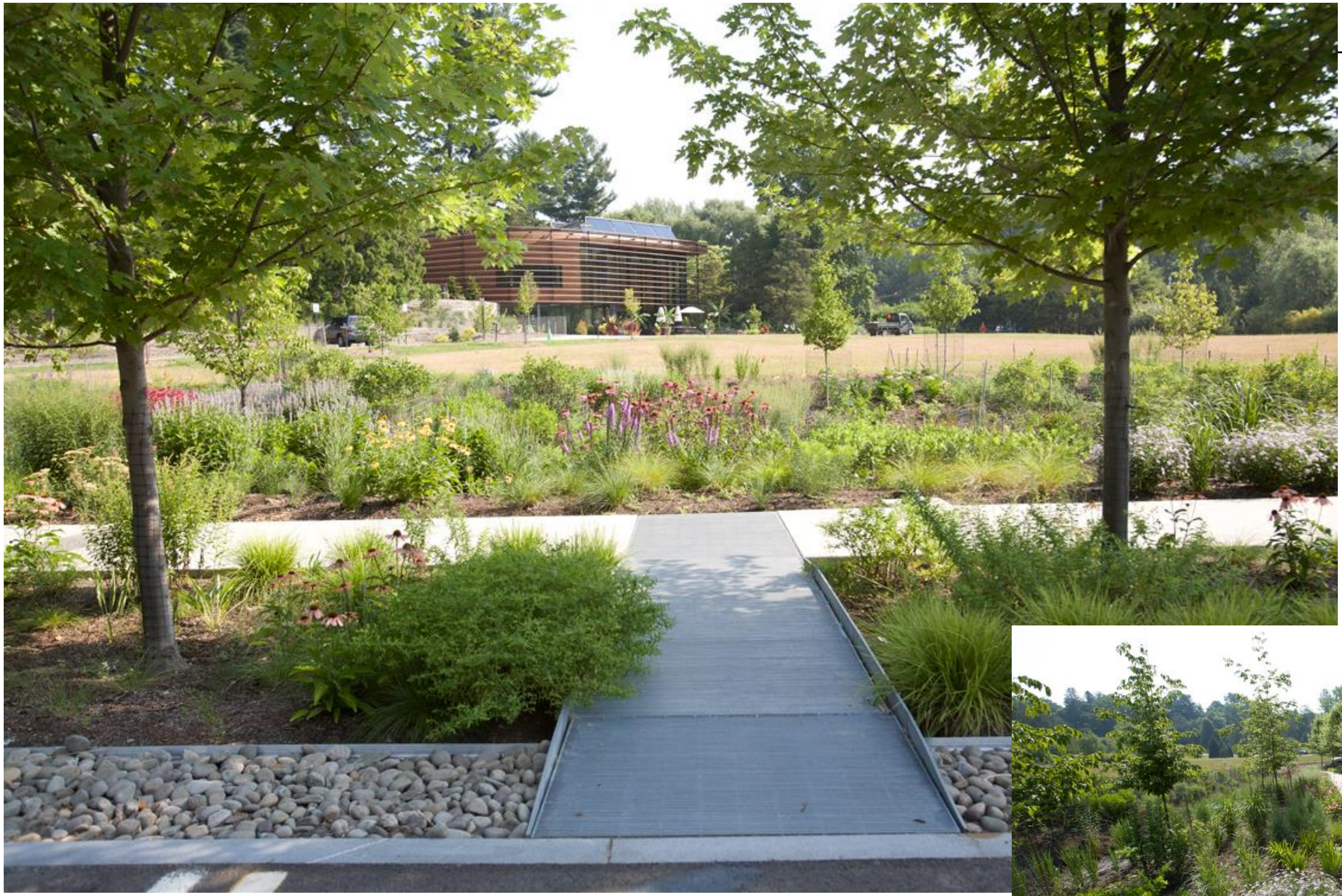
NYC/Other







Walkable Landscapes (Accessible Grates)



Cornell University Plantations

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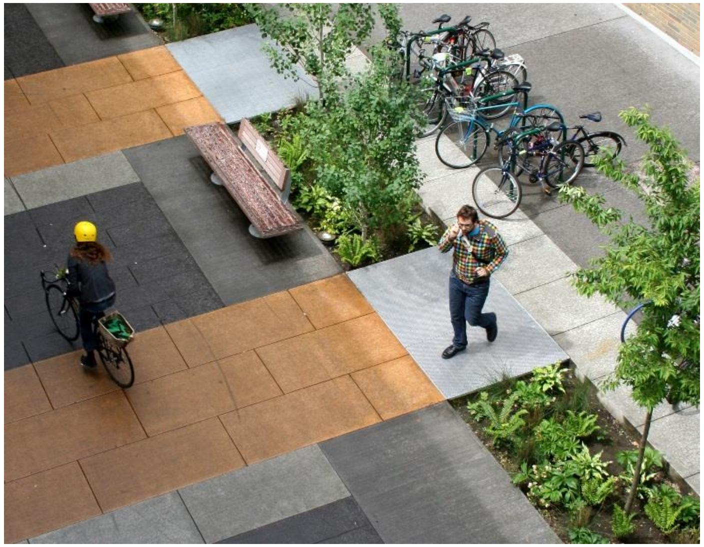
Walkable Landscapes (Accessible Grates)

Columbus, OH

Portland, OR



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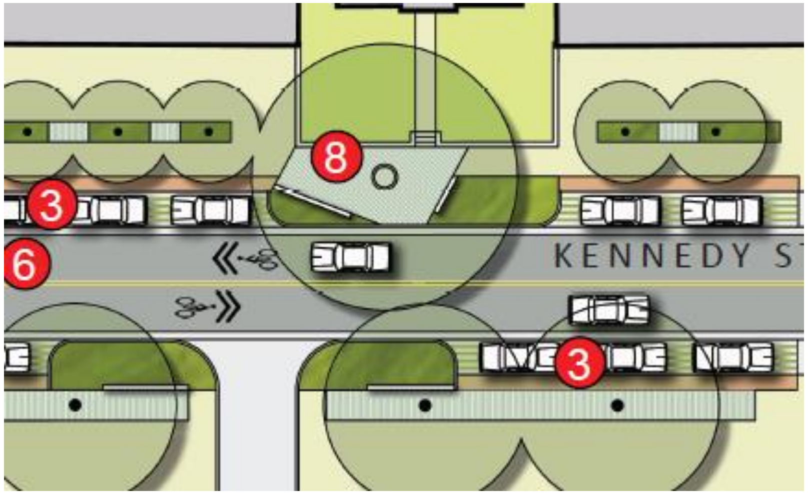
Decking at Existing Elm Tree

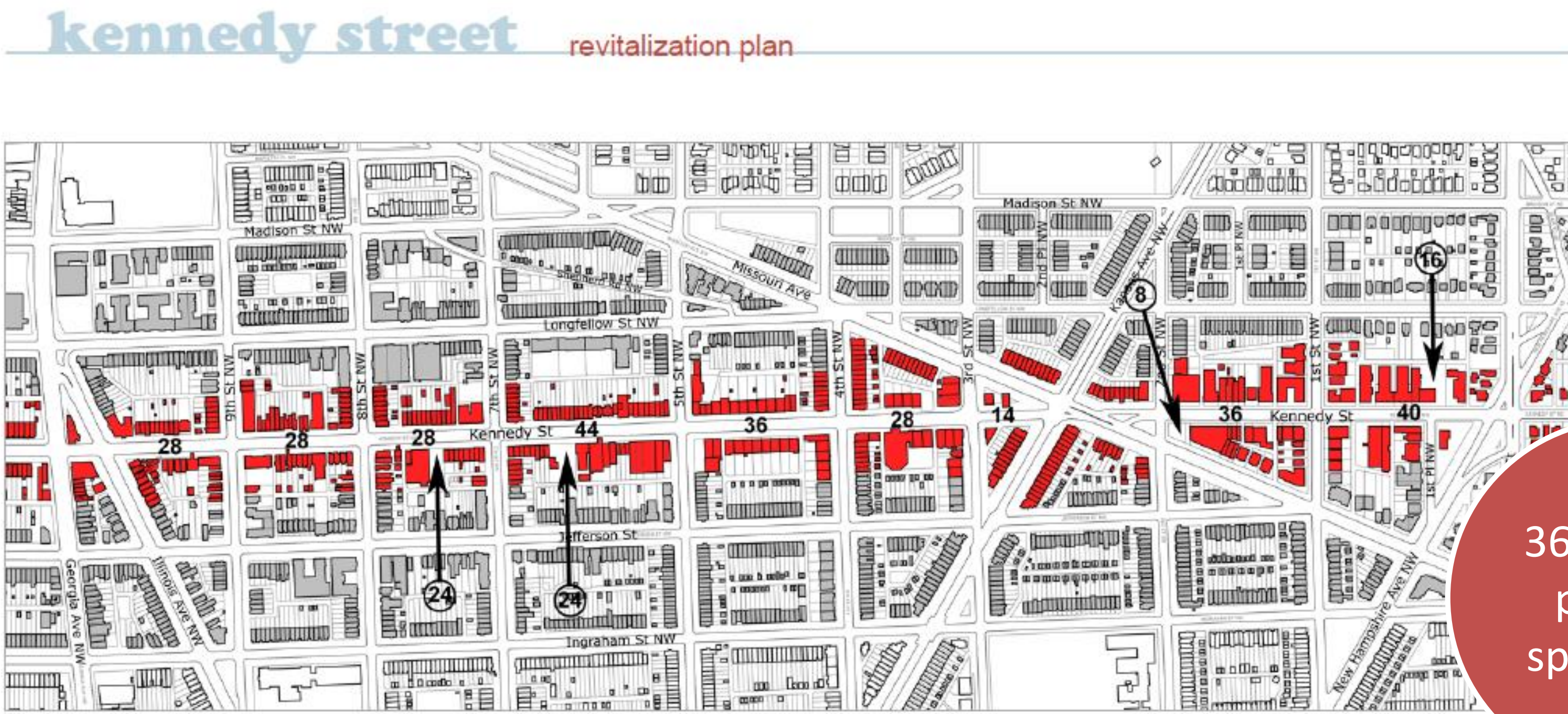


Landscape Infiltration Gaps (LIGs)

Alternate Permeable Parking Lane Materials

Applications in Pedestrian Zone

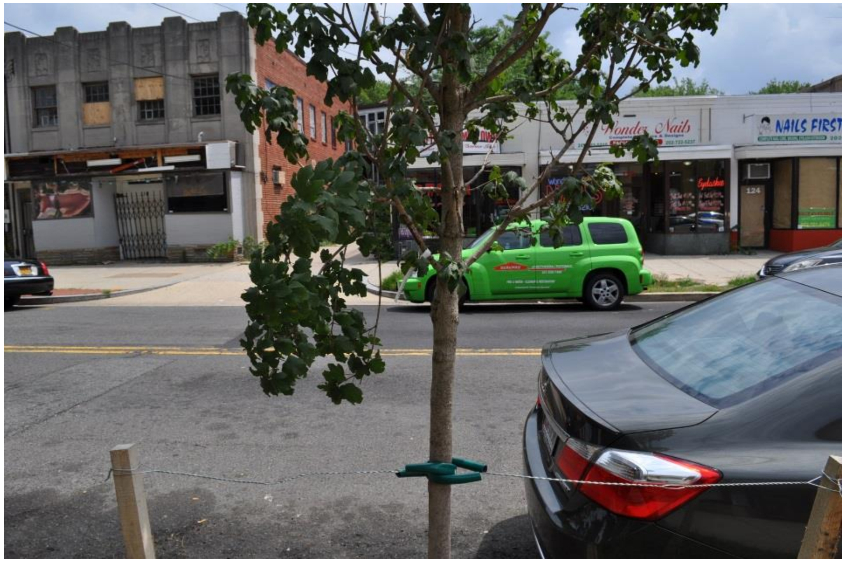
Parking



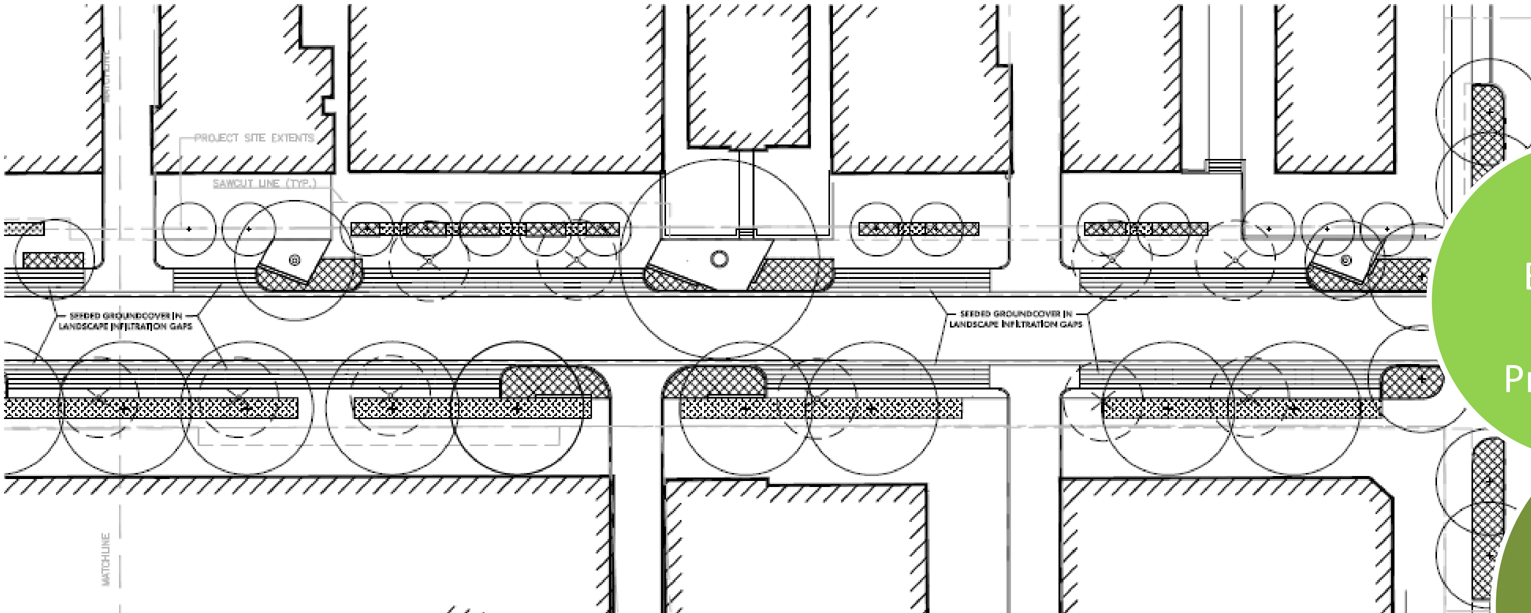
36 existing parking spaces (est.)

27 proposed parking spaces (DDOT Standard)

Existing Street Trees



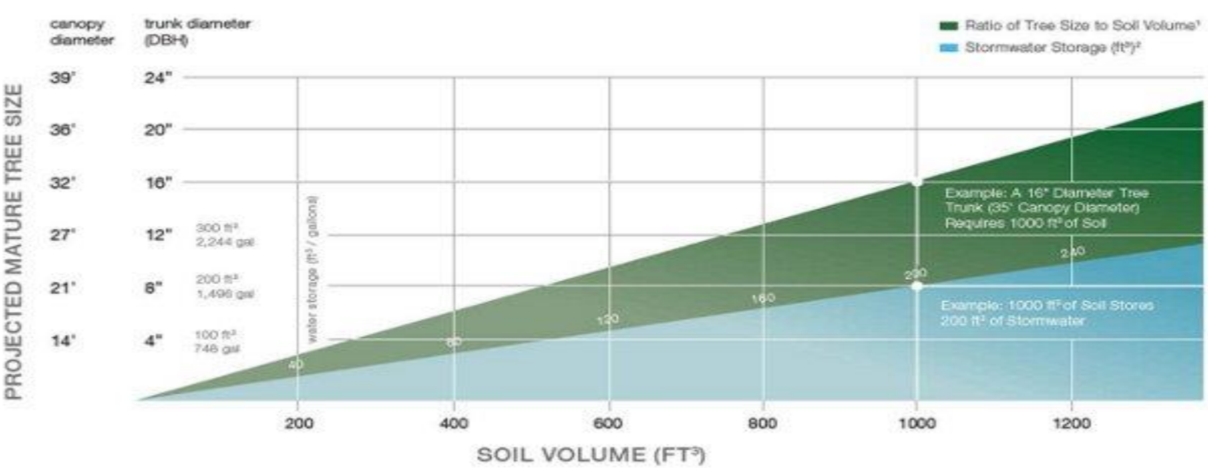
Street Trees and Soil Volumes



15 Existing Street Trees

4 Existing Trees Preserved

42 New Street Trees



June 15, 2015 Concept Design Submittal

- Preliminary List of Drawings
  - Title Sheet
  - General Notes, Standard Symbols, Abbreviations
  - Summary of Quantities
  - Demolition Plan
  - Typical Sections
  - Layout Plan
  - Landscape and Materials Plan
  - Landscape Details
  - Planting Plan
  - Grading and Drainage Plan
  - Civil Site Details
- Specifications for GI Elements

Format of deliverables and other coordination items to be discussed

District of Columbia Water and Sewer Authority
Henderson J. Brown IV, General Manager

Briefing on:

DC Clean Rivers Project
Kansas Avenue Green Infrastructure Parks

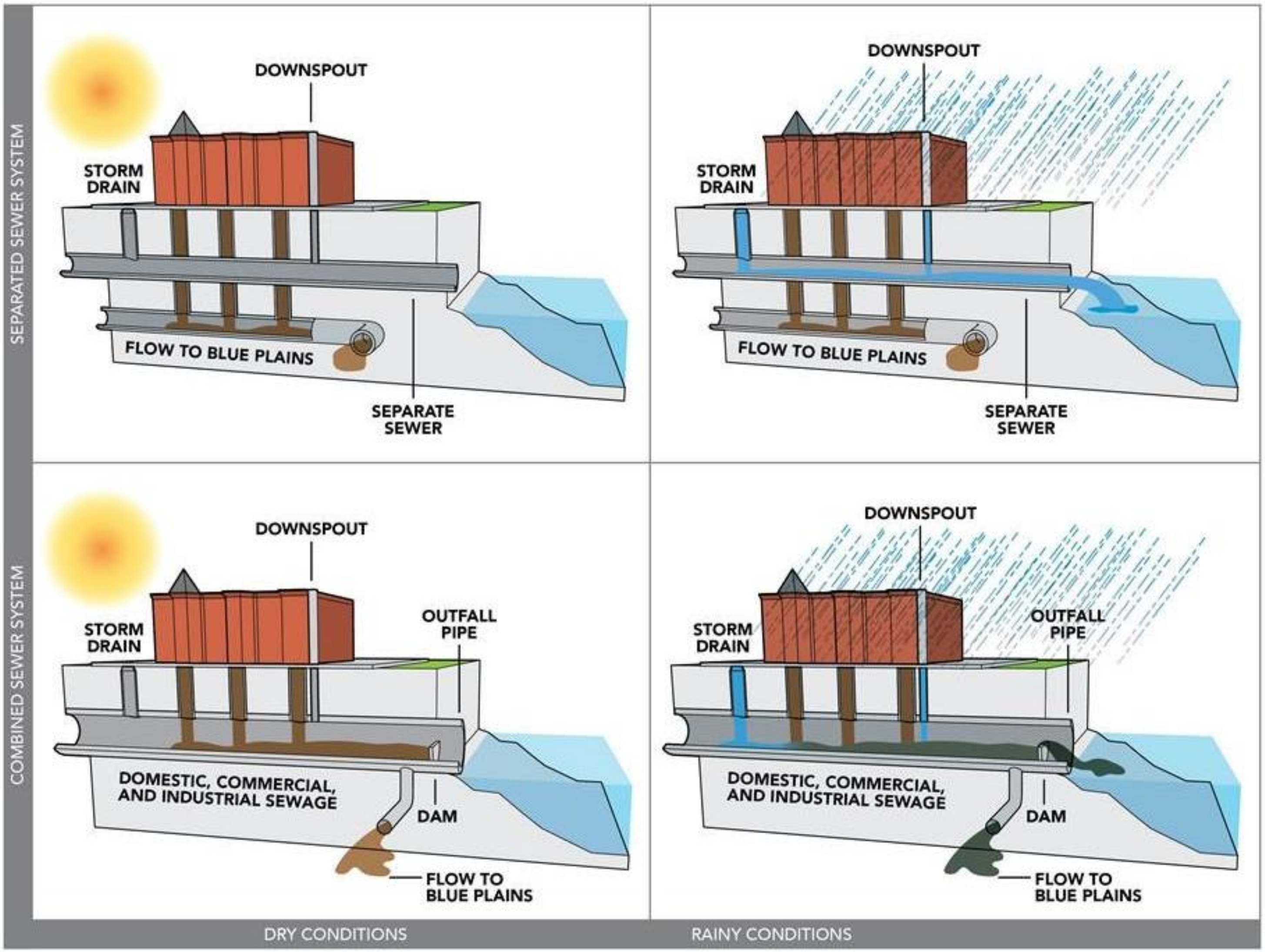
Briefing for:

NPC18

April 2018

DCWATER.COM

DC Clean Rivers Project Overview:
Sewer Systems in DC



*Discharge occurs when pipe’s capacity is exceeded

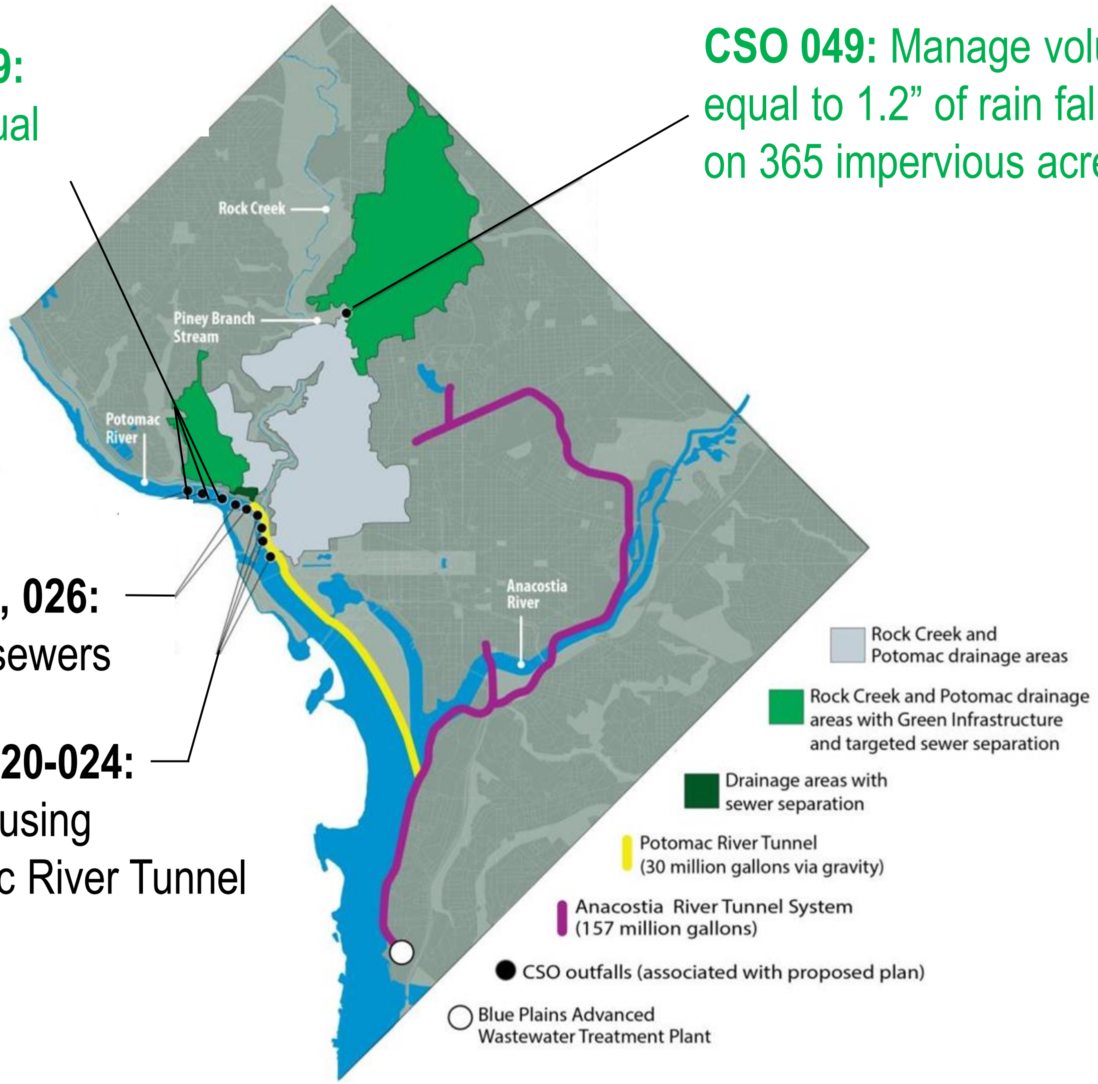
DC Clean Rivers Project Overview:
Amended Consent Decree

CSOs 027, 028, 029: Manage volume equal to 1.2" of rain falling on 133 impervious acres

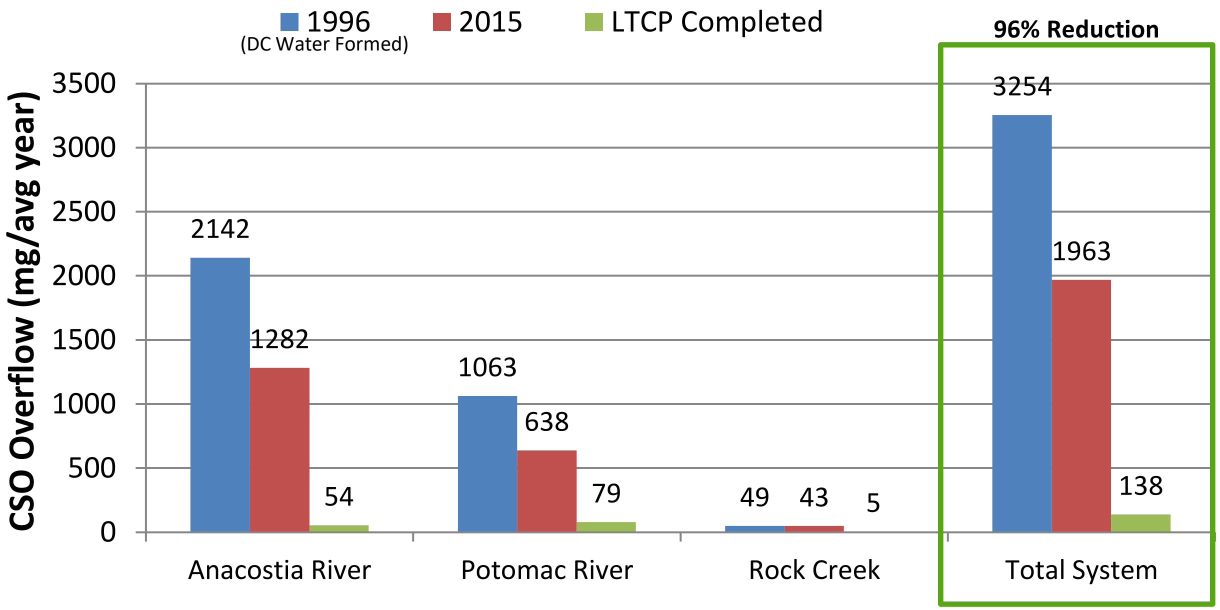
CSO 049: Manage volume equal to 1.2" of rain falling on 365 impervious acres

CSOs 025, 026: Separate sewers

CSOs 020-024: Control using Potomac River Tunnel



DC Clean Rivers Project:
Reducing Combined Sewer Overflows (CSOs)



Predicted Progress in Controlling CSOs

DC Clean Rivers Project:
Why Green Infrastructure?

- CSO benefits begin sooner for CSOs:
  - 049: Rock Creek
  - 027, 028, 029: Potomac River
- Triple Bottom Line benefits are provided beyond CSO control:
  - Social
  - Economic
  - Environmental

Pilot Green Roof Maintenance Training Program

- Green jobs are available with Green Infrastructure (GI):
  - DC Water and District MOU establishes goal of 51% of new hires to be District residents
  - GI training and certification for GI construction, maintenance and inspection
  - Opportunities for Certified Business Enterprises

Background:
Green Infrastructure Challenge Goals

- Launched in 2013
- Challenge Goals
  - Proposing practical and implementable solutions that can be constructed
  - Demonstrating performance in capturing stormwater runoff volume
  - Retrofitting the urban environment and utilizing stormwater as a site amenity
  - Advancing innovative technologies
  - Demonstrating cost effective solutions







dc clean RIVERS PROJECT

Background:
Green Infrastructure Challenge Summary

- Seven Teams Shortlisted
- CH2M HILL Selected for Final Design and Construction
- Project Area:
  - **Kansas Avenue Green Infrastructure Parks Project :**
    - Designs for 2 GI Parks
    - Convert grassed traffic medians into multi-benefit parks
- Parks Project to be built under the Rock Creek Project A contract, the first GI contract in the Rock Creek Sewershed

The Green Infrastructure Design Challenge resulted in the Kansas Avenue Green Infrastructure Parks Project





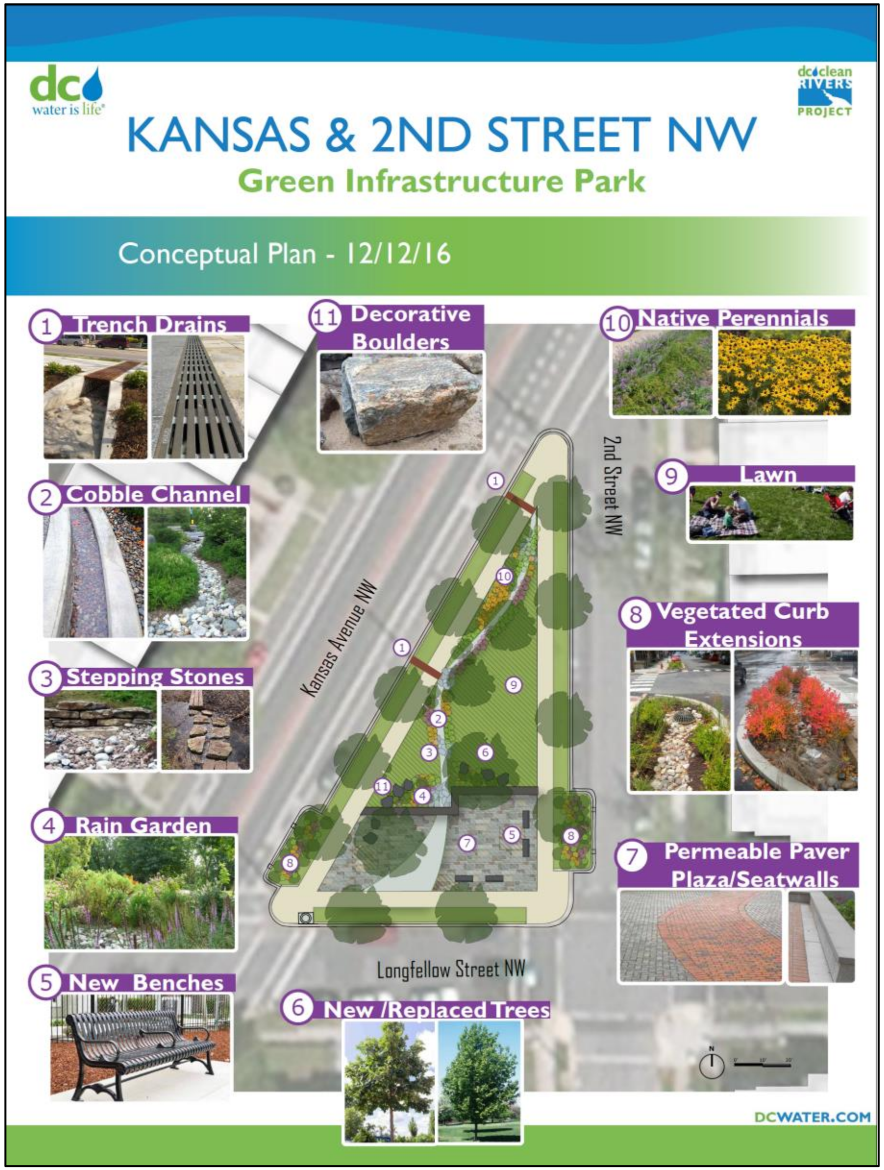

Background:
Kansas Avenue Green Infrastructure Parks Project

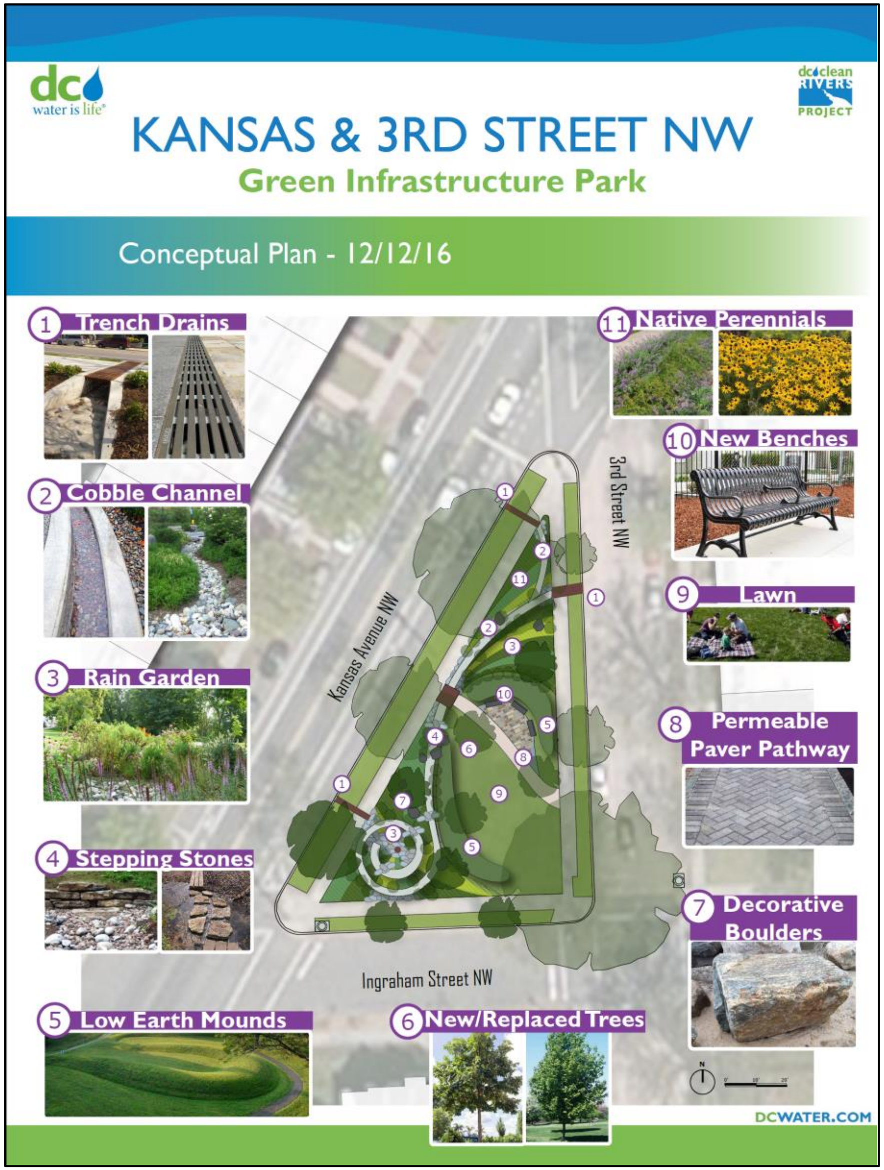
Kansas Avenue Green Infrastructure Parks Project:

- Kansas and 2nd Park:
  - Approx 150' L x 90' W. Bounded by Ingraham Street NW, Kansas Avenue NW, and 3rd Street NW
  - Brightwood Park Neighborhood
  - Existing Site Conditions:
    - Mix of shade and ornamental trees
    - Sidewalks on all sides
    - Adjacent to Washington Latin Public Charter School
    - Surrounded by row houses
- Kansas and 3rd Park:
  - Approx 170' L x 90' W. Bounded By Longfellow Street NW, Kansas Avenue NW, and 2nd Street NW
  - Brightwood Park Neighborhood
  - Existing Site Conditions:
    - Small, recently planted trees and turf
    - Sidewalks on all sides
    - Adjacent to Fort Slocum Park
    - Surrounded by row houses

Note: The Kansas Avenue Green Infrastructure Parks Project will serve as a pilot for potential future GI parks application throughout the Rock Creek Sewershed. No GI parks are planned for the Potomac River Sewershed at this time.

Initial Concept Plans





Final Concept Plans

Final Concept Plans

KANSAS AVENUE GREEN INFRASTRUCTURE PARKS PROJECT

KANSAS AND SECOND STREET N.W.

EXISTING

PROPOSED

dc clean RIVERS PROJECT

Final Concept Plans

Final Concept Plans

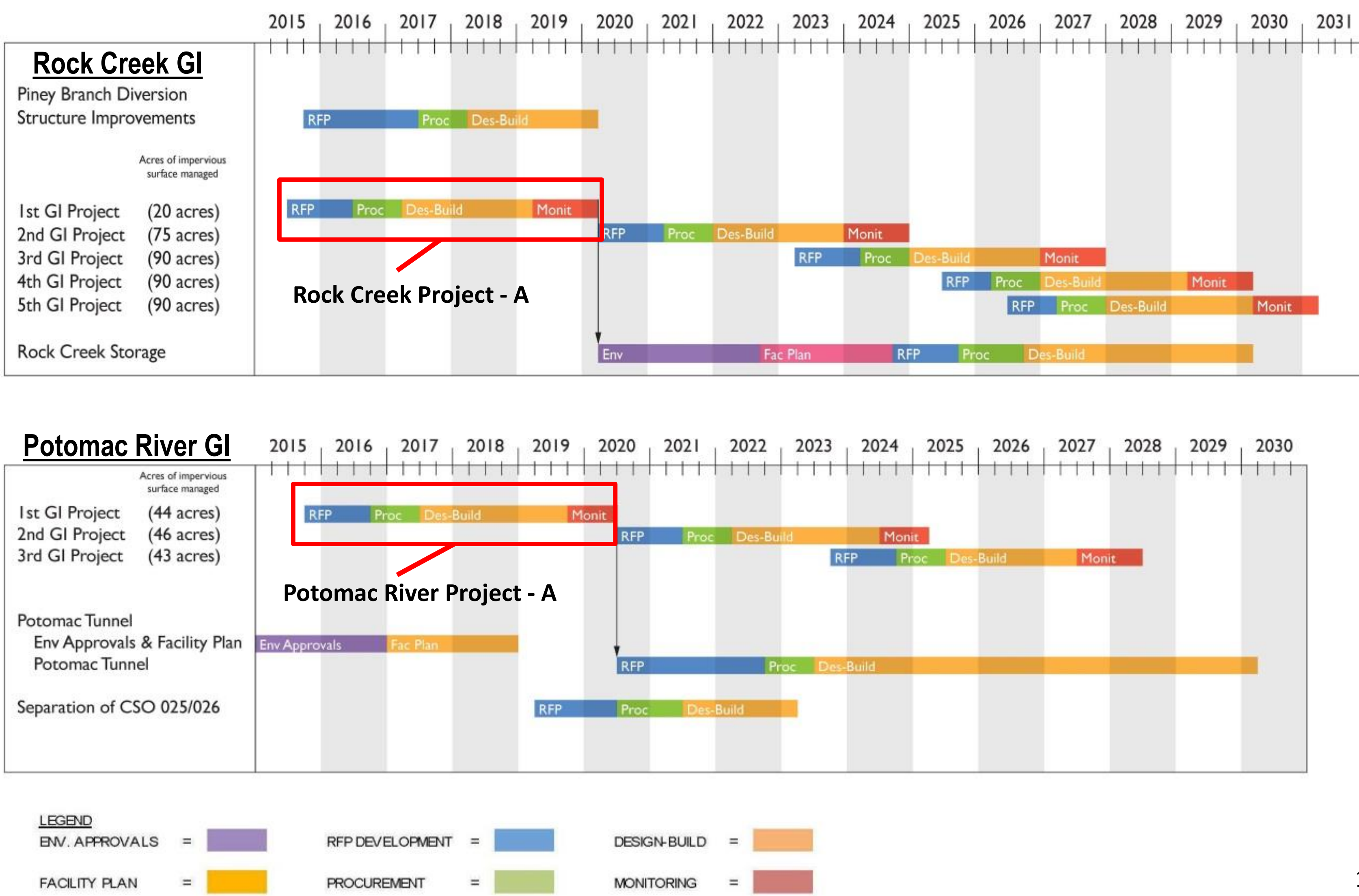
KANSAS AVENUE GREEN INFRASTRUCTURE PARKS PROJECT

KANSAS AND THIRD STREET N.W.

EXISTING

PROPOSED

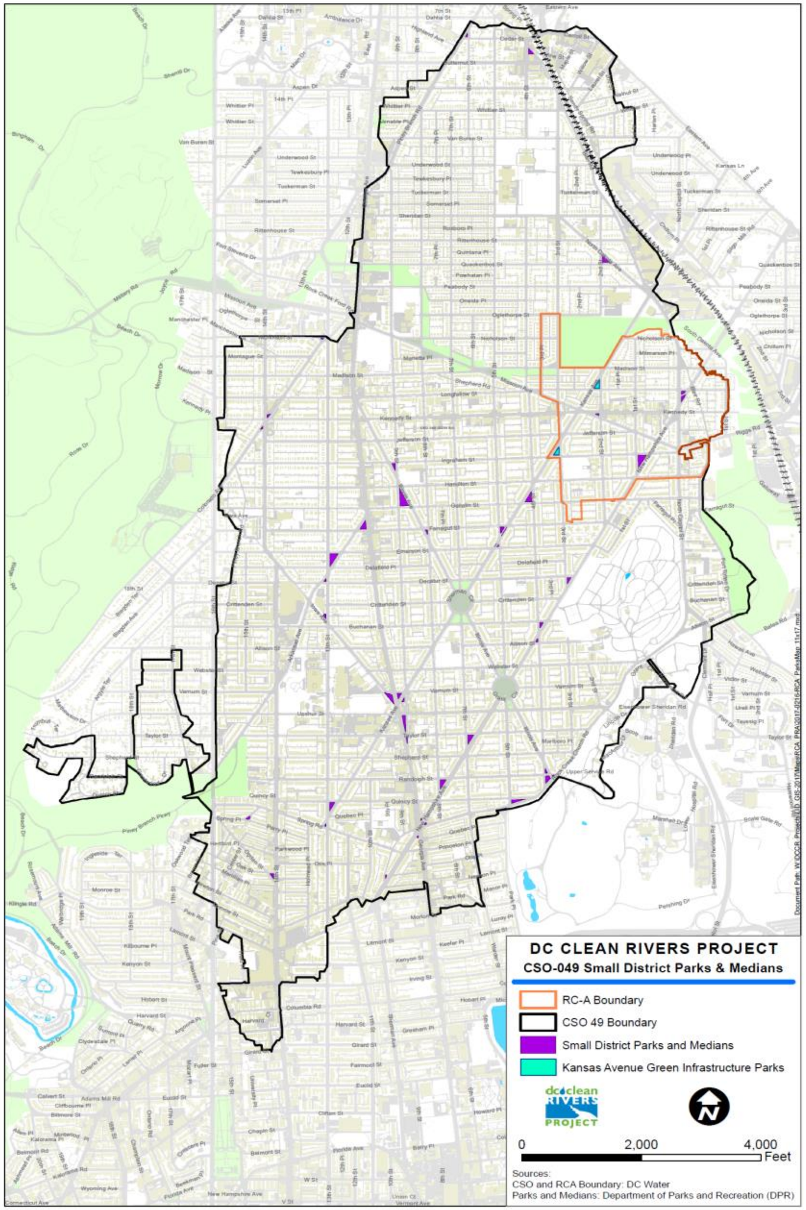
DC Clean Rivers Project:
Green Infrastructure Implementation Schedule



Next Steps:

<u>Future Rock Creek Green Infrastructure Park Opportunities:</u>

- Approximately 45 additional small parks and medians in the Rock Creek Sewershed with GI potential.
- The current submittal to the U.S. Commission of Fine Arts introduces the option for a Master Plan approach.
- DC Water is considering various procurement mechanisms for Park implementation under future phases of the Program.



Questions?

Seth Charde, PLA, LEED AP
Program Manager – Green Infrastructure Construction
DC Water
Seth.Charde@dcwater.com

http://www.dcwater.com/Green

Appendix D

DC Water GI Construction Standard Details

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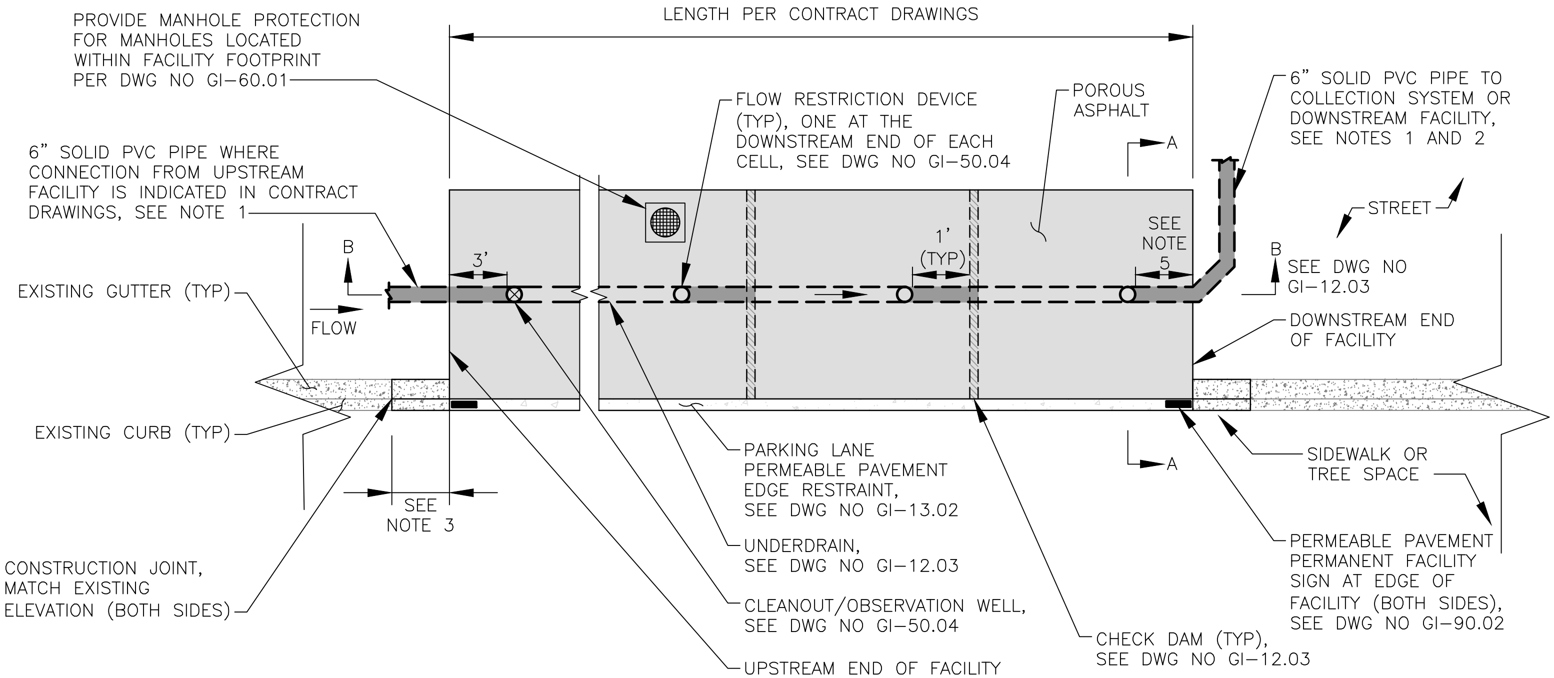


NOTES:

1. COLLECTION SYSTEM TIE IN LOCATION INDICATED ON CONTRACT DRAWINGS. ELEVATION OF CONNECTION TO COLLECTION SYSTEM AS INDICATED IN CONTRACT DRAWINGS. UNDERDRAIN PIPE SHALL TRANSITION FROM PVC SCHEDULE 40 TO PVC SDR–35 OUTSIDE THE FACILITY, WITHIN 3 LF OF THE UNDERDRAIN PENETRATION THOUGH THE WATERPROOFING MEMBRANE, AS MEASURED ALONG THE CENTERLINE OF THE UNDERDRAIN PIPE. FOR CONNECTION TO MANHOLES OR CATCH BASINS, SEE DWG NO GI–100.02. FOR CONNECTION TO SEWERS, SEE DWG NO GI–100.01. FOR CONNECTION TO DOWNSTREAM PERMEABLE PAVEMENT FACILITY, SEE DWG NO GI–50.04.

2. SEE DC WATER STANDARD DETAIL S–15.01 FOR TRENCH EXCAVATION AND FILL. BACKFILL ABOVE THE BEDDING, FOURTH COURSE, SHALL BE COMPACTED FILL MEETING DC WATER STANDARDS.

3. CONTRACTOR SHALL RESTORE CURB AND GUTTER PER DDOT STANDARDS 1' BEYOND FACILITY EXCEPT WHERE:
   - CATCH BASIN OR ALLEY APRON IS WITHIN 0–4' OF EDGE OF FACILITY, REPLACE CURB AND GUTTER TO EDGE OF CATCH BASIN OR ALLEY APRON.
   - NEXT CURB CONSTRUCTION JOINT IS WITHIN 1–4' OF EDGE OF FACILITY, REPLACE TO THAT CONSTRUCTION JOINT.
   - OTHERWISE SPECIFIED IN THE CONTRACT DRAWINGS OR BY DC WATER'S REPRESENTATIVE.

   CONTRACTOR SHALL MATCH EXISTING SURFACE FINISH.

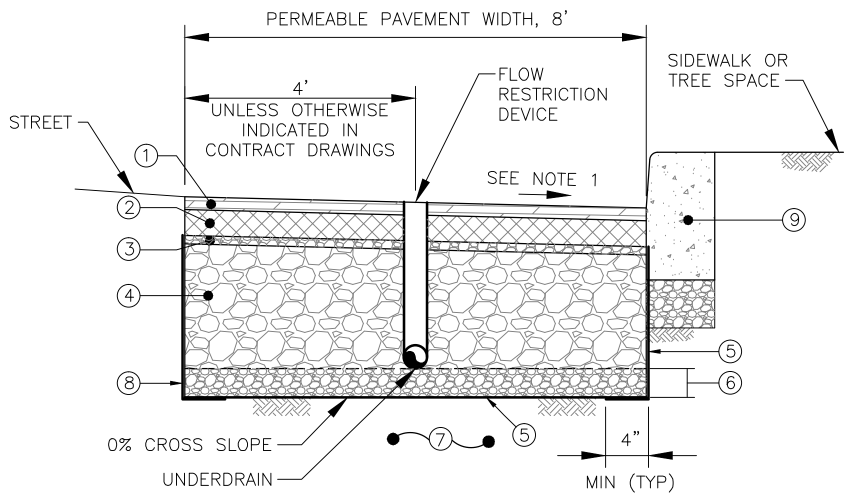
4. FOR CURB AND GUTTER AND PARKING LANE PERMEABLE PAVEMENT EDGE RESTRAINT JOINTS, SEE DDOT STANDARD SPECIFICATIONS FOR HIGHWAYS AND STRUCTURES, SECTION 606.01.

5. 4' WHERE UNDERDRAIN TIES TO SEWER WITHIN FACILITY FOOTPRINT. OTHERWISE, 1', OR PER CONTRACT DRAWINGS.

6. CONTRACTOR SHALL PROVIDE, FURNISH, AND INSTALL THREE (3) PARKING LANE PERMEABLE PAVEMENT VACUUMING SIGNS PER SIDE OF STREET BETWEEN INTERSECTIONS WITH PROPOSED PARKING LANE PERMEABLE PAVEMENT. FINAL SIGN LOCATIONS SHALL BE FIELD LOCATED BY THE CONTRACTOR IN THE TREE SPACE AND APPROVED BY DC WATER.

DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
CHIEF ENGINEER	PREPARED BY: DCCR	PARKING LANE PERMEABLE PAVEMENT FACILITY PLAN
	CHECKED BY: ________	



LEGEND:

1. POROUS ASPHALT SURFACE COURSE, 1.5" THICKNESS
2. POROUS ASPHALT BASE COURSE, 3" THICKNESS
3. CHOKER LAYER, 2" THICKNESS, AASHTO #57 STONE OR APPROVED EQUIVALENT
4. AGGREGATE STORAGE LAYER, 26" THICKNESS AT PERMEABLE PAVEMENT CONCRETE CURB, AASHTO #2 OR #3 STONE OR APPROVED EQUIVALENT
5. GEOTEXTILE, SEE NOTE 2
6. UNDERDRAIN BEDDING, 3" THICKNESS, AASHTO #57 STONE OR APPROVED EQUIVALENT
7. SUBGRADE. PREPARE SUBGRADE IN ACCORDANCE WITH DDOT GREEN INFRASTRUCTURE STANDARDS, SECTION 621.01(D)
8. WATERPROOFING MEMBRANE. AT INTERFACE WITH STREET, TRIM MEMBRANE TO TOP OF CHOKER LAYER PRIOR TO PLACEMENT OF POROUS ASPHALT BASE COURSE.
9. PARKING LANE PERMEABLE PAVEMENT EDGE RESTRAINT, SEE DWG NO GI–13.02.

NOTES:

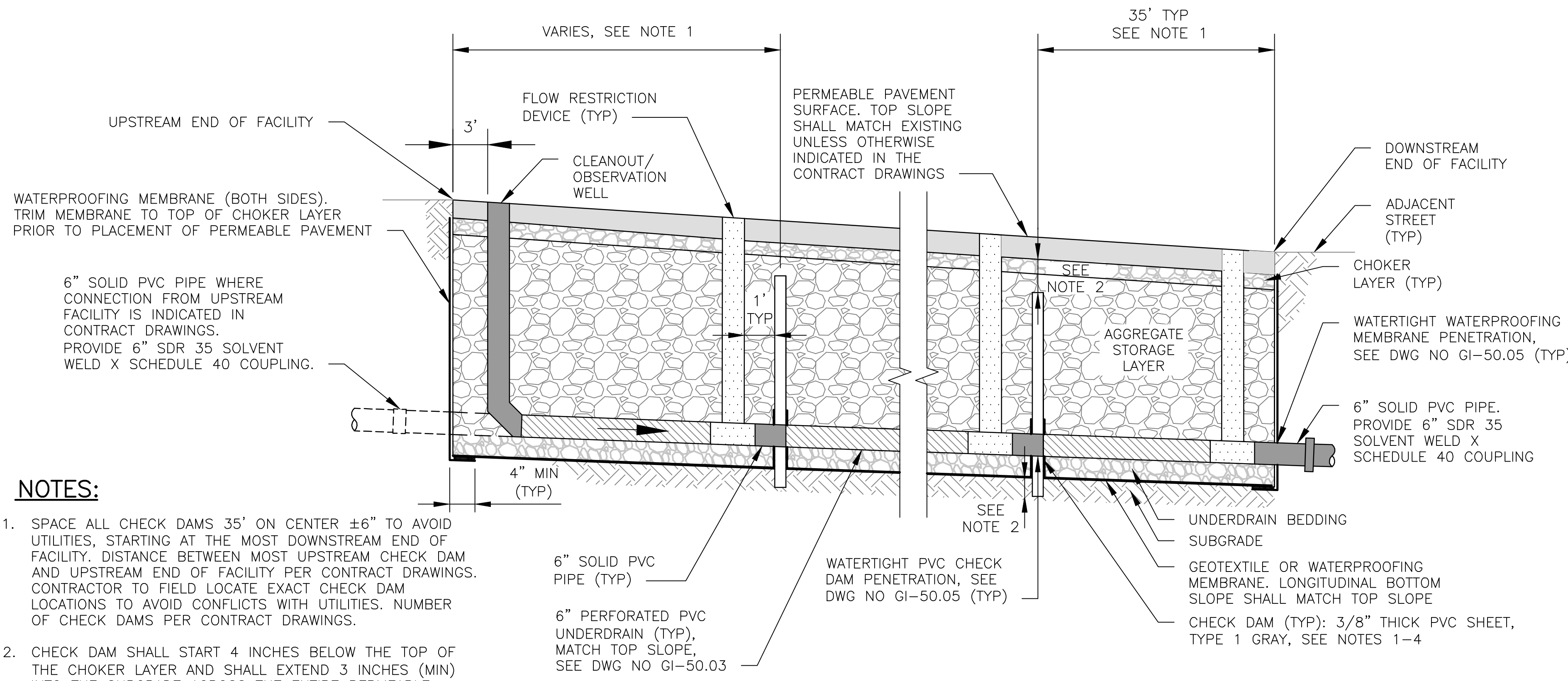
1. MATCH EXISTING SURFACE CROSS SLOPES UNLESS OTHERWISE INDICATED IN CONTRACT DRAWINGS.
2. WATERPROOFING MEMBRANE SHALL BE USED IN LIEU OF GEOTEXTILE WHERE INDICATED IN CONTRACT DRAWINGS.
3. EXCAVATION AND ALL SUPPORT OF EXCAVATION, INCLUDING SLOPES, SHALL BE A MINIMUM OF 2 FEET FROM ALL STRUCTURES, EXCLUDING MANHOLES, UTILITY RISERS AND CATCH BASINS. TEMPORARILY SUPPORT MANHOLES, POLES, AND OTHER EXISTING STRUCTURES DURING CONSTRUCTION TO PREVENT MOVEMENT DUE TO REMOVAL OF SOIL AND UNBALANCED LOADING.

DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
____________	PREPARED BY: DCCR	PARKING LANE PERMEABLE PAVEMENT FACILITY SECTION A–A
CHIEF ENGINEER	CHECKED BY: ________	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–12.03



NOTES:

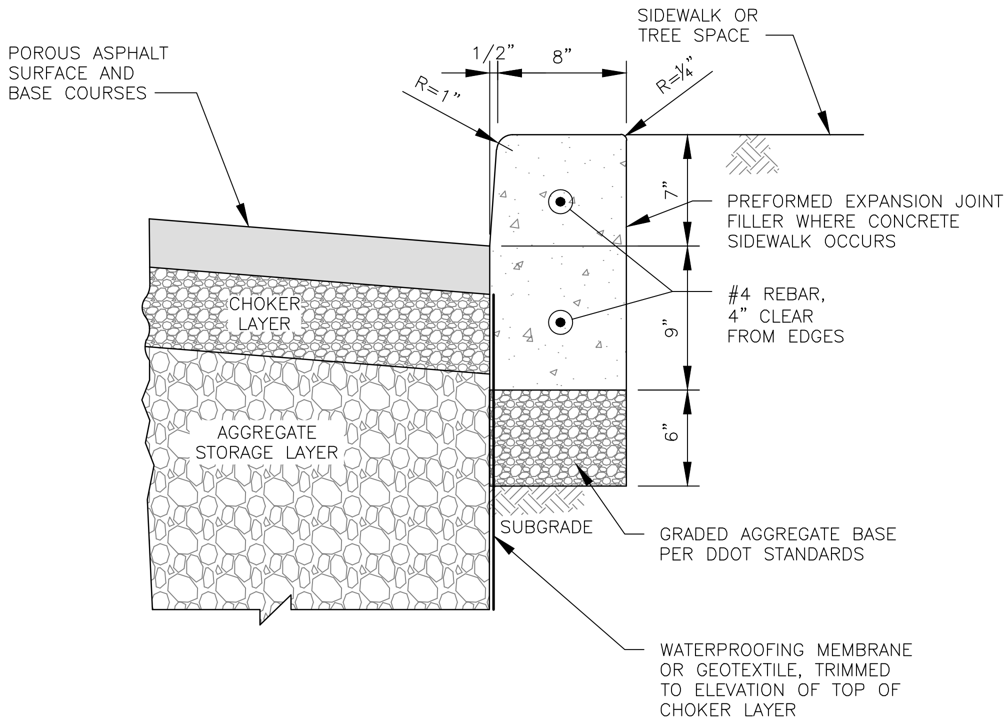
1. SPACE ALL CHECK DAMS 35' ON CENTER ±6" TO AVOID UTILITIES, STARTING AT THE MOST DOWNSTREAM END OF FACILITY. DISTANCE BETWEEN MOST UPSTREAM CHECK DAM AND UPSTREAM END OF FACILITY PER CONTRACT DRAWINGS. CONTRACTOR TO FIELD LOCATE EXACT CHECK DAM LOCATIONS TO AVOID CONFLICTS WITH UTILITIES. NUMBER OF CHECK DAMS PER CONTRACT DRAWINGS.
2. CHECK DAM SHALL START 4 INCHES BELOW THE TOP OF THE CHOKER LAYER AND SHALL EXTEND 3 INCHES (MIN) INTO THE SUBGRADE ACROSS THE ENTIRE PERMEABLE PAVEMENT WIDTH.
3. DO NOT INSTALL GEOTEXTILE OR WATERPROOFING MEMBRANE UNDER OR AROUND CHECK DAMS. TURN UP GEOTEXTILE AND/OR WATERPROOFING MEMBRANE AGAINST CHECK DAM BOTTOM AND SIDES, OVERLAP WITH CHECK DAM PER MANUFACTURER'S RECOMMENDATION AND AS APPROVED BY DC WATER, 12 INCH MINIMUM. ADHERE WATERPROOFING MEMBRANE DIRECTLY TO CHECK DAM.
4. CHECK DAMS SHALL BE CONSTRUCTED TO PREVENT ANY UNINTENDED BYPASS WITHIN THE AGGREGATE STORAGE LAYER AND UNDERDRAIN BEDDING LAYER OR AROUND THE CHECK DAMS.

DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
CHIEF ENGINEER	PREPARED BY: DCCR	PARKING LANE PERMEABLE PAVEMENT FACILITY ELEVATION ALONG UNDERDRAIN, SECTION B–B
	CHECKED BY: ________	

GI–13.02

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



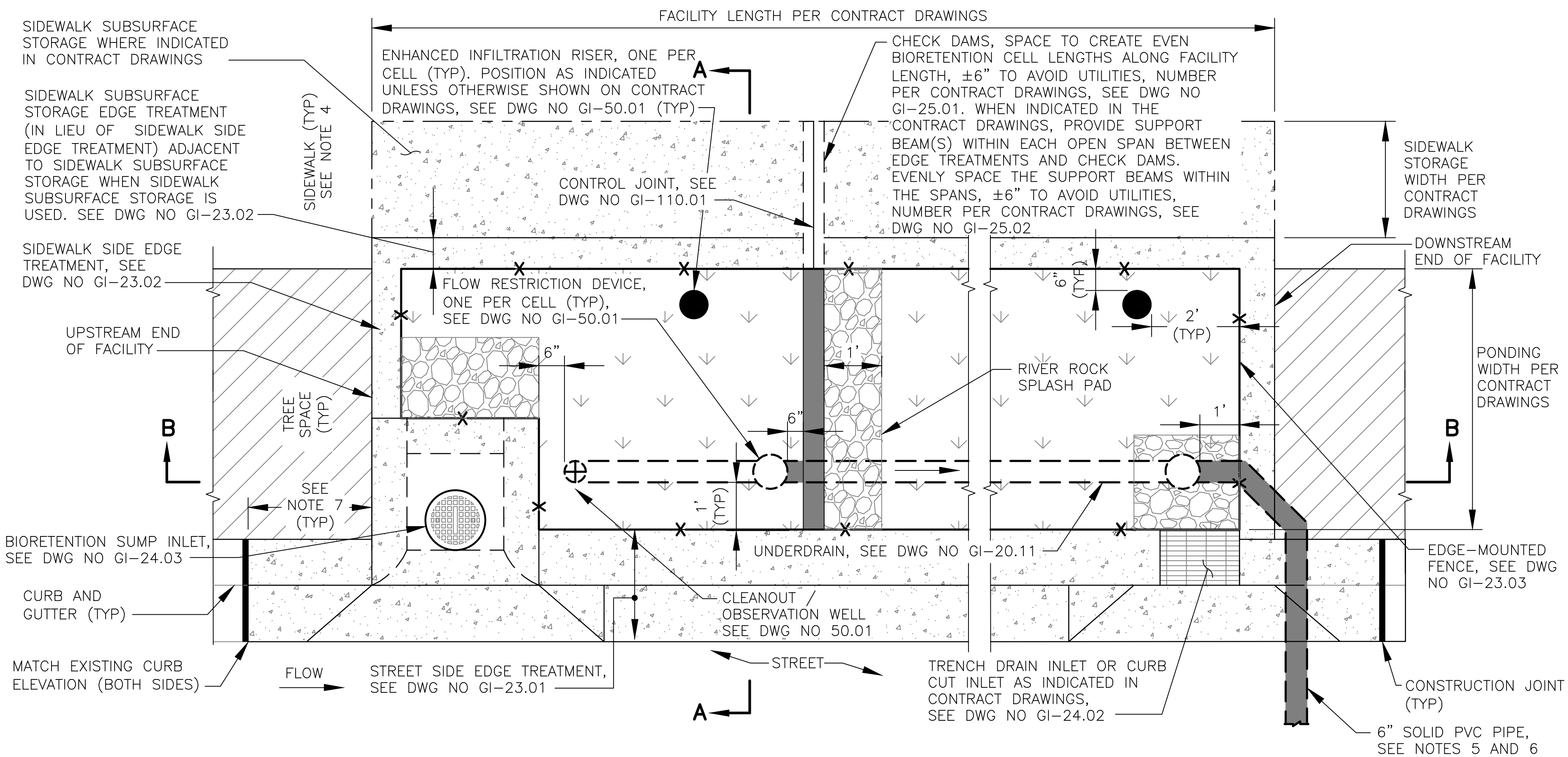
NOTES:

1. WHERE TREE ROOTS BUTTRESS OVER EXISTING CURB, EXISTING CURB SHALL REMAIN IN PLACE ADJACENT TO TREE, IN ACCORDANCE WITH CONTRACT DOCUMENTS.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	
	CHECKED BY: ______	PARKING LANE PERMEABLE PAVEMENT EDGE RESTRAINT

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	PLANTER BIORETENTION FACILITY PLAN
	CHECKED BY: ______	

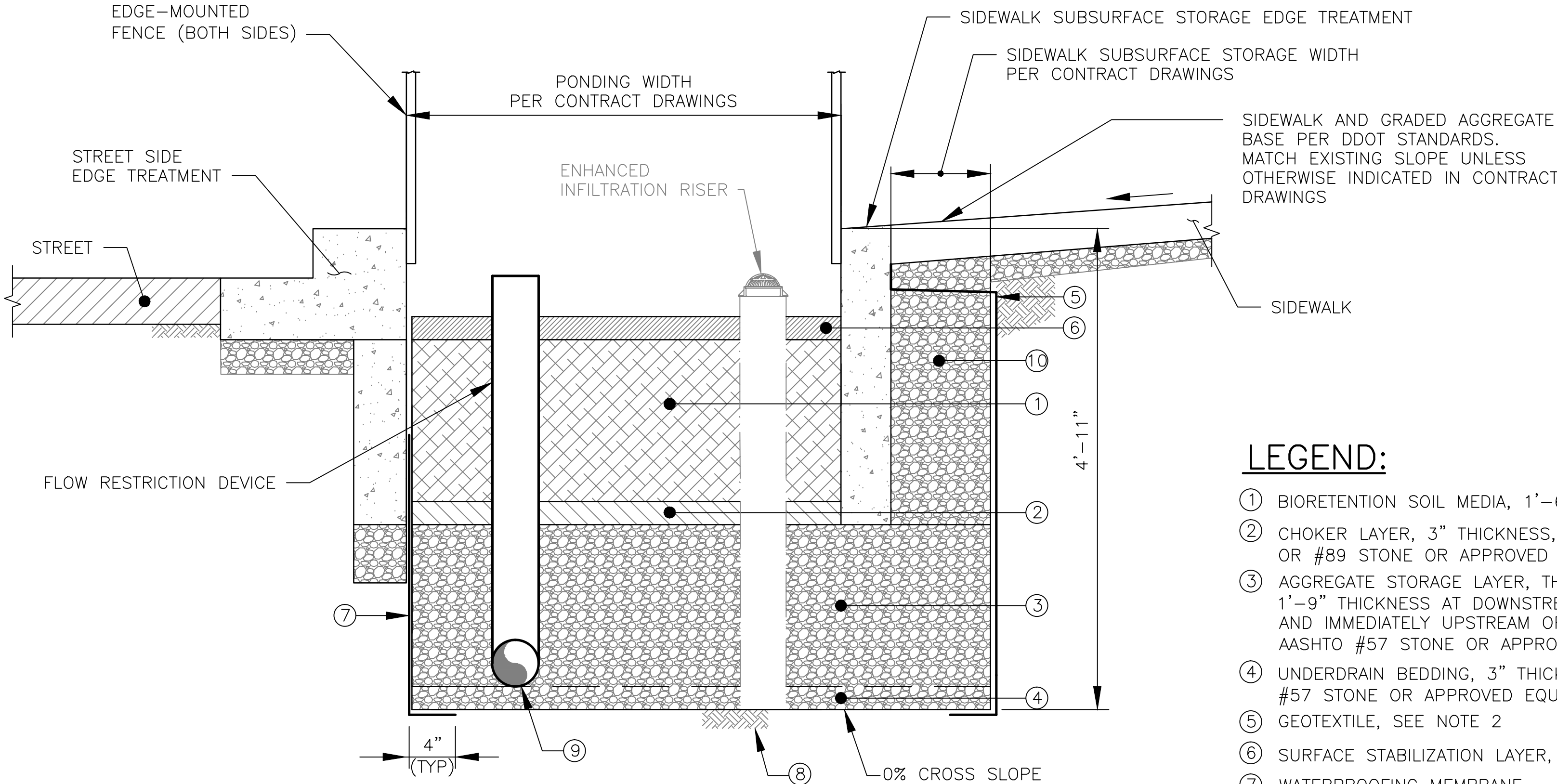
NOTES:

1. IF CONTRACT DRAWINGS INDICATE A NEW TREE WITHIN OR DIRECTLY ADJACENT TO A FACILITY, SEE DWG NO GI–70.01. PLANTINGS SHALL BE INSTALLED IN ACCORDANCE WITH DWG NOS GI–70.02 AND GI–70.03.
2. SEE CONTRACT DRAWINGS FOR INLET CONFIGURATIONS AND SIZES. PROVIDE ADDITIONAL INLETS WHERE INDICATED IN CONTRACT DRAWINGS.
3. EXISTING PEDESTRIAN PATHS LOCATED WITHIN PROPOSED FACILITY FOOTPRINT SHALL BE REMOVED.
4. REPLACE IMPACTED SIDEWALK SLABS ADJACENT TO FACILITY.
5. COLLECTION SYSTEM TIE IN LOCATION INDICATED ON CONTRACT DOCUMENTS. ELEVATION OF CONNECTION TO COLLECTION SYSTEM PER CONTRACT DRAWINGS. UNDERDRAIN PIPE SHALL TRANSITION FROM PVC SCHEDULE 40 TO PVC SDR–35 OUTSIDE THE FACILITY, WITHIN 3 LF OF THE UNDERDRAIN PENETRATION THOUGH THE WATERPROOFING MEMBRANE OR GEOTEXTILE, AS MEASURED ALONG THE CENTERLINE OF THE UNDERDRAIN PIPE. FOR CONNECTION TO MANHOLES OR CATCH BASINS, SEE DWG NO GI–100.02. FOR CONNECTION TO SEWERS, SEE DWG NO GI–100.01. FOR CONNECTION TO DOWNSTREAM PERMEABLE PAVEMENT FACILITY, SEE DWG NO GI–50.04.
6. SEE DC WATER STANDARD DETAIL S–15.01 FOR TRENCH EXCAVATION AND FILL. BACKFILL ABOVE THE BEDDING, FOURTH COURSE, SHALL BE COMPACTED FILL MEETING DC WATER STANDARDS.
7. CONTRACTOR SHALL RESTORE CURB AND GUTTER PER DDOT STANDARDS 1' BEYOND FACILITY EXCEPT WHERE:
    - CATCH BASIN OR ALLEY APRON IS WITHIN 0–4' OF EDGE OF FACILITY, REPLACE CURB AND GUTTER TO EDGE OF CATCH BASIN OR ALLEY APRON.
    - NEXT CURB CONSTRUCTION JOINT IS WITHIN 1–4' OF EDGE OF FACILITY, REPLACE TO THAT CONSTRUCTION JOINT.
    - OTHERWISE SPECIFIED IN THE CONTRACT DRAWINGS OR BY DC WATER'S REPRESENTATIVE.

    CONTRACTOR SHALL MATCH EXISTING SURFACE FINISH.

DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
____________ CHIEF ENGINEER	PREPARED BY: DCCR	PLANTER BIORETENTION FACILITY PLAN
	CHECKED BY: ________	



LEGEND:

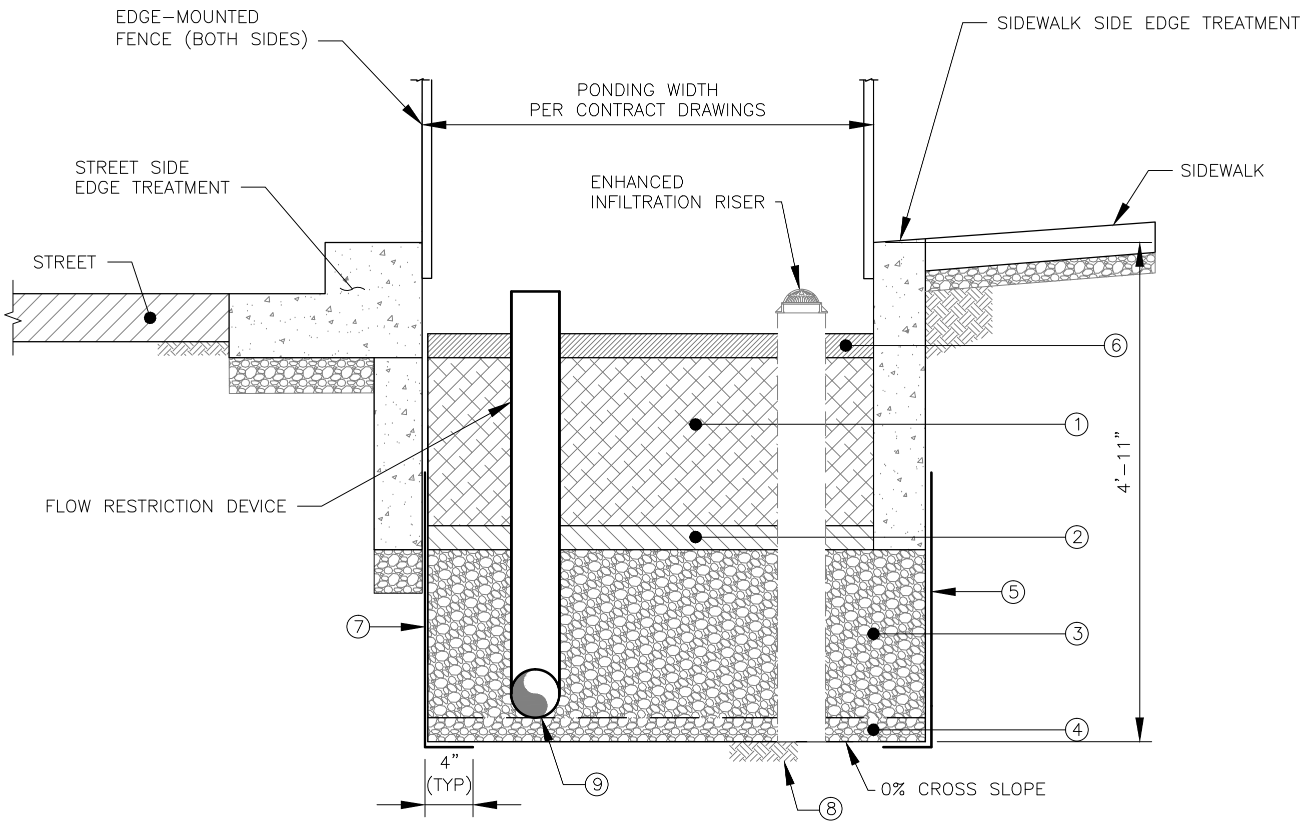
1. BIORETENTION SOIL MEDIA, 1'–6" THICKNESS
2. CHOKER LAYER, 3" THICKNESS, AASHTO #8 OR #89 STONE OR APPROVED EQUIVALENT
3. AGGREGATE STORAGE LAYER, THICKNESS VARIES, 1'–9" THICKNESS AT DOWNSTREAM END OF FACILITY AND IMMEDIATELY UPSTREAM OF CHECK DAMS, AASHTO #57 STONE OR APPROVED EQUIVALENT
4. UNDERDRAIN BEDDING, 3" THICKNESS, AASHTO #57 STONE OR APPROVED EQUIVALENT
5. GEOTEXTILE, SEE NOTE 2
6. SURFACE STABILIZATION LAYER, 2" THICKNESS
7. WATERPROOFING MEMBRANE
8. SUBGRADE, SEE NOTE 1
9. UNDERDRAIN
10. SIDEWALK SUBSURFACE STORAGE

NOTES:

1. SCARIFY SUBGRADE 3" MIN BEFORE INSTALLATION.
2. WATERPROOFING MEMBRANE SHALL BE USED IN LIEU OF GEOTEXTILE WHERE INDICATED IN CONTRACT DRAWINGS.

DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	PLANTER BIORETENTION FACILITY
	PREPARED BY: DCCR	WITH SIDEWALK SUBSURFACE STORAGE,
CHIEF ENGINEER	CHECKED BY: ______	SECTION A–A



LEGEND:

1. BIORETENTION SOIL MEDIA, 1'–6" THICKNESS
2. CHOKER LAYER, 3" THICKNESS, AASHTO #8 OR #89 STONE OR APPROVED EQUIVALENT
3. AGGREGATE STORAGE LAYER, THICKNESS VARIES, 1'–9" THICKNESS AT DOWNSTREAM END OF FACILITY AND IMMEDIATELY UPSTREAM OF CHECK DAMS, AASHTO #57 STONE OR APPROVED EQUIVALENT
4. UNDERDRAIN BEDDING, 3" THICKNESS, AASHTO #57 STONE OR APPROVED EQUIVALENT
5. GEOTEXTILE, SEE NOTE 2
6. SURFACE STABILIZATION LAYER, 2" THICKNESS
7. WATERPROOFING MEMBRANE
8. SUBGRADE, SEE NOTE 1
9. UNDERDRAIN

NOTES:

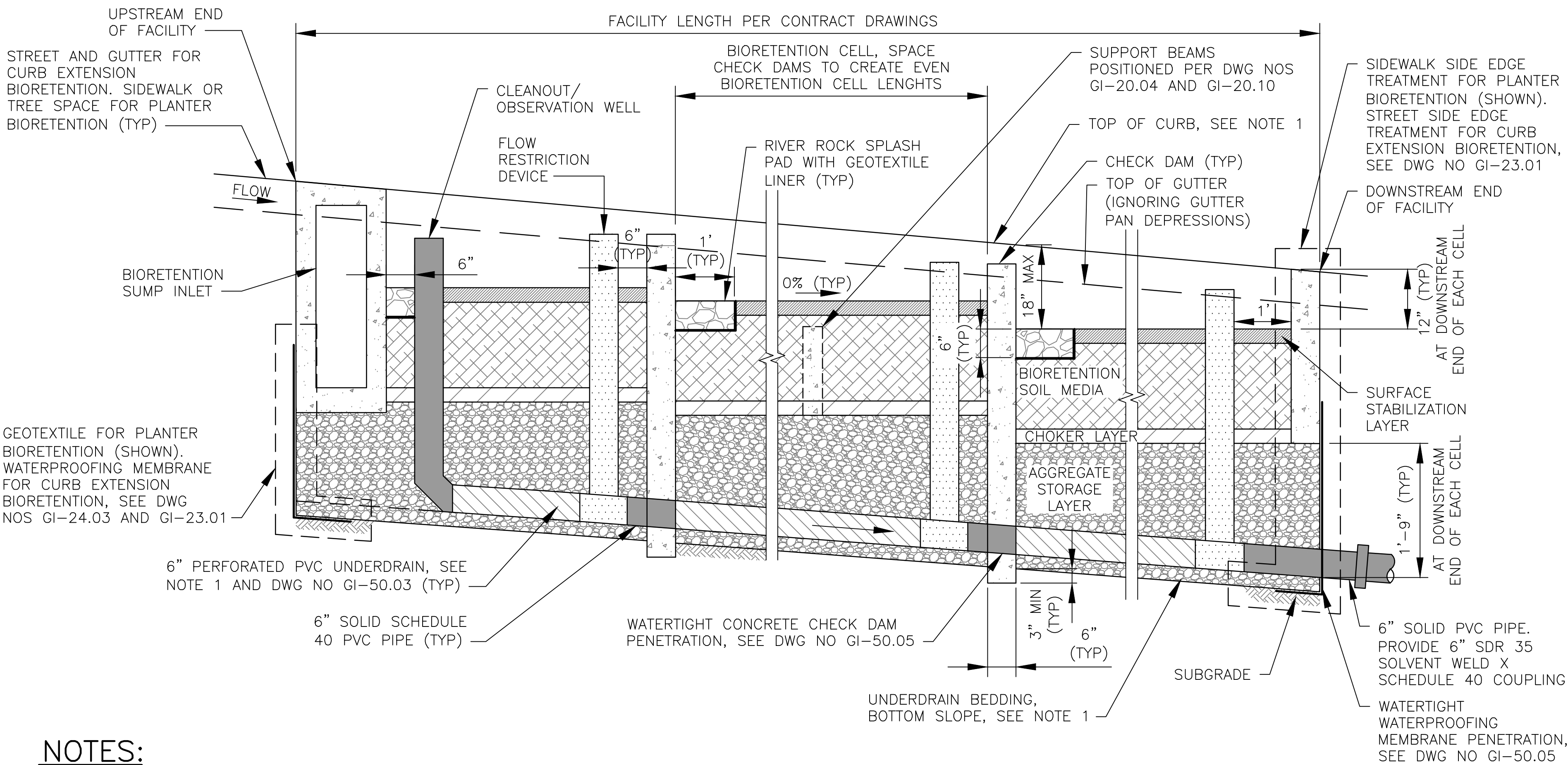
1. SCARIFY SUBGRADE 3" MIN BEFORE INSTALLATION.
2. WATERPROOFING MEMBRANE SHALL BE USED IN LIEU OF GEOTEXTILE WHERE INDICATED IN CONTRACT DRAWINGS.

DETAIL NOT TO SCALE

APPROVED DATE: ______ CHIEF ENGINEER	REVISION NO.: ______ DATE: ______ PREPARED BY: DCCR CHECKED BY: ______	STANDARD DETAIL–PR–A1 PLANTER BIORETENTION FACILITY WITHOUT SIDEWALK SUBSURFACE STORAGE, SECTION A–A

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–20.11



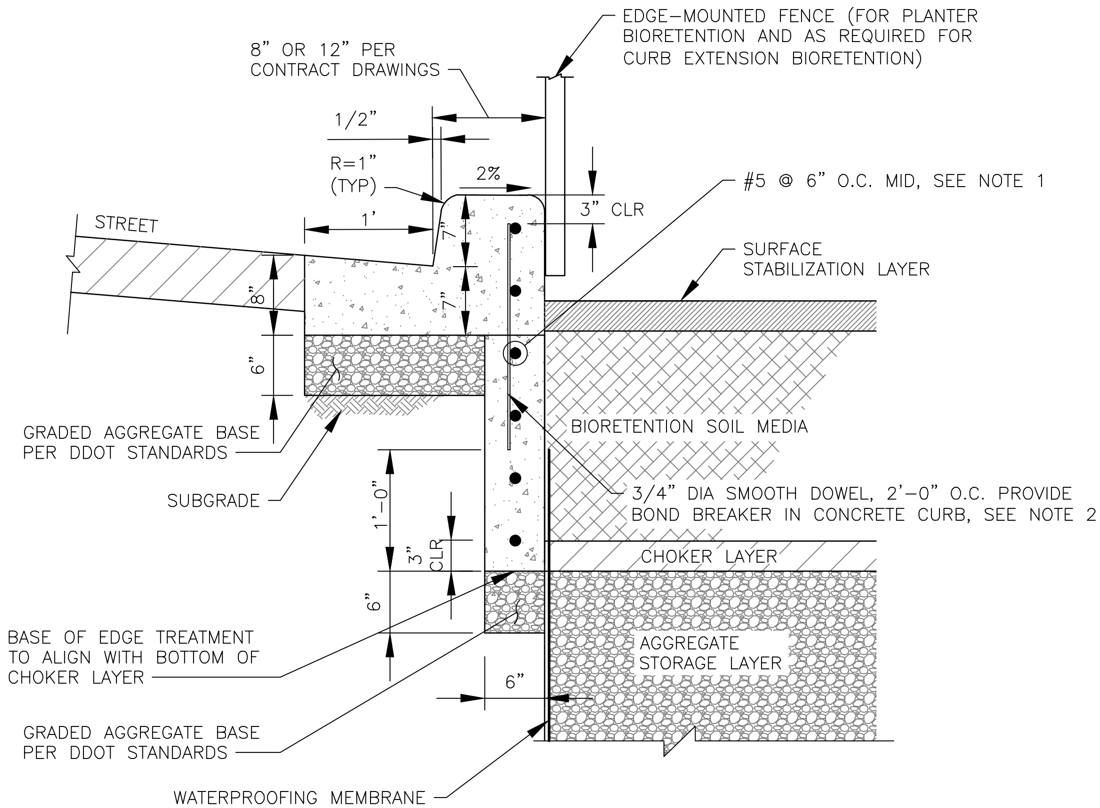
NOTES:

1. LONGITUDINAL SLOPE OF FACILITY BOTTOM, UNDERDRAIN, AND TOP OF EDGE TREATMENTS SHALL MATCH EXISTING ROAD SLOPE.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
CHIEF ENGINEER	DATE: ______	BIORETENTION FACILITY ELEVATION SECTION B–B
	PREPARED BY: DCCR	
	CHECKED BY: ______	

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY	GI–23.01



NOTES:

1. PROVIDE CORNER BARS AT CORNERS PER DWG NO GI–110.01. DOWEL INTO BIORETENTION SUMP INLETS WHERE THEY OCCUR, TO DEVELOP BAR.

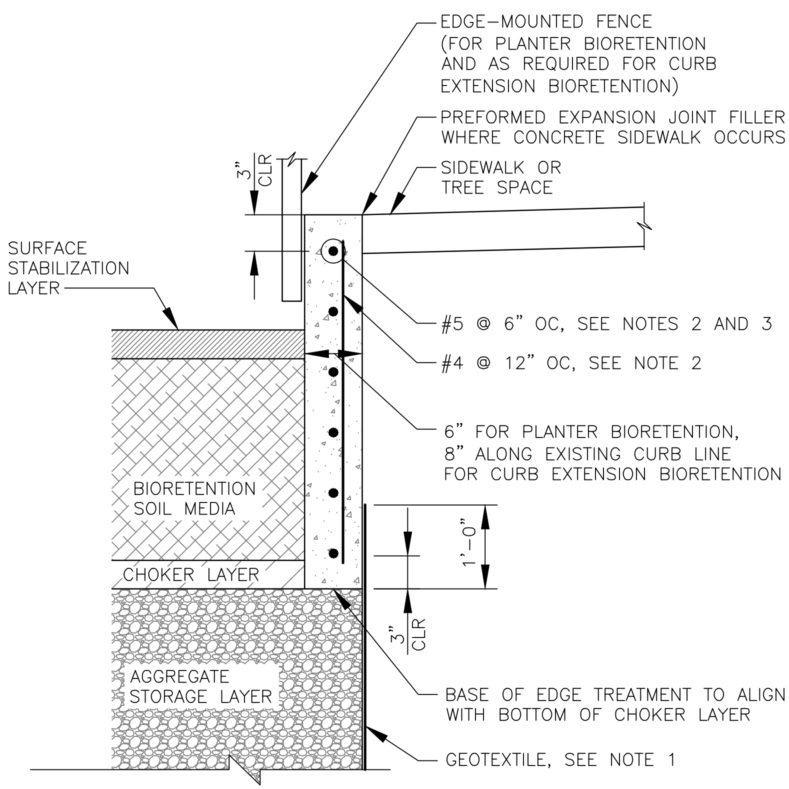
2. DOWEL BAR: ASTM A615, GR 60, SMOOTH
   BOND BREAKER: VALVOLINE TECTYL 506, OR APPROVED EQUAL

DETAIL NOT TO SCALE

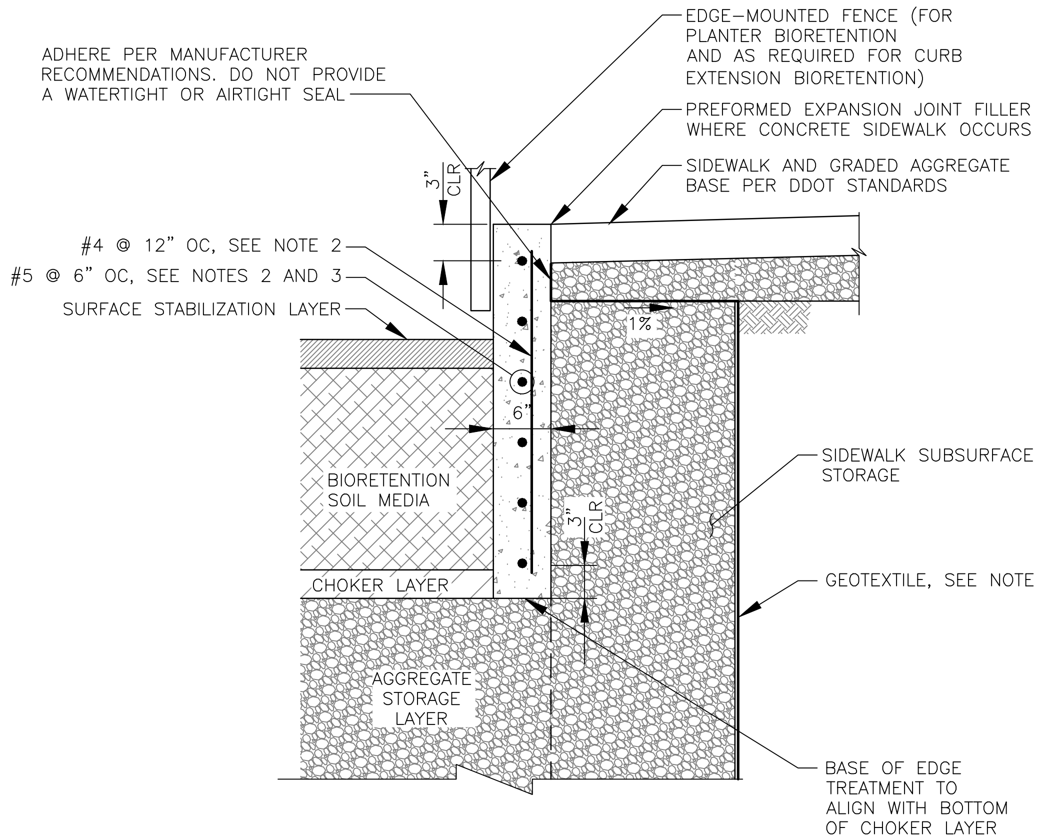
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	STREET SIDE EDGE TREATMENT
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–23.02



SIDEWALK SIDE
EDGE TREATMENT



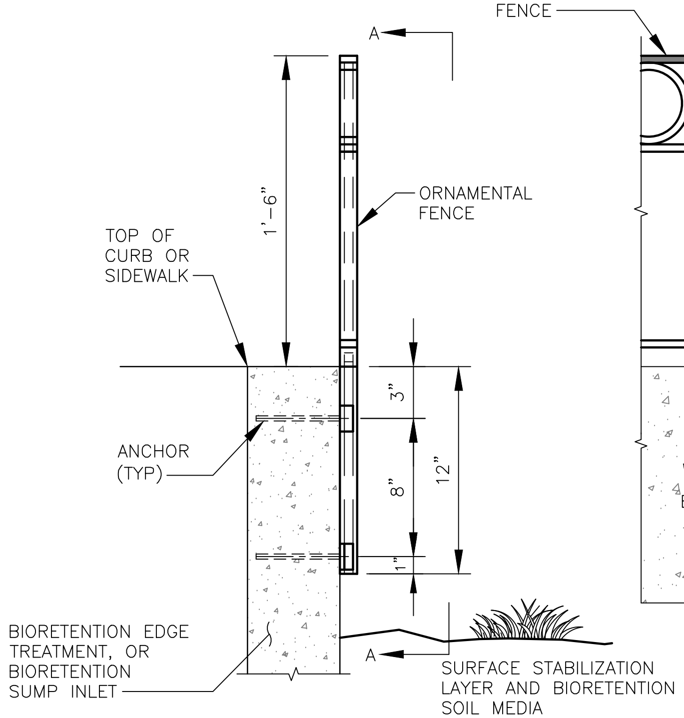
SIDEWALK SUBSURFACE
STORAGE EDGE TREATMENT

NOTES:

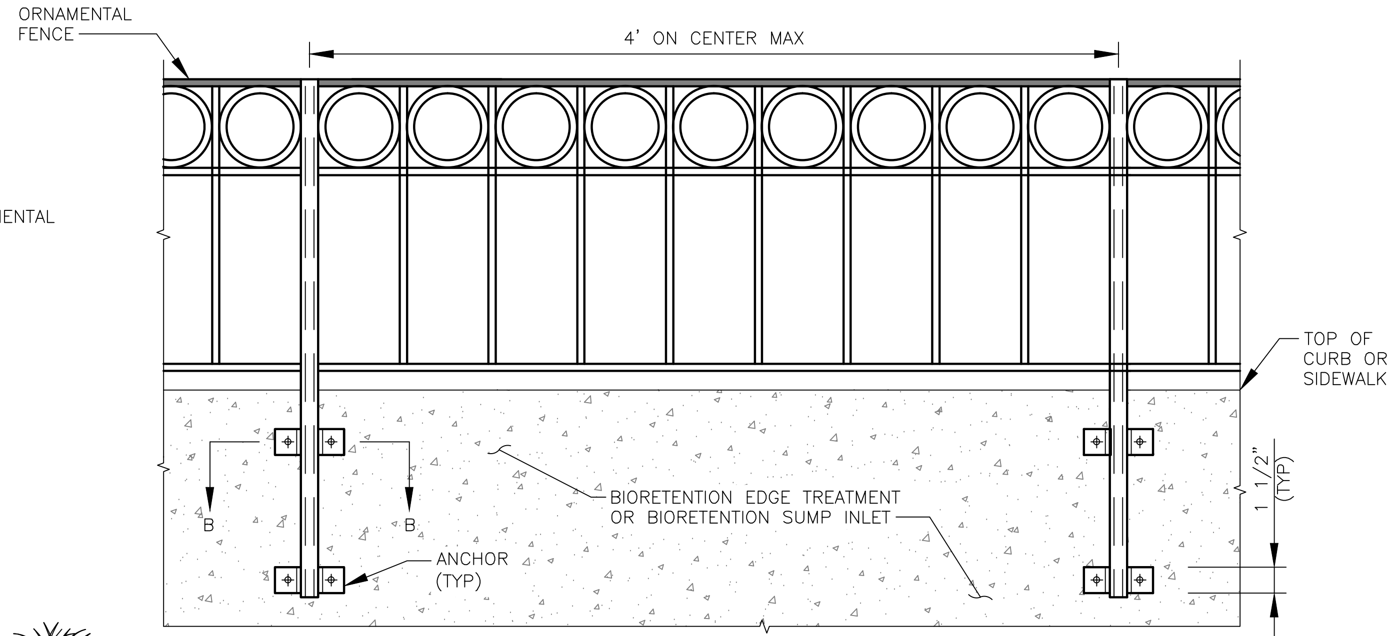
1. WATERPROOFING MEMBRANE SHALL BE USED IN LIEU OF GEOTEXTILE WHERE INDICATED IN THE CONTRACT DRAWINGS.
2. CENTER REINFORCEMENT IN EDGE TREATMENT.
3. PROVIDE CORNER BARS AT CORNERS PER DWG NO GI–110.01. DOWEL INTO BIORETENTION SUMP INLETS WHERE THEY OCCUR, TO DEVELOP BAR.

DETAIL NOT TO SCALE

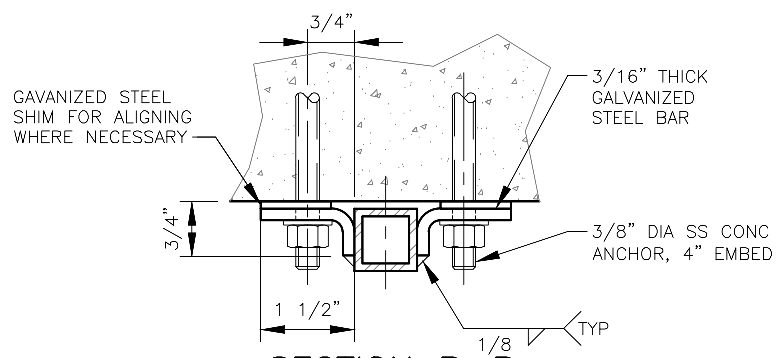
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
	PREPARED BY: DCCR	BIORETENTION EDGE TREATMENTS – SIDEWALK SIDE
CHIEF ENGINEER	CHECKED BY: ______	



ELEVATION



SECTION A–A



SECTION B–B

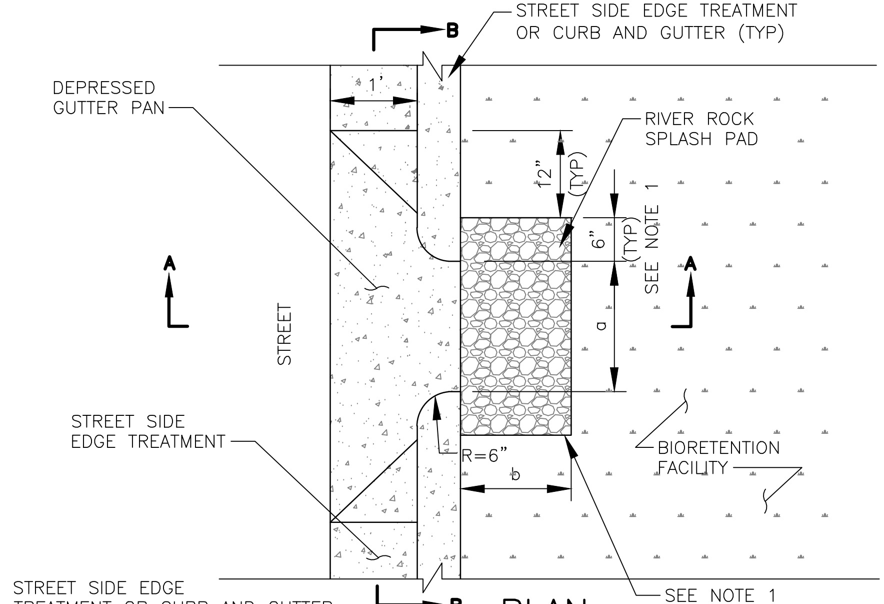
DETAIL NOT TO SCALE

NOTES:

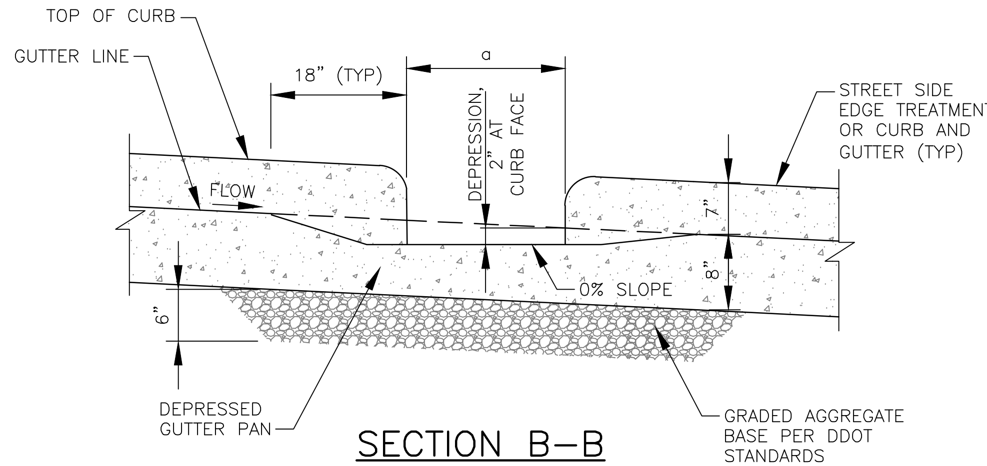
1. ANCHORS SHALL NOT BE USED ON THE SIDE OF THE BIORETENTION SUMP INLET WITH THE OPENING.
2. CORNERS OF FENCE SHALL NOT BE WELDED EXCEPT WHERE NEEDED TO SUPPORT UNANCHORED PERPENDICULAR FENCE.
3. LOCATE END POST WITHIN 1'–0" OF CORNERS.

APPROVED DATE: ____	REVISION NO.: ____	STANDARD DETAIL–PR–A1
	DATE: ____	
CHIEF ENGINEER	PREPARED BY: DCCR	EDGE–MOUNTED FENCE
	CHECKED BY: ____	

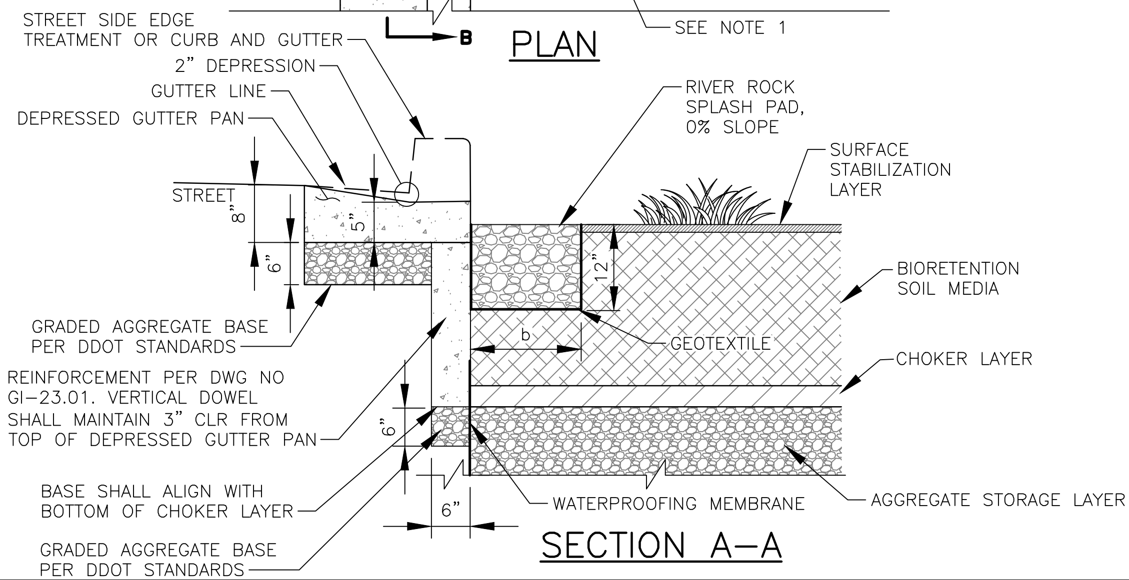
DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



PLAN



SECTION B–B



SECTION A–A

NOTES:

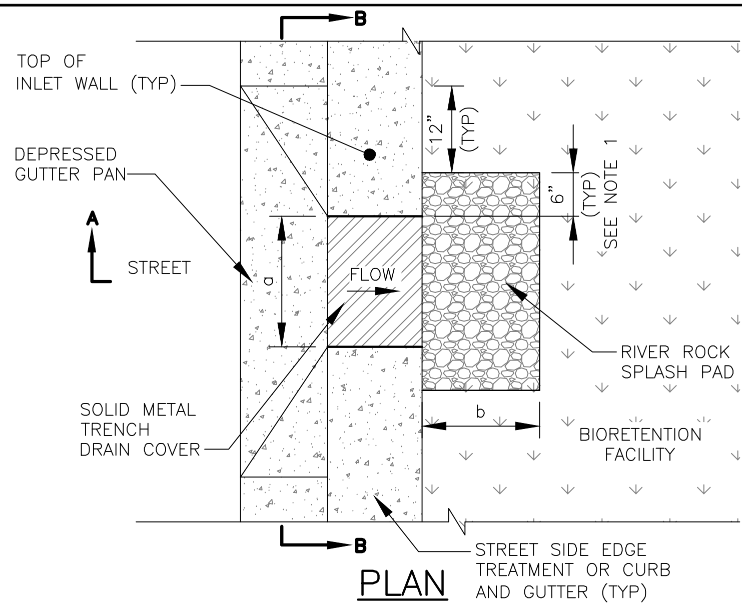
1. ELIMINATE WING OF RIVER ROCK SPLASH PAD WHERE INLET OPENING ABUTS CHECK DAM OR EDGE TREATMENT.
2. SEE CONTRACT DRAWINGS FOR DIMENSIONS a AND b.

DETAIL NOT TO SCALE

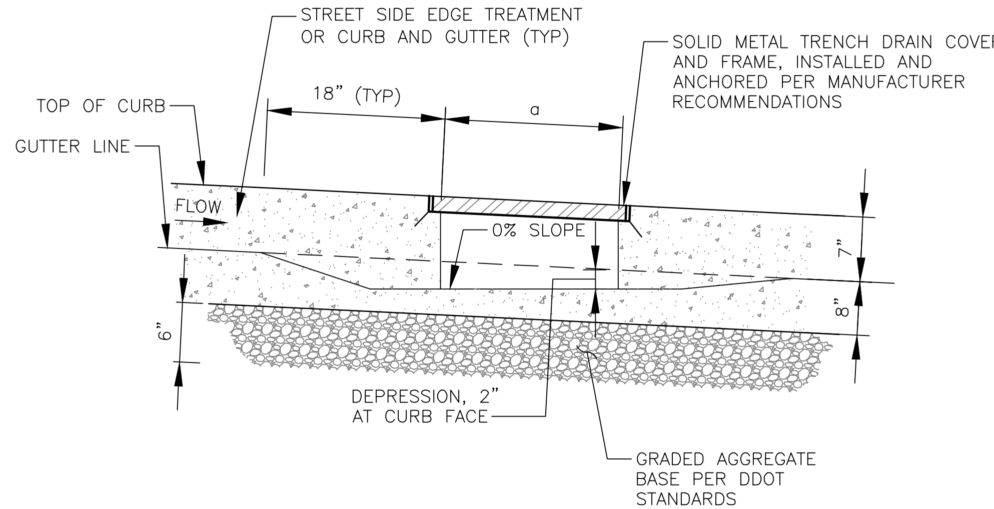
APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
____________	PREPARED BY: DCCR	CURB CUT INLET
CHIEF ENGINEER	CHECKED BY: ________	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

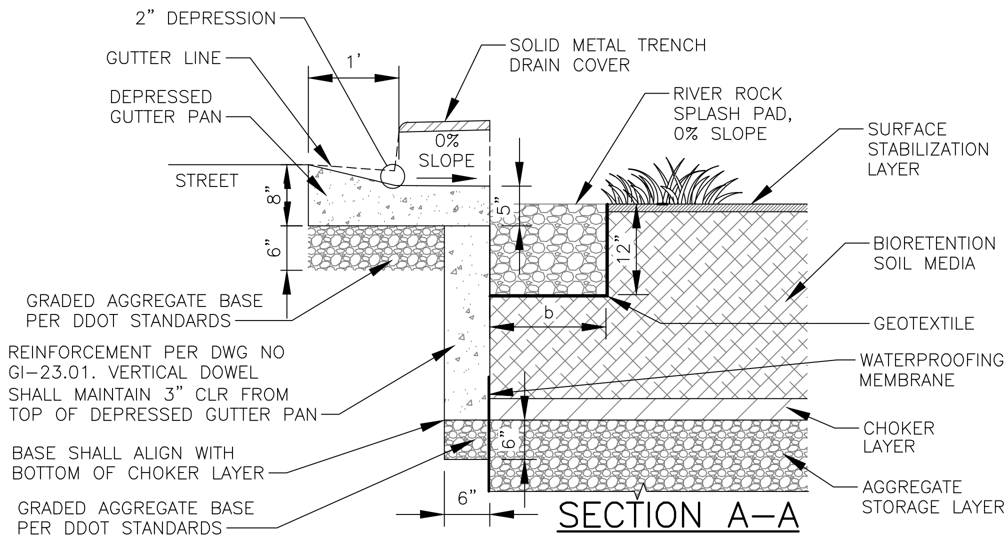
GI–24.02



PLAN



SECTION B–B



SECTION A–A

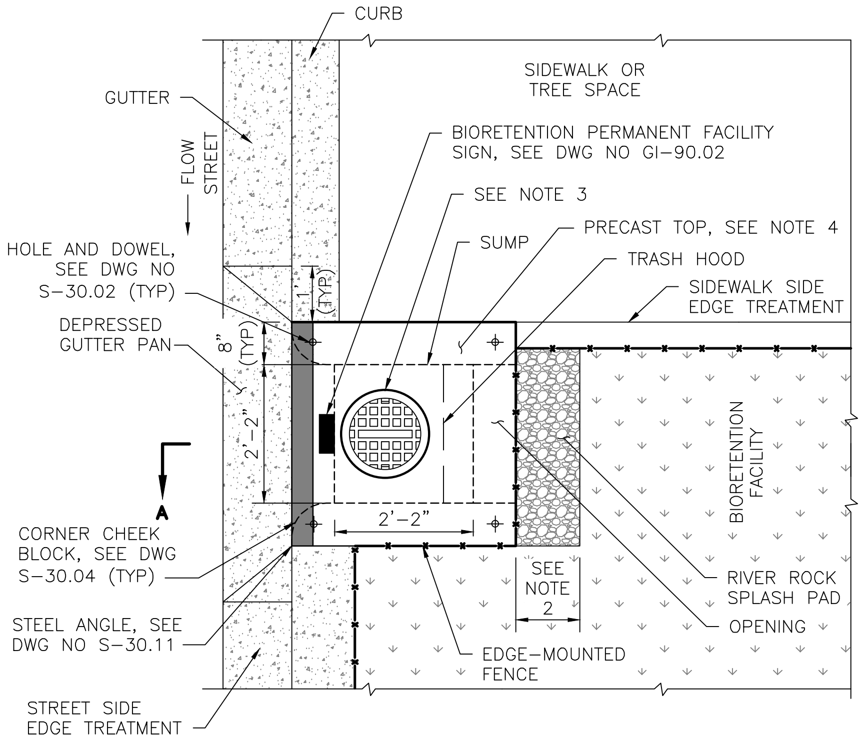
NOTES:

1. ELIMINATE WING OF RIVER ROCK SPLASH PAD WHERE INLET OPENING ABUTS CHECK DAM OR EDGE TREATMENT.
2. SEE CONTRACT DRAWINGS FOR DIMENSIONS a AND b.

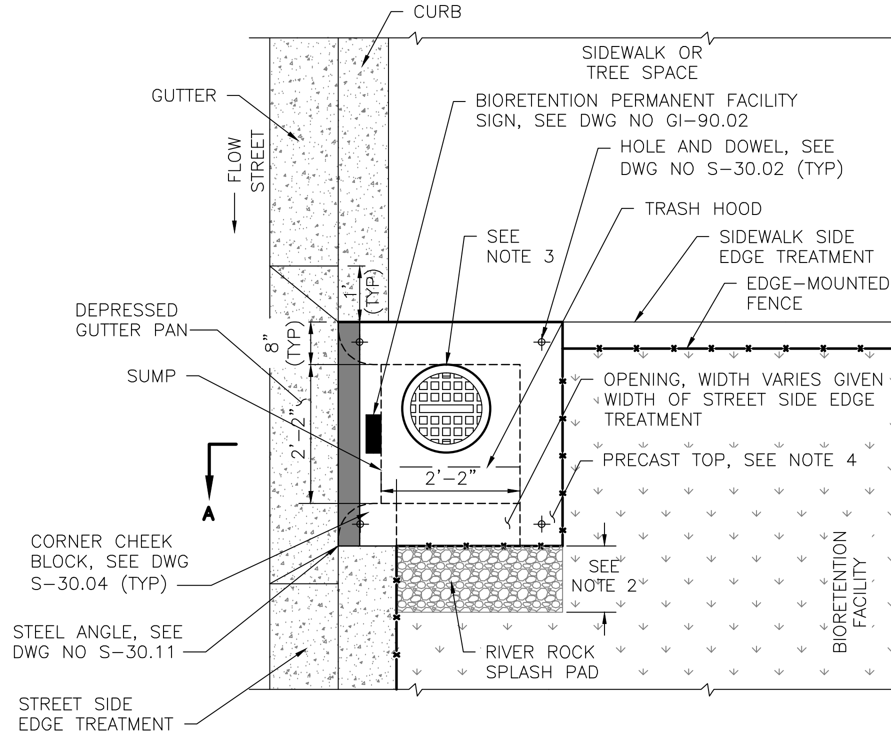
DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
____________	PREPARED BY: DCCR	SOLID TRENCH DRAIN INLET
CHIEF ENGINEER	CHECKED BY: ________	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



PLAN VIEW – TYPE A



PLAN VIEW – TYPE B

NOTES:

1. EXPANSION JOINT REQUIRED AROUND SUMP INLET AT CONCRETE INTERFACES.
2. 1'–6" UNLESS OTHERWISE SPECIFIED IN THE CONTRACT DRAWINGS.
3. 18" CAST IRON COVER AND FRAME, FLUSH WITH TOP. NEENAH R–1791–E OR APPROVED EQUIVALENT.
4. PROVIDE REINFORCING STEEL ANCHORS, AND CONCRETE PER DWG NOS S–30.02 AND S–30.11.

DETAIL NOT TO SCALE

APPROVED DATE: ____________

CHIEF ENGINEER

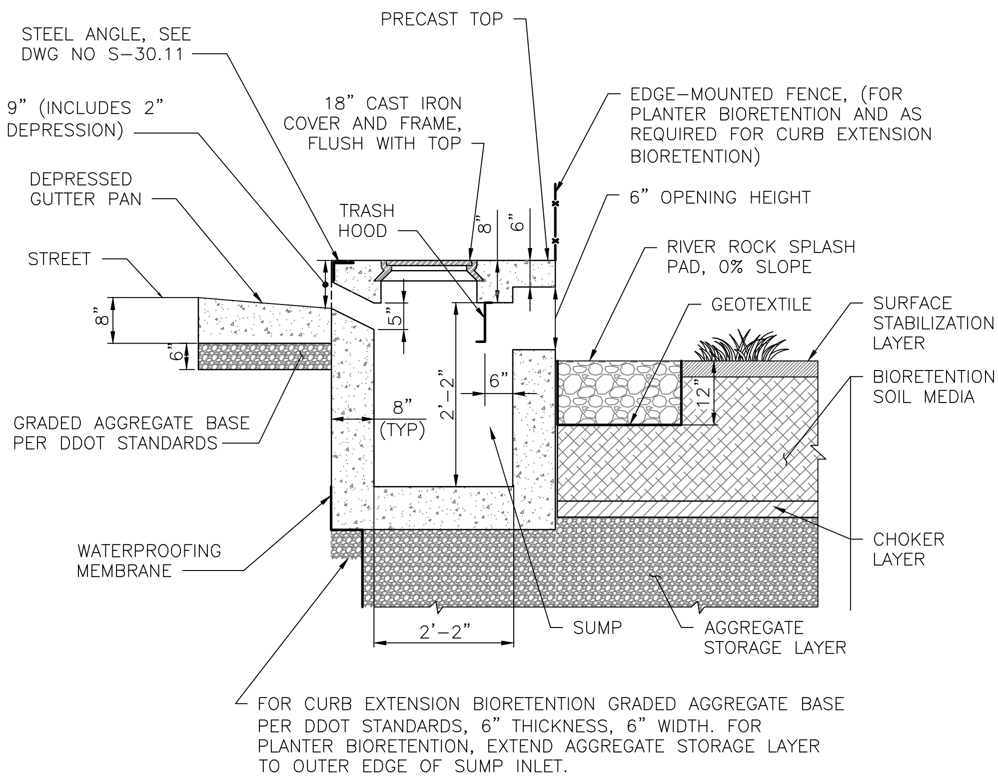
REVISION NO.: ____________
DATE: ____________
PREPARED BY: DCCR
CHECKED BY: ____________

STANDARD DETAIL–PR–A1

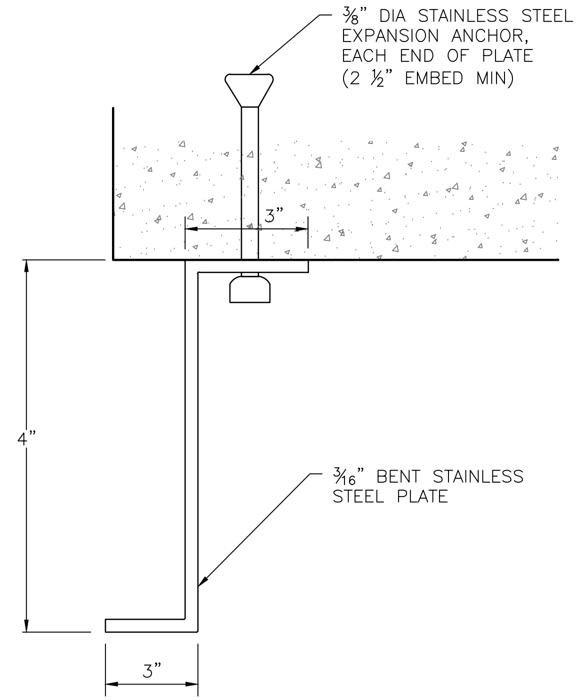
BIORETENTION SUMP INLET FOR PLANTER BIORETENTION

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–24.03
(3 OF 3)



SECTION A–A



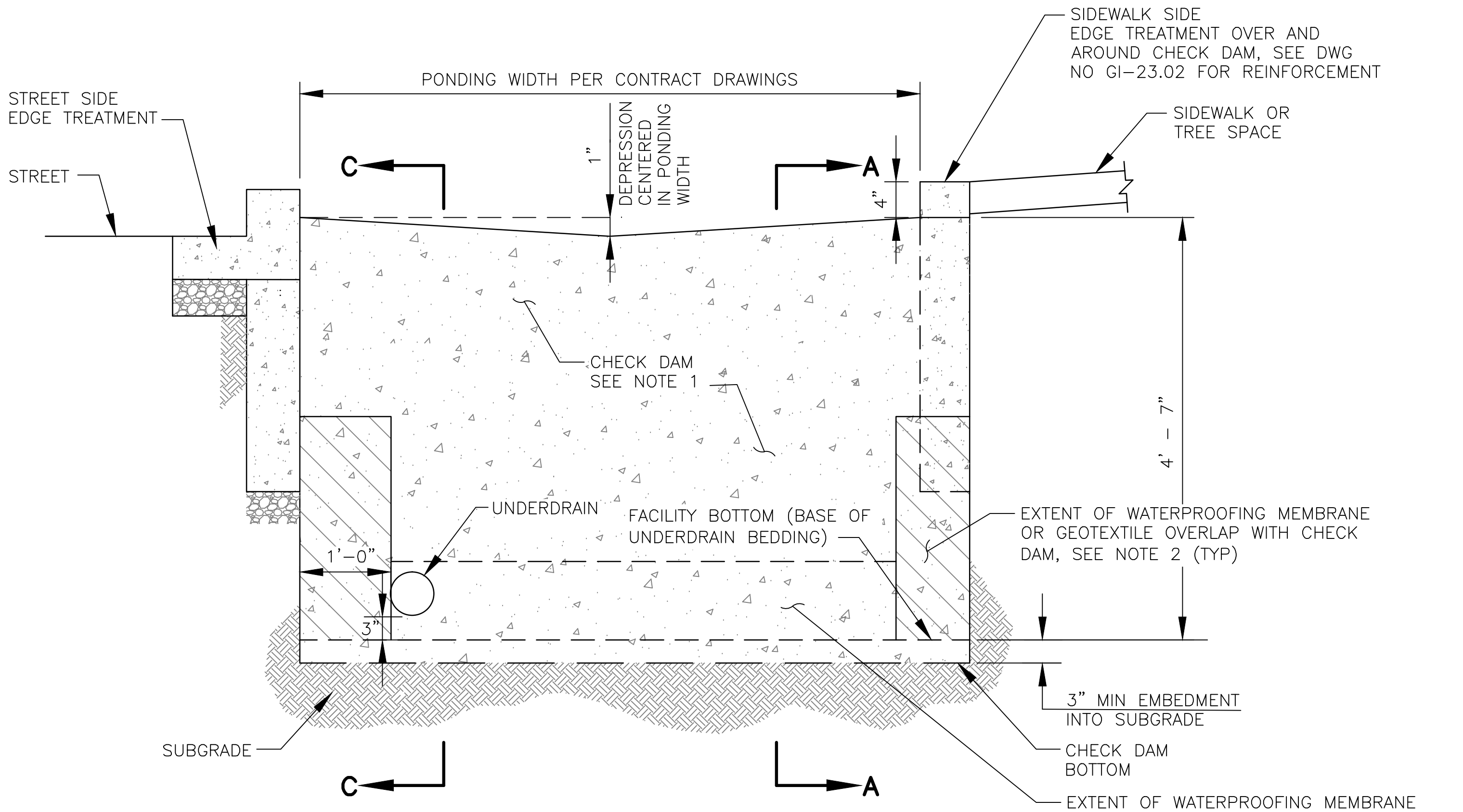
TRASH HOOD

NOTE:

1. PROVIDE REINFORCING STEEL ANCHORS AND CONCRETE PER DWG NOs S–30.02 AND S–30.11.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	BIORETENTION SUMP INLET, SECTION A–A
	CHECKED BY: ______	



NOTES:

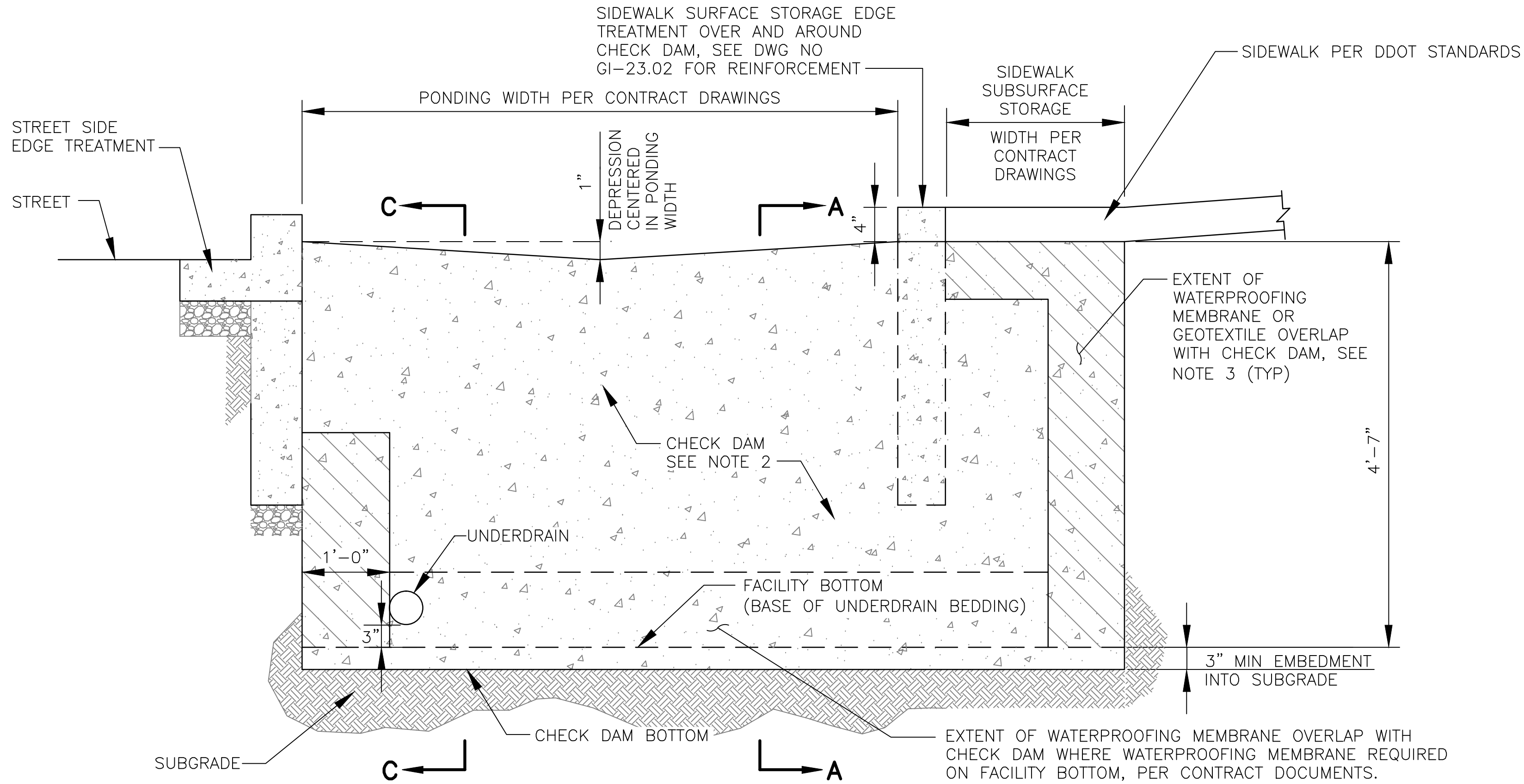
1. SEE SECTION A–A FOR REINFORCEMENT
2. DO NOT INSTALL GEOTEXTILE OR WATERPROOFING MEMBRANE UNDER OR AROUND CHECK DAMS. TURN UP GEOTEXTILE AND/OR WATERPROOFING MEMBRANE AGAINST CHECK DAM, OVERLAP WITH CHECK DAM PER MANUFACTURER'S RECOMMENDATION AND AS APPROVED BY DC WATER, 12 INCH MINIMUM. ADHERE WATERPROOFING MEMBRANE DIRECTLY TO CHECK DAM TO CREATE WATERTIGHT SEAL EXCEPT WHERE OTHERWISE INDICATED.
3. CHECK DAMS SHALL BE CONSTRUCTED TO PREVENT ANY UNINTENDED BYPASS WITHIN THE AGGREGATE STORAGE LAYER AND UNDERDRAIN BEDDING LAYER OR AROUND THE CHECK DAMS.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	BIORETENTION CHECK DAM WITHOUT SIDEWALK SUBSURFACE STORAGE
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–25.01
(2 OF 4)

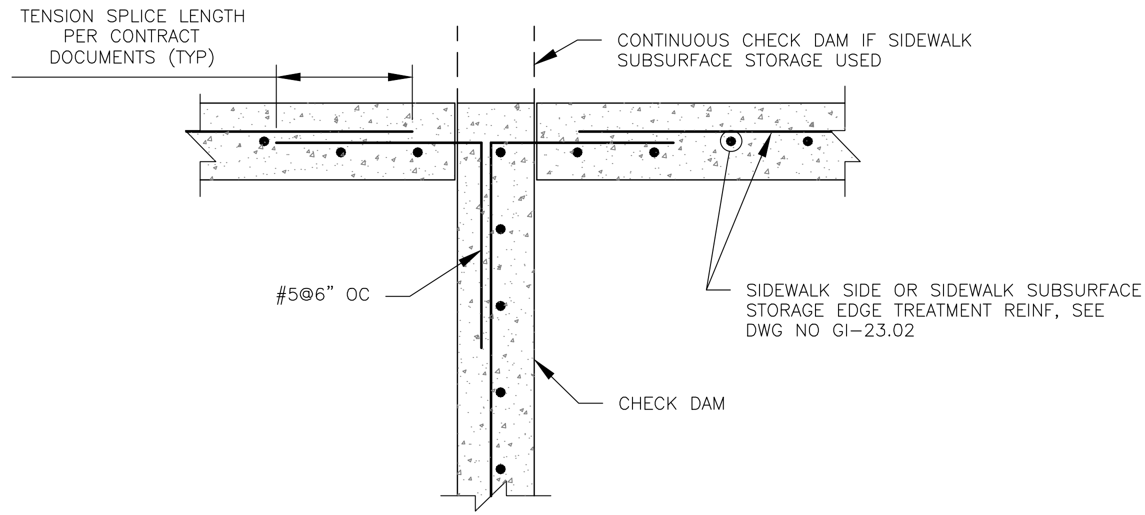


NOTES:

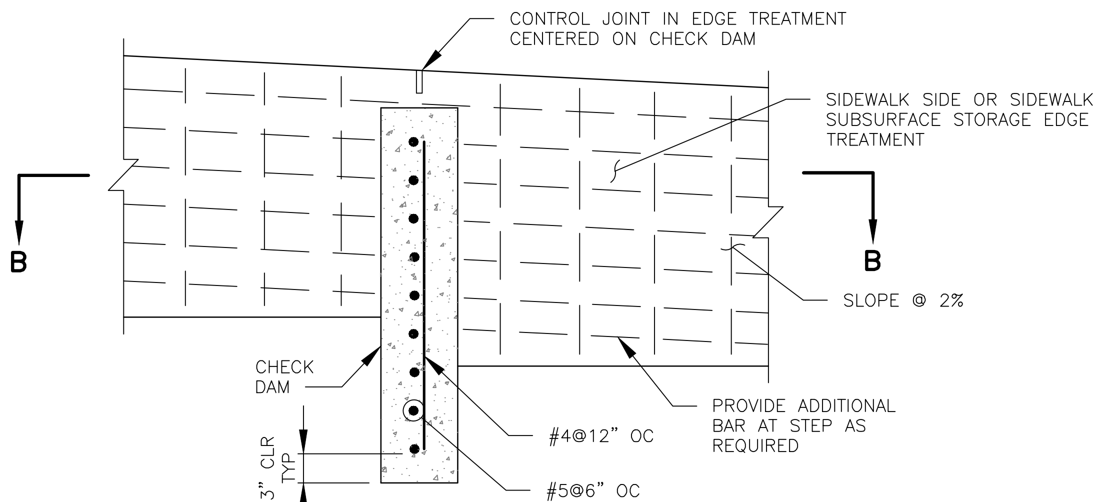
1. CHECK DAMS SHALL EXTEND THROUGH SIDEWALK SUBSURFACE STORAGE AGGREGATE. TOP OF CHECK DAM IN SIDEWALK SHALL MATCH TOP OF CHECK DAM IN BIORETENTION PONDING AREA.
2. SEE SECTION A–A FOR REINFORCEMENT.
3. DO NOT INSTALL GEOTEXTILE OR WATERPROOFING MEMBRANE UNDER OR AROUND CHECK DAMS. TURN UP GEOTEXTILE AND/OR WATERPROOFING MEMBRANE AGAINST CHECK DAM BOTTOM AND SIDES, OVERLAP WITH CHECK DAM PER MANUFACTURER'S RECOMMENDATION AND AS APPROVED BY DC WATER, 12 INCH MINIMUM. ADHERE WATERPROOFING MEMBRANE DIRECTLY TO CHECK DAM TO CREATE WATERTIGHT SEAL EXCPET WHERE OTHERWISE INDICATED.
4. CHECK DAMS SHALL BE CONSTRUCTED TO PREVENT ANY UNINTENDED BYPASS WITHIN THE AGGREGATE STORAGE LAYER AND UNDERDRAIN BEDDING LAYER OR AROUND THE CHECK DAMS.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
______ CHIEF ENGINEER	PREPARED BY: DCCR	BIORETENTION CHECK DAM WITH SIDEWALK SUBSURFACE STORAGE
	CHECKED BY: ______	



SECTION B–B



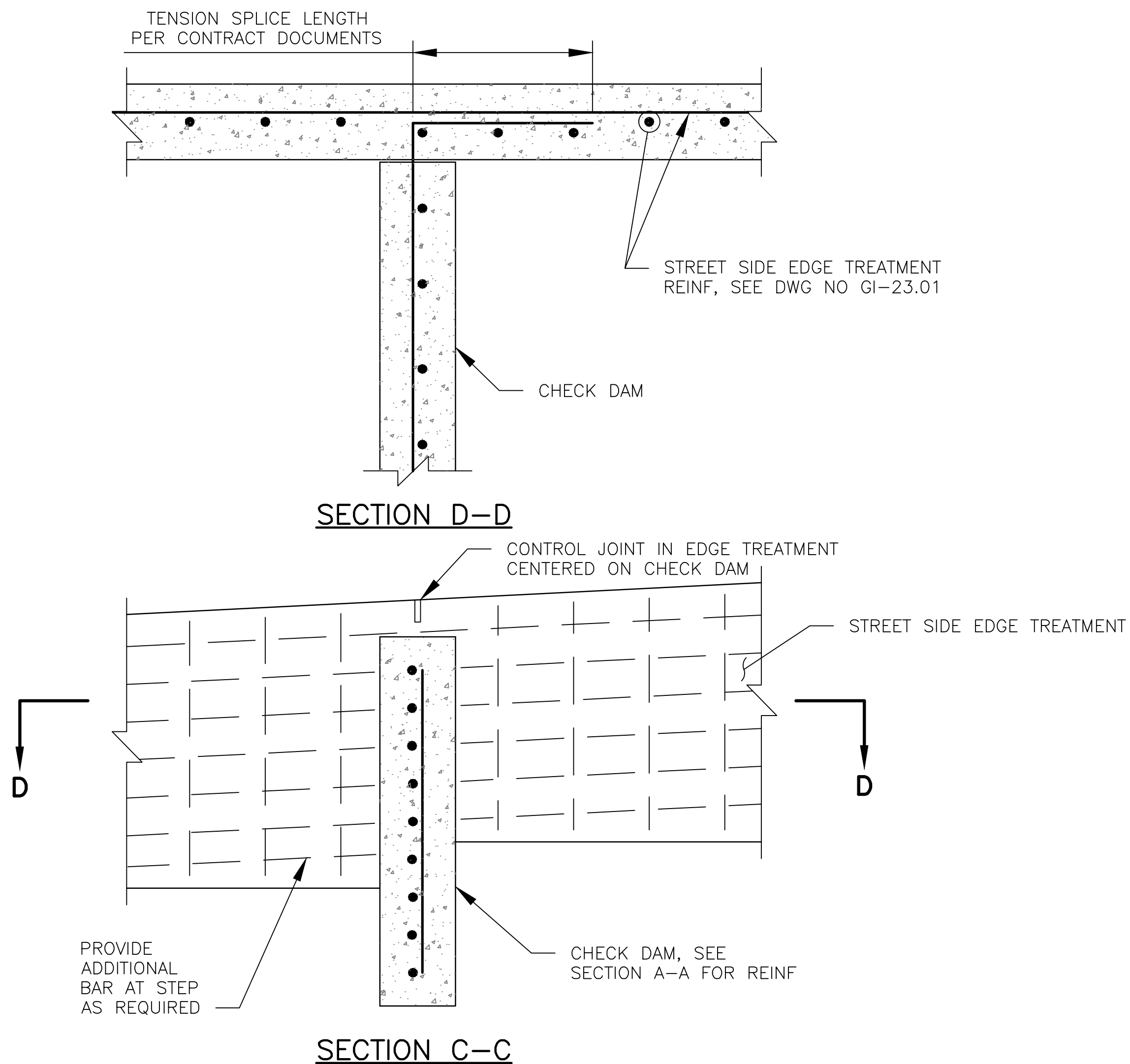
SECTION A–A

NOTES:

1. CENTER REINFORCEMENT IN CHECK DAM.

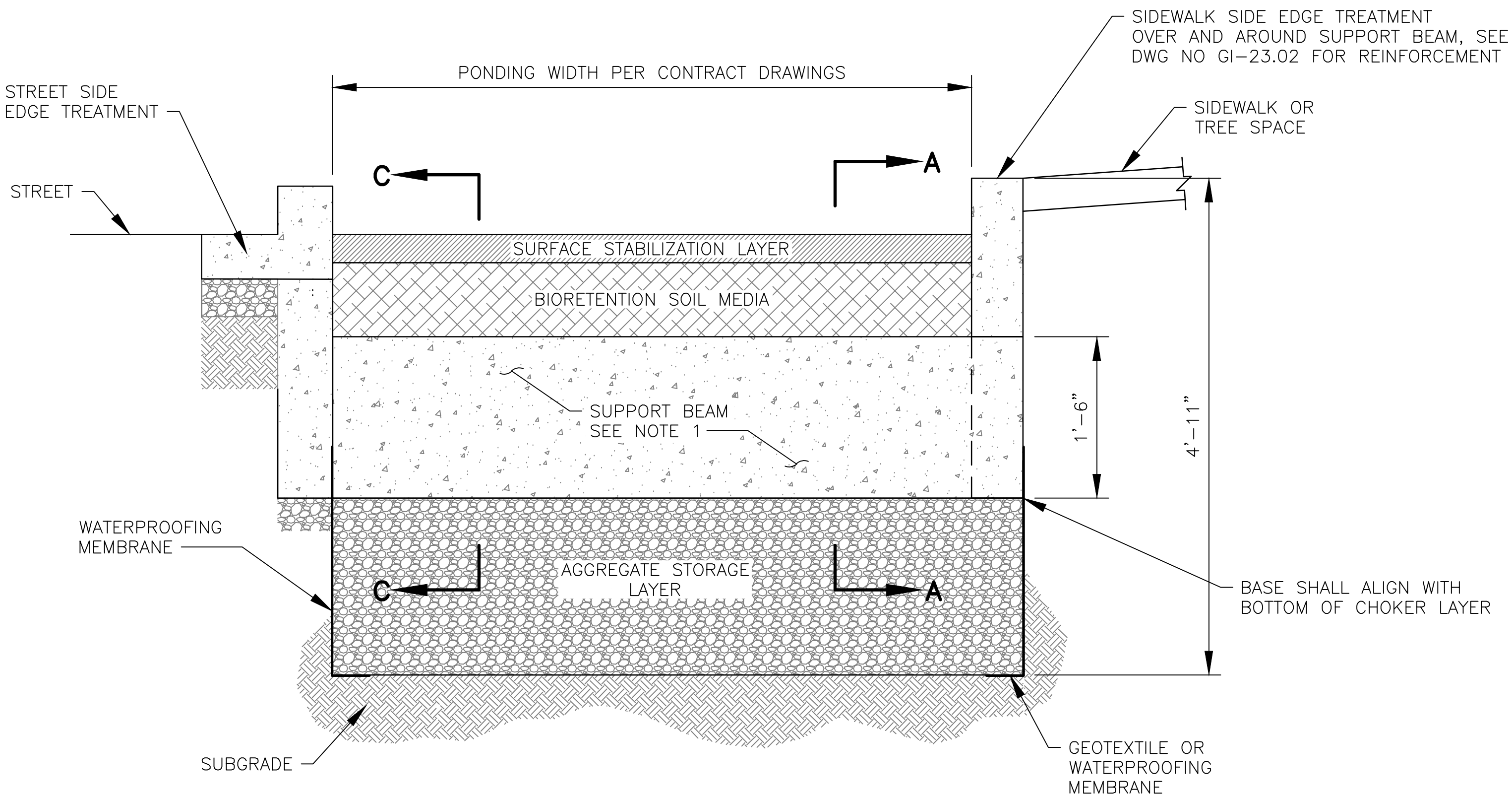
DETAIL NOT TO SCALE

APPROVED DATE:	REVISION NO.:	STANDARD DETAIL–PR–A1
	DATE:	
CHIEF ENGINEER	PREPARED BY: DCCR	CHECK DAM REINFORCEMENT – SIDEWALK SIDE SECTION A–A
	CHECKED BY:	



DETAIL NOT TO SCALE

APPROVED DATE: ____	REVISION NO.: ____	STANDARD DETAIL–PR–A1
	DATE: ____	
CHIEF ENGINEER	PREPARED BY: DCCR	CHECK DAM REINFORCEMENT – STREET SIDE SECTION C–C
	CHECKED BY: ____	

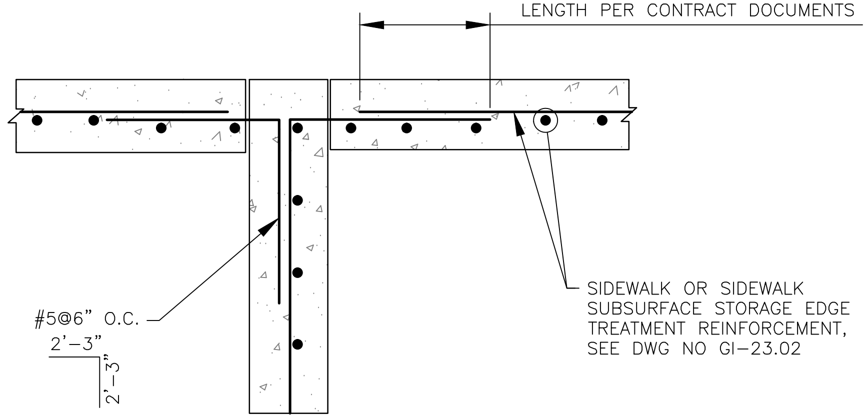


NOTES:

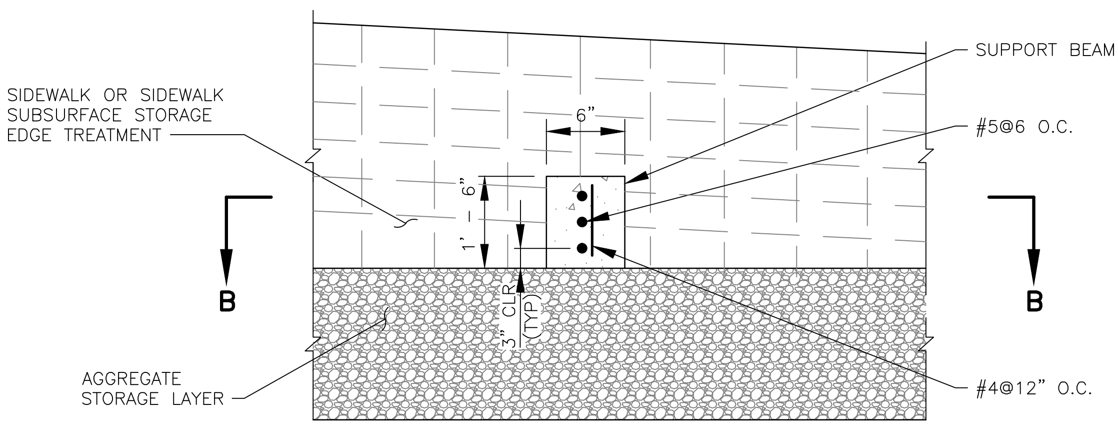
1. SEE SECTION A–A FOR REINFORCEMENT.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	SUPPORT BEAM
	CHECKED BY: ______	



SECTION B–B



NOTES:

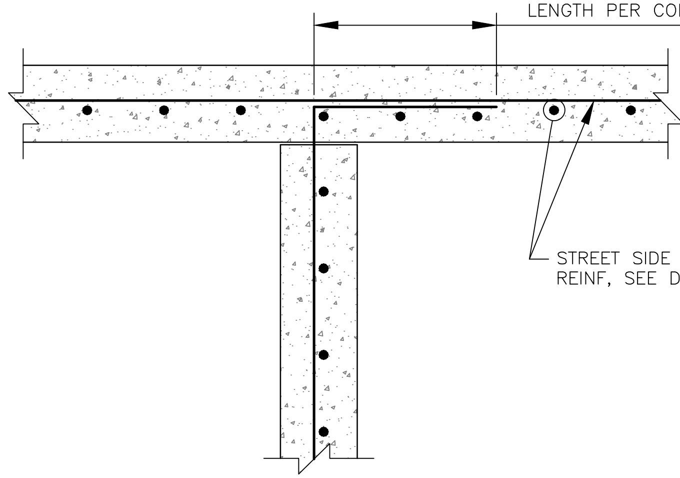
1. CENTER REINFORCEMENT IN SUPPORT BEAM.

SECTION A–A

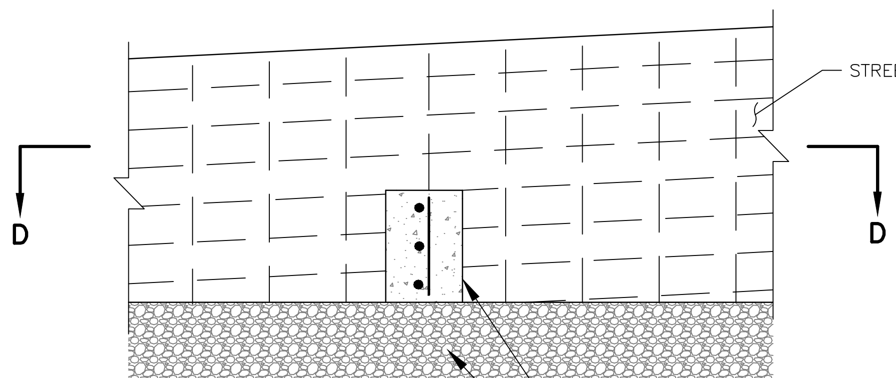
DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	SUPPORT BEAM REINFORCEMENT – SIDEWALK SIDE SECTION A–A
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



SECTION D–D

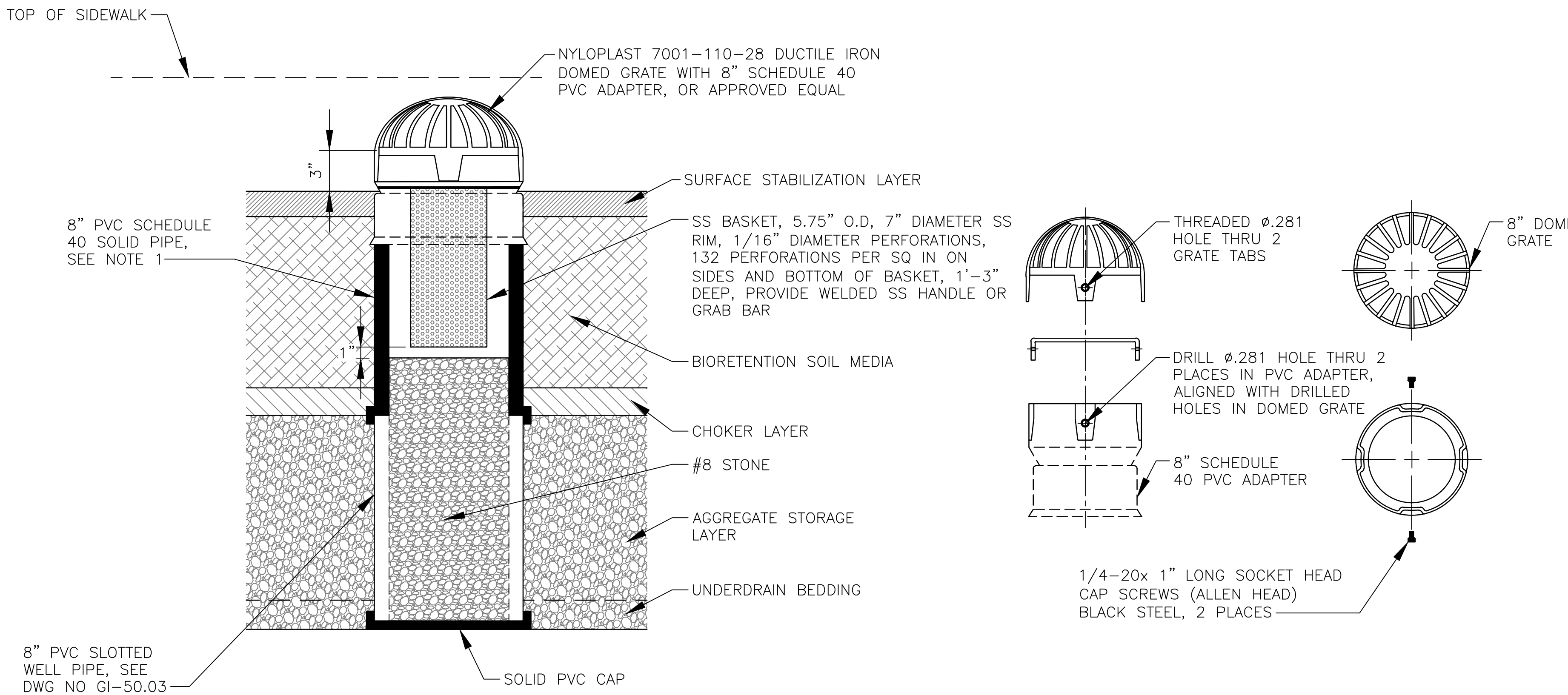


SECTION C–C

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
______	PREPARED BY: DCCR	SUPPORT BEAM REINFORCEMENT – STREET SIDE
CHIEF ENGINEER	CHECKED BY: ______	SECTION C–C

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



NOTES:

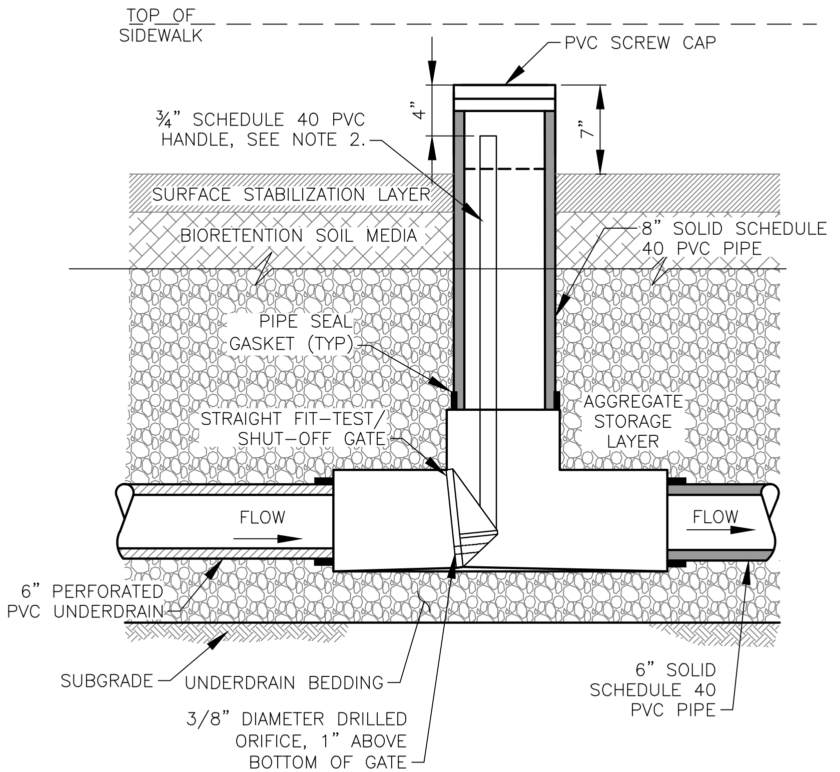
1. CONNECTING JOINTS SHALL BE SOLVENT WELD IN ACCORDANCE WITH CONTRACT DOCUMENTS.

DETAIL NOT TO SCALE

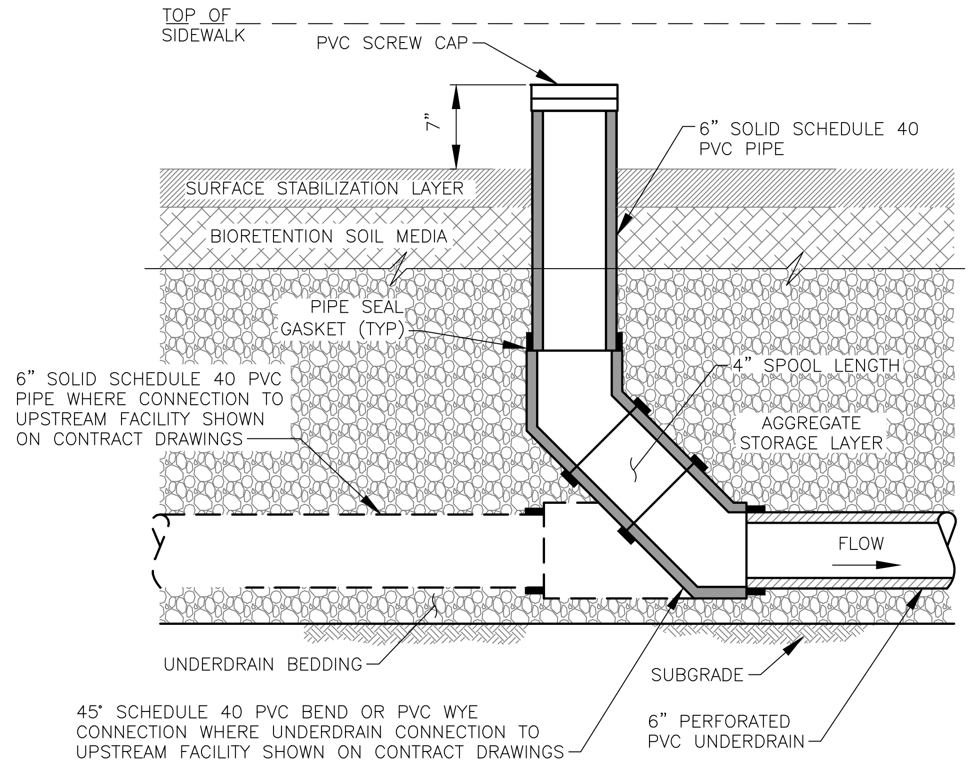
APPROVED DATE: ____________	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	ENHANCED INFILTRATION RISER
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–50.01
(2 OF 2)



FLOW RESTRICTION
DEVICE IN BIORETENTION



CLEANOUT/OBSERVATION WELL
IN BIORETENTION

NOTES:

1. FLOW RESTRICTION DEVICE SHALL BE MAINLINE STRAIGHT–FIT BACK WATER VALVE WITH TEST/SHUT–OFF GATE OR APPROVED EQUAL.
2. ADHERE HANDLE TO GATE WITH PVC CEMENT AND FASTEN WITH SCREW.

NOTES:

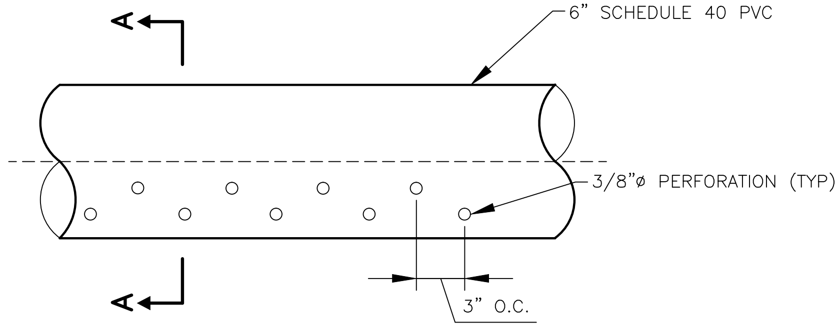
1. WHERE BIORETENTION CELL LENGTH IS LESS THAN 9' AND WHERE INDICATED IN THE CONTRACT DRAWINGS OR BY DC WATER IN THE FIELD, REPLACE THE TWO 45° BENDS WITH ONE 90° BEND AND PERFORATE THE SOLID PIPE RISER PER DWG NO GI–50.03 WITHIN THE AGGREGATE STORAGE LAYER BY DRILLING.

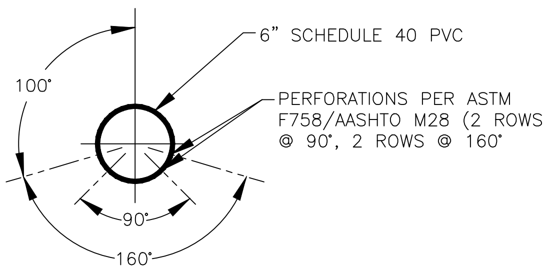
DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	BIORETENTION PIPE RISERS
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

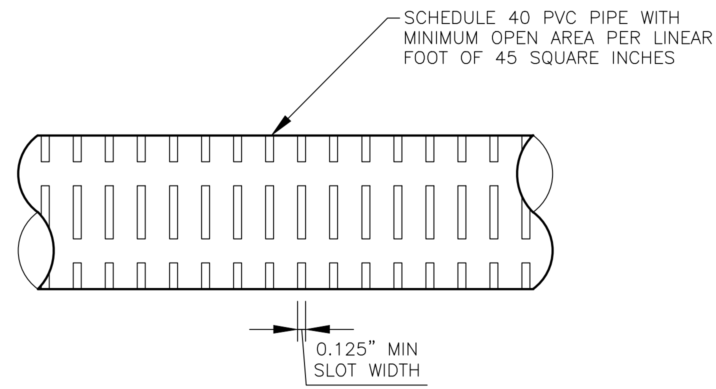
GI–50.03





SECTION A–A

6" PERFORATED PVC UNDERDRAIN



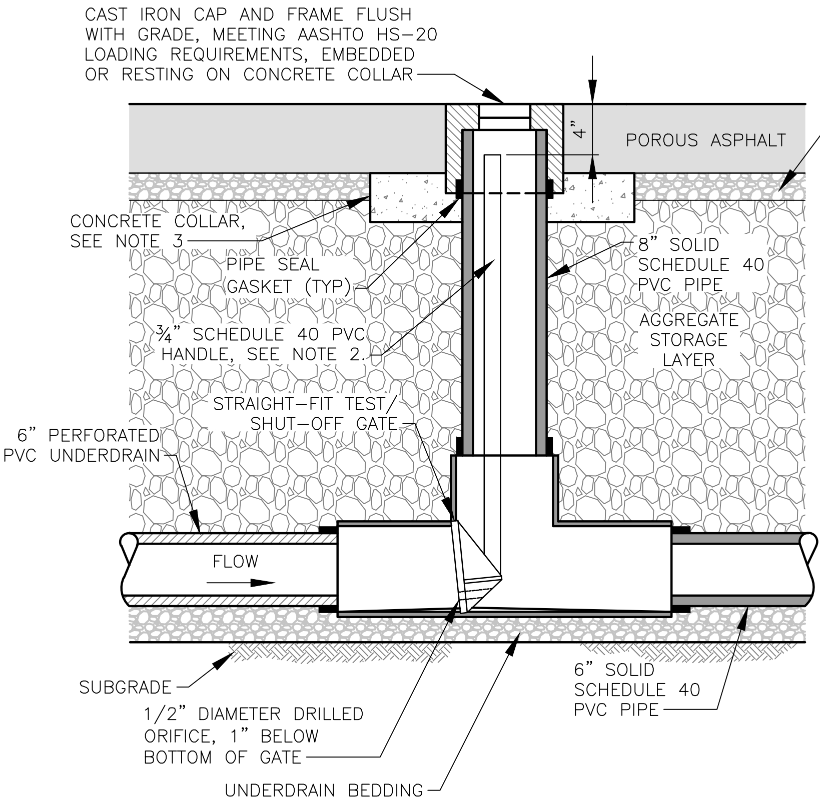
8" PVC SLOTTED WELL PIPE

DETAIL NOT TO SCALE

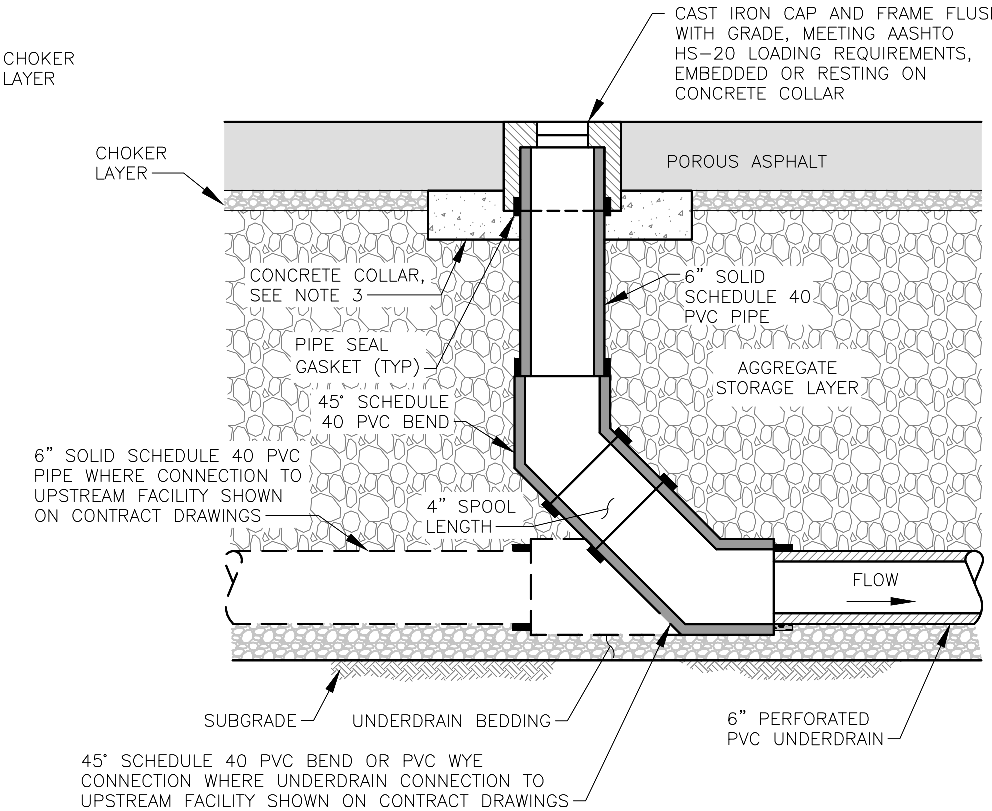
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
______	PREPARED BY: DCCR	GREEN INFRASTRUCTURE PIPING
CHIEF ENGINEER	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–50.04



FLOW RESTRICTION DEVICE IN PARKING LANE PERMEABLE PAVEMENT



CLEANOUT/OBSERVATION WELL IN PARKING LANE PERMEABLE PAVEMENT

NOTES:

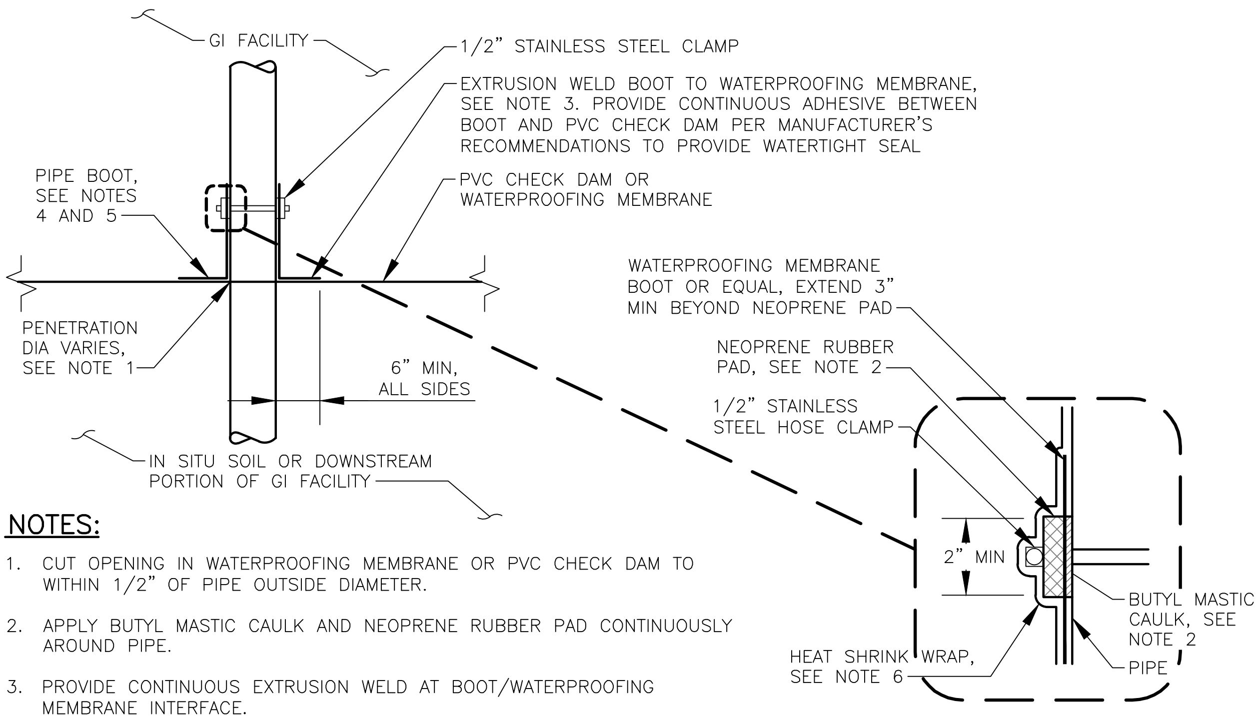
1. FLOW RESTRICTION DEVICE SHALL BE MAINLINE STRAIGHT–FIT BACK WATER VALVE WITH TEST/SHUT–OFF GATE OR APPROVED EQUAL.
2. ADHERE HANDLE TO GATE WITH PVC CEMENT AND FASTEN WITH SCREW.
3. WRAP PIPE WITH TWO LAYERS OF BUILDING PAPER BEFORE PLACING CONCRETE. CONCRETE COLLAR SHALL BE 6" BELOW CAST IRON FRAME AND BE 1'–6" LONG AND WIDE. INSTALL TWO #4 REBAR ON ALL 4 SIDES AT MID–DEPTH. BUILDING PAPER SHALL CONFORM TO ASTM D–4869 AND BE PLAIN 15LB ASPHALT TYPE 1.

DETAIL NOT TO SCALE

APPROVED DATE: ____________	REVISION NO.: ________	STANDARD DETAIL–PR–A1
	DATE: ________	
____________ CHIEF ENGINEER	PREPARED BY: DCCR	PARKING LANE PERMEABLE PAVEMENT PIPE RISERS
	CHECKED BY: ________	

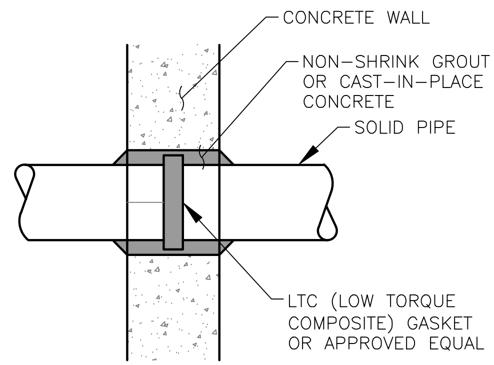
DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI-50.05



NOTES:

1. CUT OPENING IN WATERPROOFING MEMBRANE OR PVC CHECK DAM TO WITHIN 1/2" OF PIPE OUTSIDE DIAMETER.
2. APPLY BUTYL MASTIC CAULK AND NEOPRENE RUBBER PAD CONTINUOUSLY AROUND PIPE.
3. PROVIDE CONTINUOUS EXTRUSION WELD AT BOOT/WATERPROOFING MEMBRANE INTERFACE.
4. FORM BOOT WITH SUFFICIENT MATERIAL TO PREVENT OVERSTRESSING DURING BACKFILLING, BUT WITHOUT FOLDS OR WRINKLES.
5. CONSTRUCT BOOT FROM SAME MATERIAL AS THE WATERPROOFING MEMBRANE.
6. SEAL CLAMP AND END OF BOOT WITH HEAT SHRINK WRAP. EXTEND HEAT SHRINK WRAP ONE PIPE DIAMETER (MINIMUM) BEYOND CLAMP.
7. CONTRACTOR MAY USE PRE FABRICATED PIPE BOOTS IN LIEU OF FIELD-FABRICATED BOOTS. CONNECT PREFABRICATED BOOT TO PIPE WATERPROOFING MEMBRANE AND PVC CHECK DAM PER MANUFACTURER'S RECOMMENDATIONS.

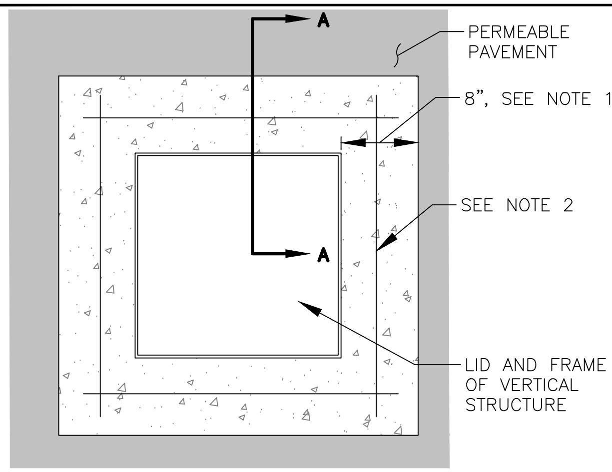


<u>WATERTIGHT PVC CHECK DAM OR WATERPROOFING MEMBRANE PENETRATION</u>

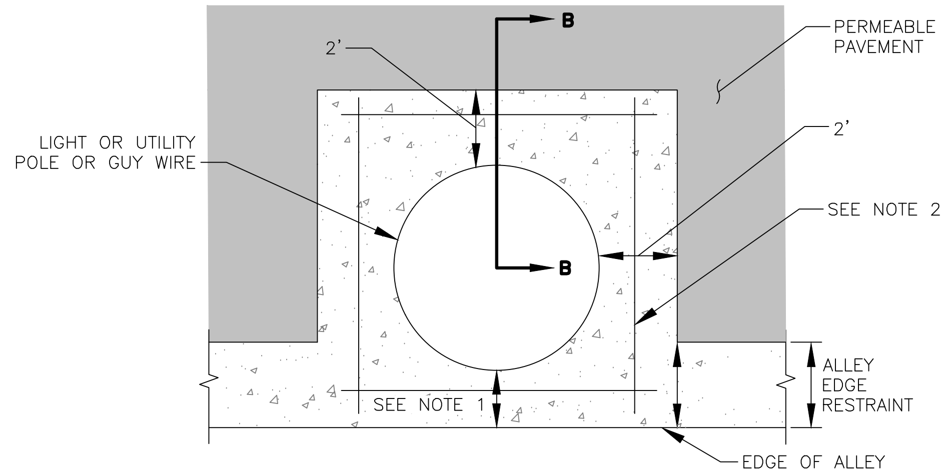
<u>WATERTIGHT CONCRETE CHECK DAM OR EDGE TREATMENT PENETRATION</u>

DETAIL NOT TO SCALE

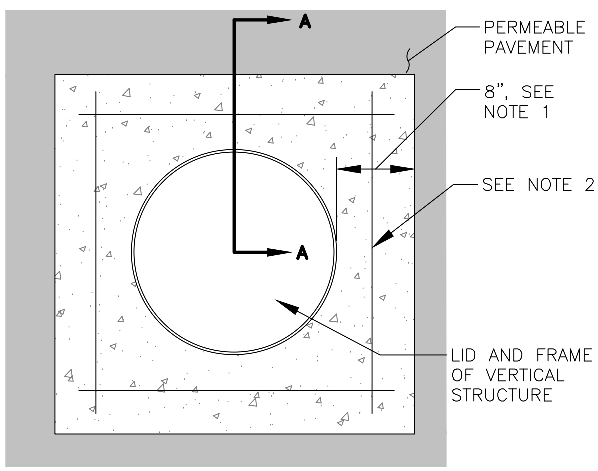
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL-PR-A1
	DATE: ______	
______	PREPARED BY: DCCR	GI FACILITY PIPE PENETRATIONS
CHIEF ENGINEER	CHECKED BY: ______	



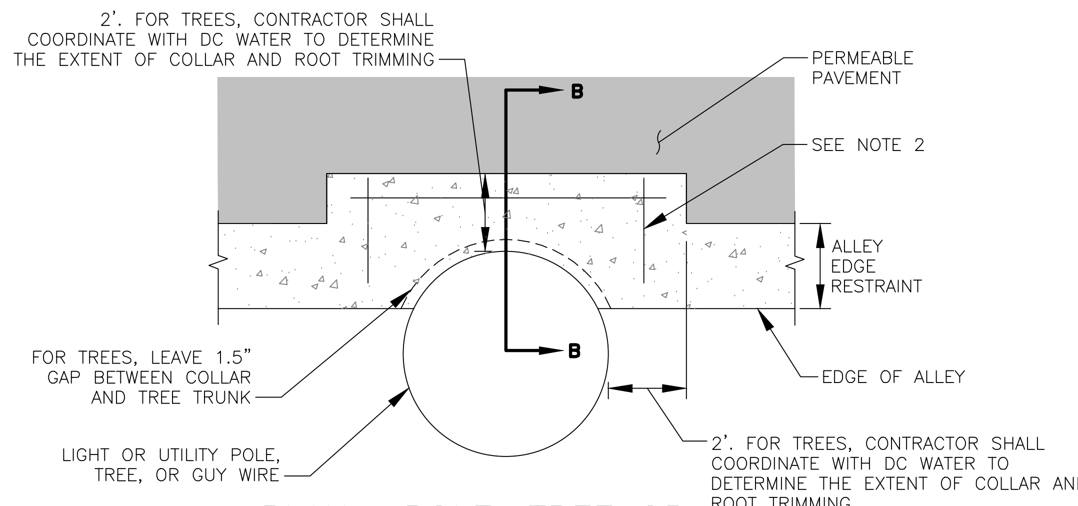
PLAN – MANHOLE W/ SQUARE FRAME



PLAN– POLE OR GUY WIRE WITHIN ALLEY



PLAN – MANHOLE W/ ROUND FRAME

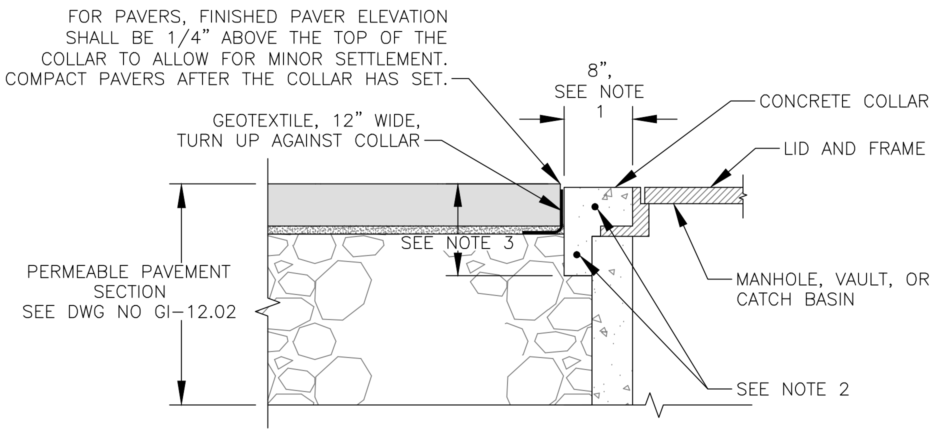


PLAN– POLE, TREE OR GUY WIRE ALONG ALLEY

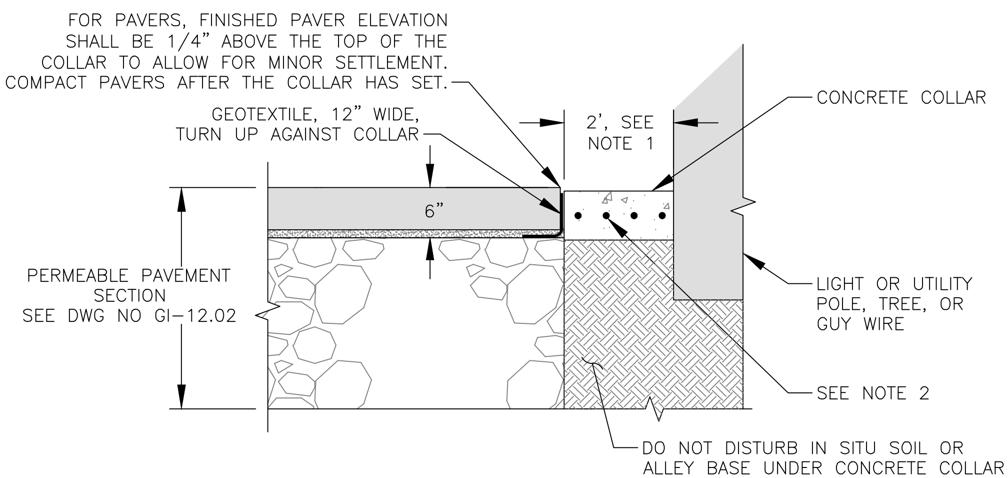
DETAIL NOT TO SCALE

APPROVED DATE: ______ CHIEF ENGINEER	REVISION NO.: ______ DATE: ______ PREPARED BY: DCCR CHECKED BY: ______	STANDARD DETAIL–PR–A1 PROTECTION OF POLES, MANHOLES, GUY WIRES, AND TREES IN PERMEABLE PAVEMENT FACILITIES

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY



SECTION A



SECTION B

NOTES:

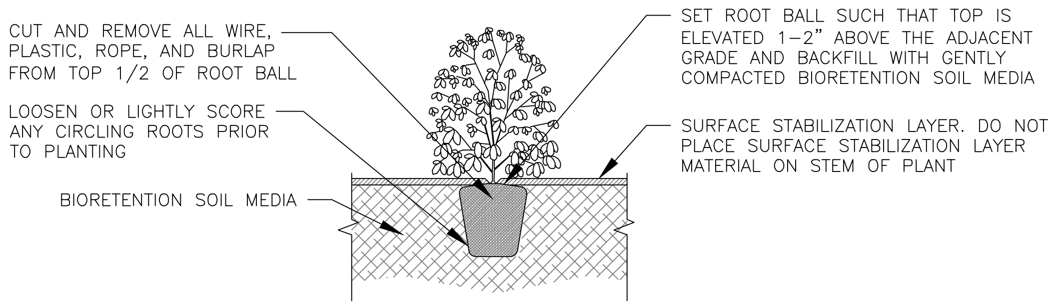
1. CONCRETE COLLAR SHALL RESIDE SOLELY WITHIN EXISTING ALLEY OR PARKING LANE EXTENTS. DO NOT COMPLETE SECTIONS OF COLLAR OUTSIDE EXTENTS.
2. ONE #4 REBAR FOR EACH 6" WIDTH AND DEPTH OF CONCRETE.
3. CONCRETE: DDOT SPECIFICATION 817, CLASS B OR CLASS C.
4. FOR POLES IN ALLEYS WITH GUY WIRES, CONNECT THE CONCRETE COLLARS AROUND THE POLE AND GUY WIRE. PROVIDE WELDED WIRE FABRIC PER DDOT STANDARDS FOR PCC ALLEYS IN THE EXTENDED COLLAR.

DETAIL NOT TO SCALE

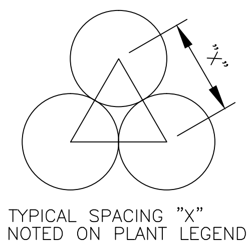
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL-PR-A1
	DATE: ______	
______ CHIEF ENGINEER	PREPARED BY: DCCR	PROTECTION OF POLES, MANHOLES, GUYWIRES AND TREES IN PERMEABLE PAVEMENT FACILITIES
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

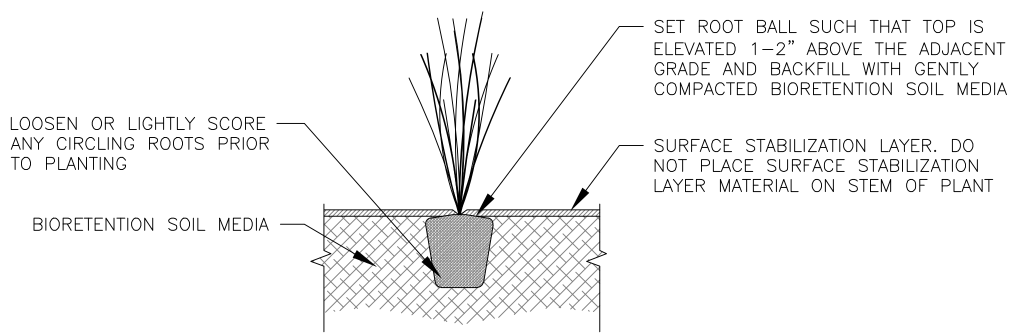
GI–70.03



BIORETENTION SHRUB PLANTING



TYPICAL SPACING DIAGRAM



BIORETENTION HERBACEOUS PLANTING

NOTES:

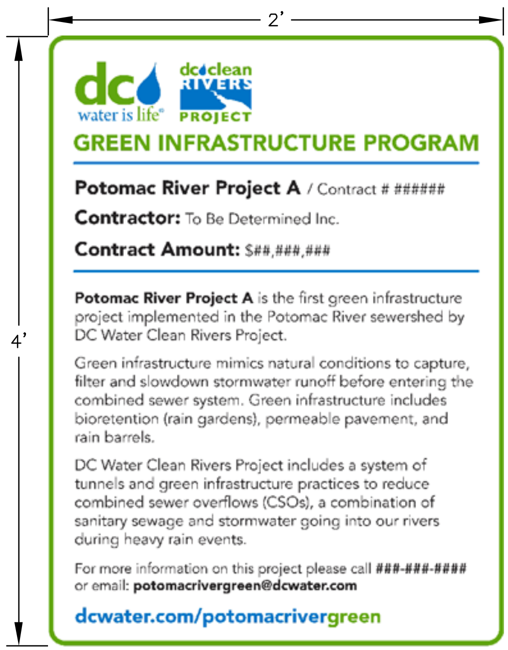
1. PLANT SPECIES, QUANTITES, AND LAYOUTS AS INDICATED IN THE CONTRACT DRAWINGS.

DETAIL NOT TO SCALE

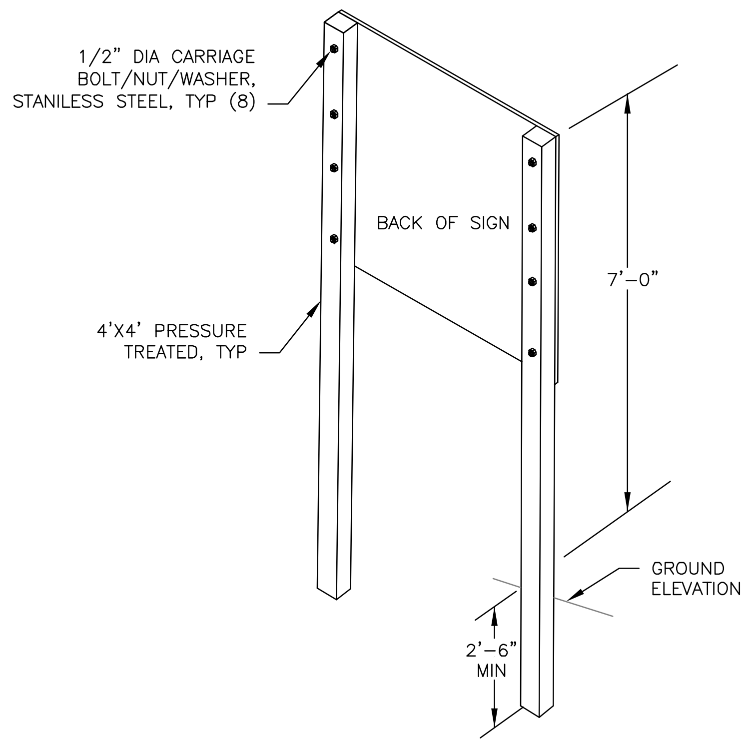
APPROVED DATE: ____	REVISION NO.: ____	STANDARD DETAIL–PR–A1
	DATE: ____	
	PREPARED BY: DCCR	SHRUB AND HERBACEOUS PLANTING DETAILS
CHIEF ENGINEER	CHECKED BY: ____	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

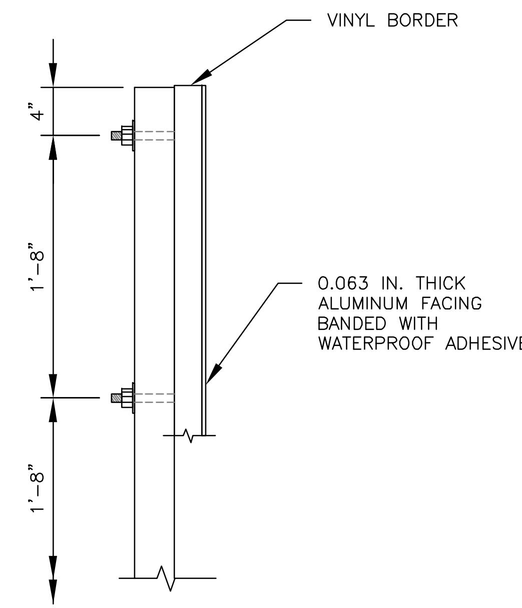
GI–90.01



CONSTRUCTION PROJECT SIGN
FRONT ELEVATION



ISOMETRIC VIEW OF SIGN SUPPORT



TYPICAL FRAME SECTION

NOTES:

1. CONTRACTOR SHALL PROVIDE, FURNISH, AND INSTALL CONSTRUCTION PROJECT SIGNS WHERE INDICATED IN THE CONTRACT DOCUMENTS.
2. SIGN SHALL HAVE A UV PROTECTIVE COAT WHICH CAN EASILY BE CLEANED.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
CHIEF ENGINEER	DATE: ______	CONSTRUCTION PROJECT SIGN
	PREPARED BY: DCCR	
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–90.02

PERMEABLE PAVEMENT PERMANENT FACILITY SIGN
FRONT ELEVATION

BIORETENTION PERMANENT FACILITY SIGN
FRONT ELEVATION

NOTES:

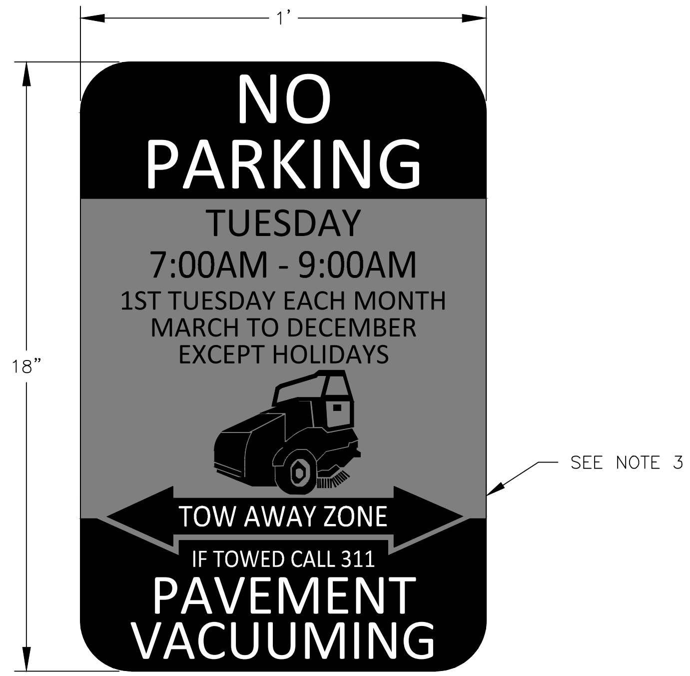
1. CONTRACTOR SHALL COORDINATE WITH DC WATER FOR FINAL SIGN AND STICKER IMAGES. CONTRACTOR SHALL SUBMIT ONE FACILITY SIGN AND ONE STICKER FOR APPROVAL BY DC WATER PRIOR TO PRODUCTION.
2. CONTRACTOR SHALL FURNISH THE FOLLOWING SIGNS OR APPROVED ALTERNATE WITH EQUAL OR BETTER DURABILITY AND FINISH: SIGNS SHALL BE STAINLESS STEEL CONSTRUCTION, PRINTED IN COLOR USING AN UV PROTECTED ENAMEL PAINT, AND INSTALLED WITH BOTH ADHESIVE AND MECHANICAL FASTENERS.
3. FOR ALLEY PERMEABLE PAVEMENT FACILITIES, CONTRACTOR SHALL INSTALL EACH SIGN ON THE TOP FACE OF THE ALLEY EDGE RESTRAINT PER THE LOCATIONS SPECIFIED IN THE CONTRACT DOCUMENTS. FOR PARKING LANE PERMEABLE PAVEMENT FACILITIES, INSTALL EACH SIGN CENTERED ON THE TOP OF THE PERMEABLE PAVEMENT CURB IN THE LOCATIONS SPECIFIED IN THE CONTRACT DOCUMENTS. FOR BIORETENTION FACILITIES, LOCATE SIGNS PER DWG NO GI–24.03.
4. CONTRACTOR SHALL ENSURE EDGES OF SIGN ARE FLUSH WITH OR MINIMALLY DEPRESSED INTO CONCRETE.
5. SIGNS SHALL BE ORIENTED TO BE LEGIBLE FROM STREET OR ALLEY.
6. STICKERS SHALL BE VINYL DECALS APPROPRIATE FOR OUTDOOR USE WITH MATTE LAMINATION, BLACK ON WHITE, 3M SCOTCHCAL SERIES 50 OR APPROVED EQUAL. EACH STICKER SHALL BE PRINTED WITH A UNIQUE IDENTIFIER PROVIDED BY DC WATER.

DETAIL NOT TO SCALE

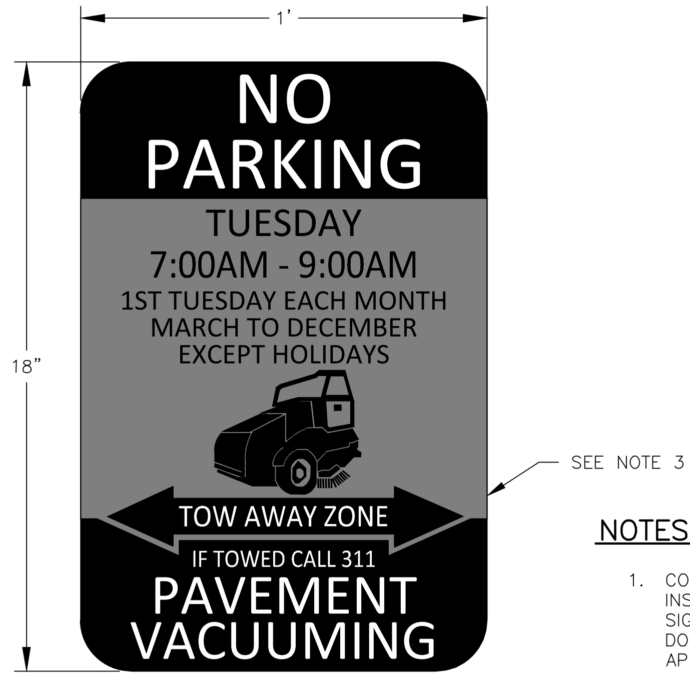
APPROVED DATE: ____________	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
____________	PREPARED BY: DCCR	PERMANENT FACILITY IDENTIFICATION SIGN
CHIEF ENGINEER	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–90.03



PARKING LANE PERMEABLE PAVEMENT
VACUUMING SIGN
FRONT ELEVATION



ALLEY PERMEABLE PAVEMENT
VACUUMING SIGN
FRONT ELEVATION

NOTES:

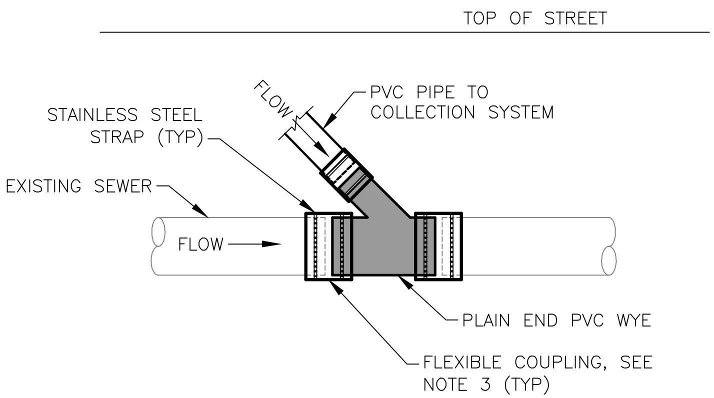
1. CONTRACTOR SHALL PROVIDE, FURNISH, AND INSTALL PERMEABLE PAVEMENT VACUUMING SIGNS WHERE INDICATED IN THE CONTRACT DOCUMENTS. FINAL LOCATIONS SHALL BE APPROVED BY DC WATER.
2. SIGN PANELS SHALL MEET THE MATERIAL AND CONSTRUCTION REQUIREMENTS SPECIFIED IN THE 2013 DDOT STANDARD SPECIFICATIONS FOR HIGHWAYS AND STRUCTURES, SECTION 616.03.
3. CONTRACTOR SHALL COORDINATE WITH DC WATER TO OBTAIN FINAL SIGN IMAGES PRIOR TO FUNCTIONAL TESTING.
4. SIGNS SHALL BE INSTALLED AND MOUNTED PER DDOT STANDARD DWG 616.10. ALLEY PERMEABLE PAVEMENT SIGN SHALL BE INSTALLED IN THE ALLEY EDGE RESTRAINT. CORE DRILL INTO THE ALLEY EDGE RESTRAINT AND PATCH WITH CLASS C OR CLASS E CONCRETE. DO NOT EMBED SIGN POST DURING FORMATION OF ALLEY EDGE RESTRAINT.

DETAIL NOT TO SCALE

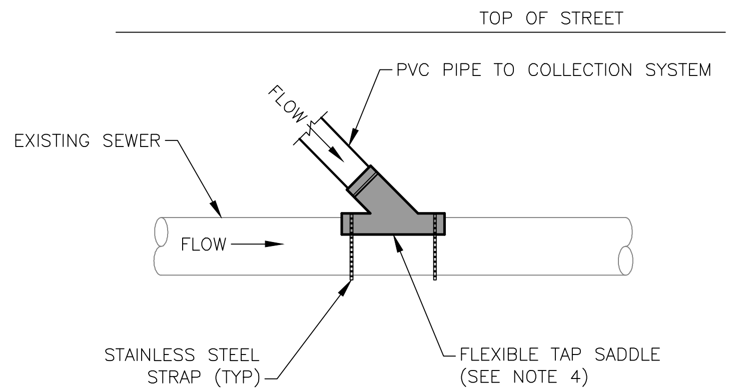
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
______	PREPARED BY: DCCR	PERMEABLE PAVEMENT VACUUMING SIGN
CHIEF ENGINEER	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–100.01



CONNECTION TO SEWERS
LESS THAN OR EQUAL TO 12"



CONNECTION TO SEWERS GREATER THAN
12" AND LESS THAN OR EQUAL TO 36"

PLAN

NOTES:

1. MATERIALS AND WORKMANSHIP ASSOCIATED WITH THE WYE BRANCH AND PVC PIPE TO COLLECTION SYSTEM SHALL BE IN ACCORDANCE WITH D.C. PLUMBING CODE.

2. VERTICAL BENDS FOR GRADE (NOT SHOWN) MAY BE REQUIRED ON PVC PIPE TO COLLECTION SYSTEM.

3. FLEXIBLE COUPLINGS SHALL MEET THE REQUIREMENTS OF ASTM C1173, BE SPECIFICALLY DESIGNED FOR THE PIPE MATERIALS TO BE JOINED, AND ALIGN THE INSIDE WALLS OF THE PIPE INVERT. ECCENTRIC COUPLINGS SHALL BE USED WHERE NECESSARY. COUPLINGS SHALL BE FERNCO, INC. OR APPROVED EQUAL.

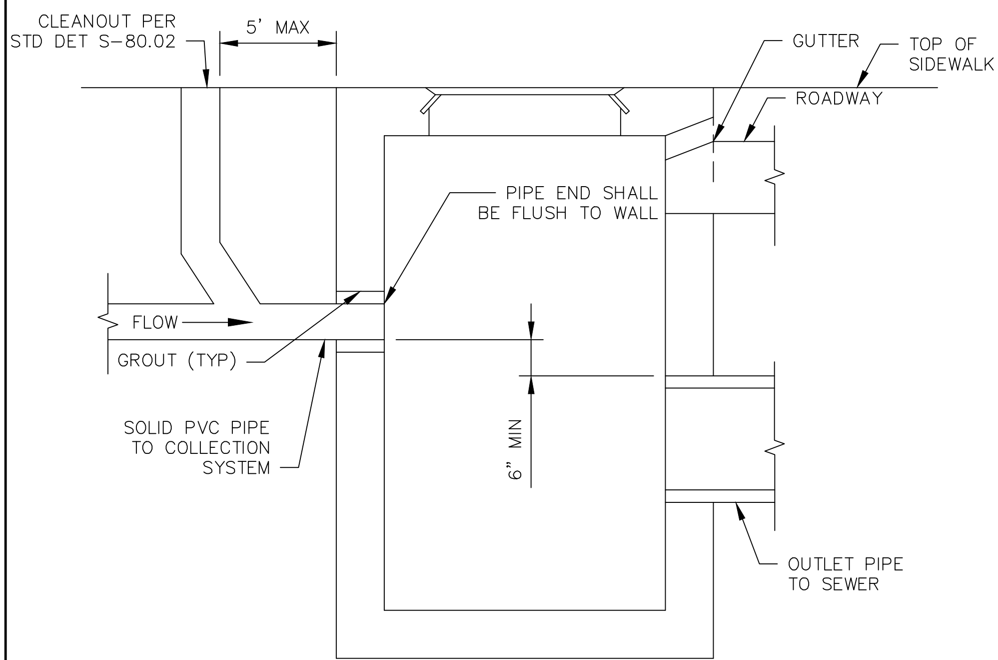
4. FLEXIBLE TAP SADDLES SHALL CONSIST OF A PVC WYE SECURED TO THE EXISTING SEWER USING STAINLESS STEEL STRAPS IN ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS. A WATERTIGHT SEAL SHALL BE PROVIDED BETWEEN THE SADDLE AND THE EXISTING PIPE. FLEXIBLE TAP SADDLES SHALL BE FERNCO, INC. OR APPROVED EQUAL.

DETAIL NOT TO SCALE

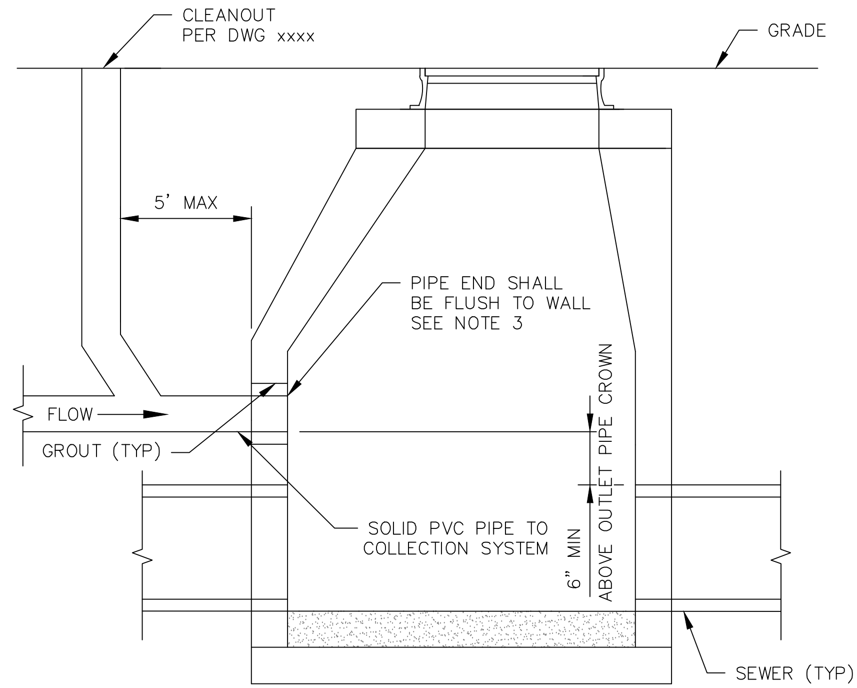
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	≤6" DIAMETER PVC PIPE CONNECTION TO SEWER
	CHECKED BY: ______	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–100.02



CATCH BASIN SECTION



MANHOLE SECTION

NOTES:

1. CLAY DAMS OR OTHER APPROVED WATERSTOPS SHALL BE PROVIDED AT 100' INTERVALS (MINIMUM ONE) ALONG THE LENGTH OF THE SOLID PVC PIPE TO COLLECTION SYSTEM TO PREVENT MIGRATION OF WATER ALONG THE LENGTH OF THE PIPE.

2. CLEANOUTS SHALL BE PLACED AT 100 FOOT INTERVALS (MINIMUM ONE SHALL BE LOCATED AT A MAX OF 5' FROM THE CATCH BASIN OR MANHOLE).

3. FOR TIE IN TO A MANHOLE, FIELD CUTS IN CONCRETE SECTIONS OF MANHOLES SHALL BE ACCOMPLISHED WITH PROPER TOOLS. UNLESS OTHERWISE APPROVED, THE OUTLINE OF THE PROPOSED HOLE SHALL BE CLEARLY MARKED AND SHALL BE LINE DRILLED NOT MORE THAN FIVE INCHES APART. THE HOLE SHALL BE MADE SMOOTH TO RECEIVE THE PIPE ENTRY SEAL AND THE PIPE. PIPE ENTRY SEALS SHALL BE USED WHEN CONNECTING A PROPOSED SANITARY OR COMBINED SEWER OF TWENTY–FOUR (24) INCHES AND SMALLER DIAMETER TO AN EXISTING MANHOLE. NONSHRINK GROUT SHALL BE USED TO FILL VOID BETWEEN ENTRY SEAL AND PIPE. FOR STORM SEWER CONNECTIONS MADE IN THE FIELD, THE ANNULAR SPACE AROUND THE CONNECTION PIPE SHALL BE FILLED WITH NONSHRINK MORTAR. FIELD CUT ENTRY HOLES WILL NOT BE PERMITTED IN PROPOSED MANHOLES UNLESS APPROVED BY DC WATER'S REPRESENTATIVE.

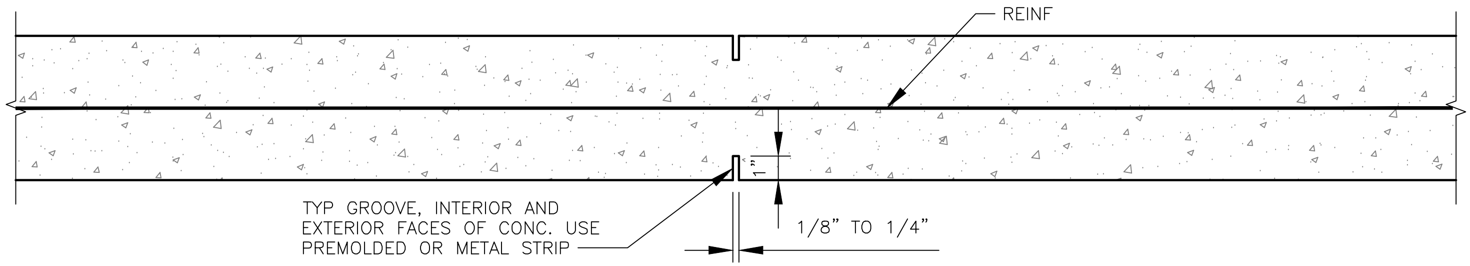
   PIPE ENTRY HOLES IN BRICK SECTIONS OF EXISTING MANHOLES SHALL BE MADE BY CAREFULLY REMOVING SECTION OF BRICKWORK. MANHOLE PIPE ENTRY SEALS SHALL BE EQUIVALENT TO "PRESS WEDGE II" GASKETS MANUFACTURED BY PRESS–SEAL GASKETS CORP., FORT WAYNE, IN: "A–LOK" GASKETS MANUFACTURED BY A–LOK PRODUCTS CORP., TRENTON, NJ; OR "KOR–N–SEAL", MANUFACTURED BY NATIONAL POLLUTION CONTROL SYSTEMS, INC., NASHUA, NH.

DETAIL NOT TO SCALE

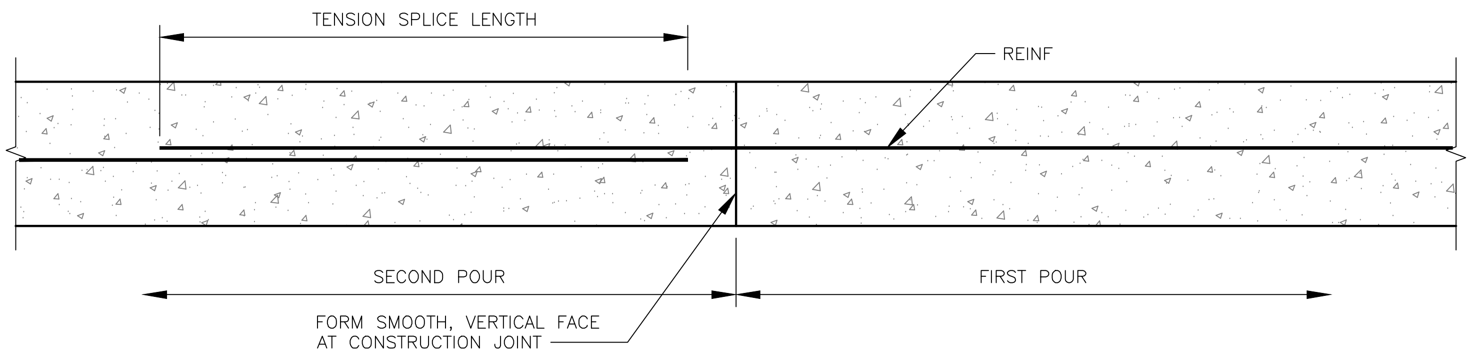
APPROVED DATE: ____	REVISION NO.: ____	STANDARD DETAIL–PR–A1
	DATE: ____	
____	PREPARED BY: DCCR	PVC PIPE CONNECTION TO
CHIEF ENGINEER	CHECKED BY: ____	CATCH BASINS AND MANHOLES

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–110.01
(1 OF 2)



CONTROL JOINT–PLAN



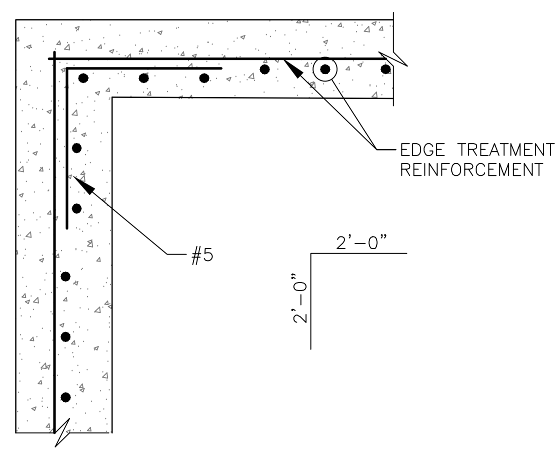
CONSTRUCTION JOINT–PLAN

NOTES:

1. PROVIDE CONTROL JOINTS 10 FT O.C. MAX CONSTRUCTION JOINTS MAY BE SUBSTITUTED FOR CONTROL JOINTS.

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
______	PREPARED BY: DCCR	BIORETENTION EDGE TREATMENT JOINTS
CHIEF ENGINEER	CHECKED BY: ______	



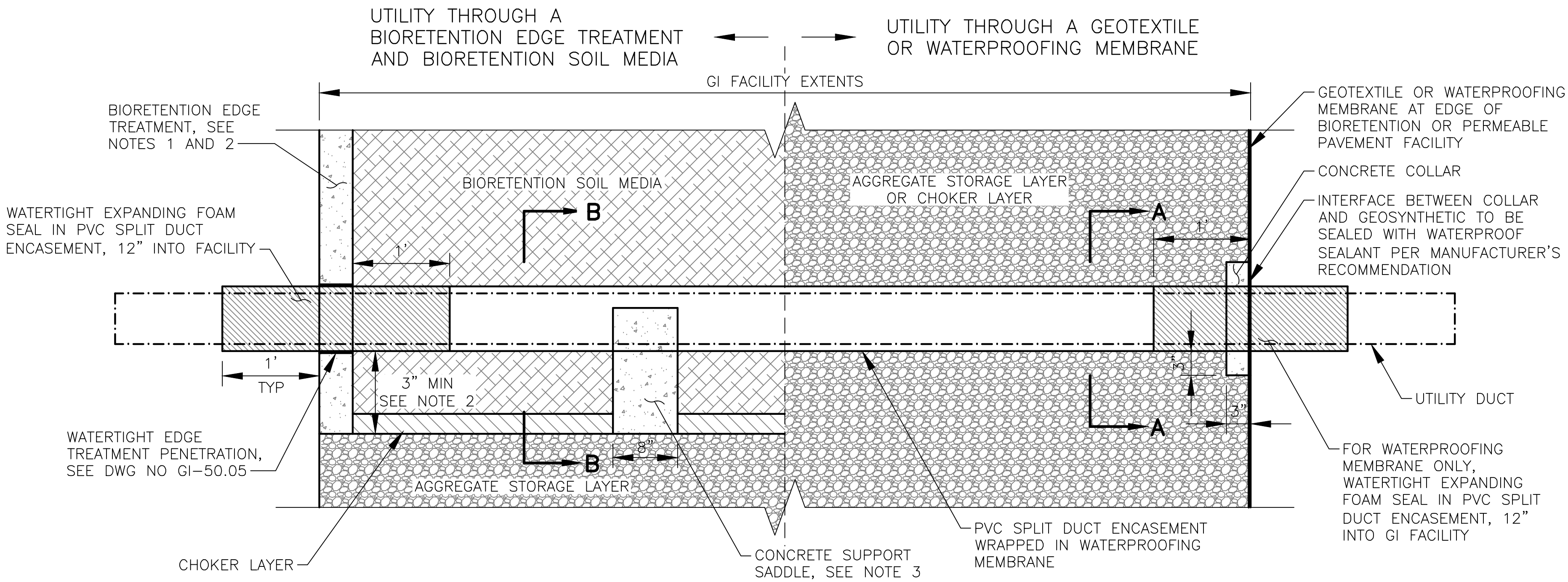
TYPICAL CORNER REINFORCEMENT

DETAIL NOT TO SCALE

APPROVED DATE:	REVISION NO.:	STANDARD DETAIL–PR–A1
	DATE:	
CHIEF ENGINEER	PREPARED BY: DCCR	BIORETENTION EDGE TREATMENT JOINTS
	CHECKED BY:	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–300.01
(1 OF 2)



ELEVATION

NOTES:

1. CONTRACTOR TO CONSTRUCT REINFORCEMENT IN BIORETENTION EDGE TREATMENT AROUND SPLIT DUCT ENCASEMENT WHERE CONFLICTS ARISE.
2. EXTEND DEPTH OF EDGE TREATMENT AS NEEDED IN AREA AROUND UTILITY TO PROVIDE 3" MIN CONCRETE ON ALL SIDES OF SPLIT DUCT ENCASEMENT.
3. WHERE SPLIT DUCT ENCASEMENT RESTS ON BIORETENTION SOIL MEDIA, PROVIDE A CONCRETE CRADLE EVERY 5' (MIN) ALONG SPANS BETWEEN CHECK DAMS, SUPPORT BEAMS, AND EDGE TREATMENTS.

DETAIL NOT TO SCALE

APPROVED DATE: ____________
CHIEF ENGINEER

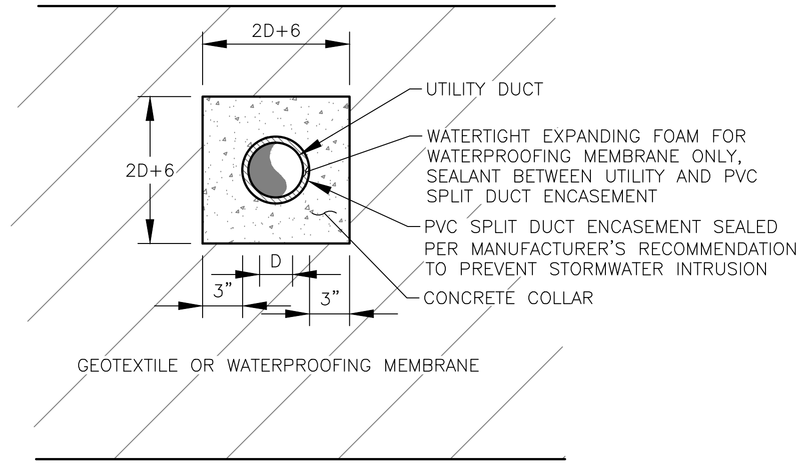
REVISION NO.: ______
DATE: ______
PREPARED BY: DCCR
CHECKED BY: ______

STANDARD DETAIL–PR–A1

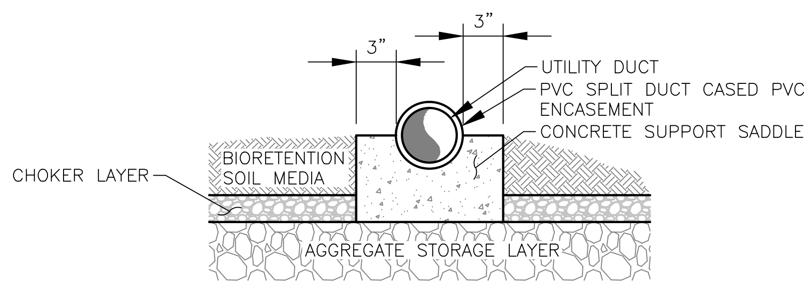
PVC SLEEVE UTILITY PROTECTION

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

GI–300.01
(2 OF 2)



CROSS SECTION A–A



CROSS SECTION B–B

DETAIL NOT TO SCALE

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL–PR–A1
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	PVC SLEEVE UTILITY PROTECTION
	CHECKED BY: ______	

GI DETAILS SPECIFIC TO APP

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DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY
AND DISTRICT DEPARTMENT OF TRANSPORTATION

S–1

PROJECT SPECIFICATIONS:

1. SPECIFICATIONS: THE FOLLOWING STANDARDS AND SPECIFICATIONS SHOULD BE INCLUDED IN THIS CONTRACT IN ADDITION TO THE SPECIFICATIONS CONTAINED HEREIN:
   a) DDOT GREEN INFRASTRUCTURE (GI) STANDARDS 2014
   b) DC WATER SPECIFICATION 30 01 31 CLEANING OF SEWERS
   c) DC WATER SPECIFICATION 33 01 32 CLEANING AND CCTV INSPECTION OF BUILDING SEWERS
   d) DDOT STANDARD SPECIFICATIONS FOR HIGHWAY STRUCTURES – 2013

2. DEFINITIONS:
   a) GI FACILITY: A GI FACILITY MAY ENCOMPASS THE ENTIRE ALLEY OR A PORTION THEREOF AND IS DEFINED BY A UNIQUE NUMERICAL IDENTIFIER.
   b) CELL: THE EXTENT OF THE GI FACILITY INCLUDING ALL LAYERS ABOVE CHECK DAM HEIGHT BETWEEN TWO CHECK DAMS OR BETWEEN EDGE OF FACILITY AND CHECK DAM.

3. SUBMITTAL OF FINAL RECORD DOCUMENTS: WITHIN TEN (10) DAYS OF THE SUBSTANTIAL COMPLETION INSPECTION, CONTRACTOR SHALL SUBMIT A DRAWING DETAILING THE FOLLOWING: EXTENT OF PERMEABLE PAVEMENT, CHECK DAM LOCATIONS, UNDERDRAIN LAYOUT, AND UNDERDRAIN TIE–IN TO SEWER. RECORD DOCUMENTS MUST BE APPROVED BY OWNER PRIOR TO ACCEPTANCE OF THE IMPROVEMENTS AND PRIOR TO FINAL PAYMENT.

4. WARRANTY: MATERIALS AND WORKMANSHIP SHALL BE GUARANTEED FOR TWELVE (12) MONTHS BEGINNING ON THE DATE OF SUBSTANTIAL COMPLETION.

   a) WHEN CORRECTING FAILED OR DAMAGED WARRANTED CONSTRUCTION, CONTRACTOR SHALL REMOVE AND REPLACE CONSTRUCTION THAT HAS BEEN DAMAGED AS A RESULT OF SUCH FAILURE OR MUST BE REMOVED AND REPLACED TO PROVIDE ACCESS FOR CORRECTION OF WARRANTED CONSTRUCTION.

   b) WHEN WORK COVERED BY A WARRANTY HAS FAILED AND BEEN CORRECTED BY REPLACEMENT OR REBUILDING, CONTRACTOR SHALL REINSTATE THE WARRANTY BY WRITTEN ENDORSEMENT. THE REINSTATED WARRANTY SHALL BE EQUAL TO THE ORIGINAL WARRANTY.

5. PROTECTION OF GI SURFACES: CONSTRUCTION SEQUENCE OF GI FACILITIES AND ADJACENT WORK SHALL BE FROM UPSTREAM TO DOWNSTREAM. GI FACILITIES SHALL BE PROTECTED FROM DAMAGE INCLUDING DAMAGE FROM SEDIMENT AND COMPACTION THROUGHOUT THE WORK. INLETS AND SURFACES TO GI FACILITIES SHALL NOT BE OPENED TO FLOW UNTIL ALL UPSTREAM FACILITIES ARE COMPLETED, THE CONTRIBUTING DRAINAGE AREA (CDA) IS STABILIZED, AND THERE ARE NO EVIDENT AREAS SUSCEPTIBLE TO EROSION WITHIN THE CDA (AS DETERMINED BY THE OWNER).

6. IMPERVIOUS CONCRETE & REBAR: CONCRETE SHALL MEET DDOT SPECIFICATION 817, CLASS B OR C. ALL REBAR SHALL BE #4 AND GRADE 60 PER DDOT STANDARD 812.02.

7. PERVIOUS CONCRETE MIX: PERVIOUS CONCRETE MIX PROPORTIONS SHALL BE AS FOLLOWS:
   a) COARSE AGGREGATE: 2,000 TO 2,500 LB/YD3
   b) CEMENTITIOUS MATERIALS: 450 TO 700 LB/YD3
   c) WATER–TO–CEMENTITIOUS RATIO: 0.27 TO 0.34
   d) AGGREGATE–TO–CEMENTITIOUS RATIO (BY MASS): 4 TO 4.5:1

8. PERVIOUS CONCRETE DESIGN PARAMETERS:
   a) TRANSVERSE JOINT SPACING: 15 FEET
   b) DESIGN FLEXURAL STRENGTH: 350 PCI
   c) COMPRESSIVE STRENGTH: 2,500 PSI

9. GI PIPING MATERIALS:
   a) ALL PIPES AND FITTINGS SHALL BE SCHEDULE 40 PVC WITH SOLVENT WELDED JOINTS AND FITTINGS AND SHALL BE A MINIMUM OF SIX (6) INCHES IN DIAMETER. WHERE PERFORATIONS ARE REQUIRED THEY SHALL BE ONE HALF (0.5) INCH IN DIAMETER.

   b) MAX ALLOWABLE ANGLE FOR ANY PIPE SEGMENT CHANGE IN DIRECTION SHALL NOT EXCEED FORTY–FIVE (45) DEGREES UNLESS CHANGE OCCURS WITHIN A MANHOLE.

   c) PROVIDE AT LEAST ONE (1) OBSERVATION WELL PER GI FACILITY.

10. GEOTEXTILE CLASS 1 SHALL BE MIRAFI 140N, PROPEX 4508, GEOTEX 451, OR APPROVED EQUAL.

11. WATERPROOFING MEMBRANE SHALL CONFORM TO PGI–1104, HAVE A MINIMUM THICKNESS OF THIRTY (30) MIL, AND BE PLASTIFLEX IG PVC OR EQUAL.

12. UTILITY PROTECTION: SHALL BE IN ACCORDANCE WITH DDOT GREEN INFRASTRUCTURE STANDARDS 33.14.6, DC WATER'S UTILITY PROTECTION DETAILS AND THE NOTES ON DRAWING NO. GI 12–02.

13. MAINTENANCE OF FLOW: THE CONTRACTOR IS FOREWARNED THAT FLOWS VARY IN THE EXISTING SEWER WIDELY AND RAPIDLY. WORK SHALL NOT BE PERFORMED DURING WET WEATHER. MAINTAIN FLOW IN EXISTING SEWERS AT ALL TIMES UNLESS OTHERWISE APPROVED BY DC WATER. DISCHARGES OF WASTEWATER ARE PROHIBITED.

14. QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC). QA/QC SHALL BE IN ACCORDANCE WITH DDOT STANDARD SPECIFICATIONS DIVISIONS 105 AND 106 AND THE FOLLOWING:

   a) TESTING LABORATORIES AND REPORTS, MANUFACTURER'S FIELD INSTALLATION SERVICES AND REPORTS, AND TEST SAMPLES SHALL BE IN CONFORMANCE WITH DDOT GI STANDARD SPECIFICATIONS 621.01, 621.02, AND 621.04.

   b) THE OWNER MAY ESTABLISH AN INDEPENDENT VERIFICATION AND ASSURANCE INSPECTION AND TESTING PROGRAM TO VALIDATE THE CONTRACTOR'S QA/QC SAMPLING AND TESTING PROGRAM. THE OWNER'S INSPECTIONS AND TESTS ARE FOR THE SOLE BENEFIT OF THE OWNER AND WILL NOT RELIEVE ANY RESPONSIBILITY OF THE CONTRACTOR FOR PROVIDING ADEQUATE QA/QC MEASURES.

APPROVED DATE: ______ ______ CHIEF ENGINEER	REVISION NO.: ______ DATE: ______ PREPARED BY: DCCR CHECKED BY: ______	STANDARD DETAIL SUPPLEMENTAL SPECIFICATIONS

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY AND DISTRICT DEPARTMENT OF TRANSPORTATION

S–2

SPECIFICATIONS CONTINUED:

c) THE CONTRACTOR SHALL PROVIDE TWENTY–FOUR (24) HOURS' NOTICE TO THE OWNER SO THAT THE OWNER MAY WITNESS ON–SITE INSPECTIONS AND TESTS. OWNER OR DESIGNATED REPRESENTATIVES WITNESSING INSPECTIONS AND TESTS DOES NOT RELIEVE THE CONTRACTOR'S OBLIGATION TO COMPLY WITH THE REQUIREMENTS OF THE CONTRACT DOCUMENTS. THE THREE HOLD/NOTIFICATION POINTS ARE AS FOLLOWS:

i. UNDERDRAIN LAYOUT, CHECK DAM, AND FLOW CONTROL DEVICE INSTALLATION/ ARRANGEMENT PRIOR TO BACKFILL.

ii. UNDERDRAIN TIE–IN TO SEWER OR MANHOLE.

e) AT FINAL COMPLETION AND PRIOR TO RELEASE OF RETAINAGE, SUBMIT TO OWNER ALL COMPLETED QA/QC DOCUMENTATION INCLUDING THE ORIGINAL INSPECTION AND TEST RECORDS DEMONSTRATING THAT THE WORK HAS BEEN SATISFACTORILY PERFORMED AND TESTED.

15. TRENCH EXCAVATION AND BACKFILL: SHALL BE IN ACCORDANCE WITH DC WATER SPECIFICATION 31 23 10 AND DC WATER STANDARD DETAIL S–15.01 POLYVINYL CHLORIDE (PVC) PIPE SEWER TRENCH LAYING CONDITION. SEWER AND WATER MAIN TRENCH OPERATIONS SHALL BE COORDINATED WITH OTHER UTILITY WORK AND SCHEDULED TO MEET MAINTENANCE OF TRAFFIC PROVISIONS.

16. FUNCTIONAL TESTING: TESTING SHALL BE PERFORMED FOR EACH GI FACILITY TO CONFIRM PERMEABILITY AND THAT CONSTRUCTION MEETS THE REQUIREMENTS OF THE CONTRACT. THE CONTRACTOR SHALL PROVIDE ALL LABOR, EQUIPMENT, MATERIALS, TOOLS, ETC. REQUIRED TO PERFORM THE FUNCTIONAL TESTING FOR ALL GI FACILITIES. THE CONTRACTOR SHALL COOPERATE WITH THE DECISIONS AND GUIDANCE PROVIDED BY THE OWNER AND ANY MANUFACTURER OR MANUFACTURER'S REPRESENTATIVE AND SHALL PERFORM TESTING ON A WEEKDAY IN THE PRESENCE OF THE OWNER. AT A MINIMUM TESTING SHALL INCLUDE:

b) FLOODING OF ONE CELL (I.E., THE AREA IN BETWEEN TWO CHECK DAMS) FOR EVERY 100 FT OF GI FACILITY LENGTH. FOR GI FACILITIES LESS THAN 100 FT IN LENGTH A MINIMUM OF TWO CELLS SHALL BE FLOODED. FLOW FROM THE TEST WATER SOURCE SHALL BE EQUALLY DISTRIBUTED OVER THE PERMEABLE SURFACE ABOVE THE CELL AND APPLIED IN A DIRECTION PARALLEL TO THE FACILITY UNDERDRAIN. TESTING FOR EACH CELL WILL BE CONSIDERED SUCCESSFUL AFTER A CONTINUOUS FLOW OF WATER HAS BEEN OBSERVED IN THE UNDERDRAIN AT THE DOWNSTREAM MOST OBSERVATION WELL/VERTICAL RISER OF THE FLOW RESTRICTION DEVICE FOR A MINIMUM OF 15 MINUTES.

17. FUNCTIONAL TESTING LOGS: SUBMIT TESTING LOGS TO THE OWNER THROUGHOUT FUNCTIONAL TESTING ACTIVITIES SHOWING COMPLIANCE, NON–COMPLIANCE, PARTIAL COMPLIANCE OF ALL SYSTEMS TESTED WITH SPECIFICATIONS AND PERFORMANCE CRITERIA, OR INDICATION OF DEFICIENT AREAS REQUIRING REMEDIATION. ALL MAINTENANCE AND SERVICING DURING FUNCTIONAL TESTING SHALL BE NOTED IN THE FUNCTIONAL TESTING LOGS. INSPECTION REPORTS SHALL BE PROVIDED TO THE OWNER.

a) FUNCTIONAL TESTING LOGS SHALL INCLUDE, AT A MINIMUM: DATE OF TEST; NAME OF CONTRACTOR'S REPRESENTATIVE OVERSEEING TEST; ALLEY SEGMENT IDENTIFIER; CELL LOCATION; WATER APPLICATION METHOD; START TIME AND END TIME OF WATER APPLICATION; PICTURE OF TEST LOCATION; AND PICTURE OF FLOW WITHIN UNDERDRAIN. IF TEST IS UNSUCCESSFUL, TEST LOG SHOULD INDICATE FAILURE AND REASON FOR FAILURE.

17. ACCEPTANCE OF WORK:

a) IF, DURING THE FUNCTIONAL TESTING, ANY PART OF THE WORK FAILS TO FULLY CONFORM TO THE REQUIREMENTS OF THE CONTRACT, THE FUNCTIONAL TESTING SHALL BE CONSIDERED TO HAVE FAILED, AND THE WORK SHALL NOT BE CONSIDERED TO BE ACCEPTABLE, AND THE OWNER SHALL SO NOTIFY THE CONTRACTOR IN WRITING. NO PAYMENT SHALL BE MADE FOR A FAILED TEST.

b) UPON FAILURE OF THE FUNCTIONAL TESTING, THE CONTRACTOR SHALL PROMPTLY REMEDY ANY DEFECTS IN THE WORK AND SHALL PROMPTLY RESCHEDULE AND RE–START THE COMPLETE FUNCTIONAL TESTING.

c) THE SUCCESSFUL COMPLETION OF THE FUNCTIONAL TESTING SHALL BE DEFINED BY SUCCESSFUL COMPLETION OF FUNCTIONAL TESTING FOR ALL SYSTEMS AND AFTER SUBMITTAL OF THE FUNCTIONAL TESTING LOGS; THE OWNER WILL APPROVE FUNCTIONAL TESTING FOR EACH GI FACILITY.

d) AT FINAL COMPLETION AND PRIOR TO RELEASE OF RETAINAGE, SUBMIT TO OWNER ALL COMPLETED QA/QC DOCUMENTATION INCLUDING THE ORIGINAL INSPECTION AND TEST RECORDS DEMONSTRATING THAT THE WORK HAS BEEN SATISFACTORILY PERFORMED AND TESTED.

19. PHOTOGRAPHS AND VIDEO SHALL BE IN ACCORDANCE WITH THE EXISTING CONTRACT WITH THE FOLLOWING ADDITION: BEFORE THE START OF WORK, THE CONTRACTOR SHALL VIDEOTAPE THE ENTIRE ALLEY SEGMENT SURFACE AREA AND PORTIONS OF THE CDA WITHIN A FIFTEEN (15) FOOT BUFFER OF THE ALLEY USING A DIGITAL CAMERA.

20. GROUNDWATER: GROUNDWATER LEVELS SHALL NOT BE WITHIN TWO (2) FEET OF THE GI FACILITY BOTTOM.

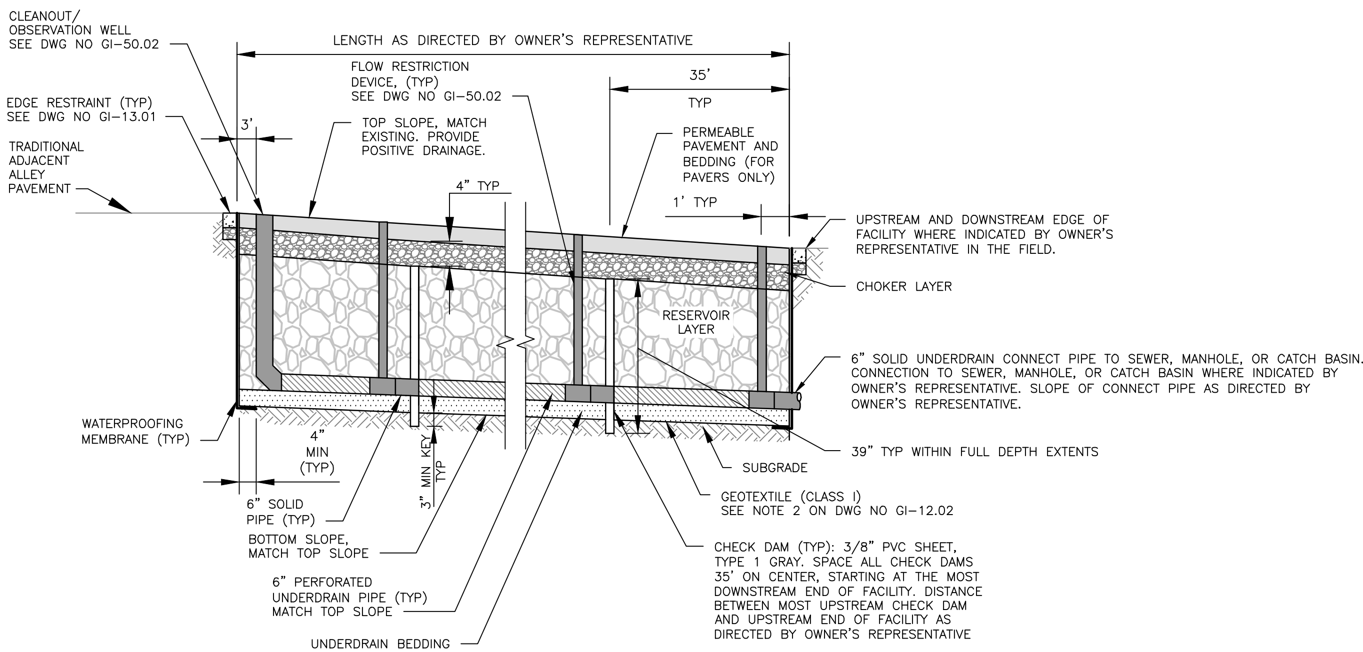
a) PRIOR TO EXCAVATION OF EACH ALLEY SEGMENT, THE CONTRACTOR SHALL PERFORM ONE (1) TEST PIT AT THE DOWNSTREAM END OF THE ALLEY AT A LOCATION APPROVED BY THE OWNER TO A DEPTH TWO (2) FEET BELOW THE FACILITY BOTTOM TO DETERMINE IF GROUNDWATER IS WITHIN TWO (2) FEET OF THE FACILITY BOTTOM. IF GROUNDWATER IS ENCOUNTERED WITHIN POTHOLE, FACILITY SHALL NOT BE CONSTRUCTED.

b) CONTRACTOR SHALL HALT ANY ACTIVITIES UPON DISCOVERY OF SHALLOW GROUNDWATER WITHIN THE GI FACILITY'S EXCAVATION.

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL
	DATE: ______	
______	PREPARED BY: DCCR	SUPPLEMENTAL SPECIFICATIONS
CHIEF ENGINEER	CHECKED BY: ______	

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY
AND DISTRICT DEPARTMENT OF TRANSPORTATION

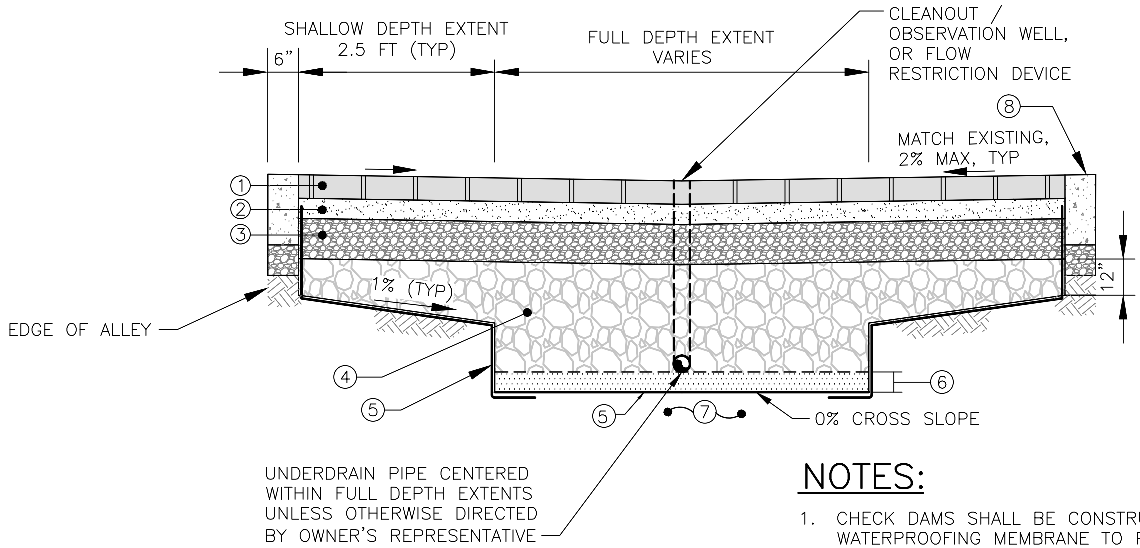
GI–12.01



APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	PERMEABLE PAVEMENT ELEVATION ALONG CENTER OF FACILITY
	CHECKED BY: ______	

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY AND DISTRICT DEPARTMENT OF TRANSPORTATION

GI–12.02



LEGEND:

① PAVEMENT SURFACE MAY VARY BY PROJECT LOCATION AND SHALL BE SPECIFIED BY THE OWNER (PAVER OPTION SHOWN ABOVE). FOR PERMEABLE INTERLOCKING PAVERS OR CLAY BRICK PAVERS THICKNESS SHALL BE 3–1/8" MIN AND 2–5/8" THICKNESS RESPECTIVELY. PROVIDE JOINTS BETWEEN PAVERS AS RECOMMENDED BY MANUFACTURER AND MEETING ADA REQUIREMENTS. FILL JOINTS WITH AASHTO #8. FOR PERVIOUS CONCRETE THICKNESS SHALL BE 6".

② BEDDING LAYER (FOR PAVERS ONLY), AASHTO #8 OR APPROVED EQUIVALENT, 2" THICKNESS.

③ CHOKER LAYER, 4" THICKNESS, AASHTO #57 OR APPROVED EQUIVALENT.

④ RESERVOIR LAYER, 33" THICKNESS AT CENTER, AASHTO #2, #3, OR APPROVED EQUIVALENT.

⑤ GEOTEXTILE, SEE NOTE 2

⑥ UNDERDRAIN BEDDING, 3" THICKNESS, SAME REQUIREMENTS AS RESERVOIR LAYER.

⑦ SUBGRADE. PREPARE SUBGRADE IN ACCORDANCE WITH DDOT GREEN INFRASTRUCTURE STANDARDS, SECTION 621.01 (D).

⑧ EDGE RESTRAINT, SEE DWG NO GI–13.01.

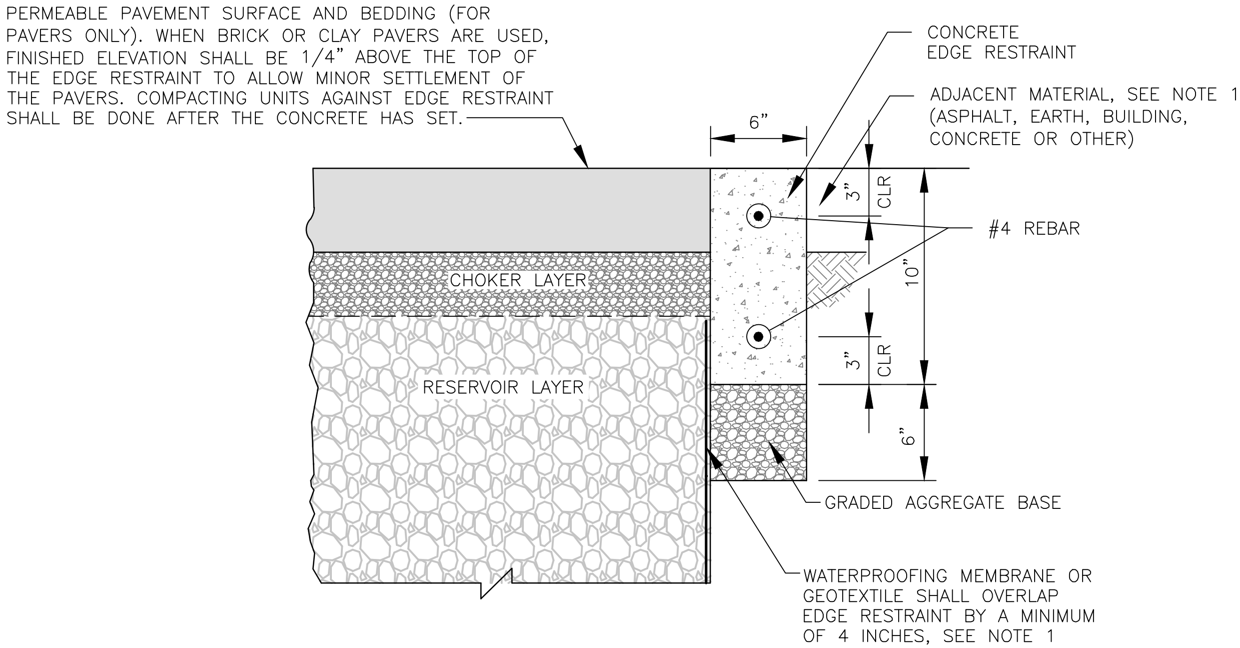
NOTES:

1. CHECK DAMS SHALL BE CONSTRUCTED AND SEAMED WITH GEOTEXTILE AND WATERPROOFING MEMBRANE TO PREVENT ANY BYPASS WITHIN THE RESERVOIR LAYER AND UNDERDRAIN BEDDING LAYER. CHECK DAM SHALL NOT EXTEND ABOVE RESERVOIR LAYER AND SHALL EXTEND 3 INCH MINIMUM INTO SUBGRADE IN BOTH SHALLOW AND FULL DEPTH EXTENTS. DO NOT INSTALL GEOTEXTILE OR WATERPROOFING MEMBRANE UNDER OR AROUND CHECK DAMS. TURN UP GEOTEXTILE AND WATERPROOFING MEMBRANE AGAINST CHECK DAM, OVERLAP PER MANUFACTURER'S RECOMMENDATION AND AS APPROVED BY OWNER'S REPRESENTATIVE, 12 INCH MINIMUM. ADHERE WATERPROOFING MEMBRANE TO CHECK DAM, NOT GEOTEXTILE.
2. WATERPROOFING MEMBRANE SHALL BE USED IN LIEU OF GEOTEXTILE FOR PORTION OF FACILITY LOCATED WITHIN A HOTSPOT, ADJACENT TO TRADITIONAL PAVEMENT OR WITHIN 10 FEET (HORIZONTALLY) OF A BUILDING OR UTILITY (LIGHT POLE, COMMUNICATION, GAS, OR ELECTRIC LINE). SEE DC WATER'S UTILITY PROTECTION GUIDELINES FOR WATERPROOFING REQUIREMENTS FOR SEWER AND WATER LINES.
3. FULL DEPTH EXCAVATION AND ALL SUPPORT OF EXCAVATION, INCLUDING SLOPES, SHALL BE A MINIMUM OF 3 FEET FROM ALL STRUCTURES, EXCLUDING MANHOLES AND UTILITY RISERS WHERE INDICATED BY OWNER'S REPRESENTATIVE.
4. FOR MANHOLES WITHIN A PERMEABLE PAVEMENT FACILITY, PROVIDE TYPICAL EDGE RESTRAINT ABUTTING MANHOLE WITH WATERPROOFING LINER UP SIDES. FOR UTILITY AND LIGHT POLES, DO NOT EXCAVATE WITHIN 3 FT HORIZONTALLY OF POLE. EDGE RESTRAINT TO BE OFFSET 3 FT FROM POLE. SHALLOW RESURFACING TO OCCUR WITHIN 3 FT OFFSET OF POLE AS DIRECTED BY OWNER'S REPRESENTATIVE.

APPROVED DATE: ____	REVISION NO.: ____	STANDARD DETAIL
	DATE: ____	
	PREPARED BY: DCCR	ALLEY PERMEABLE PAVEMENT SECTION
CHIEF ENGINEER	CHECKED BY: ____	

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY
AND DISTRICT DEPARTMENT OF TRANSPORTATION

GI–13.01



ALLEY EDGE RESTRAINT

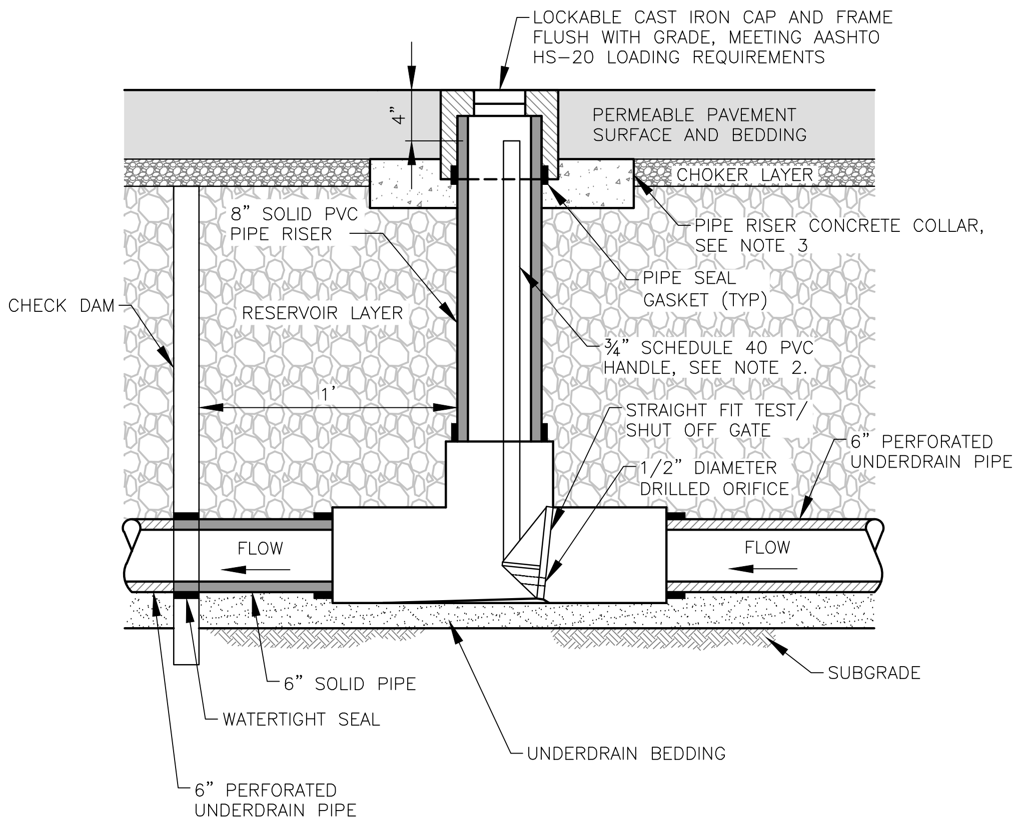
NOTES:

1. CONCRETE EDGE RESTRAINT SHALL BE OMITTED WHERE PERMEABLE PAVEMENT FACILITY ABUTS CONCRETE APRON OR ANOTHER PERMEABLE PAVEMENT FACILITY. WHERE FACILITY ABUTS A CONCRETE APRON, EXTEND WATERPROOFING MEMBRANE TO SURFACE. TRIM LINER 1" BELOW SURFACE PRIOR TO PLACEMENT OF PERMEABLE PAVEMENT WEARING COURSE. WHERE FACILITY ABUTS ANOTHER FACILITY, INSTALL TYPICAL CHECK DAM AND TYPICAL WATERPROOFING MEMBRANE OR GEOTEXTILE IN LIEU OF EDGE TREATMENT PER DWG NO GI–12.01 AND GI–12.02.

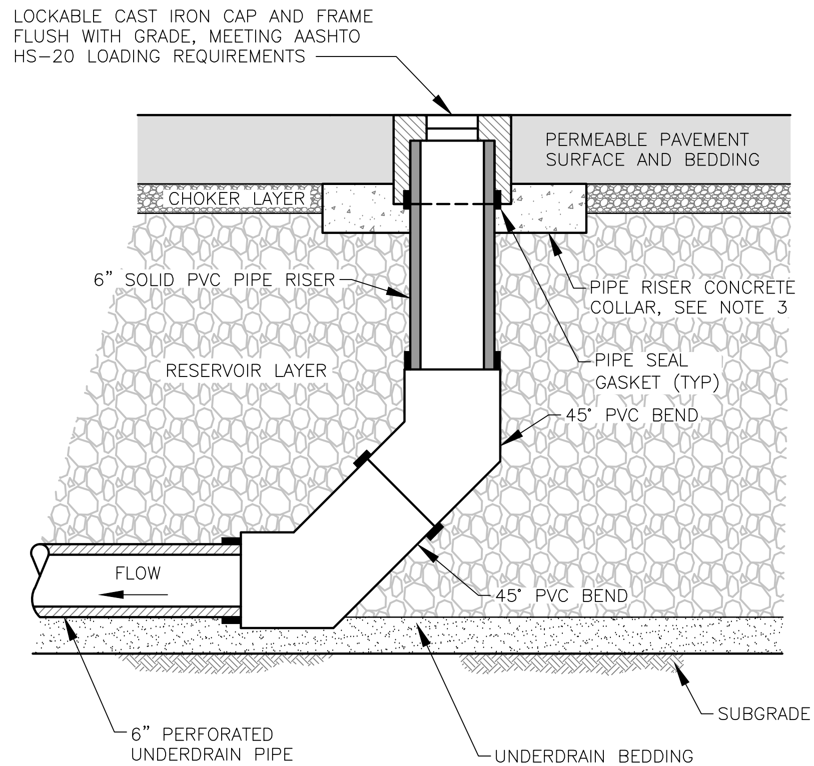
APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL
	DATE: ______	
CHIEF ENGINEER	PREPARED BY: DCCR	ALLEY EDGE RESTRAINT
	CHECKED BY: ______	

DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY
AND DISTRICT DEPARTMENT OF TRANSPORTATION

GI–50.02



FLOW RESTRICTION DEVICE

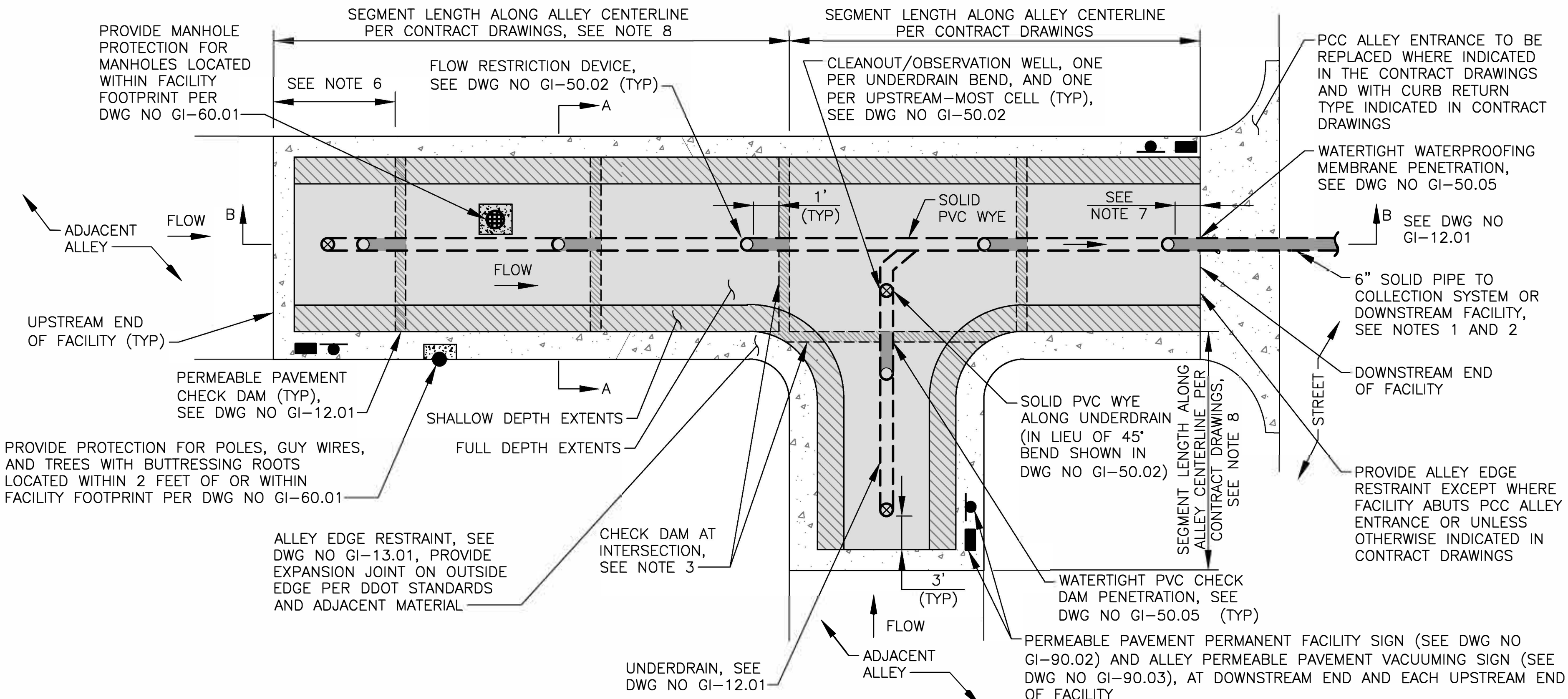


CLEANOUT/OBSERVATION WELL IN PERMEABLE PAVEMENT

NOTES:

1. FLOW RESTRICTION DEVICE SHALL BE MAINLINE STRAIGHT–FIT BACK WATER VALVE OR APPROVED EQUAL. VERTICAL ACCESS PIPE OF FLOW RESTRICTION DEVICE SHALL SERVE AS AN ADDITIONAL CLEANOUT/ OBSERVATION WELL.
2. ADHERE HANDLE TO GATE WITH PVC CEMENT AND FASTEN WITH SCREW.
3. WRAP PIPE WITH TWO LAYERS OF BUILDING PAPER BEFORE PLACING CONCRETE. CONCRETE COLLAR SHALL BE 6" THICK AND 1.5 FT LONG AND WIDE. INSTALL TWO #4 REBAR ON ALL 4 SIDES AT MID–DEPTH. BUILDING PAPER SHALL CONFORM TO ASTM D–4869 AND BE PLAIN 15LB ASPHALT TYPE 1.

APPROVED DATE: ______	REVISION NO.: ______	STANDARD DETAIL
	DATE: ______	
______	PREPARED BY: DCCR	PIPE RISERS
CHIEF ENGINEER	CHECKED BY: ______	



NOTES:

1. COLLECTION SYSTEM TIE IN LOCATION INDICATED ON CONTRACT DRAWINGS. ELEVATION OF CONNECTION TO COLLECTION SYSTEM PIPE AS INDICATED IN CONTRACT DRAWINGS. UNDERDRAIN PIPE SHALL TRANSITION FROM PVC SCHEDULE 40 TO PVC SDR-35 OUTSIDE THE FACILITY, WITHIN 3 LF OF THE UNDERDRAIN PENETRATION THOUGH THE WATERPROOFING MEMBRANE, AS MEASURED ALONG THE CENTERLINE OF THE UNDERDRAIN PIPE. FOR CONNECTION TO MANHOLES OR CATCH BASINS, SEE DWG NO GI-100.02. FOR CONNECTION TO SEWERS, SEE DWG NO GI-100.01. FOR CONNECTION TO DOWNSTREAM PERMEABLE PAVEMENT FACILITY, SEE DWG NO GI-50.04.
2. SEE DC WATER STANDARD DETAIL 5-15.01 FOR TRENCH EXCAVATION AND FILL. BACKFILL ABOVE THE BEDDING, FOURTH COURSE, SHALL BE COMPACTED FILL MEETING DC WATER STANDARDS.
3. PROVIDE AN ADDITIONAL CHECK DAM AT THE INTERFACE OF ABUTTING ALLEY PERMEABLE PAVEMENT SEGMENTS.
4. FOR POROUS CONCRETE ALLEY JOINT LAYOUT, SEE DDOT DWG NO 503.01. FOR ALLEY EDGE RESTRAINT JOINTS, SEE DDOT STANDARD SPECIFICATIONS FOR HIGHWAYS AND STRUCTURES, SECTION 606.01. AT CORNERS, PROVIDE CORNER BARS WITH TENSION LAP SPLICE LENGTH BOTH LEGS.
5. TEMPORARILY SUPPORT MANHOLES, POLES, AND OTHER EXISTING STRUCTURES DURING CONSTRUCTION TO PREVENT MOVEMENT DUE TO REMOVAL OF SOIL AND UNBALANCED LOADING.
6. DISTANCE BETWEEN MOST UPSTREAM CHECK DAM AND UPSTREAM END OF FACILITY OR SEGMENT PER CONTRACT DRAWINGS.
7. 6' WHERE CATCH BASIN ABUTS DOWNSTREAM END OF FACILITY. OTHERWISE, 1' OR PER CONTRACT DRAWINGS.
8. WHERE PROPOSED APP FACILITY'S UPSTREAM END TERMINATES WITHIN 2' DOWNSTREAM OF AN ALLEY JOINT, EXTEND THE APP FACILITY LENGTH TO THE ALLEY JOINT UNLESS OTHERWISE DIRECTED BY DC WATER OR THE CONTRACT DOCUMENTS. FACILITY LENGTHS SHALL ALSO BE ADJUSTED TO LIMIT CUTTING OF PERMEABLE PAVERS AND BRICKS, AS APPROVED BY DC WATER.

DETAIL NOT TO SCALE

ALLEY PERMEABLE PAVEMENT FACILITY PLAN

Appendix E

Model Documentation: Green Infrastructure Modeling for RC-A Area

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

Model Documentation: Green Infrastructure Modeling for RC-A area

June 2020

Prepared for:

Prepared by:

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
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Appendix D: Monitoring Timeseries for Entire Post-Construction Metering time Period

1 Introduction

1.1 Background

The development and calibration of the combined sewer model used for the LTCP is documented in *Study Memorandum LTCP 5-4: CSS Model Documentation* that was published with the LTCP in 2001. The modeling conducted to evaluate green infrastructure in the RC-A area uses refined sub-models of the metered RC-A area that were developed independently of the system-wide LTCP model.

1.2 Model Documentation

A continuous hydrologic runoff model for the RC-A study area was developed in 2016 to simulate runoff under existing, pre-GI conditions and to estimate the runoff reduction expected under future conditions with green infrastructure (GI) implemented. The runoff model is an application of the EPA SWMM5 model. SWMM5 is the current version of the most widely applied urban stormwater model across the world include for specific GI applications. EPA's long-term support to the development and application of SWMM5 and earlier SWMM models underscores its acceptance in applications to support regulatory programs. SWMM5 is the model used for the range of GI-related modeling for the DCCR. The model included subcatchments representing runoff in the RC-A project area, the sewer network conveying the flow to the outlets of the RC-A project area and the GI practices planned for RC-A. GI practices are represented in the model by combining all practices of a given practice type (alley permeable pavement, parking lane permeable pavement, bioretention practices) into one single practice per type per model subshed. A schematic of this "lumped practice" modeling approach is shown in Figure 1-1.

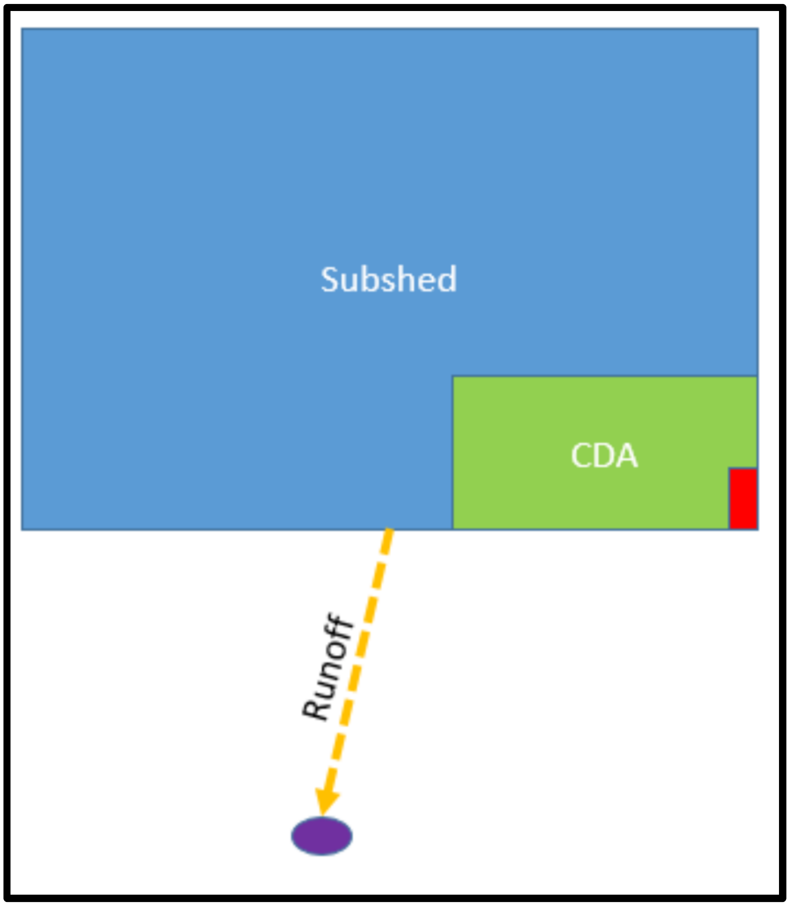

Figure 1-1. Lumped Practice Modeling Approach

1.3 Scope and Modeling Objectives

The RC-A model was developed, updated, and calibrated over the following timeline:

- The original pre-construction model was calibrated for a time period of 03/1/2016 to 6/2/2016. Additional pre-construction monitoring data was collected until 1/22/2017 and used to further improve the calibration.
- Installed GI practices were added to the model and the model was recalibrated using post-construction sewer monitoring data using data from 3/1/2019 to 7/18/2019. Model adjustments during this calibration were limited to the GI parameters only; model parameters unrelated to GI were unchanged from the pre- to post-construction models.
- The calibrated post-construction model was then used to simulate the LTCP forecast period of 1988-1990 and compared with the performance predictions from the existing 2016 model.
- Additional model calibration was conducted that incorporated practice-specific water level data. Initial practice-specific data for four practices was later supplemented by data from an additional 73 practices, although this expanded data set has captured a limited number of events as of the end of March 2020. The adjusted model based on the practice-level data was applied to the LTCP forecast period of 1988-1990.

  Table 1-1 provides an overview of all modeling timeframes.

Table 1-1. RC-A Modeling Timeframes

Modeling Purpose	Timeframe	Model Description
Rainfall Monitoring	1/22/16 – 3/22/20	For Pre Construction Period: 1/22/16 - 1/22/17 For Post Construction Period: 3/1/19 - 3/22/20
Pre-Construction Monitoring – Sewershed	1/22/16 - 1/22/17	Model data used for existing 2016 SWMM model: 3/1/16 to 6/2/16
Post Construction Monitoring – Sewershed	3/1/19 - 3/22/19	Calibration Period: 3/1/19 – 7/18/19 Retrofits Period (Data not used): 11/1/19-11/30/19 Field Corrective Actions: 12/1/19-1/31/20
Post Construction Monitoring – GI Practices	4/19/19 - 3/22/20	Calibration Period: 4/19/19 – 3/31/20 GI model parameter adjustments based on in-practice water level monitoring data for 4 practices Calibration Period: 3/12/20 – 3/22/20 GI model parameter adjustments based on in-practice water level monitoring data for 73 practices

2 Description of System

2.1 RC-A Area

The RC-A study area consists of 136 acres, and is approximately 40% impervious. Table 2-1 summarizes all GI practices installed within and outside of the study area. This includes RC-A project practices as well as Kennedy Street project practices and the GI Challenge Park. Figure 2-1 shows the RC-A study (model) area as well as all GI practices listed in Table 2-1. "Acres Managed" are based on the design practice volumes provided in the RF-C plansets and the 1.2" design storm.

Table 2-1. Constructed and Metered GI Facilities

	Constructed (project area)		Metered (study area)	
Practice Type	**Number of Practices**	**Acres Managed (% of total)**	**Number of Practices**	**Acres Managed (% of total)**
Curb Extension Bioretention (CBR)	2	0.26 (1%)	1	0.08 (0%)
Planter Bioretention (PBR)	36	4.40 (16%)	28	3.00 (15%)
Alley Permeable Pavement (APP)	51	15.09 (56%)	41	11.01 (55%)
Parking Lane Permeable Pavement (PPP)	10	2.45 (9%)	7	1.75 (9%)
Challenge Parks	2	1.91 (7%)	1	1.31 (7%)
Kennedy Street	31	2.69 (10%)	31	2.69 (14%)
Total	**132**	**26.80 (100%)**	**109**	**19.85 (100%)**

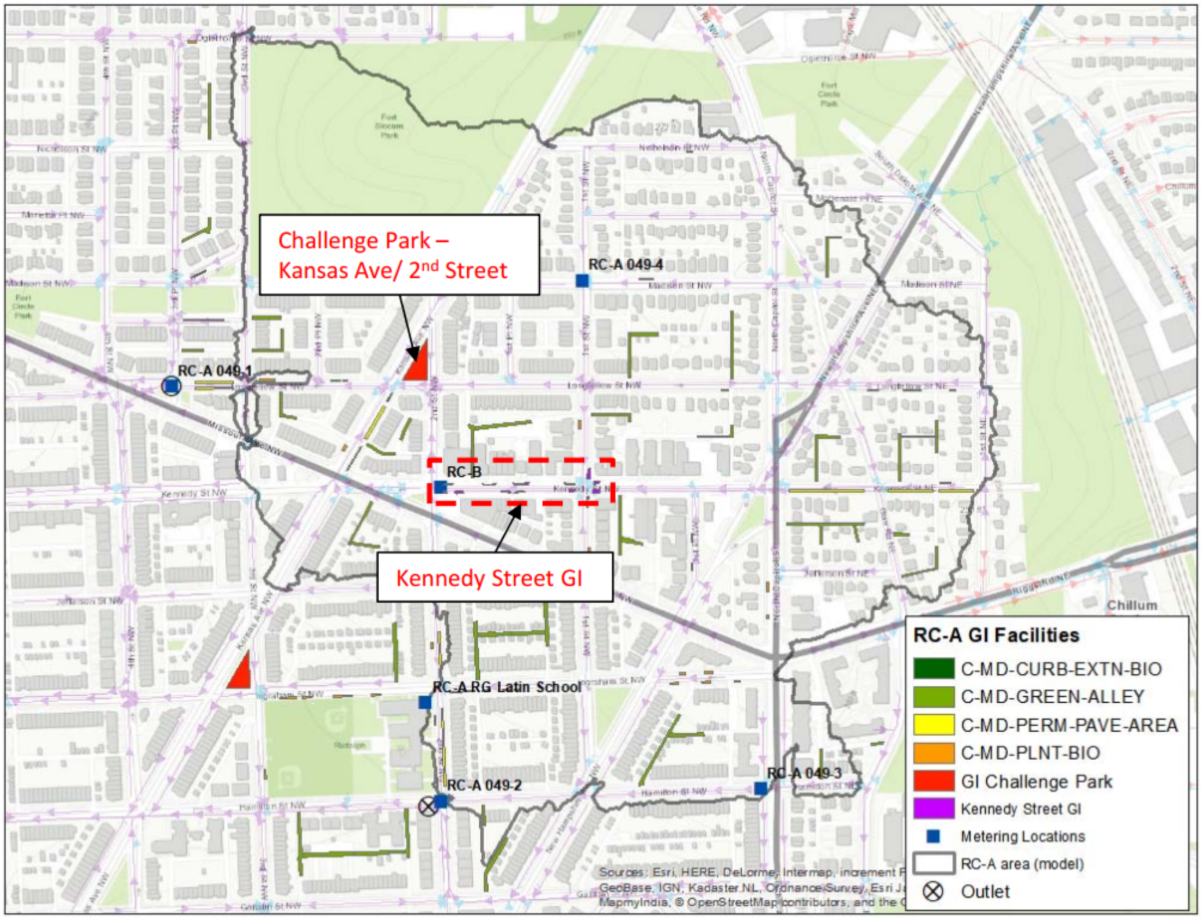

Figure 2-1. Installed RC-A GI practices

2.2 Monitoring locations and data

Four flow meter locations were selected to capture stormwater flow from a variety of practices during the pre-construction period. Three additional locations were selected for the post-construction period. Table 2-2 summarizes the flow meter purposes and the drainage areas for each meter. The metering periods were 1/22/2016 to 1/22/2017 for pre-construction and started on 3/1/2019 for the post-construction period (still ongoing). There are two outlets from RC-A that were monitored by meters 049-1 and 049-2 during both pre- and post-construction periods. The 049-1 metered area consists of 117 acres (86% of the total RC-A area), and is 39% impervious. The 049-2 metered area consists of 19 acres (14% of the total RC-A area), and is 45% impervious.

Table 2-2: RC-A Flow Meters

Meter	Purpose / Usage	Drainage Area (ac)	Pre-construction	Post-construction
RC-A 049-1	Quantify total stormwater reduction from RC-A	117	YES	YES
RC-A 049-2	Quantify total stormwater reduction from RC-A	19	YES	YES
RC-A 049-3	Monitor runoff from a specific group of GI practices (*)	0.9	YES	YES

Meter	Purpose / Usage	Drainage Area (ac)	Pre-construction	Post-construction
RC-A 049-4	Monitor runoff from a specific group of GI practices (*)	1.2	YES	YES
RC-B	Monitor runoff from a specific group of GI practices (**)	16	YES	YES

(*) Meter not used for this study due to data quality issues and insufficient drainage area size
(**) Meter not used for this study due to overlapping drainage area size

Figure 2-2 shows the locations of the meters and rain gauge, as well as the drainage areas for each of the sewer meters.

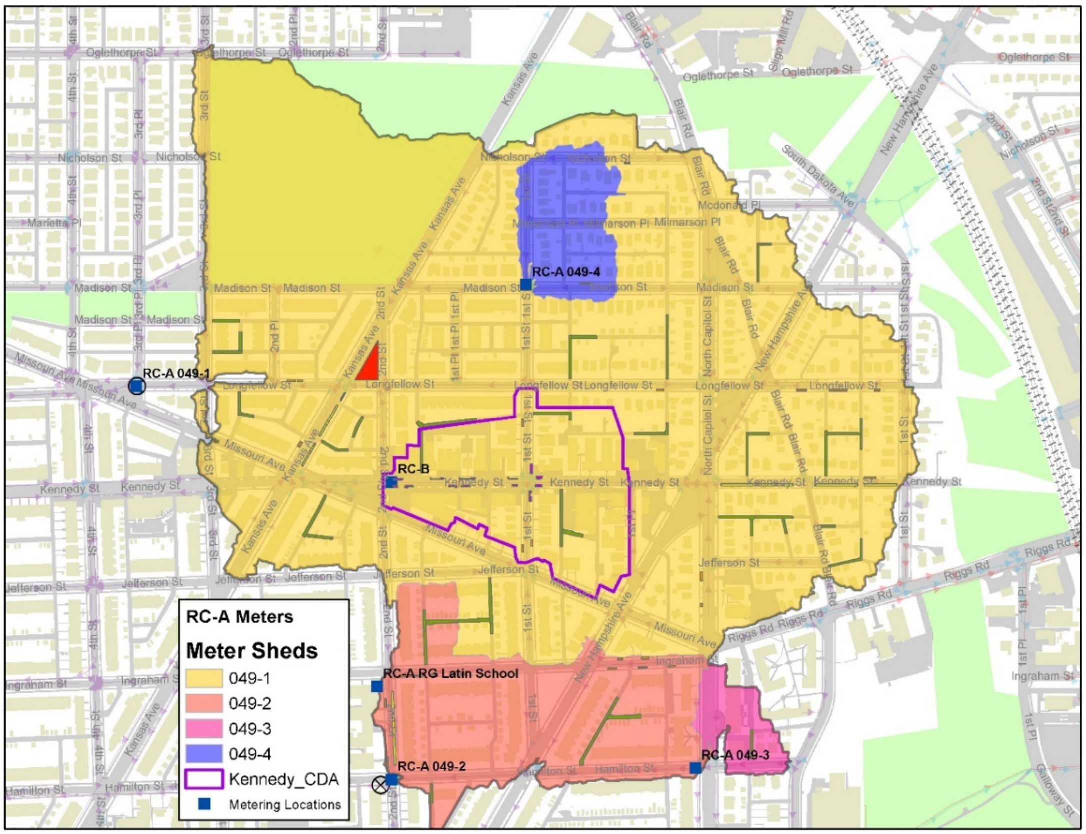

Figure 2-2: RC-A Monitoring Locations

2.3 Rainfall Monitoring

Rainfall data is critical to analyze the response of the CSS to rainfall. A rain gage with a five-minute reporting interval was installed for the RC-A area to capture local rainfall both for the pre- and post construction monitoring periods. The meter is located at Washington Latin School.

Based on the rainfall data, wet weather events were defined with a minimum event separation of 3 hours and a minimum rainfall depth of 0.1 inches. For the purposes of modeling and analysis, events were excluded from analysis if there were any suspected winter weather influences or if the flow metering data had inconsistencies. Table 2-3 summarizes the rainfall event totals for the pre- and post-construction periods.

Table 2-3: Total Rainfall During Pre- and Post-Construction Periods

Period	Total Rainfall (inches)	Number of events
2016-2017 pre-construction	34.5	70
Calibration Events	26.7	59
2019-2020 post-construction	41	74
Calibration Events	36.6	69

2.4 GI Practice Water Level Monitoring

Water level sensors from four GI practices (PBR-3503, APP-3608, APP-4105, PPP-4211) began collecting data on 4/19/2019 to monitor the filling and drawdown rates of GI on a individual practice basis. For these four practices, one water level sensor was installed in each individual cell per practice. The sensors are located in the practices' underdrain cleanouts at a level of 3" above practice bottom. Water levels in the practice that are below 3" cannot be measured. The GI model represents one type of practice within each model subshed, therefore a comparison of modeled GI practices with the individually-monitored RC-A practices is not possible.

Table 2-4 summarizes the maximum water levels observed in each of the practice-level monitoring wells for various time frames. Highlighted cells mark the maximum observed water level for each monitored cell over all time periods.

- 3/1/19 – 10/31/19: Period before practice retrofits.
- 12/1/19 – 1/31/20: Period of ongoing practice retrofits.
- 2/1/20 – 03/31/20: Period after practice rehab (completed)

Table 2-4: Maximum Observed Practice Water Levels

		Maximum Water Level (in)		
Practice ID	Type	Pre-retrofit	Retrofits ongoing	Post-retrofit (completed)
3503-A01	PBR	1.03	**1.04**	0.91
3503-A02	PBR	**1.55**	0.83	1.42
3503-A03	PBR	**6.14**	1.24	1.04
3503-A04	PBR	**4.56**	0.82	1.09
3608-A01	APP	0.65	8.99	**25.38**
3608-A02	APP	0.82	**25.85**	25.43
3608-A03	APP	0.89	**29.34**	25.56
3608-A04	APP	24.38	14.64	**23.71**
3608-A05	APP	1.51	30.01	**30.56**
3608-A06	APP	5.64	31.37	**32.72**

		Maximum Water Level (in)		
Practice ID	Type	Pre-retrofit	Retrofits ongoing	Post-retrofit (completed)
3608-A07	APP	29.52	15.78	**32.1**
3608-A08	APP	12.19	21.77	**44.03**
4105-A01	APP	1.49	1.25	**23.5**
4105-A02	APP	1.69	0.72	**33.54**
4105-A03	APP	11.1	1.03	**43.21**
4105-A04	APP	14.38	1.13	**45.98**
4211-A01	PPP	**1.09**	0.8	0.92
4211-A02	PPP	**1.26**	1.06	0.91
4211-A03	PPP	**1.54**	1	0.79
4211-A04	PPP	**11.03**	1.48	1.22
4211-A05	PPP	**5.68**	0.77	1.73
4211-A06	PPP	**9.7**	1.26	1.22
4211-A07	PPP	**0.98**	0.65	0.49
4211-A08	PPP	**8**	1.84	3.13
4211-A09	PPP	**13.37**	0.85	2.28
4211-A10	PPP	**6.67**	0.98	0
4211-A11	PPP	**10.87**	0.97	2.81
4211-A12	PPP	**8.7**	1.21	4.31

The observed practice water levels show that one (APP-3608) practice out of the monitored practices benefited from the 12/1/19 – 1/31/20 retrofits. The other three practices show no discernible increase in water levels. Upon completion of all practice retrofits, practice APP-4105 also showed a significant increase of the observed maximum water levels.

Beginning on 3/13/2020, the in-practice monitoring was extended to include all RC-A GI practices. One water level sensor was installed in the underdrain cleanout of the most downstream cell for each practice. These sensors were installed at a level of 3” above practice bottom.

Table 2-5shows observed water levels per practice type during the timeframe of 3/13/20 – 3/22/20. Practice water depths have been averaged per practice type (APP, PPP and PBR) for further analysis and model calibration. Calculated average maximum water depths for all practices within each type as the maximum observed water depth are shown.

Table 2-5: Maximum Observed Water Levels per Practice Type

Practice Type	Maximum average water level (in)	Maximum water level (in)
APP	3.8	26.4
PPP	0.2	1.6
PBR	1.3	13.1

3 Model Calibration

The existing 2016 pre-construction SWMM model of the RC-A area was updated due to several factors:

- The existing pre-construction model calibration period was limited to the available data at the time; a three month period in the first half of 2016. Data continued to be collected throughout 2016, and included 10 of the 13 rain events with peak intensities greater than 1" per hour. Only one of those 13 intense events occurred in the original three month model calibration period.
- Metering data for the largest and most intense events outside of the original calibration period indicated capped peak flows and reduced volumes, which indicated inlet bypassing within RC-A.
- The existing model was updated extensively by adopting the detailed subcatchment delineations and pipe network from the DC Water InfoWorks model.
- The revised RC-A model, based on the InfoWorks inputs, was further expanded to include an idealized street network, with flows routed first onto the streets and then to collection system inlets. Inlet flow capture rate was calibrated based on the metering data and number of inlets per subshed, in order to simulate inlet bypass during larger events.

The post-construction modeling with GI practices used the lumped practice approach that was consistent with the approach taken for the existing SWMM model. With the finer-scale subcatchments from InfoWorks, the lumped practice approach for the updated RC-A model also ended up being conducted on a finer scale. In the lumped practice approach, GI practices of similar type are represented as one element within a SWMM subcatchment.

The model setup and major calibration parameters for the updated model in comparison to the existing 2016 model are shown in Table 3-1.

Table 3-1: Model Parameter Overview

Model Parameter	Existing model from 2016 (pre-construction)	Updated Pre-construction model
Model inventory	10 subcatchments 5,000 feet of sewer pipe	75 subcatchments 22,000 feet of sewer pipe Parts of street network with sw inlets
% impervious cover	43.3%	39.9%
Saturated infiltration	0.125 inch/hour	0.5 inch/hour
Rooftop connection	Not directly modeled, included in impervious coverage	Disconnected rooftops draining to pervious areas
GI settings (for post-construction model)	• Design practice parameters • Design CDA • 22 **PLANNED** acres	• Calibrated practice parameters • CDA reduced to 25% of planned impervious CDA • 16.8 **INSTALLED** acres • Accounted for Kennedy Street GI and 2nd Street GI Park

The GI practice parameters were populated based on the calculated wet-weather-volume-treated capacities of each practice and then adjusted during calibration in order to calibrate to post-construction data. This required:

- Reduction in GI practices' contributing drainage areas
- Assumption of a 6" underdrain without an orifice (flapper gates assumed to be non-functional based on field observations)
- Reduction of both in-practice and bottom infiltration rates
- Reduction of storage layer and bioretention media porosity values

3.1 Pre-Construction Model Results

The existing 2016 pre-construction model was calibrated for the timeframe of 3/1/2016 to 6/2/2016. Only a limited number of storms with less intensity were available compared to storms in the extended pre-construction timeframe until 1/22/2017. Therefore the model was updated and re-calibrated as described earlier.

Figure 3-1 through Figure 3-4 show 1-to-1 plots for wet weather event volumes and peak flows and select individual-event hydrographs for the combined flows from metering locations 049-1 and 049-2. A complete set of event hydrographs and a rainfall event table are provided in Appendix A. Appendix B contains monthly plots for the pre-construction period.

Overall modeled predictions match event volumes well for meters 049-1 and 049-2 combined with the regression close to the 1-to-1 line and an R-squared value of 0.85. The overall wet weather volume match is acceptable with a difference of only 7%. Peak flow response is more variable in the 1-to-1 plots. The hydrograph comparisons for individual events show a great variability in metered sewer response for rainfall events of similar size.

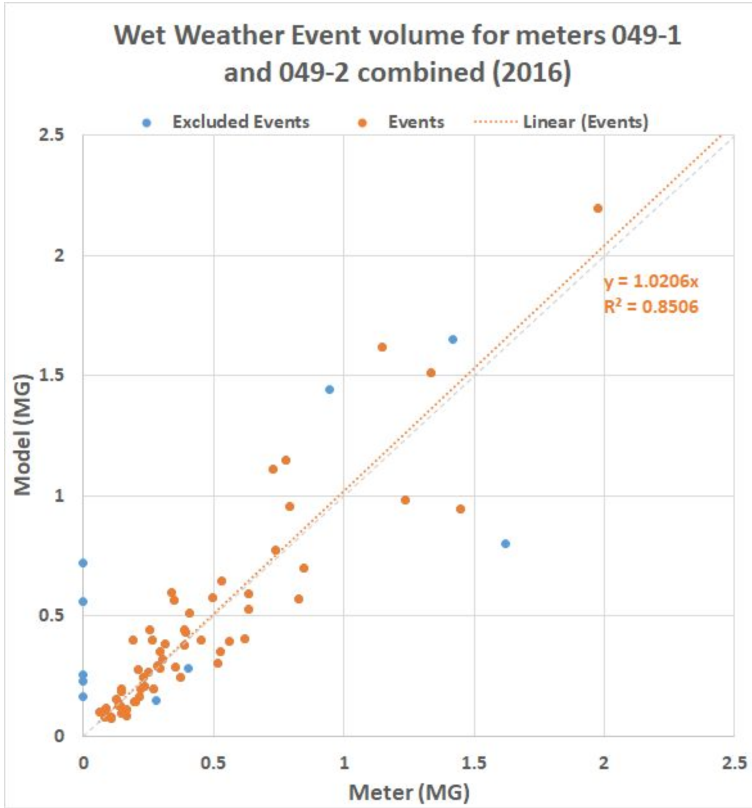

Figure 3-1: RC-A Preconstruction event volumes, 049-1 and 049-2 combined

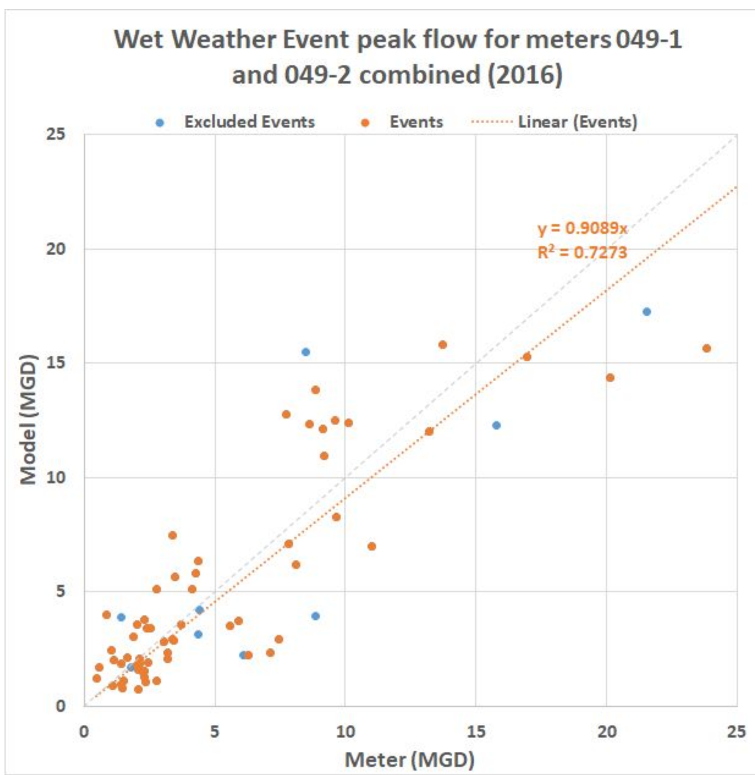

Figure 3-2: RC-A Preconstruction event peak flows, 049-1 and 049-2 combined

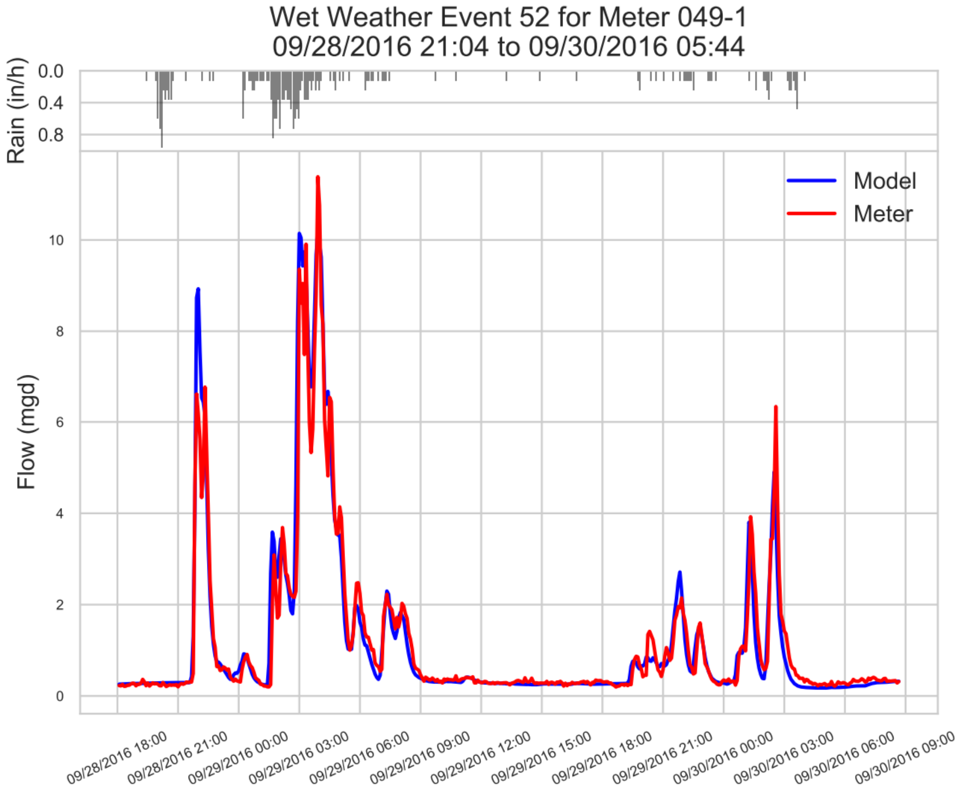

Figure 3-3: RC-A pre-construction event hydrograph, 049-1

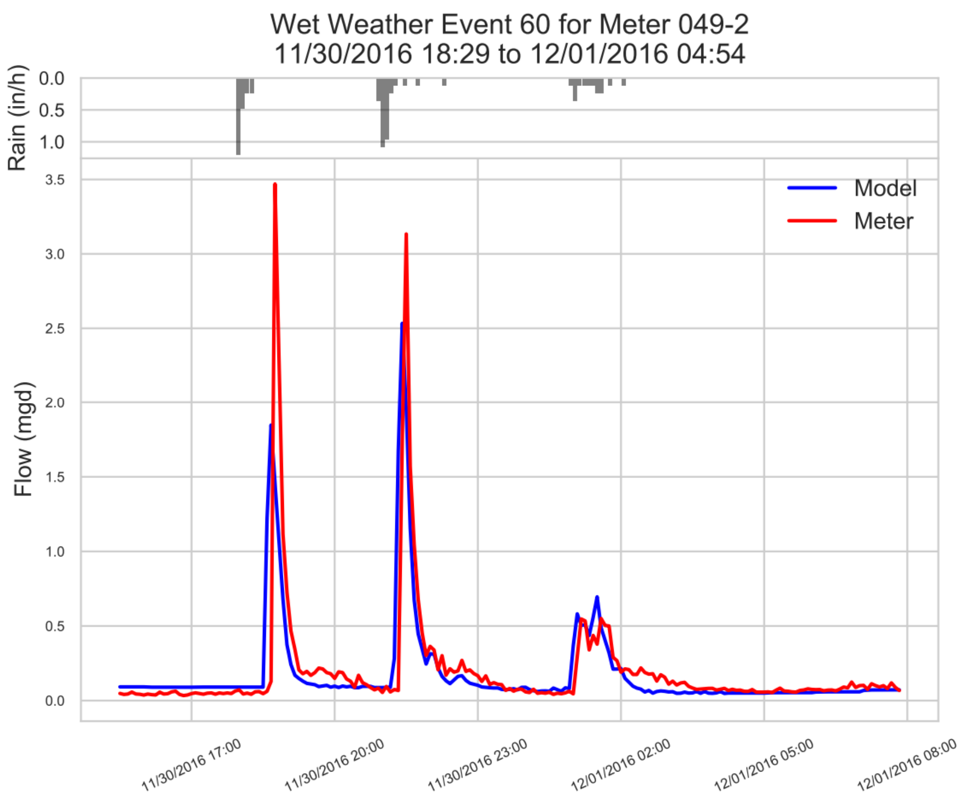

Figure 3-4: RC-A pre-construction event hydrograph, 049-2

3.2 Post-Construction Model Results (Sewershed)

The calibration timeframe for the post-construction period was 3/1/2019 – 7/18/2019. Once more data became available, the model was applied and compared to an extended timeframe.

Figure 3-5 through G show 1-to-1 plots for wet weather event volumes and peak flows and select individual-event hydrographs for the combined flows from metering locations 049-1 and 049-2. A complete set of event hydrographs and a rainfall event table are provided in Appendix C. Appendix D contains monthly plots for the entire post-construction period.

Overall modeled predictions match event volumes well for meters 049-1 and 049-2 combined, with the regression close to the 1-to-1 line and an R-squared value of 0.94 for the calibration timeframe (3/1/2019 – 7/18/2019). The overall wet weather volume match is acceptable with a difference of only 8%. Peak flow response is more variable in the 1-to-1 plots. The hydrograph comparisons for individual events show a great variability in metered sewer response for rainfall events of similar size.

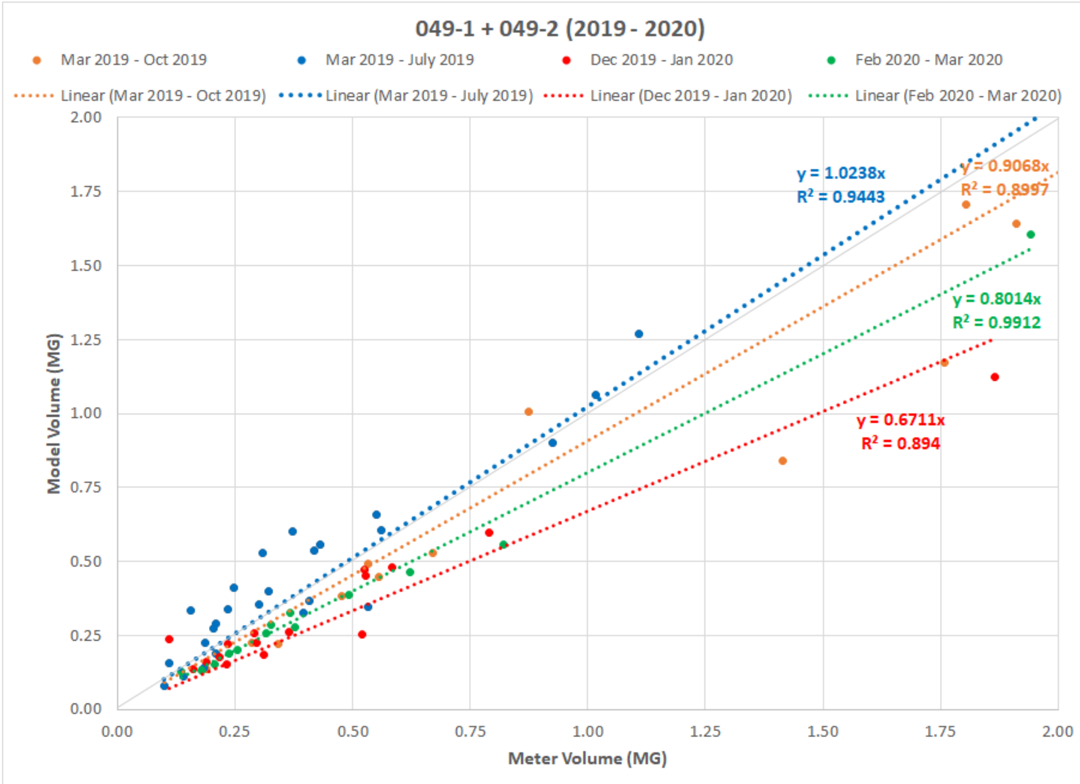

Figure 3-5: Post-construction event volumes, 049-1 and 049-2 combined

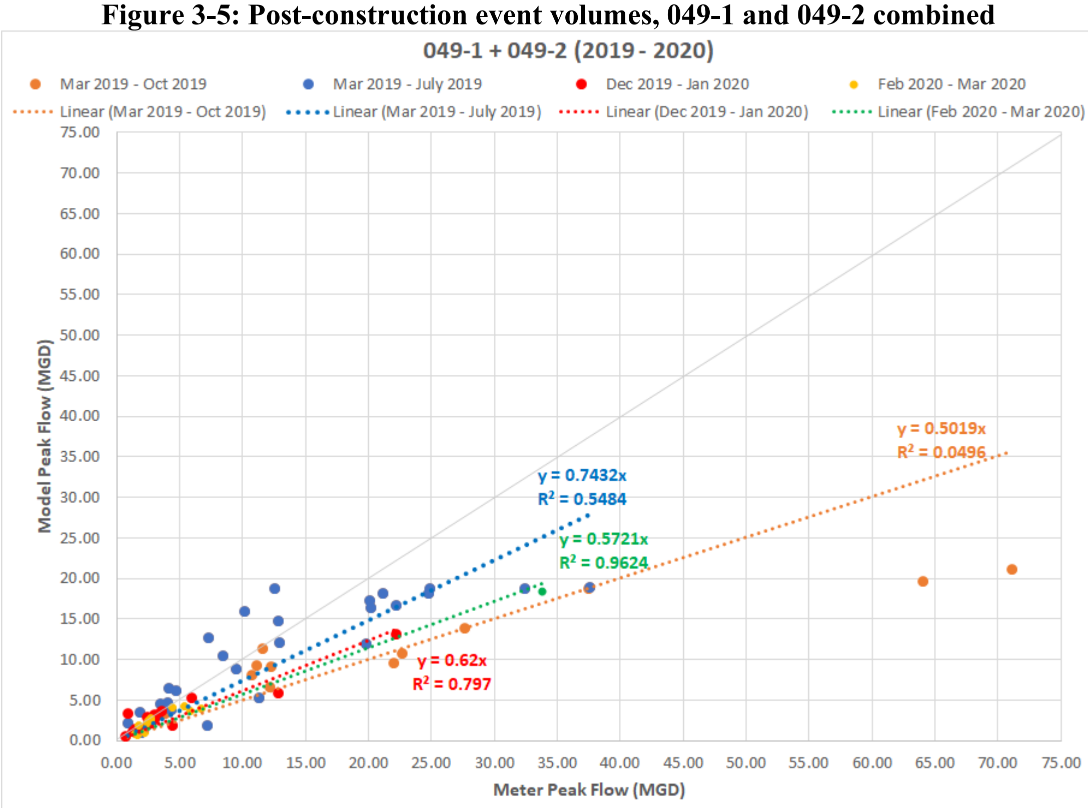

Figure 3-6: Post-construction event peak flows , 049-1 and 049-2 combined

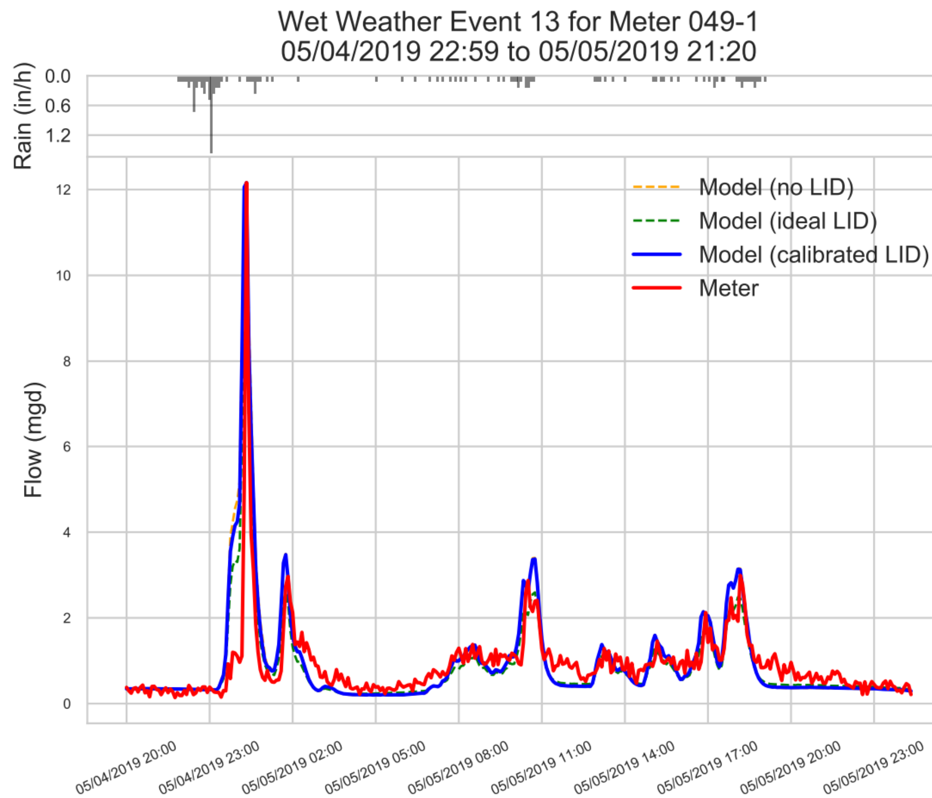

Figure 3-7: RC-A post-construction event hydrograph, 049-1

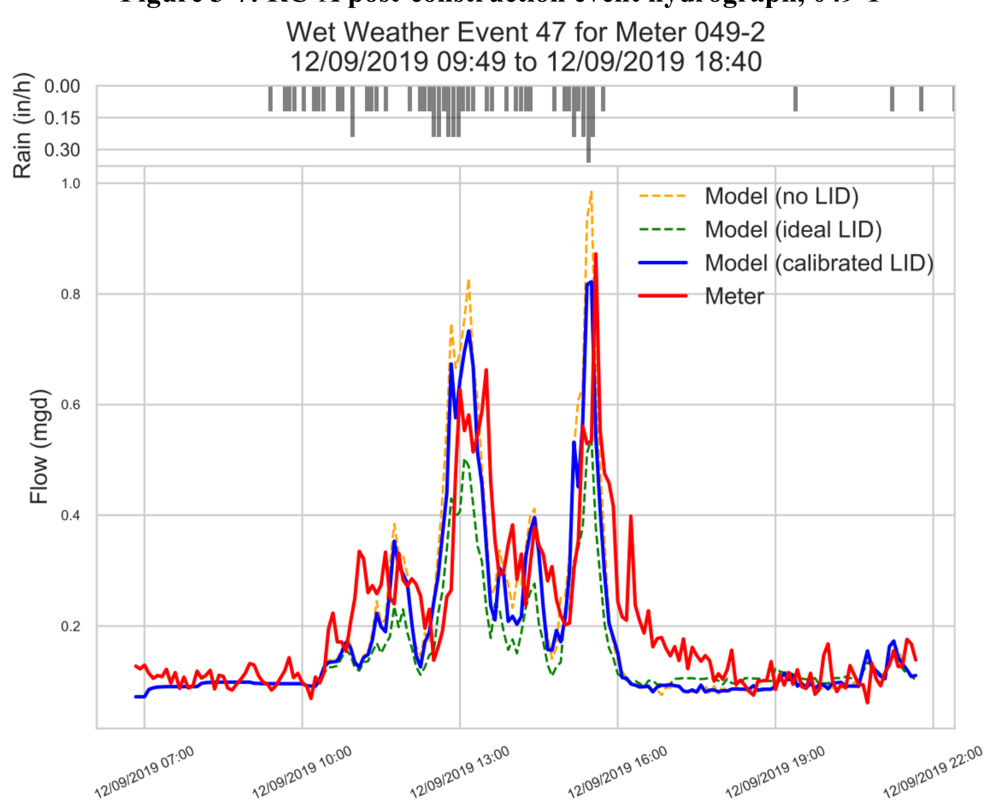

Figure 3-8: RC-A post-construction event hydrograph, 049-2

3.3 GI Practice-Level Model Adjustments

The post-construction model was calibrated using sewershed monitoring data from meters 049-1 and 049-2 for the timeframe 3/1/2019 – 7/18/2019. Modeled water levels for the GI (lumped) practices were compared with the observed in-practice water levels. GI model parameters were adjusted using this data to better match the observed in-practice water levels. The following adjustments were made:

- Re-calibration of model for all practice types (APP, PPP, PBR) using data from the four observed practices for the timeframe of 1/25/20 - 2/29/20 (five wet weather events).Data from the three of the four observed practices (3503-PBR, 3608-APP, 4211-PPP) was used to calibrate the water levels in the corresponding "lumped" model practices. The adjusted model parameters were then applied to all practices of that model type.
- Re-calibration for all model practices using data from all 73 observed practices for the timeframe of 3/13/20 – 3/22/20 (three wet weather events). Averaged water level observations for each practice type were compared to the average modeled water levels for each practice type.

Figure 3-9 show 1-to-1 plot for wet weather event volumes for the combined flows from metering locations 049-1 and 049-2. A complete set of event hydrographs, monthly plots and rainfall events tabulations are included in Appendix A.

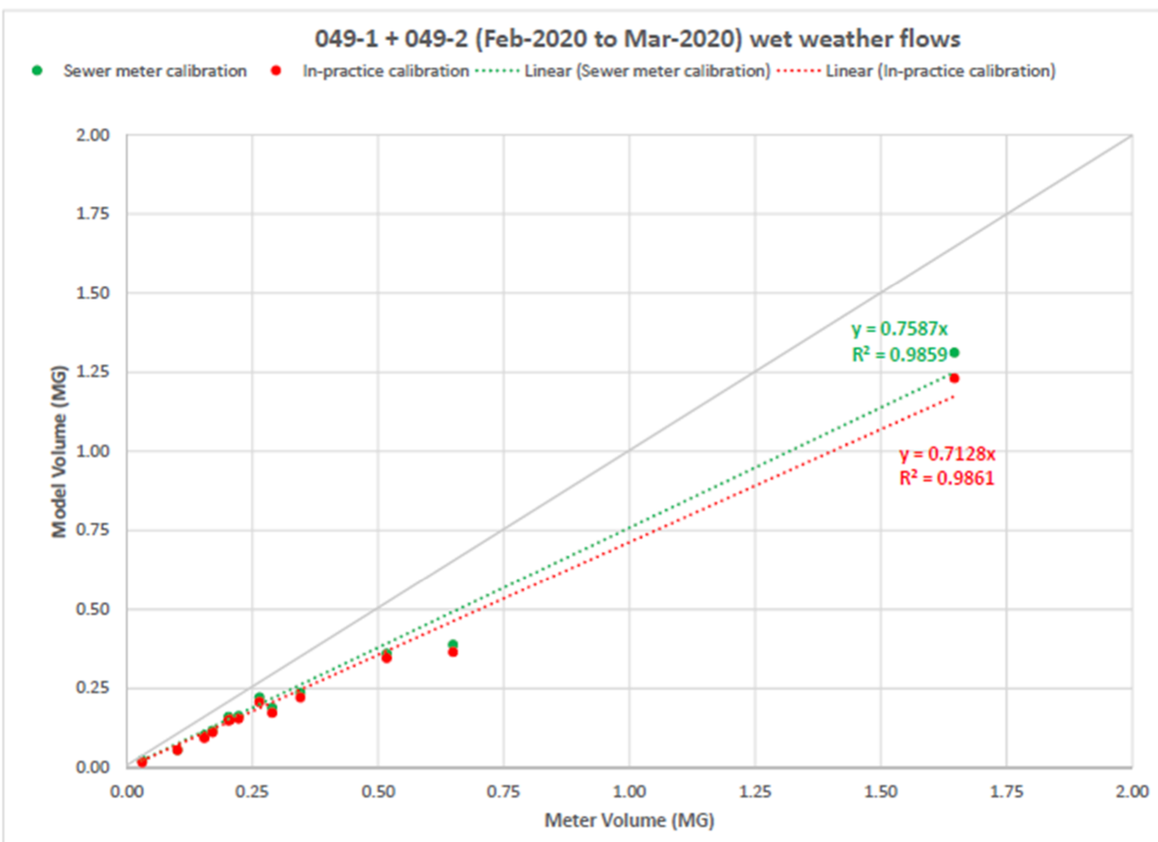

Figure 3-9. Post-Construction Event Volumes, 049-1 and 049-2 Combined

The following tables (Table 3-2 through Table 3-4) show the adjusted GI model parameters for all practice types.

Table 3-2. APP Model Parameter Calibration

Parameter	Design values	Sewer model calibration (pre-retrofits)	February in-practice calibration (post-retrofits)	March in-practice calibration (post-retrofits)
Underdrain orifice size (in)	0.25	6	0.25	< 0.25
% of CDA inflow (impervious)	100	25%	75%	85%
% of CDA inflow (pervious)	100	0%	75%	85%
storage layer porosity	0.4	0.25	0.18	0.18

Table 3-3. PPP Model Parameter Calibration

Parameter	Design values	Sewer model calibration (pre-retrofits)	February in-practice calibration (post-retrofits)	March in-practice calibration (post-retrofits)
Underdrain orifice size (in)	0.25	6	0.25	< 0.25
% of CDA inflow (impervious)	100	25%	15%	15%
% of CDA inflow (pervious)	100	0%	15%	15%
storage layer porosity	0.4	0.25	0.18	0.18

Table 3-4: PBR Model Parameter Calibration

Parameter	Design values	Sewer model calibration (pre-retrofits)	February in-practice calibration (post-retrofits)	March in-practice calibration (post-retrofits)
Underdrain orifice size (in)	0.25	6	2	1
% of CDA inflow (impervious)	100	25%	10%	10%
% of CDA inflow (pervious)	100	0%	10%	10%
storage layer porosity	0.4	0.18	0.18	0.18

4 Results

GI performance is being evaluated by comparing the total wet weather flow between the pre- and post-construction model conditions. For this evaluation, wet weather flow has been defined as the time period when predicted flows in the sewer exceeded two times average dry weather flow rates. The value of two times dry weather flow was selected because it is the original basis of design for the complete treatment capacity of the Blue Plains Advanced Wastewater Treatment Plant in the *Blue Plains Feasibility Study* (Final Report, 1984, Greeley and Hansen). The analysis was done both for the post-construction timeframe of March 2019 – March 2020 and the 1988 to 1990 average year conditions.

For the post-construction scenario, the model results reflect the GI-practice level calibration model (see previous chapter 3.3). Results from this analysis are presented in Table 4-1 below.

Table 4-1. Post Construction Practice Model Results

Sewershed	Impervious Acres treated by GI (% of total)	WWF volume Normalized Pre-construction (MG)	WWF volume Normalized Post-Construction (MG)	Predicted Volume Reduction Using Monitoring Data, Normalized to Impervious Acres Treated (%)	Predicted Volume Reduction Before Construction, Normalized to Impervious Acres Treated (%)
2019 -2020 Rainfall Conditions					
RC-A (After Retrofits) 2020 Rainfall	28.8 %	31.5	27.1	18.5%	N/A
Average Year Rainfall Conditions (1988 - 1990)					
Rock Creek Project A (After Retrofits)	28.8 %	26.7	22.9	18.7%	31.8%

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Appendix A: Pre-Construction Events for Meters 049-1 and 049-2

(Note: The y-axis varies in scale between the individual plots)

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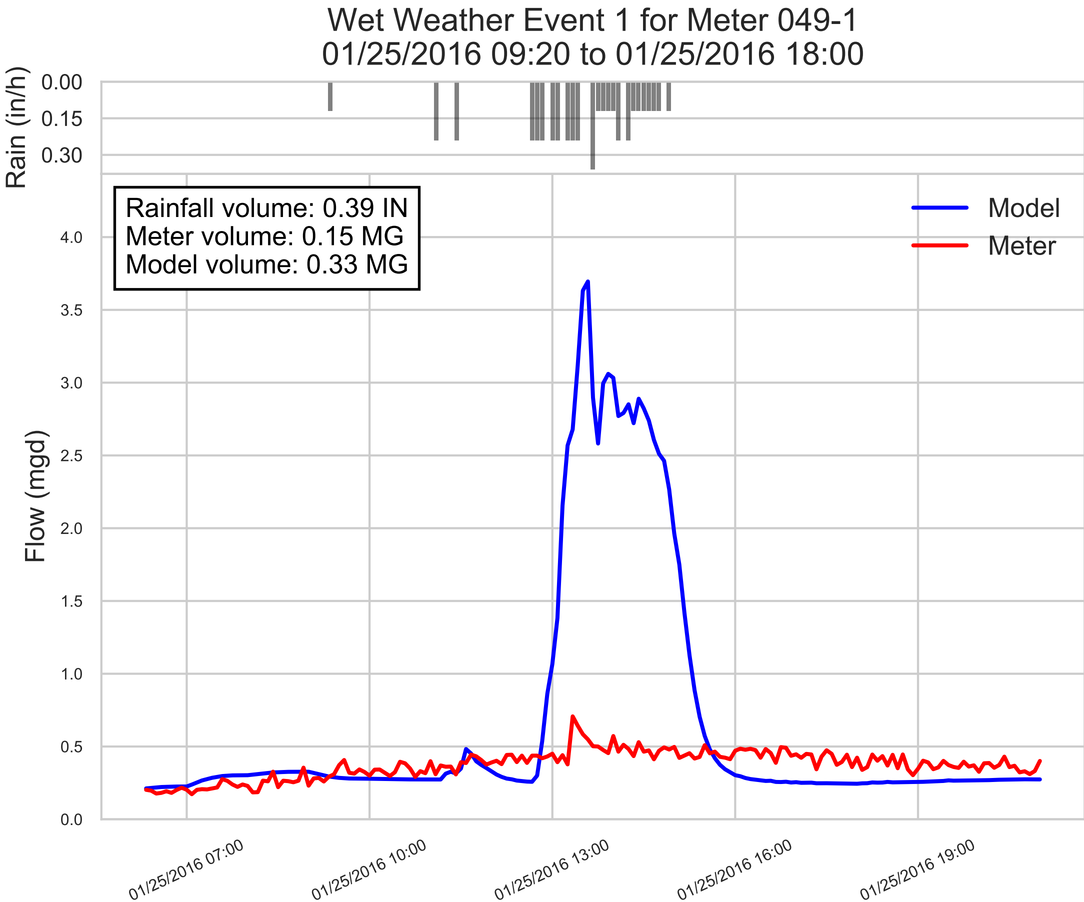
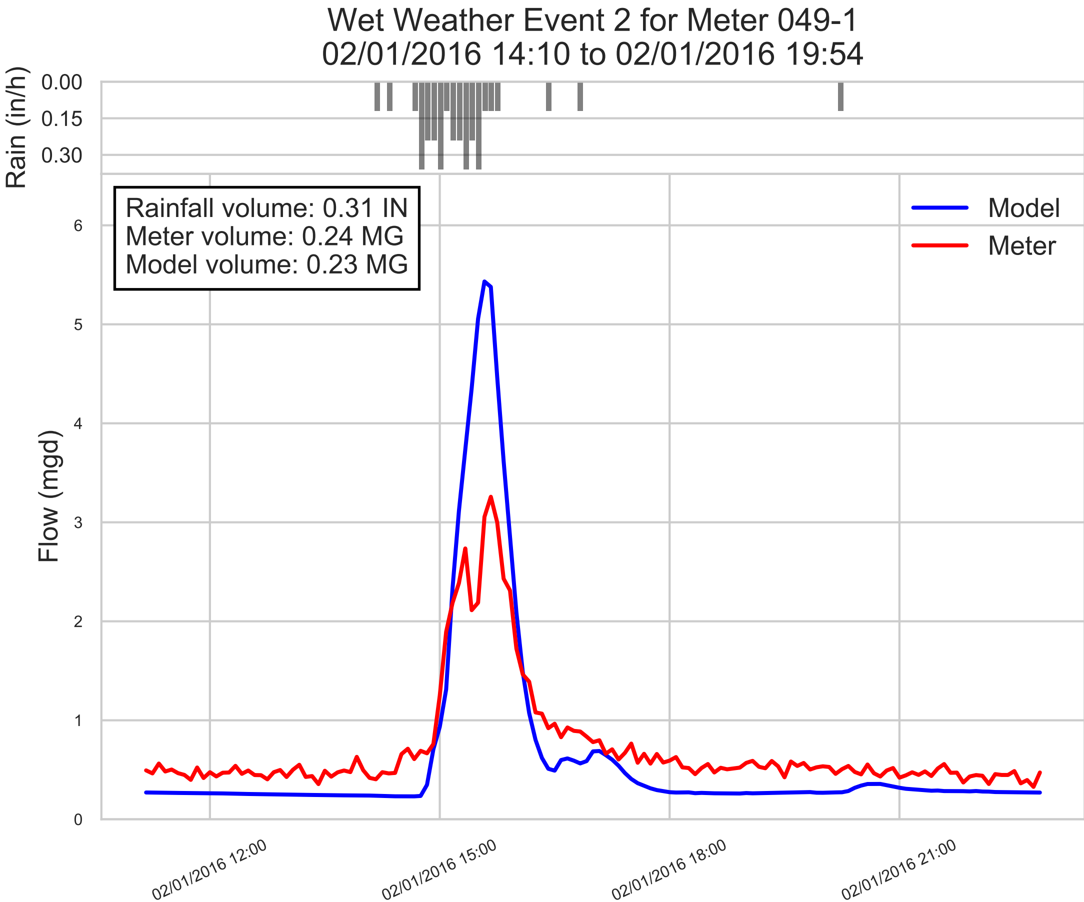
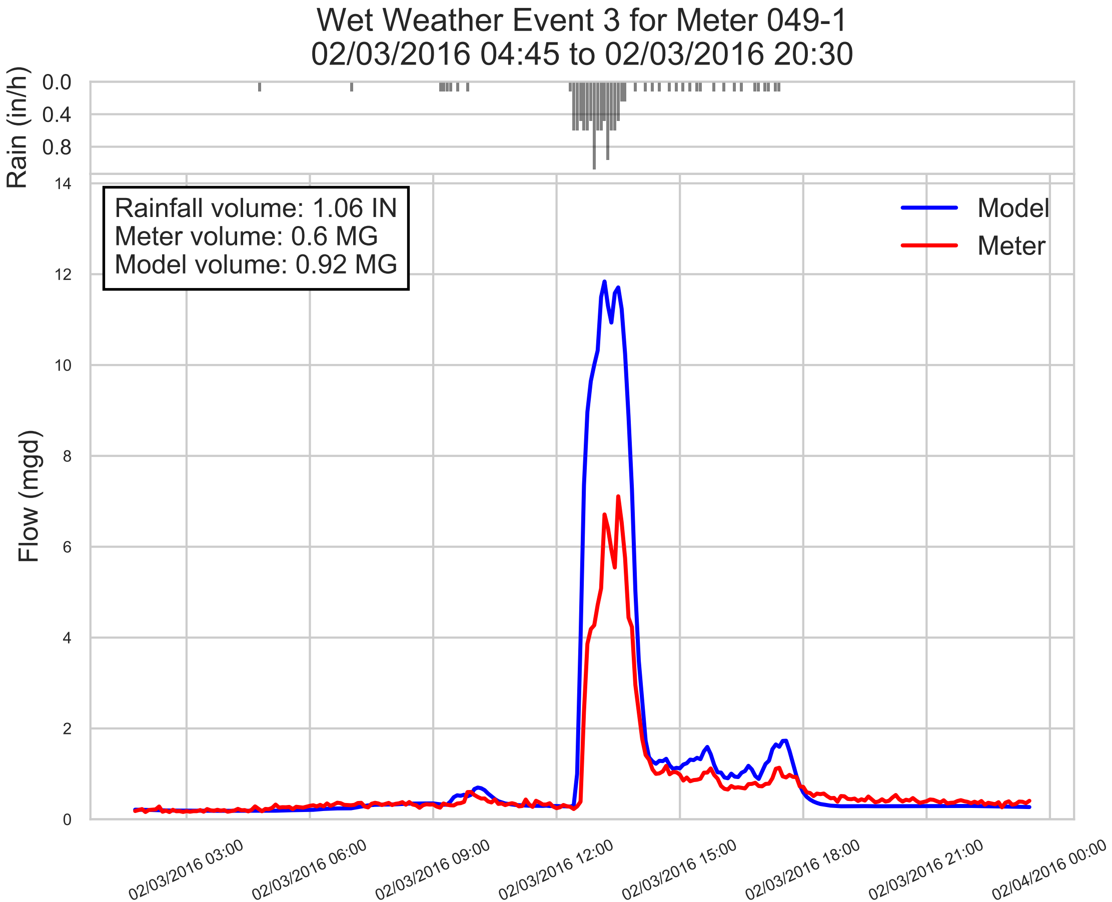


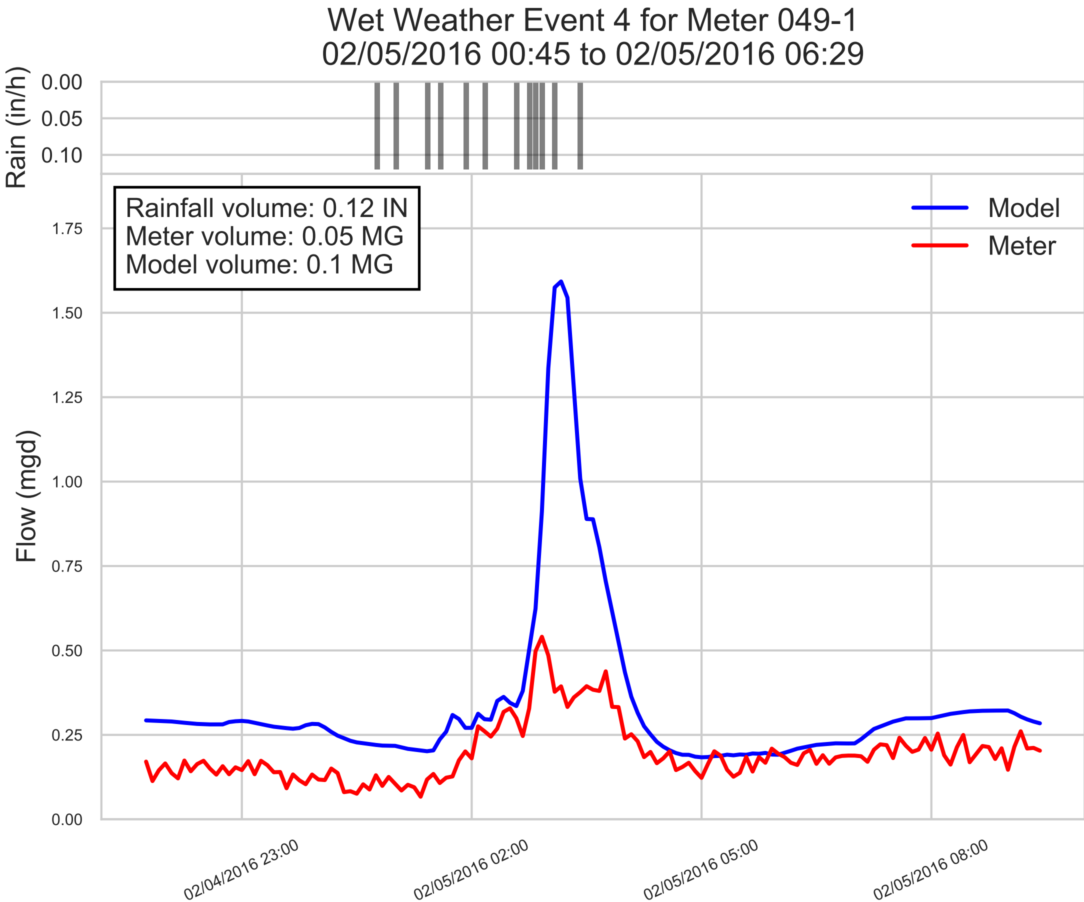
Wet Weather Event 1 for Meter 049-1
01/25/2016 09:20 to 01/25/2016 18:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.39 IN
Meter volume: 0.15 MG
Model volume: 0.33 MG
Model
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
01/25/2016 07:00
01/25/2016 10:00
01/25/2016 13:00
01/25/2016 16:00
01/25/2016 19:00



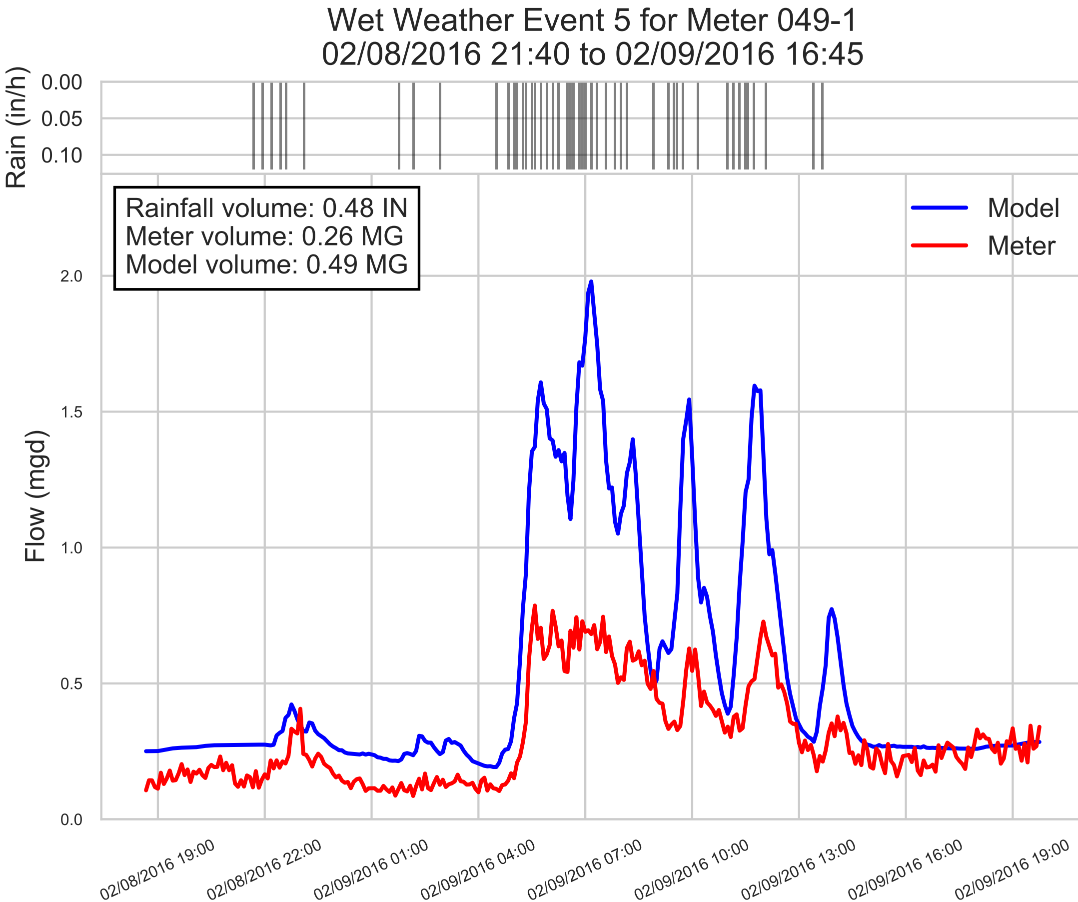
Wet Weather Event 2 for Meter 049-1
02/01/2016 14:10 to 02/01/2016 19:54
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.31 IN
Meter volume: 0.24 MG
Model volume: 0.23 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
02/01/2016 12:00
02/01/2016 15:00
02/01/2016 18:00
02/01/2016 21:00

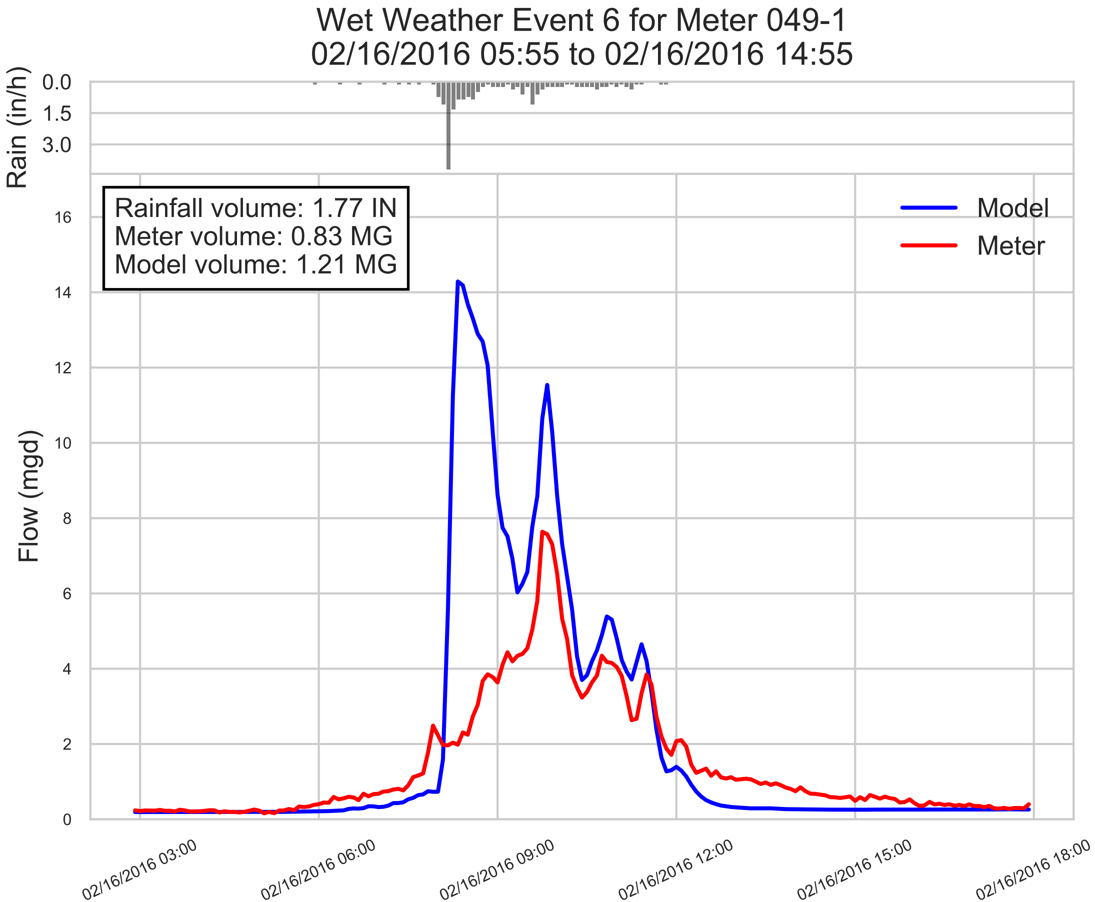


Wet Weather Event 3 for Meter 049-1
02/03/2016 04:45 to 02/03/2016 20:30
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 1.06 IN
Meter volume: 0.6 MG
Model volume: 0.92 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
02/03/2016 03:00
02/03/2016 06:00
02/03/2016 09:00
02/03/2016 12:00
02/03/2016 15:00
02/03/2016 18:00
02/03/2016 21:00
02/04/2016 00:00

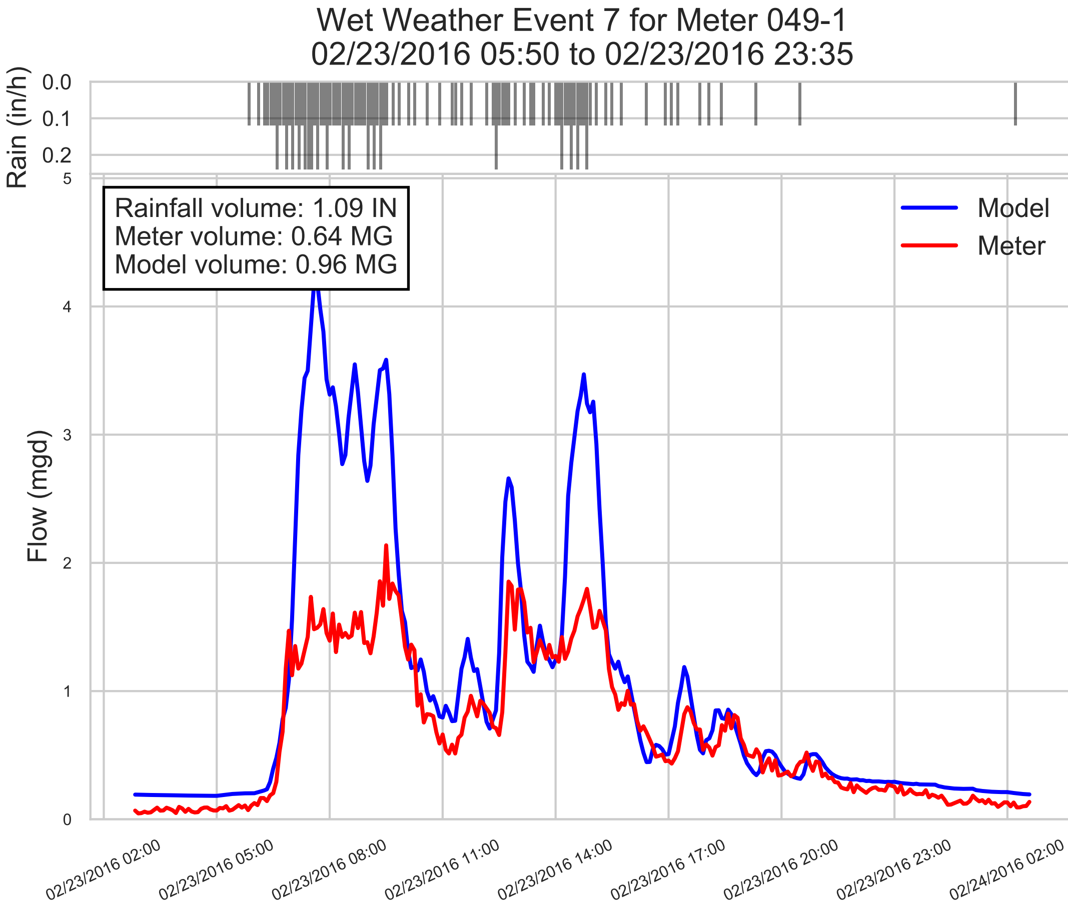


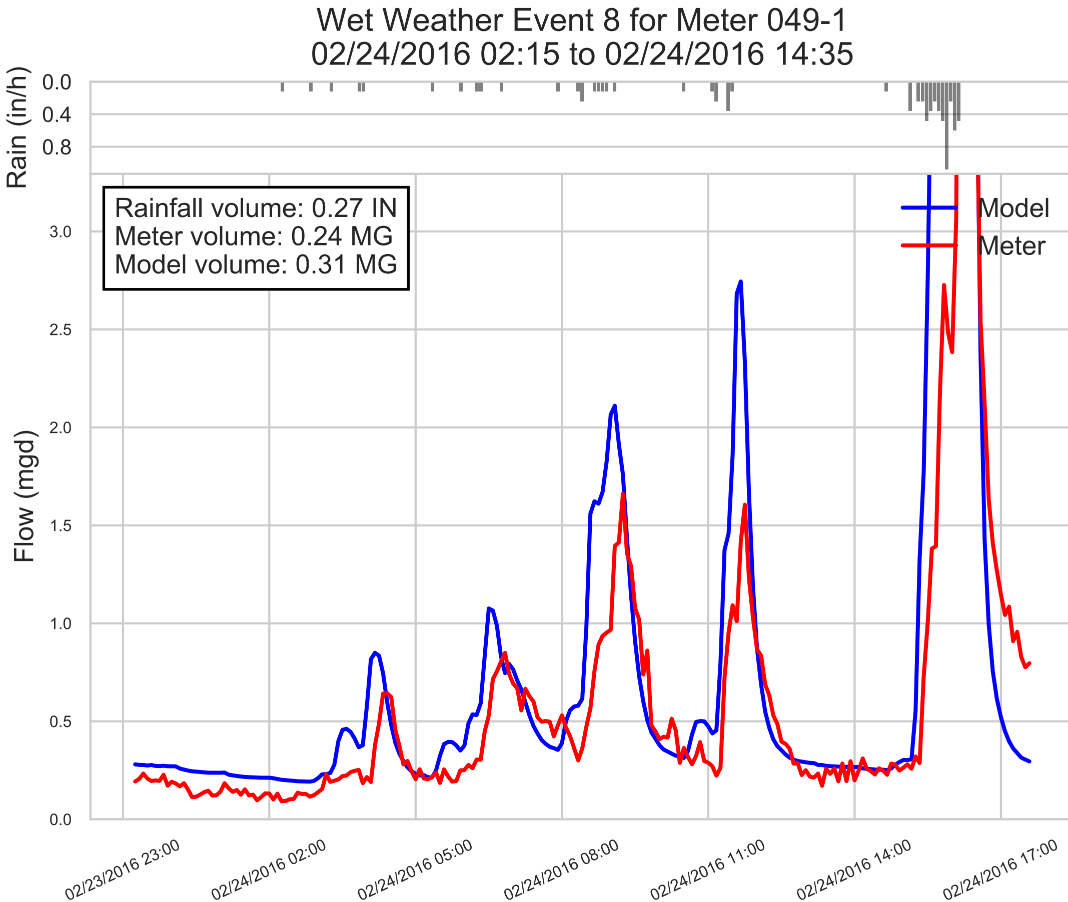
Wet Weather Event 4 for Meter 049-1
02/05/2016 00:45 to 02/05/2016 06:29
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.05 MG
Model volume: 0.1 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
02/04/2016 23:00
02/05/2016 02:00
02/05/2016 05:00
02/05/2016 08:00

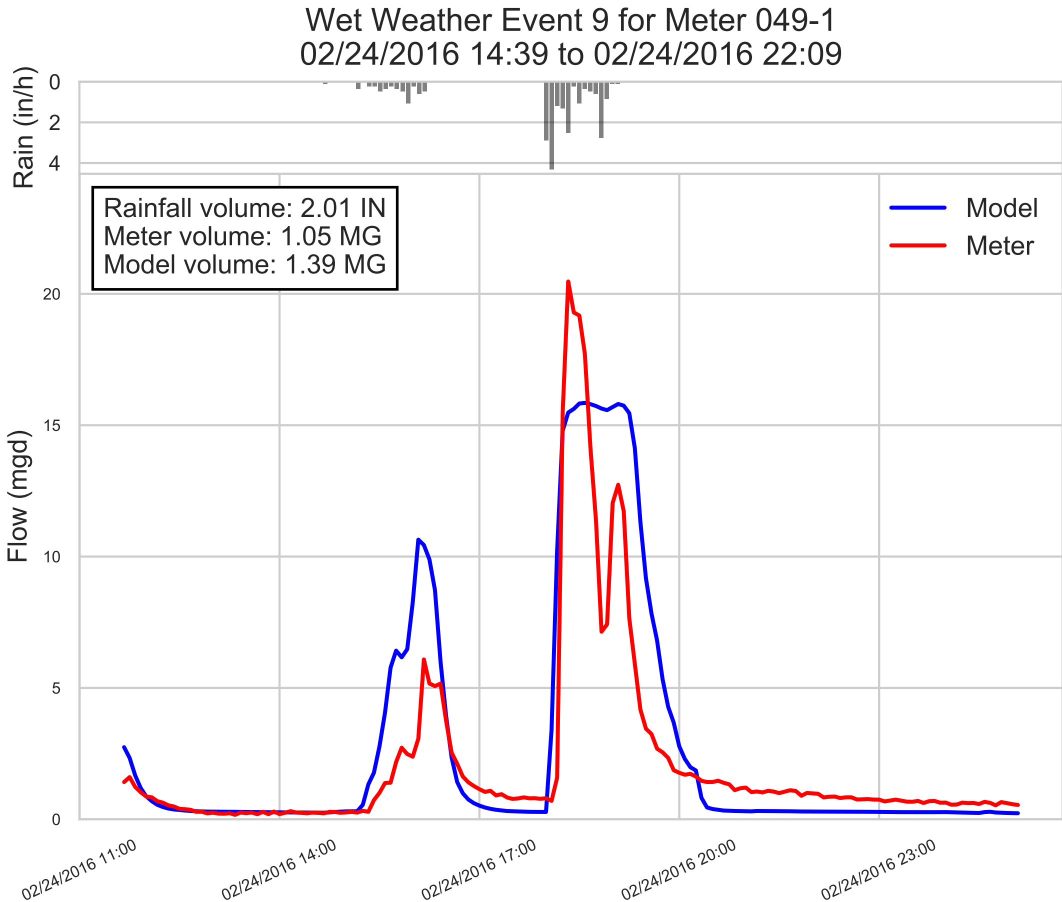

Wet Weather Event 5 for Meter 049-1
02/08/2016 21:40 to 02/09/2016 16:45
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.48 IN
Meter volume: 0.26 MG
Model volume: 0.49 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
02/08/2016 19:00
02/08/2016 22:00
02/09/2016 01:00
02/09/2016 04:00
02/09/2016 07:00
02/09/2016 10:00
02/09/2016 13:00
02/09/2016 16:00
02/09/2016 19:00

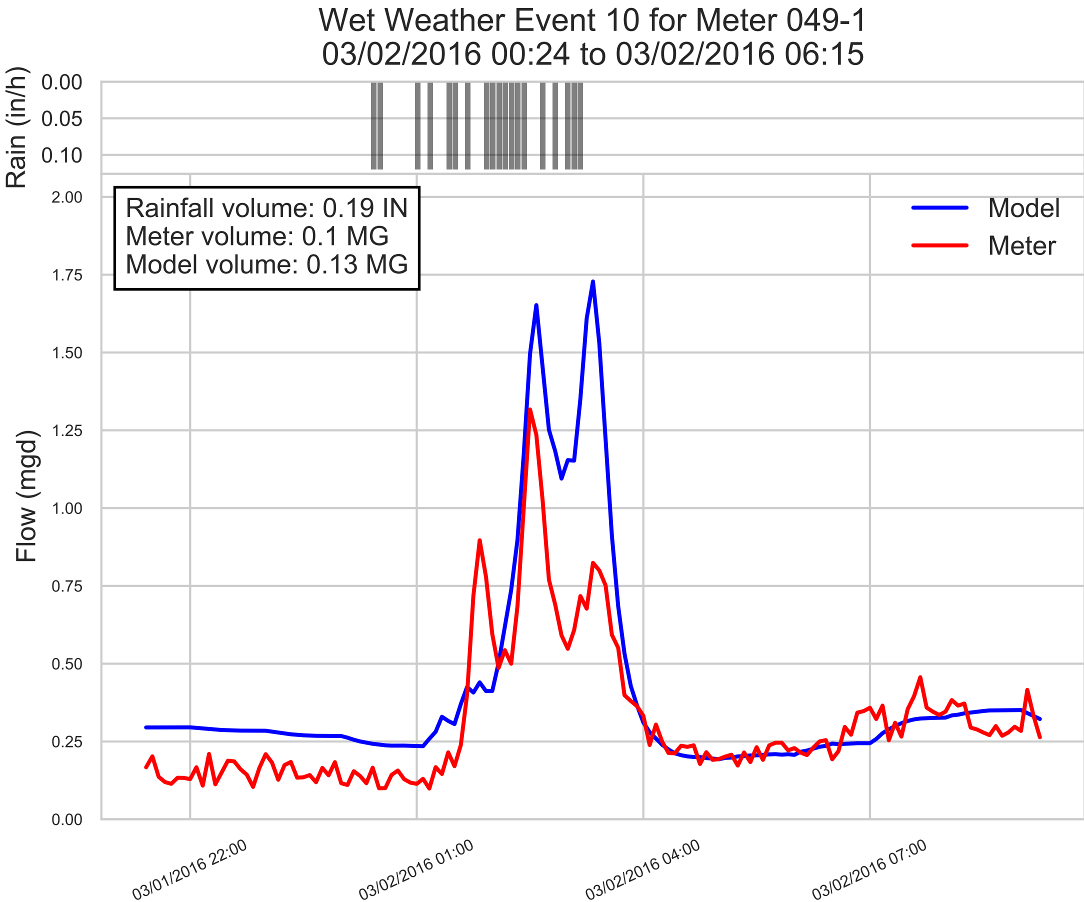


Wet Weather Event 6 for Meter 049-1
02/16/2016 05:55 to 02/16/2016 14:55
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.77 IN
Meter volume: 0.83 MG
Model volume: 1.21 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
14
16
02/16/2016 03:00
02/16/2016 06:00
02/16/2016 09:00
02/16/2016 12:00
02/16/2016 15:00
02/16/2016 18:00

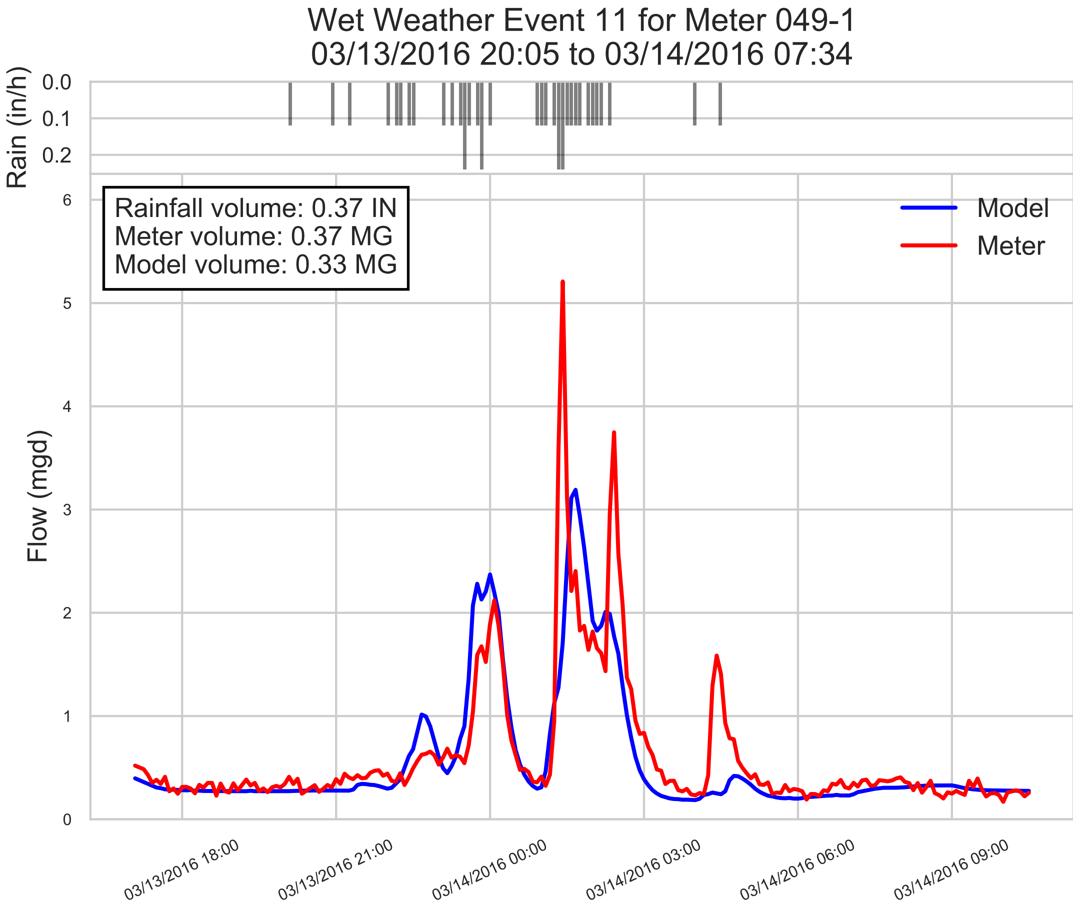

Wet Weather Event 7 for Meter 049-1
02/23/2016 05:50 to 02/23/2016 23:35
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 1.09 IN
Meter volume: 0.64 MG
Model volume: 0.96 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
02/23/2016 02:00
02/23/2016 05:00
02/23/2016 08:00
02/23/2016 11:00
02/23/2016 14:00
02/23/2016 17:00
02/23/2016 20:00
02/23/2016 23:00
02/24/2016 02:00


Wet Weather Event 8 for Meter 049-1
02/24/2016 02:15 to 02/24/2016 14:35
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.27 IN
Meter volume: 0.24 MG
Model volume: 0.31 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
02/23/2016 23:00
02/24/2016 02:00
02/24/2016 05:00
02/24/2016 08:00
02/24/2016 11:00
02/24/2016 14:00
02/24/2016 17:00

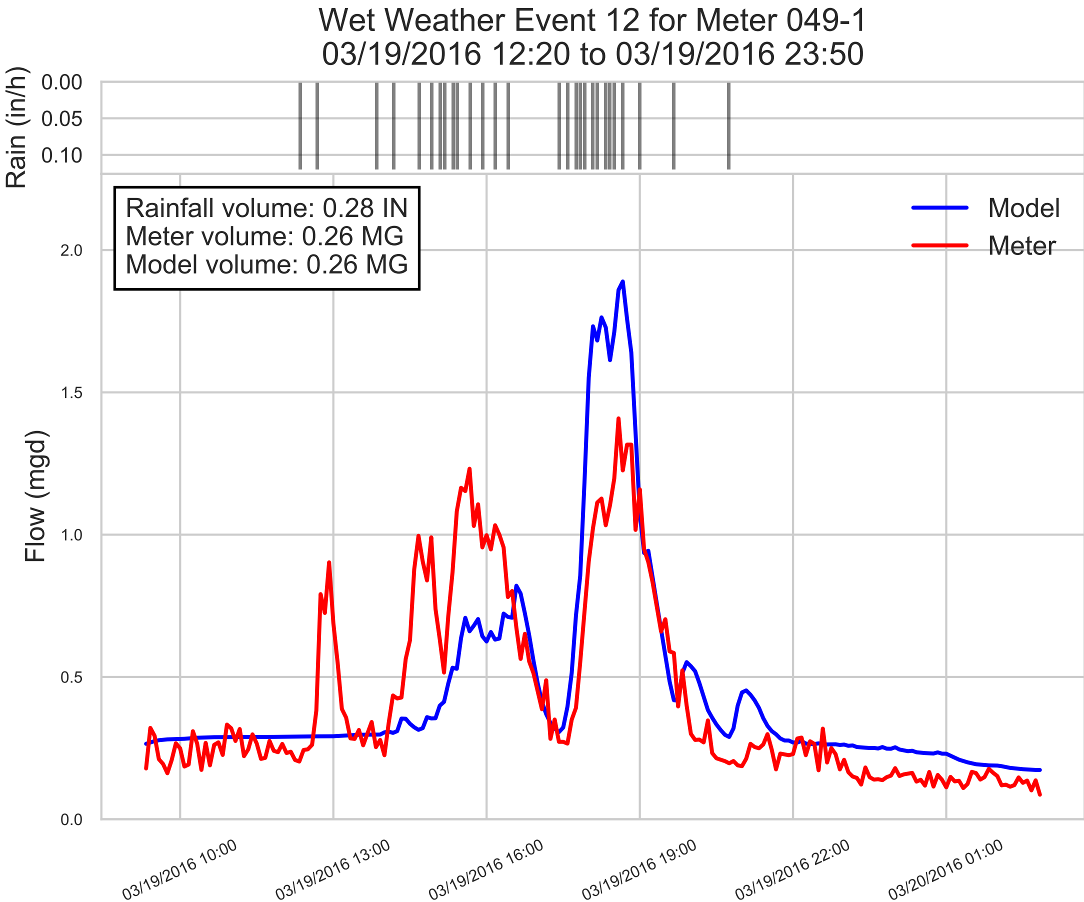

Wet Weather Event 9 for Meter 049-1
02/24/2016 14:39 to 02/24/2016 22:09
Rain (in/h)
0
2
4
Rainfall volume: 2.01 IN
Meter volume: 1.05 MG
Model volume: 1.39 MG
Model
Meter
Flow (mgd)
20
15
10
5
0
02/24/2016 11:00
02/24/2016 14:00
02/24/2016 17:00
02/24/2016 20:00
02/24/2016 23:00



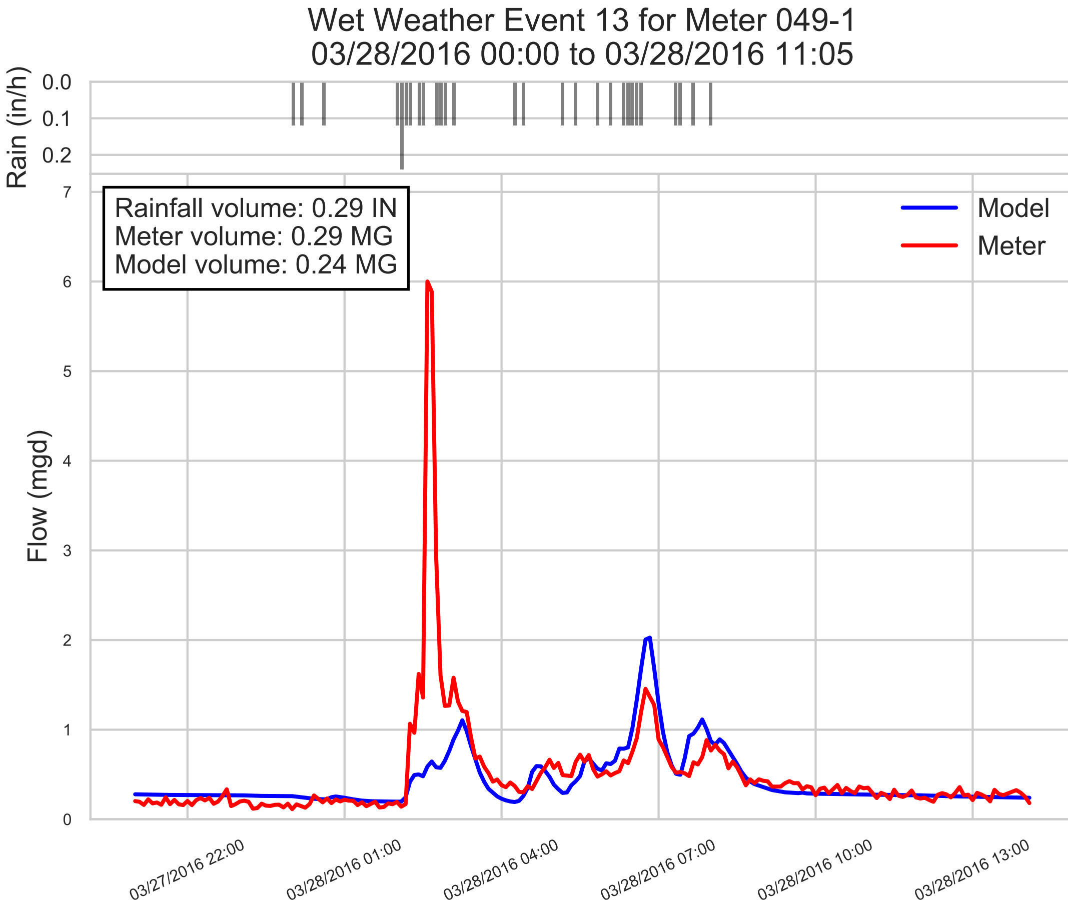
Wet Weather Event 10 for Meter 049-1
03/02/2016 00:24 to 03/02/2016 06:15
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall volume: 0.19 IN
Meter volume: 0.1 MG
Model volume: 0.13 MG
Model
Meter
03/01/2016 22:00
03/02/2016 01:00
03/02/2016 04:00
03/02/2016 07:00



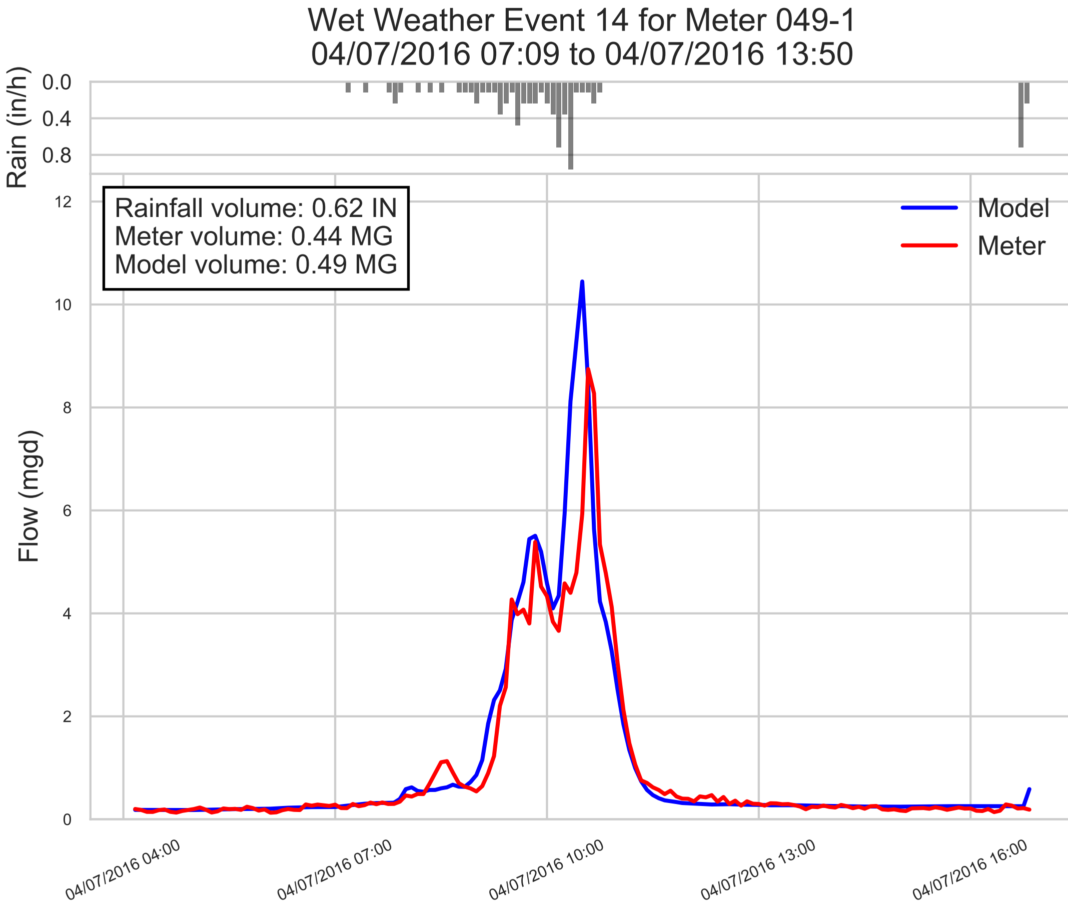
Wet Weather Event 11 for Meter 049-1
03/13/2016 20:05 to 03/14/2016 07:34
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.37 IN
Meter volume: 0.37 MG
Model volume: 0.33 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
03/13/2016 18:00
03/13/2016 21:00
03/14/2016 00:00
03/14/2016 03:00
03/14/2016 06:00
03/14/2016 09:00



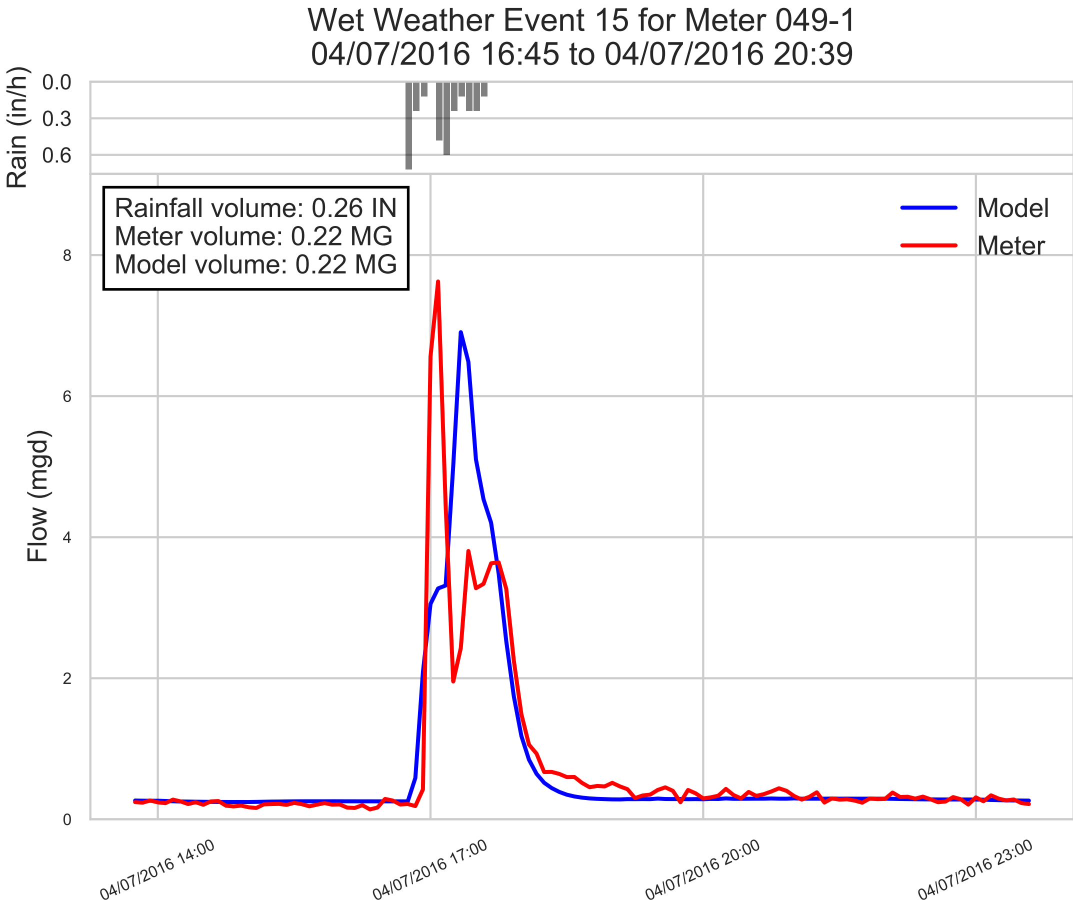
Wet Weather Event 12 for Meter 049-1
03/19/2016 12:20 to 03/19/2016 23:50
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.26 MG
Model volume: 0.26 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
03/19/2016 10:00
03/19/2016 13:00
03/19/2016 16:00
03/19/2016 19:00
03/19/2016 22:00
03/20/2016 01:00



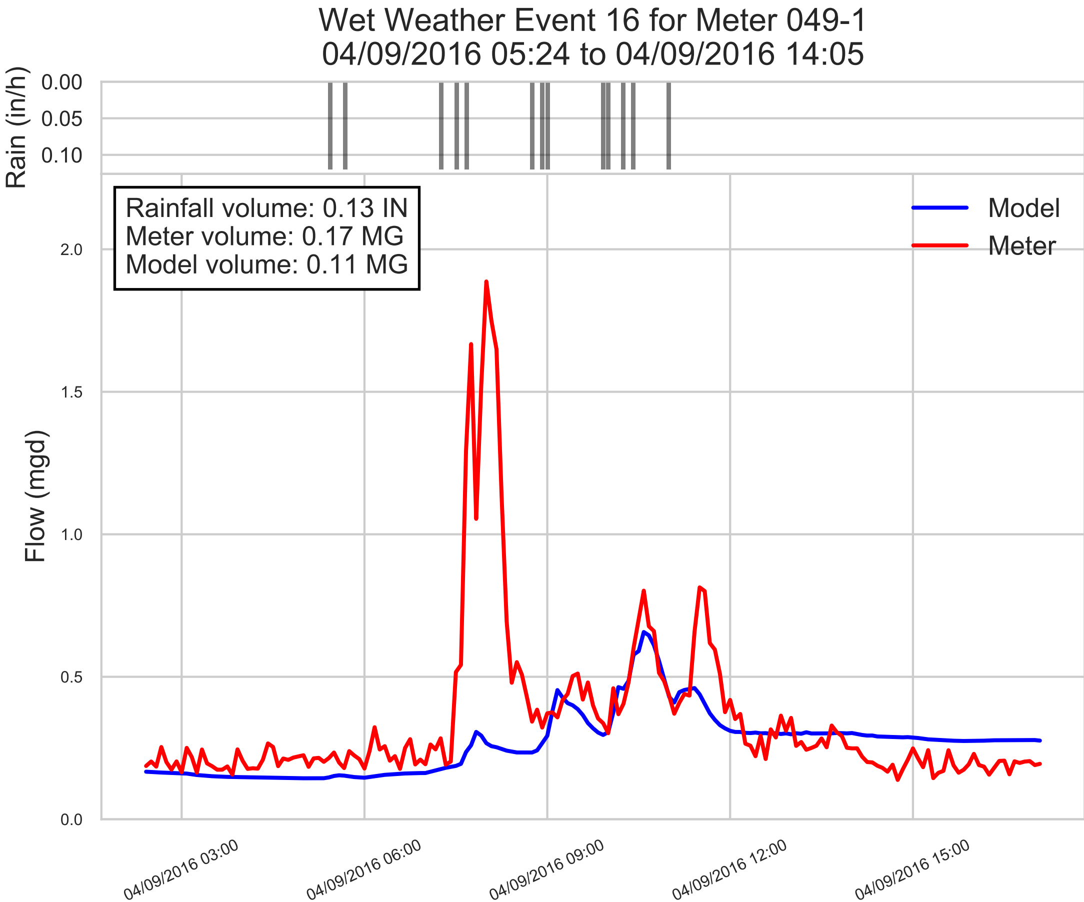
Wet Weather Event 13 for Meter 049-1
03/28/2016 00:00 to 03/28/2016 11:05
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.29 MG
Model volume: 0.24 MG
Model
Meter
Flow (mgd)
7
6
5
4
3
2
1
0
03/27/2016 22:00
03/28/2016 01:00
03/28/2016 04:00
03/28/2016 07:00
03/28/2016 10:00
03/28/2016 13:00



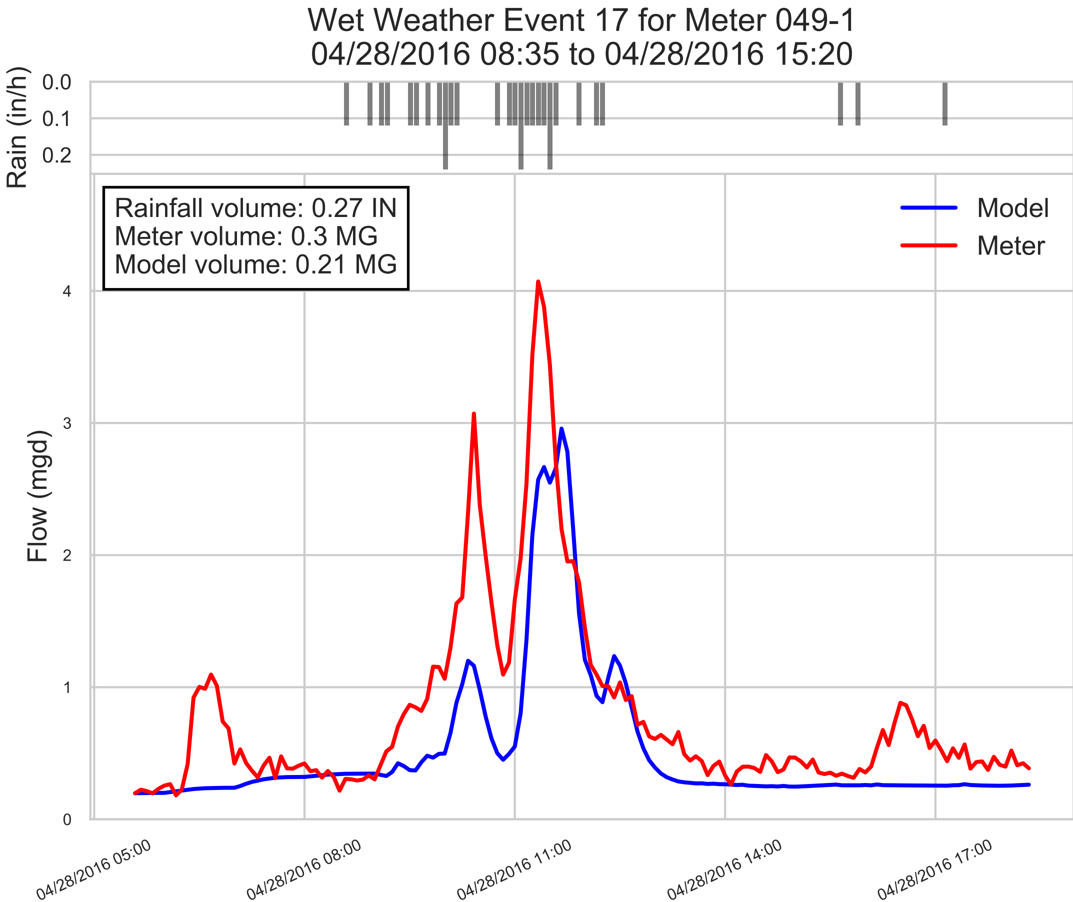
Wet Weather Event 14 for Meter 049-1
04/07/2016 07:09 to 04/07/2016 13:50
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.62 IN
Meter volume: 0.44 MG
Model volume: 0.49 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
04/07/2016 04:00
04/07/2016 07:00
04/07/2016 10:00
04/07/2016 13:00
04/07/2016 16:00

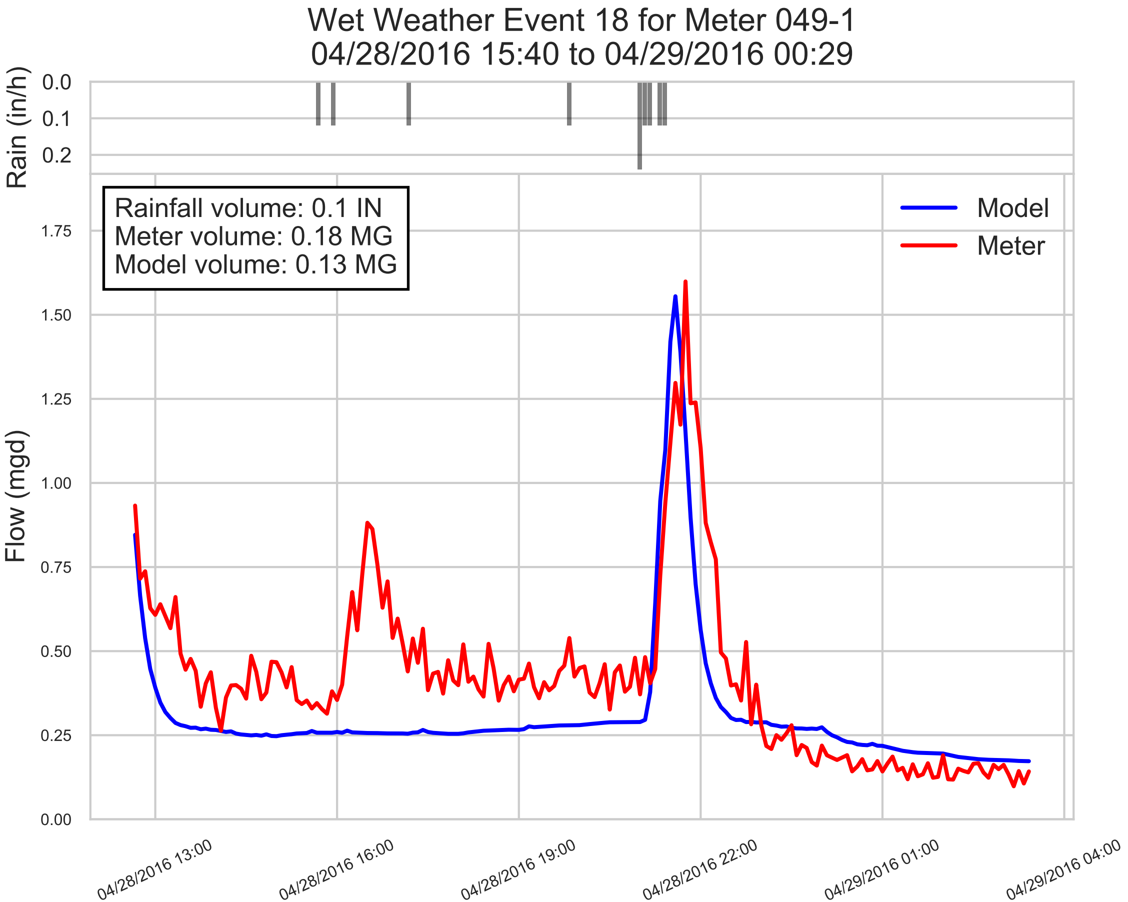


Wet Weather Event 15 for Meter 049-1
04/07/2016 16:45 to 04/07/2016 20:39
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.26 IN
Meter volume: 0.22 MG
Model volume: 0.22 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
04/07/2016 14:00
04/07/2016 17:00
04/07/2016 20:00
04/07/2016 23:00

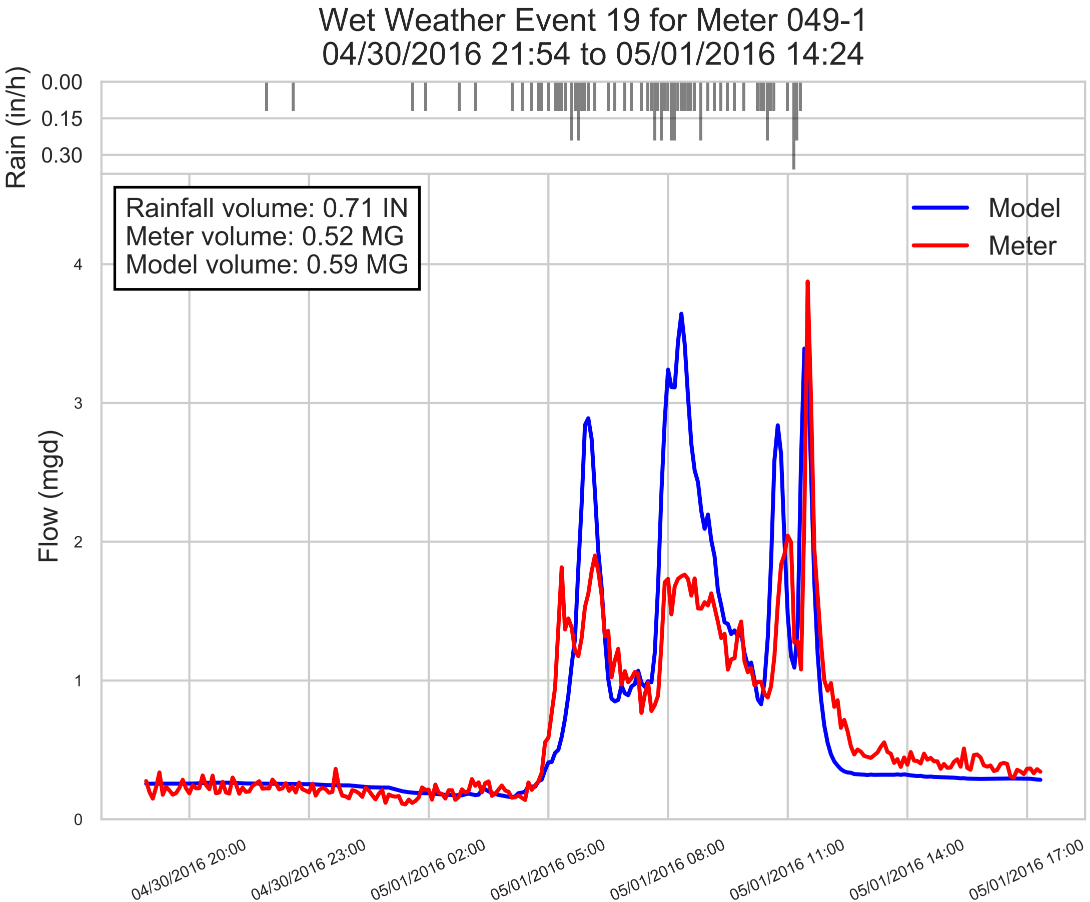


Wet Weather Event 16 for Meter 049-1
04/09/2016 05:24 to 04/09/2016 14:05
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.13 IN
Meter volume: 0.17 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
04/09/2016 03:00
04/09/2016 06:00
04/09/2016 09:00
04/09/2016 12:00
04/09/2016 15:00

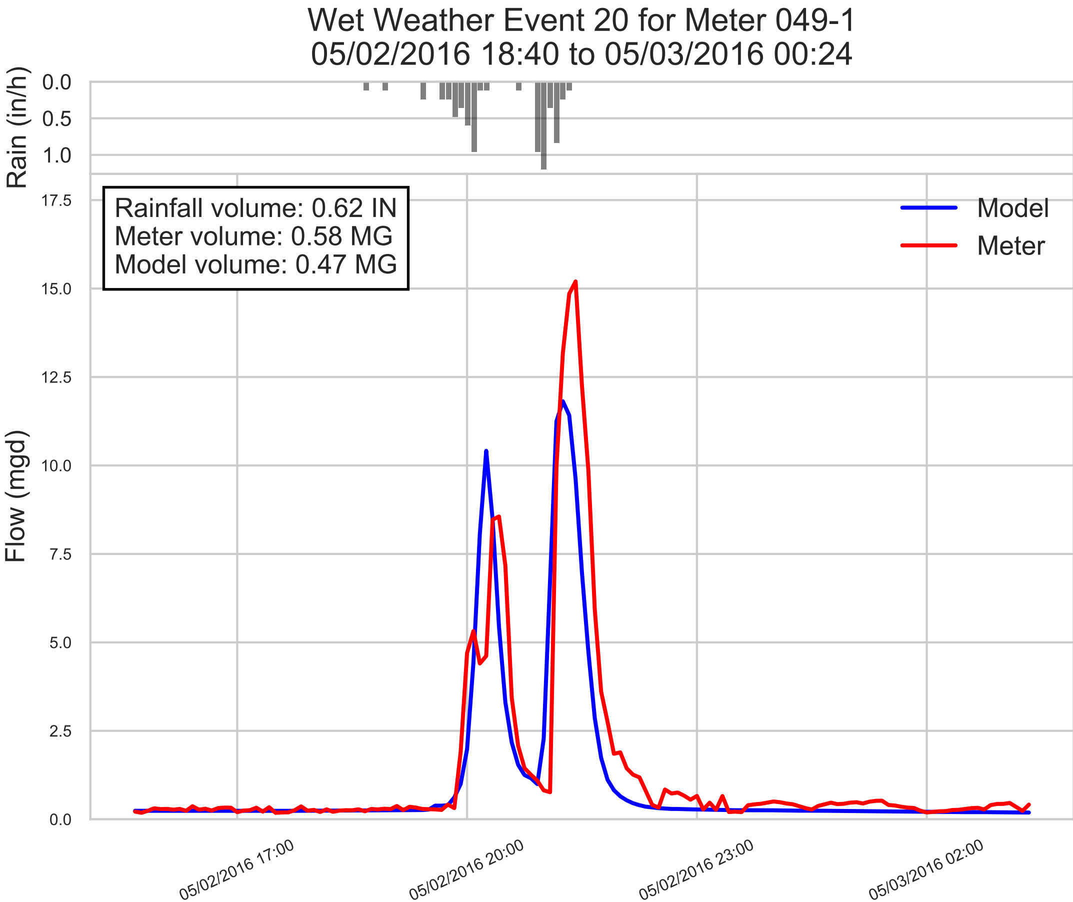

Wet Weather Event 17 for Meter 049-1
04/28/2016 08:35 to 04/28/2016 15:20
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.27 IN
Meter volume: 0.3 MG
Model volume: 0.21 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
04/28/2016 05:00
04/28/2016 08:00
04/28/2016 11:00
04/28/2016 14:00
04/28/2016 17:00



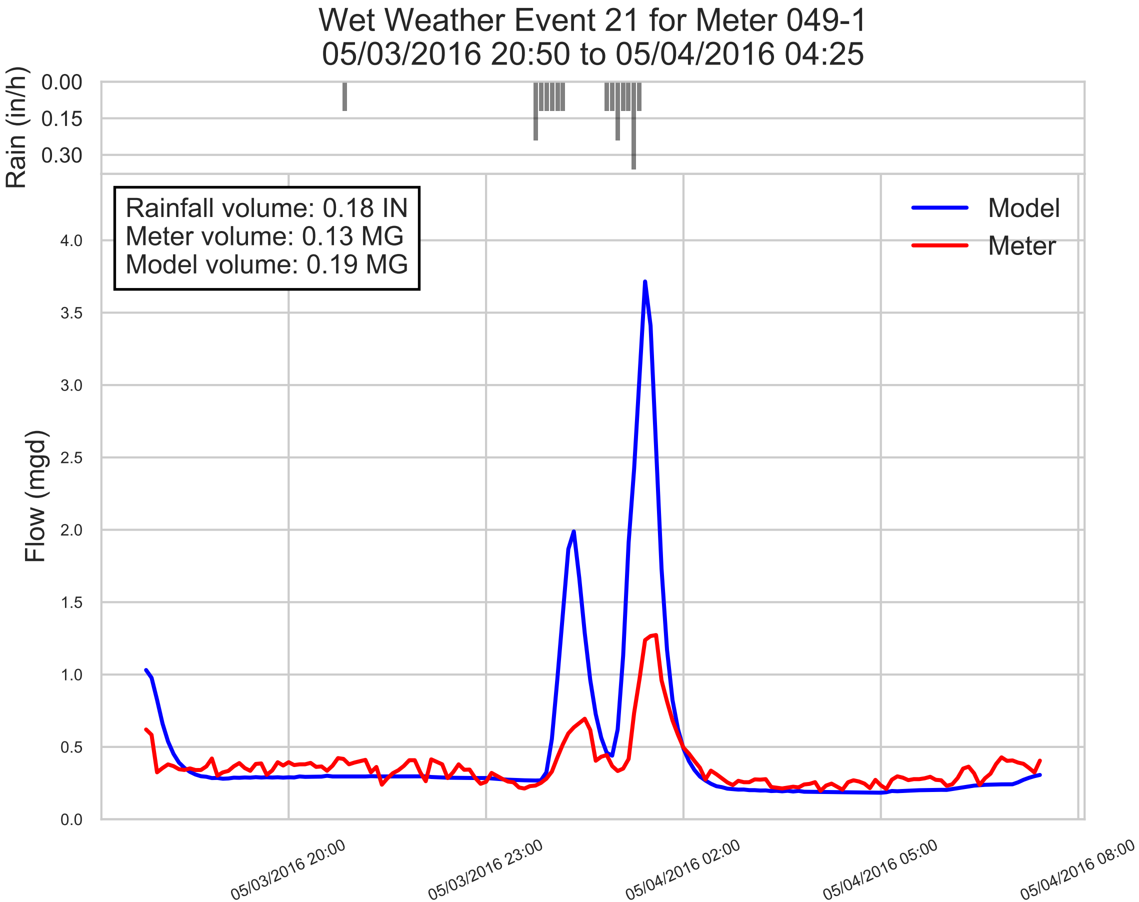
Wet Weather Event 18 for Meter 049-1
04/28/2016 15:40 to 04/29/2016 00:29
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.1 IN
Meter volume: 0.18 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
04/28/2016 13:00
04/28/2016 16:00
04/28/2016 19:00
04/28/2016 22:00
04/29/2016 01:00
04/29/2016 04:00



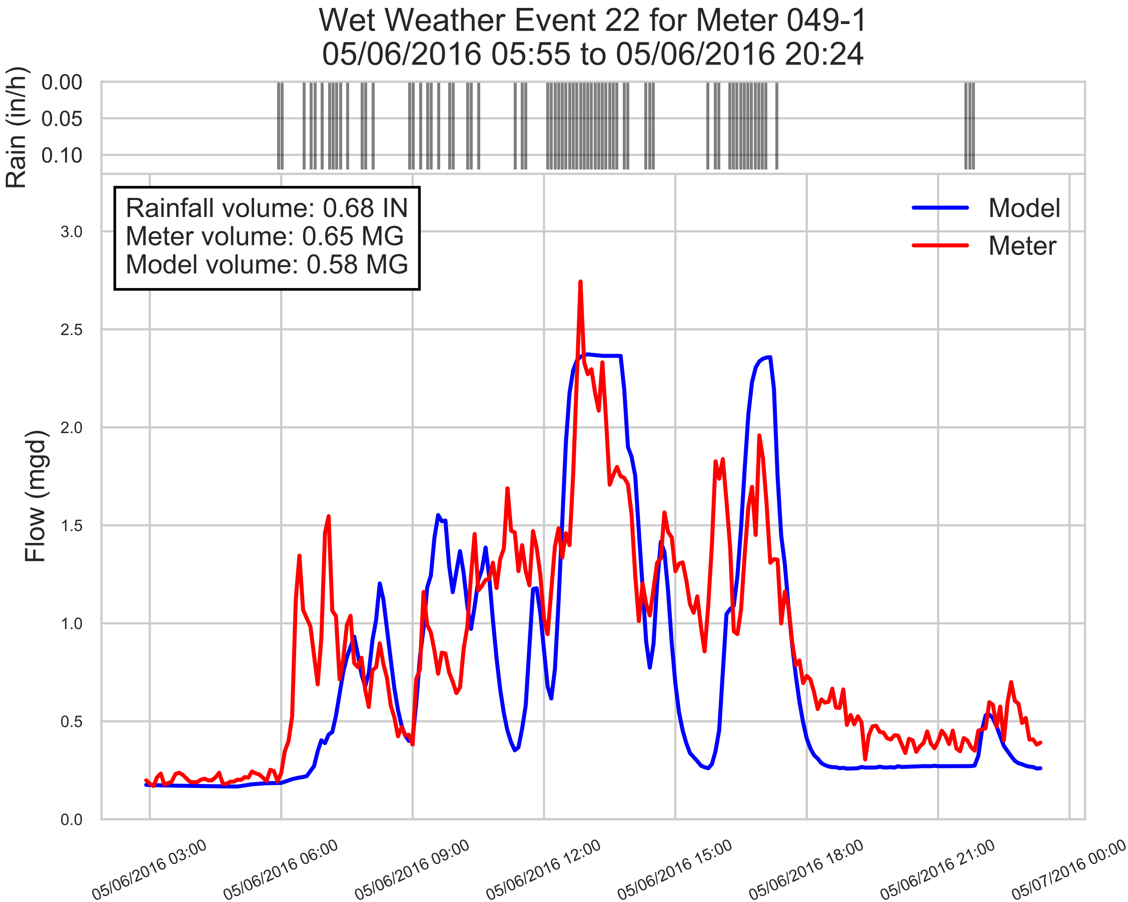
Wet Weather Event 19 for Meter 049-1
04/30/2016 21:54 to 05/01/2016 14:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.71 IN
Meter volume: 0.52 MG
Model volume: 0.59 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
04/30/2016 20:00
04/30/2016 23:00
05/01/2016 02:00
05/01/2016 05:00
05/01/2016 08:00
05/01/2016 11:00
05/01/2016 14:00
05/01/2016 17:00



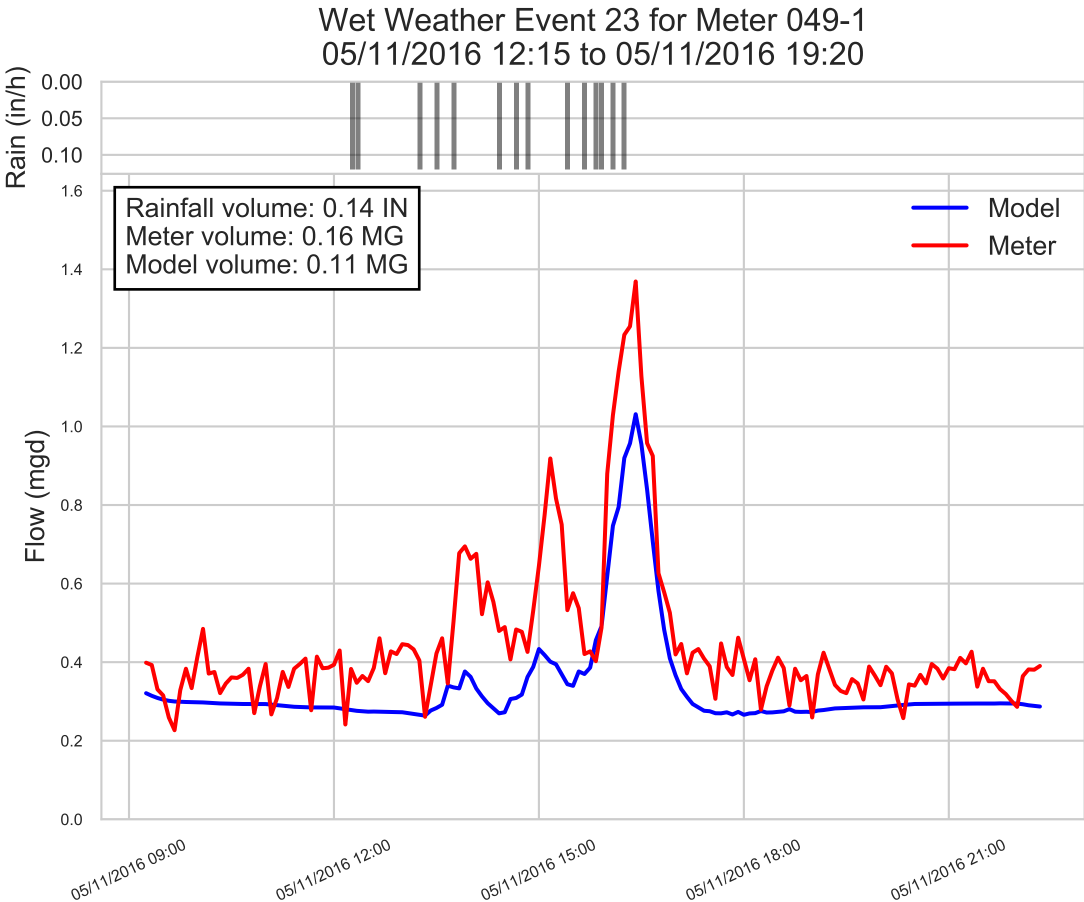
Wet Weather Event 20 for Meter 049-1
05/02/2016 18:40 to 05/03/2016 00:24
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.62 IN
Meter volume: 0.58 MG
Model volume: 0.47 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
05/02/2016 17:00
05/02/2016 20:00
05/02/2016 23:00
05/03/2016 02:00



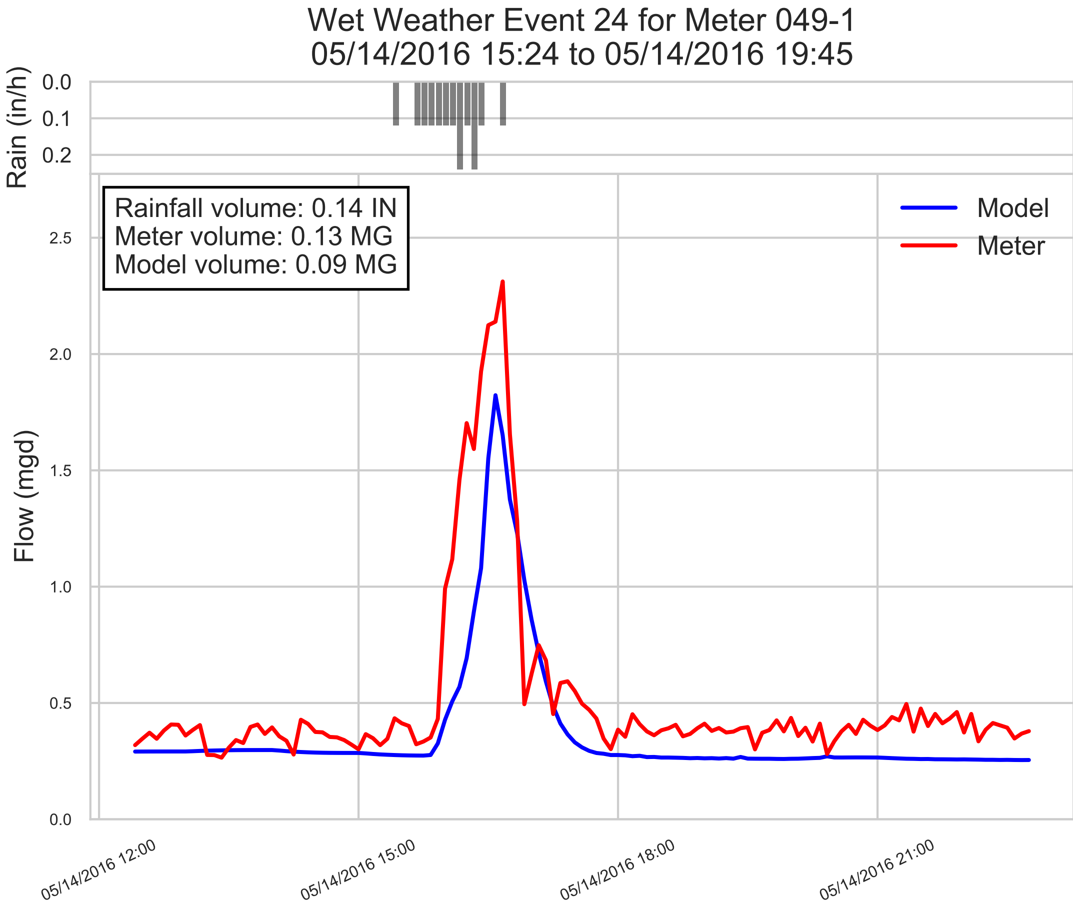
Wet Weather Event 21 for Meter 049-1
05/03/2016 20:50 to 05/04/2016 04:25
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.18 IN
Meter volume: 0.13 MG
Model volume: 0.19 MG
Model
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
05/03/2016 20:00
05/03/2016 23:00
05/04/2016 02:00
05/04/2016 05:00
05/04/2016 08:00



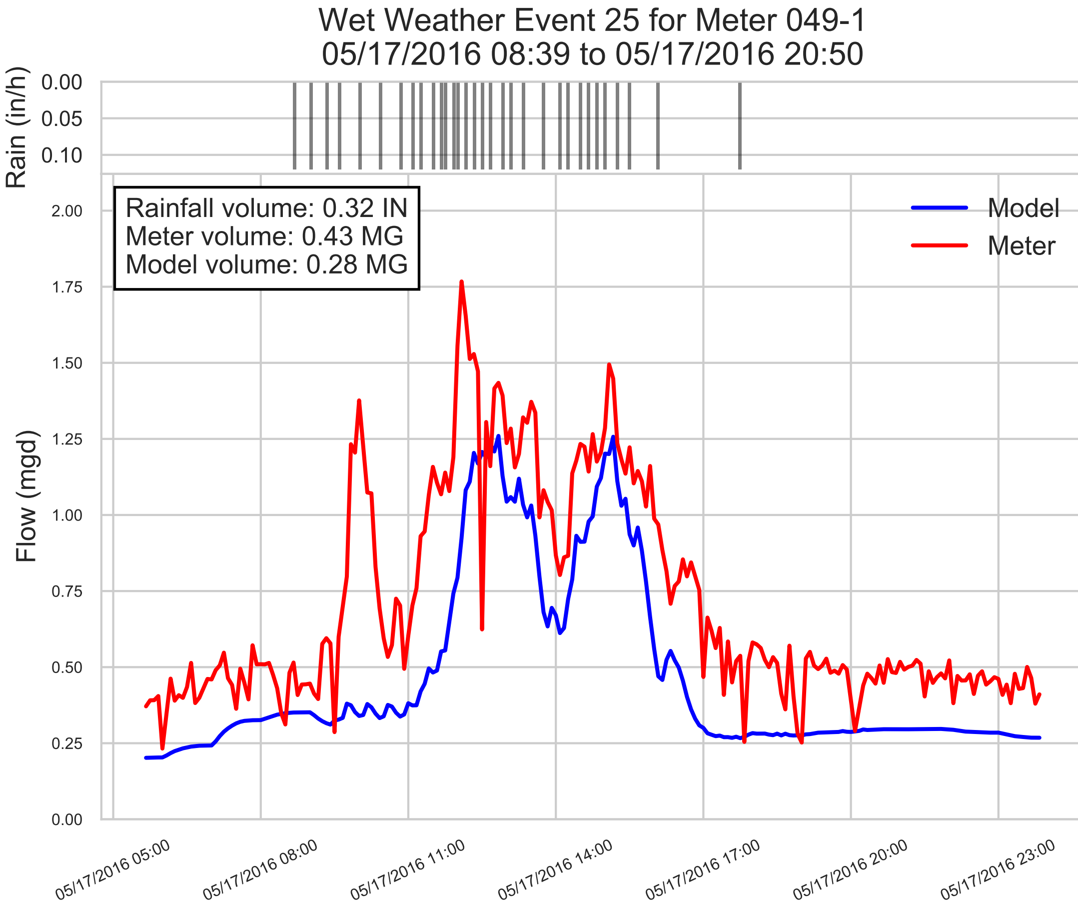
Wet Weather Event 22 for Meter 049-1
05/06/2016 05:55 to 05/06/2016 20:24
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.68 IN
Meter volume: 0.65 MG
Model volume: 0.58 MG
Model
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
05/06/2016 03:00
05/06/2016 06:00
05/06/2016 09:00
05/06/2016 12:00
05/06/2016 15:00
05/06/2016 18:00
05/06/2016 21:00
05/07/2016 00:00



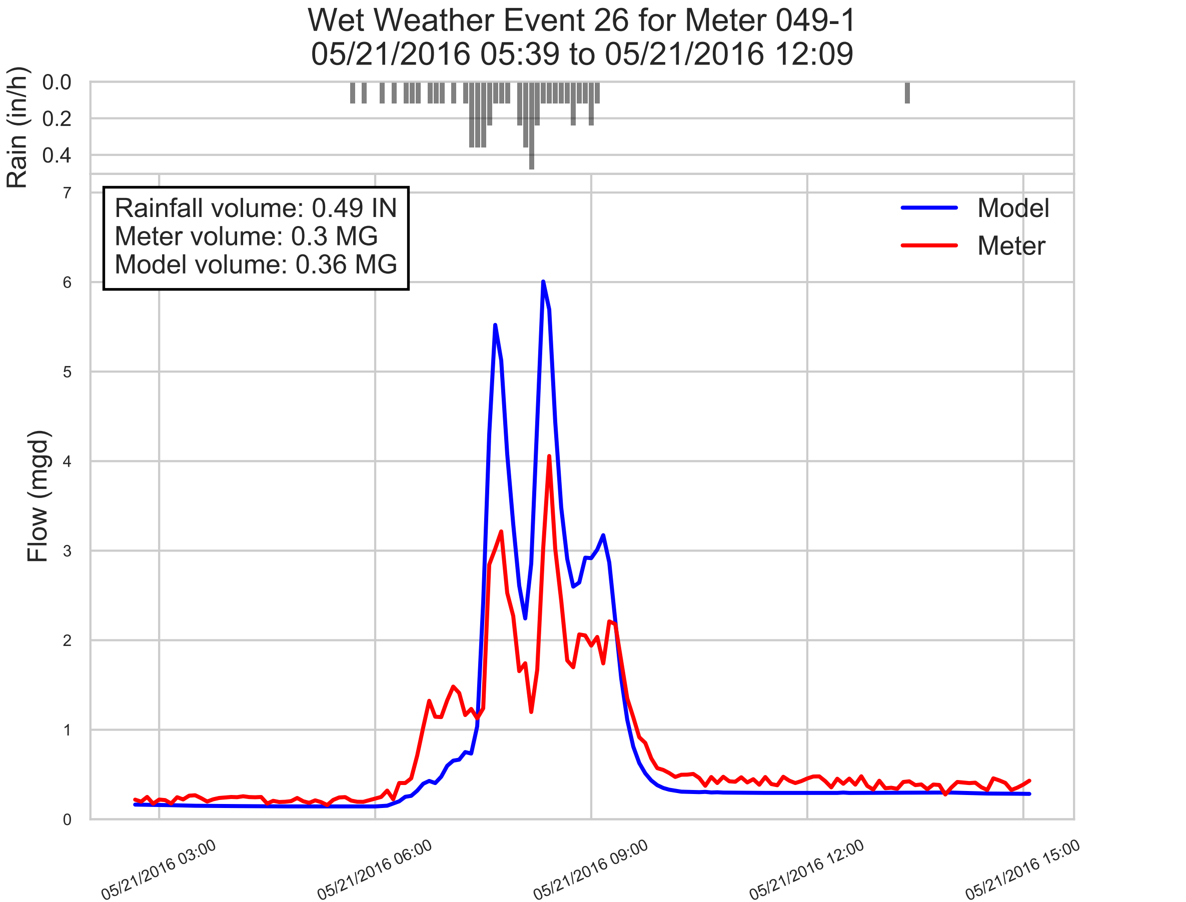
Wet Weather Event 23 for Meter 049-1
05/11/2016 12:15 to 05/11/2016 19:20
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.14 IN
Meter volume: 0.16 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
05/11/2016 09:00
05/11/2016 12:00
05/11/2016 15:00
05/11/2016 18:00
05/11/2016 21:00



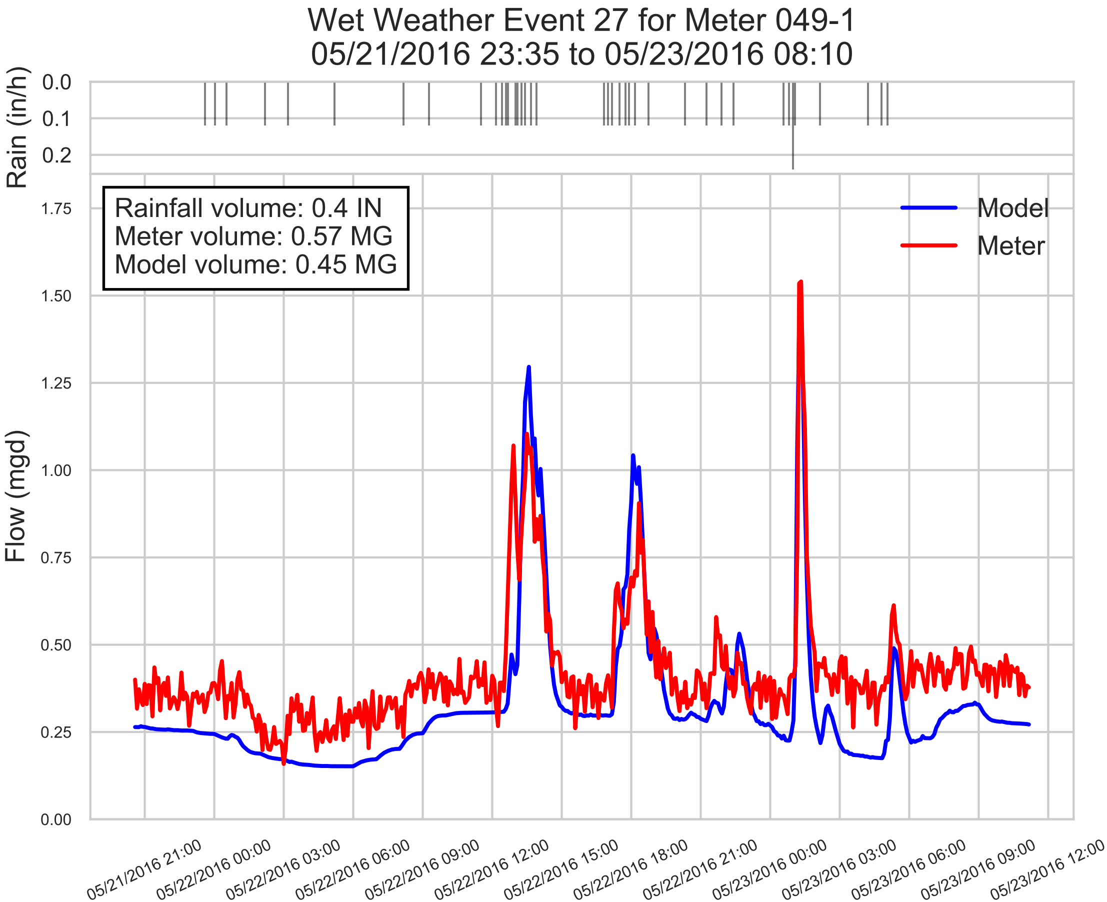
Wet Weather Event 24 for Meter 049-1
05/14/2016 15:24 to 05/14/2016 19:45
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.14 IN
Meter volume: 0.13 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
05/14/2016 12:00
05/14/2016 15:00
05/14/2016 18:00
05/14/2016 21:00



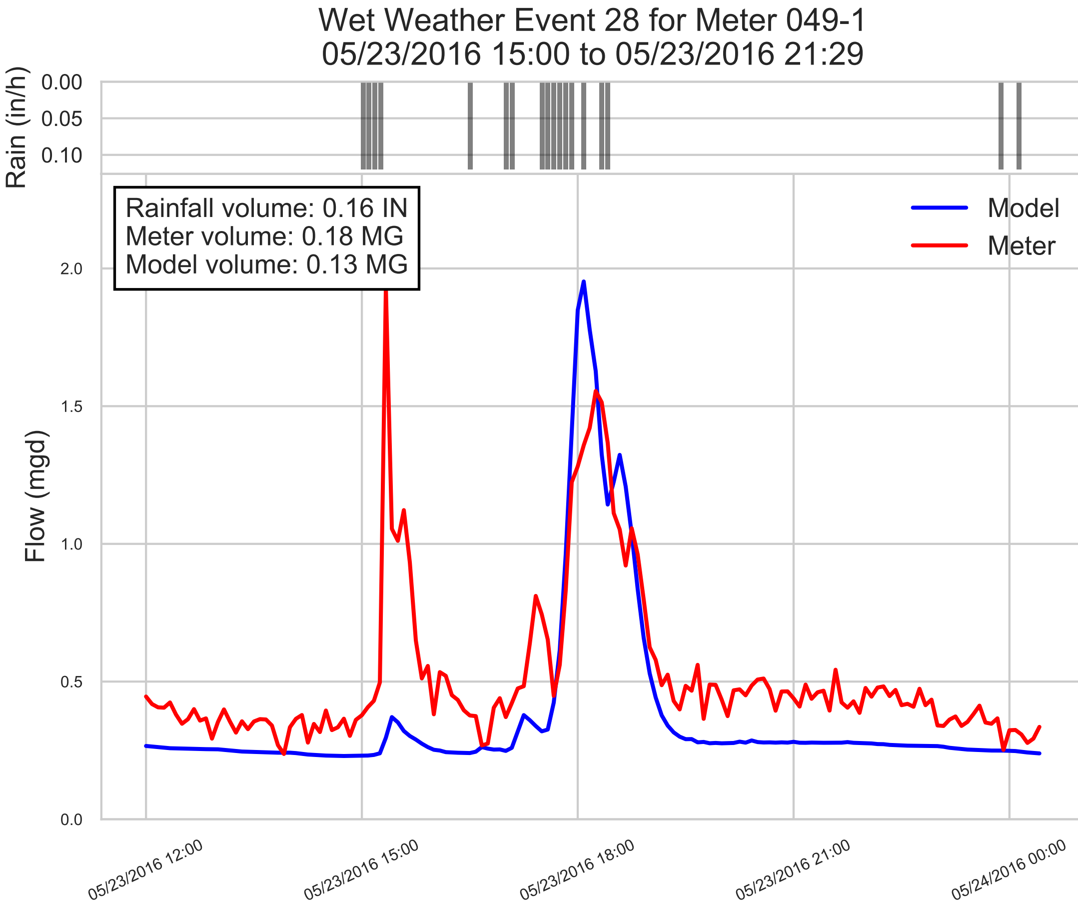
Wet Weather Event 25 for Meter 049-1
05/17/2016 08:39 to 05/17/2016 20:50
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.32 IN
Meter volume: 0.43 MG
Model volume: 0.28 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
05/17/2016 05:00
05/17/2016 08:00
05/17/2016 11:00
05/17/2016 14:00
05/17/2016 17:00
05/17/2016 20:00
05/17/2016 23:00

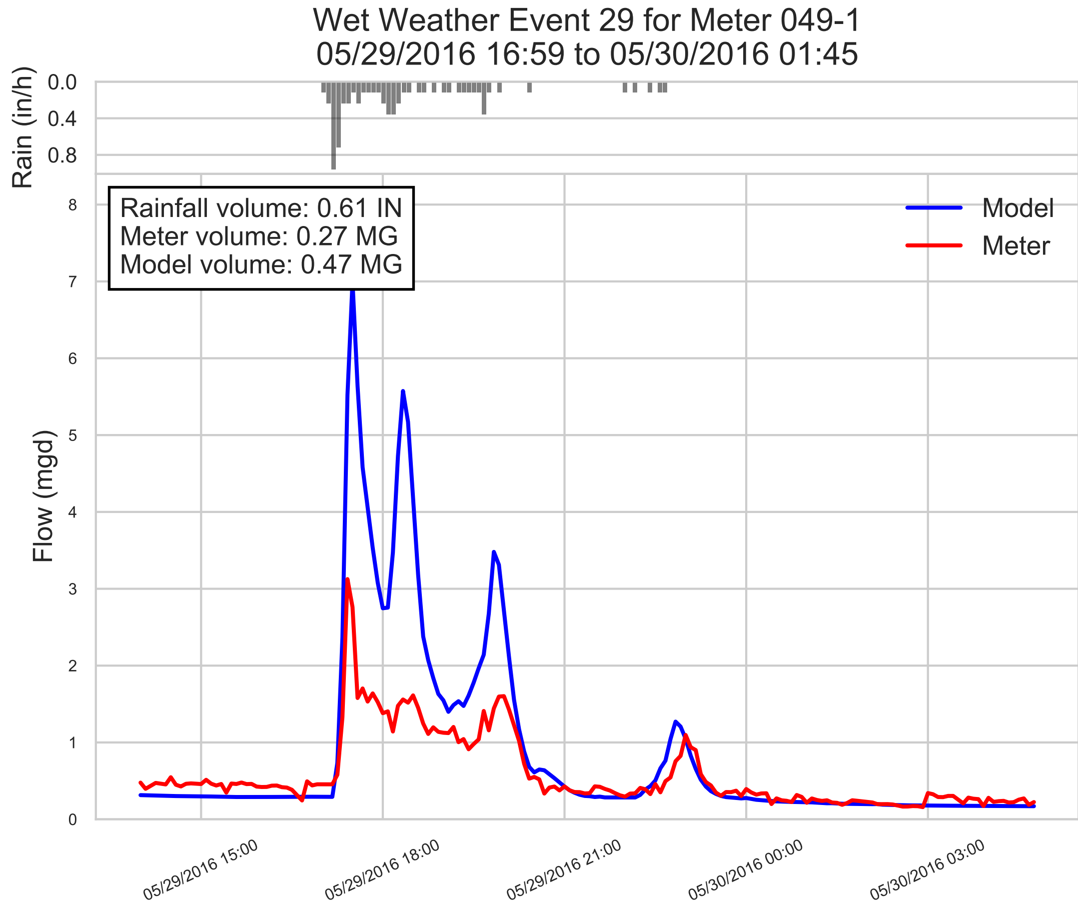


Wet Weather Event 26 for Meter 049-1
05/21/2016 05:39 to 05/21/2016 12:09
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.49 IN
Meter volume: 0.3 MG
Model volume: 0.36 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
05/21/2016 03:00
05/21/2016 06:00
05/21/2016 09:00
05/21/2016 12:00
05/21/2016 15:00

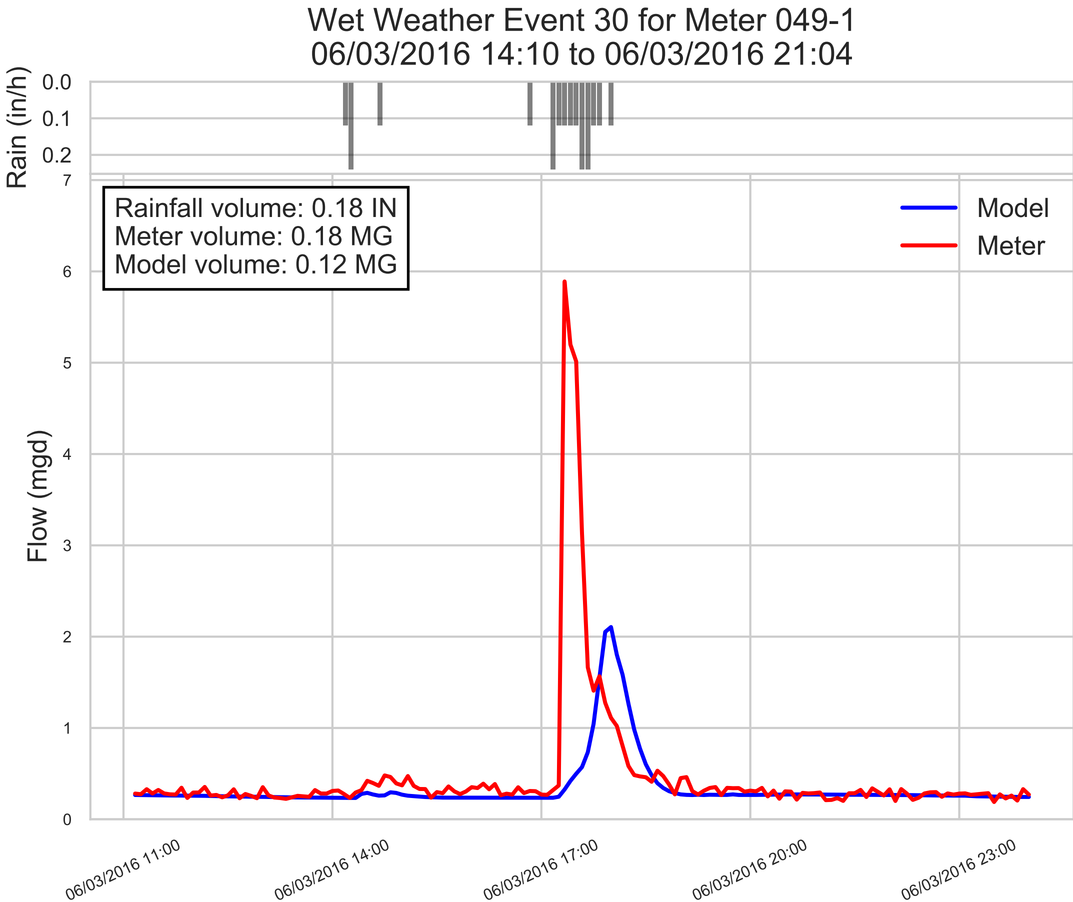


Wet Weather Event 27 for Meter 049-1
05/21/2016 23:35 to 05/23/2016 08:10
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.4 IN
Meter volume: 0.57 MG
Model volume: 0.45 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
05/21/2016 21:00
05/22/2016 00:00
05/22/2016 03:00
05/22/2016 06:00
05/22/2016 09:00
05/22/2016 12:00
05/22/2016 15:00
05/22/2016 18:00
05/22/2016 21:00
05/23/2016 00:00
05/23/2016 03:00
05/23/2016 06:00
05/23/2016 09:00
05/23/2016 12:00

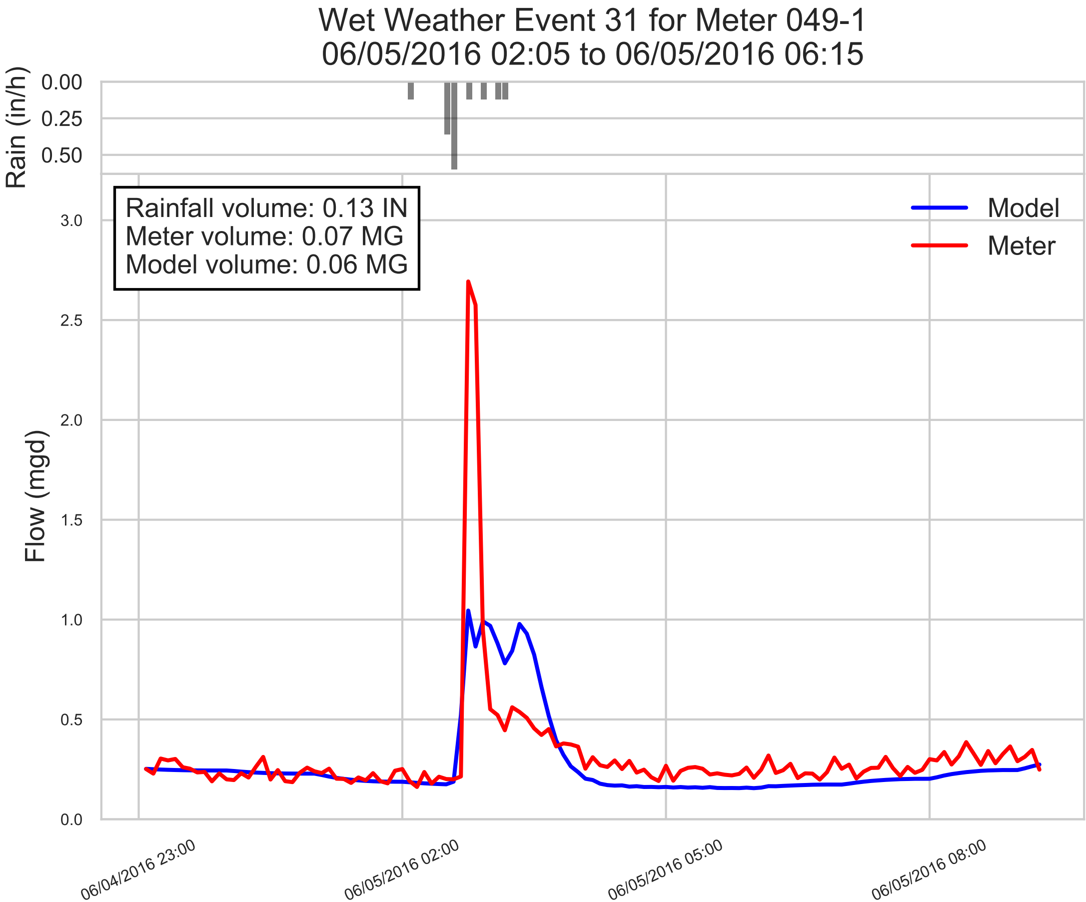

Wet Weather Event 28 for Meter 049-1
05/23/2016 15:00 to 05/23/2016 21:29
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.16 IN
Meter volume: 0.18 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
05/23/2016 12:00
05/23/2016 15:00
05/23/2016 18:00
05/23/2016 21:00
05/24/2016 00:00



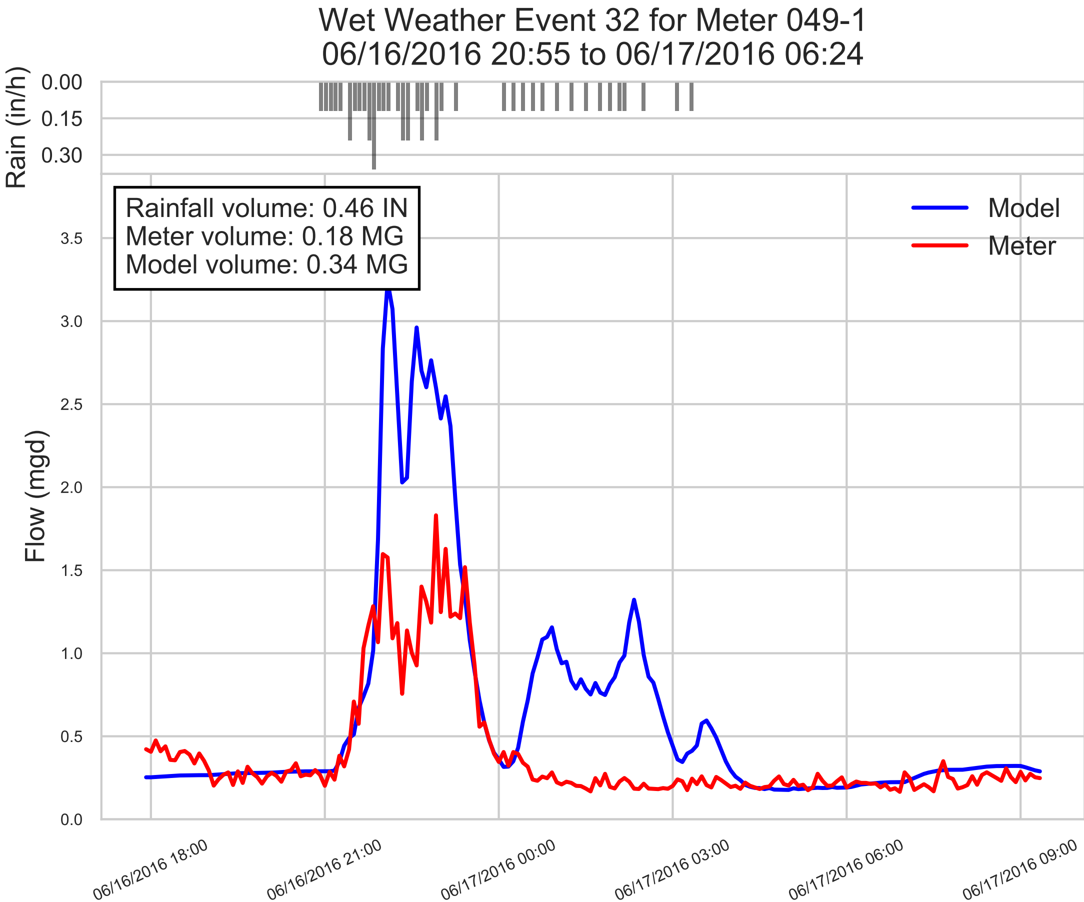
Wet Weather Event 29 for Meter 049-1
05/29/2016 16:59 to 05/30/2016 01:45
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.61 IN
Meter volume: 0.27 MG
Model volume: 0.47 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
05/29/2016 15:00
05/29/2016 18:00
05/29/2016 21:00
05/30/2016 00:00
05/30/2016 03:00



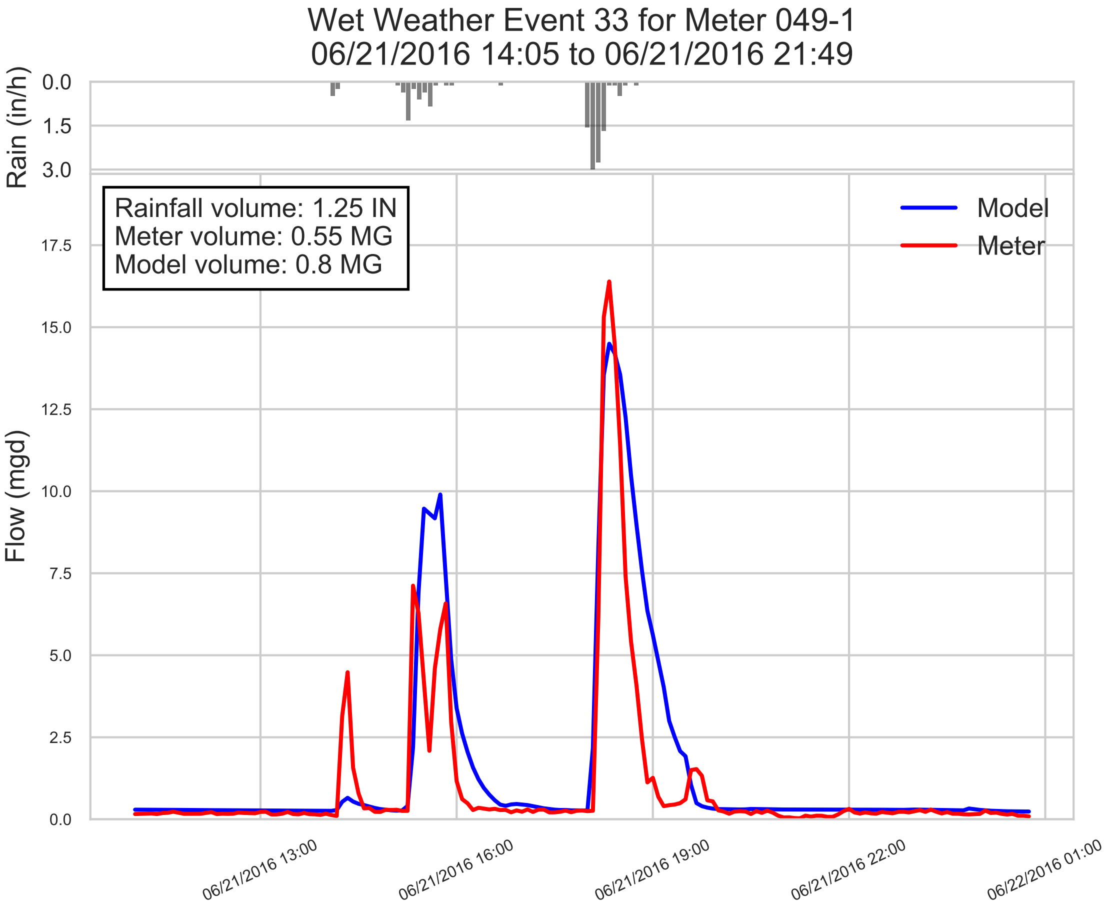
Wet Weather Event 30 for Meter 049-1
06/03/2016 14:10 to 06/03/2016 21:04
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.18 IN
Meter volume: 0.18 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
06/03/2016 11:00
06/03/2016 14:00
06/03/2016 17:00
06/03/2016 20:00
06/03/2016 23:00



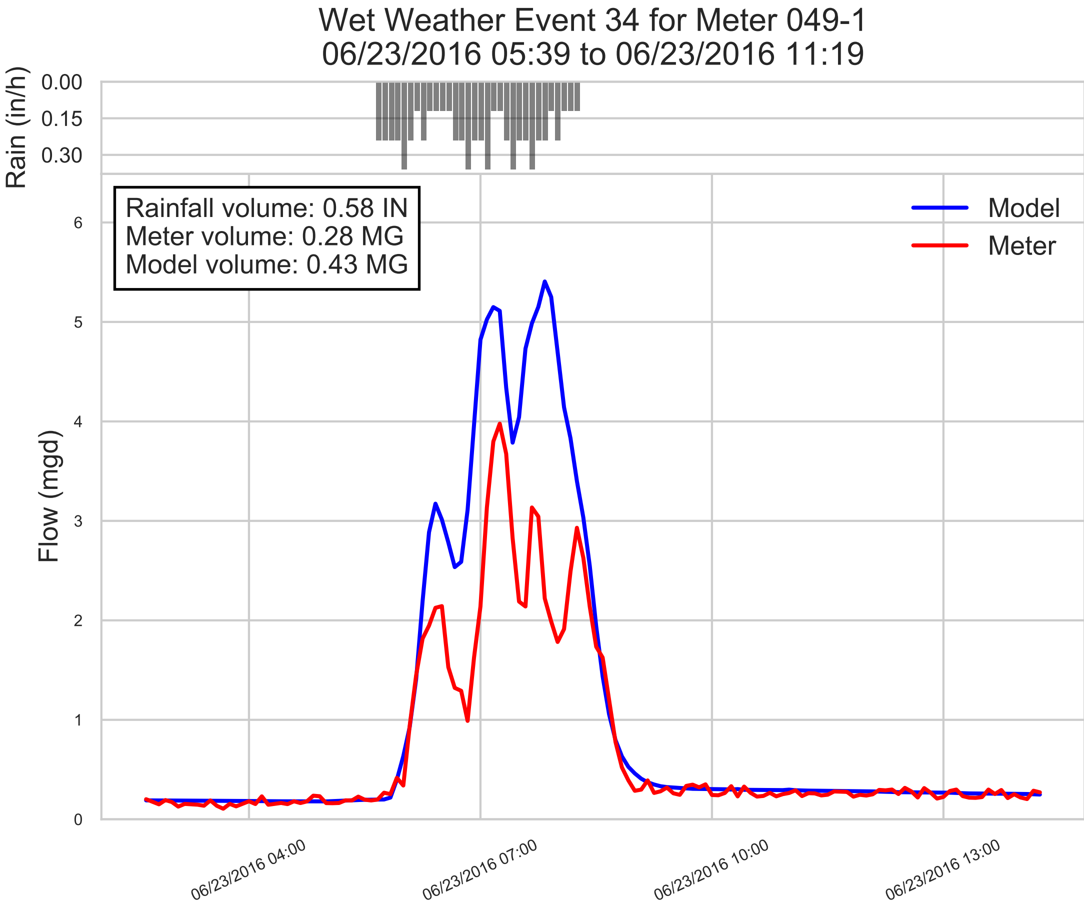
Wet Weather Event 31 for Meter 049-1
06/05/2016 02:05 to 06/05/2016 06:15
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.13 IN
Meter volume: 0.07 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06/04/2016 23:00
06/05/2016 02:00
06/05/2016 05:00
06/05/2016 08:00



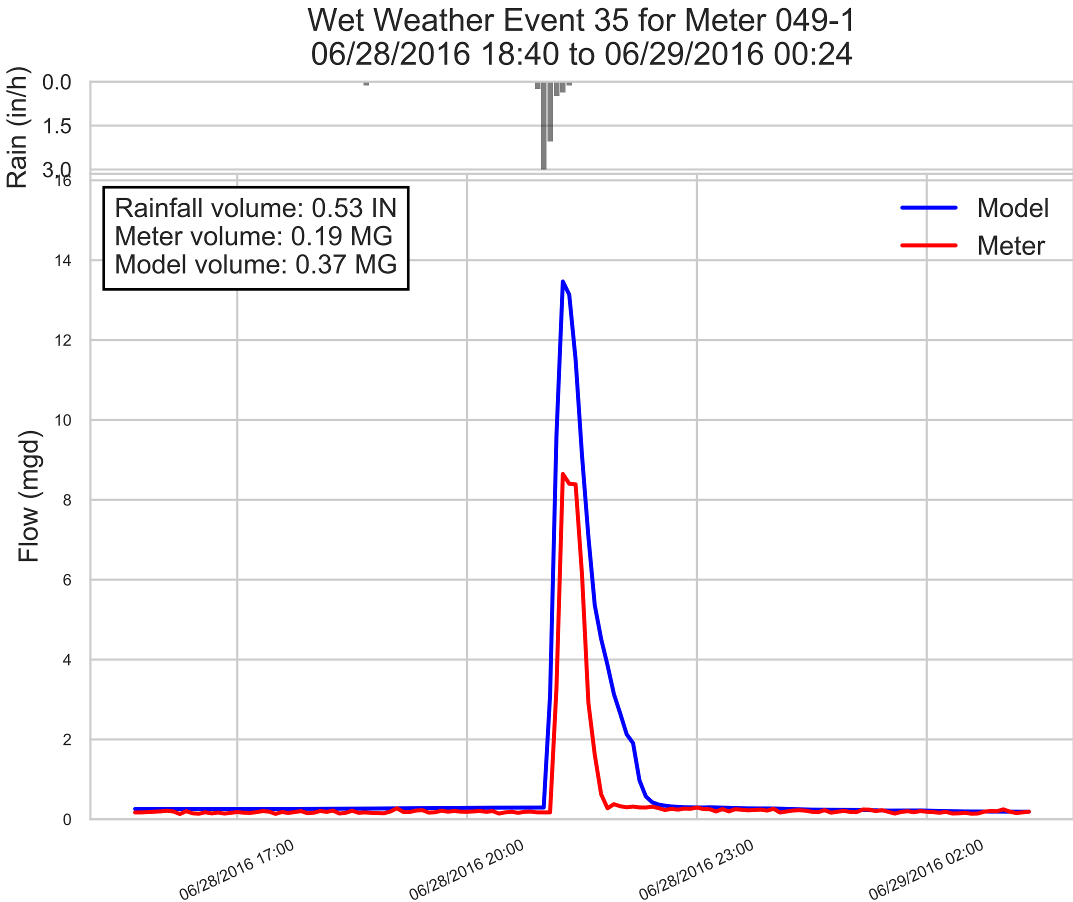
Wet Weather Event 32 for Meter 049-1
06/16/2016 20:55 to 06/17/2016 06:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.46 IN
Meter volume: 0.18 MG
Model volume: 0.34 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06/16/2016 18:00
06/16/2016 21:00
06/17/2016 00:00
06/17/2016 03:00
06/17/2016 06:00
06/17/2016 09:00

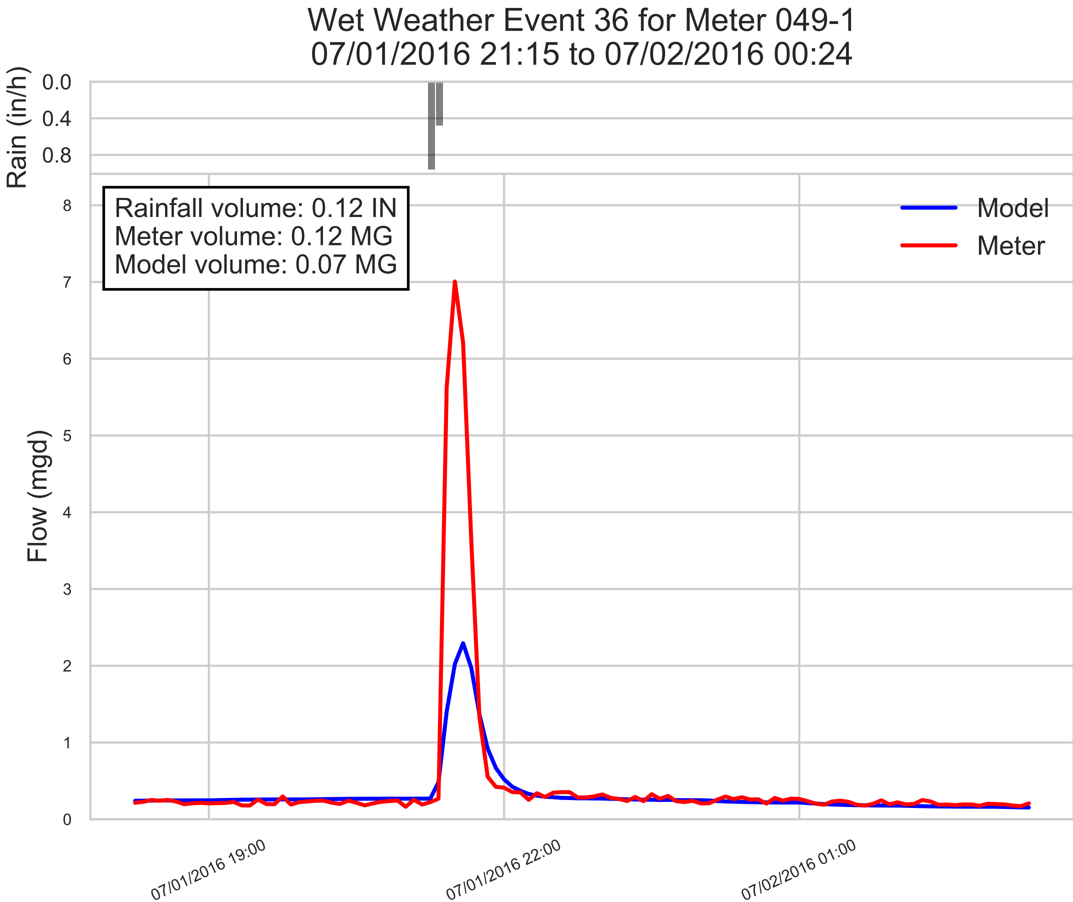


Wet Weather Event 33 for Meter 049-1
06/21/2016 14:05 to 06/21/2016 21:49
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.25 IN
Meter volume: 0.55 MG
Model volume: 0.8 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
06/21/2016 13:00
06/21/2016 16:00
06/21/2016 19:00
06/21/2016 22:00
06/22/2016 01:00

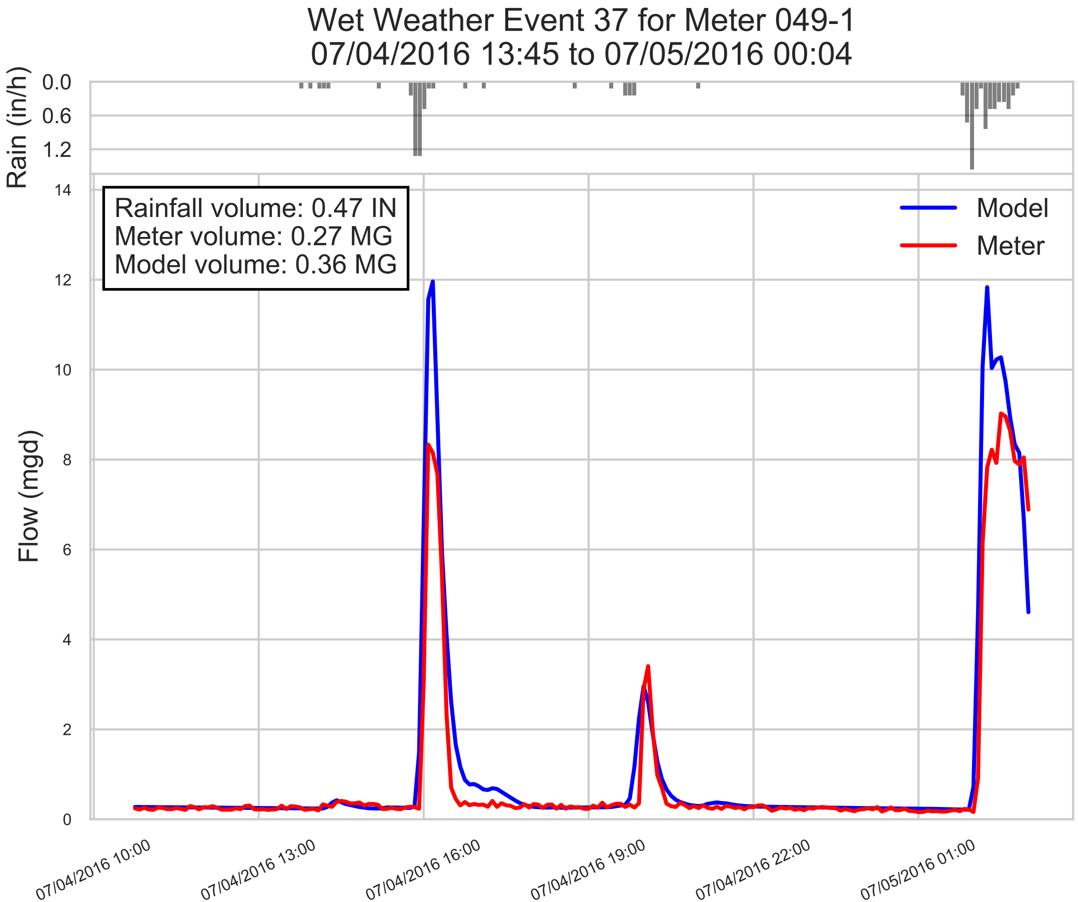


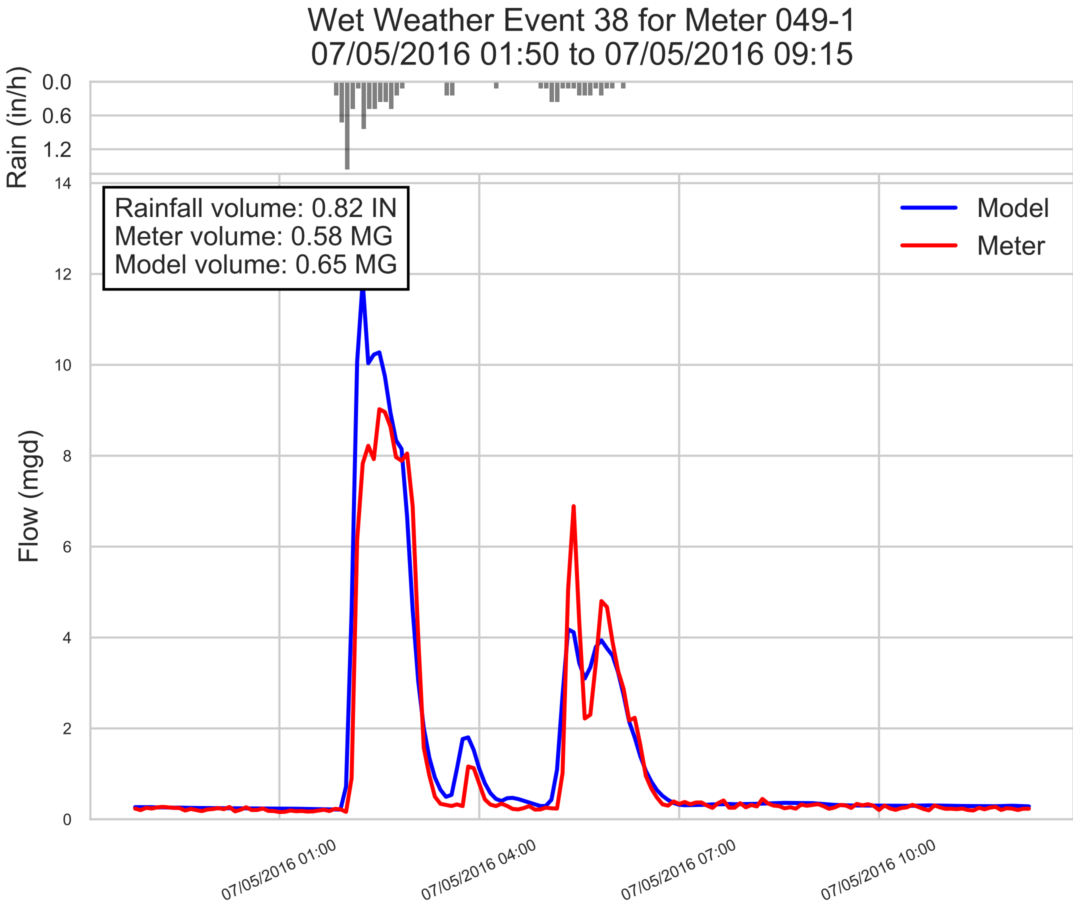
Wet Weather Event 34 for Meter 049-1
06/23/2016 05:39 to 06/23/2016 11:19
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.58 IN
Meter volume: 0.28 MG
Model volume: 0.43 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
06/23/2016 04:00
06/23/2016 07:00
06/23/2016 10:00
06/23/2016 13:00


Wet Weather Event 35 for Meter 049-1
06/28/2016 18:40 to 06/29/2016 00:24
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.53 IN
Meter volume: 0.19 MG
Model volume: 0.37 MG
Model
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
06/28/2016 17:00
06/28/2016 20:00
06/28/2016 23:00
06/29/2016 02:00

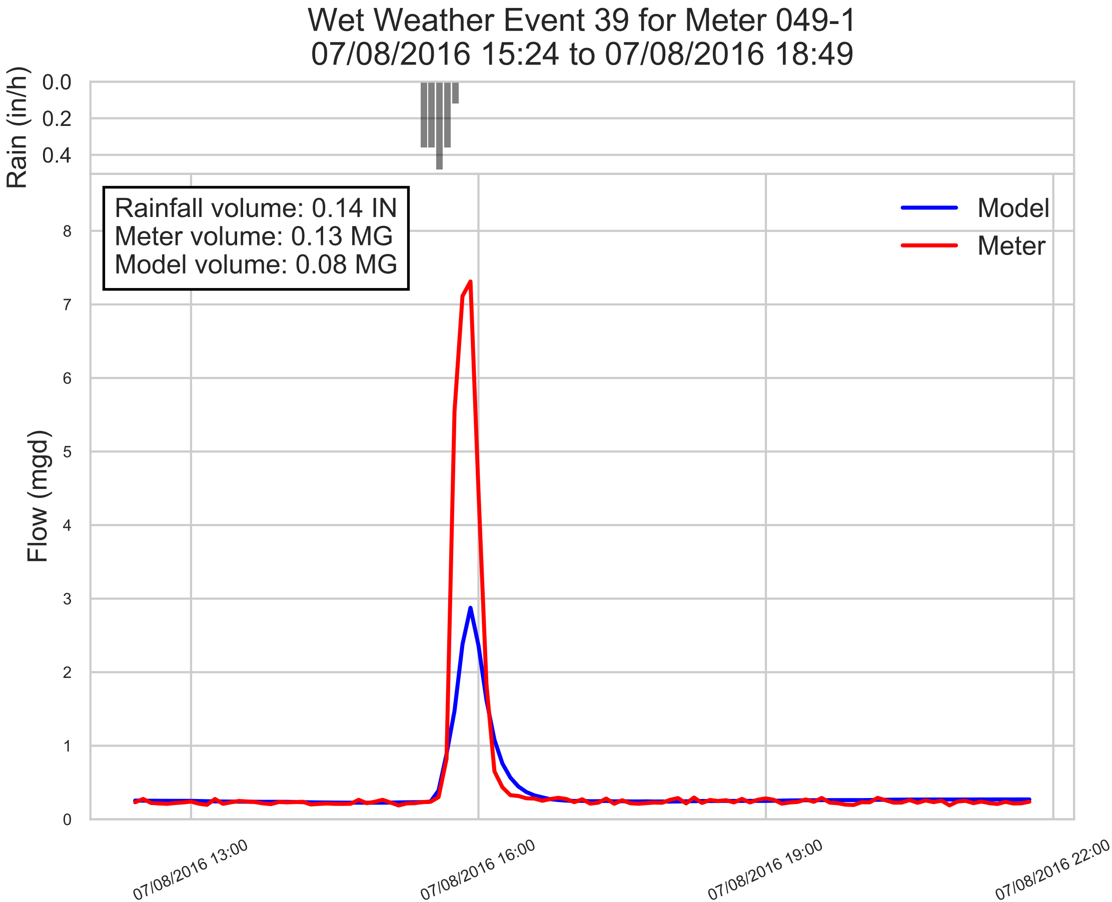


Wet Weather Event 36 for Meter 049-1
07/01/2016 21:15 to 07/02/2016 00:24
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.12 IN
Meter volume: 0.12 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
07/01/2016 19:00
07/01/2016 22:00
07/02/2016 01:00

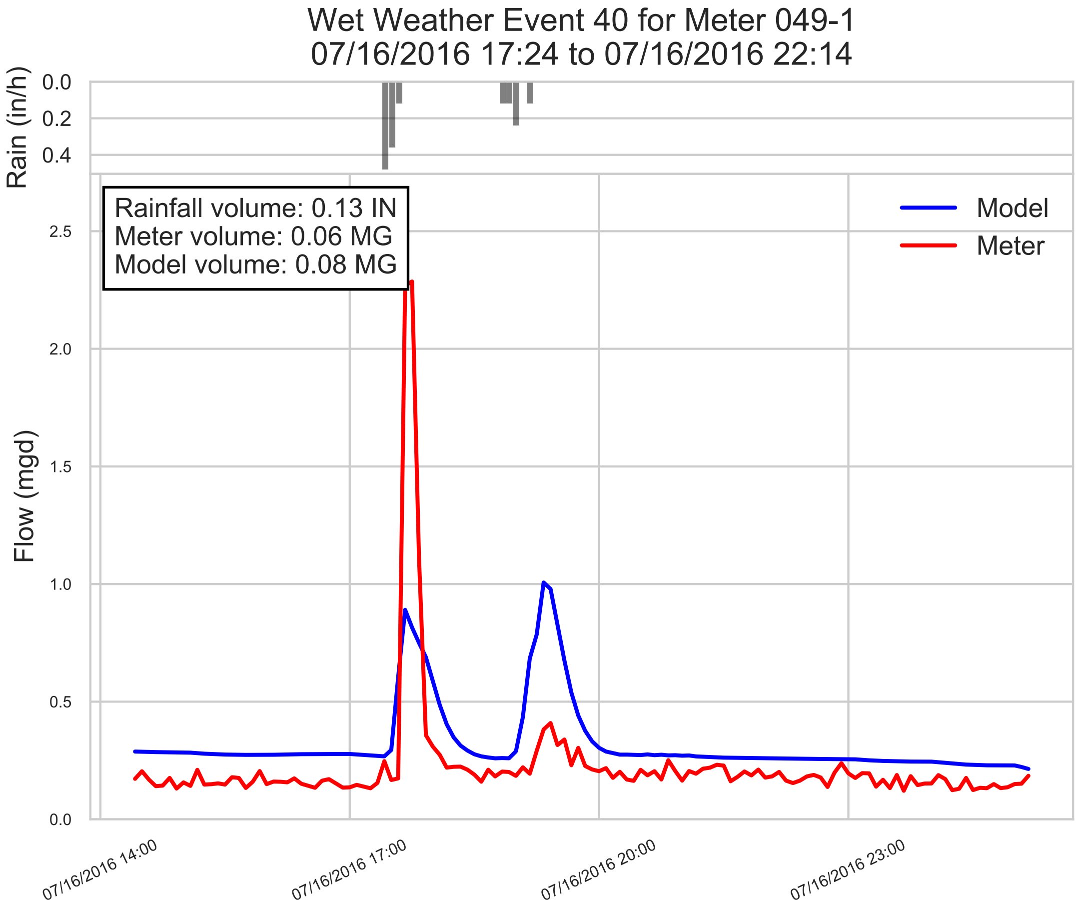

Wet Weather Event 37 for Meter 049-1
07/04/2016 13:45 to 07/05/2016 00:04
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.47 IN
Meter volume: 0.27 MG
Model volume: 0.36 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
14
07/04/2016 10:00
07/04/2016 13:00
07/04/2016 16:00
07/04/2016 19:00
07/04/2016 22:00
07/05/2016 01:00



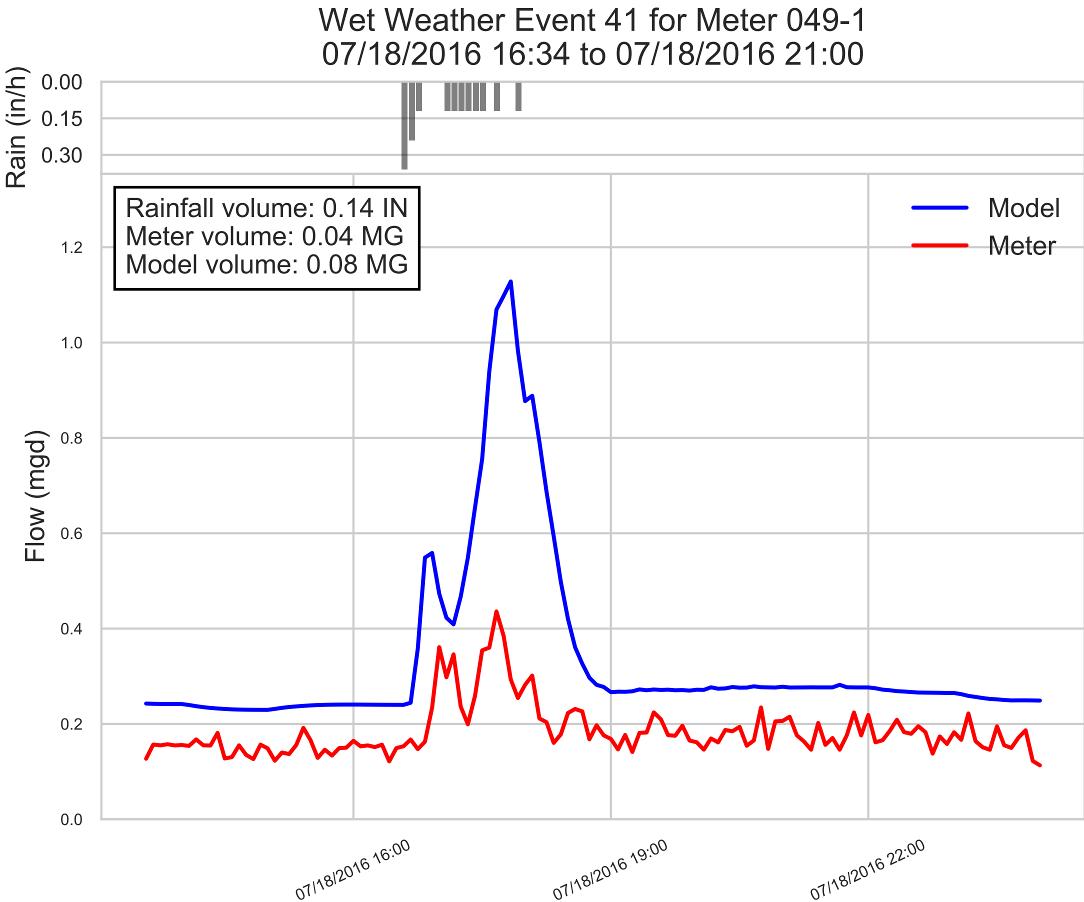
Wet Weather Event 38 for Meter 049-1
07/05/2016 01:50 to 07/05/2016 09:15
Rain (in/h)
0.0
0.6
1.2
Flow (mgd)
14
12
10
8
6
4
2
0
Rainfall volume: 0.82 IN
Meter volume: 0.58 MG
Model volume: 0.65 MG
Model
Meter
07/05/2016 01:00
07/05/2016 04:00
07/05/2016 07:00
07/05/2016 10:00



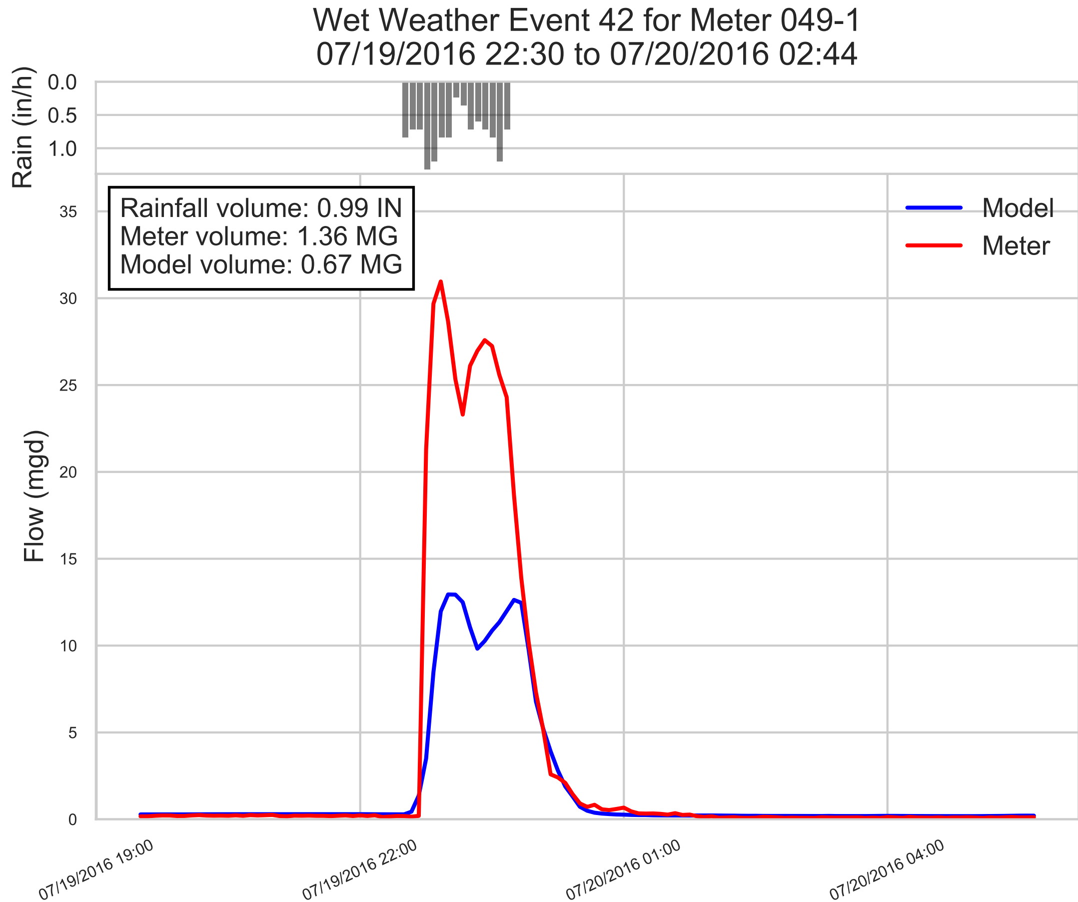
Wet Weather Event 39 for Meter 049-1
07/08/2016 15:24 to 07/08/2016 18:49
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.14 IN
Meter volume: 0.13 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
07/08/2016 13:00
07/08/2016 16:00
07/08/2016 19:00
07/08/2016 22:00

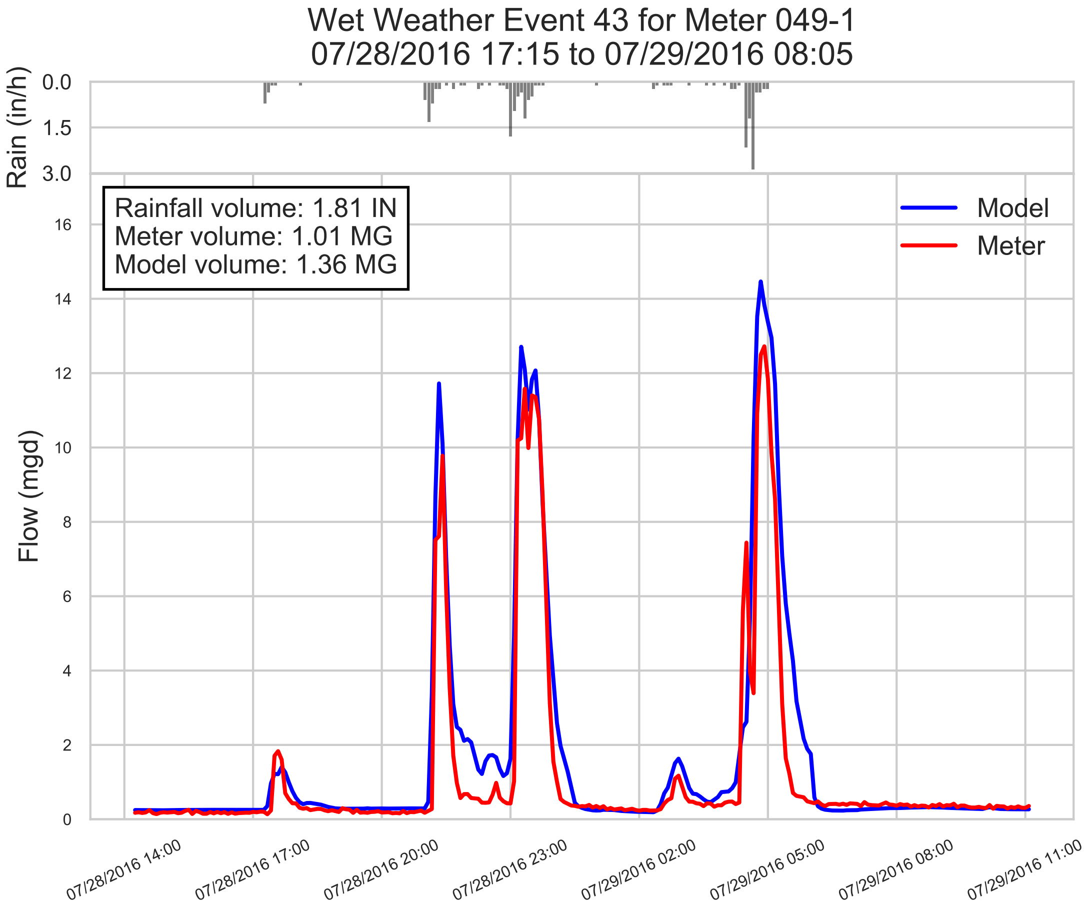


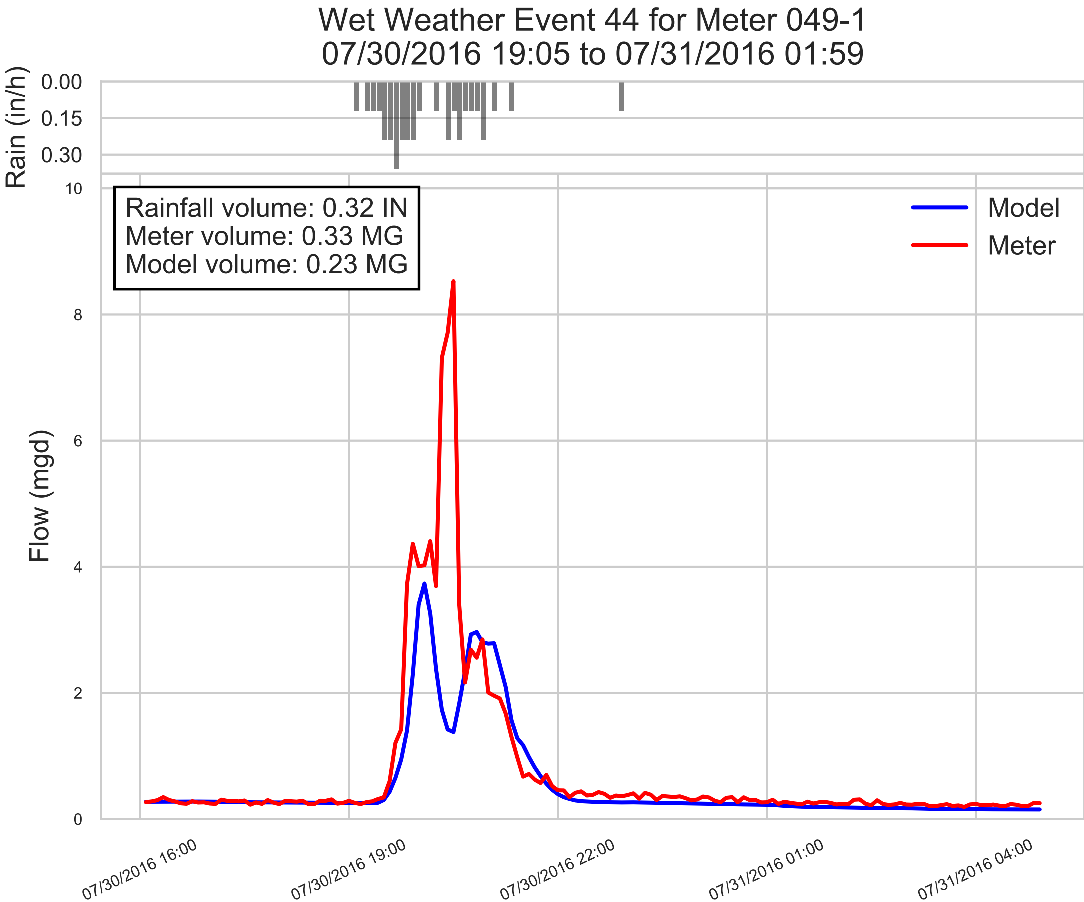
Wet Weather Event 40 for Meter 049-1
07/16/2016 17:24 to 07/16/2016 22:14
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.13 IN
Meter volume: 0.06 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
07/16/2016 14:00
07/16/2016 17:00
07/16/2016 20:00
07/16/2016 23:00



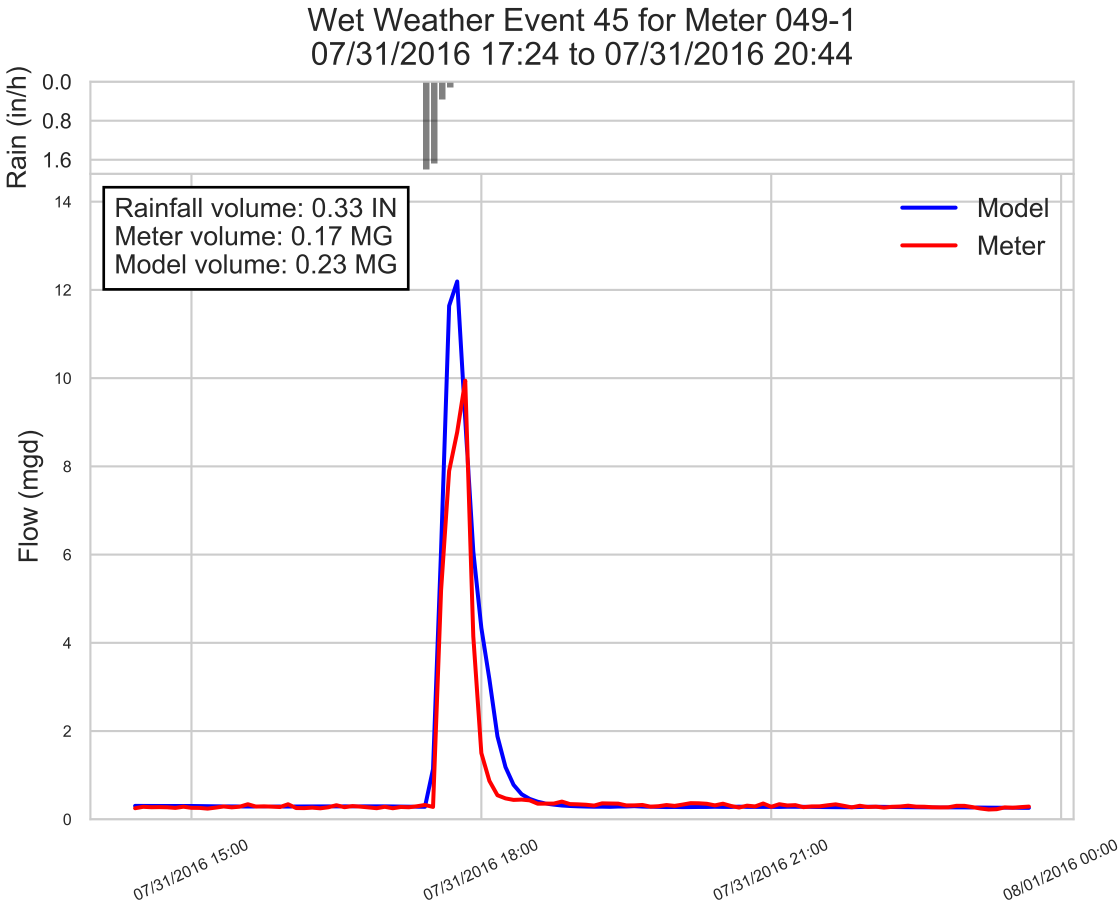
Wet Weather Event 41 for Meter 049-1
07/18/2016 16:34 to 07/18/2016 21:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.14 IN
Meter volume: 0.04 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
07/18/2016 16:00
07/18/2016 19:00
07/18/2016 22:00

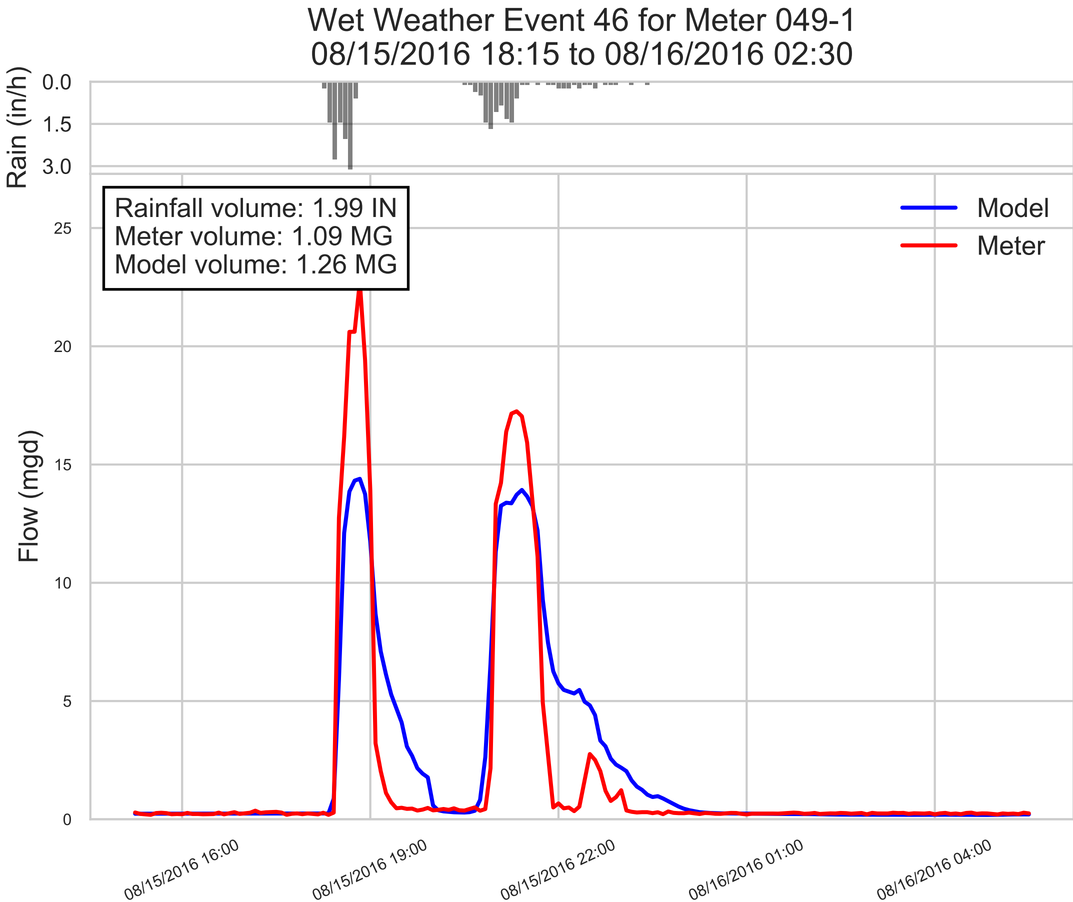

Wet Weather Event 42 for Meter 049-1
07/19/2016 22:30 to 07/20/2016 02:44
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.99 IN
Meter volume: 1.36 MG
Model volume: 0.67 MG
Model
Meter
Flow (mgd)
35
30
25
20
15
10
5
0
07/19/2016 19:00
07/19/2016 22:00
07/20/2016 01:00
07/20/2016 04:00

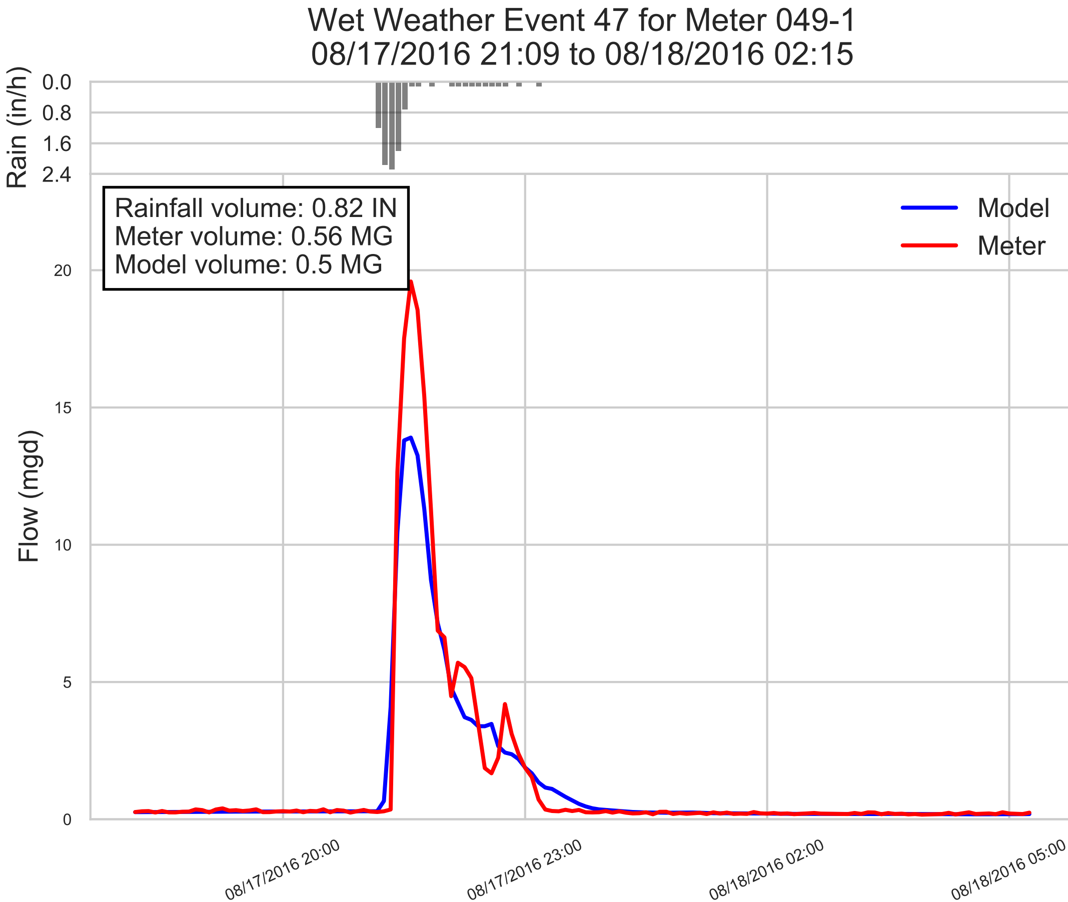

Wet Weather Event 43 for Meter 049-1
07/28/2016 17:15 to 07/29/2016 08:05
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.81 IN
Meter volume: 1.01 MG
Model volume: 1.36 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
14
16
07/28/2016 14:00
07/28/2016 17:00
07/28/2016 20:00
07/28/2016 23:00
07/29/2016 02:00
07/29/2016 05:00
07/29/2016 08:00
07/29/2016 11:00



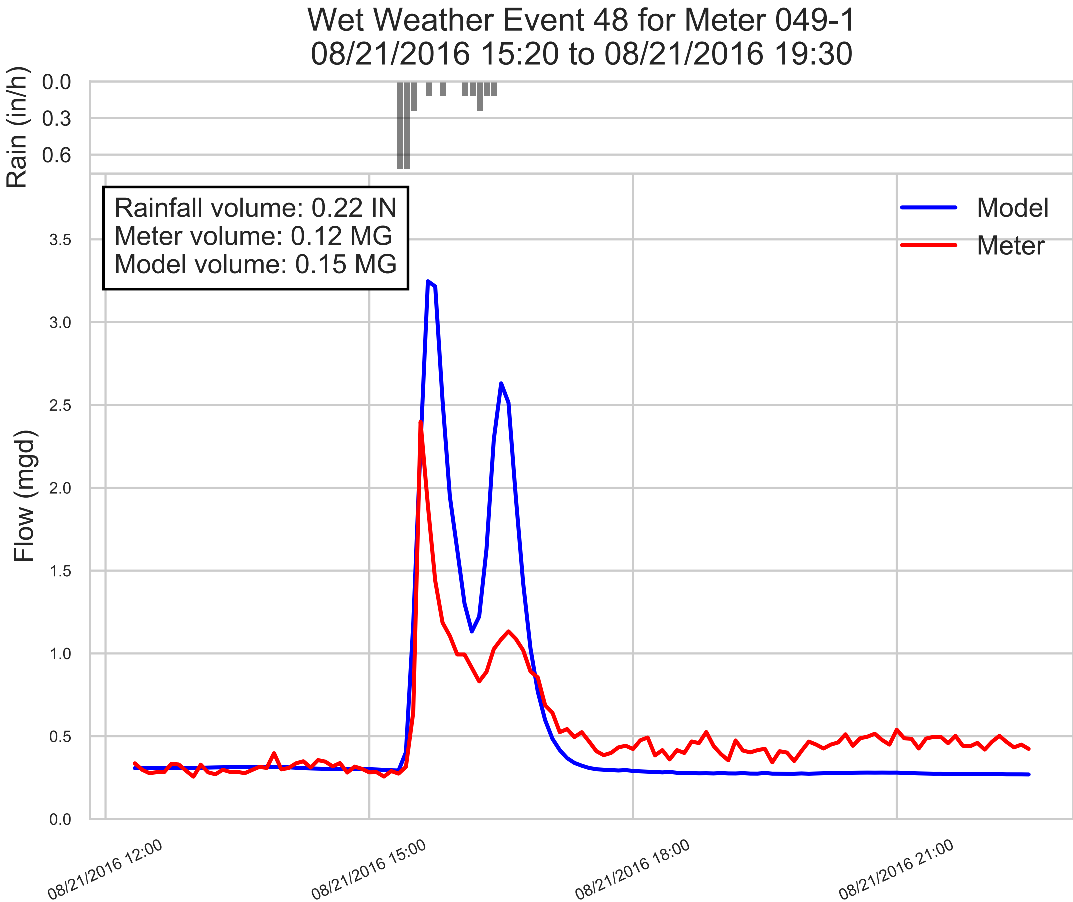
Wet Weather Event 44 for Meter 049-1
07/30/2016 19:05 to 07/31/2016 01:59
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.32 IN
Meter volume: 0.33 MG
Model volume: 0.23 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
07/30/2016 16:00
07/30/2016 19:00
07/30/2016 22:00
07/31/2016 01:00
07/31/2016 04:00

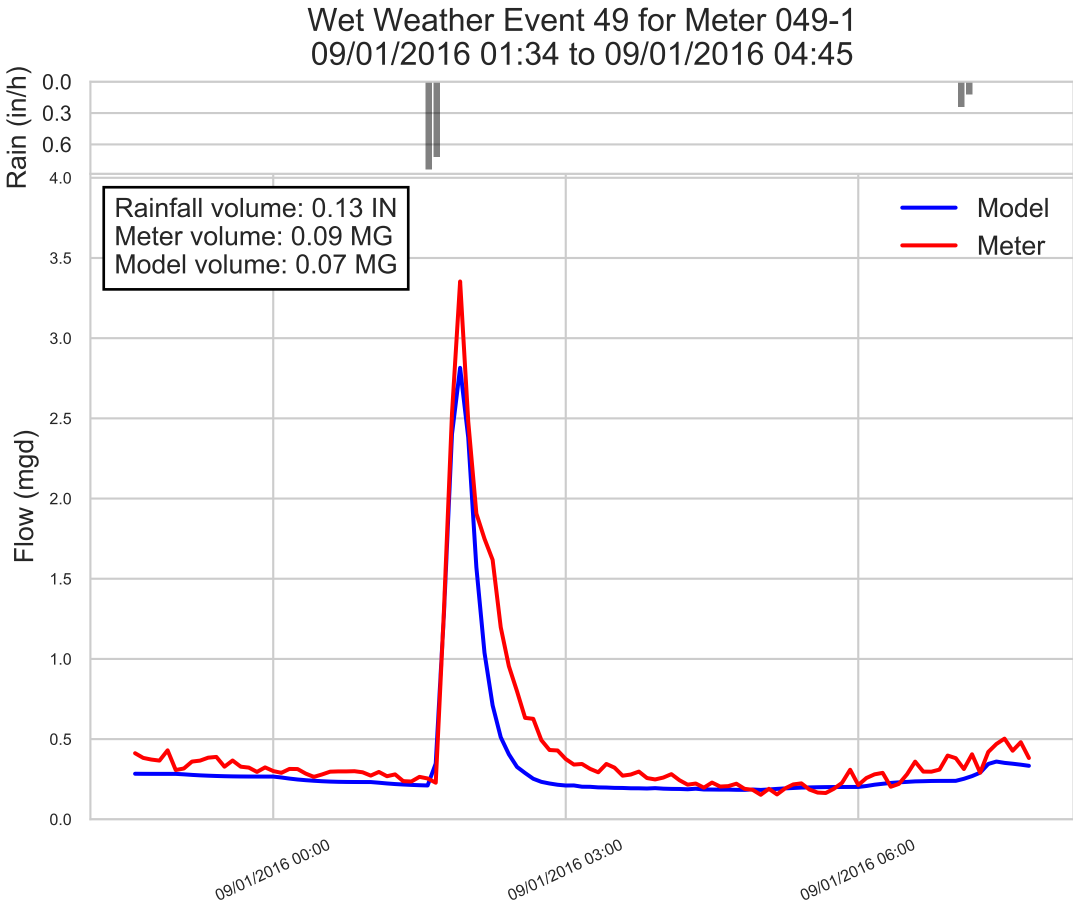

Wet Weather Event 45 for Meter 049-1
07/31/2016 17:24 to 07/31/2016 20:44
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.33 IN
Meter volume: 0.17 MG
Model volume: 0.23 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
07/31/2016 15:00
07/31/2016 18:00
07/31/2016 21:00
08/01/2016 00:00


Wet Weather Event 46 for Meter 049-1
08/15/2016 18:15 to 08/16/2016 02:30
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.99 IN
Meter volume: 1.09 MG
Model volume: 1.26 MG
Model
Meter
Flow (mgd)
0
5
10
15
20
25
08/15/2016 16:00
08/15/2016 19:00
08/15/2016 22:00
08/16/2016 01:00
08/16/2016 04:00

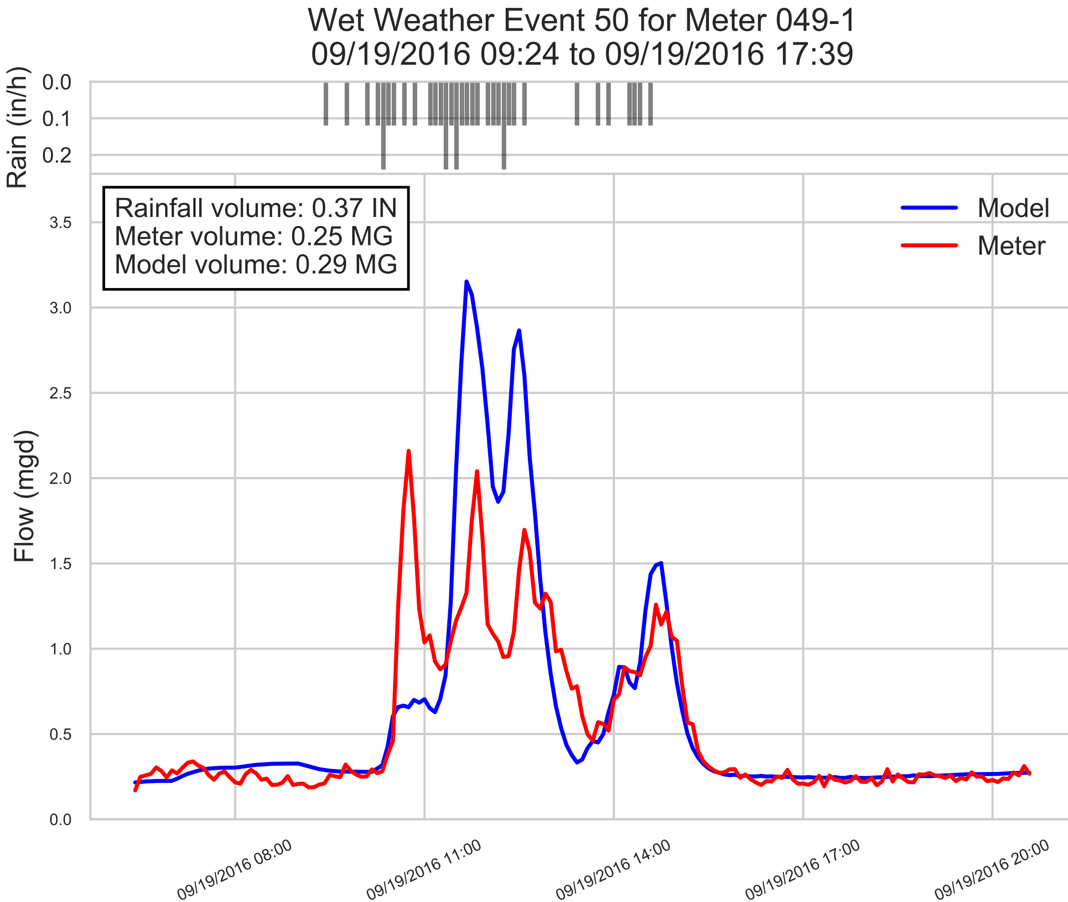


Wet Weather Event 47 for Meter 049-1
08/17/2016 21:09 to 08/18/2016 02:15
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.82 IN
Meter volume: 0.56 MG
Model volume: 0.5 MG
Model
Meter
Flow (mgd)
20
15
10
5
0
08/17/2016 20:00
08/17/2016 23:00
08/18/2016 02:00
08/18/2016 05:00

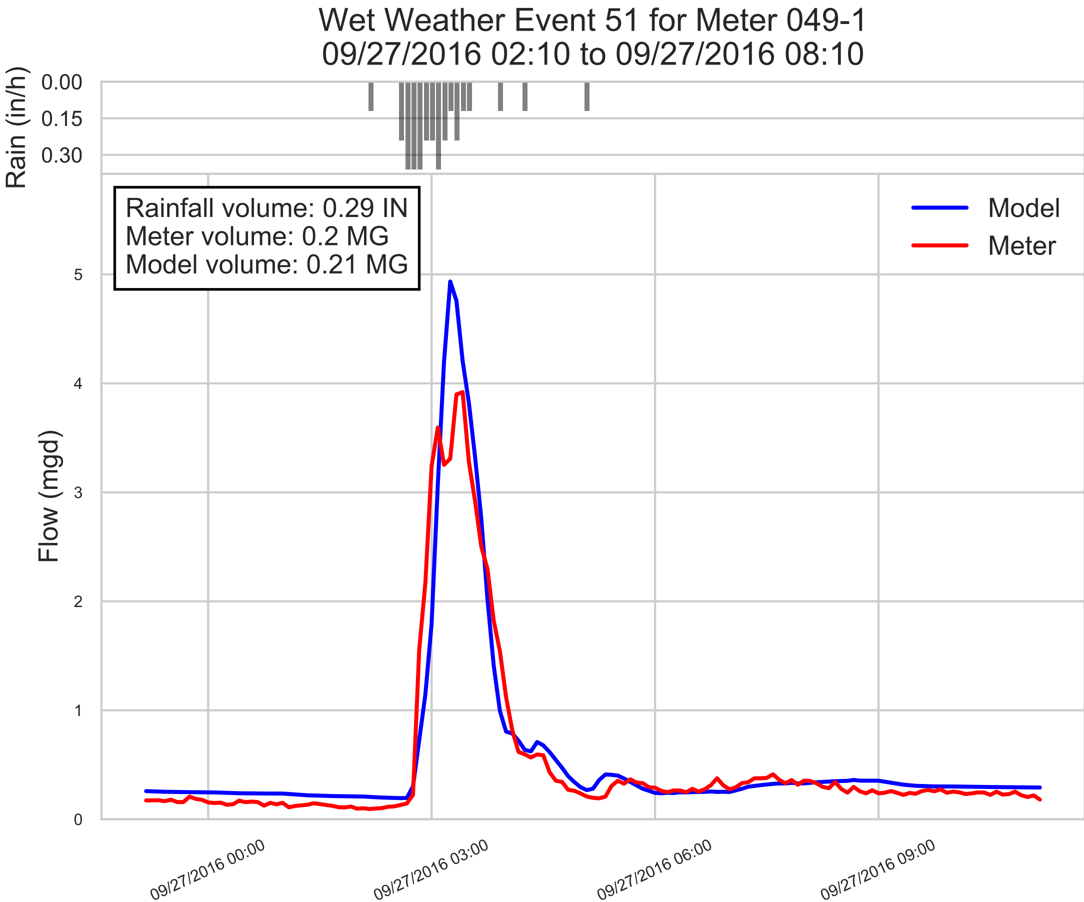

Wet Weather Event 48 for Meter 049-1
08/21/2016 15:20 to 08/21/2016 19:30
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.22 IN
Meter volume: 0.12 MG
Model volume: 0.15 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
08/21/2016 12:00
08/21/2016 15:00
08/21/2016 18:00
08/21/2016 21:00



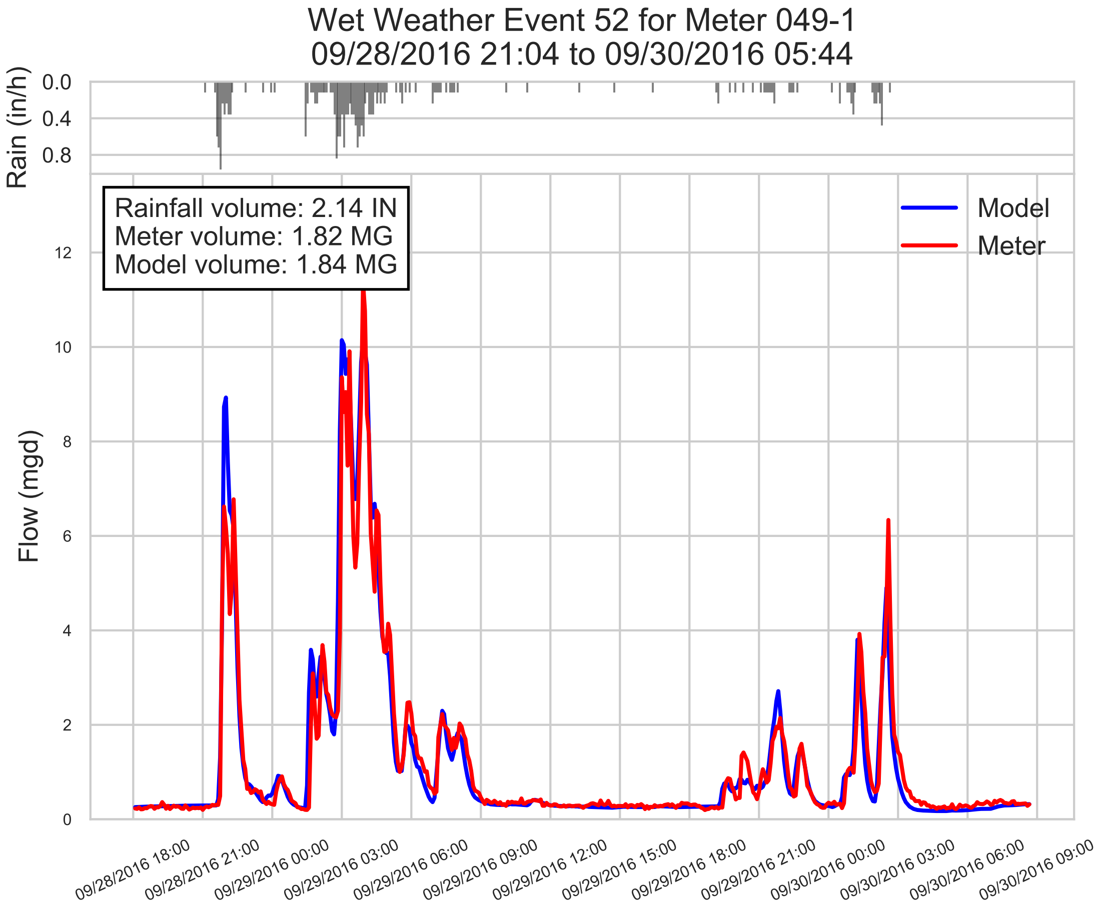
Wet Weather Event 49 for Meter 049-1
09/01/2016 01:34 to 09/01/2016 04:45
Rain (in/h)
0.0
0.3
0.6
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (mgd)
Rainfall volume: 0.13 IN
Meter volume: 0.09 MG
Model volume: 0.07 MG
Model
Meter
09/01/2016 00:00
09/01/2016 03:00
09/01/2016 06:00



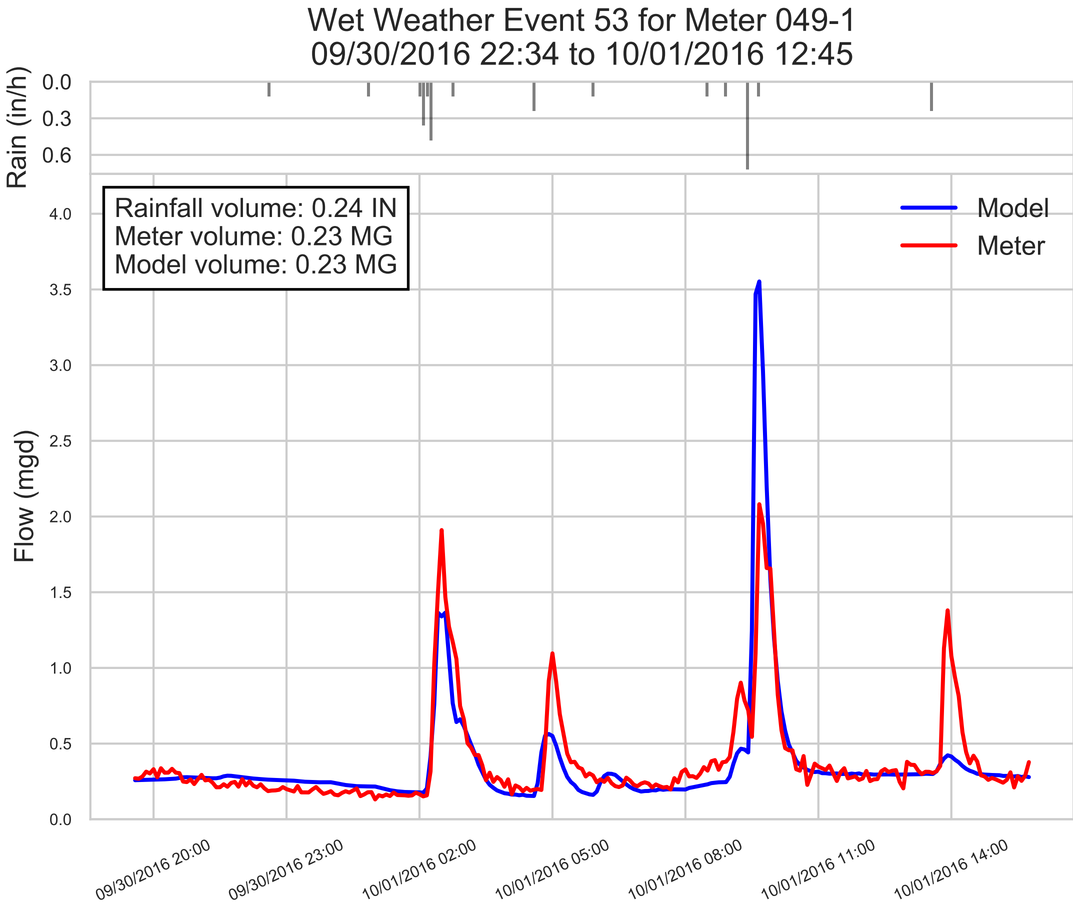
Wet Weather Event 50 for Meter 049-1
09/19/2016 09:24 to 09/19/2016 17:39
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.37 IN
Meter volume: 0.25 MG
Model volume: 0.29 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
09/19/2016 08:00
09/19/2016 11:00
09/19/2016 14:00
09/19/2016 17:00
09/19/2016 20:00



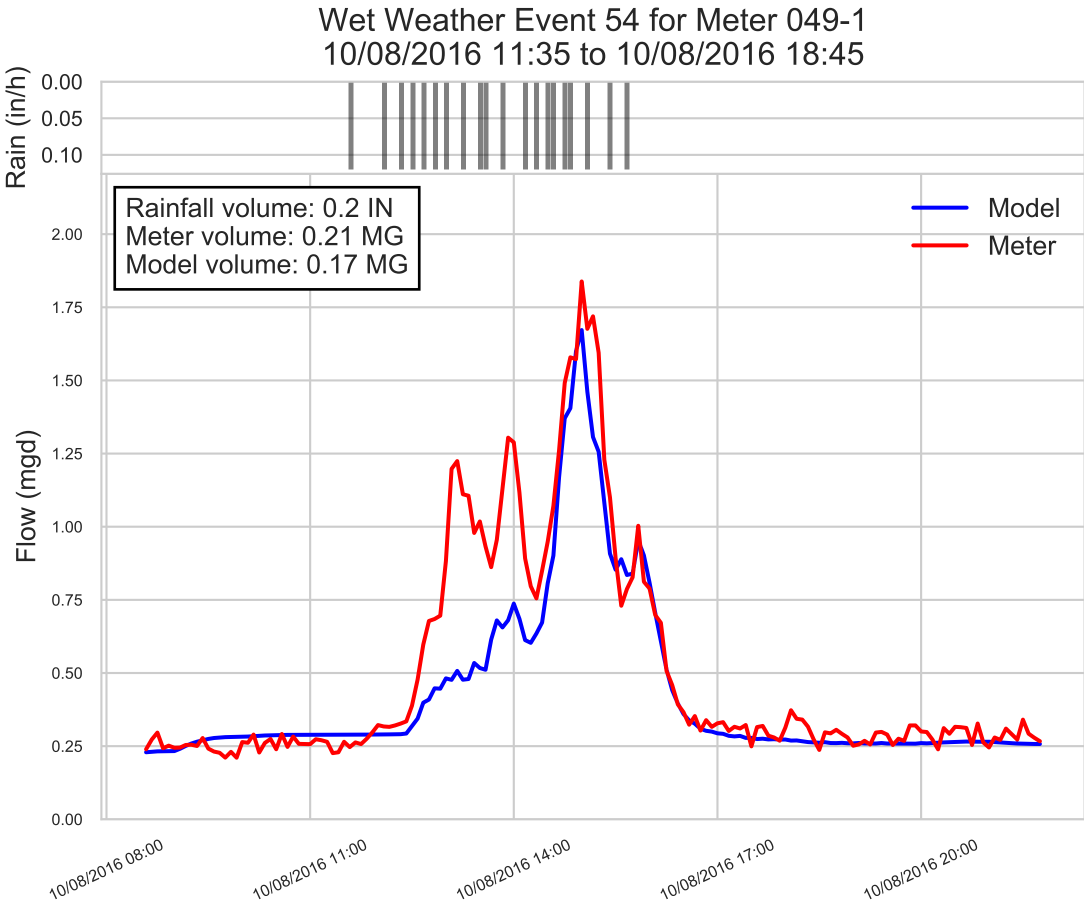
Wet Weather Event 51 for Meter 049-1
09/27/2016 02:10 to 09/27/2016 08:10
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.29 IN
Meter volume: 0.2 MG
Model volume: 0.21 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
09/27/2016 00:00
09/27/2016 03:00
09/27/2016 06:00
09/27/2016 09:00

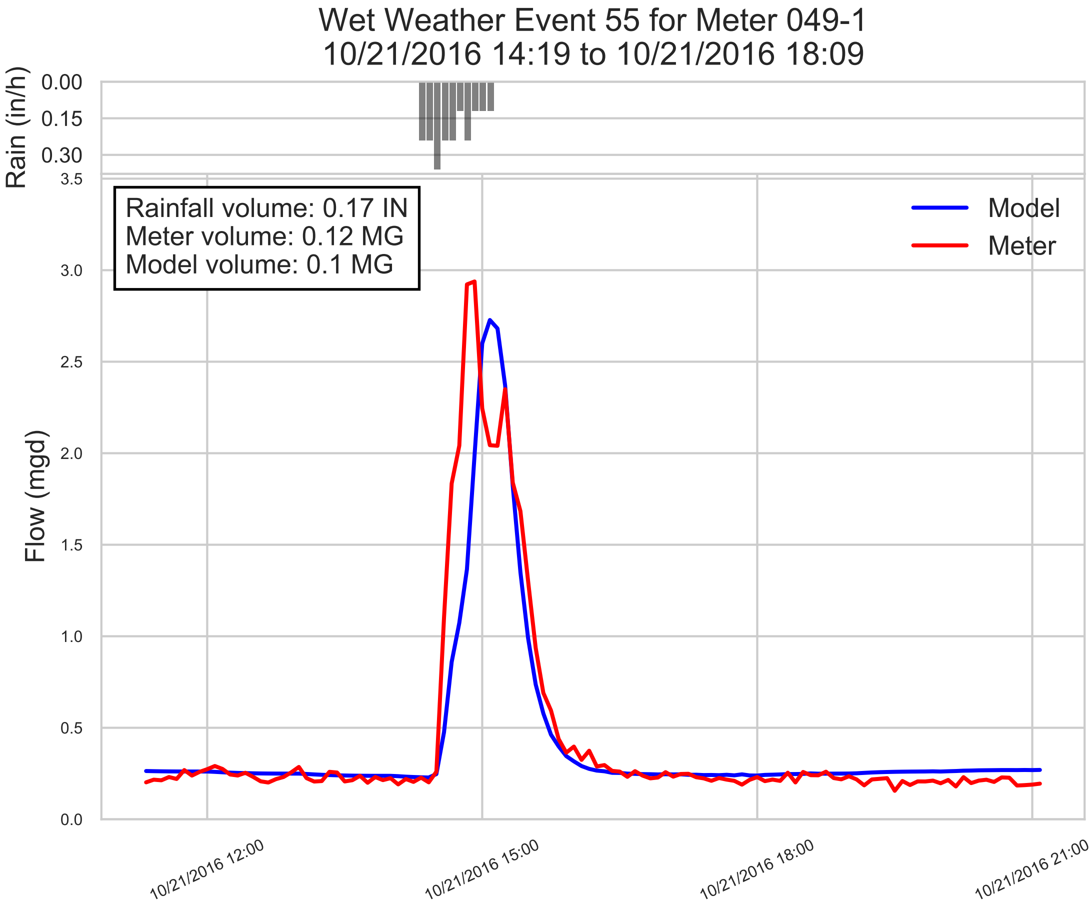


Wet Weather Event 52 for Meter 049-1
09/28/2016 21:04 to 09/30/2016 05:44
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 2.14 IN
Meter volume: 1.82 MG
Model volume: 1.84 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
09/28/2016 18:00
09/28/2016 21:00
09/29/2016 00:00
09/29/2016 03:00
09/29/2016 06:00
09/29/2016 09:00
09/29/2016 12:00
09/29/2016 15:00
09/29/2016 18:00
09/29/2016 21:00
09/30/2016 00:00
09/30/2016 03:00
09/30/2016 06:00
09/30/2016 09:00

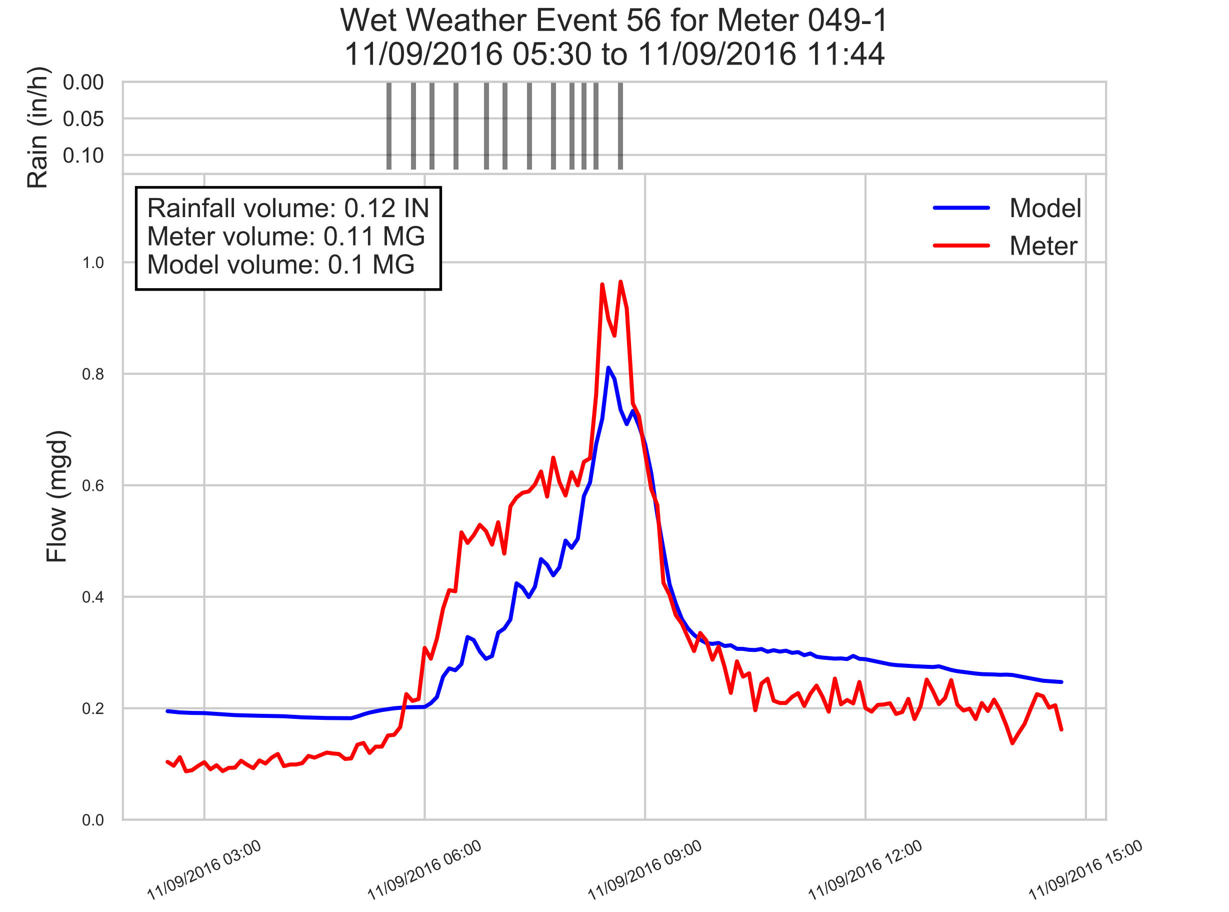


Wet Weather Event 53 for Meter 049-1
09/30/2016 22:34 to 10/01/2016 12:45
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.24 IN
Meter volume: 0.23 MG
Model volume: 0.23 MG
Model
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
09/30/2016 20:00
09/30/2016 23:00
10/01/2016 02:00
10/01/2016 05:00
10/01/2016 08:00
10/01/2016 11:00
10/01/2016 14:00

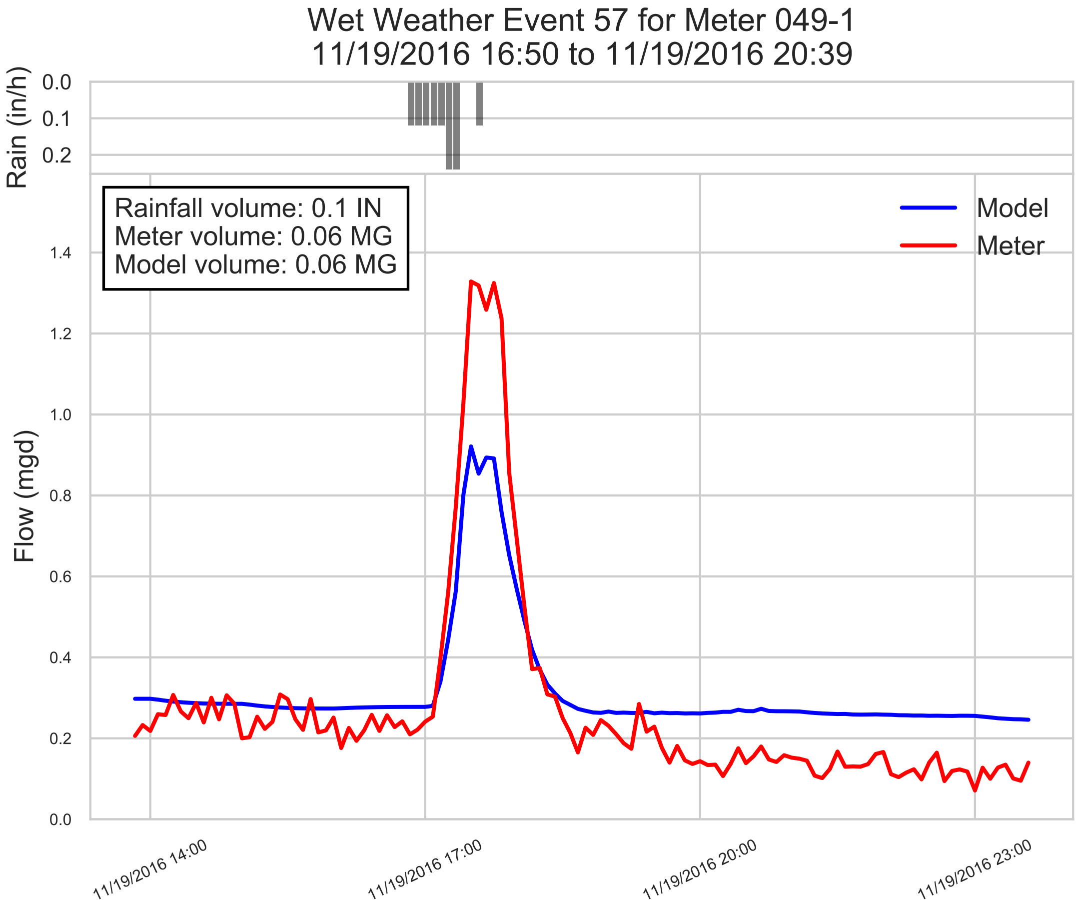

Wet Weather Event 54 for Meter 049-1
10/08/2016 11:35 to 10/08/2016 18:45
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.21 MG
Model volume: 0.17 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
10/08/2016 08:00
10/08/2016 11:00
10/08/2016 14:00
10/08/2016 17:00
10/08/2016 20:00



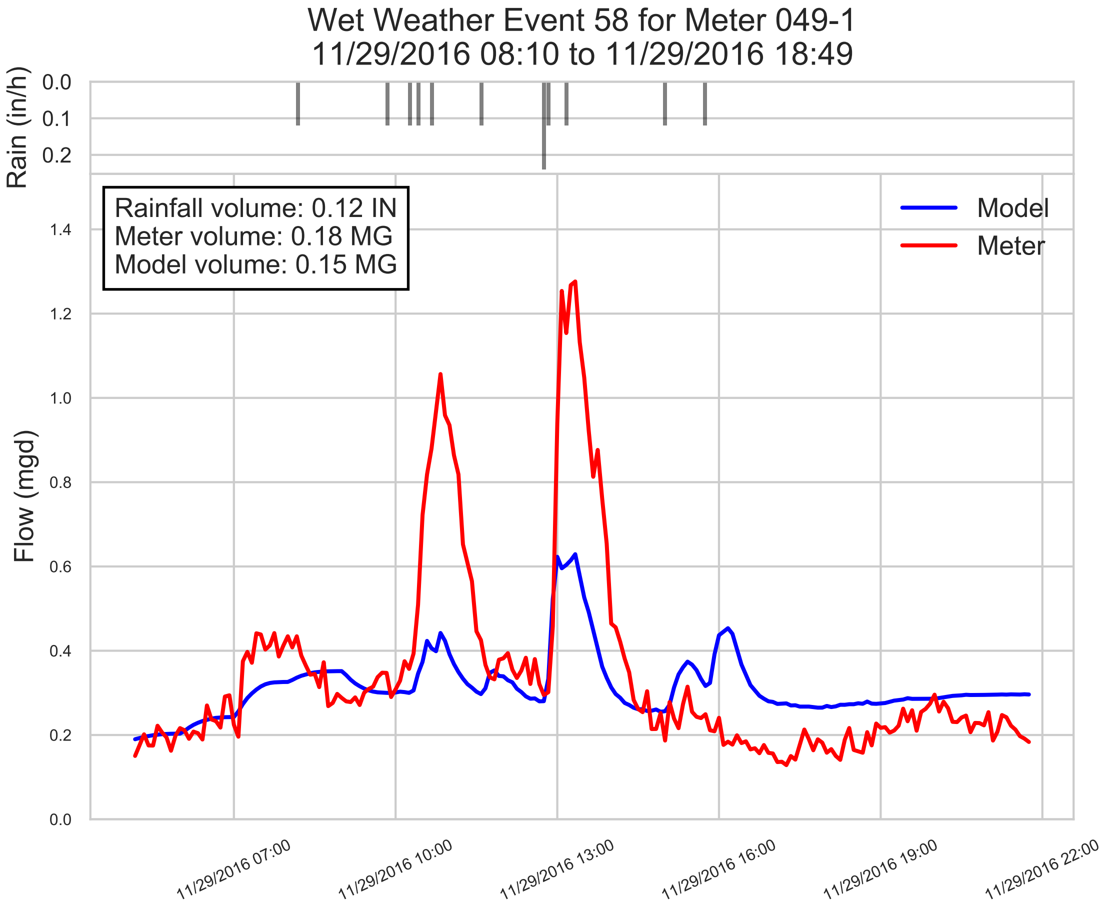
Wet Weather Event 55 for Meter 049-1
10/21/2016 14:19 to 10/21/2016 18:09
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.17 IN
Meter volume: 0.12 MG
Model volume: 0.1 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/21/2016 12:00
10/21/2016 15:00
10/21/2016 18:00
10/21/2016 21:00



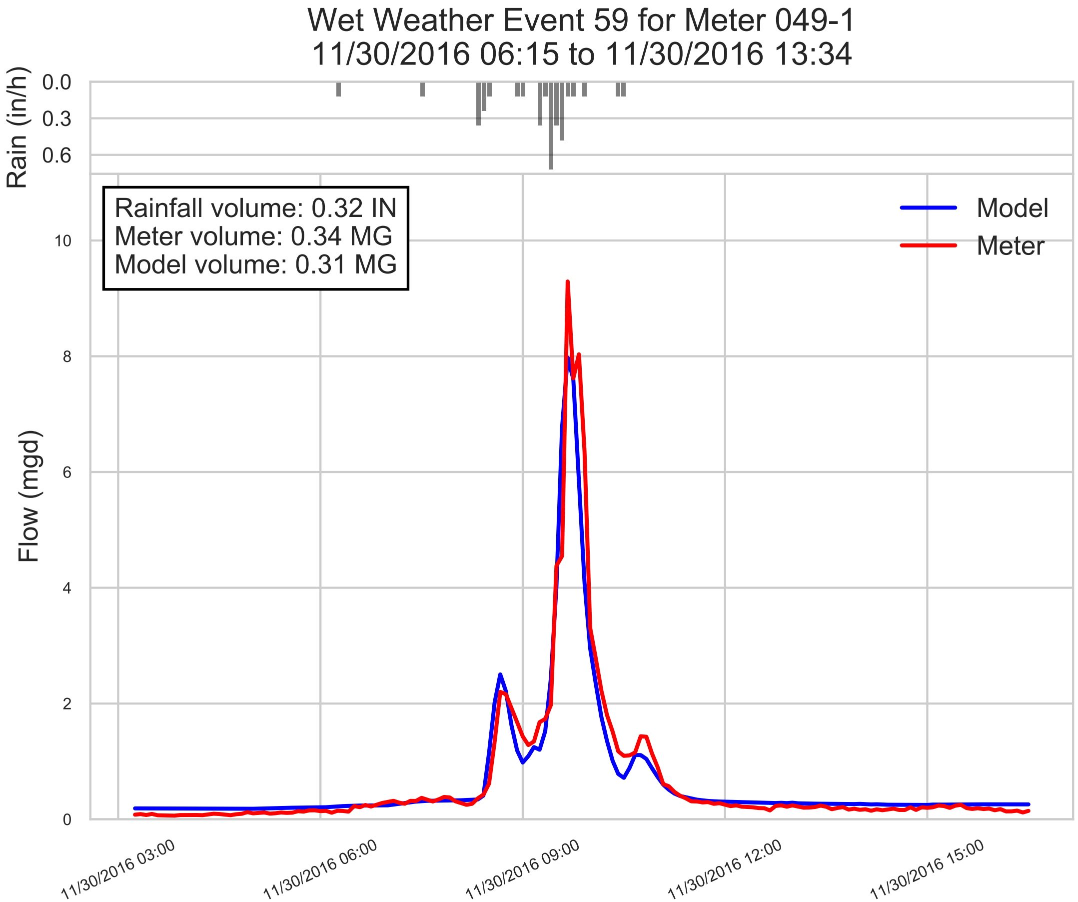
Wet Weather Event 56 for Meter 049-1
11/09/2016 05:30 to 11/09/2016 11:44
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.11 MG
Model volume: 0.1 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
11/09/2016 03:00
11/09/2016 06:00
11/09/2016 09:00
11/09/2016 12:00
11/09/2016 15:00



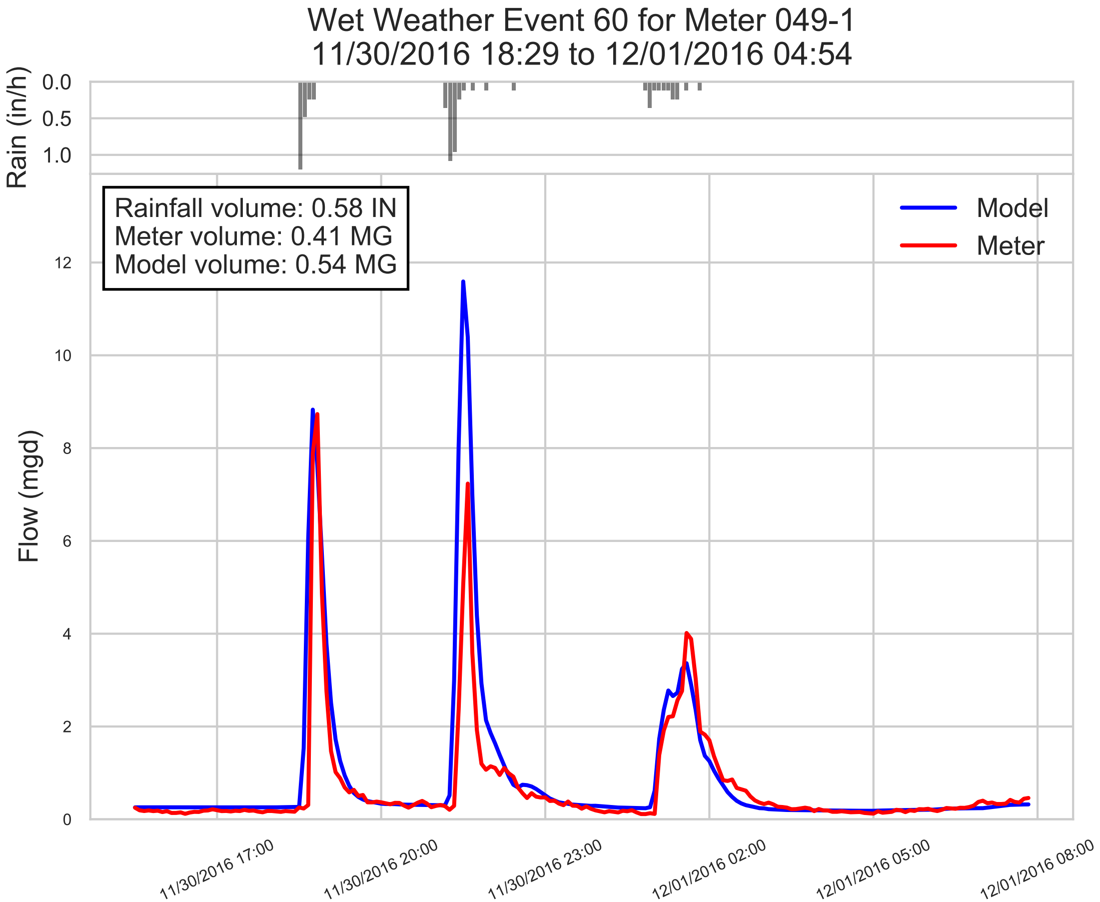
Wet Weather Event 57 for Meter 049-1
11/19/2016 16:50 to 11/19/2016 20:39
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.1 IN
Meter volume: 0.06 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/19/2016 14:00
11/19/2016 17:00
11/19/2016 20:00
11/19/2016 23:00



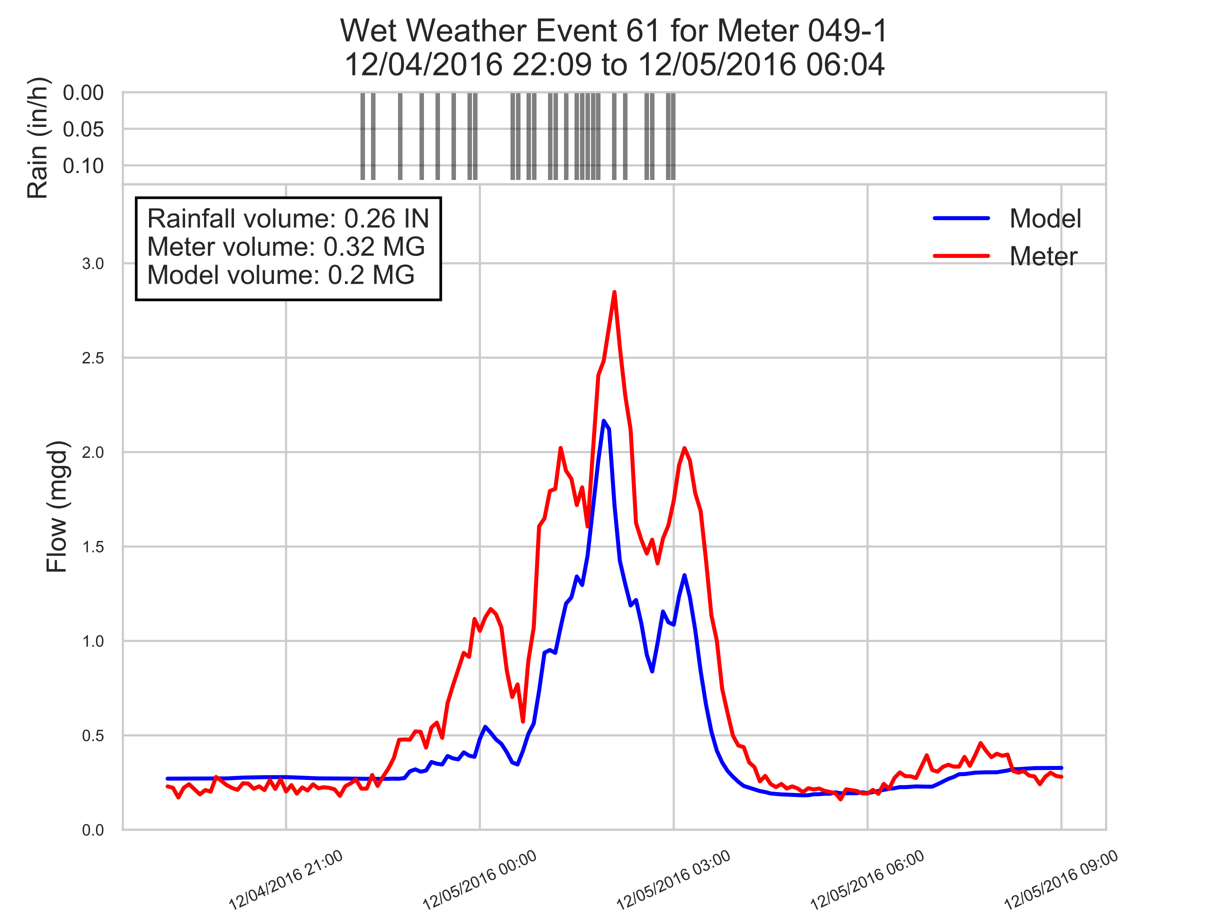
Wet Weather Event 58 for Meter 049-1
11/29/2016 08:10 to 11/29/2016 18:49
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.12 IN
Meter volume: 0.18 MG
Model volume: 0.15 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/29/2016 07:00
11/29/2016 10:00
11/29/2016 13:00
11/29/2016 16:00
11/29/2016 19:00
11/29/2016 22:00



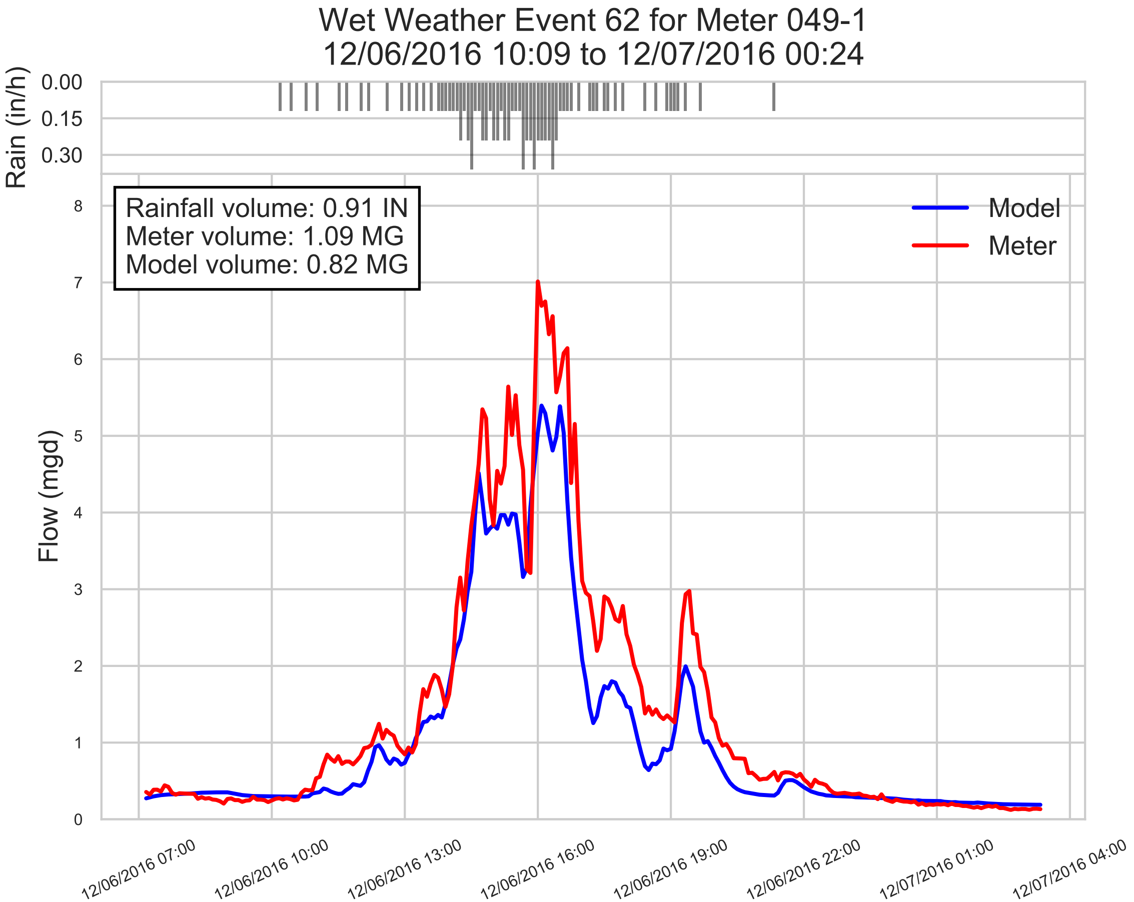
Wet Weather Event 59 for Meter 049-1
11/30/2016 06:15 to 11/30/2016 13:34
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.32 IN
Meter volume: 0.34 MG
Model volume: 0.31 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
11/30/2016 03:00
11/30/2016 06:00
11/30/2016 09:00
11/30/2016 12:00
11/30/2016 15:00



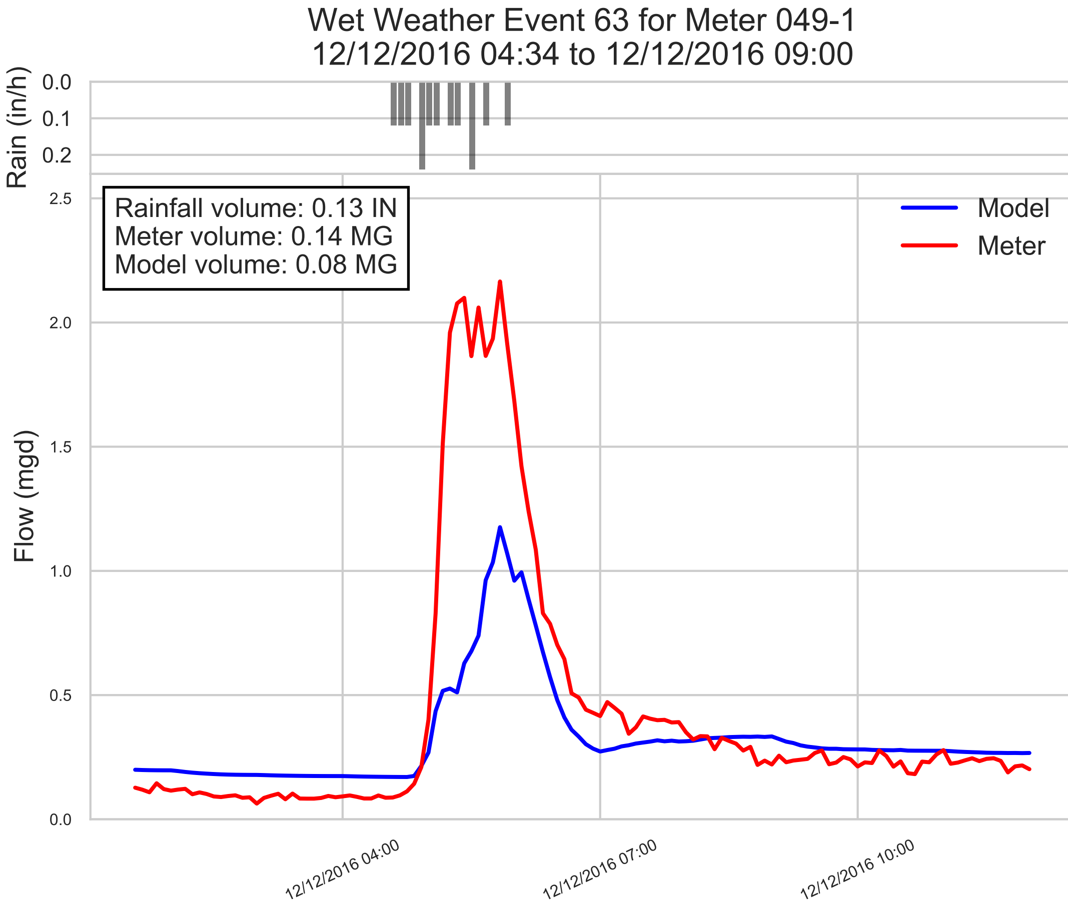
Wet Weather Event 60 for Meter 049-1
11/30/2016 18:29 to 12/01/2016 04:54
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.58 IN
Meter volume: 0.41 MG
Model volume: 0.54 MG
Model
Meter
Flow (mgd)
12
10
8
6
4
2
0
11/30/2016 17:00
11/30/2016 20:00
11/30/2016 23:00
12/01/2016 02:00
12/01/2016 05:00
12/01/2016 08:00



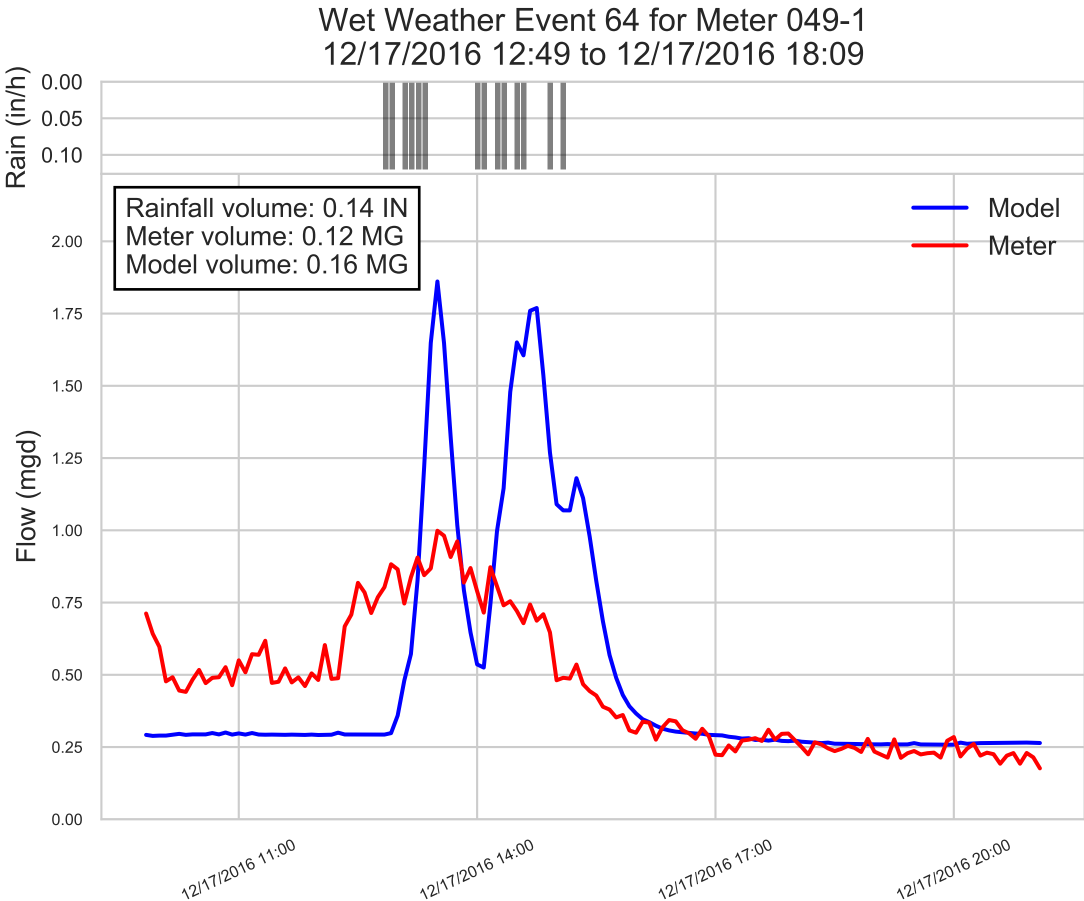
Wet Weather Event 61 for Meter 049-1
12/04/2016 22:09 to 12/05/2016 06:04
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.26 IN
Meter volume: 0.32 MG
Model volume: 0.2 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/04/2016 21:00
12/05/2016 00:00
12/05/2016 03:00
12/05/2016 06:00
12/05/2016 09:00



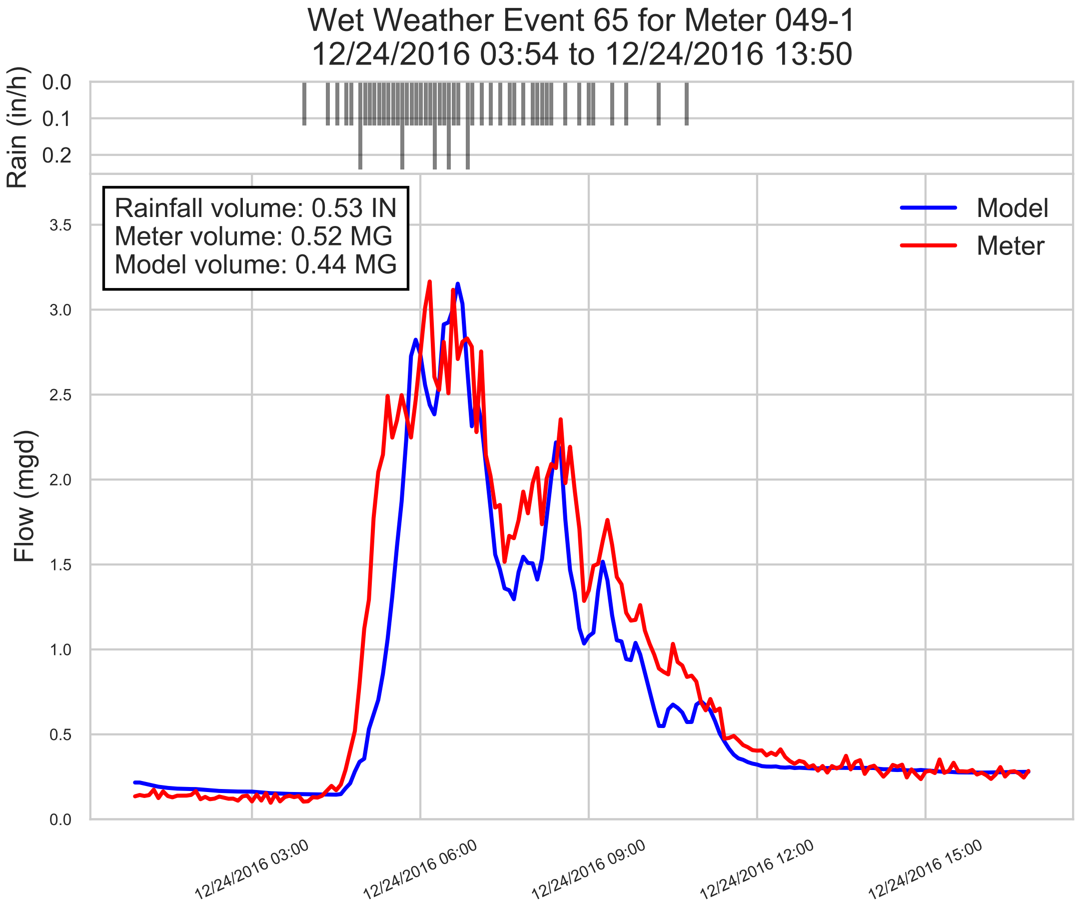
Wet Weather Event 62 for Meter 049-1
12/06/2016 10:09 to 12/07/2016 00:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.91 IN
Meter volume: 1.09 MG
Model volume: 0.82 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
12/06/2016 07:00
12/06/2016 10:00
12/06/2016 13:00
12/06/2016 16:00
12/06/2016 19:00
12/06/2016 22:00
12/07/2016 01:00
12/07/2016 04:00



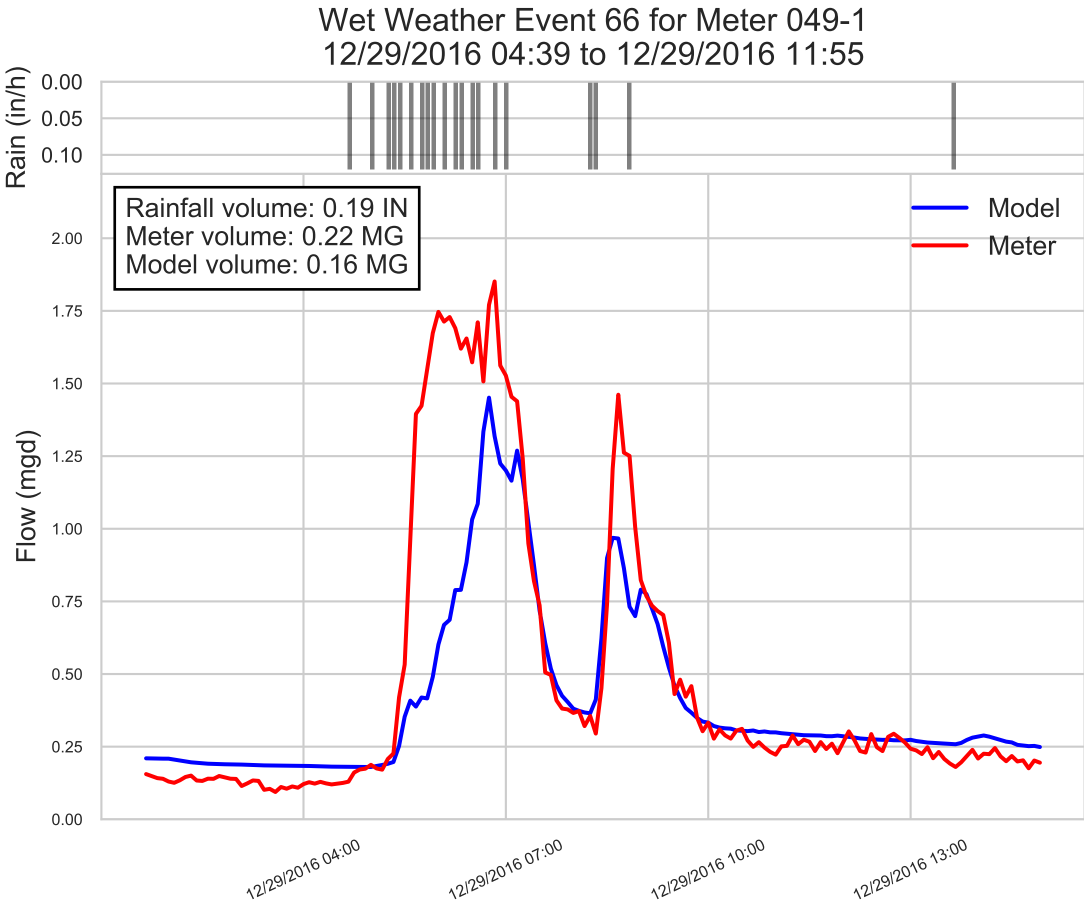
Wet Weather Event 63 for Meter 049-1
12/12/2016 04:34 to 12/12/2016 09:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.13 IN
Meter volume: 0.14 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
12/12/2016 04:00
12/12/2016 07:00
12/12/2016 10:00



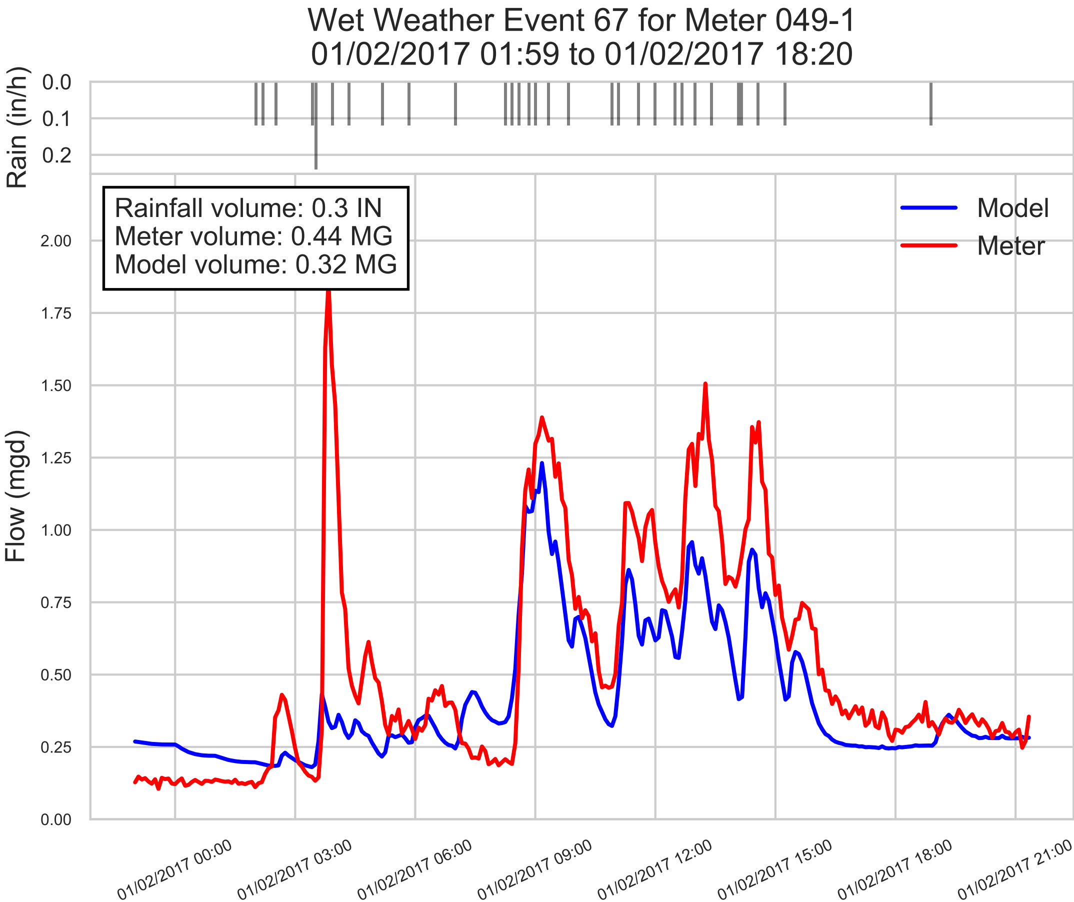
Wet Weather Event 64 for Meter 049-1
12/17/2016 12:49 to 12/17/2016 18:09
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.14 IN
Meter volume: 0.12 MG
Model volume: 0.16 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/17/2016 11:00
12/17/2016 14:00
12/17/2016 17:00
12/17/2016 20:00



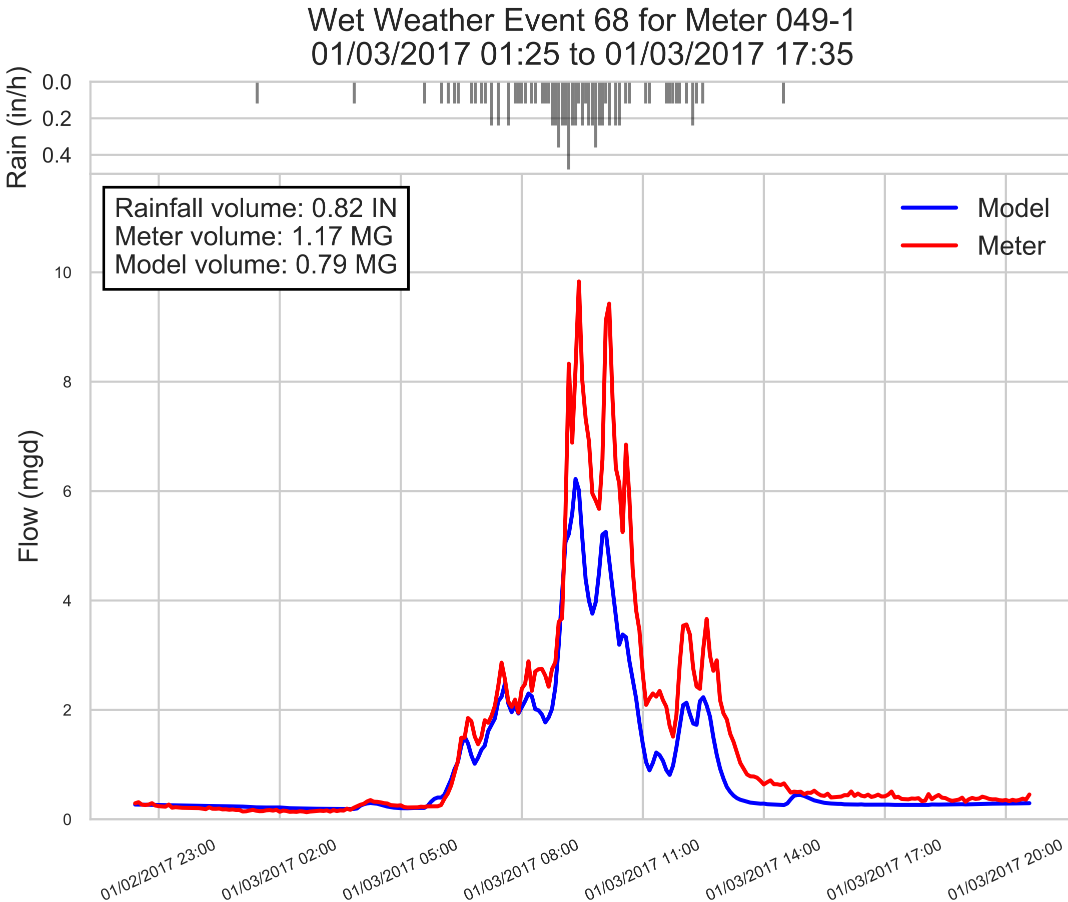
Wet Weather Event 65 for Meter 049-1
12/24/2016 03:54 to 12/24/2016 13:50
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.53 IN
Meter volume: 0.52 MG
Model volume: 0.44 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/24/2016 03:00
12/24/2016 06:00
12/24/2016 09:00
12/24/2016 12:00
12/24/2016 15:00



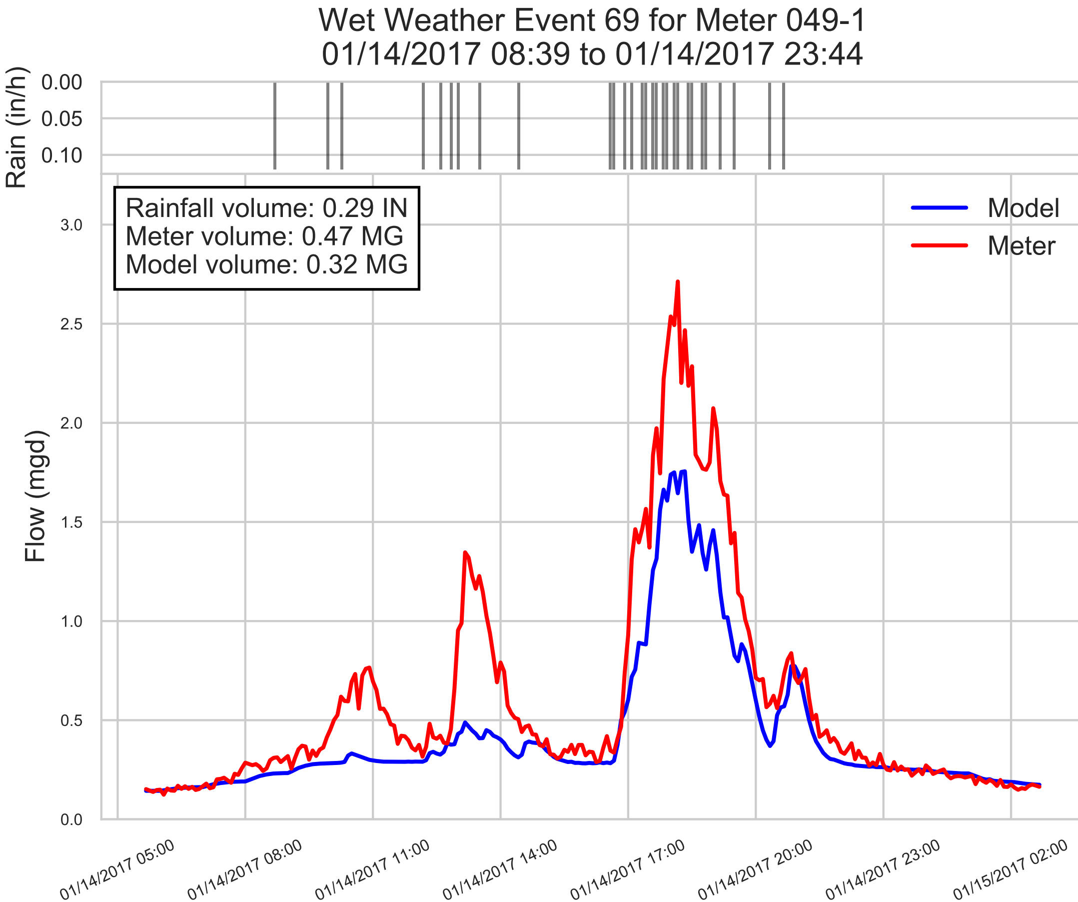
Wet Weather Event 66 for Meter 049-1
12/29/2016 04:39 to 12/29/2016 11:55
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.19 IN
Meter volume: 0.22 MG
Model volume: 0.16 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/29/2016 04:00
12/29/2016 07:00
12/29/2016 10:00
12/29/2016 13:00

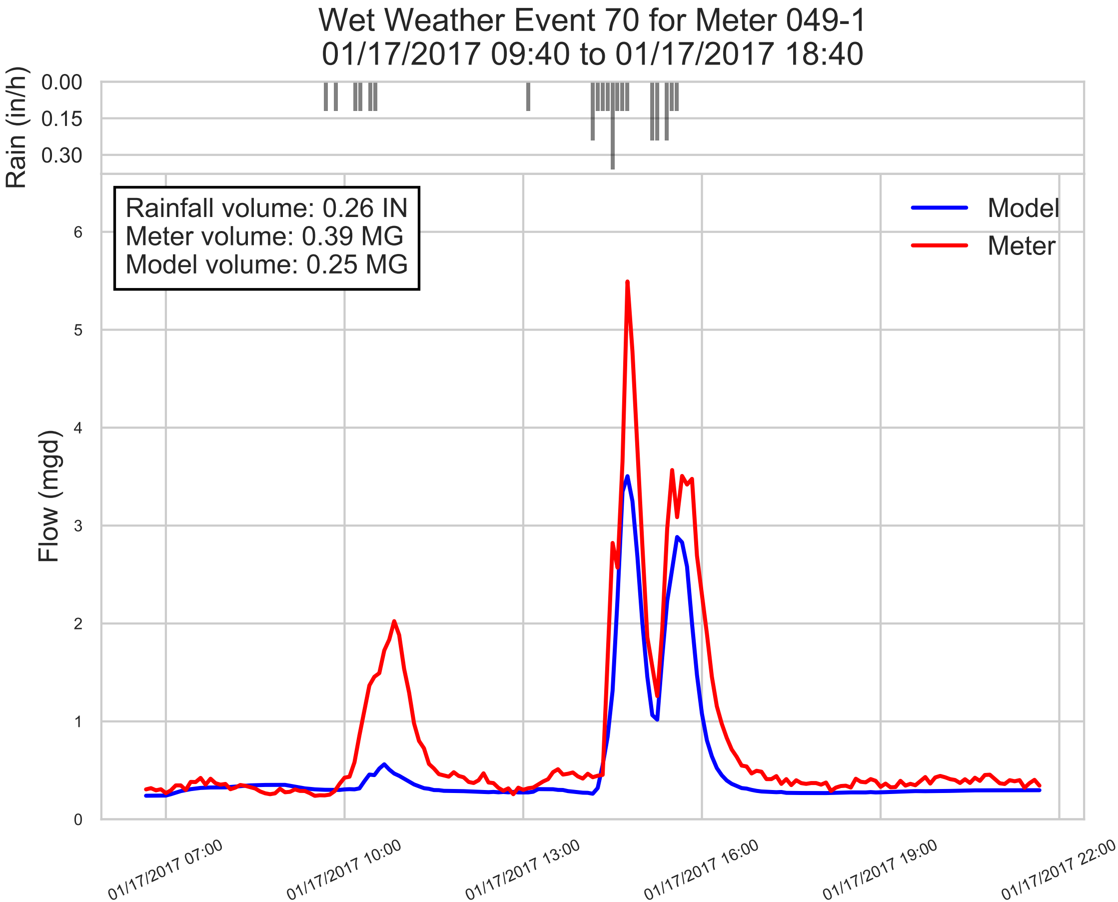


Wet Weather Event 67 for Meter 049-1
01/02/2017 01:59 to 01/02/2017 18:20
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.3 IN
Meter volume: 0.44 MG
Model volume: 0.32 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
01/02/2017 00:00
01/02/2017 03:00
01/02/2017 06:00
01/02/2017 09:00
01/02/2017 12:00
01/02/2017 15:00
01/02/2017 18:00
01/02/2017 21:00

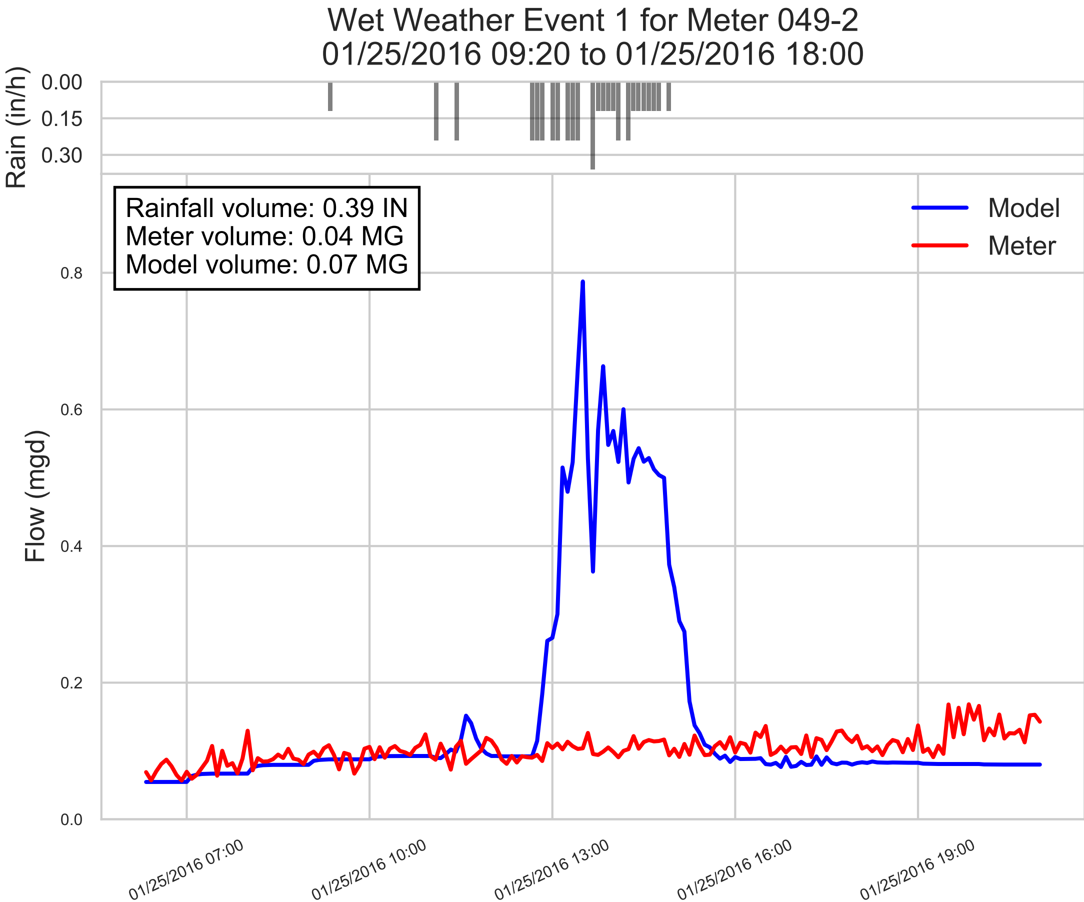


Wet Weather Event 68 for Meter 049-1
01/03/2017 01:25 to 01/03/2017 17:35
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.82 IN
Meter volume: 1.17 MG
Model volume: 0.79 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
01/02/2017 23:00
01/03/2017 02:00
01/03/2017 05:00
01/03/2017 08:00
01/03/2017 11:00
01/03/2017 14:00
01/03/2017 17:00
01/03/2017 20:00

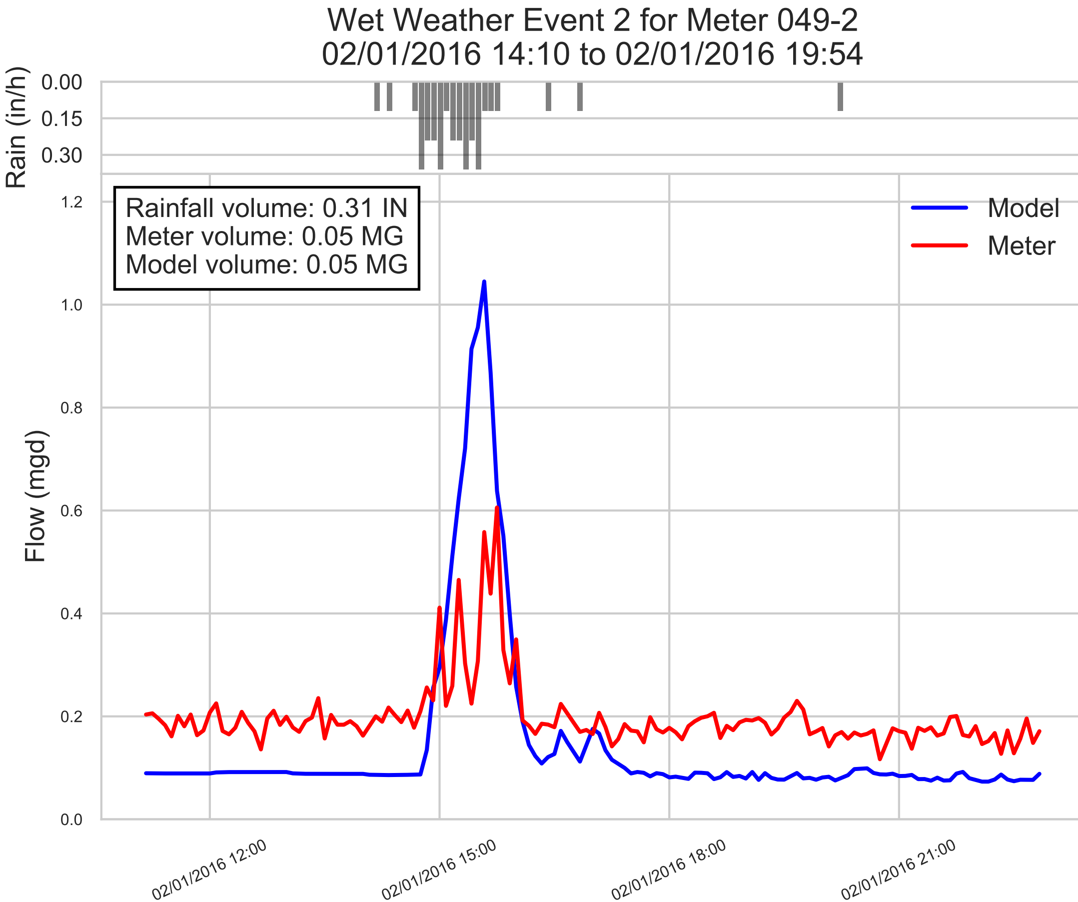

Wet Weather Event 69 for Meter 049-1
01/14/2017 08:39 to 01/14/2017 23:44
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.29 IN
Meter volume: 0.47 MG
Model volume: 0.32 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
01/14/2017 05:00
01/14/2017 08:00
01/14/2017 11:00
01/14/2017 14:00
01/14/2017 17:00
01/14/2017 20:00
01/14/2017 23:00
01/15/2017 02:00



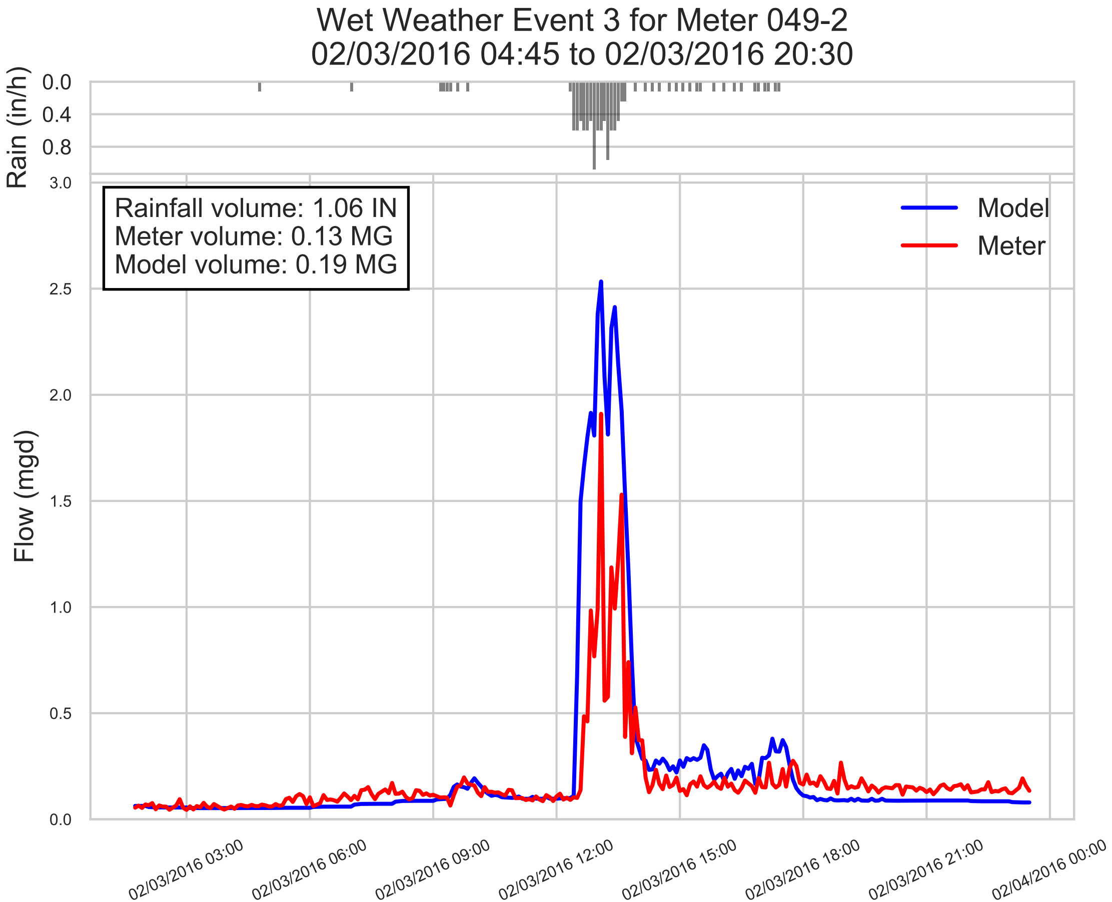
Wet Weather Event 70 for Meter 049-1
01/17/2017 09:40 to 01/17/2017 18:40
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.26 IN
Meter volume: 0.39 MG
Model volume: 0.25 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
01/17/2017 07:00
01/17/2017 10:00
01/17/2017 13:00
01/17/2017 16:00
01/17/2017 19:00
01/17/2017 22:00

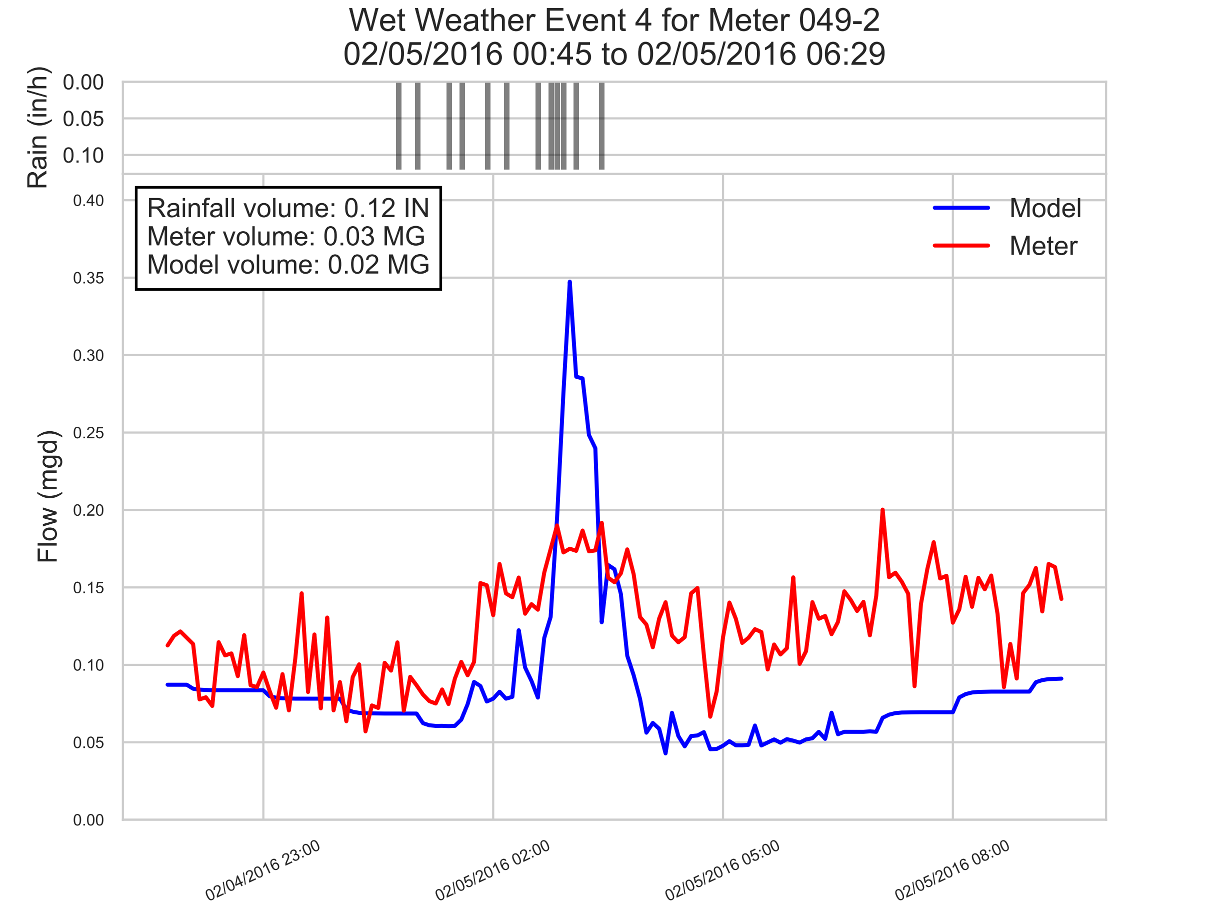


Wet Weather Event 1 for Meter 049-2
01/25/2016 09:20 to 01/25/2016 18:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.39 IN
Meter volume: 0.04 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
01/25/2016 07:00
01/25/2016 10:00
01/25/2016 13:00
01/25/2016 16:00
01/25/2016 19:00

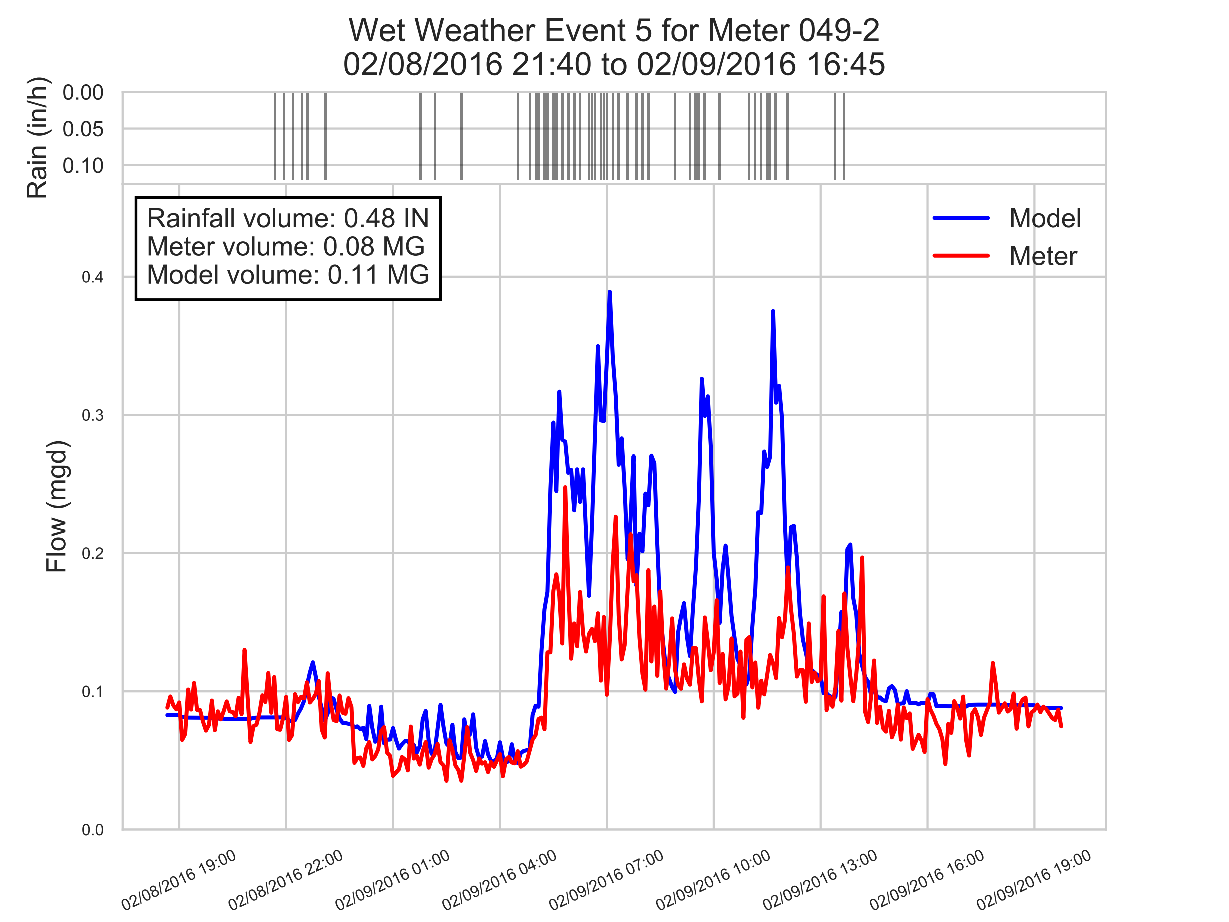


Wet Weather Event 2 for Meter 049-2
02/01/2016 14:10 to 02/01/2016 19:54
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.31 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
02/01/2016 12:00
02/01/2016 15:00
02/01/2016 18:00
02/01/2016 21:00

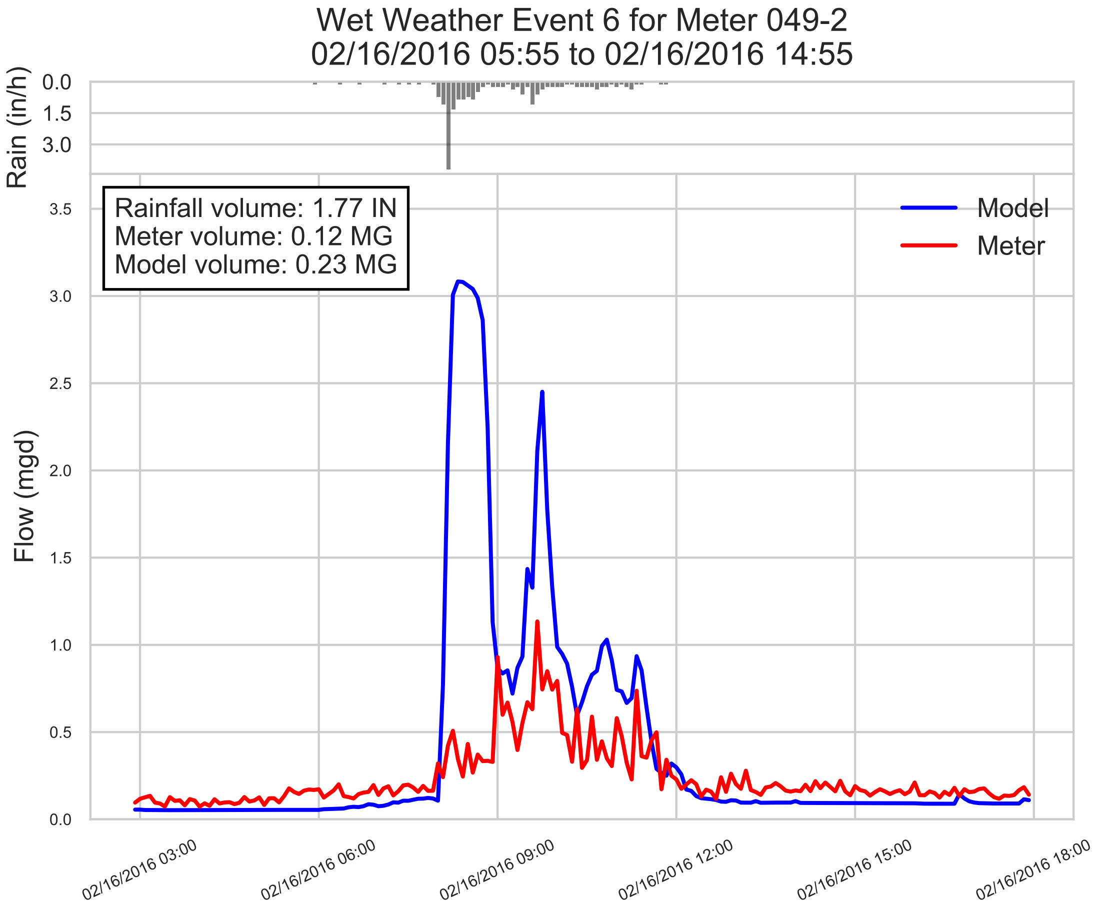

Wet Weather Event 3 for Meter 049-2
02/03/2016 04:45 to 02/03/2016 20:30
Rain (in/h)
0.0
0.4
0.8
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (mgd)
Rainfall volume: 1.06 IN
Meter volume: 0.13 MG
Model volume: 0.19 MG
Model
Meter
02/03/2016 03:00
02/03/2016 06:00
02/03/2016 09:00
02/03/2016 12:00
02/03/2016 15:00
02/03/2016 18:00
02/03/2016 21:00
02/04/2016 00:00



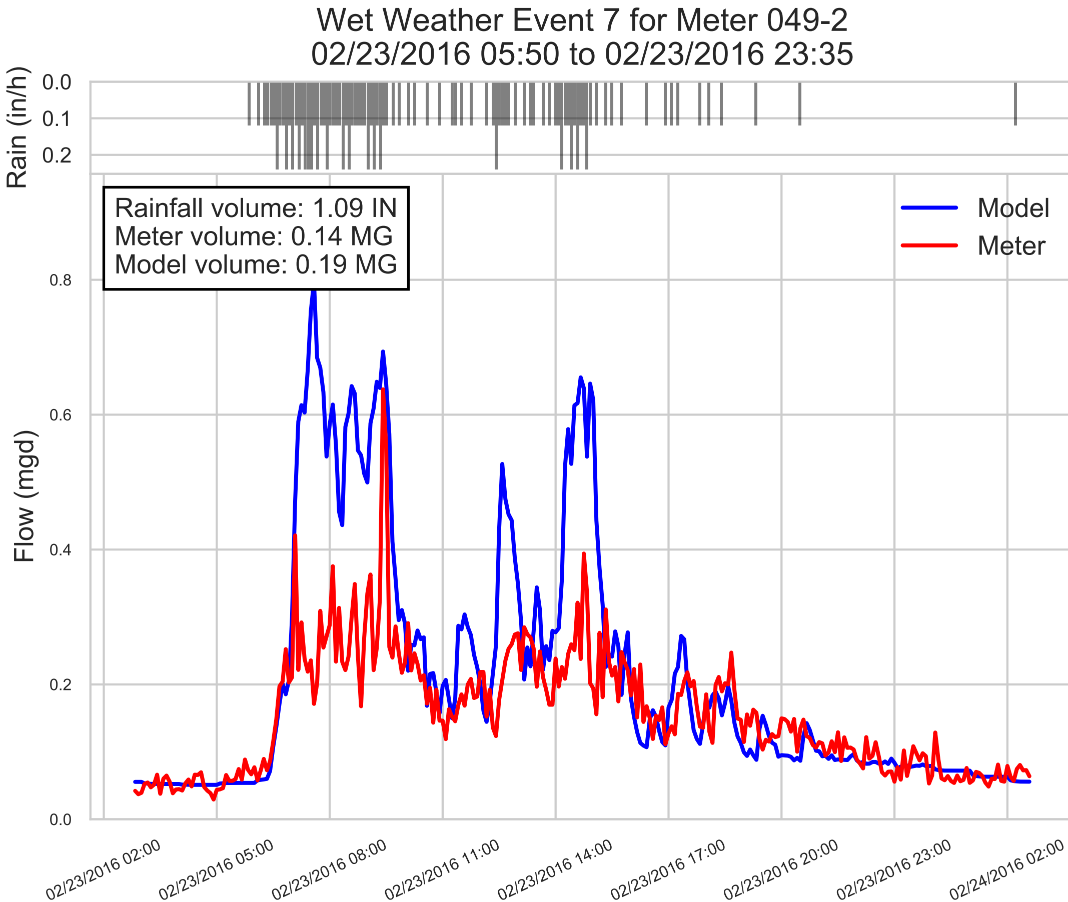
Wet Weather Event 4 for Meter 049-2
02/05/2016 00:45 to 02/05/2016 06:29
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall volume: 0.12 IN
Meter volume: 0.03 MG
Model volume: 0.02 MG
Model
Meter
02/04/2016 23:00
02/05/2016 02:00
02/05/2016 05:00
02/05/2016 08:00

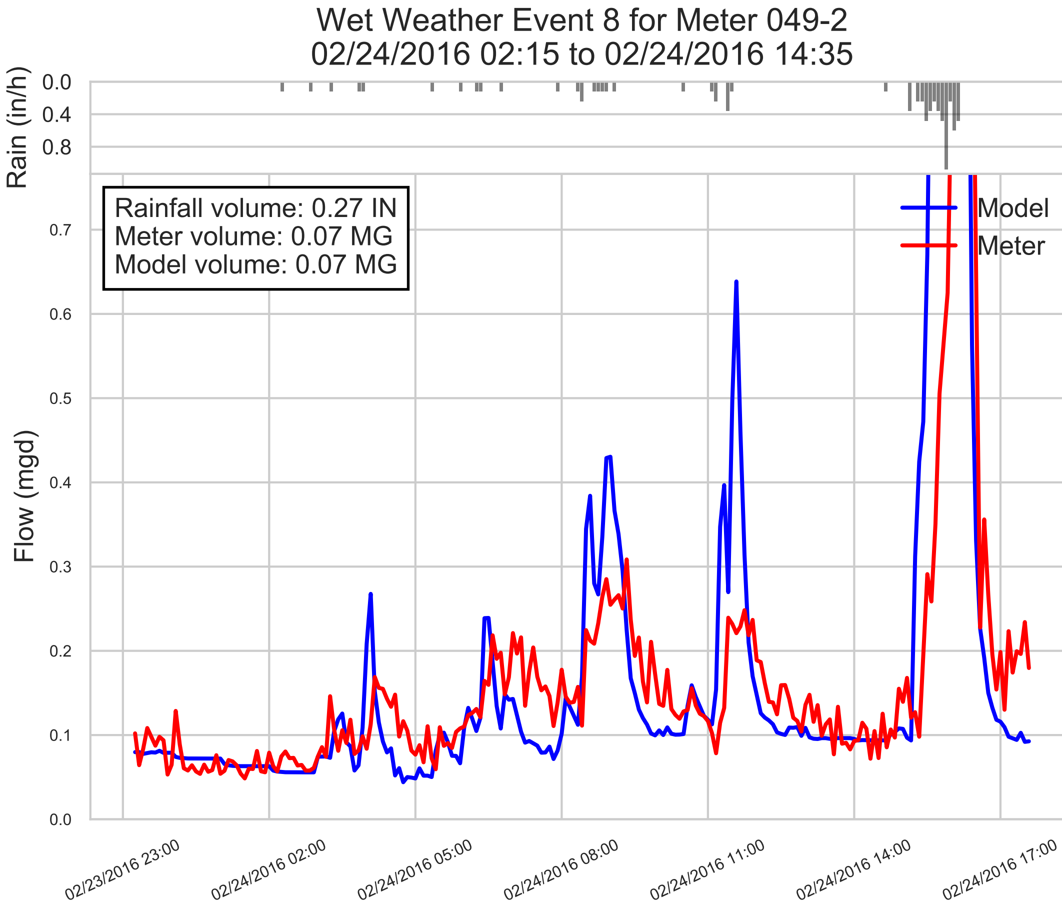


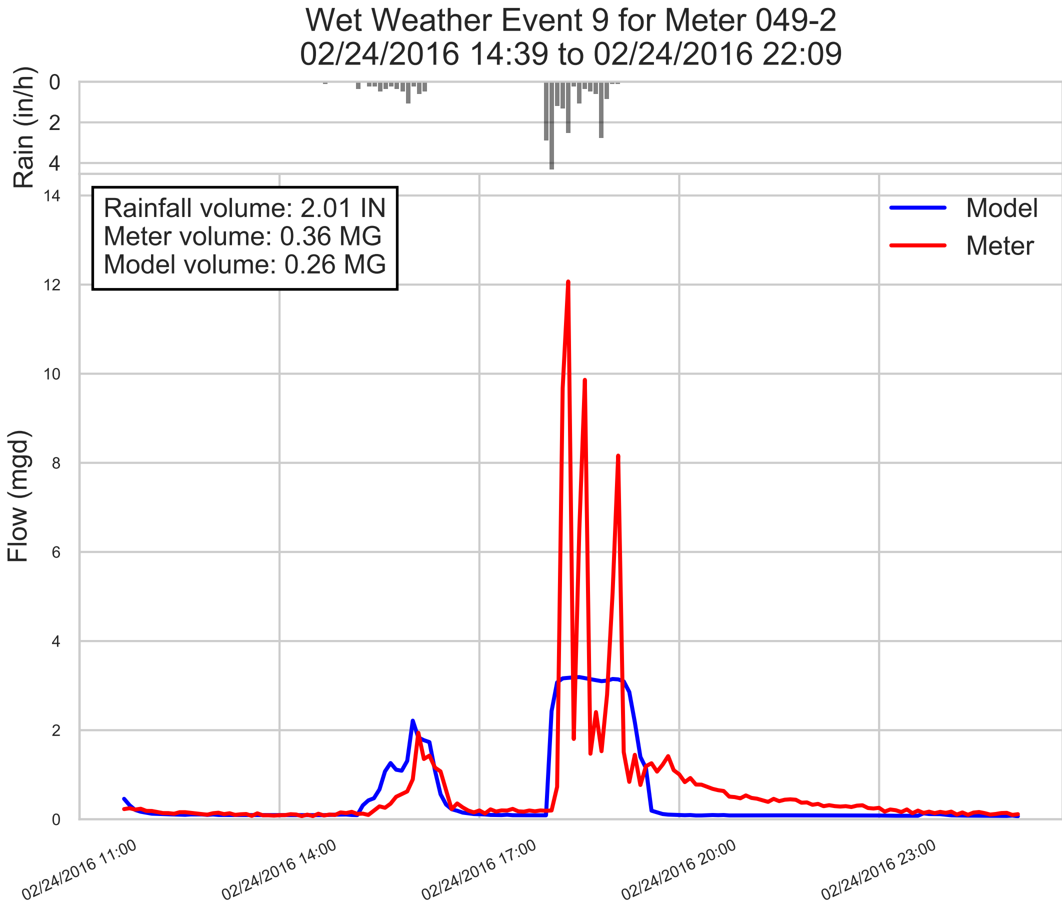
Wet Weather Event 5 for Meter 049-2
02/08/2016 21:40 to 02/09/2016 16:45
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.48 IN
Meter volume: 0.08 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
02/08/2016 19:00
02/08/2016 22:00
02/09/2016 01:00
02/09/2016 04:00
02/09/2016 07:00
02/09/2016 10:00
02/09/2016 13:00
02/09/2016 16:00
02/09/2016 19:00



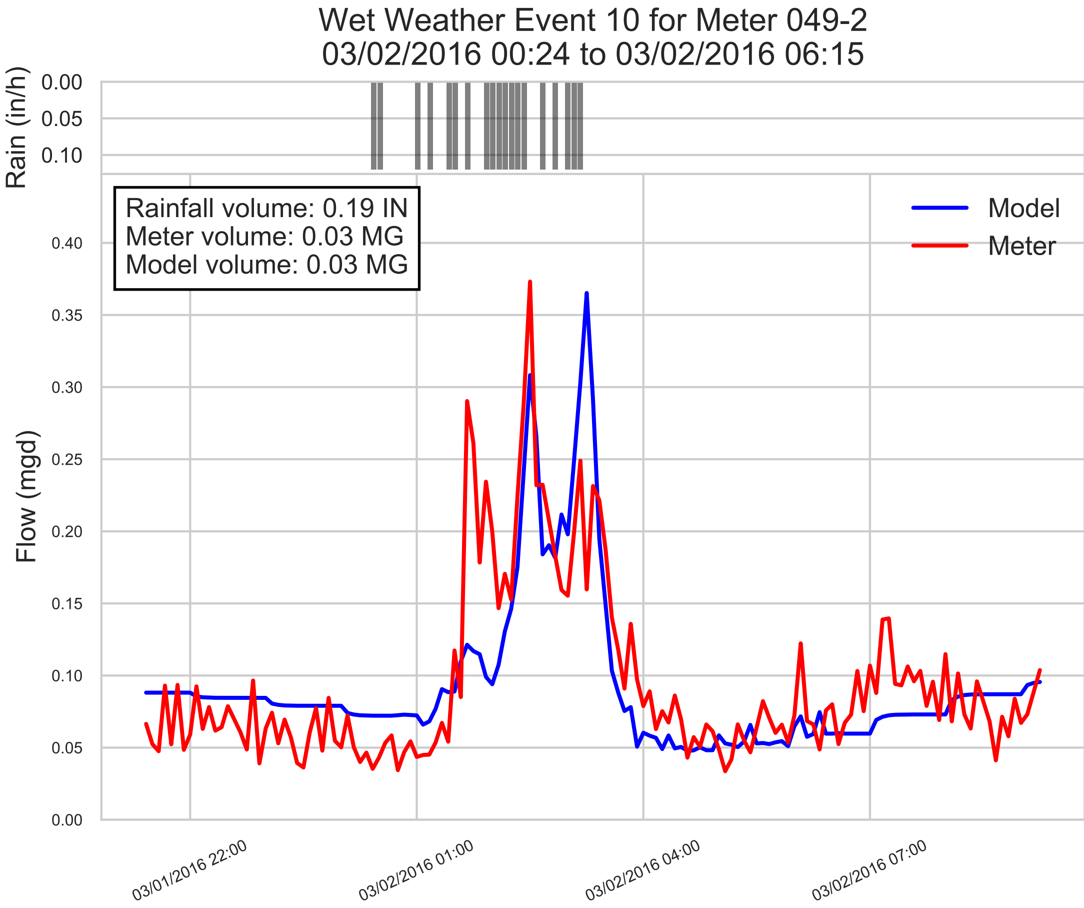
Wet Weather Event 6 for Meter 049-2
02/16/2016 05:55 to 02/16/2016 14:55
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.77 IN
Meter volume: 0.12 MG
Model volume: 0.23 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
02/16/2016 03:00
02/16/2016 06:00
02/16/2016 09:00
02/16/2016 12:00
02/16/2016 15:00
02/16/2016 18:00


Wet Weather Event 7 for Meter 049-2
02/23/2016 05:50 to 02/23/2016 23:35
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 1.09 IN
Meter volume: 0.14 MG
Model volume: 0.19 MG
Model
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
02/23/2016 02:00
02/23/2016 05:00
02/23/2016 08:00
02/23/2016 11:00
02/23/2016 14:00
02/23/2016 17:00
02/23/2016 20:00
02/23/2016 23:00
02/24/2016 02:00

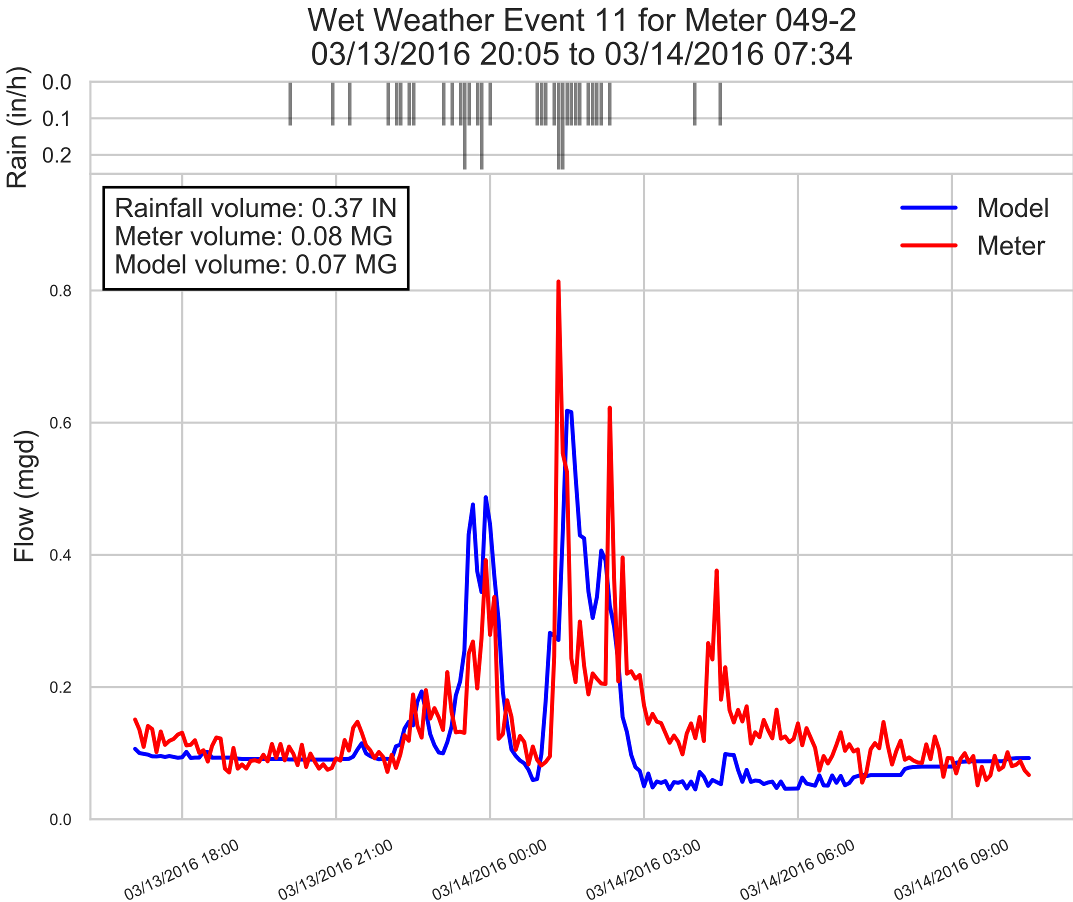

Wet Weather Event 8 for Meter 049-2
02/24/2016 02:15 to 02/24/2016 14:35
Rain (in/h)
0.0
0.4
0.8
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Rainfall volume: 0.27 IN
Meter volume: 0.07 MG
Model volume: 0.07 MG
Model
Meter
02/23/2016 23:00
02/24/2016 02:00
02/24/2016 05:00
02/24/2016 08:00
02/24/2016 11:00
02/24/2016 14:00
02/24/2016 17:00

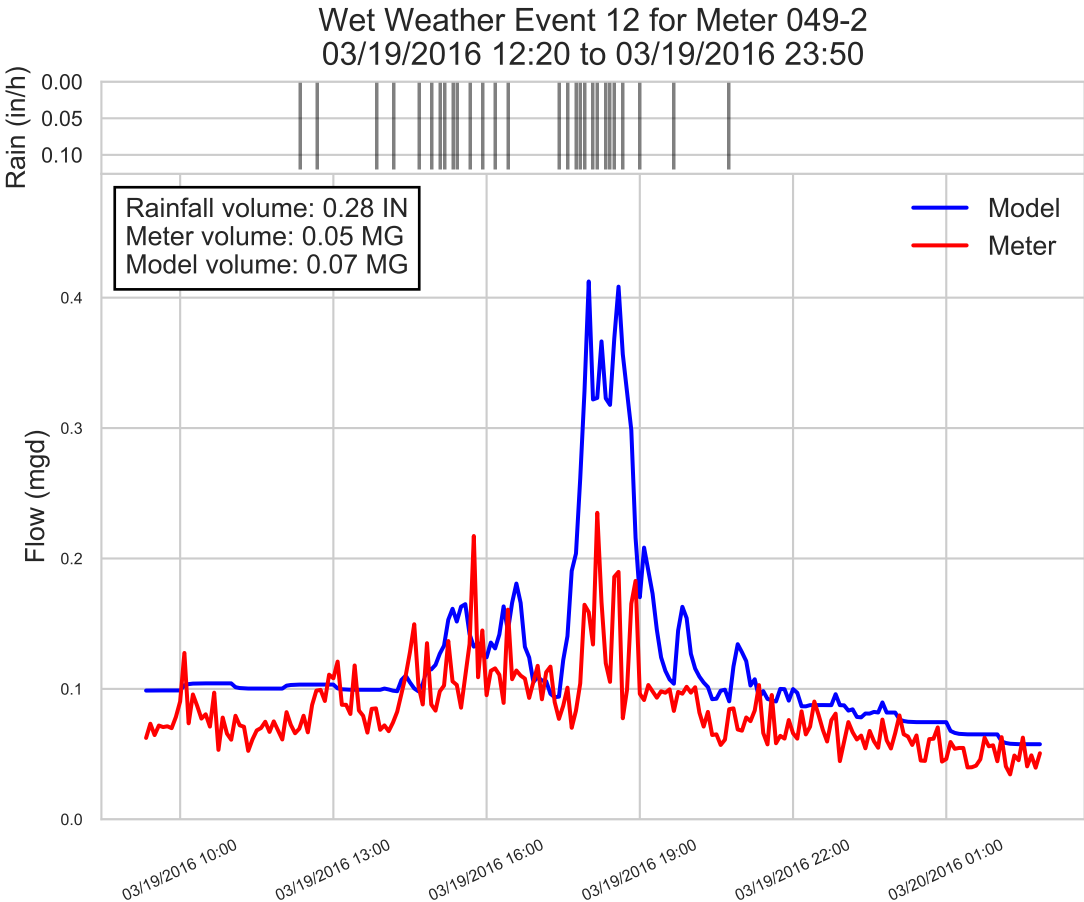


Wet Weather Event 9 for Meter 049-2
02/24/2016 14:39 to 02/24/2016 22:09
Rain (in/h)
0
2
4
Rainfall volume: 2.01 IN
Meter volume: 0.36 MG
Model volume: 0.26 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
02/24/2016 11:00
02/24/2016 14:00
02/24/2016 17:00
02/24/2016 20:00
02/24/2016 23:00

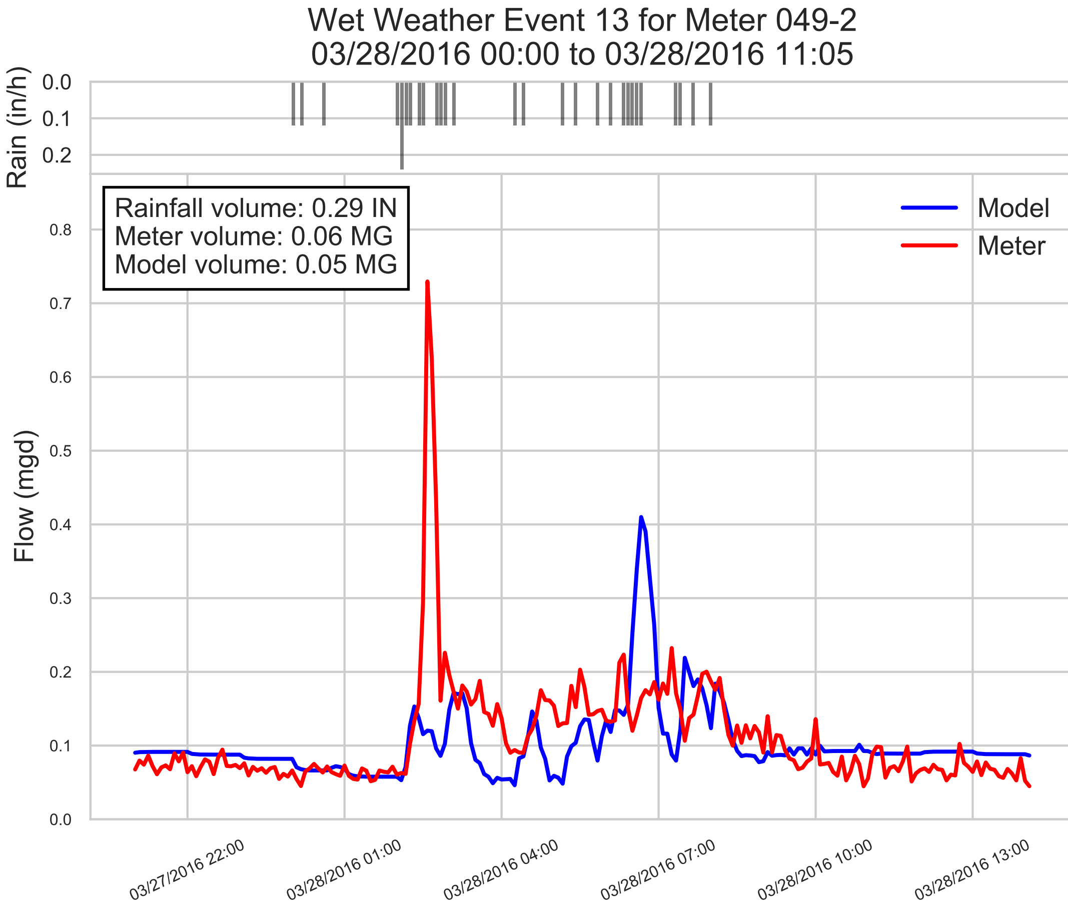


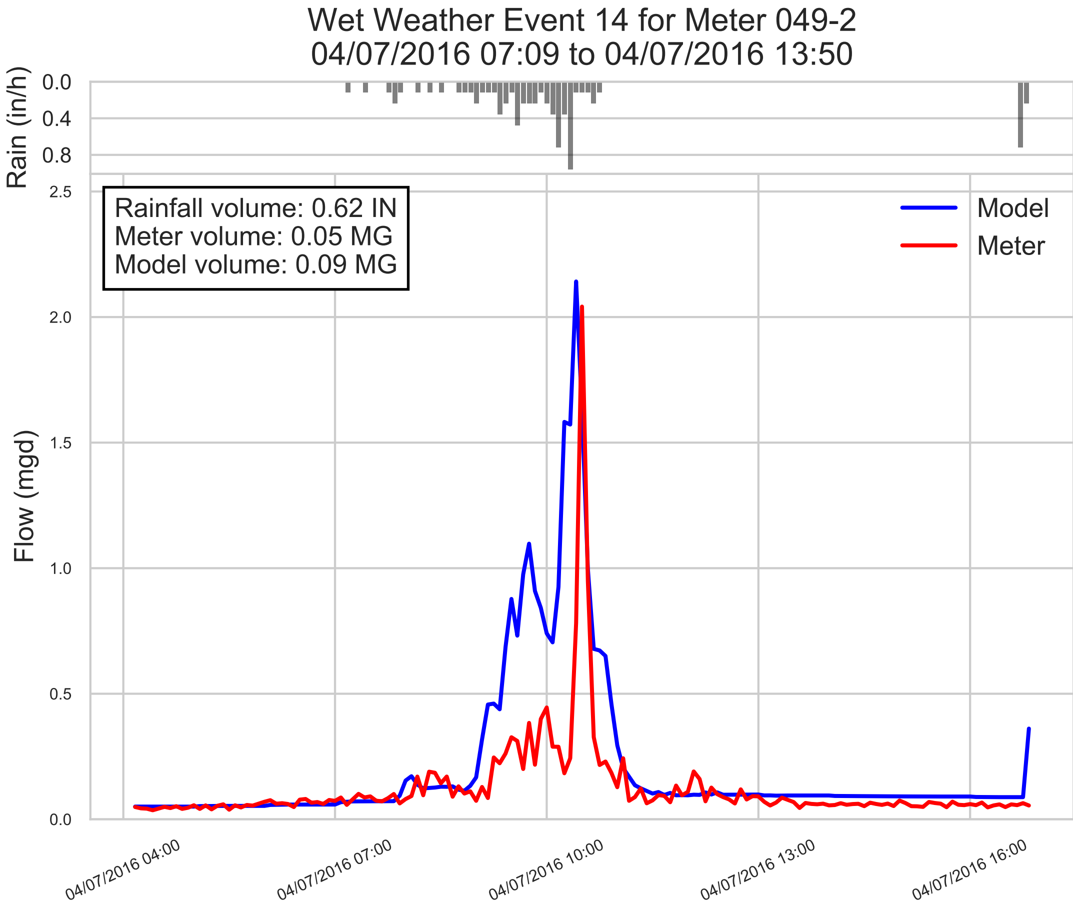
Wet Weather Event 10 for Meter 049-2
03/02/2016 00:24 to 03/02/2016 06:15
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.19 IN
Meter volume: 0.03 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
03/01/2016 22:00
03/02/2016 01:00
03/02/2016 04:00
03/02/2016 07:00

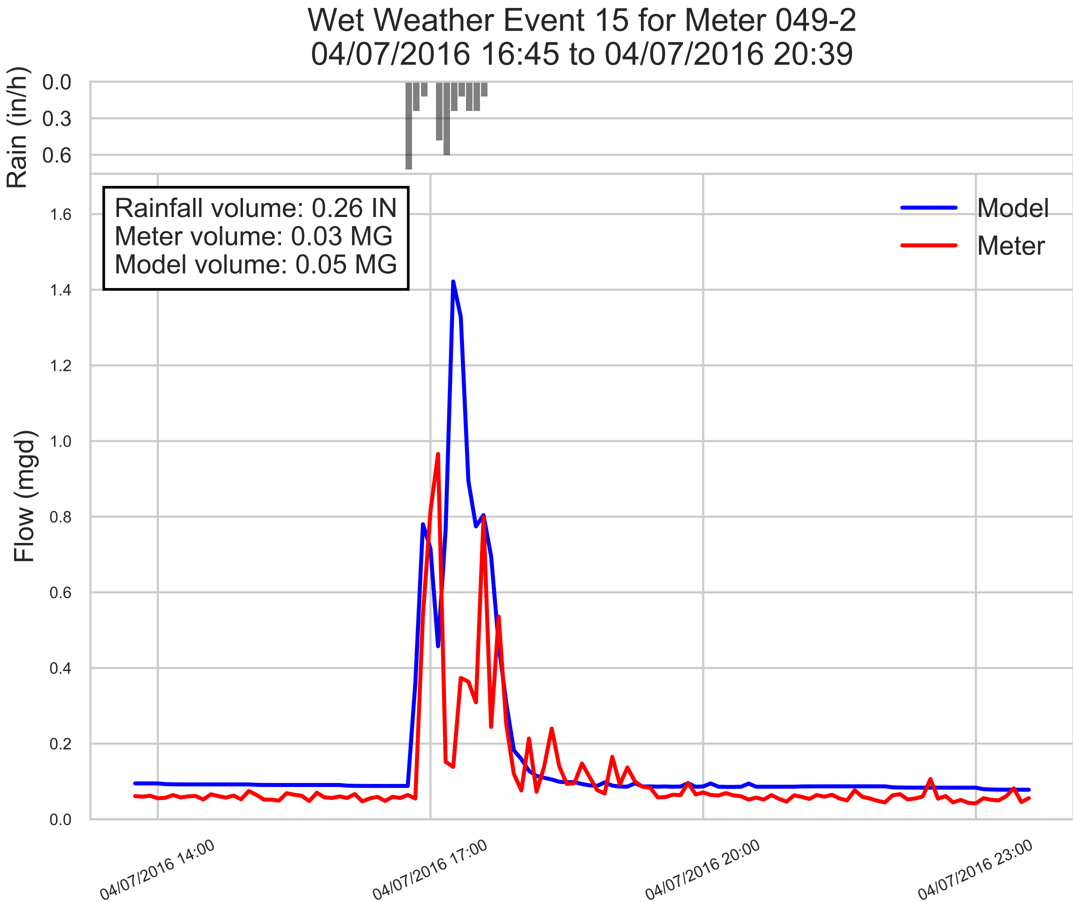

Wet Weather Event 11 for Meter 049-2
03/13/2016 20:05 to 03/14/2016 07:34
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.37 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
03/13/2016 18:00
03/13/2016 21:00
03/14/2016 00:00
03/14/2016 03:00
03/14/2016 06:00
03/14/2016 09:00



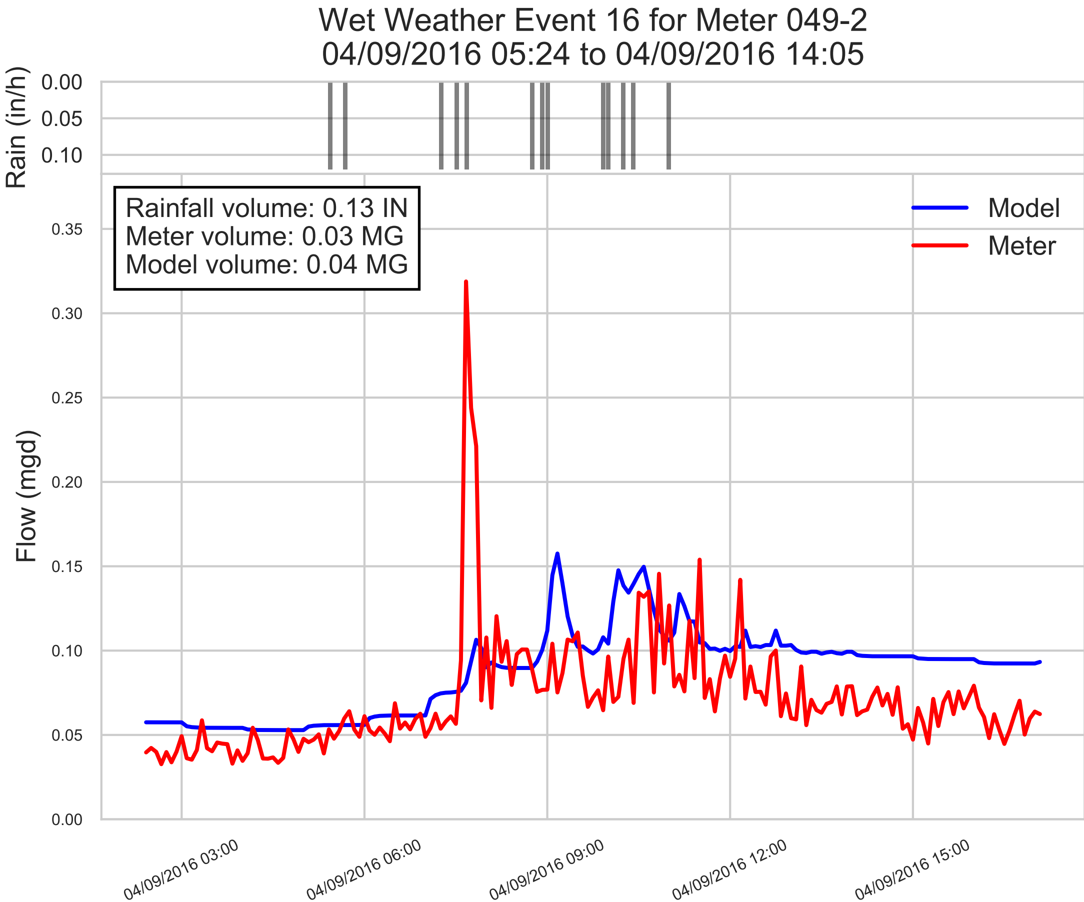
Wet Weather Event 12 for Meter 049-2
03/19/2016 12:20 to 03/19/2016 23:50
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.05 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
03/19/2016 10:00
03/19/2016 13:00
03/19/2016 16:00
03/19/2016 19:00
03/19/2016 22:00
03/20/2016 01:00


Wet Weather Event 13 for Meter 049-2
03/28/2016 00:00 to 03/28/2016 11:05
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.06 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
03/27/2016 22:00
03/28/2016 01:00
03/28/2016 04:00
03/28/2016 07:00
03/28/2016 10:00
03/28/2016 13:00

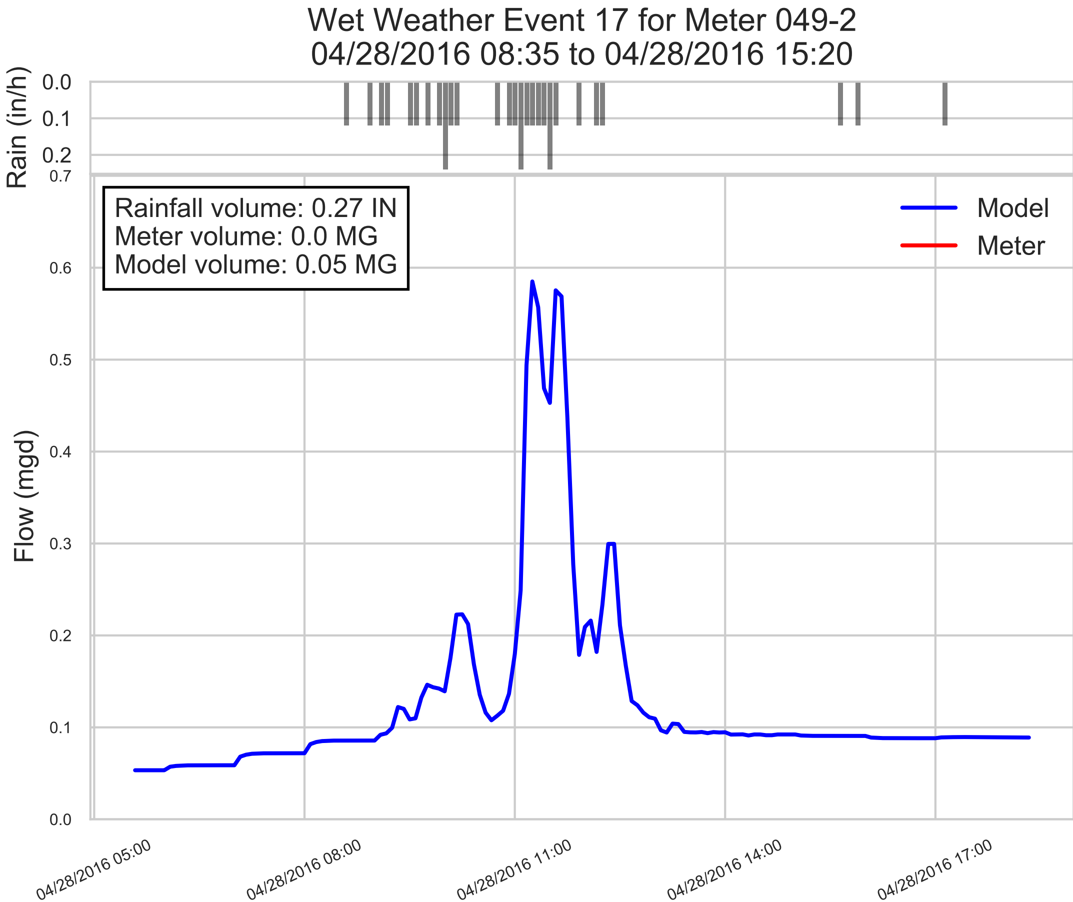

Wet Weather Event 14 for Meter 049-2
04/07/2016 07:09 to 04/07/2016 13:50
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.62 IN
Meter volume: 0.05 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
04/07/2016 04:00
04/07/2016 07:00
04/07/2016 10:00
04/07/2016 13:00
04/07/2016 16:00



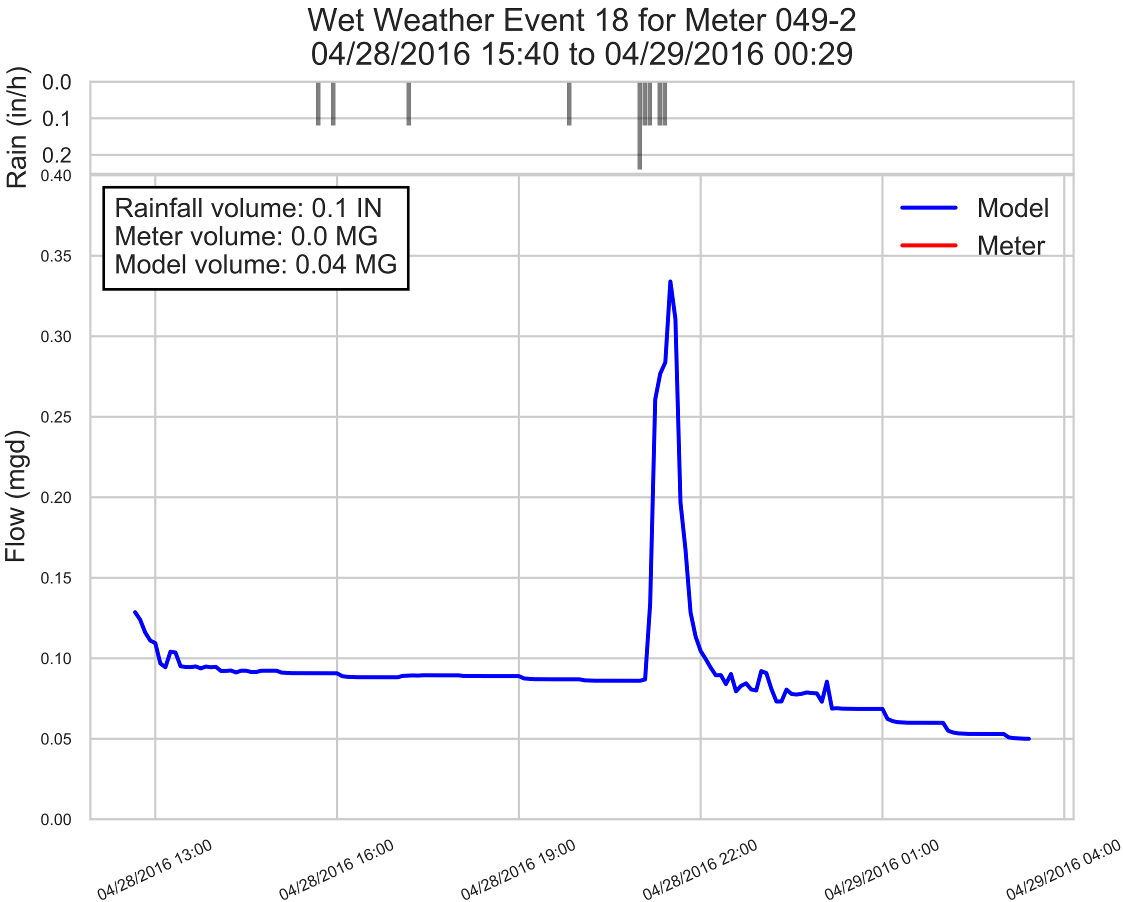
Wet Weather Event 15 for Meter 049-2
04/07/2016 16:45 to 04/07/2016 20:39
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.26 IN
Meter volume: 0.03 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
04/07/2016 14:00
04/07/2016 17:00
04/07/2016 20:00
04/07/2016 23:00



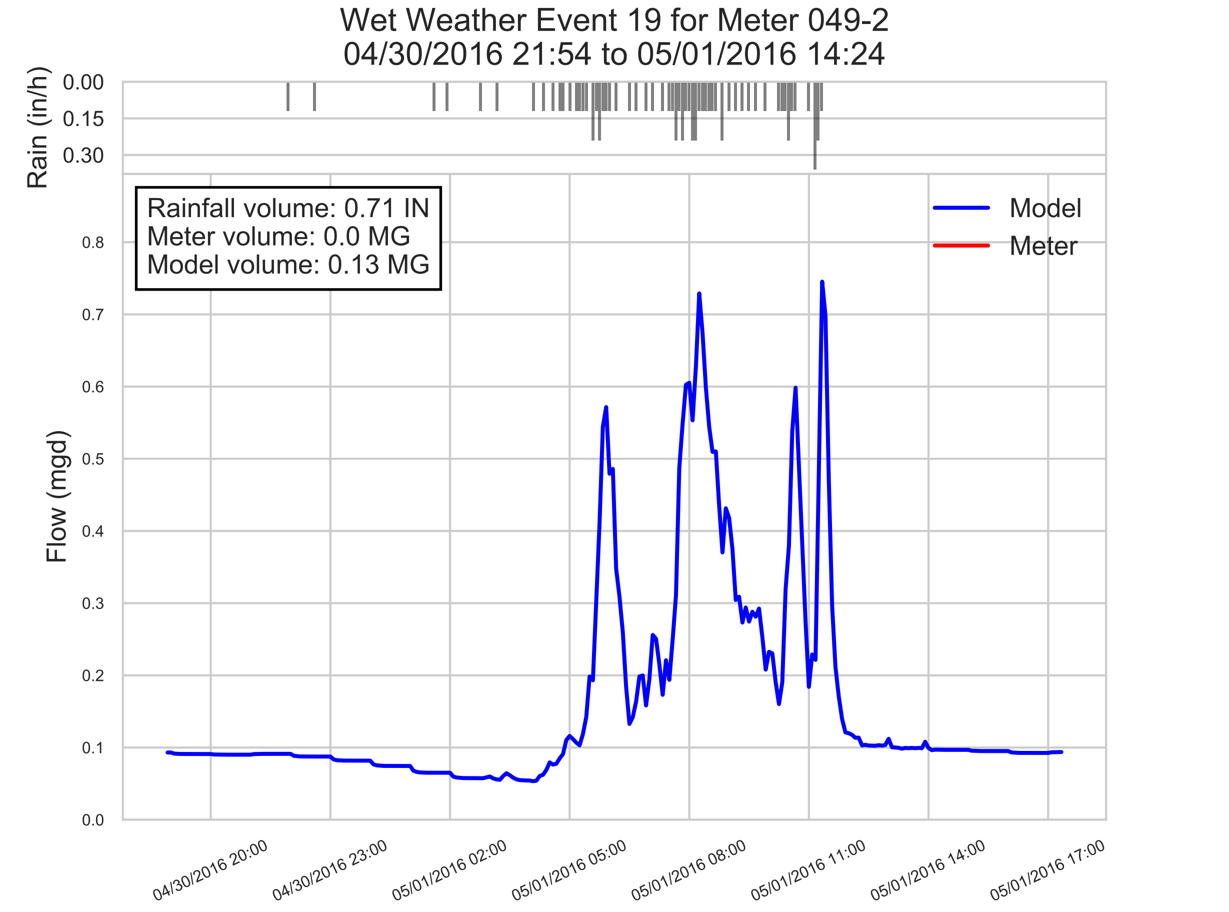
Wet Weather Event 16 for Meter 049-2
04/09/2016 05:24 to 04/09/2016 14:05
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.13 IN
Meter volume: 0.03 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
04/09/2016 03:00
04/09/2016 06:00
04/09/2016 09:00
04/09/2016 12:00
04/09/2016 15:00

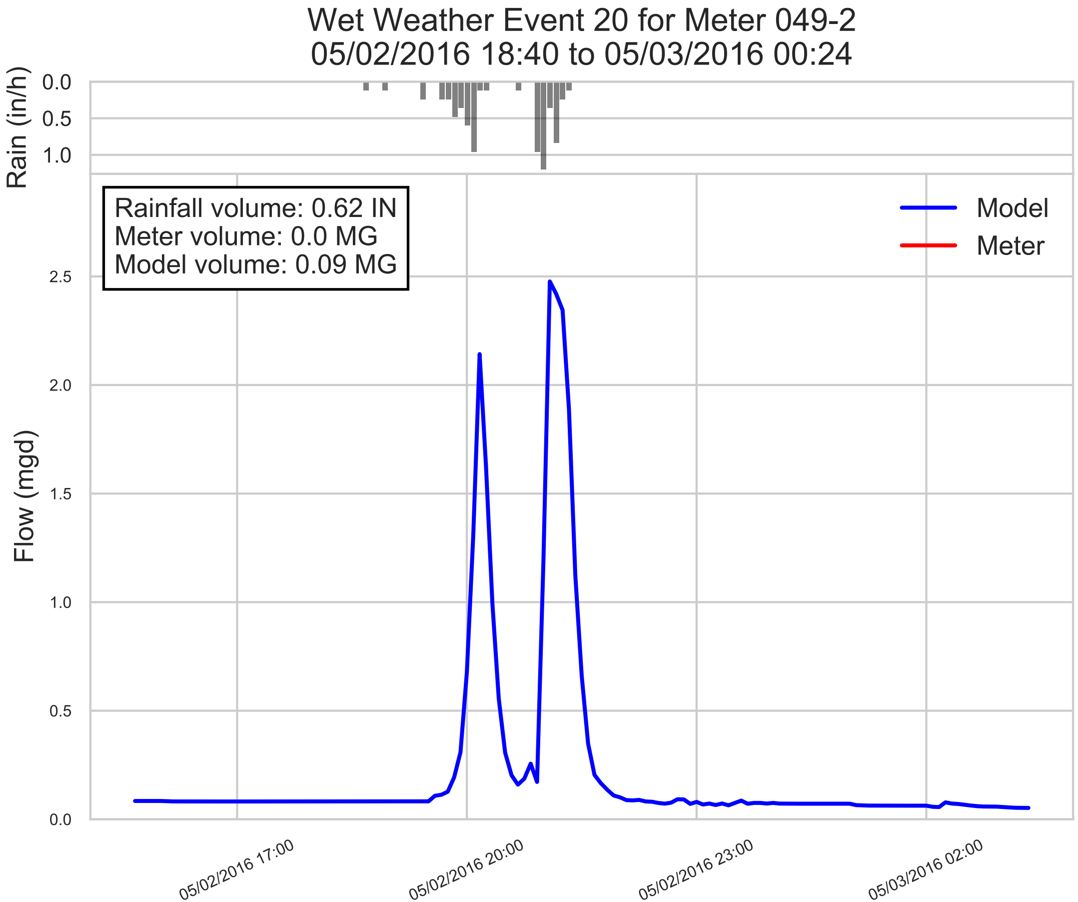


Wet Weather Event 17 for Meter 049-2
04/28/2016 08:35 to 04/28/2016 15:20
Rain (in/h)
0.0
0.1
0.2
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (mgd)
Rainfall volume: 0.27 IN
Meter volume: 0.0 MG
Model volume: 0.05 MG
Model
Meter
04/28/2016 05:00
04/28/2016 08:00
04/28/2016 11:00
04/28/2016 14:00
04/28/2016 17:00

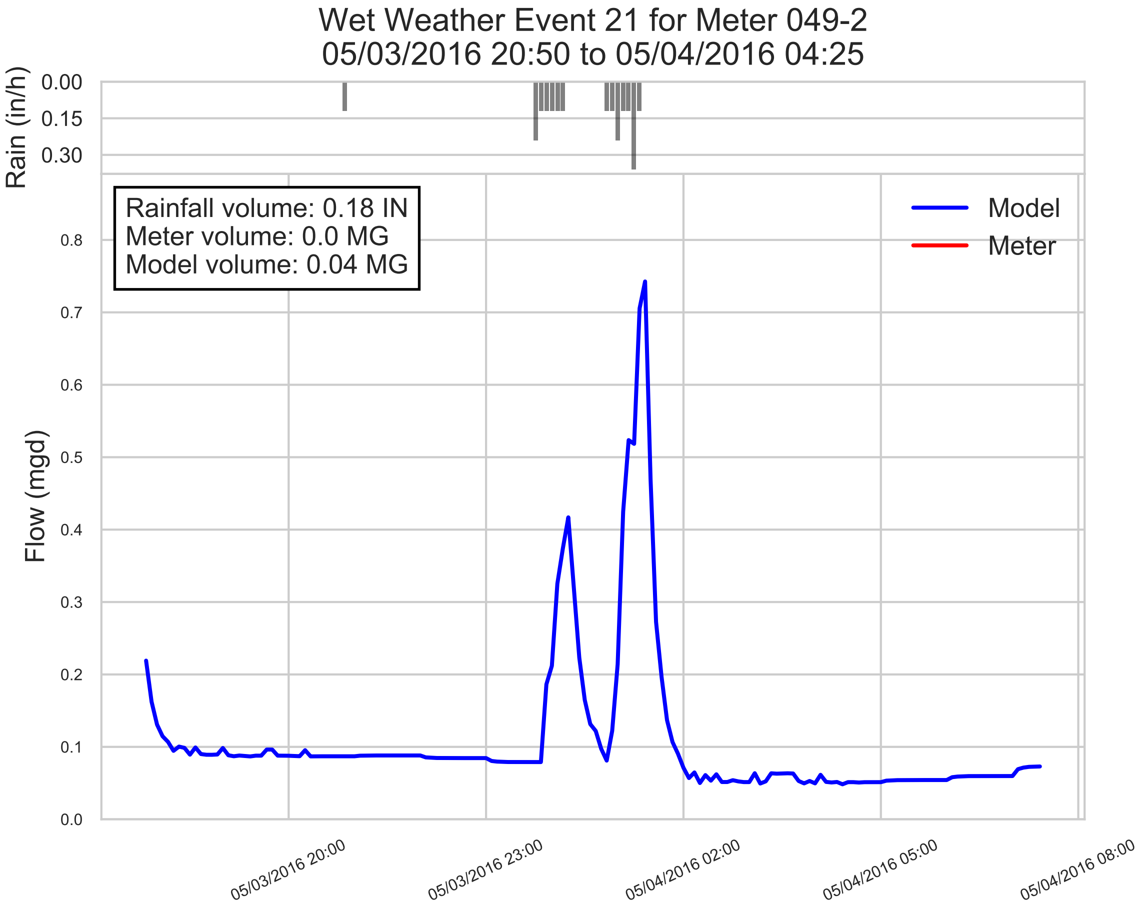


Wet Weather Event 18 for Meter 049-2
04/28/2016 15:40 to 04/29/2016 00:29
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.1 IN
Meter volume: 0.0 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
04/28/2016 13:00
04/28/2016 16:00
04/28/2016 19:00
04/28/2016 22:00
04/29/2016 01:00
04/29/2016 04:00

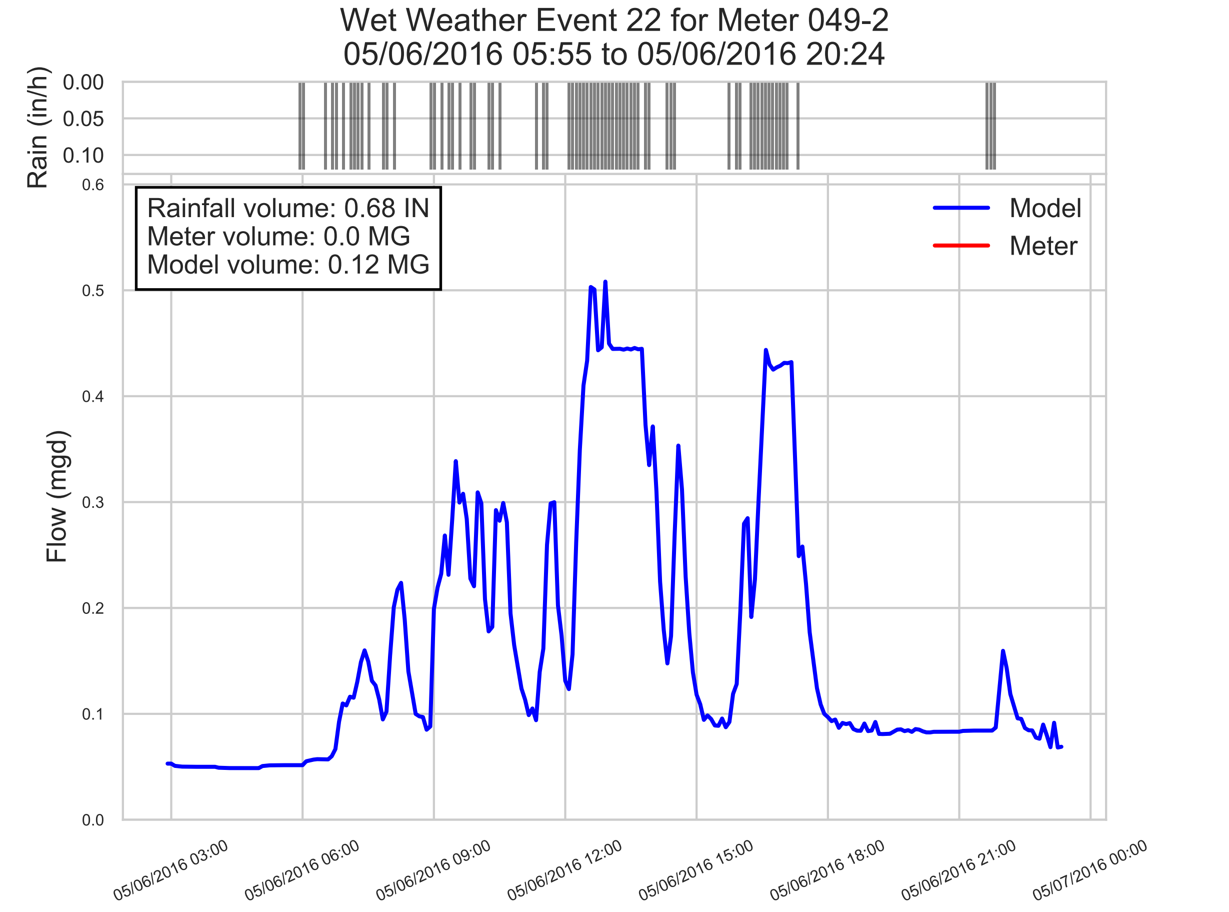

Wet Weather Event 19 for Meter 049-2
04/30/2016 21:54 to 05/01/2016 14:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.71 IN
Meter volume: 0.0 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
04/30/2016 20:00
04/30/2016 23:00
05/01/2016 02:00
05/01/2016 05:00
05/01/2016 08:00
05/01/2016 11:00
05/01/2016 14:00
05/01/2016 17:00



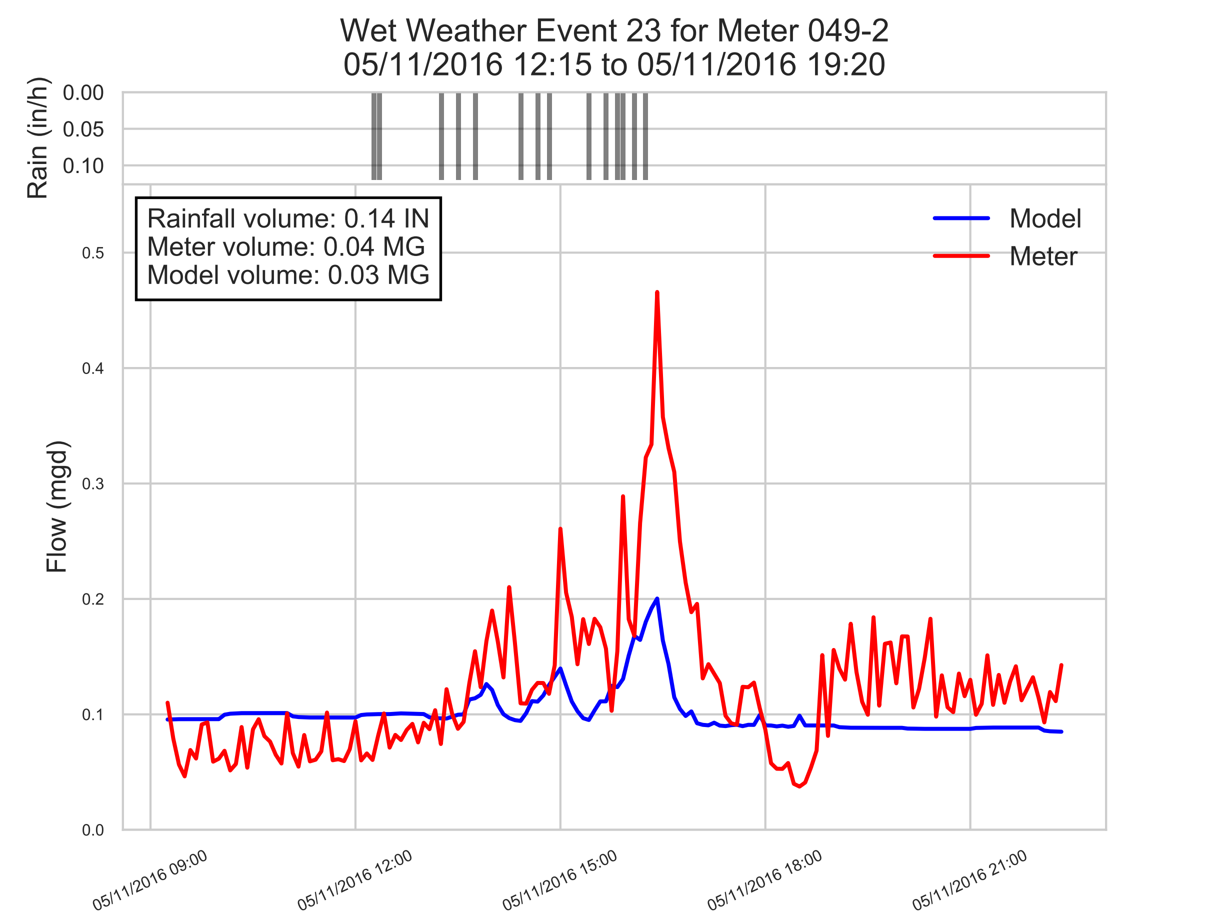
Wet Weather Event 20 for Meter 049-2
05/02/2016 18:40 to 05/03/2016 00:24
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.62 IN
Meter volume: 0.0 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
05/02/2016 17:00
05/02/2016 20:00
05/02/2016 23:00
05/03/2016 02:00

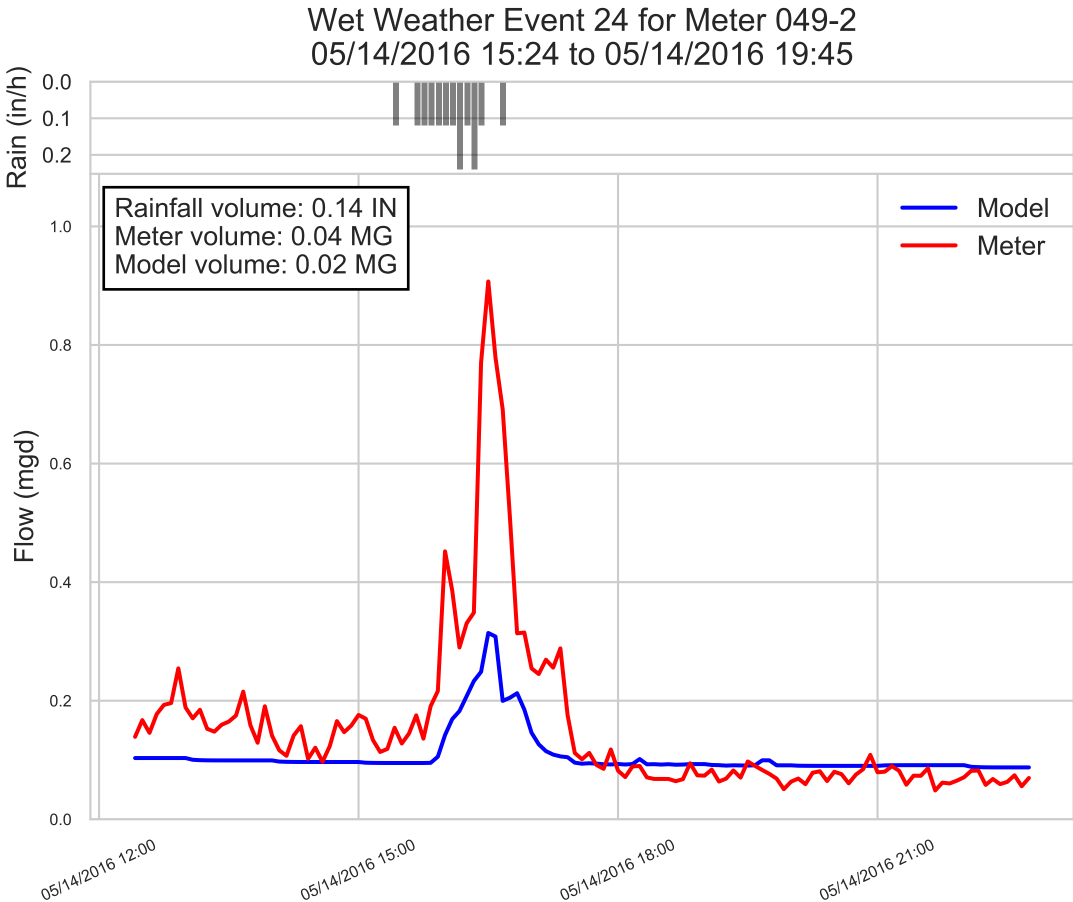


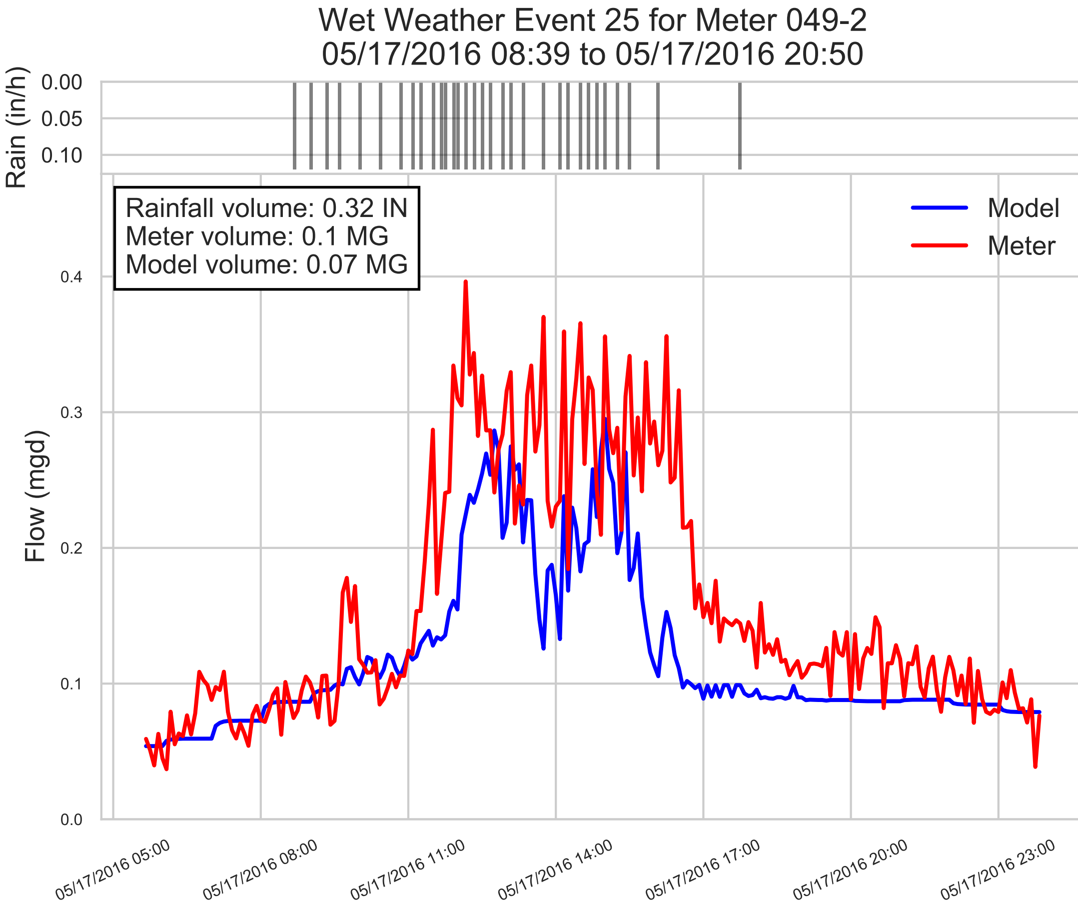
Wet Weather Event 21 for Meter 049-2
05/03/2016 20:50 to 05/04/2016 04:25
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.18 IN
Meter volume: 0.0 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
05/03/2016 20:00
05/03/2016 23:00
05/04/2016 02:00
05/04/2016 05:00
05/04/2016 08:00



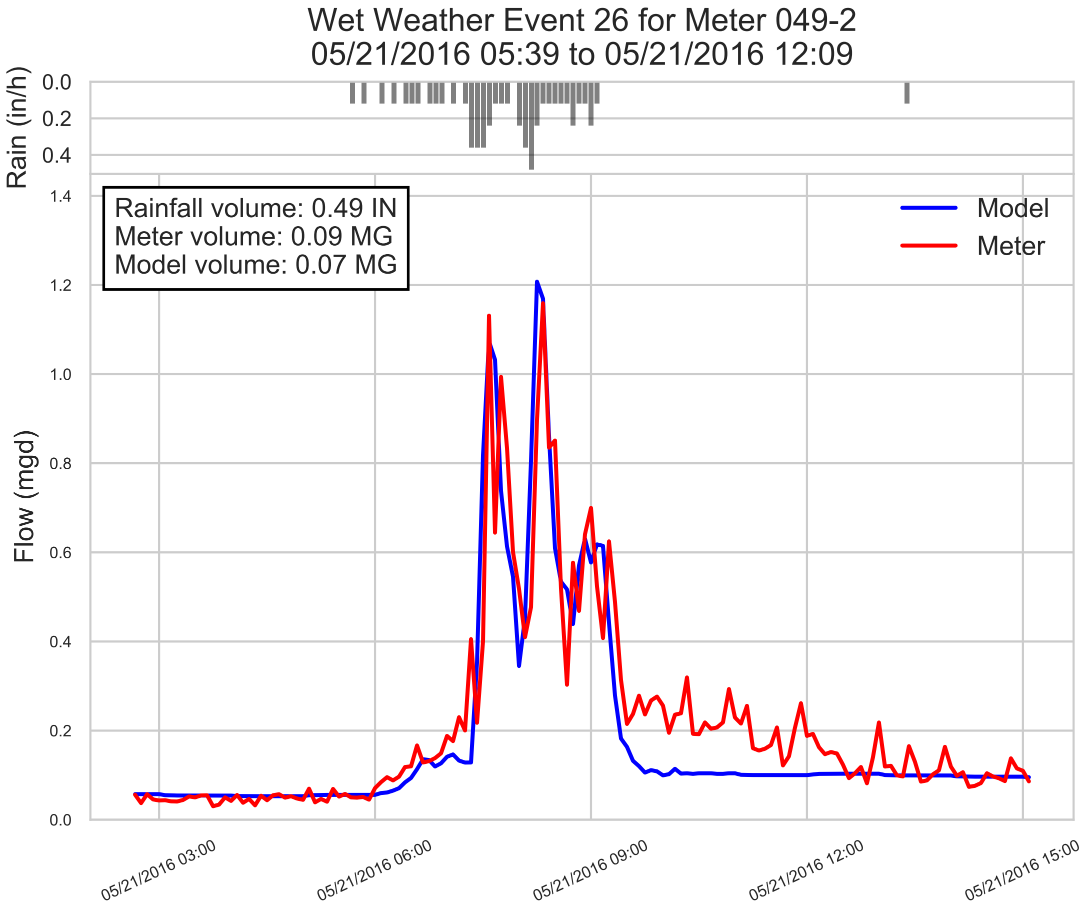
Wet Weather Event 22 for Meter 049-2
05/06/2016 05:55 to 05/06/2016 20:24
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.68 IN
Meter volume: 0.0 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
05/06/2016 03:00
05/06/2016 06:00
05/06/2016 09:00
05/06/2016 12:00
05/06/2016 15:00
05/06/2016 18:00
05/06/2016 21:00
05/07/2016 00:00

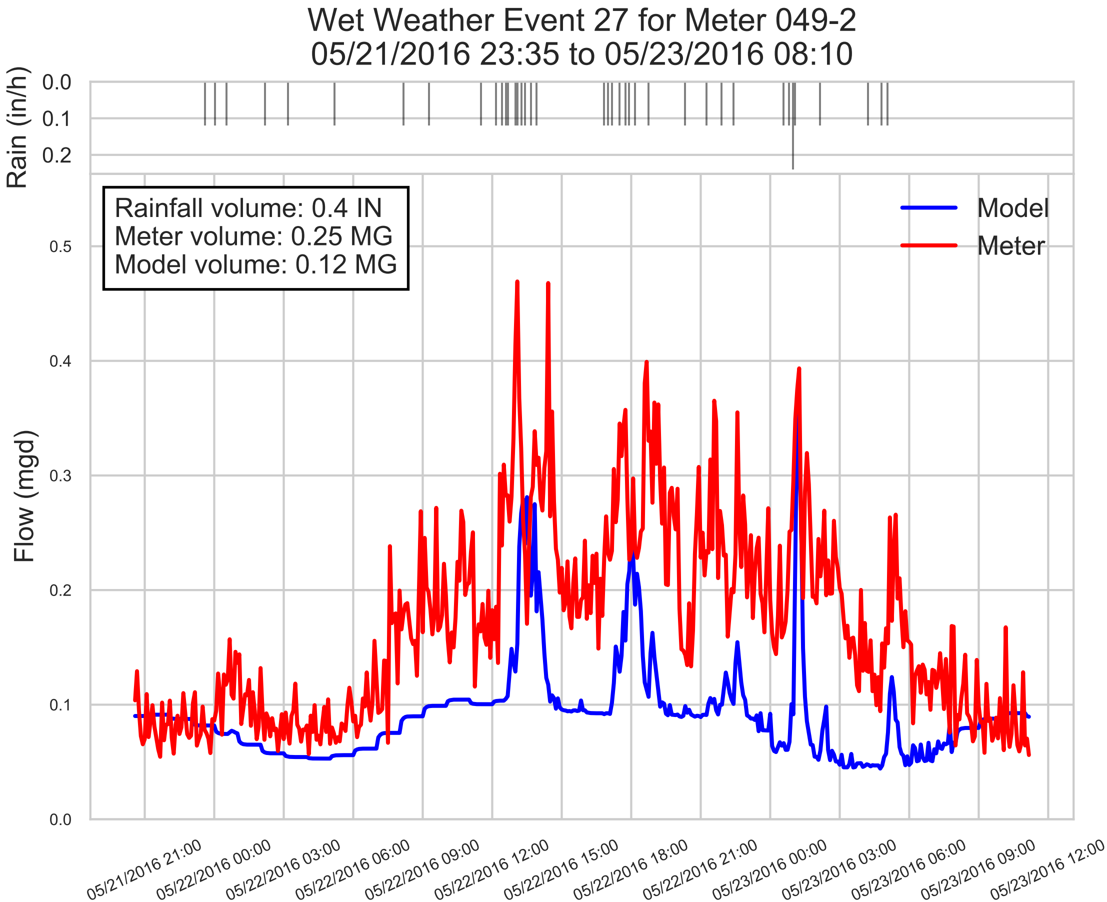

Wet Weather Event 23 for Meter 049-2
05/11/2016 12:15 to 05/11/2016 19:20
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.14 IN
Meter volume: 0.04 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
05/11/2016 09:00
05/11/2016 12:00
05/11/2016 15:00
05/11/2016 18:00
05/11/2016 21:00


Wet Weather Event 24 for Meter 049-2
05/14/2016 15:24 to 05/14/2016 19:45
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.14 IN
Meter volume: 0.04 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
05/14/2016 12:00
05/14/2016 15:00
05/14/2016 18:00
05/14/2016 21:00

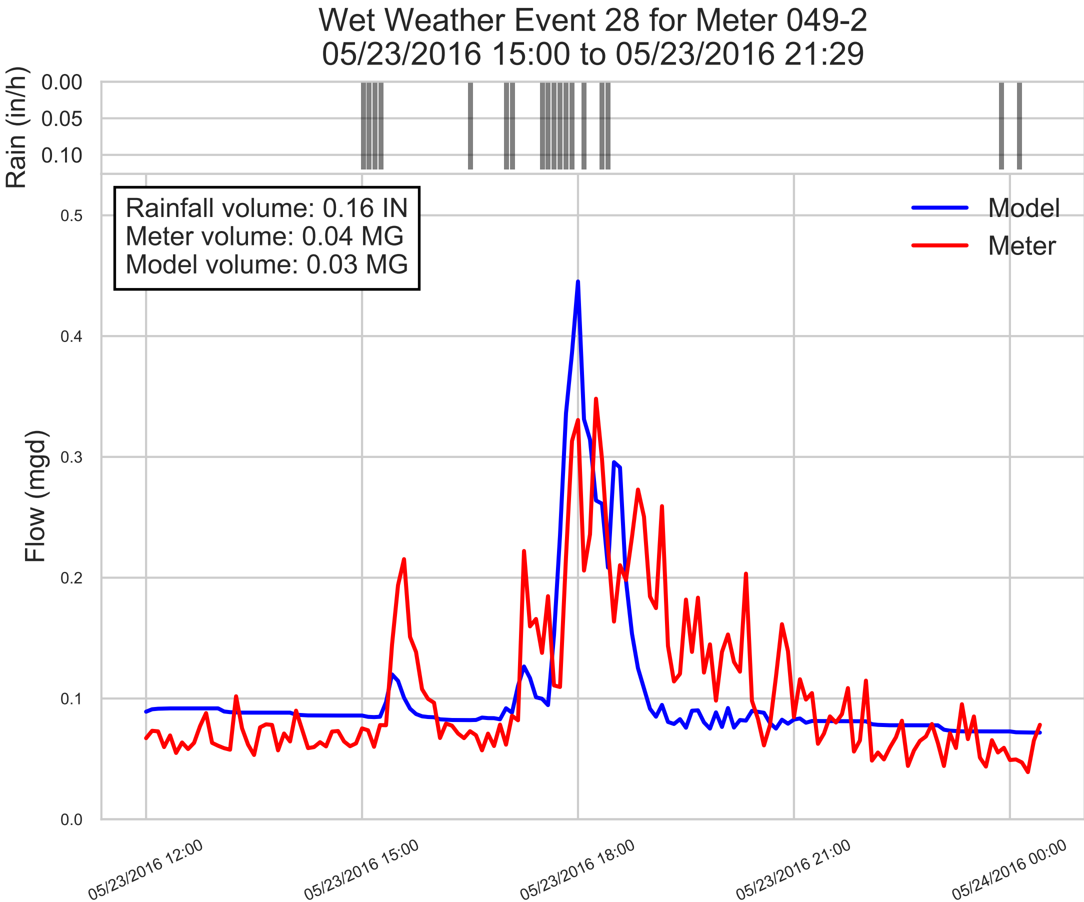


Wet Weather Event 25 for Meter 049-2
05/17/2016 08:39 to 05/17/2016 20:50
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.32 IN
Meter volume: 0.1 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
05/17/2016 05:00
05/17/2016 08:00
05/17/2016 11:00
05/17/2016 14:00
05/17/2016 17:00
05/17/2016 20:00
05/17/2016 23:00

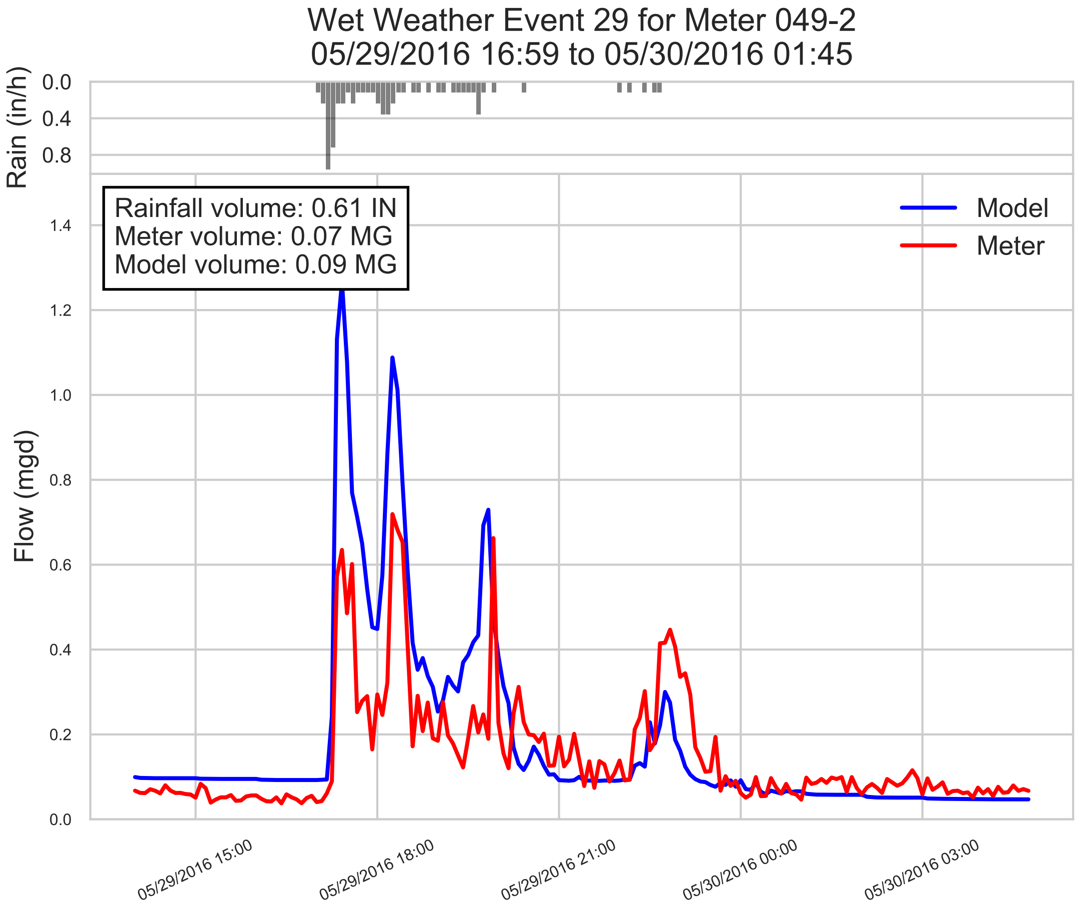

Wet Weather Event 26 for Meter 049-2
05/21/2016 05:39 to 05/21/2016 12:09
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.49 IN
Meter volume: 0.09 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
05/21/2016 03:00
05/21/2016 06:00
05/21/2016 09:00
05/21/2016 12:00
05/21/2016 15:00



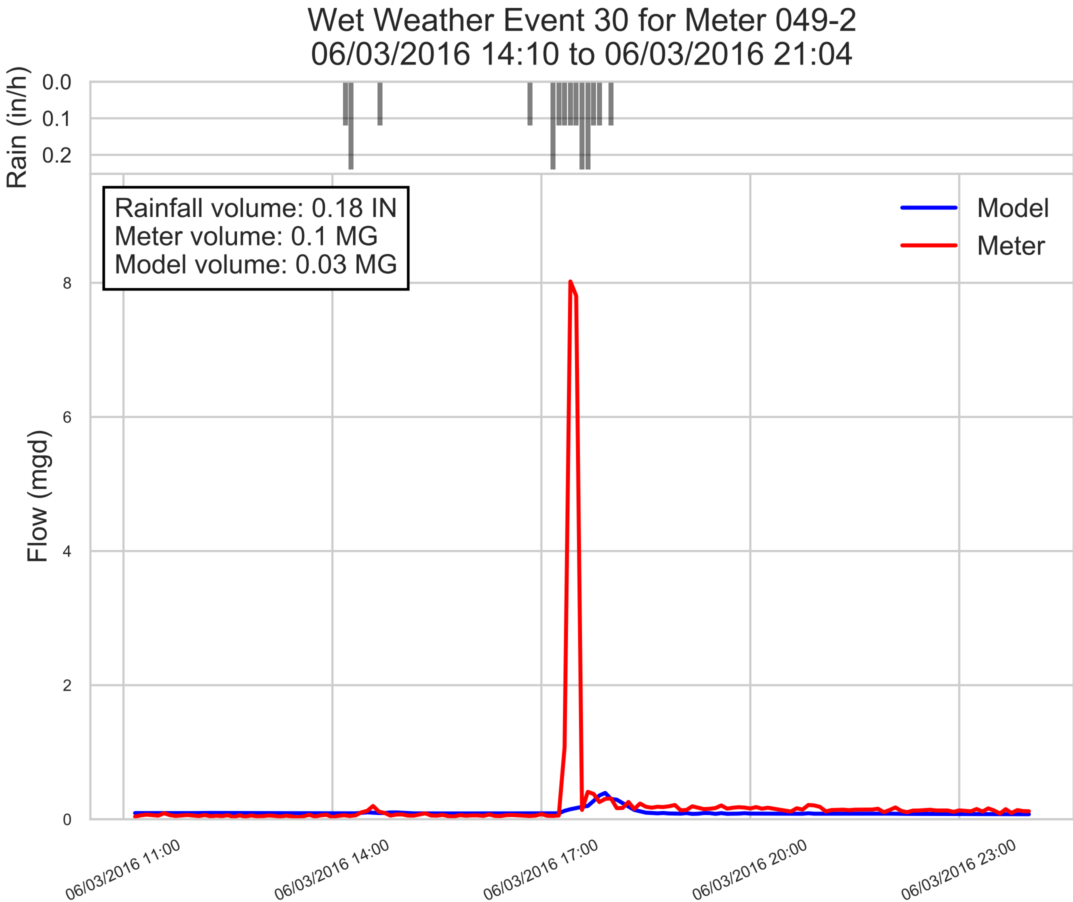
Wet Weather Event 27 for Meter 049-2
05/21/2016 23:35 to 05/23/2016 08:10
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.4 IN
Meter volume: 0.25 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
05/21/2016 21:00
05/22/2016 00:00
05/22/2016 03:00
05/22/2016 06:00
05/22/2016 09:00
05/22/2016 12:00
05/22/2016 15:00
05/22/2016 18:00
05/22/2016 21:00
05/23/2016 00:00
05/23/2016 03:00
05/23/2016 06:00
05/23/2016 09:00
05/23/2016 12:00

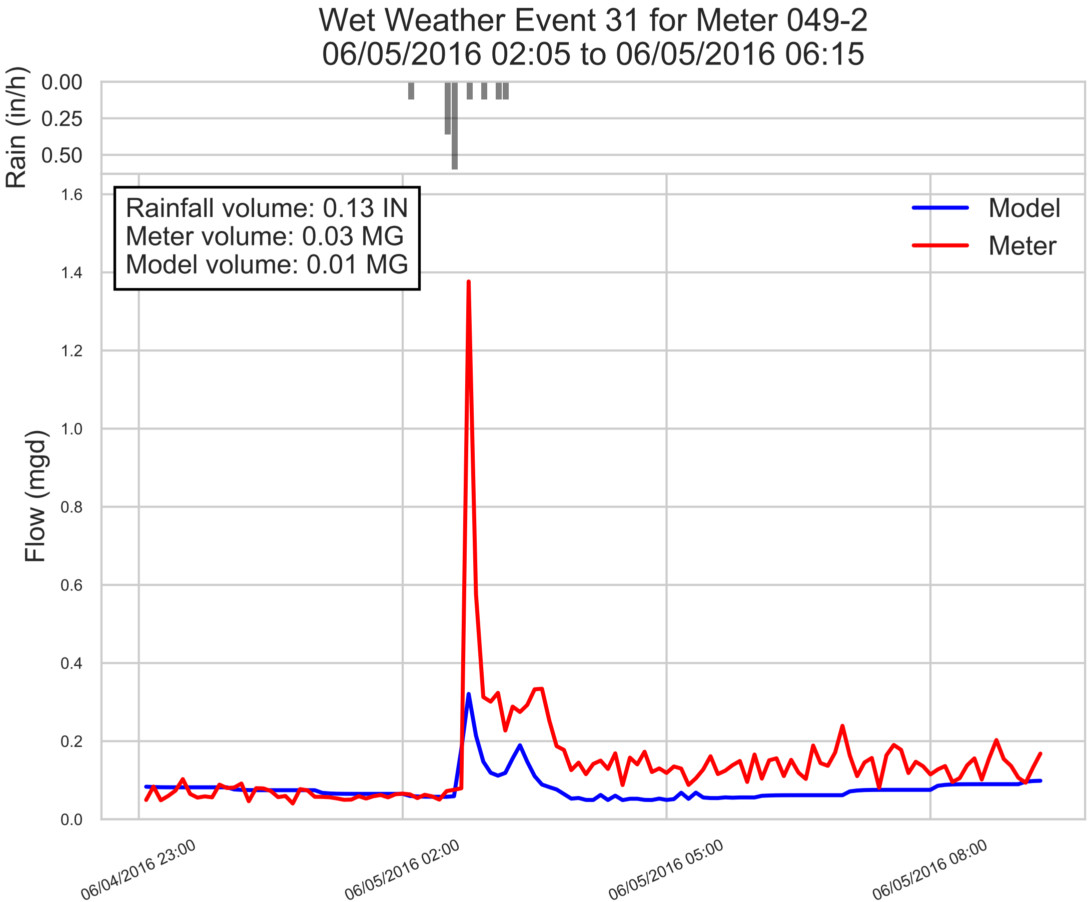


Wet Weather Event 28 for Meter 049-2
05/23/2016 15:00 to 05/23/2016 21:29
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.16 IN
Meter volume: 0.04 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
05/23/2016 12:00
05/23/2016 15:00
05/23/2016 18:00
05/23/2016 21:00
05/24/2016 00:00

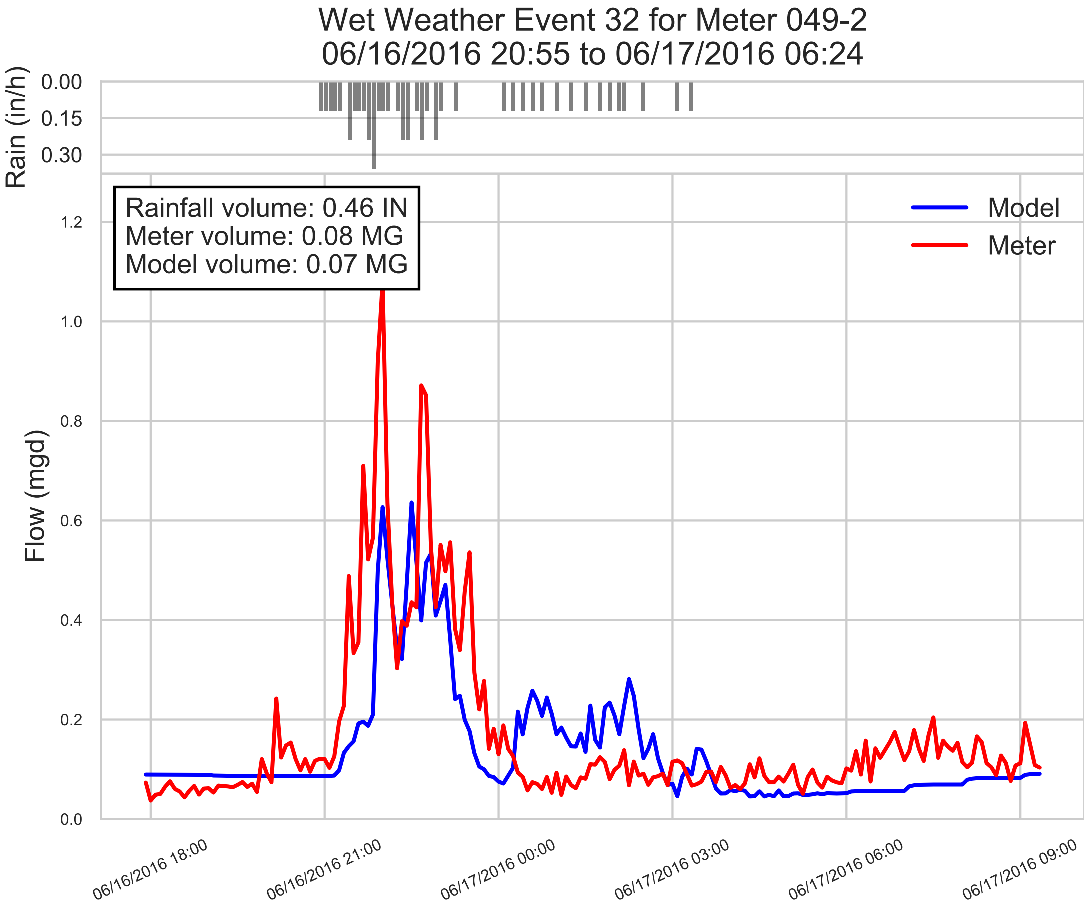


Wet Weather Event 29 for Meter 049-2
05/29/2016 16:59 to 05/30/2016 01:45
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.61 IN
Meter volume: 0.07 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
05/29/2016 15:00
05/29/2016 18:00
05/29/2016 21:00
05/30/2016 00:00
05/30/2016 03:00

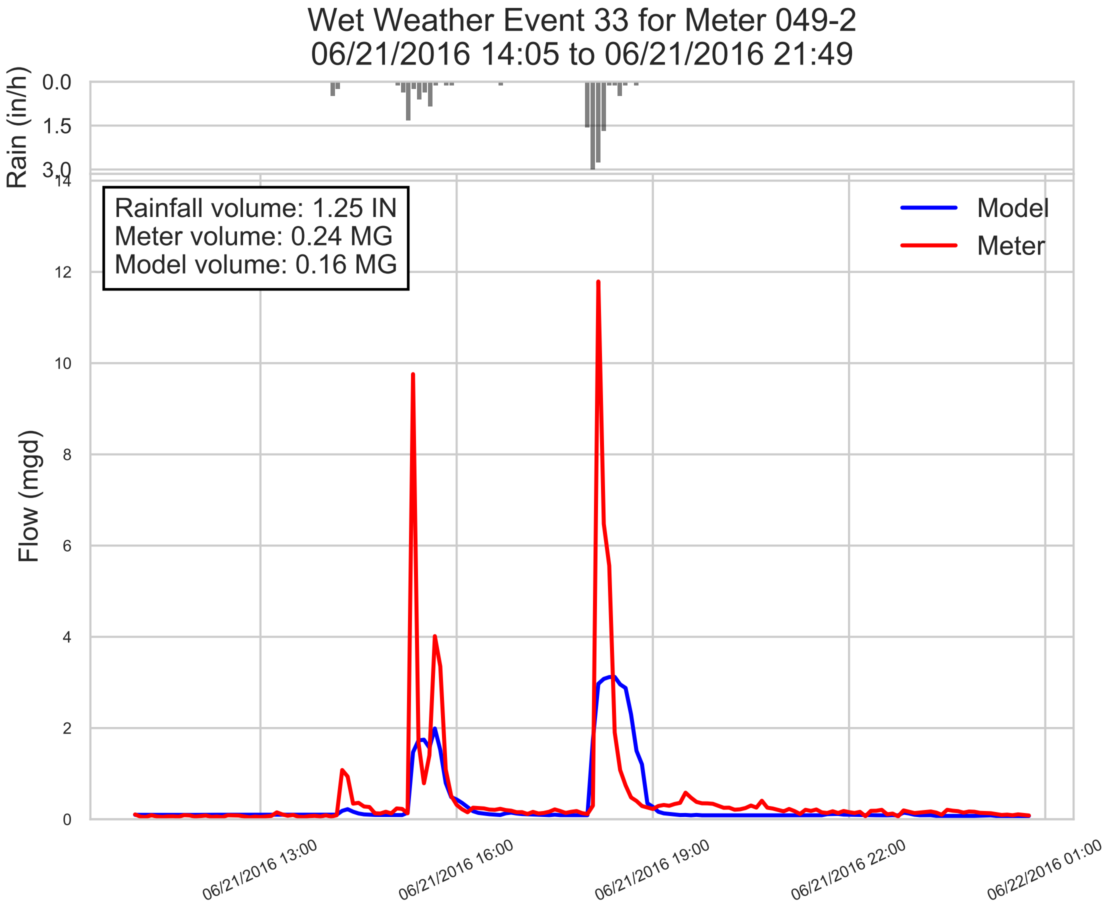

Wet Weather Event 30 for Meter 049-2
06/03/2016 14:10 to 06/03/2016 21:04
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.18 IN
Meter volume: 0.1 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
8
6
4
2
0
06/03/2016 11:00
06/03/2016 14:00
06/03/2016 17:00
06/03/2016 20:00
06/03/2016 23:00



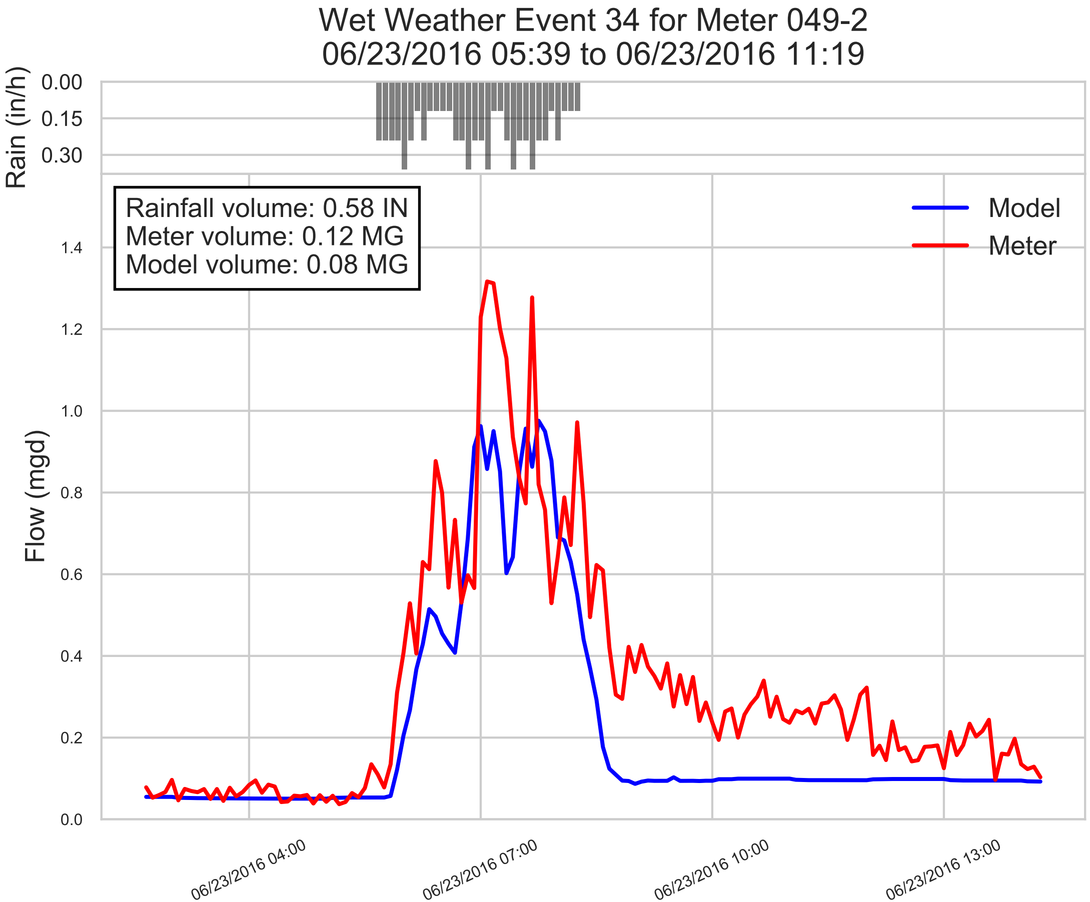
Wet Weather Event 31 for Meter 049-2
06/05/2016 02:05 to 06/05/2016 06:15
Rain (in/h)
0.00
0.25
0.50
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Rainfall volume: 0.13 IN
Meter volume: 0.03 MG
Model volume: 0.01 MG
Model
Meter
06/04/2016 23:00
06/05/2016 02:00
06/05/2016 05:00
06/05/2016 08:00



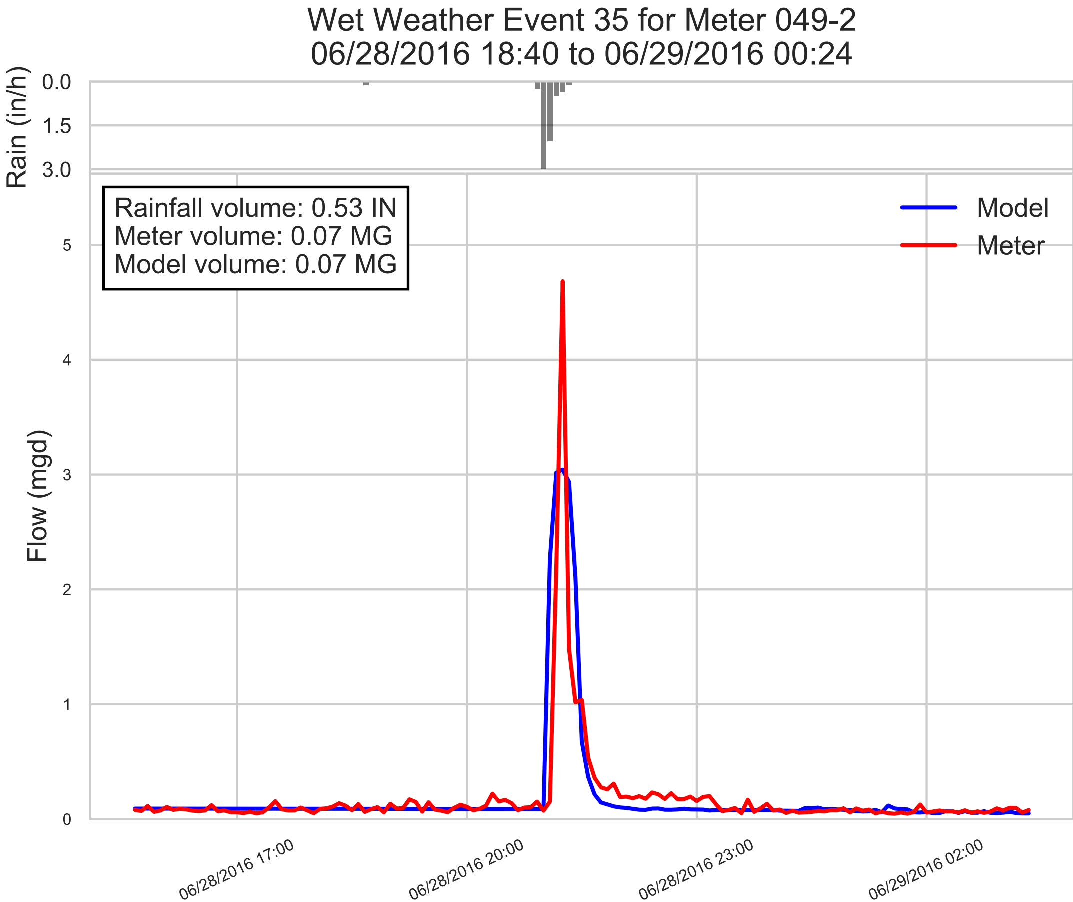
Wet Weather Event 32 for Meter 049-2
06/16/2016 20:55 to 06/17/2016 06:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.46 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
06/16/2016 18:00
06/16/2016 21:00
06/17/2016 00:00
06/17/2016 03:00
06/17/2016 06:00
06/17/2016 09:00



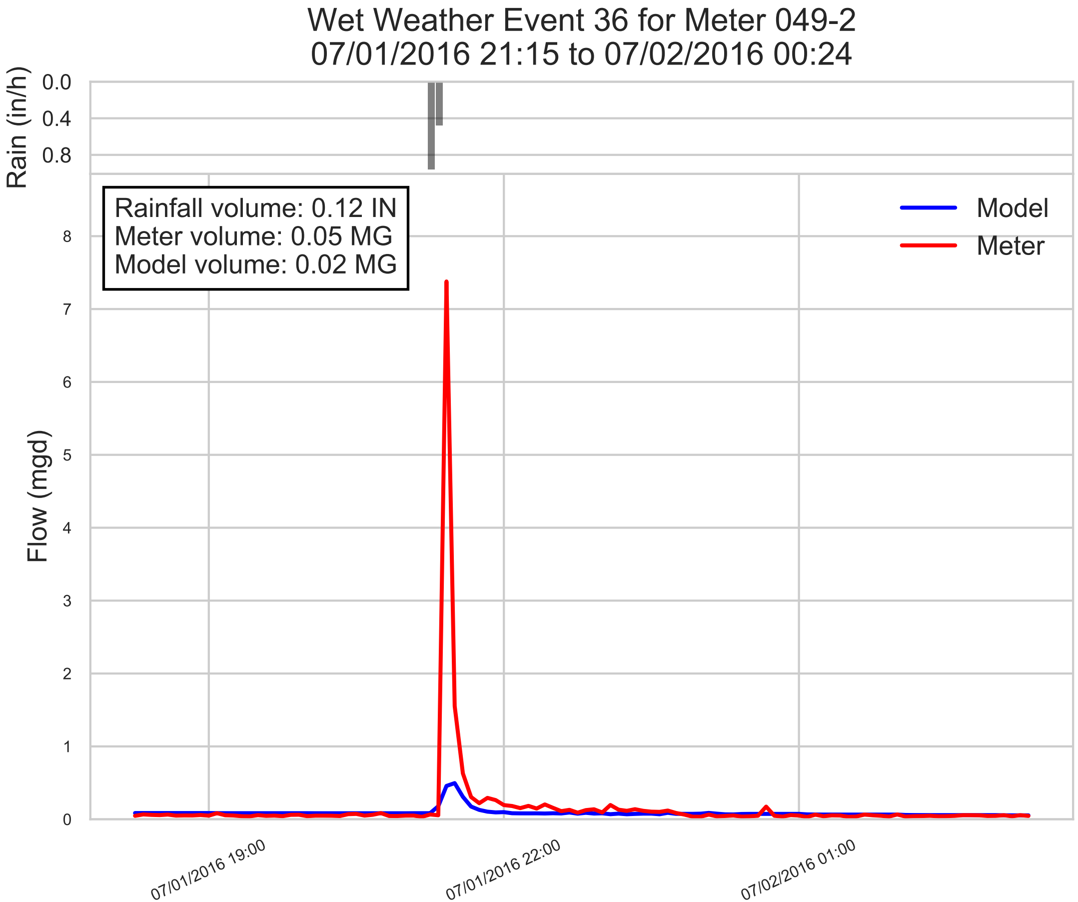
Wet Weather Event 33 for Meter 049-2
06/21/2016 14:05 to 06/21/2016 21:49
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.25 IN
Meter volume: 0.24 MG
Model volume: 0.16 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
06/21/2016 13:00
06/21/2016 16:00
06/21/2016 19:00
06/21/2016 22:00
06/22/2016 01:00

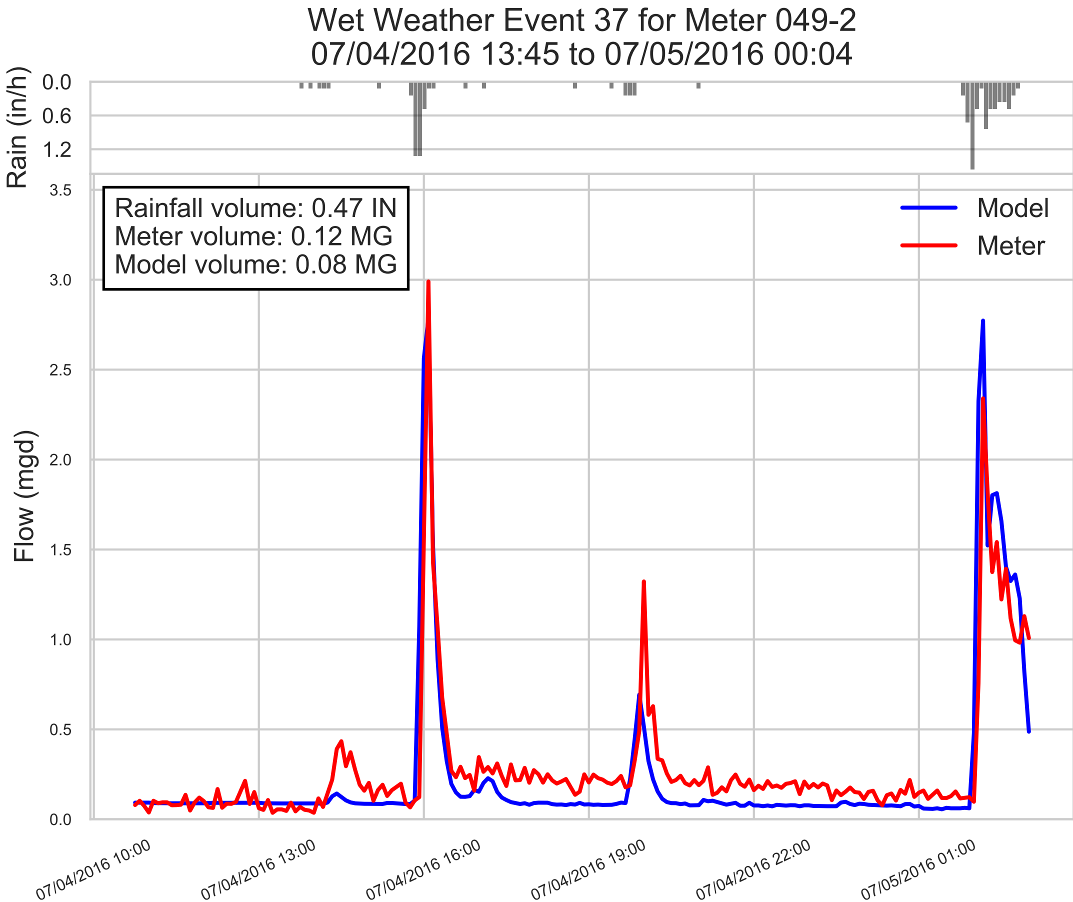


Wet Weather Event 34 for Meter 049-2
06/23/2016 05:39 to 06/23/2016 11:19
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.58 IN
Meter volume: 0.12 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
06/23/2016 04:00
06/23/2016 07:00
06/23/2016 10:00
06/23/2016 13:00

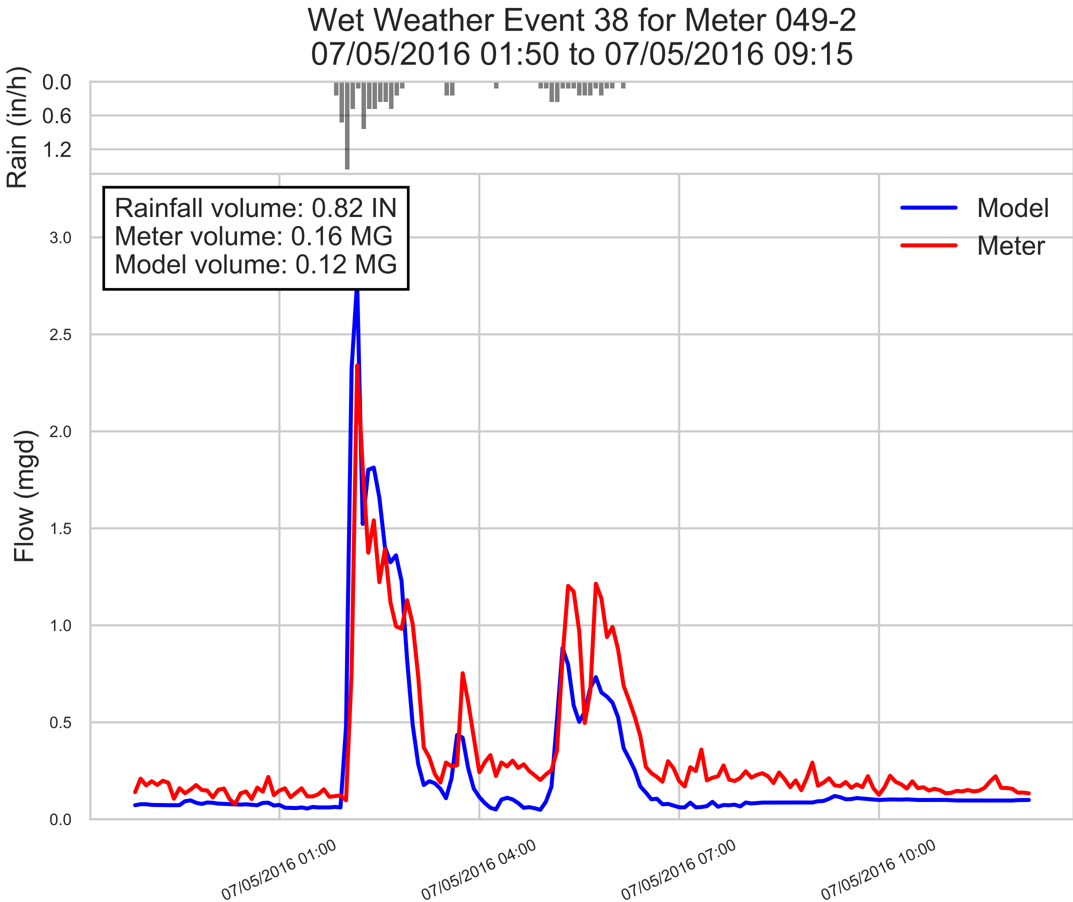


Wet Weather Event 35 for Meter 049-2
06/28/2016 18:40 to 06/29/2016 00:24
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.53 IN
Meter volume: 0.07 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
06/28/2016 17:00
06/28/2016 20:00
06/28/2016 23:00
06/29/2016 02:00

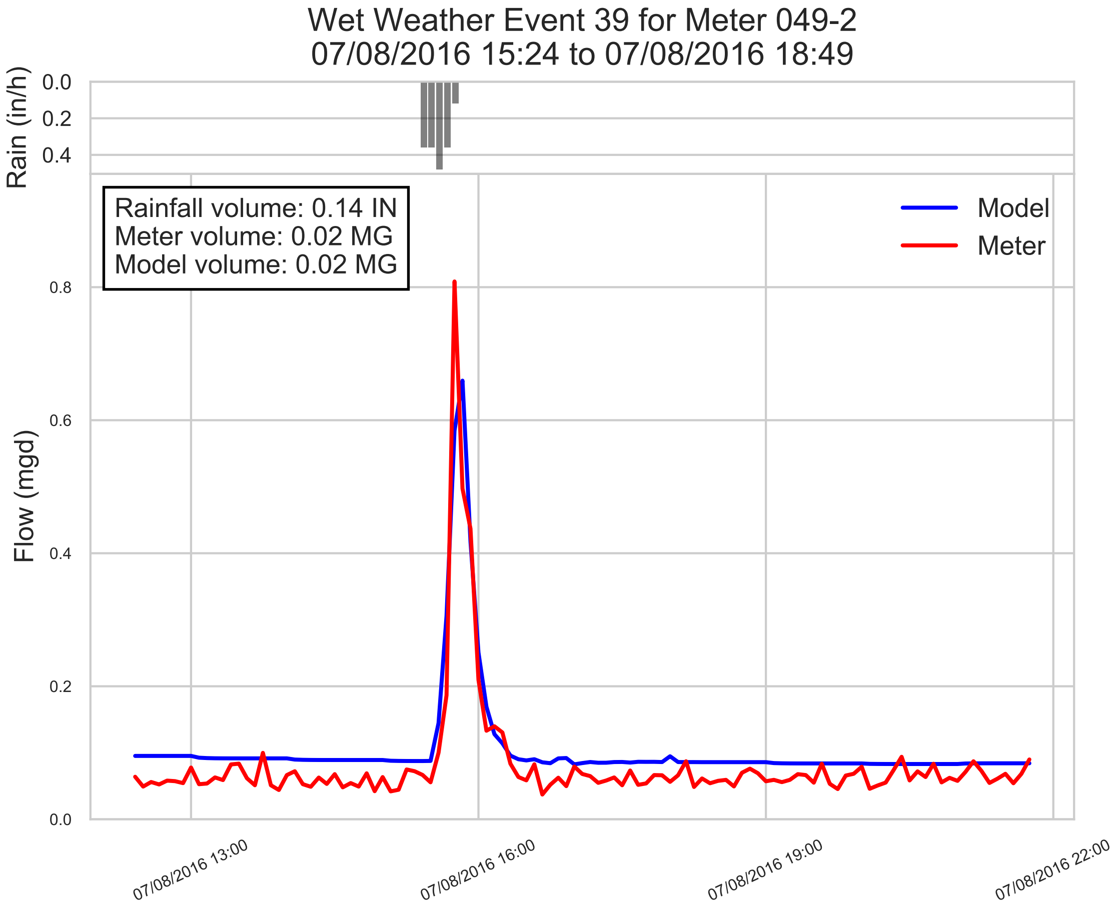

Wet Weather Event 36 for Meter 049-2
07/01/2016 21:15 to 07/02/2016 00:24
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.12 IN
Meter volume: 0.05 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
8
7
6
5
4
3
2
1
0
07/01/2016 19:00
07/01/2016 22:00
07/02/2016 01:00



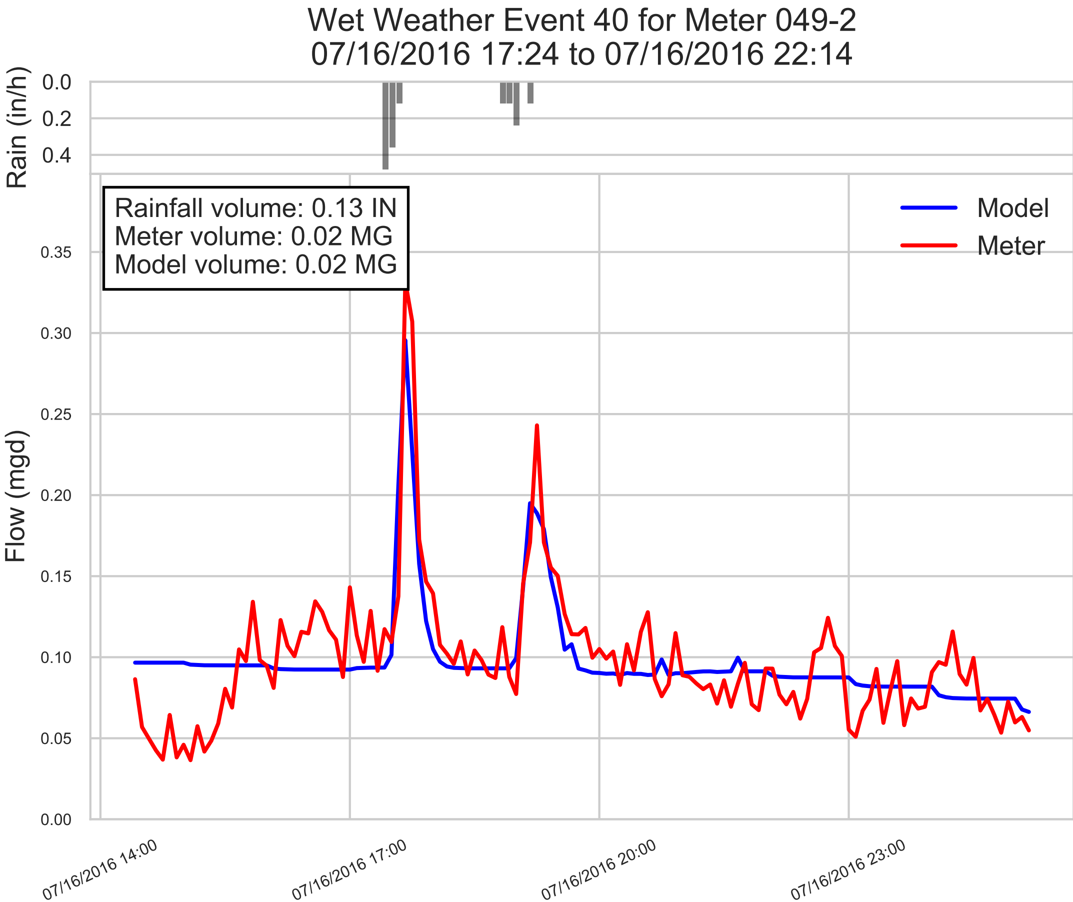
Wet Weather Event 37 for Meter 049-2
07/04/2016 13:45 to 07/05/2016 00:04
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.47 IN
Meter volume: 0.12 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
07/04/2016 10:00
07/04/2016 13:00
07/04/2016 16:00
07/04/2016 19:00
07/04/2016 22:00
07/05/2016 01:00



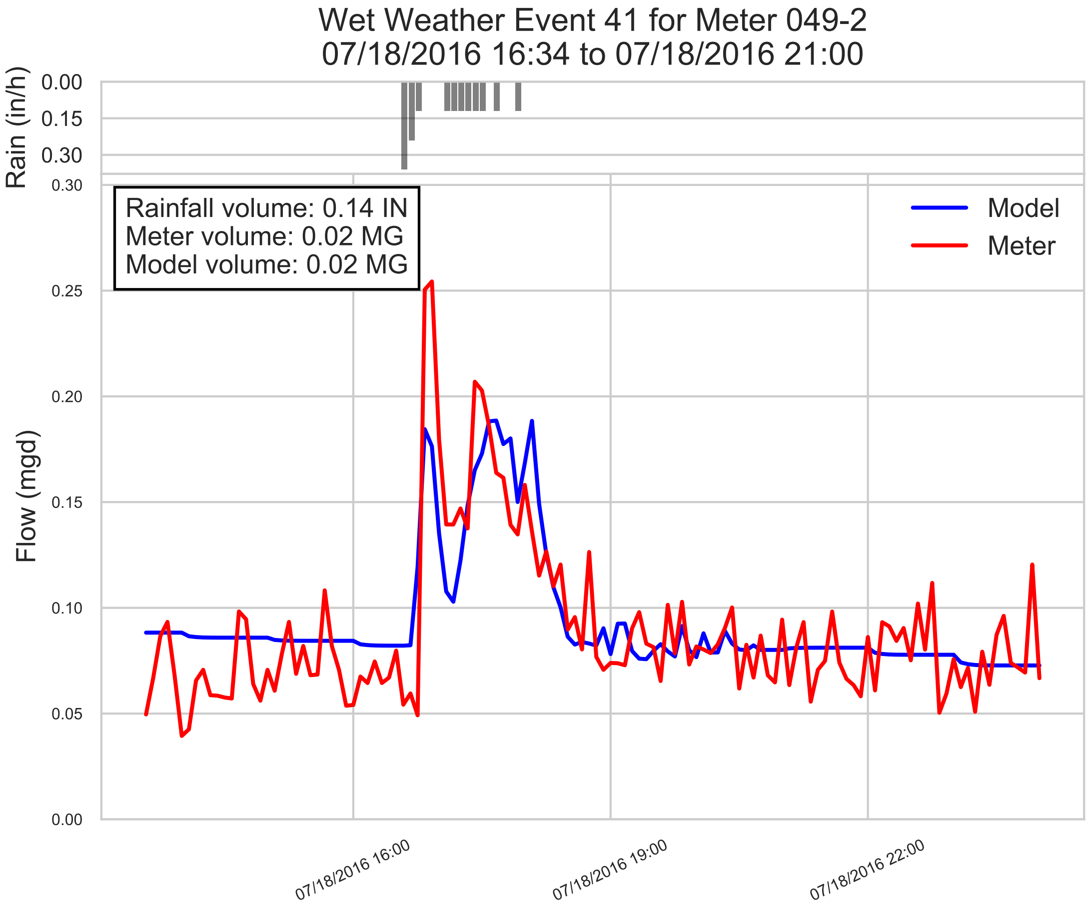
Wet Weather Event 38 for Meter 049-2
07/05/2016 01:50 to 07/05/2016 09:15
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.82 IN
Meter volume: 0.16 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
07/05/2016 01:00
07/05/2016 04:00
07/05/2016 07:00
07/05/2016 10:00

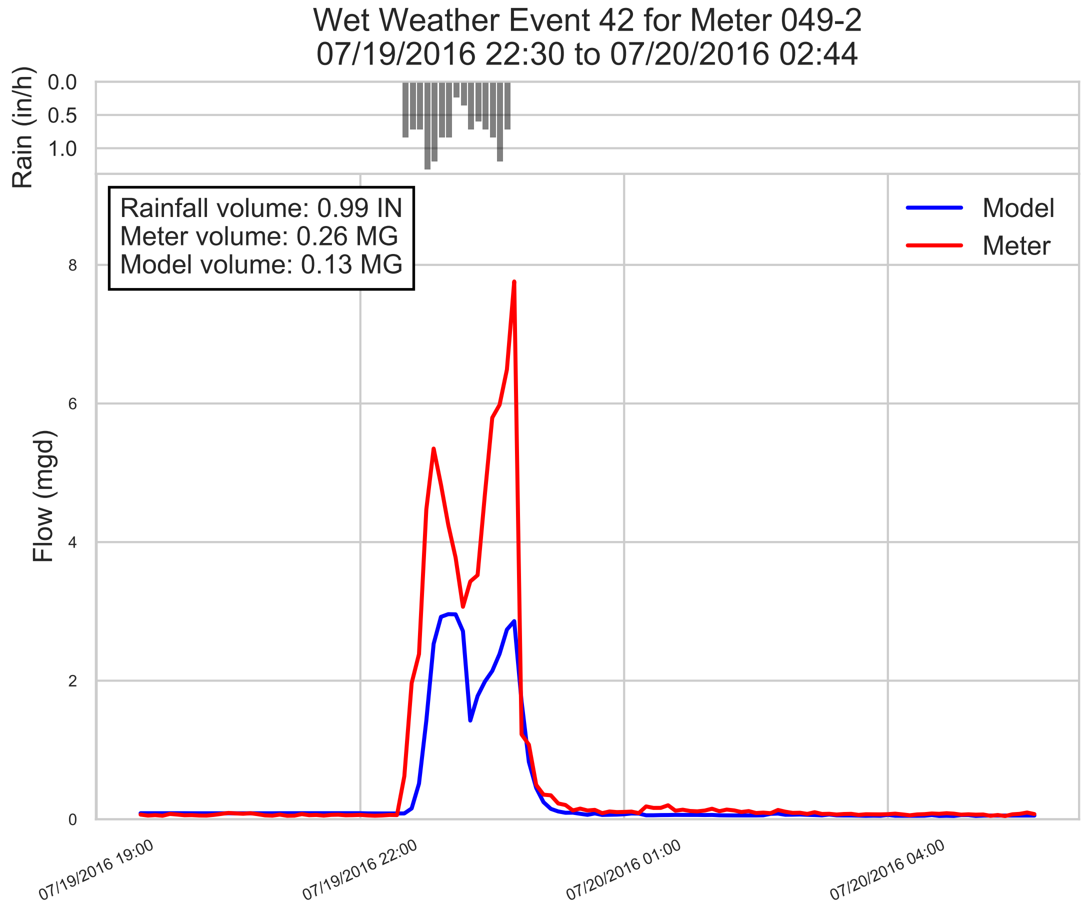


Wet Weather Event 39 for Meter 049-2
07/08/2016 15:24 to 07/08/2016 18:49
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.14 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
07/08/2016 13:00
07/08/2016 16:00
07/08/2016 19:00
07/08/2016 22:00

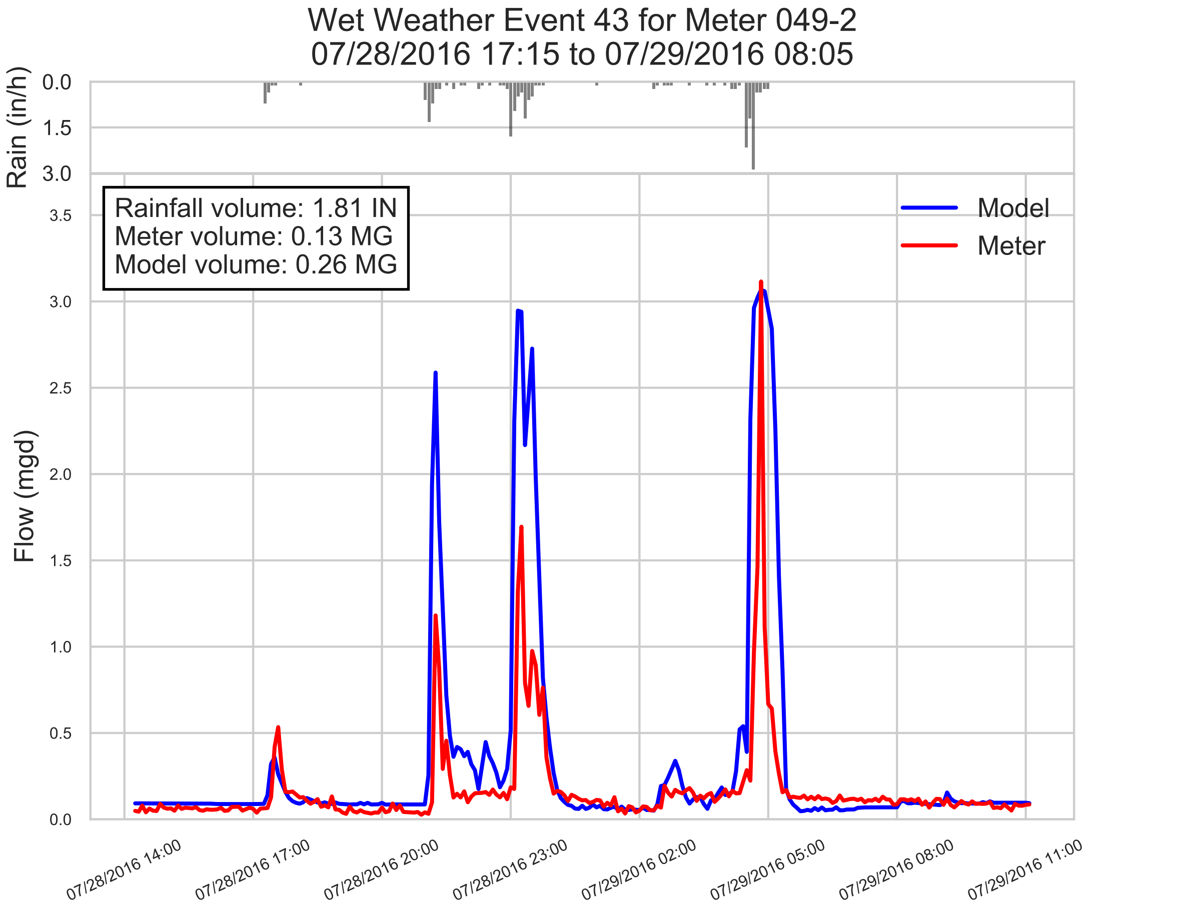


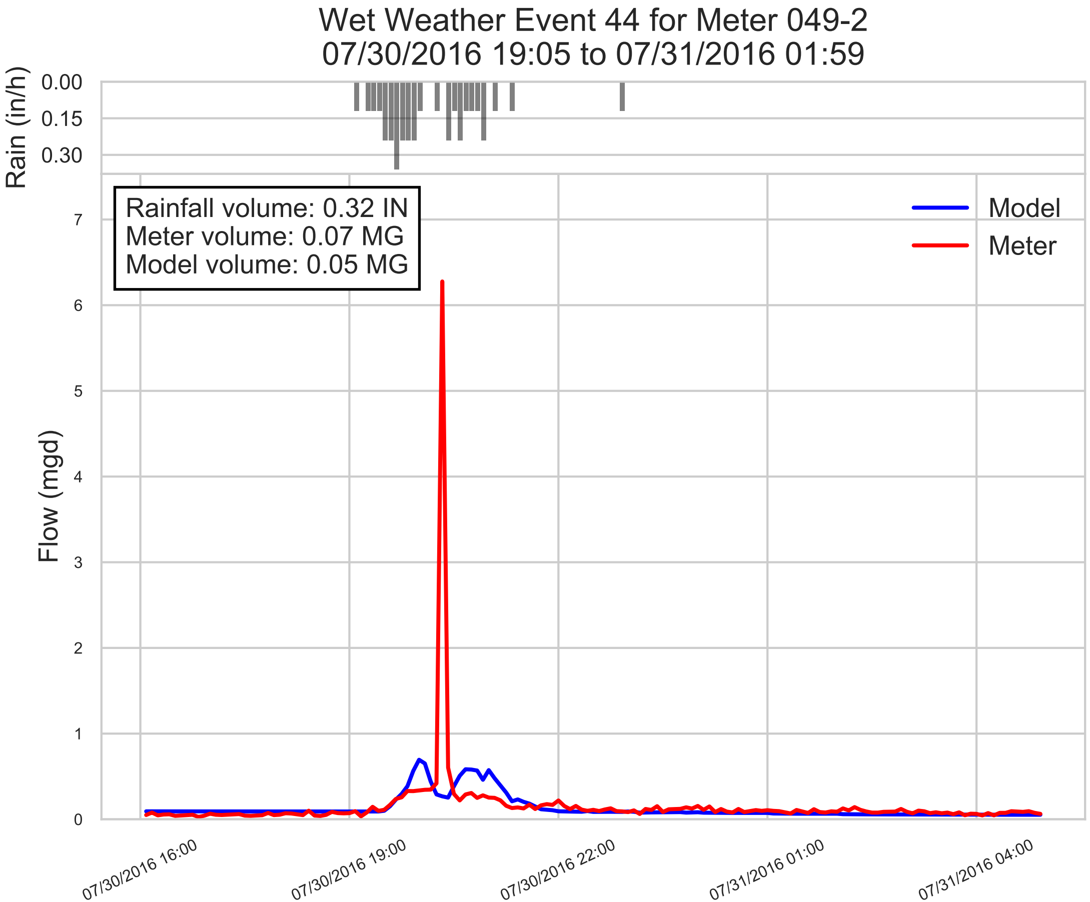
Wet Weather Event 40 for Meter 049-2
07/16/2016 17:24 to 07/16/2016 22:14
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.13 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
07/16/2016 14:00
07/16/2016 17:00
07/16/2016 20:00
07/16/2016 23:00


Wet Weather Event 41 for Meter 049-2
07/18/2016 16:34 to 07/18/2016 21:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.14 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
07/18/2016 16:00
07/18/2016 19:00
07/18/2016 22:00

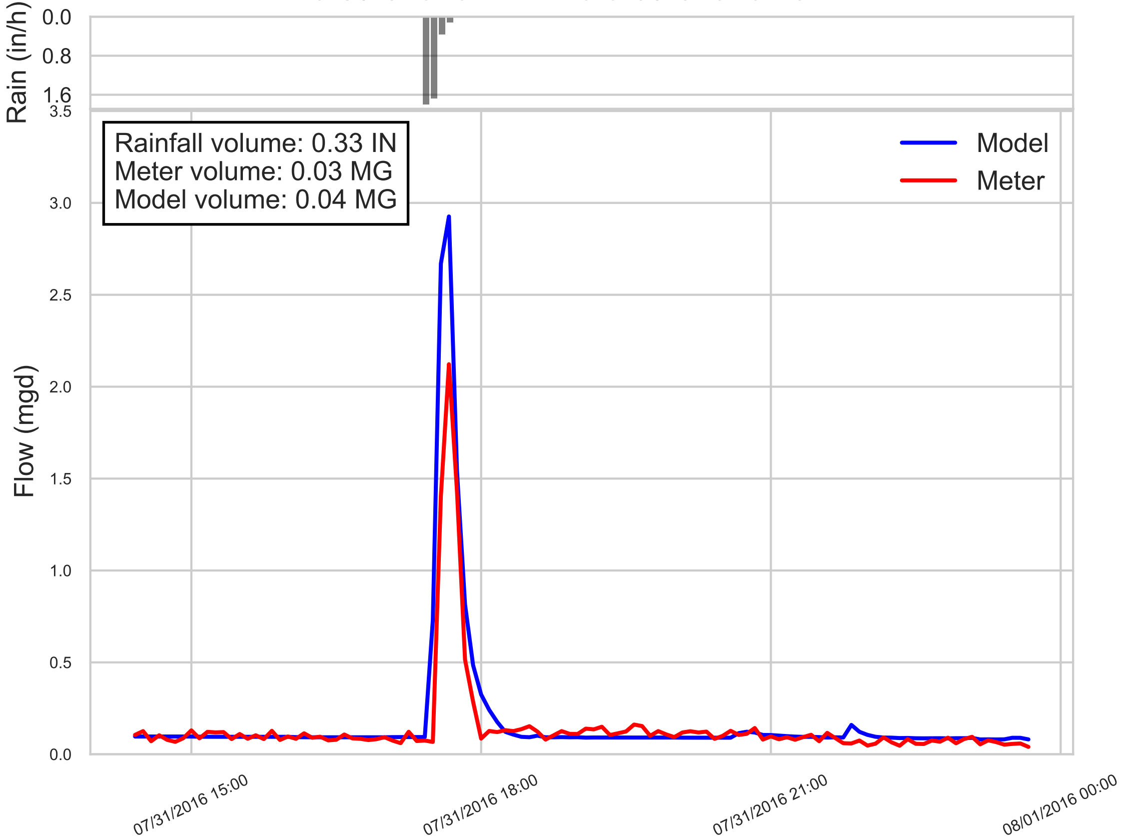


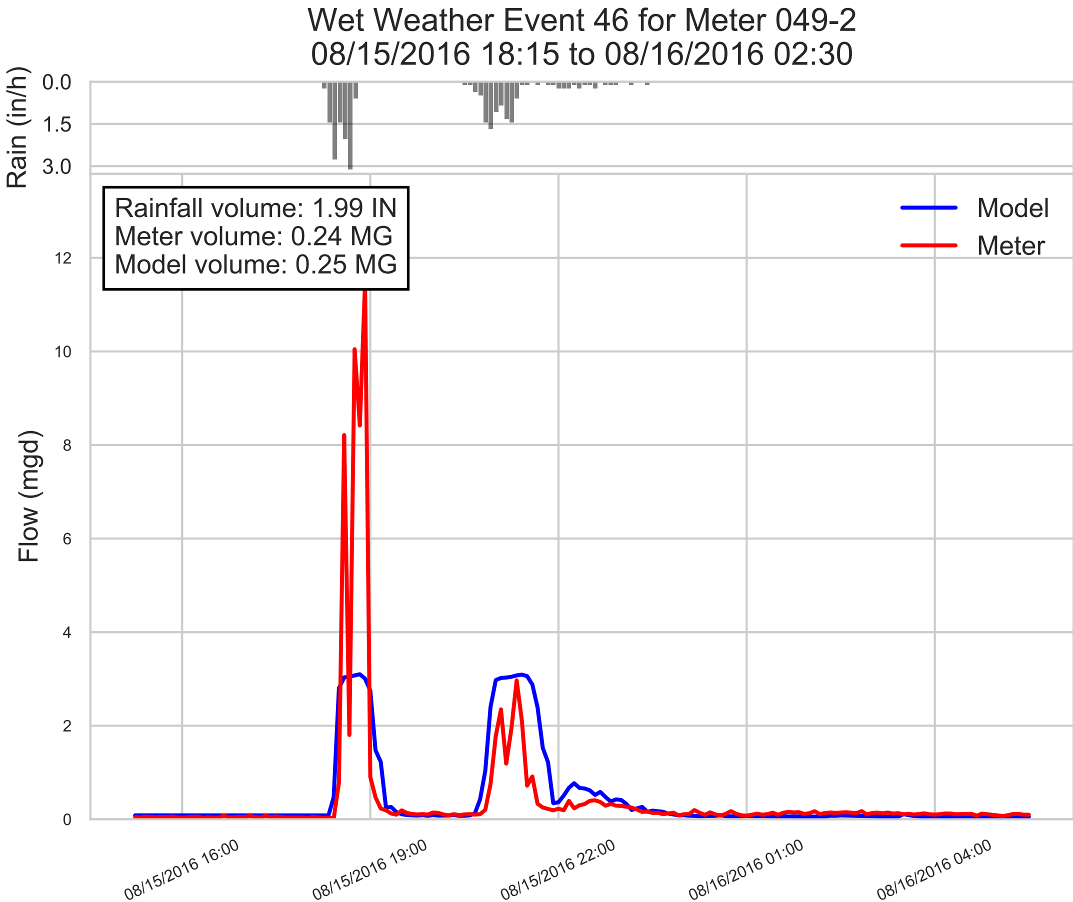
Wet Weather Event 42 for Meter 049-2
07/19/2016 22:30 to 07/20/2016 02:44
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.99 IN
Meter volume: 0.26 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
07/19/2016 19:00
07/19/2016 22:00
07/20/2016 01:00
07/20/2016 04:00


Wet Weather Event 43 for Meter 049-2
07/28/2016 17:15 to 07/29/2016 08:05
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.81 IN
Meter volume: 0.13 MG
Model volume: 0.26 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
07/28/2016 14:00
07/28/2016 17:00
07/28/2016 20:00
07/28/2016 23:00
07/29/2016 02:00
07/29/2016 05:00
07/29/2016 08:00
07/29/2016 11:00

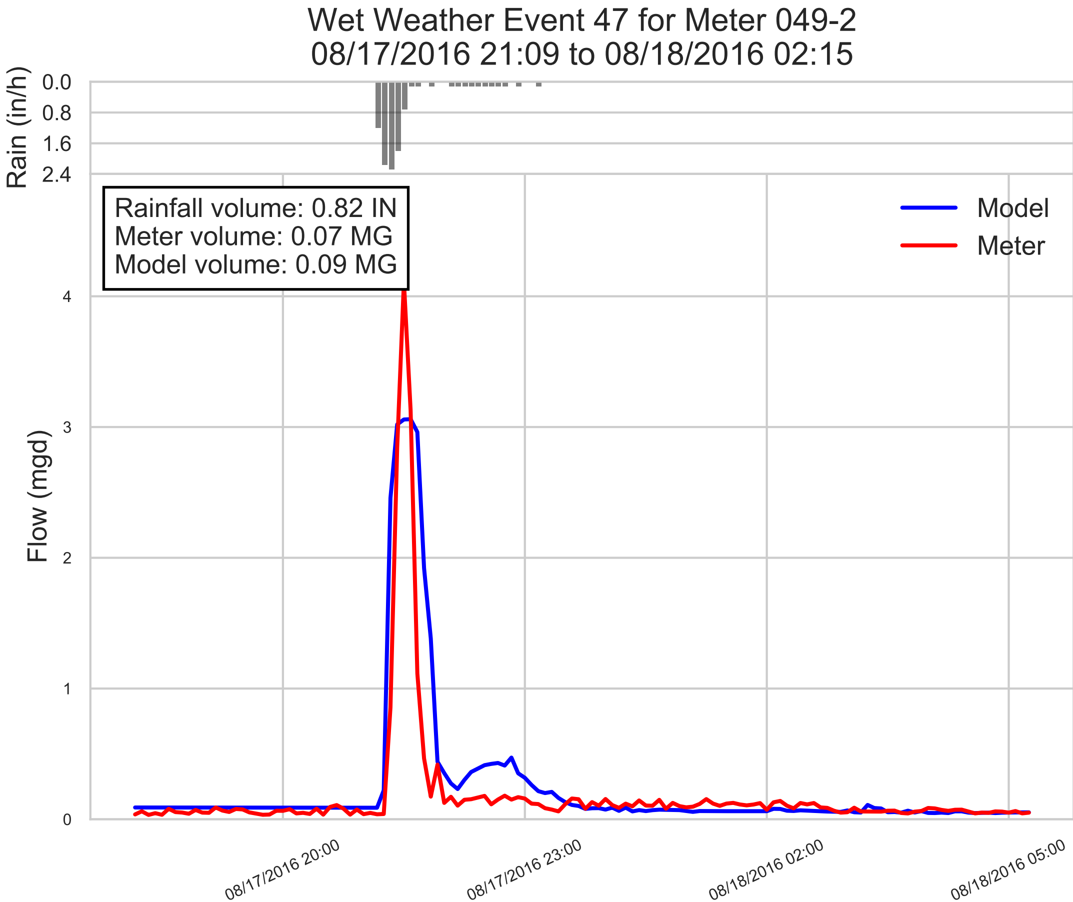

Wet Weather Event 44 for Meter 049-2
07/30/2016 19:05 to 07/31/2016 01:59
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.32 IN
Meter volume: 0.07 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
07/30/2016 16:00
07/30/2016 19:00
07/30/2016 22:00
07/31/2016 01:00
07/31/2016 04:00

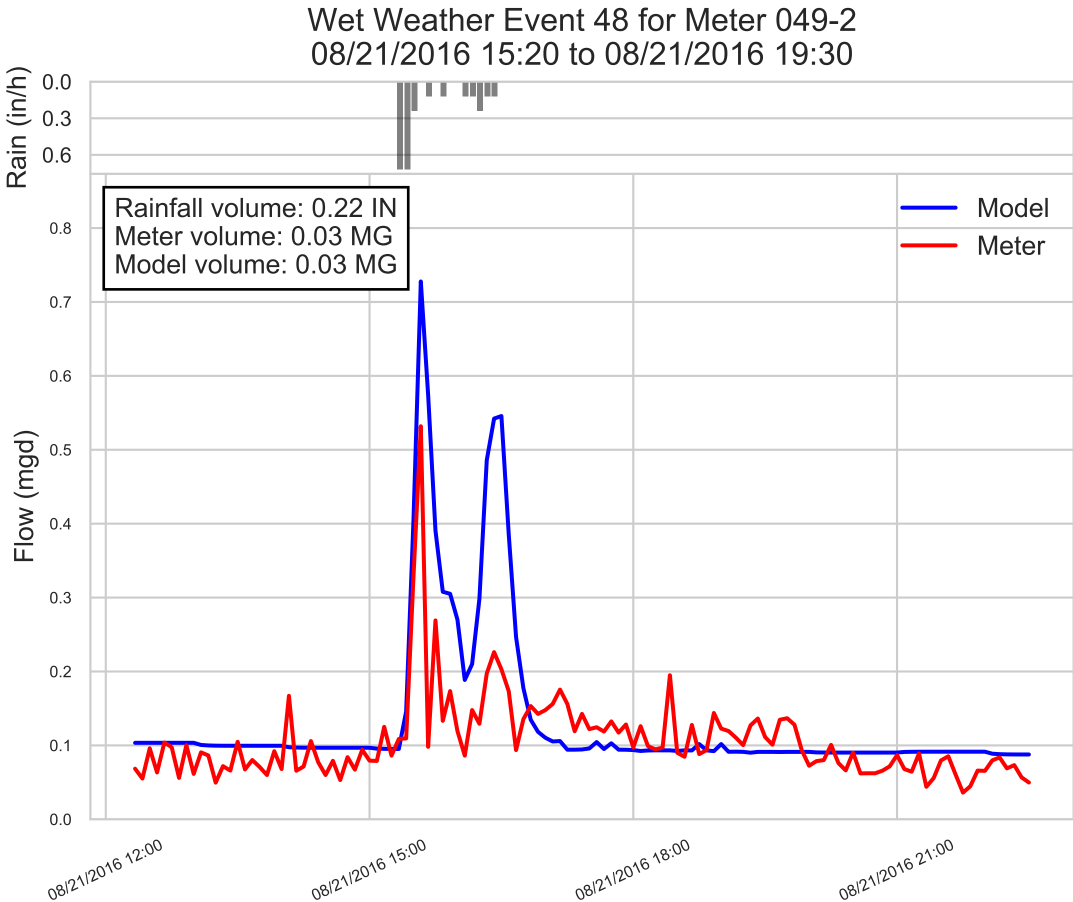
Wet Weather Event 45 for Meter 049-2
07/31/2016 17:24 to 07/31/2016 20:44



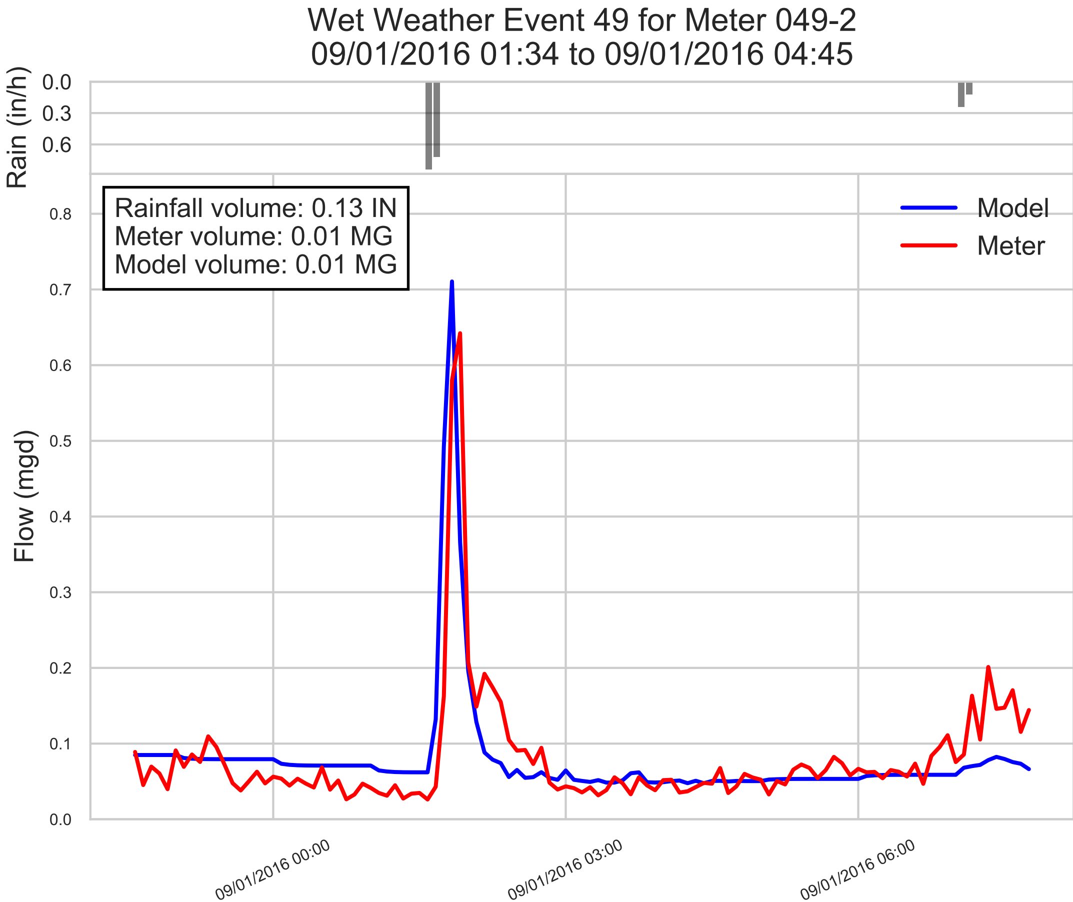


Wet Weather Event 46 for Meter 049-2
08/15/2016 18:15 to 08/16/2016 02:30
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.99 IN
Meter volume: 0.24 MG
Model volume: 0.25 MG
Model
Meter
Flow (mgd)
12
10
8
6
4
2
0
08/15/2016 16:00
08/15/2016 19:00
08/15/2016 22:00
08/16/2016 01:00
08/16/2016 04:00

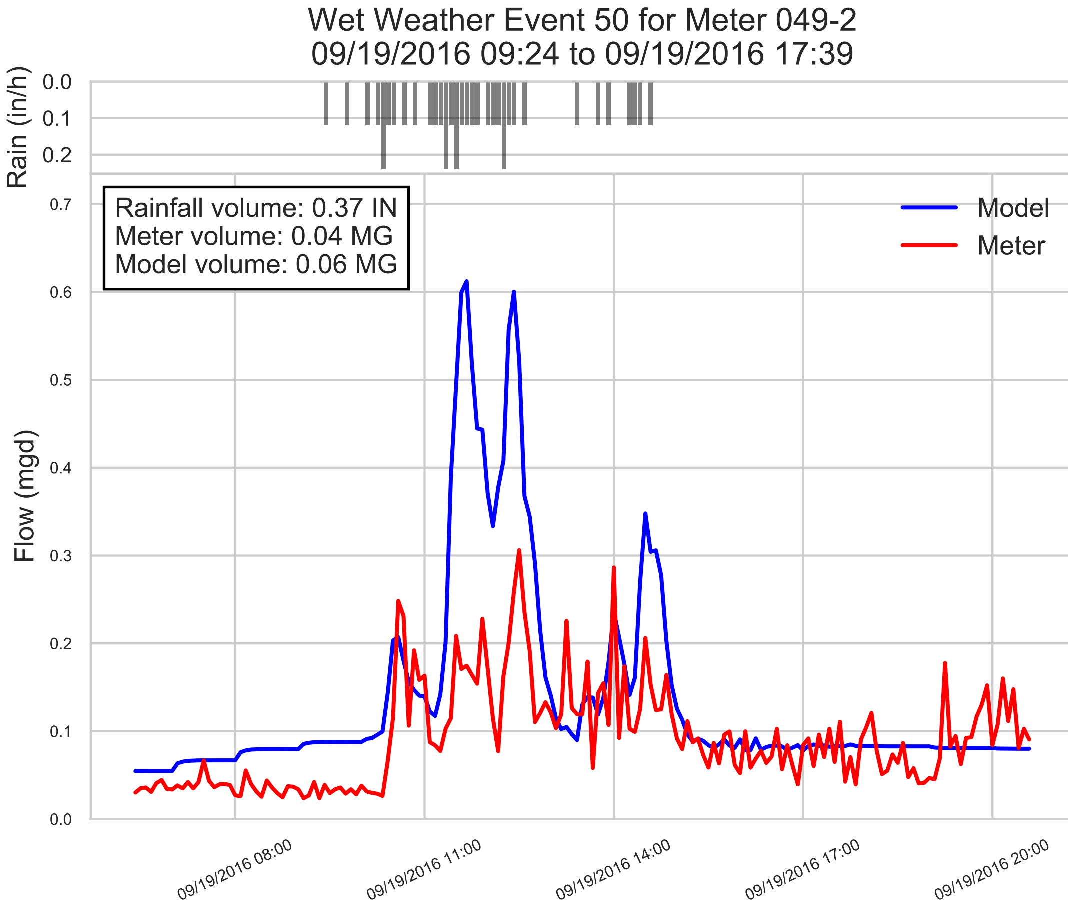

Wet Weather Event 47 for Meter 049-2
08/17/2016 21:09 to 08/18/2016 02:15
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.82 IN
Meter volume: 0.07 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
4
3
2
1
0
08/17/2016 20:00
08/17/2016 23:00
08/18/2016 02:00
08/18/2016 05:00



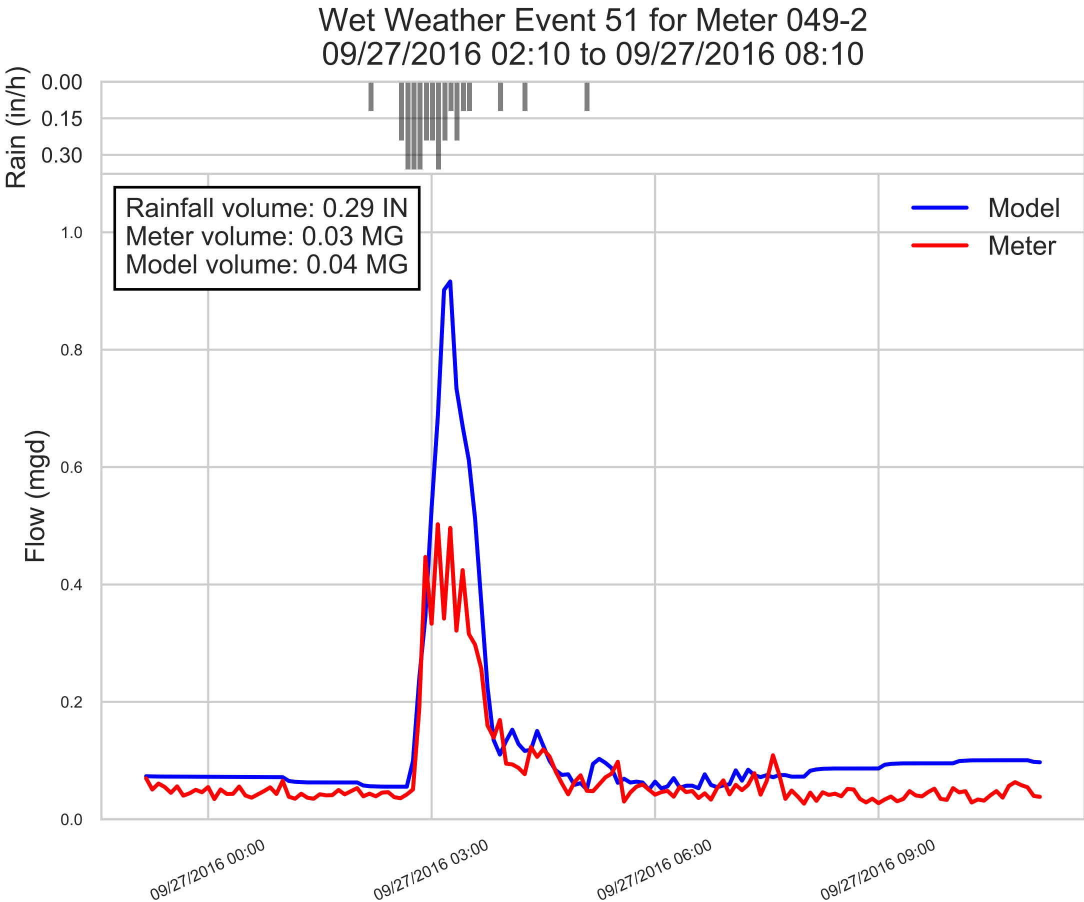
Wet Weather Event 48 for Meter 049-2
08/21/2016 15:20 to 08/21/2016 19:30
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.22 IN
Meter volume: 0.03 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
08/21/2016 12:00
08/21/2016 15:00
08/21/2016 18:00
08/21/2016 21:00



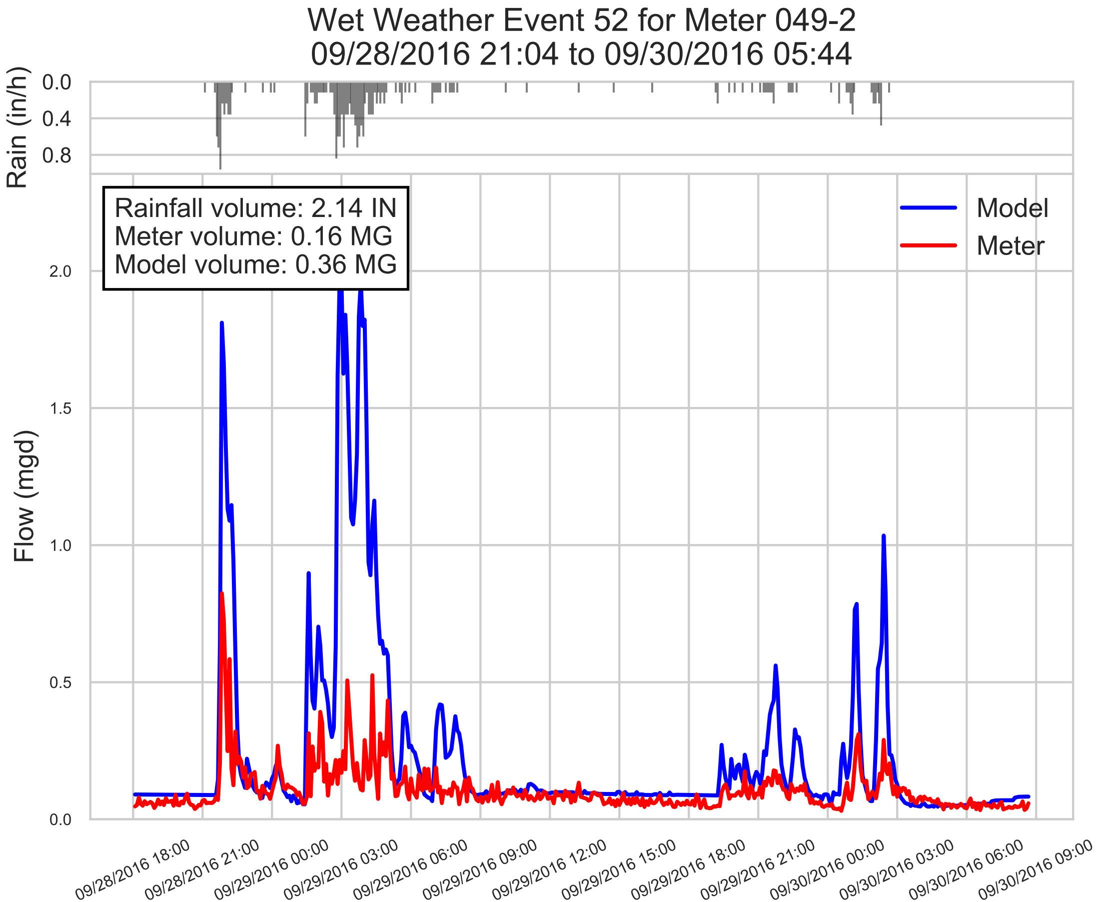
Wet Weather Event 49 for Meter 049-2
09/01/2016 01:34 to 09/01/2016 04:45
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.13 IN
Meter volume: 0.01 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
09/01/2016 00:00
09/01/2016 03:00
09/01/2016 06:00

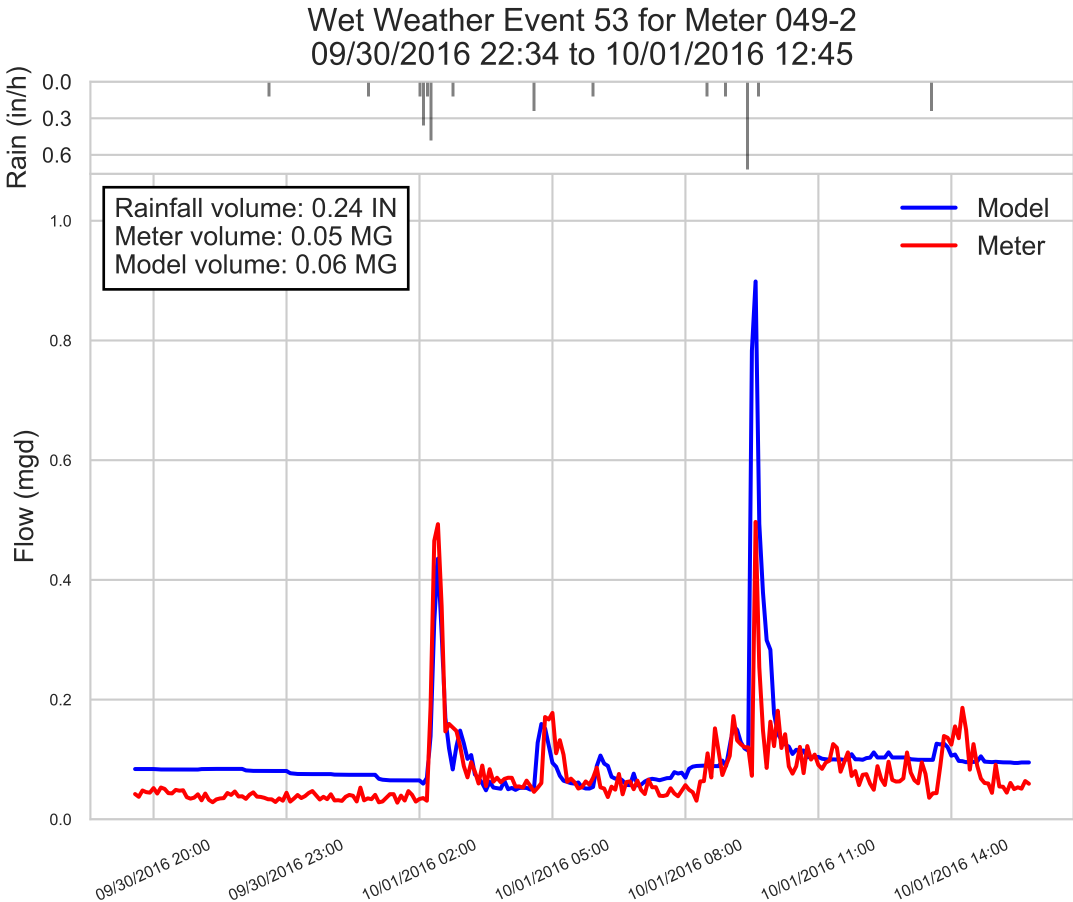


Wet Weather Event 50 for Meter 049-2
09/19/2016 09:24 to 09/19/2016 17:39
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.37 IN
Meter volume: 0.04 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
09/19/2016 08:00
09/19/2016 11:00
09/19/2016 14:00
09/19/2016 17:00
09/19/2016 20:00

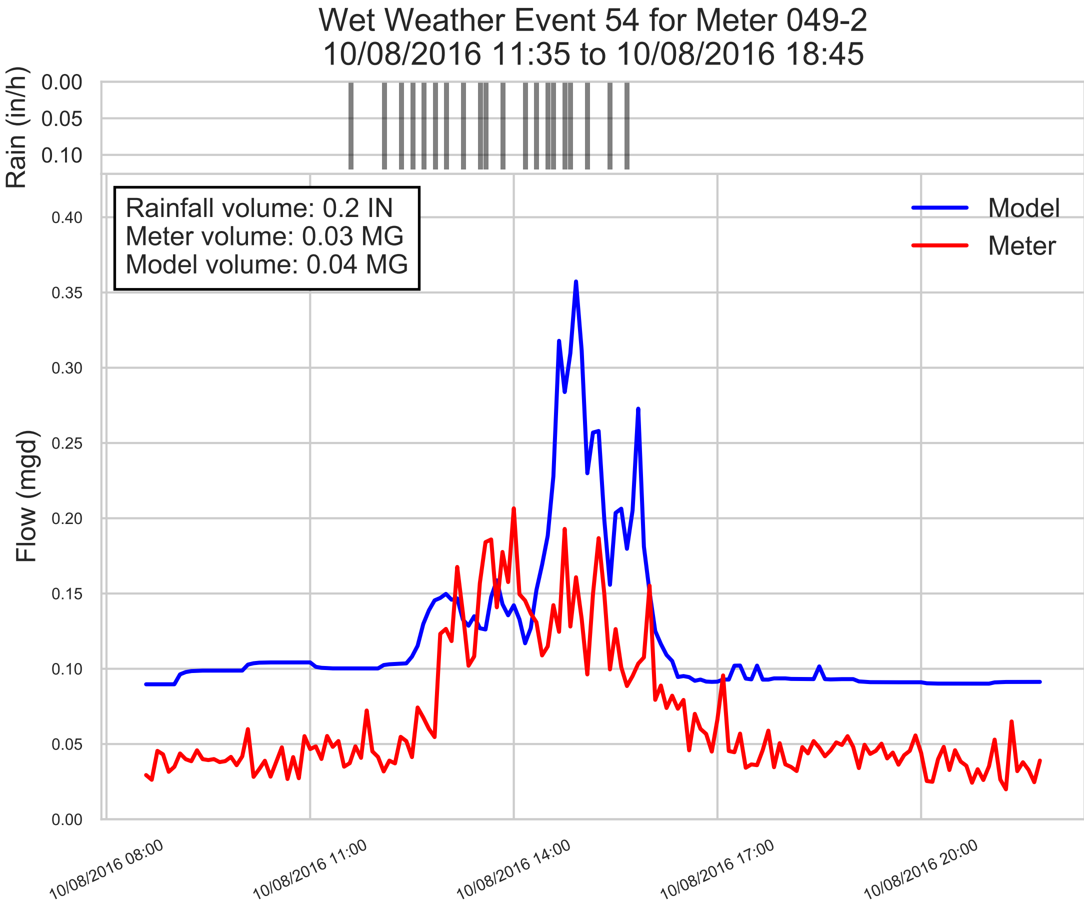


Wet Weather Event 51 for Meter 049-2
09/27/2016 02:10 to 09/27/2016 08:10
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.29 IN
Meter volume: 0.03 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
09/27/2016 00:00
09/27/2016 03:00
09/27/2016 06:00
09/27/2016 09:00

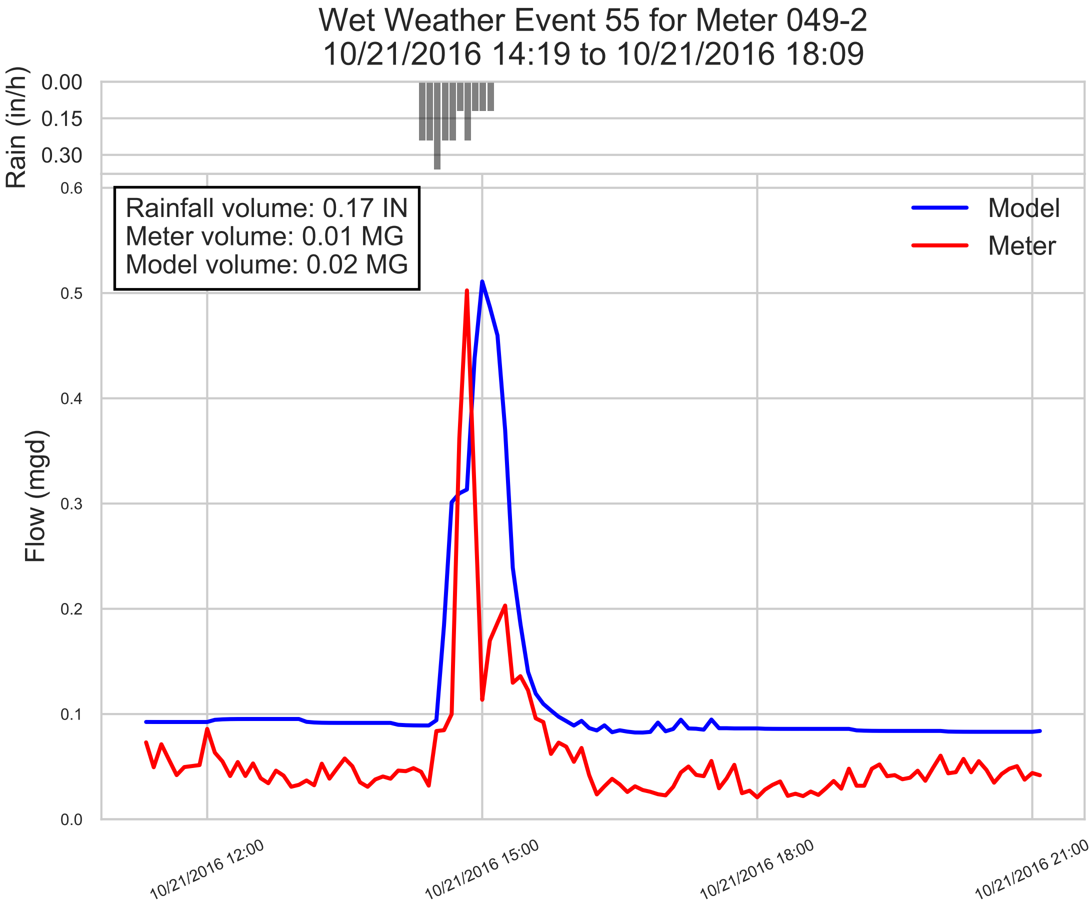

Wet Weather Event 52 for Meter 049-2
09/28/2016 21:04 to 09/30/2016 05:44
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 2.14 IN
Meter volume: 0.16 MG
Model volume: 0.36 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
09/28/2016 18:00
09/28/2016 21:00
09/29/2016 00:00
09/29/2016 03:00
09/29/2016 06:00
09/29/2016 09:00
09/29/2016 12:00
09/29/2016 15:00
09/29/2016 18:00
09/29/2016 21:00
09/30/2016 00:00
09/30/2016 03:00
09/30/2016 06:00
09/30/2016 09:00



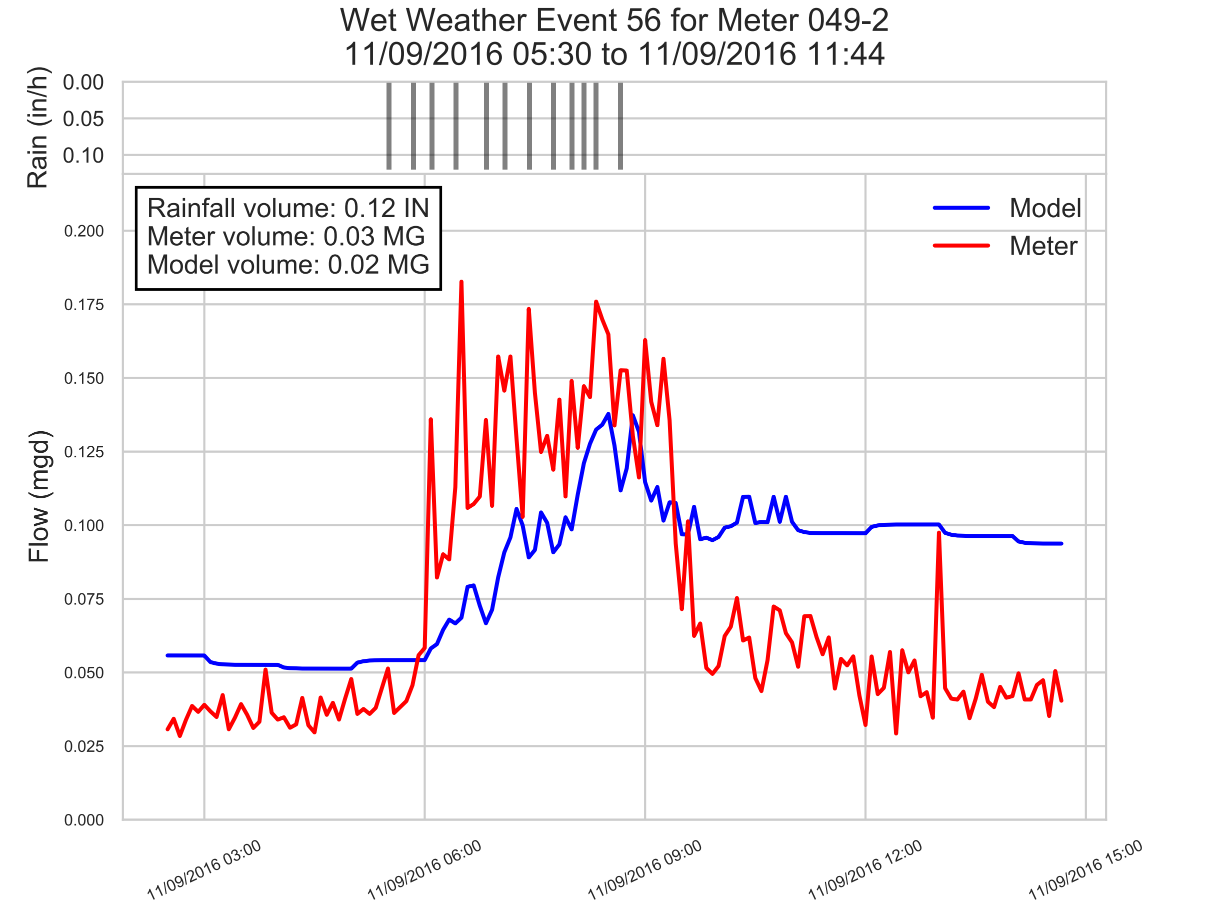
Wet Weather Event 53 for Meter 049-2
09/30/2016 22:34 to 10/01/2016 12:45
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.24 IN
Meter volume: 0.05 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
09/30/2016 20:00
09/30/2016 23:00
10/01/2016 02:00
10/01/2016 05:00
10/01/2016 08:00
10/01/2016 11:00
10/01/2016 14:00



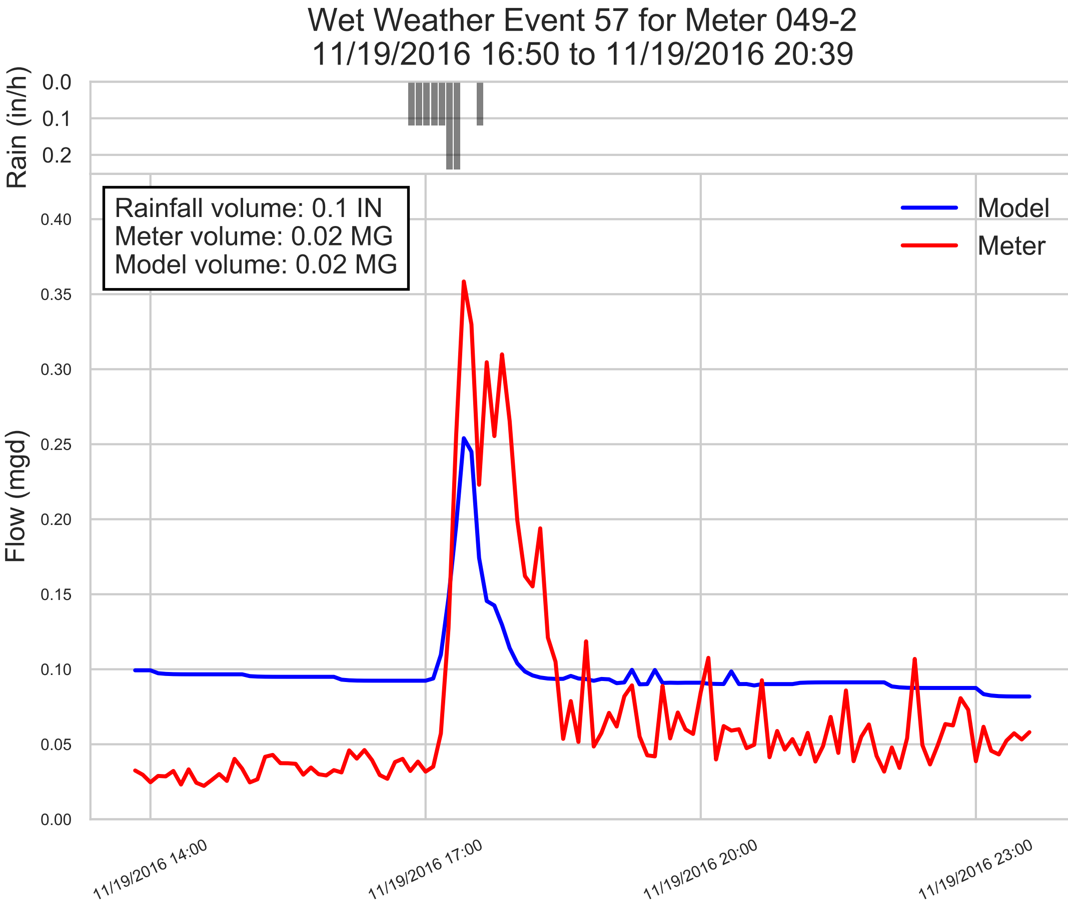
Wet Weather Event 54 for Meter 049-2
10/08/2016 11:35 to 10/08/2016 18:45
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.03 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
10/08/2016 08:00
10/08/2016 11:00
10/08/2016 14:00
10/08/2016 17:00
10/08/2016 20:00



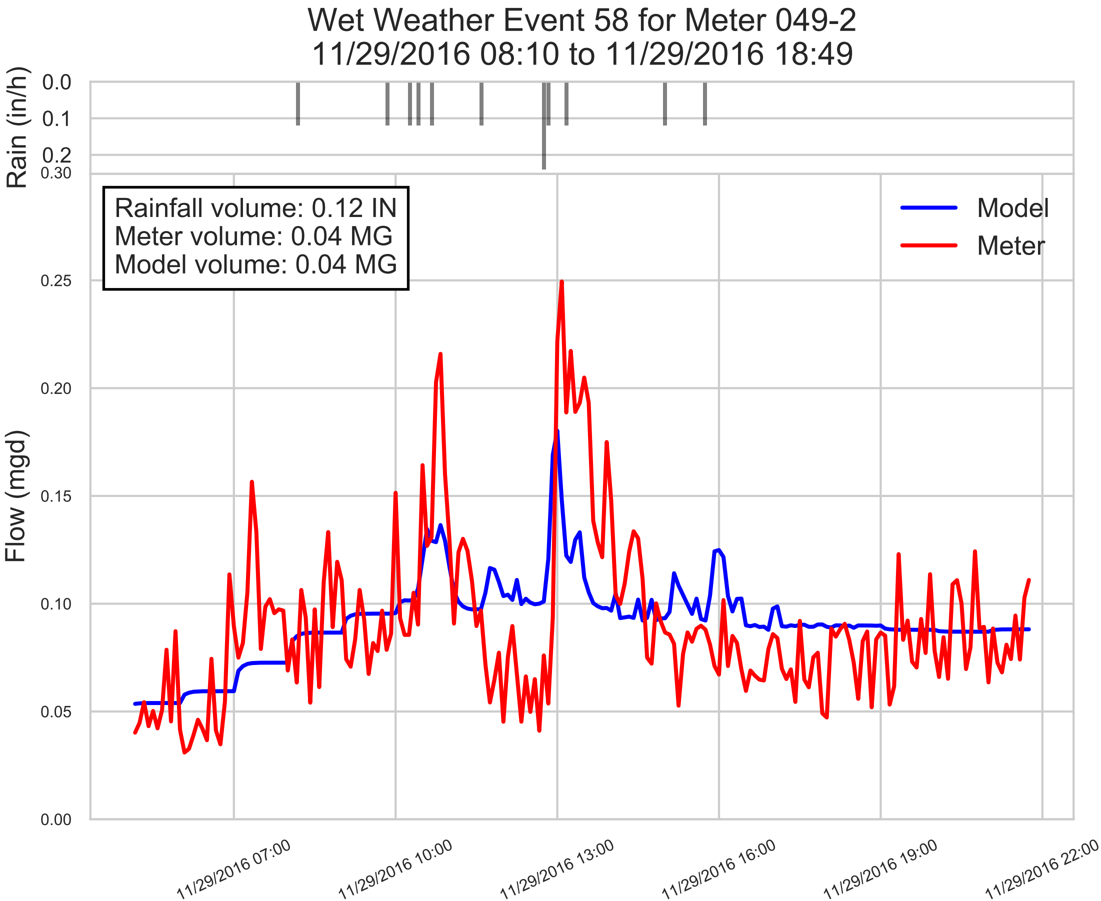
Wet Weather Event 55 for Meter 049-2
10/21/2016 14:19 to 10/21/2016 18:09
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.17 IN
Meter volume: 0.01 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
10/21/2016 12:00
10/21/2016 15:00
10/21/2016 18:00
10/21/2016 21:00



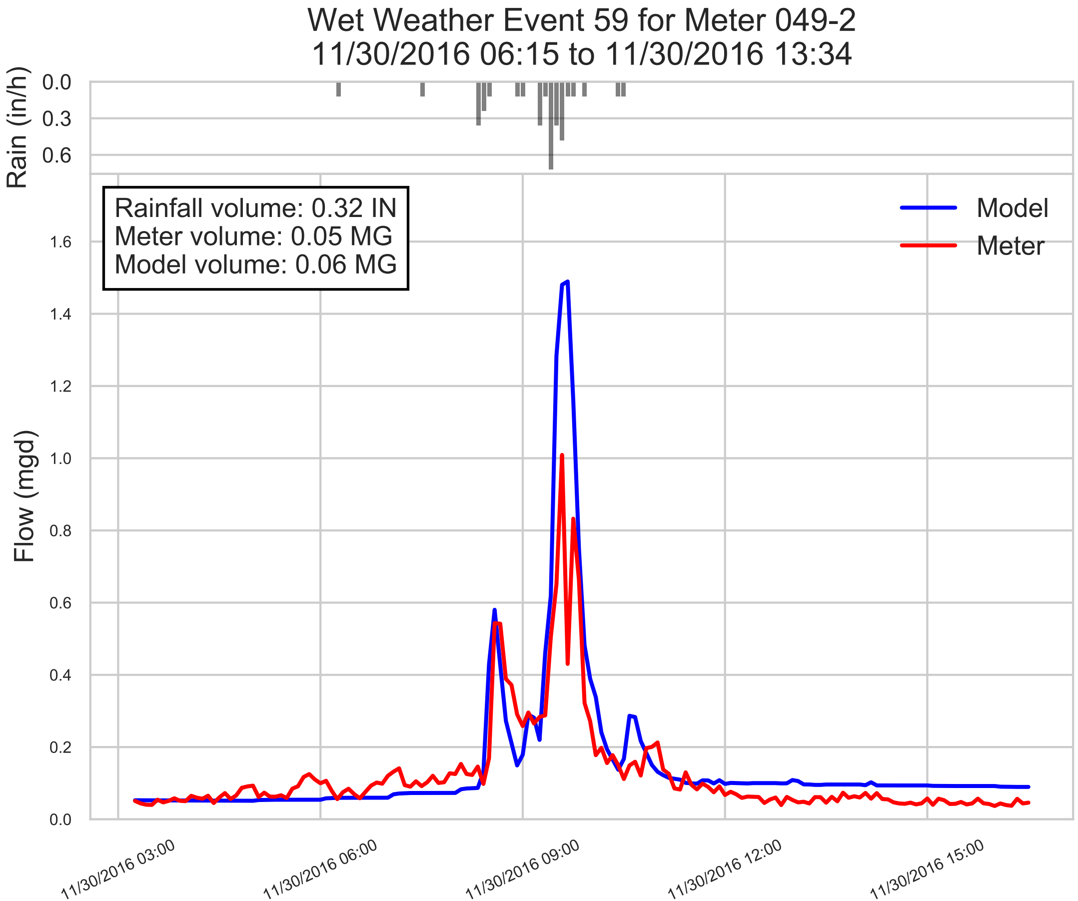
Wet Weather Event 56 for Meter 049-2
11/09/2016 05:30 to 11/09/2016 11:44
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.03 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
11/09/2016 03:00
11/09/2016 06:00
11/09/2016 09:00
11/09/2016 12:00
11/09/2016 15:00

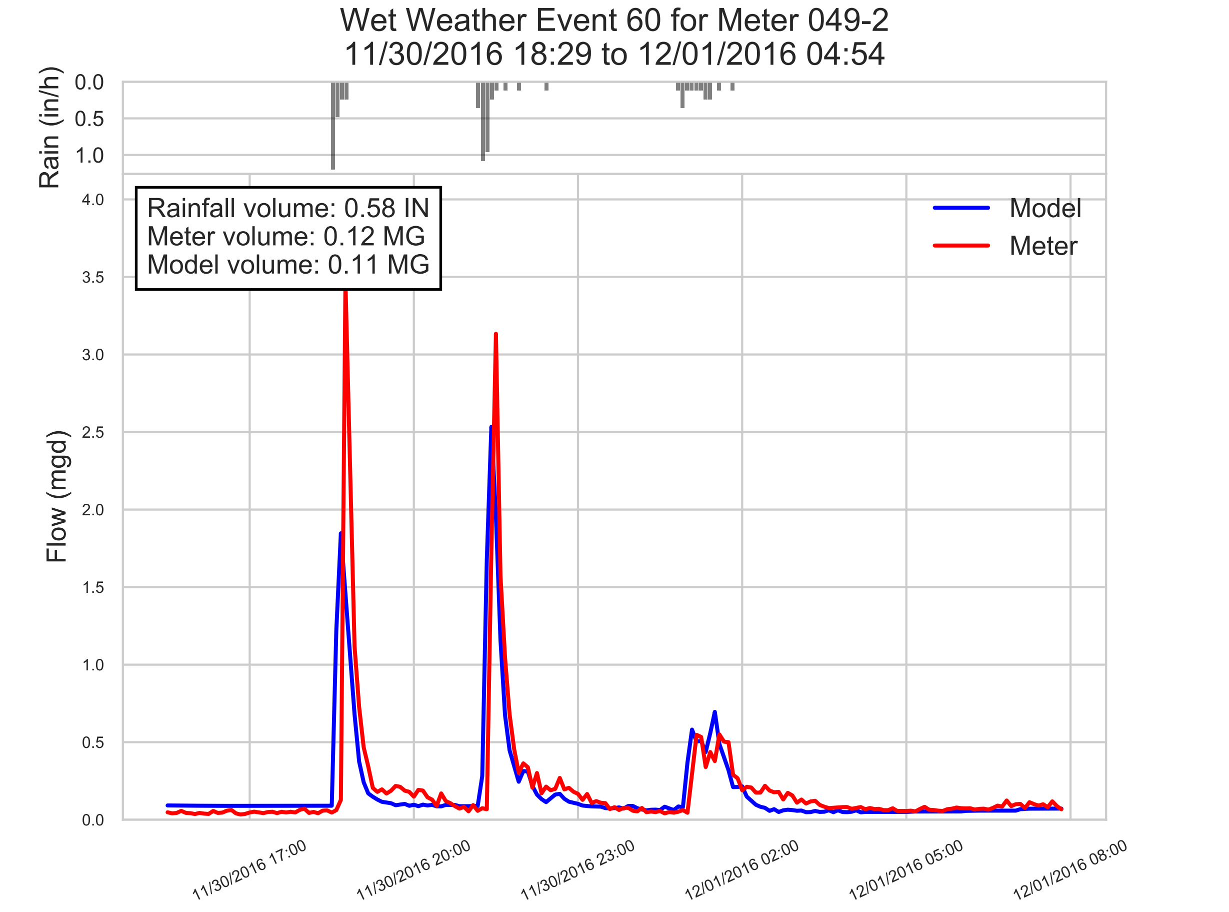


Wet Weather Event 57 for Meter 049-2
11/19/2016 16:50 to 11/19/2016 20:39
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.1 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
11/19/2016 14:00
11/19/2016 17:00
11/19/2016 20:00
11/19/2016 23:00

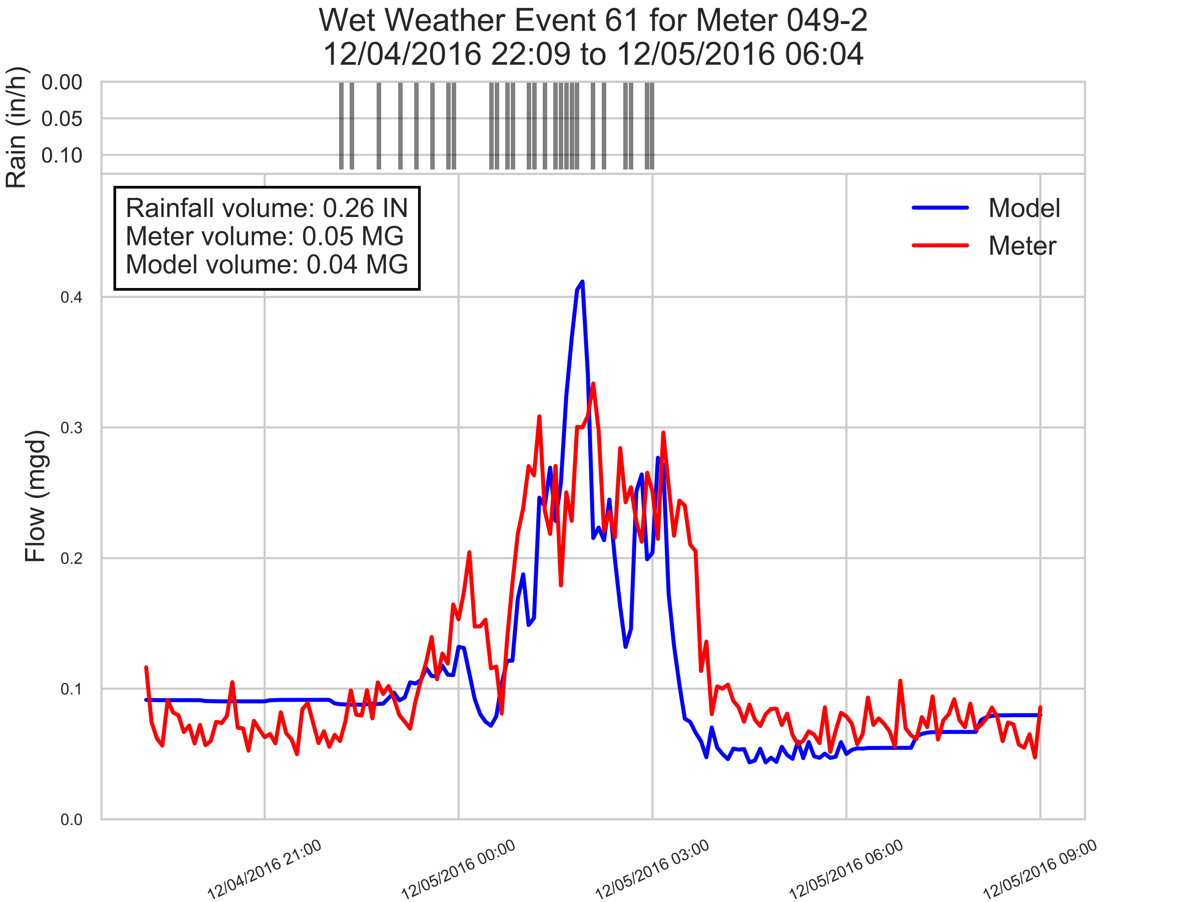


Wet Weather Event 58 for Meter 049-2
11/29/2016 08:10 to 11/29/2016 18:49
Rain (in/h)
0.0
0.1
0.2
0.30
Rainfall volume: 0.12 IN
Meter volume: 0.04 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.25
0.20
0.15
0.10
0.05
0.00
11/29/2016 07:00
11/29/2016 10:00
11/29/2016 13:00
11/29/2016 16:00
11/29/2016 19:00
11/29/2016 22:00

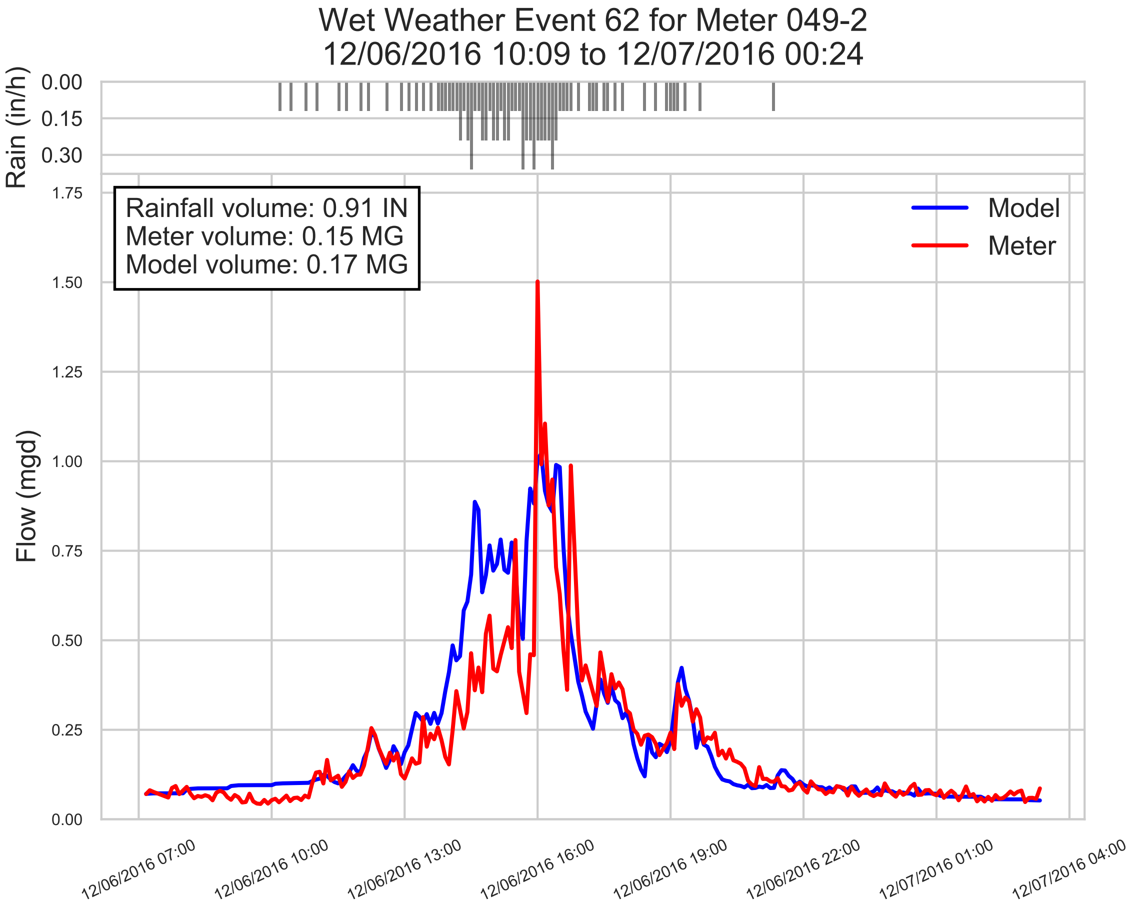

Wet Weather Event 59 for Meter 049-2
11/30/2016 06:15 to 11/30/2016 13:34
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.32 IN
Meter volume: 0.05 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/30/2016 03:00
11/30/2016 06:00
11/30/2016 09:00
11/30/2016 12:00
11/30/2016 15:00

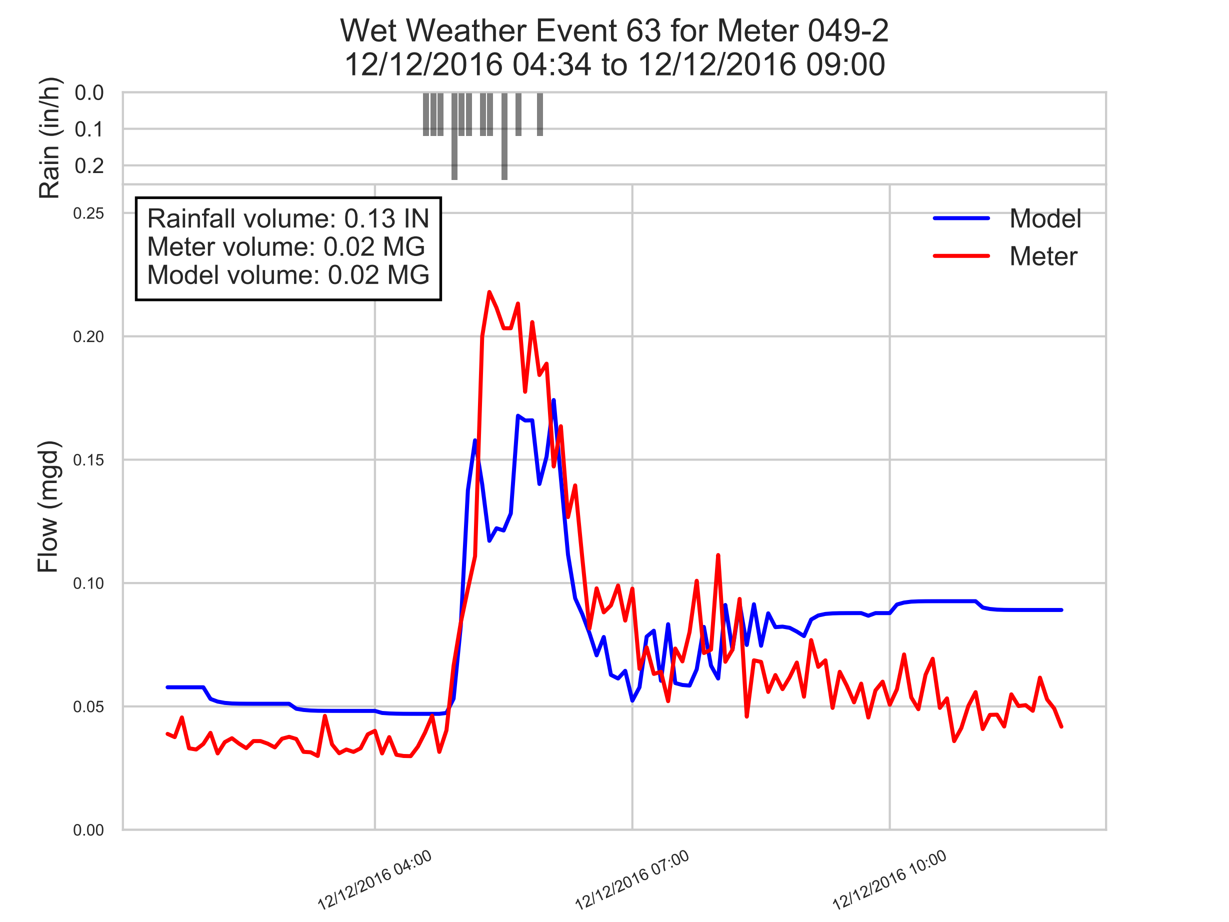


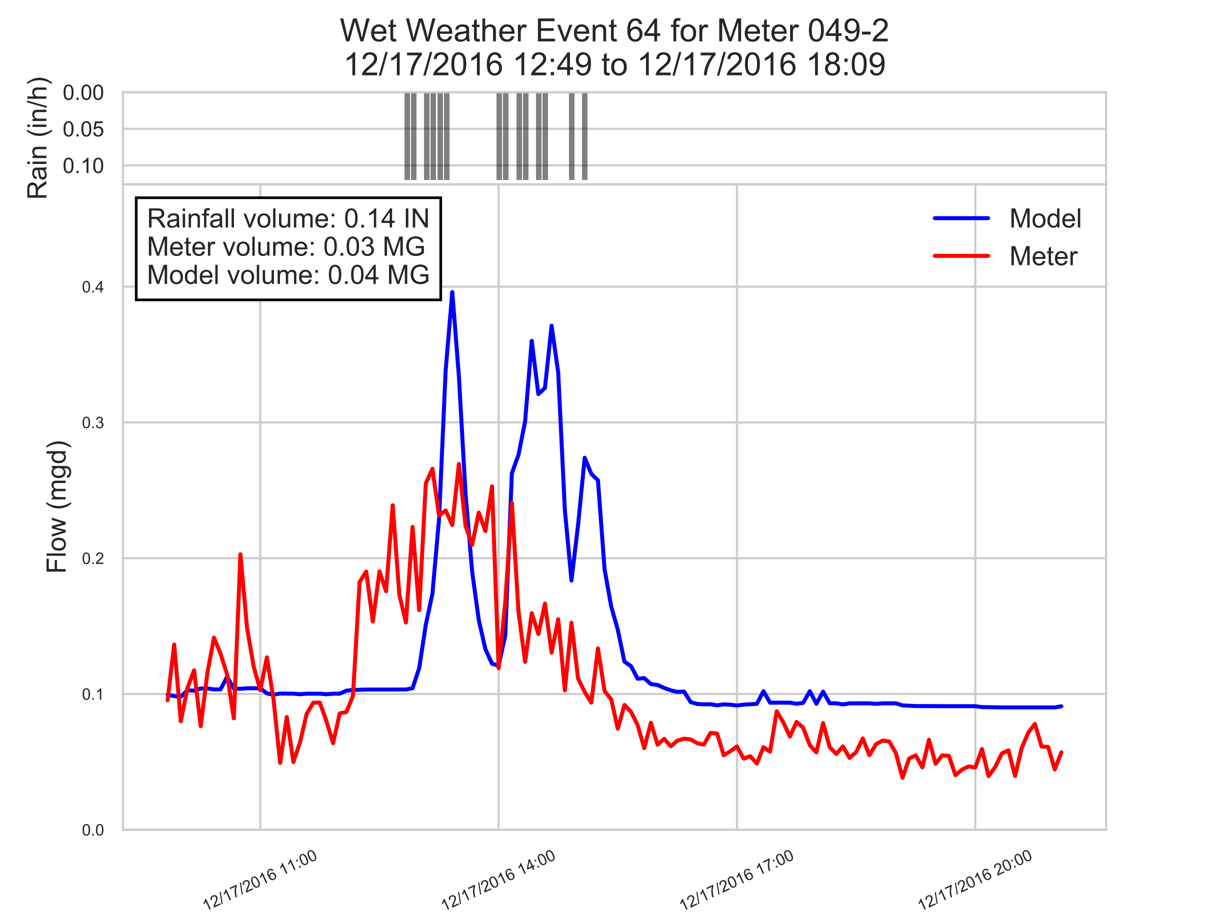
Wet Weather Event 60 for Meter 049-2
11/30/2016 18:29 to 12/01/2016 04:54
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.58 IN
Meter volume: 0.12 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/30/2016 17:00
11/30/2016 20:00
11/30/2016 23:00
12/01/2016 02:00
12/01/2016 05:00
12/01/2016 08:00

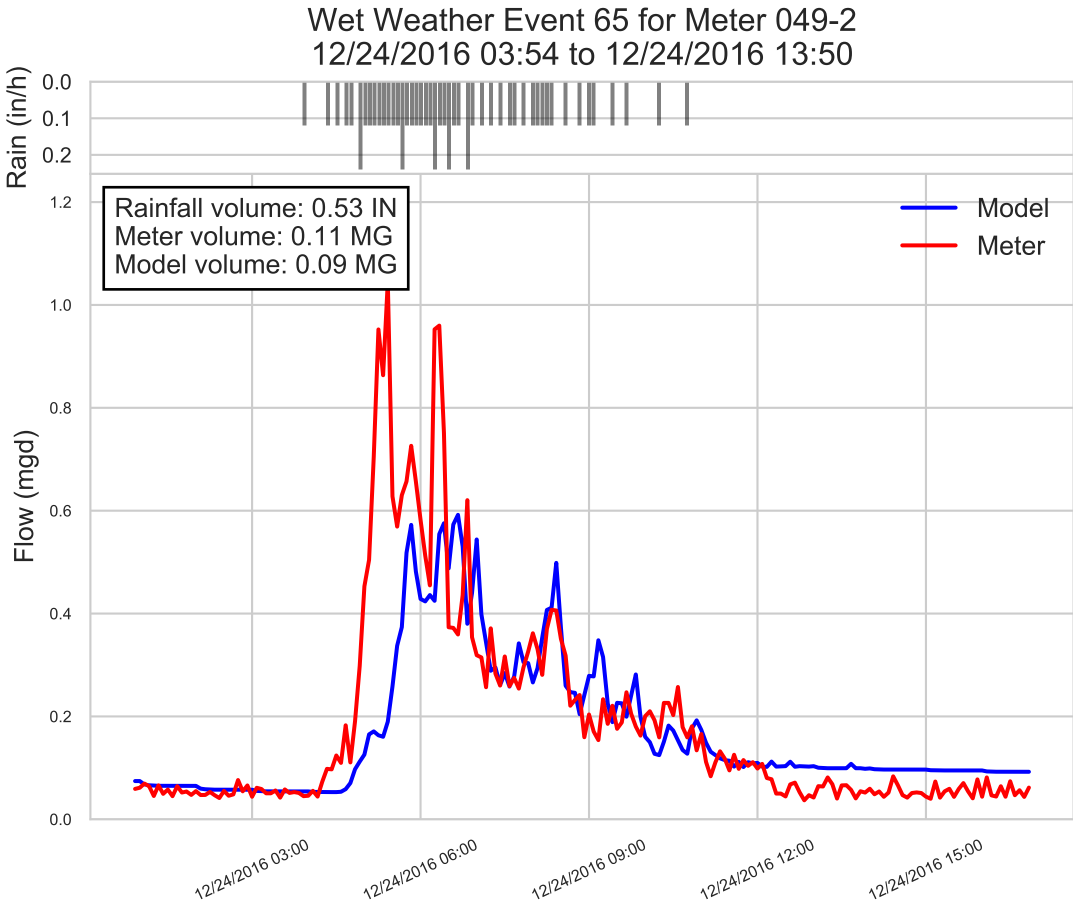


Wet Weather Event 61 for Meter 049-2
12/04/2016 22:09 to 12/05/2016 06:04
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.26 IN
Meter volume: 0.05 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
12/04/2016 21:00
12/05/2016 00:00
12/05/2016 03:00
12/05/2016 06:00
12/05/2016 09:00

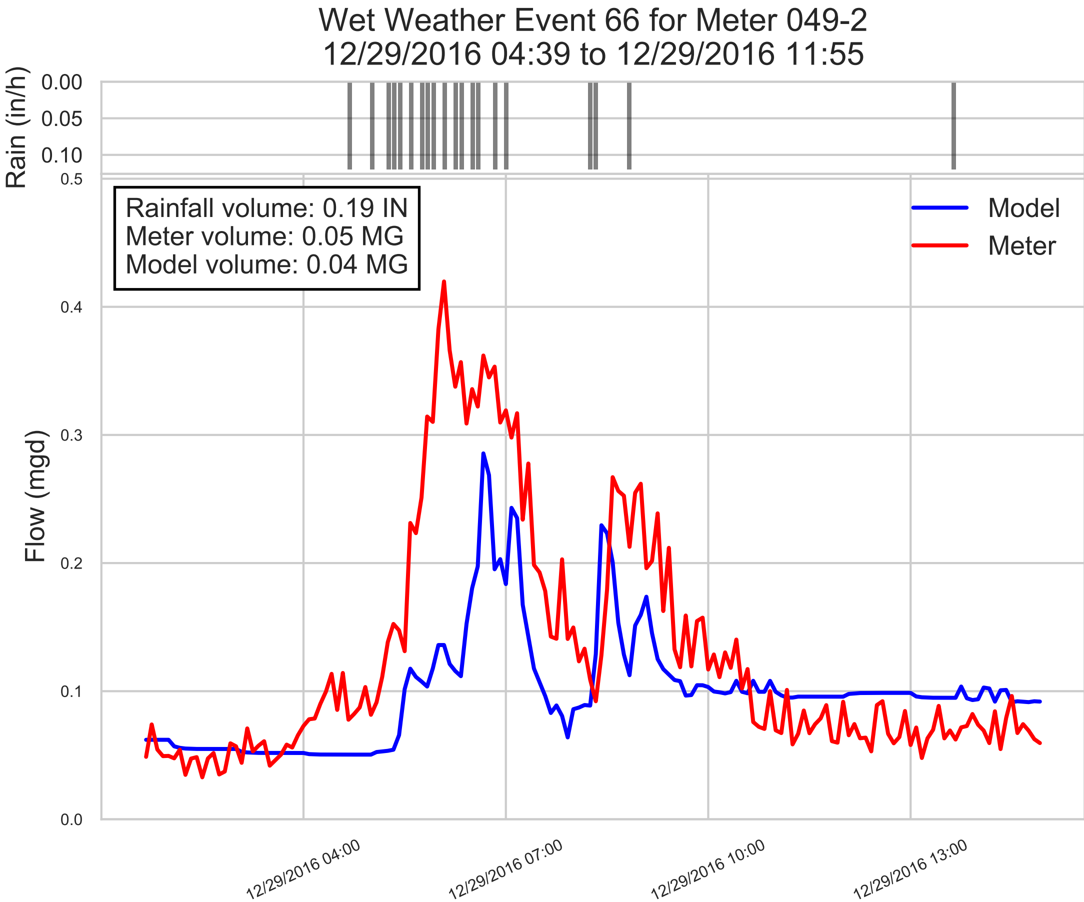

Wet Weather Event 62 for Meter 049-2
12/06/2016 10:09 to 12/07/2016 00:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.91 IN
Meter volume: 0.15 MG
Model volume: 0.17 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/06/2016 07:00
12/06/2016 10:00
12/06/2016 13:00
12/06/2016 16:00
12/06/2016 19:00
12/06/2016 22:00
12/07/2016 01:00
12/07/2016 04:00

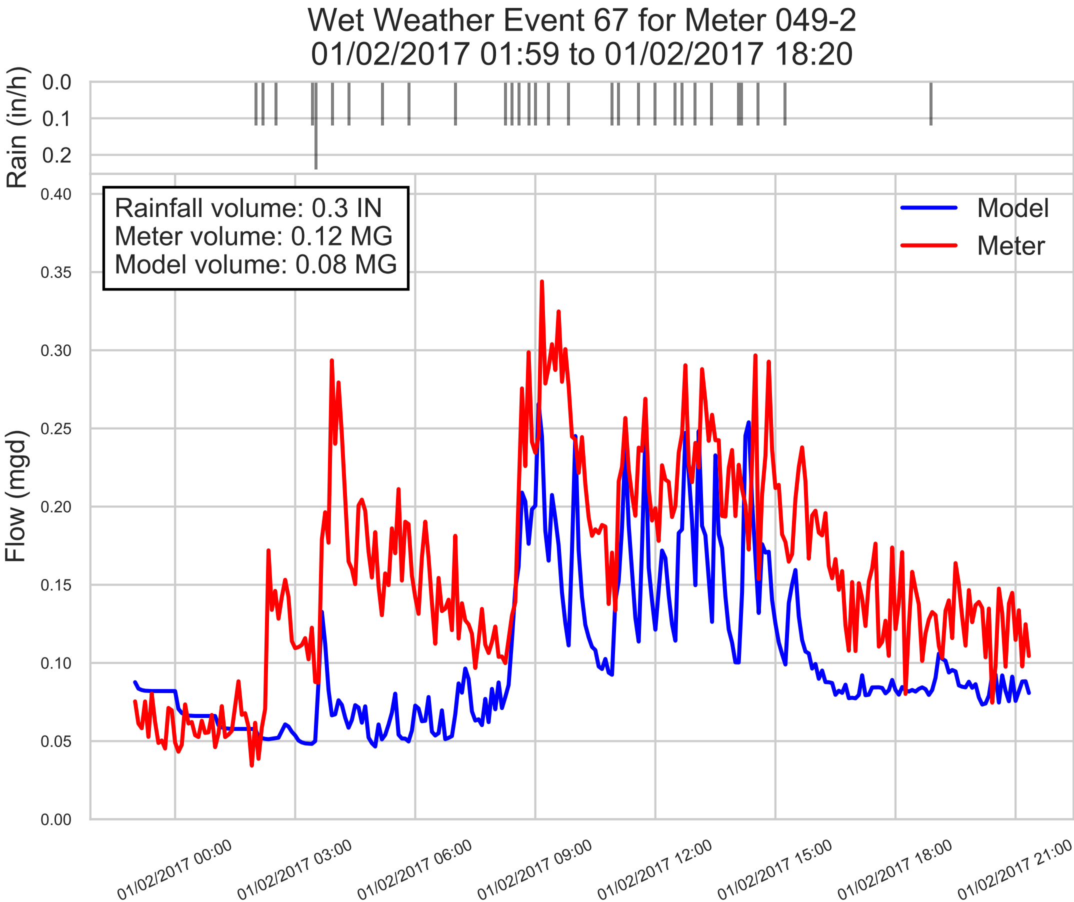

Wet Weather Event 63 for Meter 049-2
12/12/2016 04:34 to 12/12/2016 09:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall volume: 0.13 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model
Meter
12/12/2016 04:00
12/12/2016 07:00
12/12/2016 10:00


Wet Weather Event 64 for Meter 049-2
12/17/2016 12:49 to 12/17/2016 18:09
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.14 IN
Meter volume: 0.03 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
12/17/2016 11:00
12/17/2016 14:00
12/17/2016 17:00
12/17/2016 20:00

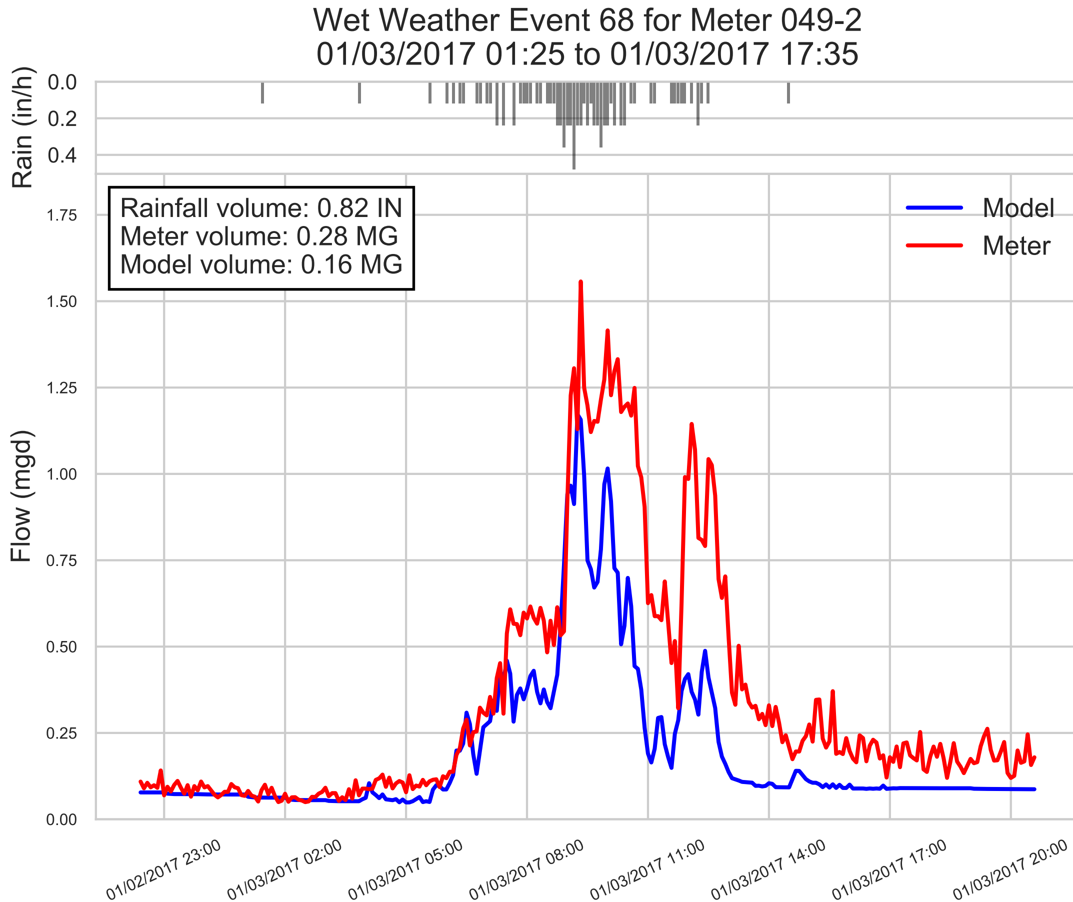


Wet Weather Event 65 for Meter 049-2
12/24/2016 03:54 to 12/24/2016 13:50
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.53 IN
Meter volume: 0.11 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/24/2016 03:00
12/24/2016 06:00
12/24/2016 09:00
12/24/2016 12:00
12/24/2016 15:00

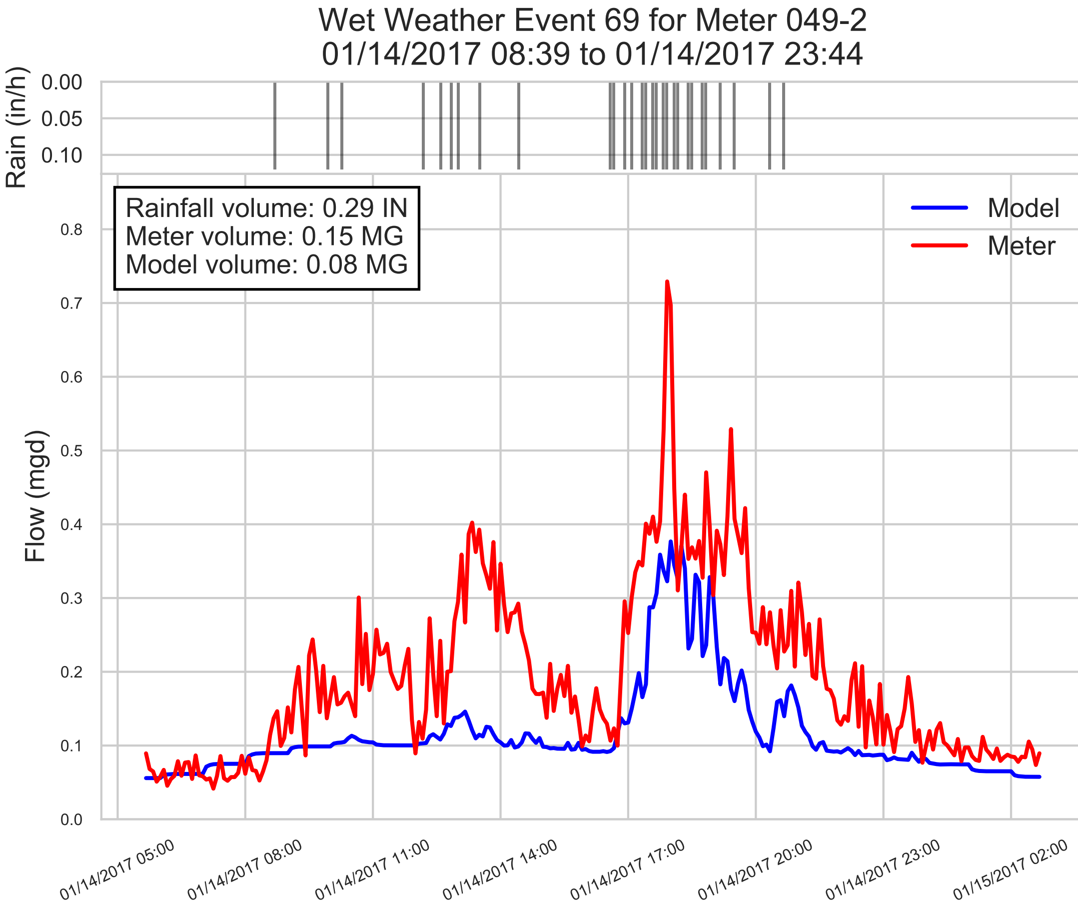

Wet Weather Event 66 for Meter 049-2
12/29/2016 04:39 to 12/29/2016 11:55
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.19 IN
Meter volume: 0.05 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
12/29/2016 04:00
12/29/2016 07:00
12/29/2016 10:00
12/29/2016 13:00



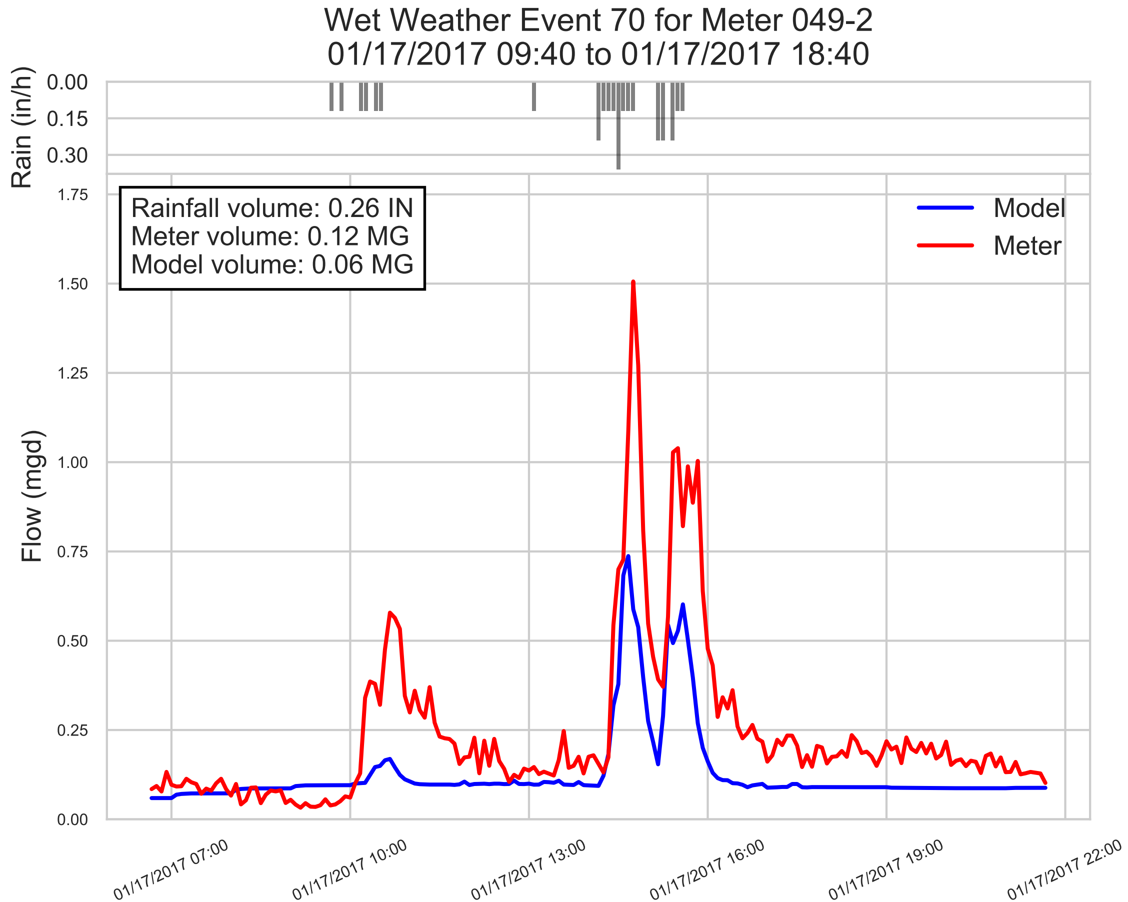
Wet Weather Event 67 for Meter 049-2
01/02/2017 01:59 to 01/02/2017 18:20
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.3 IN
Meter volume: 0.12 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
01/02/2017 00:00
01/02/2017 03:00
01/02/2017 06:00
01/02/2017 09:00
01/02/2017 12:00
01/02/2017 15:00
01/02/2017 18:00
01/02/2017 21:00



Wet Weather Event 68 for Meter 049-2
01/03/2017 01:25 to 01/03/2017 17:35
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Rainfall volume: 0.82 IN
Meter volume: 0.28 MG
Model volume: 0.16 MG
Model
Meter
01/02/2017 23:00
01/03/2017 02:00
01/03/2017 05:00
01/03/2017 08:00
01/03/2017 11:00
01/03/2017 14:00
01/03/2017 17:00
01/03/2017 20:00



Wet Weather Event 69 for Meter 049-2
01/14/2017 08:39 to 01/14/2017 23:44
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.29 IN
Meter volume: 0.15 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
01/14/2017 05:00
01/14/2017 08:00
01/14/2017 11:00
01/14/2017 14:00
01/14/2017 17:00
01/14/2017 20:00
01/14/2017 23:00
01/15/2017 02:00


Wet Weather Event 70 for Meter 049-2
01/17/2017 09:40 to 01/17/2017 18:40
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.26 IN
Meter volume: 0.12 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
01/17/2017 07:00
01/17/2017 10:00
01/17/2017 13:00
01/17/2017 16:00
01/17/2017 19:00
01/17/2017 22:00

Appendix B: Monitoring Timeseries for Entire Pre-Construction Metering Time Period

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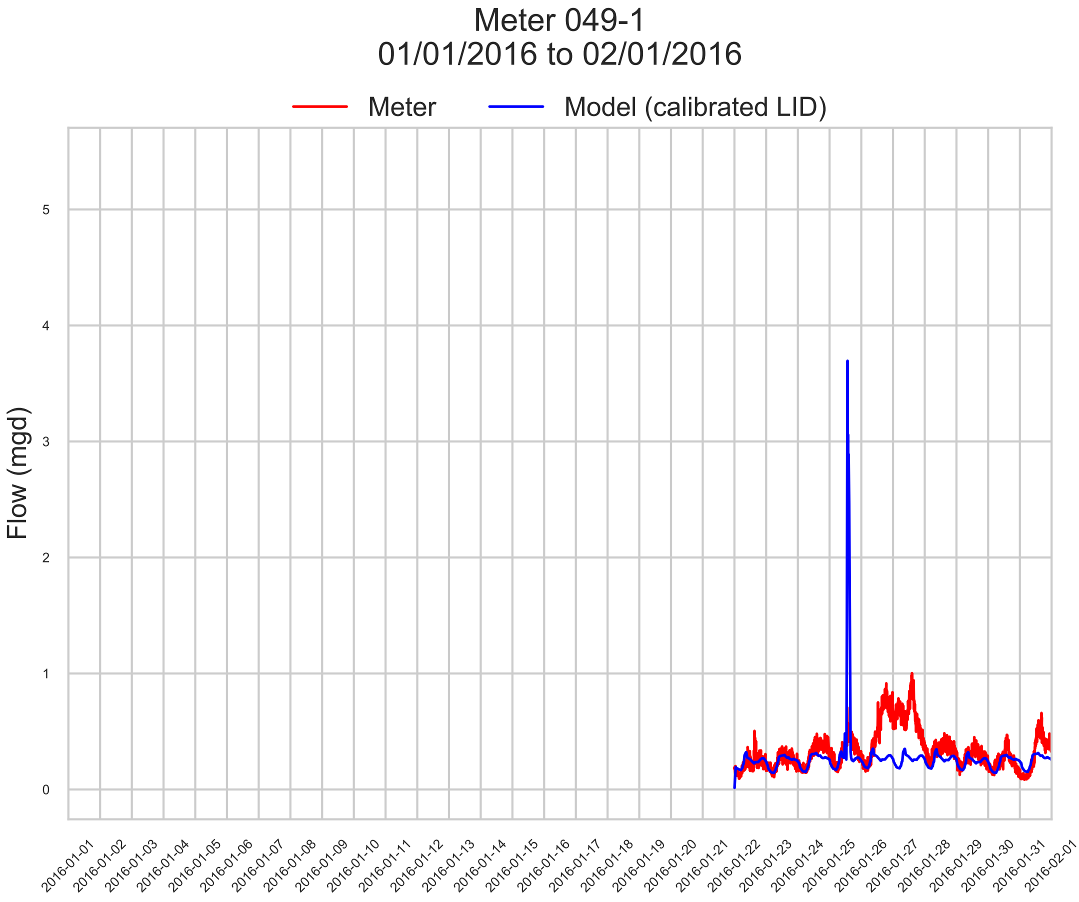
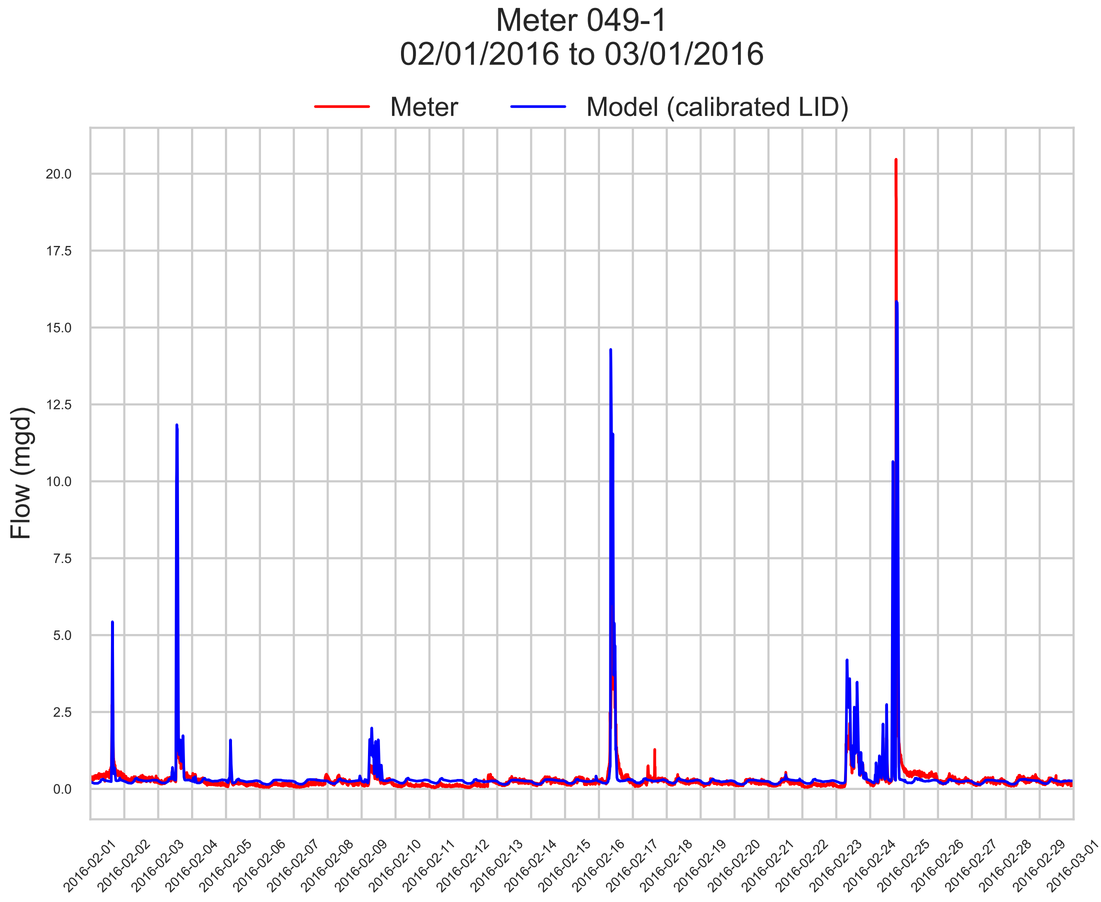
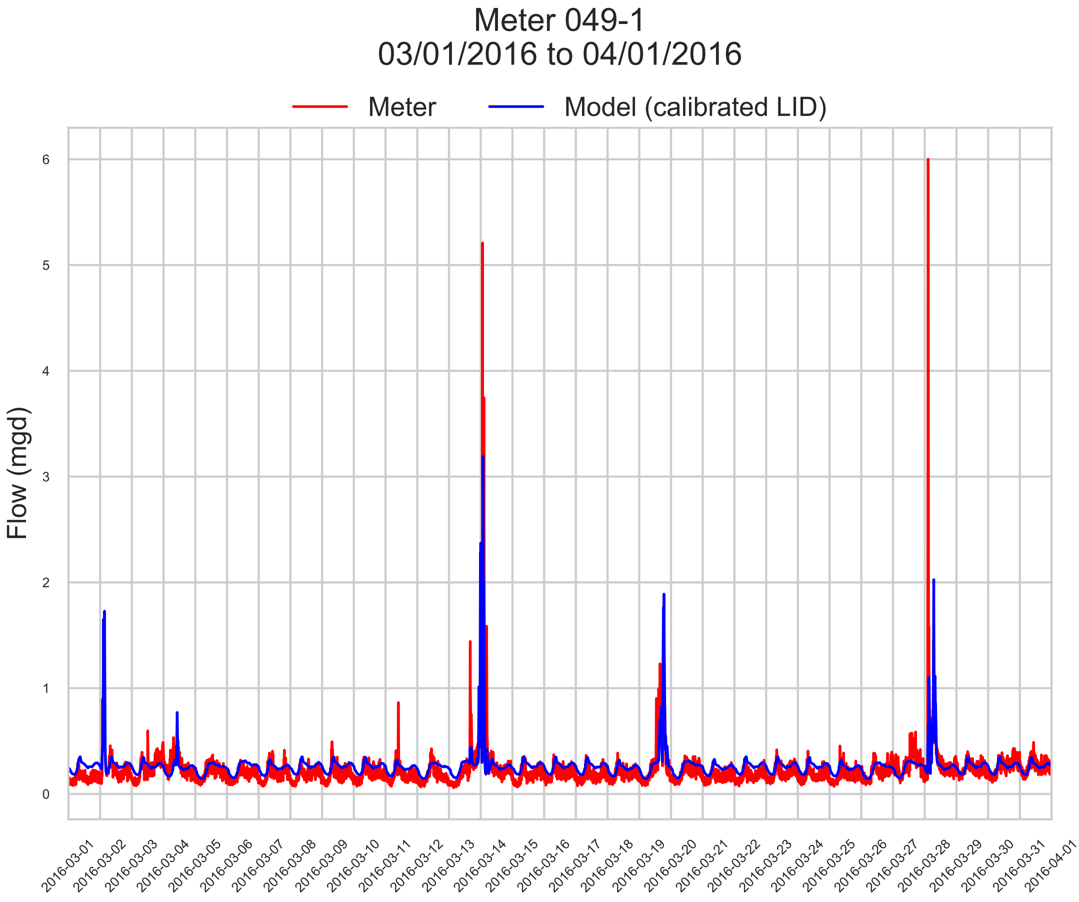
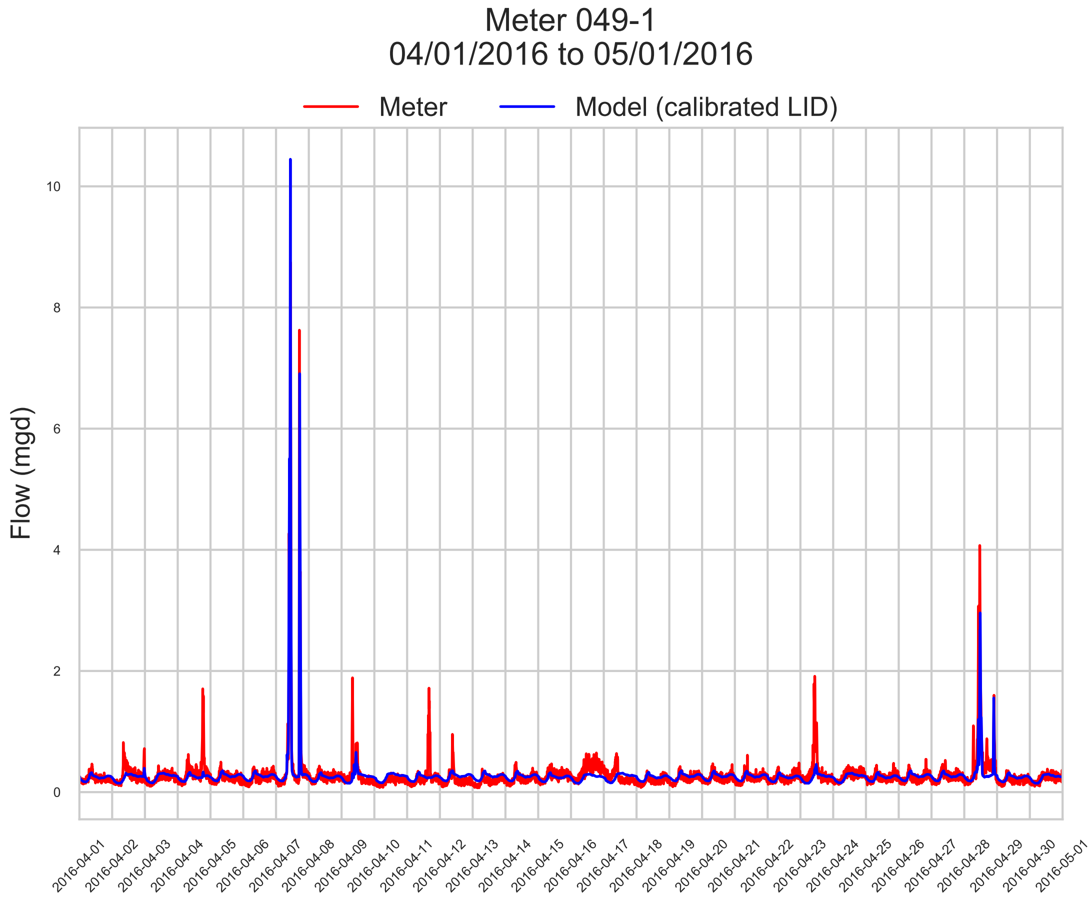

Meter 049-1
01/01/2016 to 02/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
2016-01-01
2016-01-02
2016-01-03
2016-01-04
2016-01-05
2016-01-06
2016-01-07
2016-01-08
2016-01-09
2016-01-10
2016-01-11
2016-01-12
2016-01-13
2016-01-14
2016-01-15
2016-01-16
2016-01-17
2016-01-18
2016-01-19
2016-01-20
2016-01-21
2016-01-22
2016-01-23
2016-01-24
2016-01-25
2016-01-26
2016-01-27
2016-01-28
2016-01-29
2016-01-30
2016-01-31
2016-02-01



Meter 049-1
02/01/2016 to 03/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2016-02-01
2016-02-02
2016-02-03
2016-02-04
2016-02-05
2016-02-06
2016-02-07
2016-02-08
2016-02-09
2016-02-10
2016-02-11
2016-02-12
2016-02-13
2016-02-14
2016-02-15
2016-02-16
2016-02-17
2016-02-18
2016-02-19
2016-02-20
2016-02-21
2016-02-22
2016-02-23
2016-02-24
2016-02-25
2016-02-26
2016-02-27
2016-02-28
2016-02-29
2016-03-01


Meter 049-1
03/01/2016 to 04/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
2016-03-01
2016-03-02
2016-03-03
2016-03-04
2016-03-05
2016-03-06
2016-03-07
2016-03-08
2016-03-09
2016-03-10
2016-03-11
2016-03-12
2016-03-13
2016-03-14
2016-03-15
2016-03-16
2016-03-17
2016-03-18
2016-03-19
2016-03-20
2016-03-21
2016-03-22
2016-03-23
2016-03-24
2016-03-25
2016-03-26
2016-03-27
2016-03-28
2016-03-29
2016-03-30
2016-03-31
2016-04-01



Meter 049-1
04/01/2016 to 05/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
2016-04-01
2016-04-02
2016-04-03
2016-04-04
2016-04-05
2016-04-06
2016-04-07
2016-04-08
2016-04-09
2016-04-10
2016-04-11
2016-04-12
2016-04-13
2016-04-14
2016-04-15
2016-04-16
2016-04-17
2016-04-18
2016-04-19
2016-04-20
2016-04-21
2016-04-22
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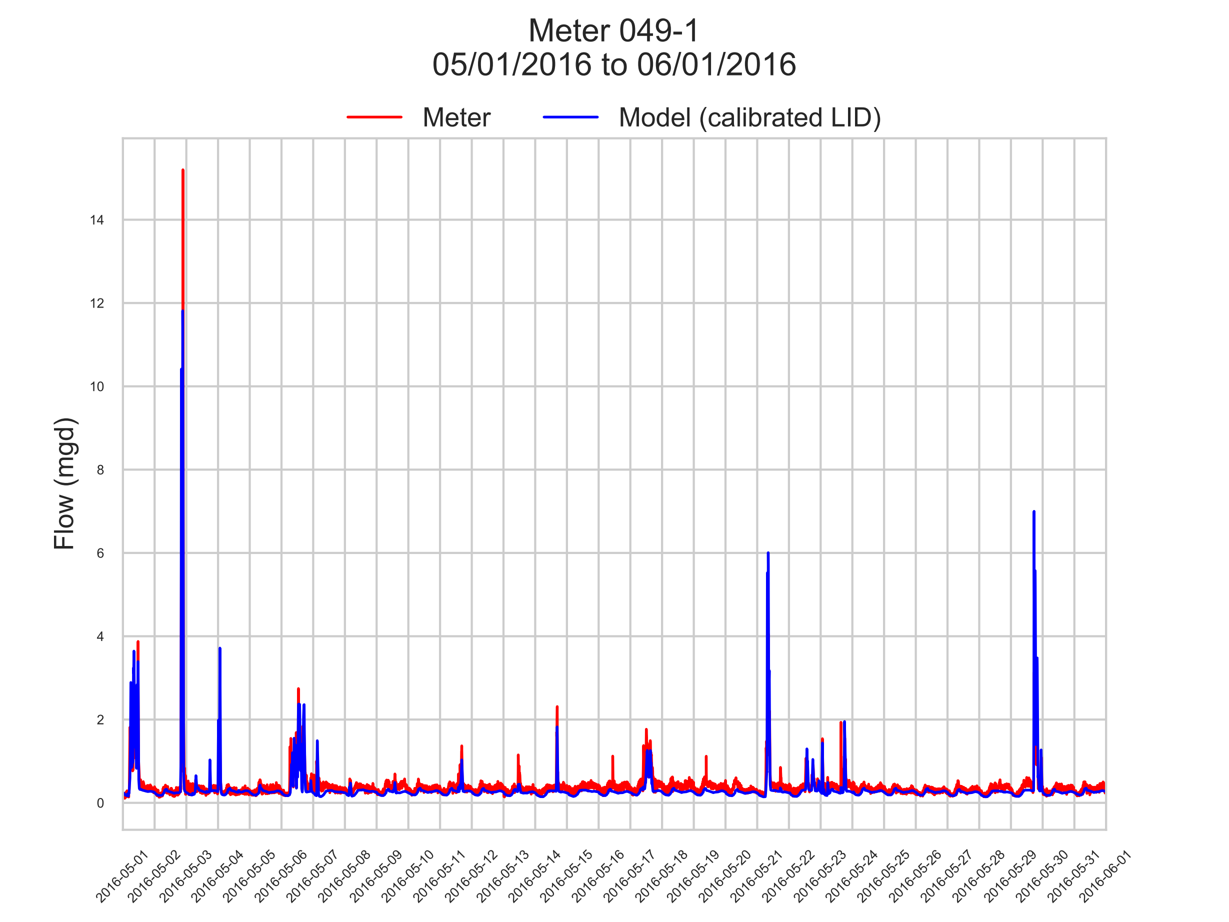
2016-04-28
2016-04-29
2016-04-30
2016-05-01



Meter 049-1
05/01/2016 to 06/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
14
2016-05-01
2016-05-02
2016-05-03
2016-05-04
2016-05-05
2016-05-06
2016-05-07
2016-05-08
2016-05-09
2016-05-10
2016-05-11
2016-05-12
2016-05-13
2016-05-14
2016-05-15
2016-05-16
2016-05-17
2016-05-18
2016-05-19
2016-05-20
2016-05-21
2016-05-22
2016-05-23
2016-05-24
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2016-05-26
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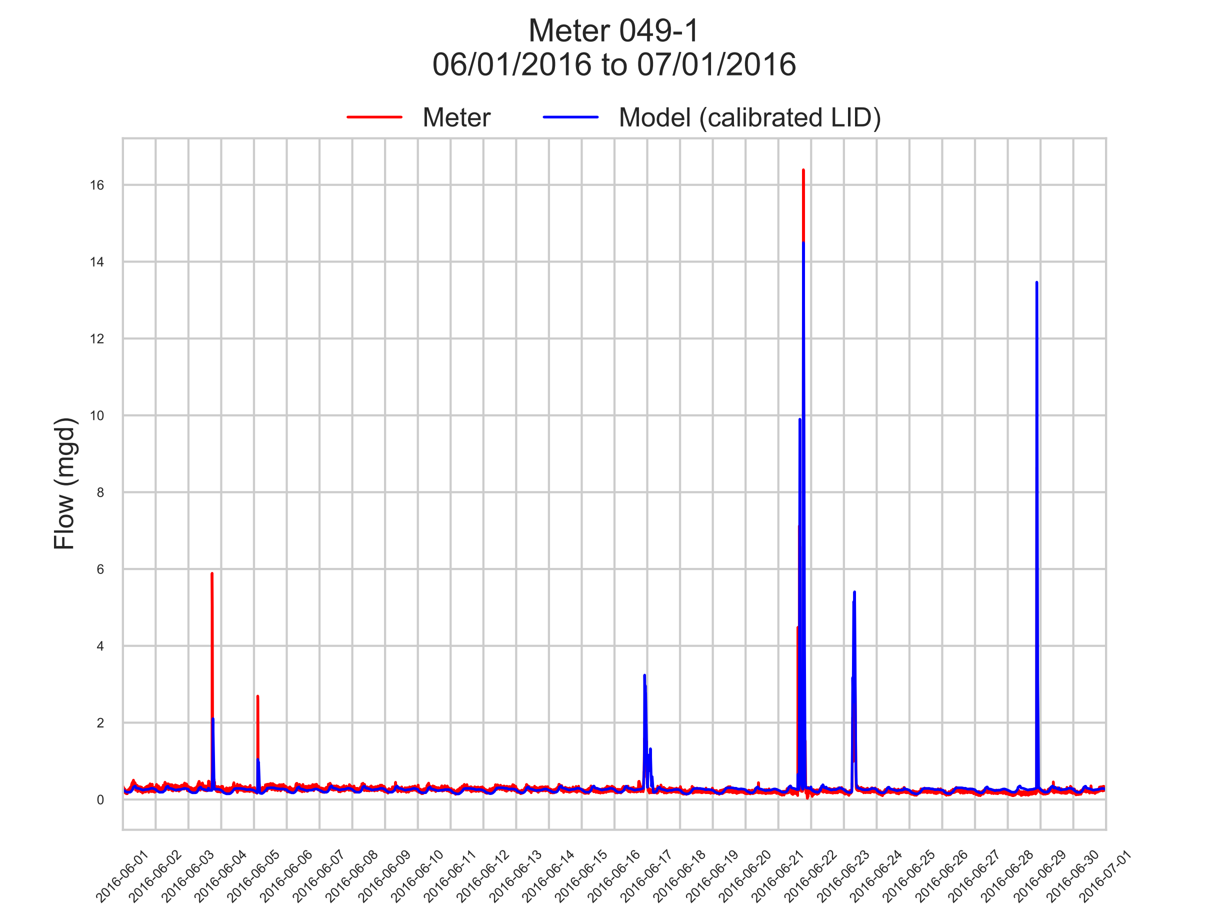
2016-05-31
2016-06-01


Meter 049-1
06/01/2016 to 07/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
14
16
2016-06-01
2016-06-02
2016-06-03
2016-06-04
2016-06-05
2016-06-06
2016-06-07
2016-06-08
2016-06-09
2016-06-10
2016-06-11
2016-06-12
2016-06-13
2016-06-14
2016-06-15
2016-06-16
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2016-06-21
2016-06-22
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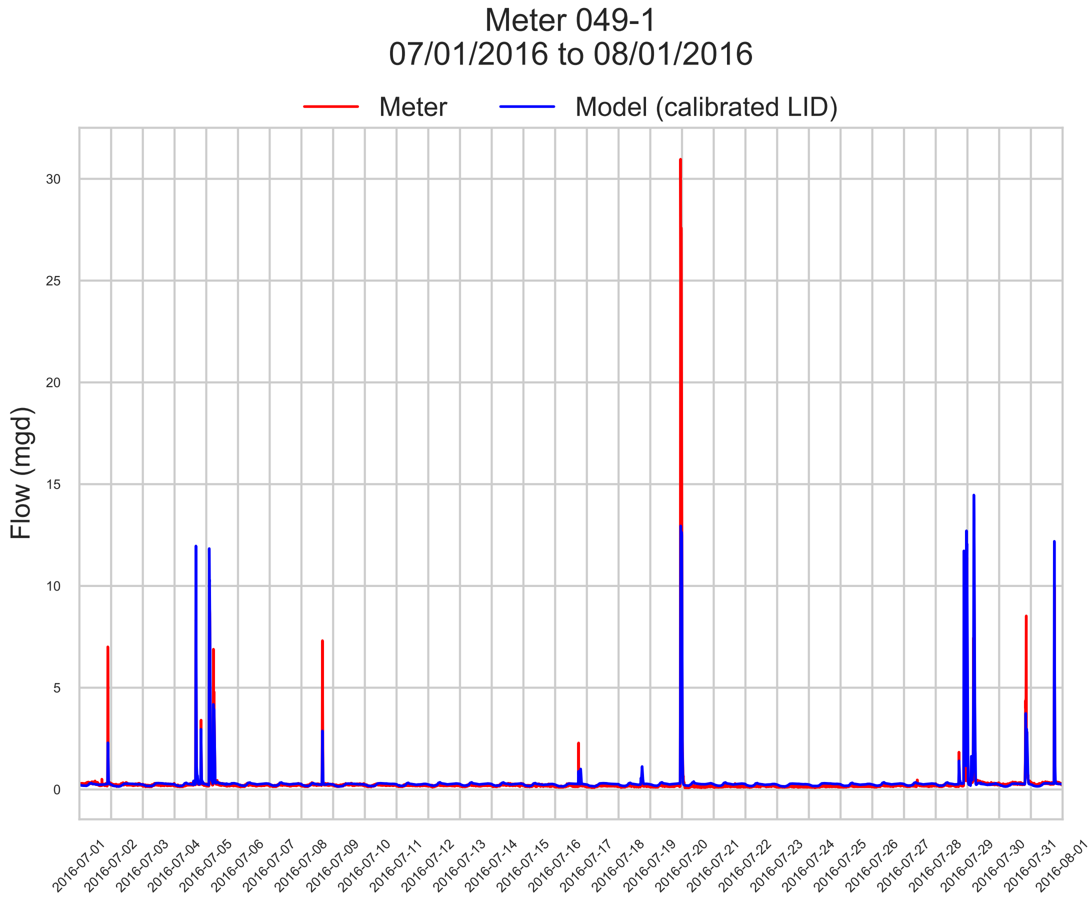
2016-06-28
2016-06-29
2016-06-30
2016-07-01


Meter 049-1
07/01/2016 to 08/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
30
2016-07-01
2016-07-02
2016-07-03
2016-07-04
2016-07-05
2016-07-06
2016-07-07
2016-07-08
2016-07-09
2016-07-10
2016-07-11
2016-07-12
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2016-07-23
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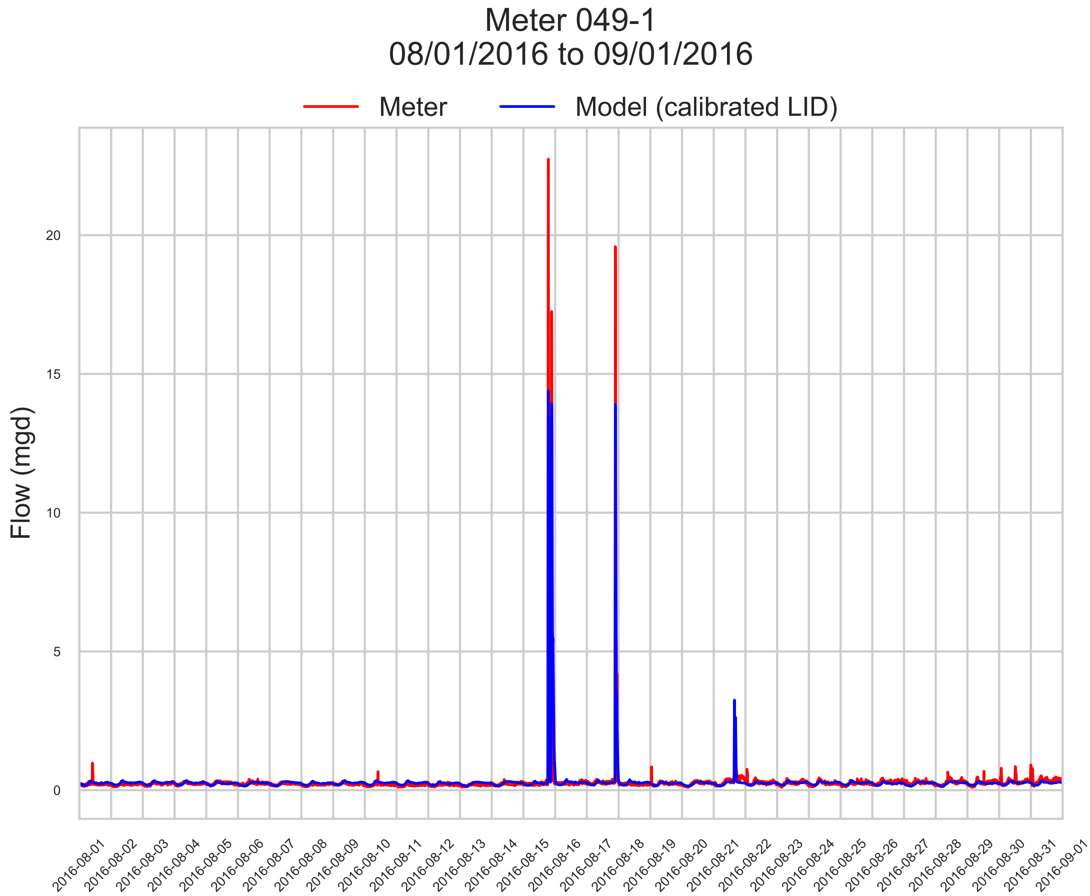
2016-07-29
2016-07-30
2016-07-31
2016-08-01



Meter 049-1
08/01/2016 to 09/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
2016-08-01
2016-08-02
2016-08-03
2016-08-04
2016-08-05
2016-08-06
2016-08-07
2016-08-08
2016-08-09
2016-08-10
2016-08-11
2016-08-12
2016-08-13
2016-08-14
2016-08-15
2016-08-16
2016-08-17
2016-08-18
2016-08-19
2016-08-20
2016-08-21
2016-08-22
2016-08-23
2016-08-24
2016-08-25
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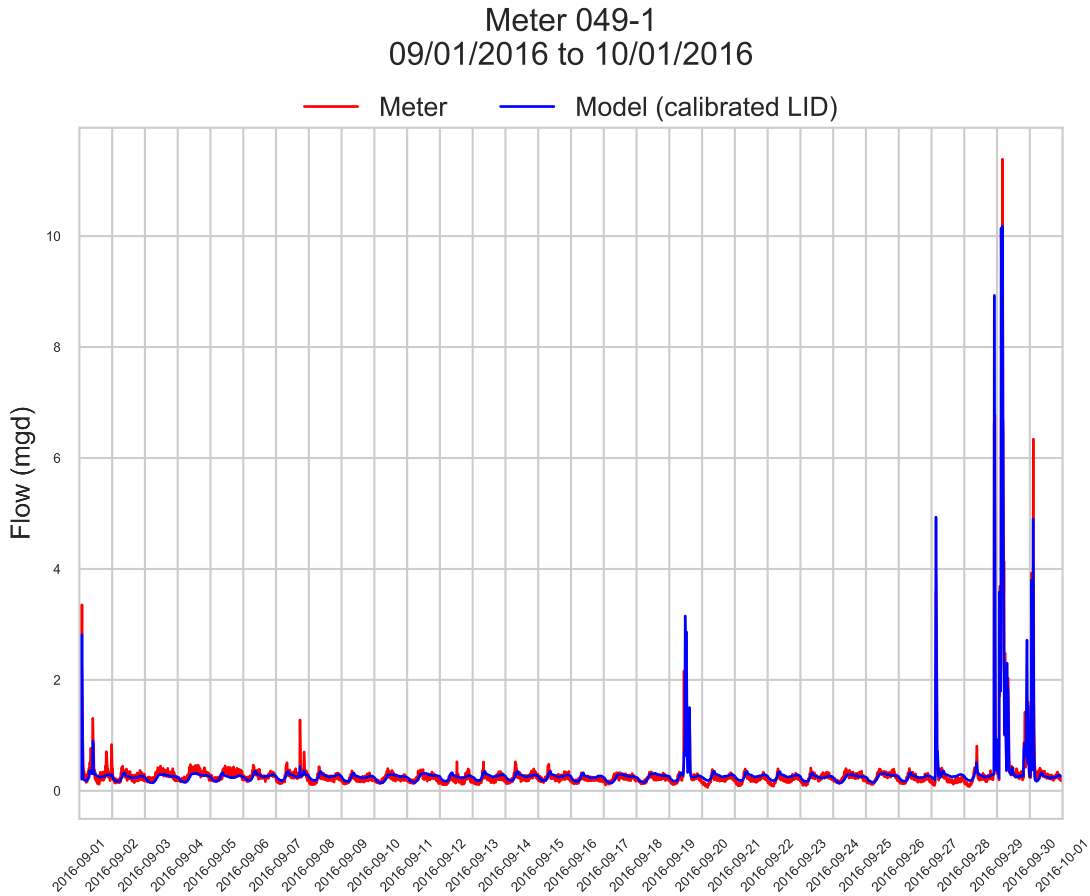
2016-08-31
2016-09-01


Meter 049-1
09/01/2016 to 10/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
2016-09-01
2016-09-02
2016-09-03
2016-09-04
2016-09-05
2016-09-06
2016-09-07
2016-09-08
2016-09-09
2016-09-10
2016-09-11
2016-09-12
2016-09-13
2016-09-14
2016-09-15
2016-09-16
2016-09-17
2016-09-18
2016-09-19
2016-09-20
2016-09-21
2016-09-22
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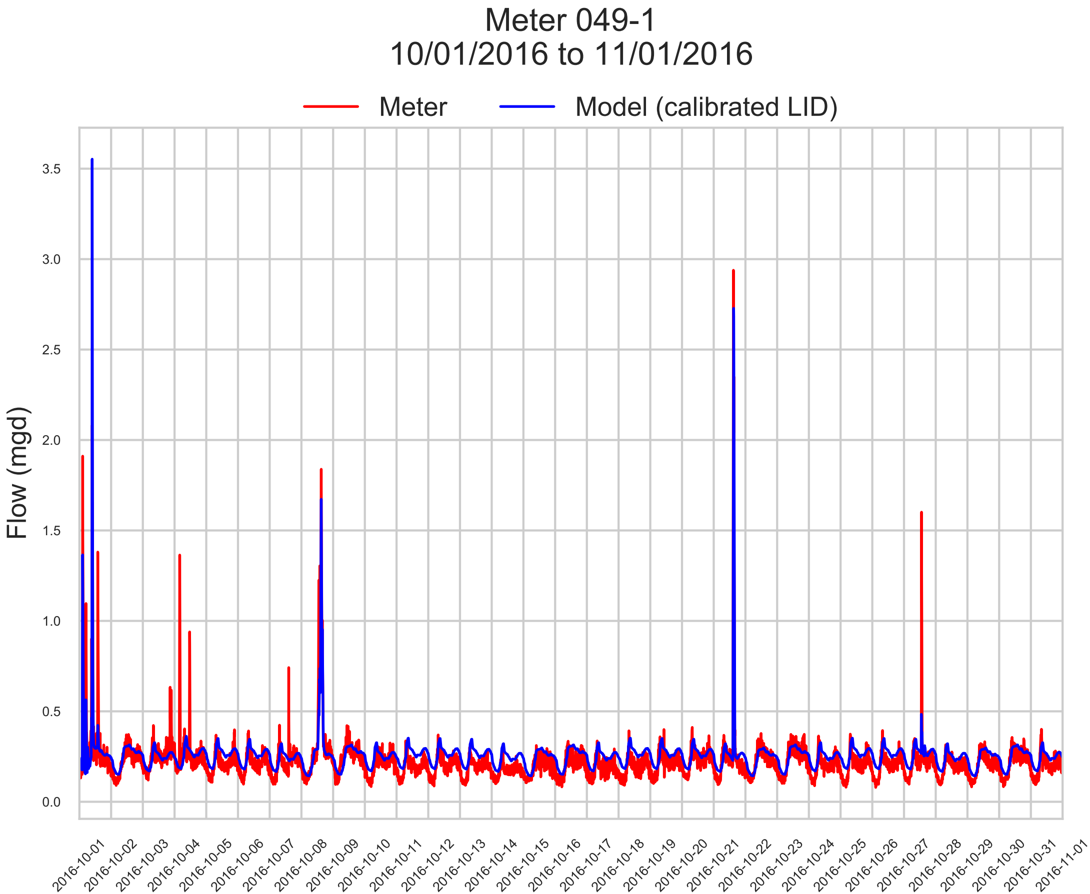
2016-09-26
2016-09-27
2016-09-28
2016-09-29
2016-09-30
2016-10-01



Meter 049-1
10/01/2016 to 11/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2016-10-01
2016-10-02
2016-10-03
2016-10-04
2016-10-05
2016-10-06
2016-10-07
2016-10-08
2016-10-09
2016-10-10
2016-10-11
2016-10-12
2016-10-13
2016-10-14
2016-10-15
2016-10-16
2016-10-17
2016-10-18
2016-10-19
2016-10-20
2016-10-21
2016-10-22
2016-10-23
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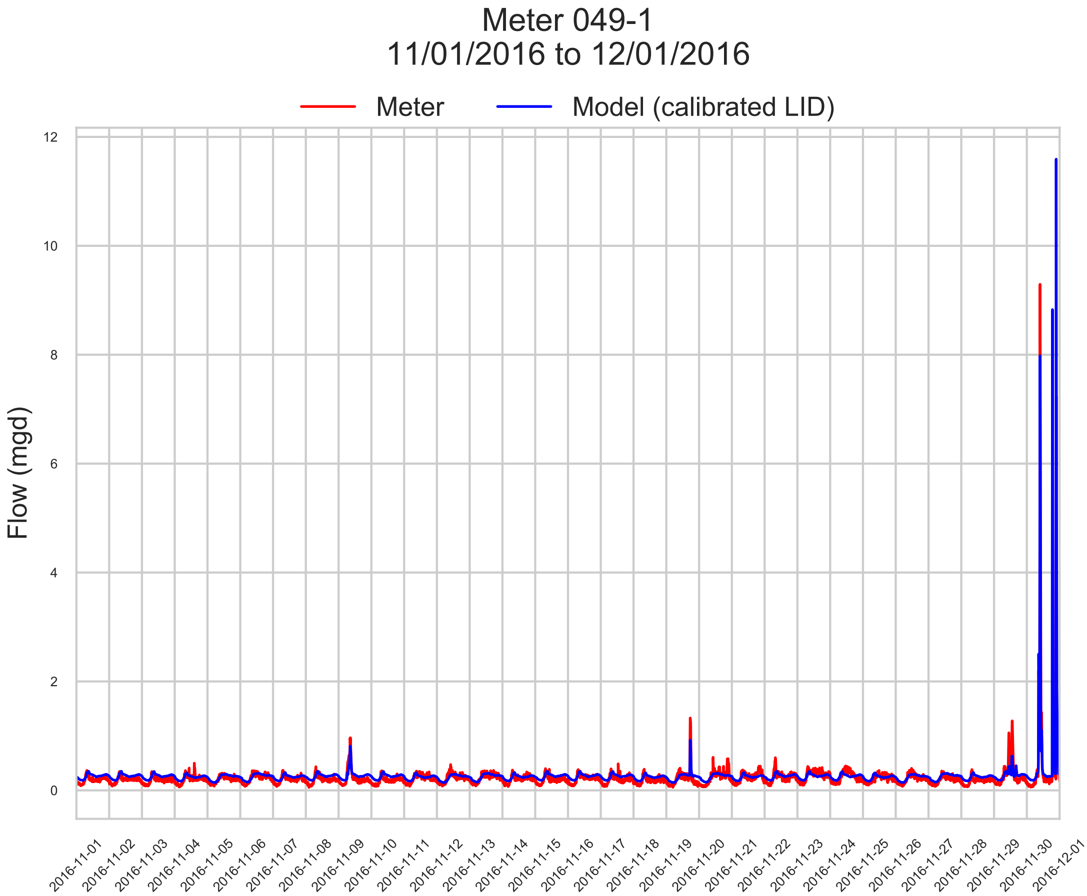
2016-10-30
2016-10-31
2016-11-01



Meter 049-1
11/01/2016 to 12/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2016-11-01
2016-11-02
2016-11-03
2016-11-04
2016-11-05
2016-11-06
2016-11-07
2016-11-08
2016-11-09
2016-11-10
2016-11-11
2016-11-12
2016-11-13
2016-11-14
2016-11-15
2016-11-16
2016-11-17
2016-11-18
2016-11-19
2016-11-20
2016-11-21
2016-11-22
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2016-11-25
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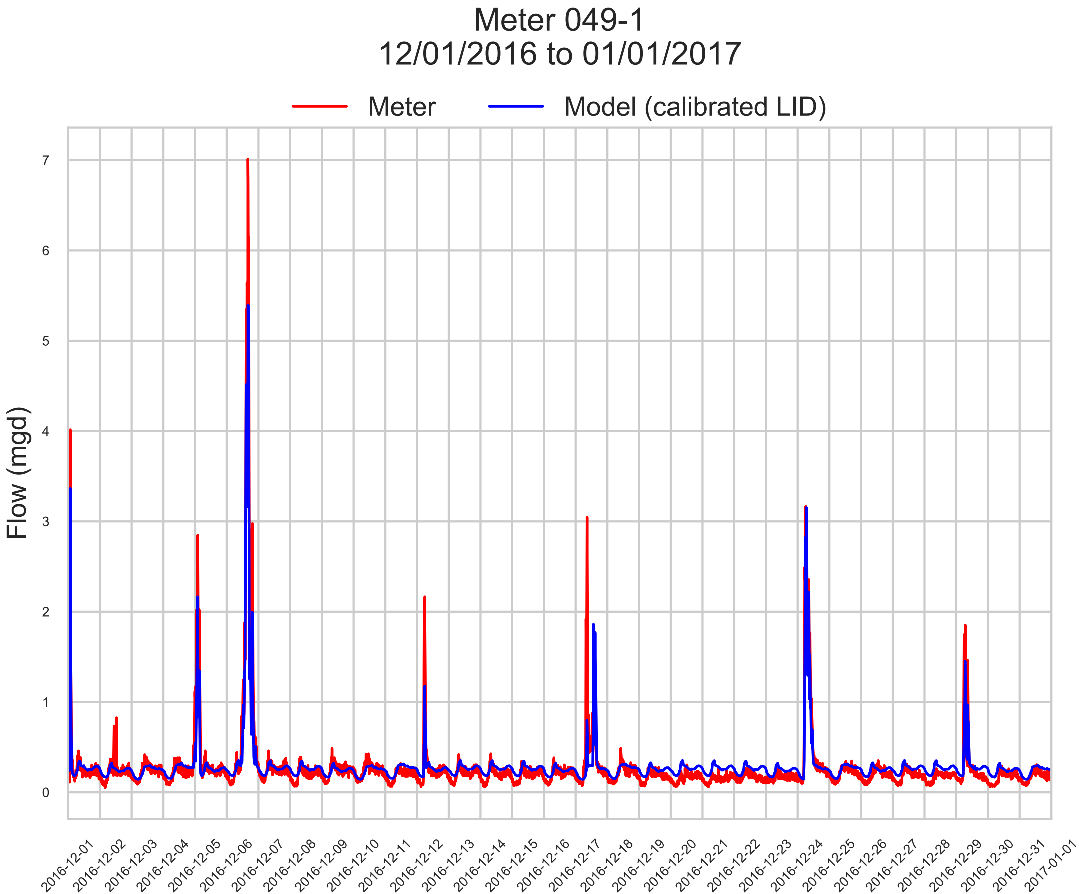
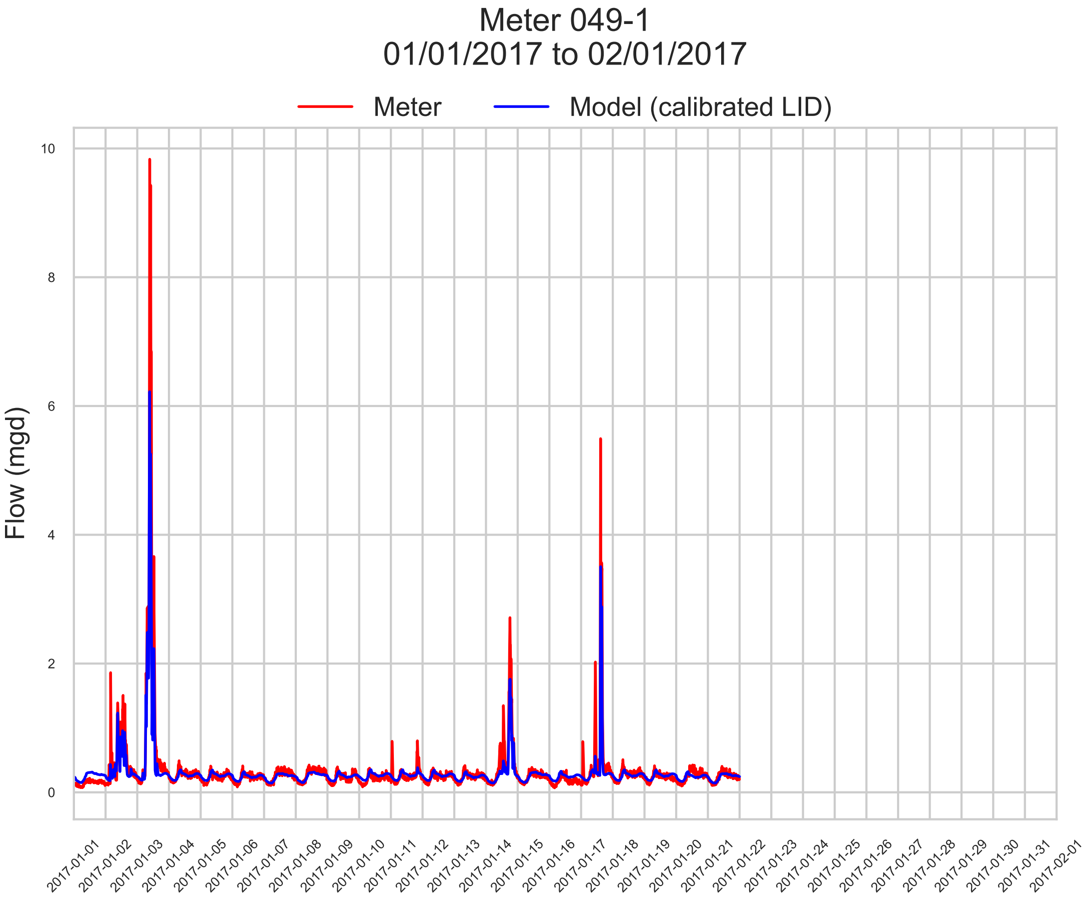
2016-11-28
2016-11-29
2016-11-30
2016-12-01



Meter 049-1
12/01/2016 to 01/01/2017
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
7
2016-12-01
2016-12-02
2016-12-03
2016-12-04
2016-12-05
2016-12-06
2016-12-07
2016-12-08
2016-12-09
2016-12-10
2016-12-11
2016-12-12
2016-12-13
2016-12-14
2016-12-15
2016-12-16
2016-12-17
2016-12-18
2016-12-19
2016-12-20
2016-12-21
2016-12-22
2016-12-23
2016-12-24
2016-12-25
2016-12-26
2016-12-27
2016-12-28
2016-12-29
2016-12-30
2016-12-31
2017-01-01


Meter 049-1
01/01/2017 to 02/01/2017
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
2017-01-01
2017-01-02
2017-01-03
2017-01-04
2017-01-05
2017-01-06
2017-01-07
2017-01-08
2017-01-09
2017-01-10
2017-01-11
2017-01-12
2017-01-13
2017-01-14
2017-01-15
2017-01-16
2017-01-17
2017-01-18
2017-01-19
2017-01-20
2017-01-21
2017-01-22
2017-01-23
2017-01-24
2017-01-25
2017-01-26
2017-01-27
2017-01-28
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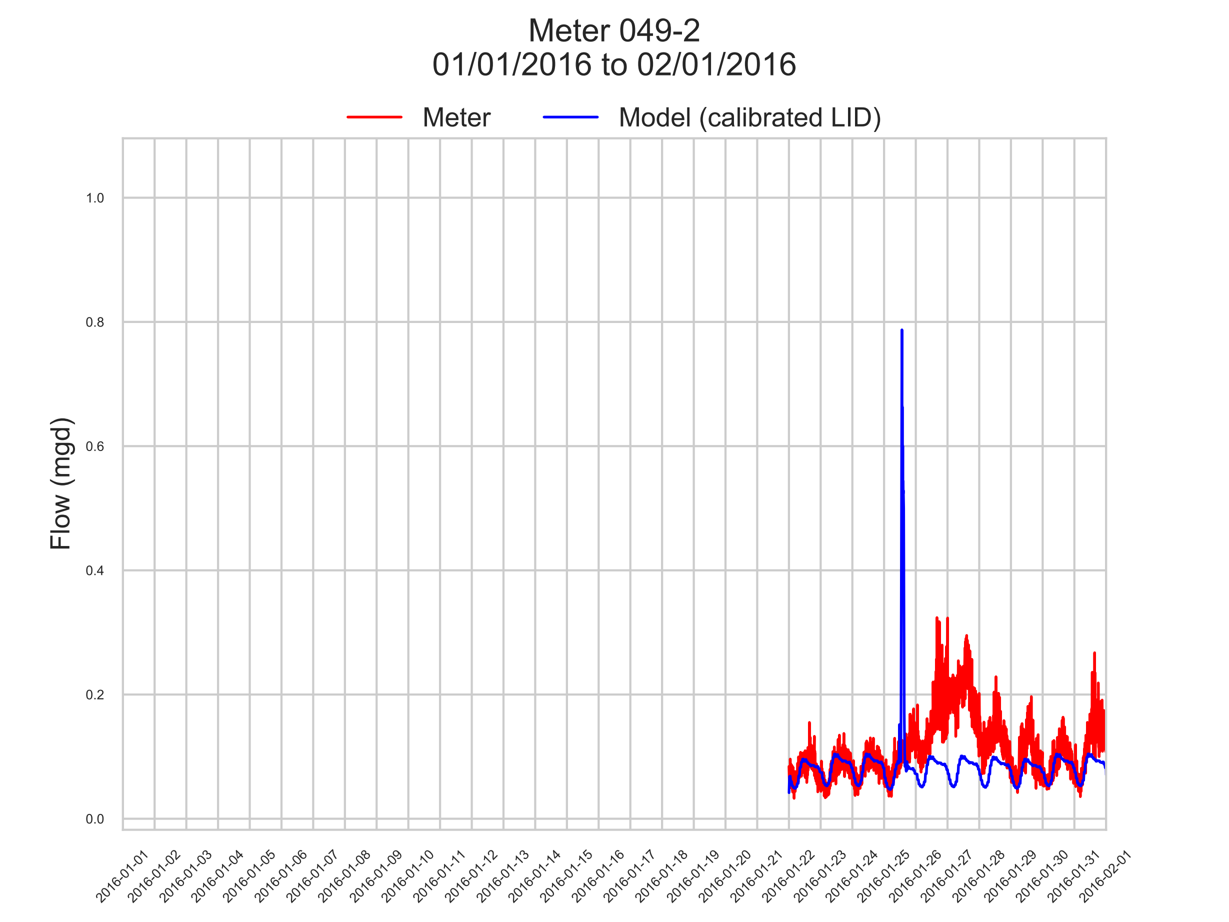
2017-01-30
2017-01-31
2017-02-01


Meter 049-2
01/01/2016 to 02/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
2016-01-01
2016-01-02
2016-01-03
2016-01-04
2016-01-05
2016-01-06
2016-01-07
2016-01-08
2016-01-09
2016-01-10
2016-01-11
2016-01-12
2016-01-13
2016-01-14
2016-01-15
2016-01-16
2016-01-17
2016-01-18
2016-01-19
2016-01-20
2016-01-21
2016-01-22
2016-01-23
2016-01-24
2016-01-25
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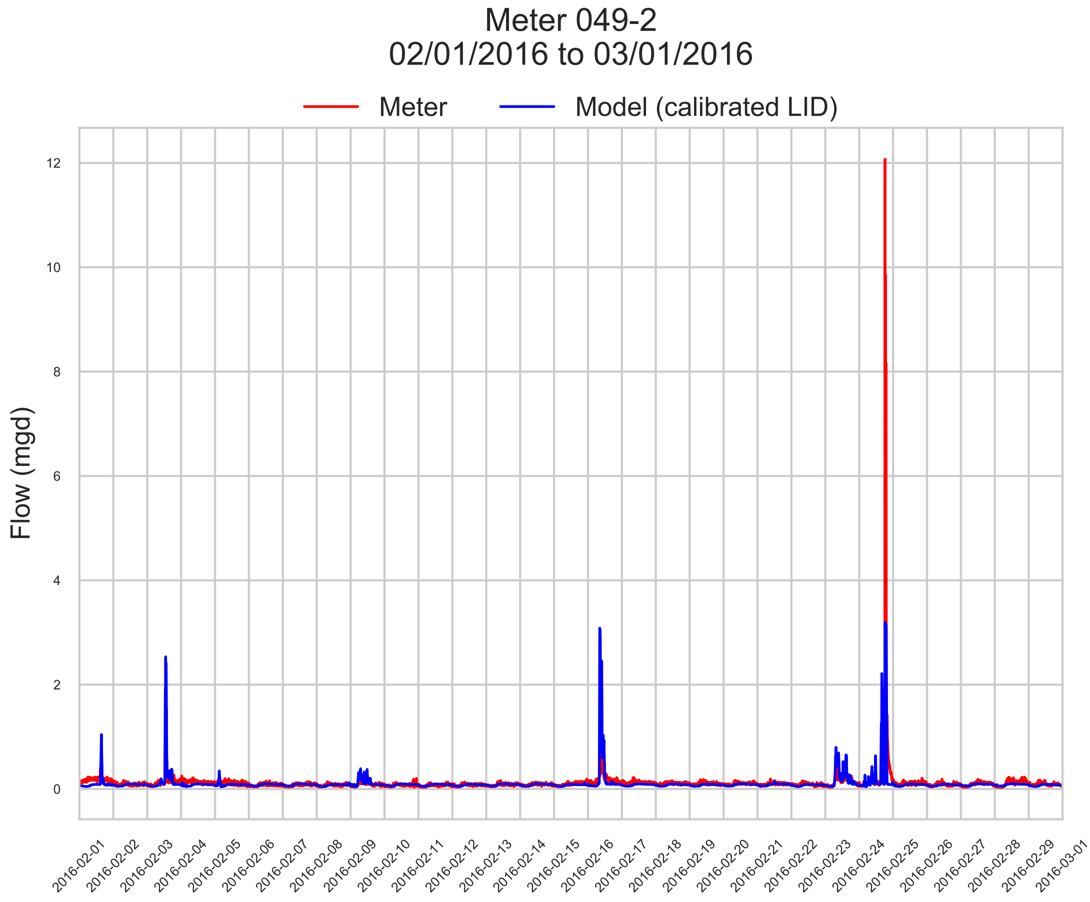
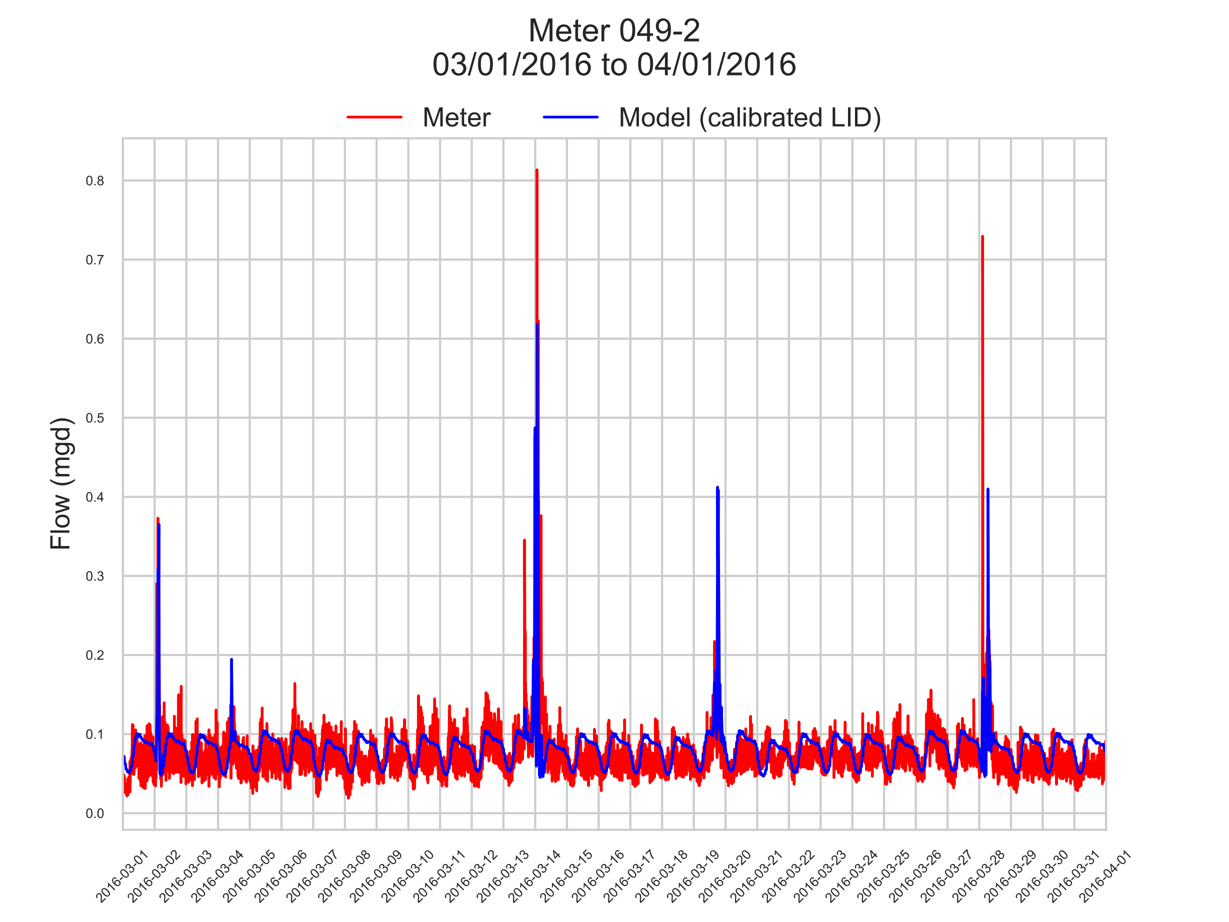
2016-01-31
2016-02-01


Meter 049-2
02/01/2016 to 03/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2016-02-01
2016-02-02
2016-02-03
2016-02-04
2016-02-05
2016-02-06
2016-02-07
2016-02-08
2016-02-09
2016-02-10
2016-02-11
2016-02-12
2016-02-13
2016-02-14
2016-02-15
2016-02-16
2016-02-17
2016-02-18
2016-02-19
2016-02-20
2016-02-21
2016-02-22
2016-02-23
2016-02-24
2016-02-25
2016-02-26
2016-02-27
2016-02-28
2016-02-29
2016-03-01



Meter 049-2
03/01/2016 to 04/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
2016-03-01
2016-03-02
2016-03-03
2016-03-04
2016-03-05
2016-03-06
2016-03-07
2016-03-08
2016-03-09
2016-03-10
2016-03-11
2016-03-12
2016-03-13
2016-03-14
2016-03-15
2016-03-16
2016-03-17
2016-03-18
2016-03-19
2016-03-20
2016-03-21
2016-03-22
2016-03-23
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2016-03-26
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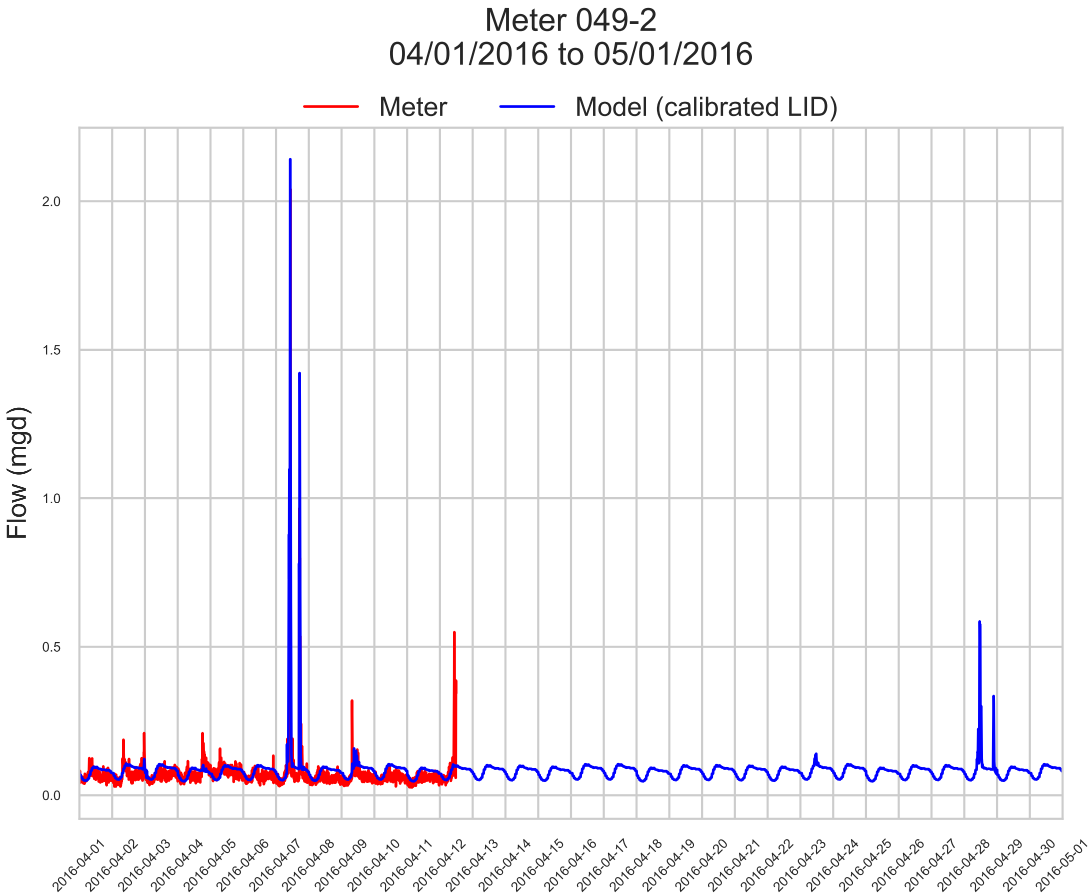
2016-03-31
2016-04-01



Meter 049-2
04/01/2016 to 05/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
2016-04-01
2016-04-02
2016-04-03
2016-04-04
2016-04-05
2016-04-06
2016-04-07
2016-04-08
2016-04-09
2016-04-10
2016-04-11
2016-04-12
2016-04-13
2016-04-14
2016-04-15
2016-04-16
2016-04-17
2016-04-18
2016-04-19
2016-04-20
2016-04-21
2016-04-22
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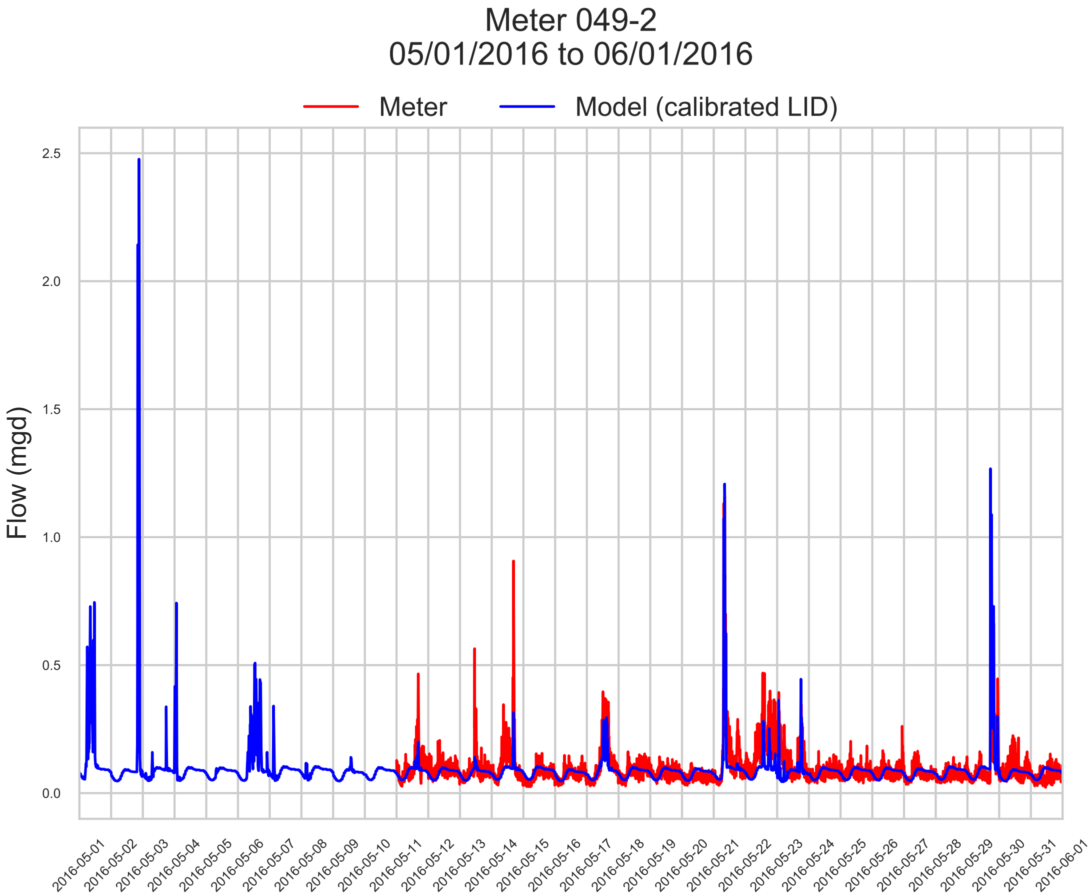
2016-04-29
2016-04-30
2016-05-01



Meter 049-2
05/01/2016 to 06/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
2016-05-01
2016-05-02
2016-05-03
2016-05-04
2016-05-05
2016-05-06
2016-05-07
2016-05-08
2016-05-09
2016-05-10
2016-05-11
2016-05-12
2016-05-13
2016-05-14
2016-05-15
2016-05-16
2016-05-17
2016-05-18
2016-05-19
2016-05-20
2016-05-21
2016-05-22
2016-05-23
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2016-05-25
2016-05-26
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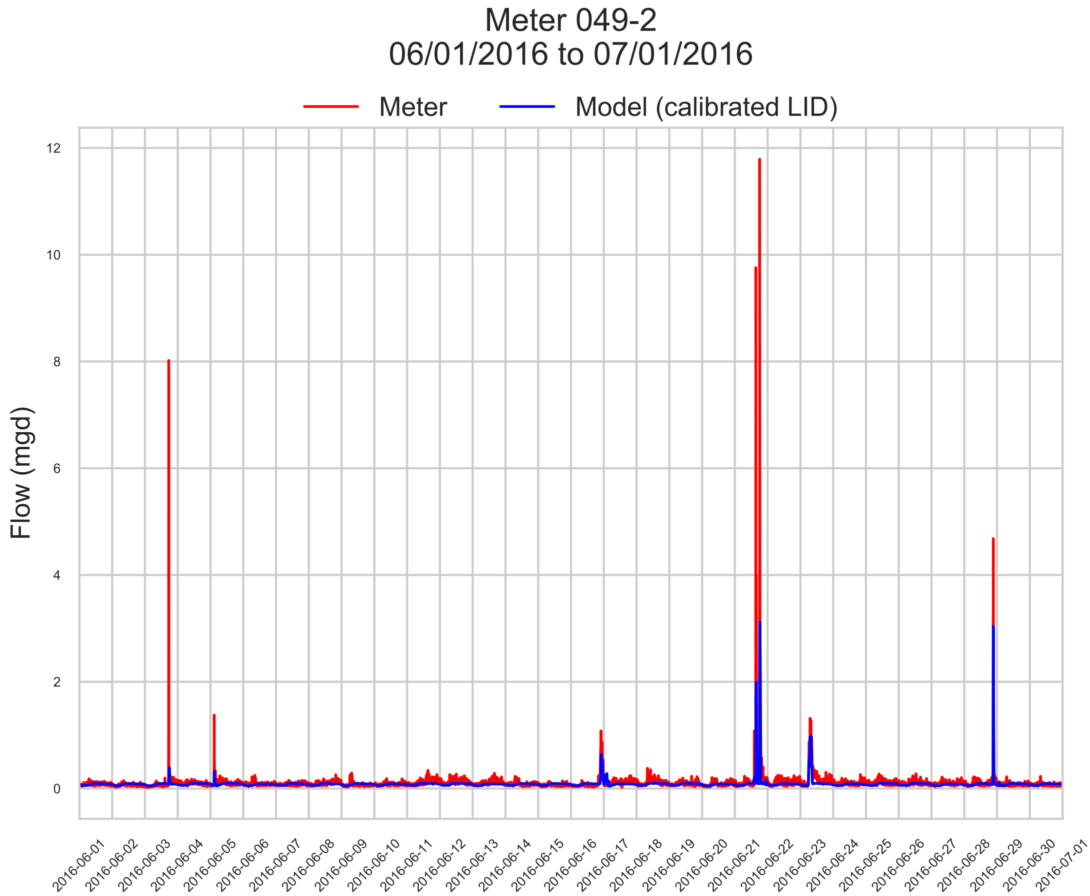
2016-05-28
2016-05-29
2016-05-30
2016-05-31
2016-06-01


Meter 049-2
06/01/2016 to 07/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2016-06-01
2016-06-02
2016-06-03
2016-06-04
2016-06-05
2016-06-06
2016-06-07
2016-06-08
2016-06-09
2016-06-10
2016-06-11
2016-06-12
2016-06-13
2016-06-14
2016-06-15
2016-06-16
2016-06-17
2016-06-18
2016-06-19
2016-06-20
2016-06-21
2016-06-22
2016-06-23
2016-06-24
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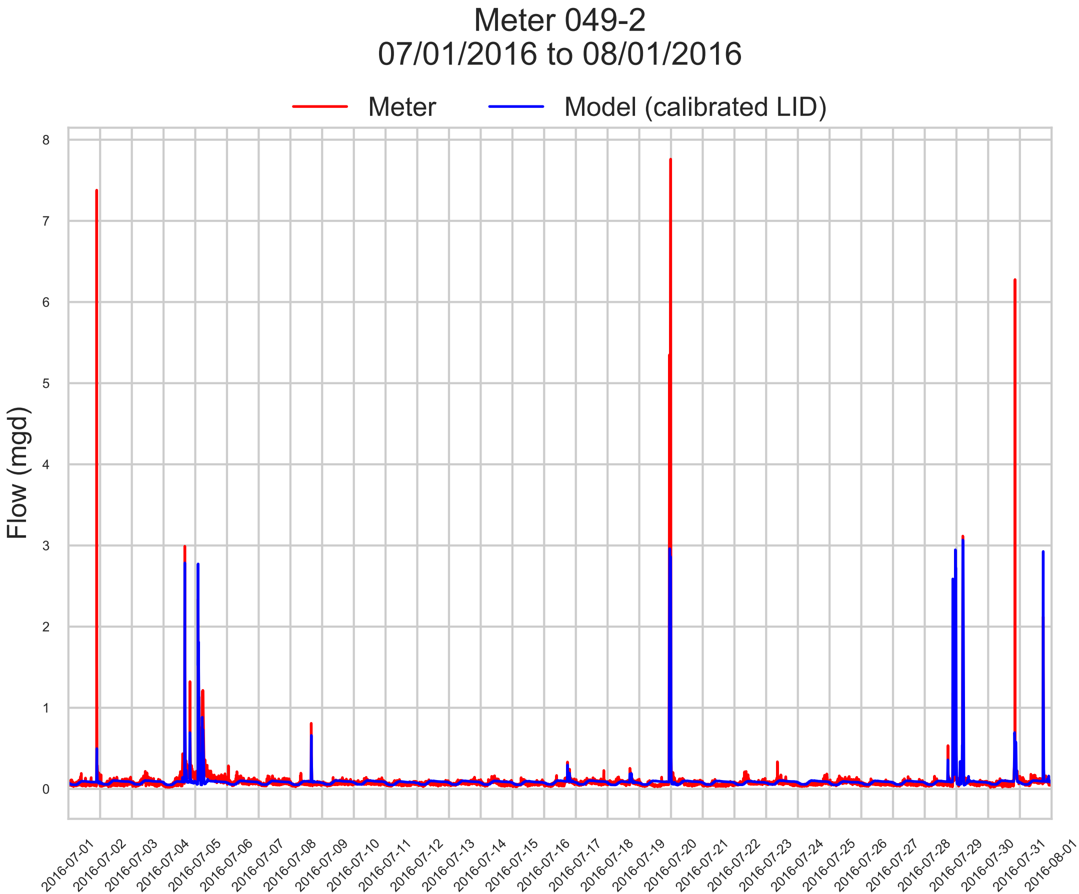
2016-06-29
2016-06-30
2016-07-01


Meter 049-2
07/01/2016 to 08/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
7
8
2016-07-01
2016-07-02
2016-07-03
2016-07-04
2016-07-05
2016-07-06
2016-07-07
2016-07-08
2016-07-09
2016-07-10
2016-07-11
2016-07-12
2016-07-13
2016-07-14
2016-07-15
2016-07-16
2016-07-17
2016-07-18
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2016-07-20
2016-07-21
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2016-07-24
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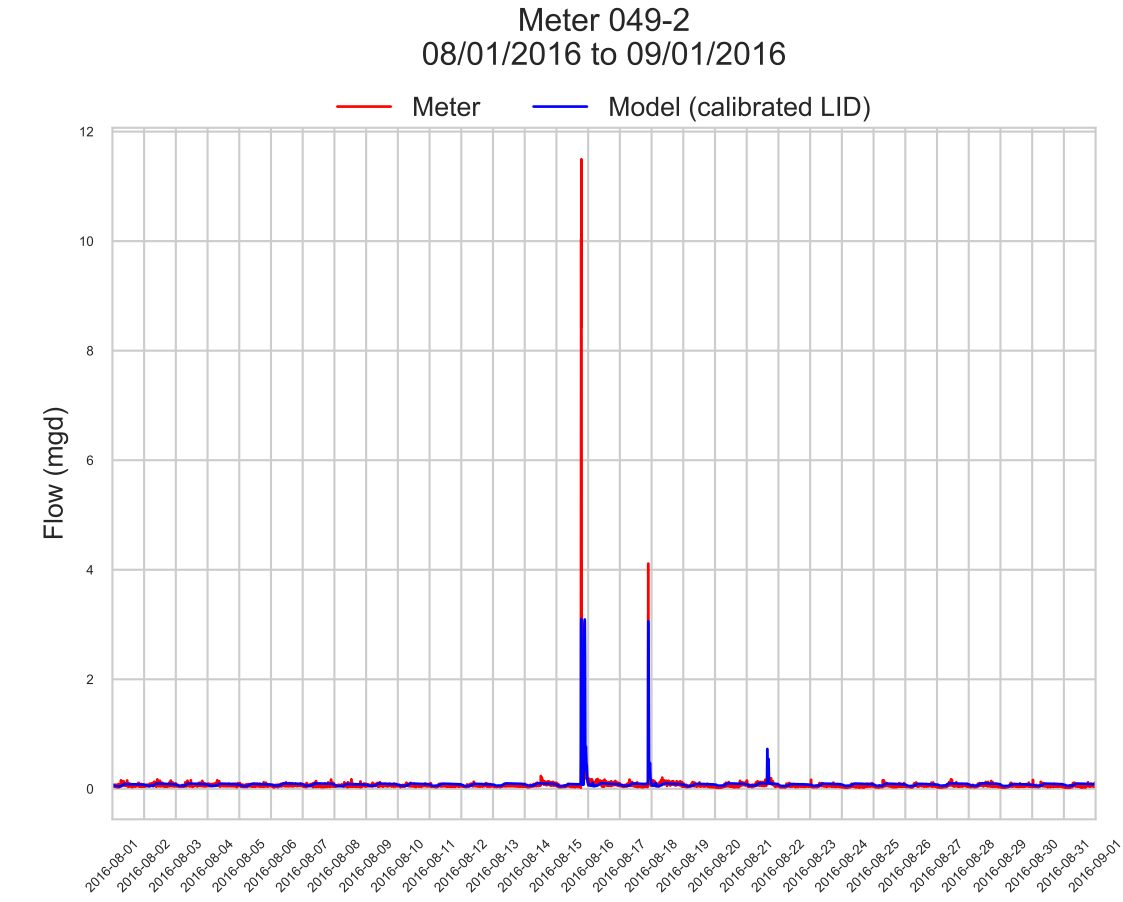
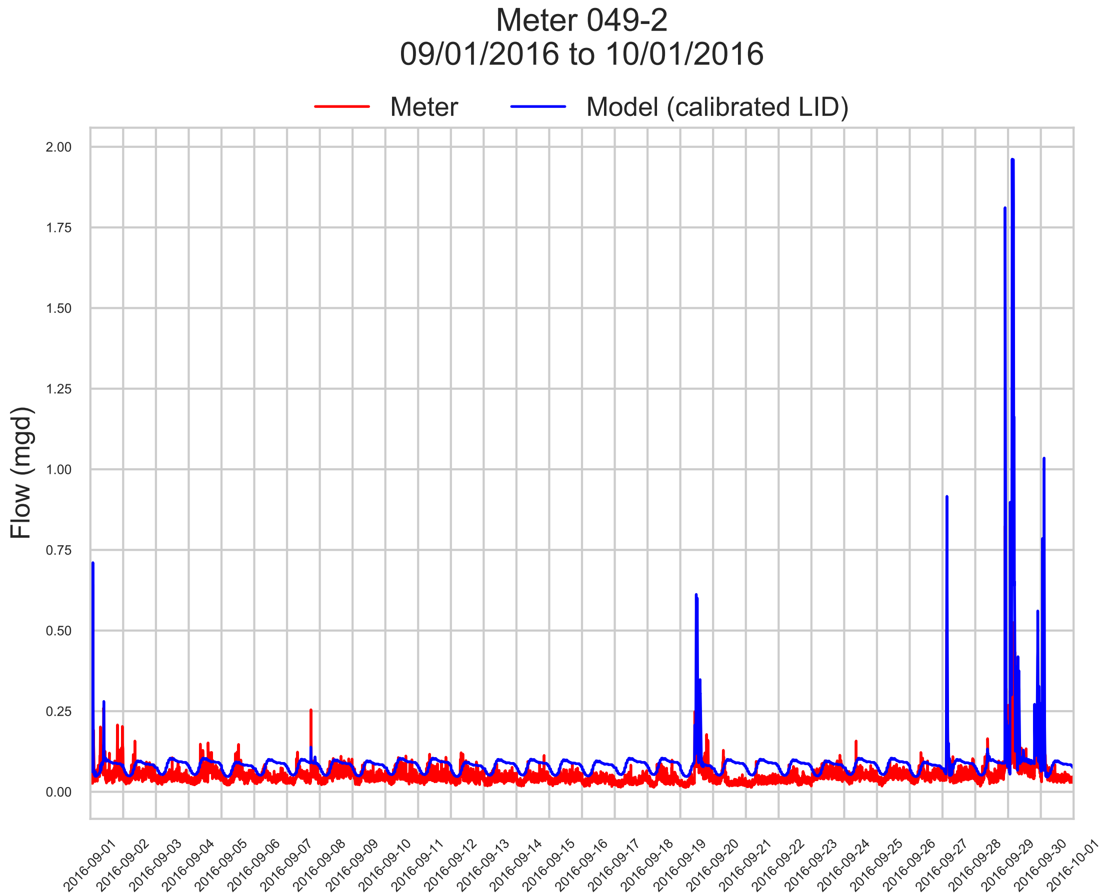
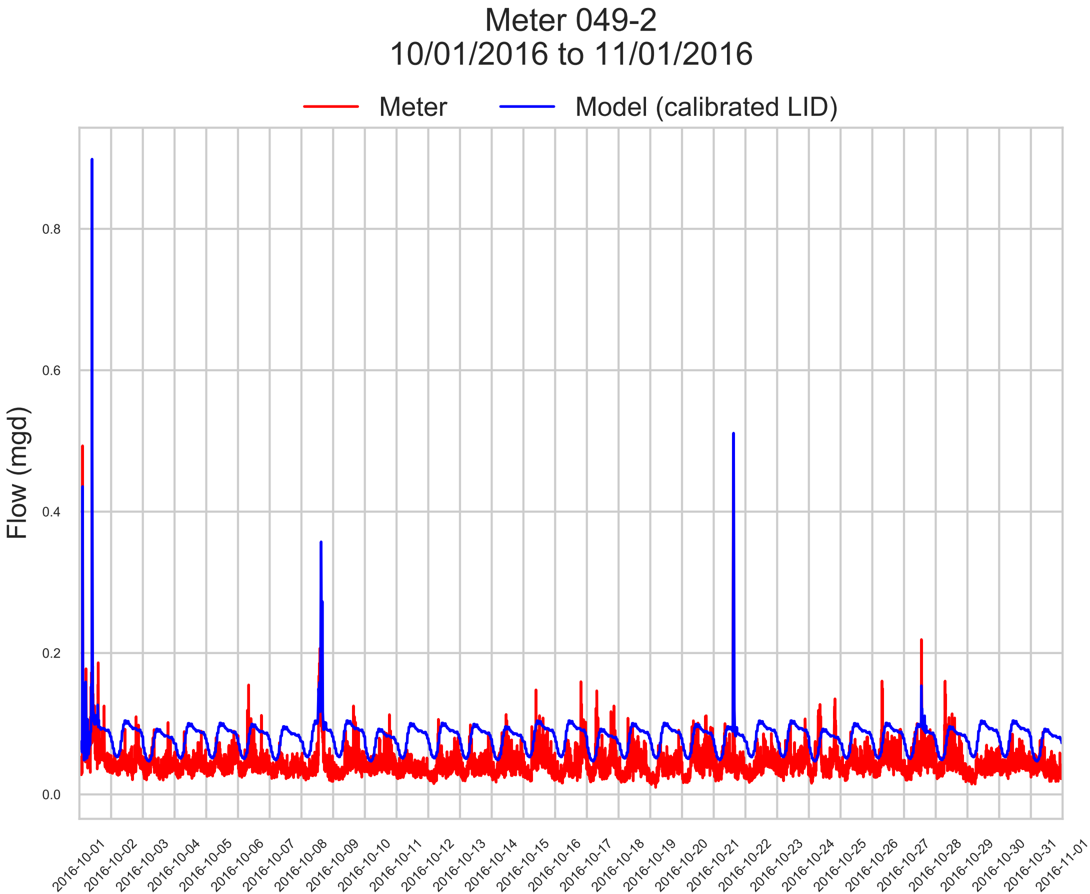
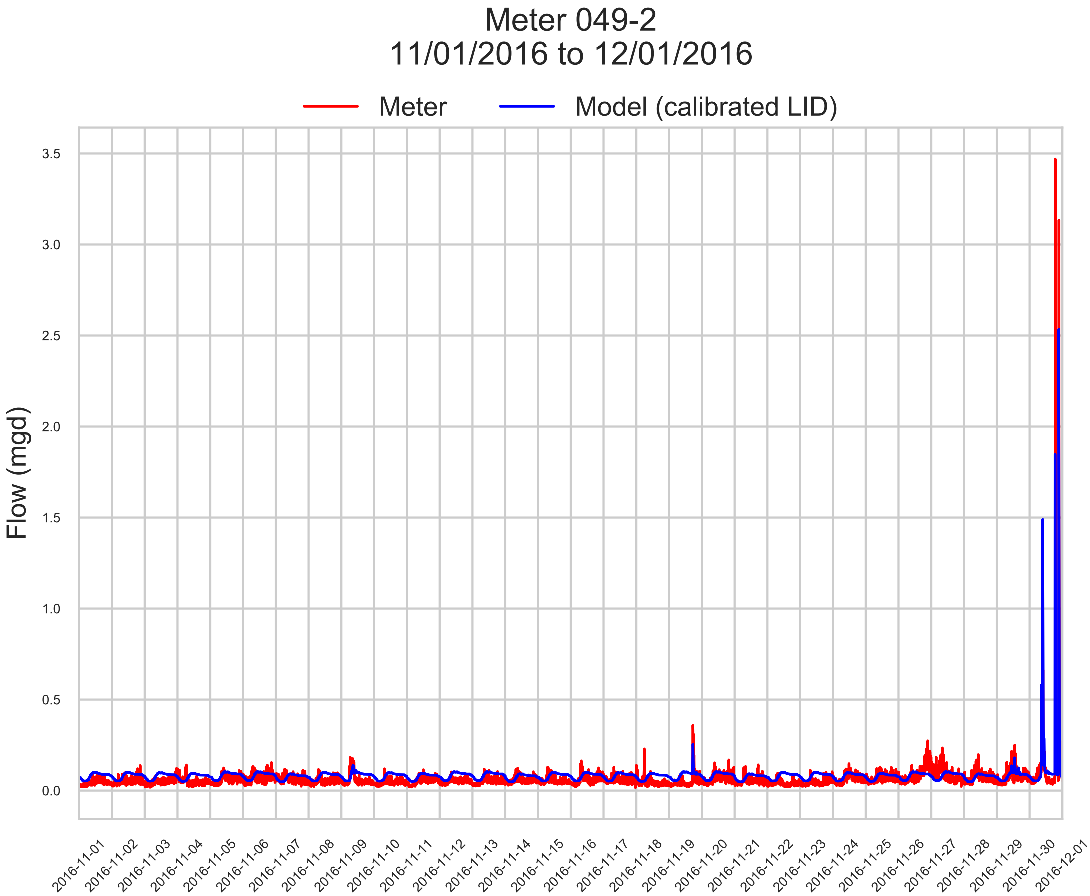
2016-07-27
2016-07-28
2016-07-29
2016-07-30
2016-07-31
2016-08-01


Meter 049-2
08/01/2016 to 09/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2016-08-01
2016-08-02
2016-08-03
2016-08-04
2016-08-05
2016-08-06
2016-08-07
2016-08-08
2016-08-09
2016-08-10
2016-08-11
2016-08-12
2016-08-13
2016-08-14
2016-08-15
2016-08-16
2016-08-17
2016-08-18
2016-08-19
2016-08-20
2016-08-21
2016-08-22
2016-08-23
2016-08-24
2016-08-25
2016-08-26
2016-08-27
2016-08-28
2016-08-29
2016-08-30
2016-08-31
2016-09-01

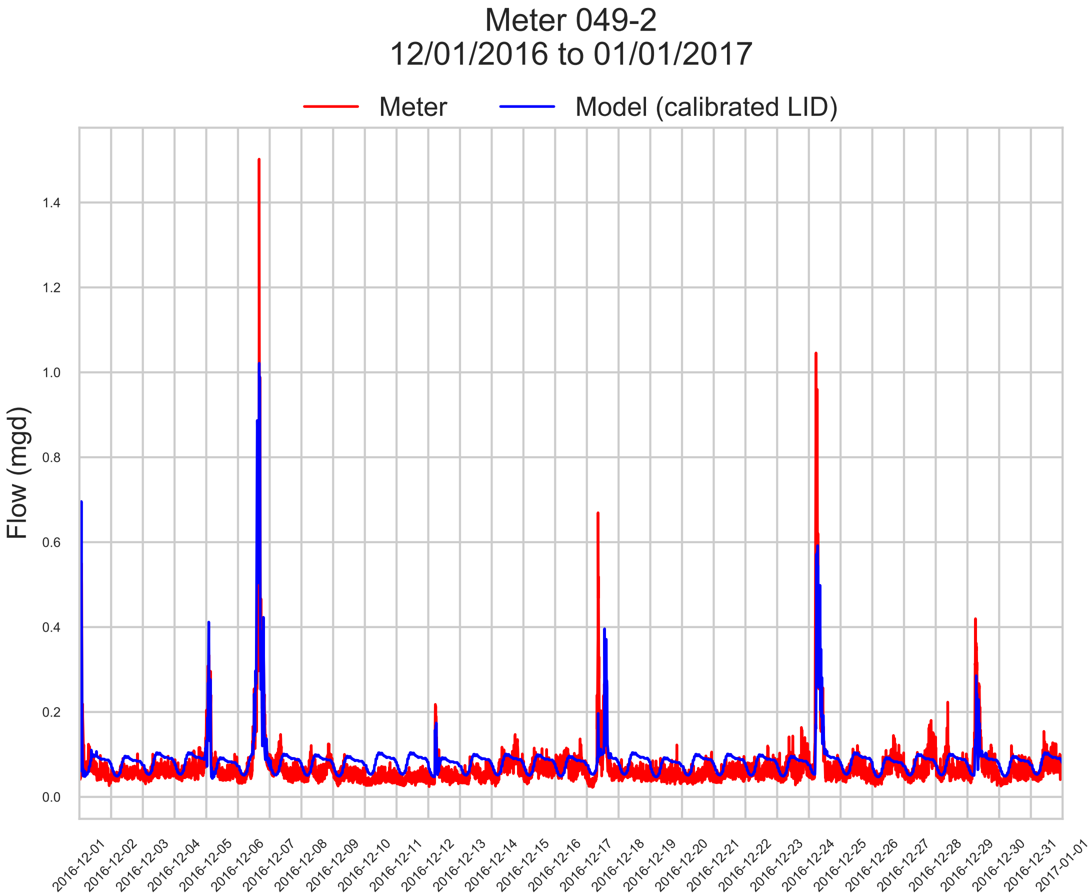

Meter 049-2
09/01/2016 to 10/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2016-09-01
2016-09-02
2016-09-03
2016-09-04
2016-09-05
2016-09-06
2016-09-07
2016-09-08
2016-09-09
2016-09-10
2016-09-11
2016-09-12
2016-09-13
2016-09-14
2016-09-15
2016-09-16
2016-09-17
2016-09-18
2016-09-19
2016-09-20
2016-09-21
2016-09-22
2016-09-23
2016-09-24
2016-09-25
2016-09-26
2016-09-27
2016-09-28
2016-09-29
2016-09-30
2016-10-01



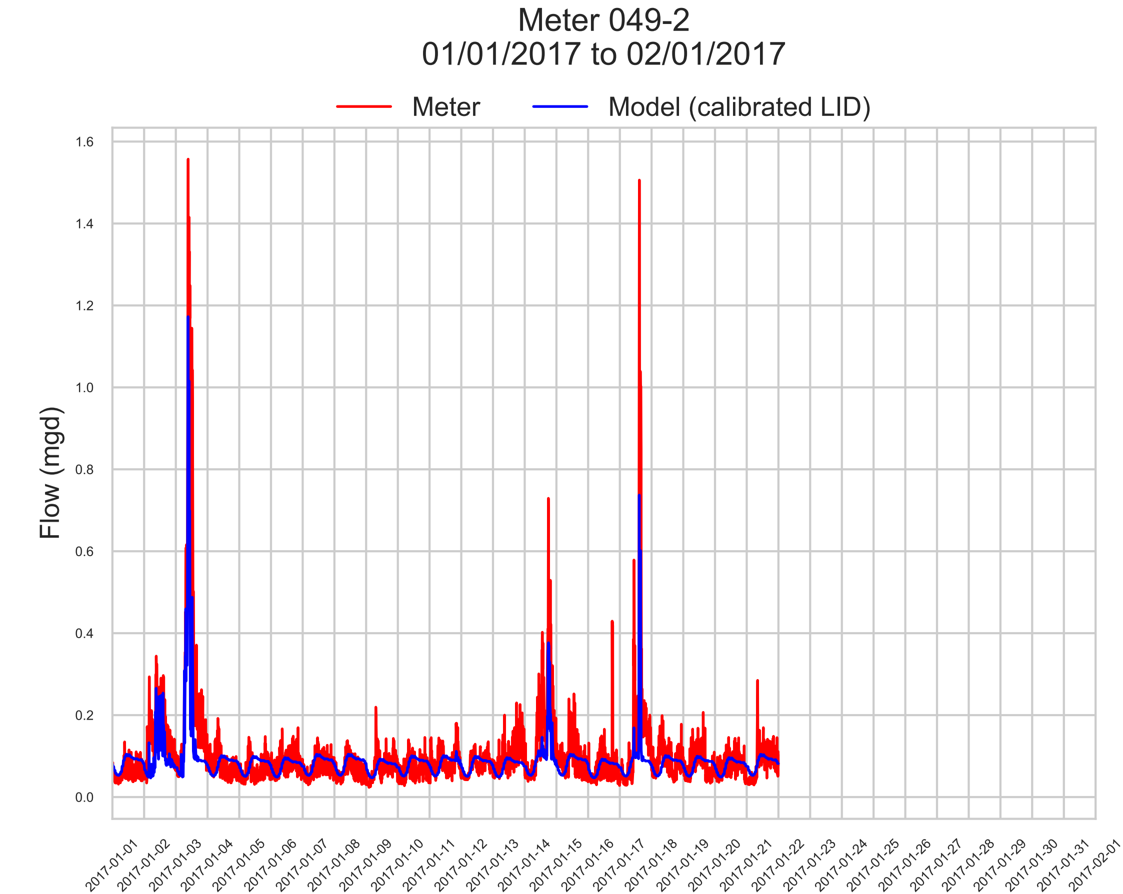
Meter 049-2
10/01/2016 to 11/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
2016-10-01
2016-10-02
2016-10-03
2016-10-04
2016-10-05
2016-10-06
2016-10-07
2016-10-08
2016-10-09
2016-10-10
2016-10-11
2016-10-12
2016-10-13
2016-10-14
2016-10-15
2016-10-16
2016-10-17
2016-10-18
2016-10-19
2016-10-20
2016-10-21
2016-10-22
2016-10-23
2016-10-24
2016-10-25
2016-10-26
2016-10-27
2016-10-28
2016-10-29
2016-10-30
2016-10-31
2016-11-01



Meter 049-2
11/01/2016 to 12/01/2016
Meter
Model (calibrated LID)
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2016-11-01
2016-11-02
2016-11-03
2016-11-04
2016-11-05
2016-11-06
2016-11-07
2016-11-08
2016-11-09
2016-11-10
2016-11-11
2016-11-12
2016-11-13
2016-11-14
2016-11-15
2016-11-16
2016-11-17
2016-11-18
2016-11-19
2016-11-20
2016-11-21
2016-11-22
2016-11-23
2016-11-24
2016-11-25
2016-11-26
2016-11-27
2016-11-28
2016-11-29
2016-11-30
2016-12-01



Meter 049-2
12/01/2016 to 01/01/2017
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
2016-12-01
2016-12-02
2016-12-03
2016-12-04
2016-12-05
2016-12-06
2016-12-07
2016-12-08
2016-12-09
2016-12-10
2016-12-11
2016-12-12
2016-12-13
2016-12-14
2016-12-15
2016-12-16
2016-12-17
2016-12-18
2016-12-19
2016-12-20
2016-12-21
2016-12-22
2016-12-23
2016-12-24
2016-12-25
2016-12-26
2016-12-27
2016-12-28
2016-12-29
2016-12-30
2016-12-31
2017-01-01


Meter 049-2
01/01/2017 to 02/01/2017
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
2017-01-01
2017-01-02
2017-01-03
2017-01-04
2017-01-05
2017-01-06
2017-01-07
2017-01-08
2017-01-09
2017-01-10
2017-01-11
2017-01-12
2017-01-13
2017-01-14
2017-01-15
2017-01-16
2017-01-17
2017-01-18
2017-01-19
2017-01-20
2017-01-21
2017-01-22
2017-01-23
2017-01-24
2017-01-25
2017-01-26
2017-01-27
2017-01-28
2017-01-29
2017-01-30
2017-01-31
2017-02-01

Appendix C: Post-Construction Events for Meters 049-1 and 049-2

(Note: The y-axis varies in scale between the individual plots)

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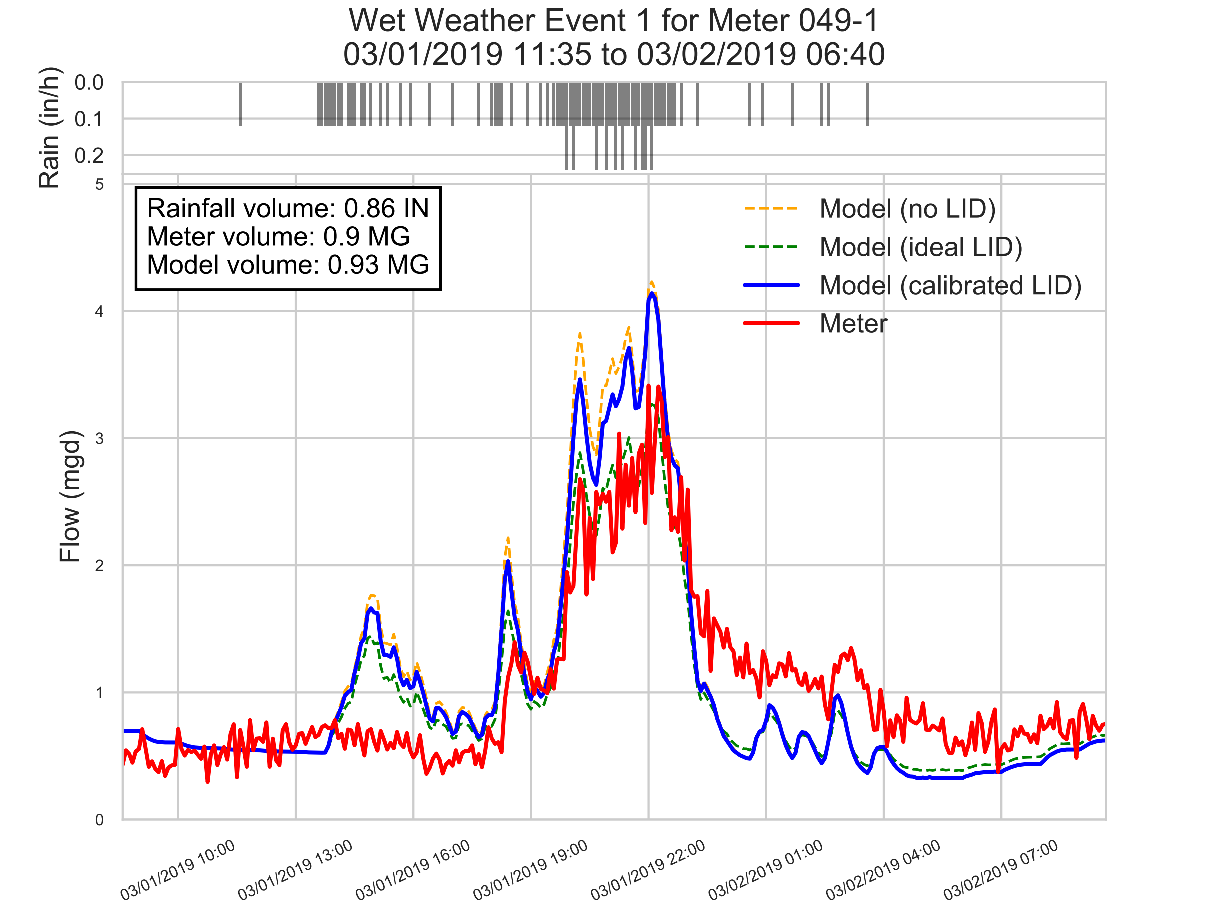
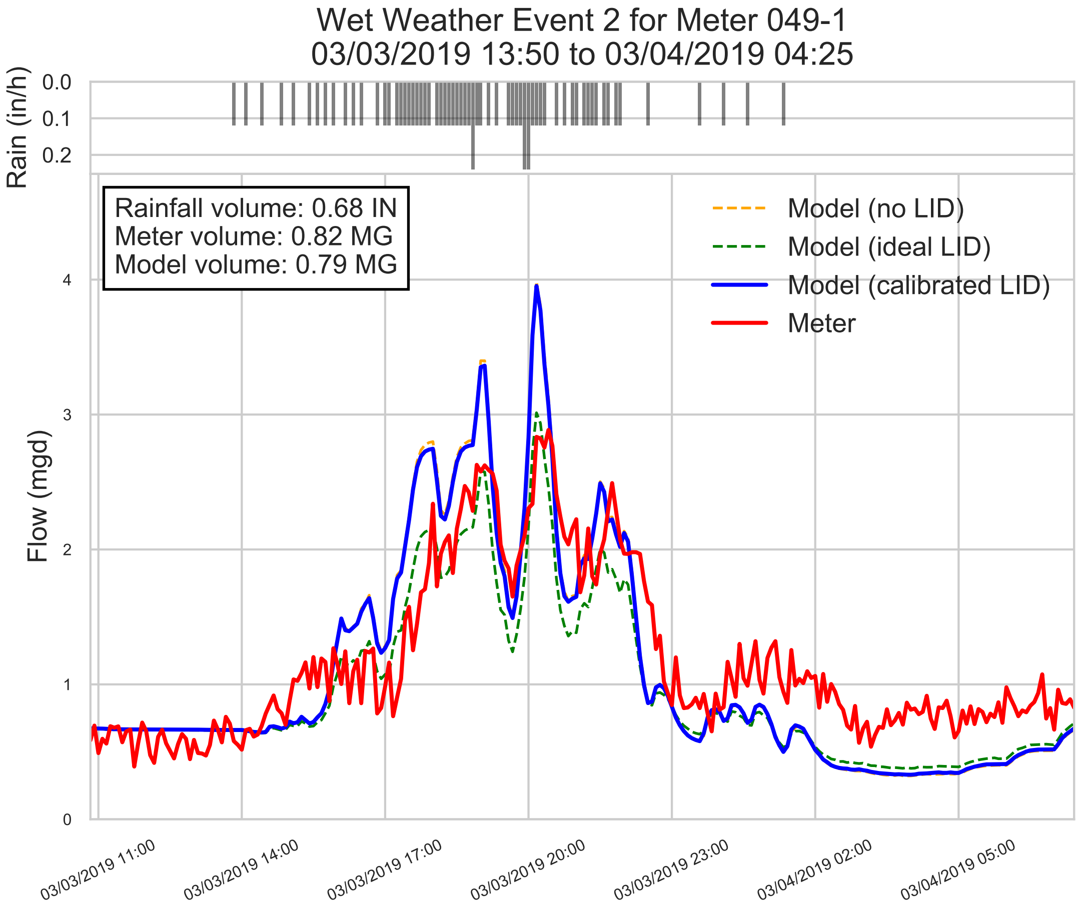
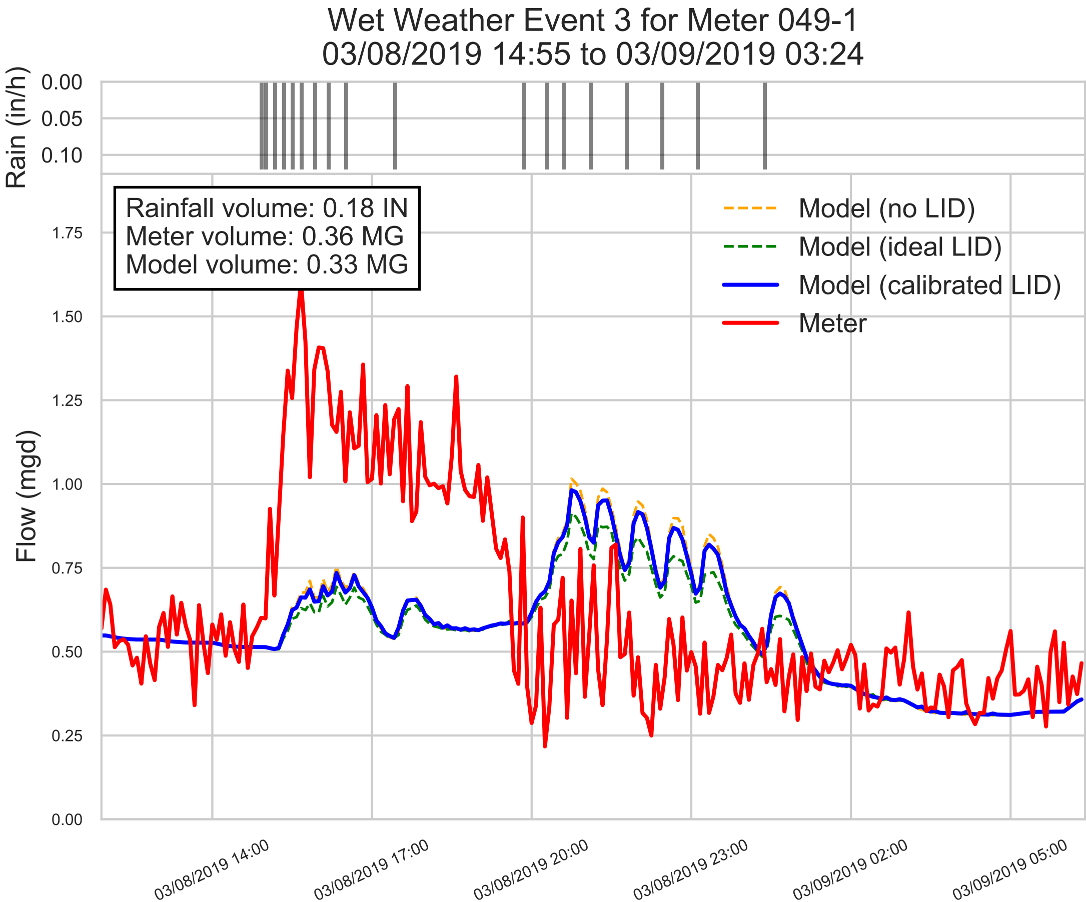
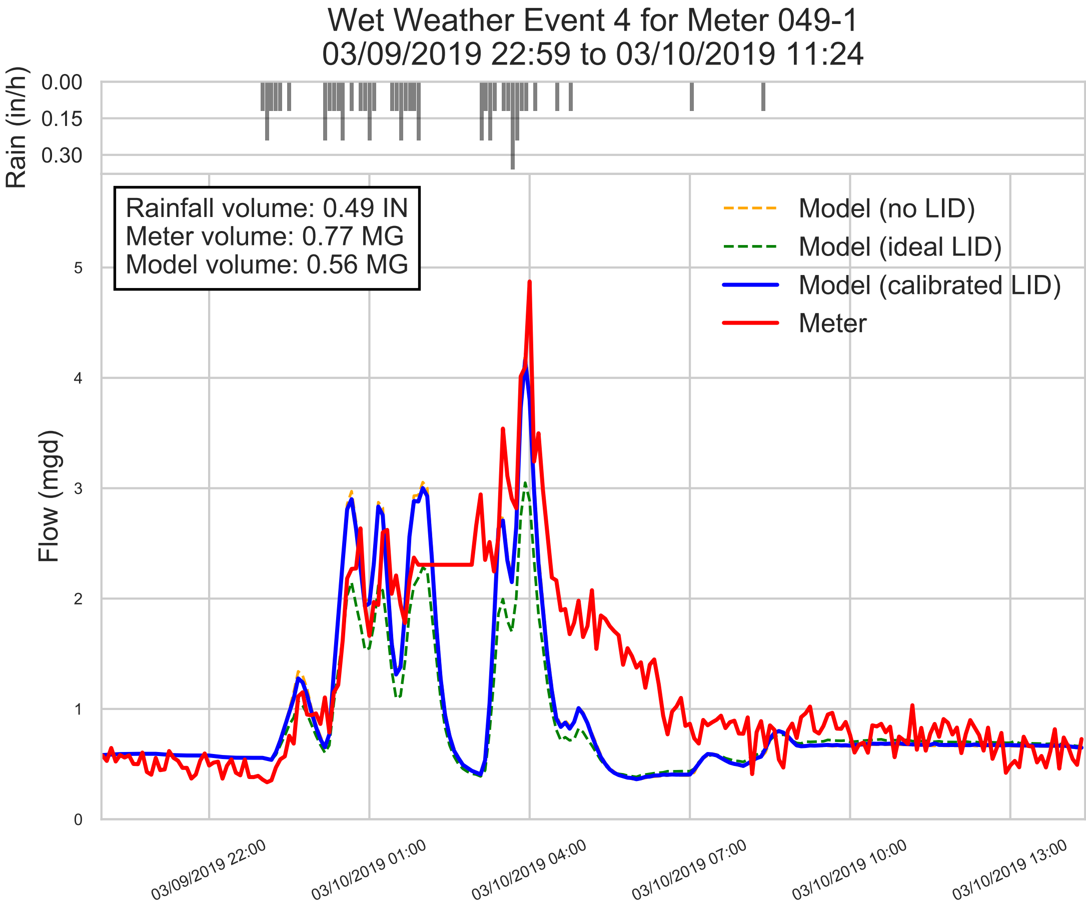

Wet Weather Event 1 for Meter 049-1
03/01/2019 11:35 to 03/02/2019 06:40
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
0
1
2
3
4
5
Rainfall volume: 0.86 IN
Meter volume: 0.9 MG
Model volume: 0.93 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
03/01/2019 10:00
03/01/2019 13:00
03/01/2019 16:00
03/01/2019 19:00
03/01/2019 22:00
03/02/2019 01:00
03/02/2019 04:00
03/02/2019 07:00



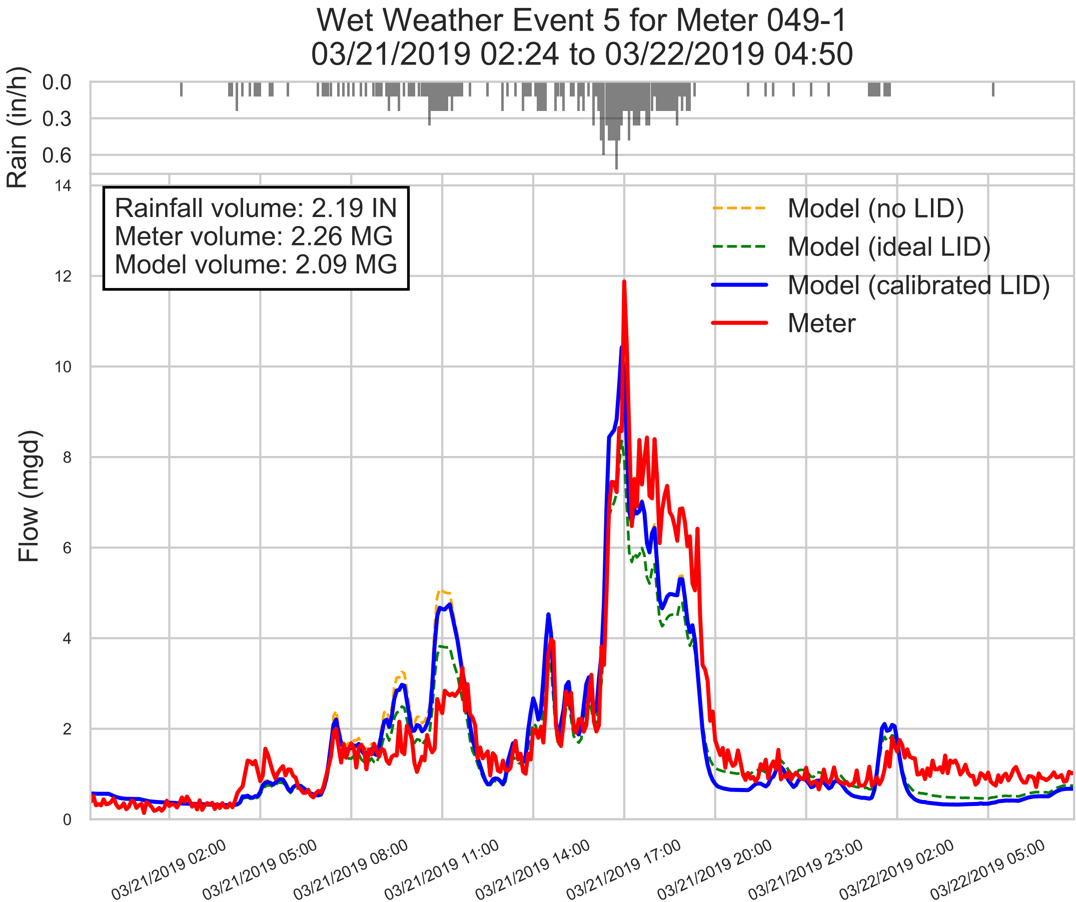
Wet Weather Event 2 for Meter 049-1
03/03/2019 13:50 to 03/04/2019 04:25
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.68 IN
Meter volume: 0.82 MG
Model volume: 0.79 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
03/03/2019 11:00
03/03/2019 14:00
03/03/2019 17:00
03/03/2019 20:00
03/03/2019 23:00
03/04/2019 02:00
03/04/2019 05:00



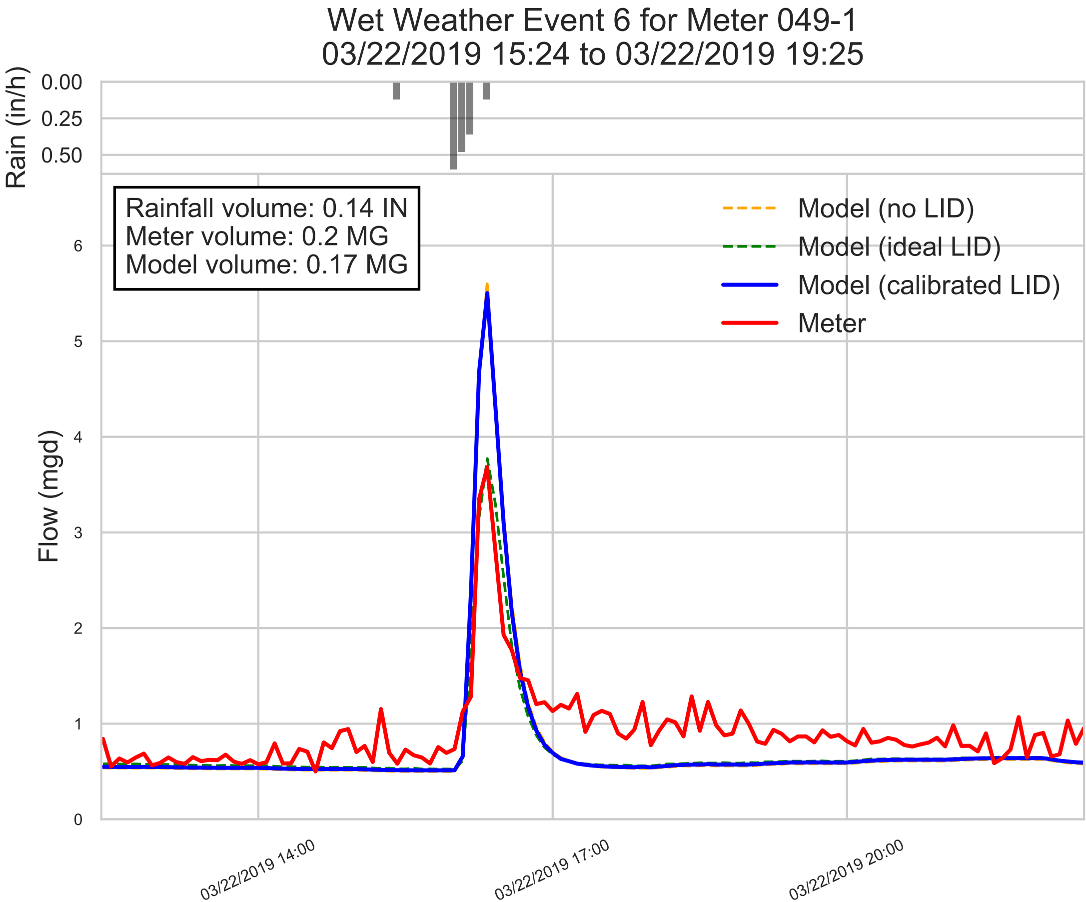
Wet Weather Event 3 for Meter 049-1
03/08/2019 14:55 to 03/09/2019 03:24
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.18 IN
Meter volume: 0.36 MG
Model volume: 0.33 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
03/08/2019 14:00
03/08/2019 17:00
03/08/2019 20:00
03/08/2019 23:00
03/09/2019 02:00
03/09/2019 05:00



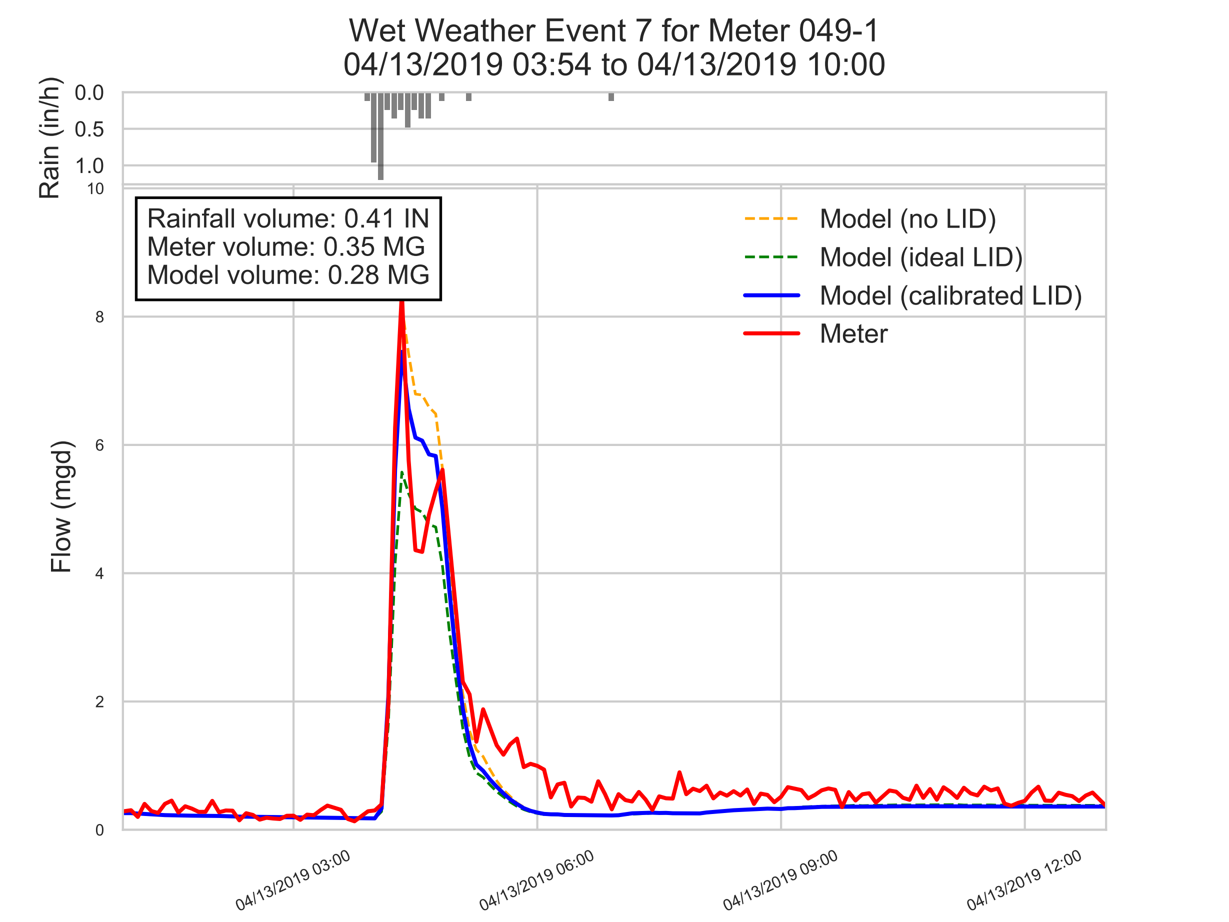
Wet Weather Event 4 for Meter 049-1
03/09/2019 22:59 to 03/10/2019 11:24
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.49 IN
Meter volume: 0.77 MG
Model volume: 0.56 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
03/09/2019 22:00
03/10/2019 01:00
03/10/2019 04:00
03/10/2019 07:00
03/10/2019 10:00
03/10/2019 13:00



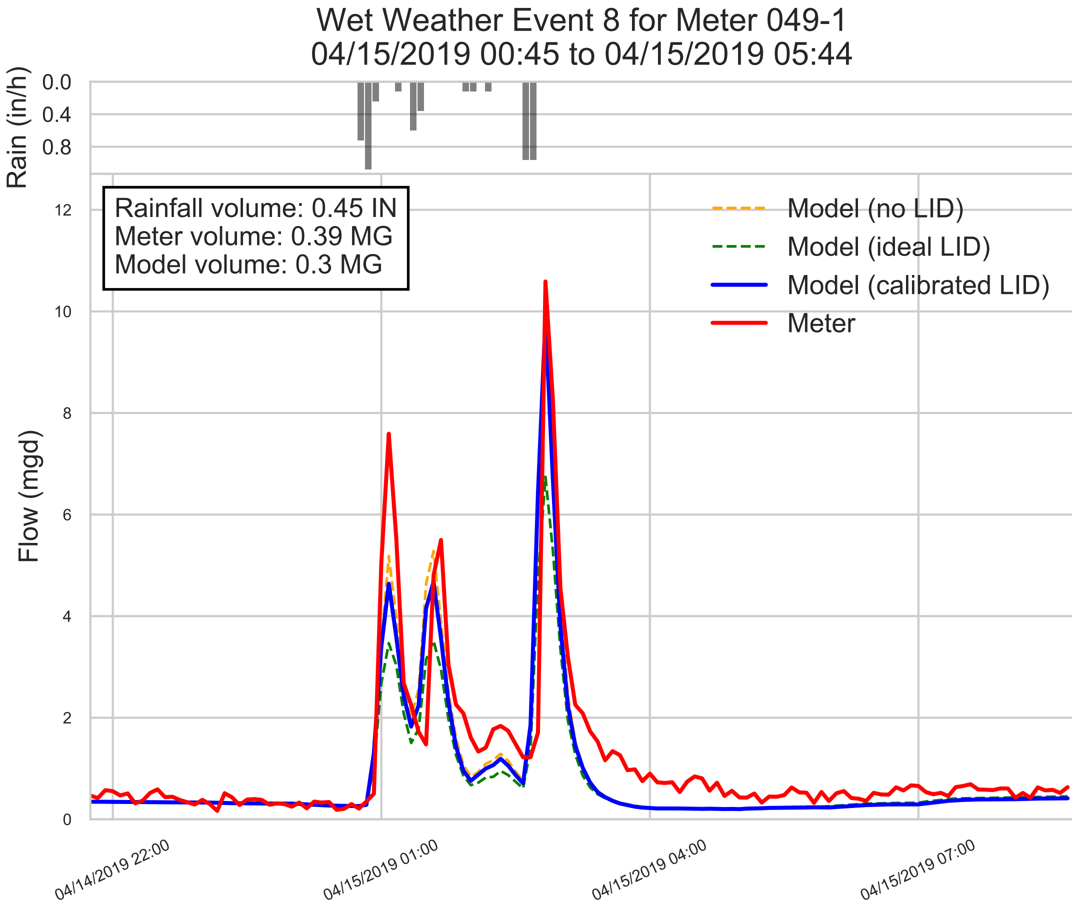
Wet Weather Event 5 for Meter 049-1
03/21/2019 02:24 to 03/22/2019 04:50
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
14
12
10
8
6
4
2
0
Rainfall volume: 2.19 IN
Meter volume: 2.26 MG
Model volume: 2.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
03/21/2019 02:00
03/21/2019 05:00
03/21/2019 08:00
03/21/2019 11:00
03/21/2019 14:00
03/21/2019 17:00
03/21/2019 20:00
03/21/2019 23:00
03/22/2019 02:00
03/22/2019 05:00



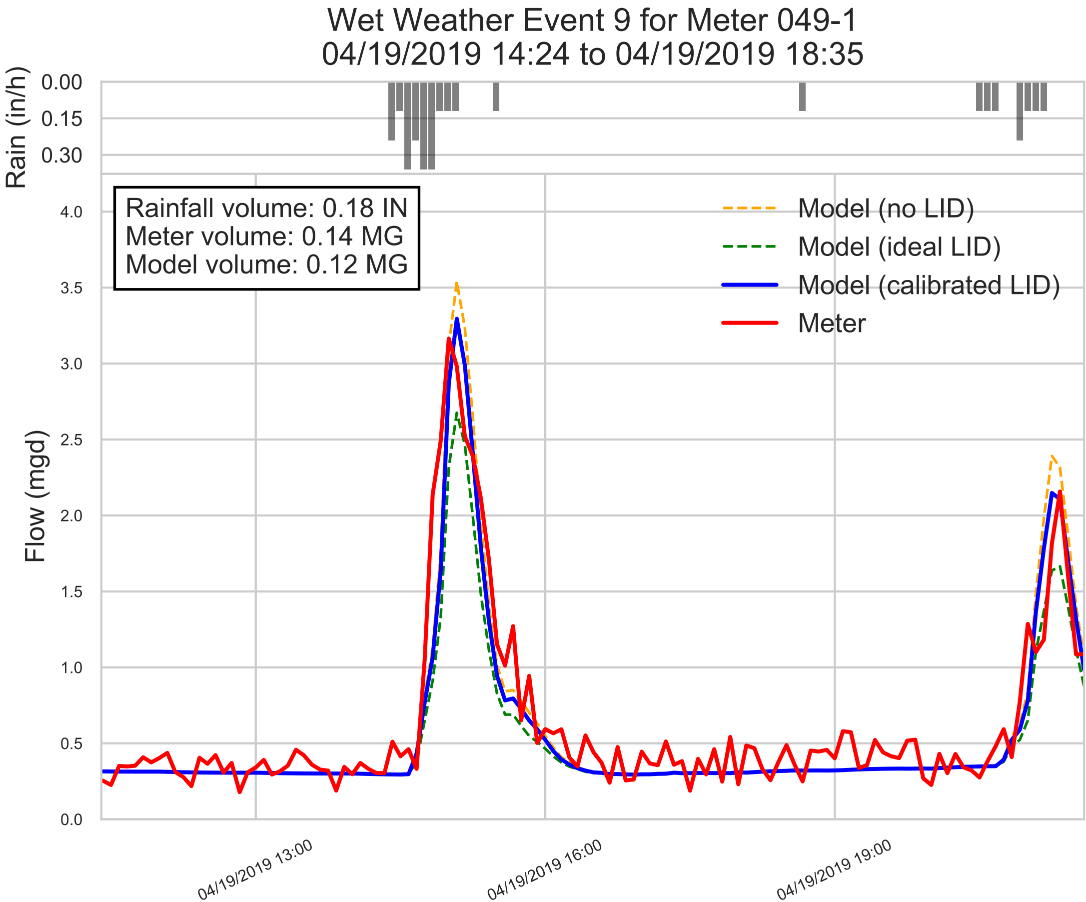
Wet Weather Event 6 for Meter 049-1
03/22/2019 15:24 to 03/22/2019 19:25
Rain (in/h)
0.00
0.25
0.50
Flow (mgd)
0
1
2
3
4
5
6
Rainfall volume: 0.14 IN
Meter volume: 0.2 MG
Model volume: 0.17 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
03/22/2019 14:00
03/22/2019 17:00
03/22/2019 20:00



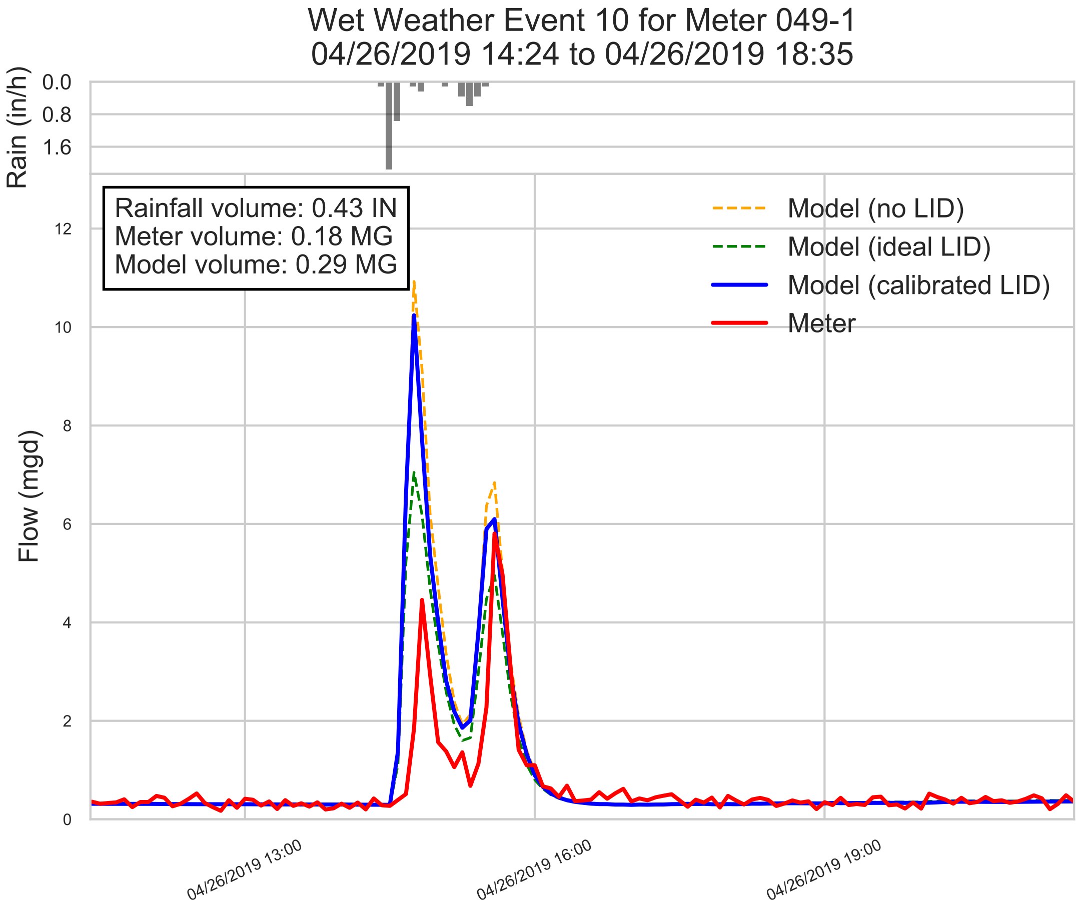
Wet Weather Event 7 for Meter 049-1
04/13/2019 03:54 to 04/13/2019 10:00
Rain (in/h)
0.0
0.5
1.0
10
8
6
4
2
0
Flow (mgd)
Rainfall volume: 0.41 IN
Meter volume: 0.35 MG
Model volume: 0.28 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
04/13/2019 03:00
04/13/2019 06:00
04/13/2019 09:00
04/13/2019 12:00



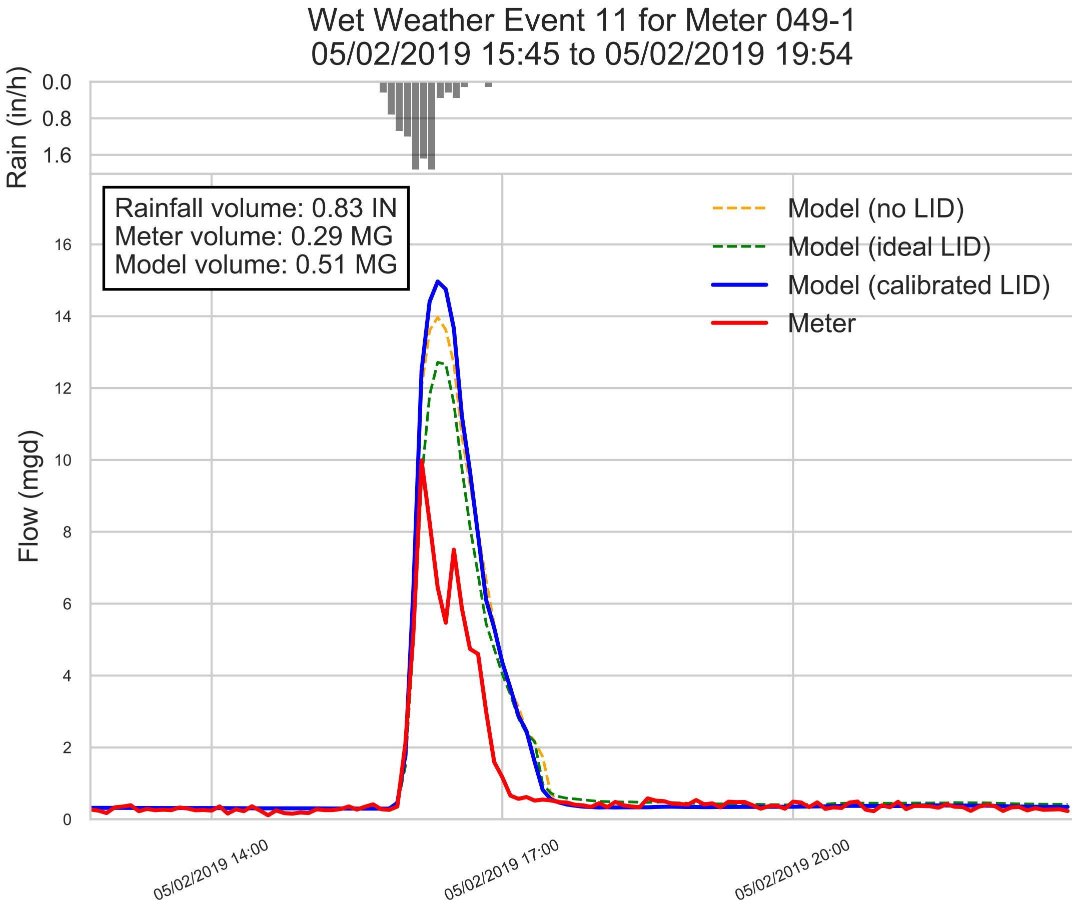
Wet Weather Event 8 for Meter 049-1
04/15/2019 00:45 to 04/15/2019 05:44
Rain (in/h)
0.0
0.4
0.8
Flow (mgd)
0
2
4
6
8
10
12
Rainfall volume: 0.45 IN
Meter volume: 0.39 MG
Model volume: 0.3 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
04/14/2019 22:00
04/15/2019 01:00
04/15/2019 04:00
04/15/2019 07:00



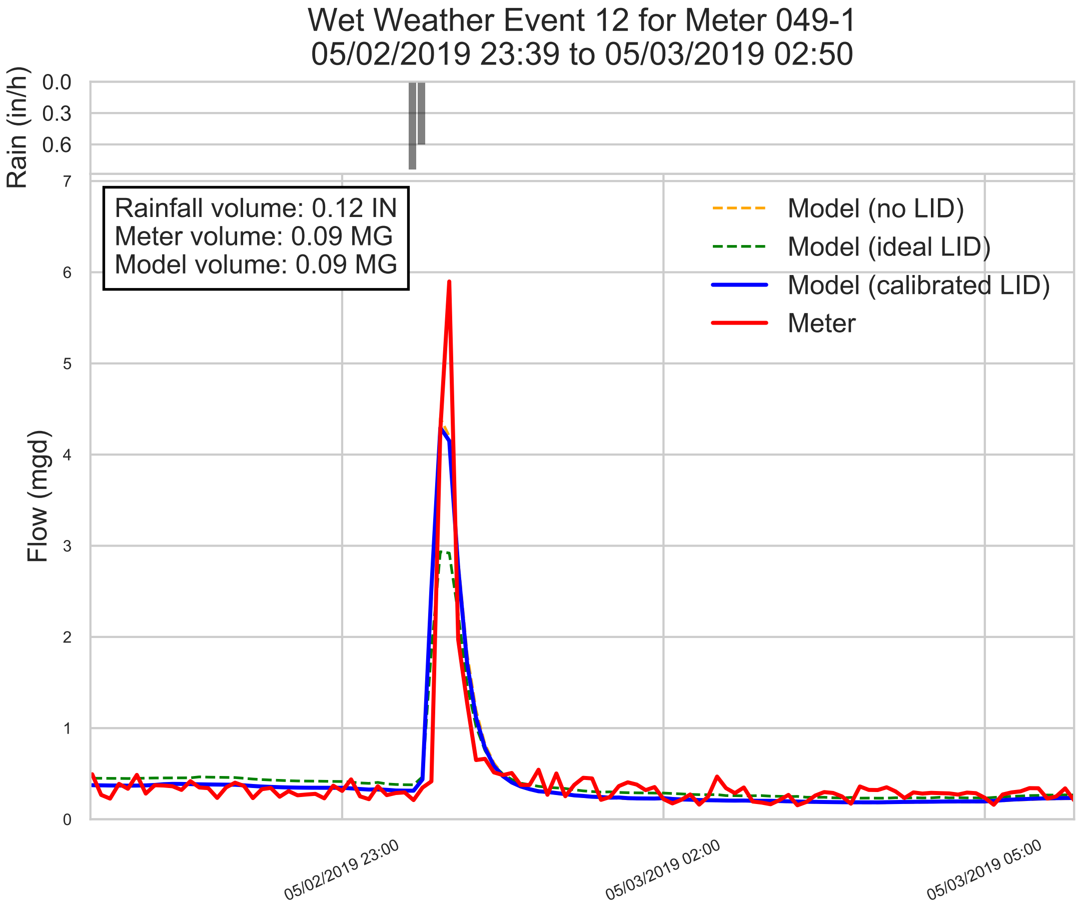
Wet Weather Event 9 for Meter 049-1
04/19/2019 14:24 to 04/19/2019 18:35
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.18 IN
Meter volume: 0.14 MG
Model volume: 0.12 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
04/19/2019 13:00
04/19/2019 16:00
04/19/2019 19:00

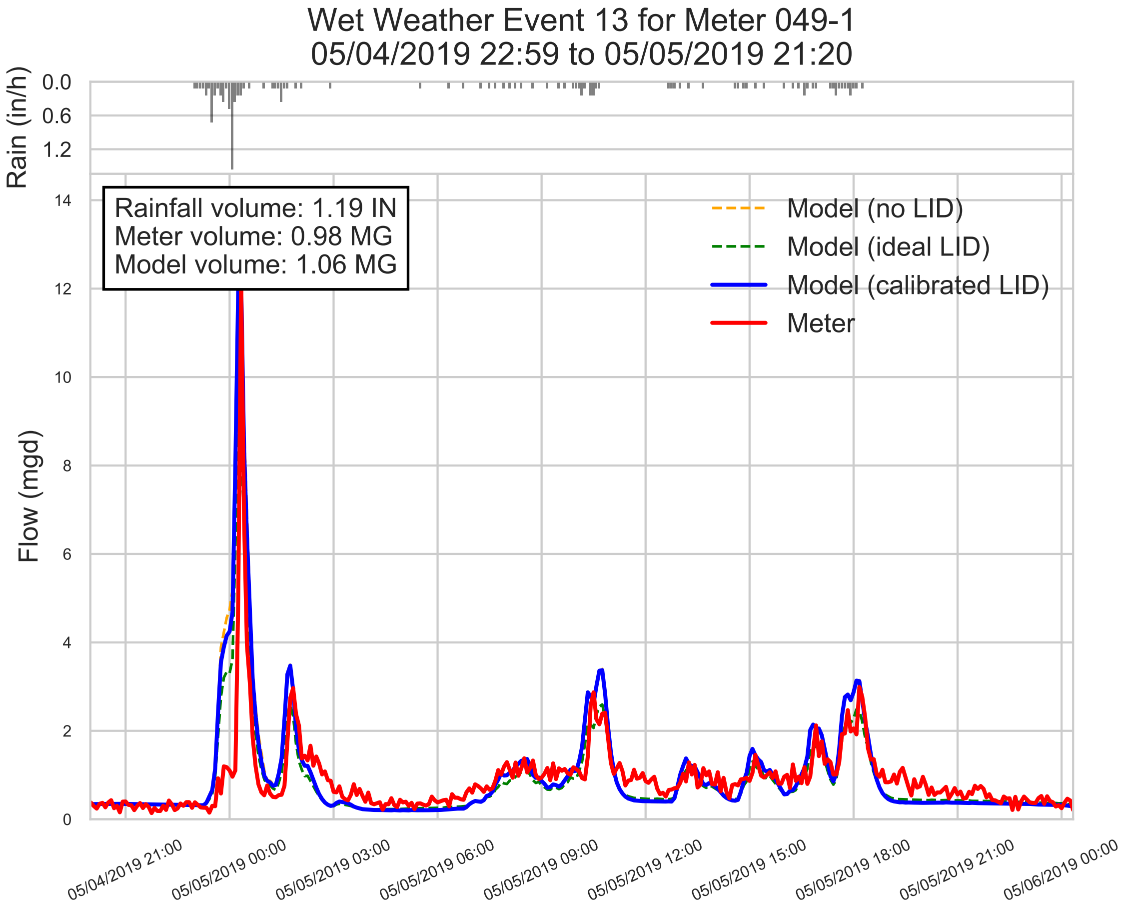


Wet Weather Event 10 for Meter 049-1
04/26/2019 14:24 to 04/26/2019 18:35
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.43 IN
Meter volume: 0.18 MG
Model volume: 0.29 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
12
10
8
6
4
2
0
04/26/2019 13:00
04/26/2019 16:00
04/26/2019 19:00

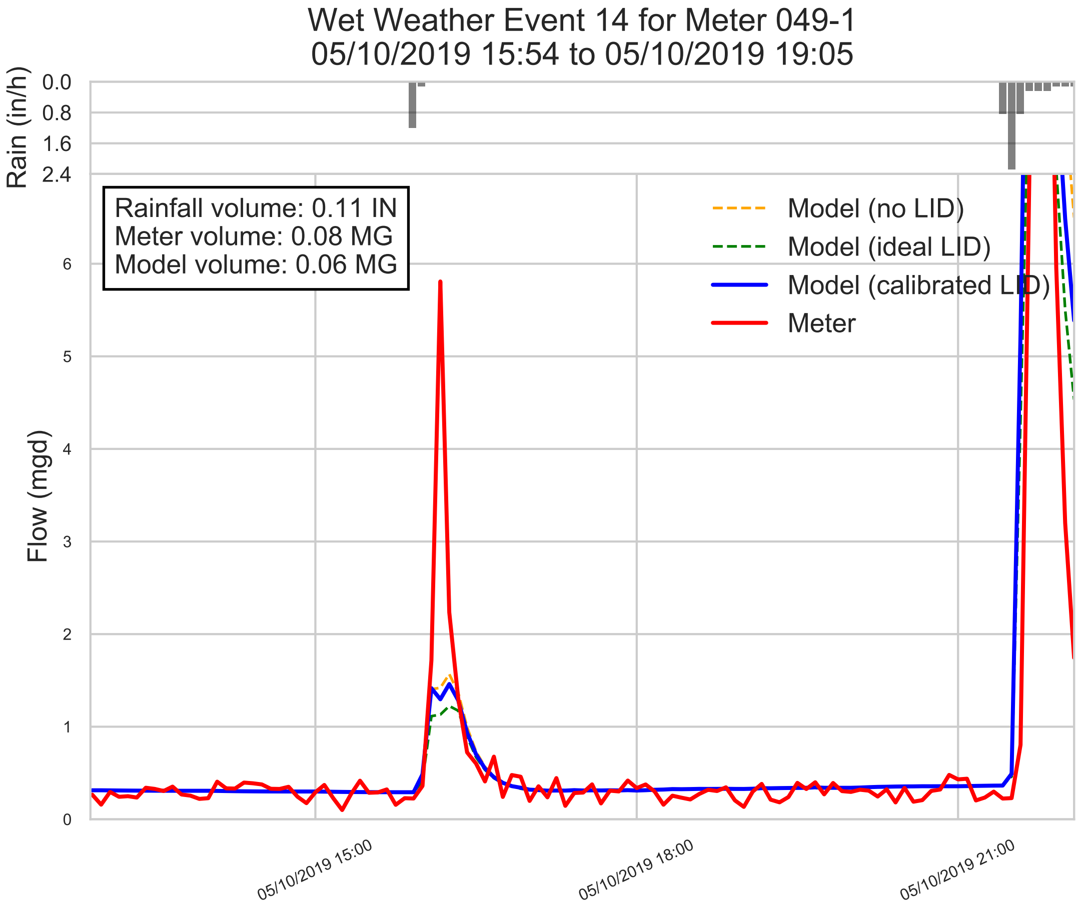


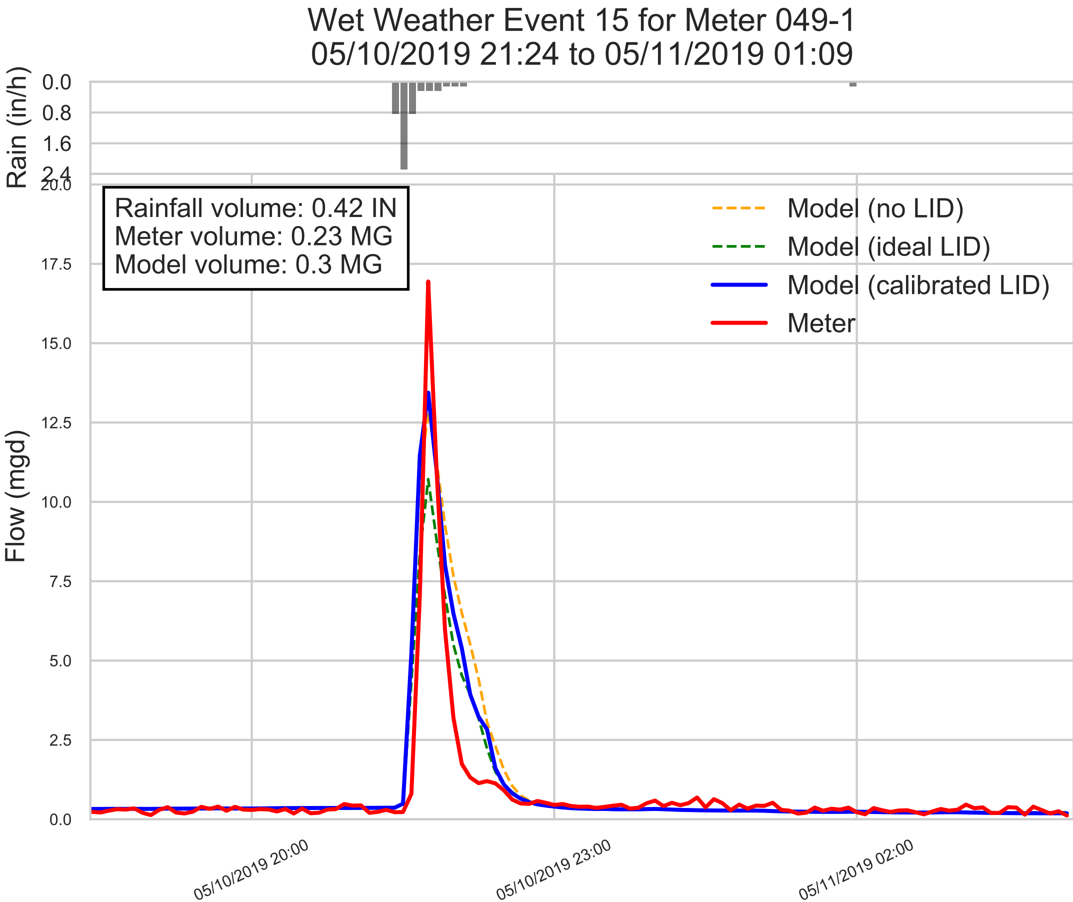
Wet Weather Event 11 for Meter 049-1
05/02/2019 15:45 to 05/02/2019 19:54
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.83 IN
Meter volume: 0.29 MG
Model volume: 0.51 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
2
4
6
8
10
12
14
16
05/02/2019 14:00
05/02/2019 17:00
05/02/2019 20:00


Wet Weather Event 12 for Meter 049-1
05/02/2019 23:39 to 05/03/2019 02:50
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
0
1
2
3
4
5
6
7
Rainfall volume: 0.12 IN
Meter volume: 0.09 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
05/02/2019 23:00
05/03/2019 02:00
05/03/2019 05:00



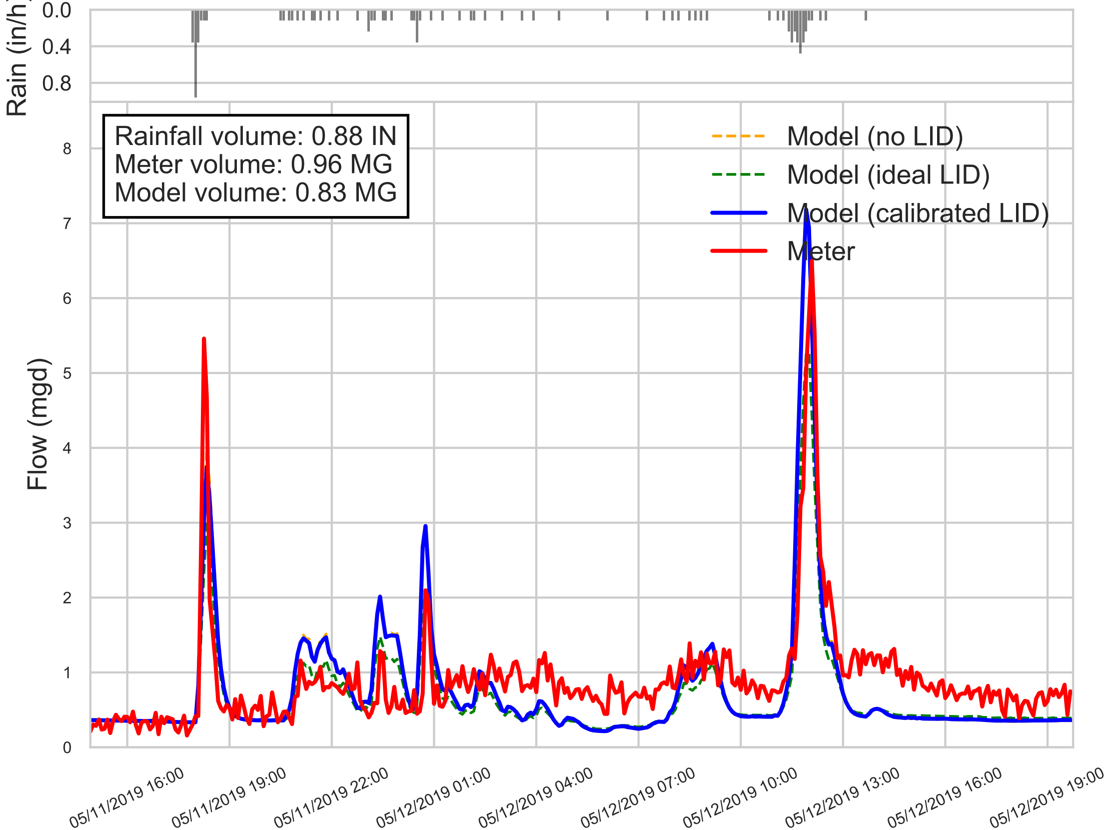
Wet Weather Event 13 for Meter 049-1
05/04/2019 22:59 to 05/05/2019 21:20
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 1.19 IN
Meter volume: 0.98 MG
Model volume: 1.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
05/04/2019 21:00
05/05/2019 00:00
05/05/2019 03:00
05/05/2019 06:00
05/05/2019 09:00
05/05/2019 12:00
05/05/2019 15:00
05/05/2019 18:00
05/05/2019 21:00
05/06/2019 00:00

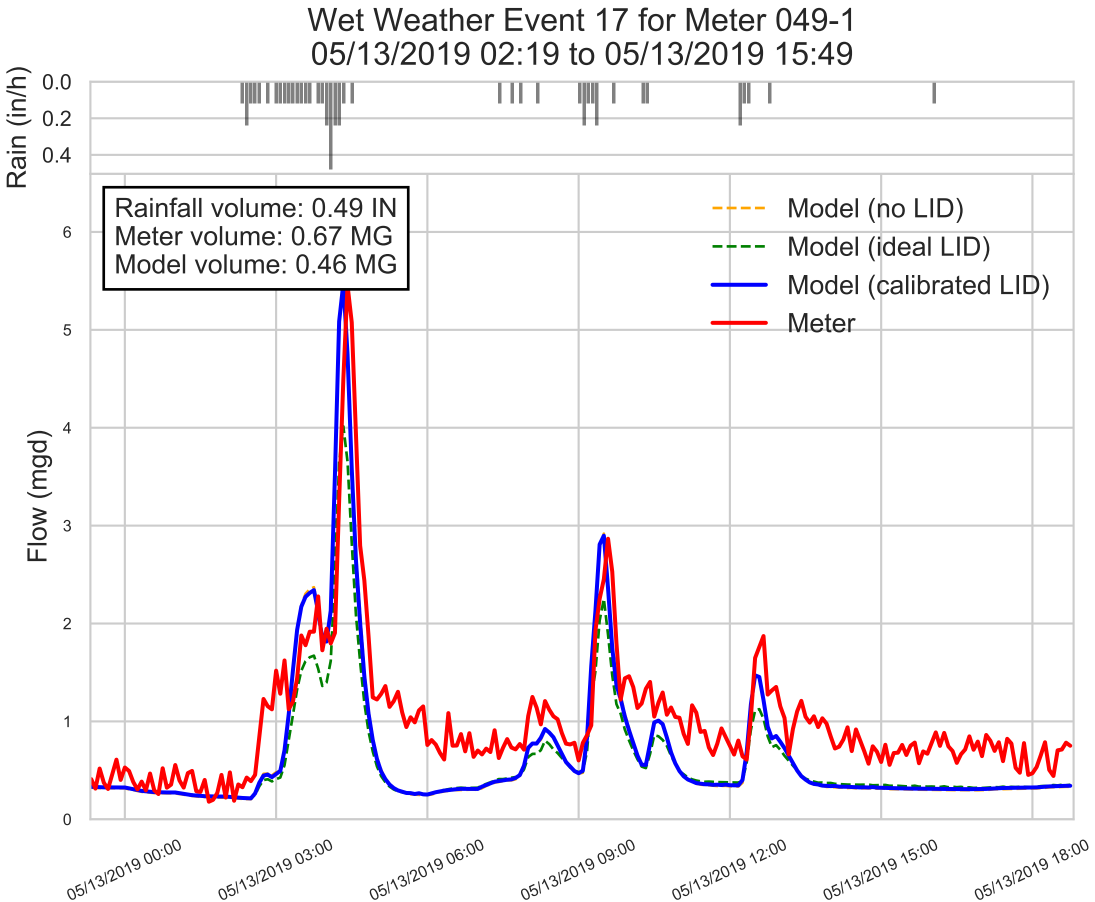

Wet Weather Event 14 for Meter 049-1
05/10/2019 15:54 to 05/10/2019 19:05
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.11 IN
Meter volume: 0.08 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
05/10/2019 15:00
05/10/2019 18:00
05/10/2019 21:00

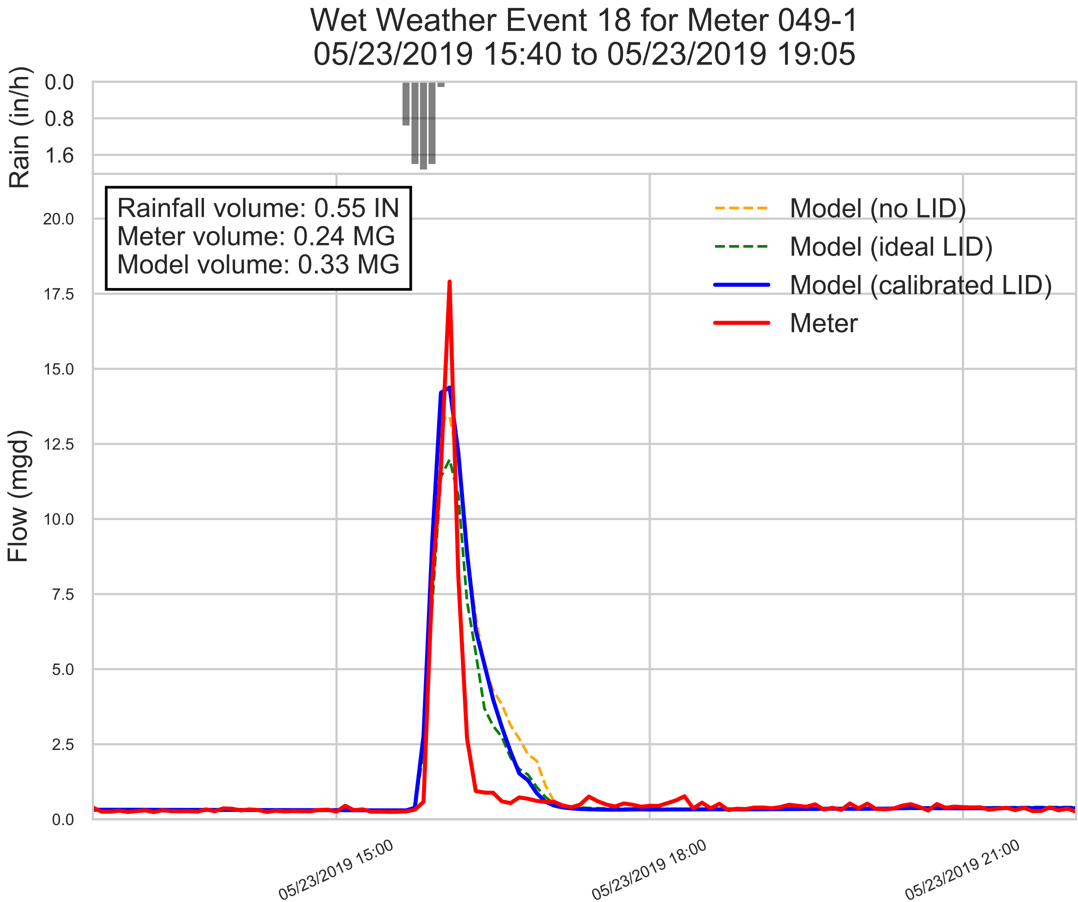


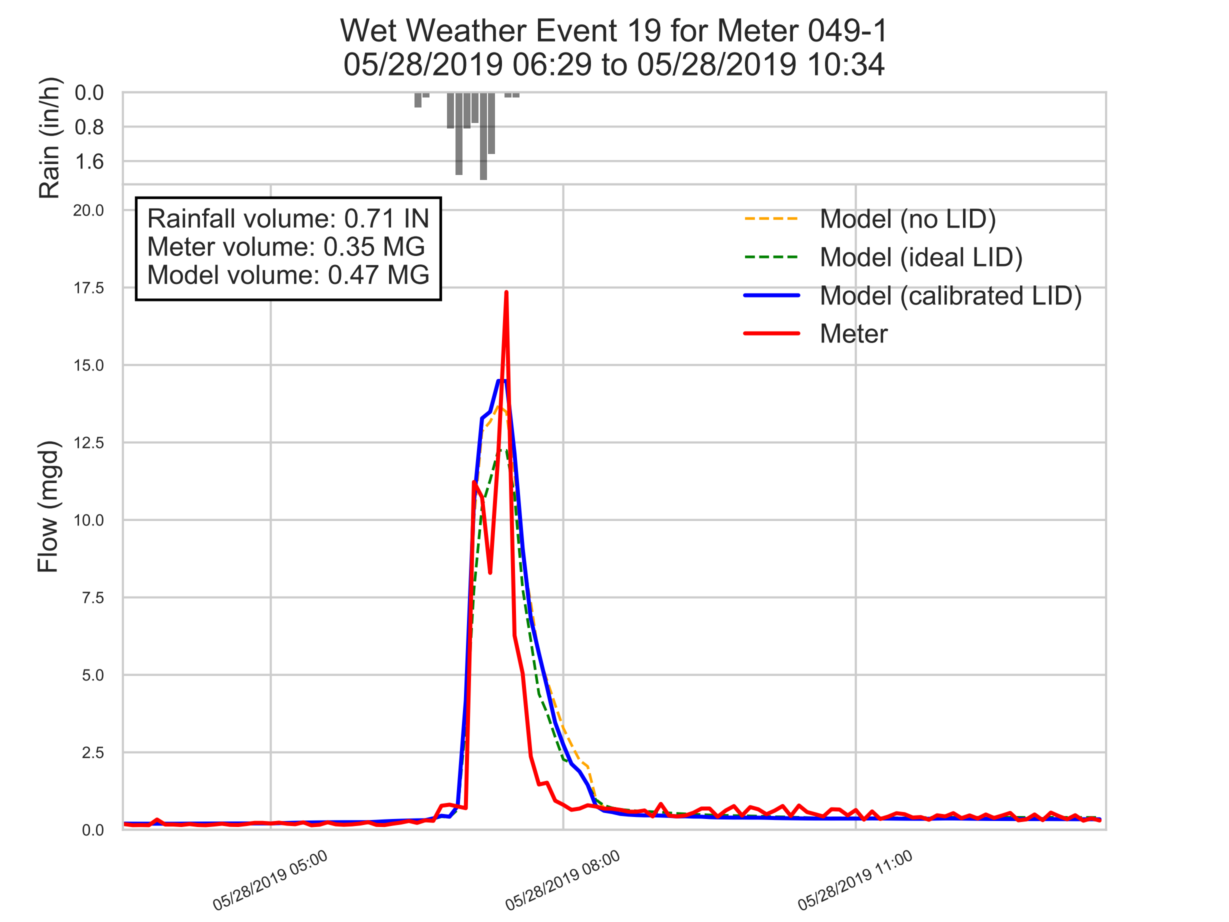
Wet Weather Event 15 for Meter 049-1
05/10/2019 21:24 to 05/11/2019 01:09
Rain (in/h)
0.0
0.8
1.6
2.4
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Rainfall volume: 0.42 IN
Meter volume: 0.23 MG
Model volume: 0.3 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
05/10/2019 20:00
05/10/2019 23:00
05/11/2019 02:00

Wet Weather Event 16 for Meter 049-1
05/11/2019 17:55 to 05/12/2019 16:45

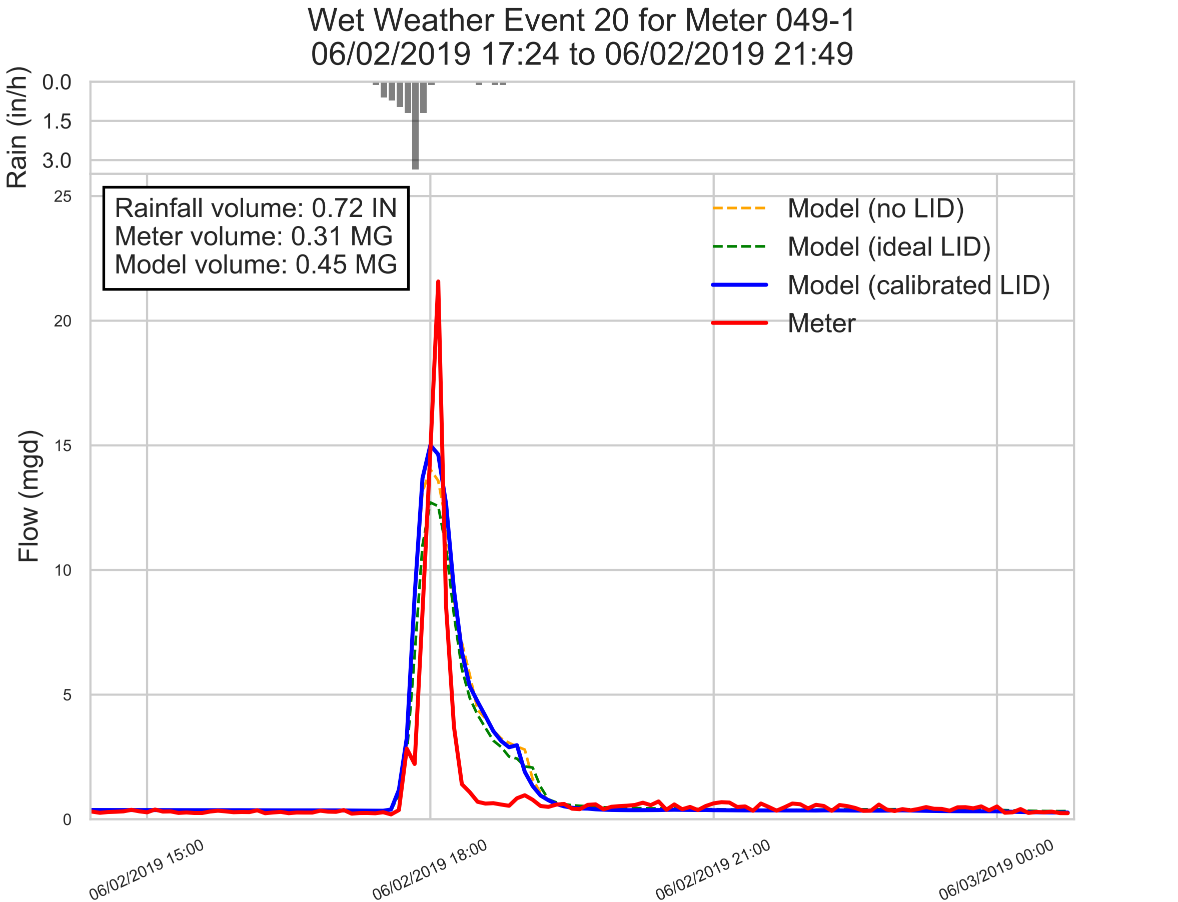



Wet Weather Event 17 for Meter 049-1
05/13/2019 02:19 to 05/13/2019 15:49
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.49 IN
Meter volume: 0.67 MG
Model volume: 0.46 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
05/13/2019 00:00
05/13/2019 03:00
05/13/2019 06:00
05/13/2019 09:00
05/13/2019 12:00
05/13/2019 15:00
05/13/2019 18:00

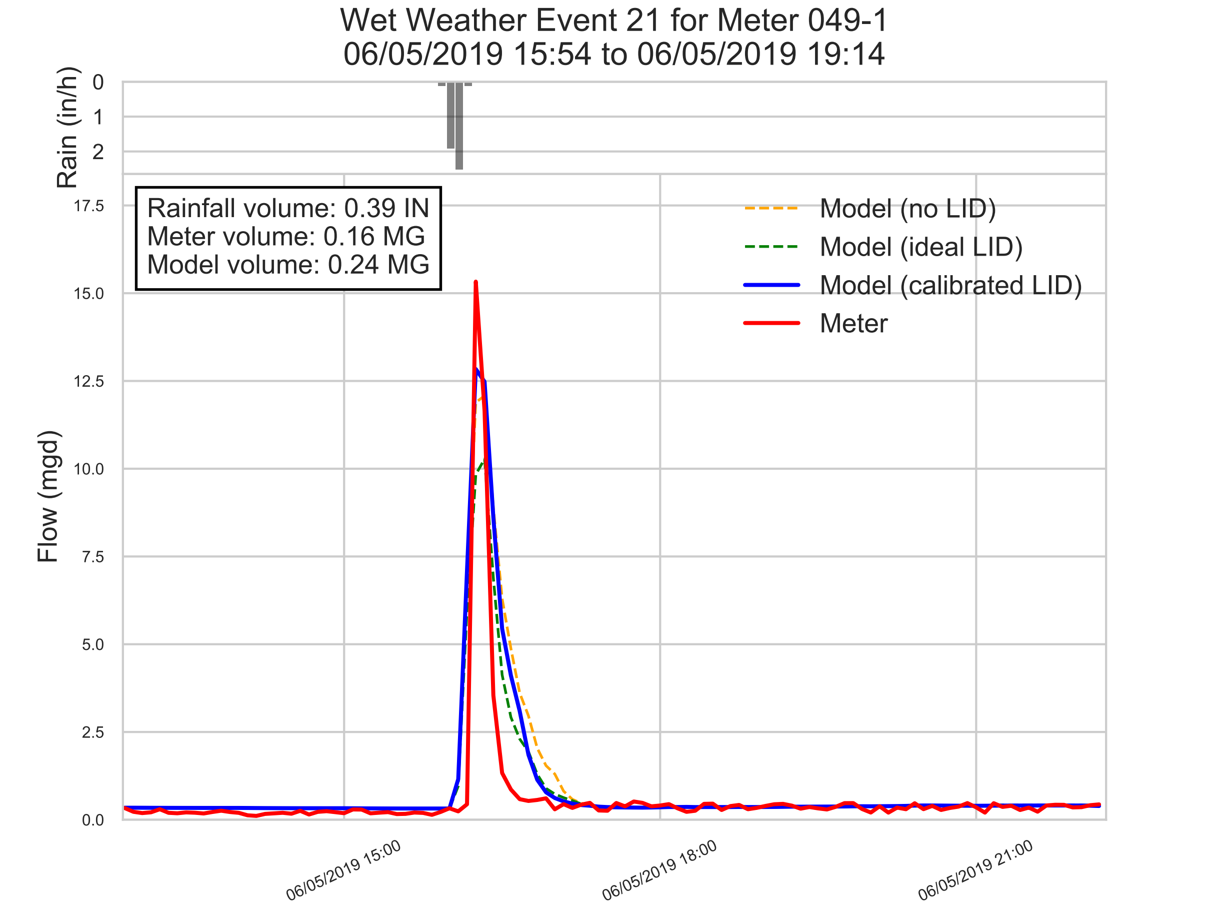

Wet Weather Event 18 for Meter 049-1
05/23/2019 15:40 to 05/23/2019 19:05
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.55 IN
Meter volume: 0.24 MG
Model volume: 0.33 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
05/23/2019 15:00
05/23/2019 18:00
05/23/2019 21:00



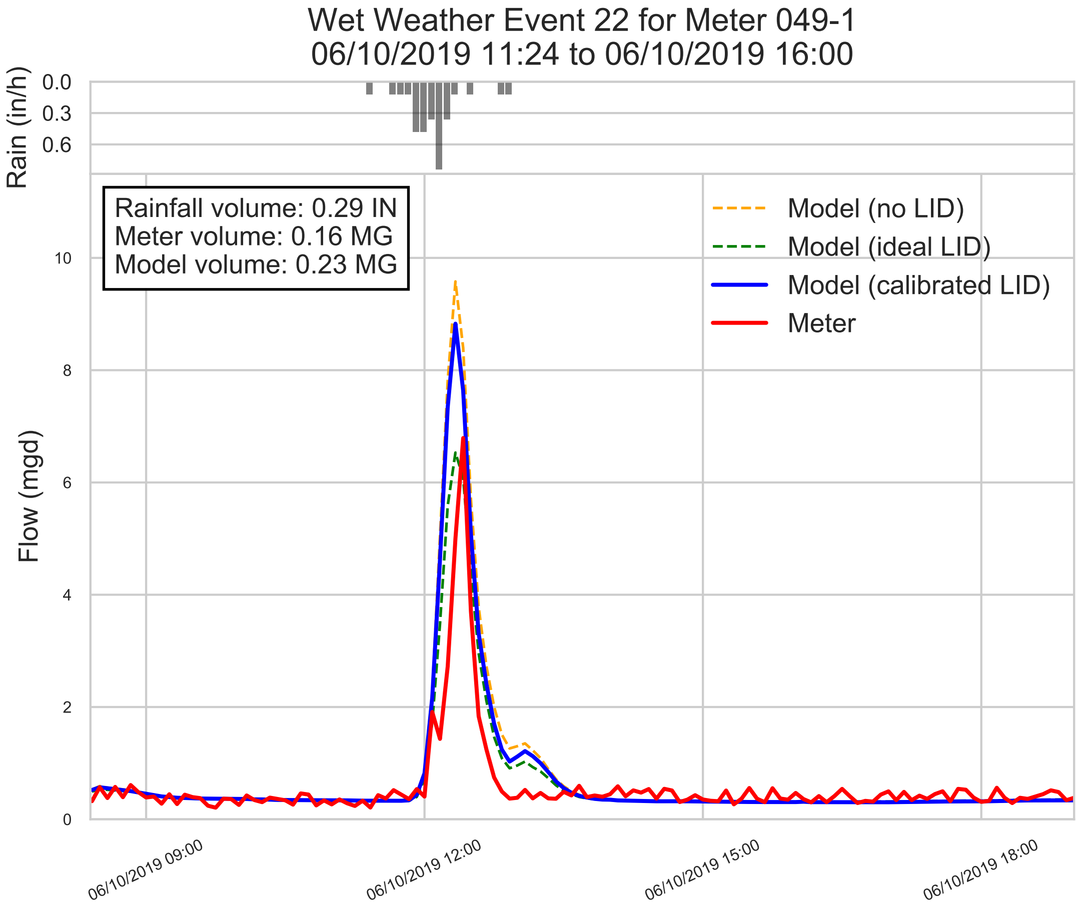
Wet Weather Event 19 for Meter 049-1
05/28/2019 06:29 to 05/28/2019 10:34
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Rainfall volume: 0.71 IN
Meter volume: 0.35 MG
Model volume: 0.47 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
05/28/2019 05:00
05/28/2019 08:00
05/28/2019 11:00



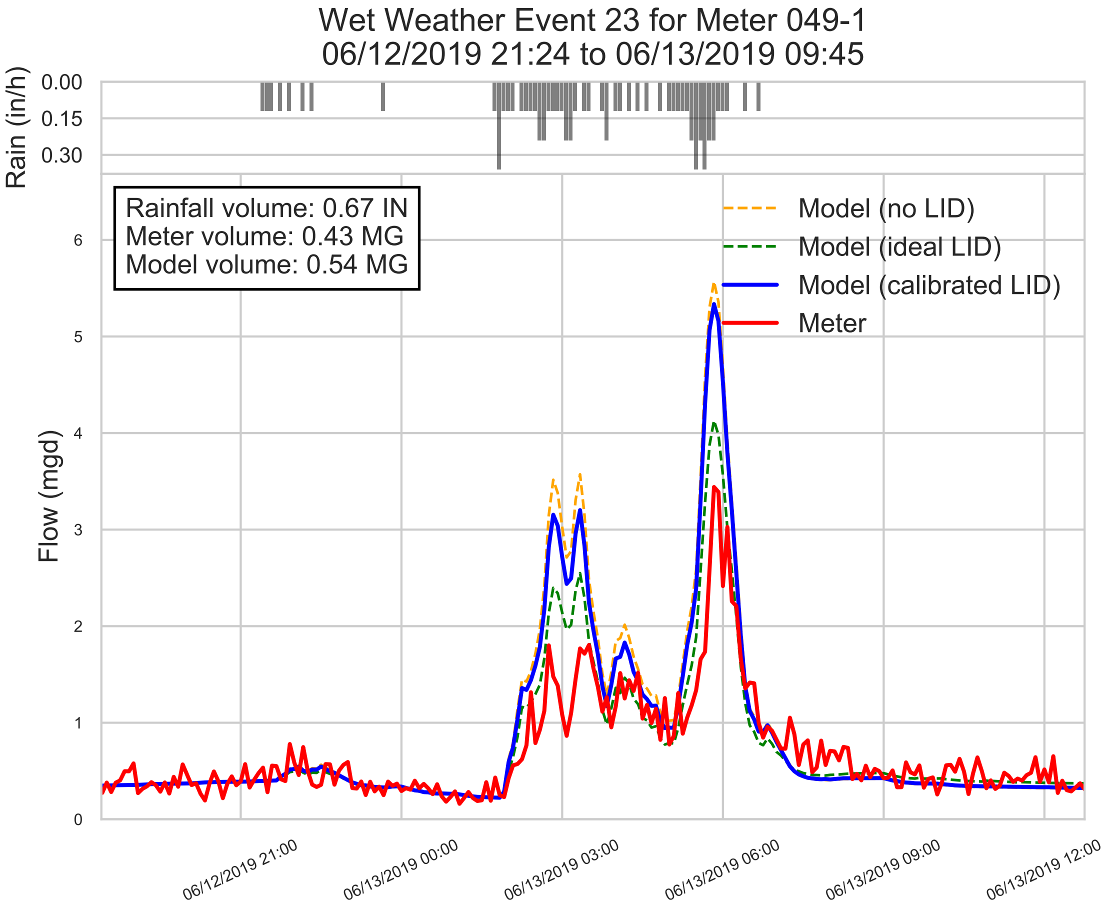
Wet Weather Event 20 for Meter 049-1
06/02/2019 17:24 to 06/02/2019 21:49
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.72 IN
Meter volume: 0.31 MG
Model volume: 0.45 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
25
20
15
10
5
0
06/02/2019 15:00
06/02/2019 18:00
06/02/2019 21:00
06/03/2019 00:00



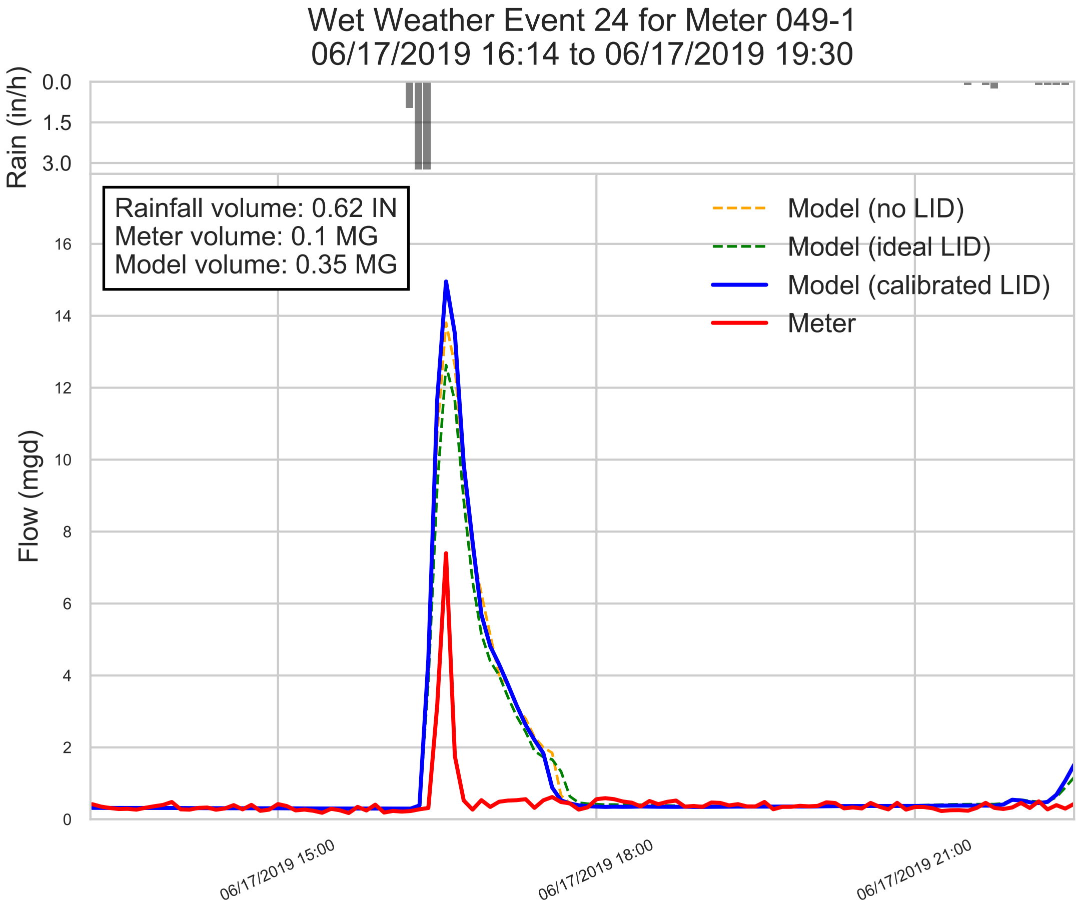
Wet Weather Event 21 for Meter 049-1
06/05/2019 15:54 to 06/05/2019 19:14
Rain (in/h)
0
1
2
Rainfall volume: 0.39 IN
Meter volume: 0.16 MG
Model volume: 0.24 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
06/05/2019 15:00
06/05/2019 18:00
06/05/2019 21:00



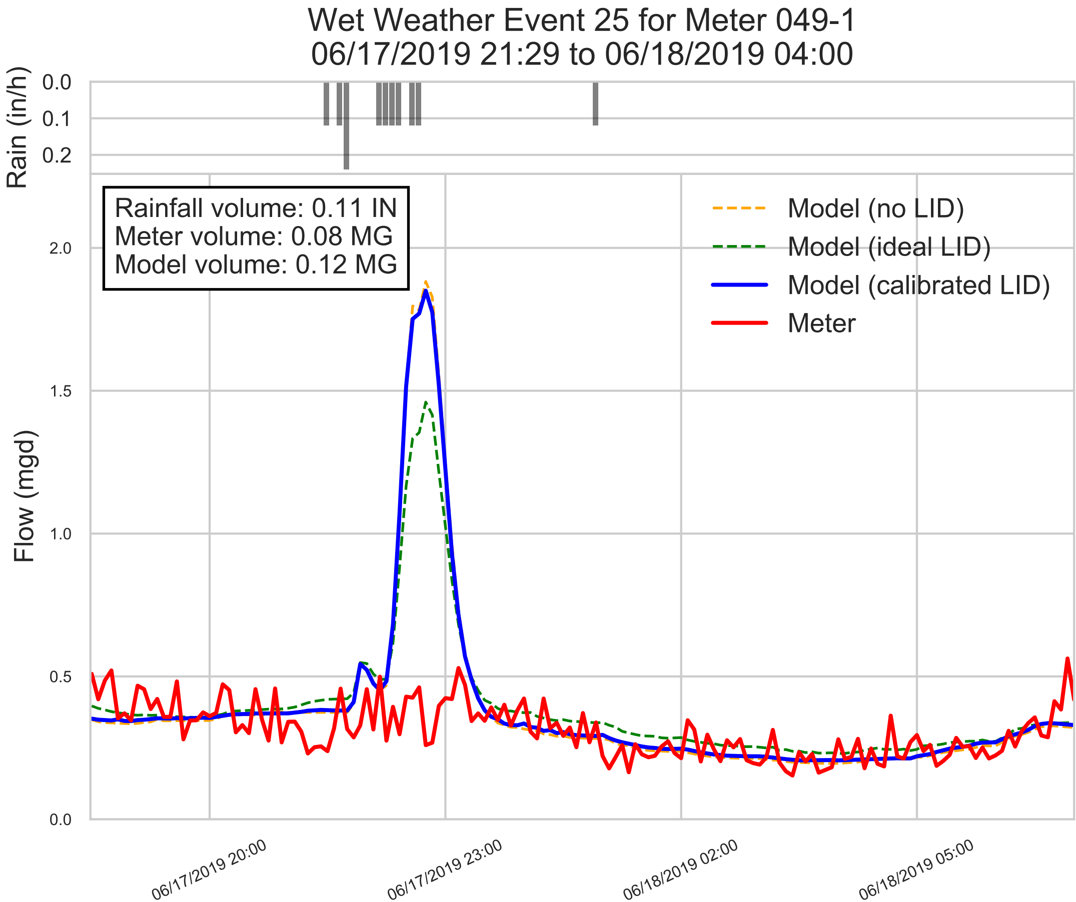
Wet Weather Event 22 for Meter 049-1
06/10/2019 11:24 to 06/10/2019 16:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.29 IN
Meter volume: 0.16 MG
Model volume: 0.23 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
10
8
6
4
2
0
06/10/2019 09:00
06/10/2019 12:00
06/10/2019 15:00
06/10/2019 18:00



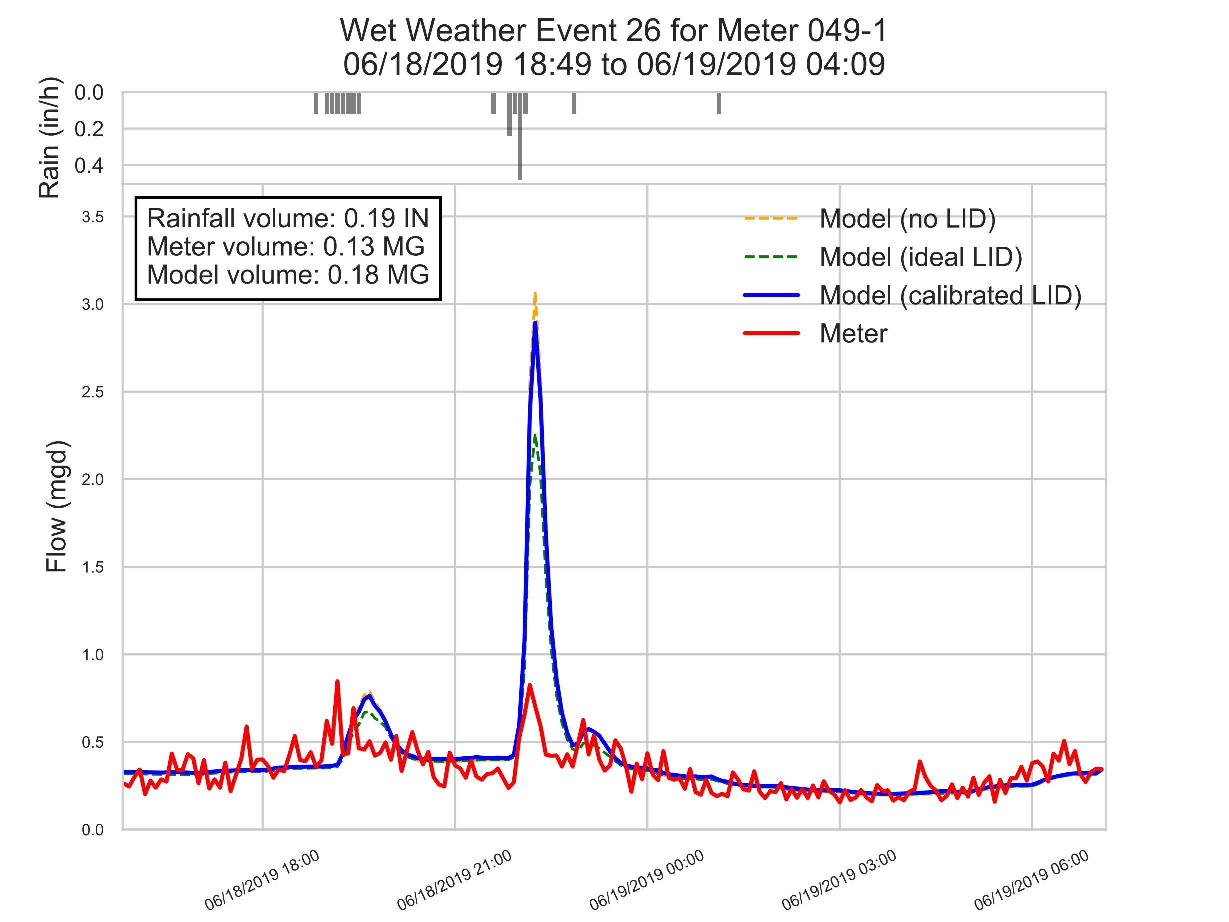
Wet Weather Event 23 for Meter 049-1
06/12/2019 21:24 to 06/13/2019 09:45
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.67 IN
Meter volume: 0.43 MG
Model volume: 0.54 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
06/12/2019 21:00
06/13/2019 00:00
06/13/2019 03:00
06/13/2019 06:00
06/13/2019 09:00
06/13/2019 12:00



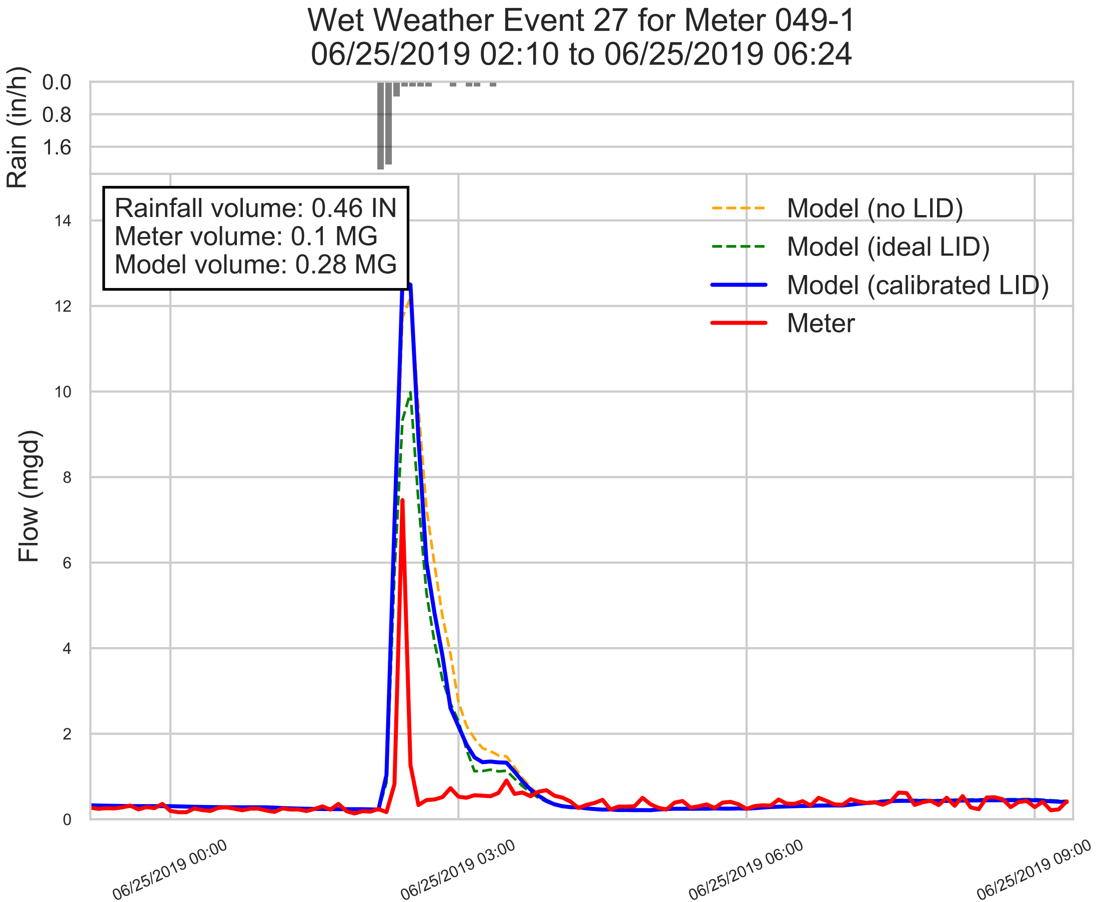
Wet Weather Event 24 for Meter 049-1
06/17/2019 16:14 to 06/17/2019 19:30
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.62 IN
Meter volume: 0.1 MG
Model volume: 0.35 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
2
4
6
8
10
12
14
16
06/17/2019 15:00
06/17/2019 18:00
06/17/2019 21:00



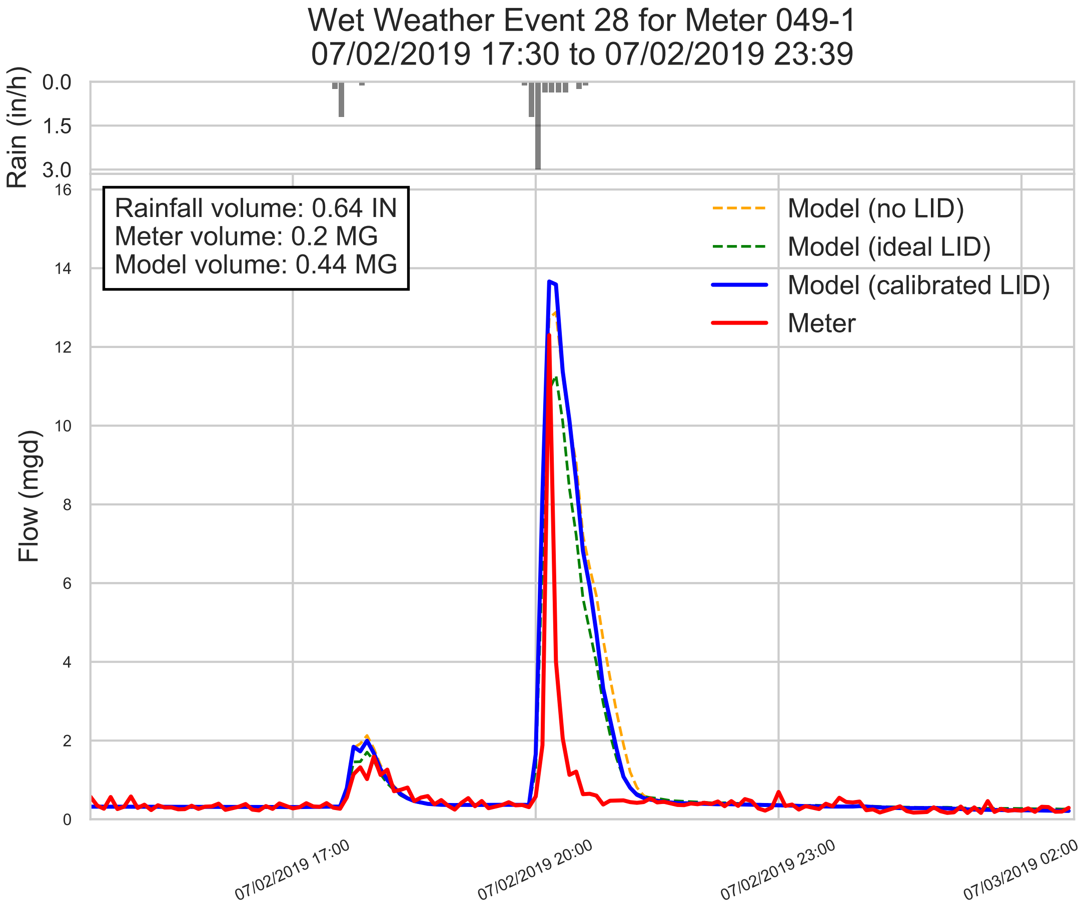
Wet Weather Event 25 for Meter 049-1
06/17/2019 21:29 to 06/18/2019 04:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.11 IN
Meter volume: 0.08 MG
Model volume: 0.12 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
06/17/2019 20:00
06/17/2019 23:00
06/18/2019 02:00
06/18/2019 05:00



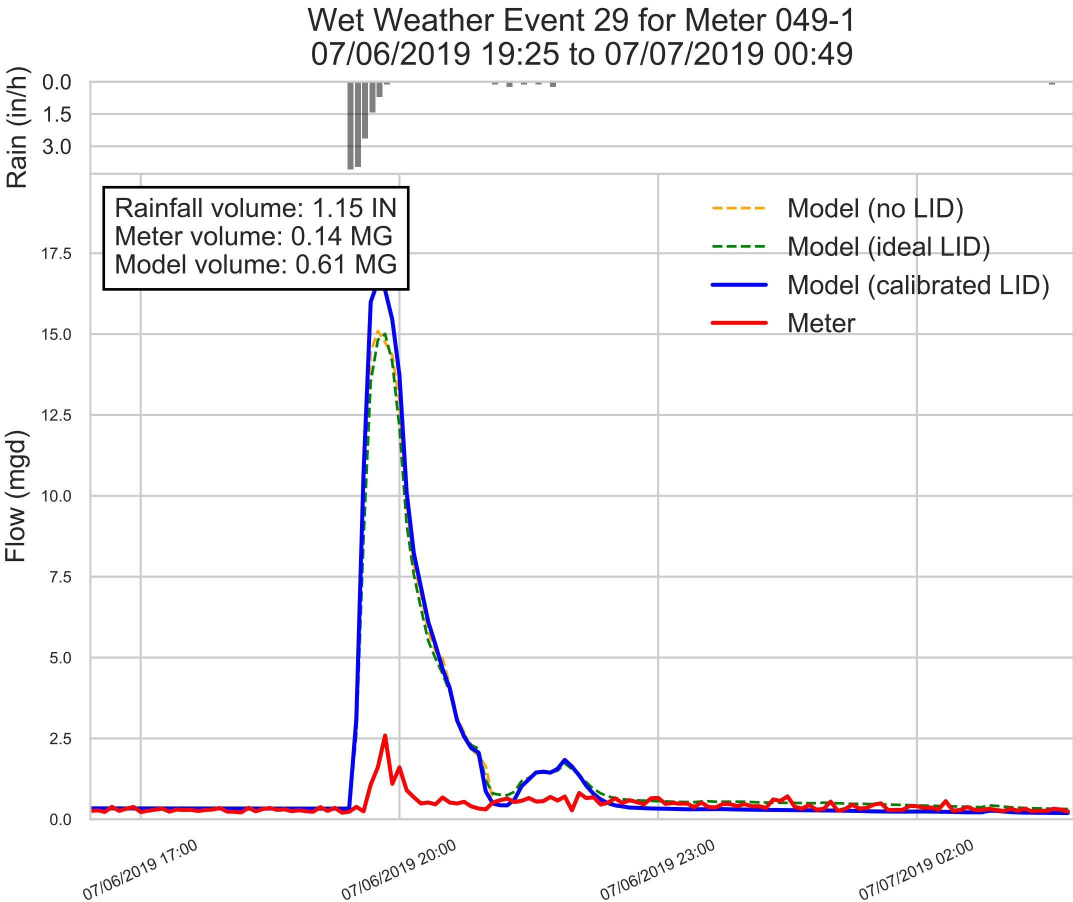
Wet Weather Event 26 for Meter 049-1
06/18/2019 18:49 to 06/19/2019 04:09
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.19 IN
Meter volume: 0.13 MG
Model volume: 0.18 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
06/18/2019 18:00
06/18/2019 21:00
06/19/2019 00:00
06/19/2019 03:00
06/19/2019 06:00



Wet Weather Event 27 for Meter 049-1
06/25/2019 02:10 to 06/25/2019 06:24
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.46 IN
Meter volume: 0.1 MG
Model volume: 0.28 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
06/25/2019 00:00
06/25/2019 03:00
06/25/2019 06:00
06/25/2019 09:00

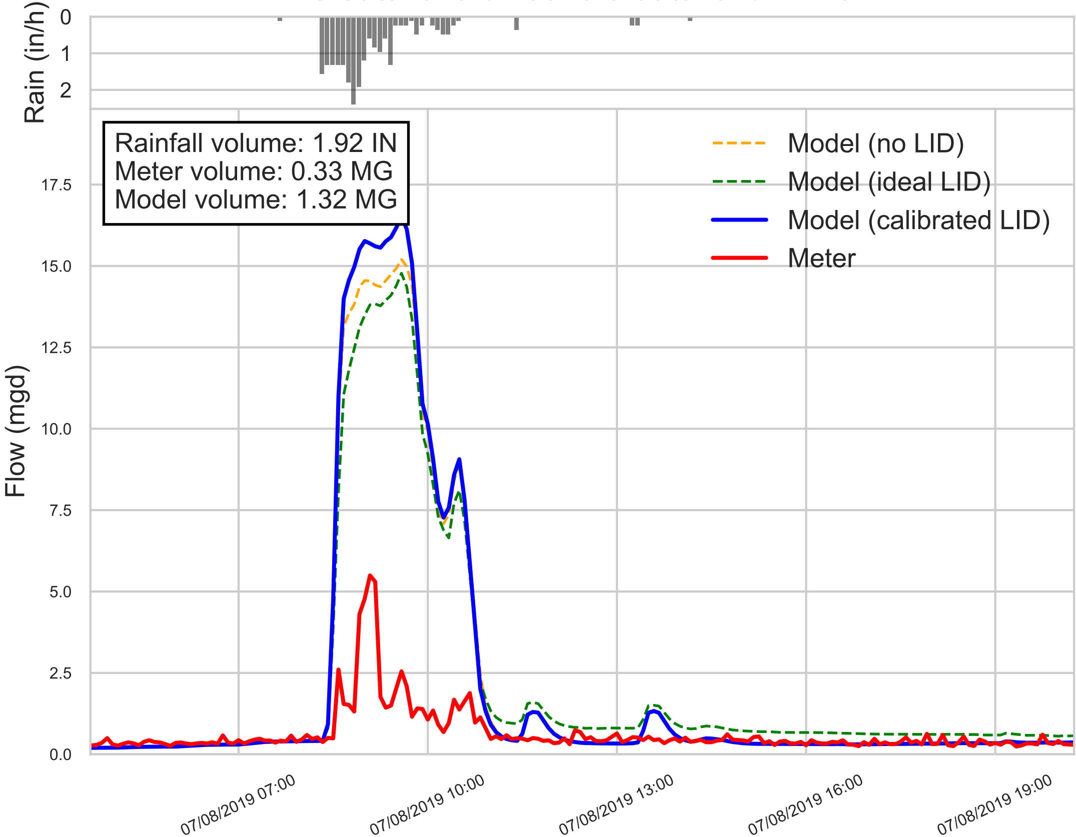


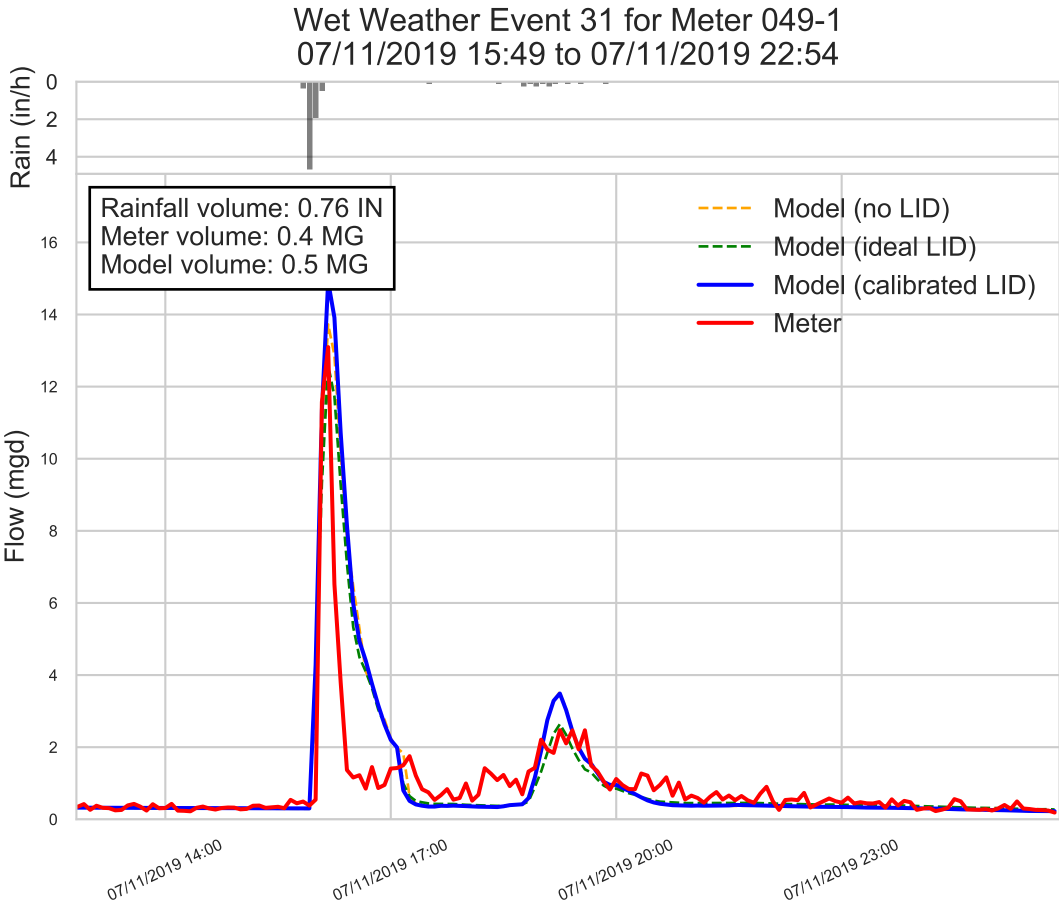
Wet Weather Event 28 for Meter 049-1
07/02/2019 17:30 to 07/02/2019 23:39
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.64 IN
Meter volume: 0.2 MG
Model volume: 0.44 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
2
4
6
8
10
12
14
16
07/02/2019 17:00
07/02/2019 20:00
07/02/2019 23:00
07/03/2019 02:00

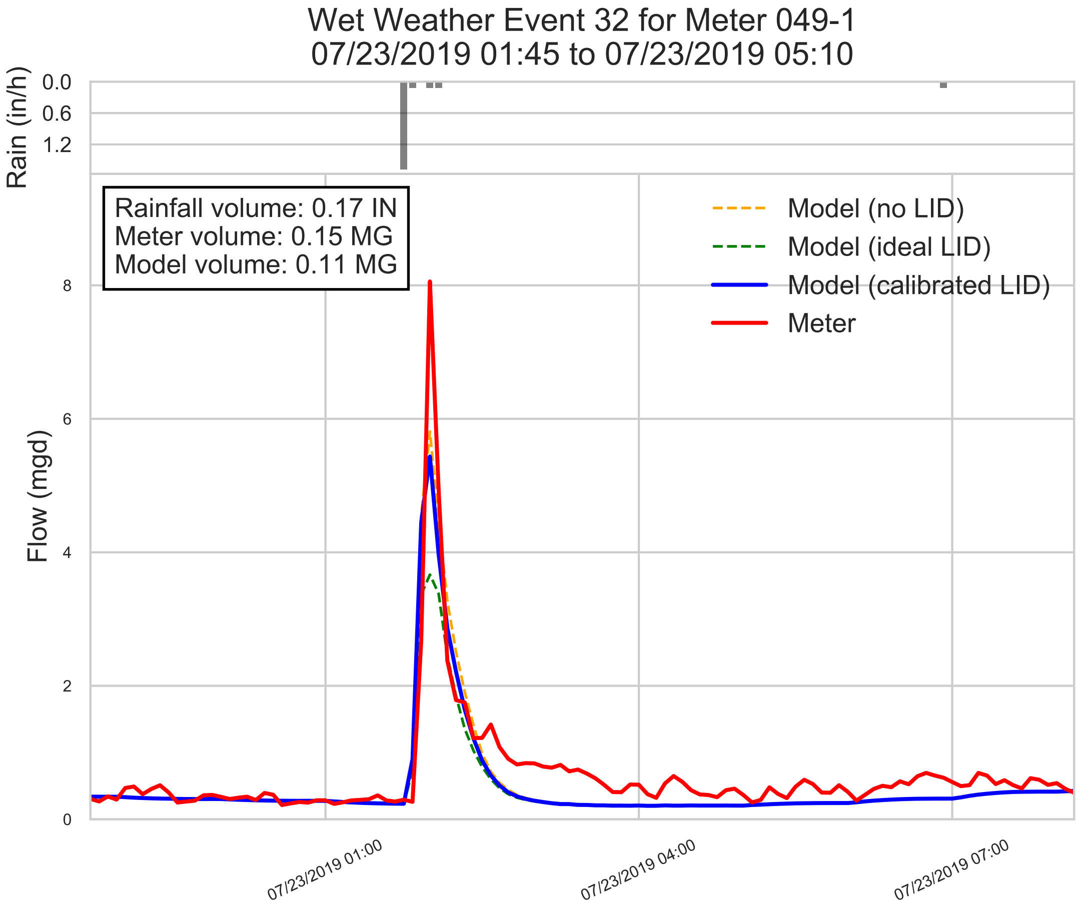


Wet Weather Event 29 for Meter 049-1
07/06/2019 19:25 to 07/07/2019 00:49
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Rainfall volume: 1.15 IN
Meter volume: 0.14 MG
Model volume: 0.61 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
07/06/2019 17:00
07/06/2019 20:00
07/06/2019 23:00
07/07/2019 02:00

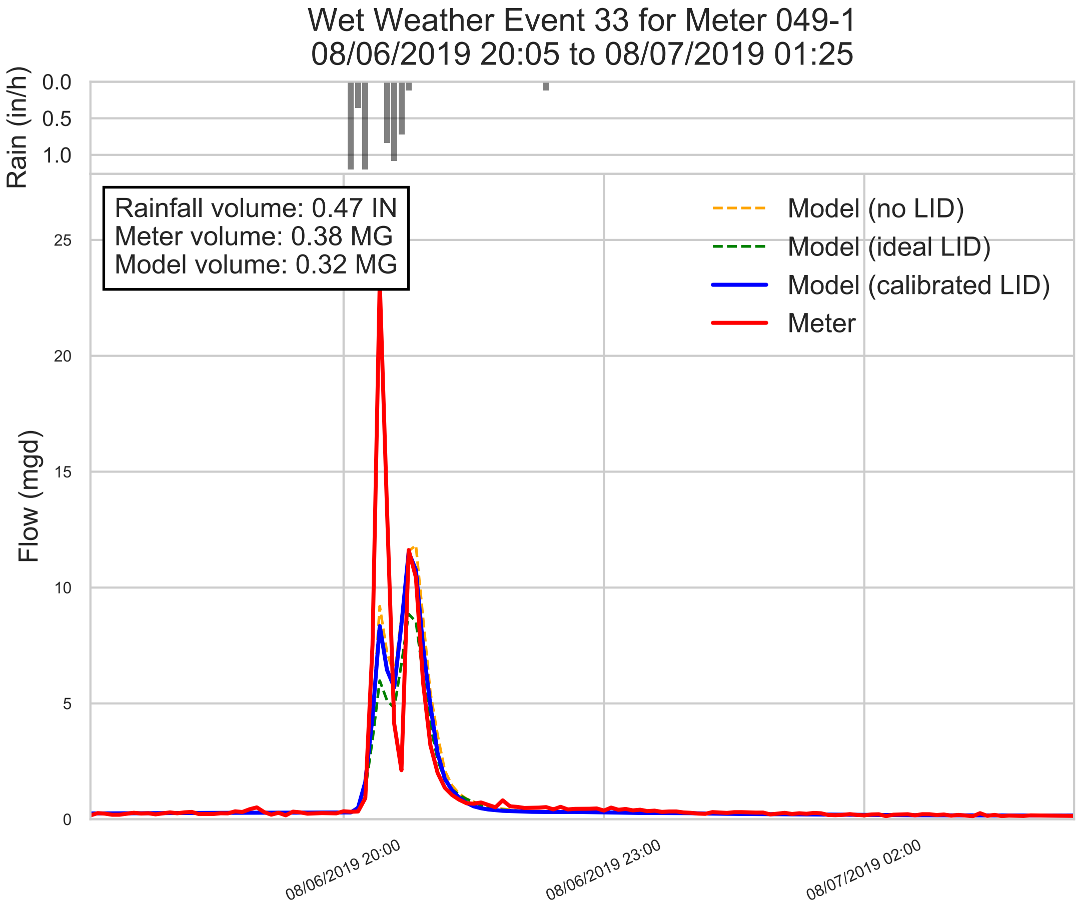
Wet Weather Event 30 for Meter 049-1
07/08/2019 07:39 to 07/08/2019 17:15

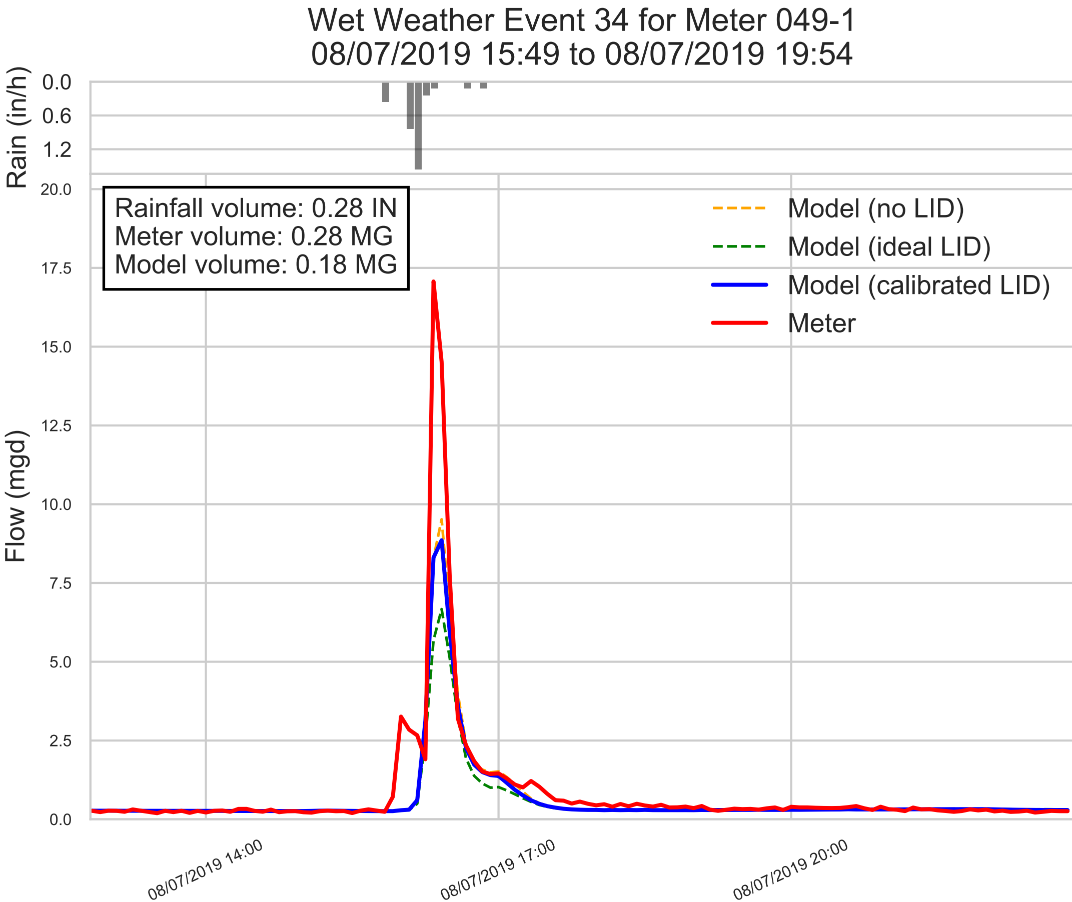



Wet Weather Event 31 for Meter 049-1
07/11/2019 15:49 to 07/11/2019 22:54
Rain (in/h)
0
2
4
Rainfall volume: 0.76 IN
Meter volume: 0.4 MG
Model volume: 0.5 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
07/11/2019 14:00
07/11/2019 17:00
07/11/2019 20:00
07/11/2019 23:00

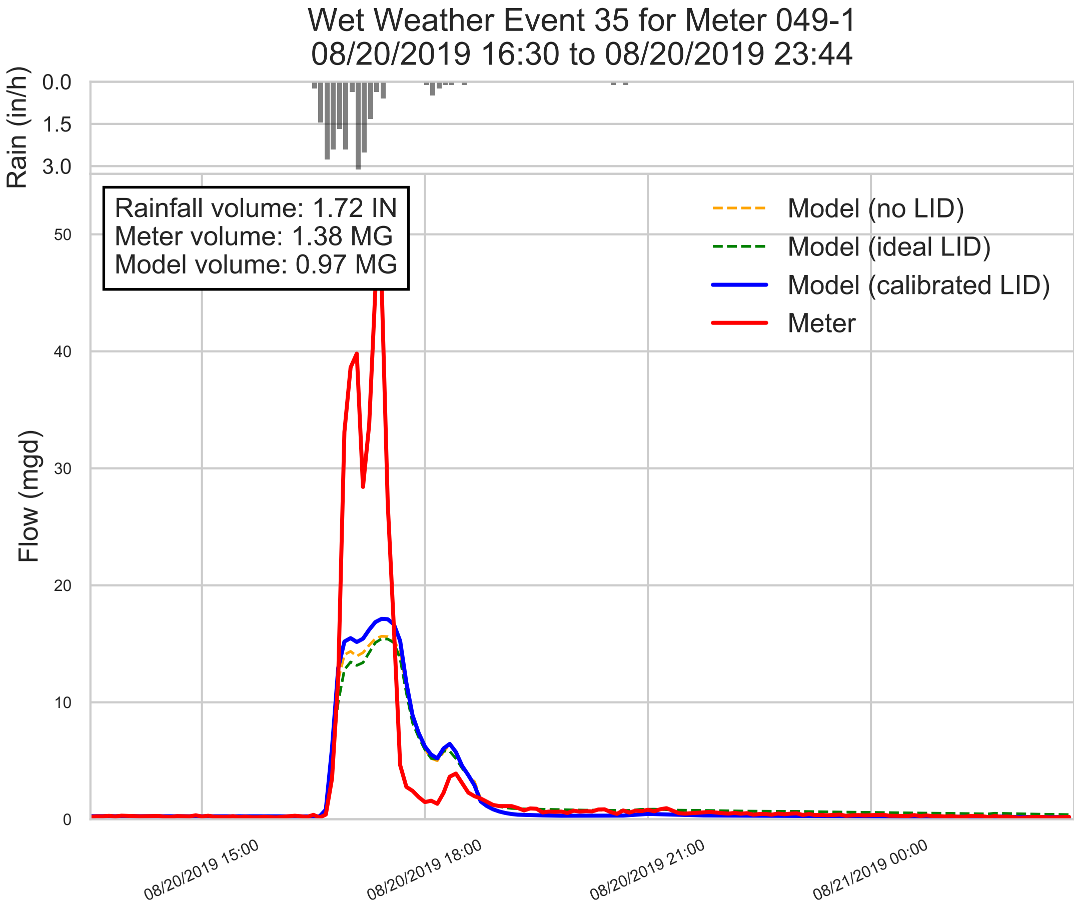


Wet Weather Event 32 for Meter 049-1
07/23/2019 01:45 to 07/23/2019 05:10
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.17 IN
Meter volume: 0.15 MG
Model volume: 0.11 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
8
6
4
2
0
07/23/2019 01:00
07/23/2019 04:00
07/23/2019 07:00

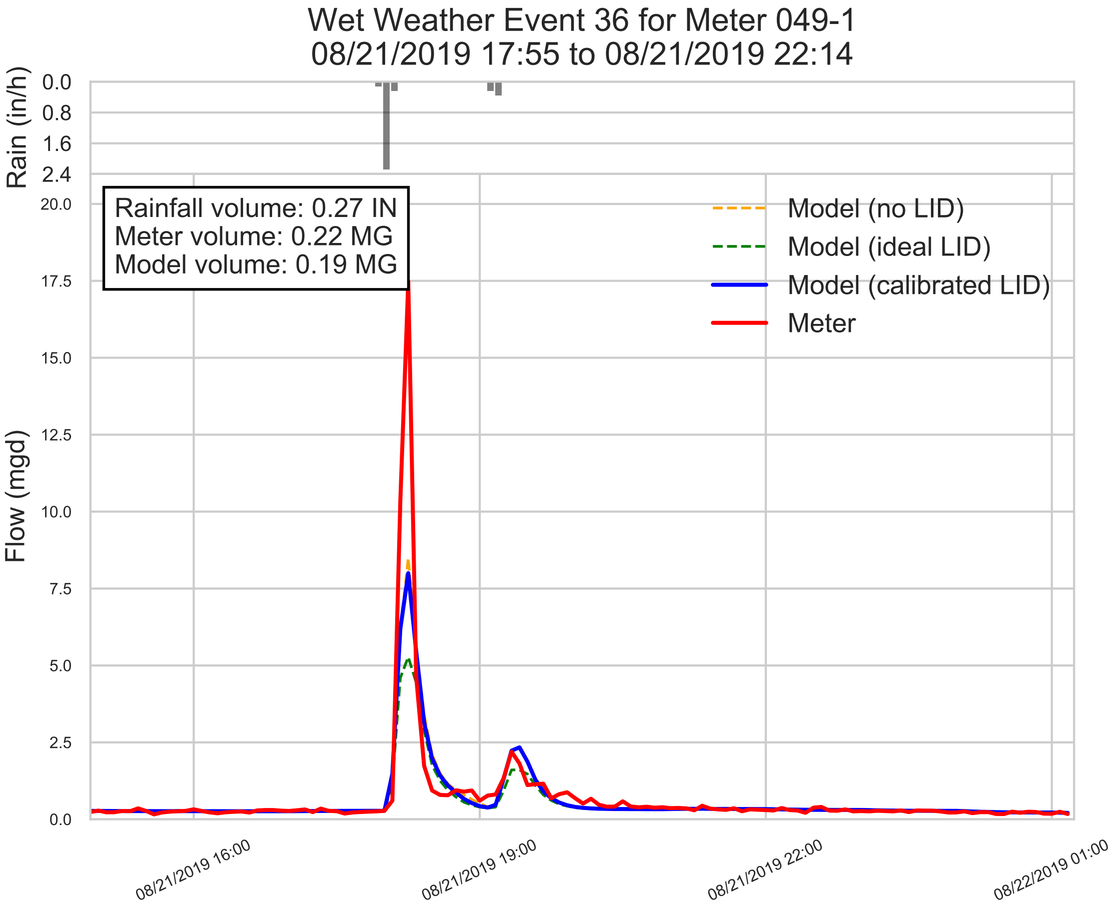

Wet Weather Event 33 for Meter 049-1
08/06/2019 20:05 to 08/07/2019 01:25
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.47 IN
Meter volume: 0.38 MG
Model volume: 0.32 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
25
20
15
10
5
0
08/06/2019 20:00
08/06/2019 23:00
08/07/2019 02:00



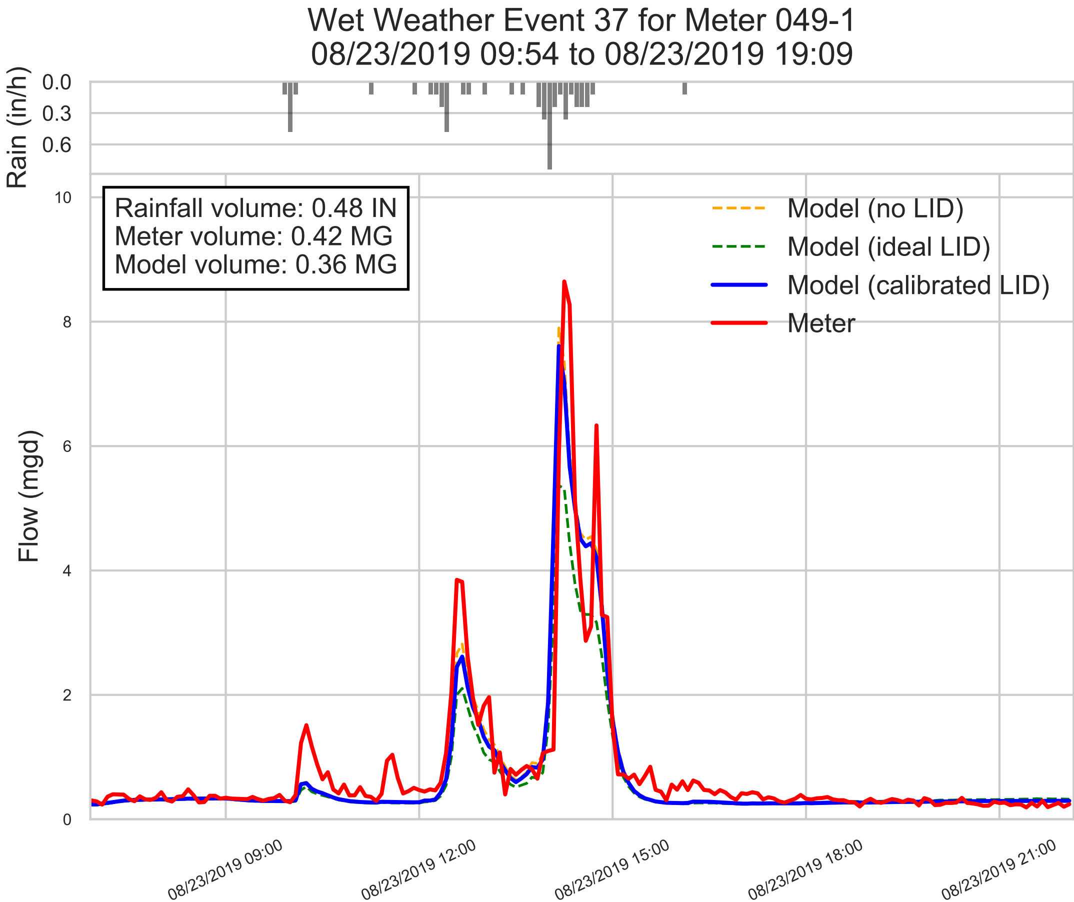
Wet Weather Event 34 for Meter 049-1
08/07/2019 15:49 to 08/07/2019 19:54
Rain (in/h)
0.0
0.6
1.2
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Rainfall volume: 0.28 IN
Meter volume: 0.28 MG
Model volume: 0.18 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
08/07/2019 14:00
08/07/2019 17:00
08/07/2019 20:00

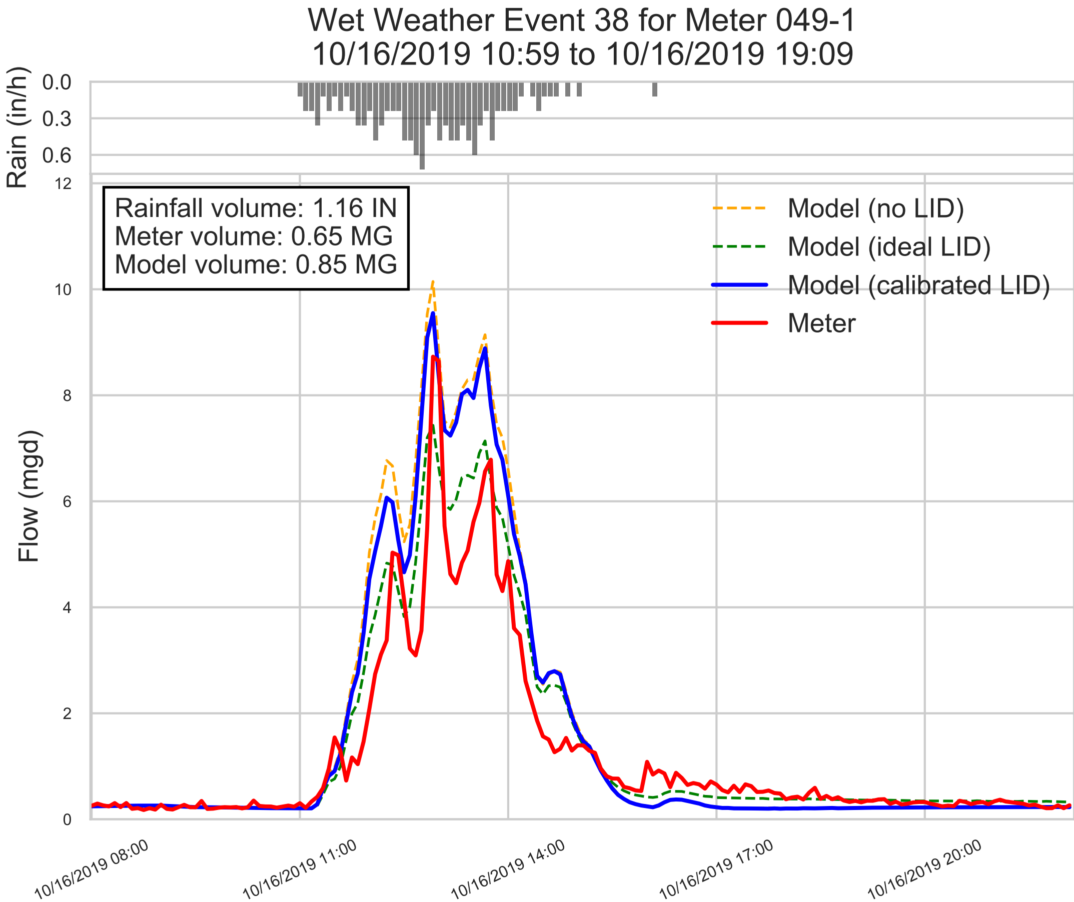


Wet Weather Event 35 for Meter 049-1
08/20/2019 16:30 to 08/20/2019 23:44
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.72 IN
Meter volume: 1.38 MG
Model volume: 0.97 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
50
40
30
20
10
0
08/20/2019 15:00
08/20/2019 18:00
08/20/2019 21:00
08/21/2019 00:00

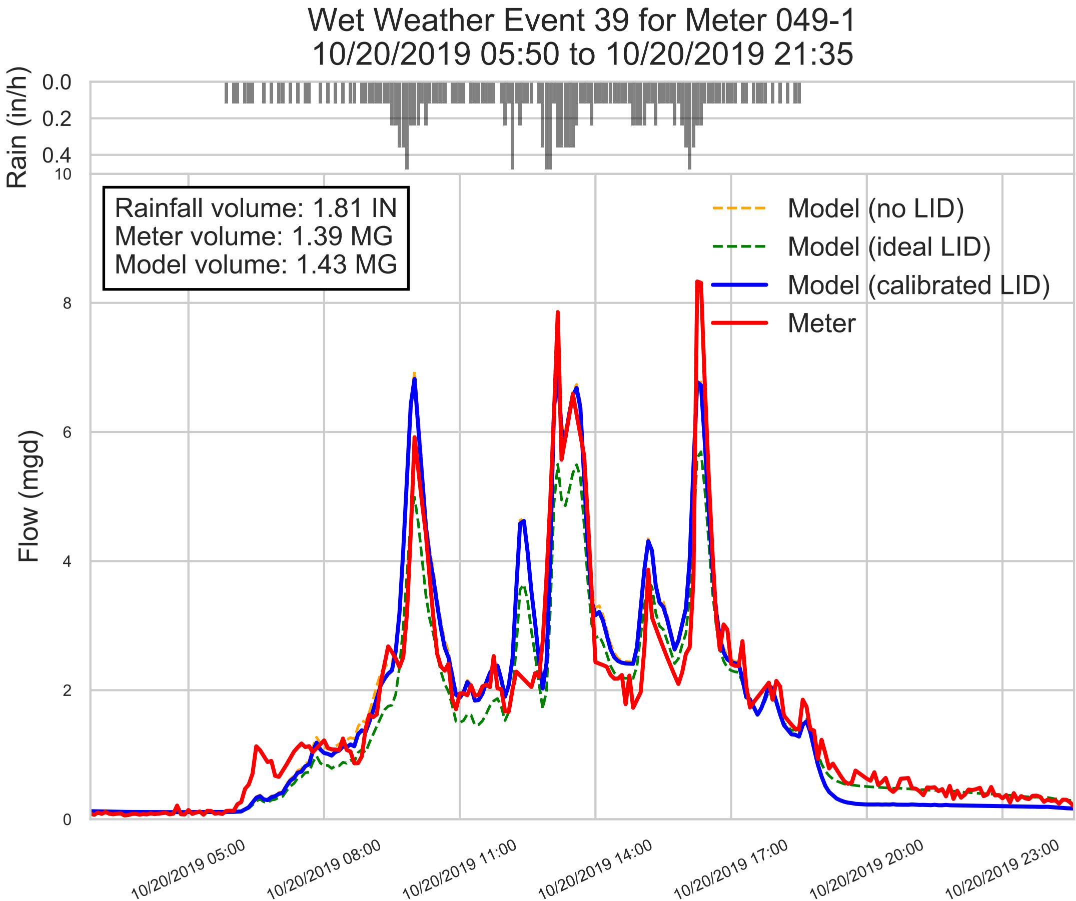


Wet Weather Event 36 for Meter 049-1
08/21/2019 17:55 to 08/21/2019 22:14
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.27 IN
Meter volume: 0.22 MG
Model volume: 0.19 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
08/21/2019 16:00
08/21/2019 19:00
08/21/2019 22:00
08/22/2019 01:00

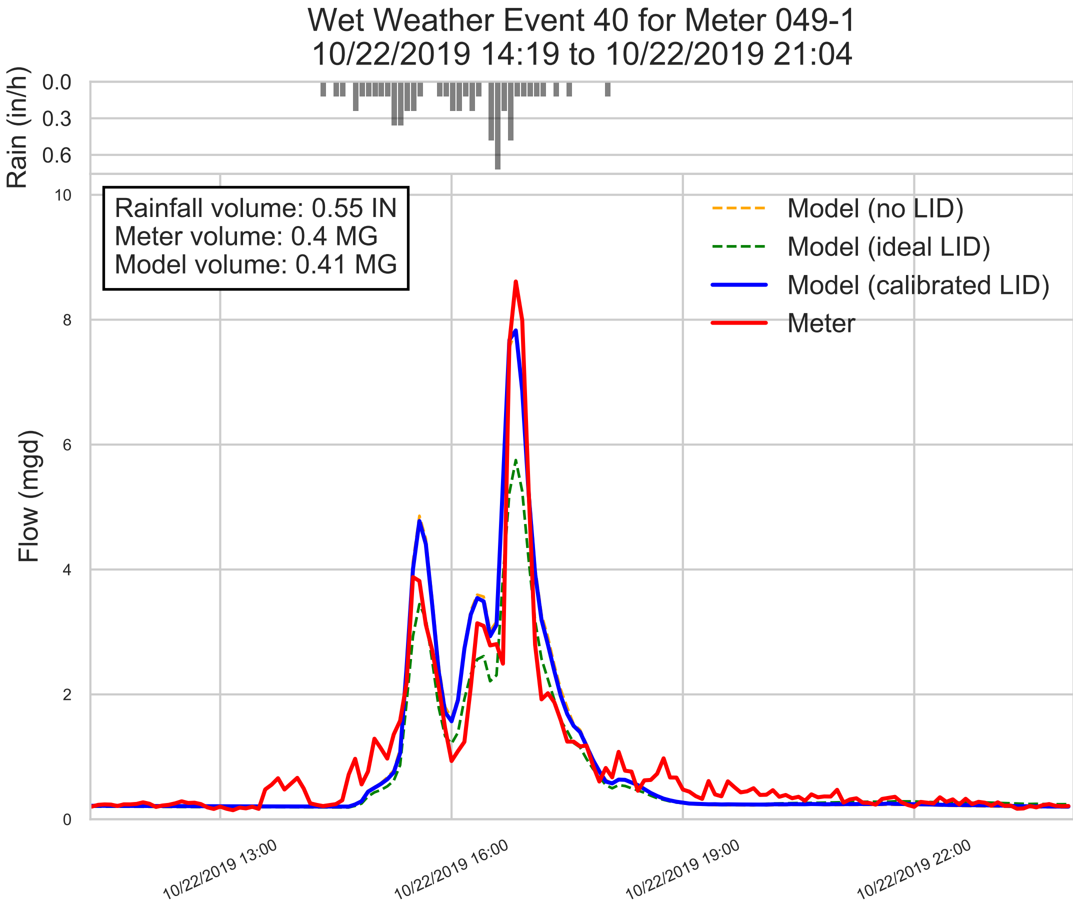

Wet Weather Event 37 for Meter 049-1
08/23/2019 09:54 to 08/23/2019 19:09
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.48 IN
Meter volume: 0.42 MG
Model volume: 0.36 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
10
8
6
4
2
0
08/23/2019 09:00
08/23/2019 12:00
08/23/2019 15:00
08/23/2019 18:00
08/23/2019 21:00

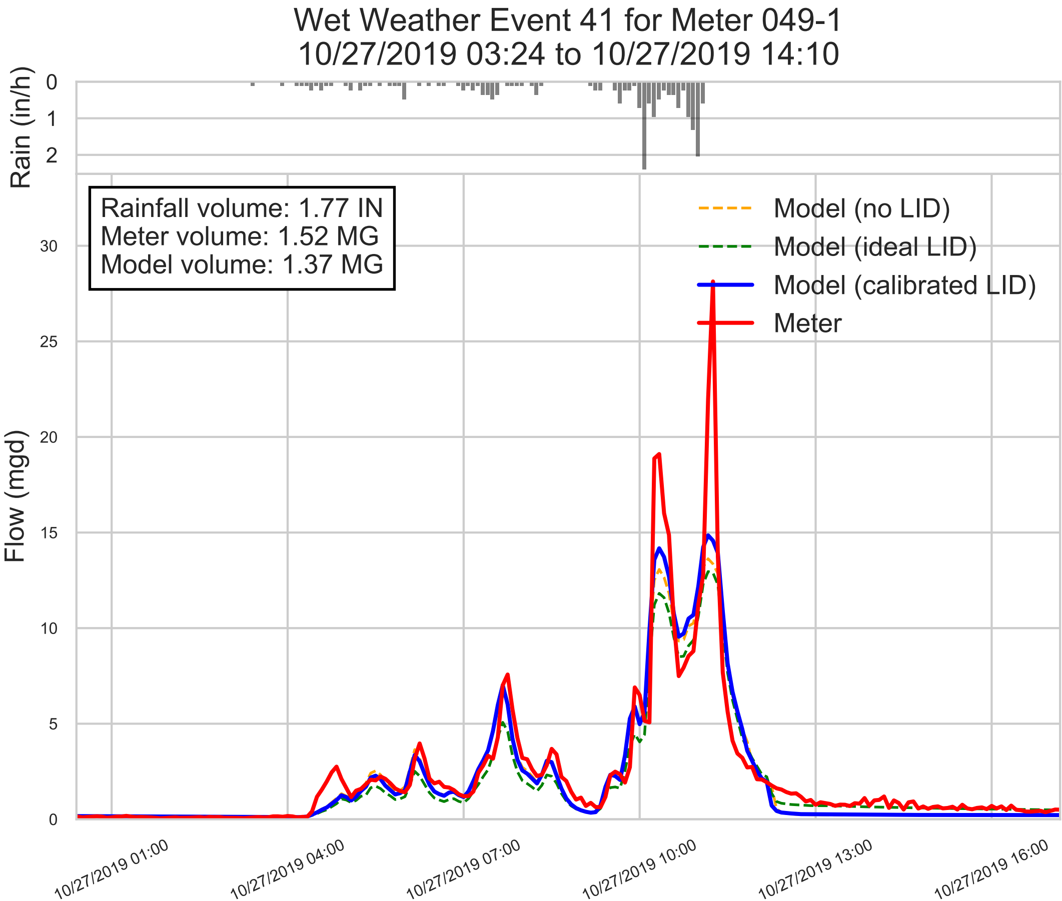


Wet Weather Event 38 for Meter 049-1
10/16/2019 10:59 to 10/16/2019 19:09
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 1.16 IN
Meter volume: 0.65 MG
Model volume: 0.85 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
12
10
8
6
4
2
0
10/16/2019 08:00
10/16/2019 11:00
10/16/2019 14:00
10/16/2019 17:00
10/16/2019 20:00

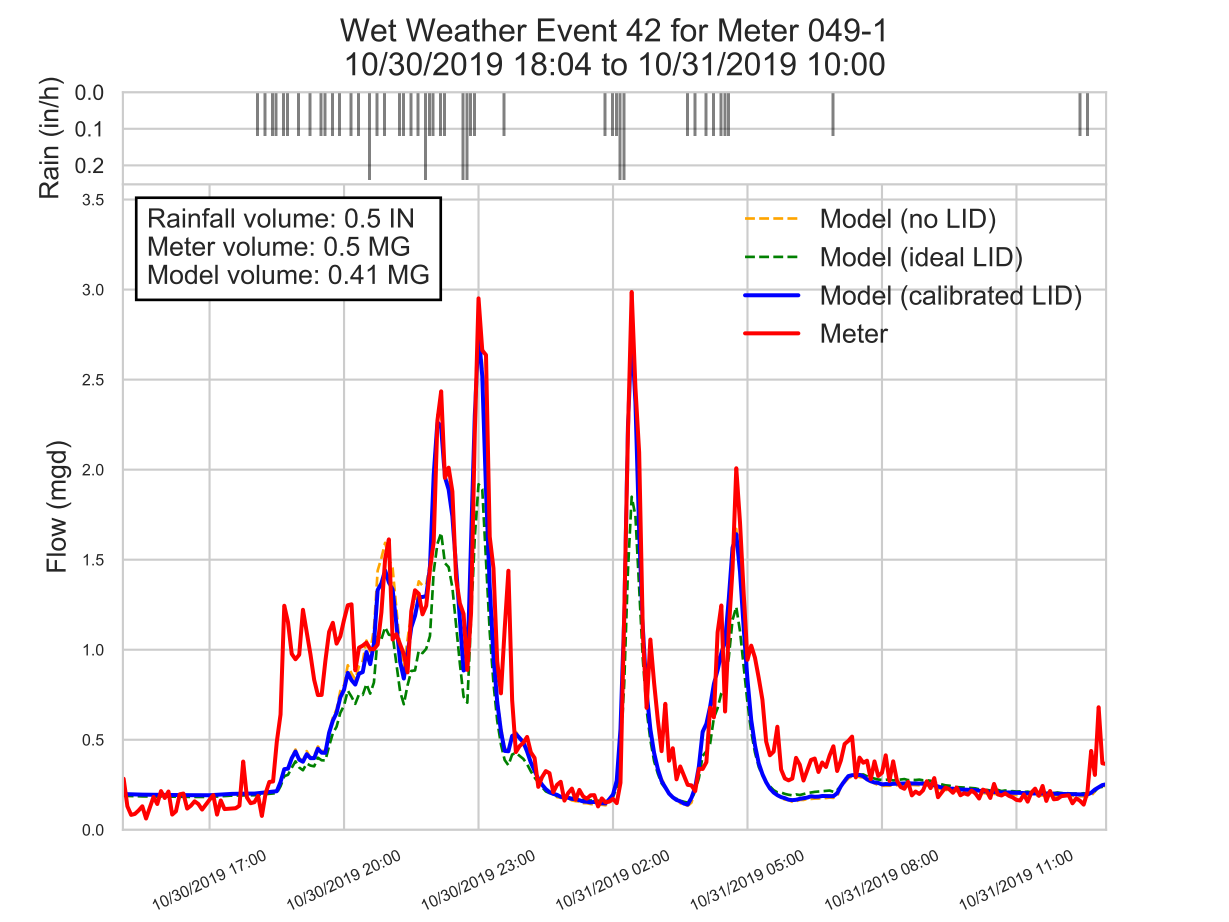


Wet Weather Event 39 for Meter 049-1
10/20/2019 05:50 to 10/20/2019 21:35
Rain (in/h)
0.0
0.2
0.4
10
8
6
4
2
0
Flow (mgd)
Rainfall volume: 1.81 IN
Meter volume: 1.39 MG
Model volume: 1.43 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
10/20/2019 05:00
10/20/2019 08:00
10/20/2019 11:00
10/20/2019 14:00
10/20/2019 17:00
10/20/2019 20:00
10/20/2019 23:00

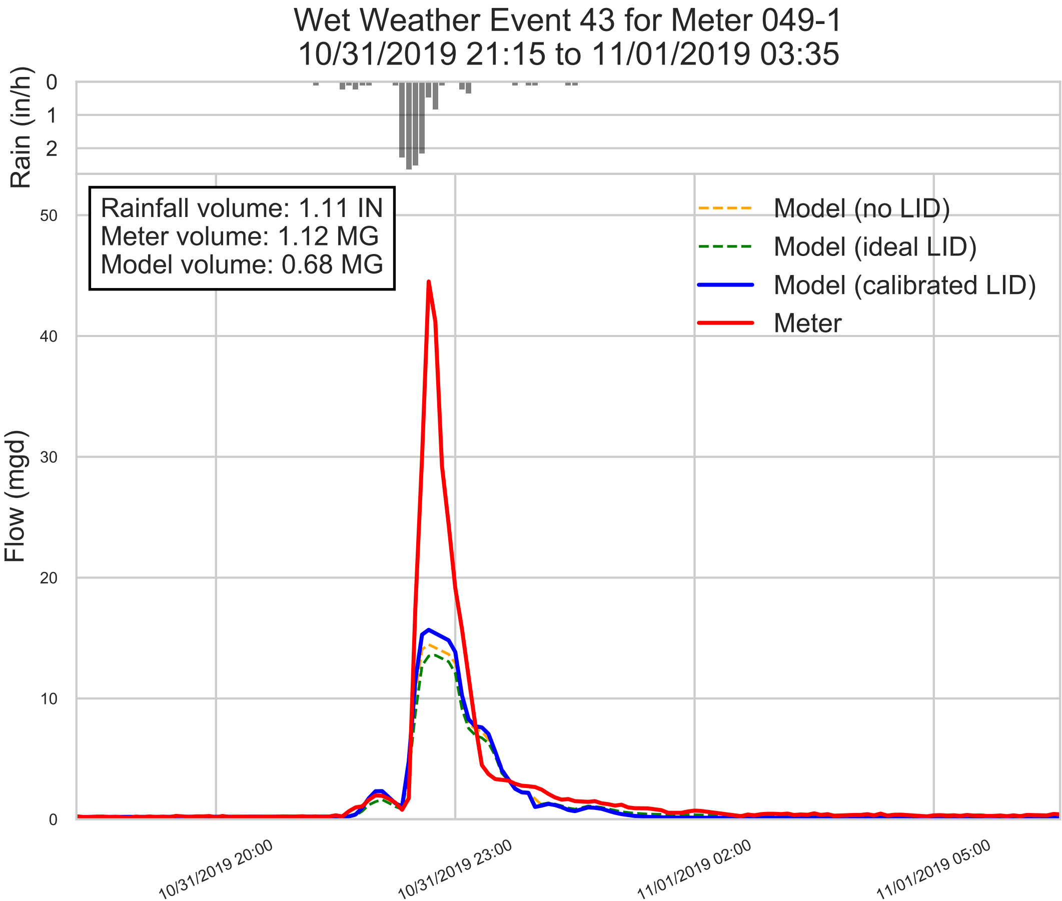

Wet Weather Event 40 for Meter 049-1
10/22/2019 14:19 to 10/22/2019 21:04
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
10
8
6
4
2
0
Rainfall volume: 0.55 IN
Meter volume: 0.4 MG
Model volume: 0.41 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
10/22/2019 13:00
10/22/2019 16:00
10/22/2019 19:00
10/22/2019 22:00

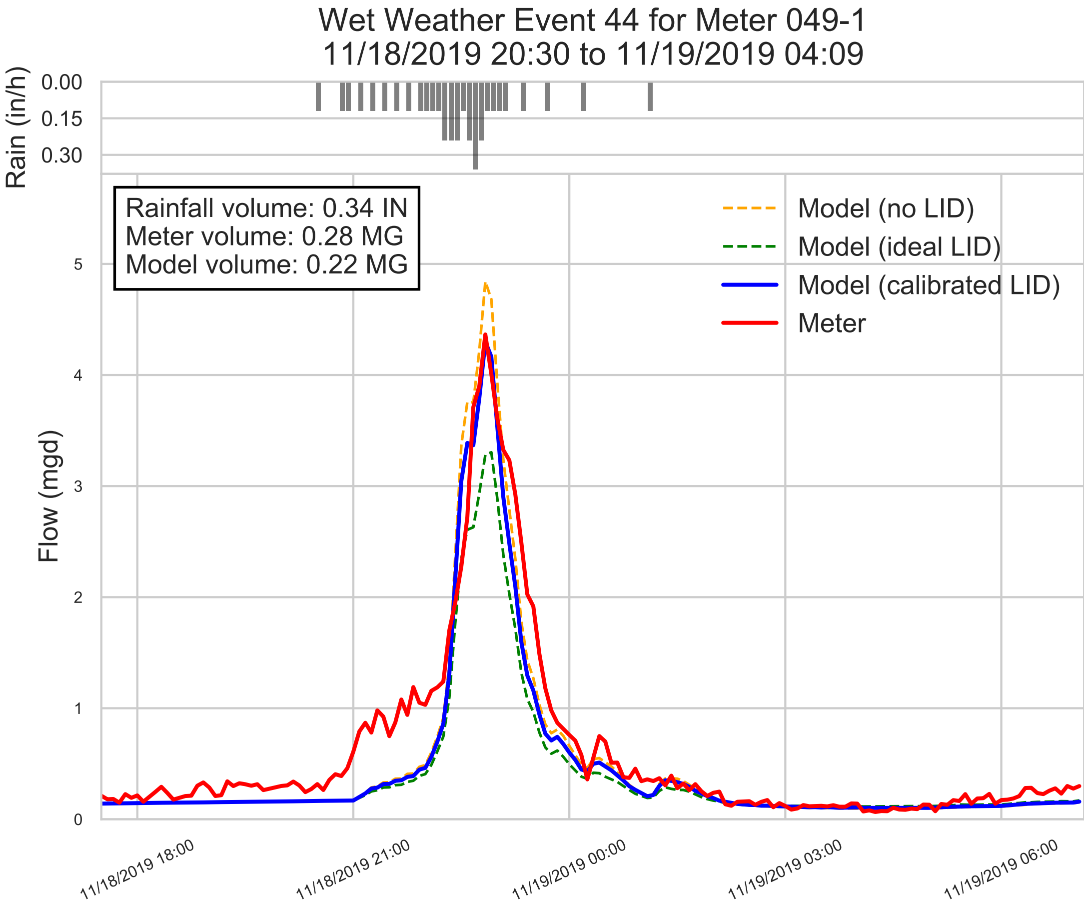


Wet Weather Event 41 for Meter 049-1
10/27/2019 03:24 to 10/27/2019 14:10
Rain (in/h)
0
1
2
Rainfall volume: 1.77 IN
Meter volume: 1.52 MG
Model volume: 1.37 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
30
25
20
15
10
5
0
10/27/2019 01:00
10/27/2019 04:00
10/27/2019 07:00
10/27/2019 10:00
10/27/2019 13:00
10/27/2019 16:00

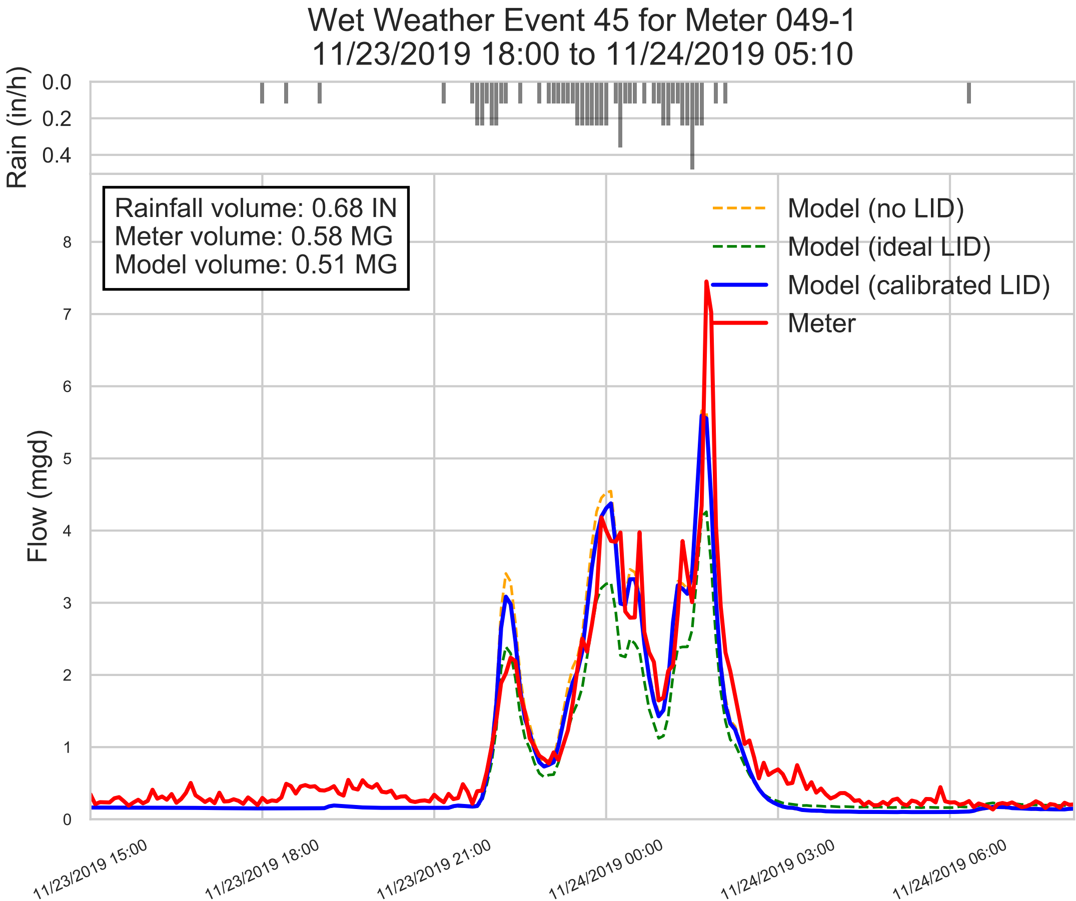


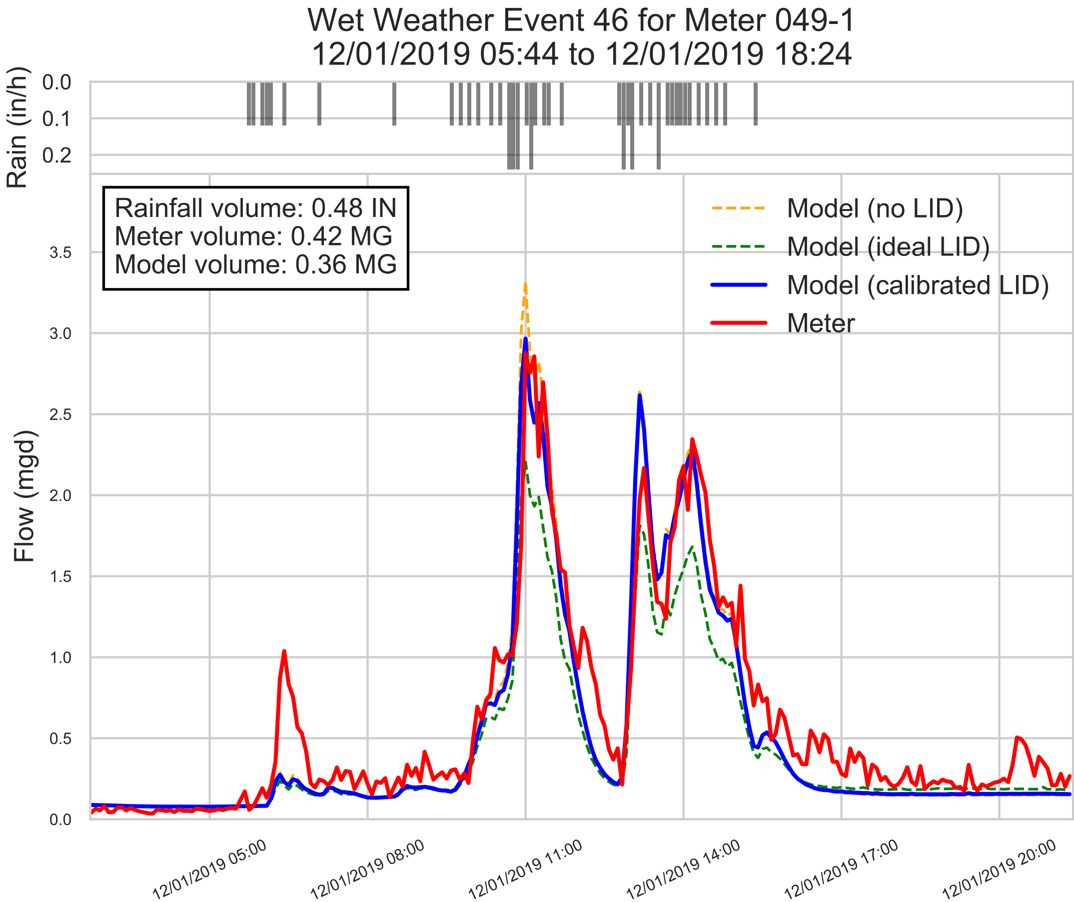
Wet Weather Event 42 for Meter 049-1
10/30/2019 18:04 to 10/31/2019 10:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall volume: 0.5 IN
Meter volume: 0.5 MG
Model volume: 0.41 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
10/30/2019 17:00
10/30/2019 20:00
10/30/2019 23:00
10/31/2019 02:00
10/31/2019 05:00
10/31/2019 08:00
10/31/2019 11:00


Wet Weather Event 43 for Meter 049-1
10/31/2019 21:15 to 11/01/2019 03:35
Rain (in/h)
0
1
2
Rainfall volume: 1.11 IN
Meter volume: 1.12 MG
Model volume: 0.68 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
50
40
30
20
10
0
10/31/2019 20:00
10/31/2019 23:00
11/01/2019 02:00
11/01/2019 05:00

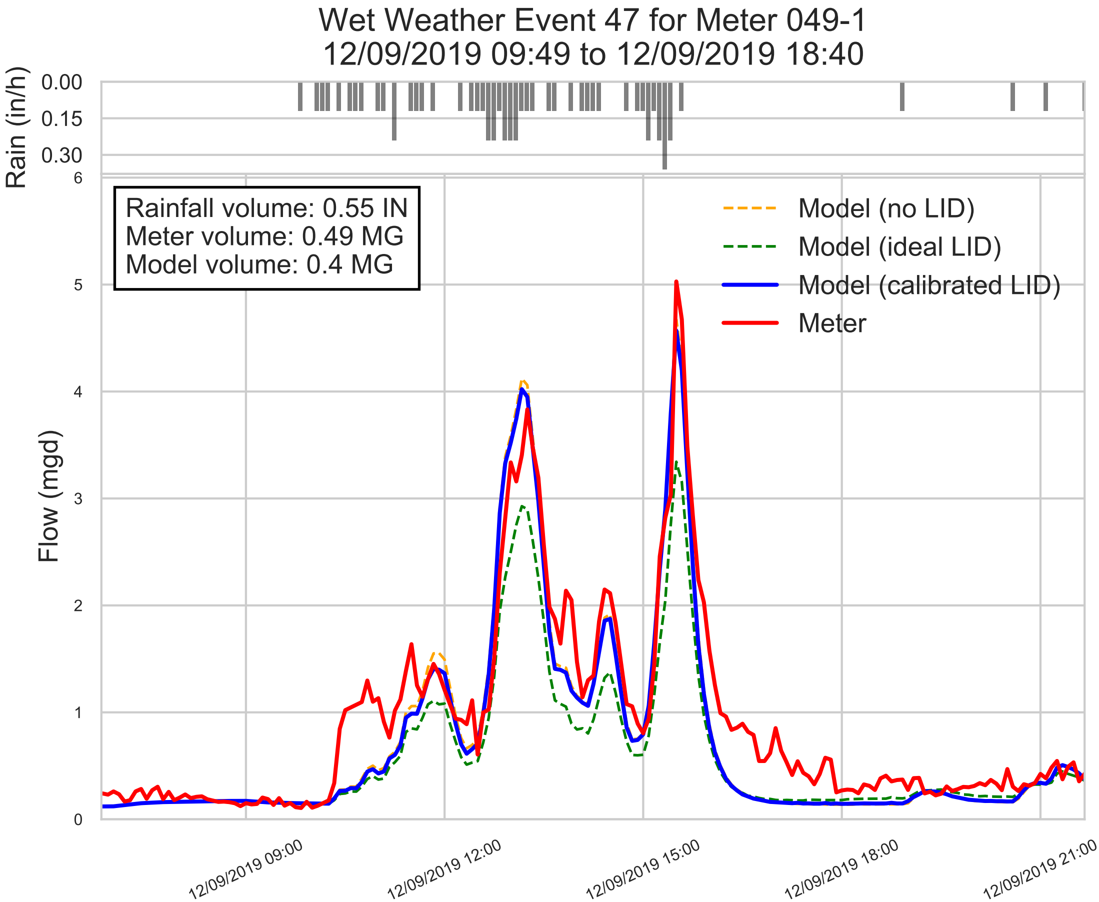


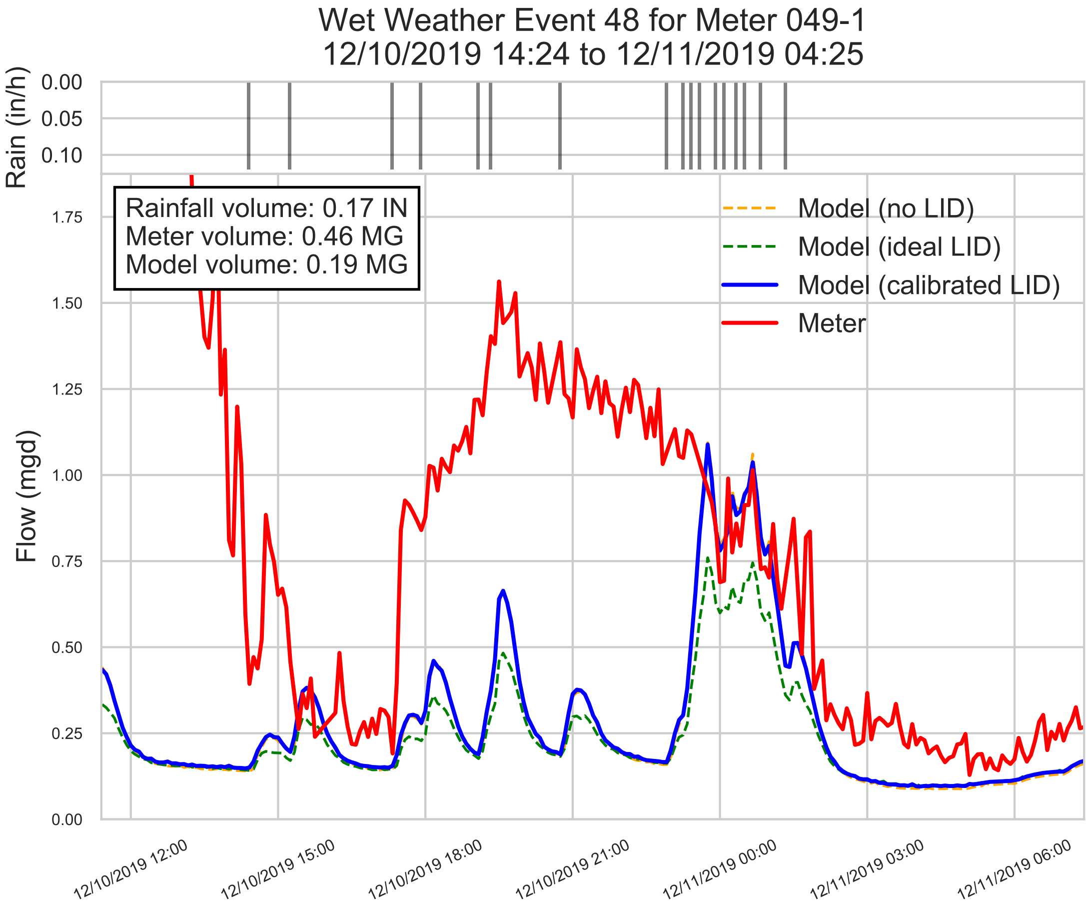
Wet Weather Event 44 for Meter 049-1
11/18/2019 20:30 to 11/19/2019 04:09
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.34 IN
Meter volume: 0.28 MG
Model volume: 0.22 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
11/18/2019 18:00
11/18/2019 21:00
11/19/2019 00:00
11/19/2019 03:00
11/19/2019 06:00


Wet Weather Event 45 for Meter 049-1
11/23/2019 18:00 to 11/24/2019 05:10
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.68 IN
Meter volume: 0.58 MG
Model volume: 0.51 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
11/23/2019 15:00
11/23/2019 18:00
11/23/2019 21:00
11/24/2019 00:00
11/24/2019 03:00
11/24/2019 06:00

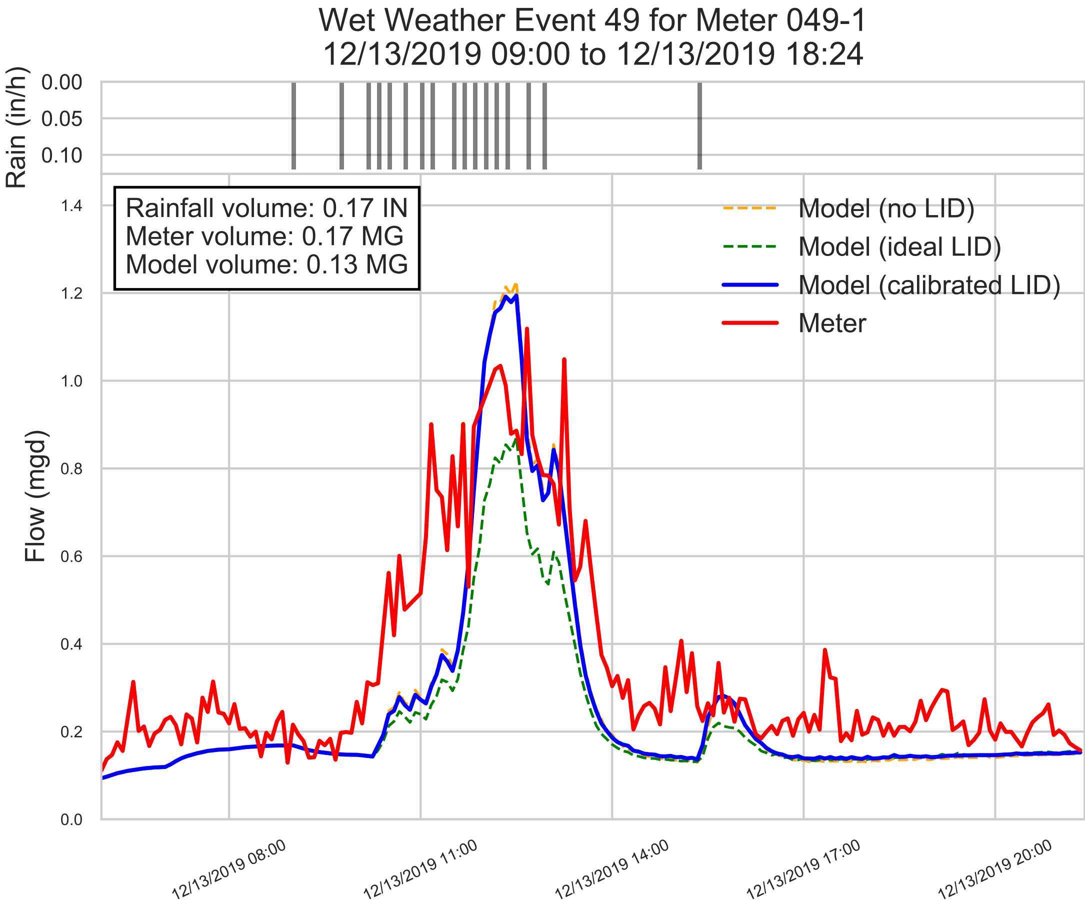


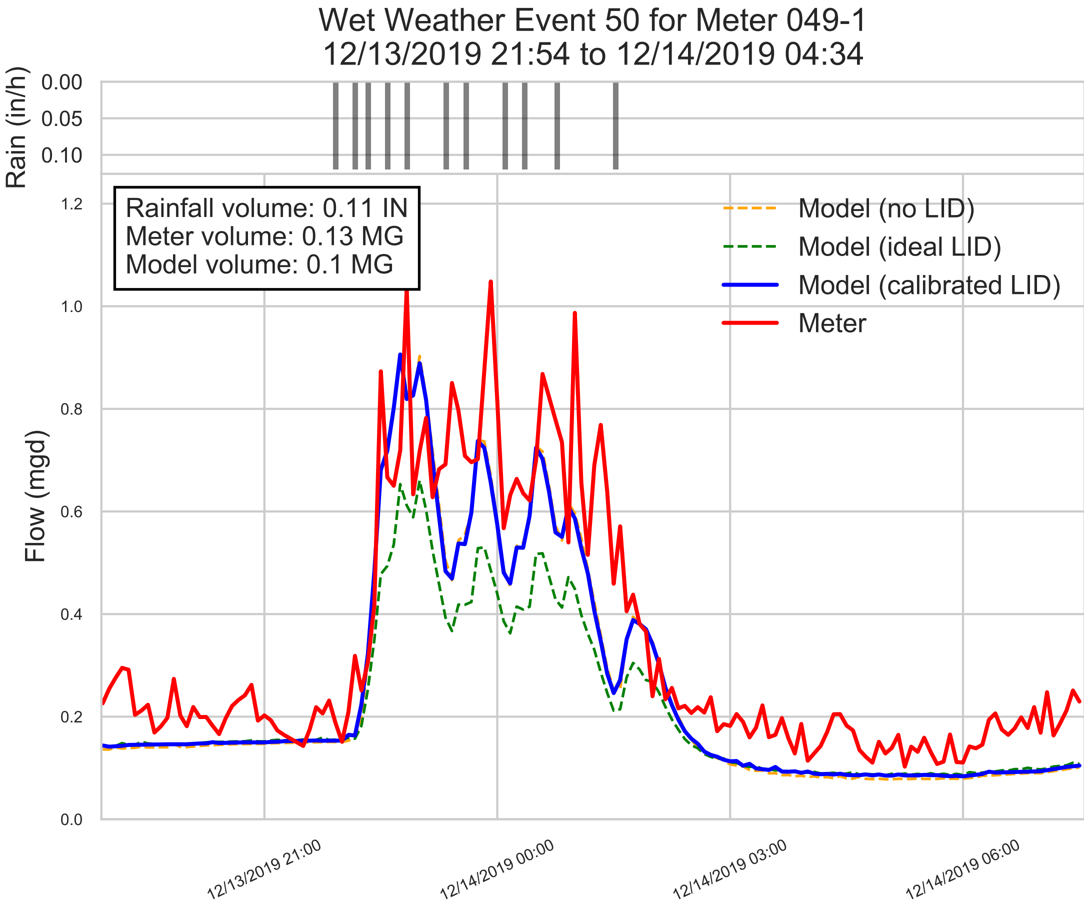
Wet Weather Event 46 for Meter 049-1
12/01/2019 05:44 to 12/01/2019 18:24
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.48 IN
Meter volume: 0.42 MG
Model volume: 0.36 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/01/2019 05:00
12/01/2019 08:00
12/01/2019 11:00
12/01/2019 14:00
12/01/2019 17:00
12/01/2019 20:00


Wet Weather Event 47 for Meter 049-1
12/09/2019 09:49 to 12/09/2019 18:40
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
0
1
2
3
4
5
6
Rainfall volume: 0.55 IN
Meter volume: 0.49 MG
Model volume: 0.4 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
12/09/2019 09:00
12/09/2019 12:00
12/09/2019 15:00
12/09/2019 18:00
12/09/2019 21:00

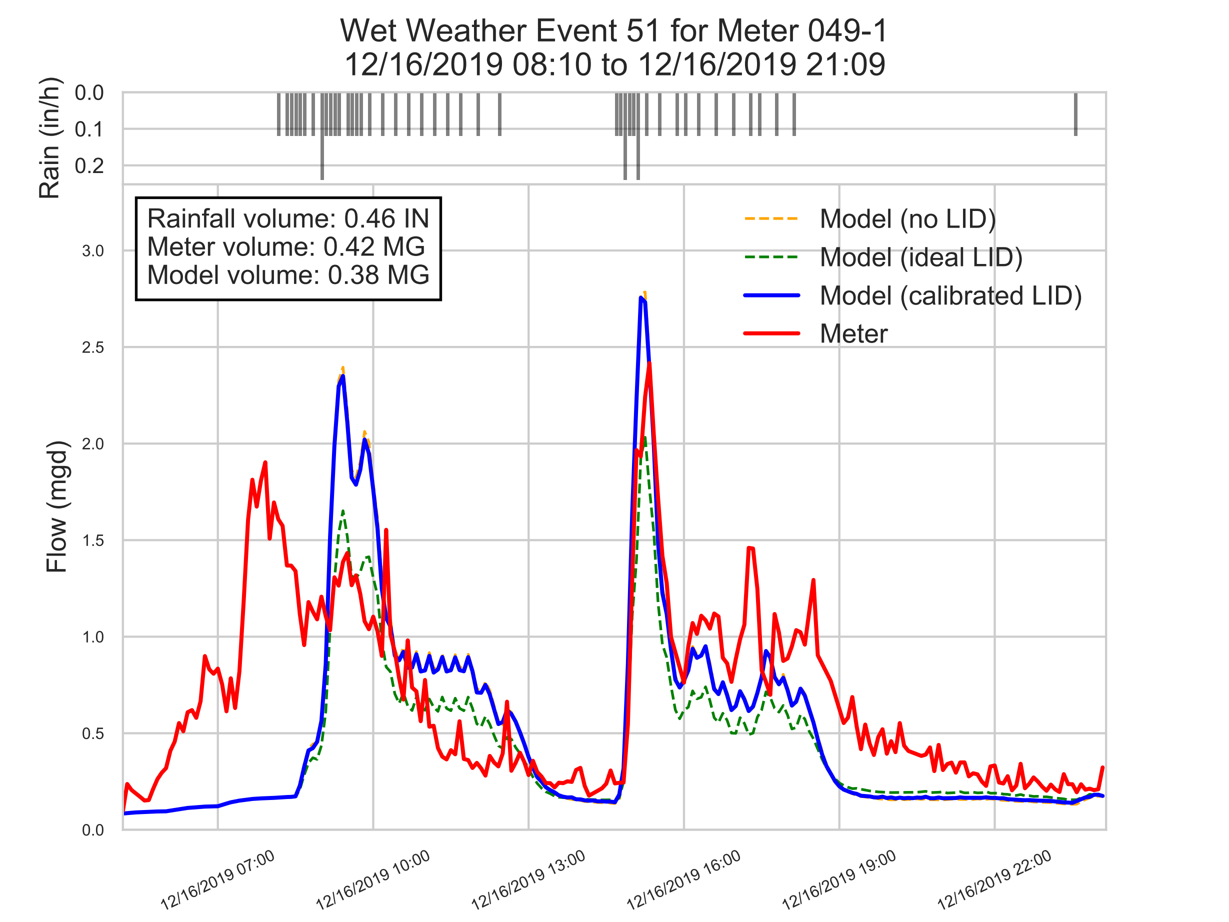


Wet Weather Event 48 for Meter 049-1
12/10/2019 14:24 to 12/11/2019 04:25
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.17 IN
Meter volume: 0.46 MG
Model volume: 0.19 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/10/2019 12:00
12/10/2019 15:00
12/10/2019 18:00
12/10/2019 21:00
12/11/2019 00:00
12/11/2019 03:00
12/11/2019 06:00

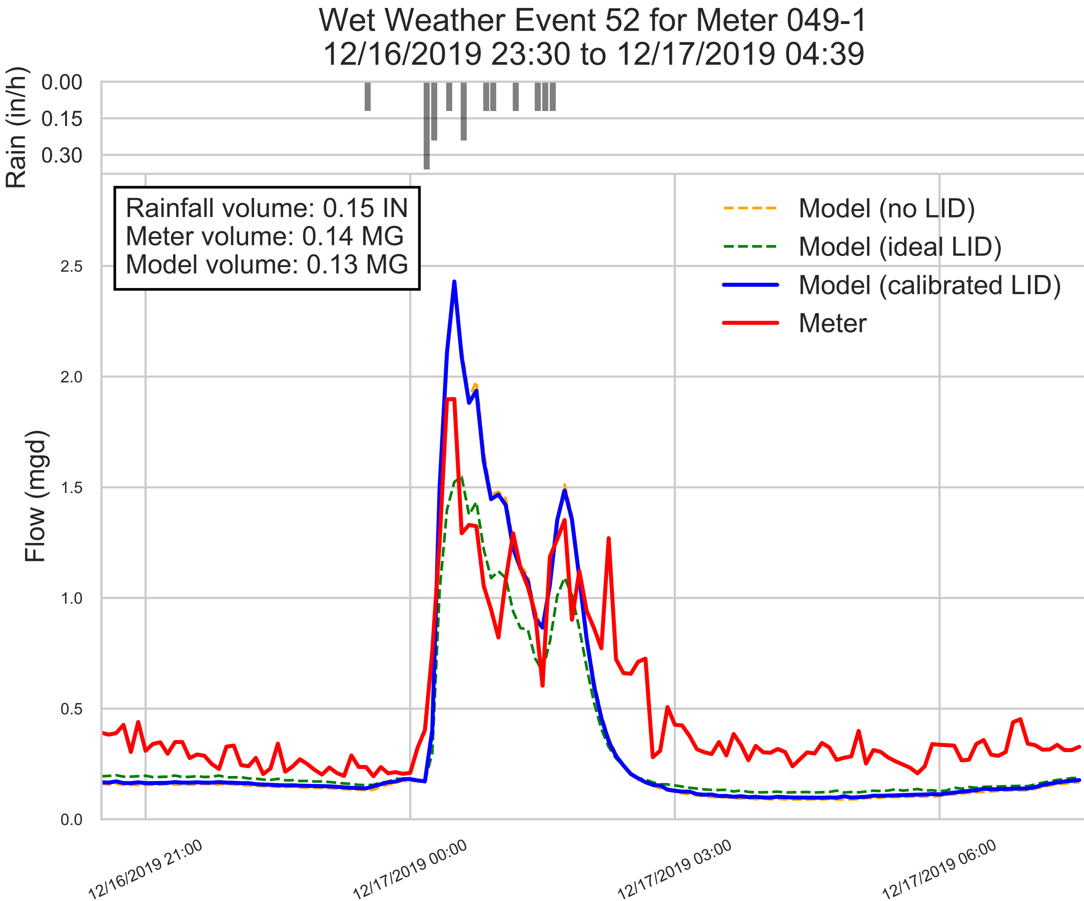

Wet Weather Event 49 for Meter 049-1
12/13/2019 09:00 to 12/13/2019 18:24
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.17 IN
Meter volume: 0.17 MG
Model volume: 0.13 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
12/13/2019 08:00
12/13/2019 11:00
12/13/2019 14:00
12/13/2019 17:00
12/13/2019 20:00



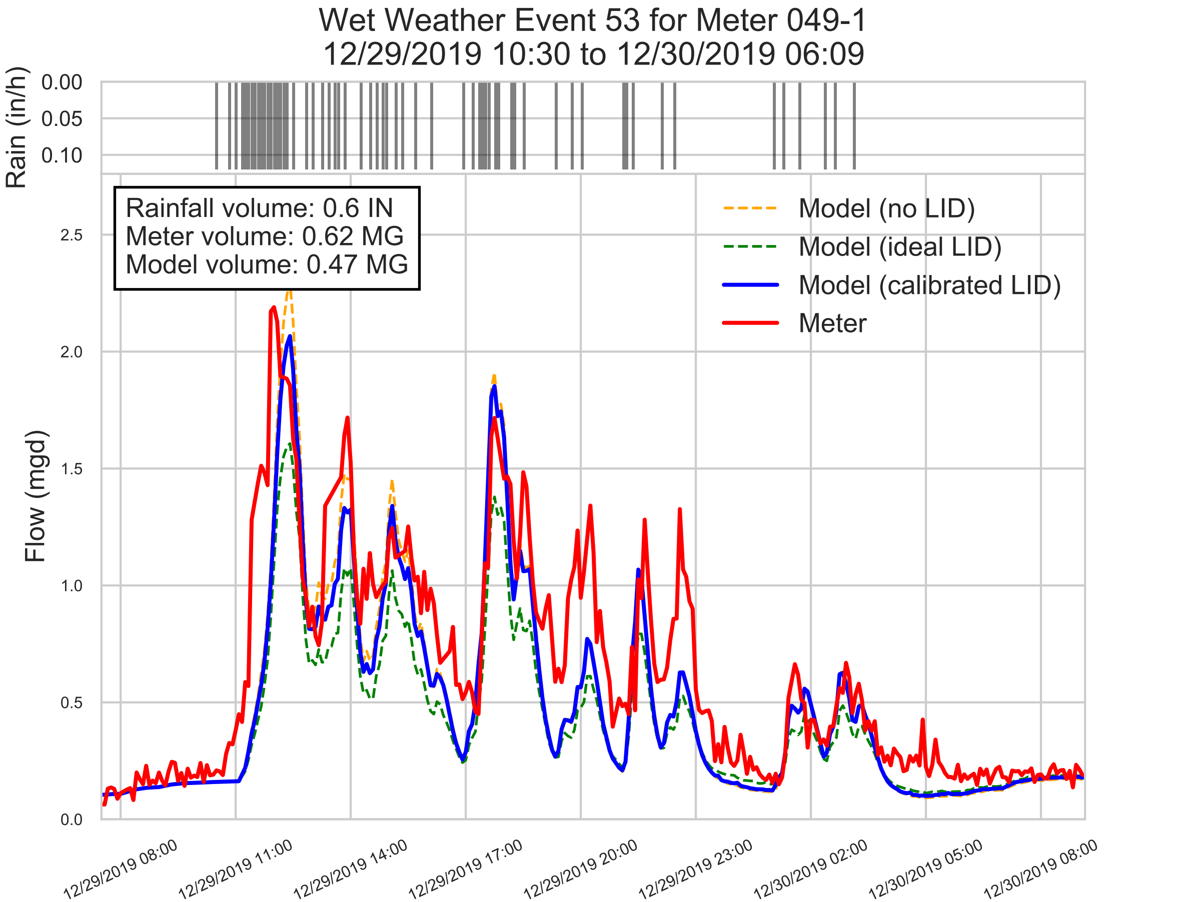
Wet Weather Event 50 for Meter 049-1
12/13/2019 21:54 to 12/14/2019 04:34
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.11 IN
Meter volume: 0.13 MG
Model volume: 0.1 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/13/2019 21:00
12/14/2019 00:00
12/14/2019 03:00
12/14/2019 06:00



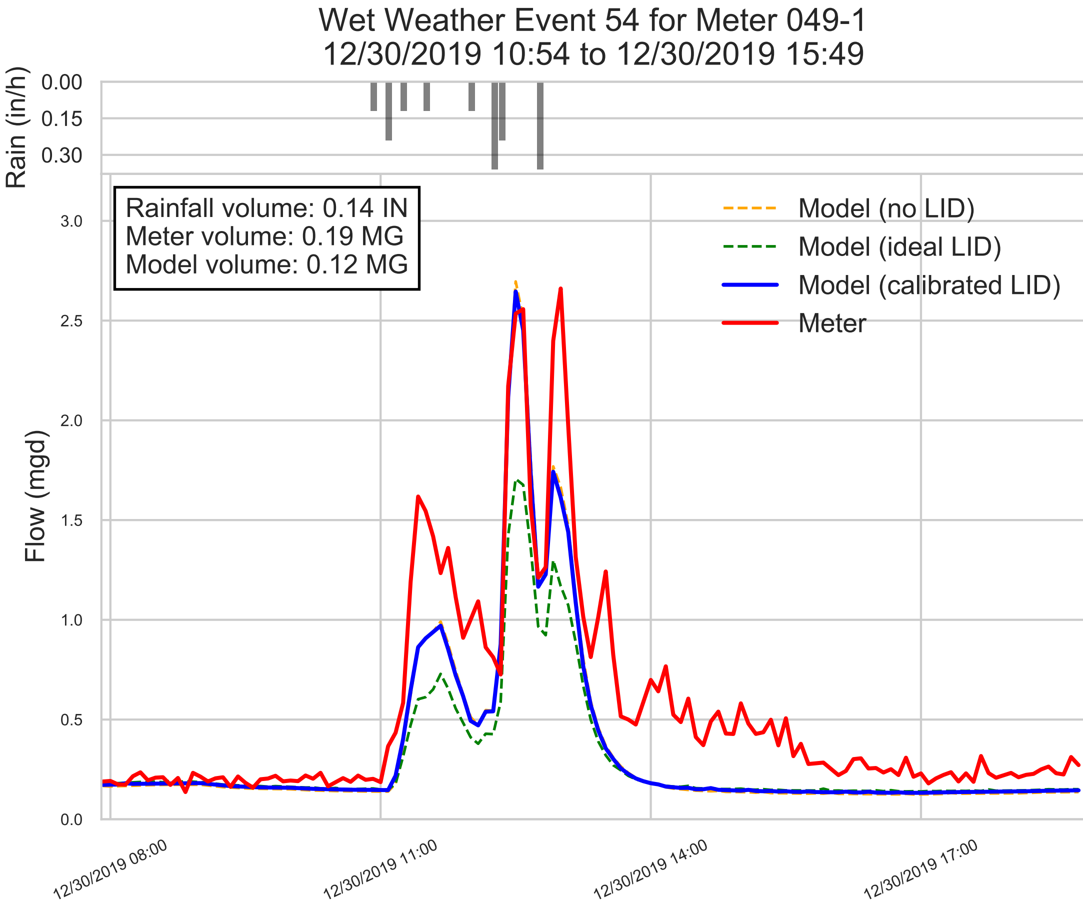
Wet Weather Event 51 for Meter 049-1
12/16/2019 08:10 to 12/16/2019 21:09
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.46 IN
Meter volume: 0.42 MG
Model volume: 0.38 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/16/2019 07:00
12/16/2019 10:00
12/16/2019 13:00
12/16/2019 16:00
12/16/2019 19:00
12/16/2019 22:00



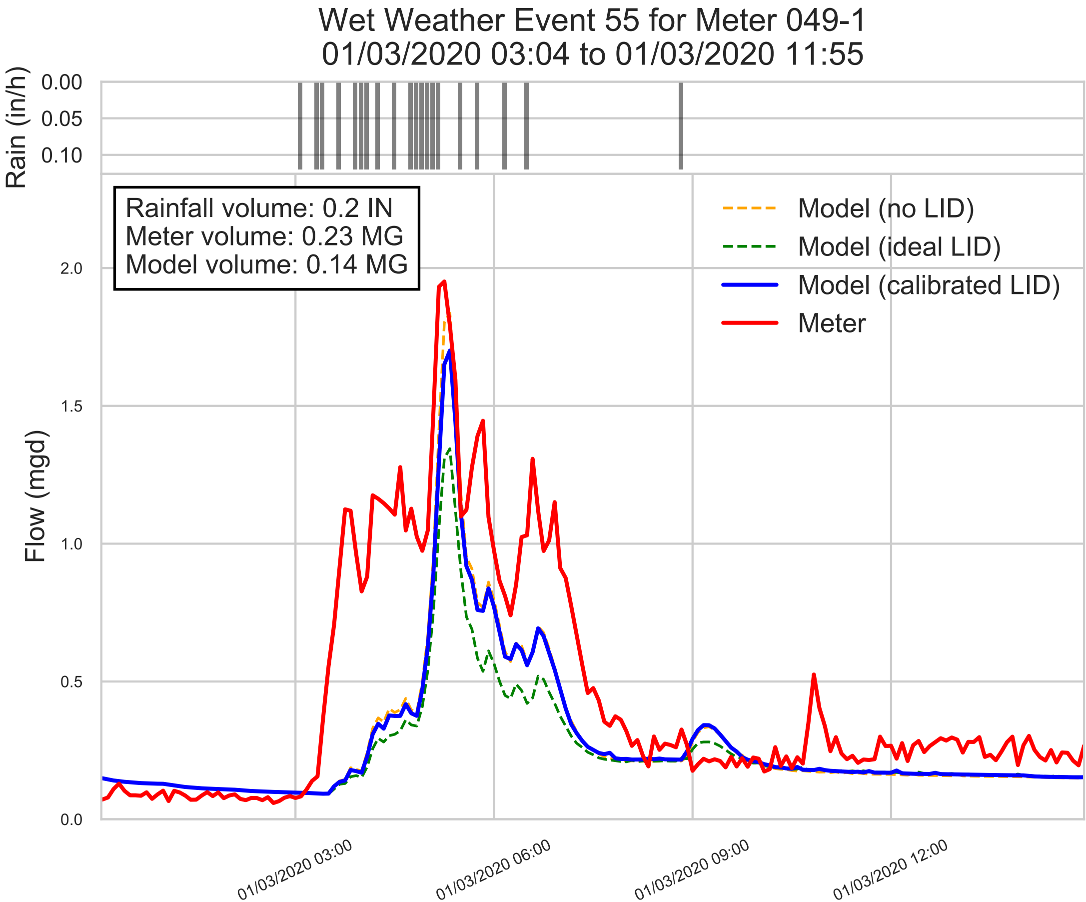
Wet Weather Event 52 for Meter 049-1
12/16/2019 23:30 to 12/17/2019 04:39
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.15 IN
Meter volume: 0.14 MG
Model volume: 0.13 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
12/16/2019 21:00
12/17/2019 00:00
12/17/2019 03:00
12/17/2019 06:00



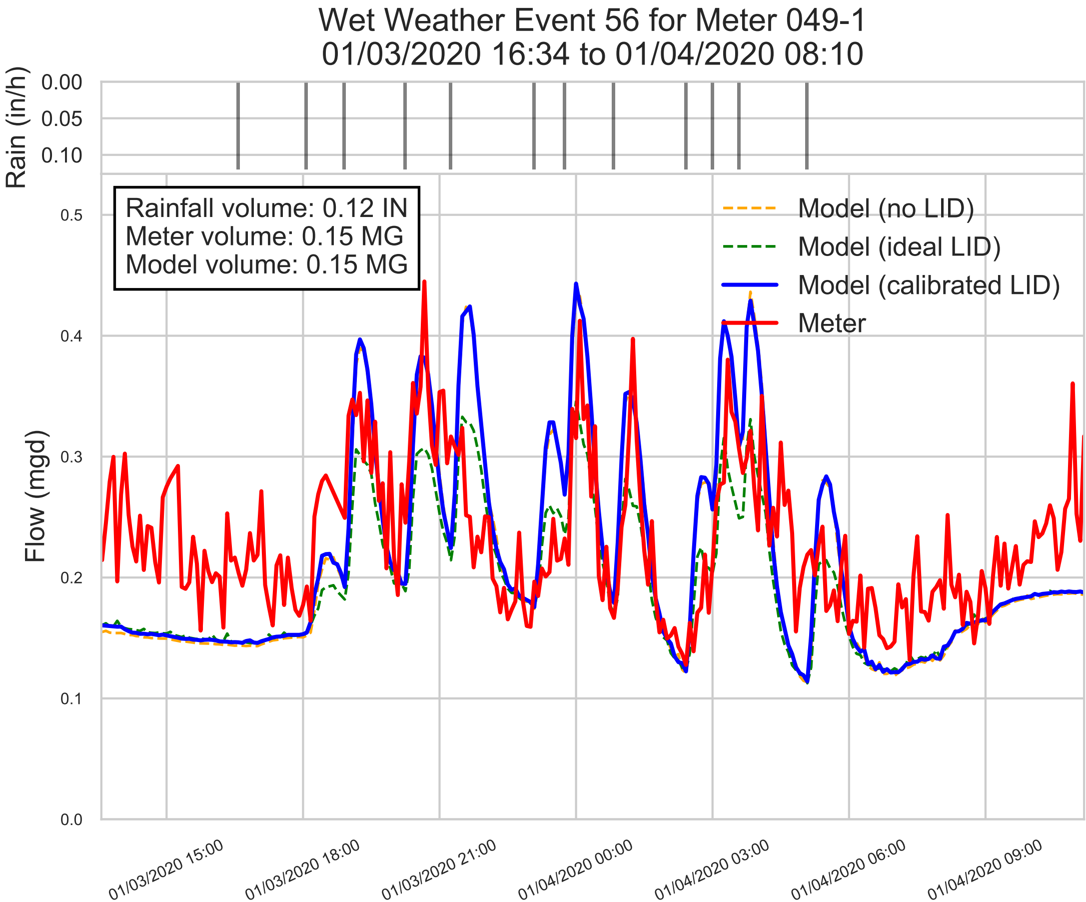
Wet Weather Event 53 for Meter 049-1
12/29/2019 10:30 to 12/30/2019 06:09
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.6 IN
Meter volume: 0.62 MG
Model volume: 0.47 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
12/29/2019 08:00
12/29/2019 11:00
12/29/2019 14:00
12/29/2019 17:00
12/29/2019 20:00
12/29/2019 23:00
12/30/2019 02:00
12/30/2019 05:00
12/30/2019 08:00



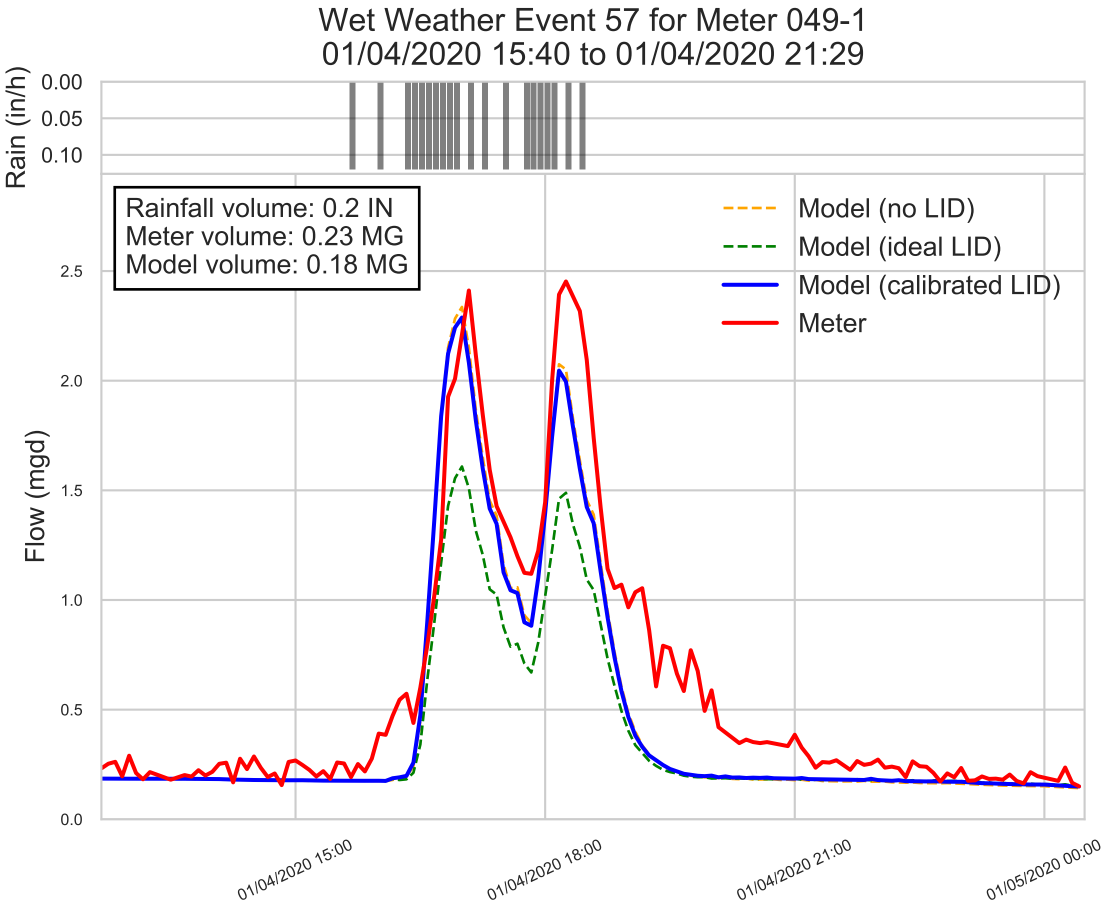
Wet Weather Event 54 for Meter 049-1
12/30/2019 10:54 to 12/30/2019 15:49
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.14 IN
Meter volume: 0.19 MG
Model volume: 0.12 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/30/2019 08:00
12/30/2019 11:00
12/30/2019 14:00
12/30/2019 17:00

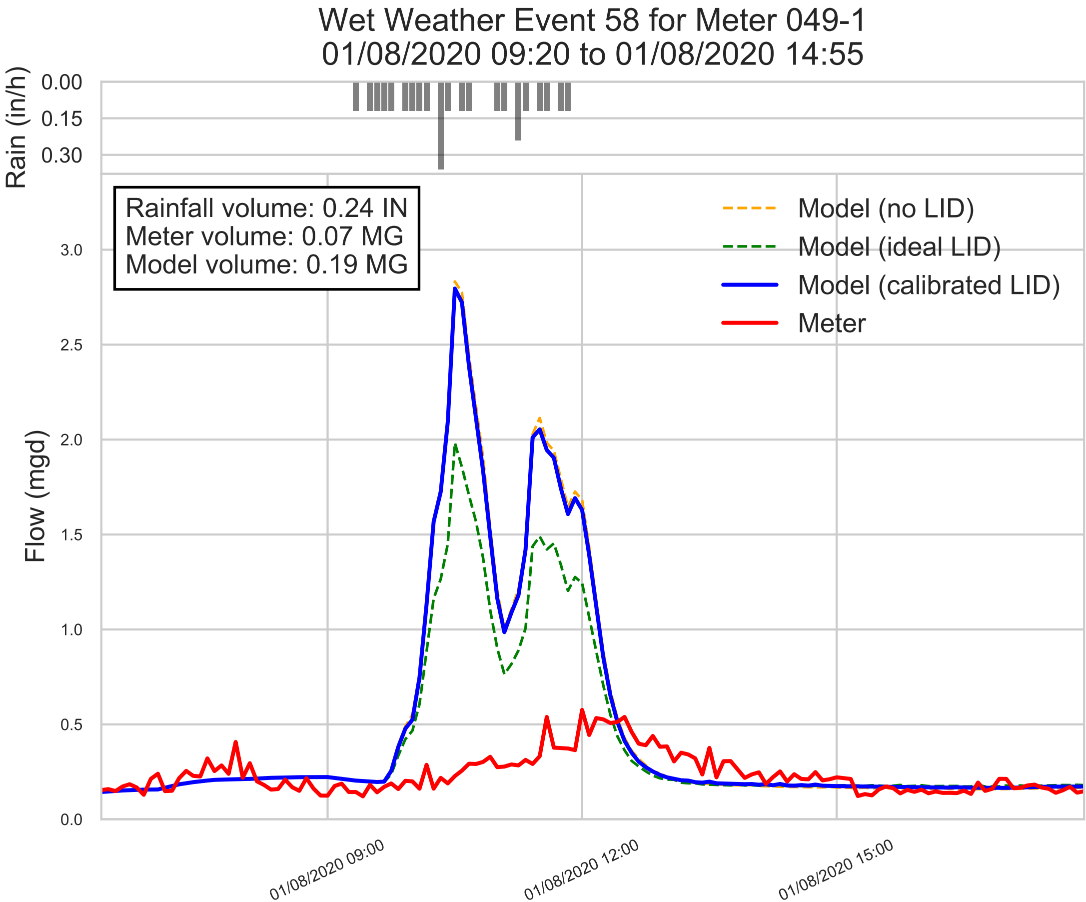


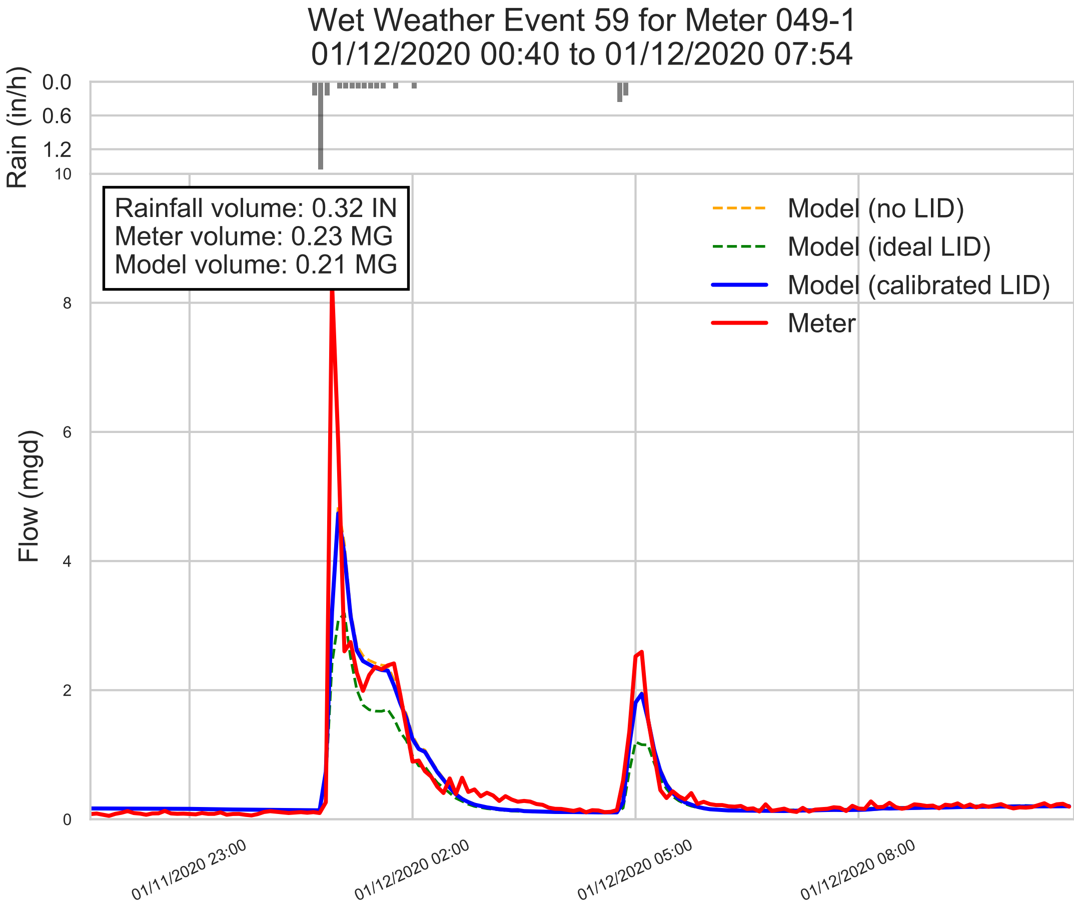
Wet Weather Event 55 for Meter 049-1
01/03/2020 03:04 to 01/03/2020 11:55
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.23 MG
Model volume: 0.14 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
01/03/2020 03:00
01/03/2020 06:00
01/03/2020 09:00
01/03/2020 12:00

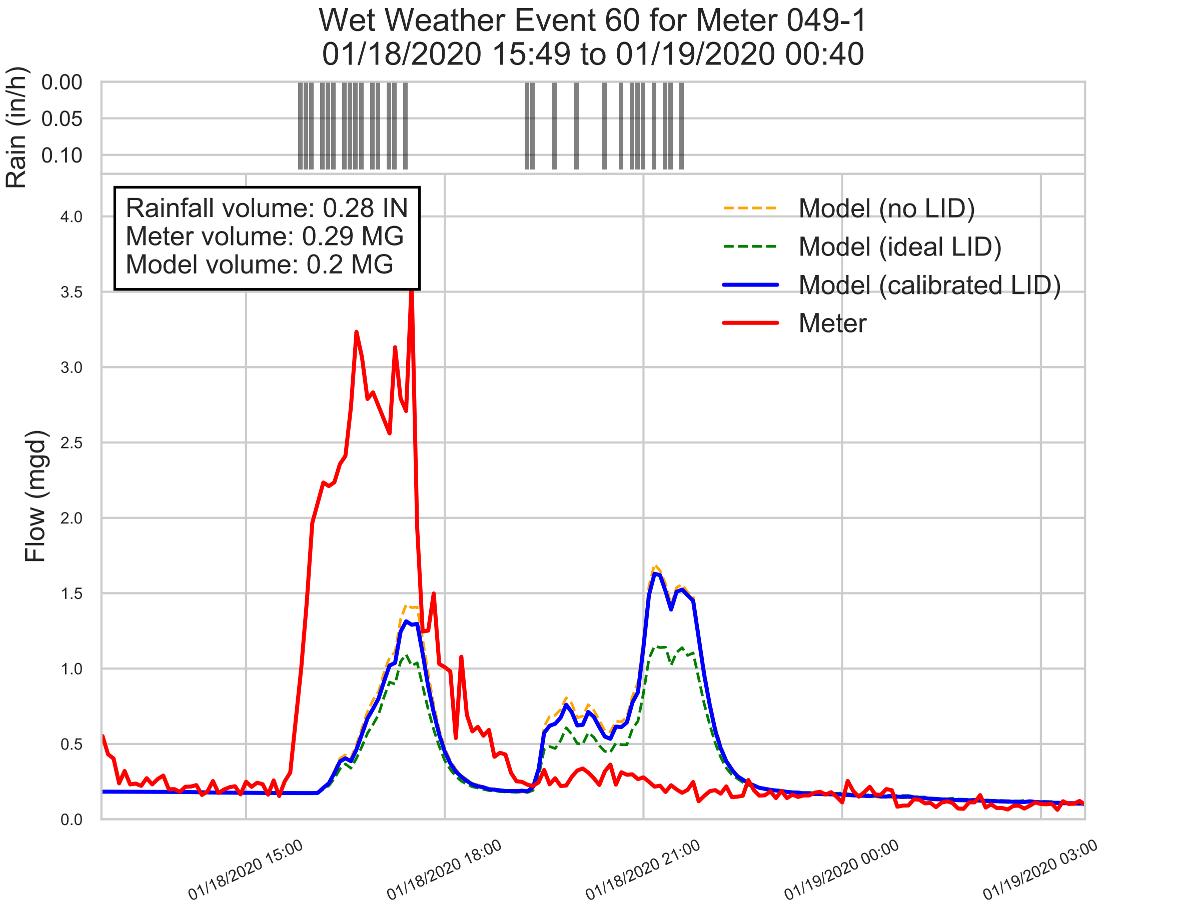


Wet Weather Event 56 for Meter 049-1
01/03/2020 16:34 to 01/04/2020 08:10
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.15 MG
Model volume: 0.15 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
01/03/2020 15:00
01/03/2020 18:00
01/03/2020 21:00
01/04/2020 00:00
01/04/2020 03:00
01/04/2020 06:00
01/04/2020 09:00

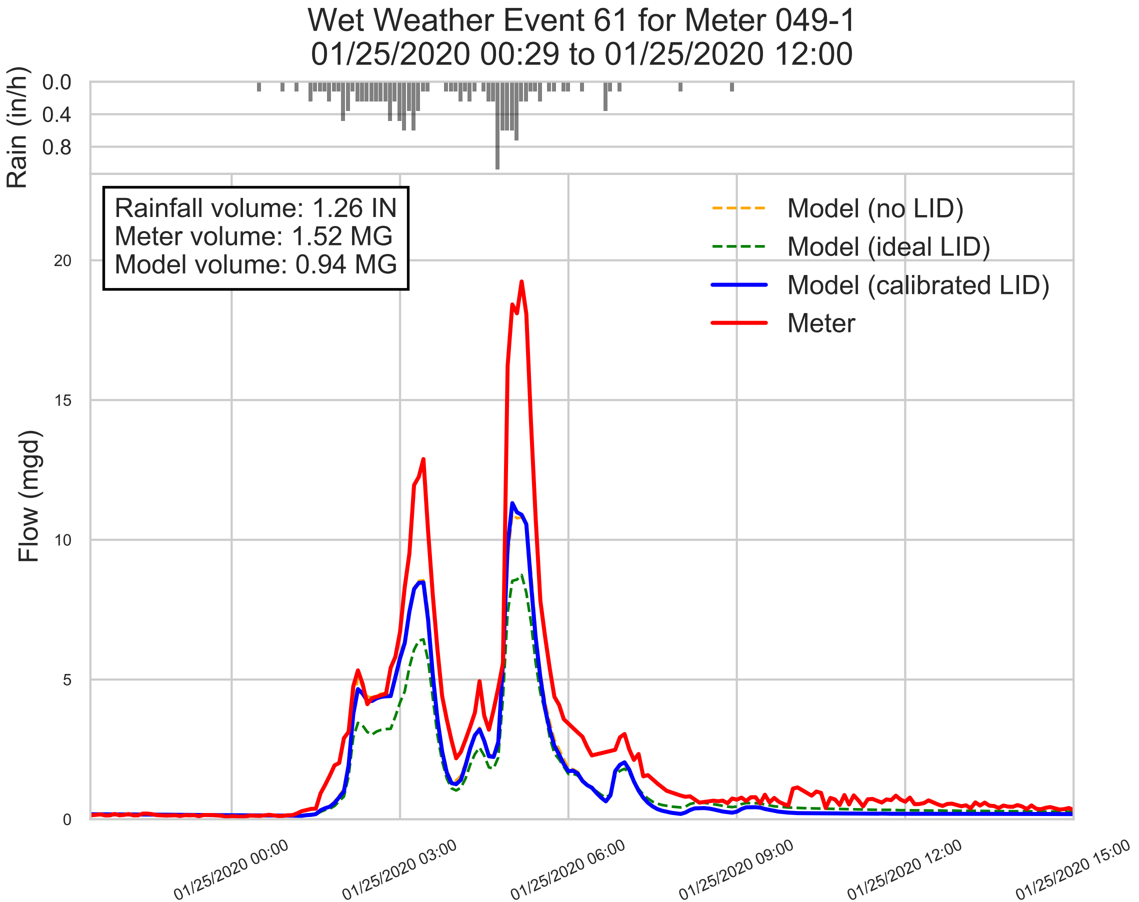

Wet Weather Event 57 for Meter 049-1
01/04/2020 15:40 to 01/04/2020 21:29
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.23 MG
Model volume: 0.18 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
01/04/2020 15:00
01/04/2020 18:00
01/04/2020 21:00
01/05/2020 00:00

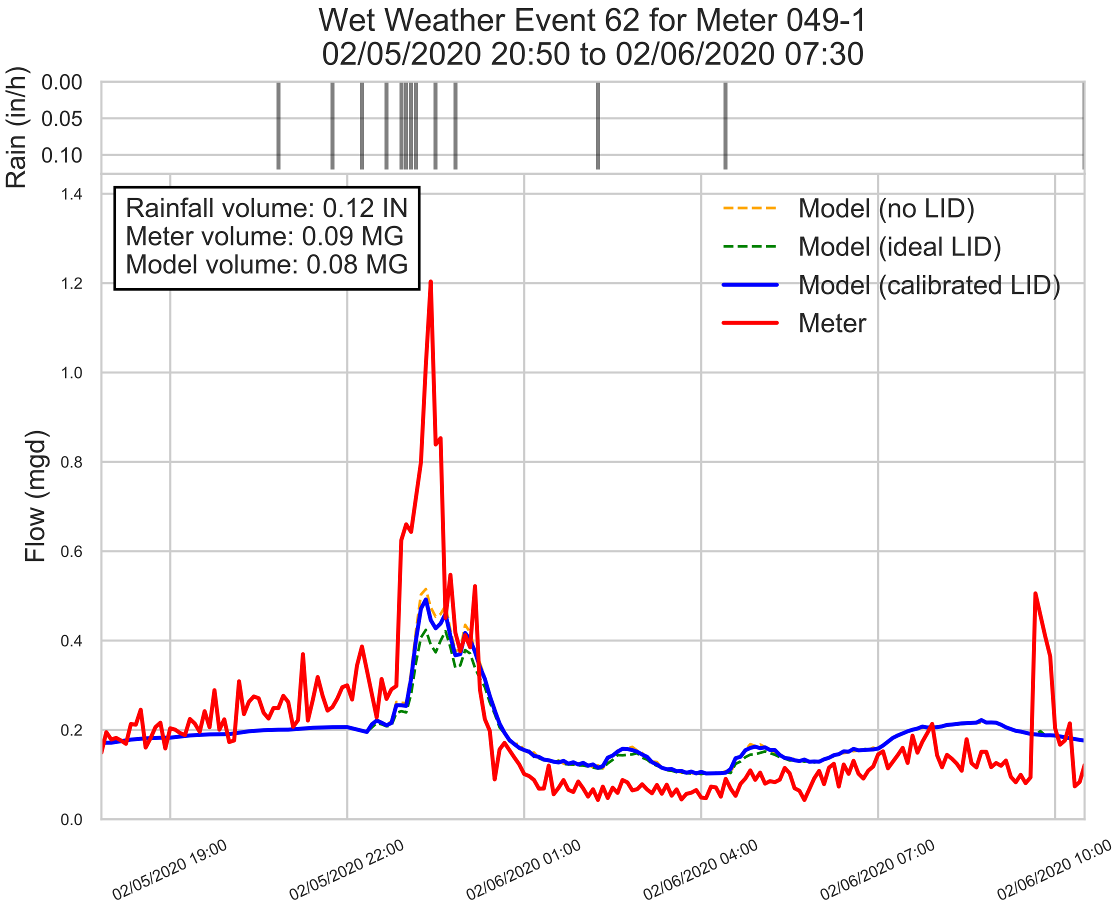

Wet Weather Event 58 for Meter 049-1
01/08/2020 09:20 to 01/08/2020 14:55
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.24 IN
Meter volume: 0.07 MG
Model volume: 0.19 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
01/08/2020 09:00
01/08/2020 12:00
01/08/2020 15:00


Wet Weather Event 59 for Meter 049-1
01/12/2020 00:40 to 01/12/2020 07:54
Rain (in/h)
0.0
0.6
1.2
10
8
6
4
2
0
Flow (mgd)
Rainfall volume: 0.32 IN
Meter volume: 0.23 MG
Model volume: 0.21 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
01/11/2020 23:00
01/12/2020 02:00
01/12/2020 05:00
01/12/2020 08:00

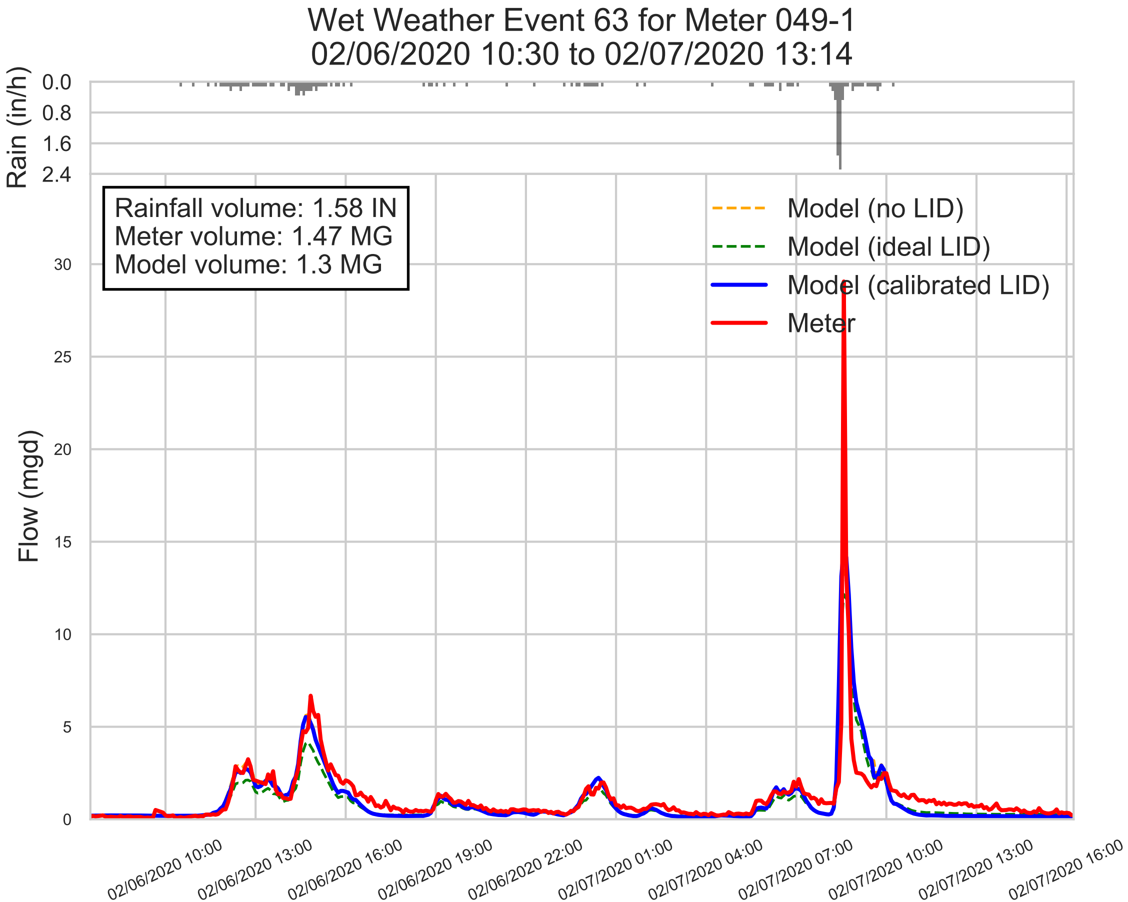


Wet Weather Event 60 for Meter 049-1
01/18/2020 15:49 to 01/19/2020 00:40
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.29 MG
Model volume: 0.2 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
01/18/2020 15:00
01/18/2020 18:00
01/18/2020 21:00
01/19/2020 00:00
01/19/2020 03:00

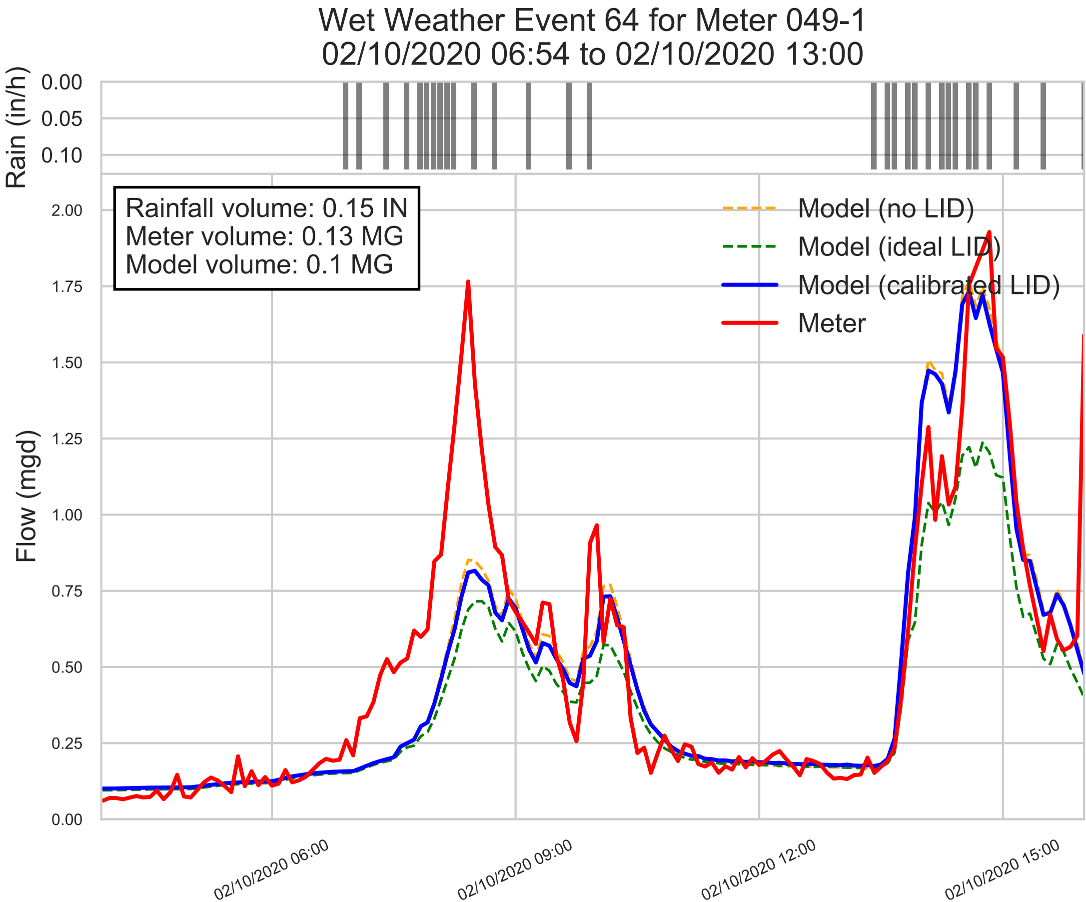

Wet Weather Event 61 for Meter 049-1
01/25/2020 00:29 to 01/25/2020 12:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 1.26 IN
Meter volume: 1.52 MG
Model volume: 0.94 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
20
15
10
5
0
01/25/2020 00:00
01/25/2020 03:00
01/25/2020 06:00
01/25/2020 09:00
01/25/2020 12:00
01/25/2020 15:00



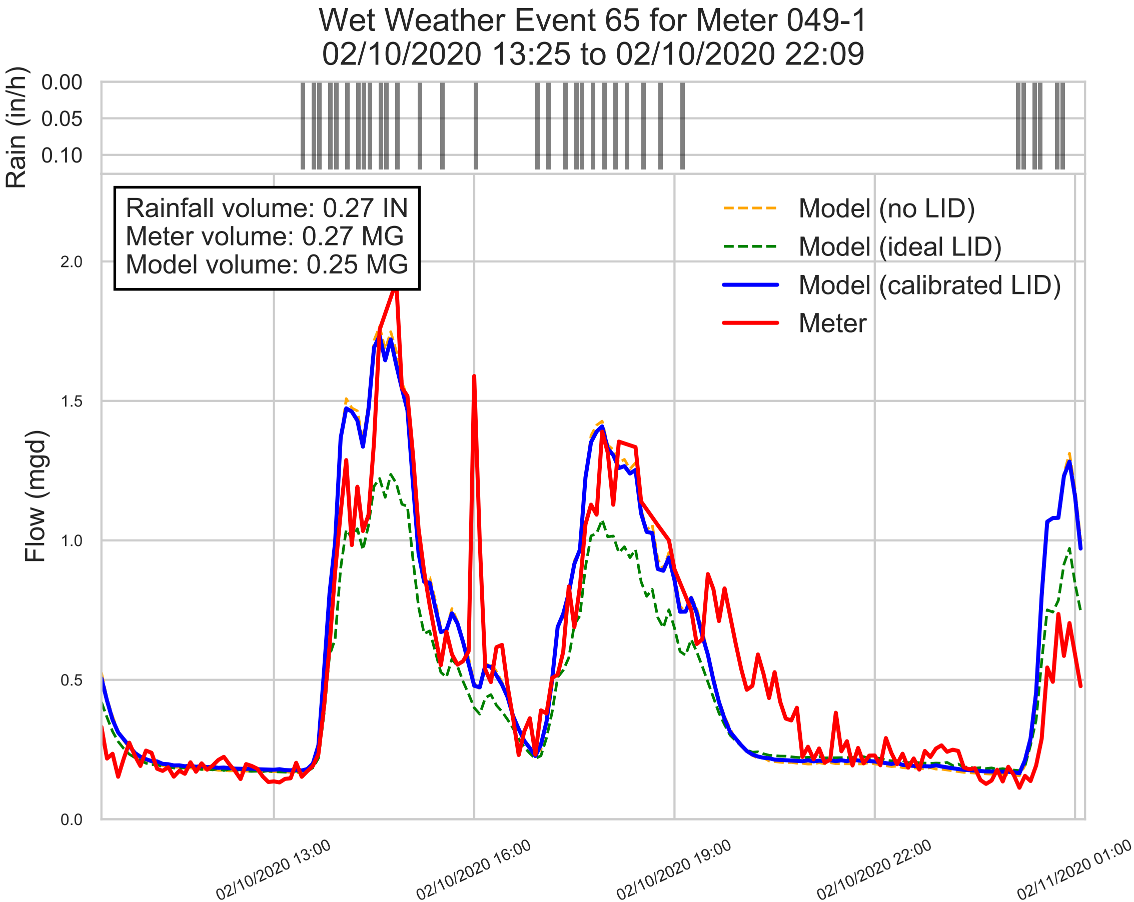
Wet Weather Event 62 for Meter 049-1
02/05/2020 20:50 to 02/06/2020 07:30
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.09 MG
Model volume: 0.08 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
02/05/2020 19:00
02/05/2020 22:00
02/06/2020 01:00
02/06/2020 04:00
02/06/2020 07:00
02/06/2020 10:00



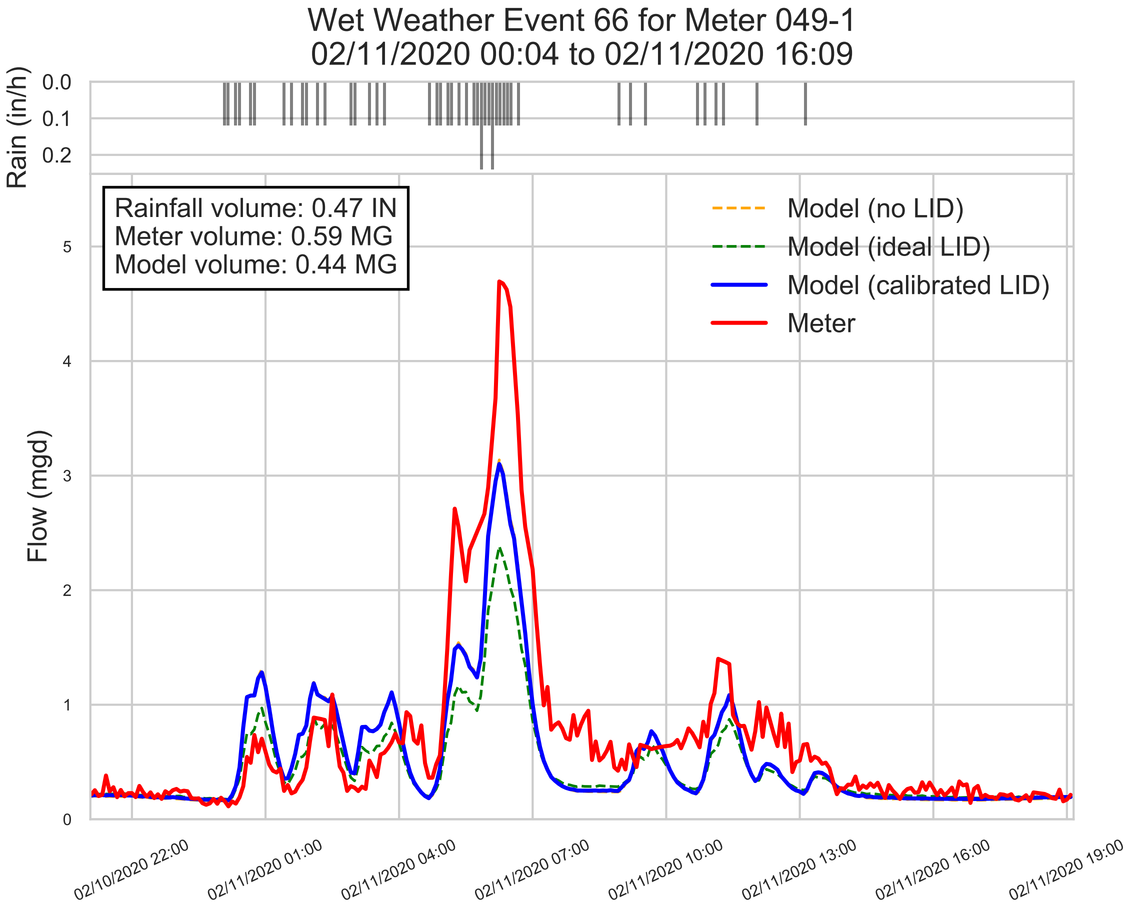
Wet Weather Event 63 for Meter 049-1
02/06/2020 10:30 to 02/07/2020 13:14
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 1.58 IN
Meter volume: 1.47 MG
Model volume: 1.3 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
30
25
20
15
10
5
0
02/06/2020 10:00
02/06/2020 13:00
02/06/2020 16:00
02/06/2020 19:00
02/06/2020 22:00
02/07/2020 01:00
02/07/2020 04:00
02/07/2020 07:00
02/07/2020 10:00
02/07/2020 13:00
02/07/2020 16:00



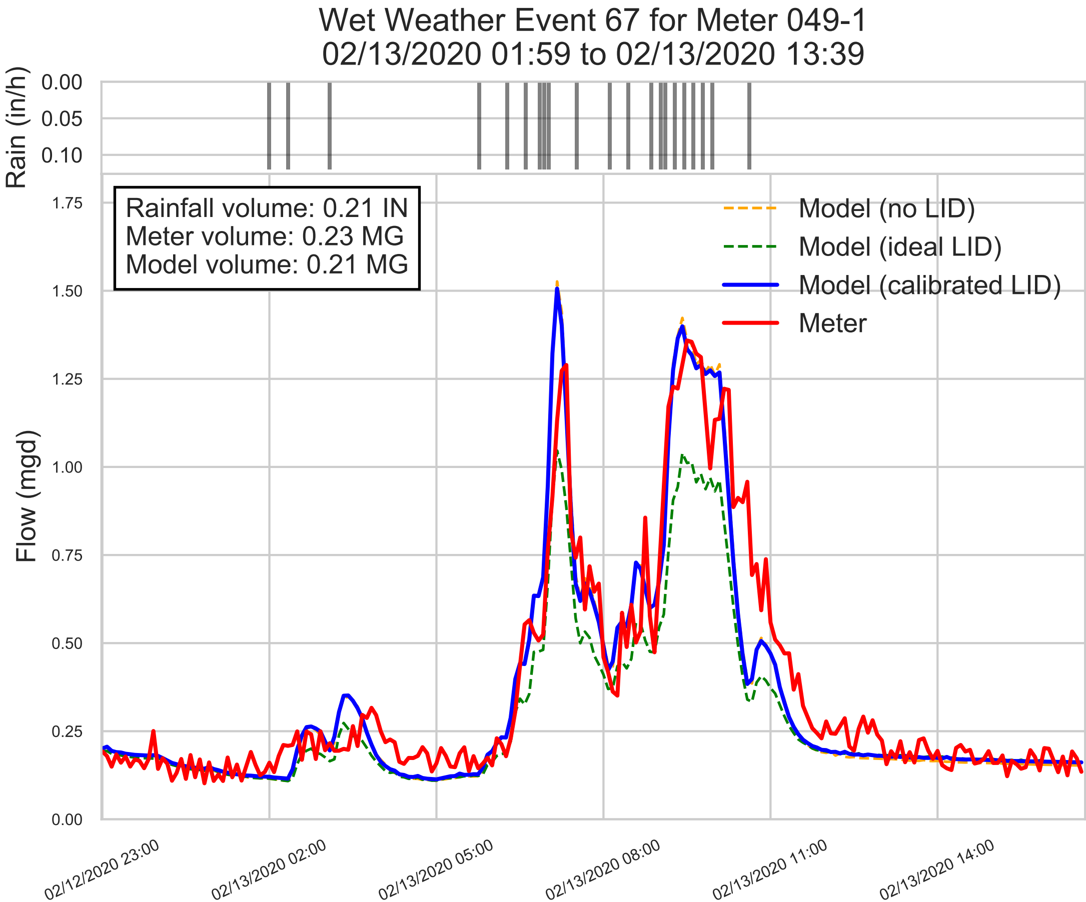
Wet Weather Event 64 for Meter 049-1
02/10/2020 06:54 to 02/10/2020 13:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.15 IN
Meter volume: 0.13 MG
Model volume: 0.1 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
02/10/2020 06:00
02/10/2020 09:00
02/10/2020 12:00
02/10/2020 15:00



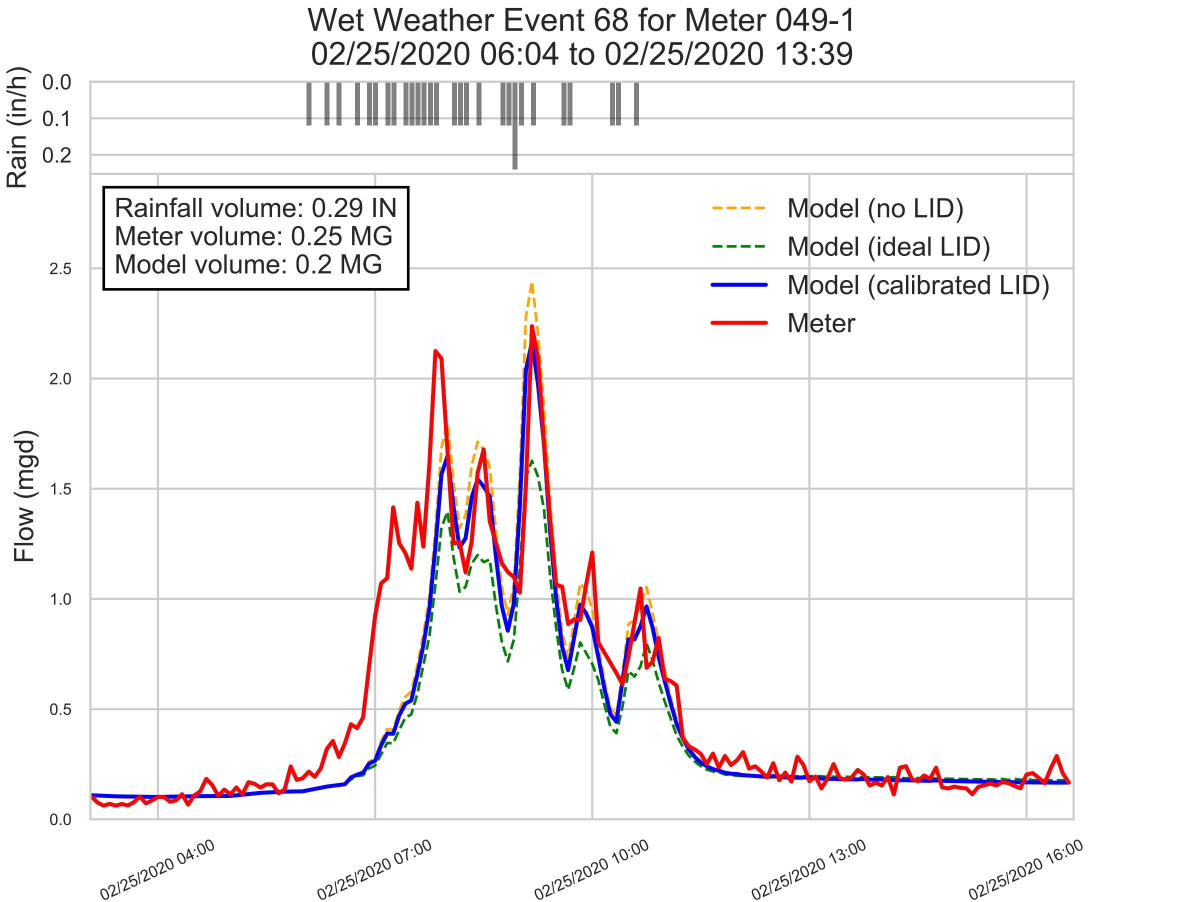
Wet Weather Event 65 for Meter 049-1
02/10/2020 13:25 to 02/10/2020 22:09
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.27 IN
Meter volume: 0.27 MG
Model volume: 0.25 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
02/10/2020 13:00
02/10/2020 16:00
02/10/2020 19:00
02/10/2020 22:00
02/11/2020 01:00



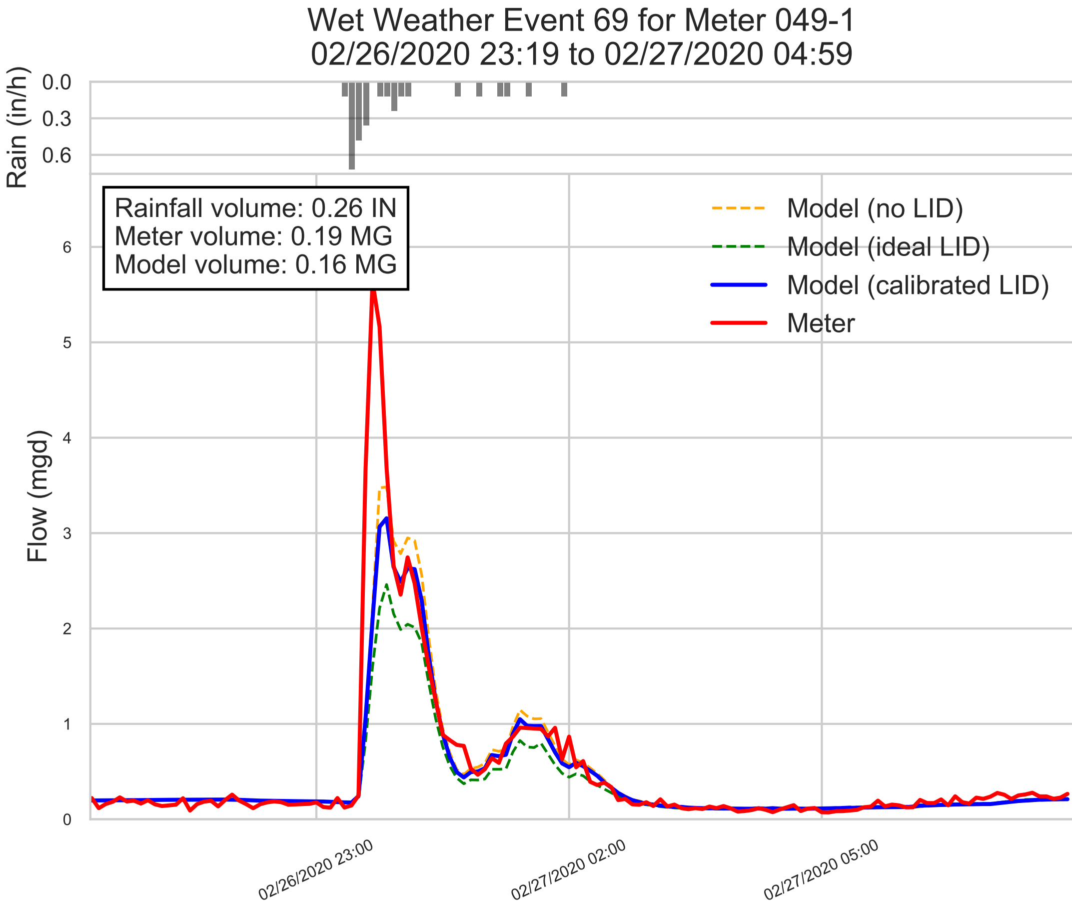
Wet Weather Event 66 for Meter 049-1
02/11/2020 00:04 to 02/11/2020 16:09
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.47 IN
Meter volume: 0.59 MG
Model volume: 0.44 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
02/10/2020 22:00
02/11/2020 01:00
02/11/2020 04:00
02/11/2020 07:00
02/11/2020 10:00
02/11/2020 13:00
02/11/2020 16:00
02/11/2020 19:00

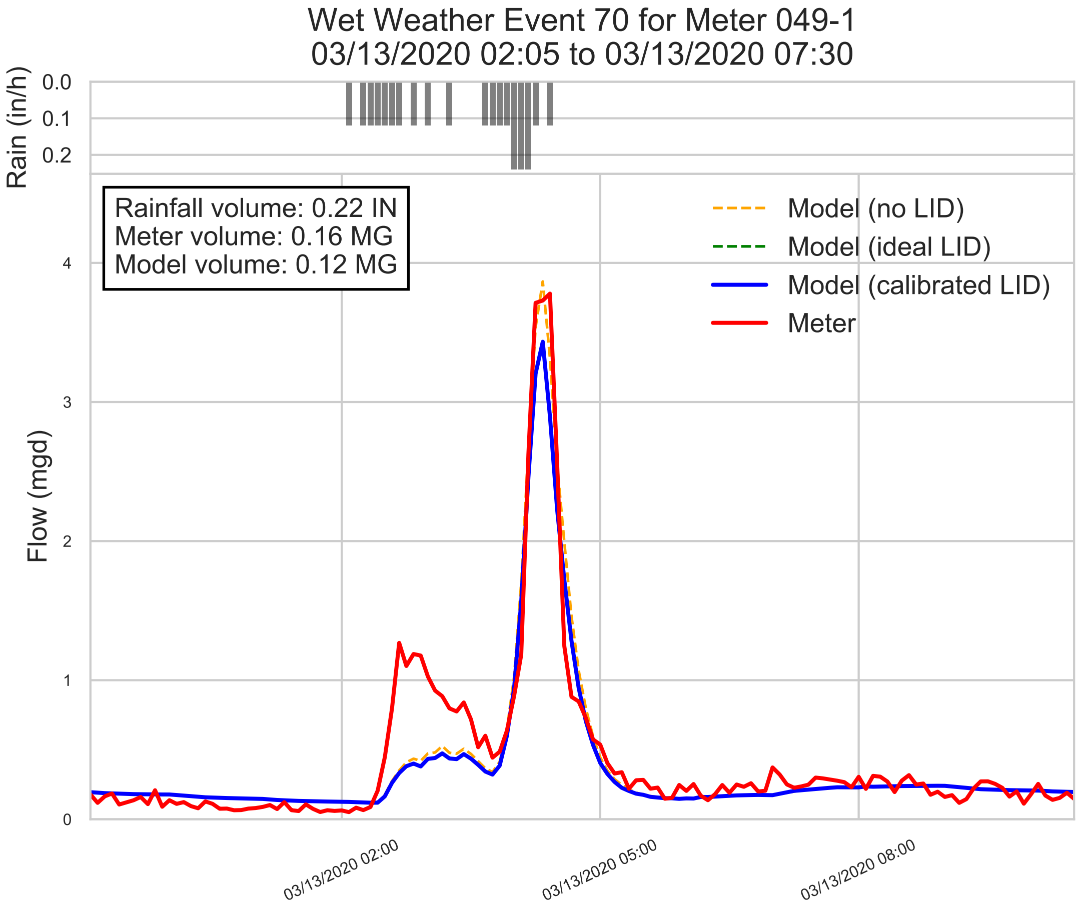


Wet Weather Event 67 for Meter 049-1
02/13/2020 01:59 to 02/13/2020 13:39
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.21 IN
Meter volume: 0.23 MG
Model volume: 0.21 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
02/12/2020 23:00
02/13/2020 02:00
02/13/2020 05:00
02/13/2020 08:00
02/13/2020 11:00
02/13/2020 14:00

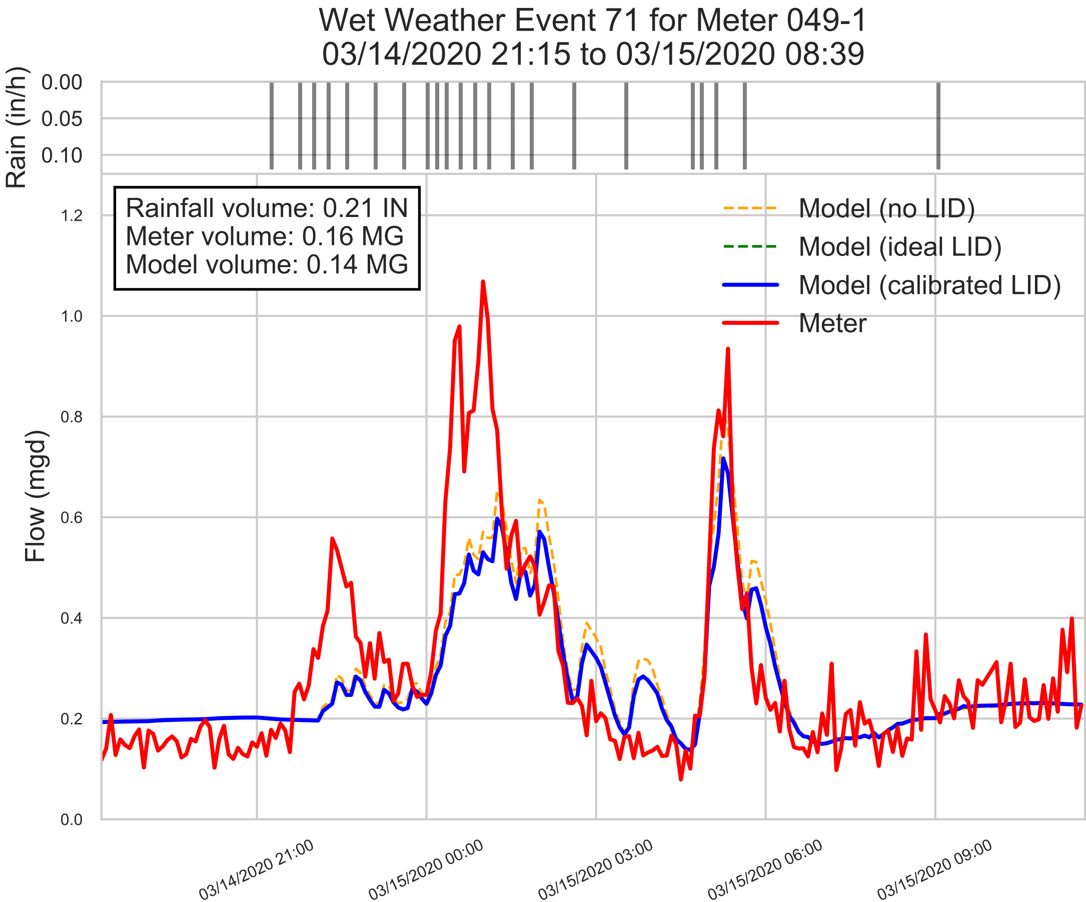


Wet Weather Event 68 for Meter 049-1
02/25/2020 06:04 to 02/25/2020 13:39
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.25 MG
Model volume: 0.2 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
02/25/2020 04:00
02/25/2020 07:00
02/25/2020 10:00
02/25/2020 13:00
02/25/2020 16:00

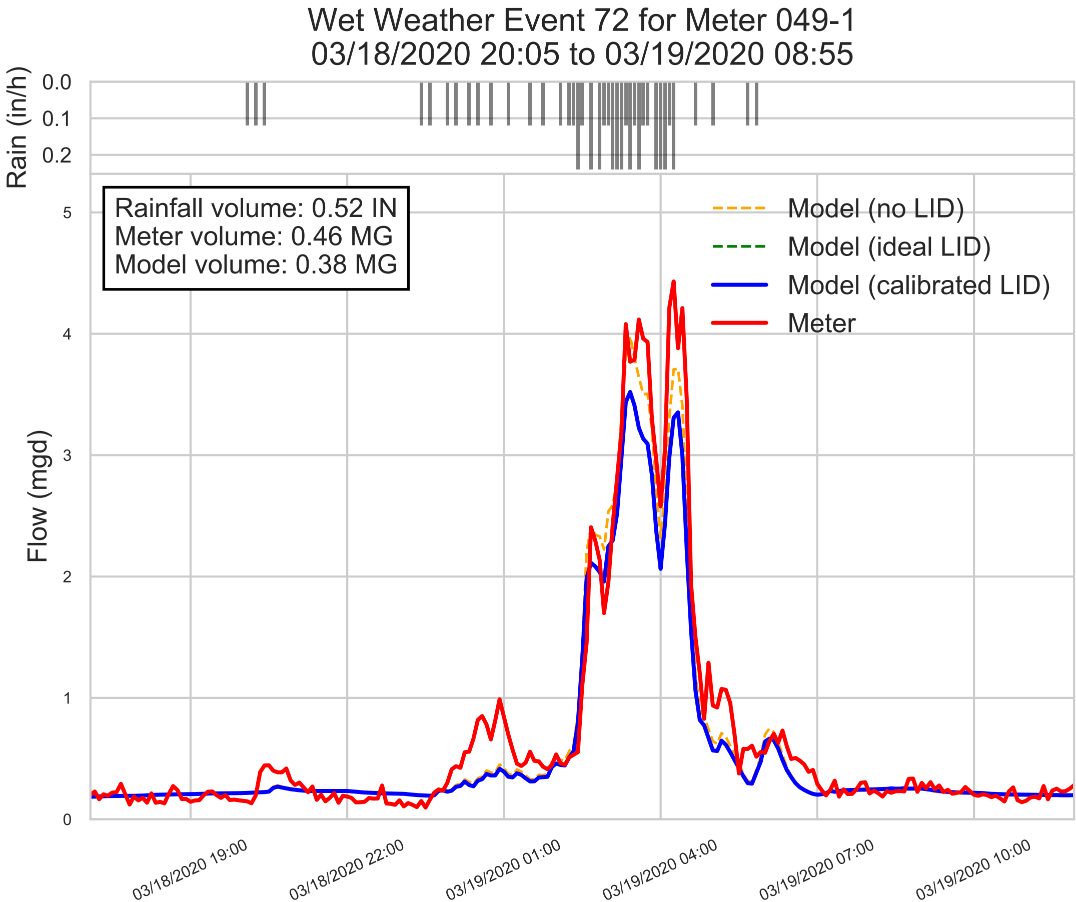

Wet Weather Event 69 for Meter 049-1
02/26/2020 23:19 to 02/27/2020 04:59
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.26 IN
Meter volume: 0.19 MG
Model volume: 0.16 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
02/26/2020 23:00
02/27/2020 02:00
02/27/2020 05:00



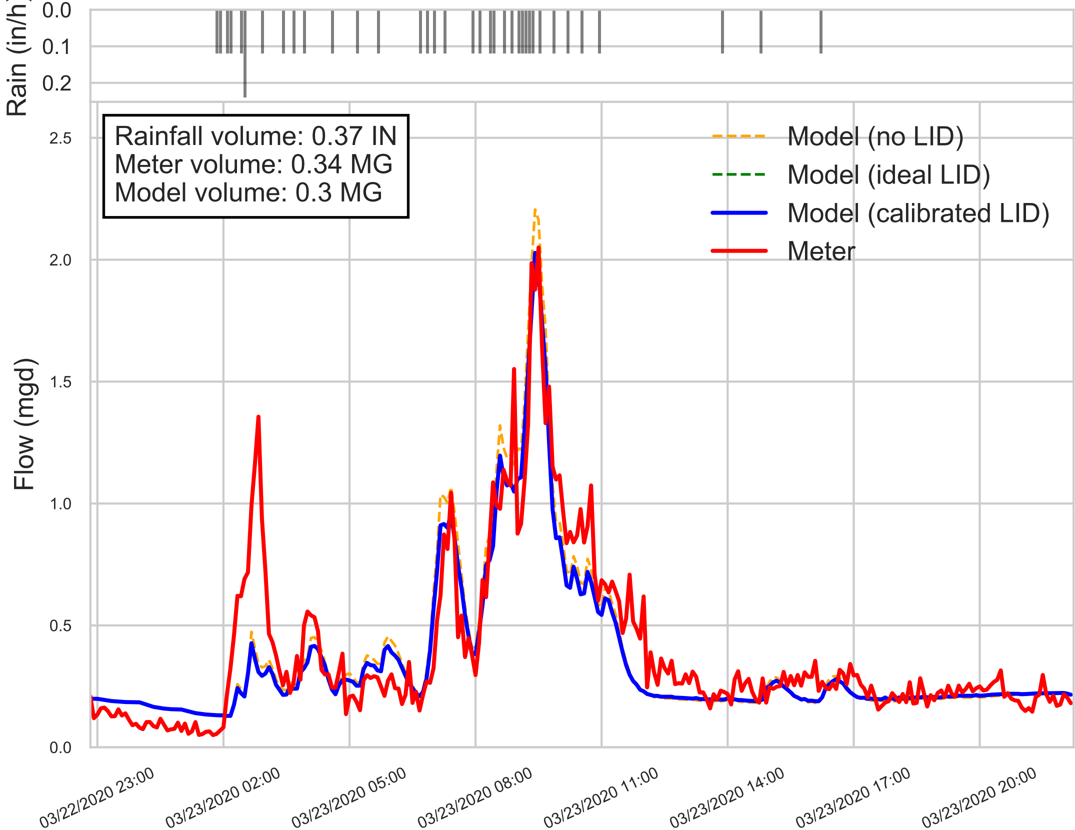
Wet Weather Event 70 for Meter 049-1
03/13/2020 02:05 to 03/13/2020 07:30
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.22 IN
Meter volume: 0.16 MG
Model volume: 0.12 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
4
3
2
1
0
03/13/2020 02:00
03/13/2020 05:00
03/13/2020 08:00

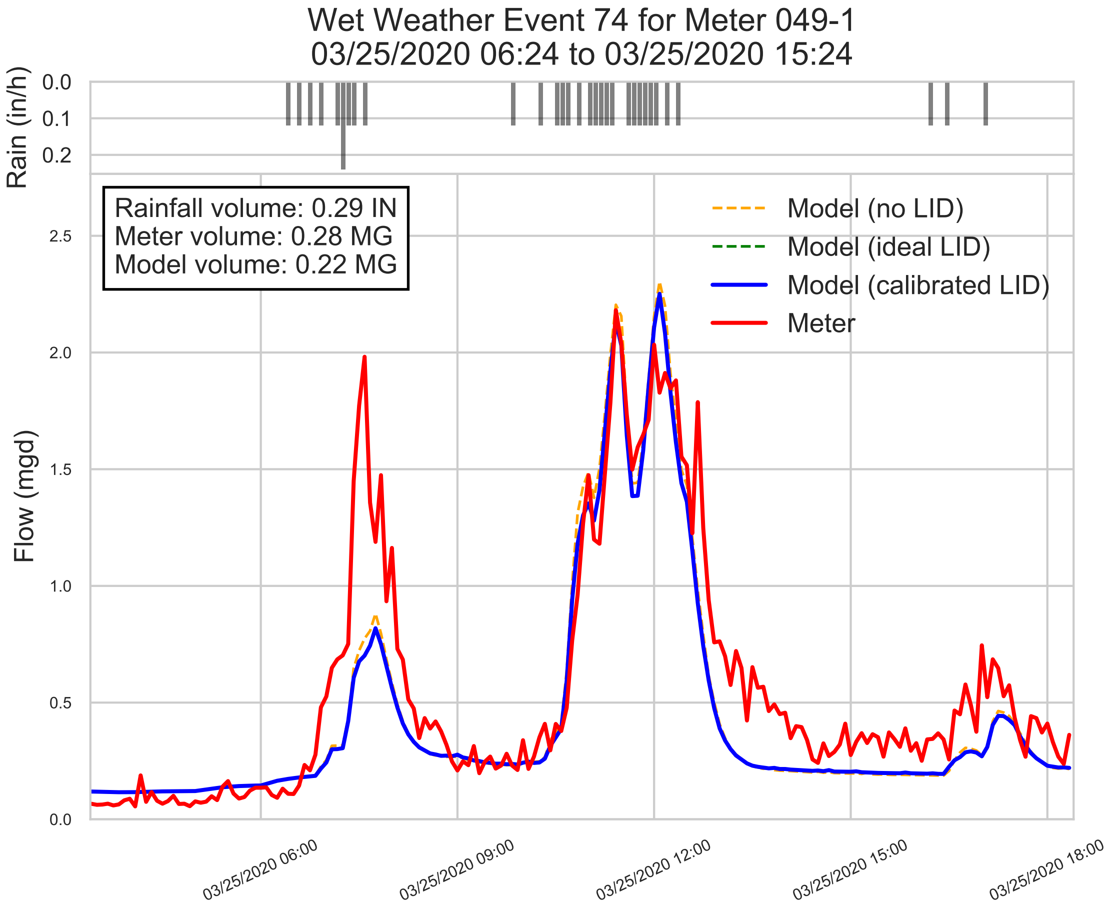


Wet Weather Event 71 for Meter 049-1
03/14/2020 21:15 to 03/15/2020 08:39
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.21 IN
Meter volume: 0.16 MG
Model volume: 0.14 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
03/14/2020 21:00
03/15/2020 00:00
03/15/2020 03:00
03/15/2020 06:00
03/15/2020 09:00

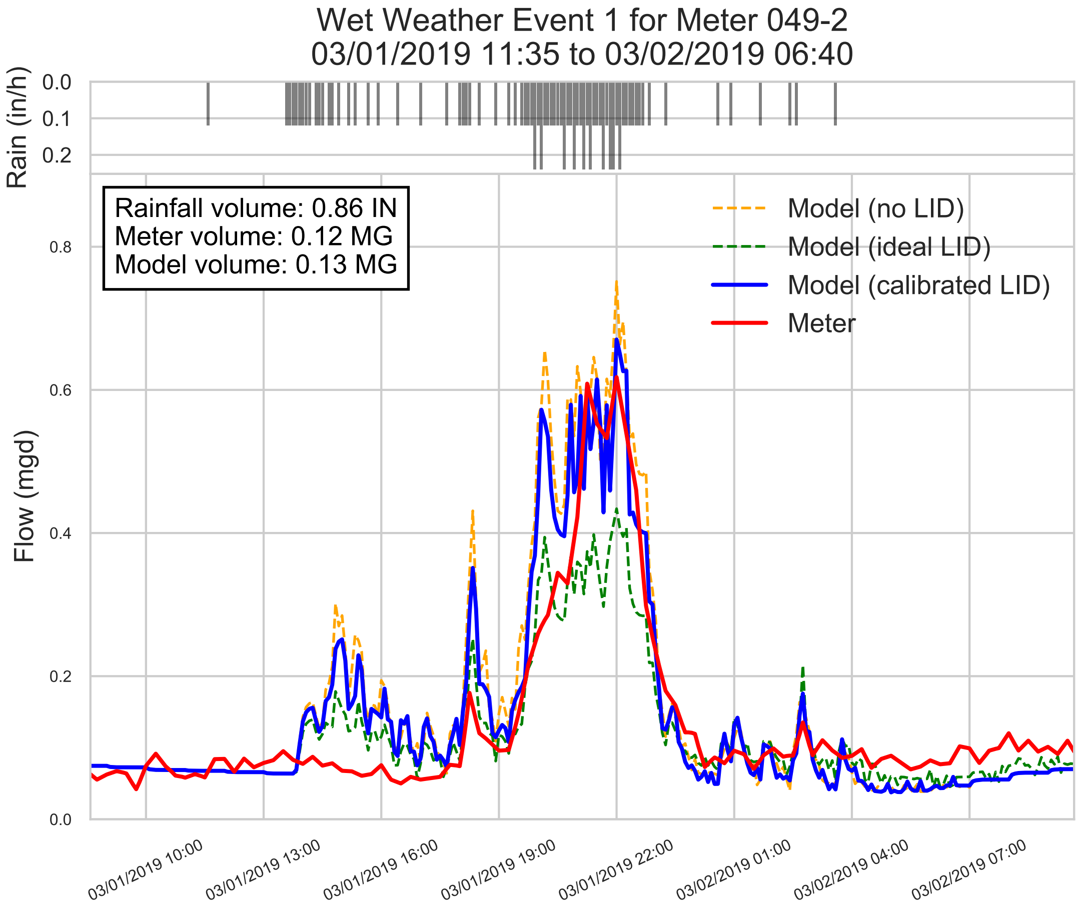

Wet Weather Event 72 for Meter 049-1
03/18/2020 20:05 to 03/19/2020 08:55
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.52 IN
Meter volume: 0.46 MG
Model volume: 0.38 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
03/18/2020 19:00
03/18/2020 22:00
03/19/2020 01:00
03/19/2020 04:00
03/19/2020 07:00
03/19/2020 10:00

Wet Weather Event 73 for Meter 049-1
03/23/2020 01:50 to 03/23/2020 19:14

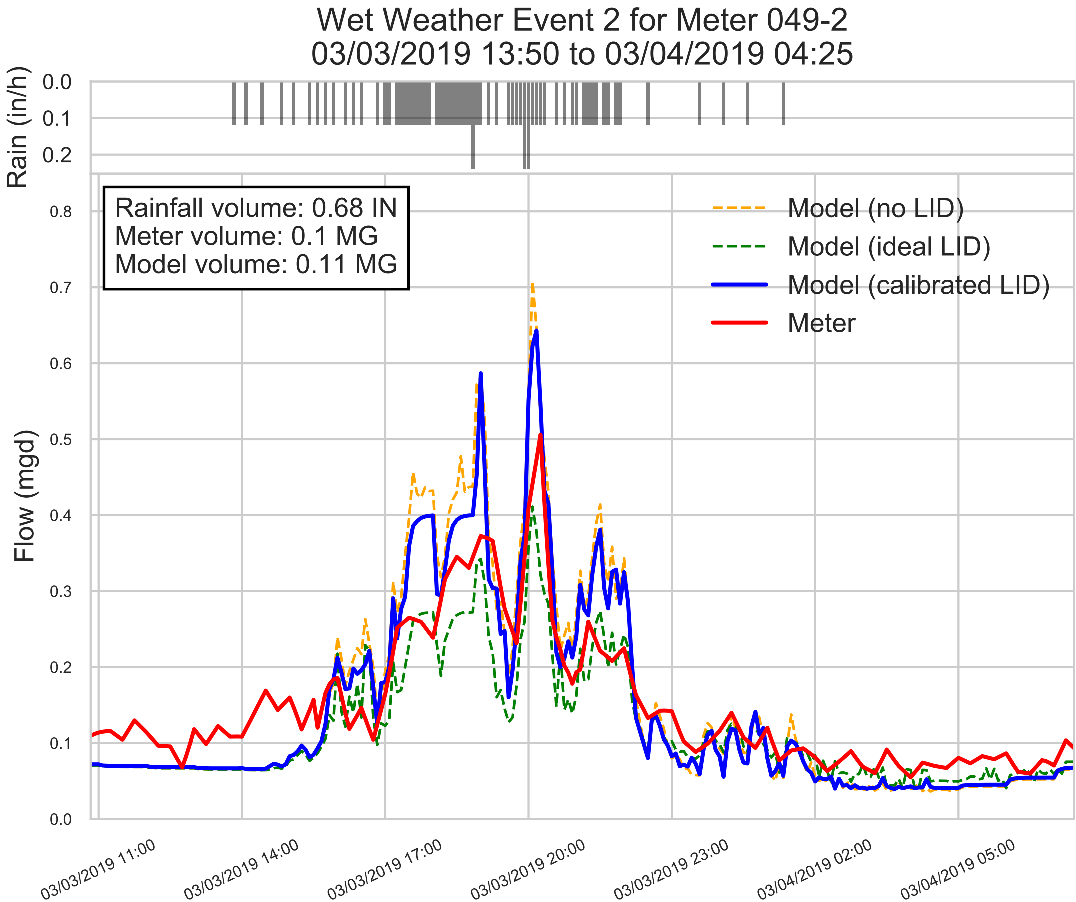


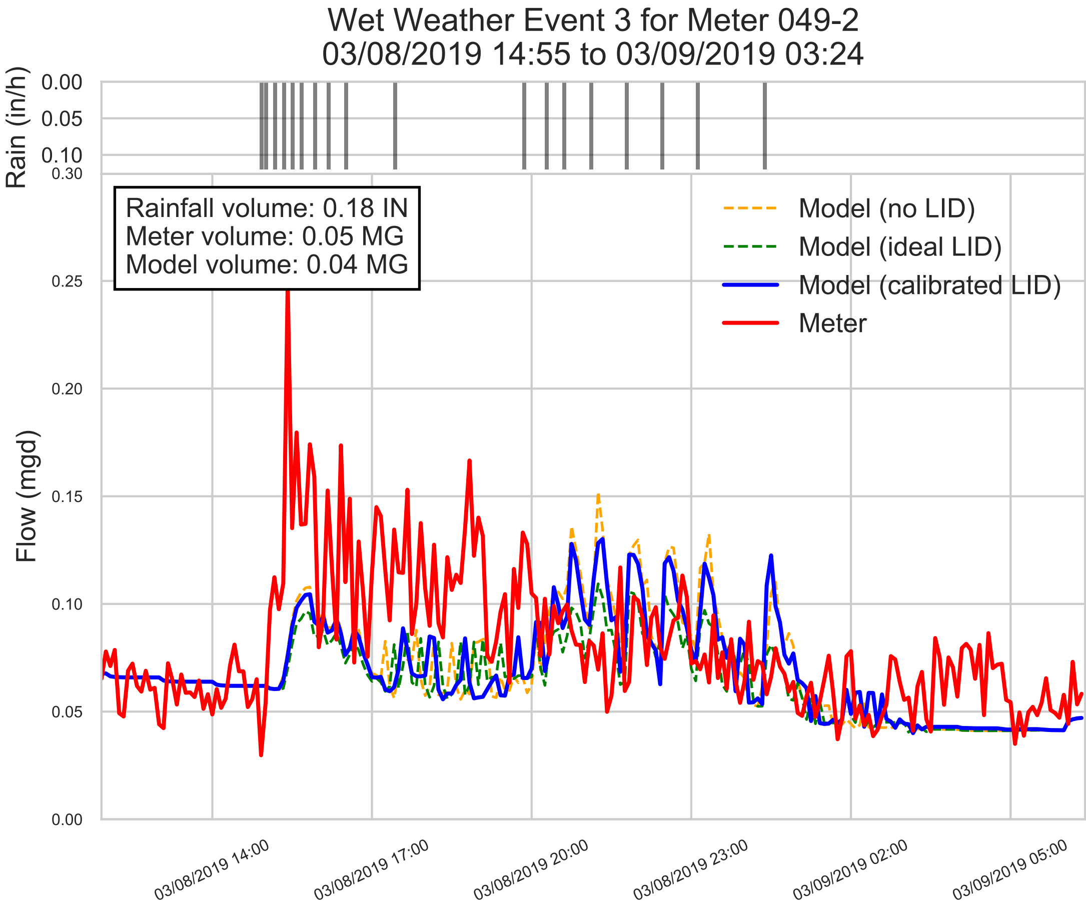


Wet Weather Event 74 for Meter 049-1
03/25/2020 06:24 to 03/25/2020 15:24
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.28 MG
Model volume: 0.22 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
03/25/2020 06:00
03/25/2020 09:00
03/25/2020 12:00
03/25/2020 15:00
03/25/2020 18:00

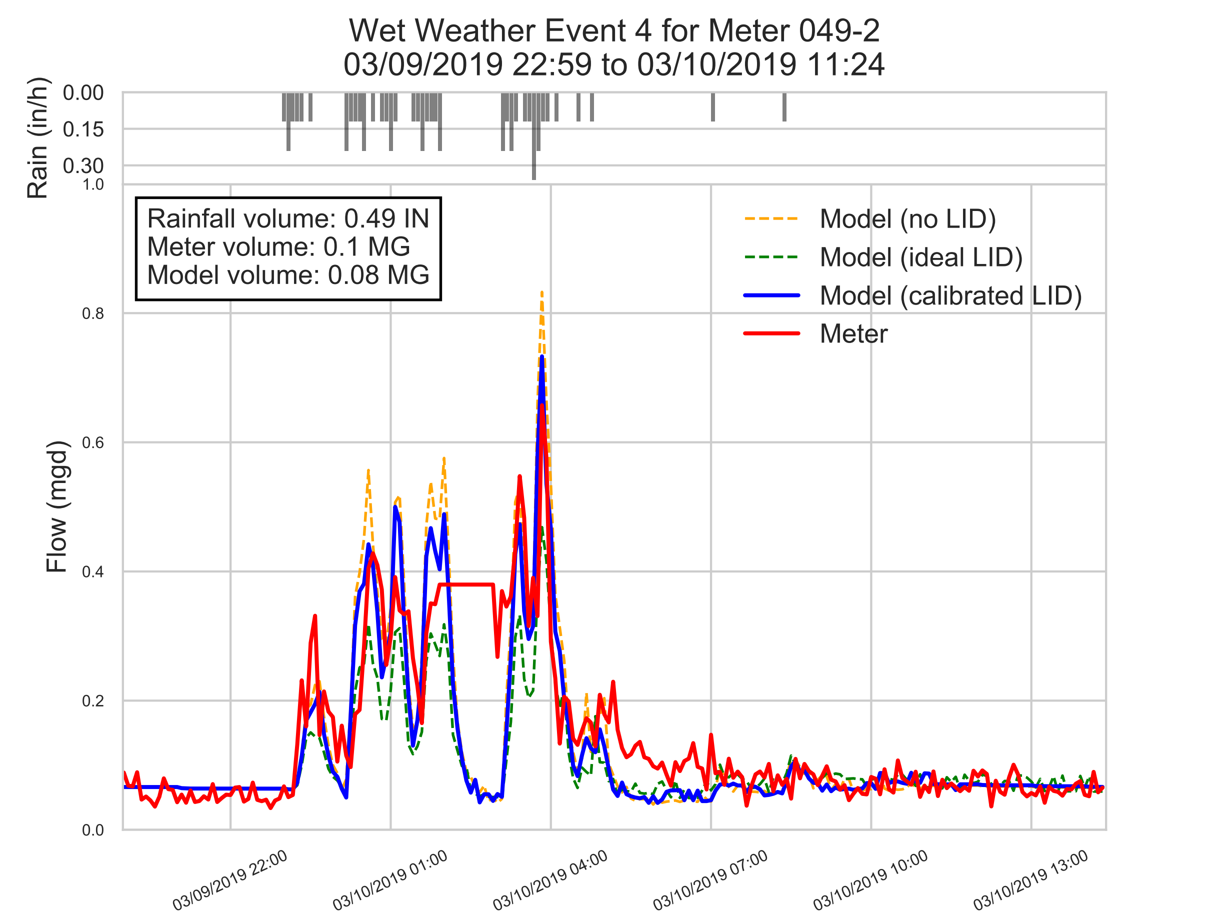


Wet Weather Event 1 for Meter 049-2
03/01/2019 11:35 to 03/02/2019 06:40
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.86 IN
Meter volume: 0.12 MG
Model volume: 0.13 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
03/01/2019 10:00
03/01/2019 13:00
03/01/2019 16:00
03/01/2019 19:00
03/01/2019 22:00
03/02/2019 01:00
03/02/2019 04:00
03/02/2019 07:00

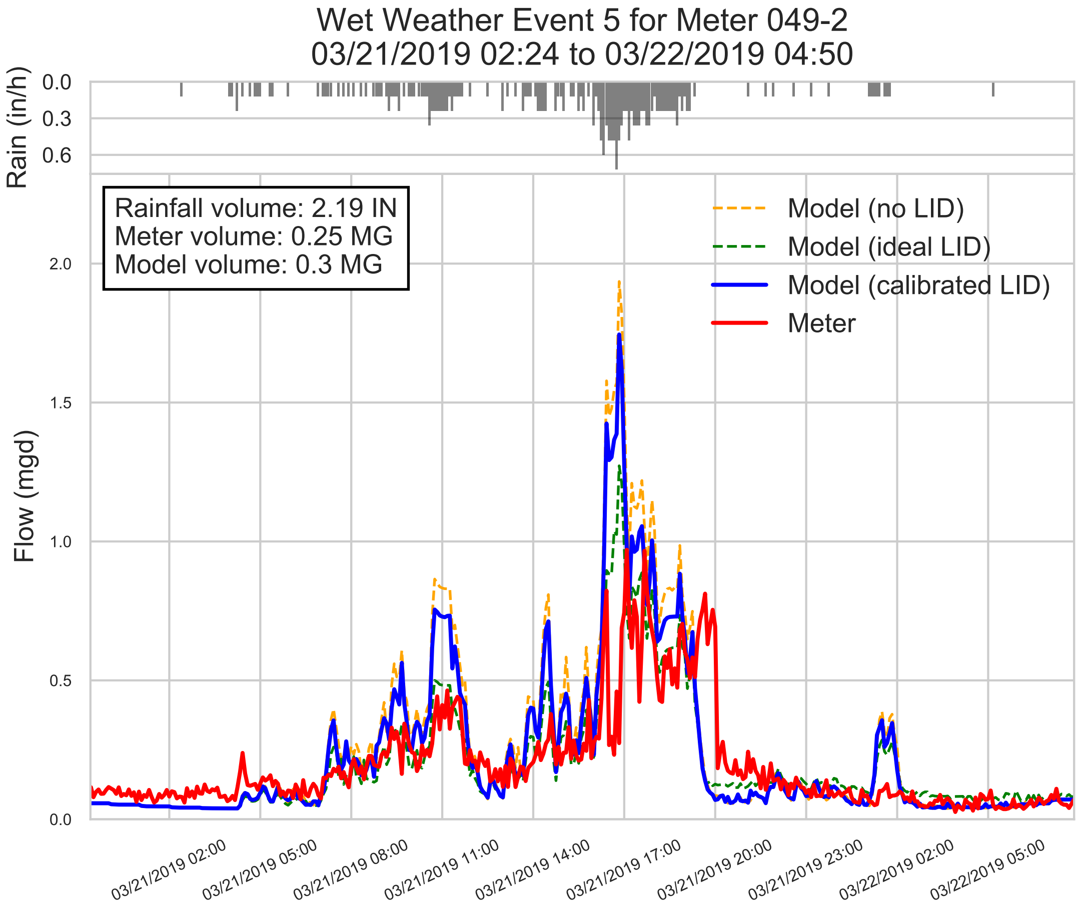

Wet Weather Event 2 for Meter 049-2
03/03/2019 13:50 to 03/04/2019 04:25
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.68 IN
Meter volume: 0.1 MG
Model volume: 0.11 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
03/03/2019 11:00
03/03/2019 14:00
03/03/2019 17:00
03/03/2019 20:00
03/03/2019 23:00
03/04/2019 02:00
03/04/2019 05:00



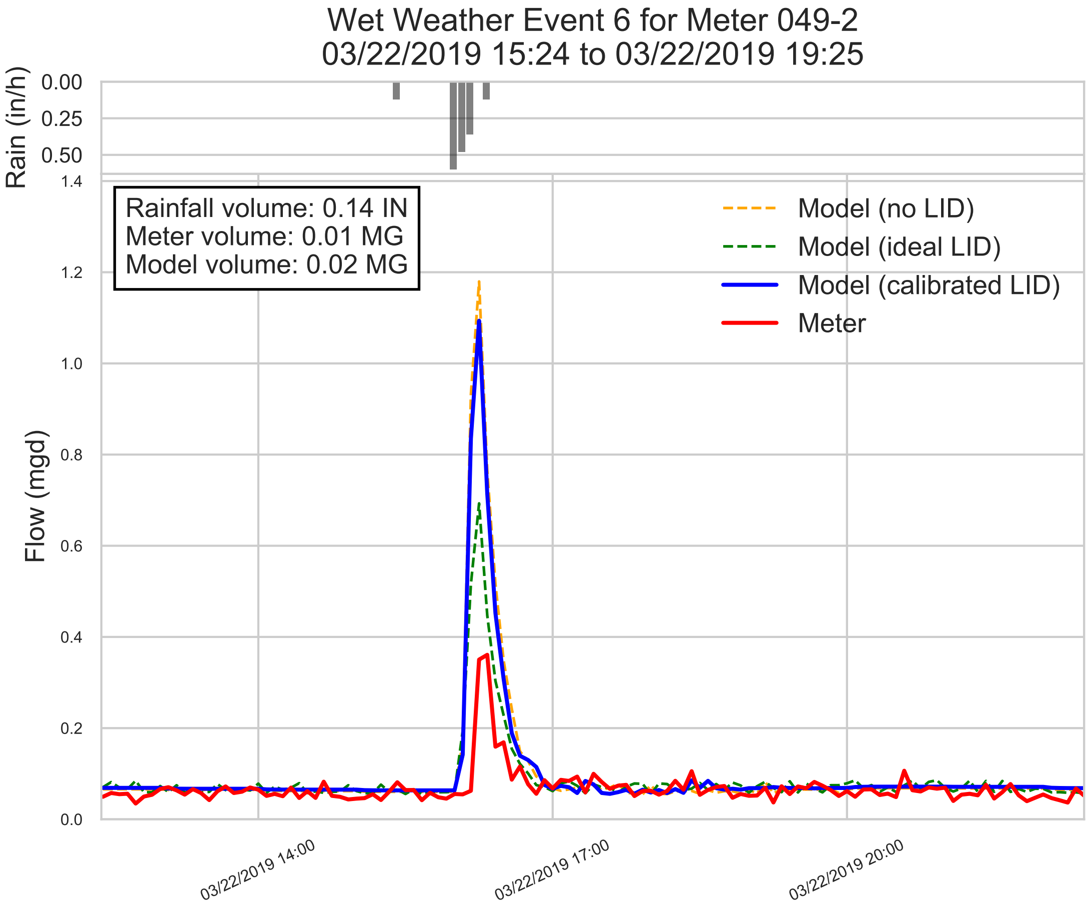
Wet Weather Event 3 for Meter 049-2
03/08/2019 14:55 to 03/09/2019 03:24
Rain (in/h)
0.00
0.05
0.10
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Flow (mgd)
Rainfall volume: 0.18 IN
Meter volume: 0.05 MG
Model volume: 0.04 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
03/08/2019 14:00
03/08/2019 17:00
03/08/2019 20:00
03/08/2019 23:00
03/09/2019 02:00
03/09/2019 05:00

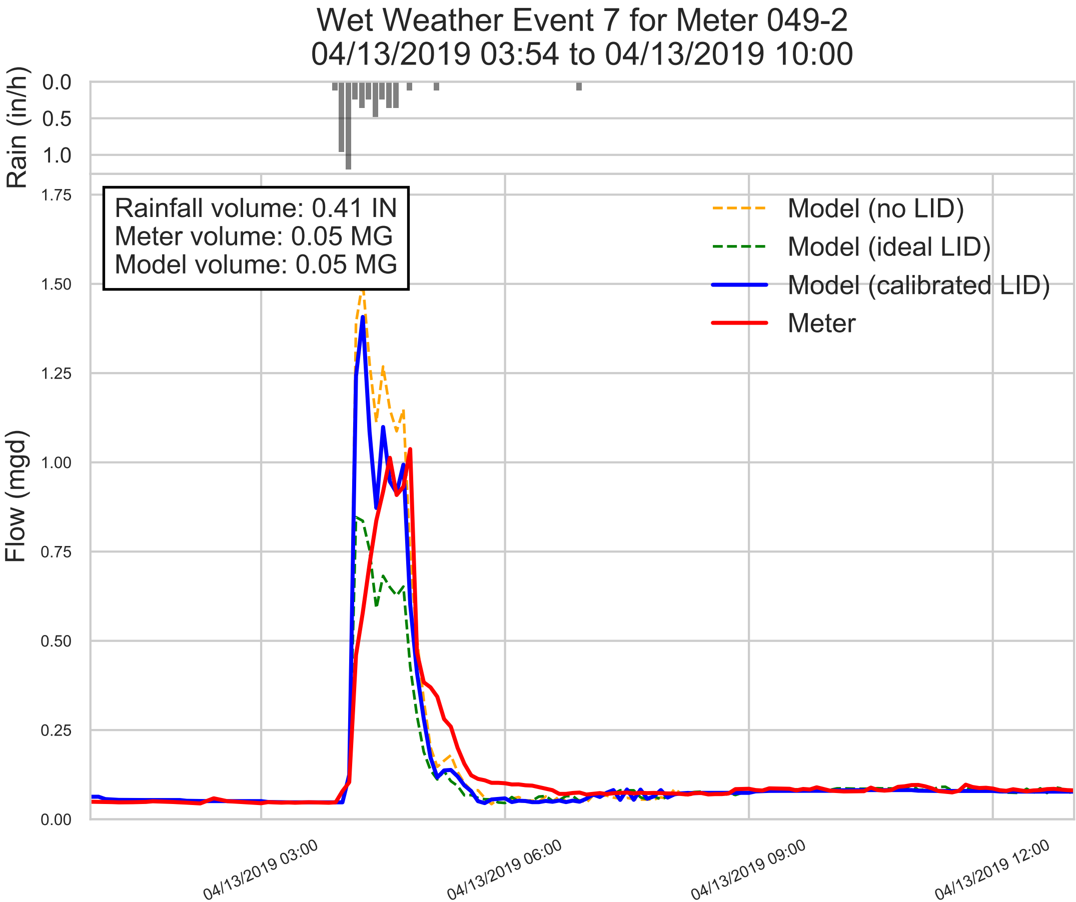


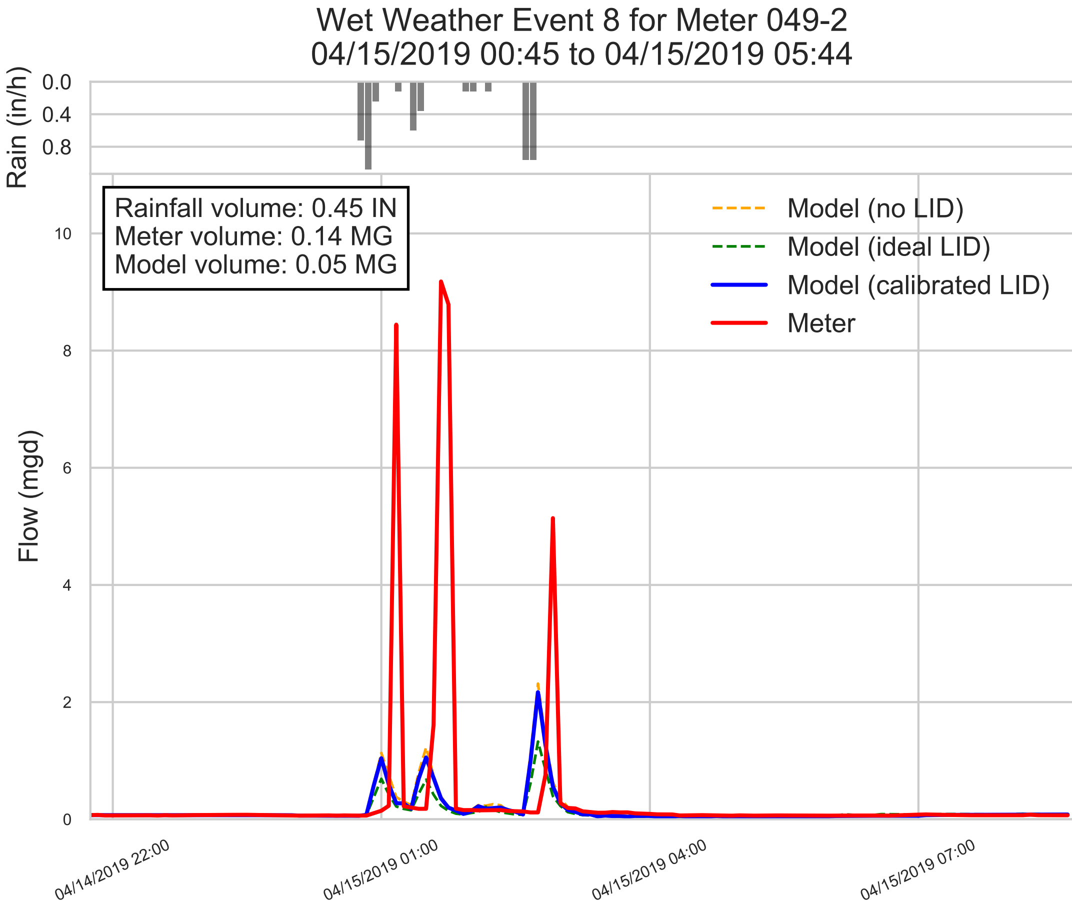
Wet Weather Event 4 for Meter 049-2
03/09/2019 22:59 to 03/10/2019 11:24
Rain (in/h)
0.00
0.15
0.30
1.0
Rainfall volume: 0.49 IN
Meter volume: 0.1 MG
Model volume: 0.08 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
03/09/2019 22:00
03/10/2019 01:00
03/10/2019 04:00
03/10/2019 07:00
03/10/2019 10:00
03/10/2019 13:00



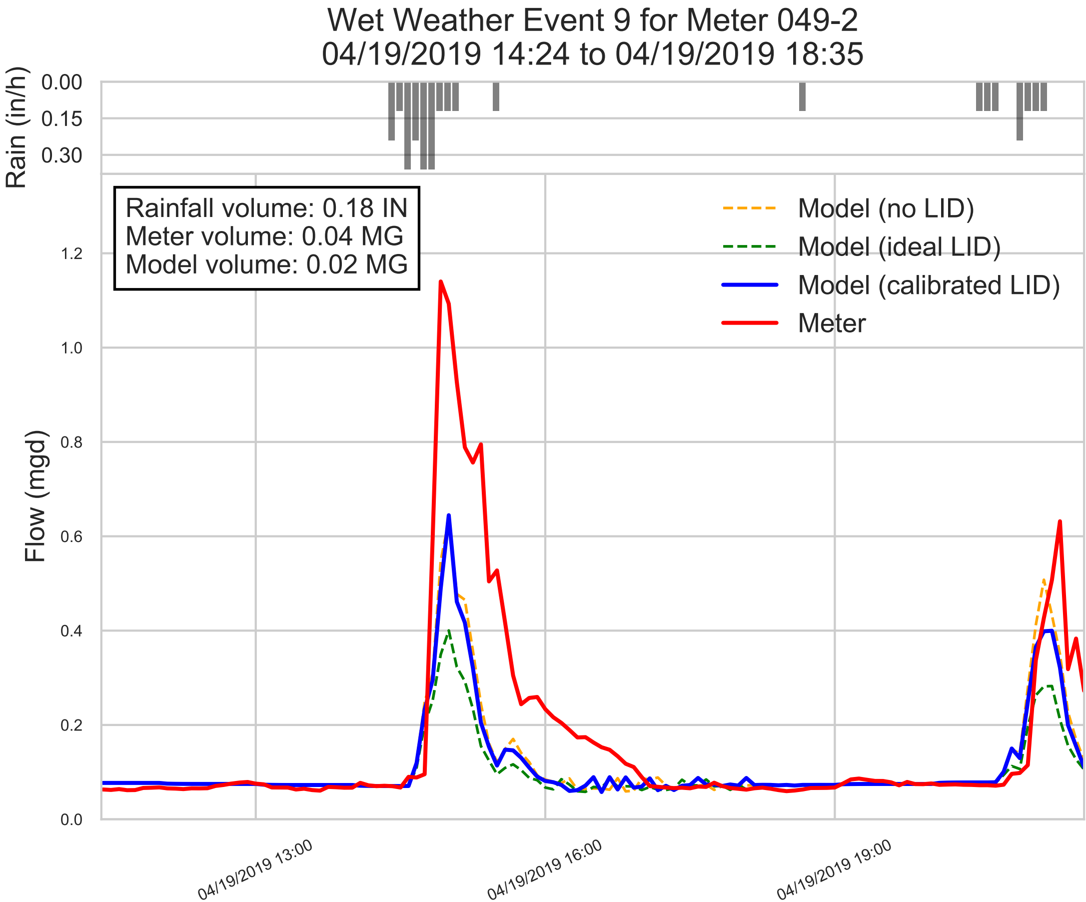
Wet Weather Event 5 for Meter 049-2
03/21/2019 02:24 to 03/22/2019 04:50
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 2.19 IN
Meter volume: 0.25 MG
Model volume: 0.3 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
03/21/2019 02:00
03/21/2019 05:00
03/21/2019 08:00
03/21/2019 11:00
03/21/2019 14:00
03/21/2019 17:00
03/21/2019 20:00
03/21/2019 23:00
03/22/2019 02:00
03/22/2019 05:00


Wet Weather Event 6 for Meter 049-2
03/22/2019 15:24 to 03/22/2019 19:25
Rain (in/h)
0.00
0.25
0.50
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Rainfall volume: 0.14 IN
Meter volume: 0.01 MG
Model volume: 0.02 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
03/22/2019 14:00
03/22/2019 17:00
03/22/2019 20:00

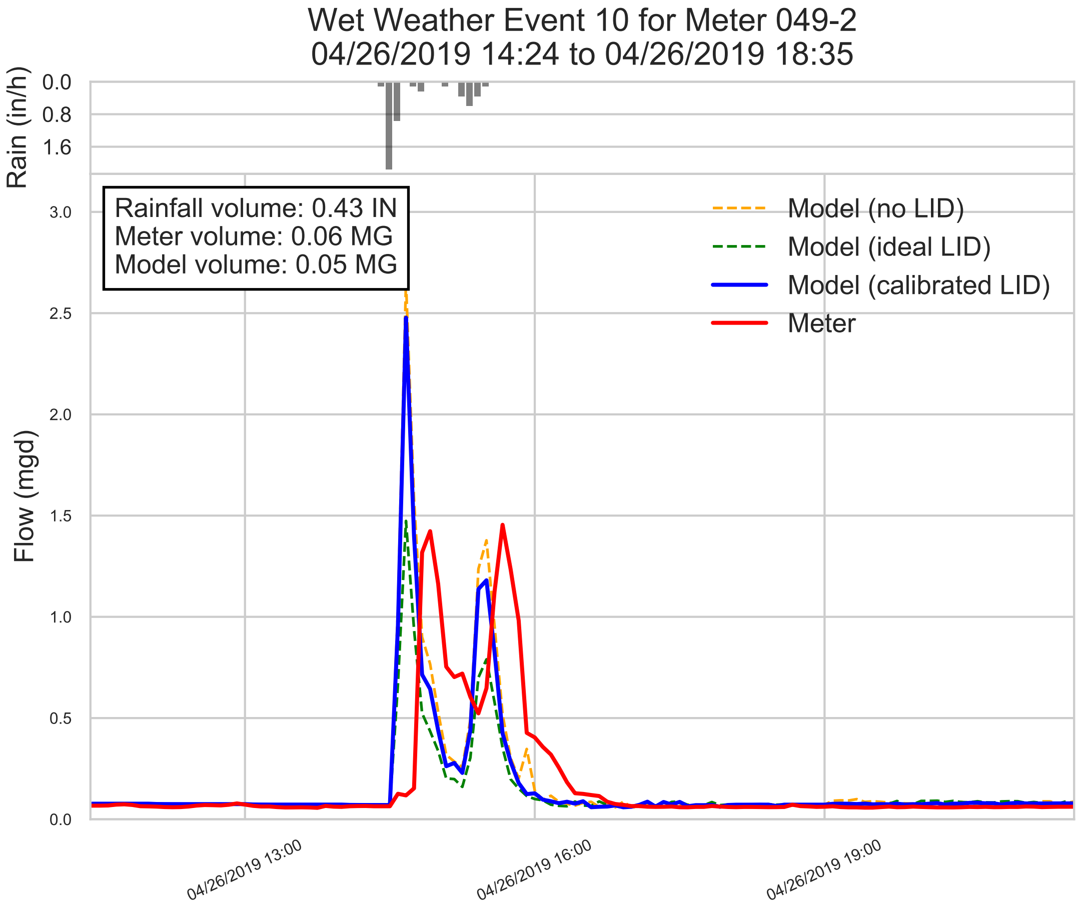

Wet Weather Event 7 for Meter 049-2
04/13/2019 03:54 to 04/13/2019 10:00
Rain (in/h)
0.0
0.5
1.0
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall volume: 0.41 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
04/13/2019 03:00
04/13/2019 06:00
04/13/2019 09:00
04/13/2019 12:00



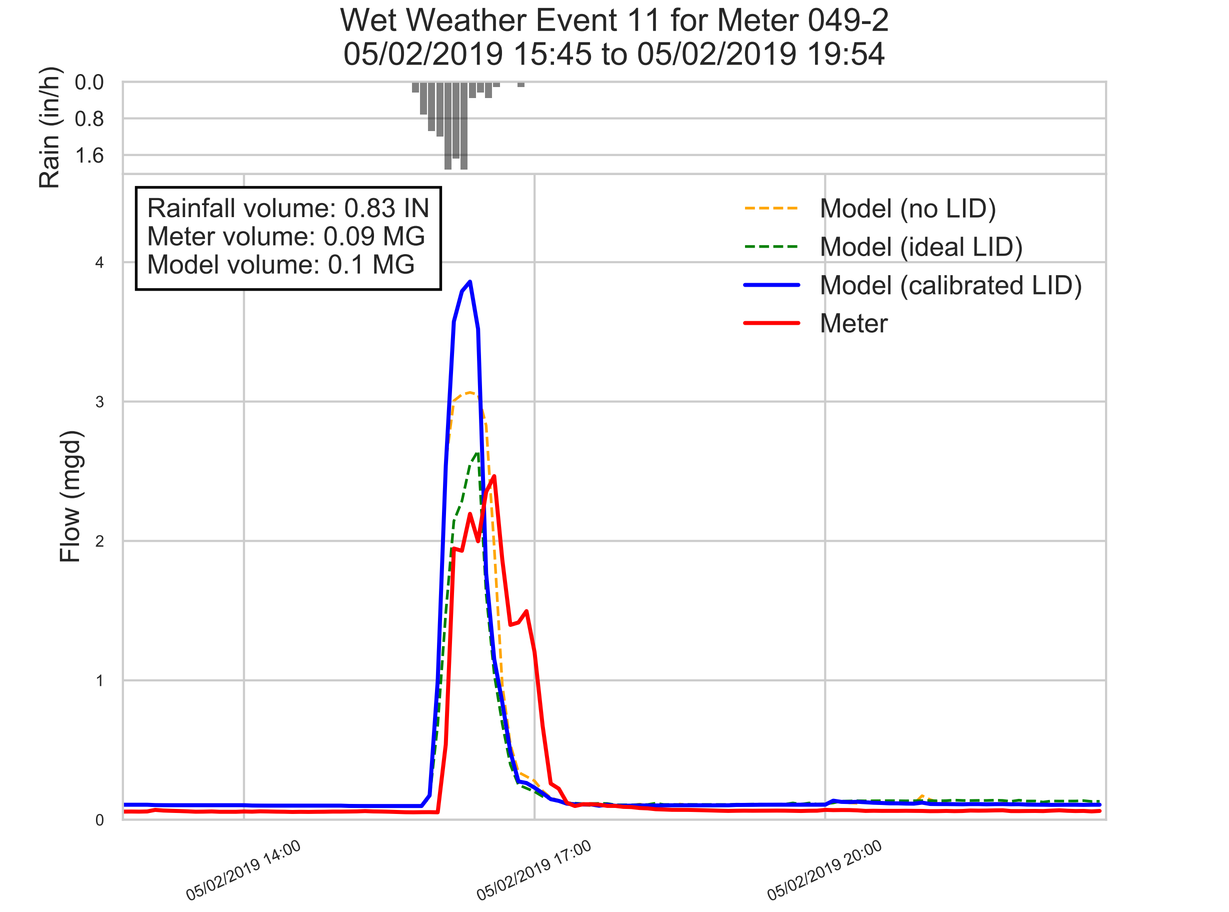
Wet Weather Event 8 for Meter 049-2
04/15/2019 00:45 to 04/15/2019 05:44
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.45 IN
Meter volume: 0.14 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
10
8
6
4
2
0
04/14/2019 22:00
04/15/2019 01:00
04/15/2019 04:00
04/15/2019 07:00



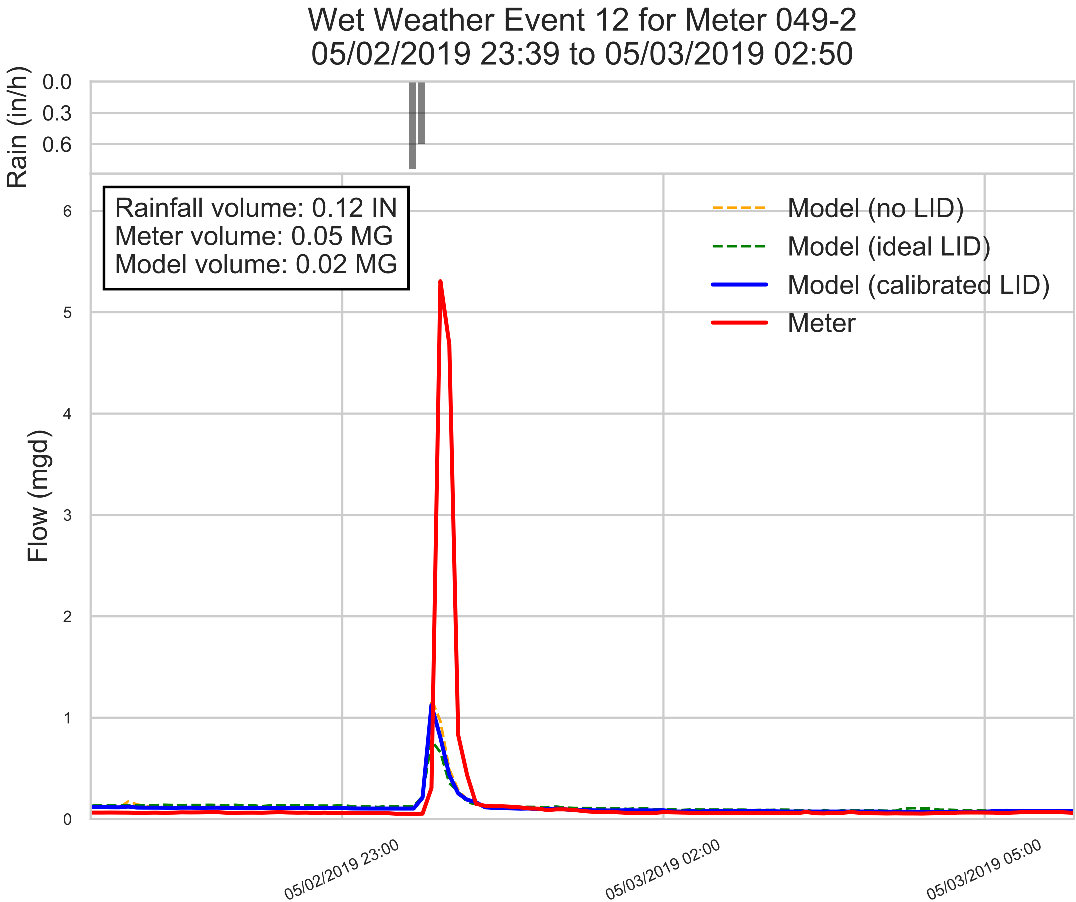
Wet Weather Event 9 for Meter 049-2
04/19/2019 14:24 to 04/19/2019 18:35
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.18 IN
Meter volume: 0.04 MG
Model volume: 0.02 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
04/19/2019 13:00
04/19/2019 16:00
04/19/2019 19:00

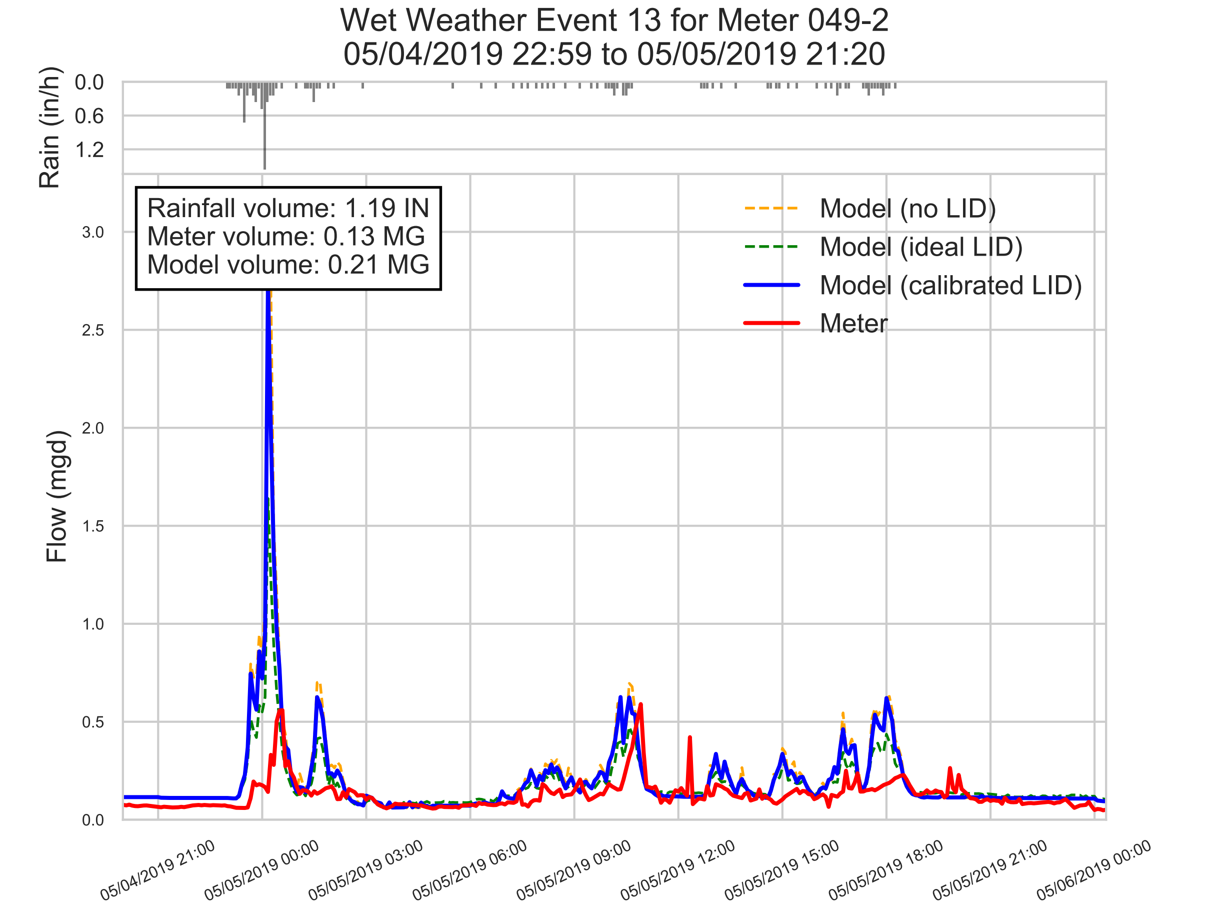


Wet Weather Event 10 for Meter 049-2
04/26/2019 14:24 to 04/26/2019 18:35
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.43 IN
Meter volume: 0.06 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
04/26/2019 13:00
04/26/2019 16:00
04/26/2019 19:00

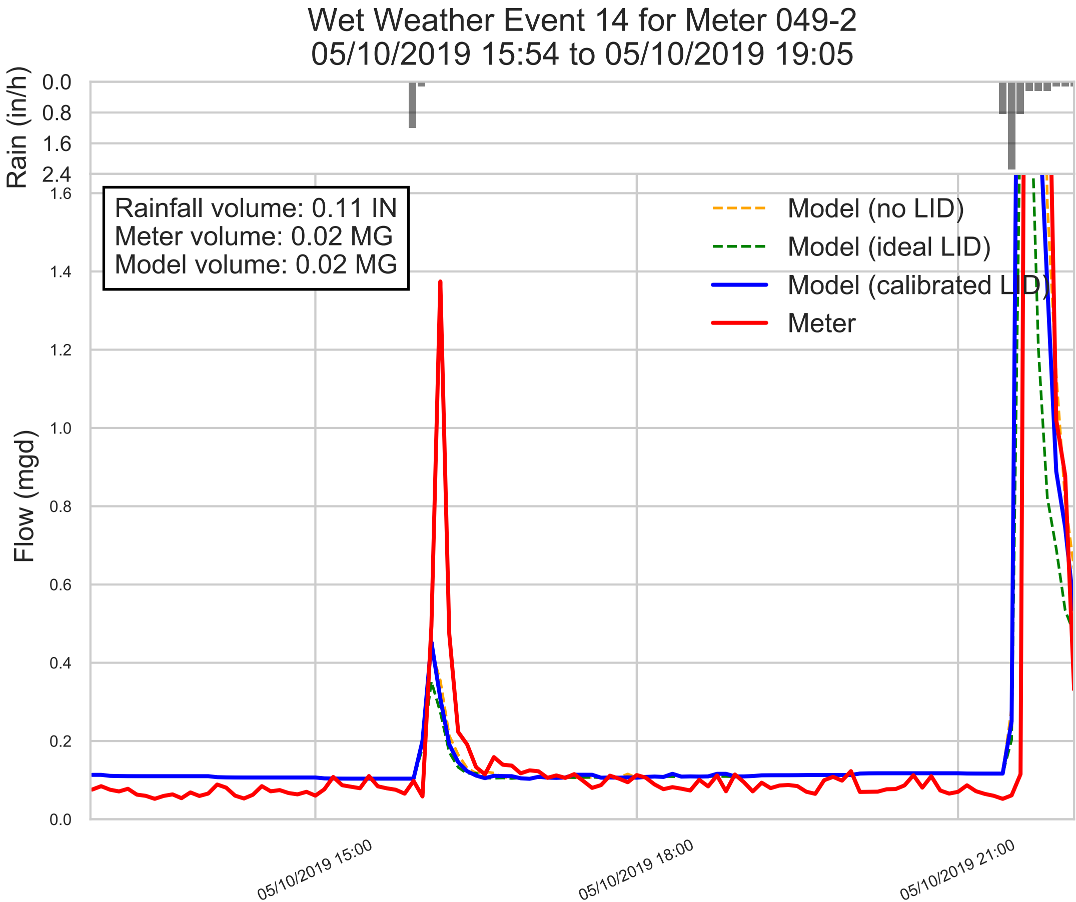


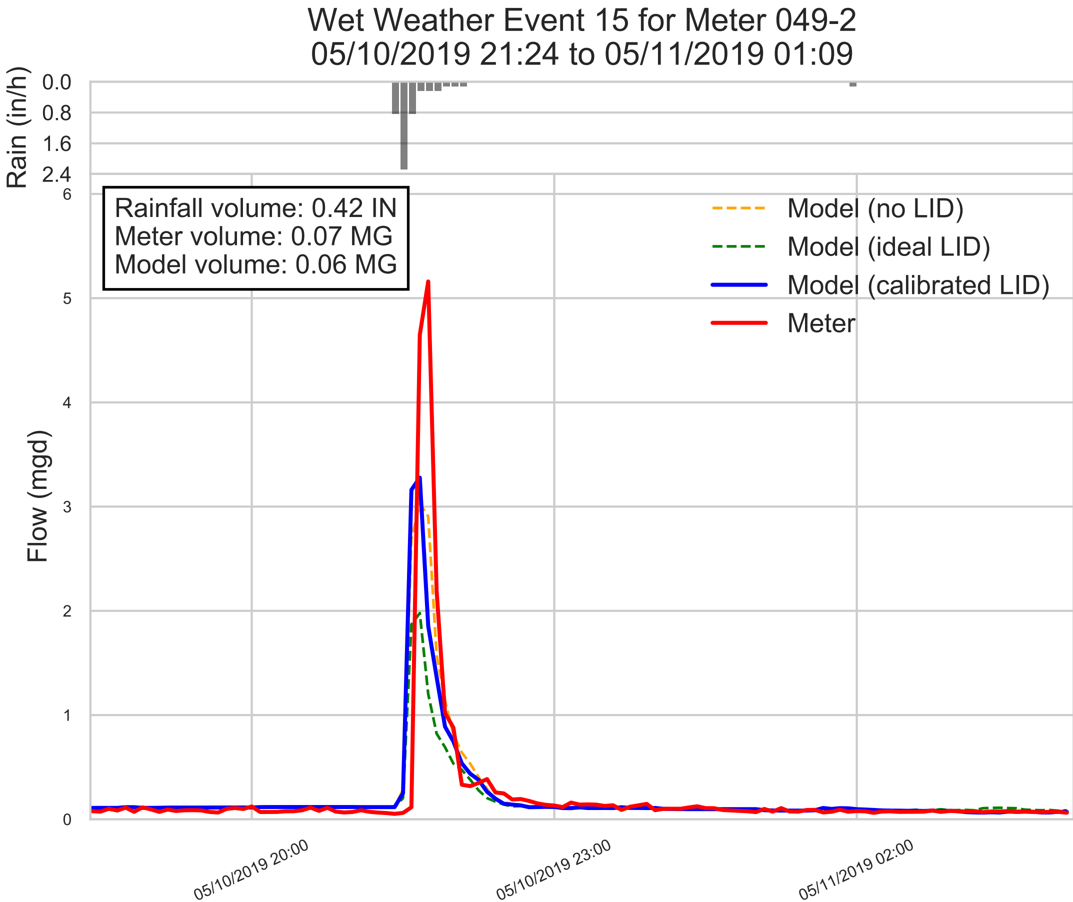
Wet Weather Event 11 for Meter 049-2
05/02/2019 15:45 to 05/02/2019 19:54
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.83 IN
Meter volume: 0.09 MG
Model volume: 0.1 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
05/02/2019 14:00
05/02/2019 17:00
05/02/2019 20:00

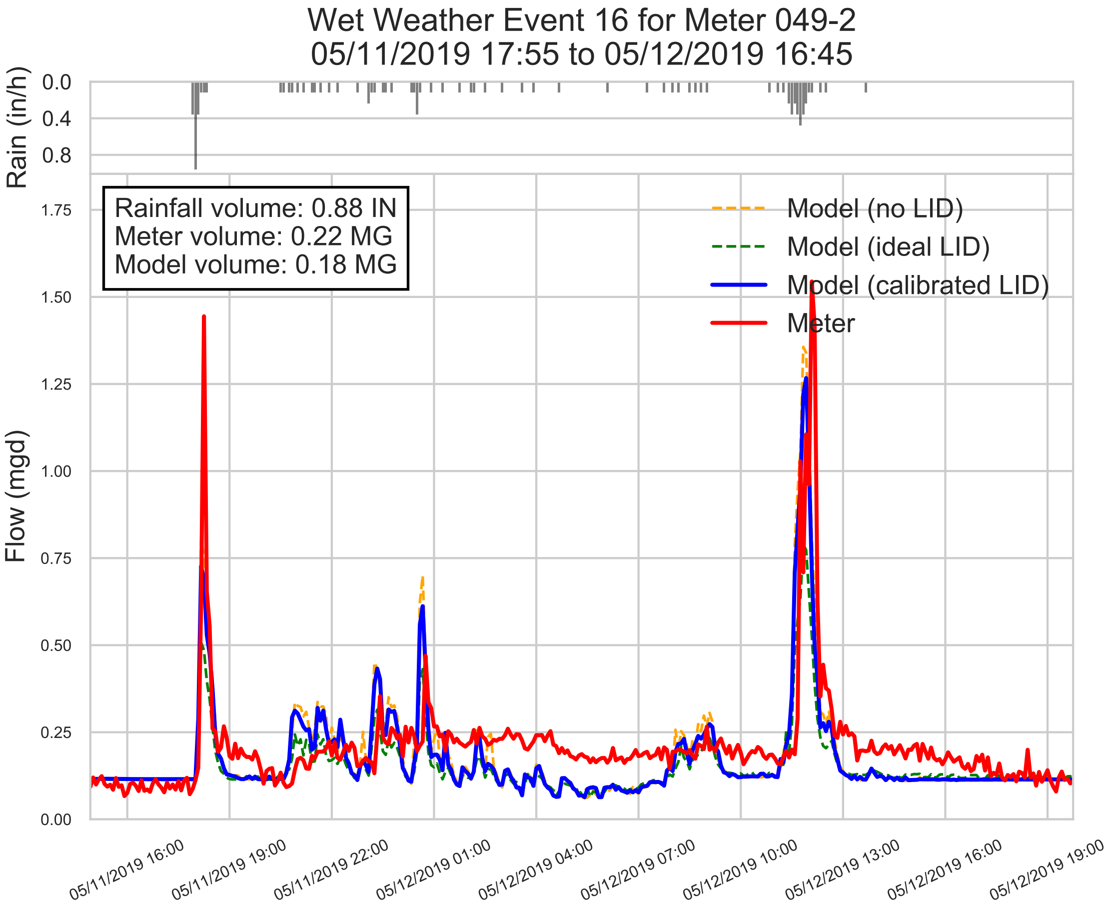

Wet Weather Event 12 for Meter 049-2
05/02/2019 23:39 to 05/03/2019 02:50
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.12 IN
Meter volume: 0.05 MG
Model volume: 0.02 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
05/02/2019 23:00
05/03/2019 02:00
05/03/2019 05:00

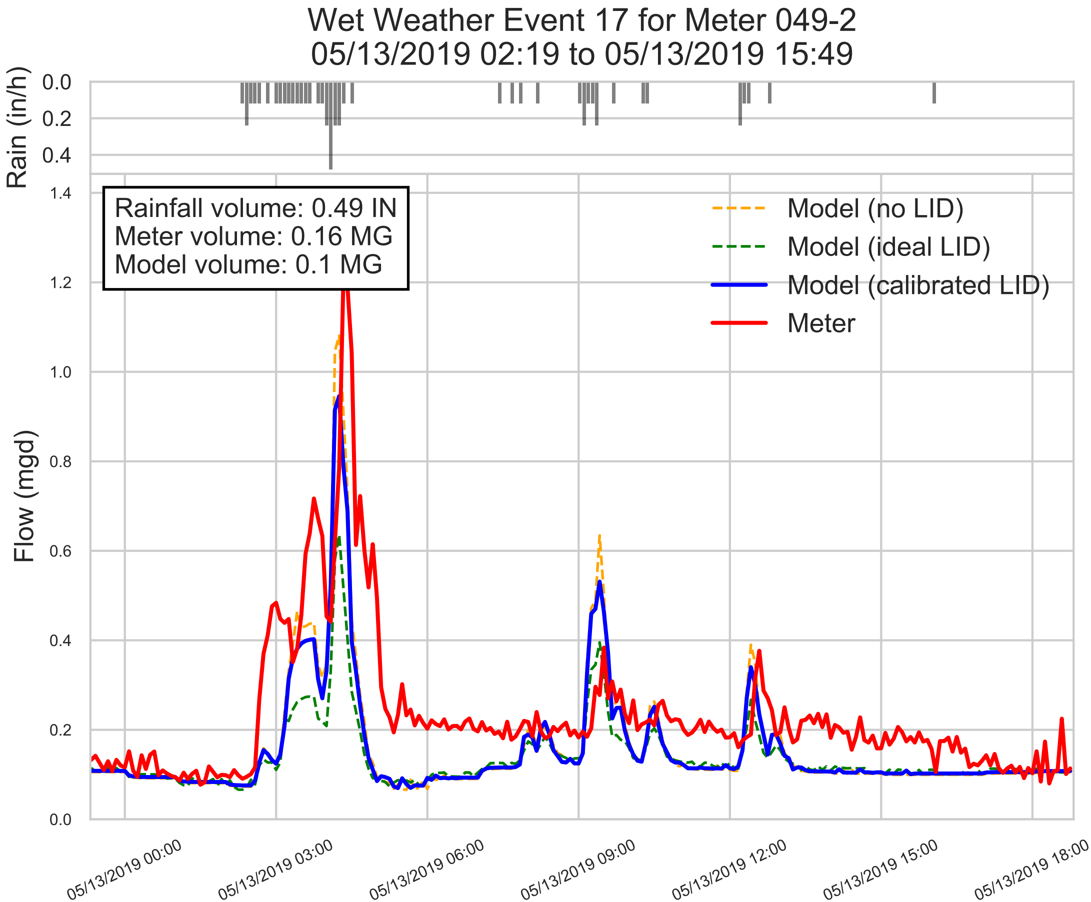


Wet Weather Event 13 for Meter 049-2
05/04/2019 22:59 to 05/05/2019 21:20
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 1.19 IN
Meter volume: 0.13 MG
Model volume: 0.21 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
05/04/2019 21:00
05/05/2019 00:00
05/05/2019 03:00
05/05/2019 06:00
05/05/2019 09:00
05/05/2019 12:00
05/05/2019 15:00
05/05/2019 18:00
05/05/2019 21:00
05/06/2019 00:00

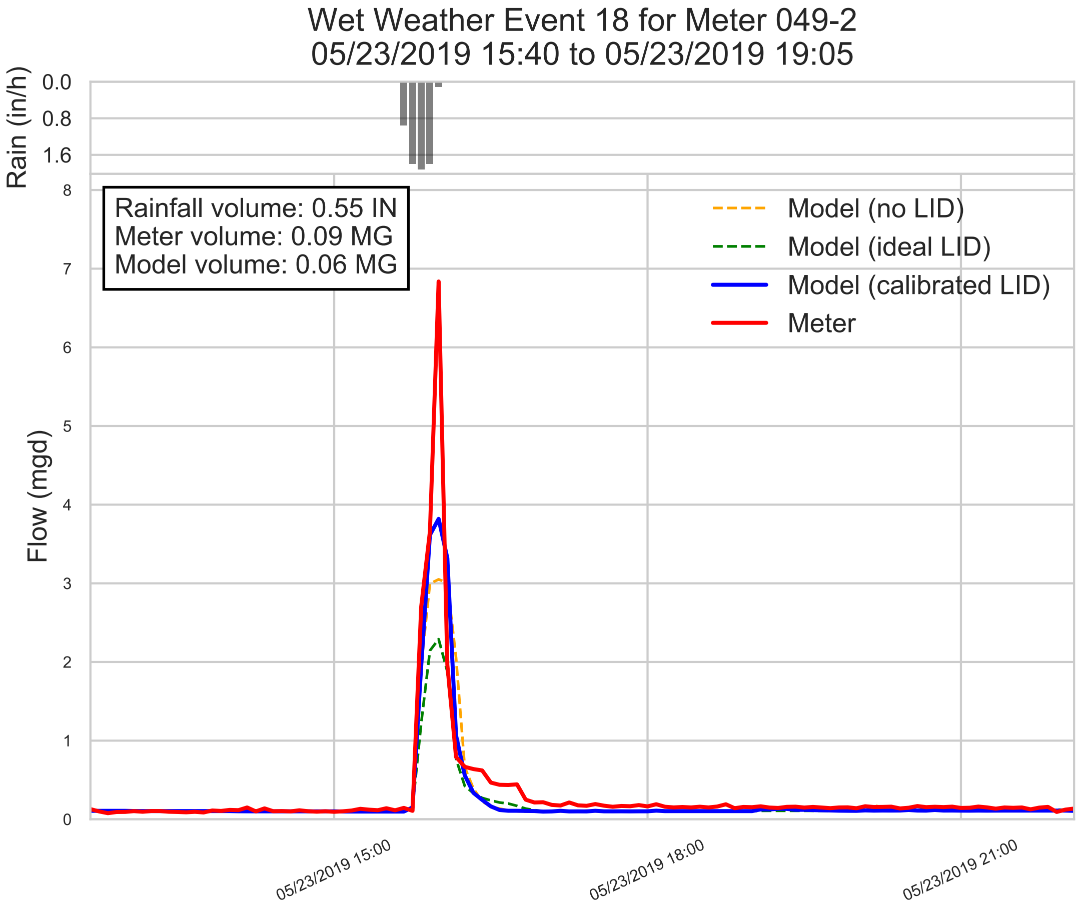

Wet Weather Event 14 for Meter 049-2
05/10/2019 15:54 to 05/10/2019 19:05
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.11 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
05/10/2019 15:00
05/10/2019 18:00
05/10/2019 21:00


Wet Weather Event 15 for Meter 049-2
05/10/2019 21:24 to 05/11/2019 01:09
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.42 IN
Meter volume: 0.07 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
6
05/10/2019 20:00
05/10/2019 23:00
05/11/2019 02:00

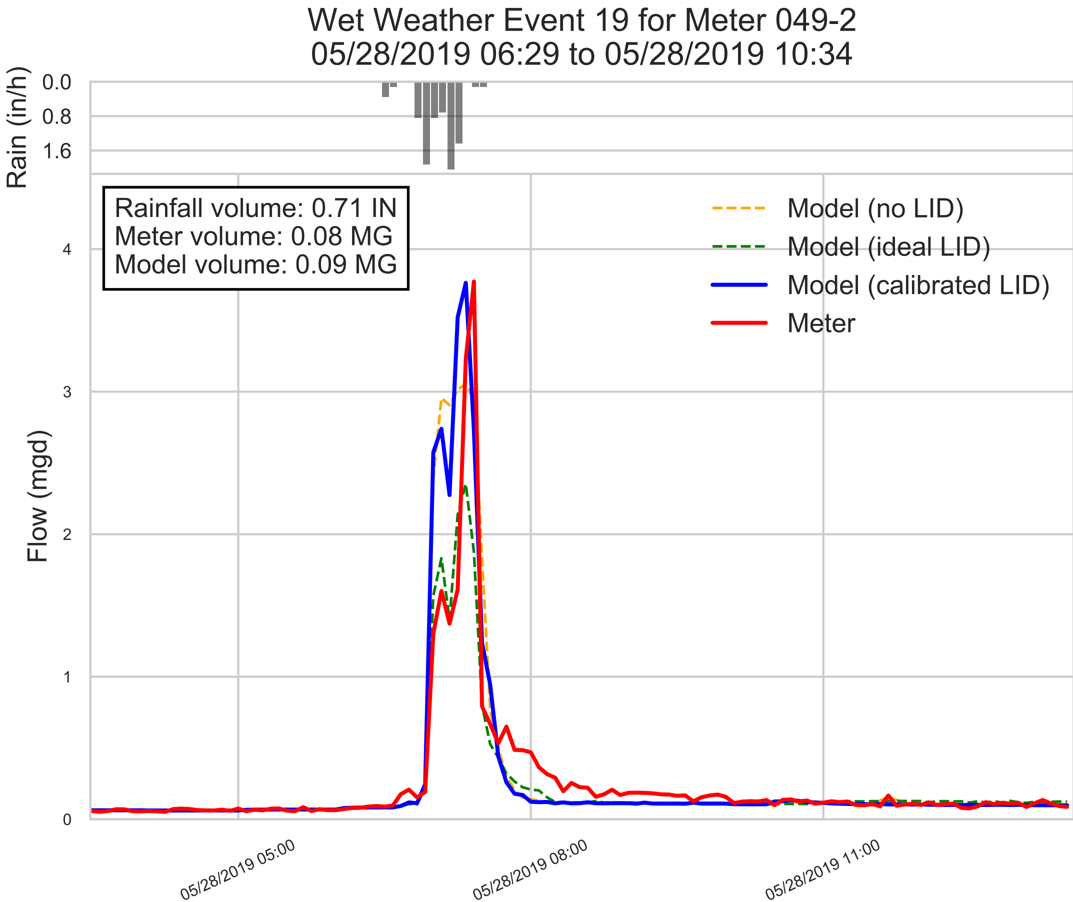

Wet Weather Event 16 for Meter 049-2
05/11/2019 17:55 to 05/12/2019 16:45
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.88 IN
Meter volume: 0.22 MG
Model volume: 0.18 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
05/11/2019 16:00
05/11/2019 19:00
05/11/2019 22:00
05/12/2019 01:00
05/12/2019 04:00
05/12/2019 07:00
05/12/2019 10:00
05/12/2019 13:00
05/12/2019 16:00
05/12/2019 19:00



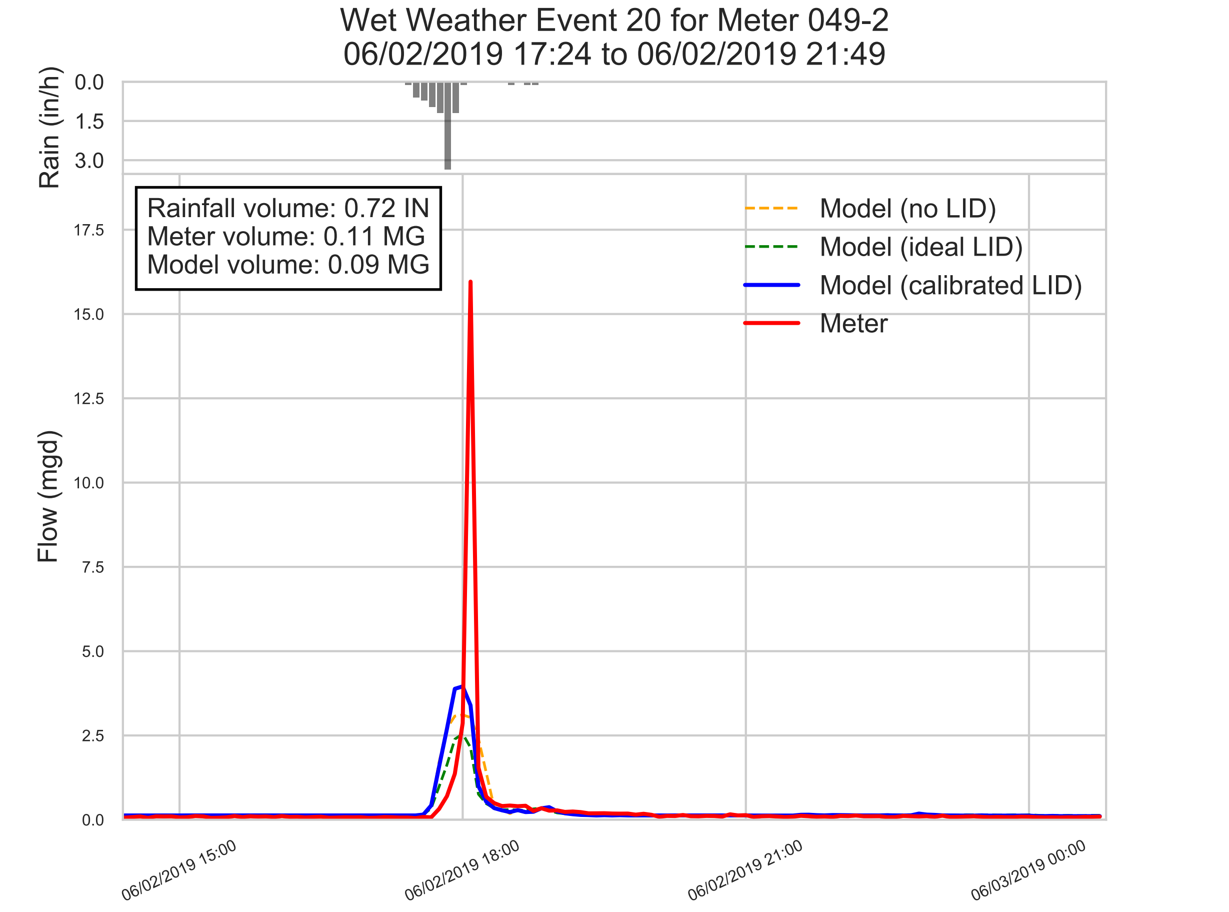
Wet Weather Event 17 for Meter 049-2
05/13/2019 02:19 to 05/13/2019 15:49
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.49 IN
Meter volume: 0.16 MG
Model volume: 0.1 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
05/13/2019 00:00
05/13/2019 03:00
05/13/2019 06:00
05/13/2019 09:00
05/13/2019 12:00
05/13/2019 15:00
05/13/2019 18:00



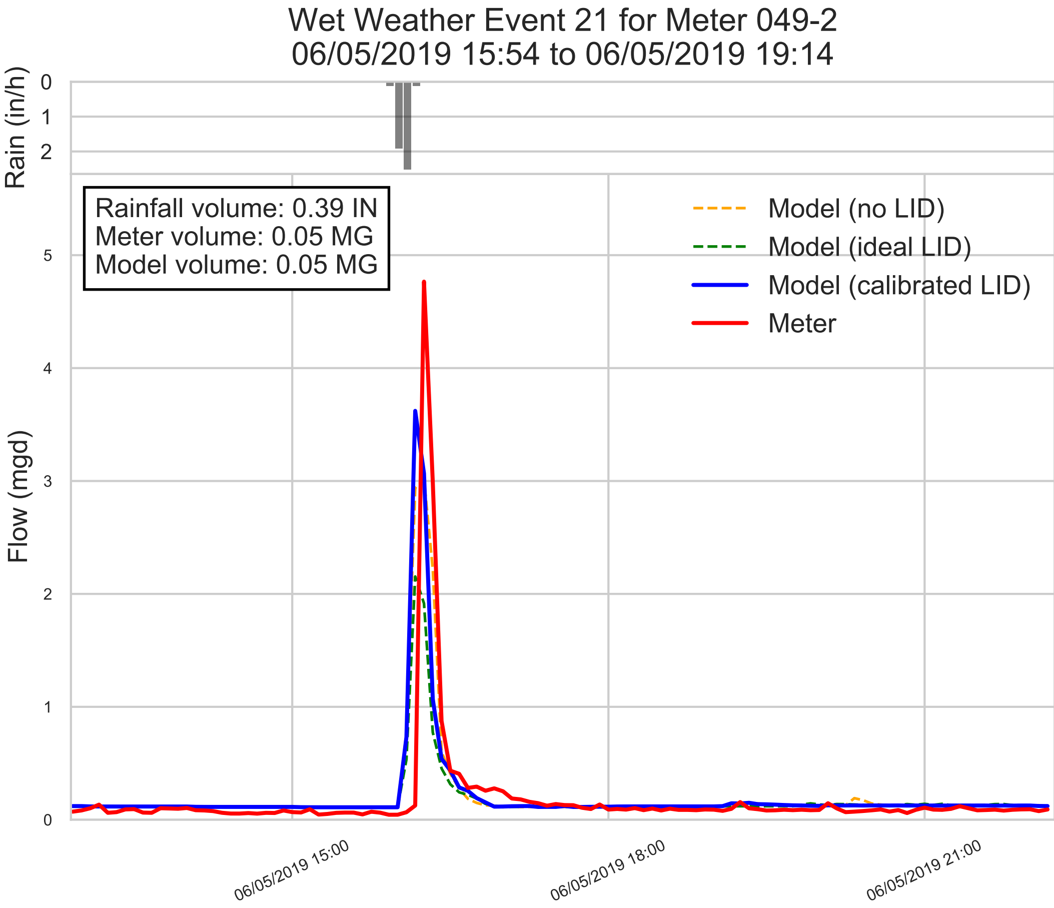
Wet Weather Event 18 for Meter 049-2
05/23/2019 15:40 to 05/23/2019 19:05
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.55 IN
Meter volume: 0.09 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
8
7
6
5
4
3
2
1
0
05/23/2019 15:00
05/23/2019 18:00
05/23/2019 21:00

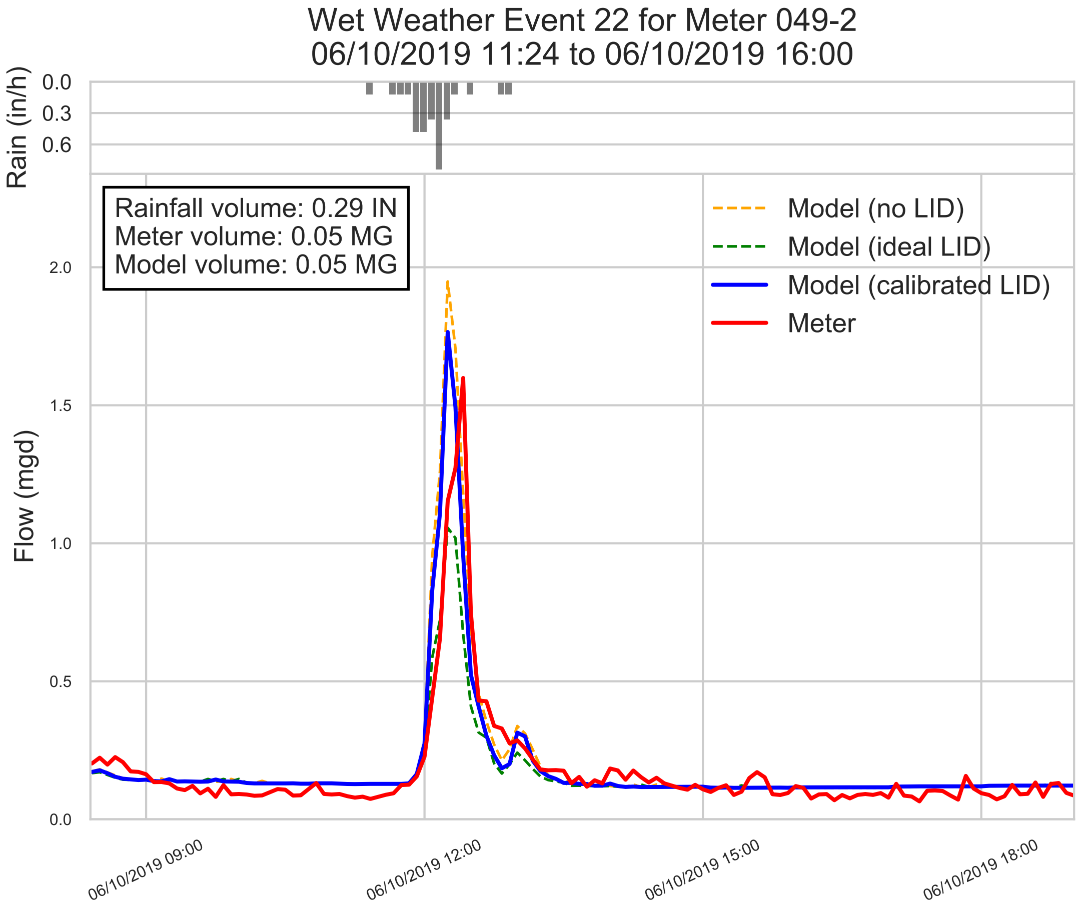


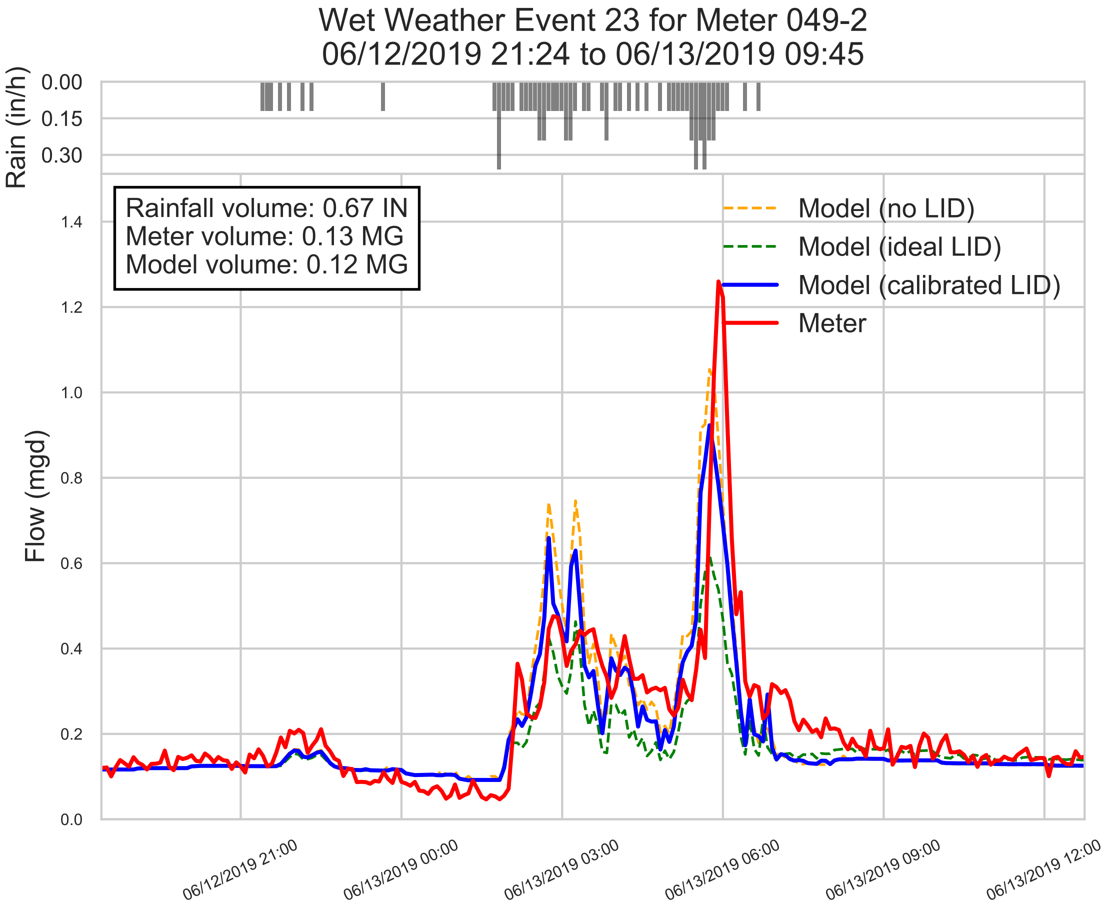
Wet Weather Event 19 for Meter 049-2
05/28/2019 06:29 to 05/28/2019 10:34
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.71 IN
Meter volume: 0.08 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
4
3
2
1
0
05/28/2019 05:00
05/28/2019 08:00
05/28/2019 11:00



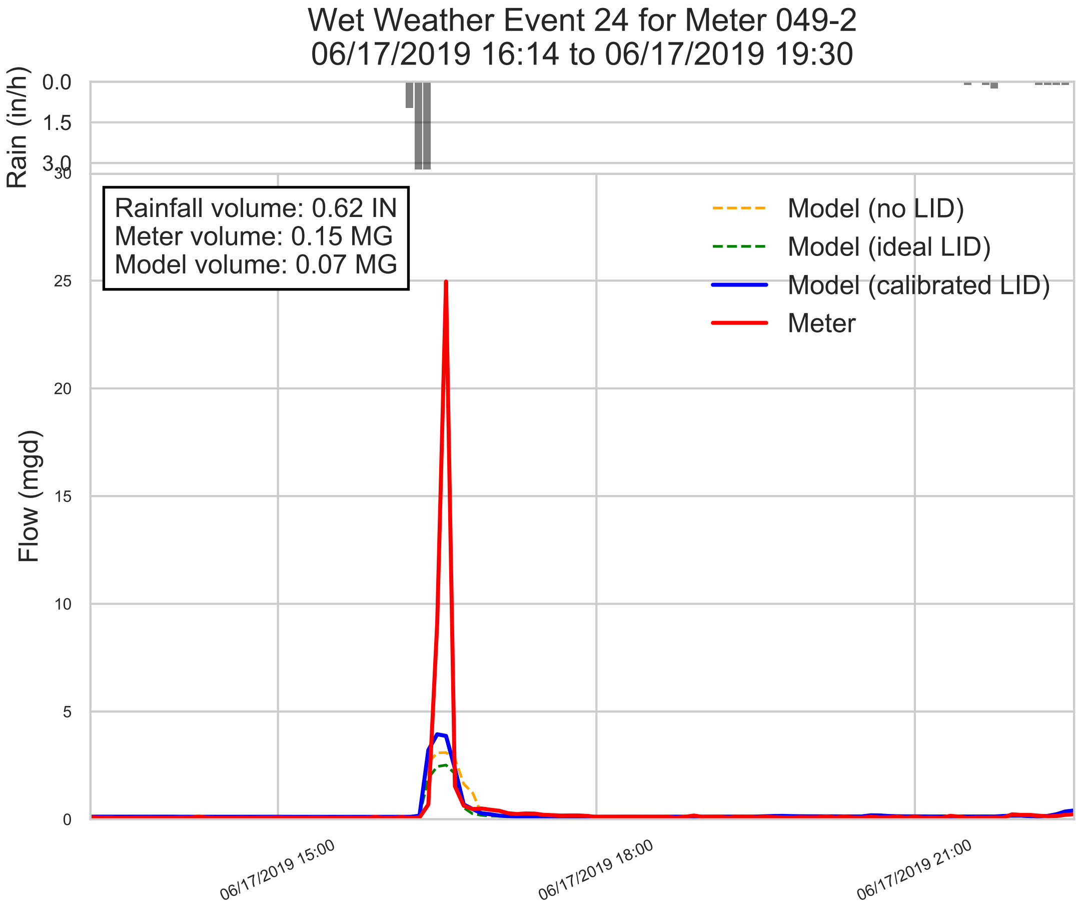
Wet Weather Event 20 for Meter 049-2
06/02/2019 17:24 to 06/02/2019 21:49
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.72 IN
Meter volume: 0.11 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
06/02/2019 15:00
06/02/2019 18:00
06/02/2019 21:00
06/03/2019 00:00


Wet Weather Event 21 for Meter 049-2
06/05/2019 15:54 to 06/05/2019 19:14
Rain (in/h)
0
1
2
Rainfall volume: 0.39 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
06/05/2019 15:00
06/05/2019 18:00
06/05/2019 21:00

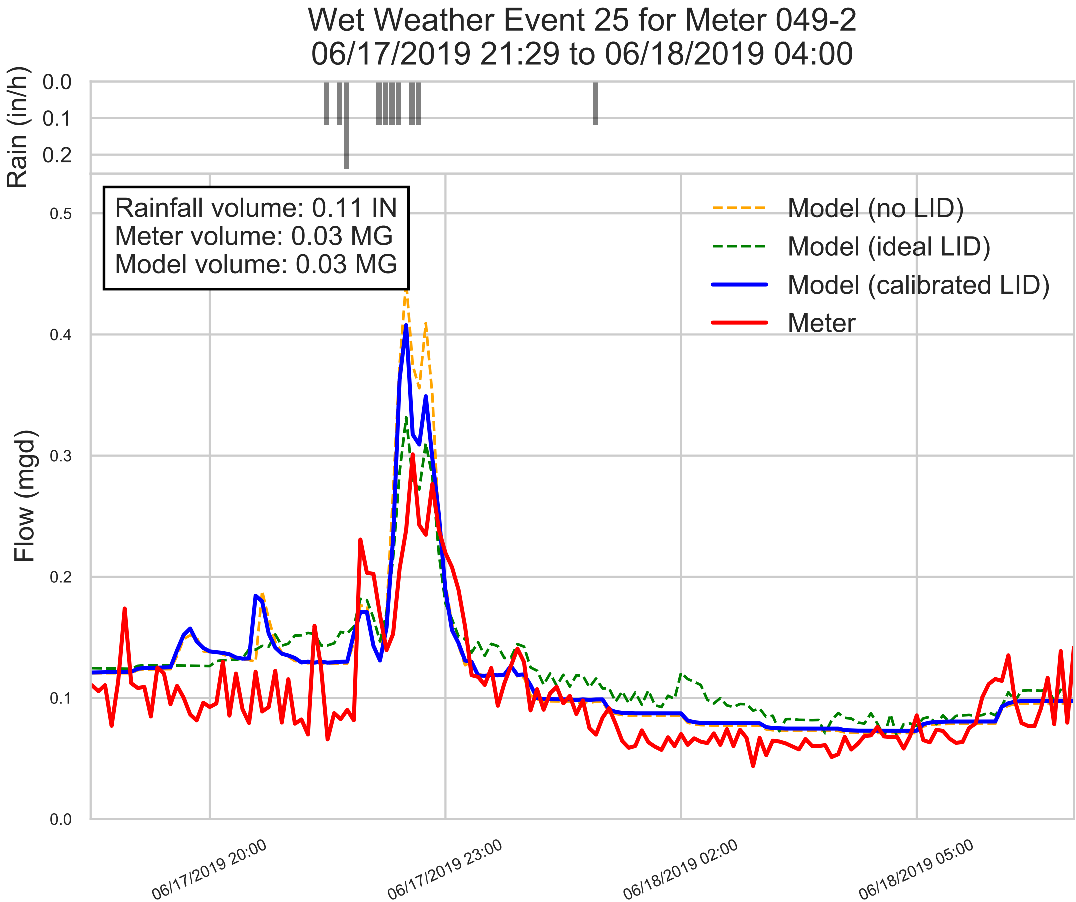

Wet Weather Event 22 for Meter 049-2
06/10/2019 11:24 to 06/10/2019 16:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.29 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
06/10/2019 09:00
06/10/2019 12:00
06/10/2019 15:00
06/10/2019 18:00



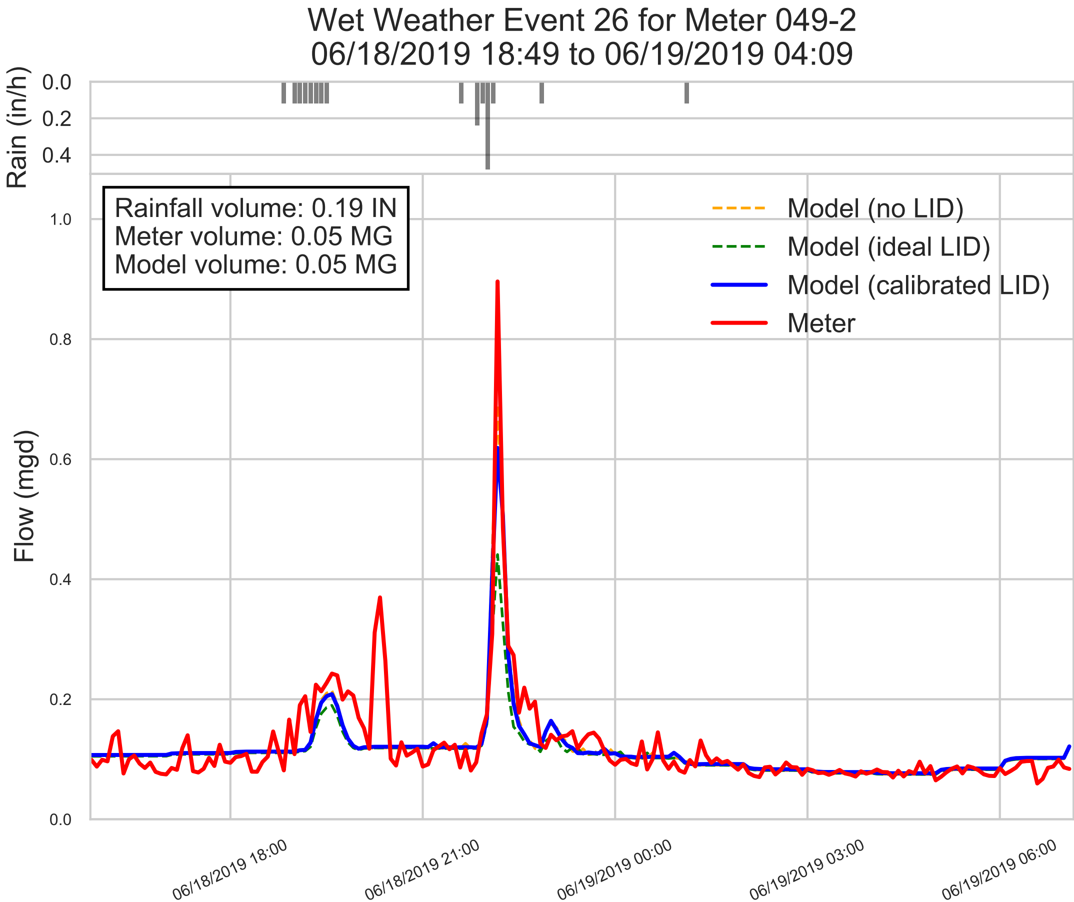
Wet Weather Event 23 for Meter 049-2
06/12/2019 21:24 to 06/13/2019 09:45
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.67 IN
Meter volume: 0.13 MG
Model volume: 0.12 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
06/12/2019 21:00
06/13/2019 00:00
06/13/2019 03:00
06/13/2019 06:00
06/13/2019 09:00
06/13/2019 12:00



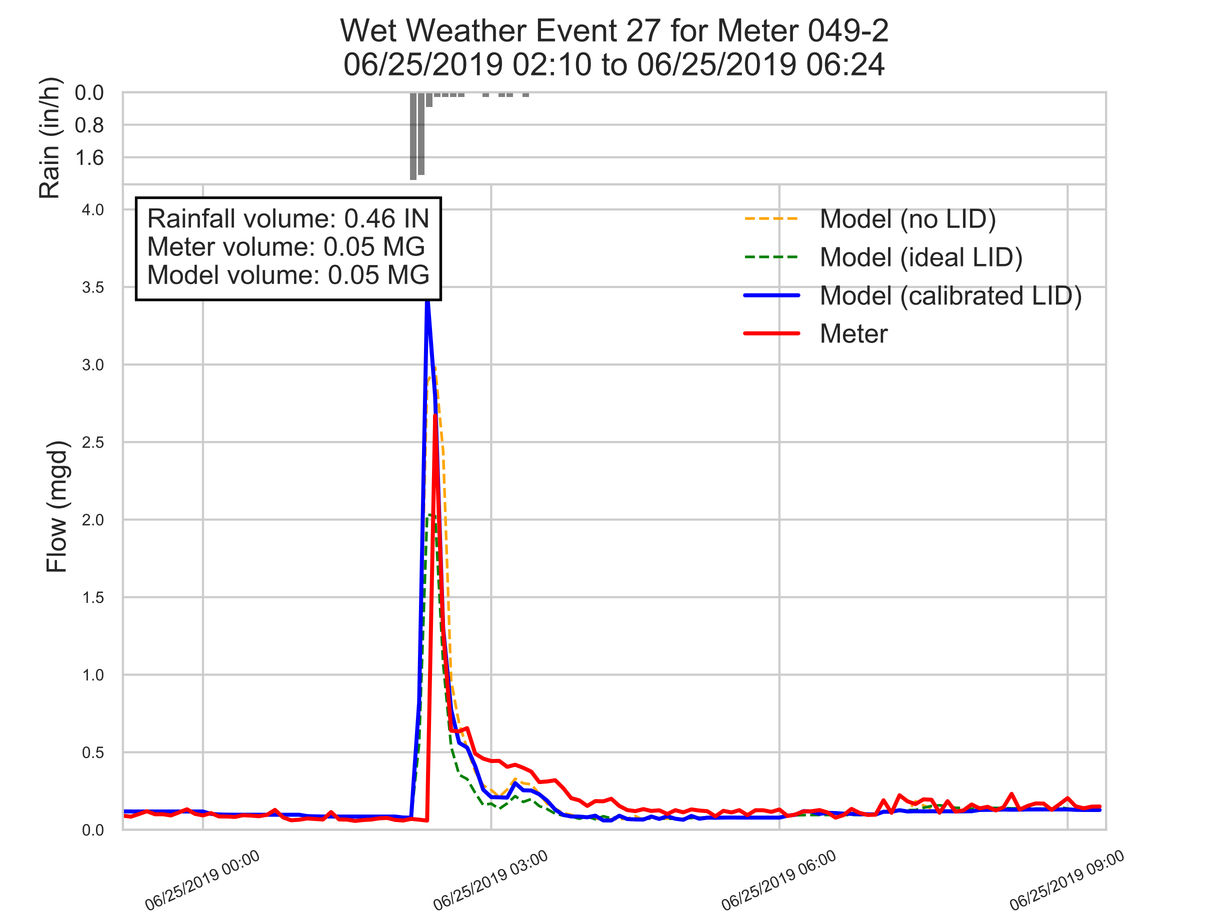
Wet Weather Event 24 for Meter 049-2
06/17/2019 16:14 to 06/17/2019 19:30
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
30
25
20
15
10
5
0
Rainfall volume: 0.62 IN
Meter volume: 0.15 MG
Model volume: 0.07 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
06/17/2019 15:00
06/17/2019 18:00
06/17/2019 21:00



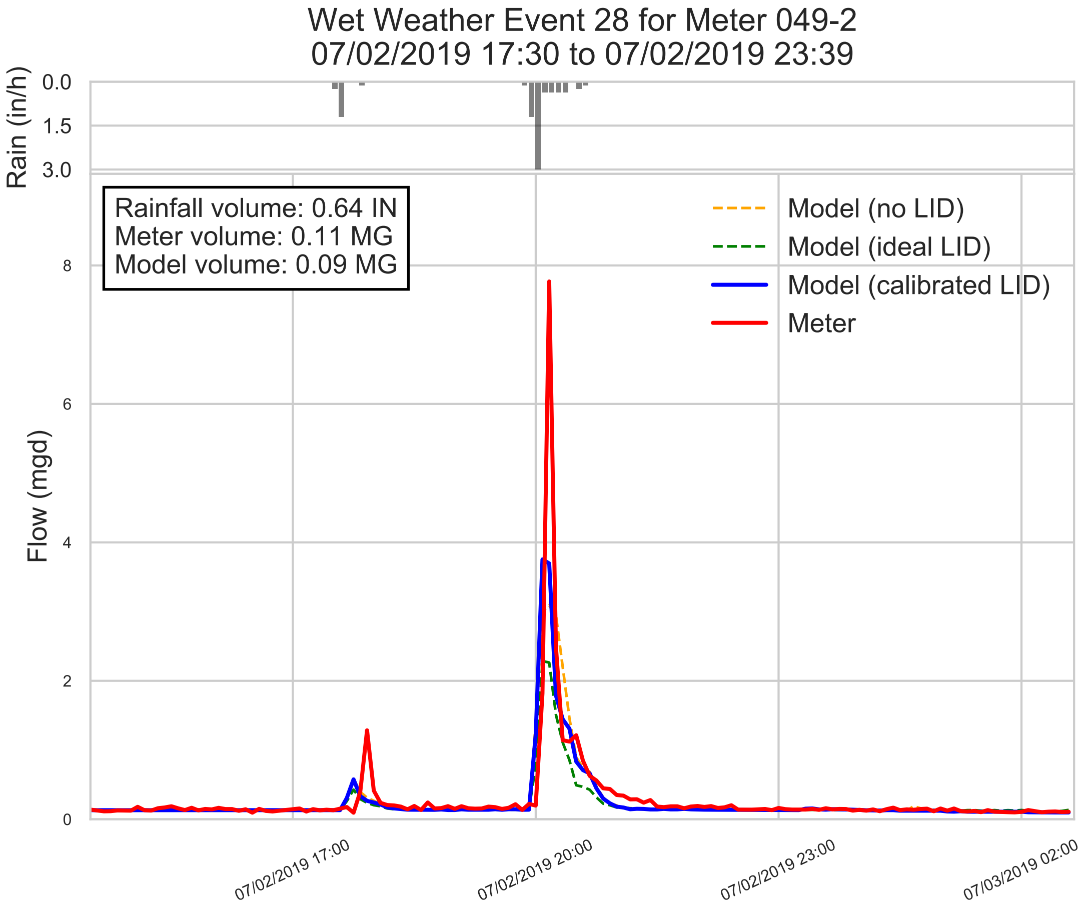
Wet Weather Event 25 for Meter 049-2
06/17/2019 21:29 to 06/18/2019 04:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.11 IN
Meter volume: 0.03 MG
Model volume: 0.03 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
06/17/2019 20:00
06/17/2019 23:00
06/18/2019 02:00
06/18/2019 05:00

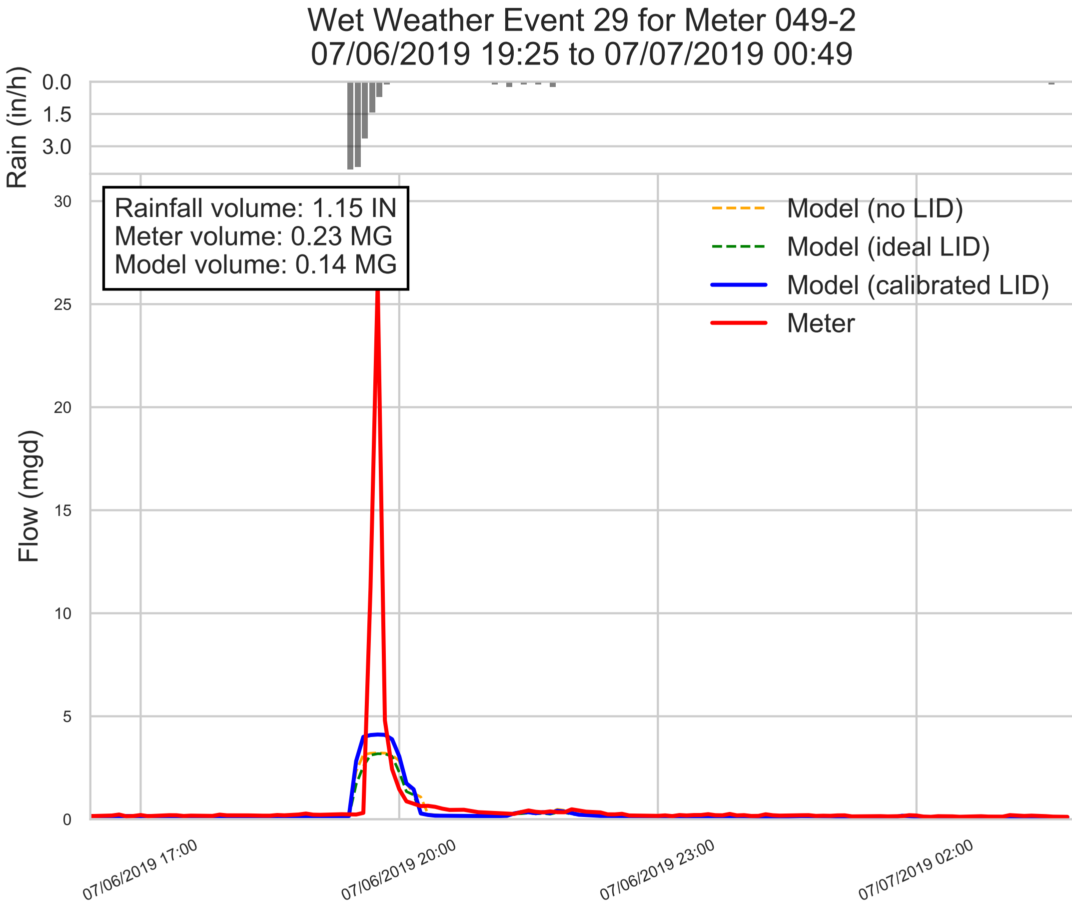


Wet Weather Event 26 for Meter 049-2
06/18/2019 18:49 to 06/19/2019 04:09
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.19 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
06/18/2019 18:00
06/18/2019 21:00
06/19/2019 00:00
06/19/2019 03:00
06/19/2019 06:00

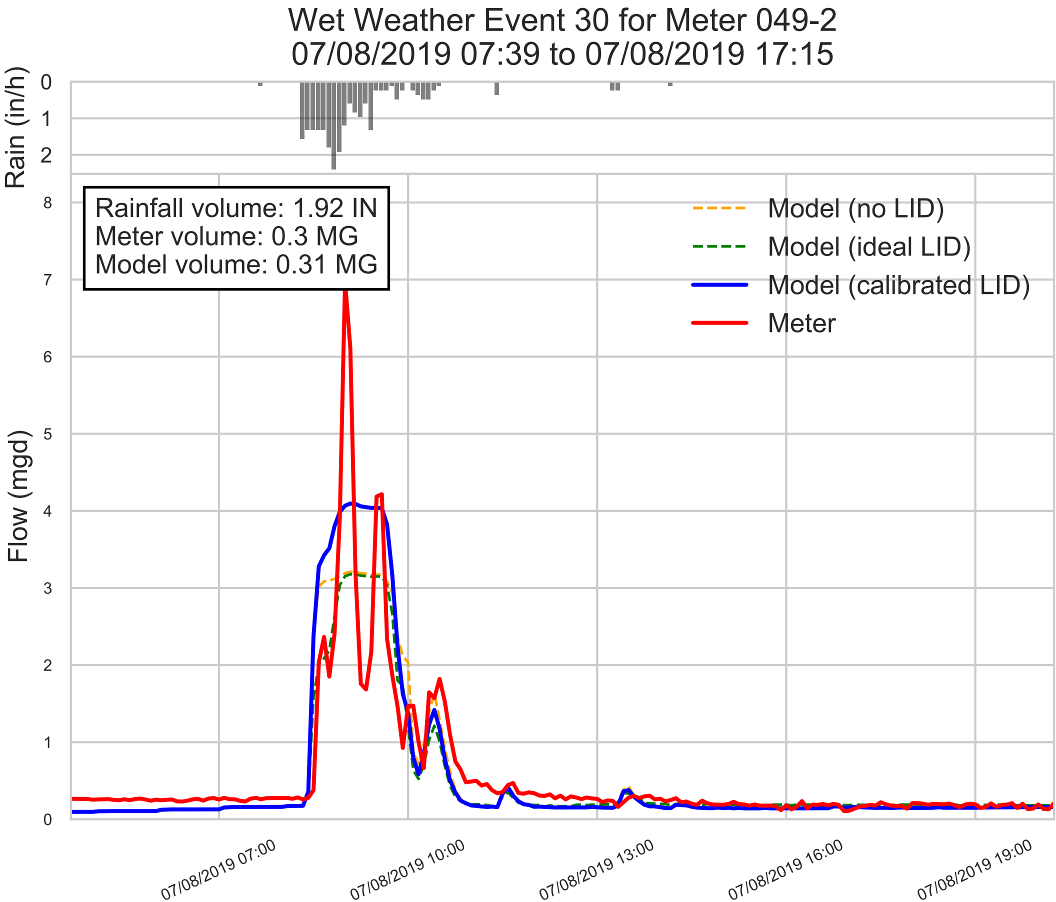


Wet Weather Event 27 for Meter 049-2
06/25/2019 02:10 to 06/25/2019 06:24
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall volume: 0.46 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
06/25/2019 00:00
06/25/2019 03:00
06/25/2019 06:00
06/25/2019 09:00

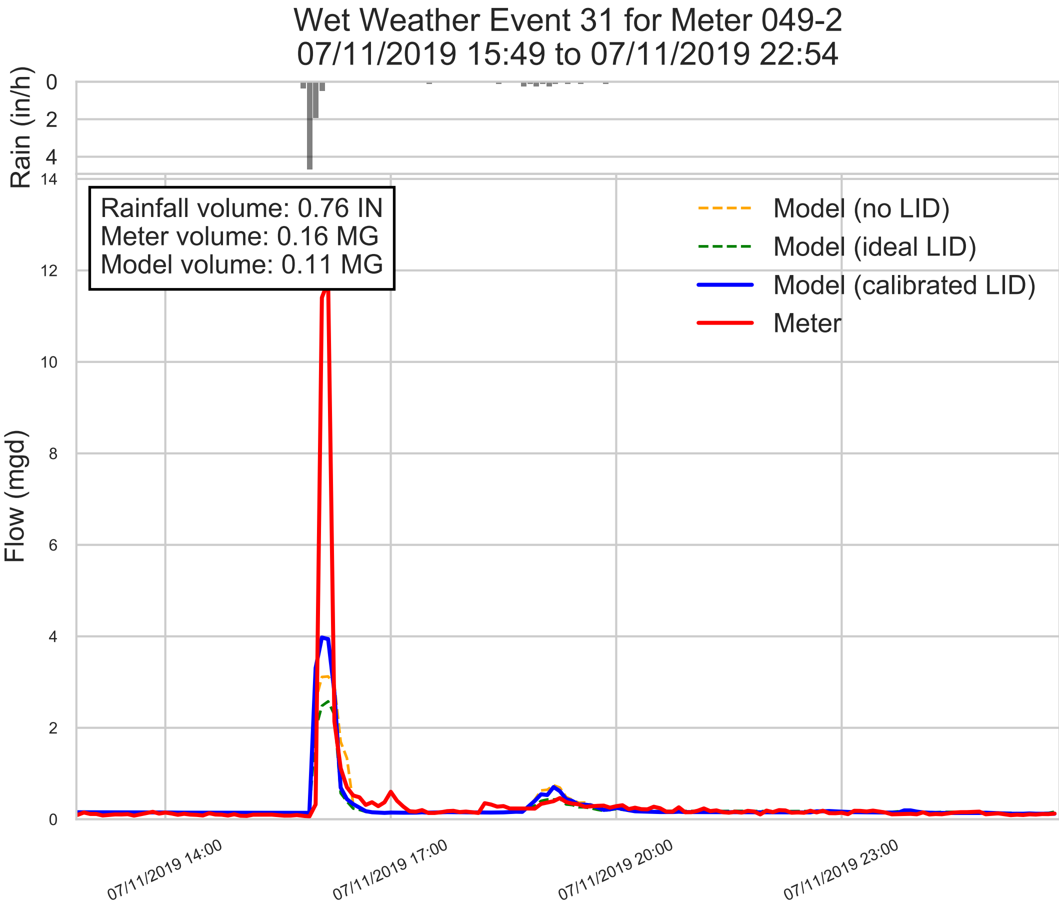

Wet Weather Event 28 for Meter 049-2
07/02/2019 17:30 to 07/02/2019 23:39
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.64 IN
Meter volume: 0.11 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
2
4
6
8
07/02/2019 17:00
07/02/2019 20:00
07/02/2019 23:00
07/03/2019 02:00

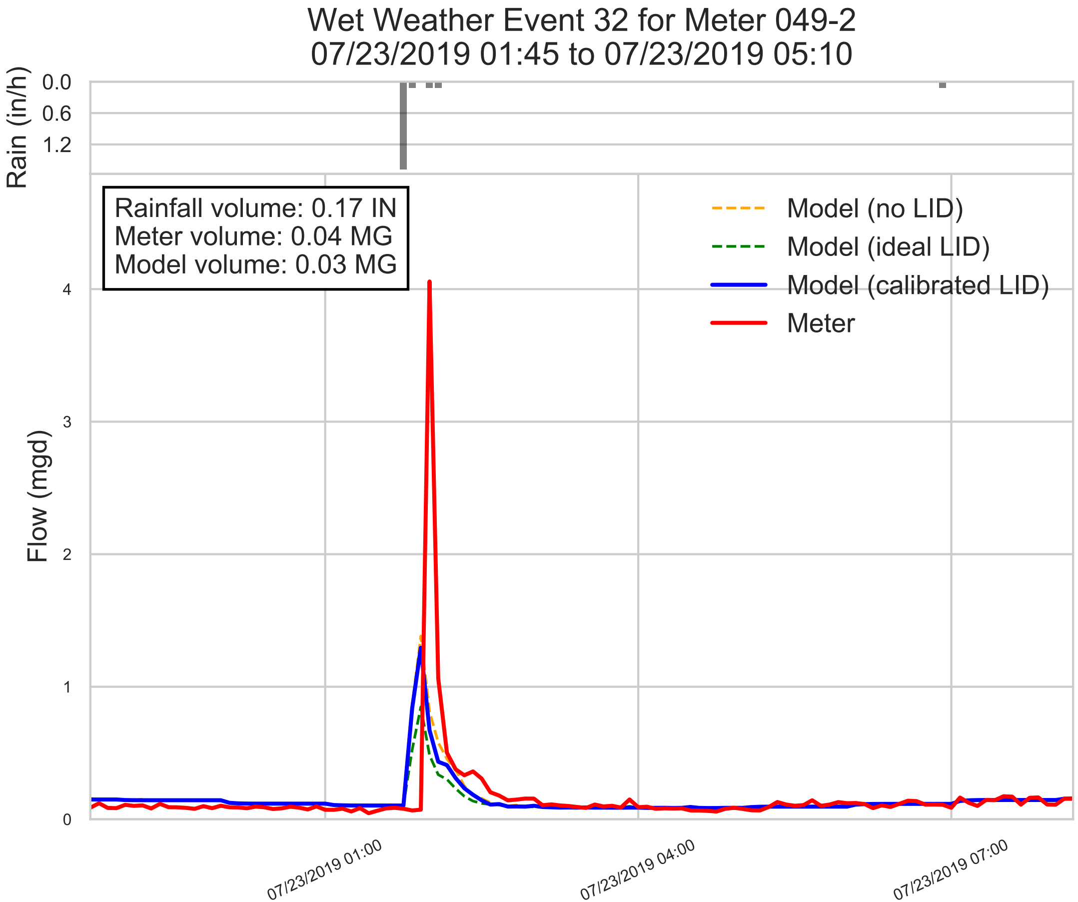


Wet Weather Event 29 for Meter 049-2
07/06/2019 19:25 to 07/07/2019 00:49
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.15 IN
Meter volume: 0.23 MG
Model volume: 0.14 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
30
25
20
15
10
5
0
07/06/2019 17:00
07/06/2019 20:00
07/06/2019 23:00
07/07/2019 02:00

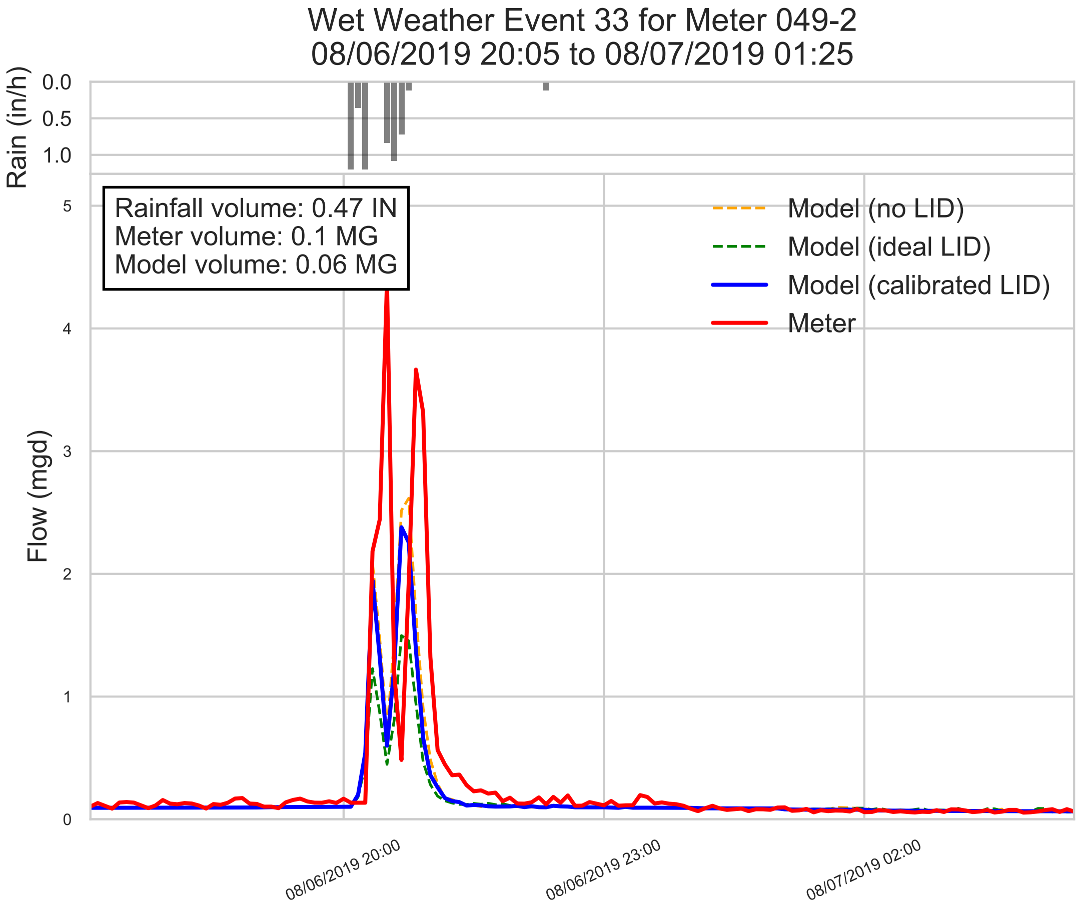


Wet Weather Event 30 for Meter 049-2
07/08/2019 07:39 to 07/08/2019 17:15
Rain (in/h)
0
1
2
Flow (mgd)
8
7
6
5
4
3
2
1
0
Rainfall volume: 1.92 IN
Meter volume: 0.3 MG
Model volume: 0.31 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
07/08/2019 07:00
07/08/2019 10:00
07/08/2019 13:00
07/08/2019 16:00
07/08/2019 19:00

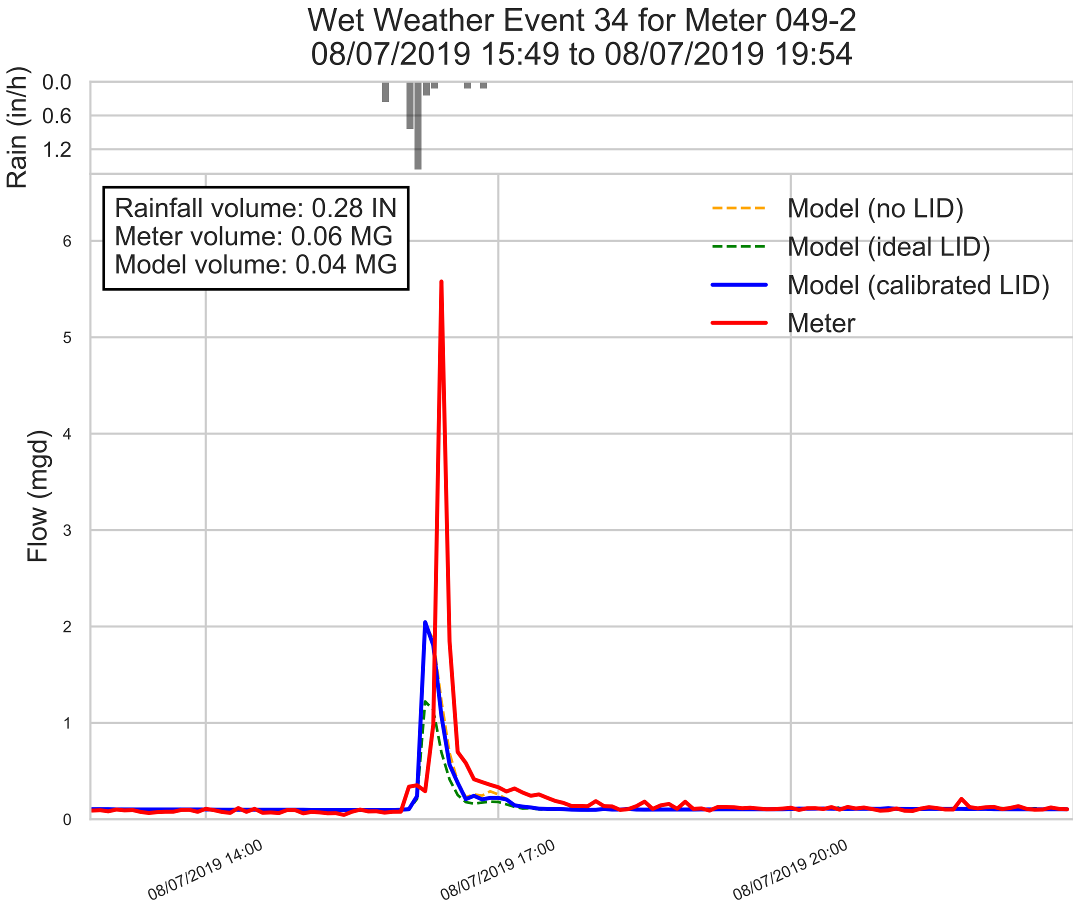

Wet Weather Event 31 for Meter 049-2
07/11/2019 15:49 to 07/11/2019 22:54
Rain (in/h)
0
2
4
Flow (mgd)
14
12
10
8
6
4
2
0
Rainfall volume: 0.76 IN
Meter volume: 0.16 MG
Model volume: 0.11 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
07/11/2019 14:00
07/11/2019 17:00
07/11/2019 20:00
07/11/2019 23:00

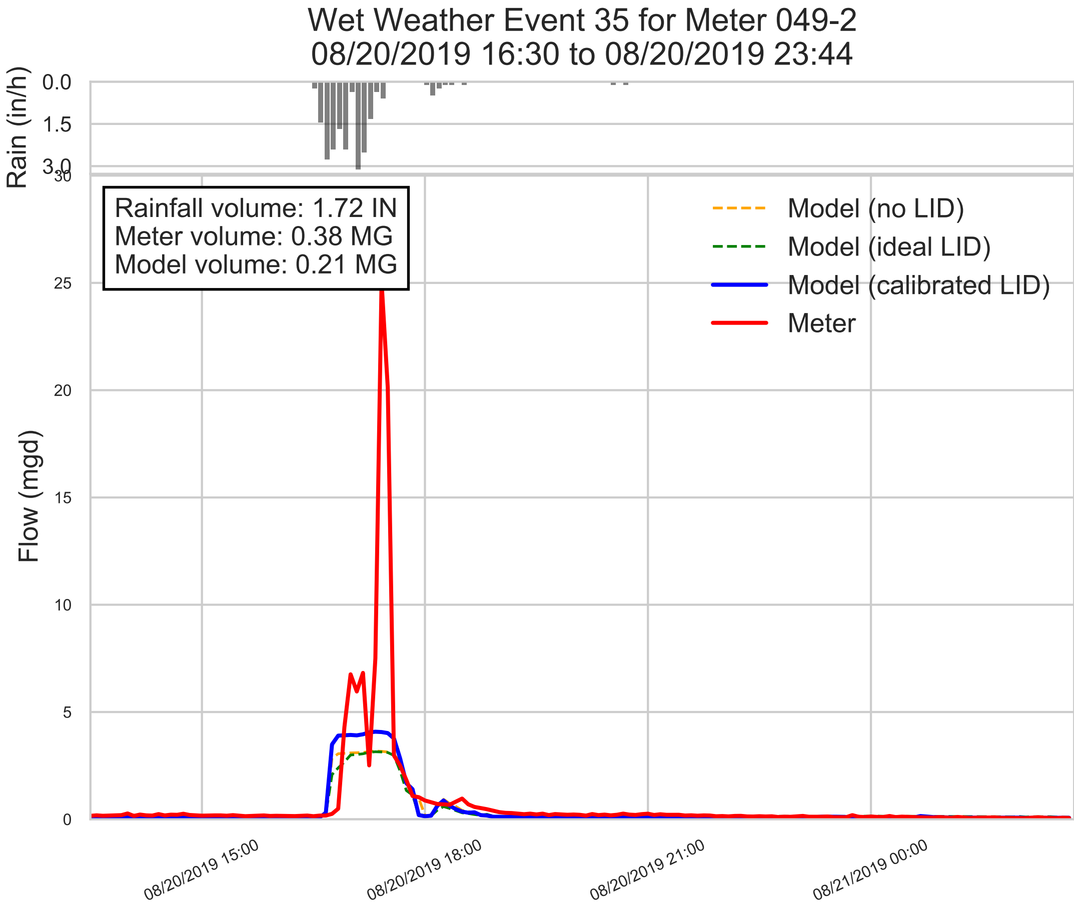


Wet Weather Event 32 for Meter 049-2
07/23/2019 01:45 to 07/23/2019 05:10
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.17 IN
Meter volume: 0.04 MG
Model volume: 0.03 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
4
3
2
1
0
07/23/2019 01:00
07/23/2019 04:00
07/23/2019 07:00

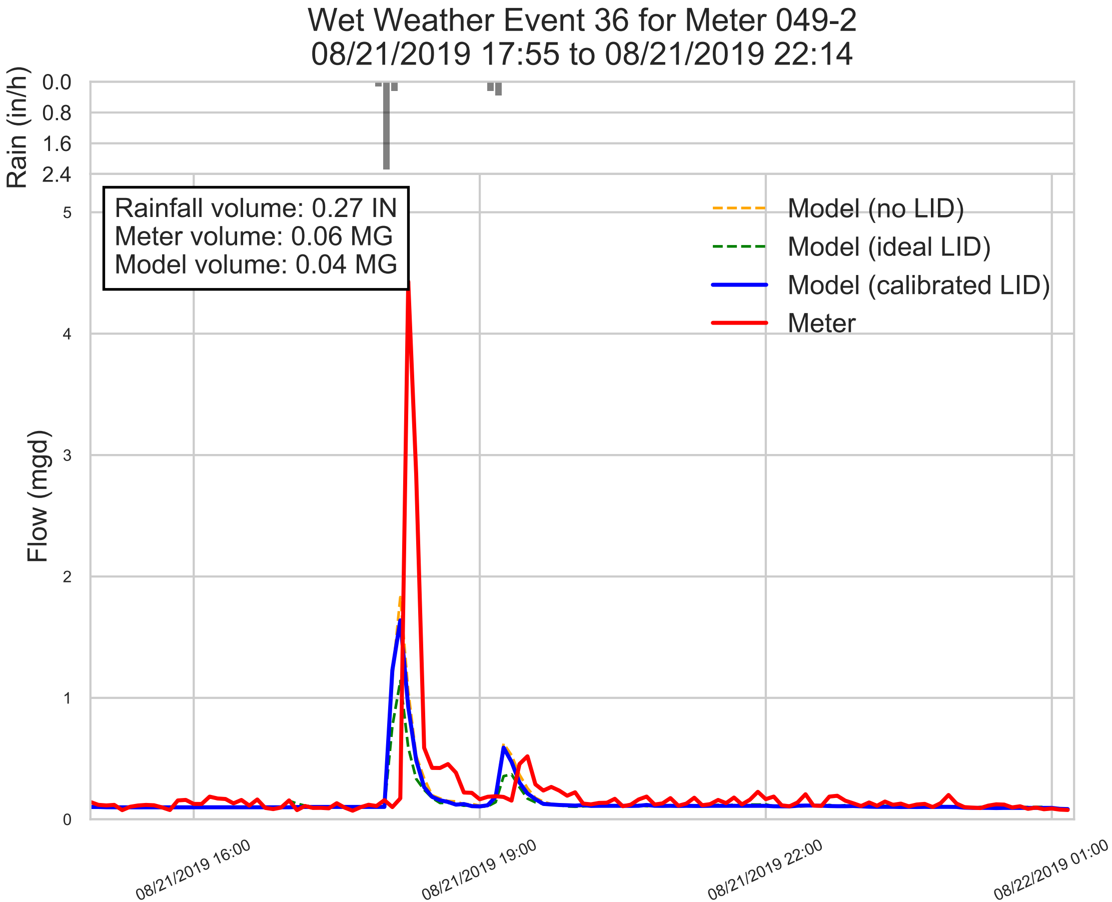


Wet Weather Event 33 for Meter 049-2
08/06/2019 20:05 to 08/07/2019 01:25
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.47 IN
Meter volume: 0.1 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
5
4
3
2
1
0
08/06/2019 20:00
08/06/2019 23:00
08/07/2019 02:00

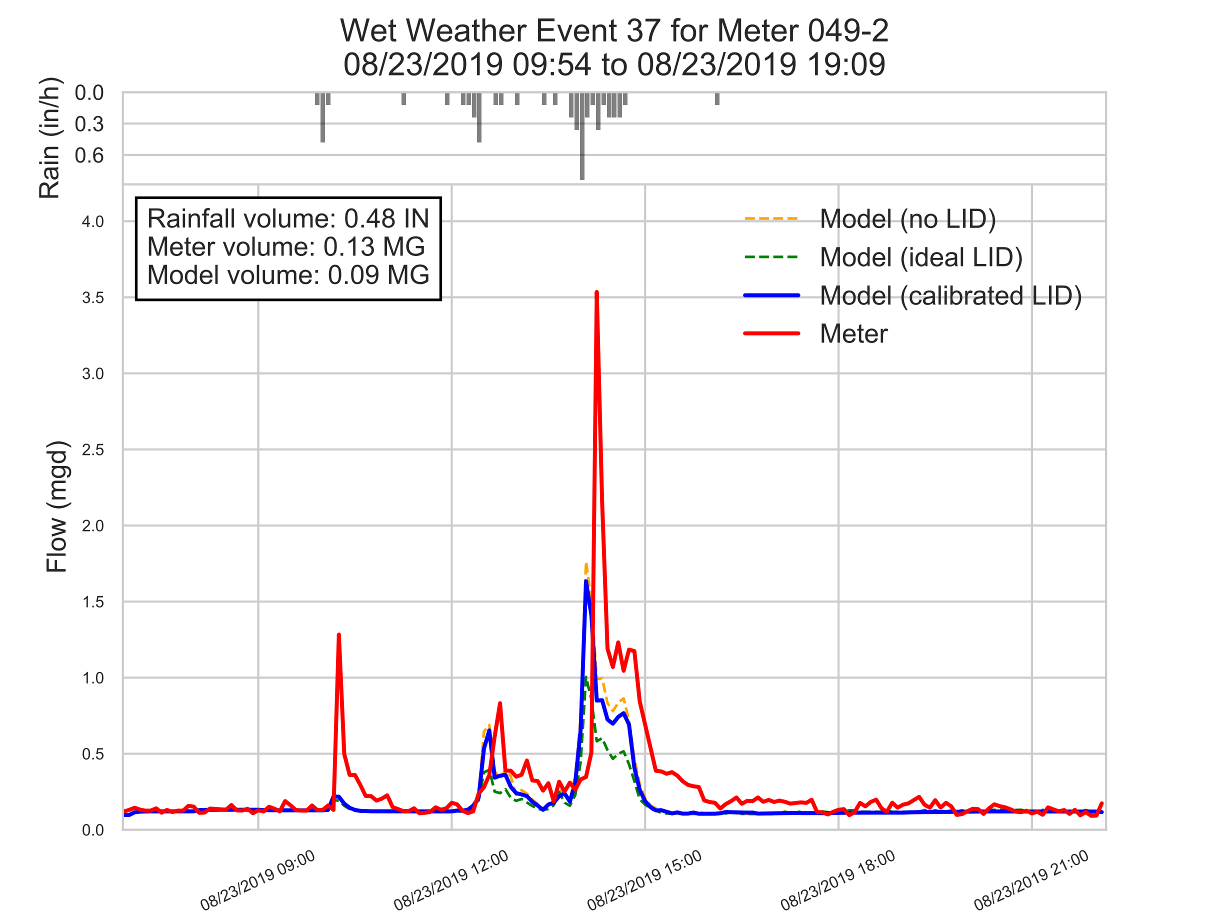

Wet Weather Event 34 for Meter 049-2
08/07/2019 15:49 to 08/07/2019 19:54
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.28 IN
Meter volume: 0.06 MG
Model volume: 0.04 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
6
5
4
3
2
1
0
08/07/2019 14:00
08/07/2019 17:00
08/07/2019 20:00



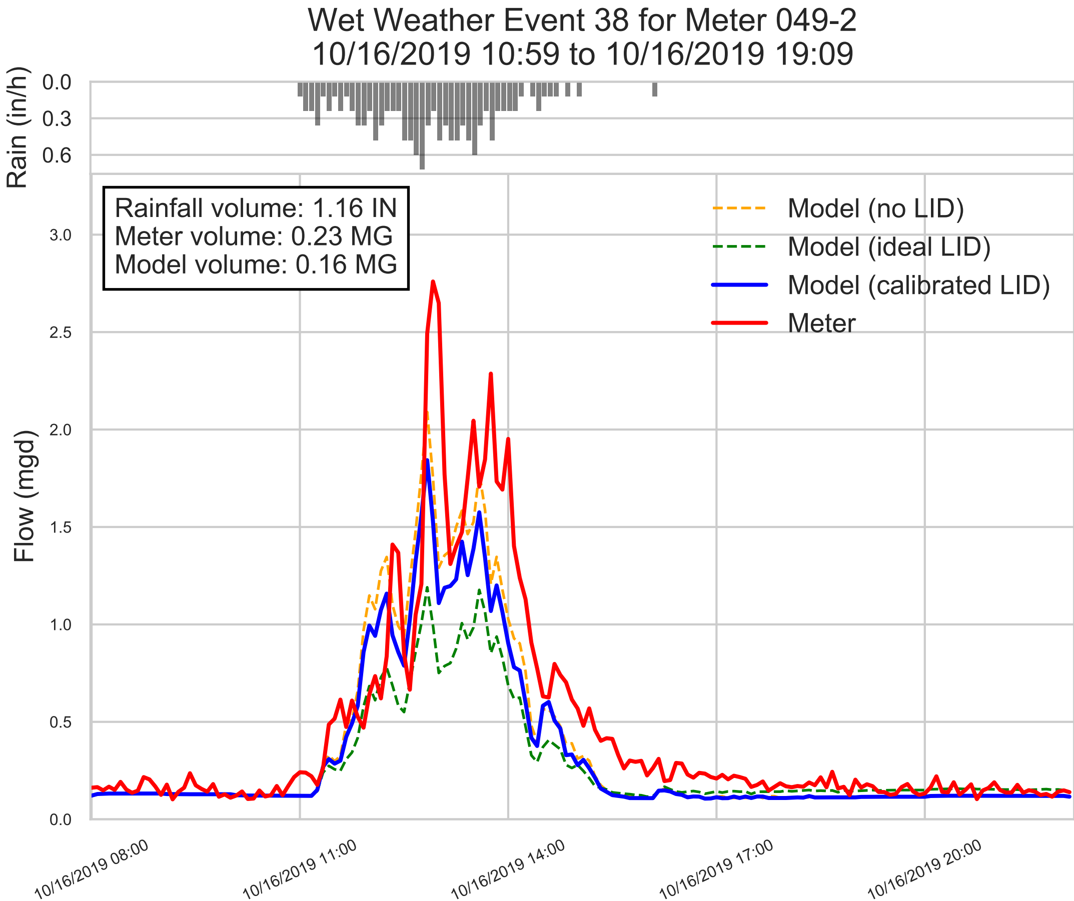
Wet Weather Event 35 for Meter 049-2
08/20/2019 16:30 to 08/20/2019 23:44
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
30
25
20
15
10
5
0
Rainfall volume: 1.72 IN
Meter volume: 0.38 MG
Model volume: 0.21 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
08/20/2019 15:00
08/20/2019 18:00
08/20/2019 21:00
08/21/2019 00:00

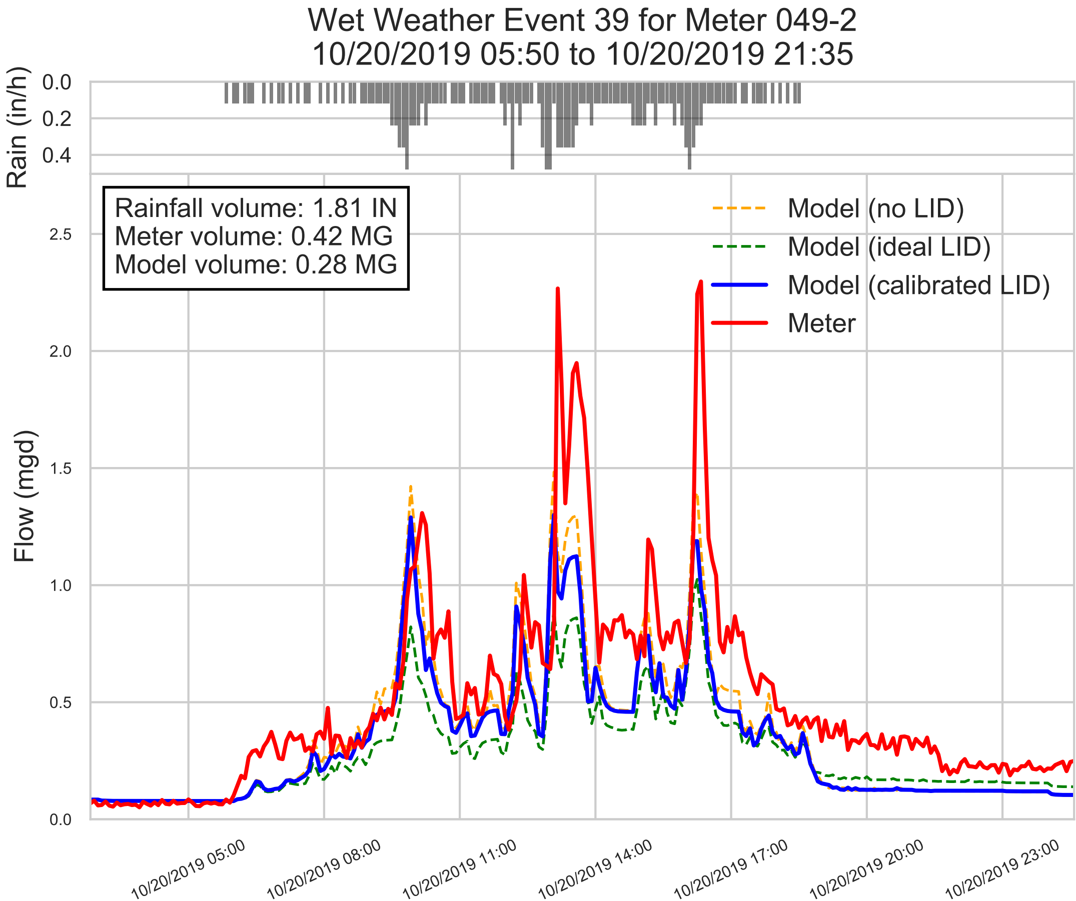


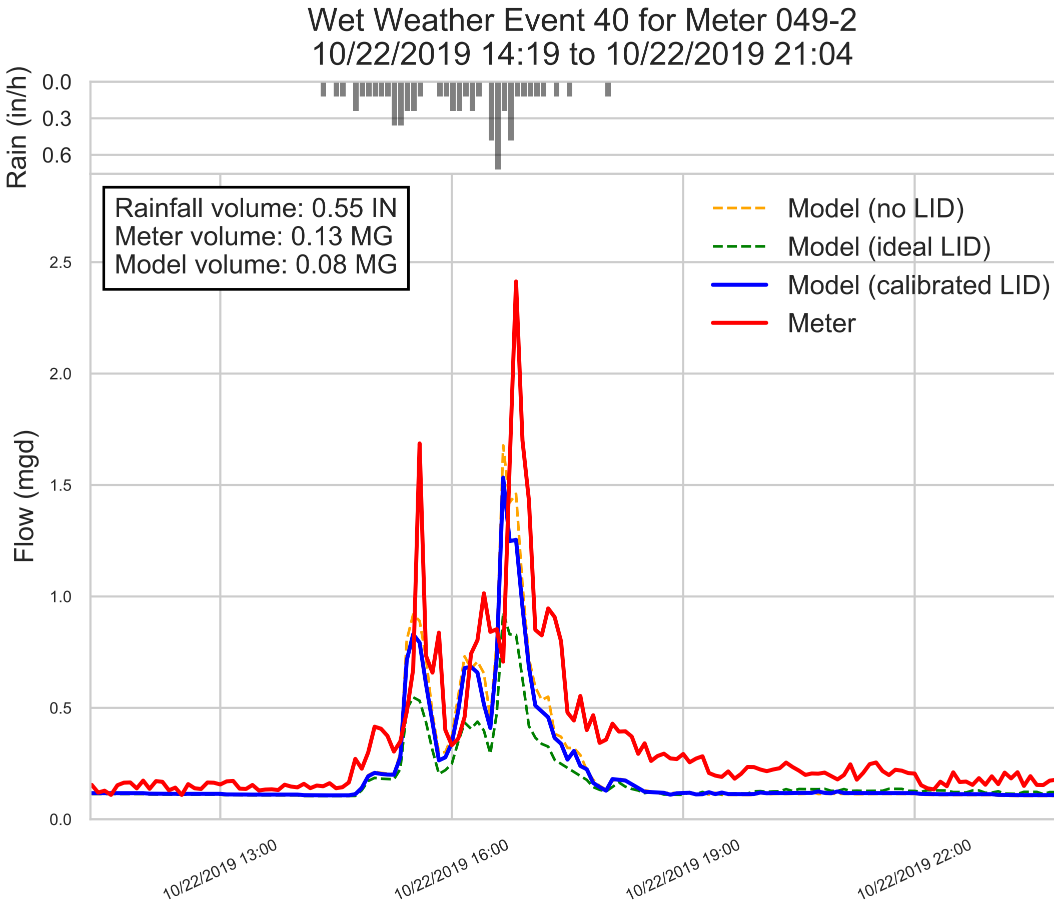
Wet Weather Event 36 for Meter 049-2
08/21/2019 17:55 to 08/21/2019 22:14
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 0.27 IN
Meter volume: 0.06 MG
Model volume: 0.04 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
5
4
3
2
1
0
08/21/2019 16:00
08/21/2019 19:00
08/21/2019 22:00
08/22/2019 01:00



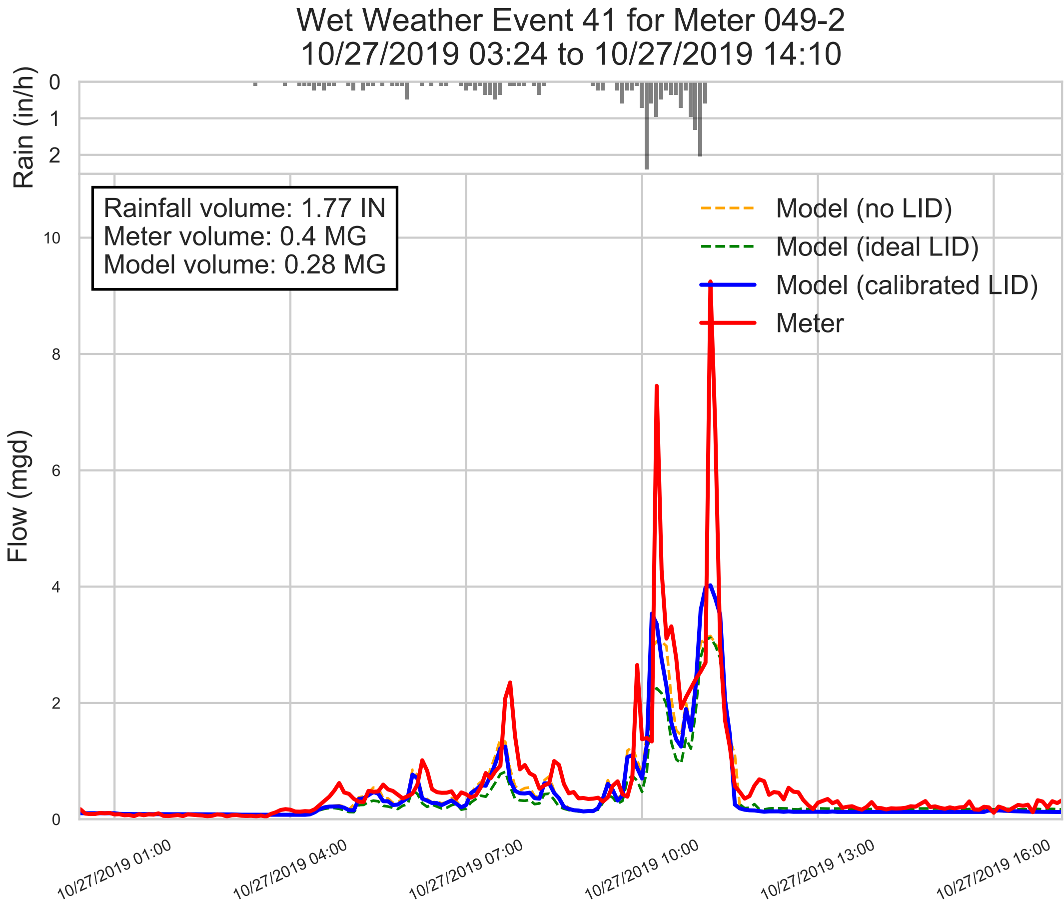
Wet Weather Event 37 for Meter 049-2
08/23/2019 09:54 to 08/23/2019 19:09
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.48 IN
Meter volume: 0.13 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
08/23/2019 09:00
08/23/2019 12:00
08/23/2019 15:00
08/23/2019 18:00
08/23/2019 21:00


Wet Weather Event 38 for Meter 049-2
10/16/2019 10:59 to 10/16/2019 19:09
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 1.16 IN
Meter volume: 0.23 MG
Model volume: 0.16 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/16/2019 08:00
10/16/2019 11:00
10/16/2019 14:00
10/16/2019 17:00
10/16/2019 20:00

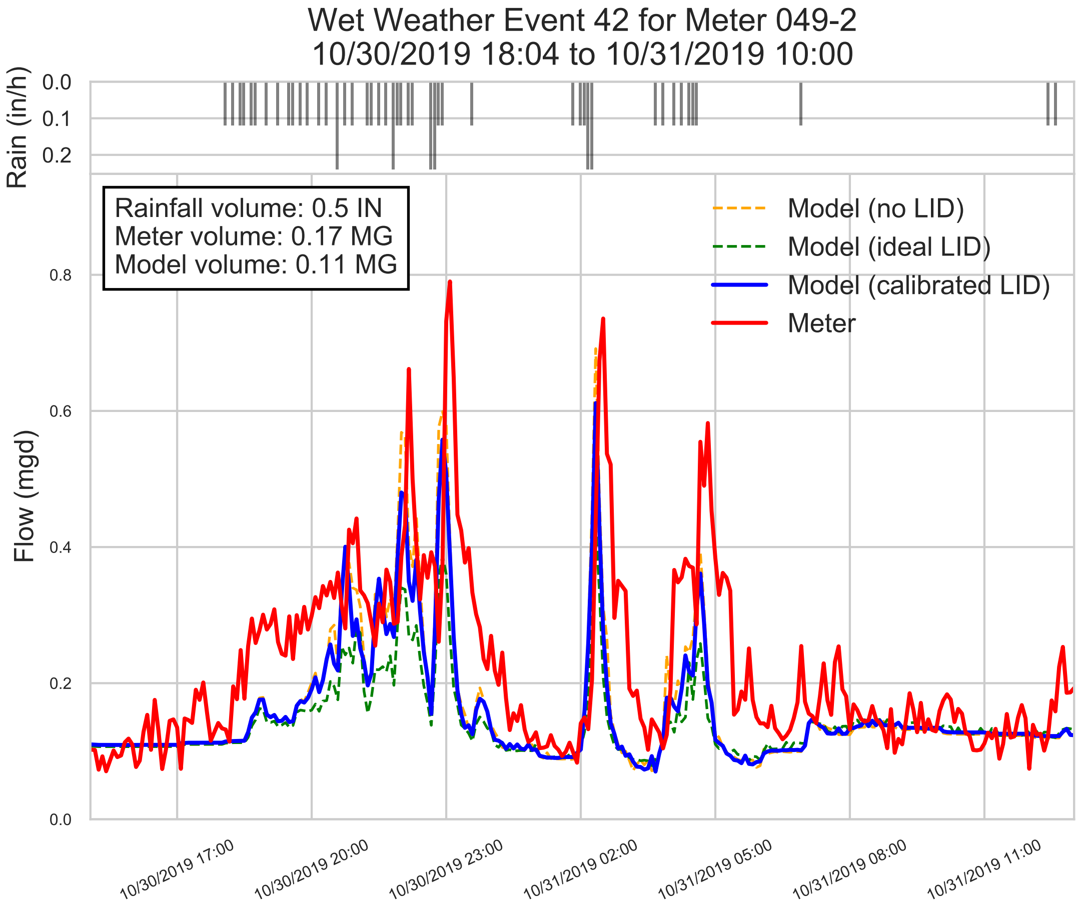

Wet Weather Event 39 for Meter 049-2
10/20/2019 05:50 to 10/20/2019 21:35
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 1.81 IN
Meter volume: 0.42 MG
Model volume: 0.28 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
10/20/2019 05:00
10/20/2019 08:00
10/20/2019 11:00
10/20/2019 14:00
10/20/2019 17:00
10/20/2019 20:00
10/20/2019 23:00



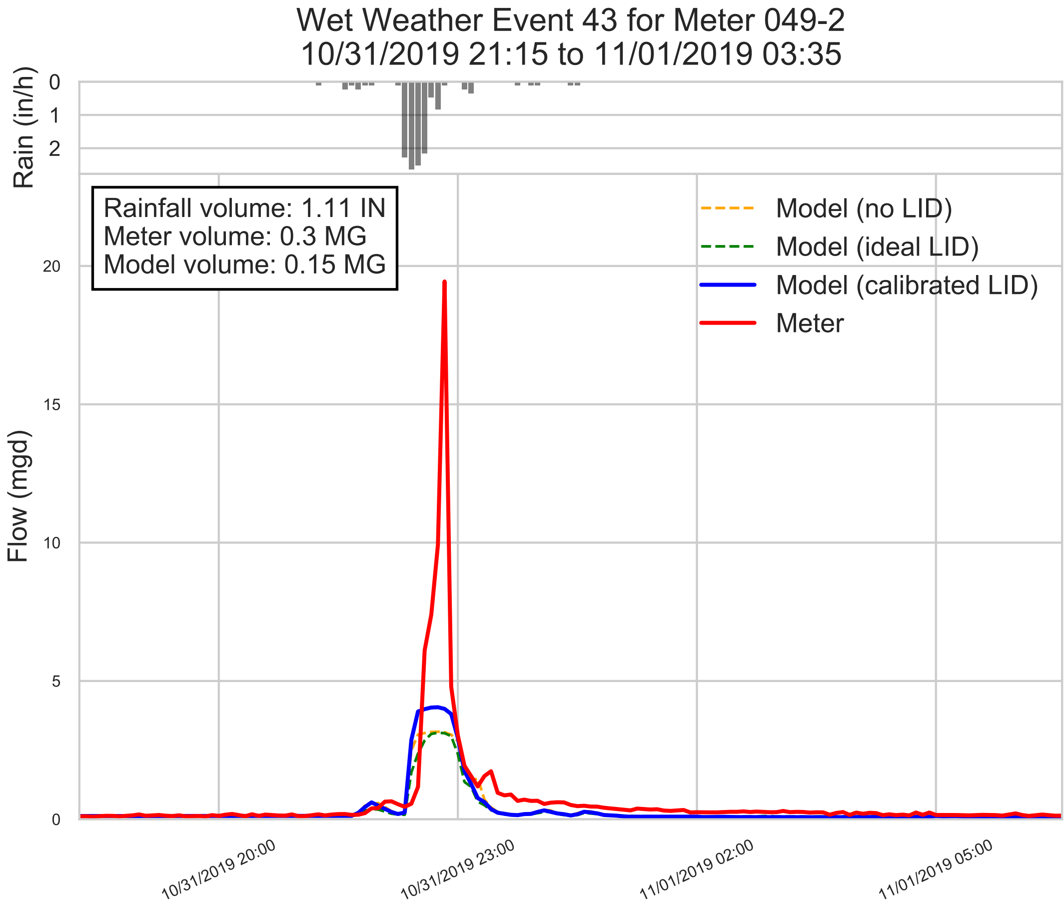
Wet Weather Event 40 for Meter 049-2
10/22/2019 14:19 to 10/22/2019 21:04
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.55 IN
Meter volume: 0.13 MG
Model volume: 0.08 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
10/22/2019 13:00
10/22/2019 16:00
10/22/2019 19:00
10/22/2019 22:00



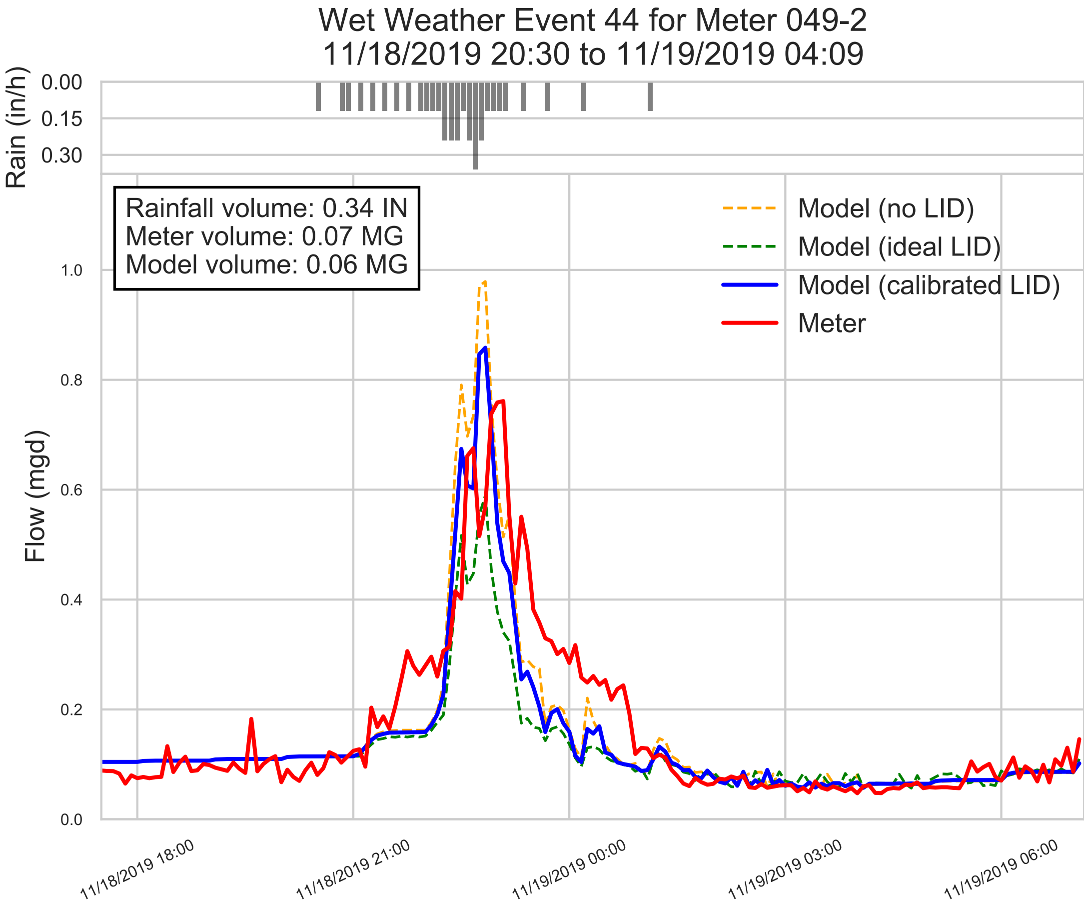
Wet Weather Event 41 for Meter 049-2
10/27/2019 03:24 to 10/27/2019 14:10
Rain (in/h)
0
1
2
Rainfall volume: 1.77 IN
Meter volume: 0.4 MG
Model volume: 0.28 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
2
4
6
8
10
10/27/2019 01:00
10/27/2019 04:00
10/27/2019 07:00
10/27/2019 10:00
10/27/2019 13:00
10/27/2019 16:00



Wet Weather Event 42 for Meter 049-2
10/30/2019 18:04 to 10/31/2019 10:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.5 IN
Meter volume: 0.17 MG
Model volume: 0.11 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
10/30/2019 17:00
10/30/2019 20:00
10/30/2019 23:00
10/31/2019 02:00
10/31/2019 05:00
10/31/2019 08:00
10/31/2019 11:00

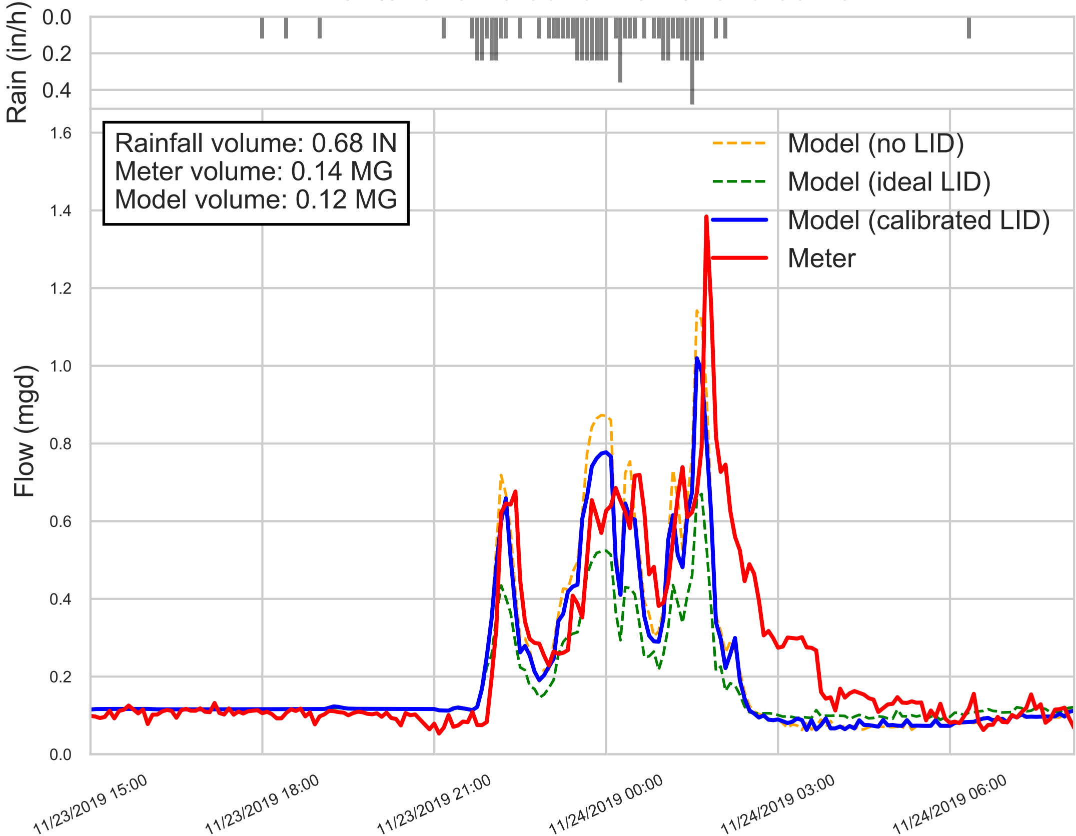


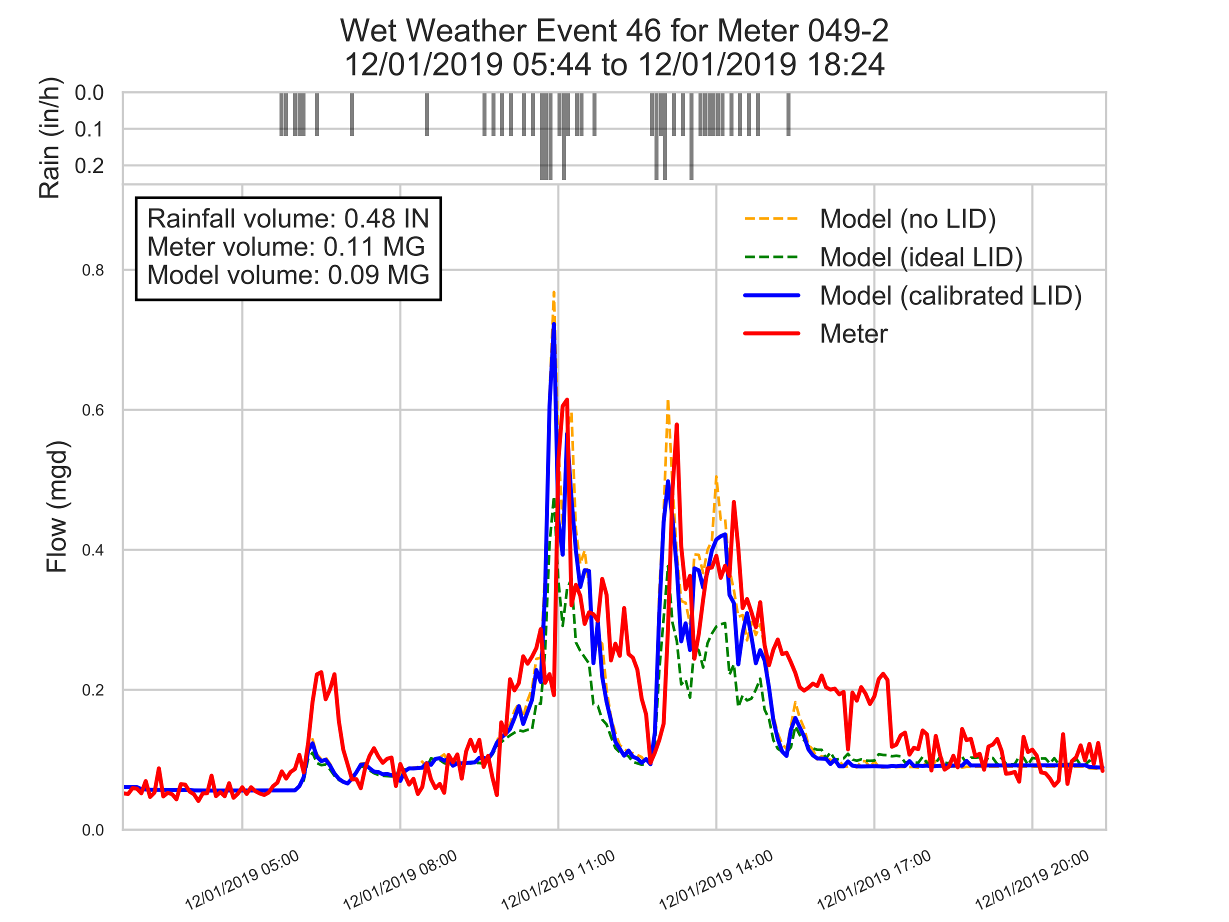
Wet Weather Event 43 for Meter 049-2
10/31/2019 21:15 to 11/01/2019 03:35
Rain (in/h)
0
1
2
Rainfall volume: 1.11 IN
Meter volume: 0.3 MG
Model volume: 0.15 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
20
15
10
5
0
10/31/2019 20:00
10/31/2019 23:00
11/01/2019 02:00
11/01/2019 05:00



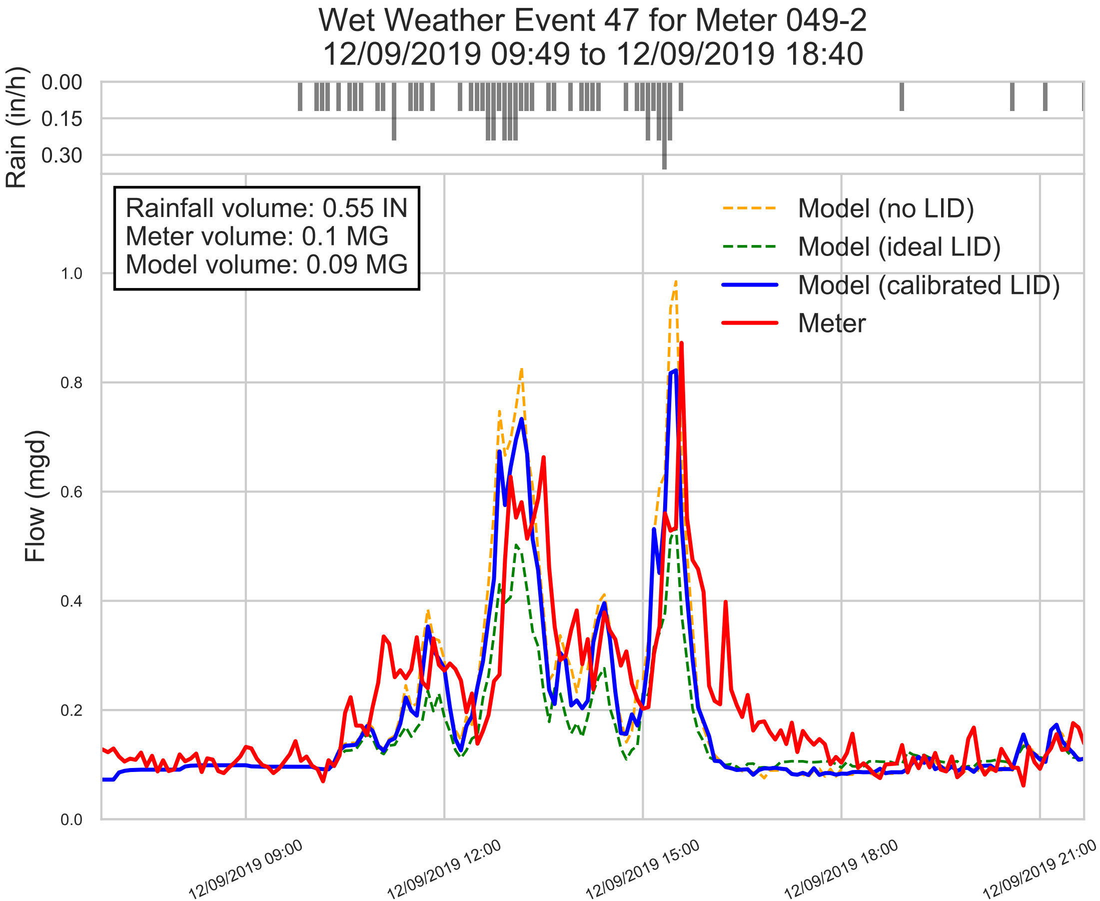
Wet Weather Event 44 for Meter 049-2
11/18/2019 20:30 to 11/19/2019 04:09
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.34 IN
Meter volume: 0.07 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
11/18/2019 18:00
11/18/2019 21:00
11/19/2019 00:00
11/19/2019 03:00
11/19/2019 06:00

Wet Weather Event 45 for Meter 049-2
11/23/2019 18:00 to 11/24/2019 05:10

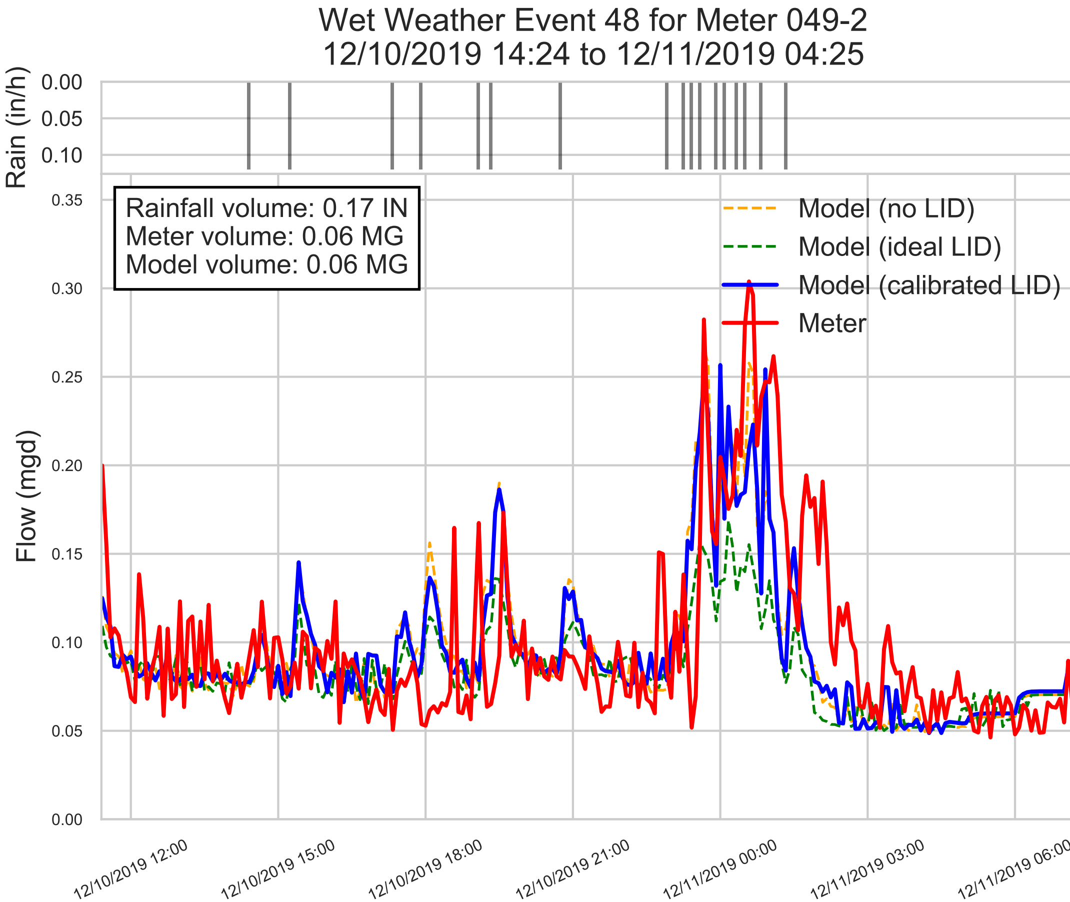




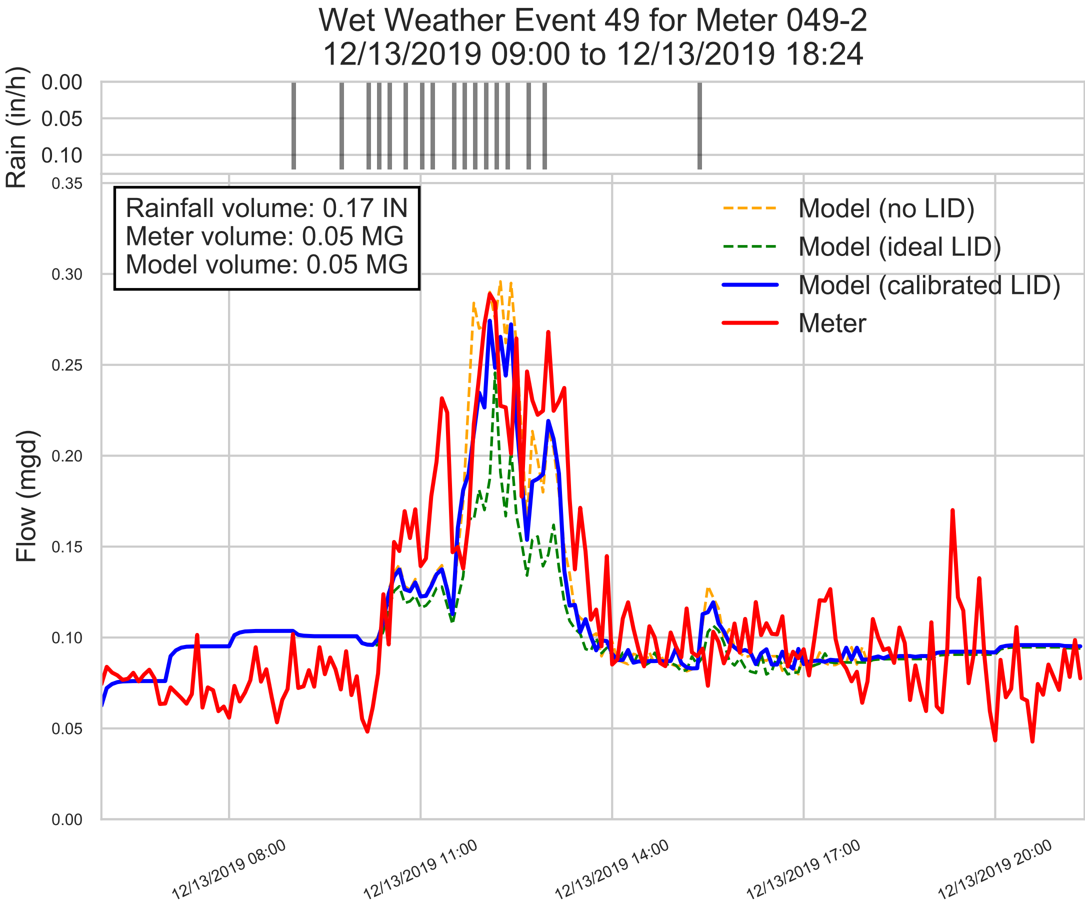
Wet Weather Event 46 for Meter 049-2
12/01/2019 05:44 to 12/01/2019 18:24
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.48 IN
Meter volume: 0.11 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
12/01/2019 05:00
12/01/2019 08:00
12/01/2019 11:00
12/01/2019 14:00
12/01/2019 17:00
12/01/2019 20:00



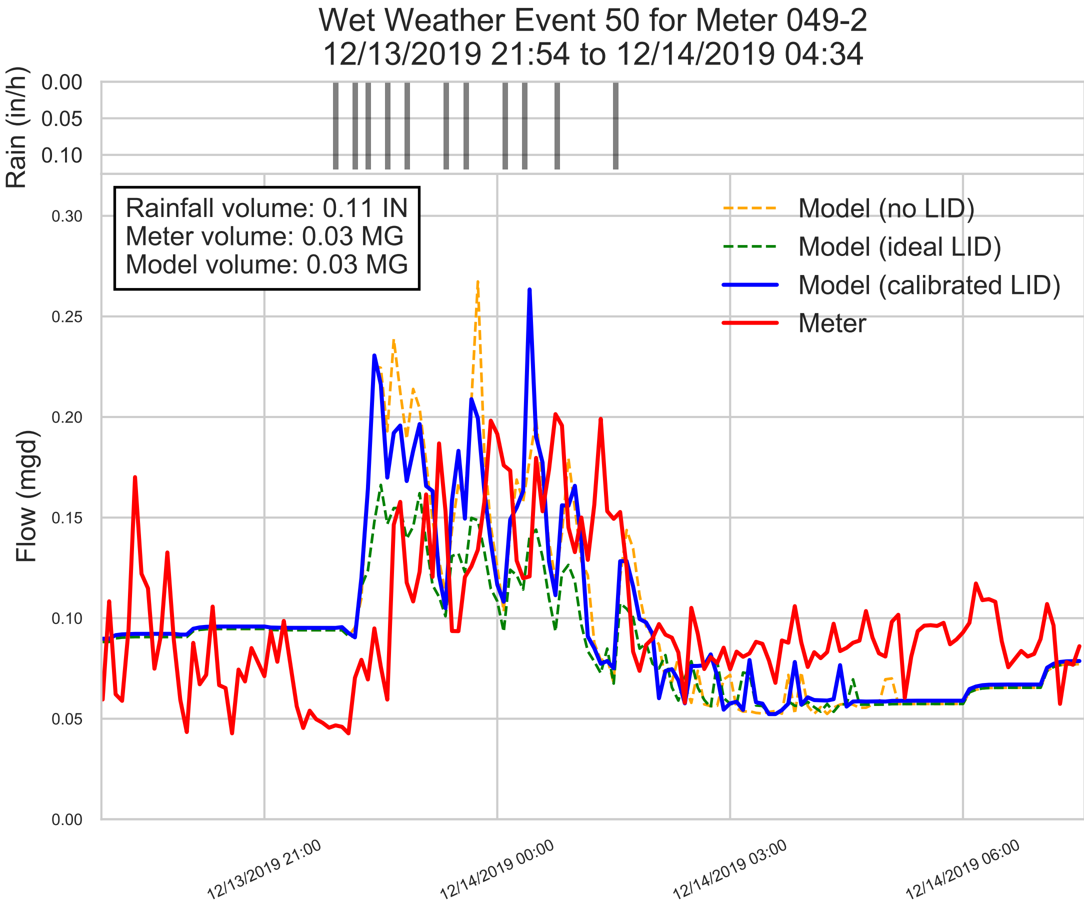
Wet Weather Event 47 for Meter 049-2
12/09/2019 09:49 to 12/09/2019 18:40
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.55 IN
Meter volume: 0.1 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
12/09/2019 09:00
12/09/2019 12:00
12/09/2019 15:00
12/09/2019 18:00
12/09/2019 21:00



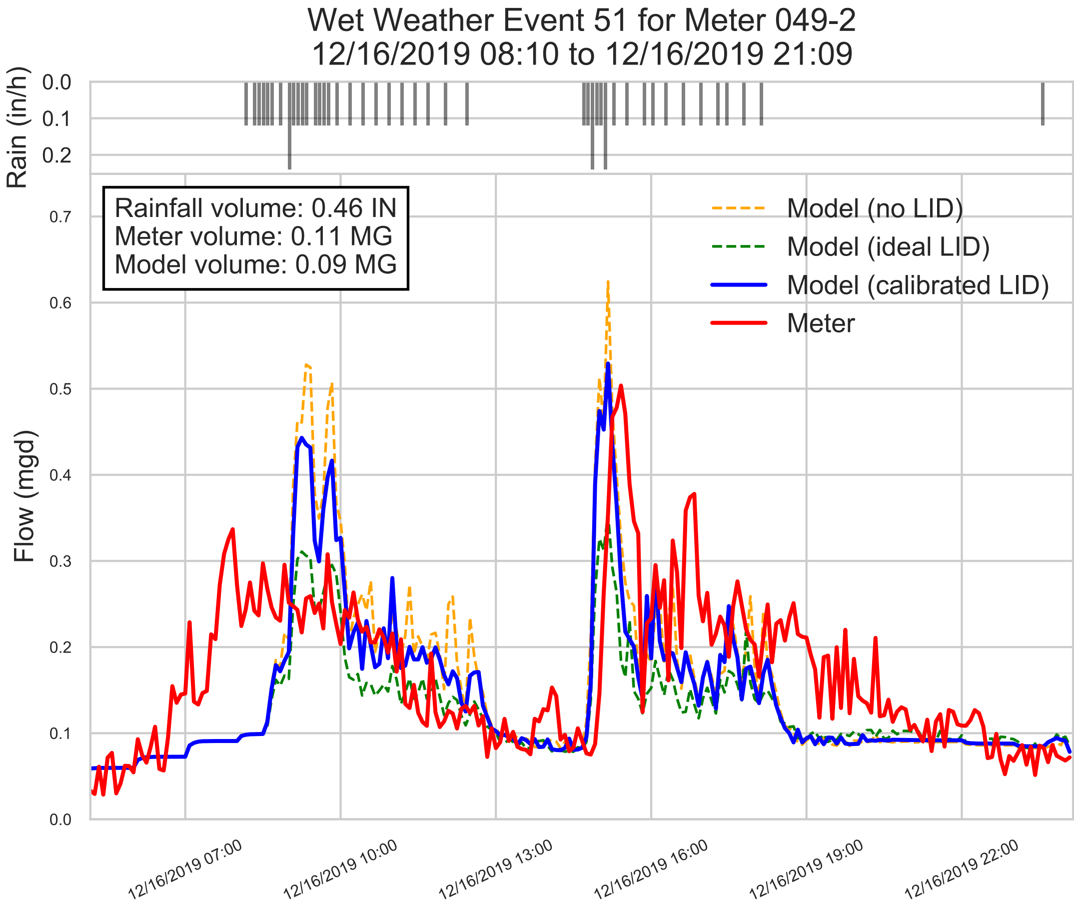
Wet Weather Event 48 for Meter 049-2
12/10/2019 14:24 to 12/11/2019 04:25
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.17 IN
Meter volume: 0.06 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
12/10/2019 12:00
12/10/2019 15:00
12/10/2019 18:00
12/10/2019 21:00
12/11/2019 00:00
12/11/2019 03:00
12/11/2019 06:00

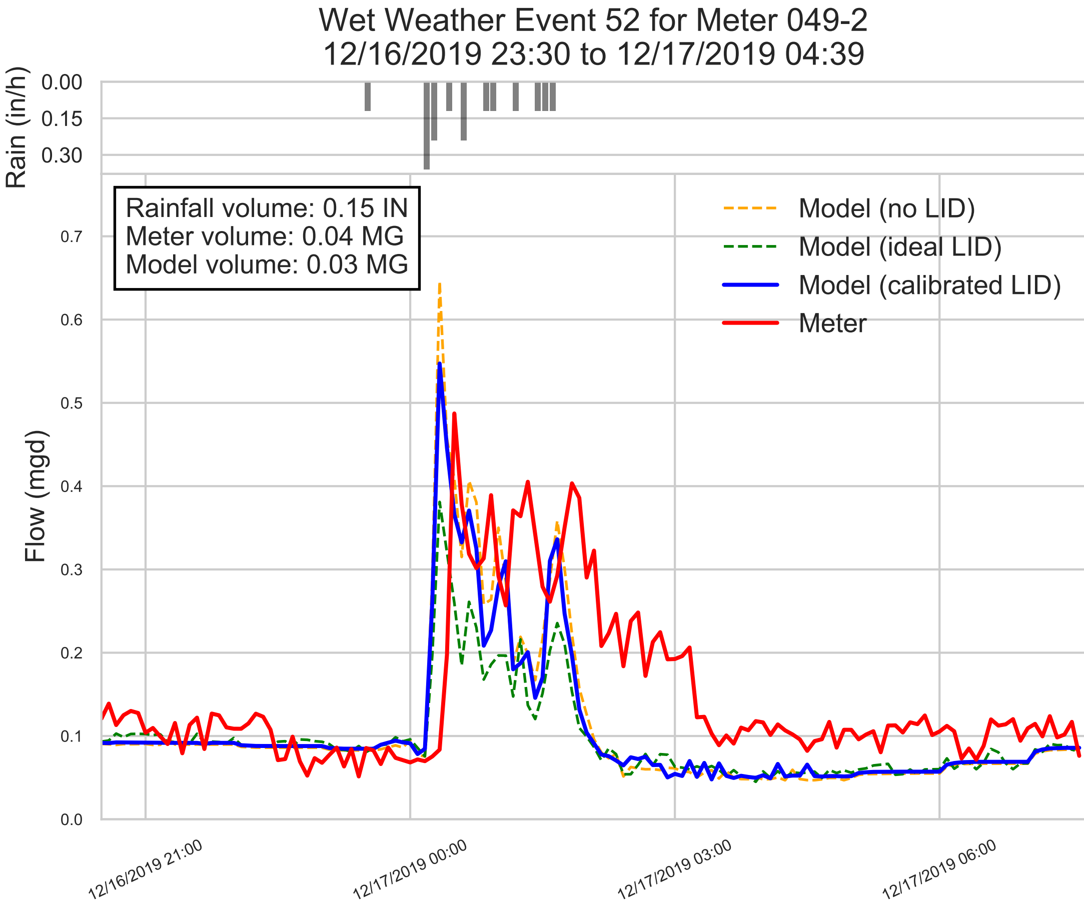


Wet Weather Event 49 for Meter 049-2
12/13/2019 09:00 to 12/13/2019 18:24
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall volume: 0.17 IN
Meter volume: 0.05 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
12/13/2019 08:00
12/13/2019 11:00
12/13/2019 14:00
12/13/2019 17:00
12/13/2019 20:00

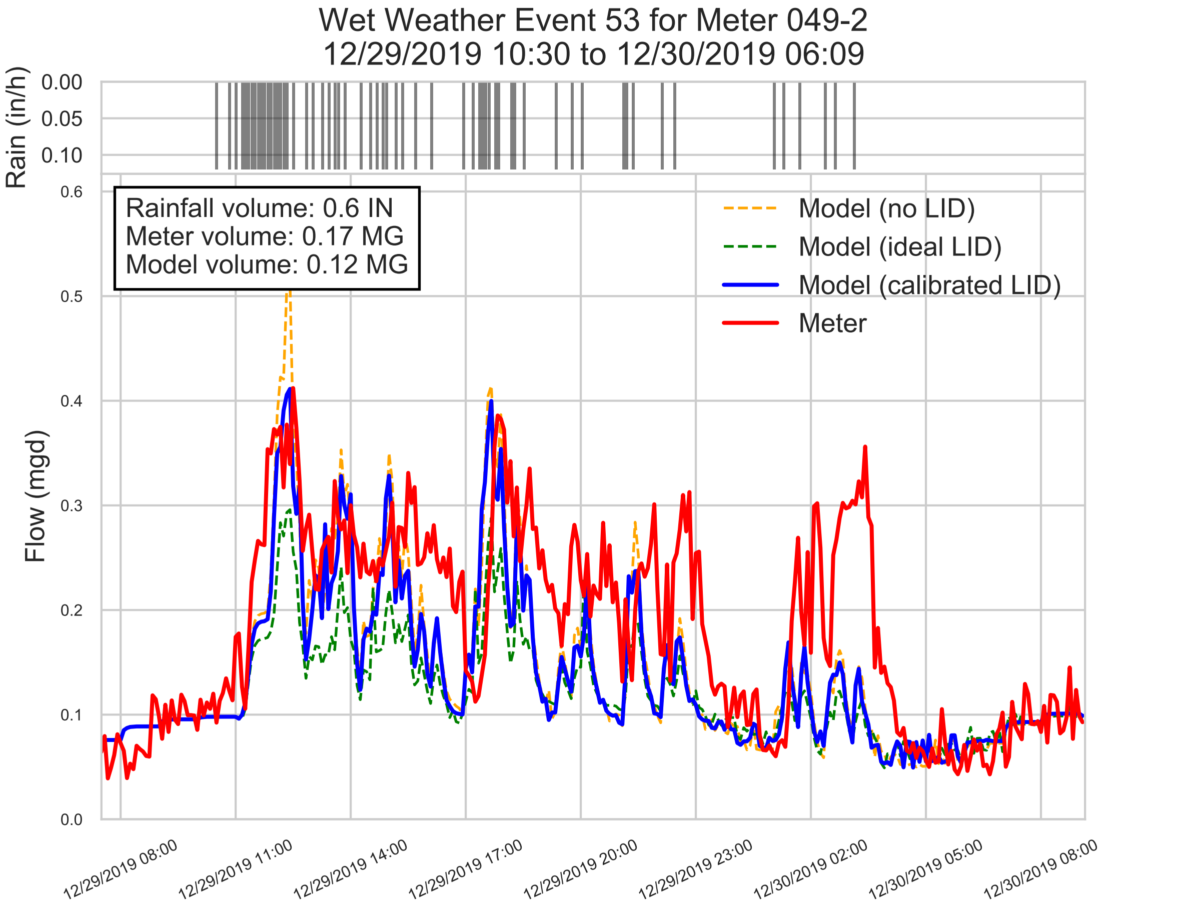


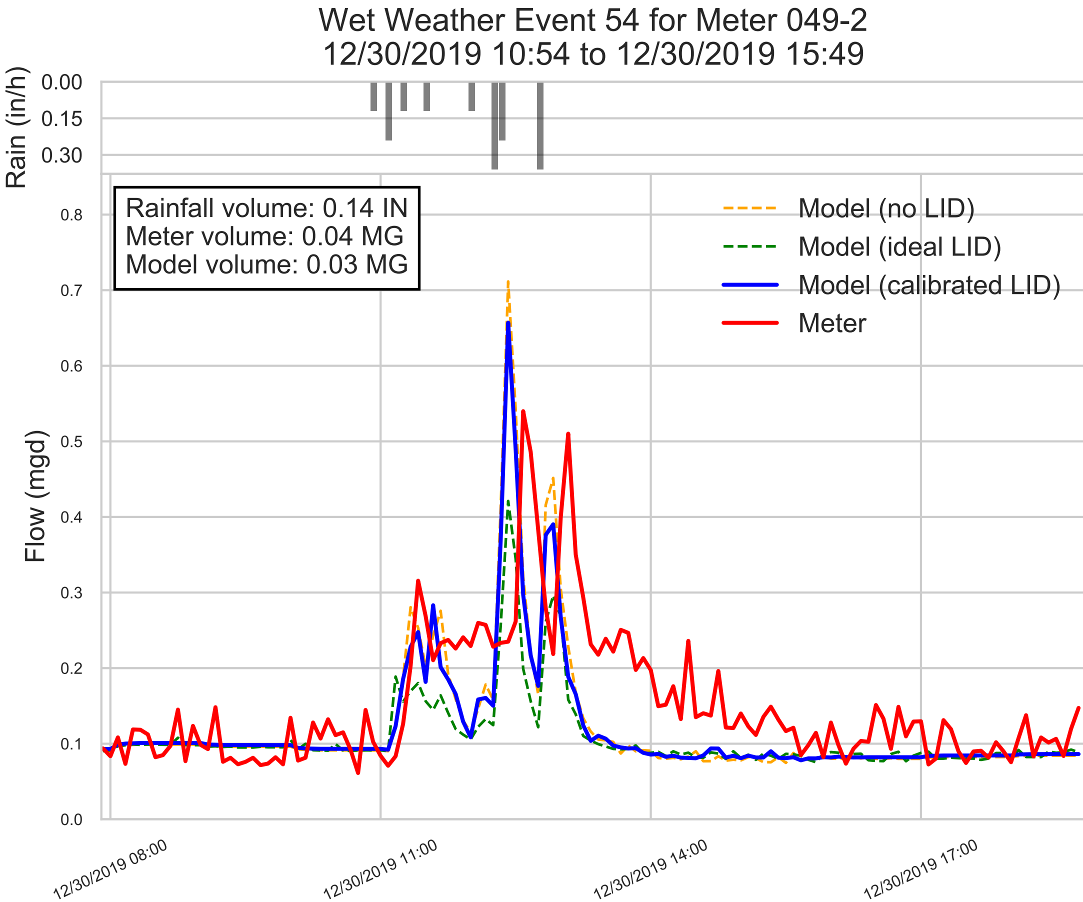
Wet Weather Event 50 for Meter 049-2
12/13/2019 21:54 to 12/14/2019 04:34
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.11 IN
Meter volume: 0.03 MG
Model volume: 0.03 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
12/13/2019 21:00
12/14/2019 00:00
12/14/2019 03:00
12/14/2019 06:00


Wet Weather Event 51 for Meter 049-2
12/16/2019 08:10 to 12/16/2019 21:09
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.46 IN
Meter volume: 0.11 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
12/16/2019 07:00
12/16/2019 10:00
12/16/2019 13:00
12/16/2019 16:00
12/16/2019 19:00
12/16/2019 22:00

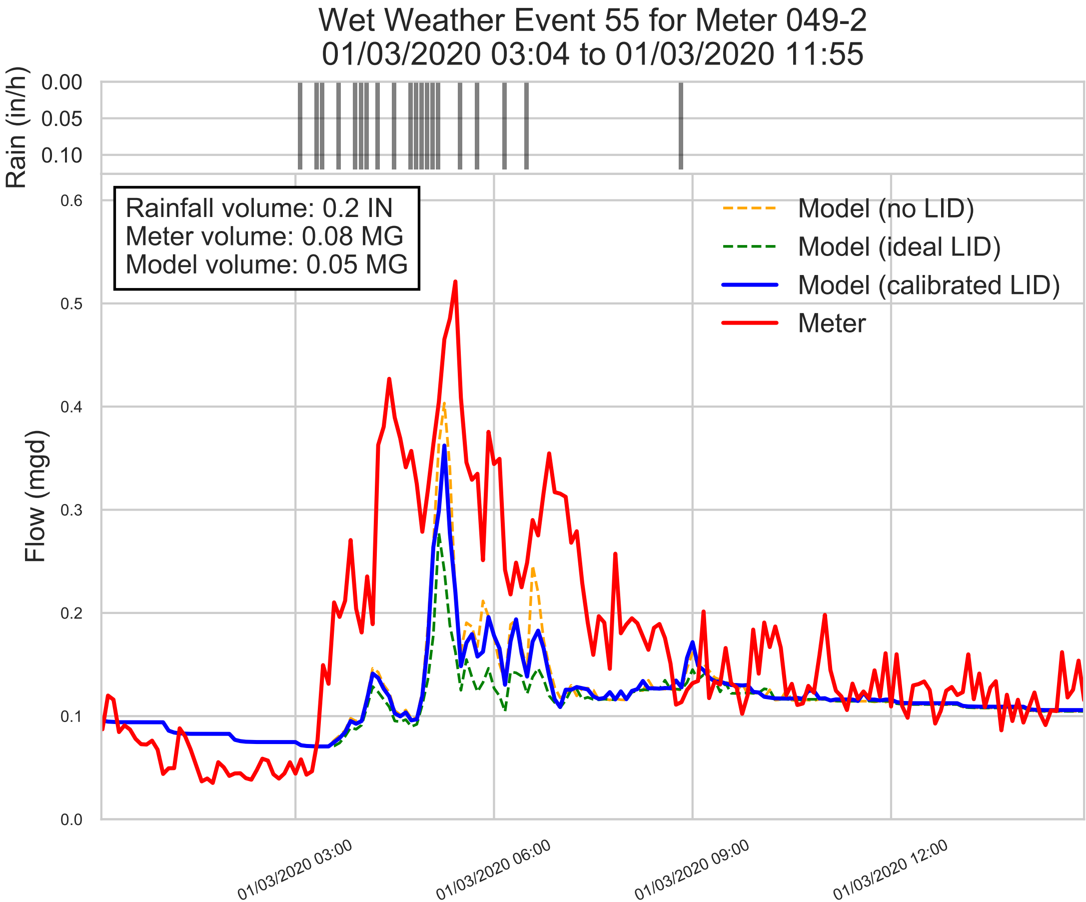


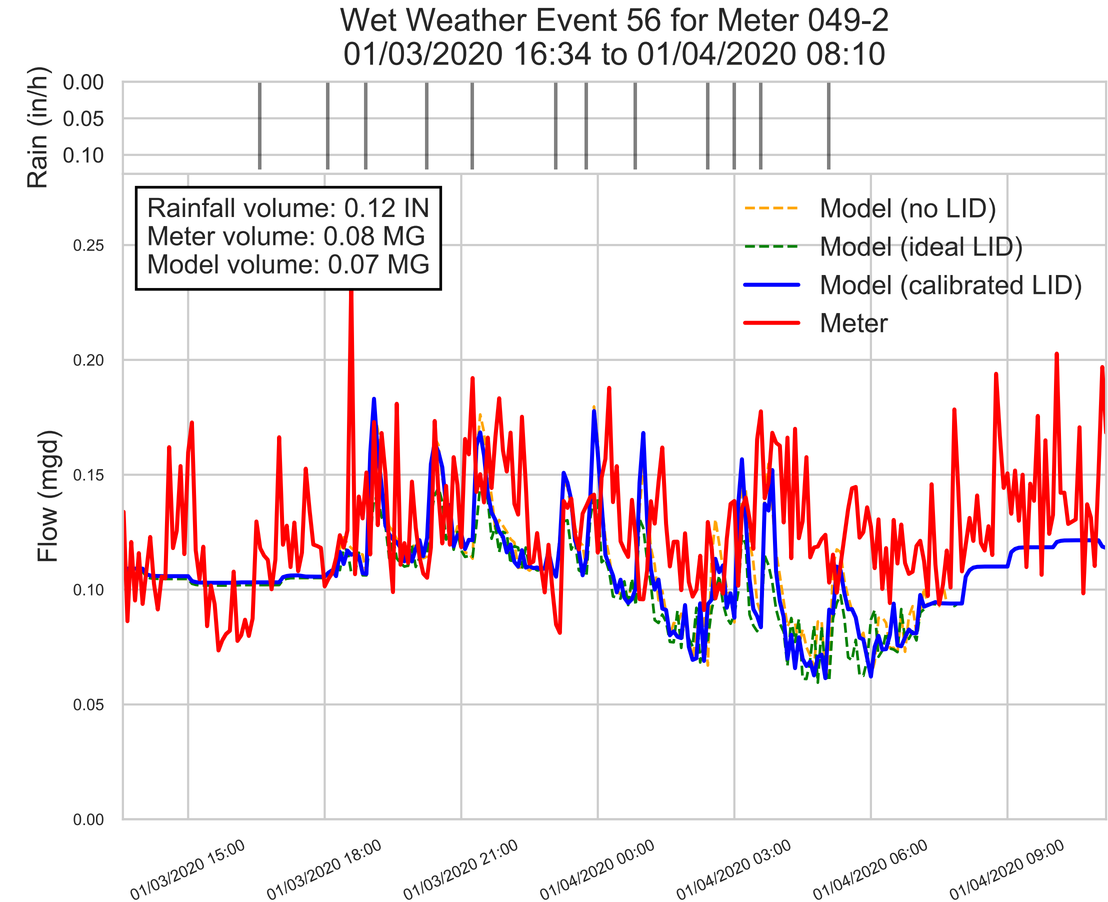
Wet Weather Event 52 for Meter 049-2
12/16/2019 23:30 to 12/17/2019 04:39
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.15 IN
Meter volume: 0.04 MG
Model volume: 0.03 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
12/16/2019 21:00
12/17/2019 00:00
12/17/2019 03:00
12/17/2019 06:00


Wet Weather Event 53 for Meter 049-2
12/29/2019 10:30 to 12/30/2019 06:09
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Rainfall volume: 0.6 IN
Meter volume: 0.17 MG
Model volume: 0.12 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
12/29/2019 08:00
12/29/2019 11:00
12/29/2019 14:00
12/29/2019 17:00
12/29/2019 20:00
12/29/2019 23:00
12/30/2019 02:00
12/30/2019 05:00
12/30/2019 08:00

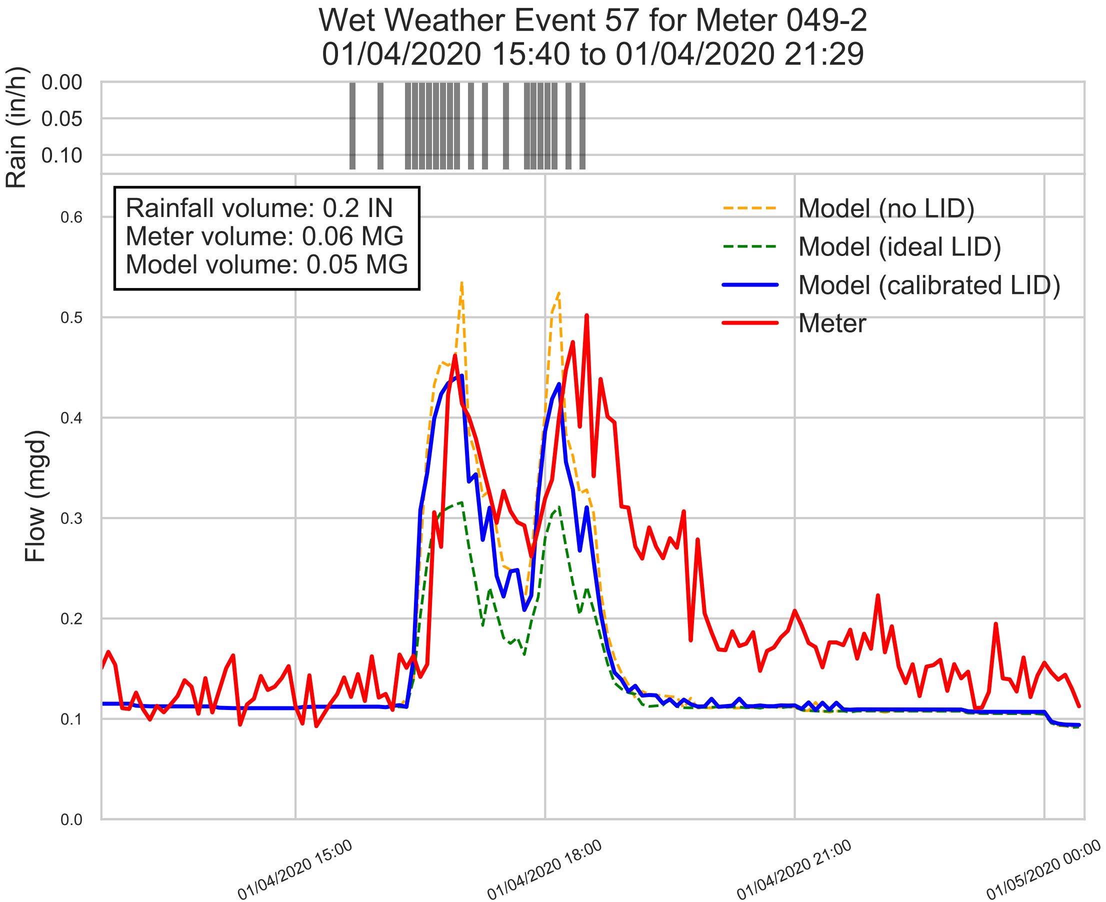


Wet Weather Event 54 for Meter 049-2
12/30/2019 10:54 to 12/30/2019 15:49
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.14 IN
Meter volume: 0.04 MG
Model volume: 0.03 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
12/30/2019 08:00
12/30/2019 11:00
12/30/2019 14:00
12/30/2019 17:00

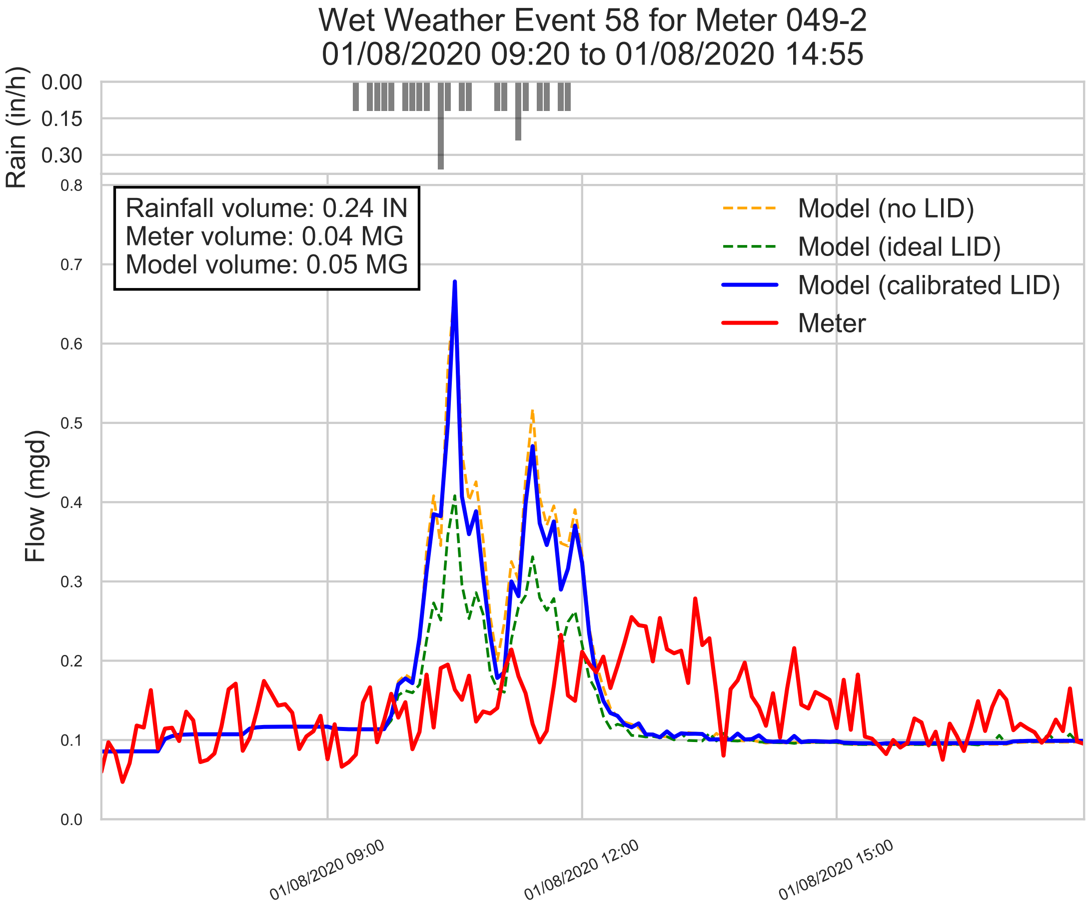

Wet Weather Event 55 for Meter 049-2
01/03/2020 03:04 to 01/03/2020 11:55
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Rainfall volume: 0.2 IN
Meter volume: 0.08 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
01/03/2020 03:00
01/03/2020 06:00
01/03/2020 09:00
01/03/2020 12:00



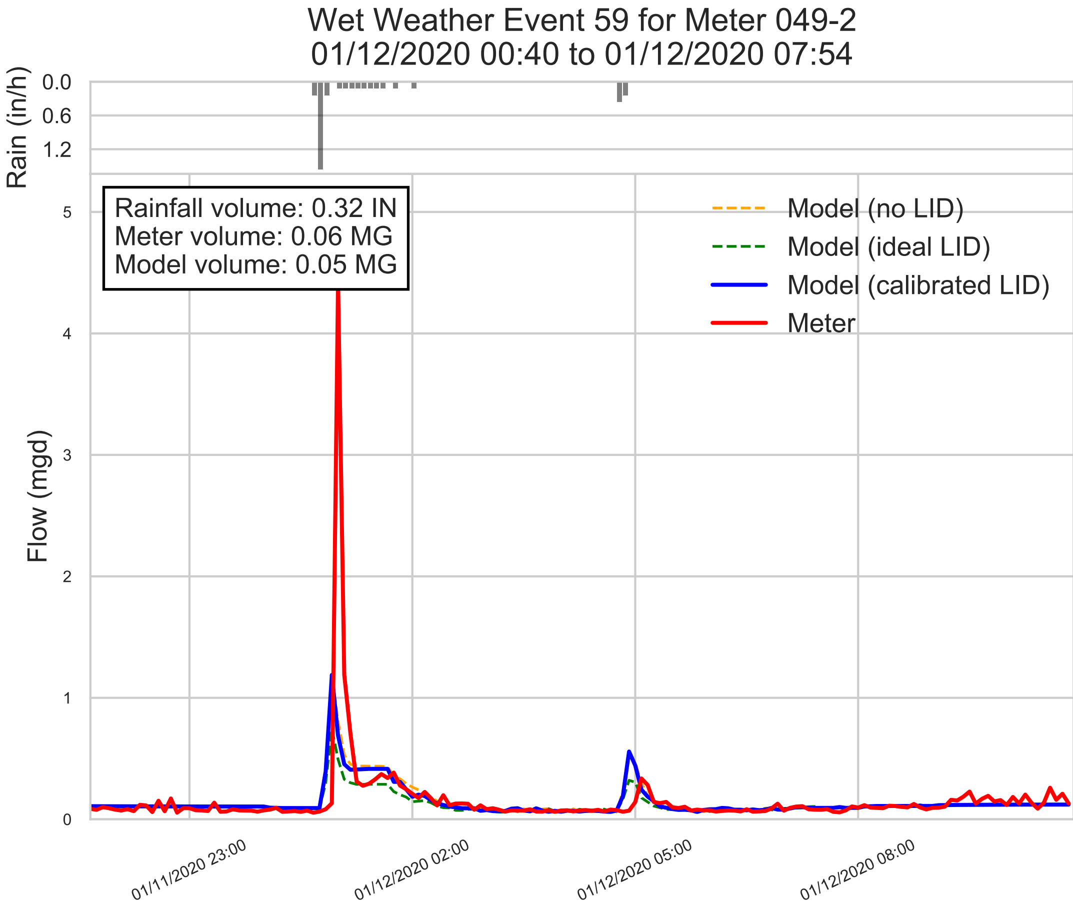
Wet Weather Event 56 for Meter 049-2
01/03/2020 16:34 to 01/04/2020 08:10
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.25
0.20
0.15
0.10
0.05
0.00
01/03/2020 15:00
01/03/2020 18:00
01/03/2020 21:00
01/04/2020 00:00
01/04/2020 03:00
01/04/2020 06:00
01/04/2020 09:00



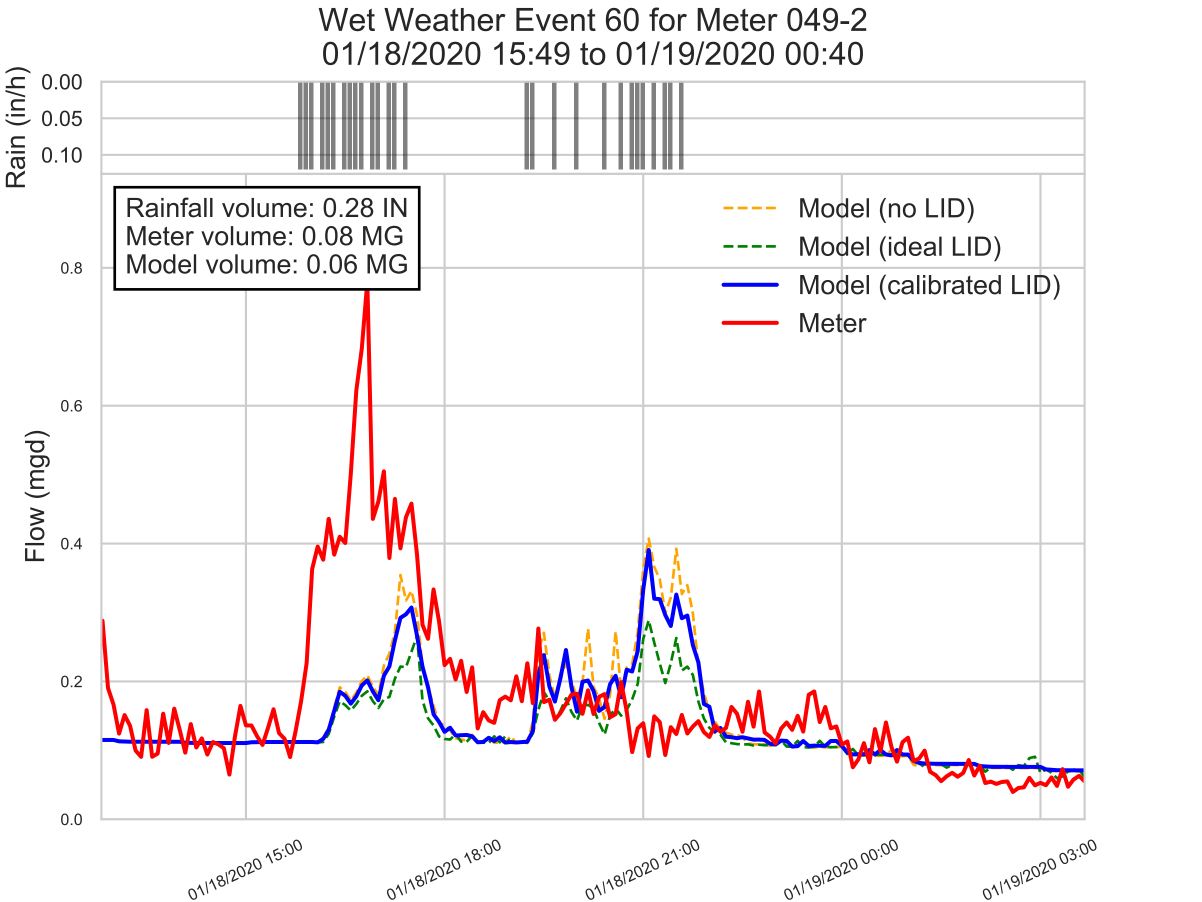
Wet Weather Event 57 for Meter 049-2
01/04/2020 15:40 to 01/04/2020 21:29
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.06 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
01/04/2020 15:00
01/04/2020 18:00
01/04/2020 21:00
01/05/2020 00:00

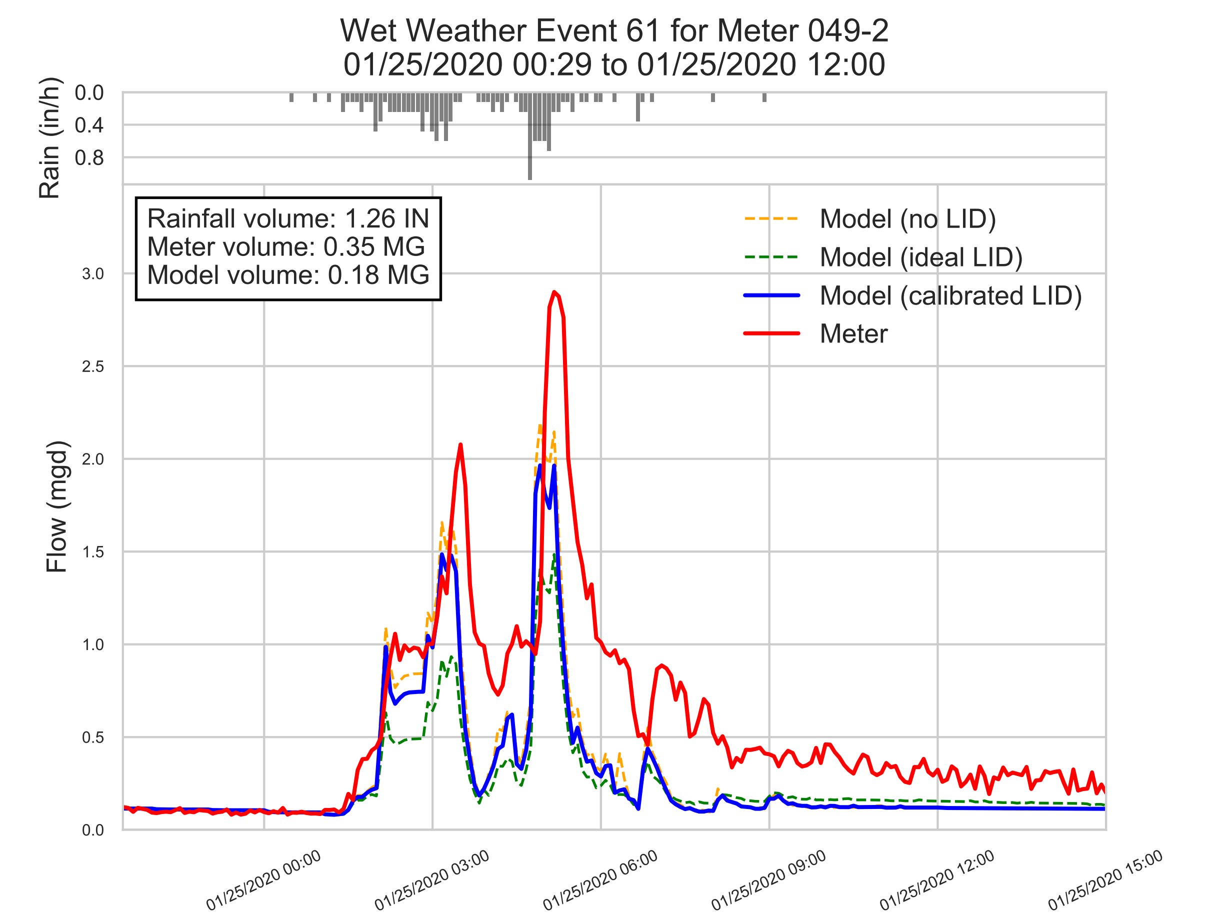


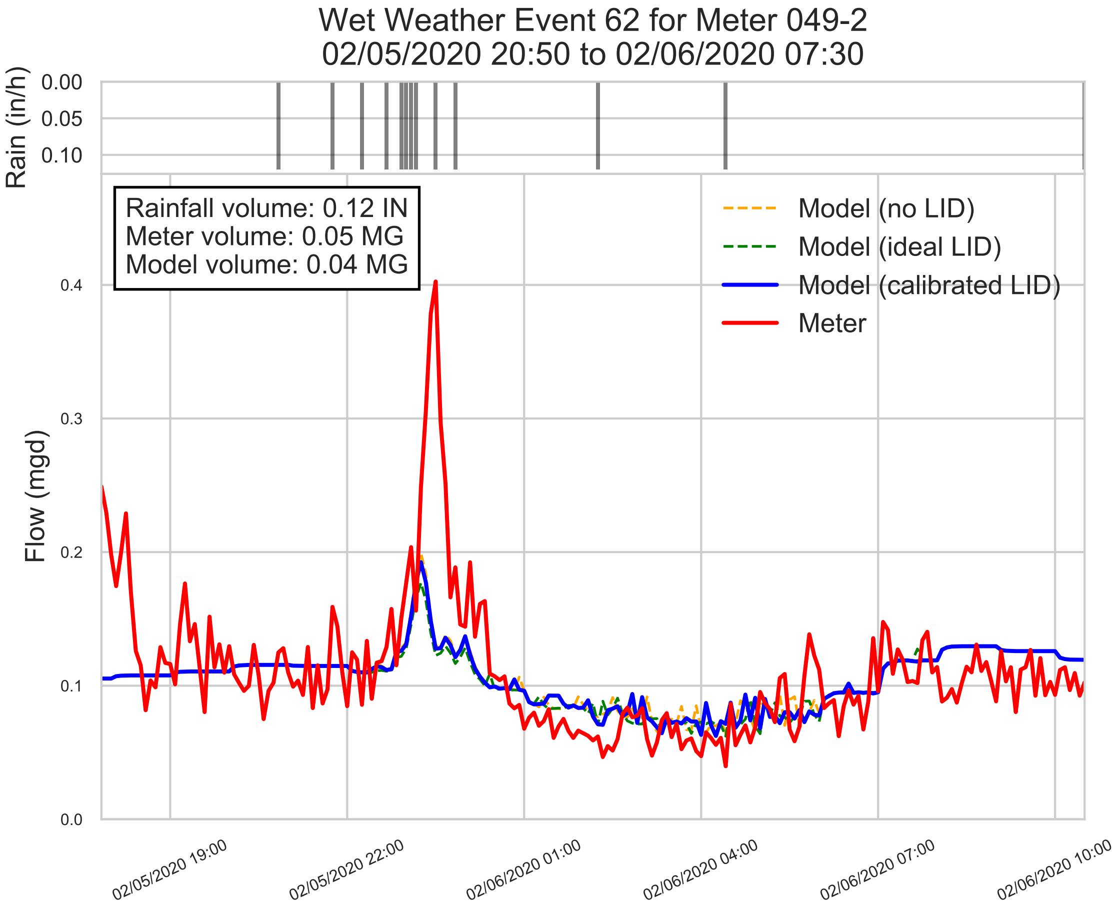
Wet Weather Event 58 for Meter 049-2
01/08/2020 09:20 to 01/08/2020 14:55
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Rainfall volume: 0.24 IN
Meter volume: 0.04 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
01/08/2020 09:00
01/08/2020 12:00
01/08/2020 15:00



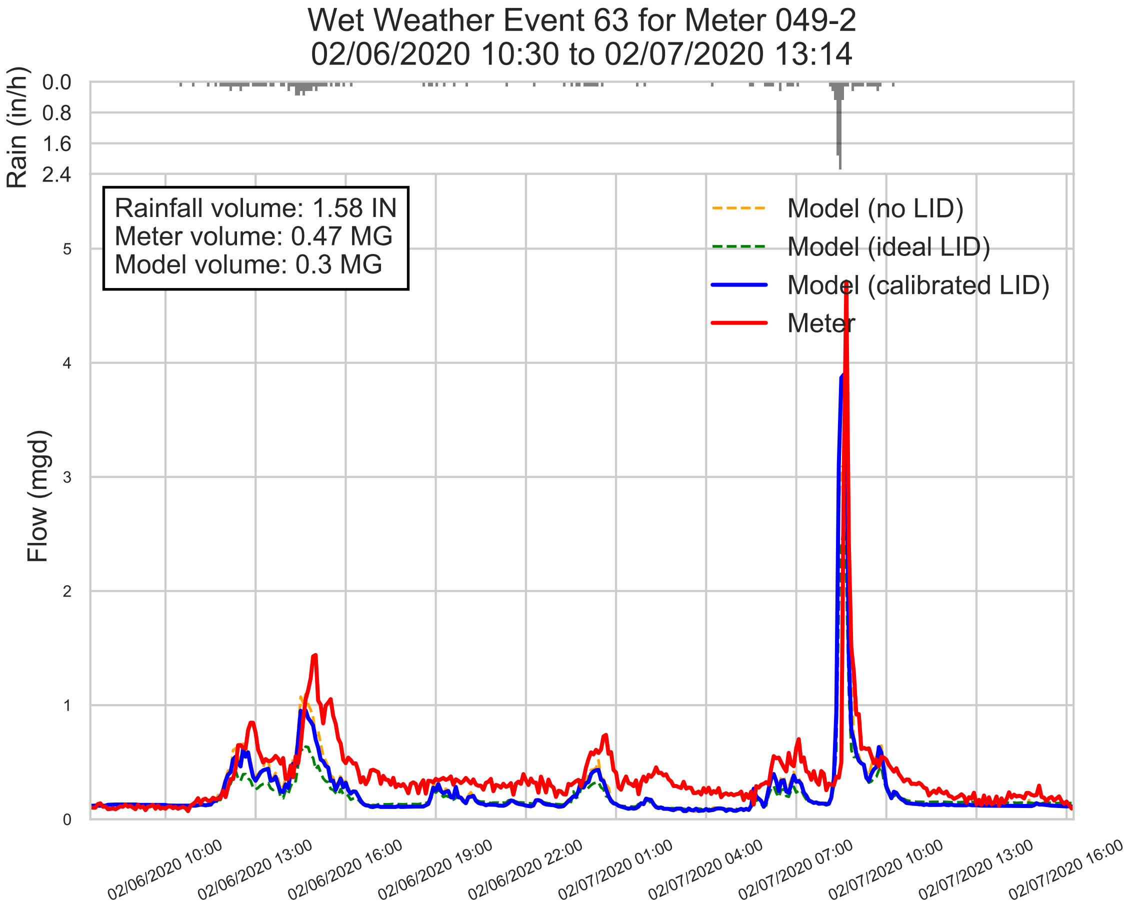
Wet Weather Event 59 for Meter 049-2
01/12/2020 00:40 to 01/12/2020 07:54
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.32 IN
Meter volume: 0.06 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
01/11/2020 23:00
01/12/2020 02:00
01/12/2020 05:00
01/12/2020 08:00

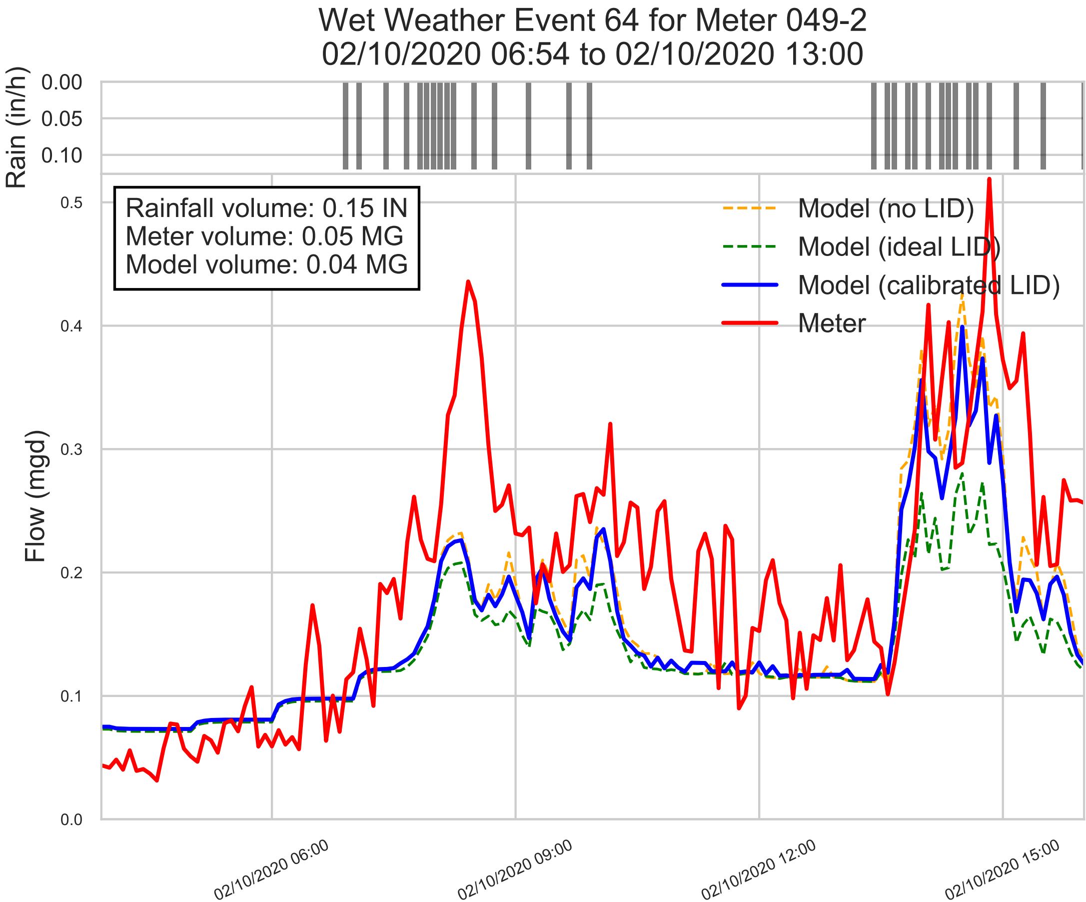

Wet Weather Event 60 for Meter 049-2
01/18/2020 15:49 to 01/19/2020 00:40
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.08 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
01/18/2020 15:00
01/18/2020 18:00
01/18/2020 21:00
01/19/2020 00:00
01/19/2020 03:00


Wet Weather Event 61 for Meter 049-2
01/25/2020 00:29 to 01/25/2020 12:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 1.26 IN
Meter volume: 0.35 MG
Model volume: 0.18 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
01/25/2020 00:00
01/25/2020 03:00
01/25/2020 06:00
01/25/2020 09:00
01/25/2020 12:00
01/25/2020 15:00

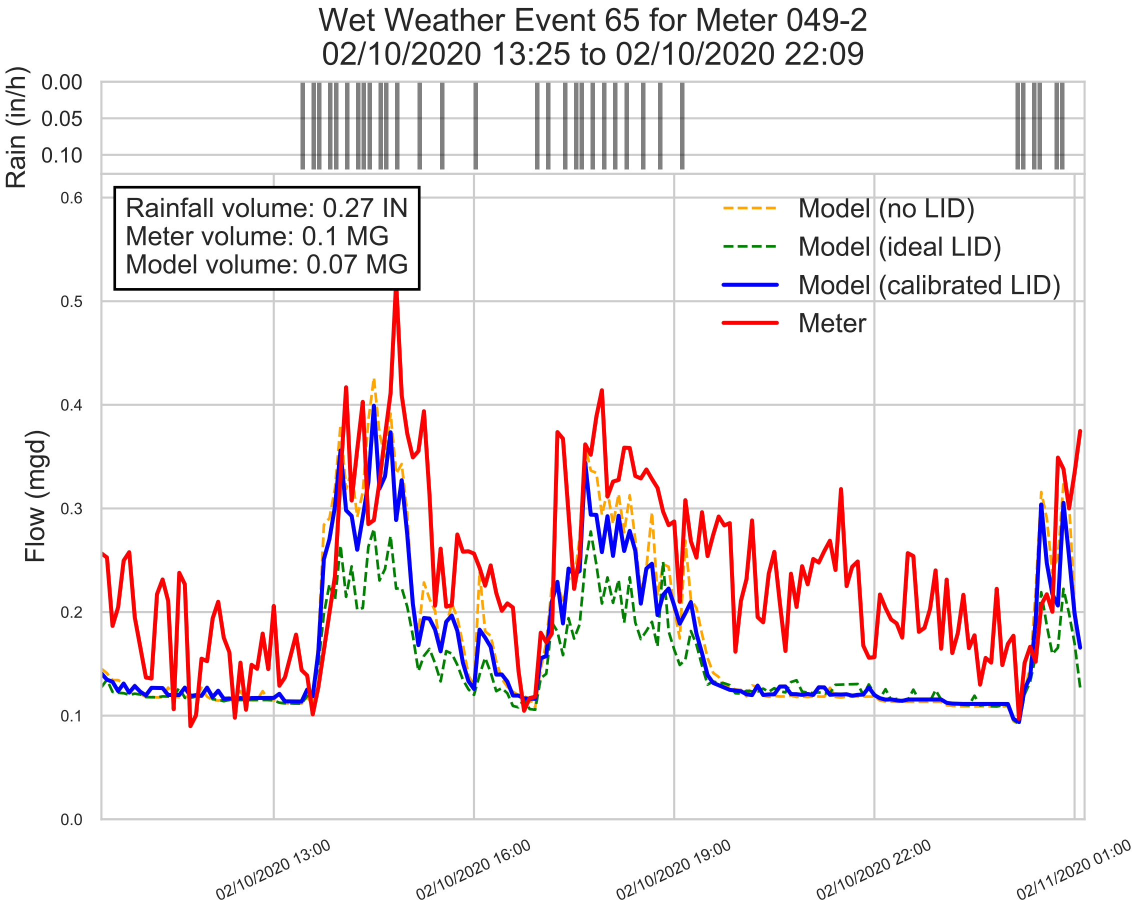


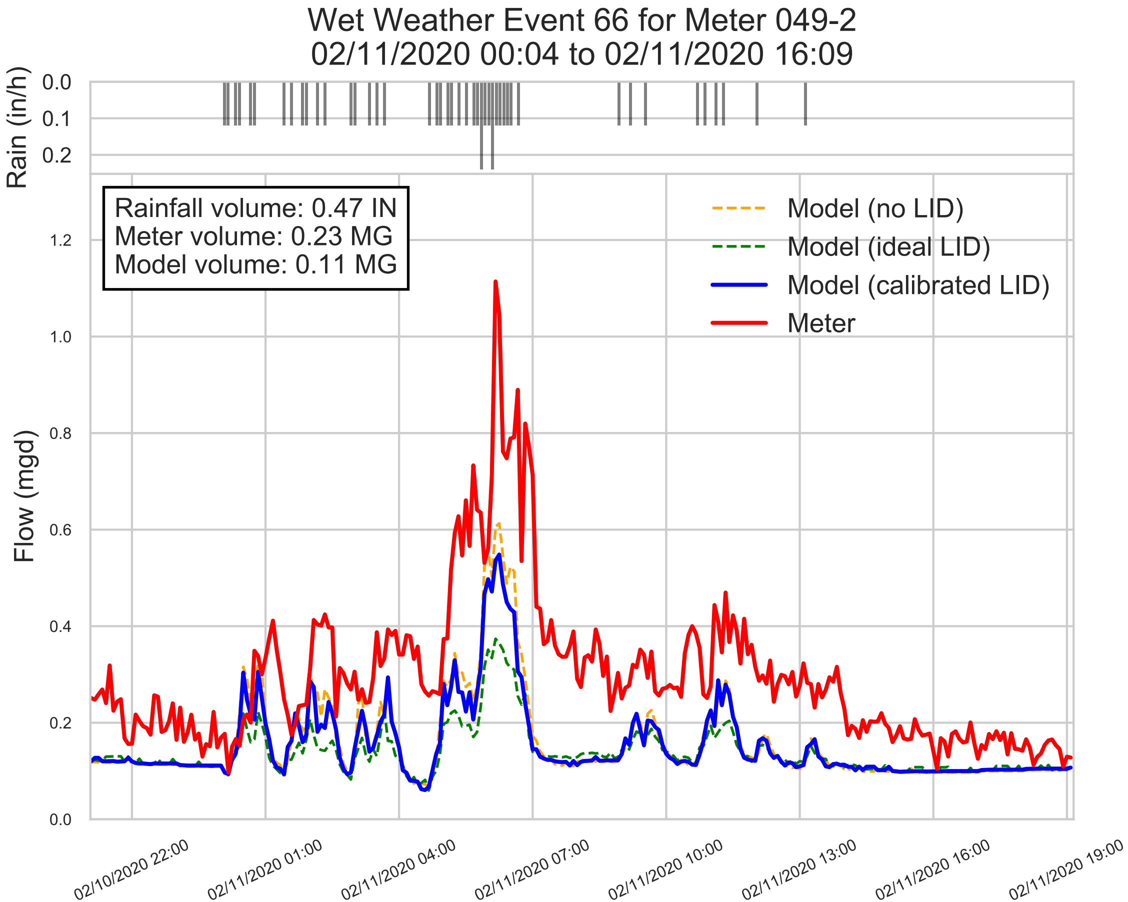
Wet Weather Event 62 for Meter 049-2
02/05/2020 20:50 to 02/06/2020 07:30
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.05 MG
Model volume: 0.04 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
02/05/2020 19:00
02/05/2020 22:00
02/06/2020 01:00
02/06/2020 04:00
02/06/2020 07:00
02/06/2020 10:00


Wet Weather Event 63 for Meter 049-2
02/06/2020 10:30 to 02/07/2020 13:14
Rain (in/h)
0.0
0.8
1.6
2.4
Rainfall volume: 1.58 IN
Meter volume: 0.47 MG
Model volume: 0.3 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0
1
2
3
4
5
02/06/2020 10:00
02/06/2020 13:00
02/06/2020 16:00
02/06/2020 19:00
02/06/2020 22:00
02/07/2020 01:00
02/07/2020 04:00
02/07/2020 07:00
02/07/2020 10:00
02/07/2020 13:00
02/07/2020 16:00

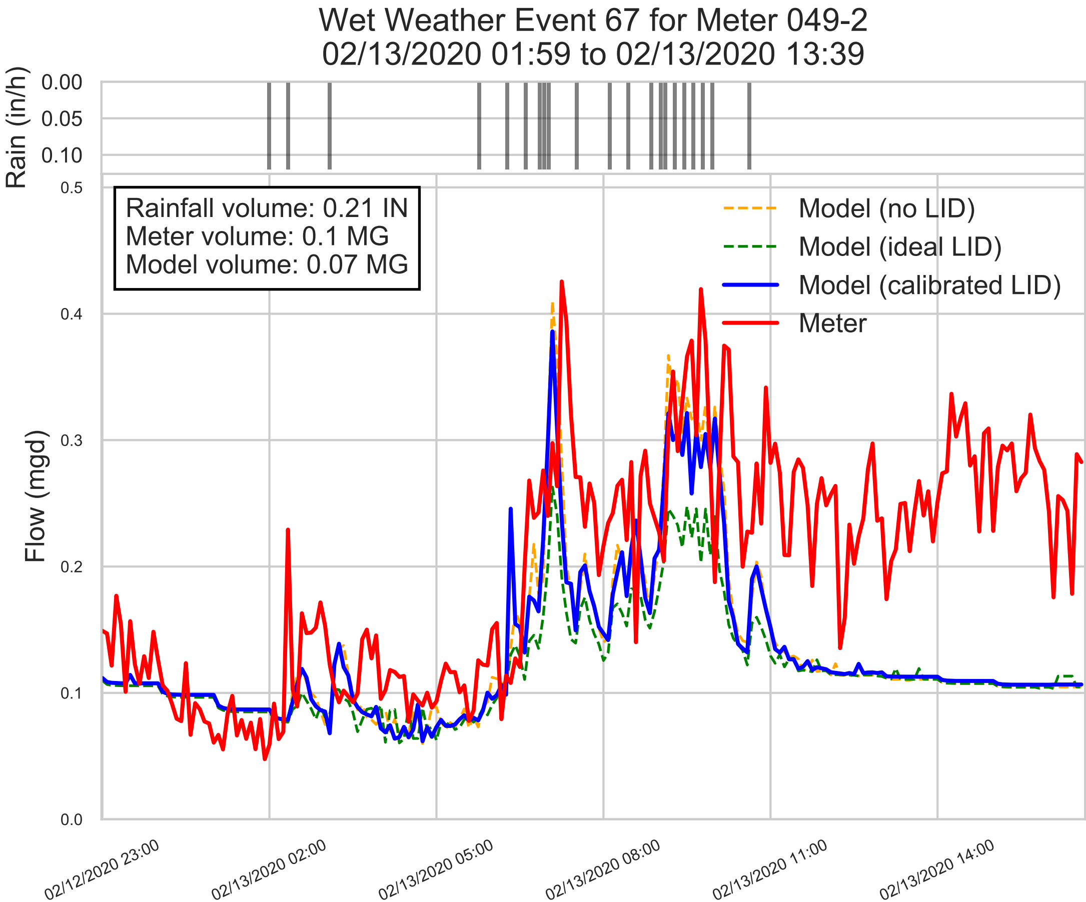


Wet Weather Event 64 for Meter 049-2
02/10/2020 06:54 to 02/10/2020 13:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.15 IN
Meter volume: 0.05 MG
Model volume: 0.04 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
02/10/2020 06:00
02/10/2020 09:00
02/10/2020 12:00
02/10/2020 15:00

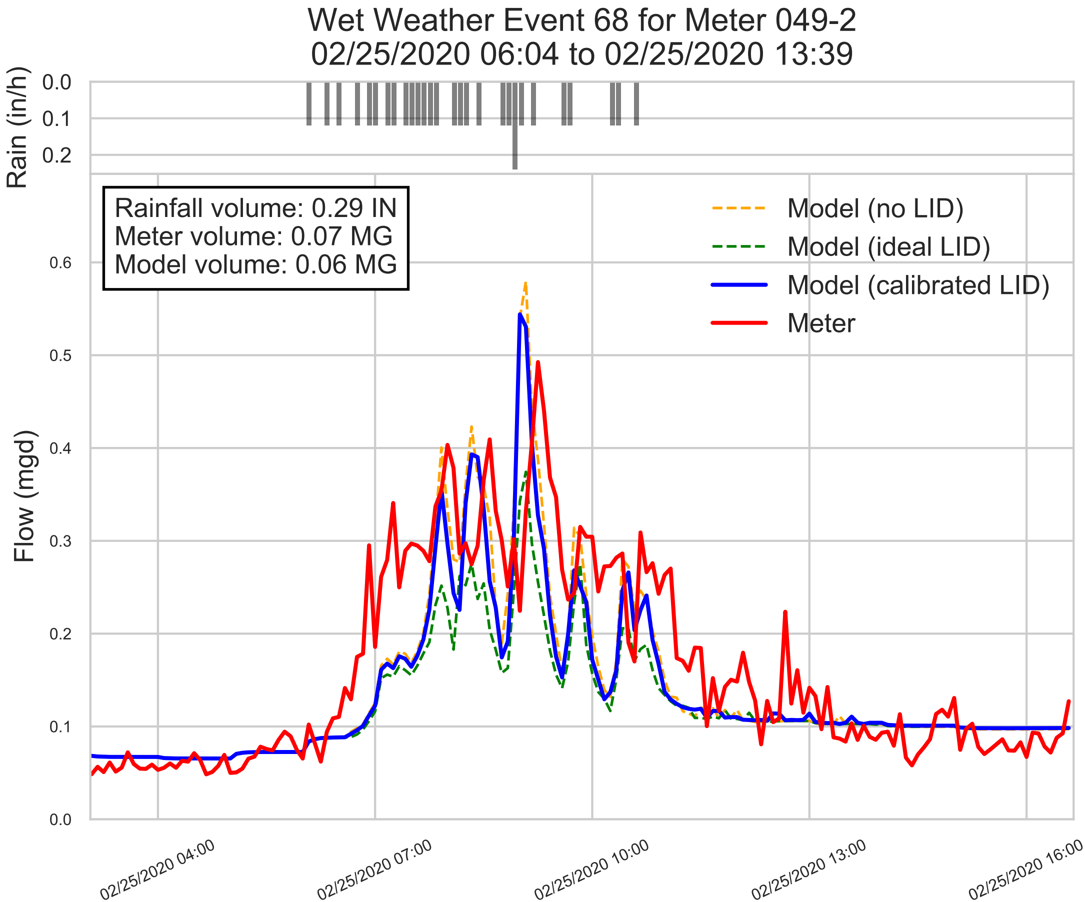

Wet Weather Event 65 for Meter 049-2
02/10/2020 13:25 to 02/10/2020 22:09
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.27 IN
Meter volume: 0.1 MG
Model volume: 0.07 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
02/10/2020 13:00
02/10/2020 16:00
02/10/2020 19:00
02/10/2020 22:00
02/11/2020 01:00

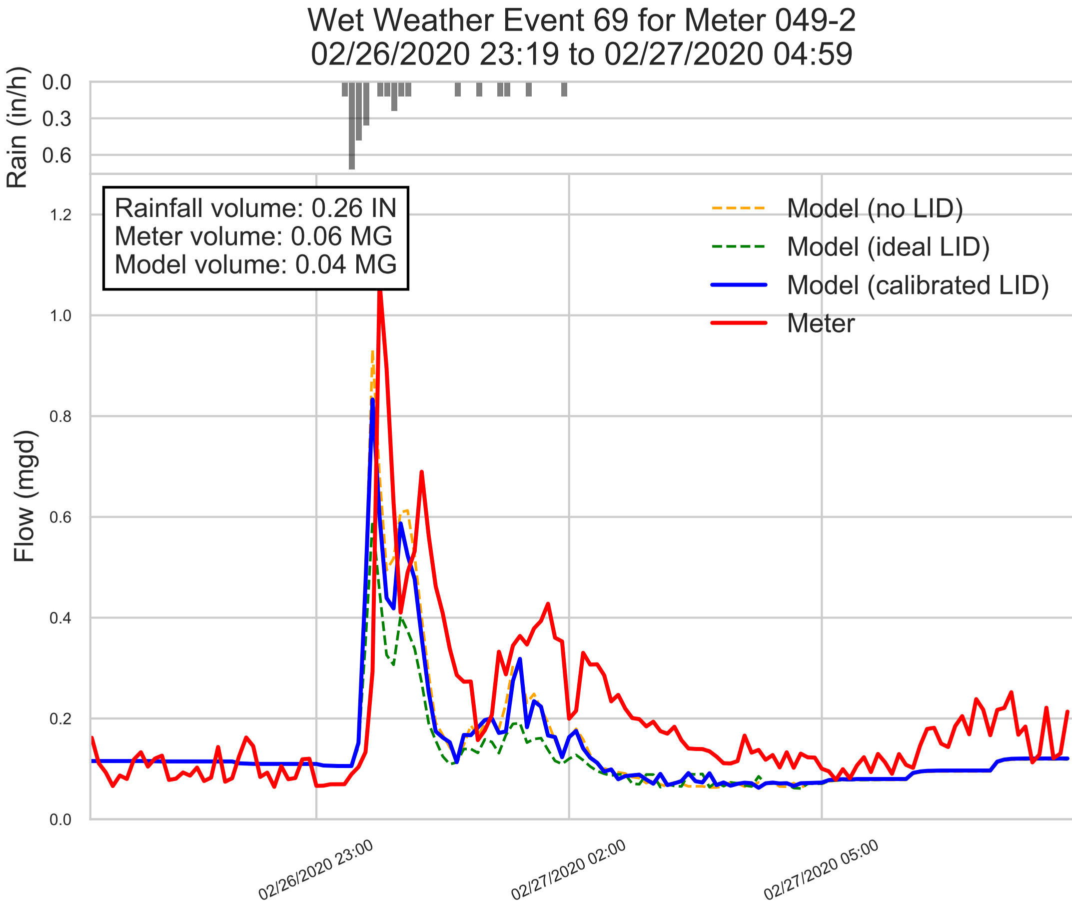


Wet Weather Event 66 for Meter 049-2
02/11/2020 00:04 to 02/11/2020 16:09
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.47 IN
Meter volume: 0.23 MG
Model volume: 0.11 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
02/10/2020 22:00
02/11/2020 01:00
02/11/2020 04:00
02/11/2020 07:00
02/11/2020 10:00
02/11/2020 13:00
02/11/2020 16:00
02/11/2020 19:00

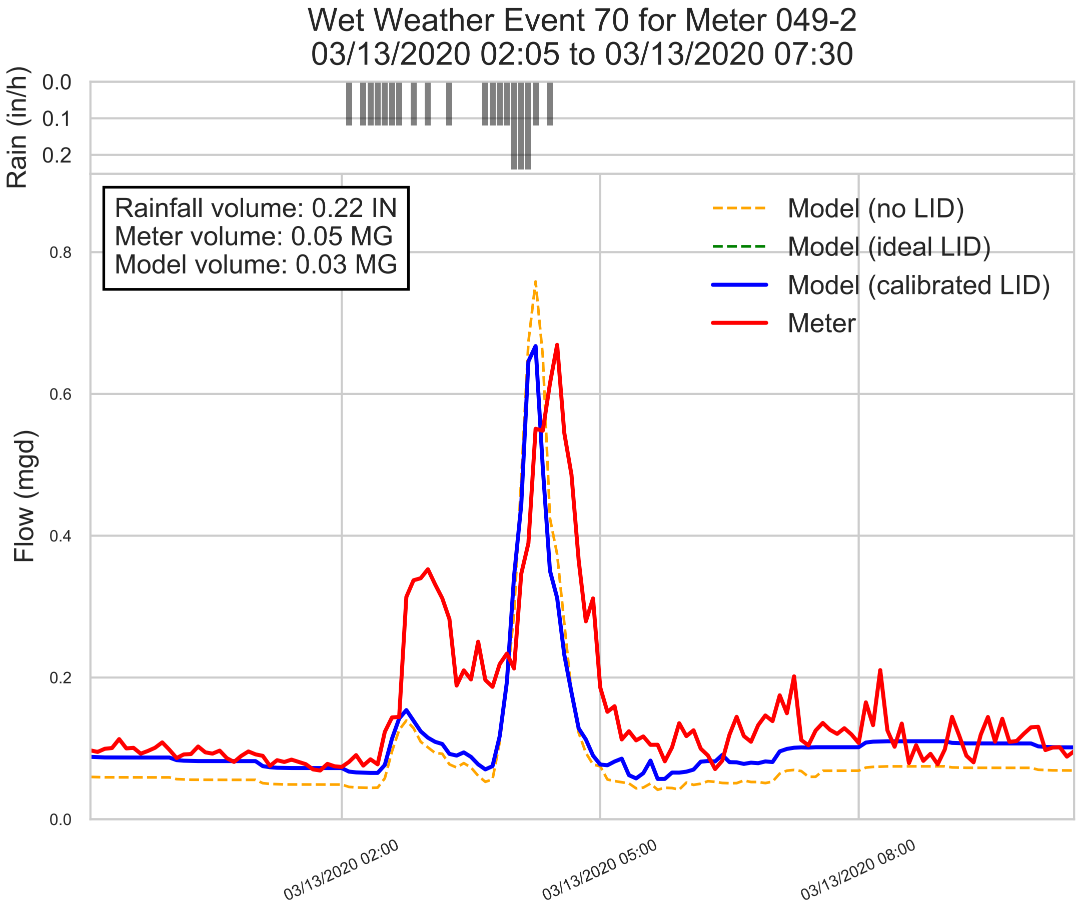


Wet Weather Event 67 for Meter 049-2
02/13/2020 01:59 to 02/13/2020 13:39
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.21 IN
Meter volume: 0.1 MG
Model volume: 0.07 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
02/12/2020 23:00
02/13/2020 02:00
02/13/2020 05:00
02/13/2020 08:00
02/13/2020 11:00
02/13/2020 14:00

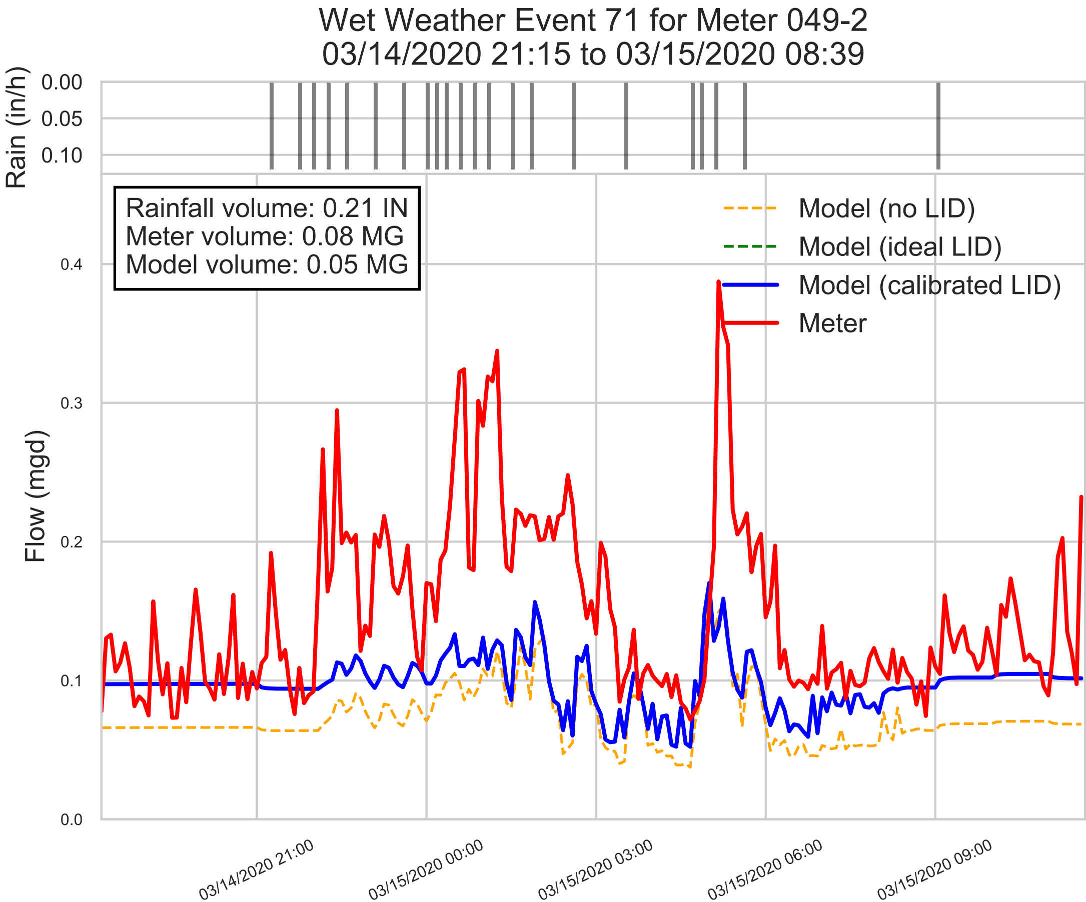

Wet Weather Event 68 for Meter 049-2
02/25/2020 06:04 to 02/25/2020 13:39
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.07 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
02/25/2020 04:00
02/25/2020 07:00
02/25/2020 10:00
02/25/2020 13:00
02/25/2020 16:00



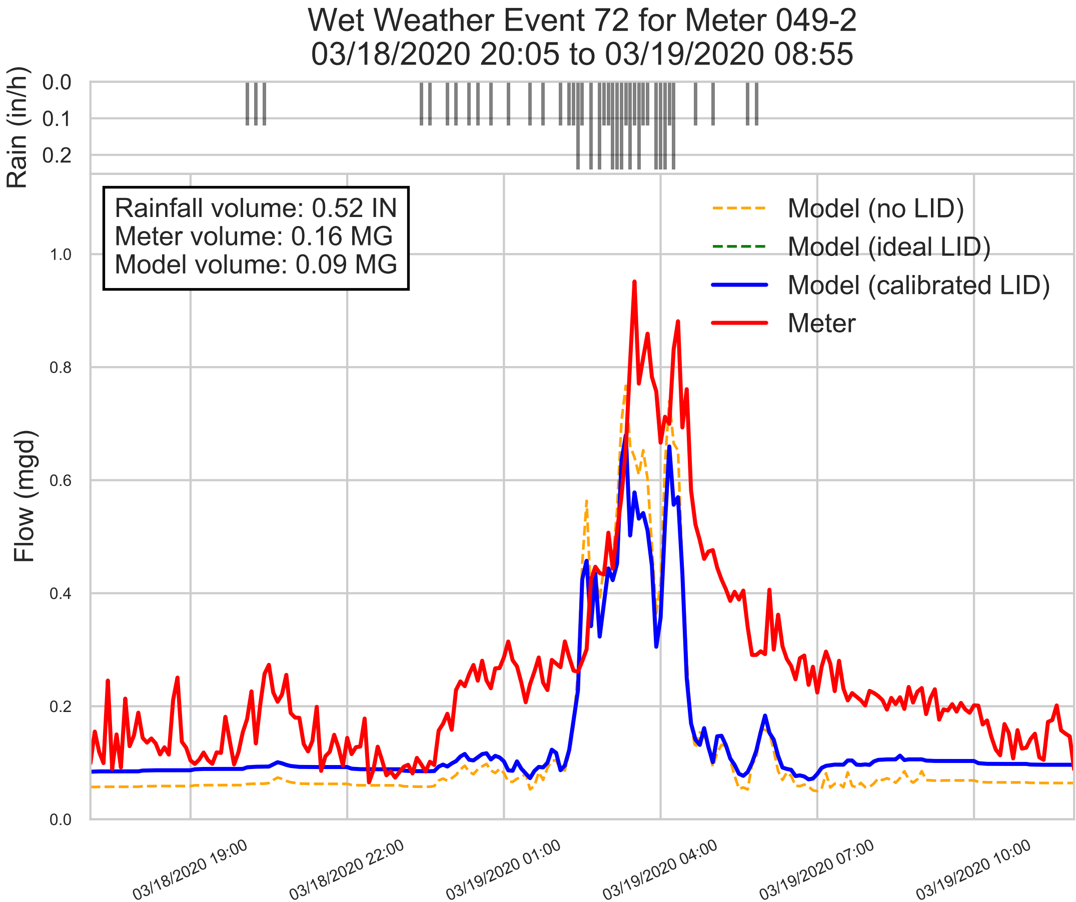
Wet Weather Event 69 for Meter 049-2
02/26/2020 23:19 to 02/27/2020 04:59
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.26 IN
Meter volume: 0.06 MG
Model volume: 0.04 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
02/26/2020 23:00
02/27/2020 02:00
02/27/2020 05:00



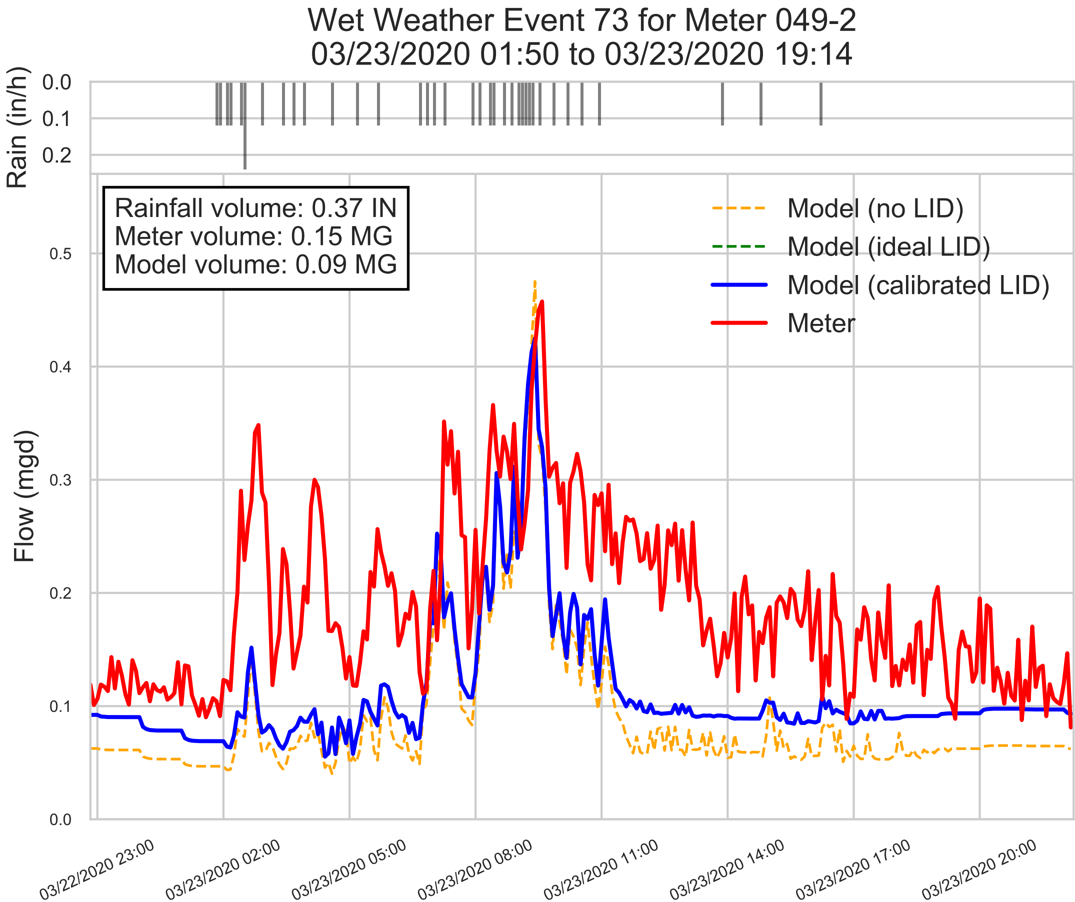
Wet Weather Event 70 for Meter 049-2
03/13/2020 02:05 to 03/13/2020 07:30
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.22 IN
Meter volume: 0.05 MG
Model volume: 0.03 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
03/13/2020 02:00
03/13/2020 05:00
03/13/2020 08:00

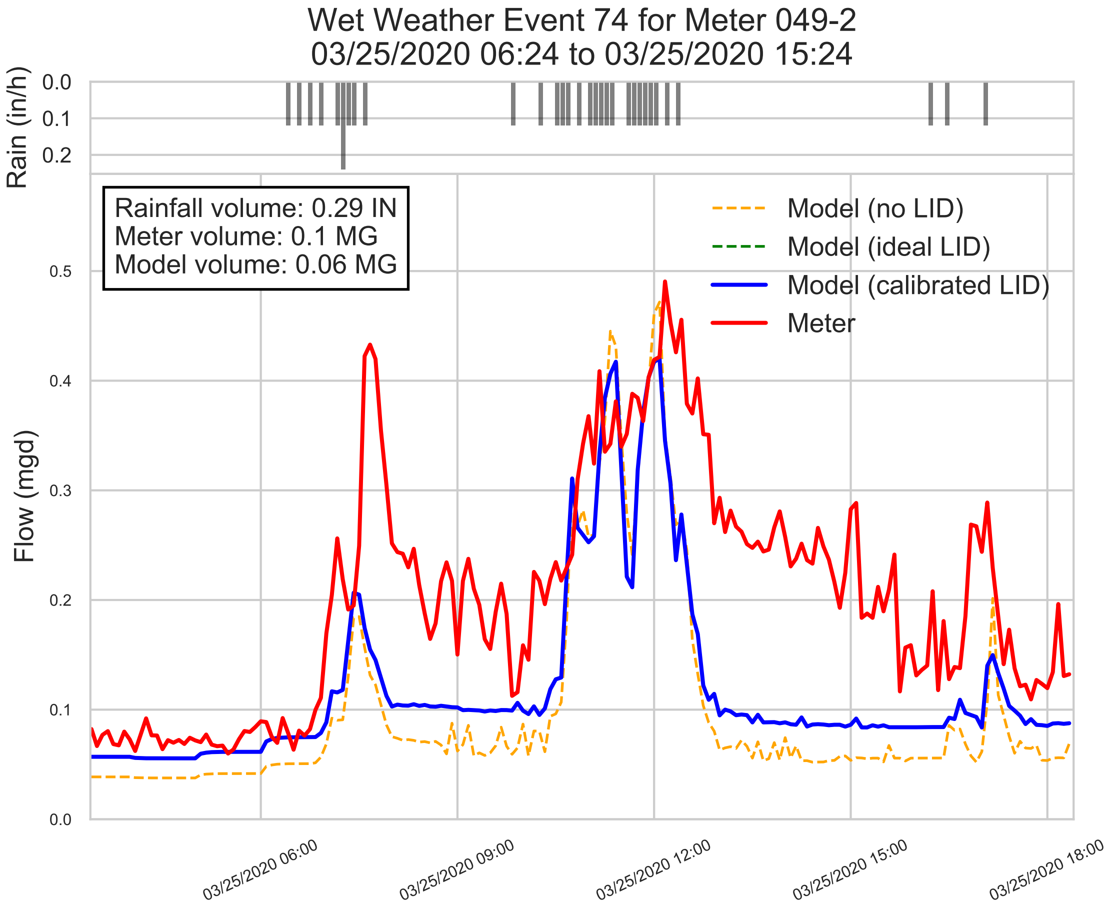


Wet Weather Event 71 for Meter 049-2
03/14/2020 21:15 to 03/15/2020 08:39
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.21 IN
Meter volume: 0.08 MG
Model volume: 0.05 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
03/14/2020 21:00
03/15/2020 00:00
03/15/2020 03:00
03/15/2020 06:00
03/15/2020 09:00



Wet Weather Event 72 for Meter 049-2
03/18/2020 20:05 to 03/19/2020 08:55
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.52 IN
Meter volume: 0.16 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
03/18/2020 19:00
03/18/2020 22:00
03/19/2020 01:00
03/19/2020 04:00
03/19/2020 07:00
03/19/2020 10:00


Wet Weather Event 73 for Meter 049-2
03/23/2020 01:50 to 03/23/2020 19:14
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.37 IN
Meter volume: 0.15 MG
Model volume: 0.09 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
03/22/2020 23:00
03/23/2020 02:00
03/23/2020 05:00
03/23/2020 08:00
03/23/2020 11:00
03/23/2020 14:00
03/23/2020 17:00
03/23/2020 20:00


Wet Weather Event 74 for Meter 049-2
03/25/2020 06:24 to 03/25/2020 15:24
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.1 MG
Model volume: 0.06 MG
Model (no LID)
Model (ideal LID)
Model (calibrated LID)
Meter
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
03/25/2020 06:00
03/25/2020 09:00
03/25/2020 12:00
03/25/2020 15:00
03/25/2020 18:00

Appendix D: Monitoring Timeseries for Entire Post-Construction Metering Time Period

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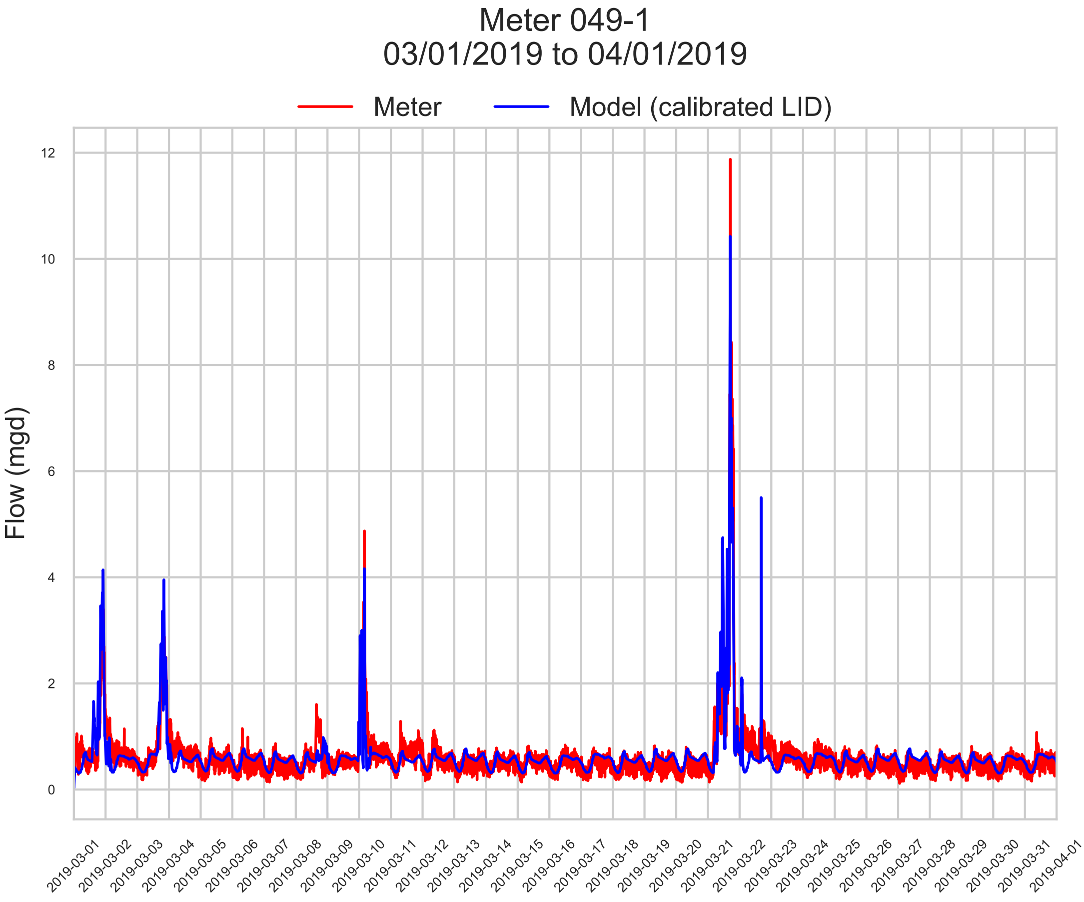
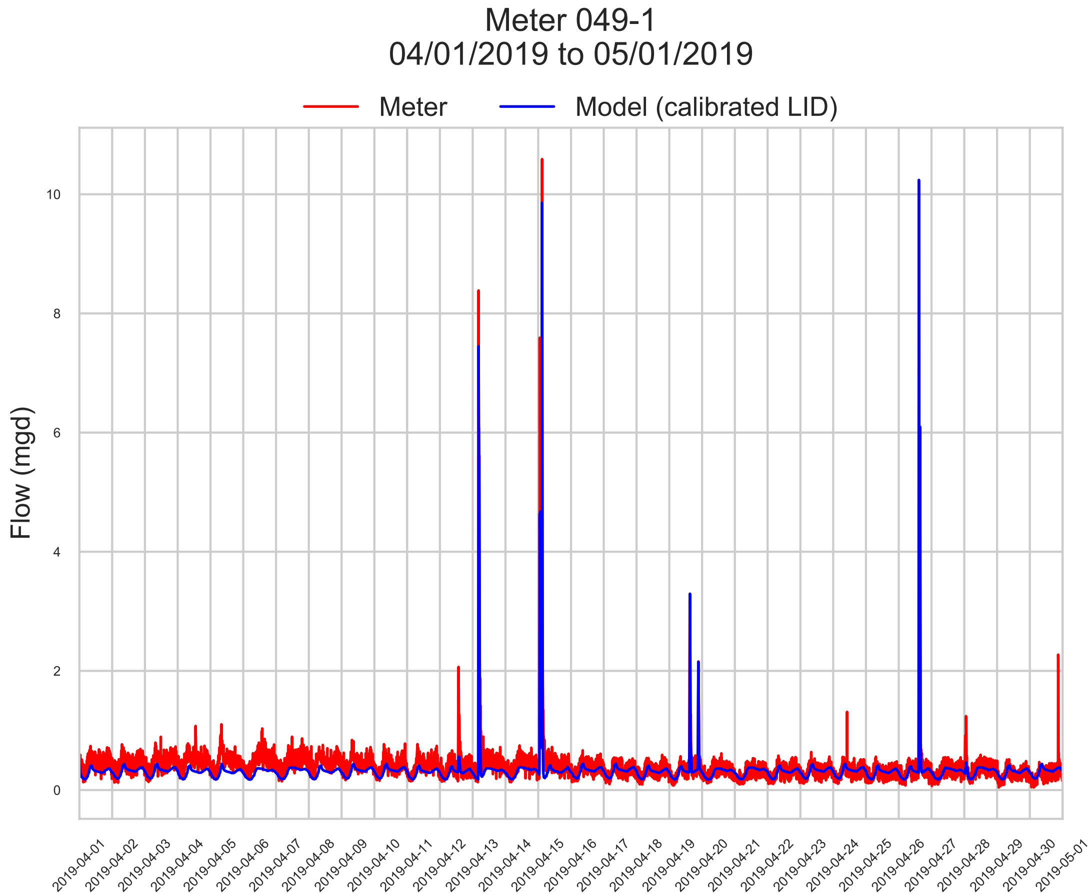
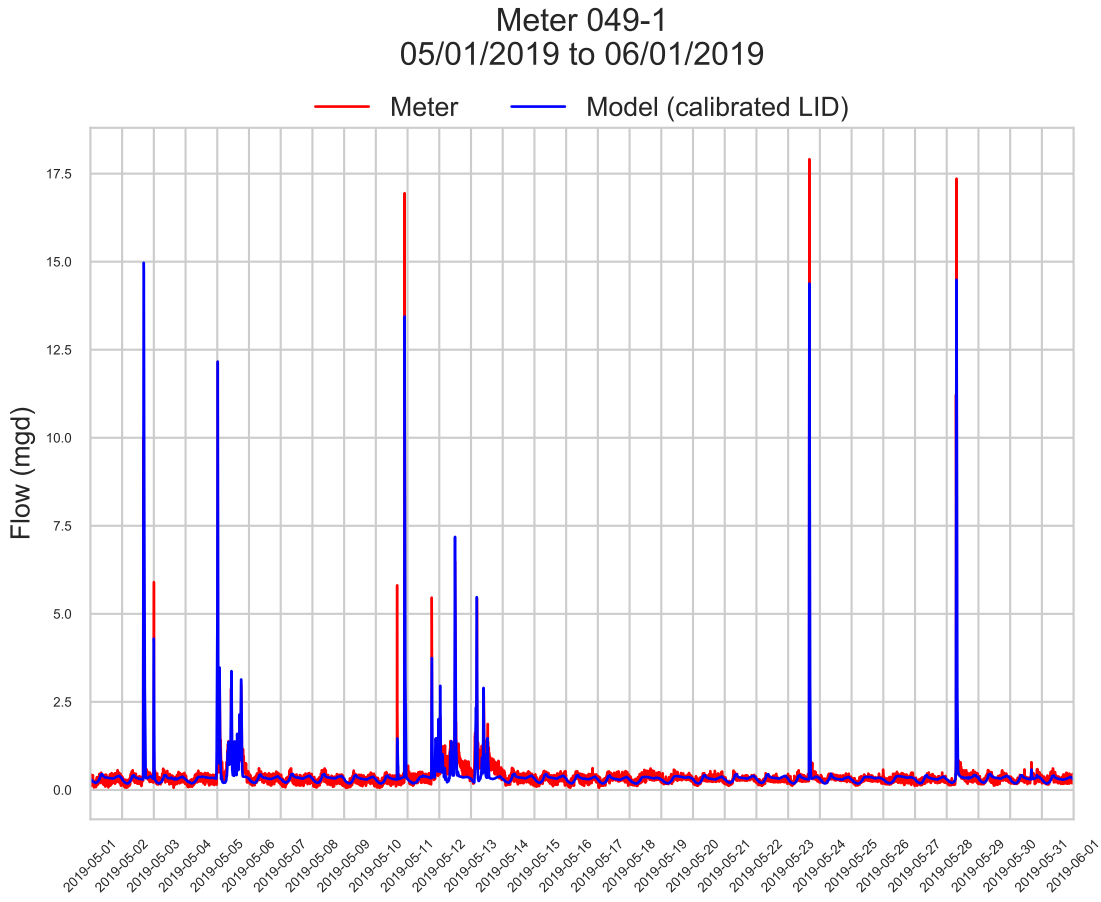
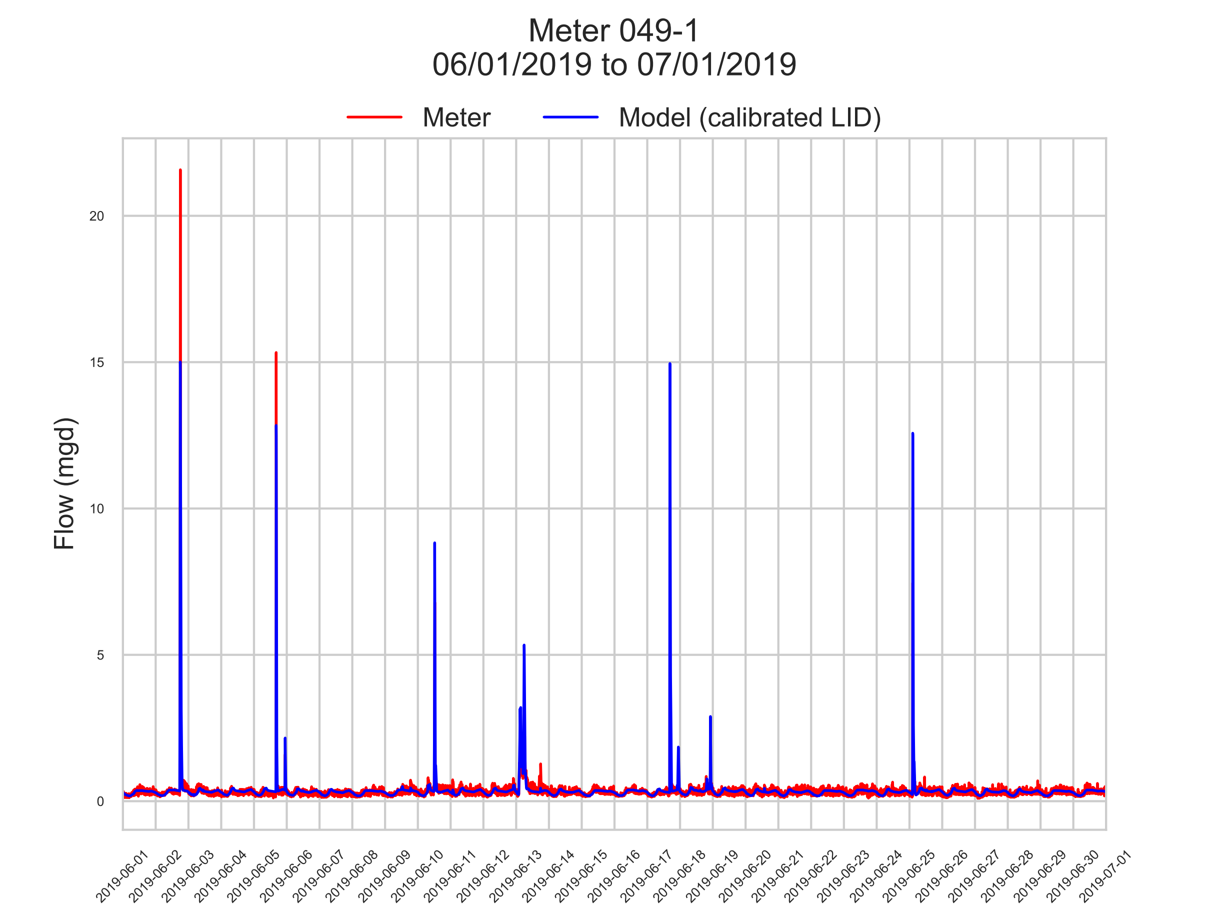

Meter 049-1
03/01/2019 to 04/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2019-03-01
2019-03-02
2019-03-03
2019-03-04
2019-03-05
2019-03-06
2019-03-07
2019-03-08
2019-03-09
2019-03-10
2019-03-11
2019-03-12
2019-03-13
2019-03-14
2019-03-15
2019-03-16
2019-03-17
2019-03-18
2019-03-19
2019-03-20
2019-03-21
2019-03-22
2019-03-23
2019-03-24
2019-03-25
2019-03-26
2019-03-27
2019-03-28
2019-03-29
2019-03-30
2019-03-31
2019-04-01



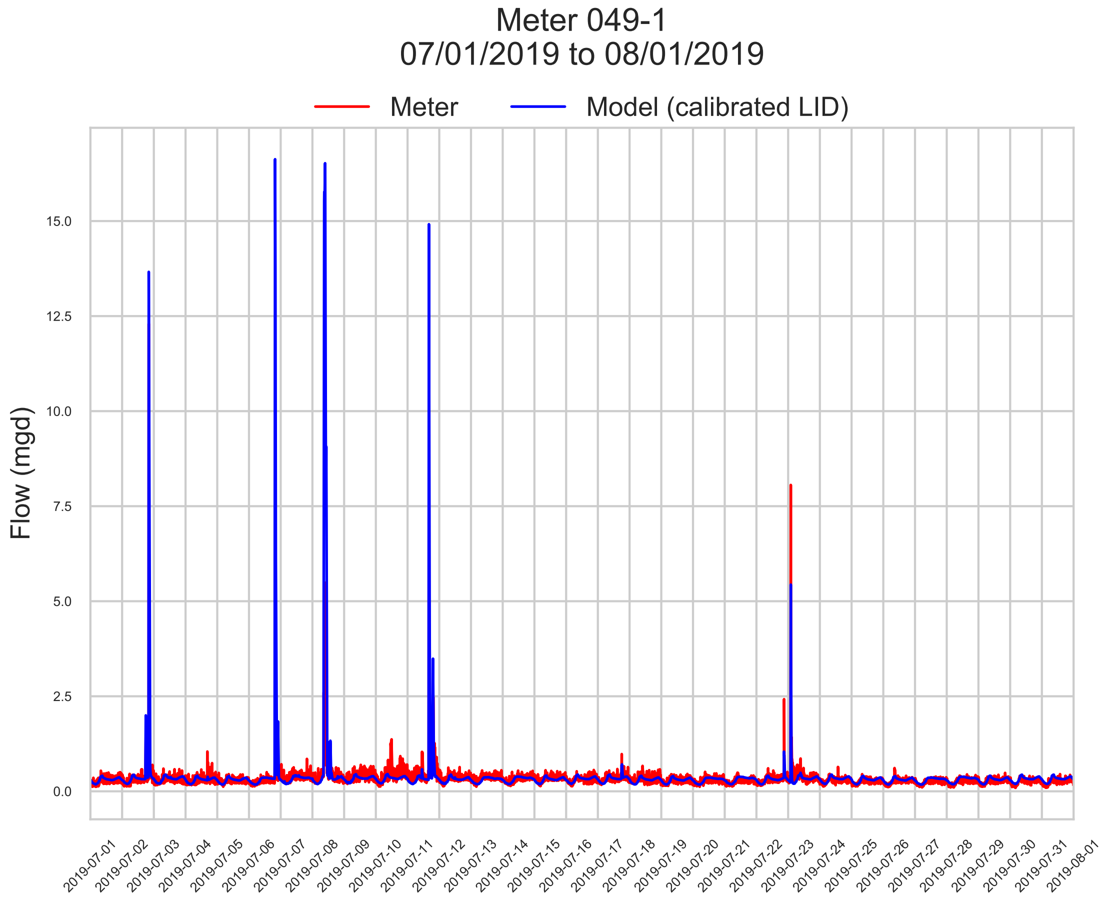
Meter 049-1
04/01/2019 to 05/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
2019-04-01
2019-04-02
2019-04-03
2019-04-04
2019-04-05
2019-04-06
2019-04-07
2019-04-08
2019-04-09
2019-04-10
2019-04-11
2019-04-12
2019-04-13
2019-04-14
2019-04-15
2019-04-16
2019-04-17
2019-04-18
2019-04-19
2019-04-20
2019-04-21
2019-04-22
2019-04-23
2019-04-24
2019-04-25
2019-04-26
2019-04-27
2019-04-28
2019-04-29
2019-04-30
2019-05-01

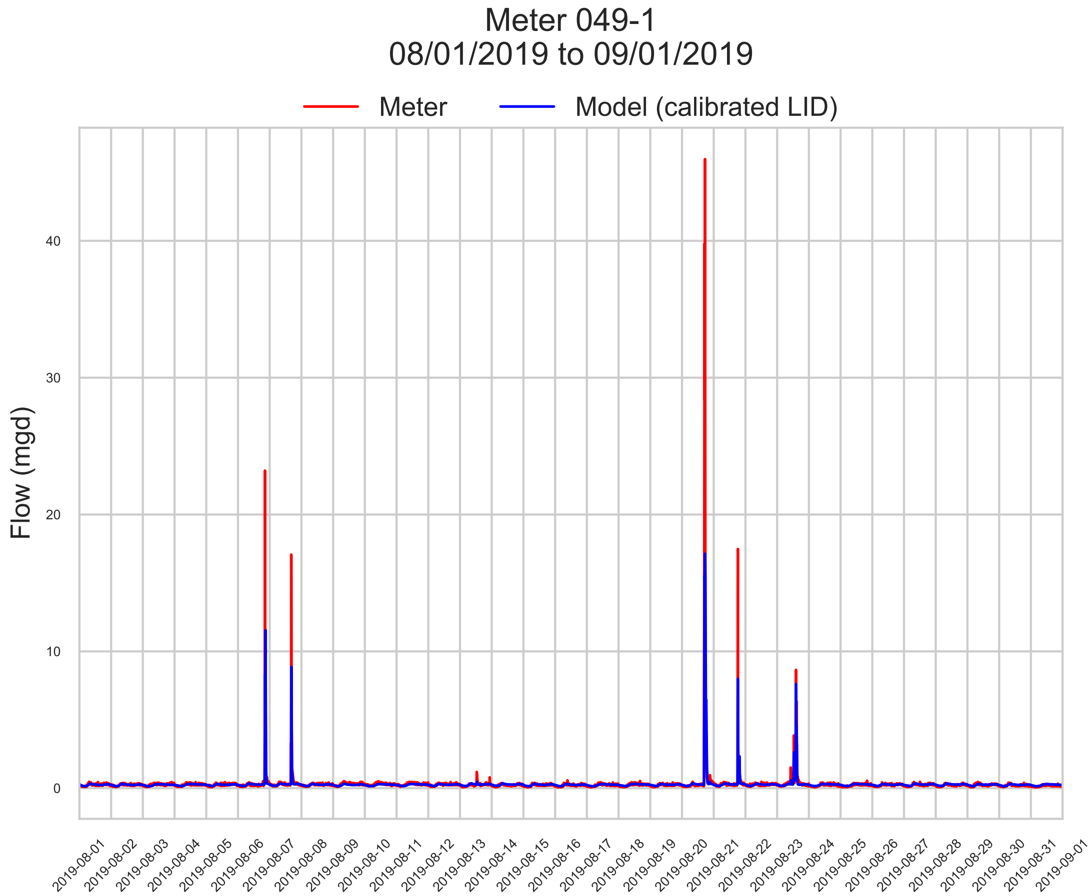


Meter 049-1
05/01/2019 to 06/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
2019-05-01
2019-05-02
2019-05-03
2019-05-04
2019-05-05
2019-05-06
2019-05-07
2019-05-08
2019-05-09
2019-05-10
2019-05-11
2019-05-12
2019-05-13
2019-05-14
2019-05-15
2019-05-16
2019-05-17
2019-05-18
2019-05-19
2019-05-20
2019-05-21
2019-05-22
2019-05-23
2019-05-24
2019-05-25
2019-05-26
2019-05-27
2019-05-28
2019-05-29
2019-05-30
2019-05-31
2019-06-01



Meter 049-1
06/01/2019 to 07/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
2019-06-01
2019-06-02
2019-06-03
2019-06-04
2019-06-05
2019-06-06
2019-06-07
2019-06-08
2019-06-09
2019-06-10
2019-06-11
2019-06-12
2019-06-13
2019-06-14
2019-06-15
2019-06-16
2019-06-17
2019-06-18
2019-06-19
2019-06-20
2019-06-21
2019-06-22
2019-06-23
2019-06-24
2019-06-25
2019-06-26
2019-06-27
2019-06-28
2019-06-29
2019-06-30
2019-07-01


Meter 049-1
07/01/2019 to 08/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2019-07-01
2019-07-02
2019-07-03
2019-07-04
2019-07-05
2019-07-06
2019-07-07
2019-07-08
2019-07-09
2019-07-10
2019-07-11
2019-07-12
2019-07-13
2019-07-14
2019-07-15
2019-07-16
2019-07-17
2019-07-18
2019-07-19
2019-07-20
2019-07-21
2019-07-22
2019-07-23
2019-07-24
2019-07-25
2019-07-26
2019-07-27
2019-07-28
2019-07-29
2019-07-30
2019-07-31
2019-08-01


Meter 049-1
08/01/2019 to 09/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
10
20
30
40
2019-08-01
2019-08-02
2019-08-03
2019-08-04
2019-08-05
2019-08-06
2019-08-07
2019-08-08
2019-08-09
2019-08-10
2019-08-11
2019-08-12
2019-08-13
2019-08-14
2019-08-15
2019-08-16
2019-08-17
2019-08-18
2019-08-19
2019-08-20
2019-08-21
2019-08-22
2019-08-23
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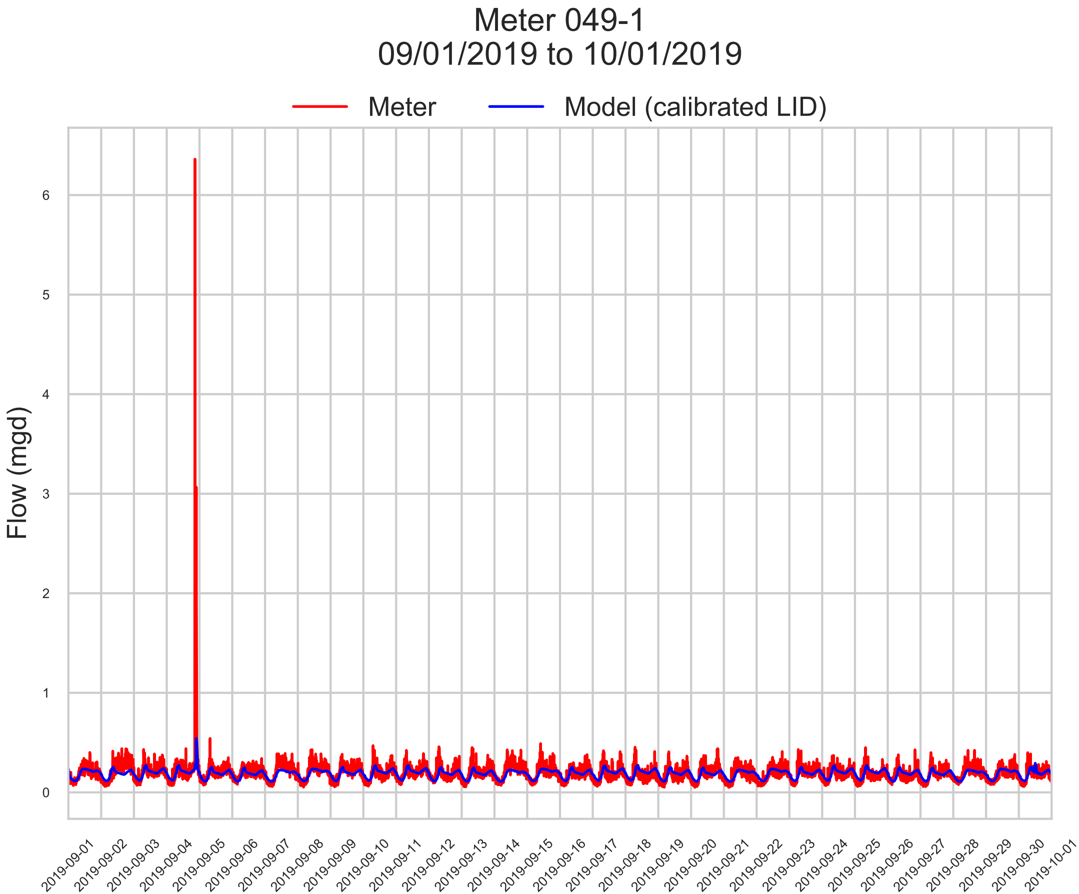
2019-09-01



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09/01/2019 to 10/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
2019-09-01
2019-09-02
2019-09-03
2019-09-04
2019-09-05
2019-09-06
2019-09-07
2019-09-08
2019-09-09
2019-09-10
2019-09-11
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2019-09-15
2019-09-16
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2019-09-20
2019-09-21
2019-09-22
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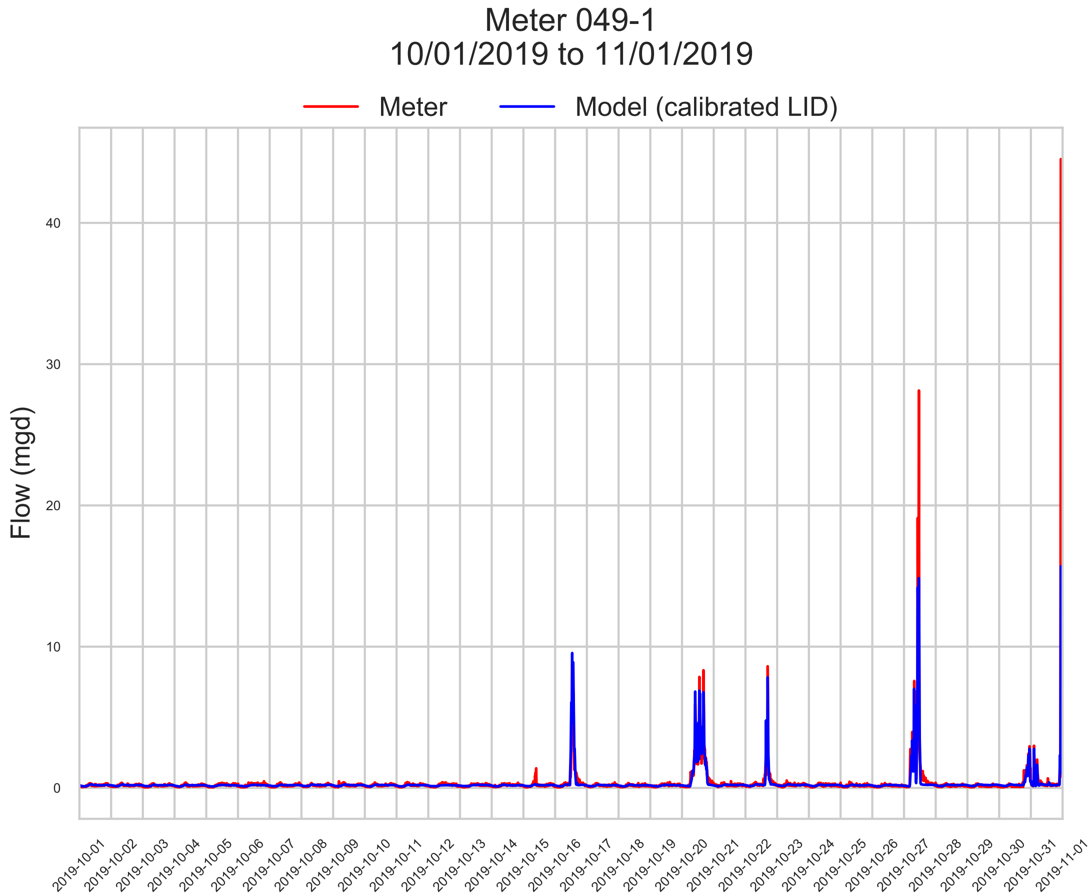
2019-09-30
2019-10-01



Meter 049-1
10/01/2019 to 11/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
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10
20
30
40
2019-10-01
2019-10-02
2019-10-03
2019-10-04
2019-10-05
2019-10-06
2019-10-07
2019-10-08
2019-10-09
2019-10-10
2019-10-11
2019-10-12
2019-10-13
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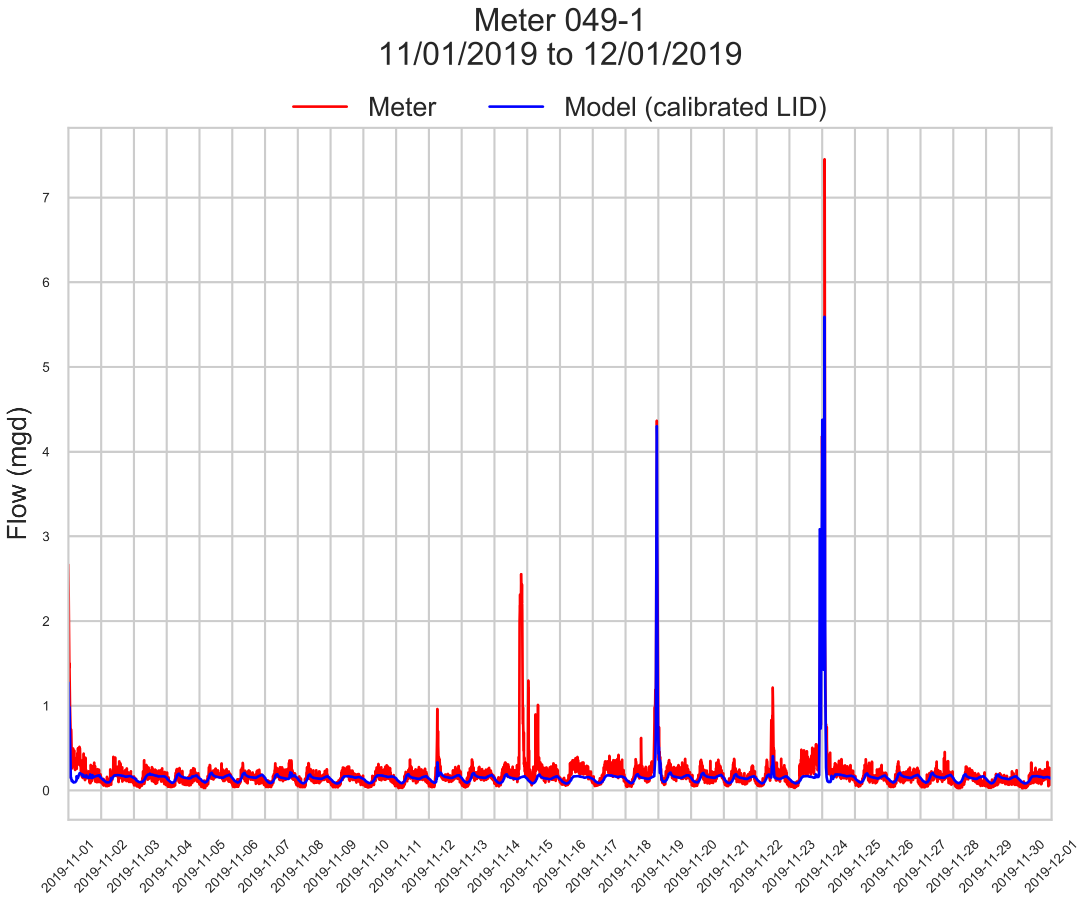
2019-10-31
2019-11-01



Meter 049-1
11/01/2019 to 12/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
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2
3
4
5
6
7
2019-11-01
2019-11-02
2019-11-03
2019-11-04
2019-11-05
2019-11-06
2019-11-07
2019-11-08
2019-11-09
2019-11-10
2019-11-11
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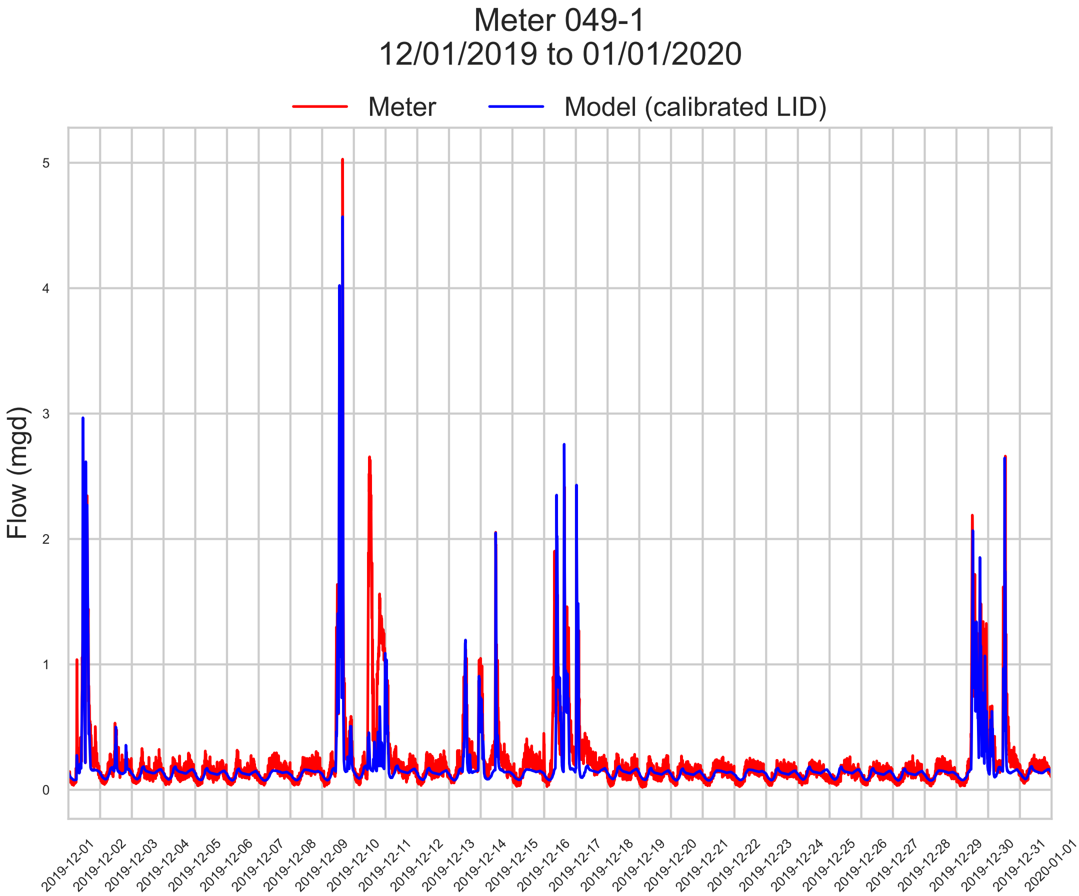
2019-12-01



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Meter
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2
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2019-12-02
2019-12-03
2019-12-04
2019-12-05
2019-12-06
2019-12-07
2019-12-08
2019-12-09
2019-12-10
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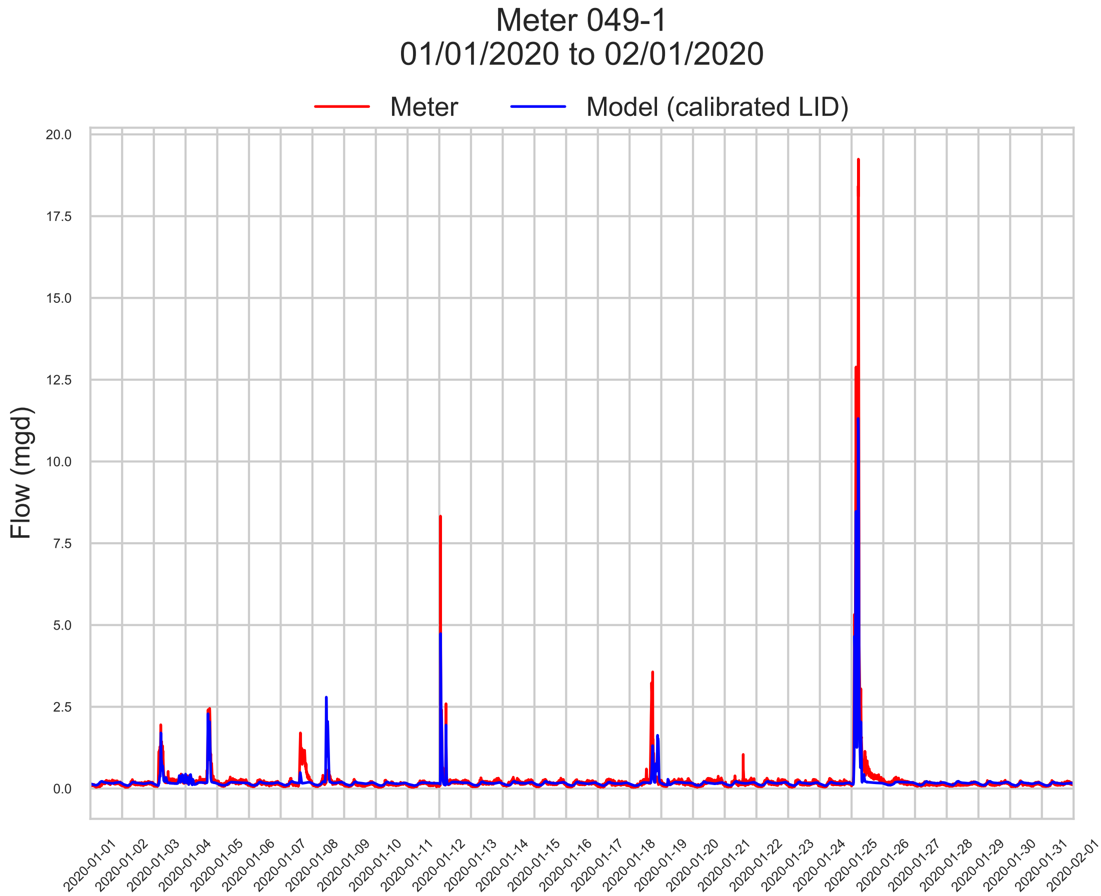
2020-01-01



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01/01/2020 to 02/01/2020
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Model (calibrated LID)
Flow (mgd)
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17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2020-01-01
2020-01-02
2020-01-03
2020-01-04
2020-01-05
2020-01-06
2020-01-07
2020-01-08
2020-01-09
2020-01-10
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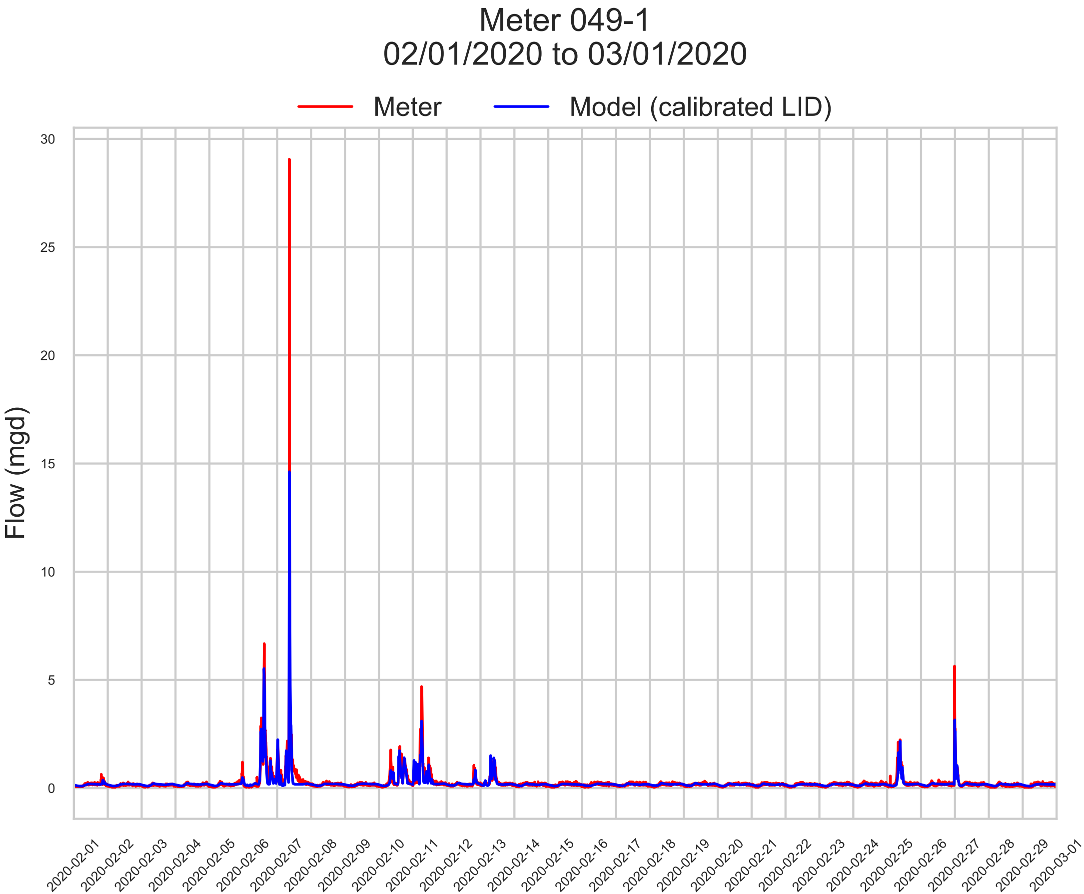
2020-02-01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02/01/2020 to 03/01/2020
Meter
Model (calibrated LID)
Flow (mgd)
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20
25
30
2020-02-01
2020-02-02
2020-02-03
2020-02-04
2020-02-05
2020-02-06
2020-02-07
2020-02-08
2020-02-09
2020-02-10
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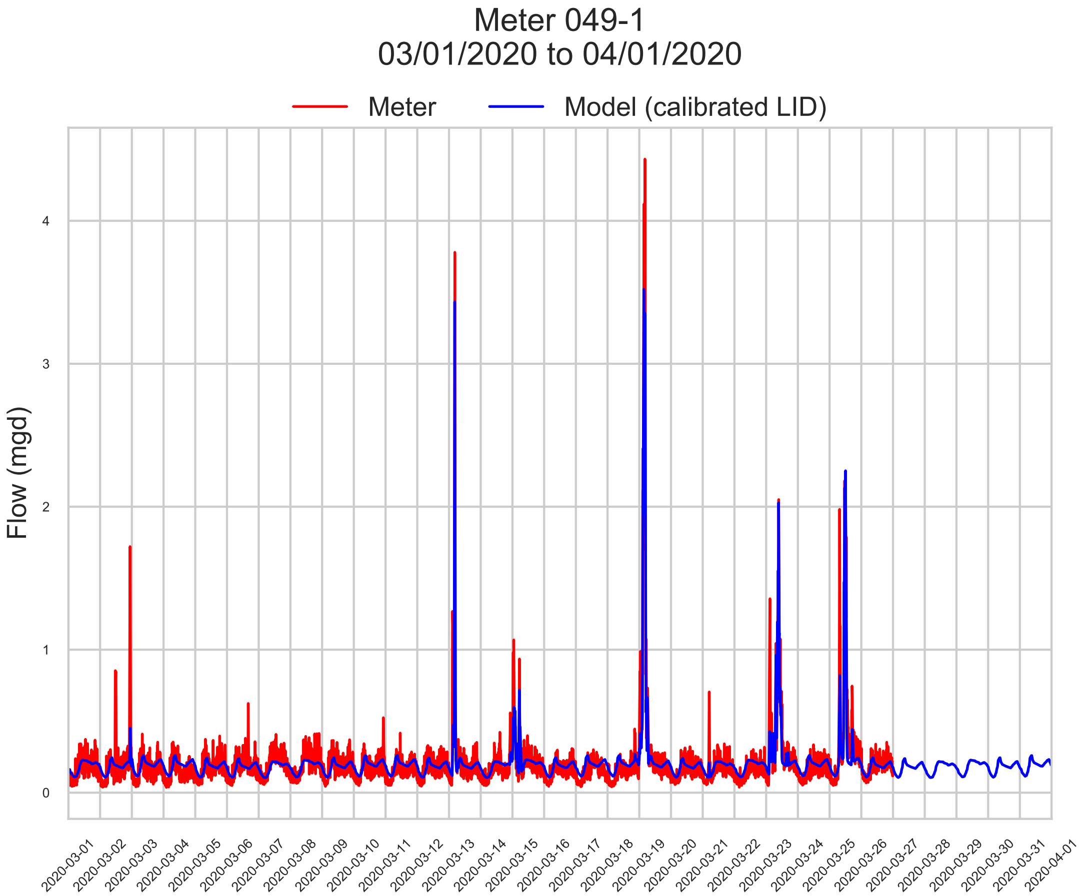
2020-03-01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03/01/2020 to 04/01/2020
Meter
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Flow (mgd)
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3
4
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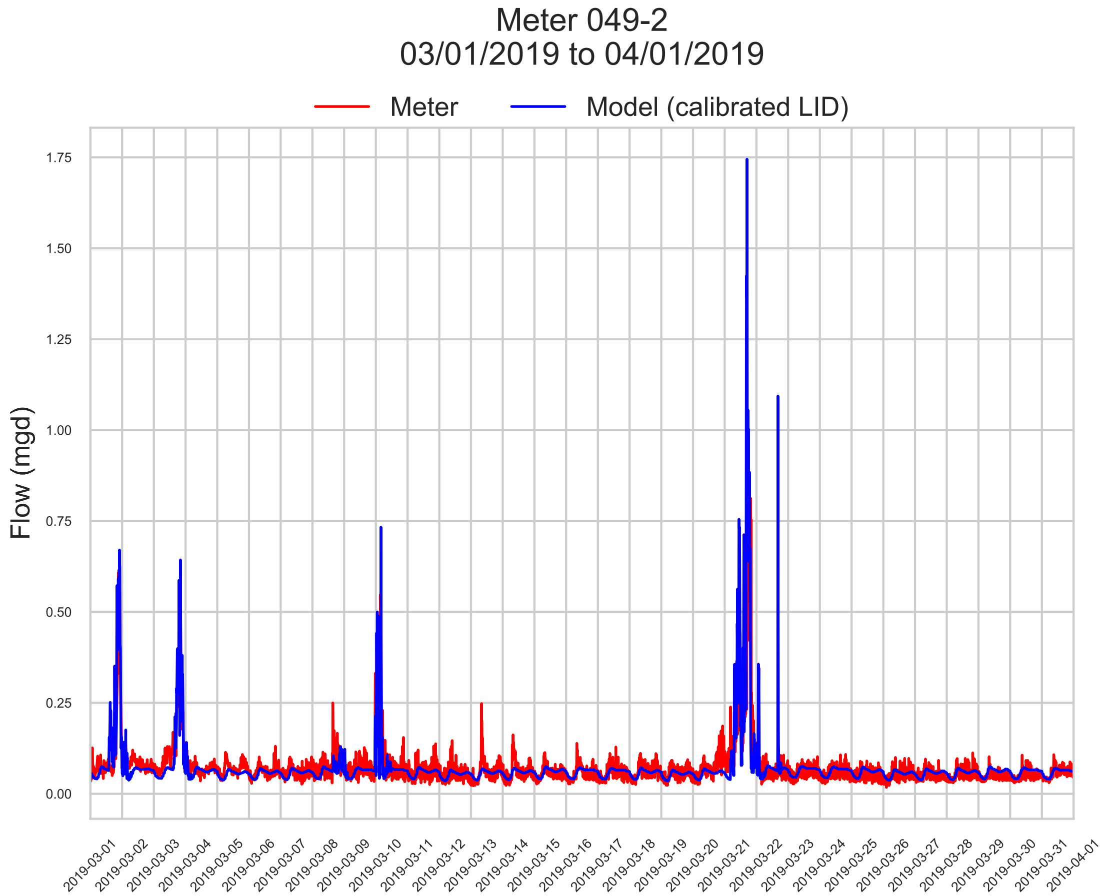
2020-04-01



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Model (calibrated LID)
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2019-03-01
2019-03-02
2019-03-03
2019-03-04
2019-03-05
2019-03-06
2019-03-07
2019-03-08
2019-03-09
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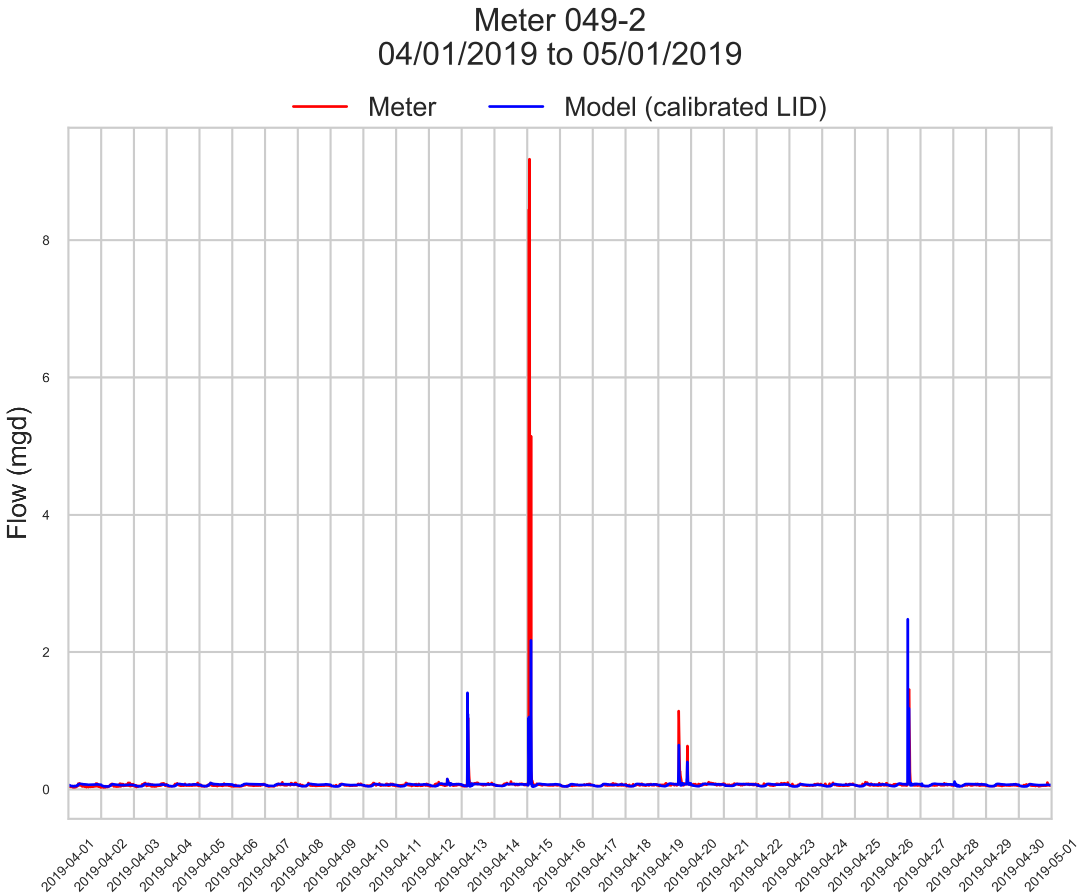
2019-03-31
2019-04-01


Meter 049-2
04/01/2019 to 05/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
2019-04-01
2019-04-02
2019-04-03
2019-04-04
2019-04-05
2019-04-06
2019-04-07
2019-04-08
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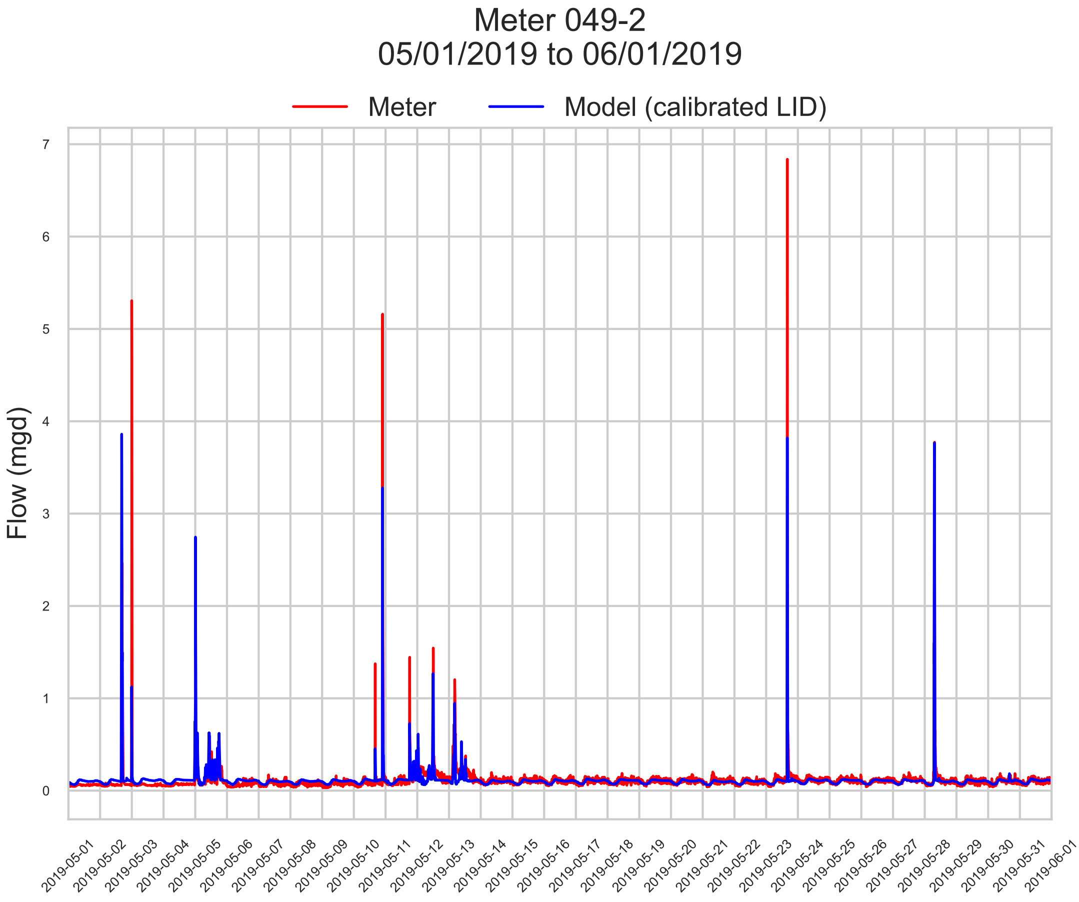
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05/01/2019 to 06/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
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1
2
3
4
5
6
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2019-05-01
2019-05-02
2019-05-03
2019-05-04
2019-05-05
2019-05-06
2019-05-07
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2019-05-23
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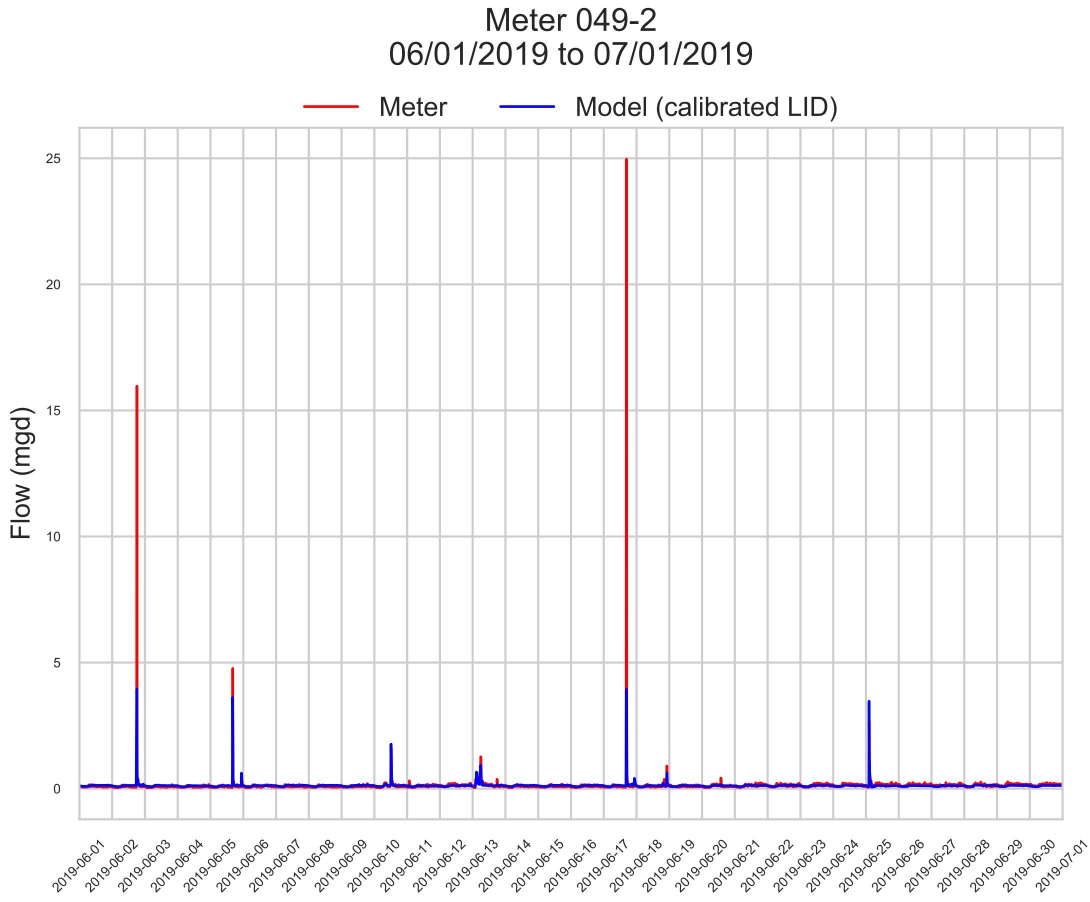
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06/01/2019 to 07/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
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5
10
15
20
25
2019-06-01
2019-06-02
2019-06-03
2019-06-04
2019-06-05
2019-06-06
2019-06-07
2019-06-08
2019-06-09
2019-06-10
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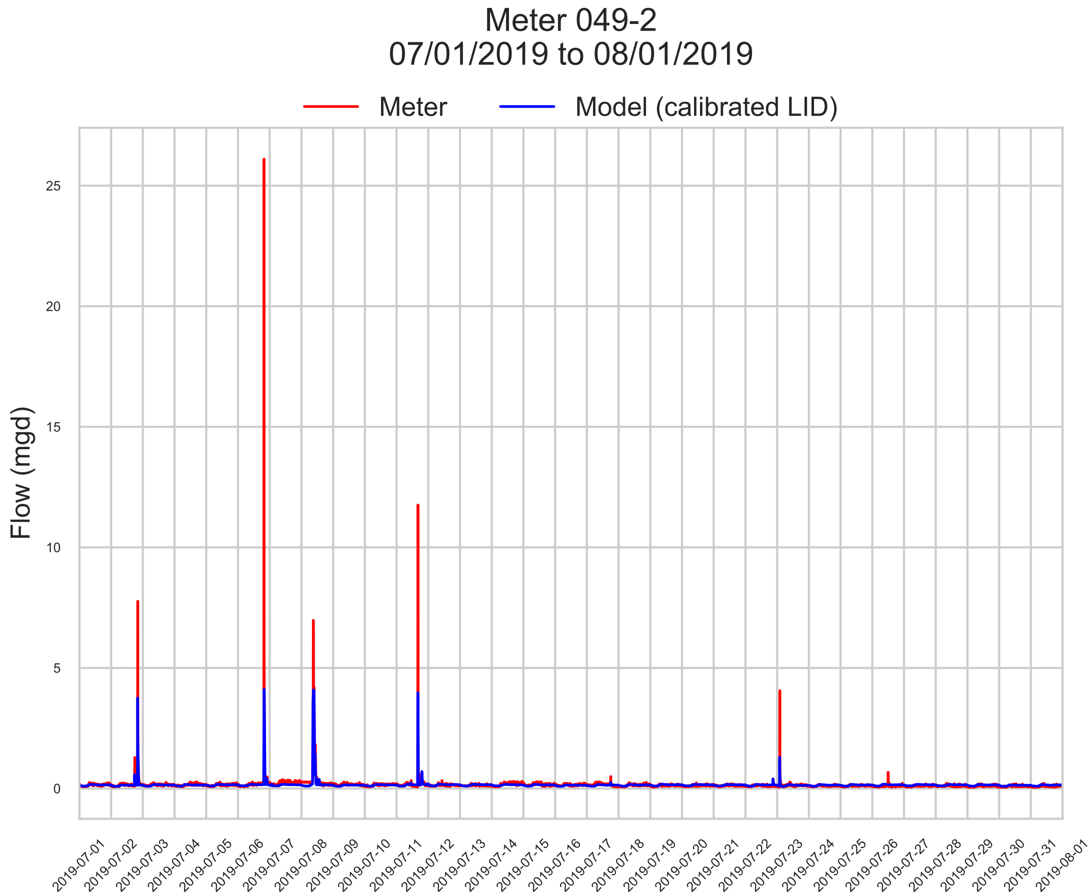

Meter 049-2
07/01/2019 to 08/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
2019-07-01
2019-07-02
2019-07-03
2019-07-04
2019-07-05
2019-07-06
2019-07-07
2019-07-08
2019-07-09
2019-07-10
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2019-07-23
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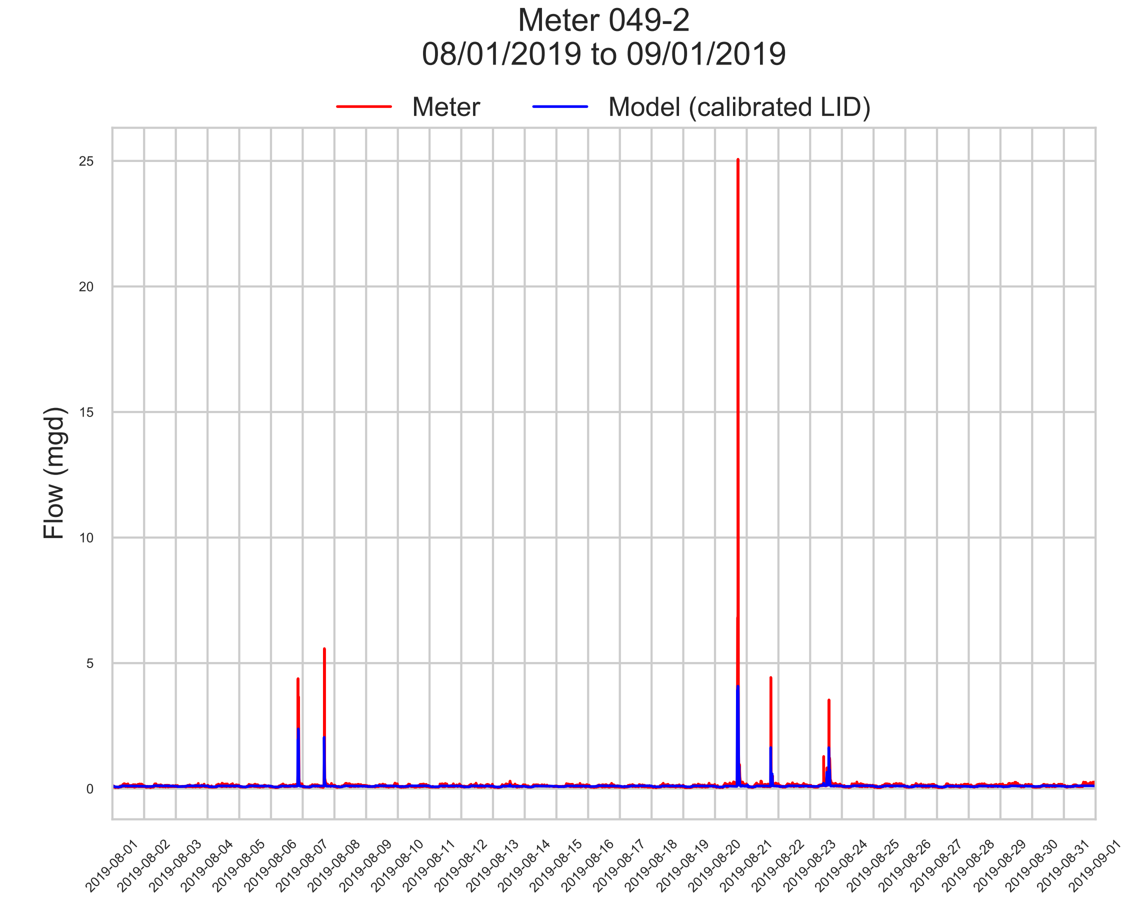
2019-08-01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08/01/2019 to 09/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
2019-08-01
2019-08-02
2019-08-03
2019-08-04
2019-08-05
2019-08-06
2019-08-07
2019-08-08
2019-08-09
2019-08-10
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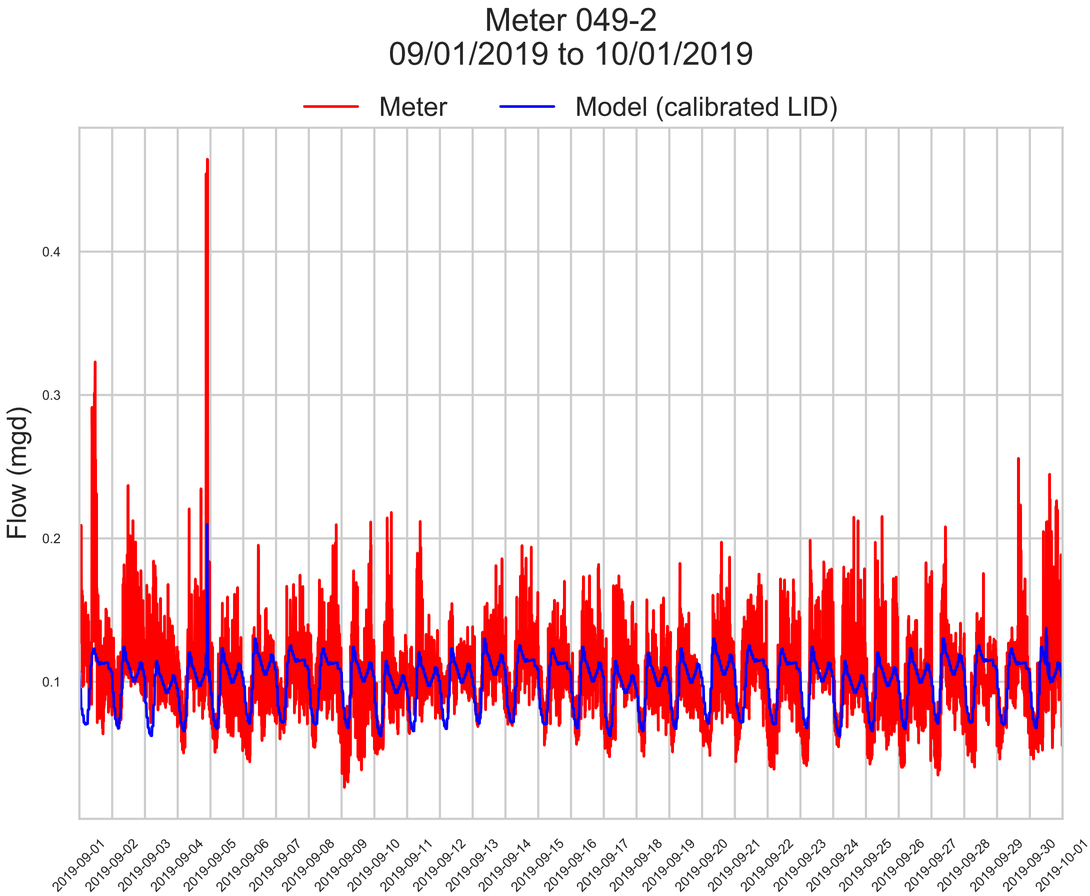
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2019-09-22
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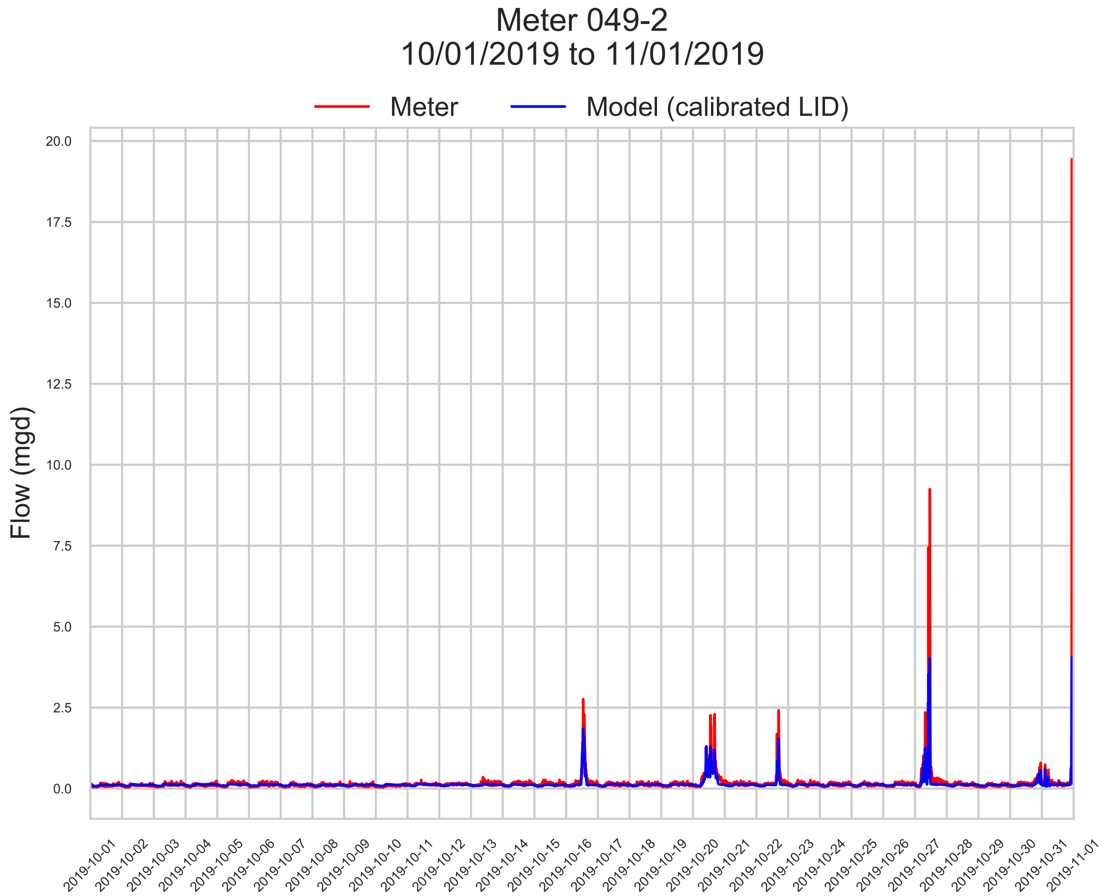
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10/01/2019 to 11/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
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17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2019-10-01
2019-10-02
2019-10-03
2019-10-04
2019-10-05
2019-10-06
2019-10-07
2019-10-08
2019-10-09
2019-10-10
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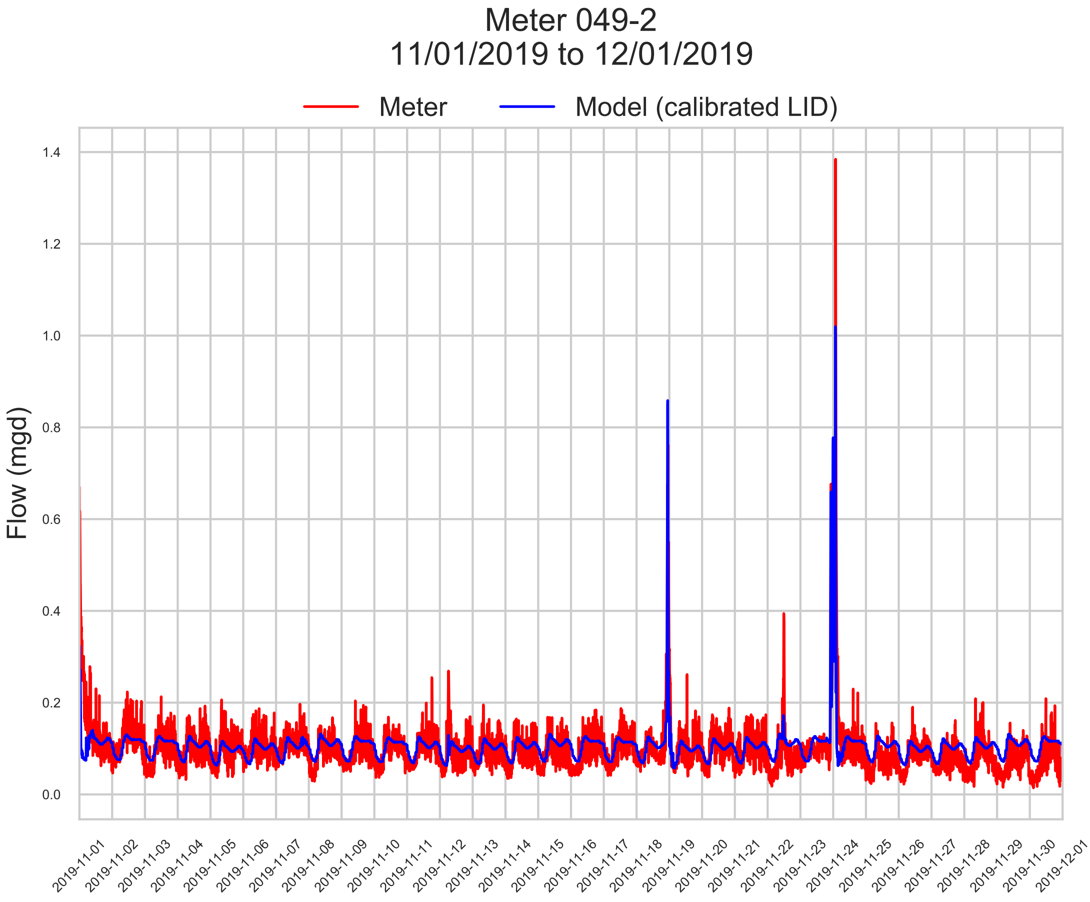
2019-11-01



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11/01/2019 to 12/01/2019
Meter
Model (calibrated LID)
Flow (mgd)
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0.2
0.4
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1.2
1.4
2019-11-01
2019-11-02
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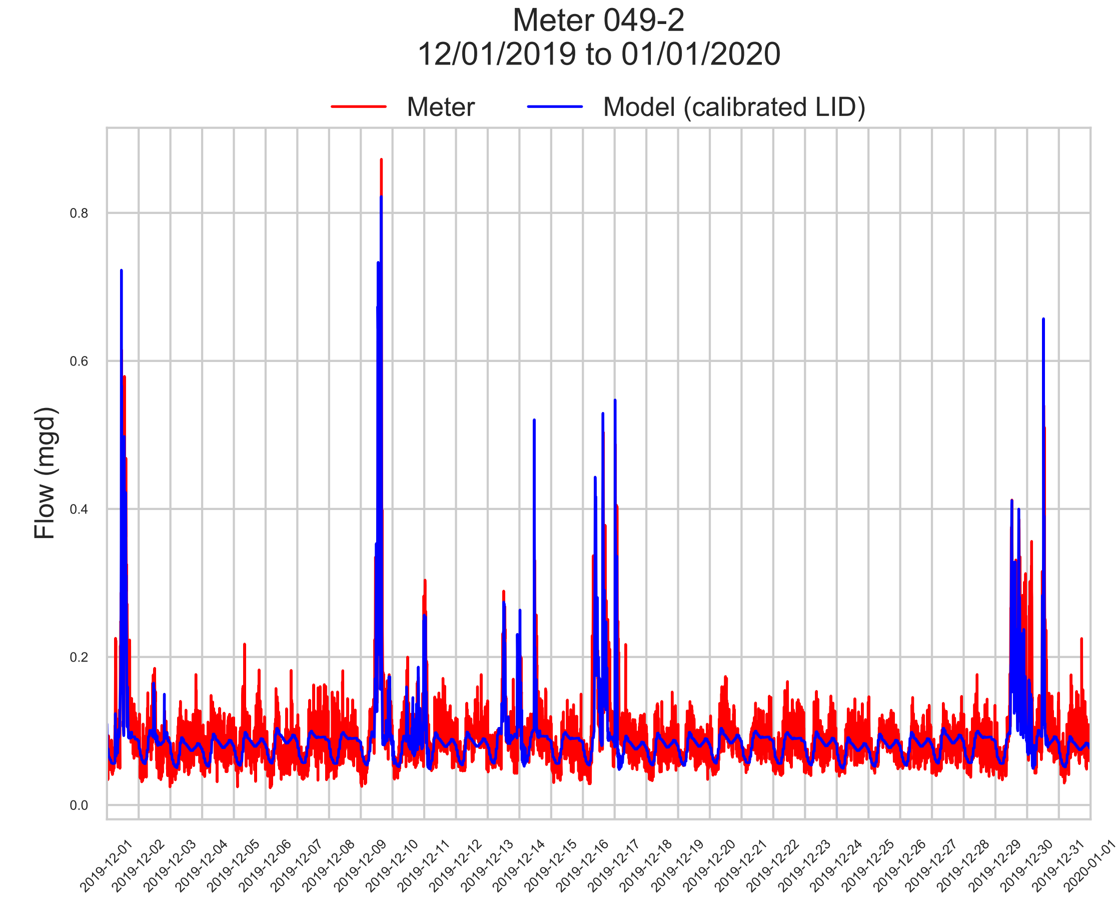

Meter 049-2
12/01/2019 to 01/01/2020
Meter
Model (calibrated LID)
Flow (mgd)
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0.2
0.4
0.6
0.8
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2019-12-02
2019-12-03
2019-12-04
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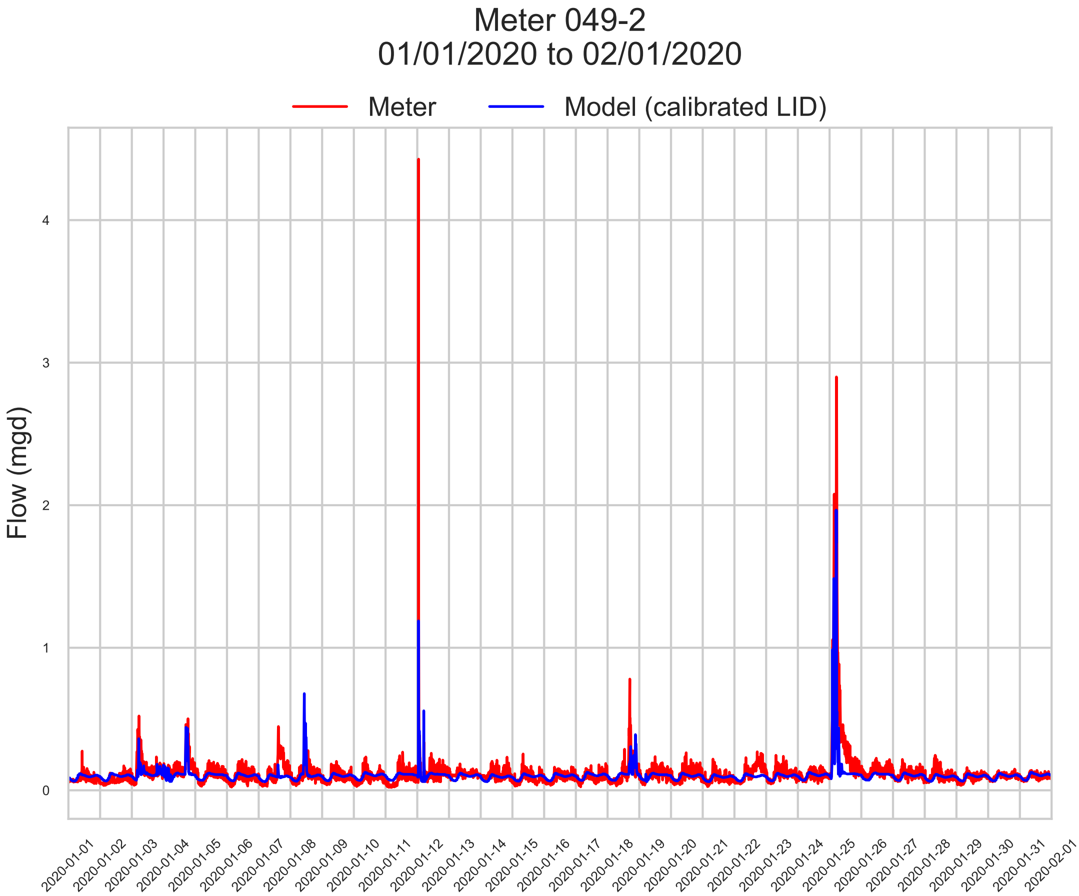
2020-01-01



Meter 049-2
01/01/2020 to 02/01/2020
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
2020-01-01
2020-01-02
2020-01-03
2020-01-04
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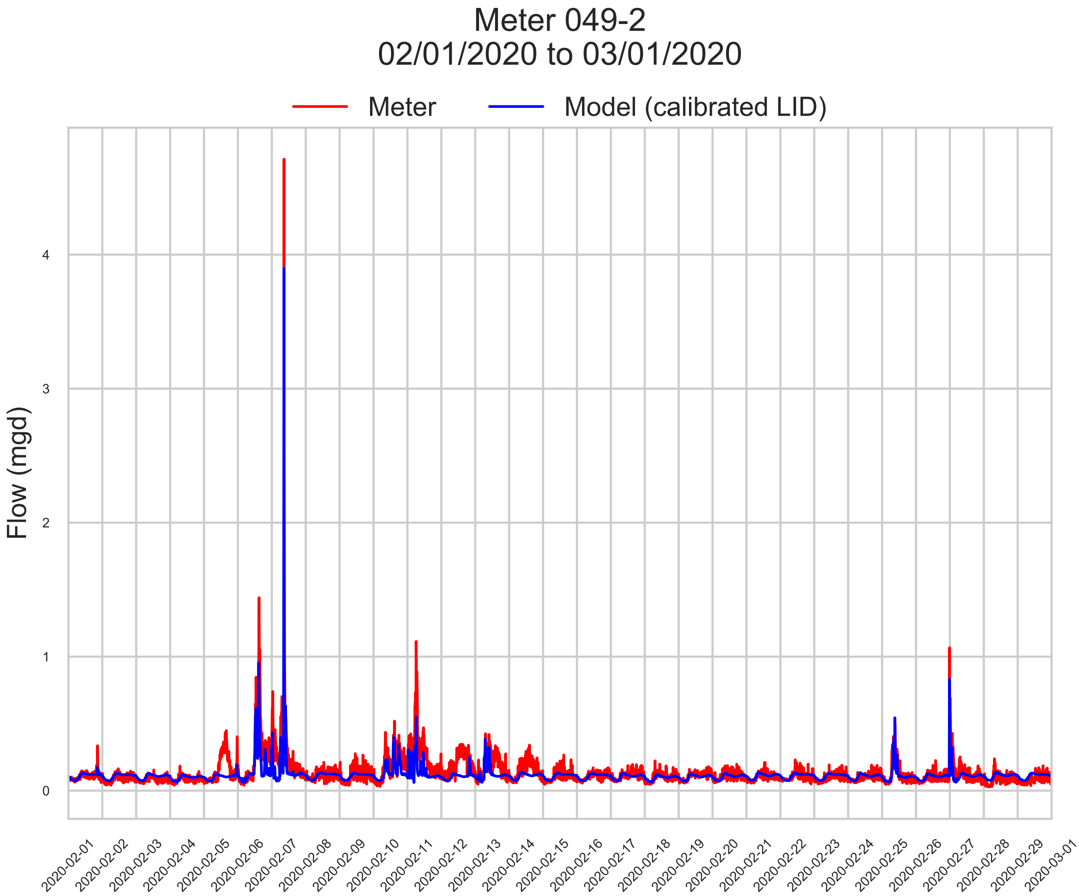

Meter 049-2
02/01/2020 to 03/01/2020
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Model (calibrated LID)
Flow (mgd)
0
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2
3
4
2020-02-01
2020-02-02
2020-02-03
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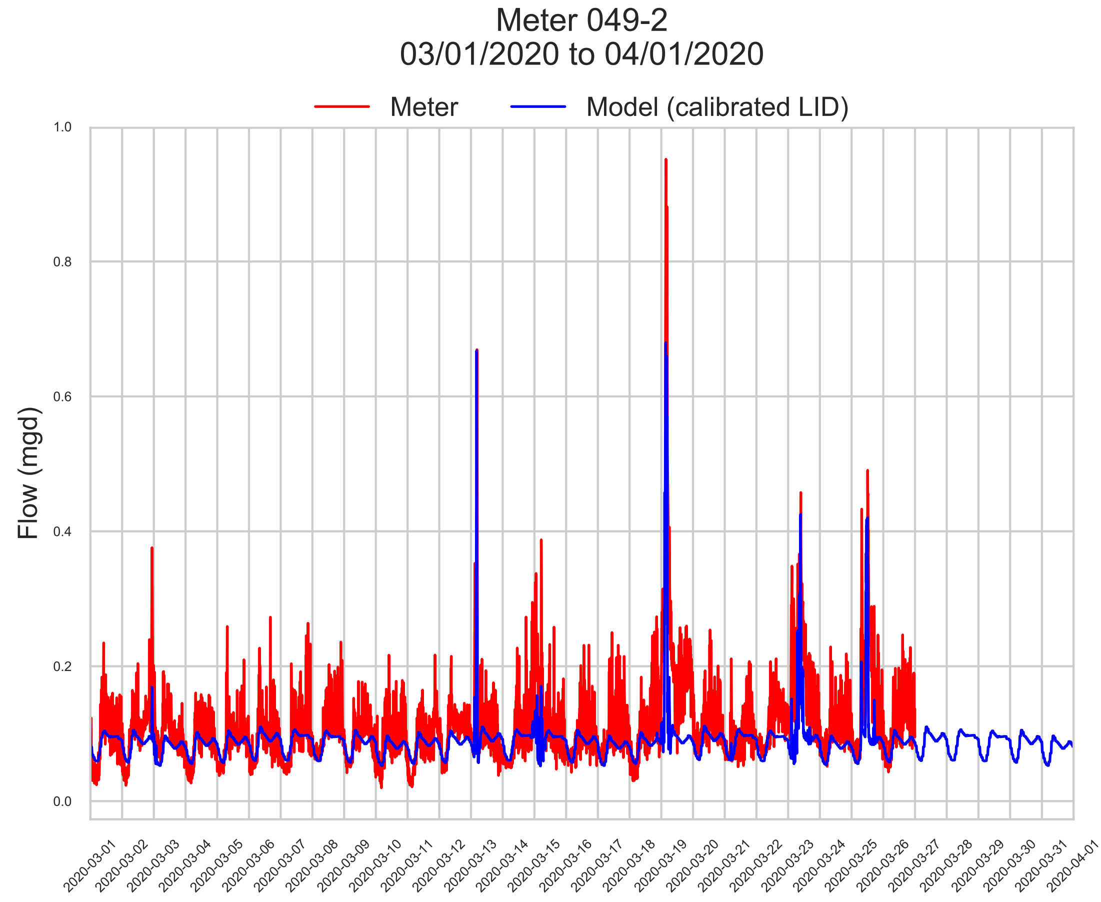
2020-03-01



Meter 049-2
03/01/2020 to 04/01/2020
Meter
Model (calibrated LID)
Flow (mgd)
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0.6
0.4
0.2
0.0
2020-03-01
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2020-03-26
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2020-03-30
2020-03-31
2020-04-01

Appendix F

Model Documentation:
Green Infrastructure Modeling for PR-A Area

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

Model Documentation: Green Infrastructure Modeling for PR-A area

June 2020

Prepared for:

Prepared by:

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 20032

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Appendices

1 Introduction

1.1 Background

The development and calibration of the combined sewer model used for the LTCP is documented in *Study Memorandum LTCP 5-4: CSS Model Documentation* that was published with the LTCP in 2001. The modeling conducted to evaluate green infrastructure in the PR-A area uses refined sub-models of the metered PR-A area that were developed independently of the system-wide LTCP model.

1.2 Model Documentation

The PR-A SWMM runoff model is an application of the EPA SWMM5 model. SWMM5 is the current version of the most widely applied urban stormwater model across the world include for specific GI applications. EPA's long-term support to the development and application of SWMM5 and earlier SWMM models underscores its acceptance in applications to support regulatory programs. SWMM5 is the model used for the range of GI-related modeling for the DCCR. The model included subcatchments representing runoff in the PR-A project area, the sewer network conveying the flow to the outlets of the PR-A project area and the GI practices planned for PR-A. GI practices are represented in the model by combining all practices of a given practice type (alley permeable pavement, parking lane permeable pavement, bioretention practices) into one single practice per type per model subshed. A schematic of this "lumped practice" modeling approach is shown in Figure 1-1.

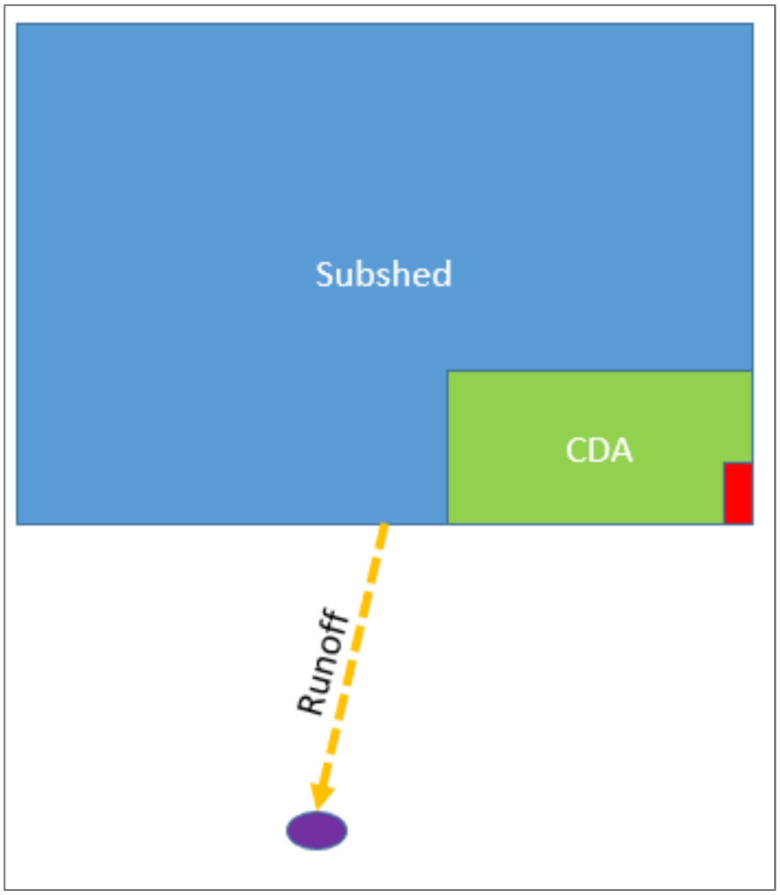

Figure 1-1. Lumped Practice Modeling Approach

1.3 Scope and Modeling Objectives

The development, calibration, and application of the PR-A SWMM model followed a similar effort for the RC-A Green Infrastructure project. The model was developed to reflect conditions prior to GI installation, followed by calibration to the pre-construction monitoring period. A post-construction model was then developed to reflect the installation of GI; this model was calibrated to the post-construction data. The calibrated post-construction model was then applied to predict overall wet weather reductions for the LTCP average year period of 1988-1990.

- The pre-construction model was calibrated for a time period of 2/5/2016 to 2/4/2017.
- Installed GI practices were added to the model and the model was calibrated using post-construction sewer monitoring data using data from 4/16/2019 to 3/26/2020. Model adjustments during this calibration were limited to the GI parameters only, although model adjustments were minor and did not deviate from the GI design/as-built parameters. Model parameters unrelated to GI were unchanged from the pre- to post-construction models.
- The calibrated post-construction model was used to simulate the LTCP forecast period of 1988-1990.
- Additional comparisons were made between model-predicted GI practice performance and practice-specific water level data. Practice-specific data for six practices for the period of 11/14/2019 to 3/26/2020 were compared with modeled water levels for lumped practices on the subshed level. Table 1-1 provides an overview of all modeling timeframes.

Table 1-1. PR-A Modeling Timeframes

Modeling Purpose	Timeframe	Model Description
Rainfall Monitoring	2/5/16 – 3/26/20	For Pre Construction Period: 2/5/16 - 2/4/17 For Post Construction Period: 4/16/19 - 3/26/20
Pre-Construction Monitoring – Sewershed	2/5/16 - 2/4/17	Entire monitoring period served as calibration period
Post-Construction Monitoring – Sewershed	4/16/19 - 3/26/20	Entire monitoring period served as calibration period
Post-Construction Monitoring – GI Practices	11/14/19 - 3/26/20	Comparison of modeled WLs with practice-specific WL data.

2 Description of System

2.1 PR-A Area

The PR-A study area consists of 190 acres, and is approximately 46% impervious. Table 2-1 summarizes all GI practices installed within and outside of the study area. "Acres Managed" are based on the impervious portion of the GI CDA. Figure 2-1 shows the PR-A GI facility locations.

Table 2-1. Constructed and metered GI Facilities

	Constructed & Modeled (project area)	
Practice Type	**Number of Practices**	**Acres Managed (% of total impervious acres managed)**
Planter Bioretention (PBR)	5	0.3 (3.5%)
Alley Permeable Pavement (APP)	23	5.69 (71.5%)
Parking Lane Permeable Pavement (PPP)	15	1.99 (25.0%)
Total	**43**	**7.95 (100%)**

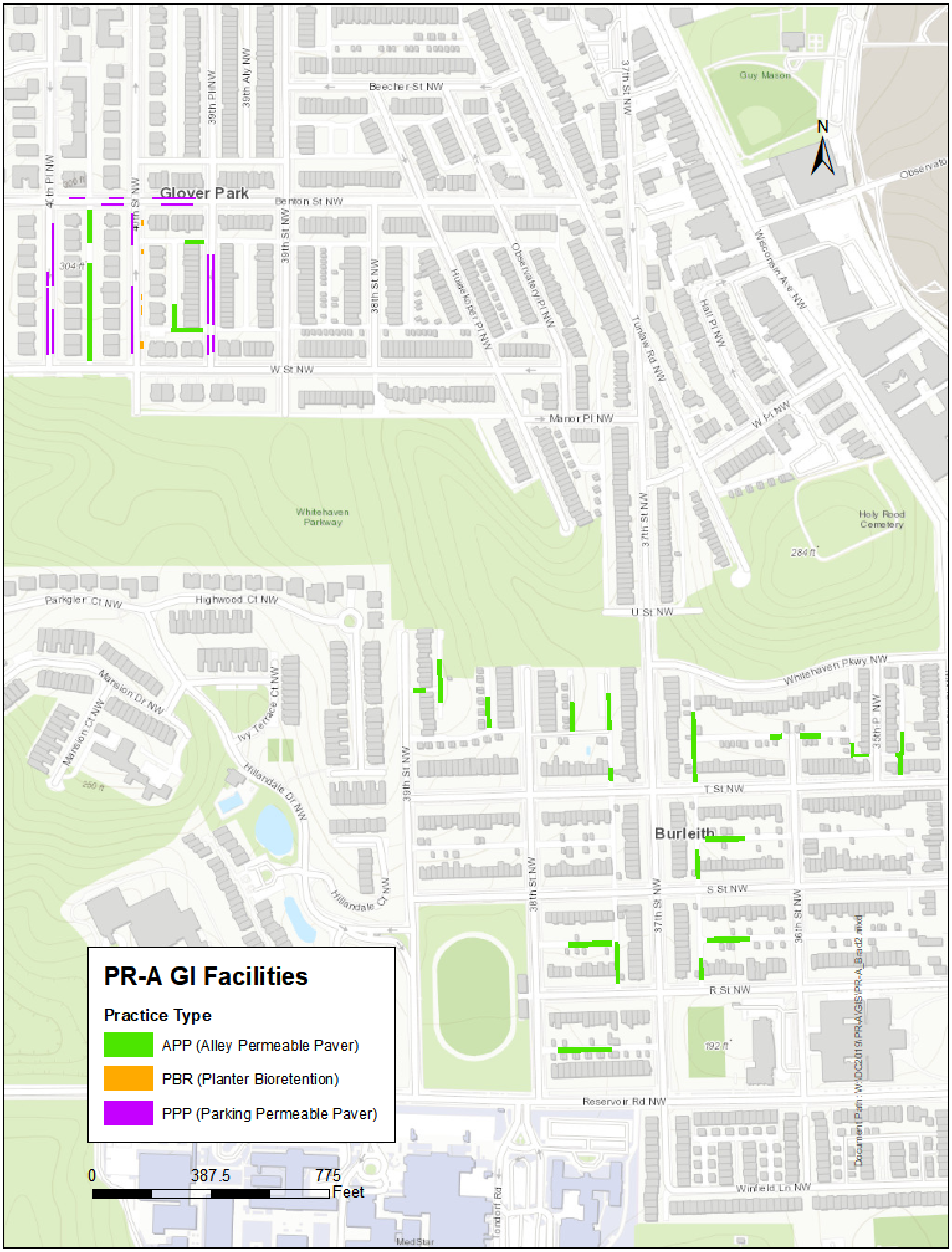

Figure 2-1. Installed PR-A GI practices

2.2 Monitoring locations and data

There are two outlets from PR-A, with interconnections between them, that were monitored by meters 029-5 and 029-6 during both pre- and post-construction periods. Those two meters' flows were summed for model calibration. There are also two upstream meters with interconnections, 029-1 and 029-2, which were also summed for calibration. The combined 029-1 and 029-2 area covers 33 acres, and is 50% impervious. The installed green infrastructure practices consist mostly of pervious pavers, with only a few bioretention cells. About 40% of the GI practices are concentrated in the 029-1 and 029-2 meter sheds, with the remainder in the 029-5 and 029-6 meter sheds. Overall, the PR-A study area consists of 190 acres, and is 46% impervious. Table 2-2 summarizes the PR-A meter areas.

Table 2-2: PR-A Flow Meters

Meter	Purpose / Usage	Drainage Area (ac)	Pre-construction	Post-construction
PR-A 029-1	Quantify runoff from a specific group of GI practices	33.4	YES	YES
PR-A 029-2	Quantify runoff from a specific group of GI practices		YES	YES
PR-A 029-3	Quantify runoff from a specific area (*, **)	22.7	YES	YES
PR-A 029-4	Quantify runoff from a specific area (*, **)	40.5	YES	YES
PR-A 029-5	Quantify total flows in PR-A area	190.0	YES	YES
PR-A 029-6	Quantify total flows in PR-A area		YES	YES

(*) Internal Meter, not used for this study due to inconsistencies in flows from pre- to post-construction periods, as well as absence of GI practices within these meter sheds
(**) Meter not used for this study due to overlapping drainage area size or data quality issues

Figure 2-2 shows the locations of the meters and rain gauge, as well as the drainage areas for the sewer meters and meter groupings.

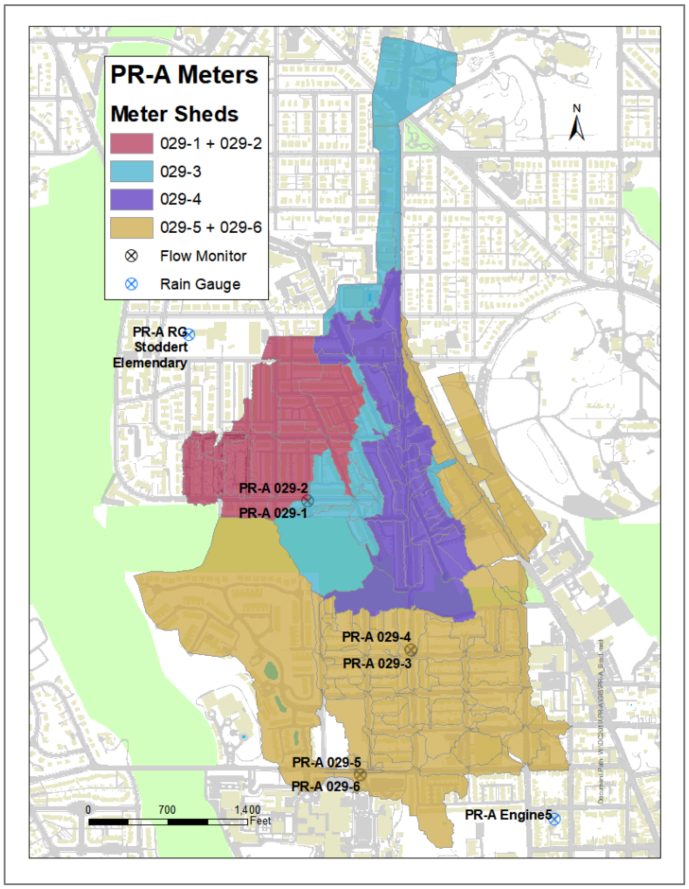

Figure 2-2: PR-A Monitoring Locations and Sheds

2.3 Rainfall Monitoring

A rain gauge with a five-minute reporting interval was installed at the Stoddert Elementary and was active for both the pre-construction and post-construction periods. For the purposes of modeling and analysis, events were excluded from analysis if there were any suspected winter weather influences, if there was an extreme disconnect between sewer metering data and rain data, or if there was substantial disagreement between the rain gauge and other DC Water rain gauges. There were no events excluded from the pre-construction period, and two events excluded from the post-construction period. Table 2-3 summarizes the rainfall event totals for the pre- and post-construction periods.

Table 2-3: Total Rainfall During Pre- and Post-Construction Periods

Period	Total Rainfall (inches)	Number of events
2016-2017 pre-construction	28.33	60
2019-2020 post-construction	39.25	84
Calibration Events	35.41	82

2.4 GI Practice Water Level Monitoring

Sensors in six GI practices (APP-0707, APP-0905, PBR-0902, PBR-0903, PBR-0904, PPP-0901) began recording water levels in November 2019 to monitor the filling and drawdown rates of GI on a individual practice basis. For these six practices, one water level sensor was installed in each individual cell of each practice. The sensors are located in the practices' underdrain cleanouts at a level of 3" above practice bottom. Water levels in the practice that are below 3" cannot be measured. The GI model represents one type of practice within each model subshed, therefore a comparison of modeled GI practices with the individually-monitored PR-A practices is not possible.

Table 2-4 summarizes the maximum water levels observed in each of the practice-level monitoring wells. In all cases, the "A01" cell is the most upstream practice cell.

Table 2-4: Maximum Observed Practice Water Levels

Practice ID	Type	Maximum Water Level (in)
0707-A01	APP	1.24
0707-A02	APP	5.30
0905-A01	APP	27.37
0905-A02	APP	31.49
0905-A03	APP	19.37
0905-A04	APP	27.84
0905-A05	APP	33.05
0902-A01	PBR	20.87
0902-A02	PBR	14.86
0902-A03	PBR	11.84
0903-A01	PBR	5.92
0903-A02	PBR	8.86
0903-A03	PBR	4.73
0903-A04	PBR	15.73
0904-A01	PBR	3.00
0904-A02	PBR	5.66
0901-A01	PPP	3.68
0901-A02	PPP	0.64
0901-A03	PPP	4.88
0901-A04	PPP	32.55
0901-A05	PPP	34.31
0901-A06	PPP	37.04

3 Model Calibration

The pre-construction model calibration consisted of adjustments to impervious percentages and infiltration rates in the runoff model, and adjustments to flow splits and regulator parameters in the hydraulic model. The calibrated pre-construction model then served as the basis for the post-construction modeling.

The post-construction modeling with GI practices used the lumped practice approach that was consistent with the approach taken for the RC-A modeling work. In the lumped practice approach, GI practices of similar type are represented as one element within a SWMM subcatchment.

The GI practice parameters were populated based on the calculated wet-weather-volume-treated capacities of each practice. All pervious pavers were characterized as having no bottom infiltration because these practices are all lined. A ¼” orifice was assumed for the underdrains. No adjustments were needed to the GI parameters during calibration. The model setup and major calibration parameters are shown in the Table 3-1.

Table 3-1: PR-A Model Parameters

Model Parameter	PR-A model
Model inventory	132 subcatchments, 190 acres 61,646 feet of conduit
% impervious cover	46% impervious
Saturated infiltration	Varies by subcatchment; 0.165 - 0.5 in/hr, 0.36 in/hr average
GI settings (for post-construction model)	• As-built CDAs • Porosity/void-ratio values based on volume-managed calculations • 0.25” orifices in 6” underdrain pipes • Lined pervious paver practices

3.1 Pre-Construction Model Results

Figure 3-1 through Figure 3-6 are 1-to-1 volume and peak flow plots and select individual event hydrographs for the combined 029-1 + 029-2 meter locations and 029-5 + 029-6 meter locations, comparing metered flows versus modeled predictions.

Modeled predictions match event volumes well for both 029-1 + 029-2 and 029-5 + 029-6 locations. Peak flow response is more variable, with the model generally predicting somewhat higher peak flows, but with significant variability from event to event.

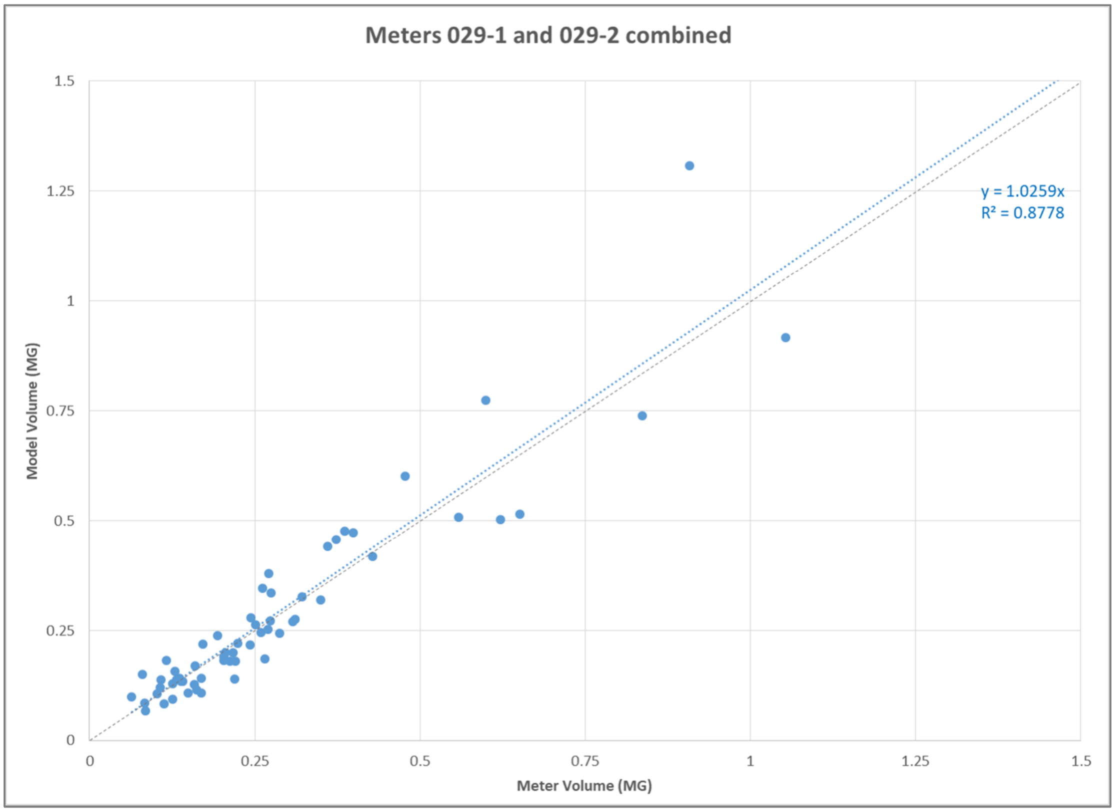

Figure 3-1: PR-A Pre-construction event volumes, 029-1 + 029-2

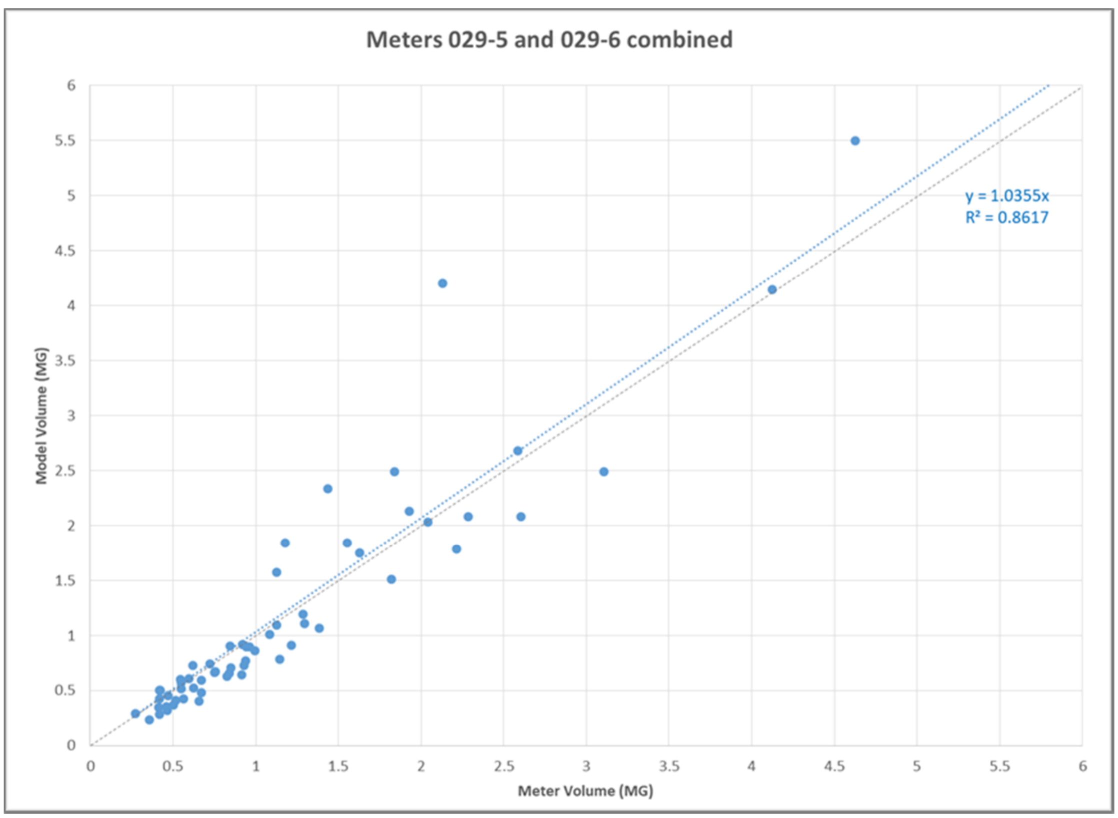

Figure 3-2: PR-A Pre-construction event volumes, 029-5 + 029-6

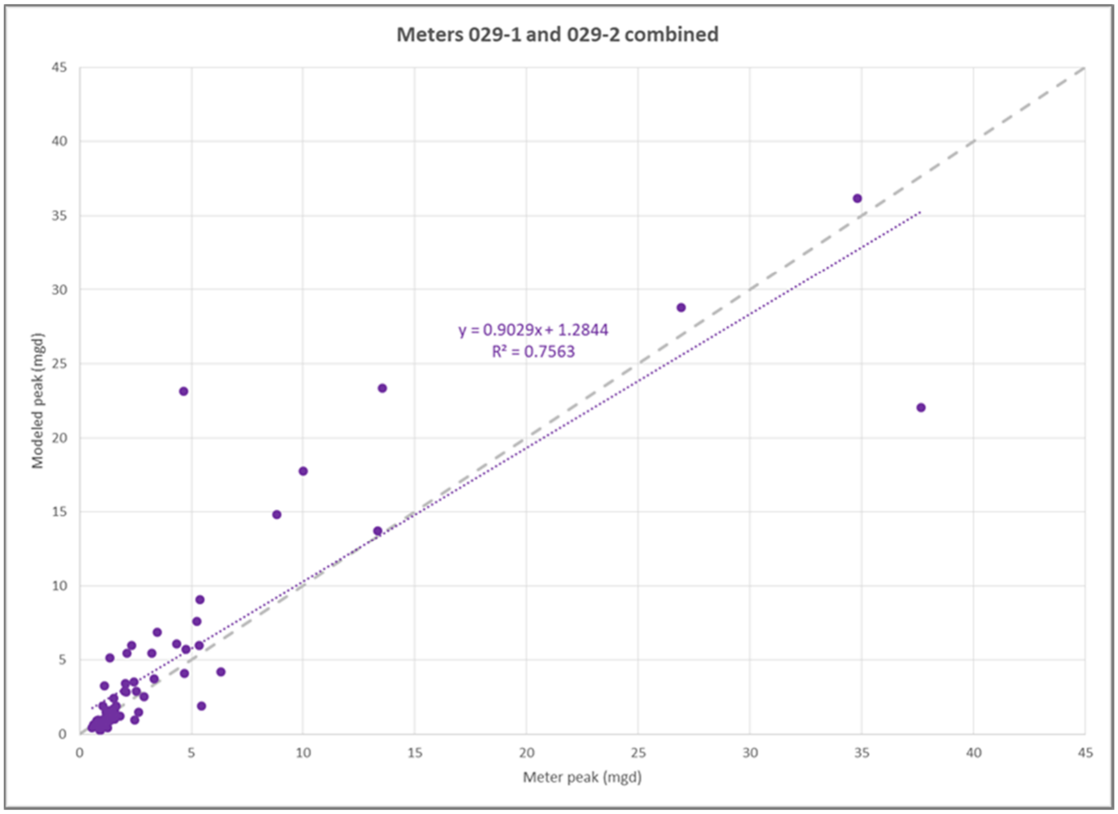

Figure 3-3. PR-A Pre-construction event peak flows, 029-1 + 029-2

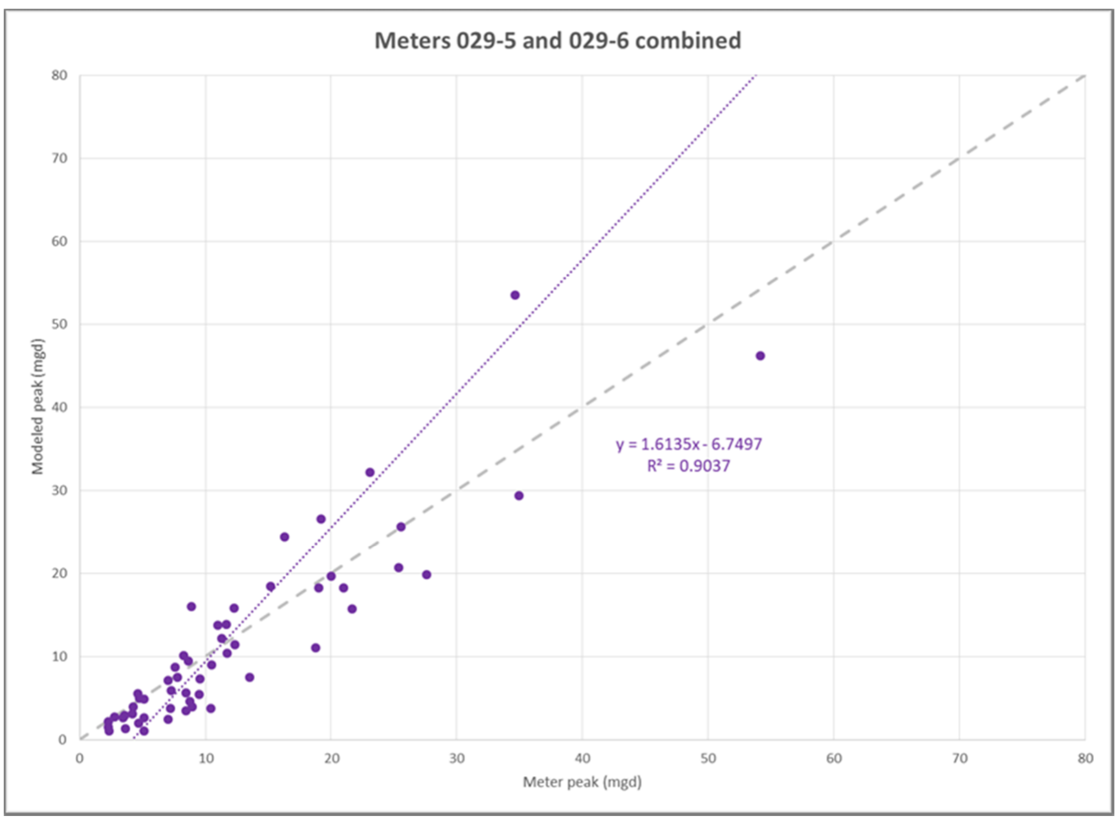

Figure 3-4. PR-A Pre-construction event peak flows, 029-5 + 029-6

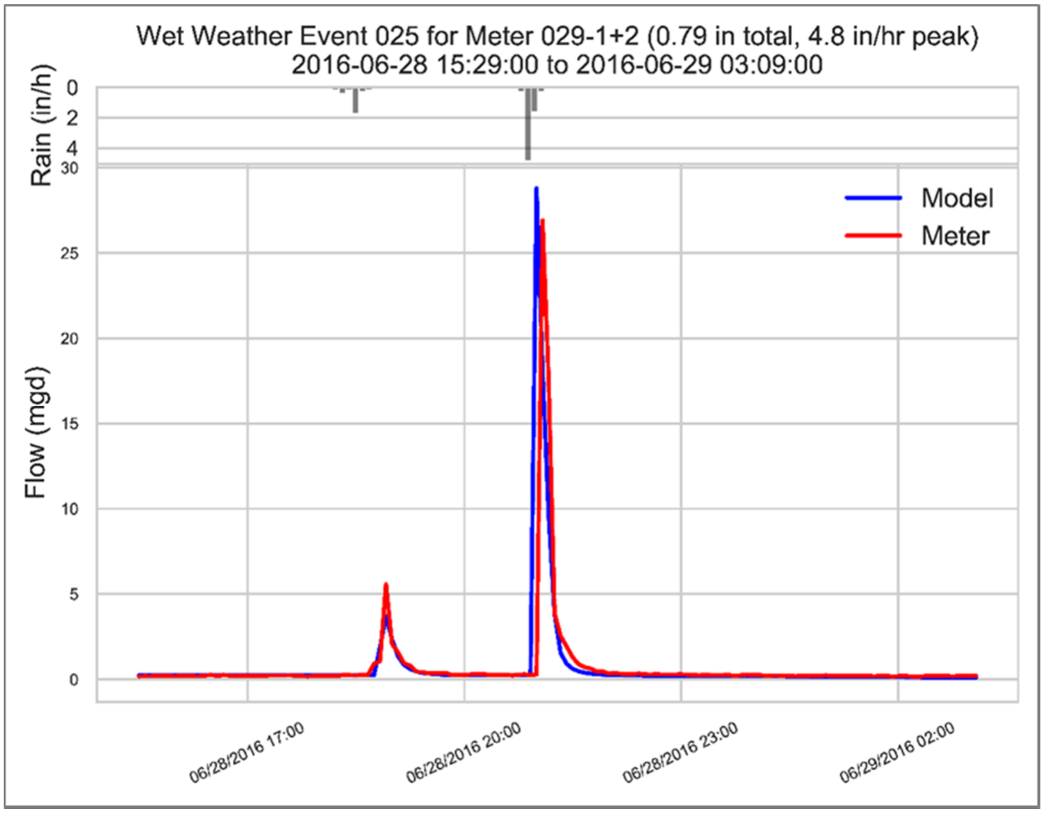

Figure 3-5: PR-A Pre-construction event hydrograph, 029-1 + 029-2

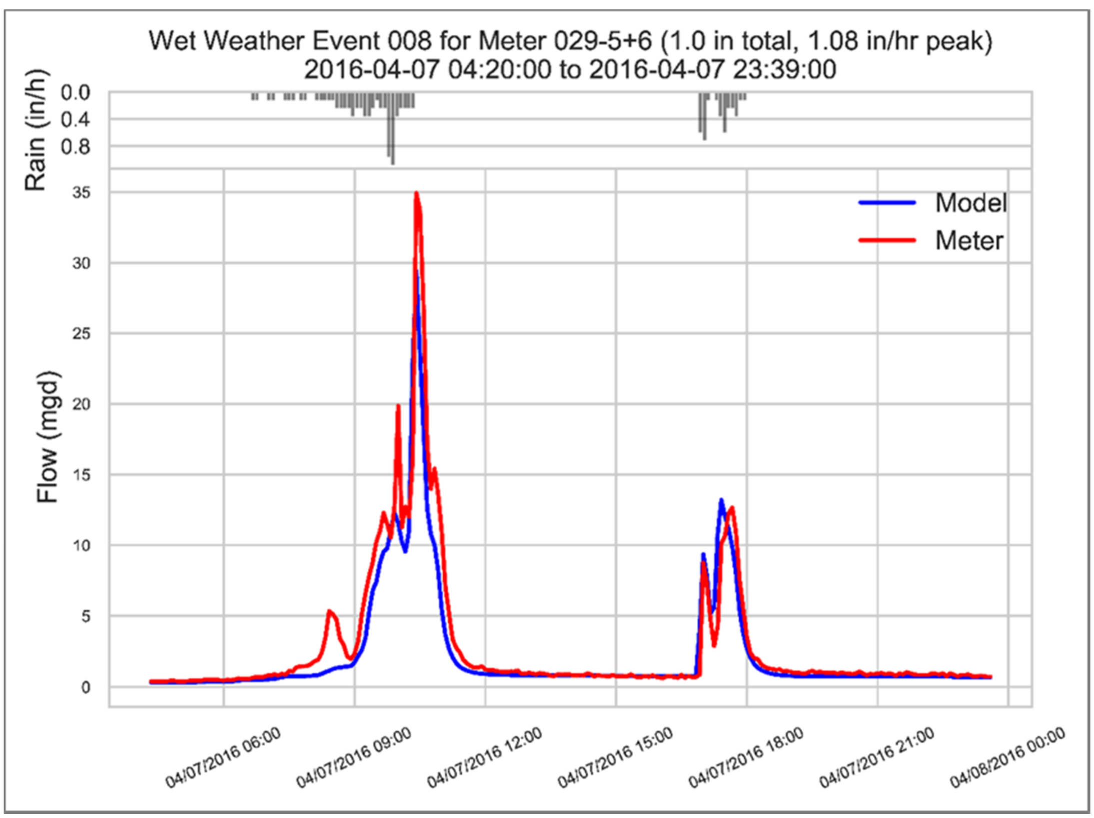

Figure 3-6: PR-A Pre-construction event hydrograph, 029-5 + 029-6

3.2 Post-Construction Model Results

Figure 3-7 through Figure 3-12 are 1-to-1 volume and peak flow plots and select individual event hydrographs for the combined 029-1 + 029-2 meter locations and 029-5 + 029-6 meter locations, comparing metered flows versus modeled predictions.

Modeled predictions match event volumes well for 029-1 + 029-2. The event volume comparison is less favorable for 029-5 + 029-6. In consideration that (a) the pre-construction model matches event volumes well for those downstream meters, and (b) the volume match is very good for the post-construction model at the upstream 029-1 + 029-2 meters where about half of the GI is concentrated, it was decided not to undertake additional model calibration.

As with the pre-construction model, peak flow response was more variable; the predicted peak flows were generally lower than metered flow peaks at 029-1 +029-2, and higher than metered flow peaks at 029-5 + 029-6.

The 1-to-1 plots delineate 2019 versus 2020 in order to identify metering data trends over time. As the respective trendlines indicate, for the 029-1 + 029-2 area, there is increased wet weather response in 2020, when compared with 2019. For the entire PR-A study area though – as captured by the 029-5 + 029-6 meters – that trend is reversed, with decreased wet weather response in 2020, when compared with 2019. The caveat when comparing 2019 with 2020 is that there are 62 calibration events for 2019, but only 20 calibration events for 2020.

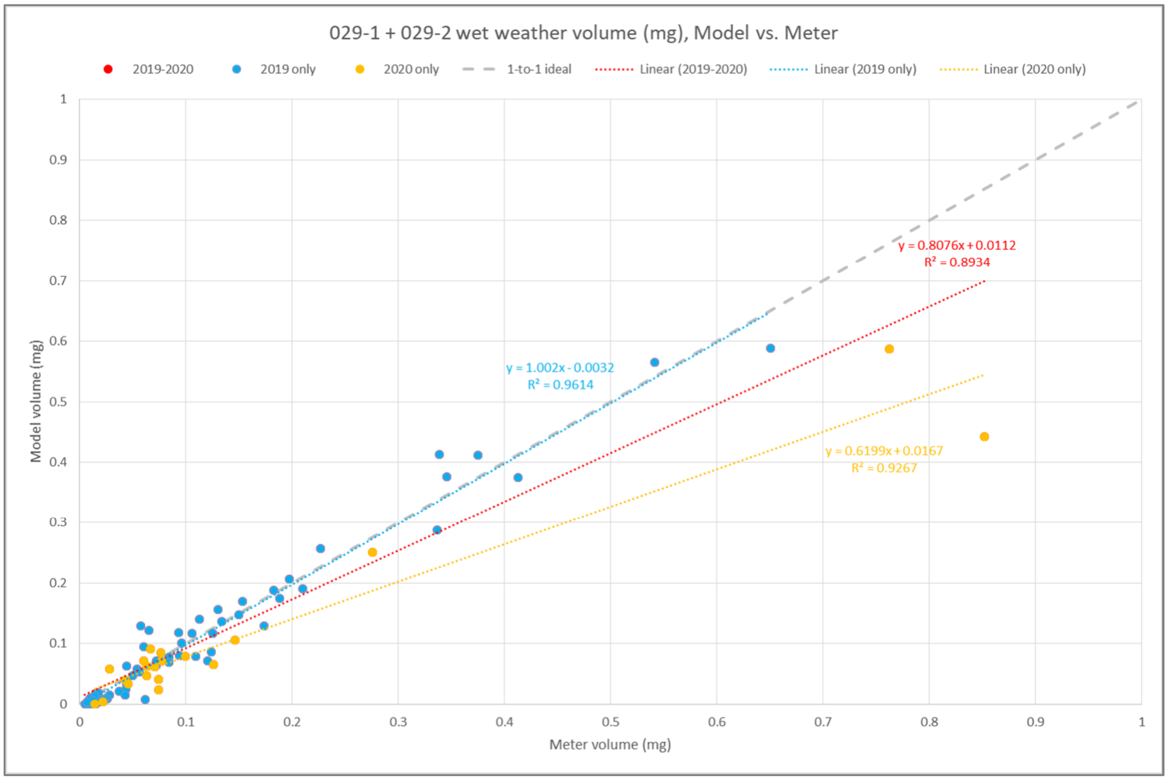

Figure 3-7: PR-A Post-construction event volumes, 029-1 + 029-2

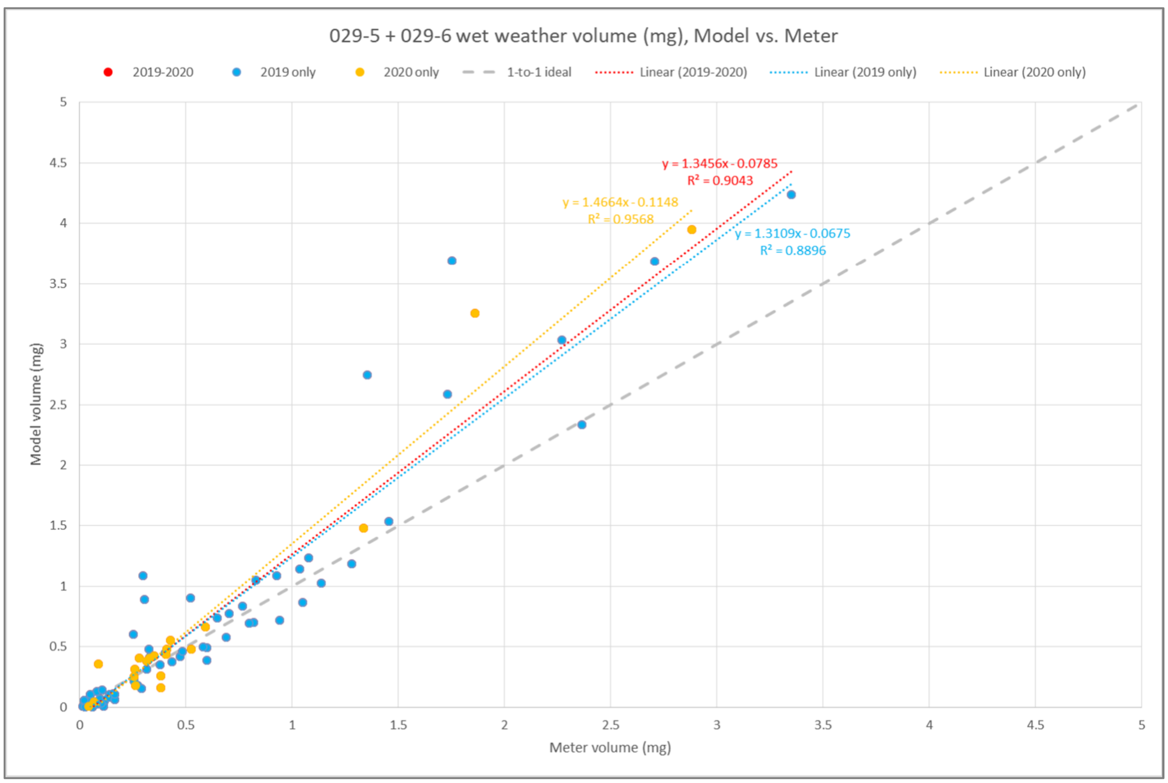

Figure 3-8: PR-A Post-construction event volumes , 029-5 + 029-6

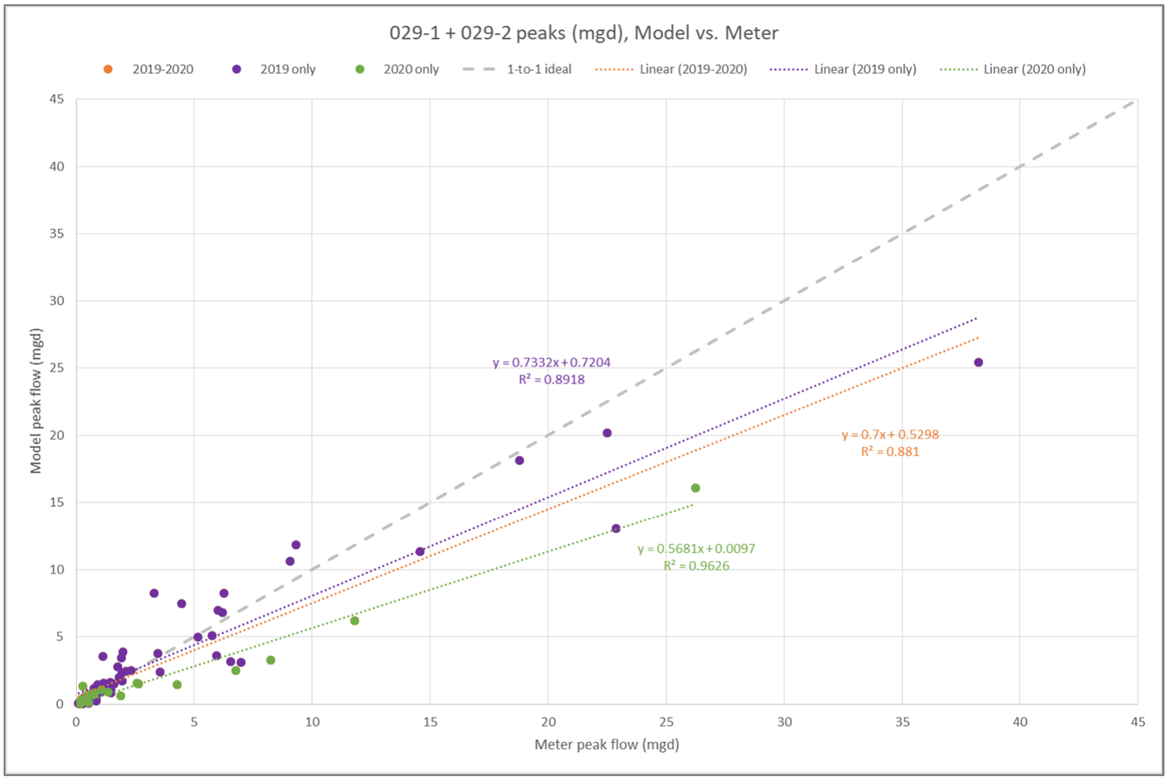

Figure 3-9. PR-A Post-construction event peak flows, 092-1 + 029-2

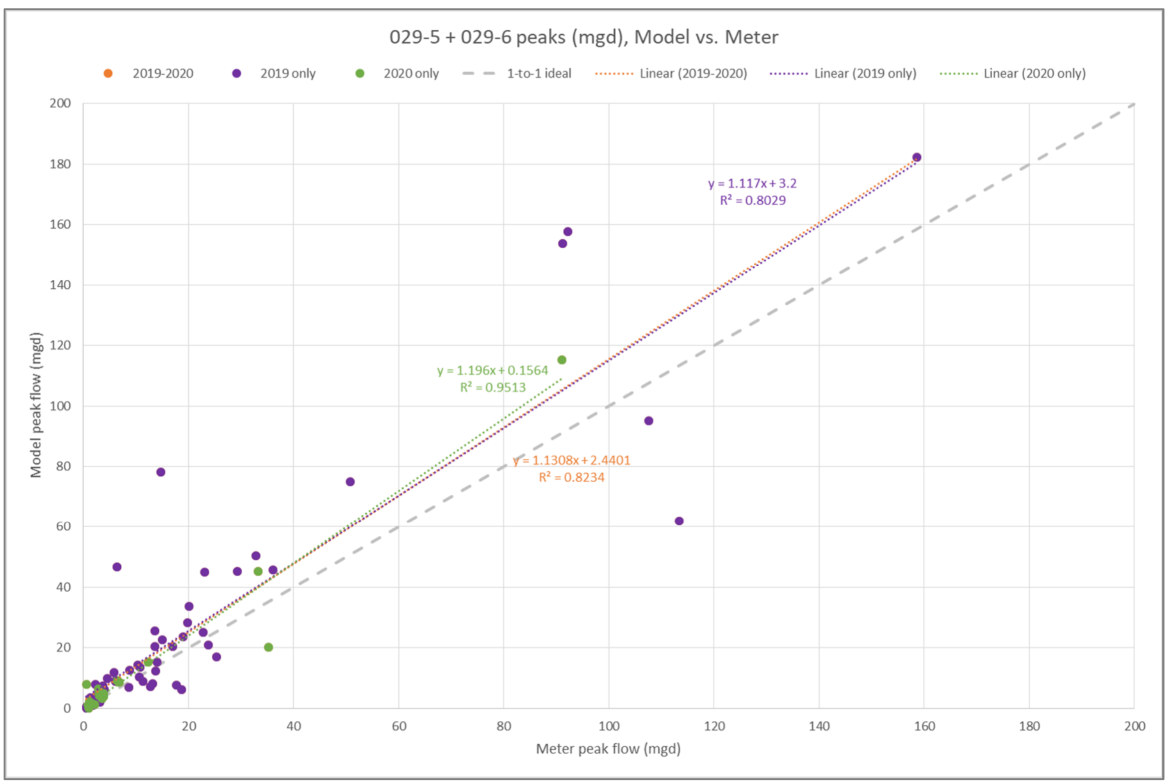

Figure 3-10. PR-A Post-construction event peak flows, 029-5 + 029-6

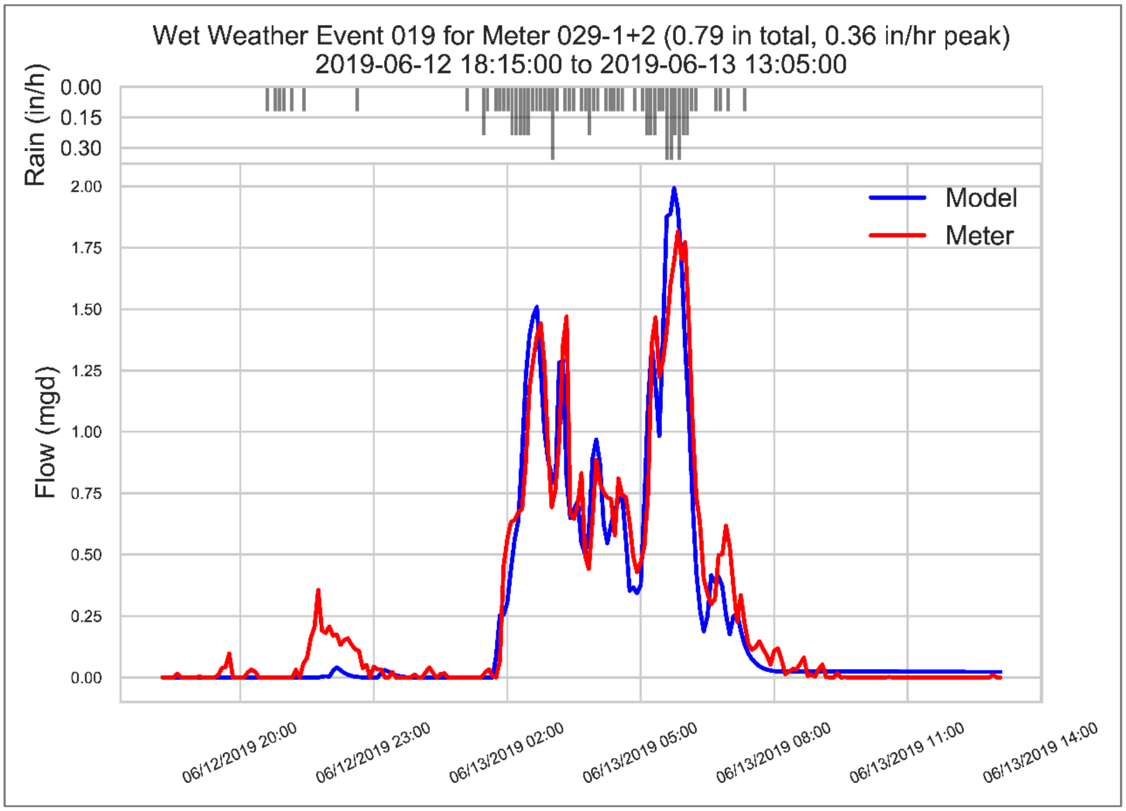

Figure 3-11: PR-A Post-construction event hydrograph, 029-1 + 029-2

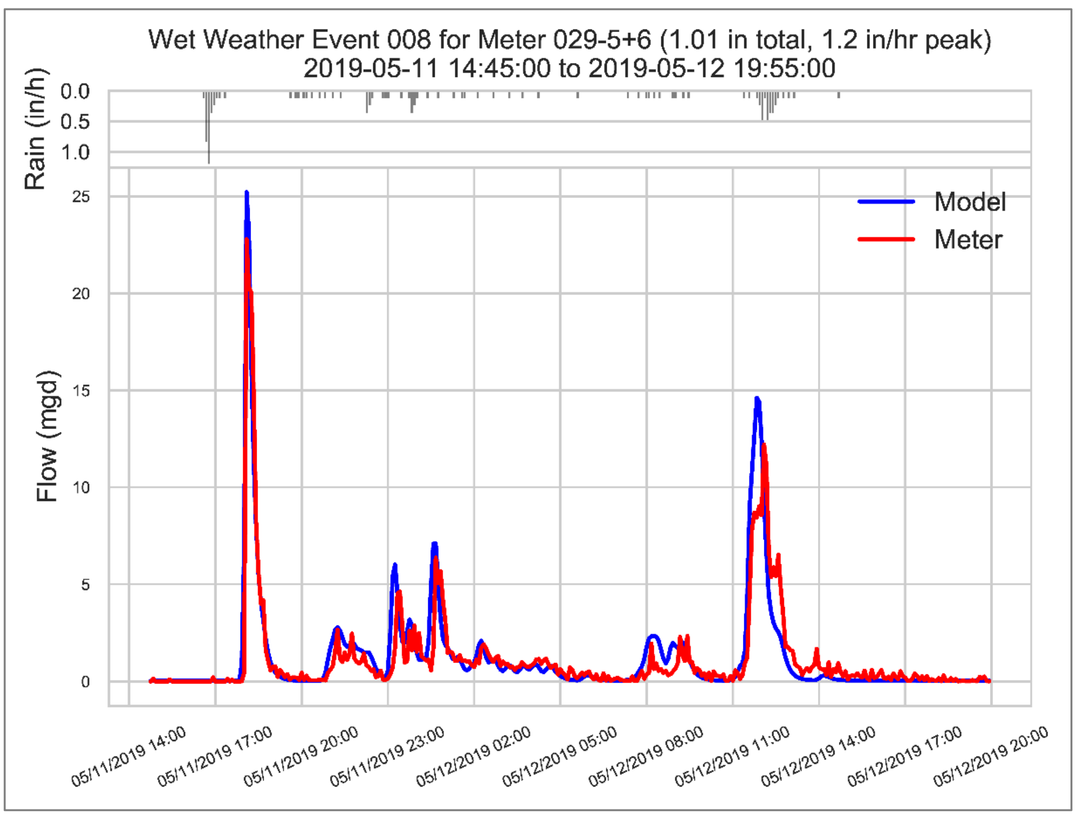

Figure 3-12: PR-A Post-construction event hydrograph, 029-5 + 029-6

4 Results

GI performance is being evaluated by comparing the total wet weather flow between the pre- and post-construction model conditions. For this evaluation, wet weather flow has been defined as the time period when predicted flows in the sewer exceeded two times average dry weather flow rates. The value of two times dry weather flow was selected because it is the original basis of design for the complete treatment capacity of the Blue Plains Advanced Wastewater Treatment Plant in the *Blue Plains Feasibility Study* (Final Report, 1984, Greeley and Hansen). The analysis was done both for the post-construction timeframe of March 2019 – March 2020 and the 1988 to 1990 average year conditions and results are presented in Table 3-1 below.

There were no predictions made on WWF reductions prior to the construction of PRA. As the predictions from post-construction model using as-built GI matched the observed meter data to an acceptable degree without major calibration and since the as-built GI did not deviate significantly from the designed GI, it is assumed that actual modeled volume reduction and expected volume reduction are same for the period 1988-1990.

Table 4-1.PR-A Wet Weather Performance, Predicted Results

Simulated Time Period	Impervious Acres treated by GI (% of total)	WWF volume – Pre-Construction (MG)	WWF volume – Post Construction (MG)	Predicted Volume Reduction Using Monitoring Data, Normalized to Impervious Acres Treated (%)	Predicted Volume Reduction Before Construction, Normalized to Impervious Acres Treated (%)
PR-A Model, 2019-2020 Rainfall Conditions	9.1 %	81.98	77.24	5.78%	N/A
1988-1990 Average-Year LTCP Forecast Period	9.1 %	77.73	72.56	6.65%	6.65%

The calibrated model predicts wet weather flow reduction percentages that are roughly equivalent to the total percentage of PR-A area treated by GI.

Appendix A: Pre-Construction Event Hydrographs

(Note: The y-axis varies in scale between the individual plots)

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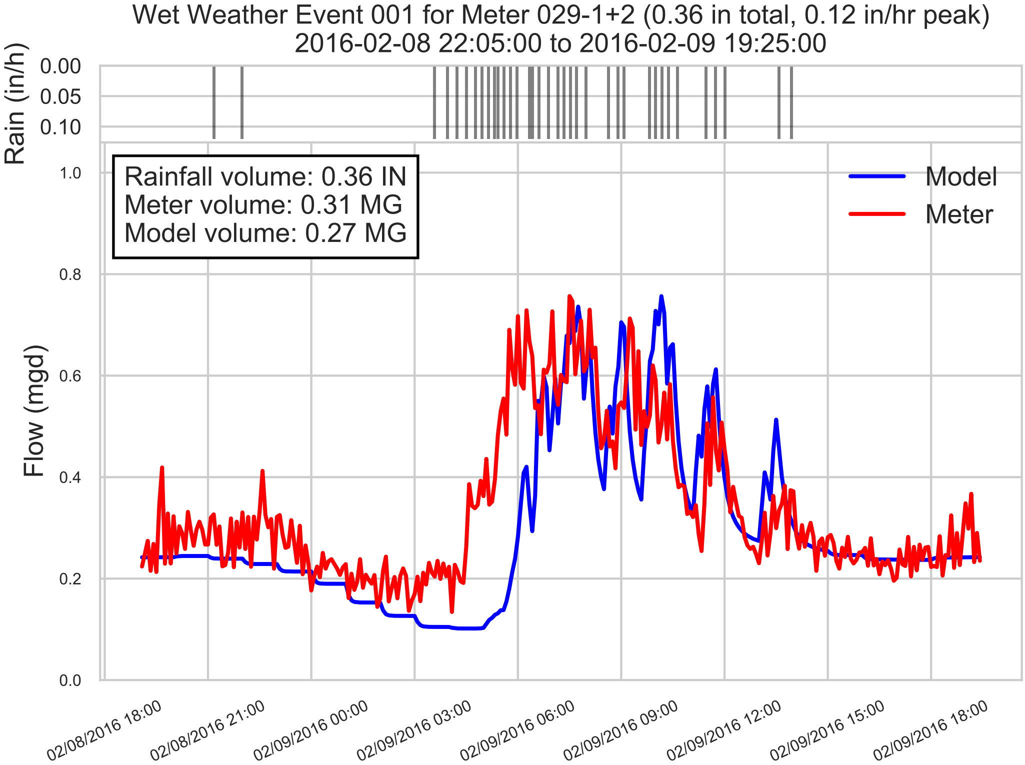
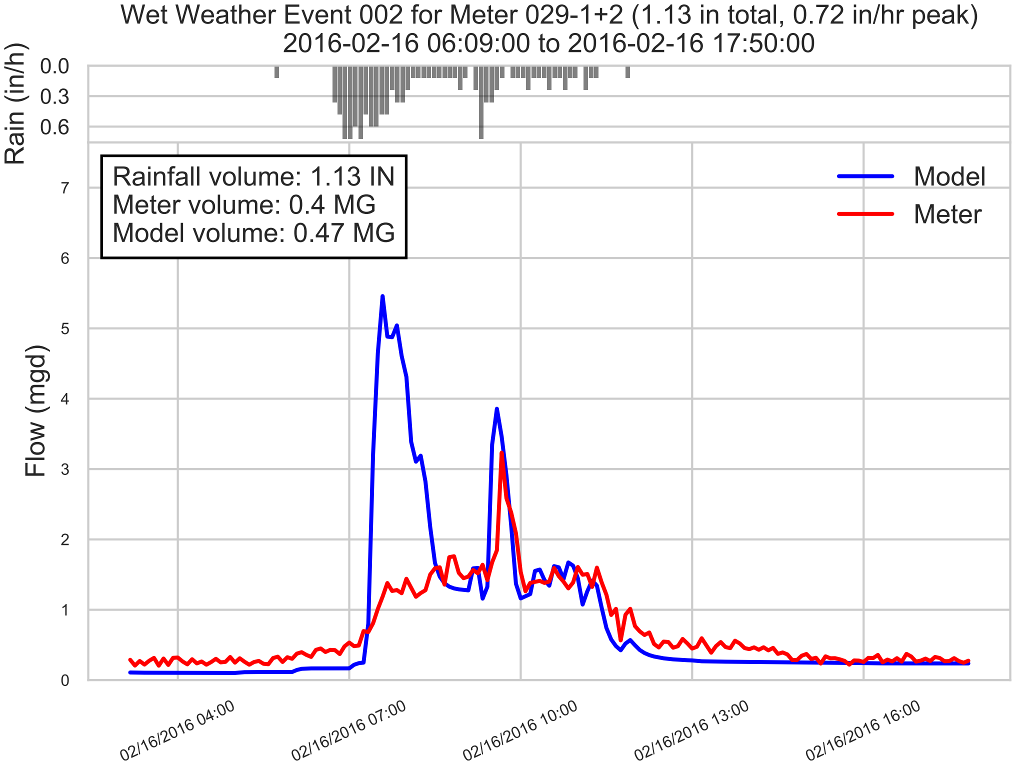
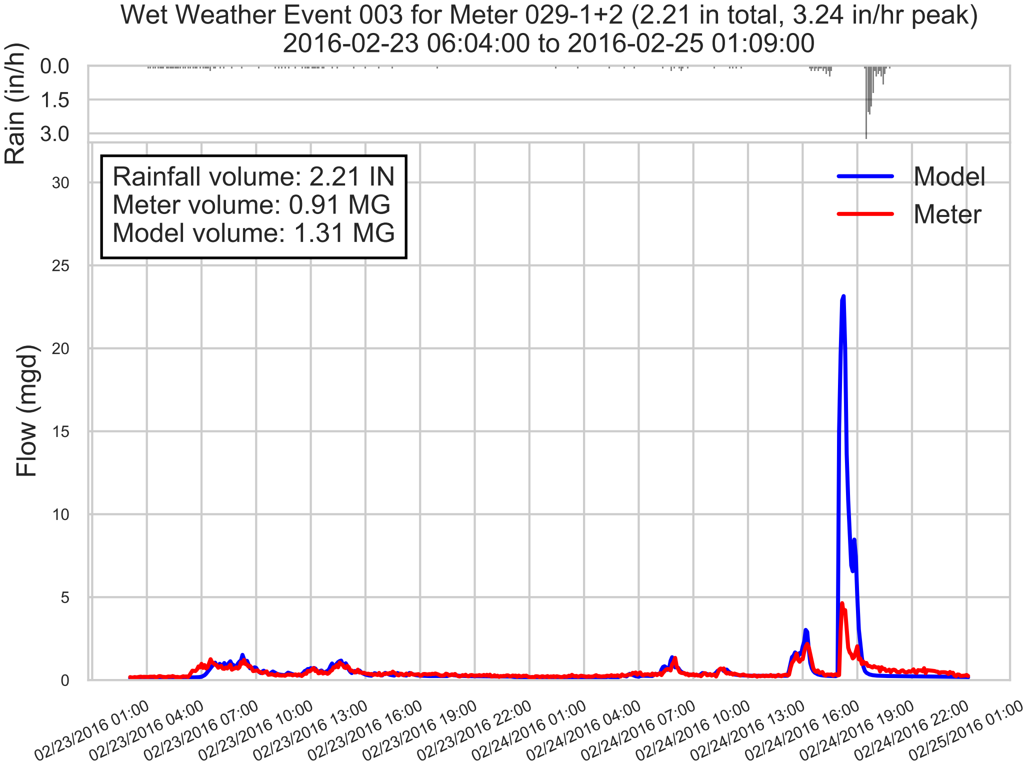


Wet Weather Event 001 for Meter 029-1+2 (0.36 in total, 0.12 in/hr peak)
2016-02-08 22:05:00 to 2016-02-09 19:25:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.36 IN
Meter volume: 0.31 MG
Model volume: 0.27 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
02/08/2016 18:00
02/08/2016 21:00
02/09/2016 00:00
02/09/2016 03:00
02/09/2016 06:00
02/09/2016 09:00
02/09/2016 12:00
02/09/2016 15:00
02/09/2016 18:00



Wet Weather Event 002 for Meter 029-1+2 (1.13 in total, 0.72 in/hr peak)
2016-02-16 06:09:00 to 2016-02-16 17:50:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 1.13 IN
Meter volume: 0.4 MG
Model volume: 0.47 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
02/16/2016 04:00
02/16/2016 07:00
02/16/2016 10:00
02/16/2016 13:00
02/16/2016 16:00



Wet Weather Event 003 for Meter 029-1+2 (2.21 in total, 3.24 in/hr peak)
2016-02-23 06:04:00 to 2016-02-25 01:09:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 2.21 IN
Meter volume: 0.91 MG
Model volume: 1.31 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
02/23/2016 01:00
02/23/2016 04:00
02/23/2016 07:00
02/23/2016 10:00
02/23/2016 13:00
02/23/2016 16:00
02/23/2016 19:00
02/23/2016 22:00
02/24/2016 01:00
02/24/2016 04:00
02/24/2016 07:00
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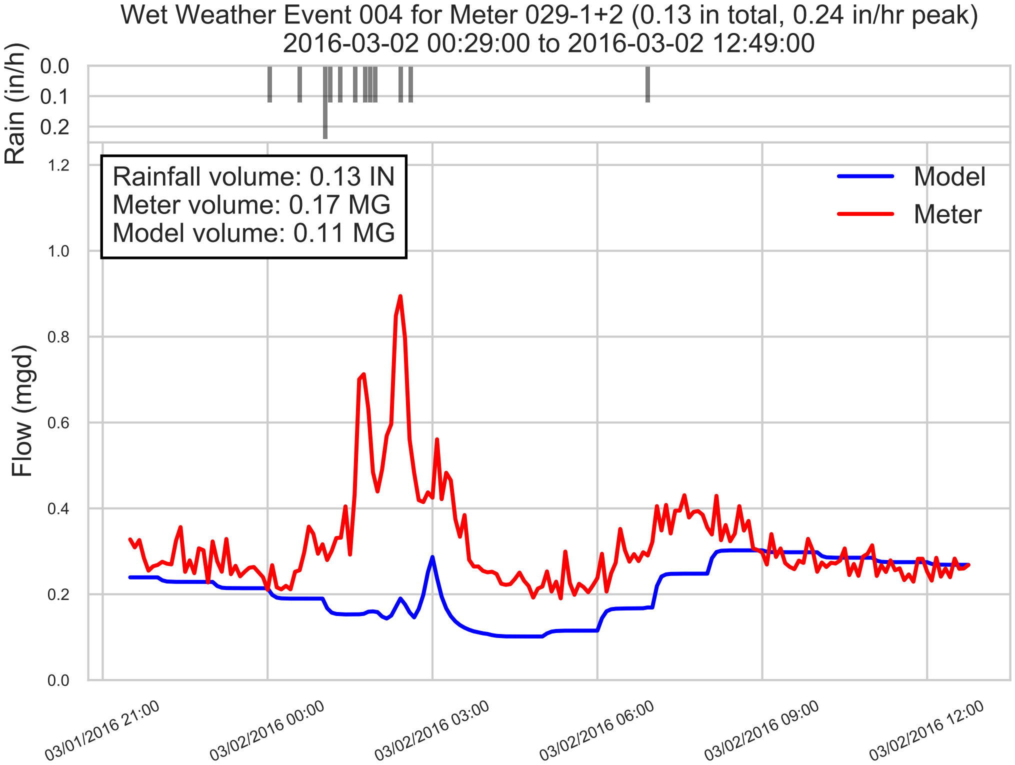
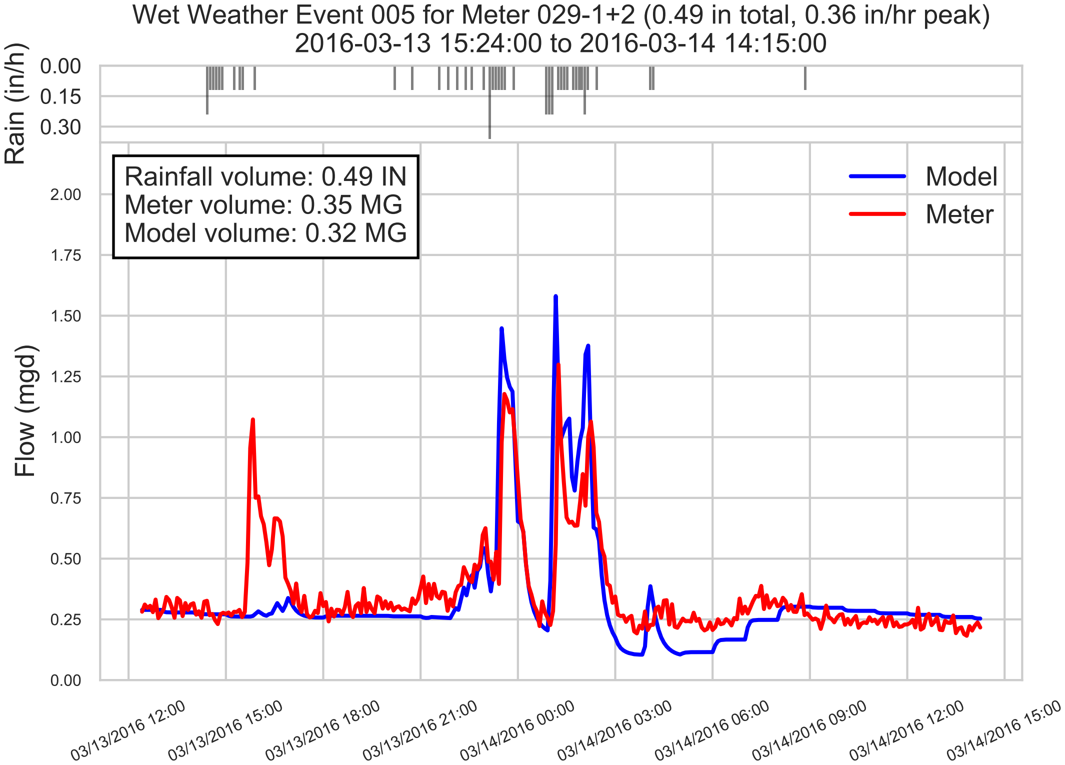
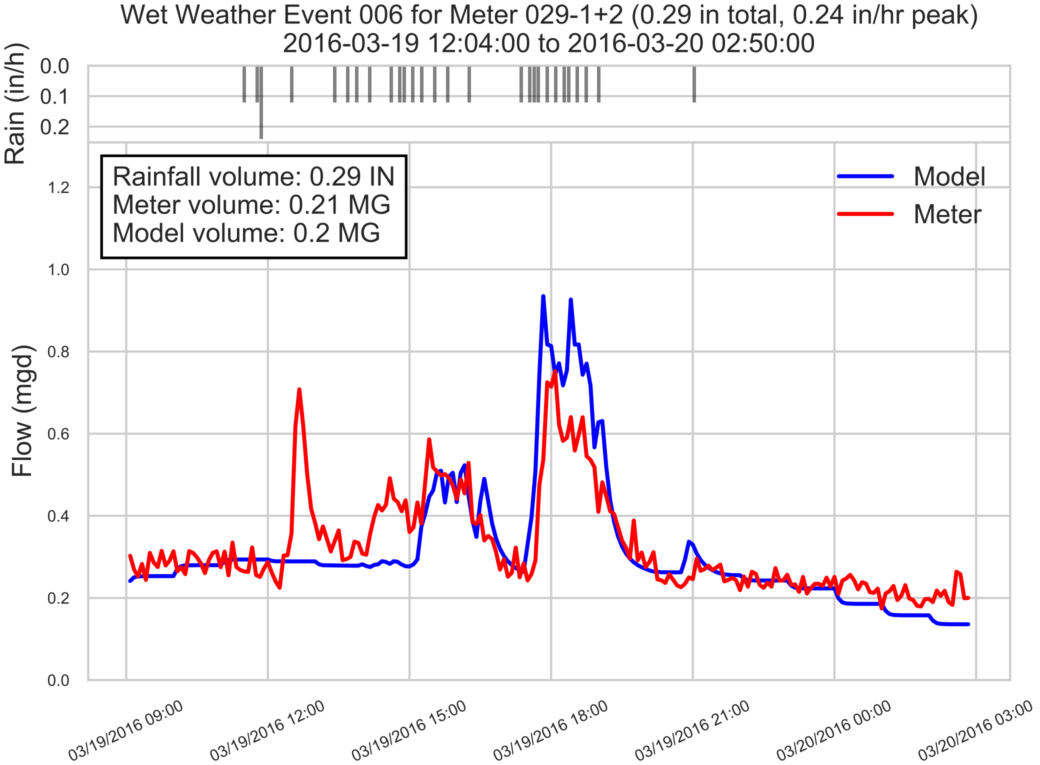
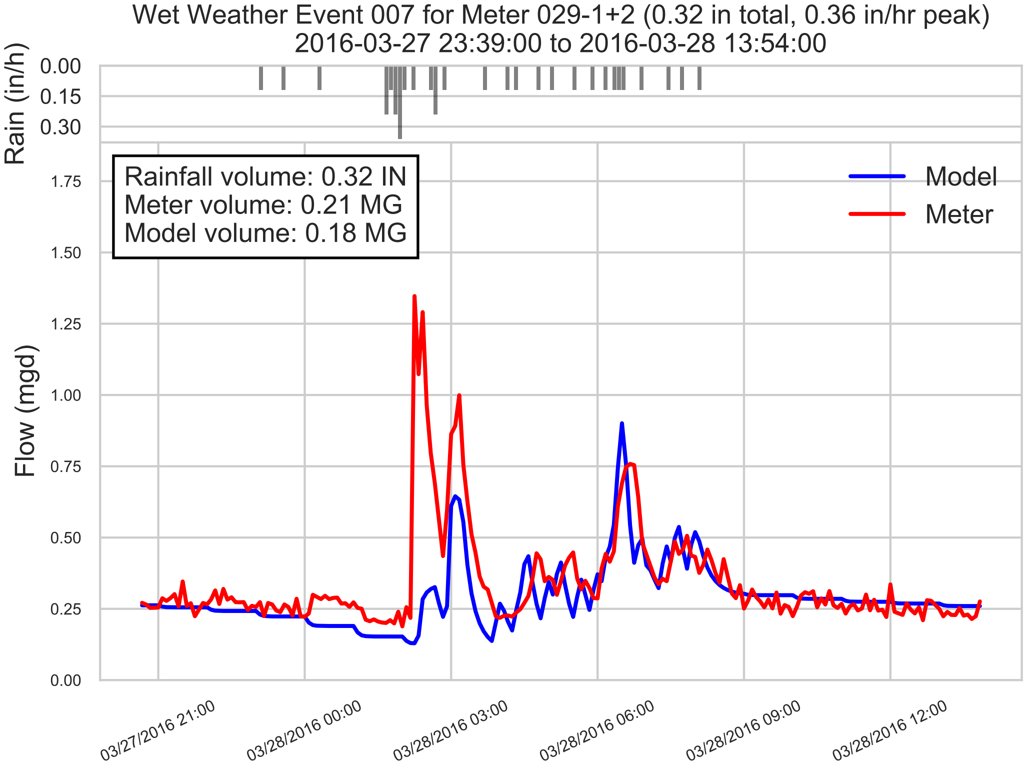
02/24/2016 22:00
02/25/2016 01:00

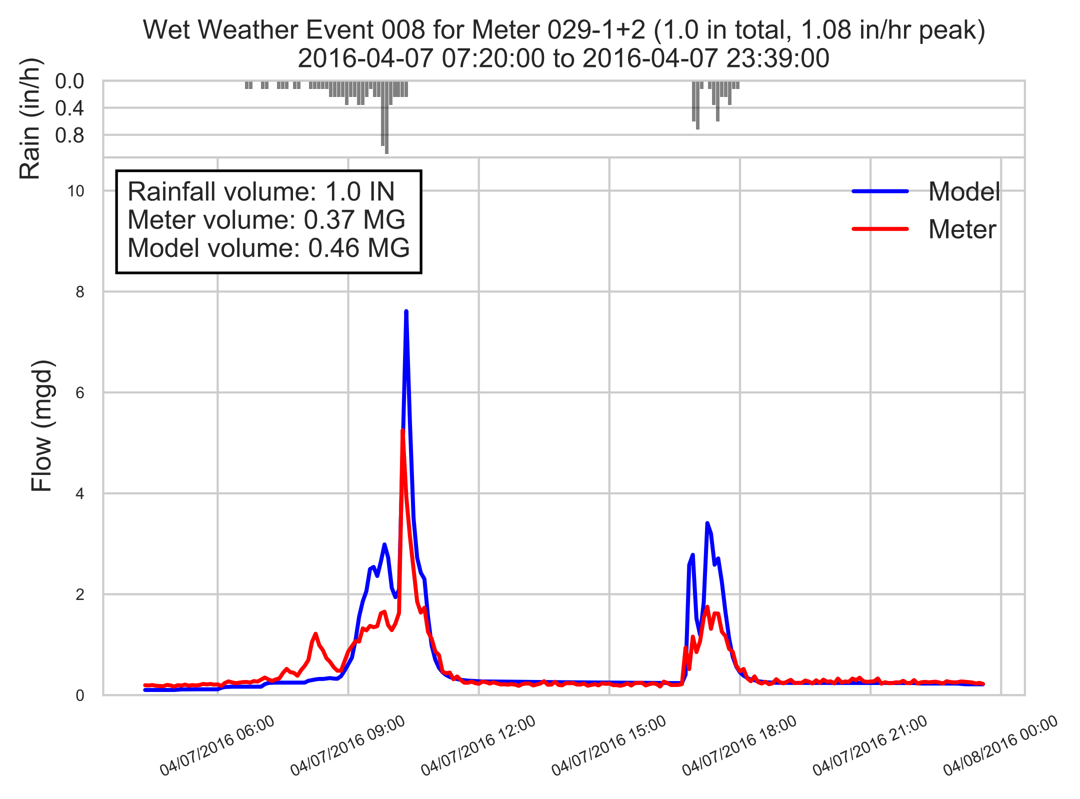

Wet Weather Event 004 for Meter 029-1+2 (0.13 in total, 0.24 in/hr peak)
2016-03-02 00:29:00 to 2016-03-02 12:49:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Rainfall volume: 0.13 IN
Meter volume: 0.17 MG
Model volume: 0.11 MG
Model
Meter
03/01/2016 21:00
03/02/2016 00:00
03/02/2016 03:00
03/02/2016 06:00
03/02/2016 09:00
03/02/2016 12:00



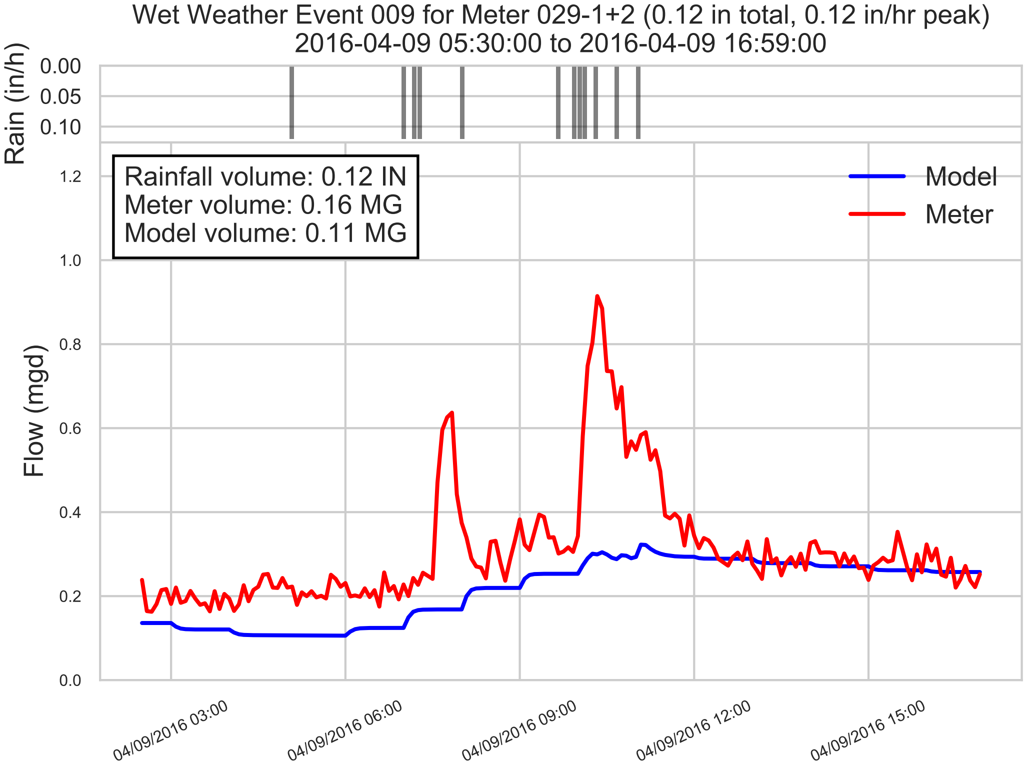
Wet Weather Event 005 for Meter 029-1+2 (0.49 in total, 0.36 in/hr peak)
2016-03-13 15:24:00 to 2016-03-14 14:15:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.49 IN
Meter volume: 0.35 MG
Model volume: 0.32 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
03/13/2016 12:00
03/13/2016 15:00
03/13/2016 18:00
03/13/2016 21:00
03/14/2016 00:00
03/14/2016 03:00
03/14/2016 06:00
03/14/2016 09:00
03/14/2016 12:00
03/14/2016 15:00


Wet Weather Event 006 for Meter 029-1+2 (0.29 in total, 0.24 in/hr peak)
2016-03-19 12:04:00 to 2016-03-20 02:50:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.21 MG
Model volume: 0.2 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
03/19/2016 09:00
03/19/2016 12:00
03/19/2016 15:00
03/19/2016 18:00
03/19/2016 21:00
03/20/2016 00:00
03/20/2016 03:00

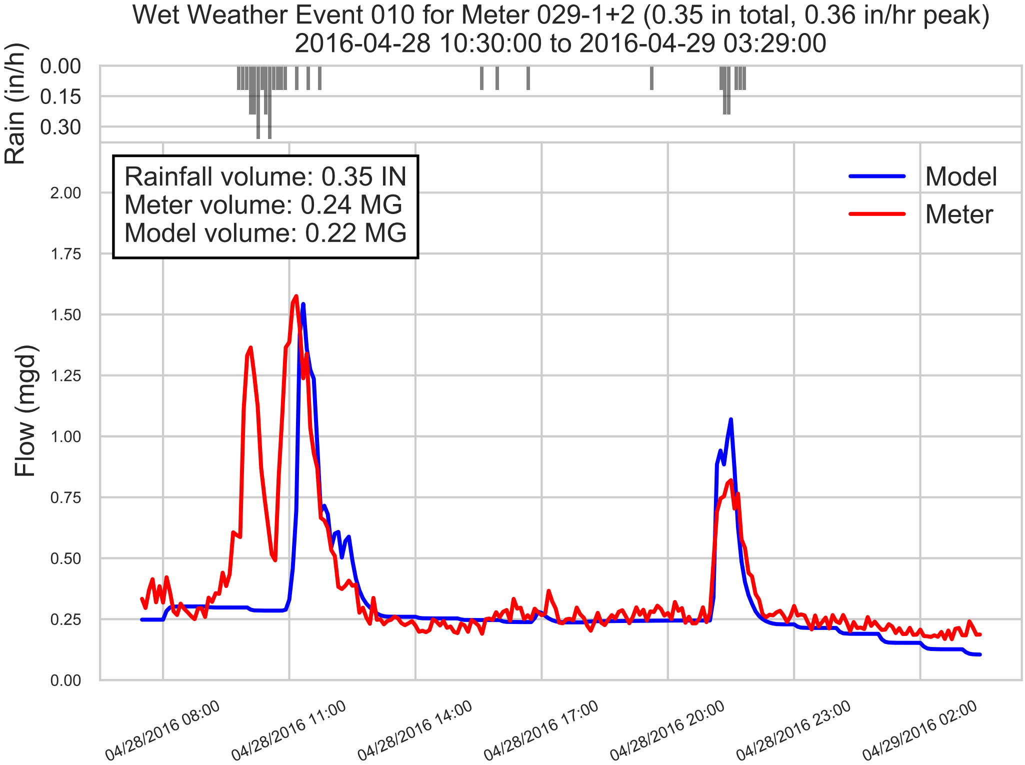

Wet Weather Event 007 for Meter 029-1+2 (0.32 in total, 0.36 in/hr peak)
2016-03-27 23:39:00 to 2016-03-28 13:54:00
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Rainfall volume: 0.32 IN
Meter volume: 0.21 MG
Model volume: 0.18 MG
Model
Meter
03/27/2016 21:00
03/28/2016 00:00
03/28/2016 03:00
03/28/2016 06:00
03/28/2016 09:00
03/28/2016 12:00

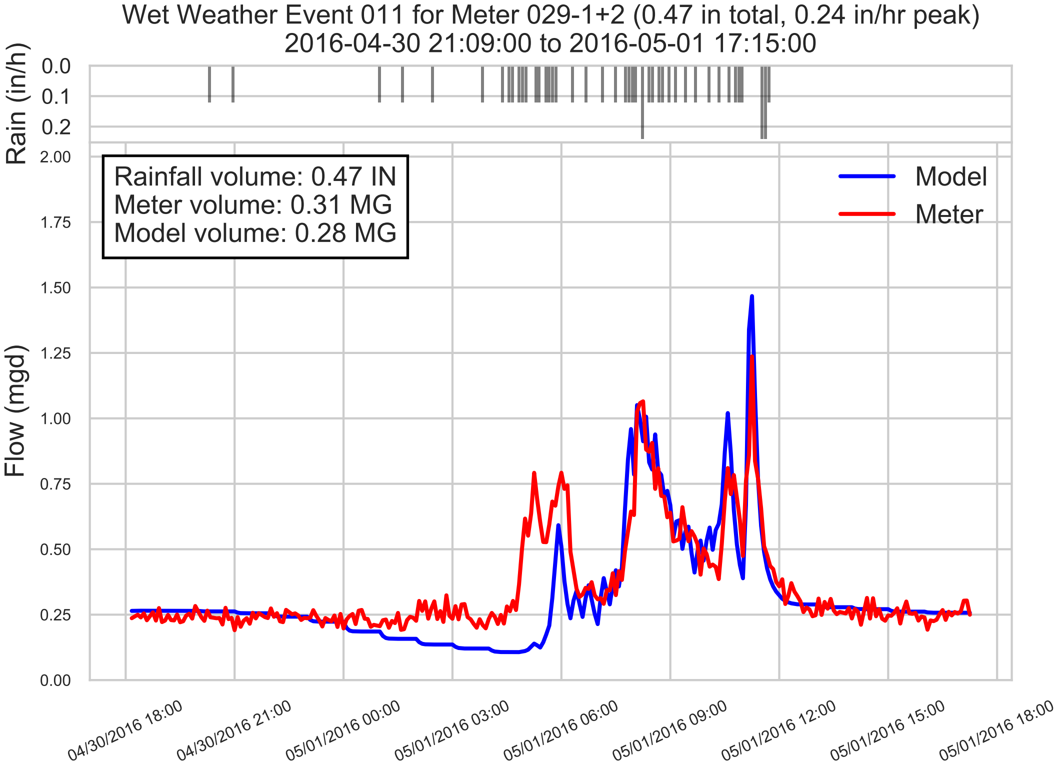


Wet Weather Event 008 for Meter 029-1+2 (1.0 in total, 1.08 in/hr peak)
2016-04-07 07:20:00 to 2016-04-07 23:39:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 1.0 IN
Meter volume: 0.37 MG
Model volume: 0.46 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
04/07/2016 06:00
04/07/2016 09:00
04/07/2016 12:00
04/07/2016 15:00
04/07/2016 18:00
04/07/2016 21:00
04/08/2016 00:00

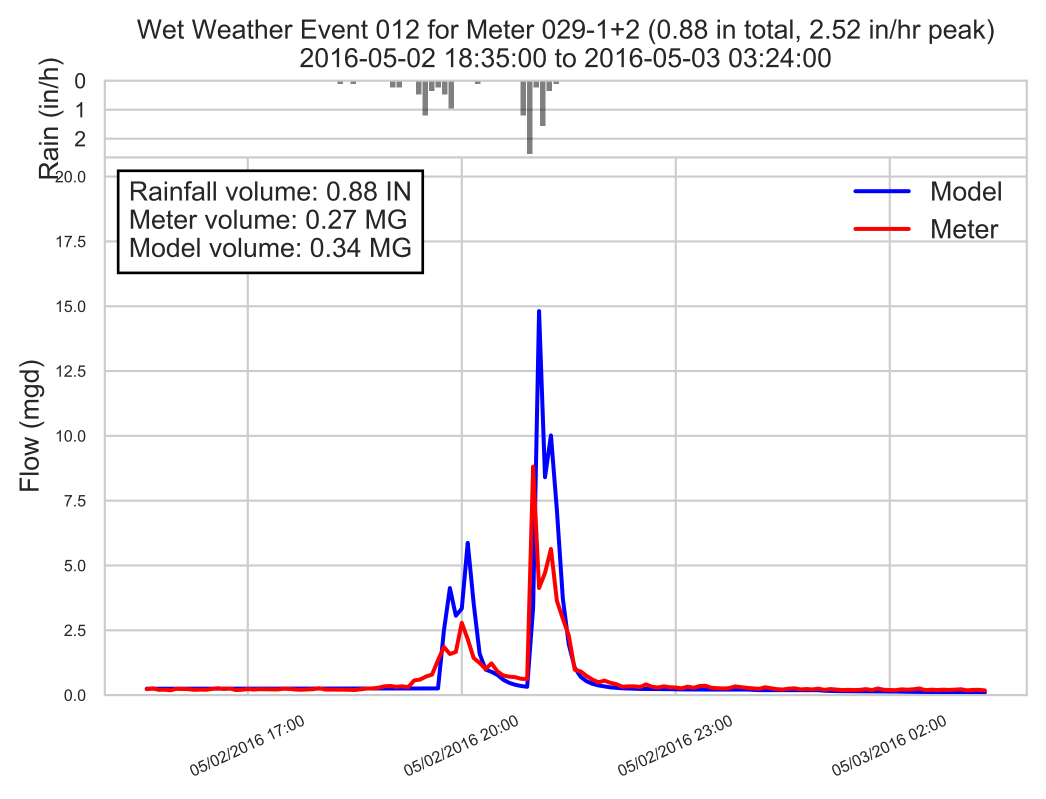


Wet Weather Event 009 for Meter 029-1+2 (0.12 in total, 0.12 in/hr peak)
2016-04-09 05:30:00 to 2016-04-09 16:59:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.12 IN
Meter volume: 0.16 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
04/09/2016 03:00
04/09/2016 06:00
04/09/2016 09:00
04/09/2016 12:00
04/09/2016 15:00

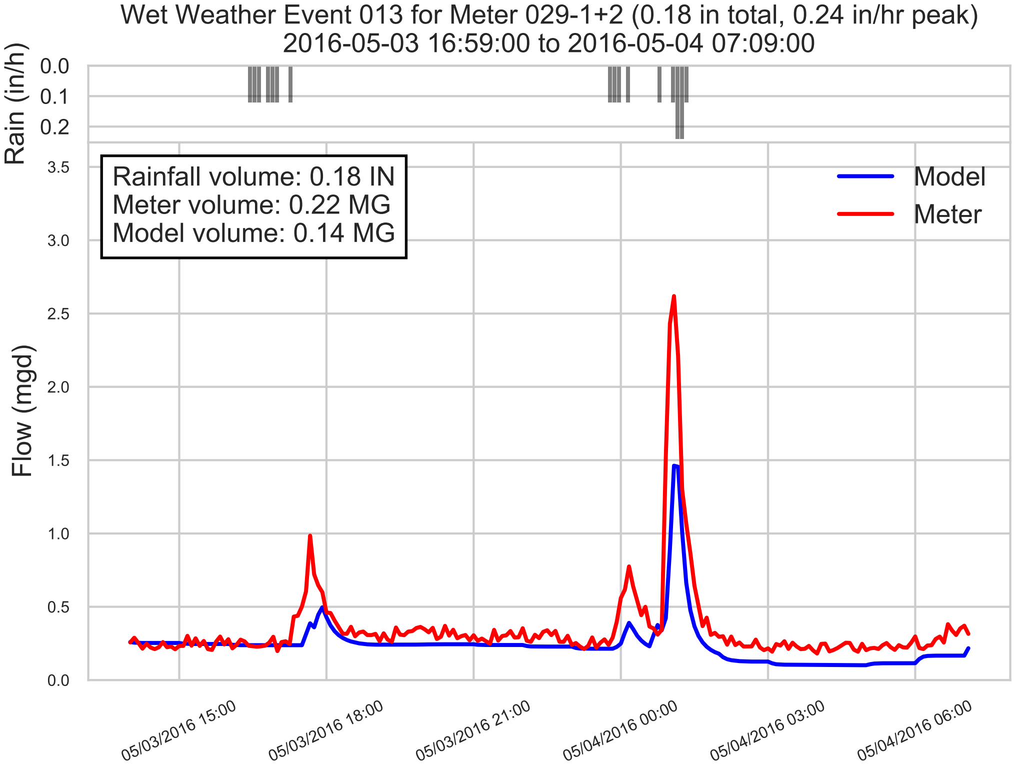

Wet Weather Event 010 for Meter 029-1+2 (0.35 in total, 0.36 in/hr peak)
2016-04-28 10:30:00 to 2016-04-29 03:29:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.35 IN
Meter volume: 0.24 MG
Model volume: 0.22 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
04/28/2016 08:00
04/28/2016 11:00
04/28/2016 14:00
04/28/2016 17:00
04/28/2016 20:00
04/28/2016 23:00
04/29/2016 02:00

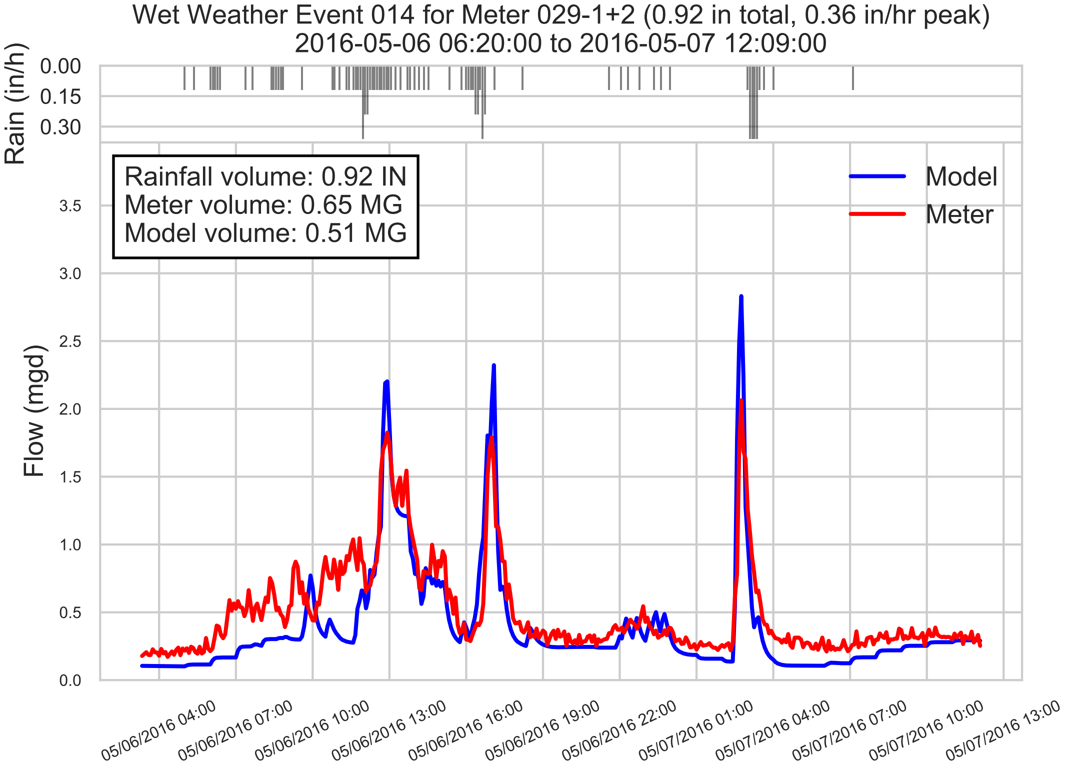


Wet Weather Event 011 for Meter 029-1+2 (0.47 in total, 0.24 in/hr peak)
2016-04-30 21:09:00 to 2016-05-01 17:15:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall volume: 0.47 IN
Meter volume: 0.31 MG
Model volume: 0.28 MG
Model
Meter
04/30/2016 18:00
04/30/2016 21:00
05/01/2016 00:00
05/01/2016 03:00
05/01/2016 06:00
05/01/2016 09:00
05/01/2016 12:00
05/01/2016 15:00
05/01/2016 18:00

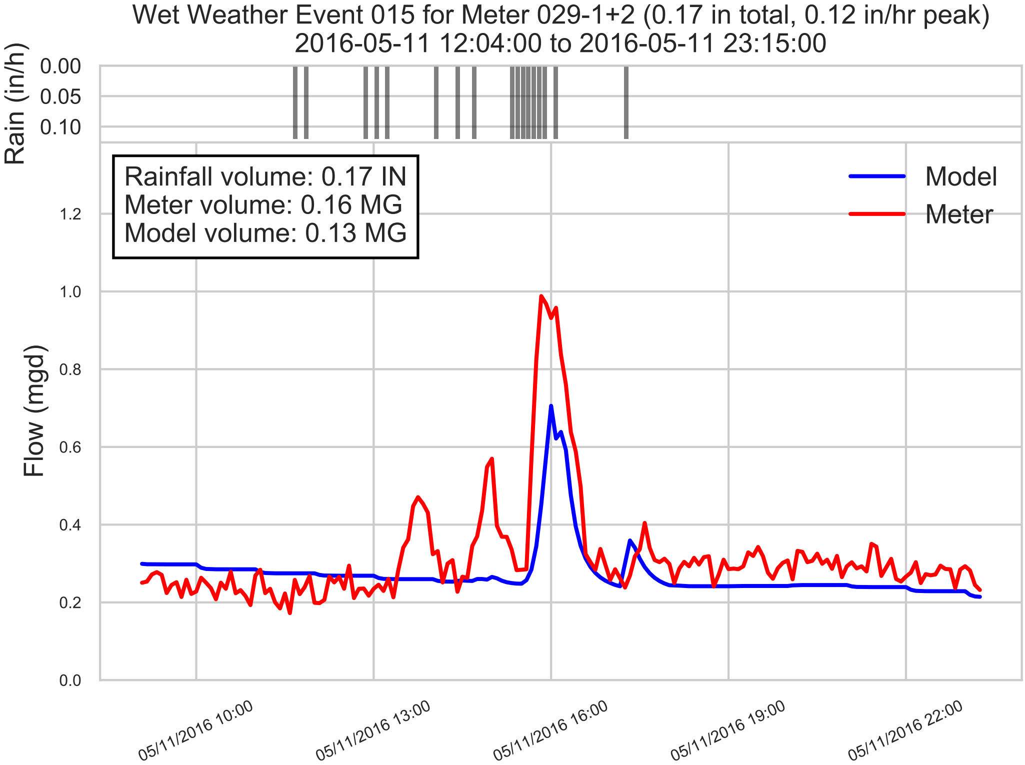


Wet Weather Event 012 for Meter 029-1+2 (0.88 in total, 2.52 in/hr peak)
2016-05-02 18:35:00 to 2016-05-03 03:24:00
Rain (in/h)
0
1
2
Rainfall volume: 0.88 IN
Meter volume: 0.27 MG
Model volume: 0.34 MG
Model
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
05/02/2016 17:00
05/02/2016 20:00
05/02/2016 23:00
05/03/2016 02:00

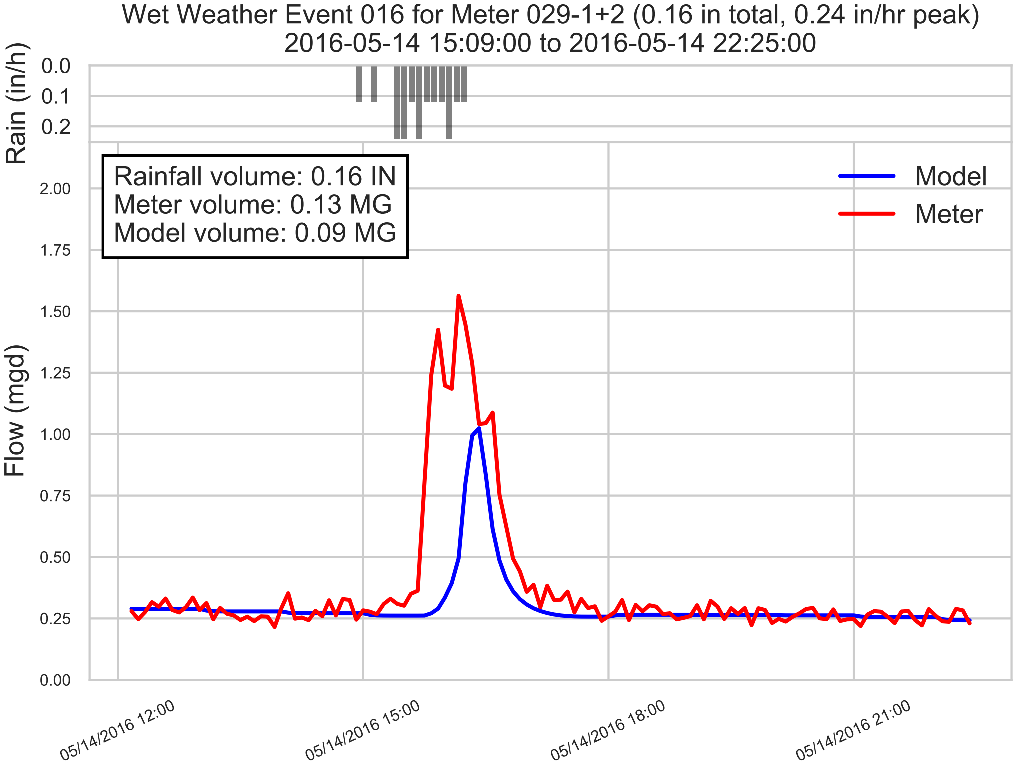

Wet Weather Event 013 for Meter 029-1+2 (0.18 in total, 0.24 in/hr peak)
2016-05-03 16:59:00 to 2016-05-04 07:09:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Rainfall volume: 0.18 IN
Meter volume: 0.22 MG
Model volume: 0.14 MG
Model
Meter
05/03/2016 15:00
05/03/2016 18:00
05/03/2016 21:00
05/04/2016 00:00
05/04/2016 03:00
05/04/2016 06:00



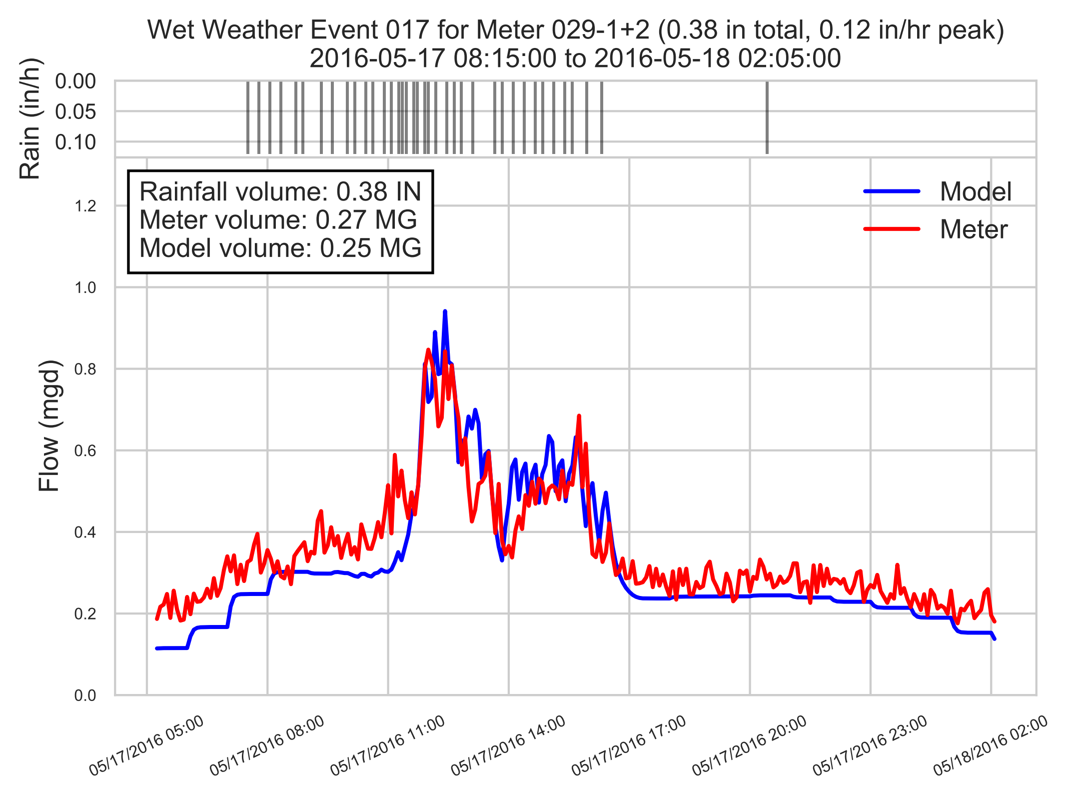
Wet Weather Event 014 for Meter 029-1+2 (0.92 in total, 0.36 in/hr peak)
2016-05-06 06:20:00 to 2016-05-07 12:09:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.92 IN
Meter volume: 0.65 MG
Model volume: 0.51 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
05/06/2016 04:00
05/06/2016 07:00
05/06/2016 10:00
05/06/2016 13:00
05/06/2016 16:00
05/06/2016 19:00
05/06/2016 22:00
05/07/2016 01:00
05/07/2016 04:00
05/07/2016 07:00
05/07/2016 10:00
05/07/2016 13:00



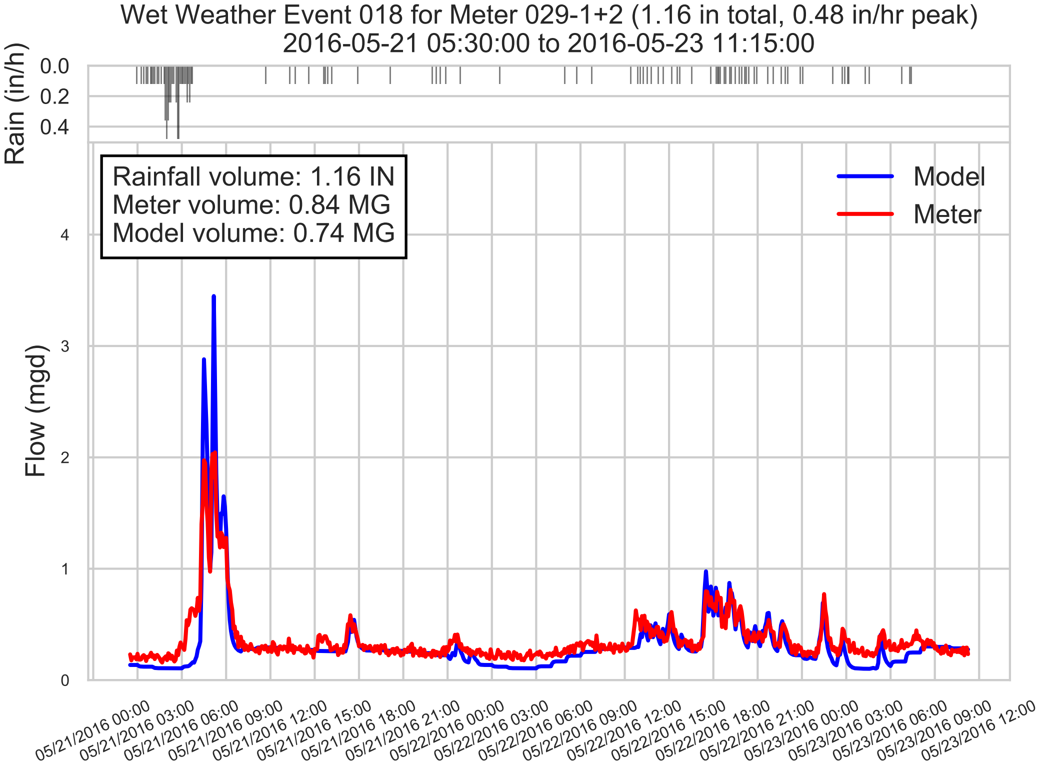
Wet Weather Event 015 for Meter 029-1+2 (0.17 in total, 0.12 in/hr peak)
2016-05-11 12:04:00 to 2016-05-11 23:15:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.17 IN
Meter volume: 0.16 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
05/11/2016 10:00
05/11/2016 13:00
05/11/2016 16:00
05/11/2016 19:00
05/11/2016 22:00



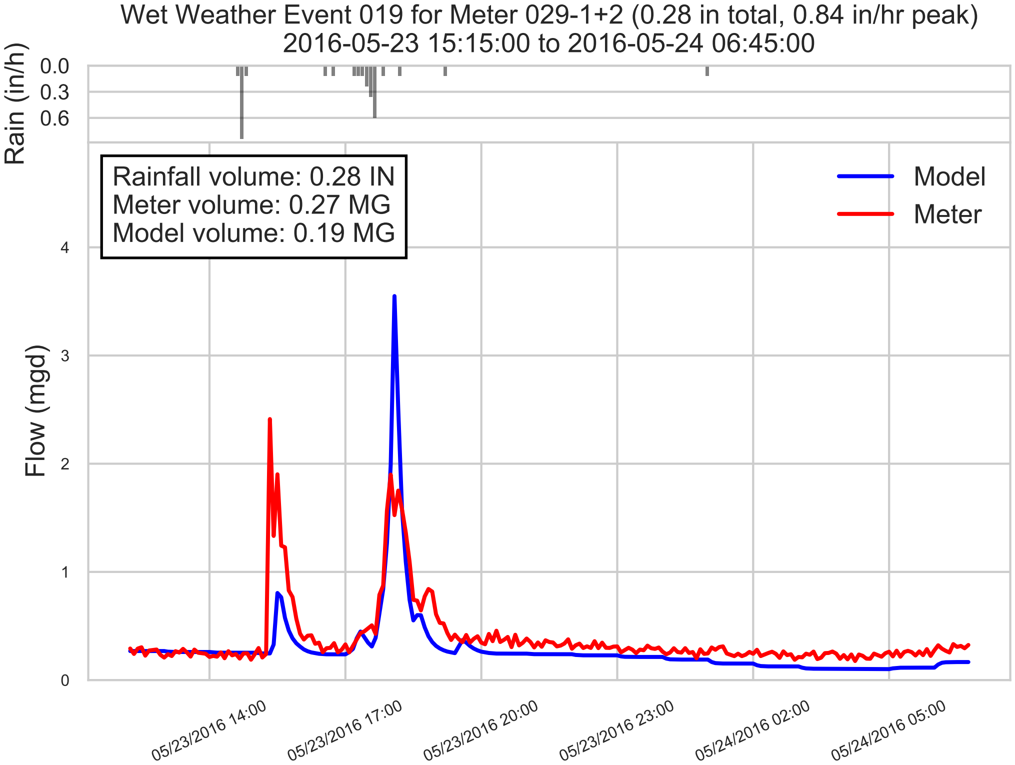
Wet Weather Event 016 for Meter 029-1+2 (0.16 in total, 0.24 in/hr peak)
2016-05-14 15:09:00 to 2016-05-14 22:25:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.16 IN
Meter volume: 0.13 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
05/14/2016 12:00
05/14/2016 15:00
05/14/2016 18:00
05/14/2016 21:00



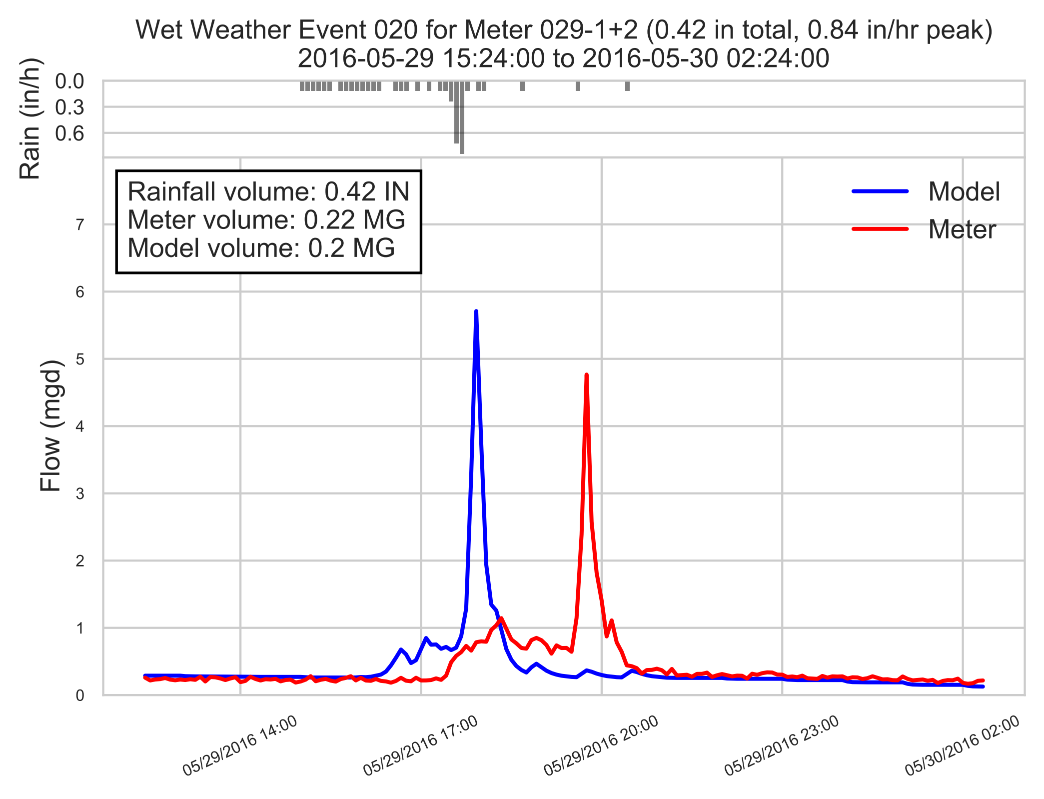
Wet Weather Event 017 for Meter 029-1+2 (0.38 in total, 0.12 in/hr peak)
2016-05-17 08:15:00 to 2016-05-18 02:05:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.38 IN
Meter volume: 0.27 MG
Model volume: 0.25 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
05/17/2016 05:00
05/17/2016 08:00
05/17/2016 11:00
05/17/2016 14:00
05/17/2016 17:00
05/17/2016 20:00
05/17/2016 23:00
05/18/2016 02:00



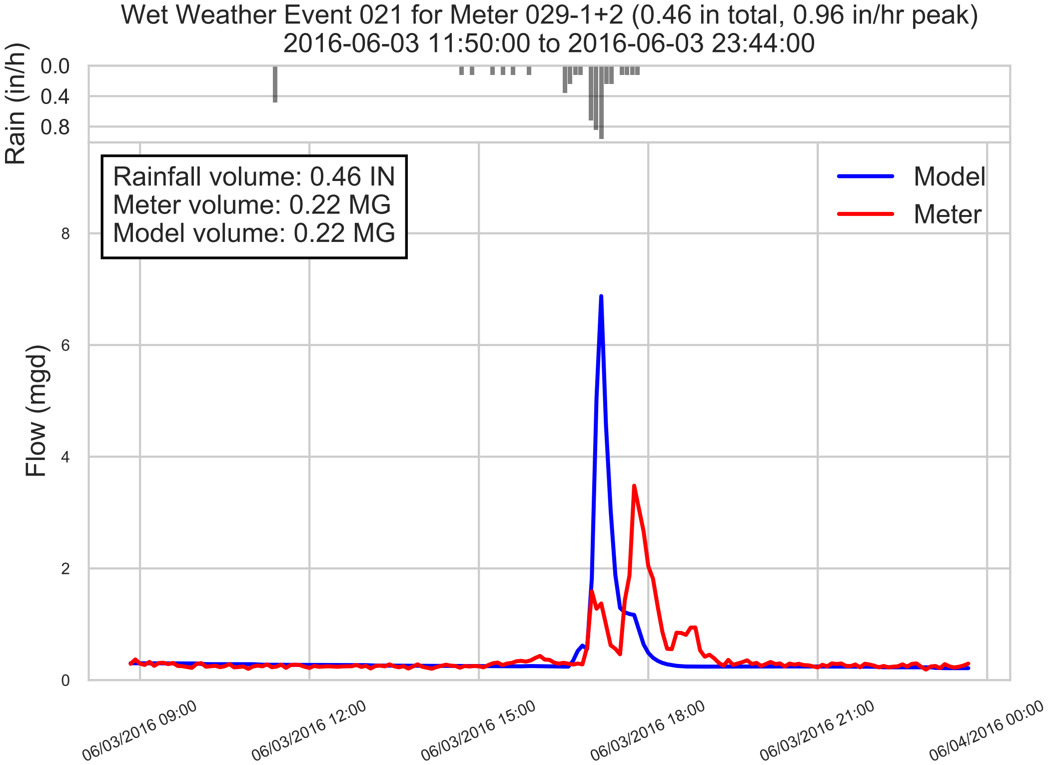
Wet Weather Event 018 for Meter 029-1+2 (1.16 in total, 0.48 in/hr peak)
2016-05-21 05:30:00 to 2016-05-23 11:15:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 1.16 IN
Meter volume: 0.84 MG
Model volume: 0.74 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
05/21/2016 00:00
05/21/2016 03:00
05/21/2016 06:00
05/21/2016 09:00
05/21/2016 12:00
05/21/2016 15:00
05/21/2016 18:00
05/21/2016 21:00
05/22/2016 00:00
05/22/2016 03:00
05/22/2016 06:00
05/22/2016 09:00
05/22/2016 12:00
05/22/2016 15:00
05/22/2016 18:00
05/22/2016 21:00
05/23/2016 00:00
05/23/2016 03:00
05/23/2016 06:00
05/23/2016 09:00
05/23/2016 12:00



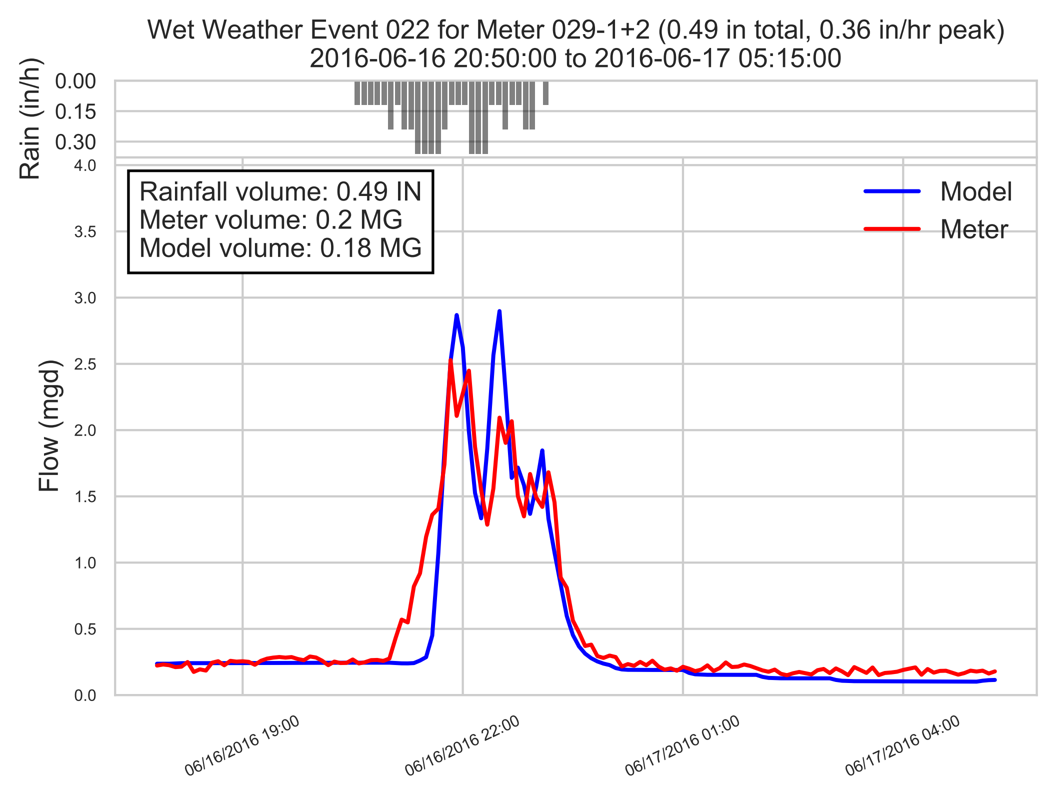
Wet Weather Event 019 for Meter 029-1+2 (0.28 in total, 0.84 in/hr peak)
2016-05-23 15:15:00 to 2016-05-24 06:45:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.28 IN
Meter volume: 0.27 MG
Model volume: 0.19 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
05/23/2016 14:00
05/23/2016 17:00
05/23/2016 20:00
05/23/2016 23:00
05/24/2016 02:00
05/24/2016 05:00



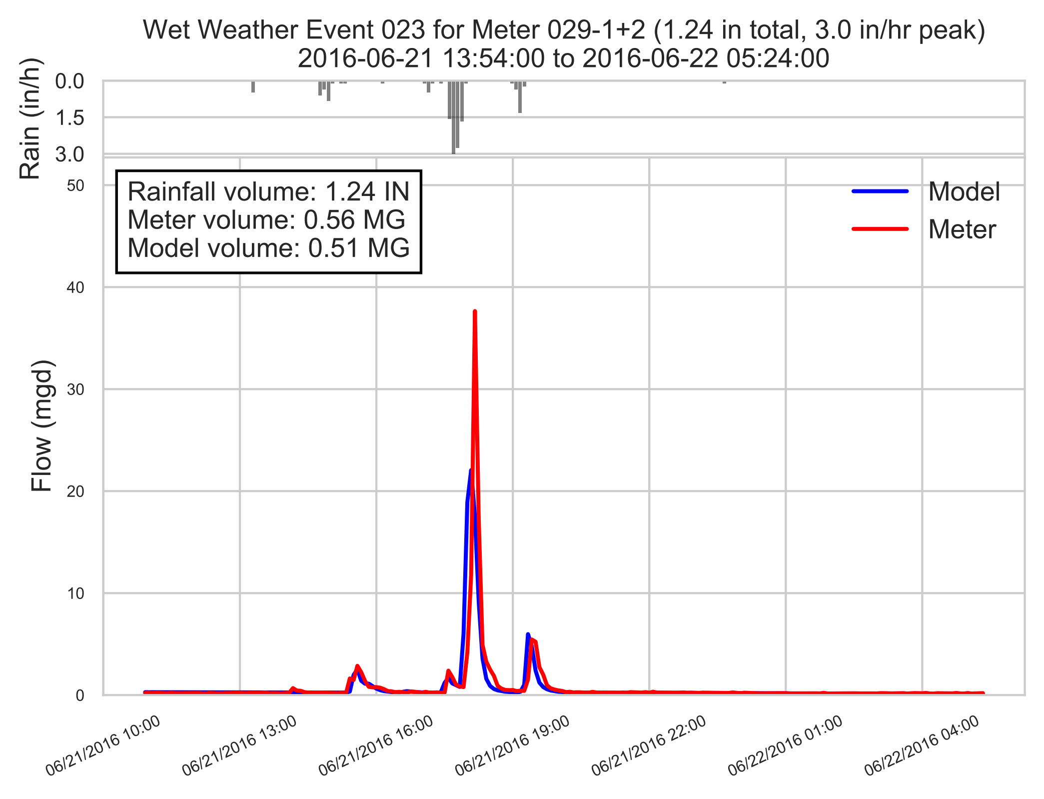
Wet Weather Event 020 for Meter 029-1+2 (0.42 in total, 0.84 in/hr peak)
2016-05-29 15:24:00 to 2016-05-30 02:24:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.42 IN
Meter volume: 0.22 MG
Model volume: 0.2 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
05/29/2016 14:00
05/29/2016 17:00
05/29/2016 20:00
05/29/2016 23:00
05/30/2016 02:00

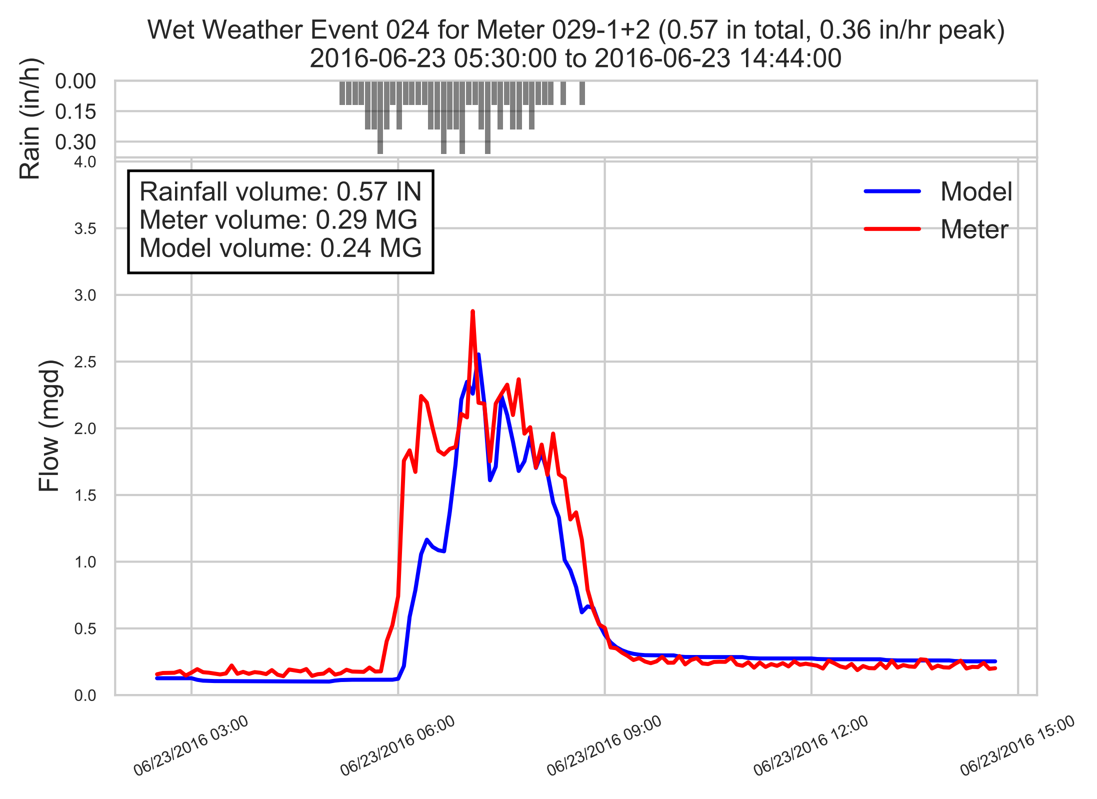


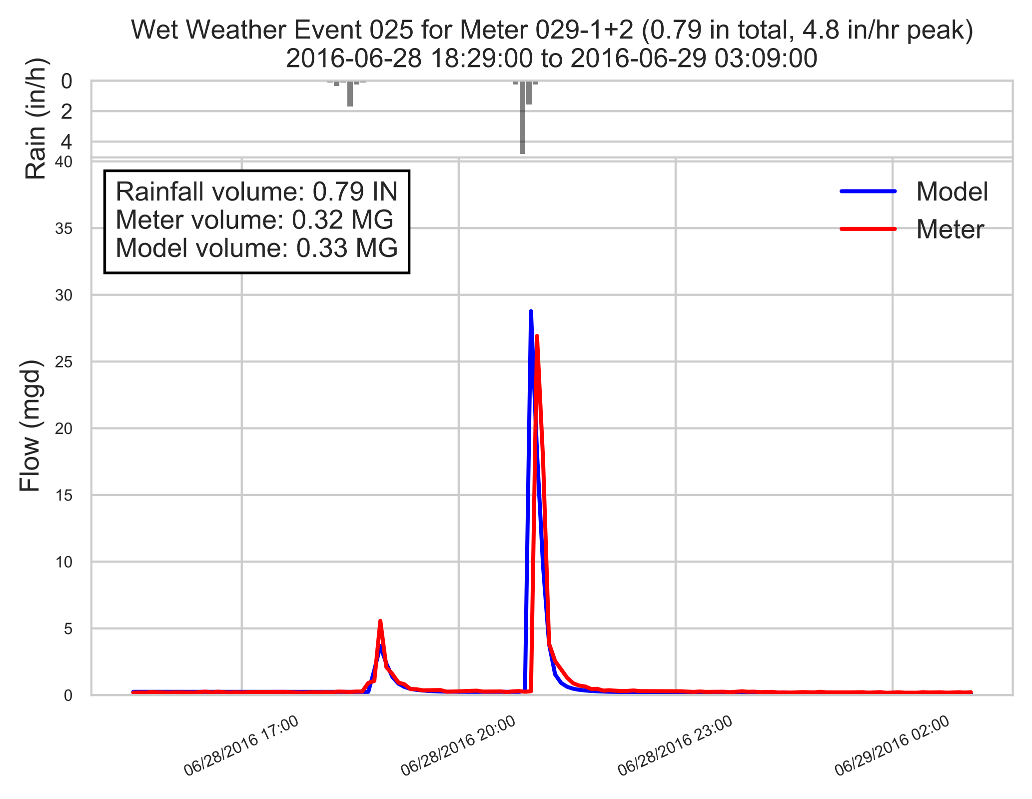
Wet Weather Event 021 for Meter 029-1+2 (0.46 in total, 0.96 in/hr peak)
2016-06-03 11:50:00 to 2016-06-03 23:44:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.46 IN
Meter volume: 0.22 MG
Model volume: 0.22 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
06/03/2016 09:00
06/03/2016 12:00
06/03/2016 15:00
06/03/2016 18:00
06/03/2016 21:00
06/04/2016 00:00



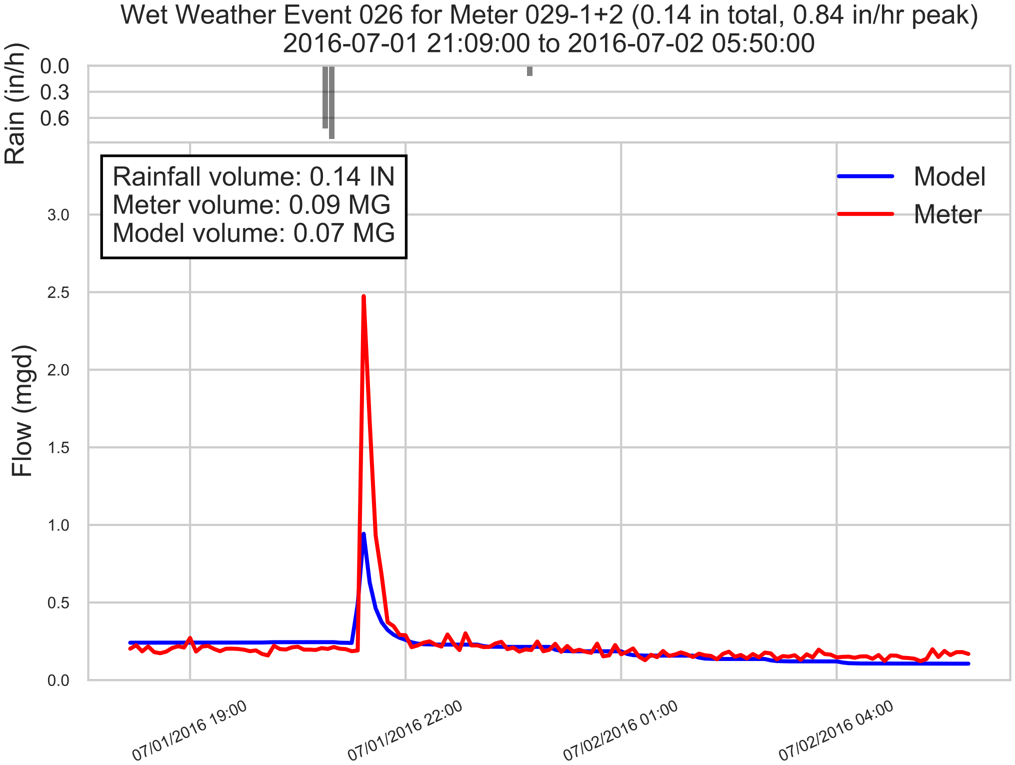
Wet Weather Event 022 for Meter 029-1+2 (0.49 in total, 0.36 in/hr peak)
2016-06-16 20:50:00 to 2016-06-17 05:15:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.49 IN
Meter volume: 0.2 MG
Model volume: 0.18 MG
Model
Meter
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06/16/2016 19:00
06/16/2016 22:00
06/17/2016 01:00
06/17/2016 04:00


Wet Weather Event 023 for Meter 029-1+2 (1.24 in total, 3.0 in/hr peak)
2016-06-21 13:54:00 to 2016-06-22 05:24:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
0
10
20
30
40
50
Rainfall volume: 1.24 IN
Meter volume: 0.56 MG
Model volume: 0.51 MG
Model
Meter
06/21/2016 10:00
06/21/2016 13:00
06/21/2016 16:00
06/21/2016 19:00
06/21/2016 22:00
06/22/2016 01:00
06/22/2016 04:00

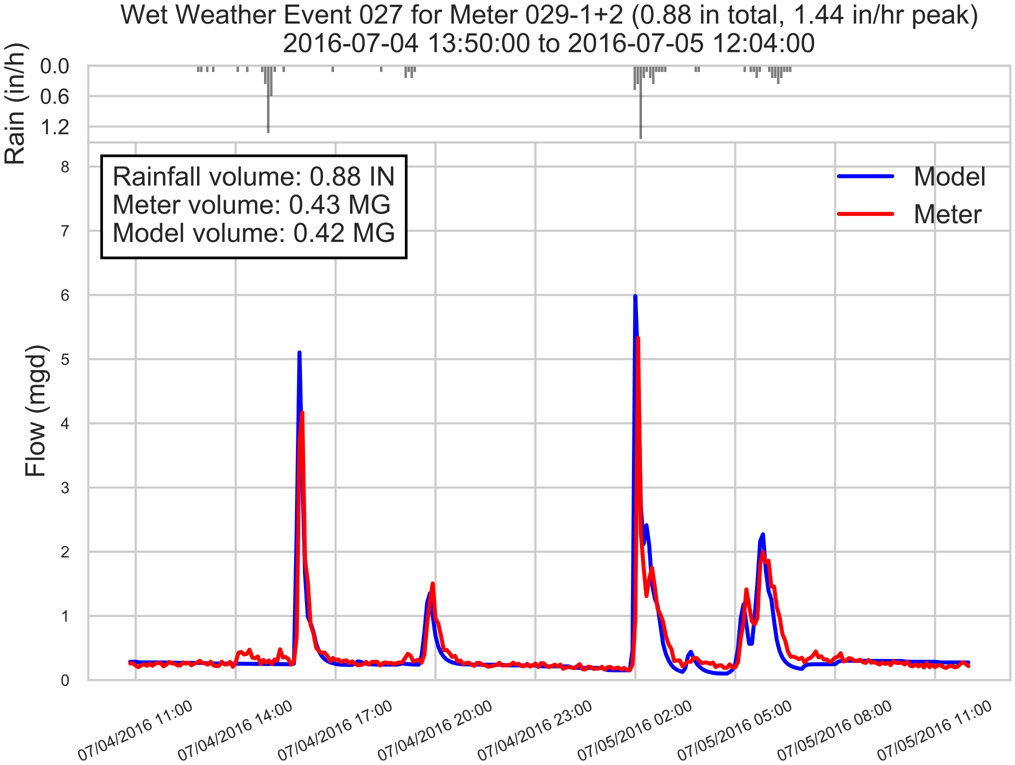

Wet Weather Event 024 for Meter 029-1+2 (0.57 in total, 0.36 in/hr peak)
2016-06-23 05:30:00 to 2016-06-23 14:44:00
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall volume: 0.57 IN
Meter volume: 0.29 MG
Model volume: 0.24 MG
Model
Meter
06/23/2016 03:00
06/23/2016 06:00
06/23/2016 09:00
06/23/2016 12:00
06/23/2016 15:00



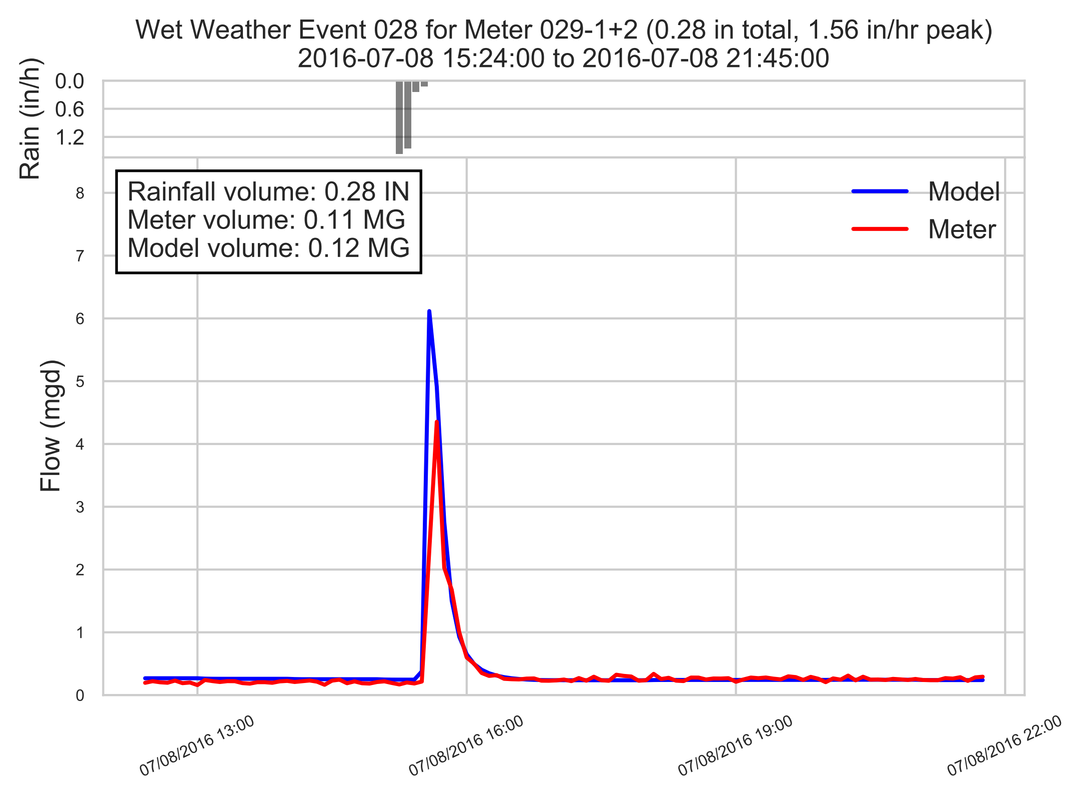
Wet Weather Event 025 for Meter 029-1+2 (0.79 in total, 4.8 in/hr peak)
2016-06-28 18:29:00 to 2016-06-29 03:09:00
Rain (in/h)
0
2
4
40
35
30
25
20
15
10
5
0
Flow (mgd)
Rainfall volume: 0.79 IN
Meter volume: 0.32 MG
Model volume: 0.33 MG
Model
Meter
06/28/2016 17:00
06/28/2016 20:00
06/28/2016 23:00
06/29/2016 02:00

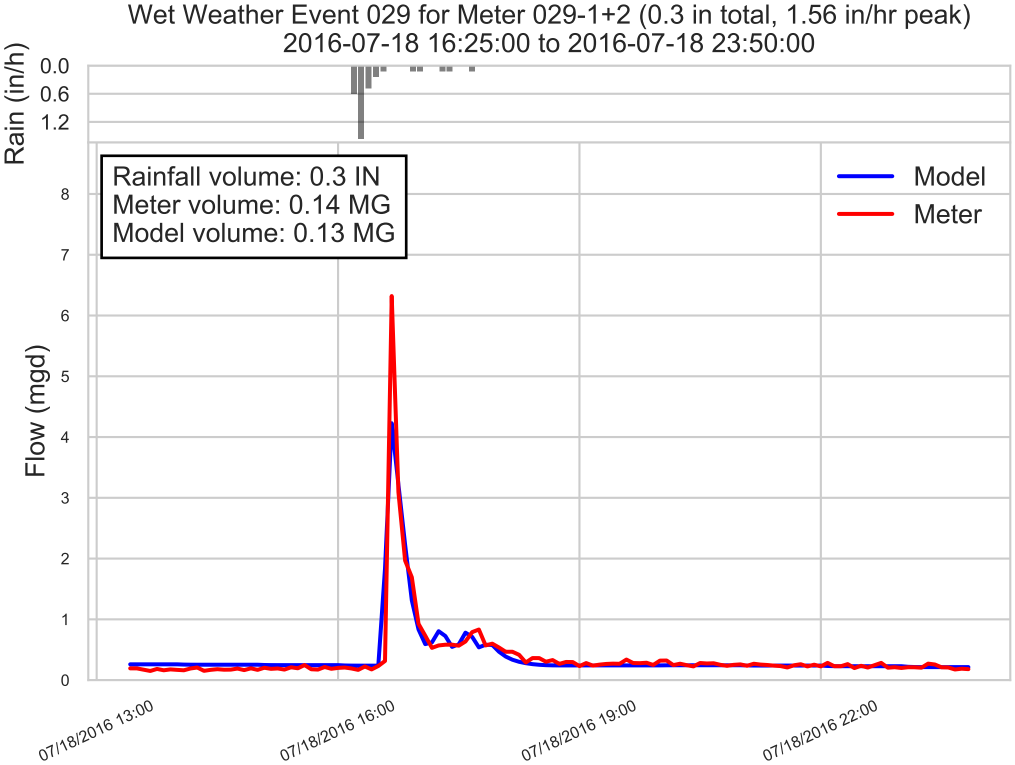


Wet Weather Event 026 for Meter 029-1+2 (0.14 in total, 0.84 in/hr peak)
2016-07-01 21:09:00 to 2016-07-02 05:50:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.14 IN
Meter volume: 0.09 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
07/01/2016 19:00
07/01/2016 22:00
07/02/2016 01:00
07/02/2016 04:00

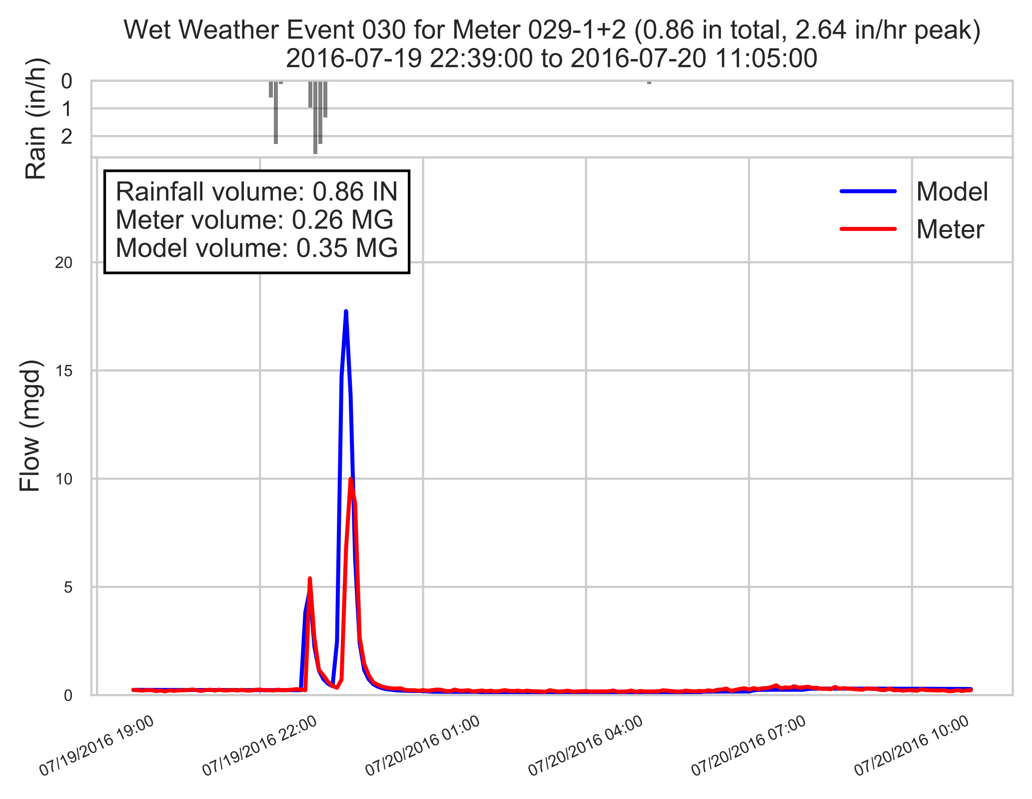


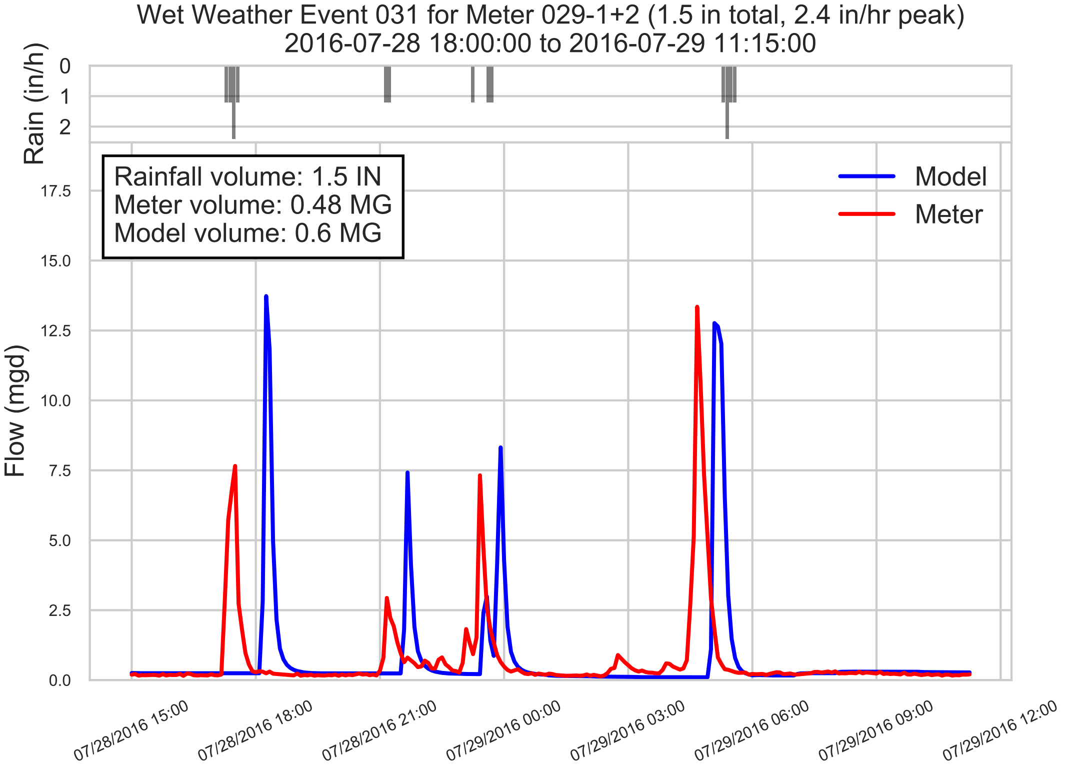
Wet Weather Event 027 for Meter 029-1+2 (0.88 in total, 1.44 in/hr peak)
2016-07-04 13:50:00 to 2016-07-05 12:04:00
Rain (in/h)
0.0
0.6
1.2
Flow (mgd)
0
1
2
3
4
5
6
7
8
Rainfall volume: 0.88 IN
Meter volume: 0.43 MG
Model volume: 0.42 MG
Model
Meter
07/04/2016 11:00
07/04/2016 14:00
07/04/2016 17:00
07/04/2016 20:00
07/04/2016 23:00
07/05/2016 02:00
07/05/2016 05:00
07/05/2016 08:00
07/05/2016 11:00

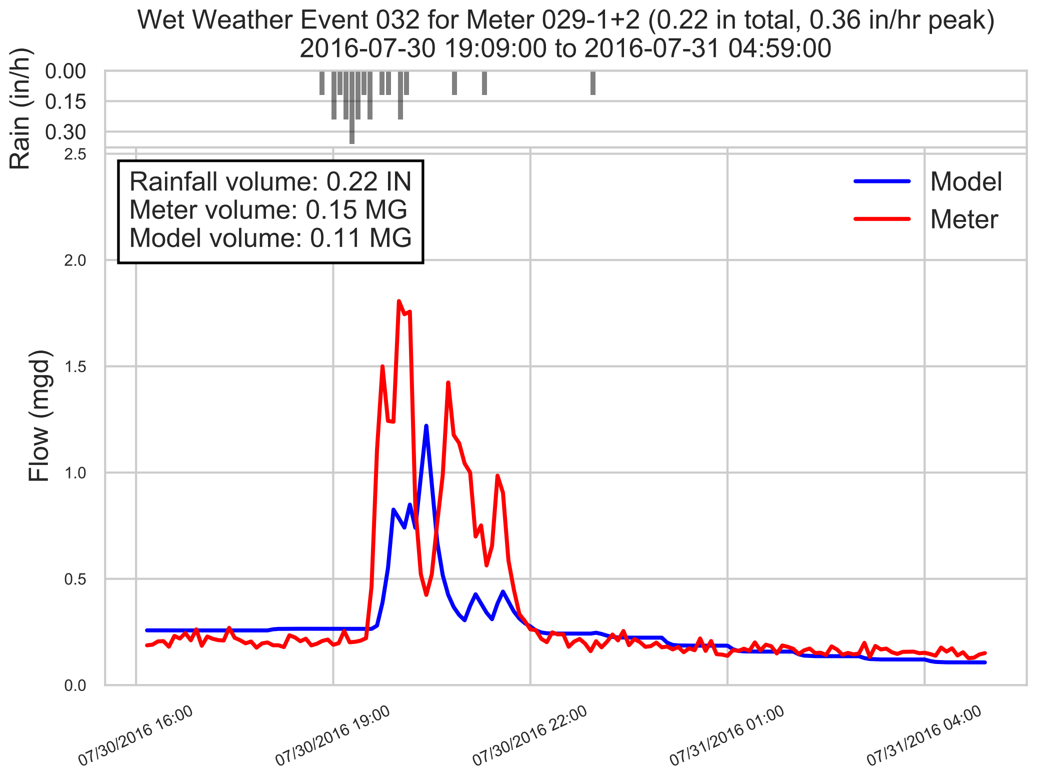

Wet Weather Event 028 for Meter 029-1+2 (0.28 in total, 1.56 in/hr peak)
2016-07-08 15:24:00 to 2016-07-08 21:45:00
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.28 IN
Meter volume: 0.11 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
07/08/2016 13:00
07/08/2016 16:00
07/08/2016 19:00
07/08/2016 22:00



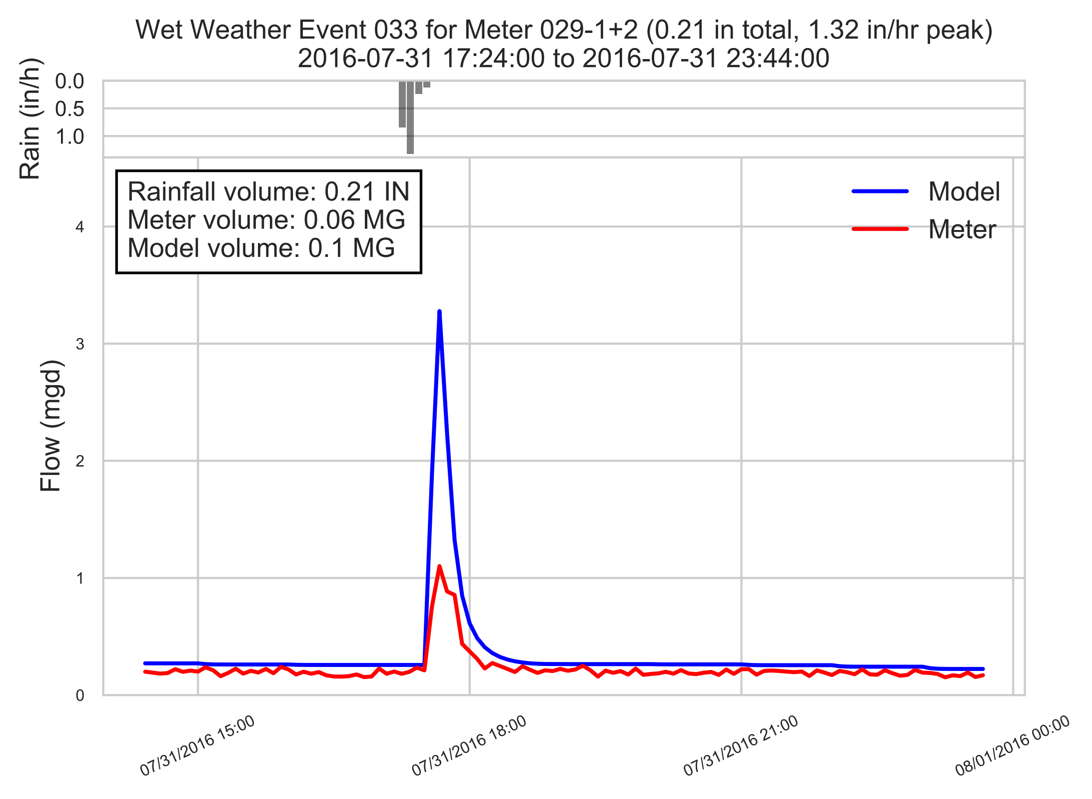
Wet Weather Event 029 for Meter 029-1+2 (0.3 in total, 1.56 in/hr peak)
2016-07-18 16:25:00 to 2016-07-18 23:50:00
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.3 IN
Meter volume: 0.14 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
07/18/2016 13:00
07/18/2016 16:00
07/18/2016 19:00
07/18/2016 22:00


Wet Weather Event 030 for Meter 029-1+2 (0.86 in total, 2.64 in/hr peak)
2016-07-19 22:39:00 to 2016-07-20 11:05:00
Rain (in/h)
0
1
2
Rainfall volume: 0.86 IN
Meter volume: 0.26 MG
Model volume: 0.35 MG
Model
Meter
Flow (mgd)
20
15
10
5
0
07/19/2016 19:00
07/19/2016 22:00
07/20/2016 01:00
07/20/2016 04:00
07/20/2016 07:00
07/20/2016 10:00

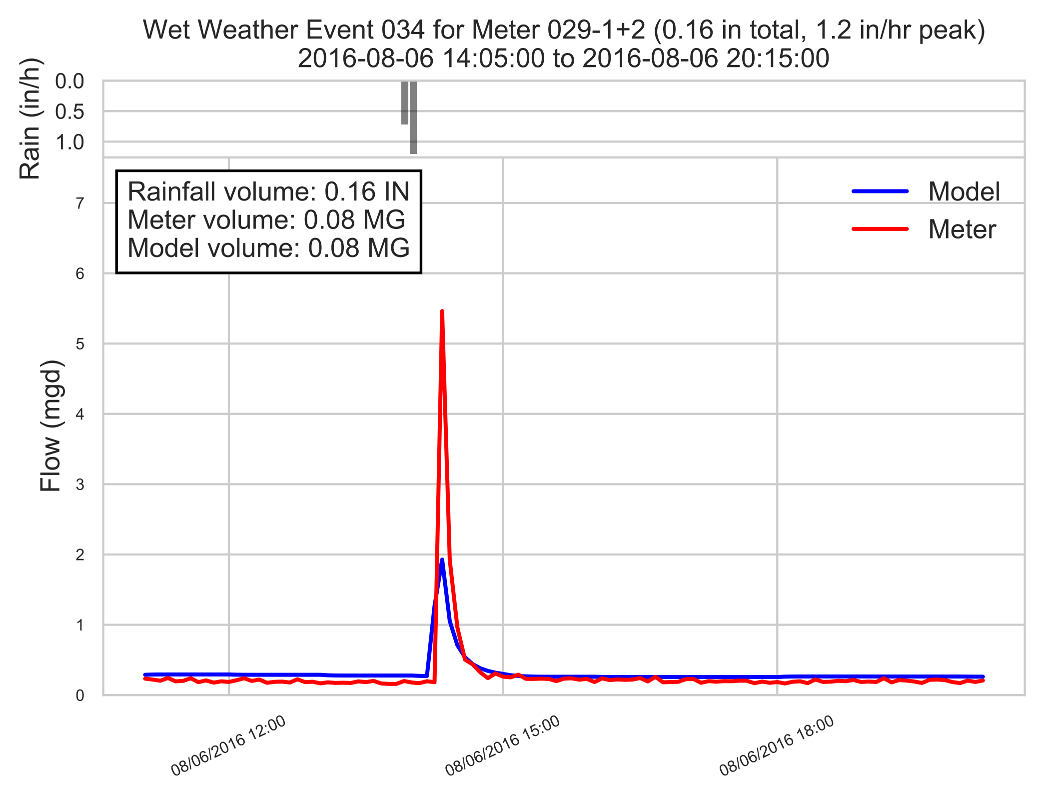

Wet Weather Event 031 for Meter 029-1+2 (1.5 in total, 2.4 in/hr peak)
2016-07-28 18:00:00 to 2016-07-29 11:15:00
Rain (in/h)
0
1
2
Rainfall volume: 1.5 IN
Meter volume: 0.48 MG
Model volume: 0.6 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
07/28/2016 15:00
07/28/2016 18:00
07/28/2016 21:00
07/29/2016 00:00
07/29/2016 03:00
07/29/2016 06:00
07/29/2016 09:00
07/29/2016 12:00

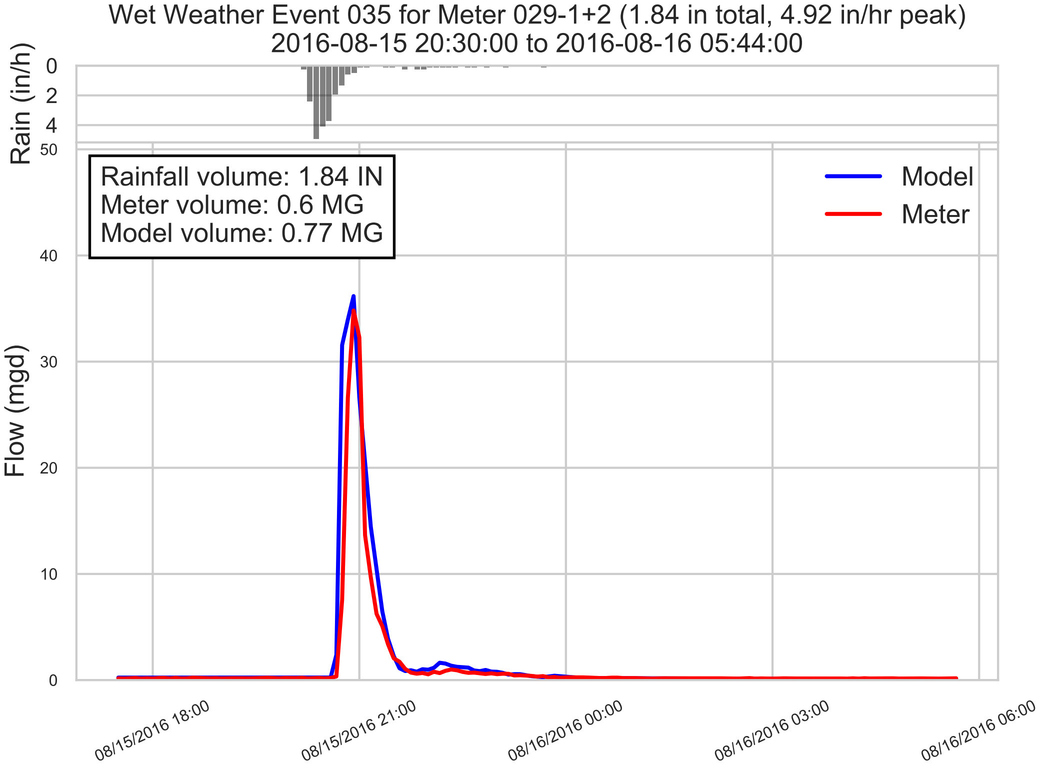


Wet Weather Event 032 for Meter 029-1+2 (0.22 in total, 0.36 in/hr peak)
2016-07-30 19:09:00 to 2016-07-31 04:59:00
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
Rainfall volume: 0.22 IN
Meter volume: 0.15 MG
Model volume: 0.11 MG
Model
Meter
07/30/2016 16:00
07/30/2016 19:00
07/30/2016 22:00
07/31/2016 01:00
07/31/2016 04:00

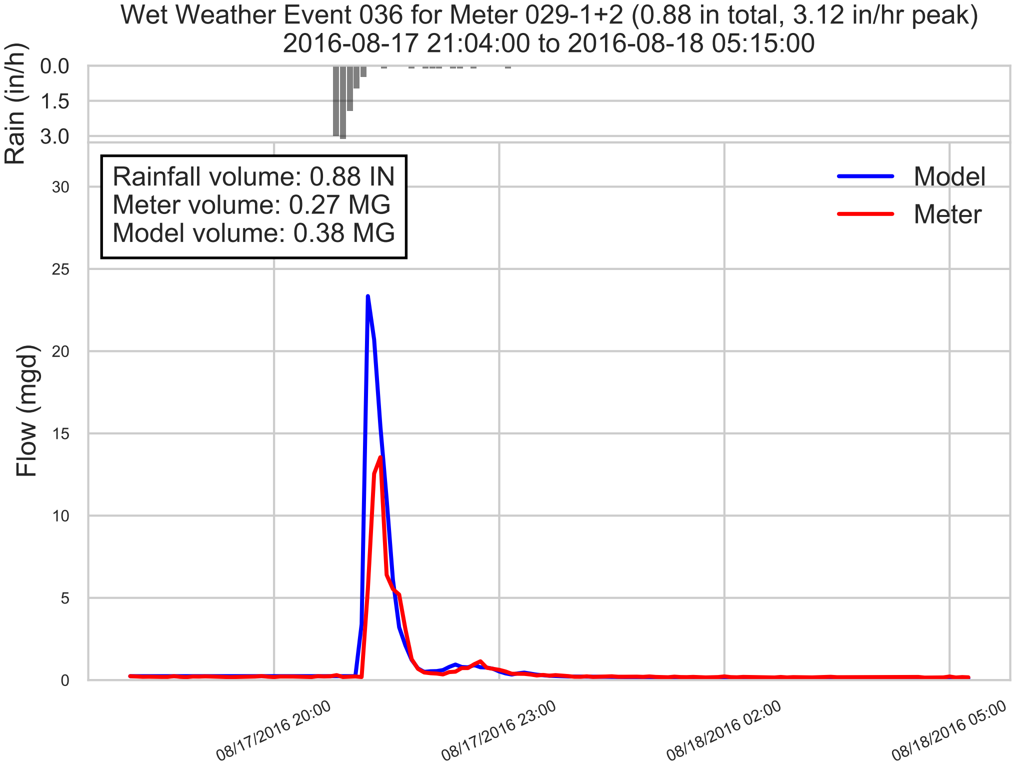


Wet Weather Event 033 for Meter 029-1+2 (0.21 in total, 1.32 in/hr peak)
2016-07-31 17:24:00 to 2016-07-31 23:44:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.21 IN
Meter volume: 0.06 MG
Model volume: 0.1 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
07/31/2016 15:00
07/31/2016 18:00
07/31/2016 21:00
08/01/2016 00:00

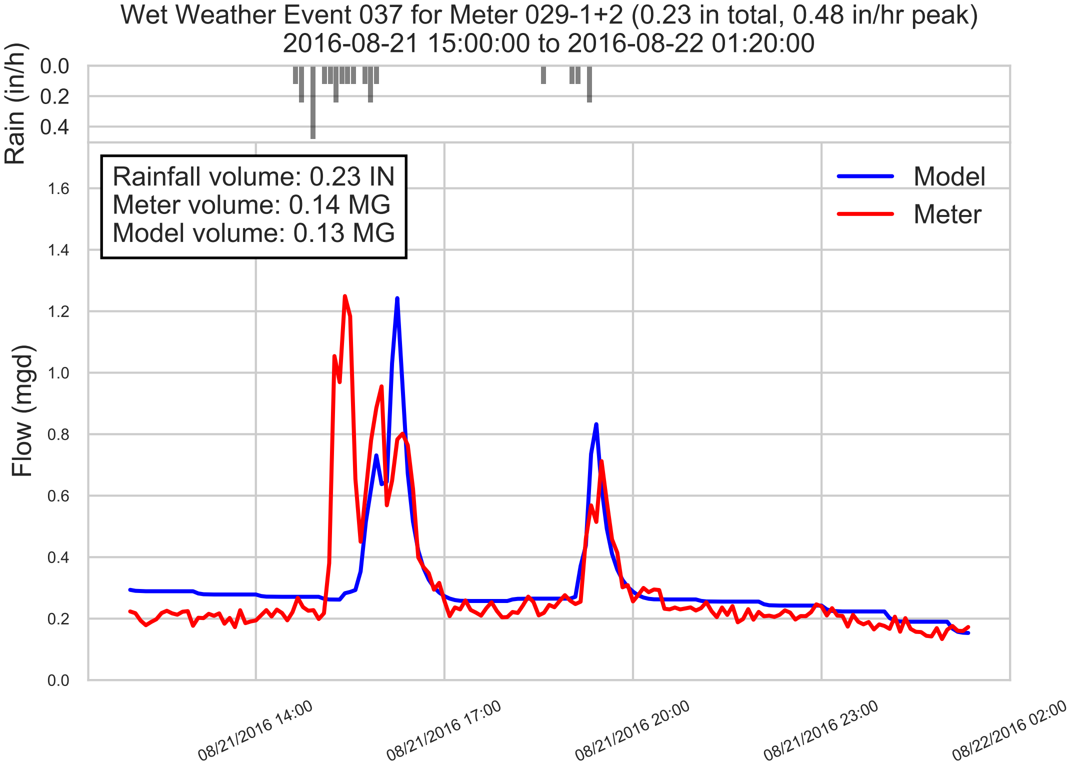

Wet Weather Event 034 for Meter 029-1+2 (0.16 in total, 1.2 in/hr peak)
2016-08-06 14:05:00 to 2016-08-06 20:15:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.16 IN
Meter volume: 0.08 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
08/06/2016 12:00
08/06/2016 15:00
08/06/2016 18:00

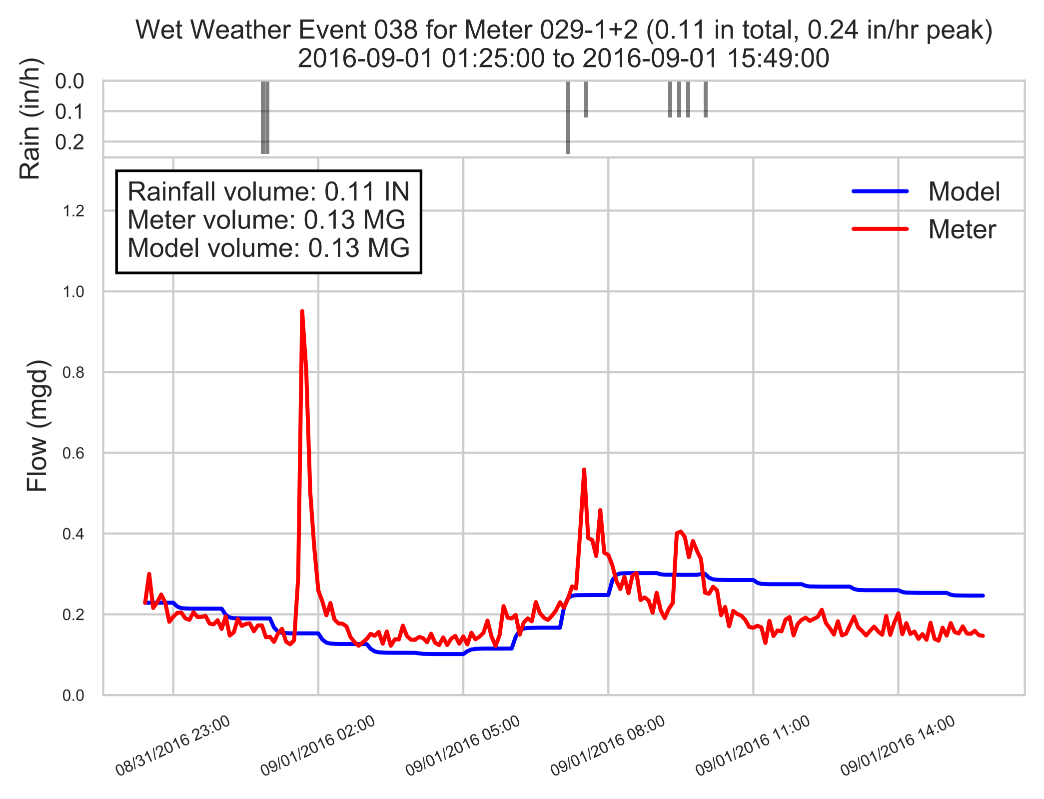


Wet Weather Event 035 for Meter 029-1+2 (1.84 in total, 4.92 in/hr peak)
2016-08-15 20:30:00 to 2016-08-16 05:44:00
Rain (in/h)
0
2
4
Flow (mgd)
50
40
30
20
10
0
Rainfall volume: 1.84 IN
Meter volume: 0.6 MG
Model volume: 0.77 MG
Model
Meter
08/15/2016 18:00
08/15/2016 21:00
08/16/2016 00:00
08/16/2016 03:00
08/16/2016 06:00

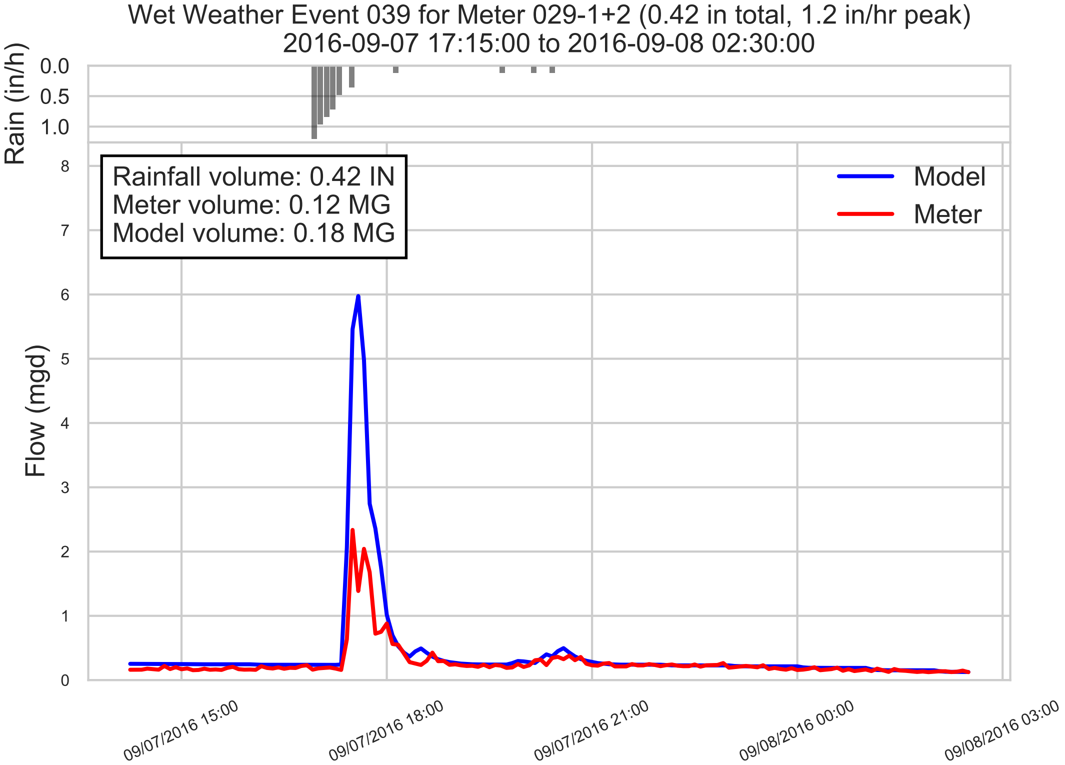


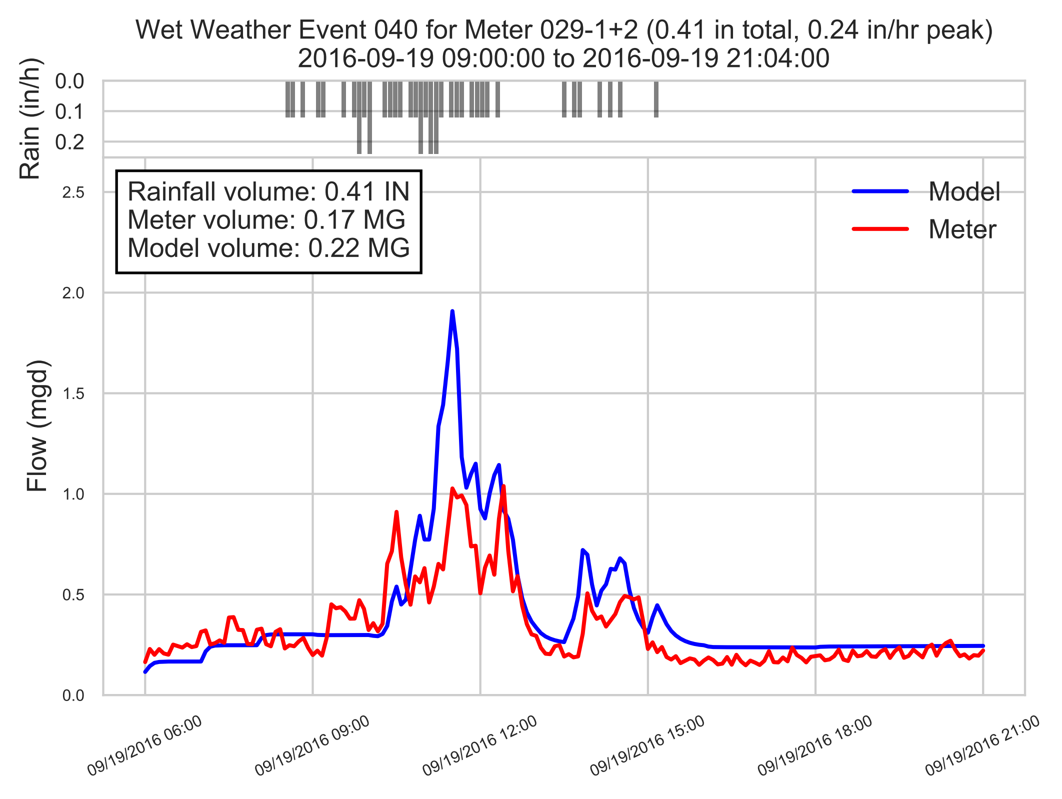
Wet Weather Event 036 for Meter 029-1+2 (0.88 in total, 3.12 in/hr peak)
2016-08-17 21:04:00 to 2016-08-18 05:15:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.88 IN
Meter volume: 0.27 MG
Model volume: 0.38 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
08/17/2016 20:00
08/17/2016 23:00
08/18/2016 02:00
08/18/2016 05:00


Wet Weather Event 037 for Meter 029-1+2 (0.23 in total, 0.48 in/hr peak)
2016-08-21 15:00:00 to 2016-08-22 01:20:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.23 IN
Meter volume: 0.14 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
08/21/2016 14:00
08/21/2016 17:00
08/21/2016 20:00
08/21/2016 23:00
08/22/2016 02:00

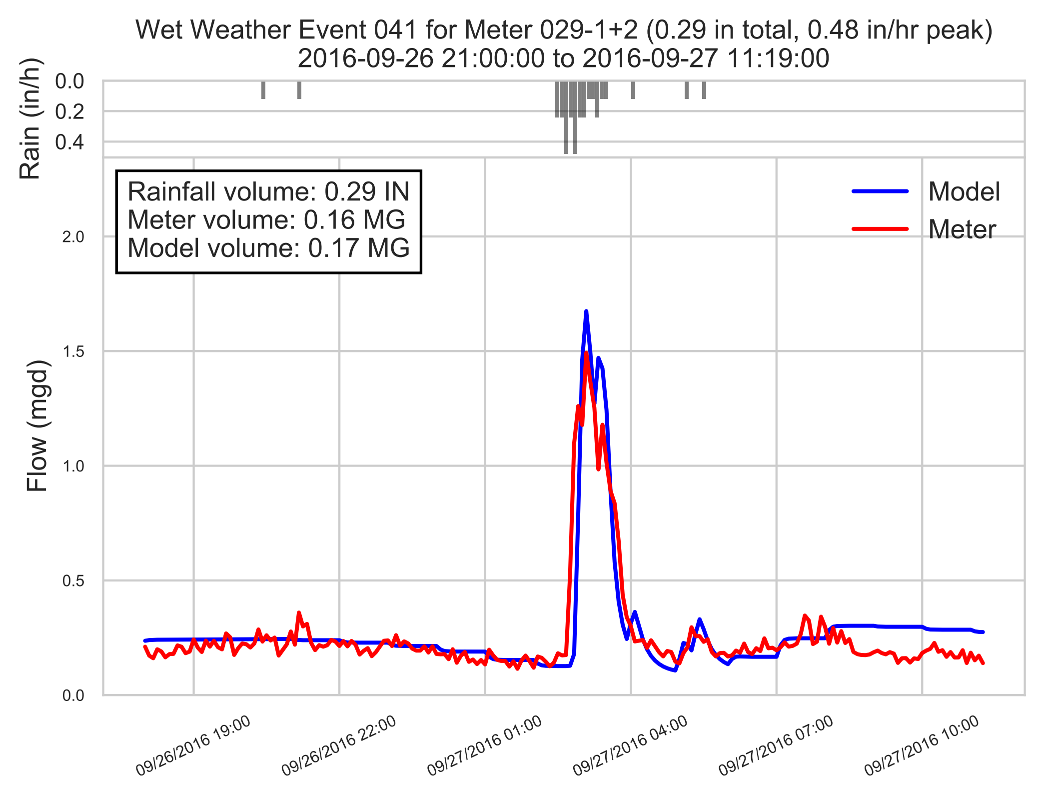


Wet Weather Event 038 for Meter 029-1+2 (0.11 in total, 0.24 in/hr peak)
2016-09-01 01:25:00 to 2016-09-01 15:49:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.11 IN
Meter volume: 0.13 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
08/31/2016 23:00
09/01/2016 02:00
09/01/2016 05:00
09/01/2016 08:00
09/01/2016 11:00
09/01/2016 14:00

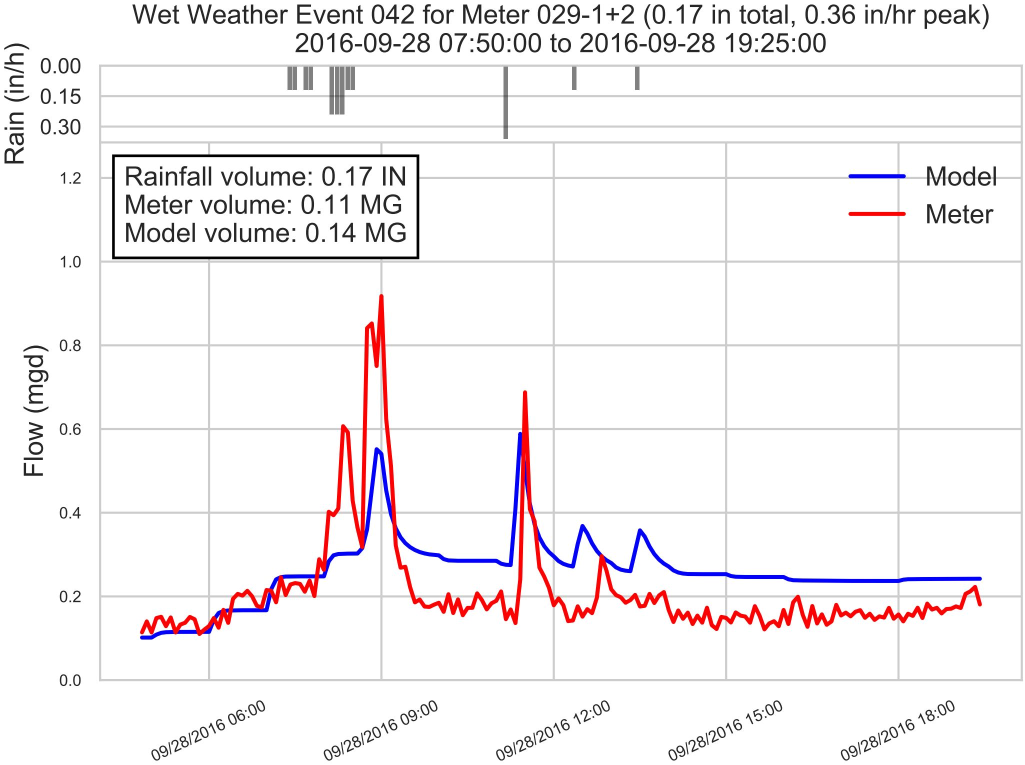

Wet Weather Event 039 for Meter 029-1+2 (0.42 in total, 1.2 in/hr peak)
2016-09-07 17:15:00 to 2016-09-08 02:30:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.42 IN
Meter volume: 0.12 MG
Model volume: 0.18 MG
Model
Meter
Flow (mgd)
8
7
6
5
4
3
2
1
0
09/07/2016 15:00
09/07/2016 18:00
09/07/2016 21:00
09/08/2016 00:00
09/08/2016 03:00

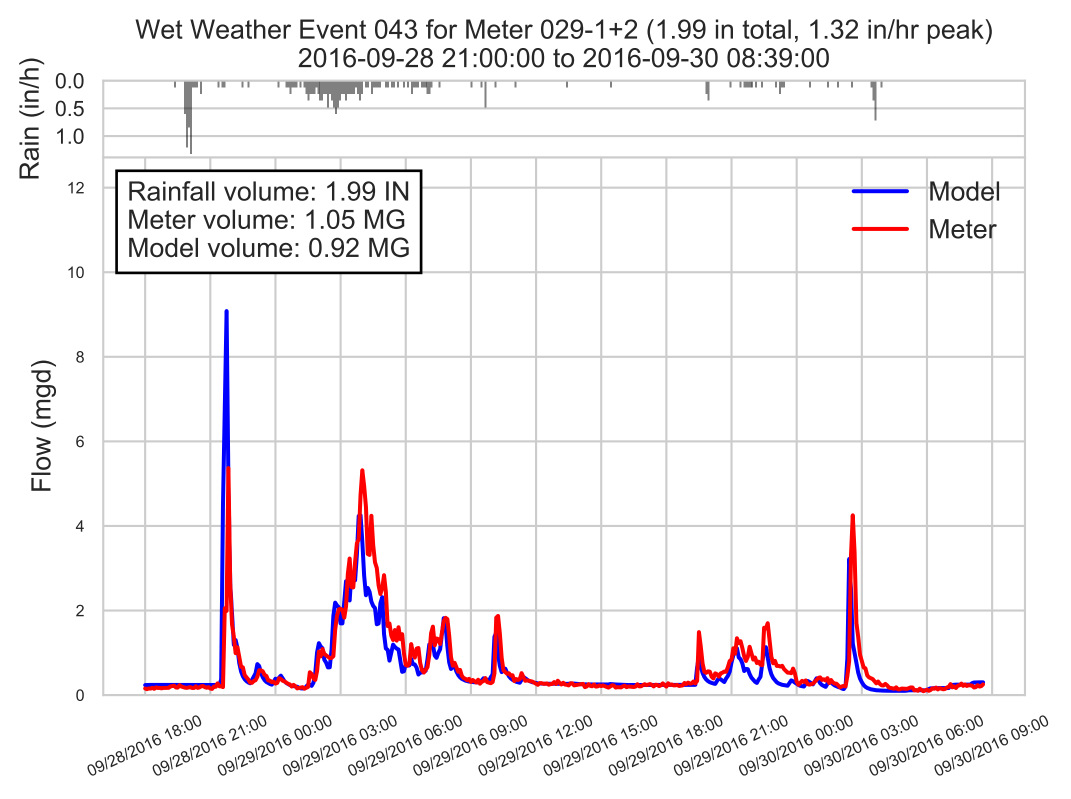


Wet Weather Event 040 for Meter 029-1+2 (0.41 in total, 0.24 in/hr peak)
2016-09-19 09:00:00 to 2016-09-19 21:04:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
Rainfall volume: 0.41 IN
Meter volume: 0.17 MG
Model volume: 0.22 MG
Model
Meter
09/19/2016 06:00
09/19/2016 09:00
09/19/2016 12:00
09/19/2016 15:00
09/19/2016 18:00
09/19/2016 21:00

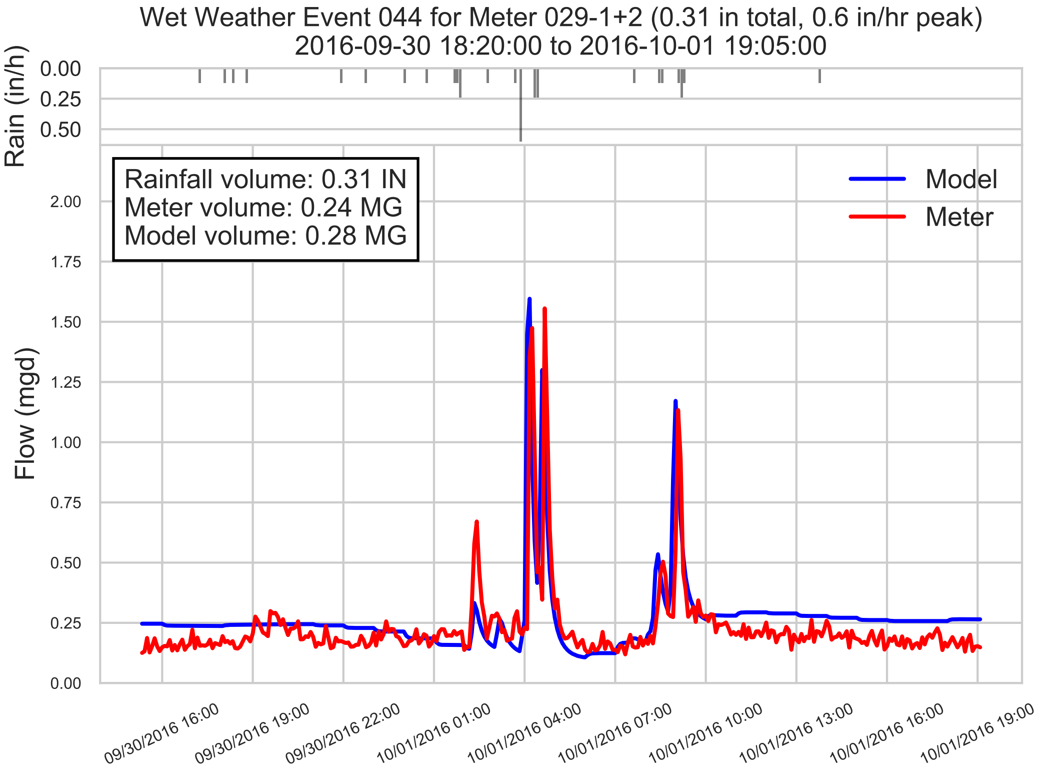


Wet Weather Event 041 for Meter 029-1+2 (0.29 in total, 0.48 in/hr peak)
2016-09-26 21:00:00 to 2016-09-27 11:19:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.29 IN
Meter volume: 0.16 MG
Model volume: 0.17 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
09/26/2016 19:00
09/26/2016 22:00
09/27/2016 01:00
09/27/2016 04:00
09/27/2016 07:00
09/27/2016 10:00

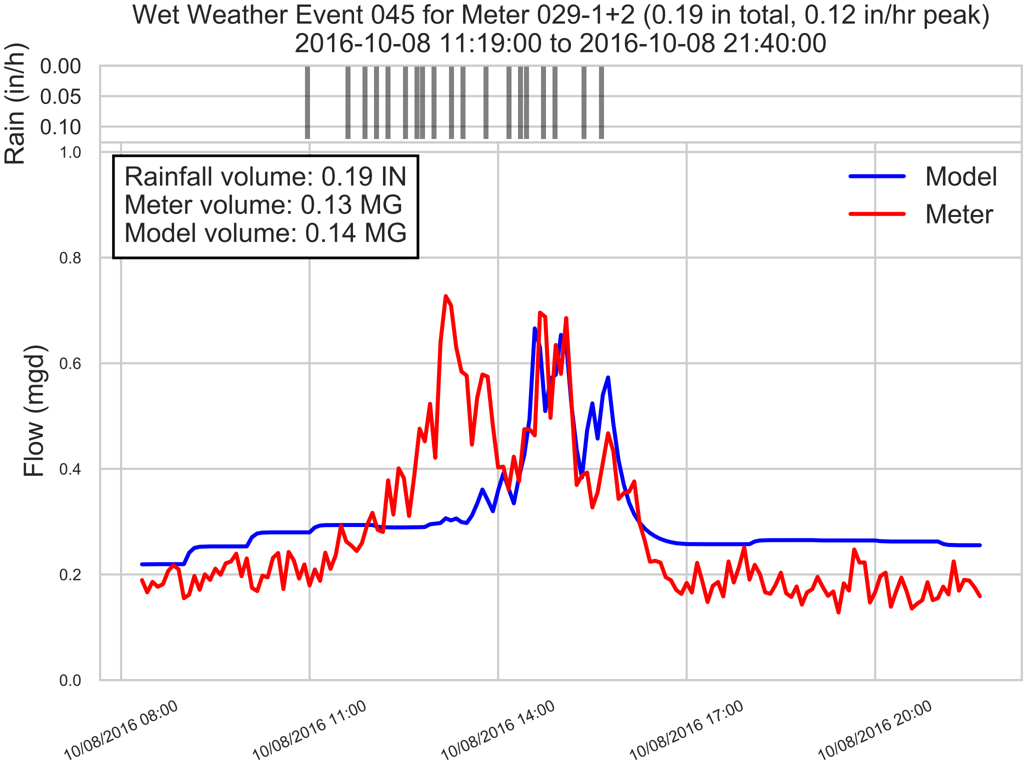

Wet Weather Event 042 for Meter 029-1+2 (0.17 in total, 0.36 in/hr peak)
2016-09-28 07:50:00 to 2016-09-28 19:25:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.17 IN
Meter volume: 0.11 MG
Model volume: 0.14 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
09/28/2016 06:00
09/28/2016 09:00
09/28/2016 12:00
09/28/2016 15:00
09/28/2016 18:00



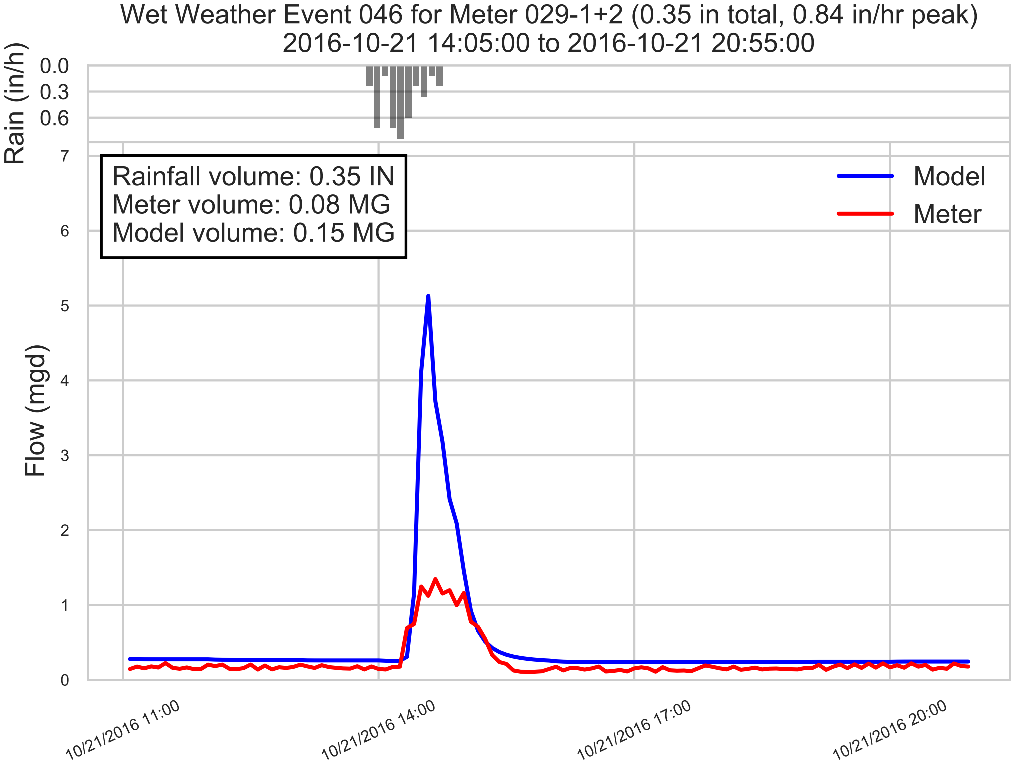
Wet Weather Event 043 for Meter 029-1+2 (1.99 in total, 1.32 in/hr peak)
2016-09-28 21:00:00 to 2016-09-30 08:39:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.99 IN
Meter volume: 1.05 MG
Model volume: 0.92 MG
Model
Meter
Flow (mgd)
12
10
8
6
4
2
0
09/28/2016 18:00
09/28/2016 21:00
09/29/2016 00:00
09/29/2016 03:00
09/29/2016 06:00
09/29/2016 09:00
09/29/2016 12:00
09/29/2016 15:00
09/29/2016 18:00
09/29/2016 21:00
09/30/2016 00:00
09/30/2016 03:00
09/30/2016 06:00
09/30/2016 09:00



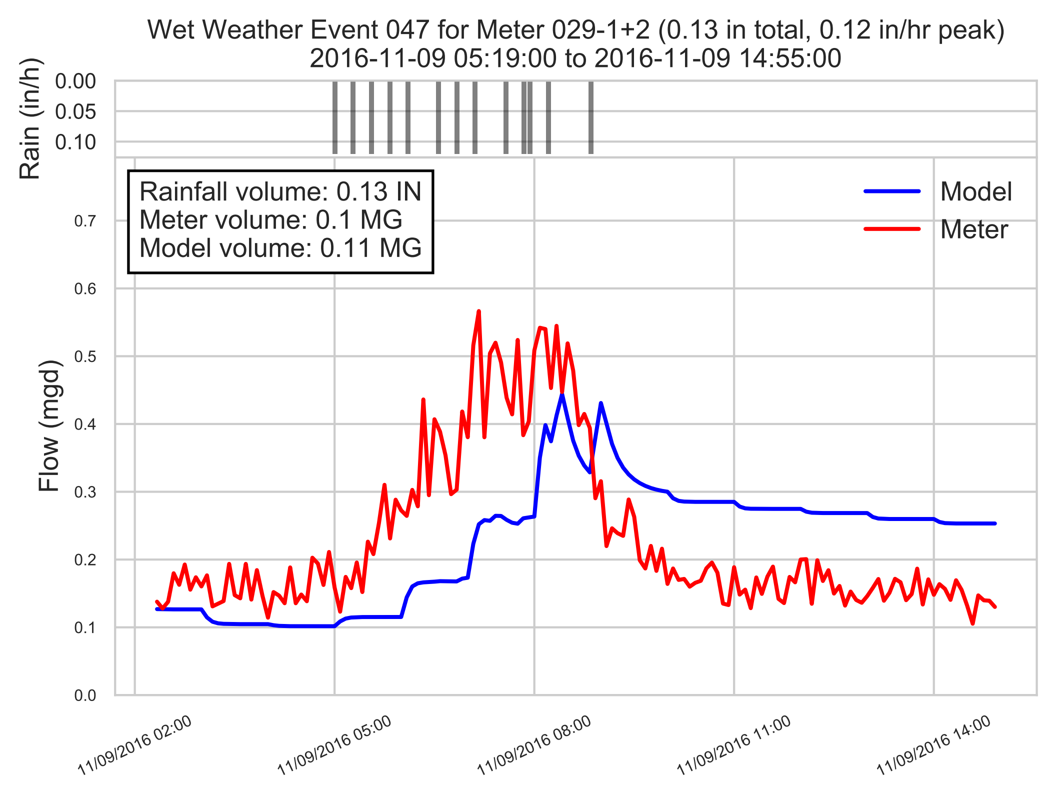
Wet Weather Event 044 for Meter 029-1+2 (0.31 in total, 0.6 in/hr peak)
2016-09-30 18:20:00 to 2016-10-01 19:05:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.31 IN
Meter volume: 0.24 MG
Model volume: 0.28 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
09/30/2016 16:00
09/30/2016 19:00
09/30/2016 22:00
10/01/2016 01:00
10/01/2016 04:00
10/01/2016 07:00
10/01/2016 10:00
10/01/2016 13:00
10/01/2016 16:00
10/01/2016 19:00



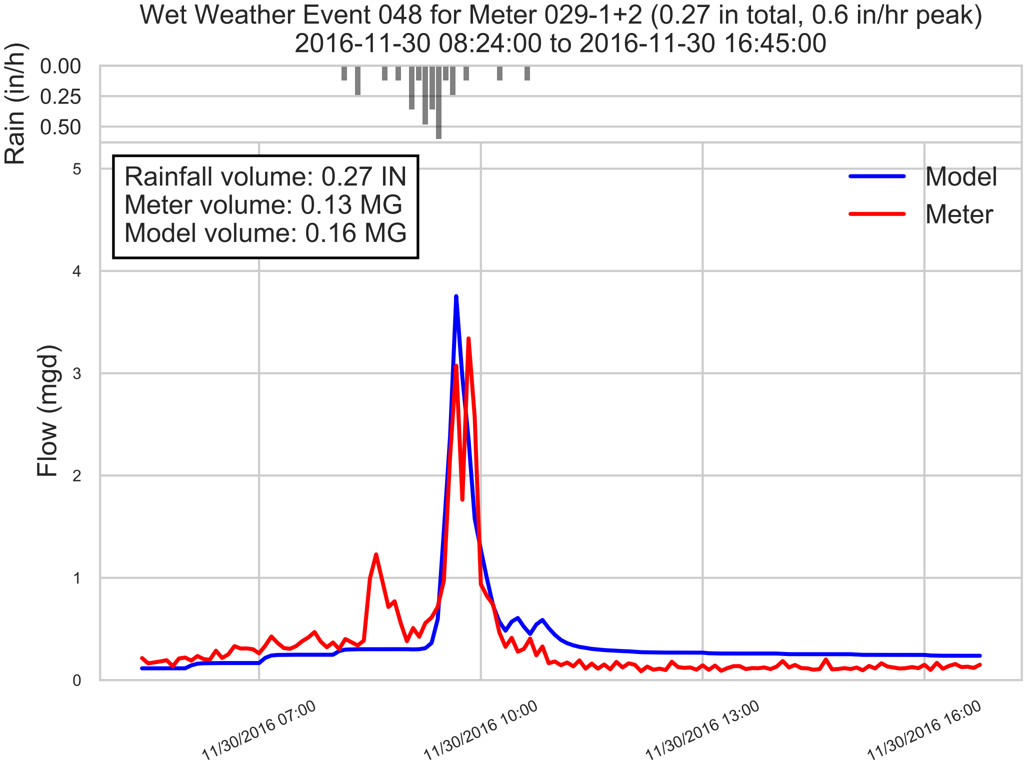
Wet Weather Event 045 for Meter 029-1+2 (0.19 in total, 0.12 in/hr peak)
2016-10-08 11:19:00 to 2016-10-08 21:40:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
Rainfall volume: 0.19 IN
Meter volume: 0.13 MG
Model volume: 0.14 MG
Model
Meter
10/08/2016 08:00
10/08/2016 11:00
10/08/2016 14:00
10/08/2016 17:00
10/08/2016 20:00



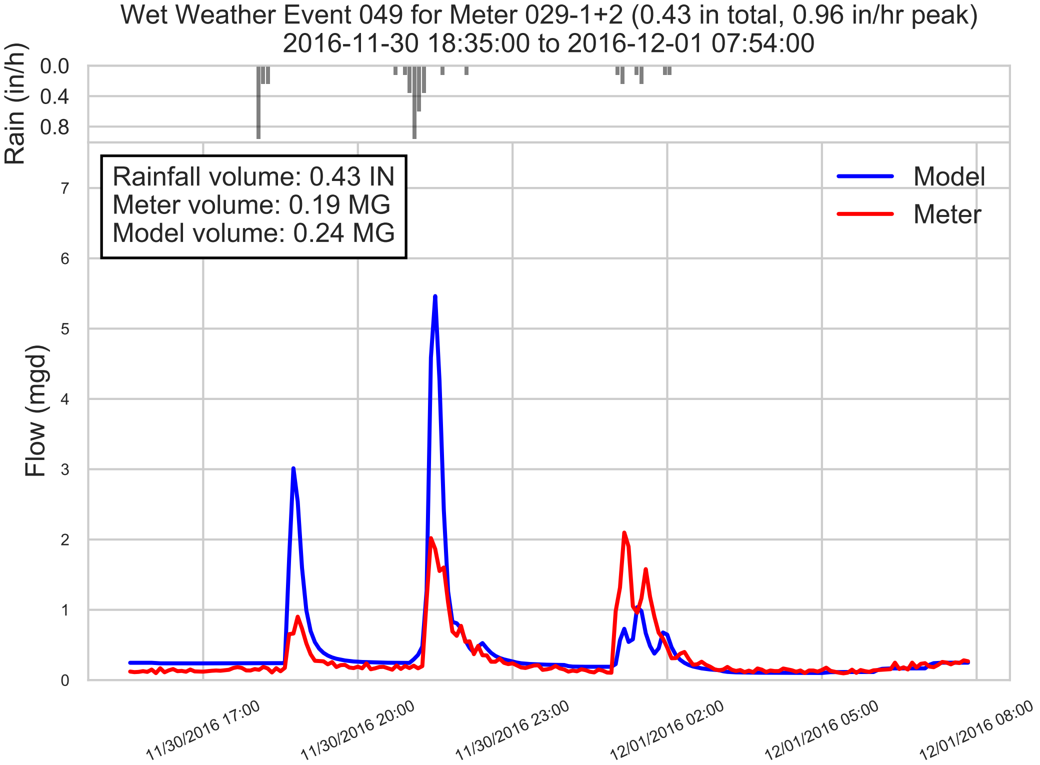
Wet Weather Event 046 for Meter 029-1+2 (0.35 in total, 0.84 in/hr peak)
2016-10-21 14:05:00 to 2016-10-21 20:55:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.35 IN
Meter volume: 0.08 MG
Model volume: 0.15 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
10/21/2016 11:00
10/21/2016 14:00
10/21/2016 17:00
10/21/2016 20:00



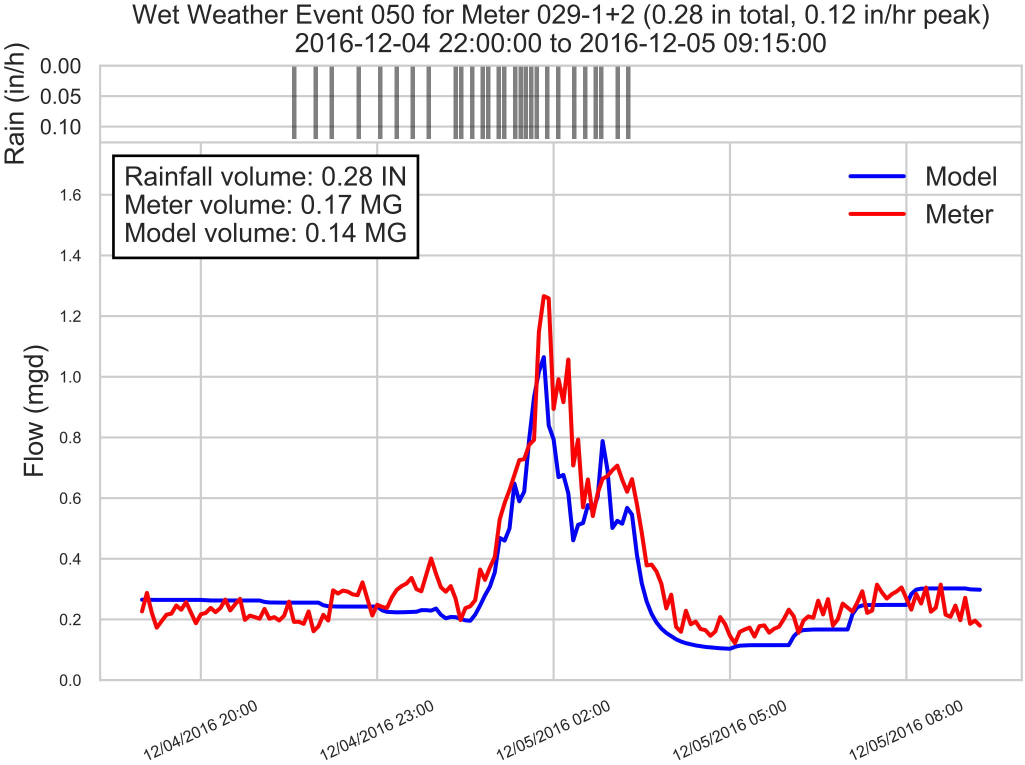
Wet Weather Event 047 for Meter 029-1+2 (0.13 in total, 0.12 in/hr peak)
2016-11-09 05:19:00 to 2016-11-09 14:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.13 IN
Meter volume: 0.1 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/09/2016 02:00
11/09/2016 05:00
11/09/2016 08:00
11/09/2016 11:00
11/09/2016 14:00



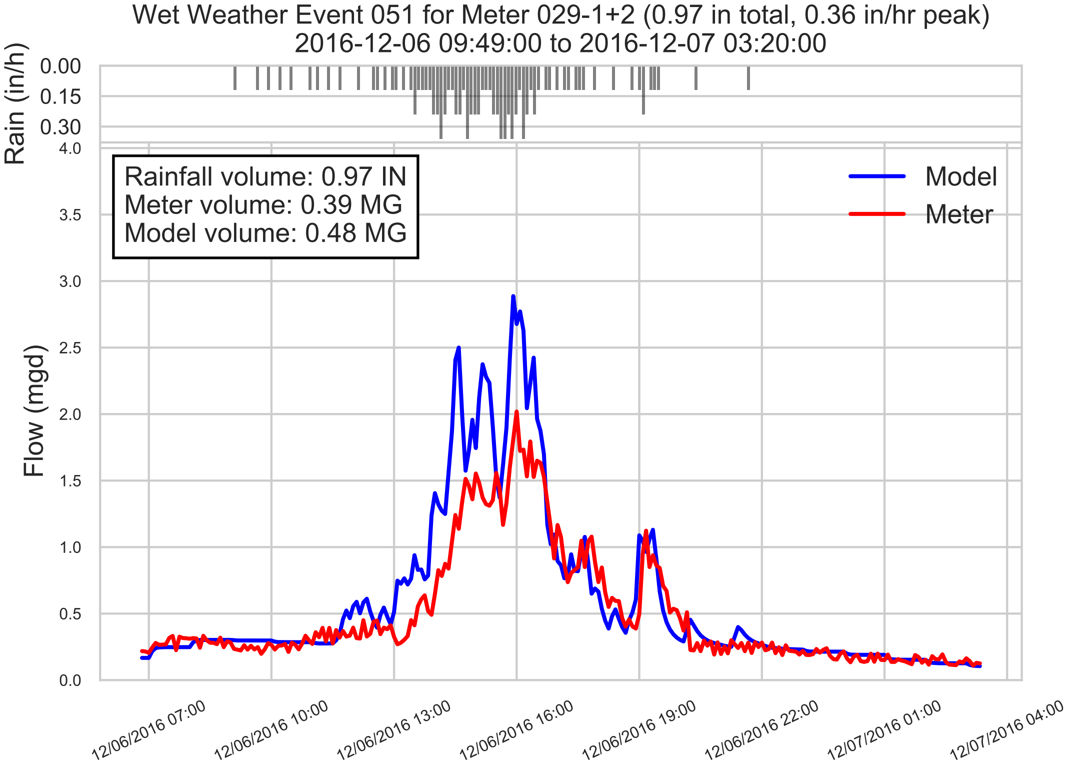
Wet Weather Event 048 for Meter 029-1+2 (0.27 in total, 0.6 in/hr peak)
2016-11-30 08:24:00 to 2016-11-30 16:45:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.27 IN
Meter volume: 0.13 MG
Model volume: 0.16 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
11/30/2016 07:00
11/30/2016 10:00
11/30/2016 13:00
11/30/2016 16:00



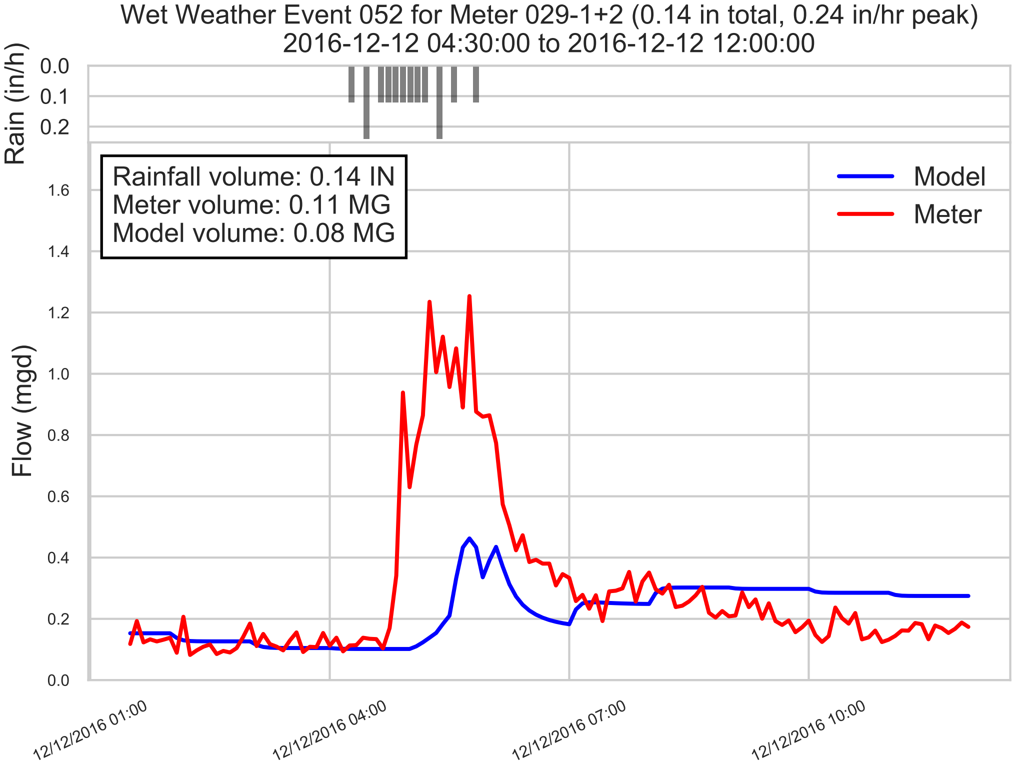
Wet Weather Event 049 for Meter 029-1+2 (0.43 in total, 0.96 in/hr peak)
2016-11-30 18:35:00 to 2016-12-01 07:54:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.43 IN
Meter volume: 0.19 MG
Model volume: 0.24 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
11/30/2016 17:00
11/30/2016 20:00
11/30/2016 23:00
12/01/2016 02:00
12/01/2016 05:00
12/01/2016 08:00

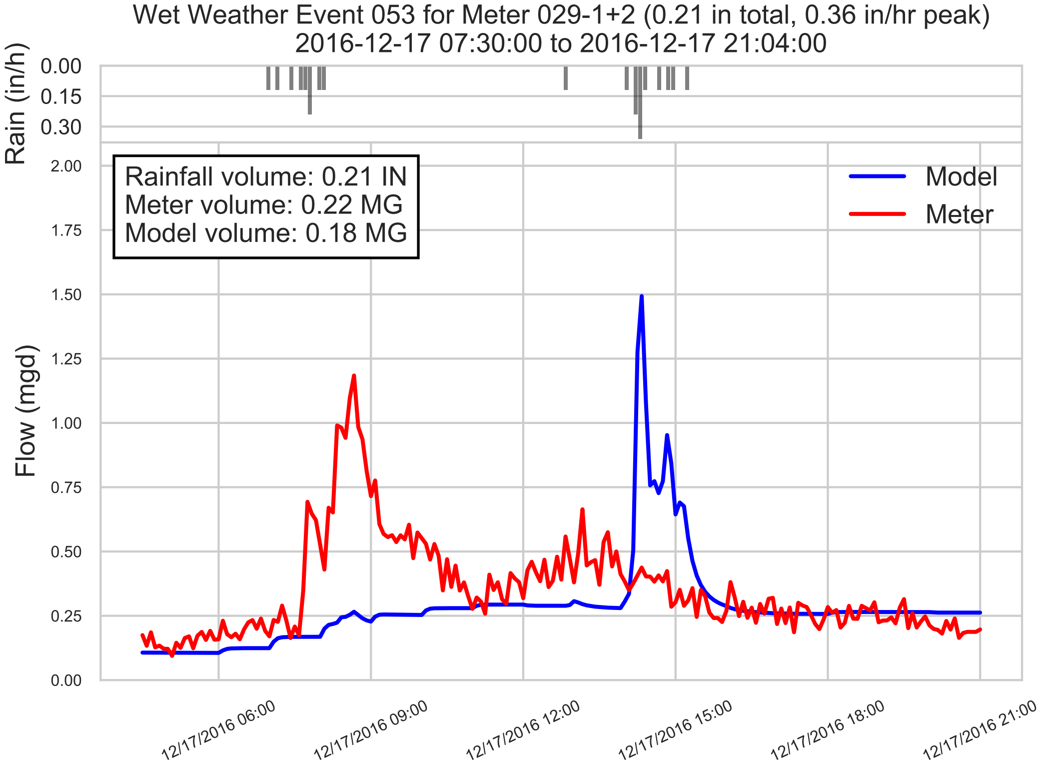


Wet Weather Event 050 for Meter 029-1+2 (0.28 in total, 0.12 in/hr peak)
2016-12-04 22:00:00 to 2016-12-05 09:15:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.17 MG
Model volume: 0.14 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
12/04/2016 20:00
12/04/2016 23:00
12/05/2016 02:00
12/05/2016 05:00
12/05/2016 08:00

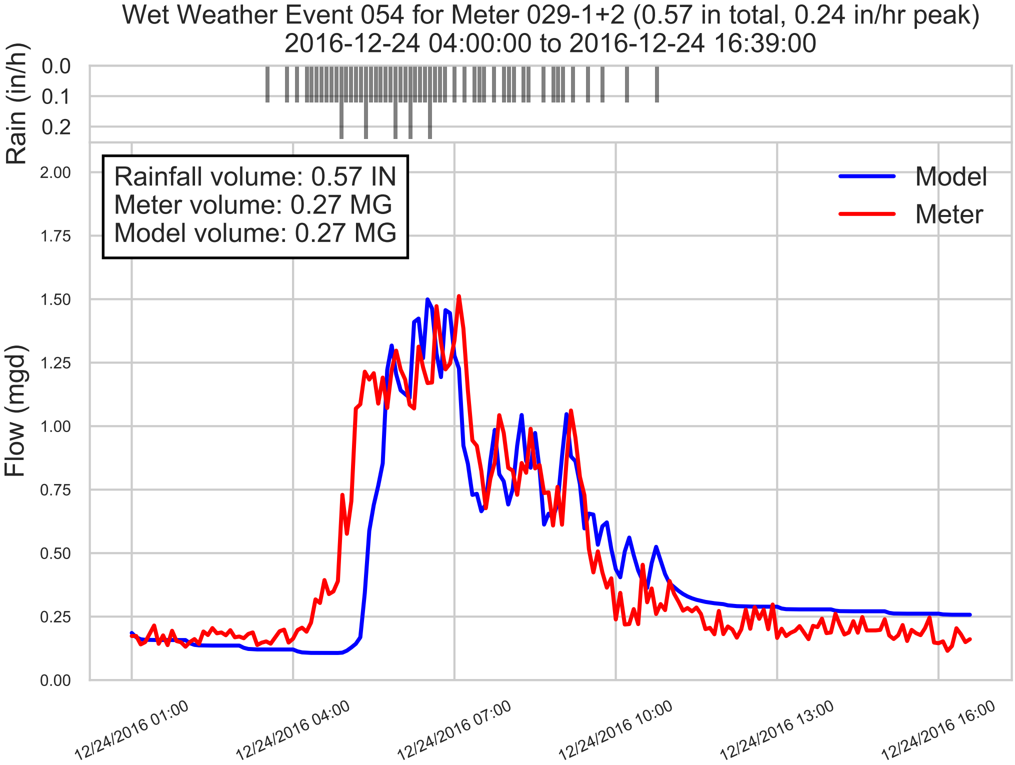


Wet Weather Event 051 for Meter 029-1+2 (0.97 in total, 0.36 in/hr peak)
2016-12-06 09:49:00 to 2016-12-07 03:20:00
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall volume: 0.97 IN
Meter volume: 0.39 MG
Model volume: 0.48 MG
Model
Meter
12/06/2016 07:00
12/06/2016 10:00
12/06/2016 13:00
12/06/2016 16:00
12/06/2016 19:00
12/06/2016 22:00
12/07/2016 01:00
12/07/2016 04:00

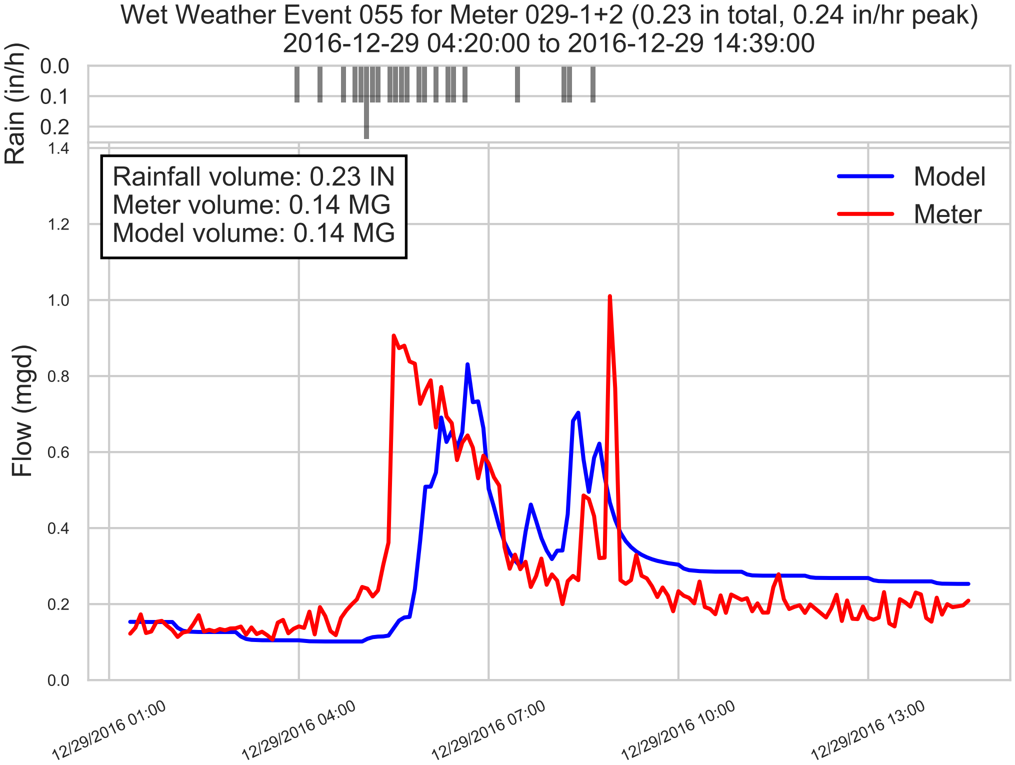

Wet Weather Event 052 for Meter 029-1+2 (0.14 in total, 0.24 in/hr peak)
2016-12-12 04:30:00 to 2016-12-12 12:00:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.14 IN
Meter volume: 0.11 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/12/2016 01:00
12/12/2016 04:00
12/12/2016 07:00
12/12/2016 10:00



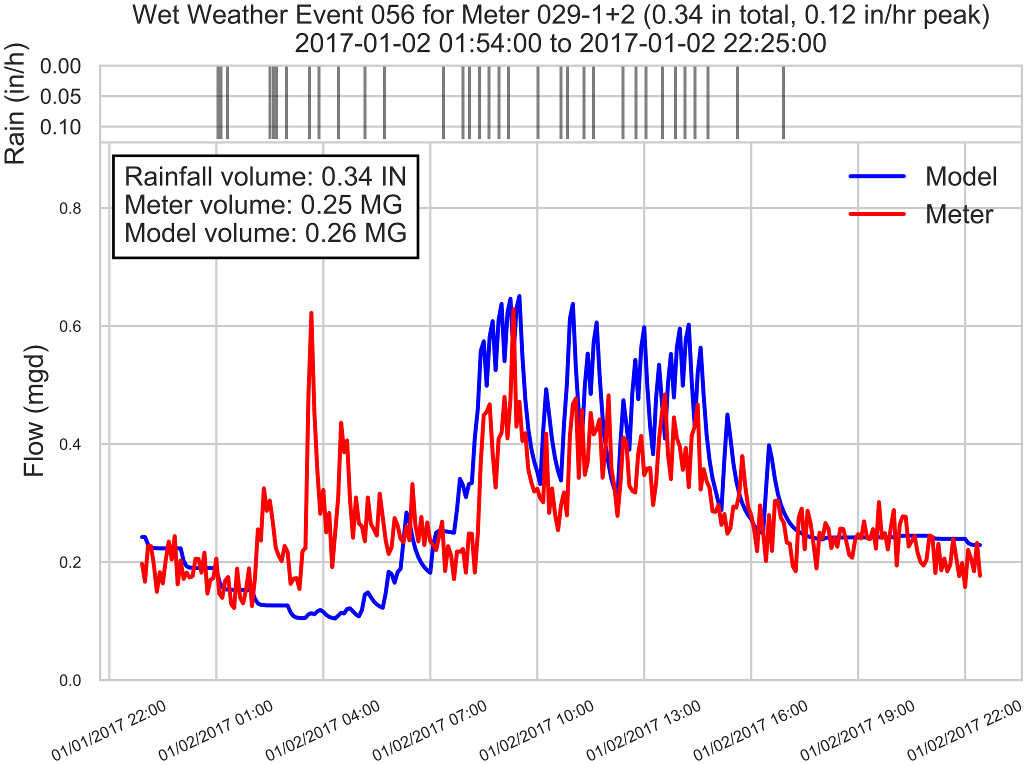
Wet Weather Event 053 for Meter 029-1+2 (0.21 in total, 0.36 in/hr peak)
2016-12-17 07:30:00 to 2016-12-17 21:04:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.21 IN
Meter volume: 0.22 MG
Model volume: 0.18 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/17/2016 06:00
12/17/2016 09:00
12/17/2016 12:00
12/17/2016 15:00
12/17/2016 18:00
12/17/2016 21:00



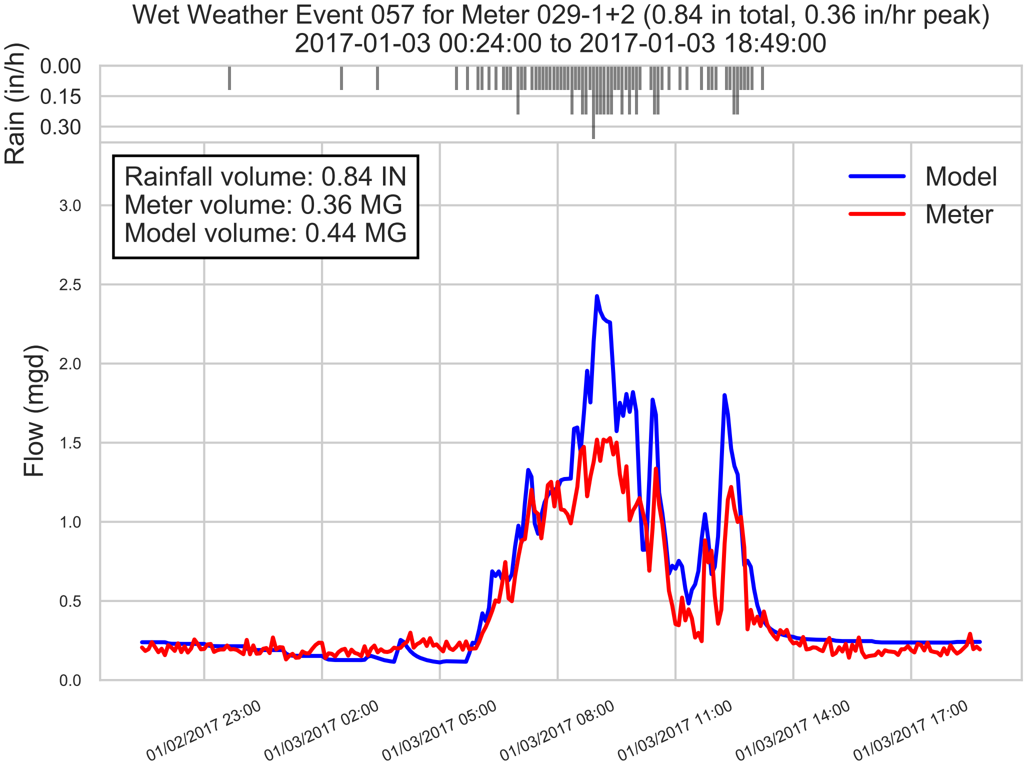
Wet Weather Event 054 for Meter 029-1+2 (0.57 in total, 0.24 in/hr peak)
2016-12-24 04:00:00 to 2016-12-24 16:39:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.57 IN
Meter volume: 0.27 MG
Model volume: 0.27 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/24/2016 01:00
12/24/2016 04:00
12/24/2016 07:00
12/24/2016 10:00
12/24/2016 13:00
12/24/2016 16:00



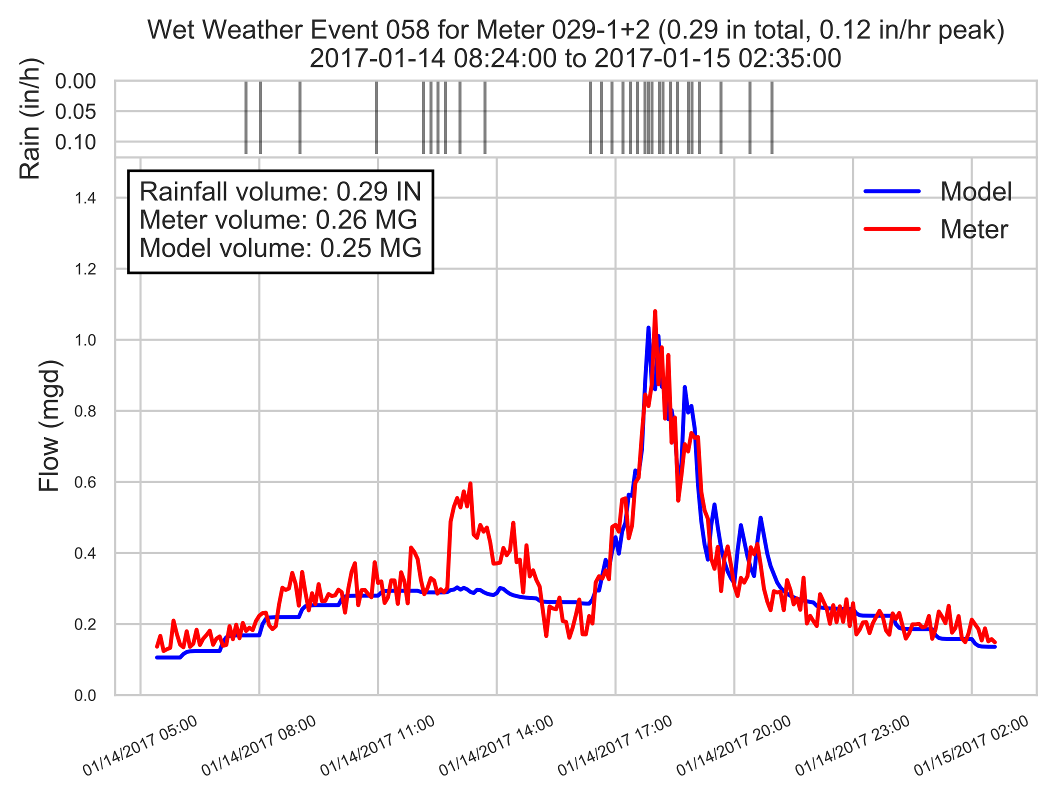
Wet Weather Event 055 for Meter 029-1+2 (0.23 in total, 0.24 in/hr peak)
2016-12-29 04:20:00 to 2016-12-29 14:39:00
Rain (in/h)
0.0
0.1
0.2
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Flow (mgd)
Rainfall volume: 0.23 IN
Meter volume: 0.14 MG
Model volume: 0.14 MG
Model
Meter
12/29/2016 01:00
12/29/2016 04:00
12/29/2016 07:00
12/29/2016 10:00
12/29/2016 13:00



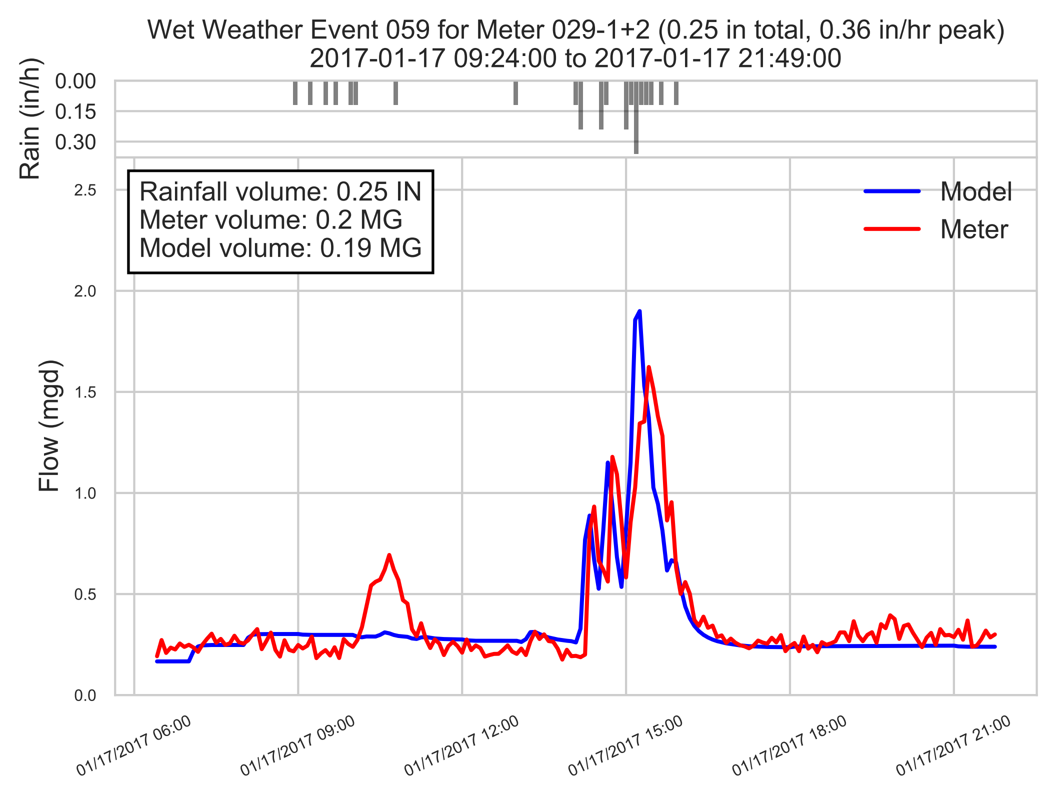
Wet Weather Event 056 for Meter 029-1+2 (0.34 in total, 0.12 in/hr peak)
2017-01-02 01:54:00 to 2017-01-02 22:25:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
Rainfall volume: 0.34 IN
Meter volume: 0.25 MG
Model volume: 0.26 MG
Model
Meter
01/01/2017 22:00
01/02/2017 01:00
01/02/2017 04:00
01/02/2017 07:00
01/02/2017 10:00
01/02/2017 13:00
01/02/2017 16:00
01/02/2017 19:00
01/02/2017 22:00



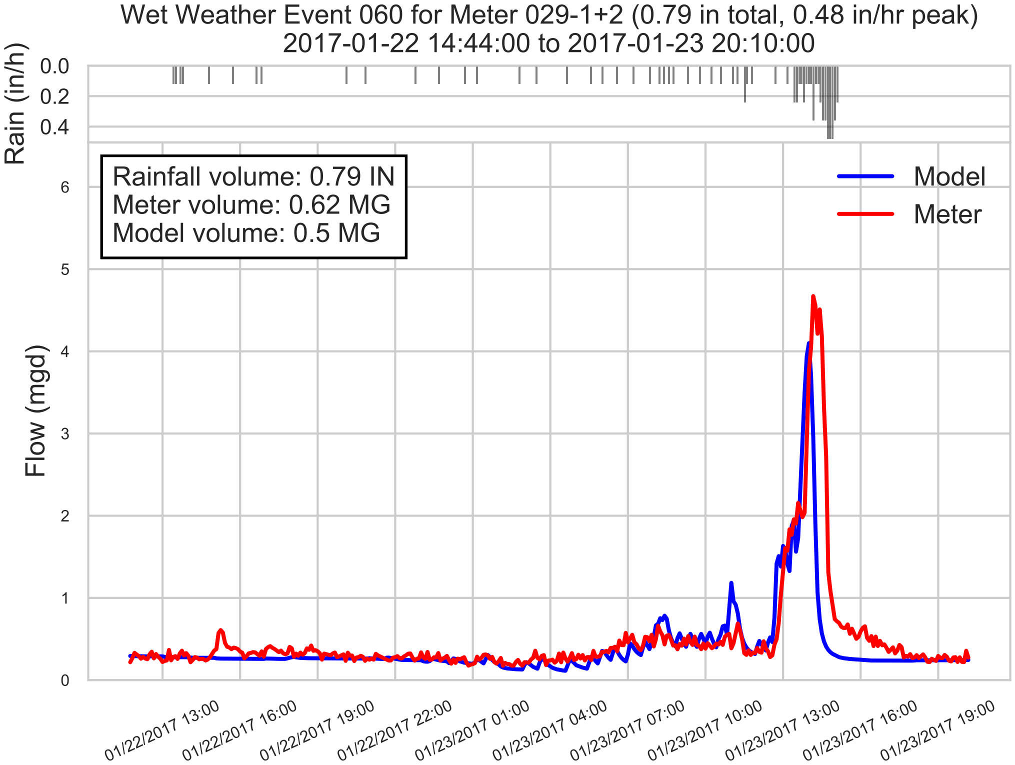
Wet Weather Event 057 for Meter 029-1+2 (0.84 in total, 0.36 in/hr peak)
2017-01-03 00:24:00 to 2017-01-03 18:49:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.84 IN
Meter volume: 0.36 MG
Model volume: 0.44 MG
Model
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
01/02/2017 23:00
01/03/2017 02:00
01/03/2017 05:00
01/03/2017 08:00
01/03/2017 11:00
01/03/2017 14:00
01/03/2017 17:00



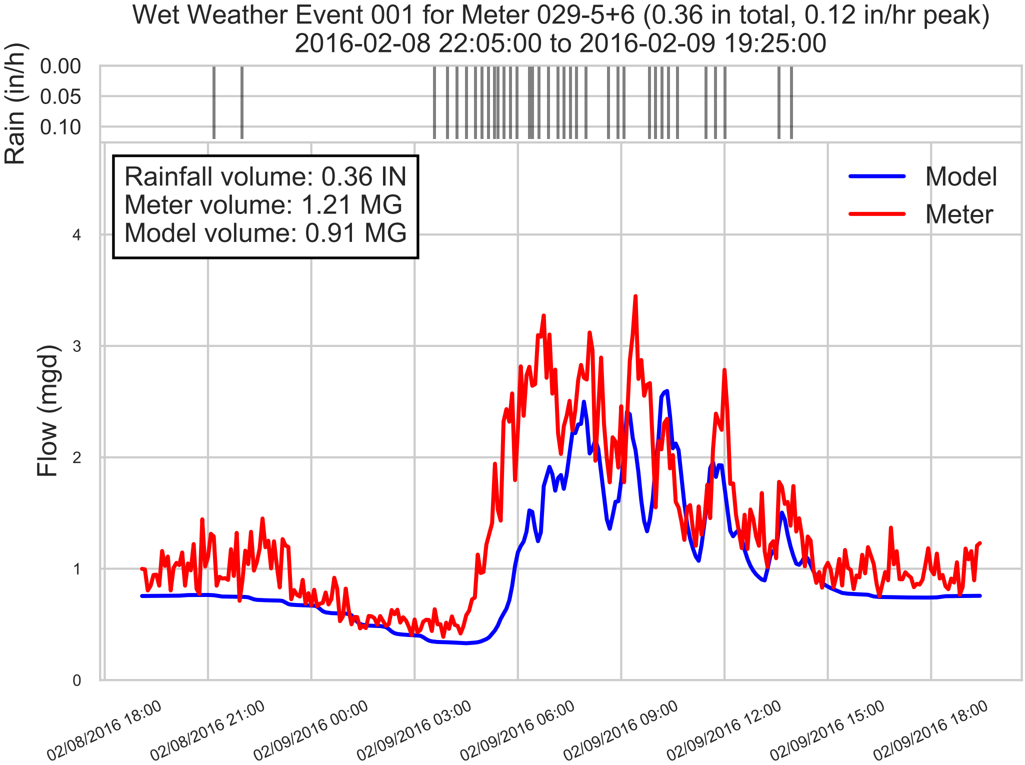
Wet Weather Event 058 for Meter 029-1+2 (0.29 in total, 0.12 in/hr peak)
2017-01-14 08:24:00 to 2017-01-15 02:35:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.29 IN
Meter volume: 0.26 MG
Model volume: 0.25 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
01/14/2017 05:00
01/14/2017 08:00
01/14/2017 11:00
01/14/2017 14:00
01/14/2017 17:00
01/14/2017 20:00
01/14/2017 23:00
01/15/2017 02:00

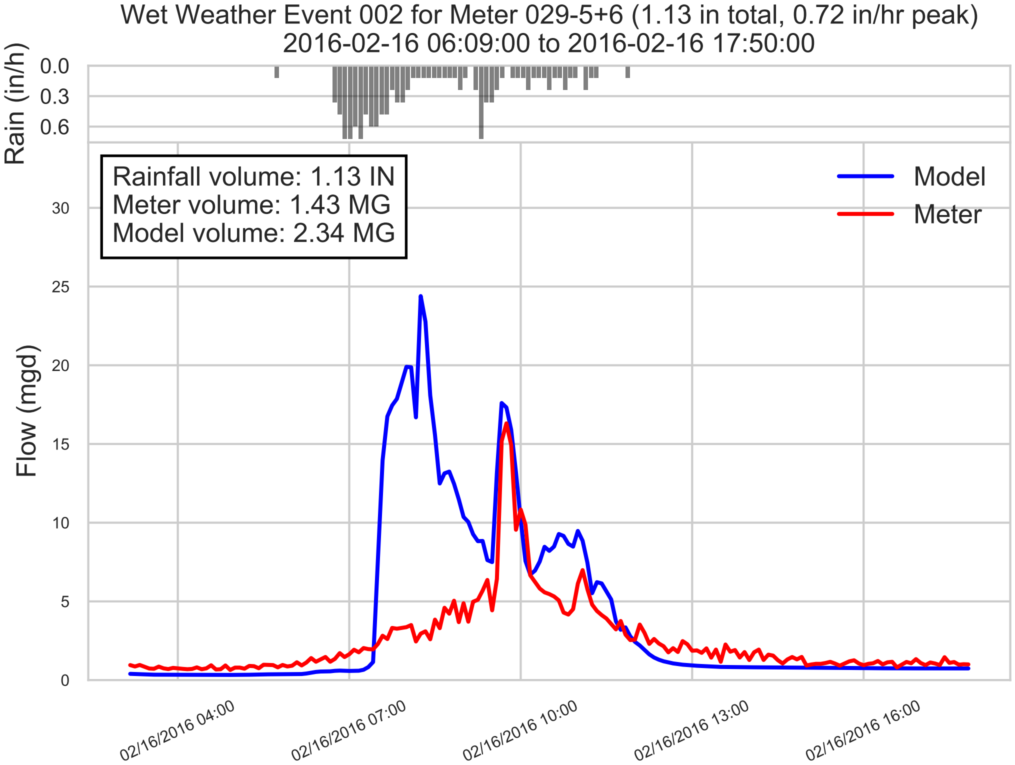


Wet Weather Event 059 for Meter 029-1+2 (0.25 in total, 0.36 in/hr peak)
2017-01-17 09:24:00 to 2017-01-17 21:49:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.25 IN
Meter volume: 0.2 MG
Model volume: 0.19 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
01/17/2017 06:00
01/17/2017 09:00
01/17/2017 12:00
01/17/2017 15:00
01/17/2017 18:00
01/17/2017 21:00

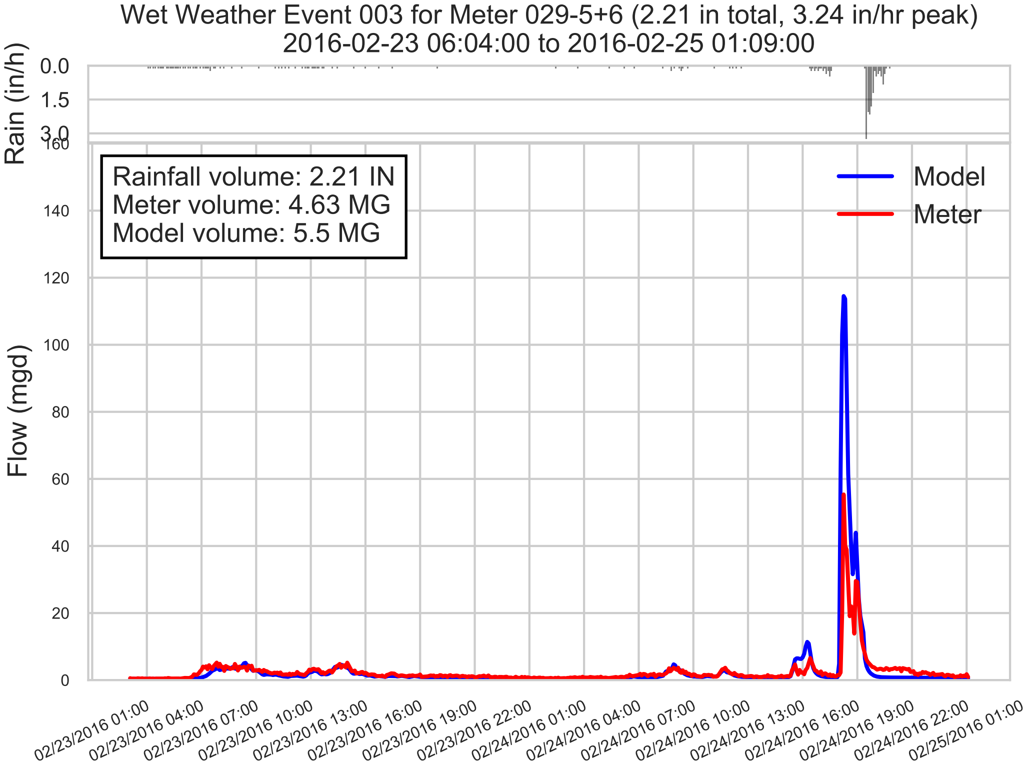


Wet Weather Event 060 for Meter 029-1+2 (0.79 in total, 0.48 in/hr peak)
2017-01-22 14:44:00 to 2017-01-23 20:10:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.79 IN
Meter volume: 0.62 MG
Model volume: 0.5 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
01/22/2017 13:00
01/22/2017 16:00
01/22/2017 19:00
01/22/2017 22:00
01/23/2017 01:00
01/23/2017 04:00
01/23/2017 07:00
01/23/2017 10:00
01/23/2017 13:00
01/23/2017 16:00
01/23/2017 19:00

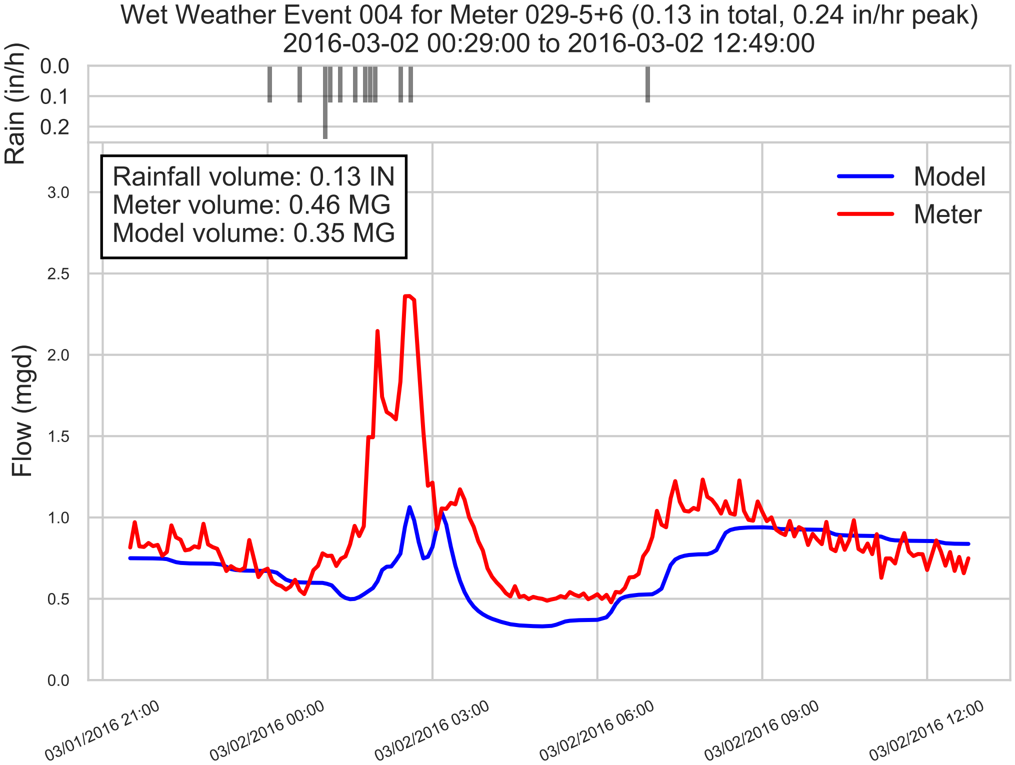

Wet Weather Event 001 for Meter 029-5+6 (0.36 in total, 0.12 in/hr peak)
2016-02-08 22:05:00 to 2016-02-09 19:25:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.36 IN
Meter volume: 1.21 MG
Model volume: 0.91 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
02/08/2016 18:00
02/08/2016 21:00
02/09/2016 00:00
02/09/2016 03:00
02/09/2016 06:00
02/09/2016 09:00
02/09/2016 12:00
02/09/2016 15:00
02/09/2016 18:00



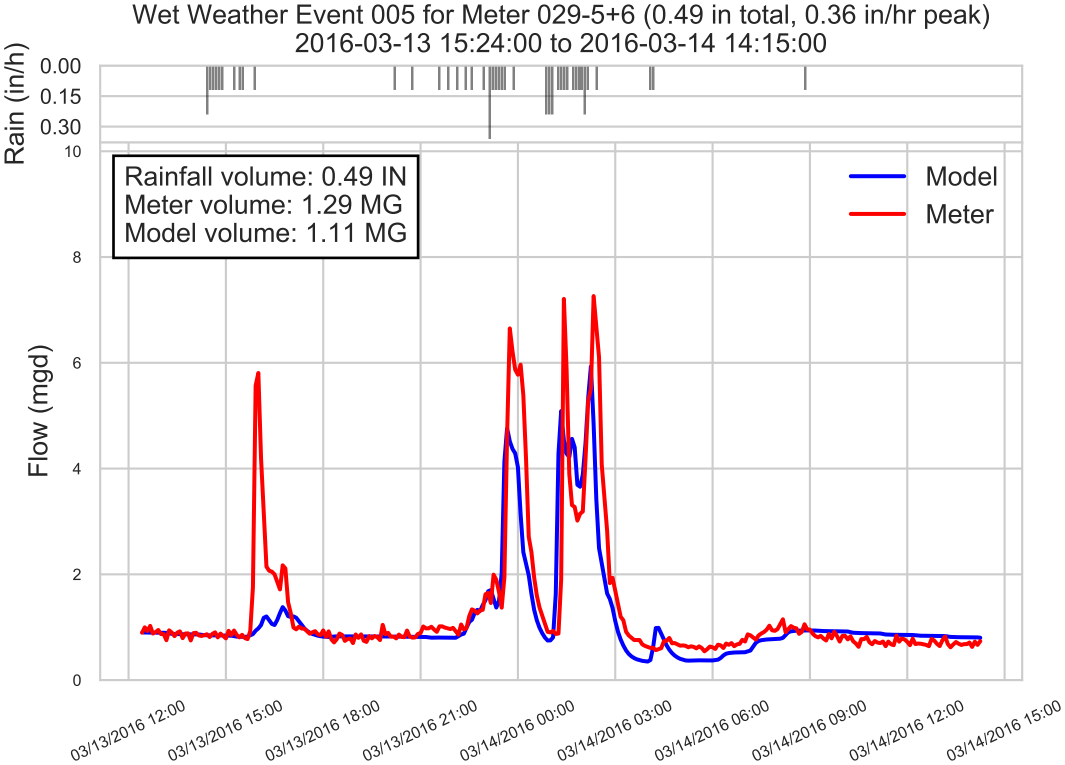
Wet Weather Event 002 for Meter 029-5+6 (1.13 in total, 0.72 in/hr peak)
2016-02-16 06:09:00 to 2016-02-16 17:50:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 1.13 IN
Meter volume: 1.43 MG
Model volume: 2.34 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
02/16/2016 04:00
02/16/2016 07:00
02/16/2016 10:00
02/16/2016 13:00
02/16/2016 16:00



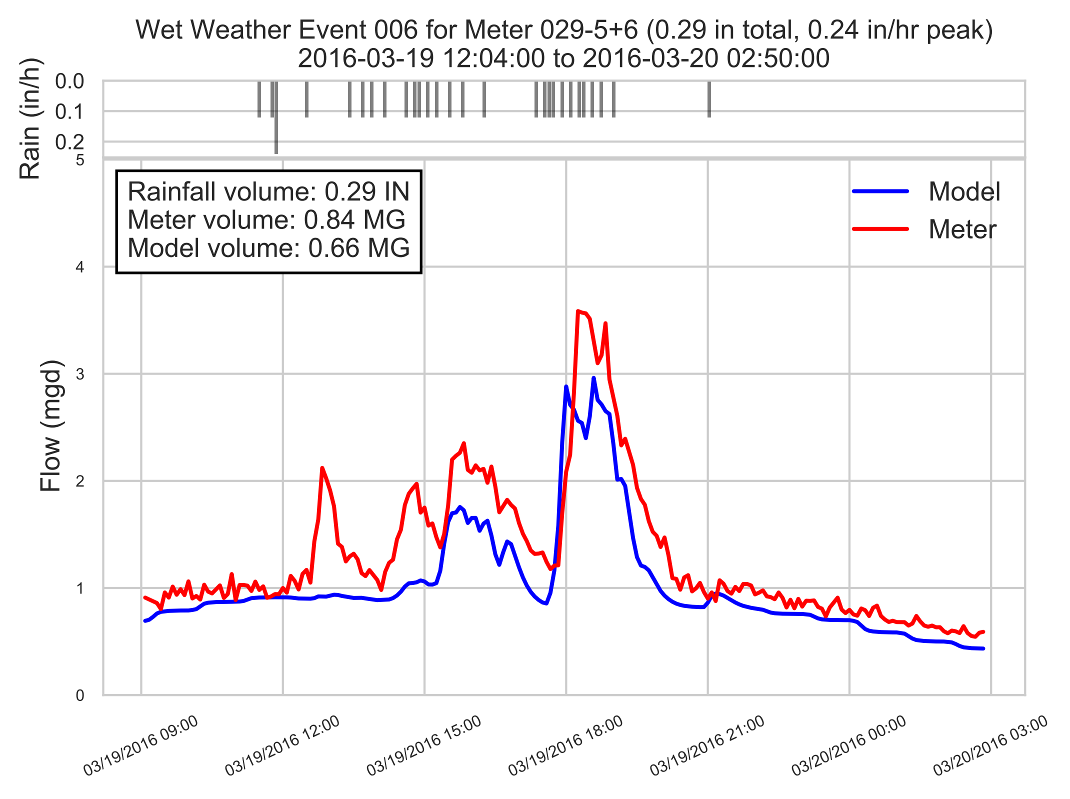
Wet Weather Event 003 for Meter 029-5+6 (2.21 in total, 3.24 in/hr peak)
2016-02-23 06:04:00 to 2016-02-25 01:09:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 2.21 IN
Meter volume: 4.63 MG
Model volume: 5.5 MG
Model
Meter
Flow (mgd)
160
140
120
100
80
60
40
20
0
02/23/2016 01:00
02/23/2016 04:00
02/23/2016 07:00
02/23/2016 10:00
02/23/2016 13:00
02/23/2016 16:00
02/23/2016 19:00
02/23/2016 22:00
02/24/2016 01:00
02/24/2016 04:00
02/24/2016 07:00
02/24/2016 10:00
02/24/2016 13:00
02/24/2016 16:00
02/24/2016 19:00
02/24/2016 22:00
02/25/2016 01:00



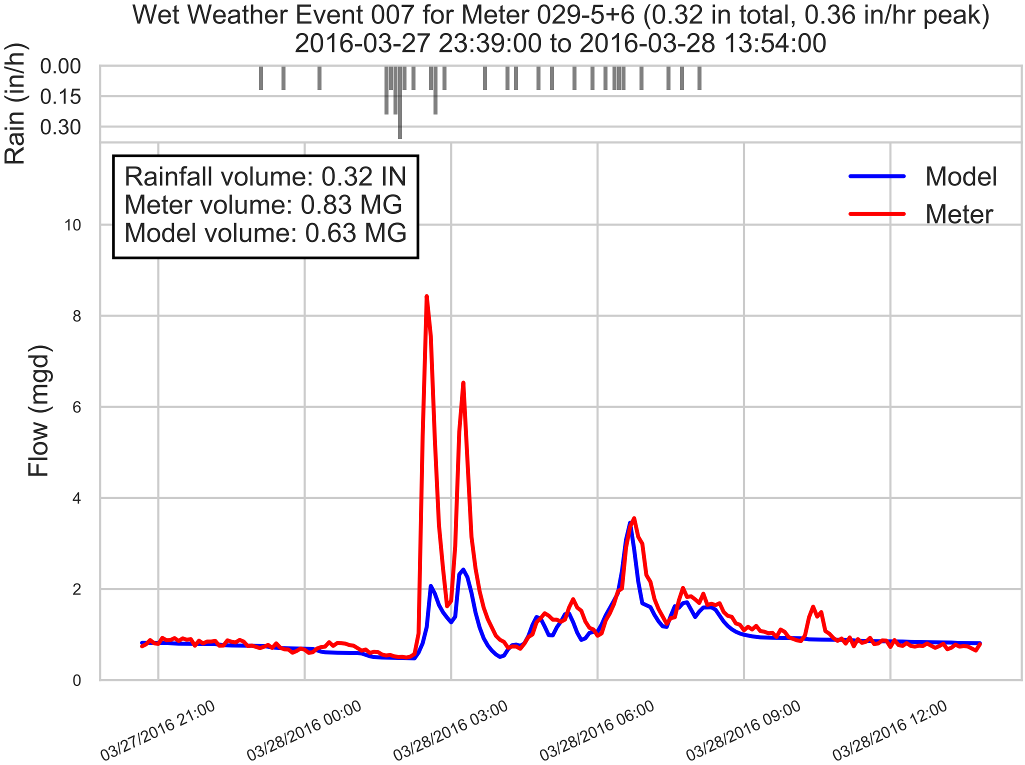
Wet Weather Event 004 for Meter 029-5+6 (0.13 in total, 0.24 in/hr peak)
2016-03-02 00:29:00 to 2016-03-02 12:49:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.13 IN
Meter volume: 0.46 MG
Model volume: 0.35 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
03/01/2016 21:00
03/02/2016 00:00
03/02/2016 03:00
03/02/2016 06:00
03/02/2016 09:00
03/02/2016 12:00



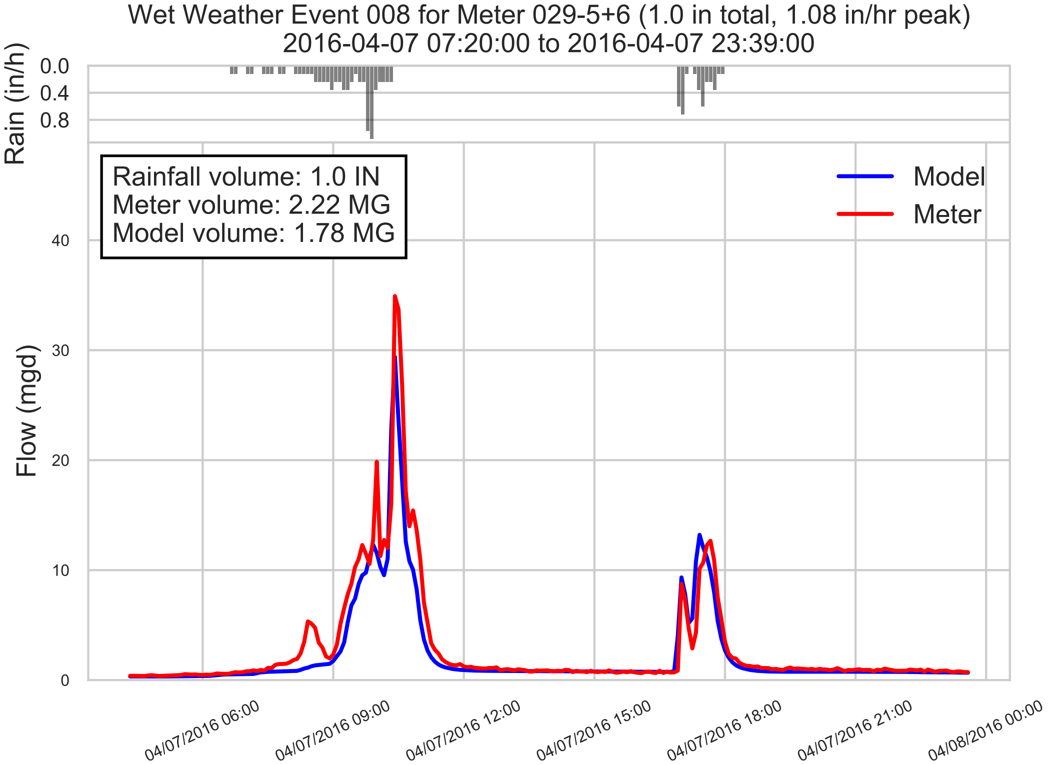
Wet Weather Event 005 for Meter 029-5+6 (0.49 in total, 0.36 in/hr peak)
2016-03-13 15:24:00 to 2016-03-14 14:15:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.49 IN
Meter volume: 1.29 MG
Model volume: 1.11 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
03/13/2016 12:00
03/13/2016 15:00
03/13/2016 18:00
03/13/2016 21:00
03/14/2016 00:00
03/14/2016 03:00
03/14/2016 06:00
03/14/2016 09:00
03/14/2016 12:00
03/14/2016 15:00



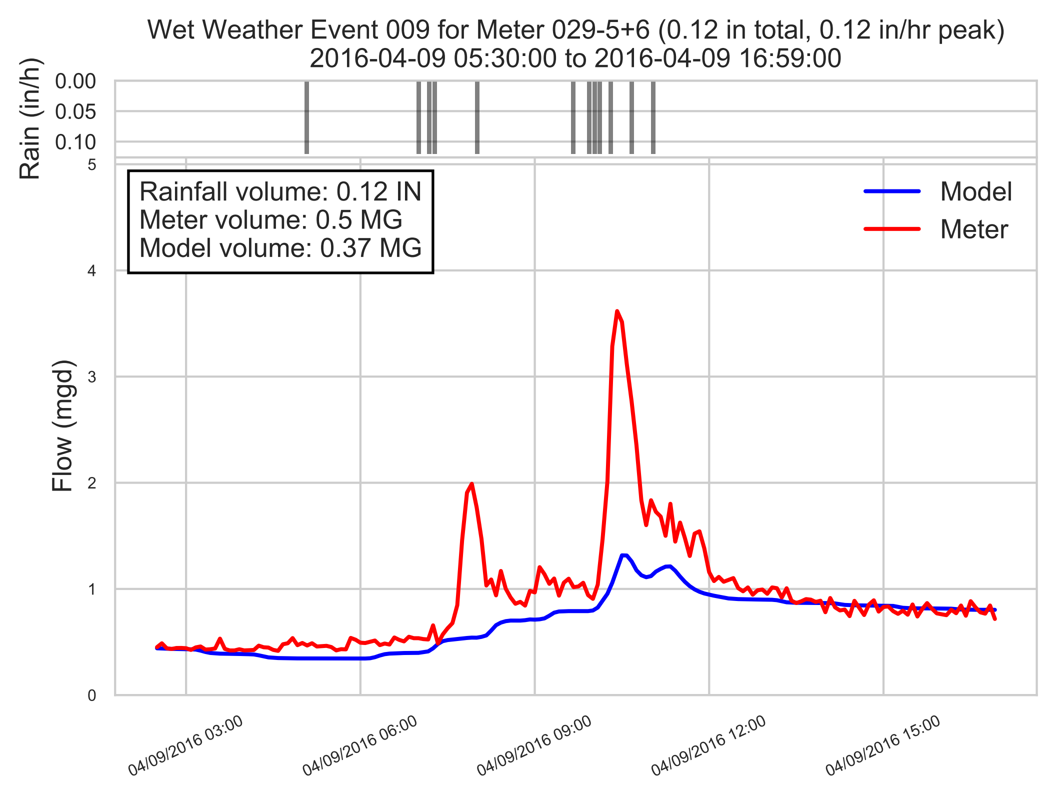
Wet Weather Event 006 for Meter 029-5+6 (0.29 in total, 0.24 in/hr peak)
2016-03-19 12:04:00 to 2016-03-20 02:50:00
Rain (in/h)
0.0
0.1
0.2
5
4
3
2
1
0
Flow (mgd)
Rainfall volume: 0.29 IN
Meter volume: 0.84 MG
Model volume: 0.66 MG
Model
Meter
03/19/2016 09:00
03/19/2016 12:00
03/19/2016 15:00
03/19/2016 18:00
03/19/2016 21:00
03/20/2016 00:00
03/20/2016 03:00



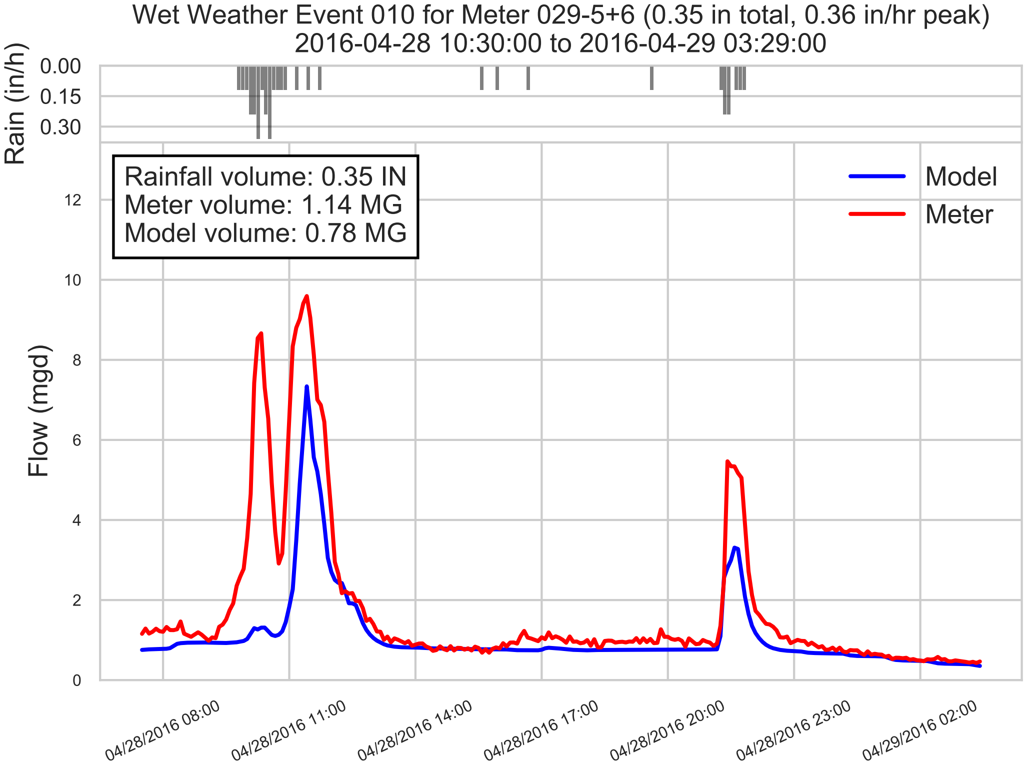
Wet Weather Event 007 for Meter 029-5+6 (0.32 in total, 0.36 in/hr peak)
2016-03-27 23:39:00 to 2016-03-28 13:54:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.32 IN
Meter volume: 0.83 MG
Model volume: 0.63 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
03/27/2016 21:00
03/28/2016 00:00
03/28/2016 03:00
03/28/2016 06:00
03/28/2016 09:00
03/28/2016 12:00



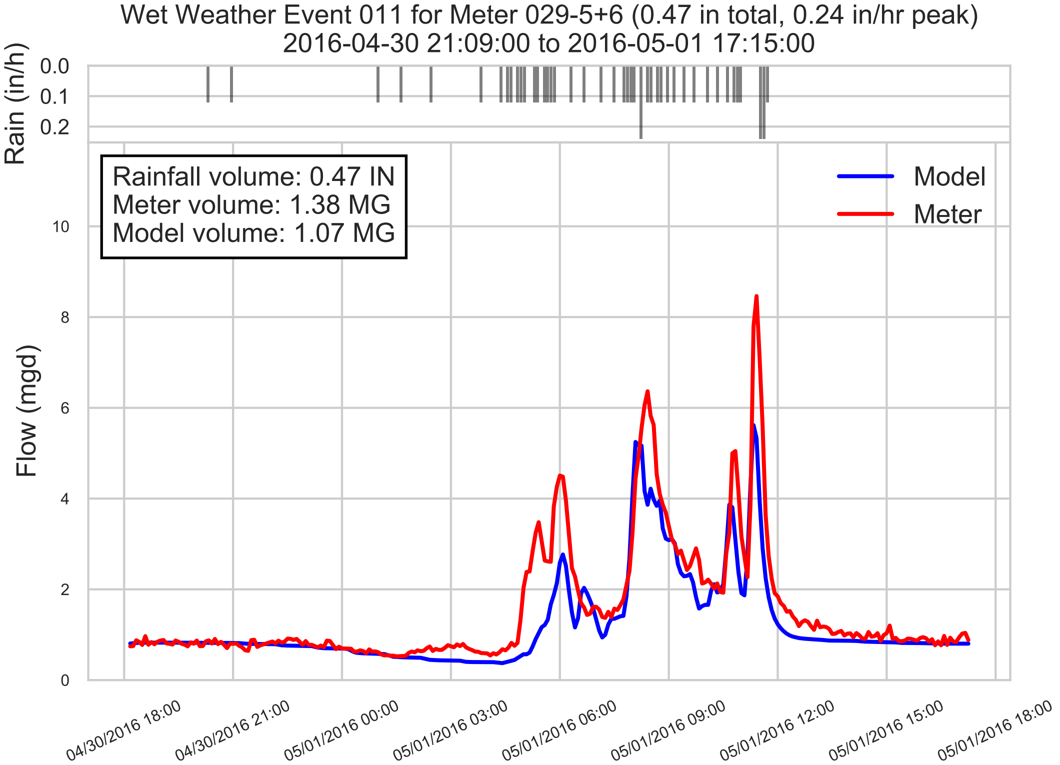
Wet Weather Event 008 for Meter 029-5+6 (1.0 in total, 1.08 in/hr peak)
2016-04-07 07:20:00 to 2016-04-07 23:39:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 1.0 IN
Meter volume: 2.22 MG
Model volume: 1.78 MG
Model
Meter
Flow (mgd)
40
30
20
10
0
04/07/2016 06:00
04/07/2016 09:00
04/07/2016 12:00
04/07/2016 15:00
04/07/2016 18:00
04/07/2016 21:00
04/08/2016 00:00



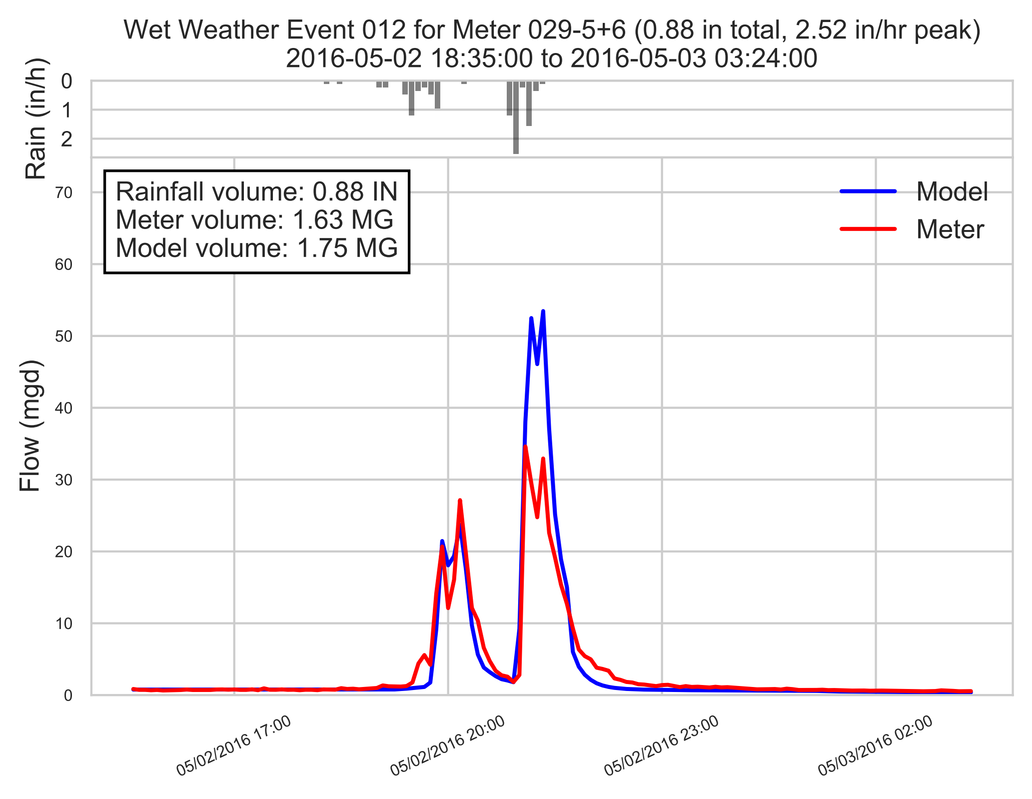
Wet Weather Event 009 for Meter 029-5+6 (0.12 in total, 0.12 in/hr peak)
2016-04-09 05:30:00 to 2016-04-09 16:59:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0
1
2
3
4
5
Rainfall volume: 0.12 IN
Meter volume: 0.5 MG
Model volume: 0.37 MG
Model
Meter
04/09/2016 03:00
04/09/2016 06:00
04/09/2016 09:00
04/09/2016 12:00
04/09/2016 15:00



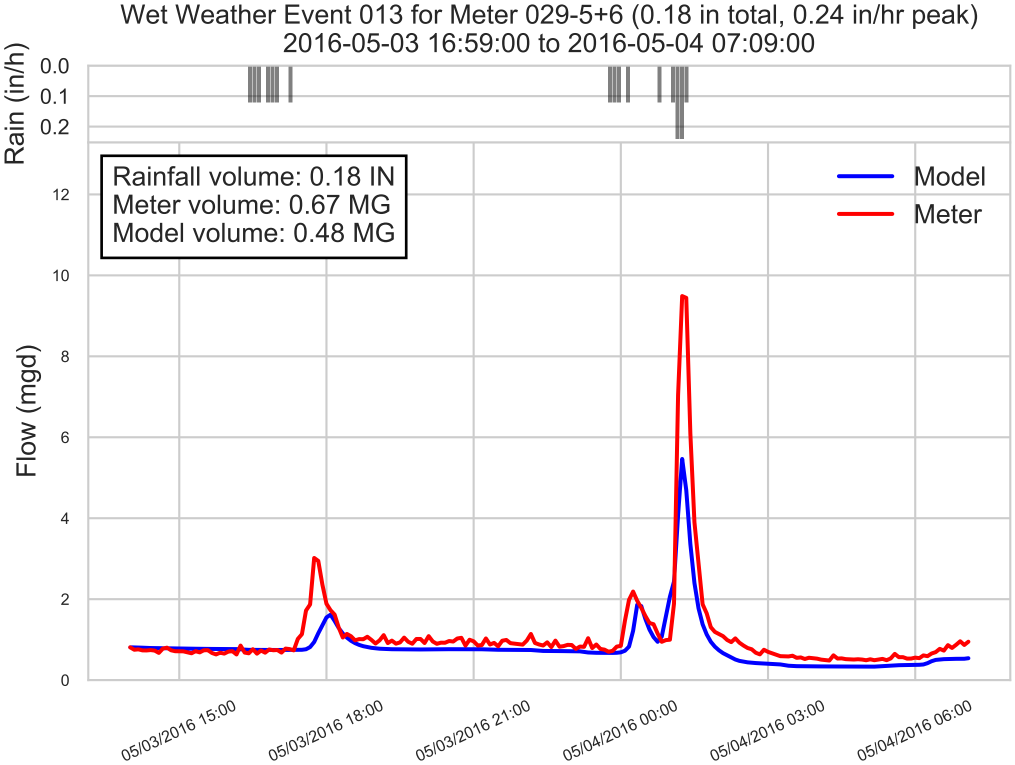
Wet Weather Event 010 for Meter 029-5+6 (0.35 in total, 0.36 in/hr peak)
2016-04-28 10:30:00 to 2016-04-29 03:29:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.35 IN
Meter volume: 1.14 MG
Model volume: 0.78 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
04/28/2016 08:00
04/28/2016 11:00
04/28/2016 14:00
04/28/2016 17:00
04/28/2016 20:00
04/28/2016 23:00
04/29/2016 02:00



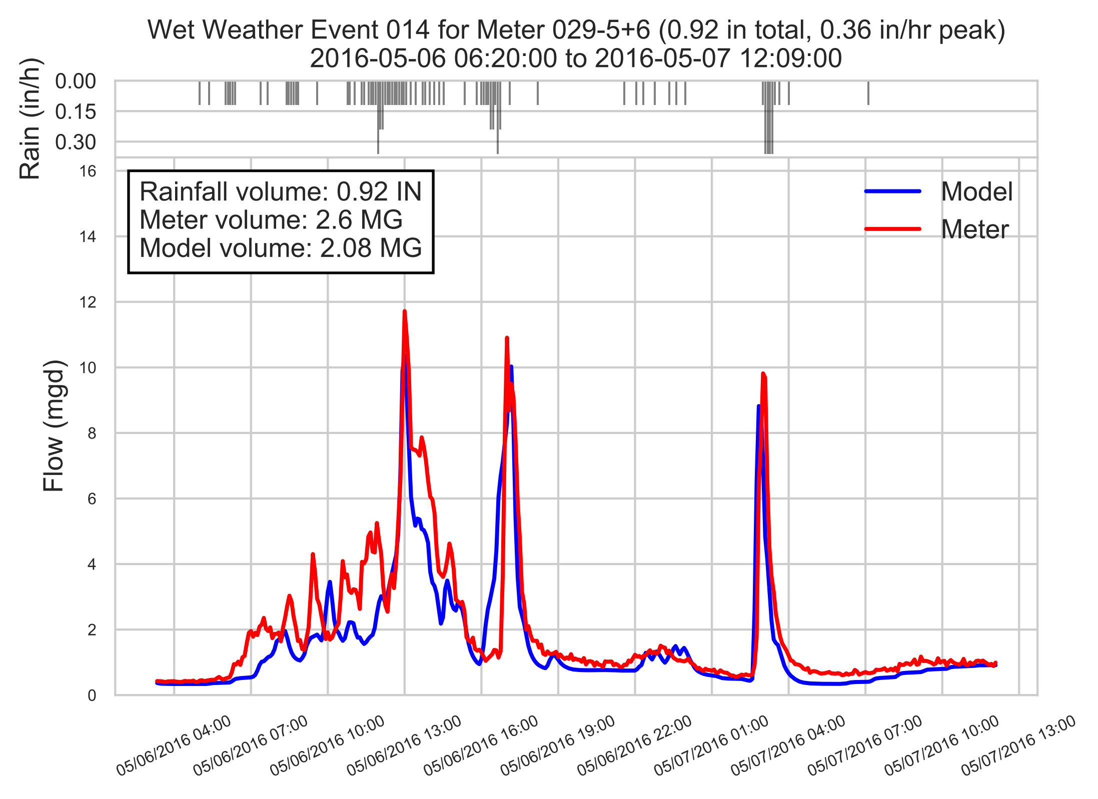
Wet Weather Event 011 for Meter 029-5+6 (0.47 in total, 0.24 in/hr peak)
2016-04-30 21:09:00 to 2016-05-01 17:15:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.47 IN
Meter volume: 1.38 MG
Model volume: 1.07 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
04/30/2016 18:00
04/30/2016 21:00
05/01/2016 00:00
05/01/2016 03:00
05/01/2016 06:00
05/01/2016 09:00
05/01/2016 12:00
05/01/2016 15:00
05/01/2016 18:00



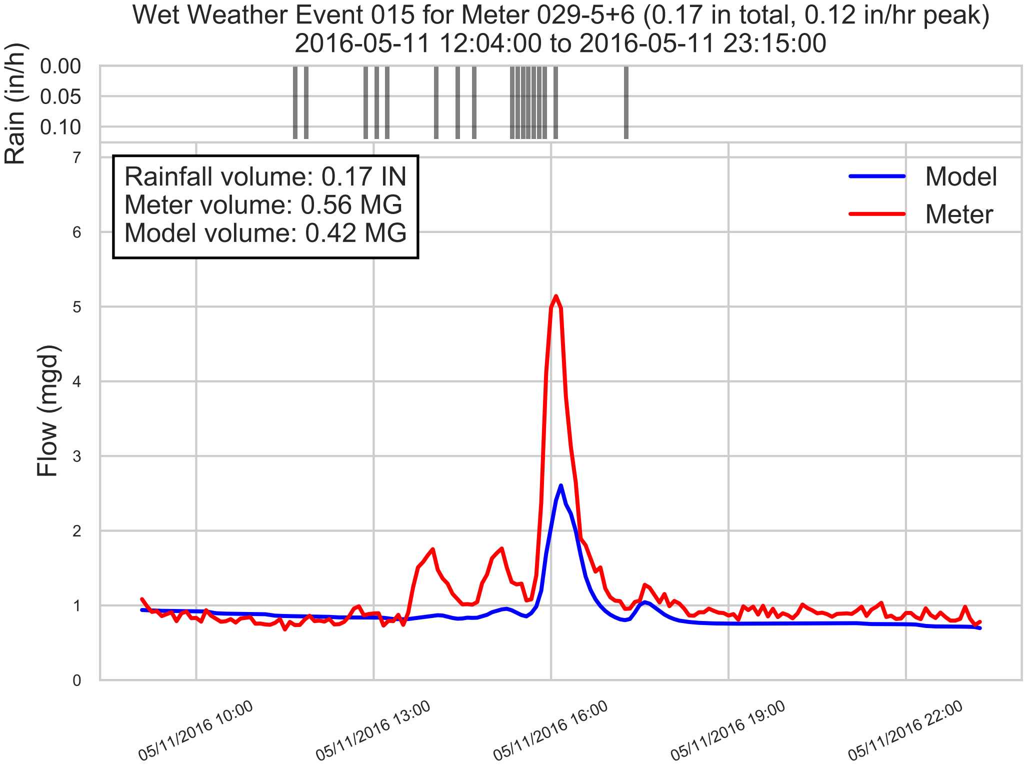
Wet Weather Event 012 for Meter 029-5+6 (0.88 in total, 2.52 in/hr peak)
2016-05-02 18:35:00 to 2016-05-03 03:24:00
Rain (in/h)
0
1
2
Rainfall volume: 0.88 IN
Meter volume: 1.63 MG
Model volume: 1.75 MG
Model
Meter
Flow (mgd)
0
10
20
30
40
50
60
70
05/02/2016 17:00
05/02/2016 20:00
05/02/2016 23:00
05/03/2016 02:00



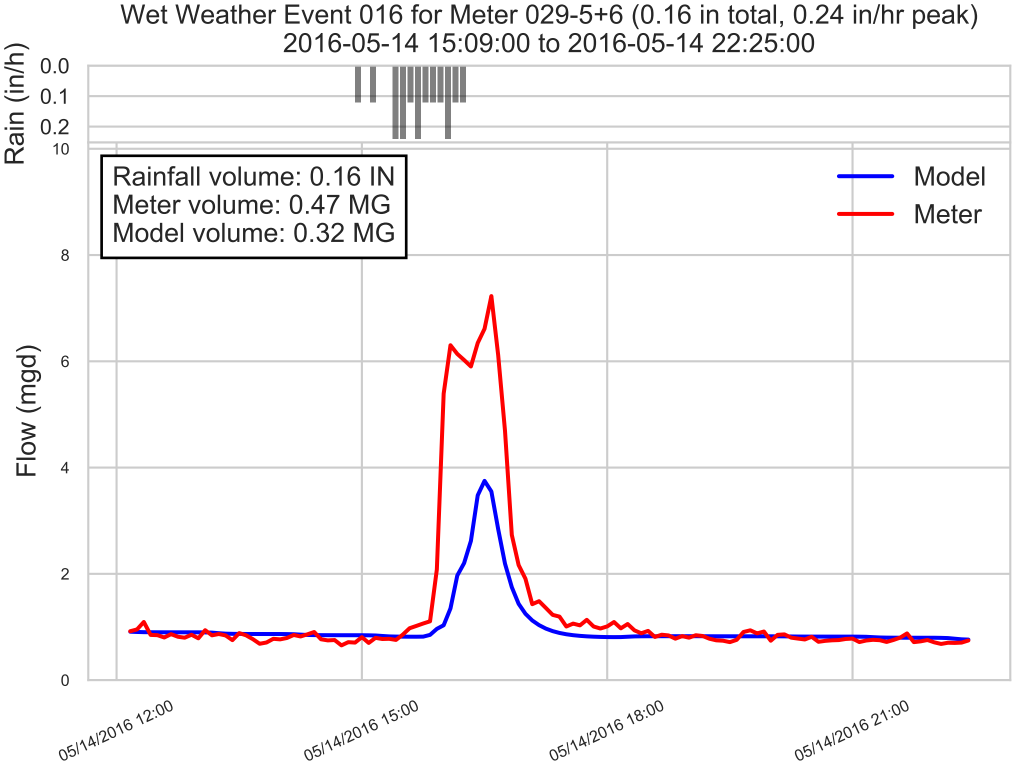
Wet Weather Event 013 for Meter 029-5+6 (0.18 in total, 0.24 in/hr peak)
2016-05-03 16:59:00 to 2016-05-04 07:09:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.18 IN
Meter volume: 0.67 MG
Model volume: 0.48 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
05/03/2016 15:00
05/03/2016 18:00
05/03/2016 21:00
05/04/2016 00:00
05/04/2016 03:00
05/04/2016 06:00



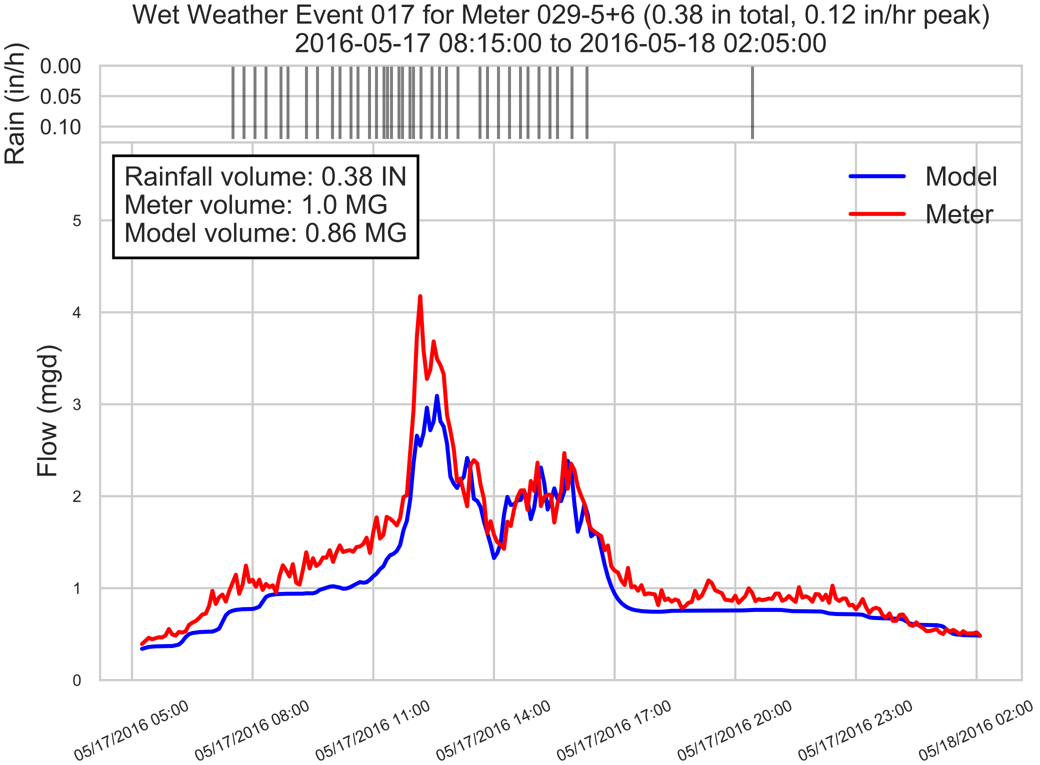
Wet Weather Event 014 for Meter 029-5+6 (0.92 in total, 0.36 in/hr peak)
2016-05-06 06:20:00 to 2016-05-07 12:09:00
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
16
14
12
10
8
6
4
2
0
Rainfall volume: 0.92 IN
Meter volume: 2.6 MG
Model volume: 2.08 MG
Model
Meter
05/06/2016 04:00
05/06/2016 07:00
05/06/2016 10:00
05/06/2016 13:00
05/06/2016 16:00
05/06/2016 19:00
05/06/2016 22:00
05/07/2016 01:00
05/07/2016 04:00
05/07/2016 07:00
05/07/2016 10:00
05/07/2016 13:00



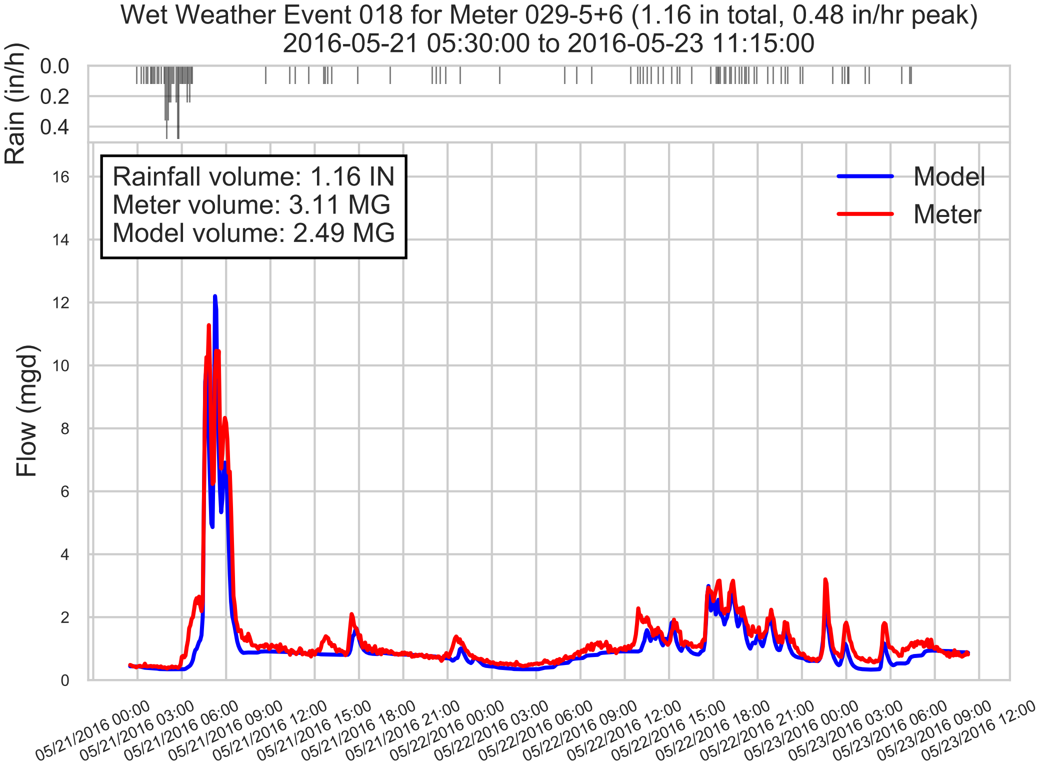
Wet Weather Event 015 for Meter 029-5+6 (0.17 in total, 0.12 in/hr peak)
2016-05-11 12:04:00 to 2016-05-11 23:15:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0
1
2
3
4
5
6
7
Rainfall volume: 0.17 IN
Meter volume: 0.56 MG
Model volume: 0.42 MG
Model
Meter
05/11/2016 10:00
05/11/2016 13:00
05/11/2016 16:00
05/11/2016 19:00
05/11/2016 22:00



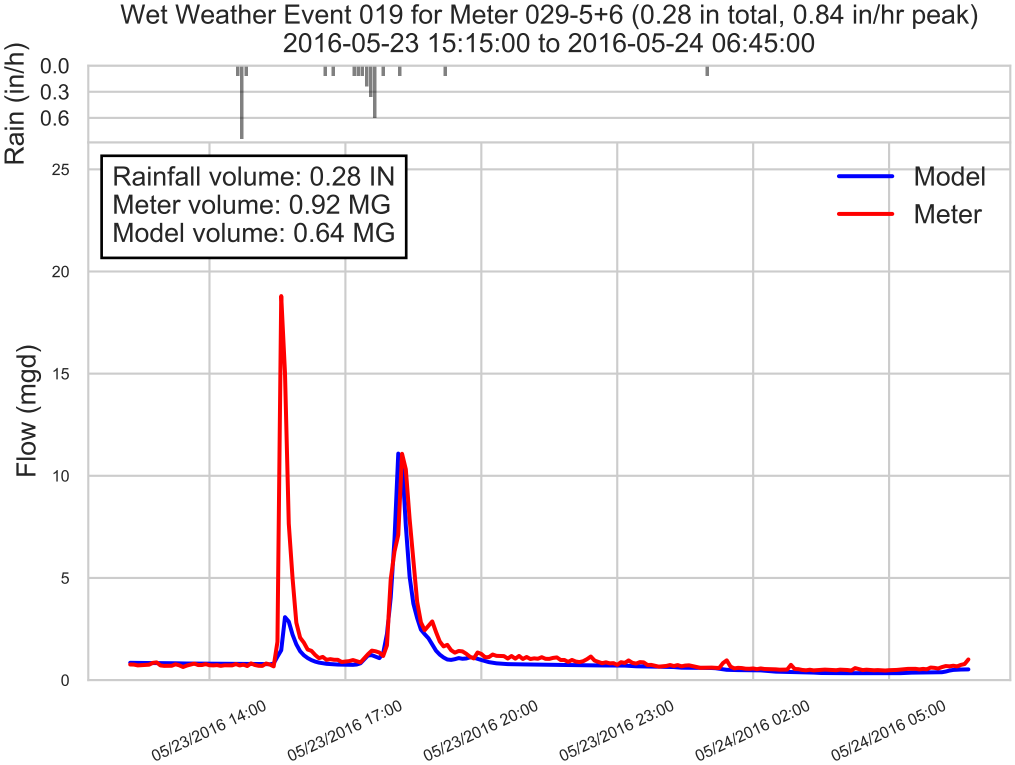
Wet Weather Event 016 for Meter 029-5+6 (0.16 in total, 0.24 in/hr peak)
2016-05-14 15:09:00 to 2016-05-14 22:25:00
Rain (in/h)
0.0
0.1
0.2
10
8
6
4
2
0
Flow (mgd)
Rainfall volume: 0.16 IN
Meter volume: 0.47 MG
Model volume: 0.32 MG
Model
Meter
05/14/2016 12:00
05/14/2016 15:00
05/14/2016 18:00
05/14/2016 21:00



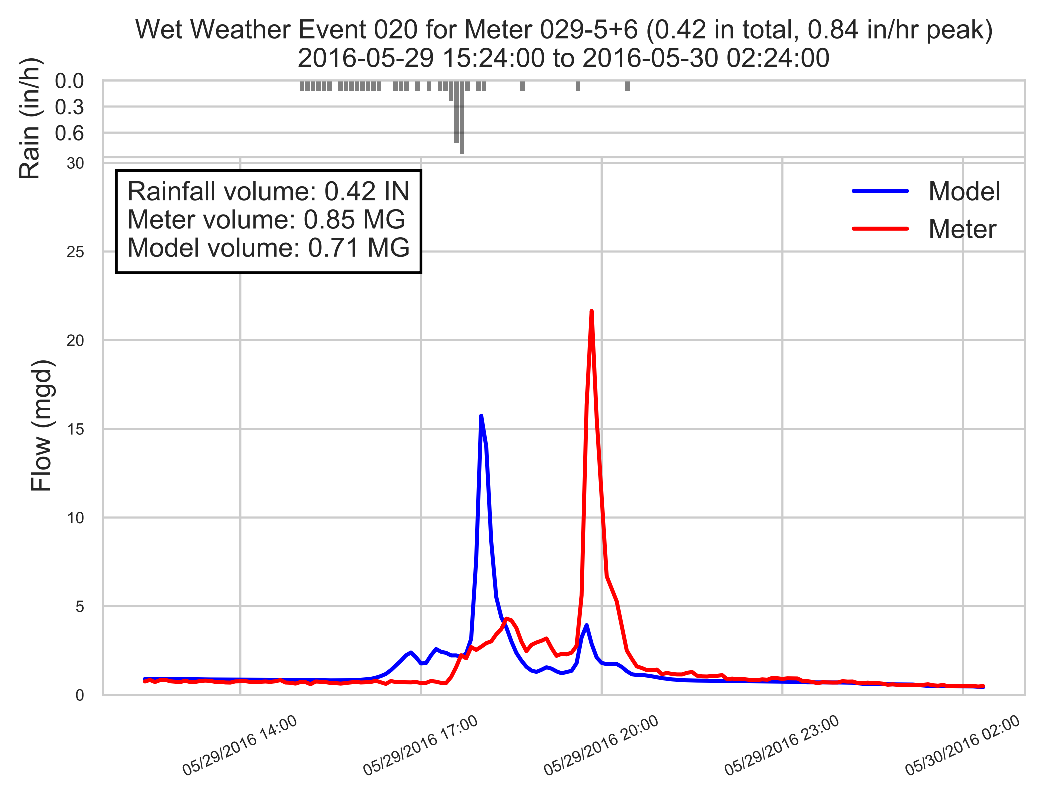
Wet Weather Event 017 for Meter 029-5+6 (0.38 in total, 0.12 in/hr peak)
2016-05-17 08:15:00 to 2016-05-18 02:05:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.38 IN
Meter volume: 1.0 MG
Model volume: 0.86 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
05/17/2016 05:00
05/17/2016 08:00
05/17/2016 11:00
05/17/2016 14:00
05/17/2016 17:00
05/17/2016 20:00
05/17/2016 23:00
05/18/2016 02:00



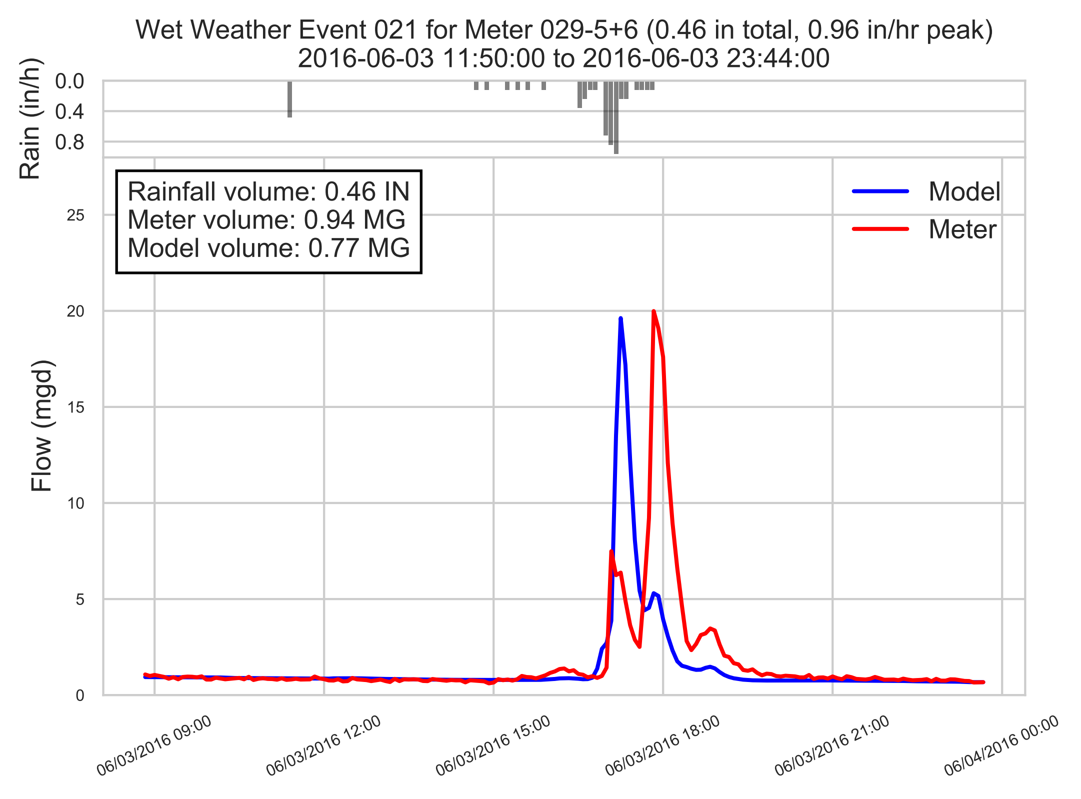
Wet Weather Event 018 for Meter 029-5+6 (1.16 in total, 0.48 in/hr peak)
2016-05-21 05:30:00 to 2016-05-23 11:15:00
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
0
2
4
6
8
10
12
14
16
Rainfall volume: 1.16 IN
Meter volume: 3.11 MG
Model volume: 2.49 MG
Model
Meter
05/21/2016 00:00
05/21/2016 03:00
05/21/2016 06:00
05/21/2016 09:00
05/21/2016 12:00
05/21/2016 15:00
05/21/2016 18:00
05/21/2016 21:00
05/22/2016 00:00
05/22/2016 03:00
05/22/2016 06:00
05/22/2016 09:00
05/22/2016 12:00
05/22/2016 15:00
05/22/2016 18:00
05/22/2016 21:00
05/23/2016 00:00
05/23/2016 03:00
05/23/2016 06:00
05/23/2016 09:00
05/23/2016 12:00



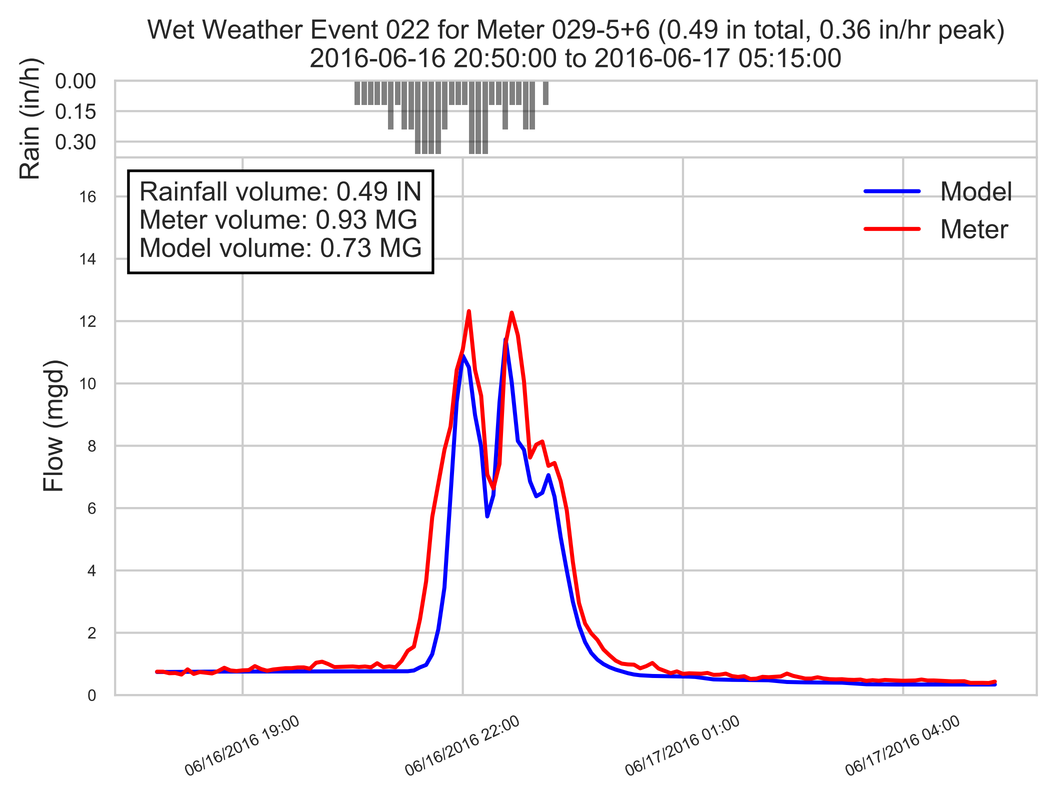
Wet Weather Event 019 for Meter 029-5+6 (0.28 in total, 0.84 in/hr peak)
2016-05-23 15:15:00 to 2016-05-24 06:45:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.28 IN
Meter volume: 0.92 MG
Model volume: 0.64 MG
Model
Meter
Flow (mgd)
25
20
15
10
5
0
05/23/2016 14:00
05/23/2016 17:00
05/23/2016 20:00
05/23/2016 23:00
05/24/2016 02:00
05/24/2016 05:00



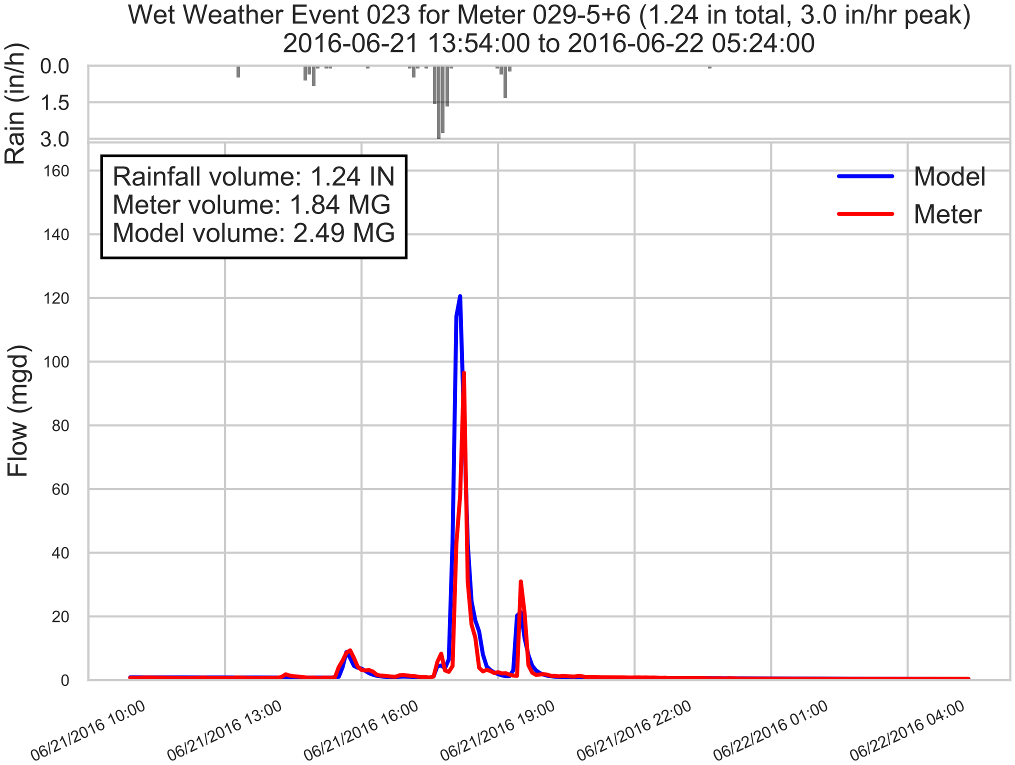
Wet Weather Event 020 for Meter 029-5+6 (0.42 in total, 0.84 in/hr peak)
2016-05-29 15:24:00 to 2016-05-30 02:24:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.42 IN
Meter volume: 0.85 MG
Model volume: 0.71 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
05/29/2016 14:00
05/29/2016 17:00
05/29/2016 20:00
05/29/2016 23:00
05/30/2016 02:00

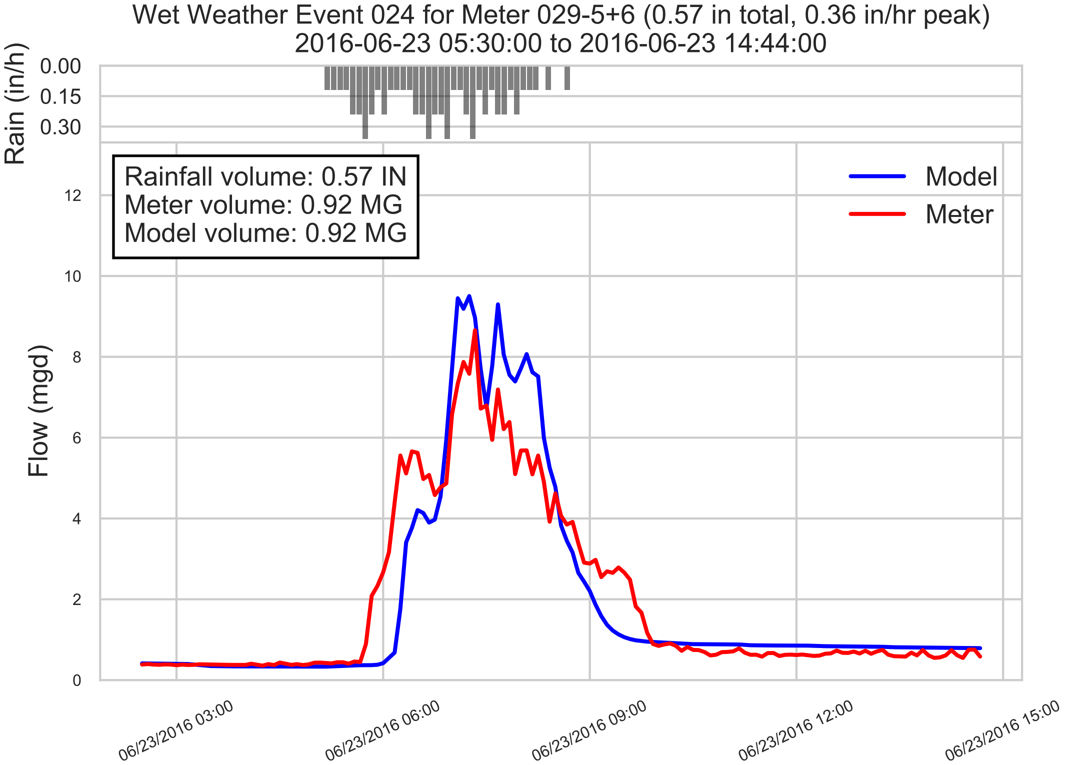


Wet Weather Event 021 for Meter 029-5+6 (0.46 in total, 0.96 in/hr peak)
2016-06-03 11:50:00 to 2016-06-03 23:44:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.46 IN
Meter volume: 0.94 MG
Model volume: 0.77 MG
Model
Meter
Flow (mgd)
25
20
15
10
5
0
06/03/2016 09:00
06/03/2016 12:00
06/03/2016 15:00
06/03/2016 18:00
06/03/2016 21:00
06/04/2016 00:00

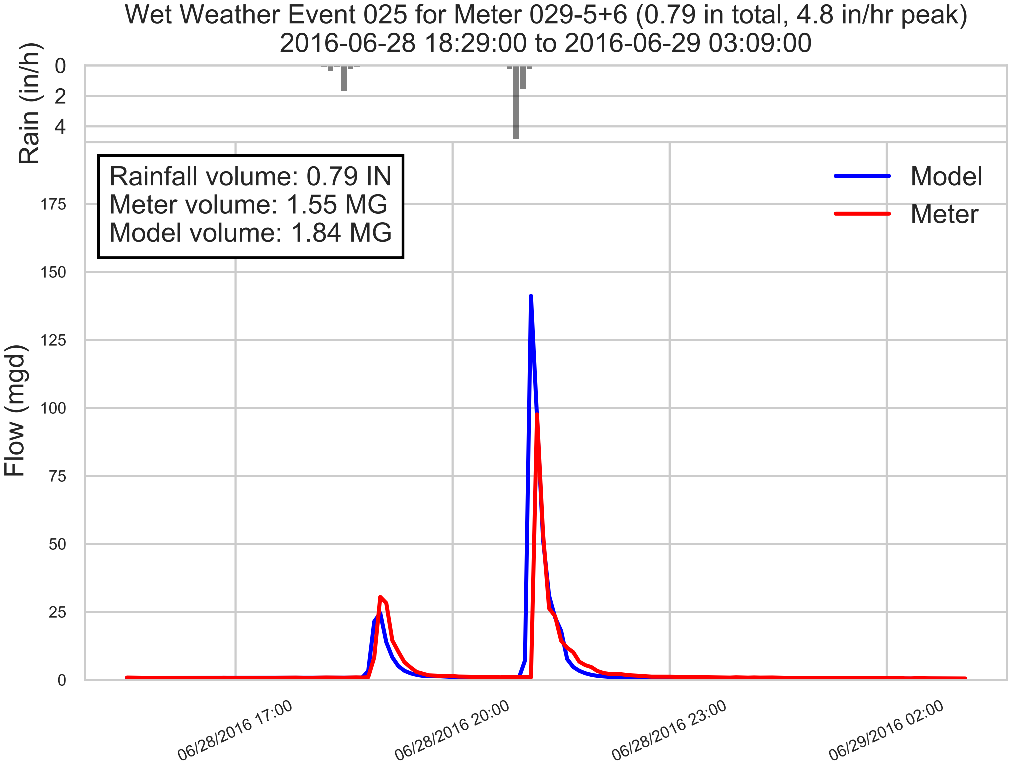


Wet Weather Event 022 for Meter 029-5+6 (0.49 in total, 0.36 in/hr peak)
2016-06-16 20:50:00 to 2016-06-17 05:15:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.49 IN
Meter volume: 0.93 MG
Model volume: 0.73 MG
Model
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
06/16/2016 19:00
06/16/2016 22:00
06/17/2016 01:00
06/17/2016 04:00

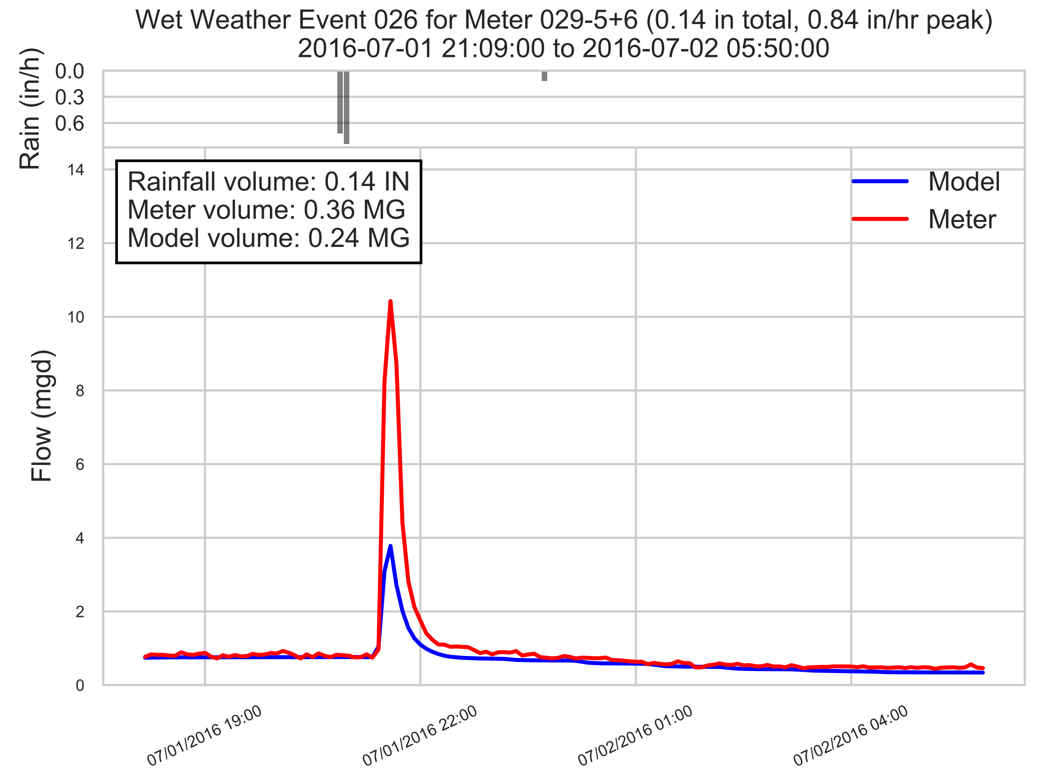

Wet Weather Event 023 for Meter 029-5+6 (1.24 in total, 3.0 in/hr peak)
2016-06-21 13:54:00 to 2016-06-22 05:24:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.24 IN
Meter volume: 1.84 MG
Model volume: 2.49 MG
Model
Meter
Flow (mgd)
160
140
120
100
80
60
40
20
0
06/21/2016 10:00
06/21/2016 13:00
06/21/2016 16:00
06/21/2016 19:00
06/21/2016 22:00
06/22/2016 01:00
06/22/2016 04:00

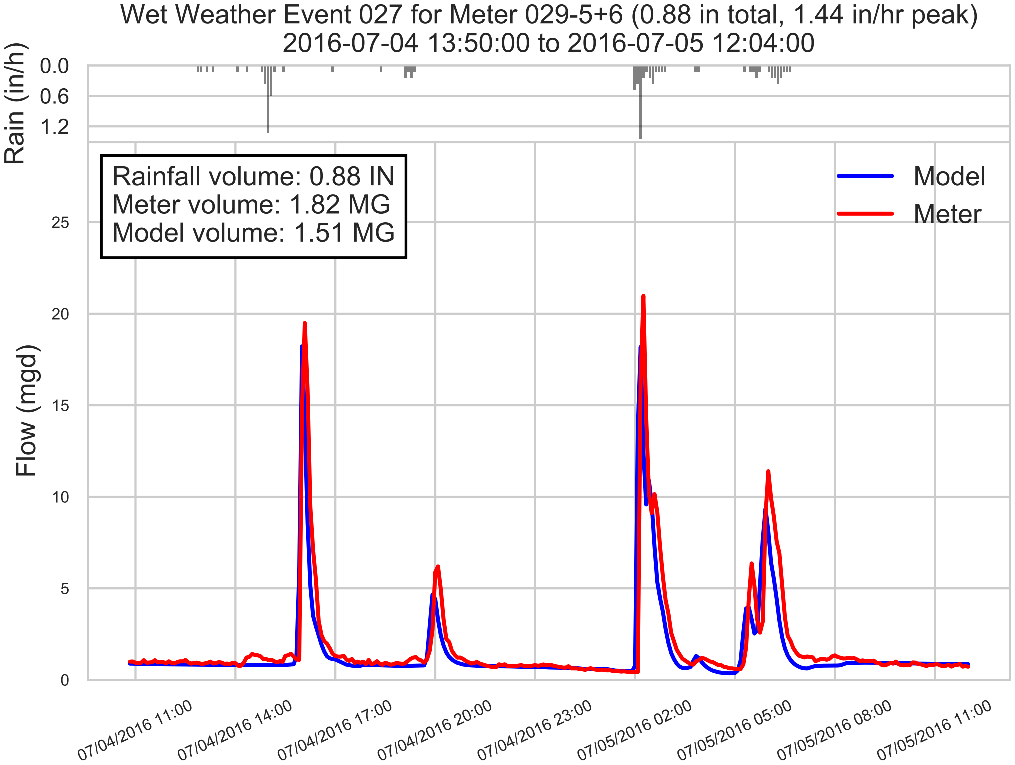


Wet Weather Event 024 for Meter 029-5+6 (0.57 in total, 0.36 in/hr peak)
2016-06-23 05:30:00 to 2016-06-23 14:44:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.57 IN
Meter volume: 0.92 MG
Model volume: 0.92 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
06/23/2016 03:00
06/23/2016 06:00
06/23/2016 09:00
06/23/2016 12:00
06/23/2016 15:00

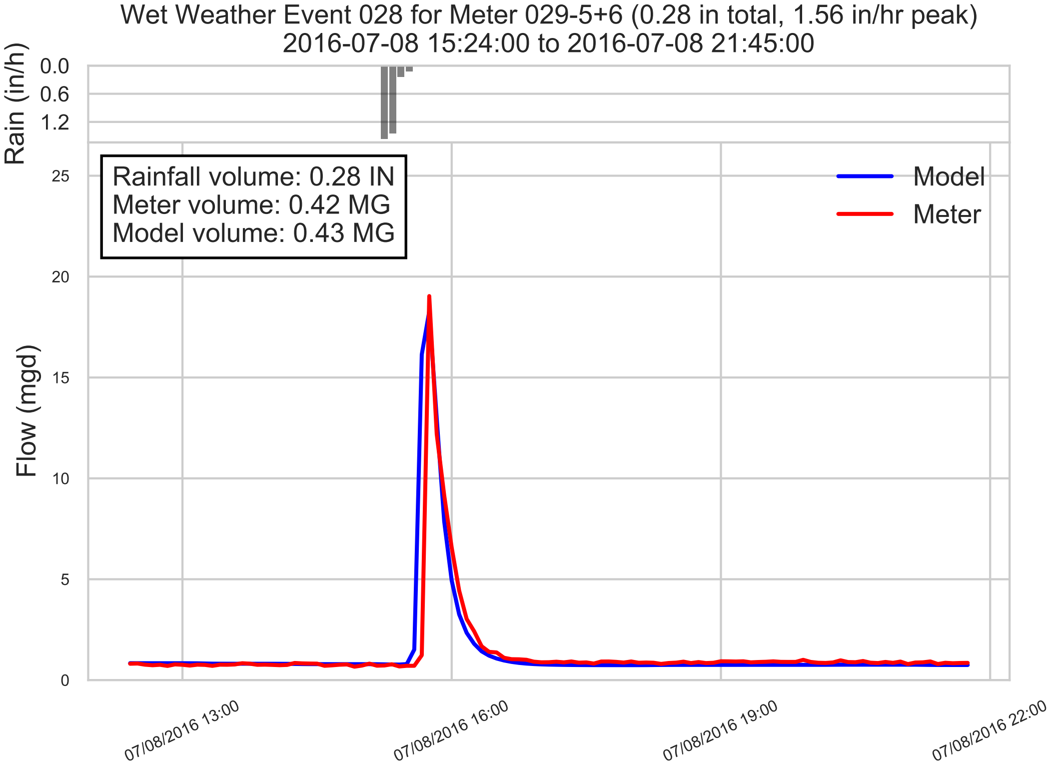


Wet Weather Event 025 for Meter 029-5+6 (0.79 in total, 4.8 in/hr peak)
2016-06-28 18:29:00 to 2016-06-29 03:09:00
Rain (in/h)
0
2
4
Rainfall volume: 0.79 IN
Meter volume: 1.55 MG
Model volume: 1.84 MG
Model
Meter
Flow (mgd)
175
150
125
100
75
50
25
0
06/28/2016 17:00
06/28/2016 20:00
06/28/2016 23:00
06/29/2016 02:00

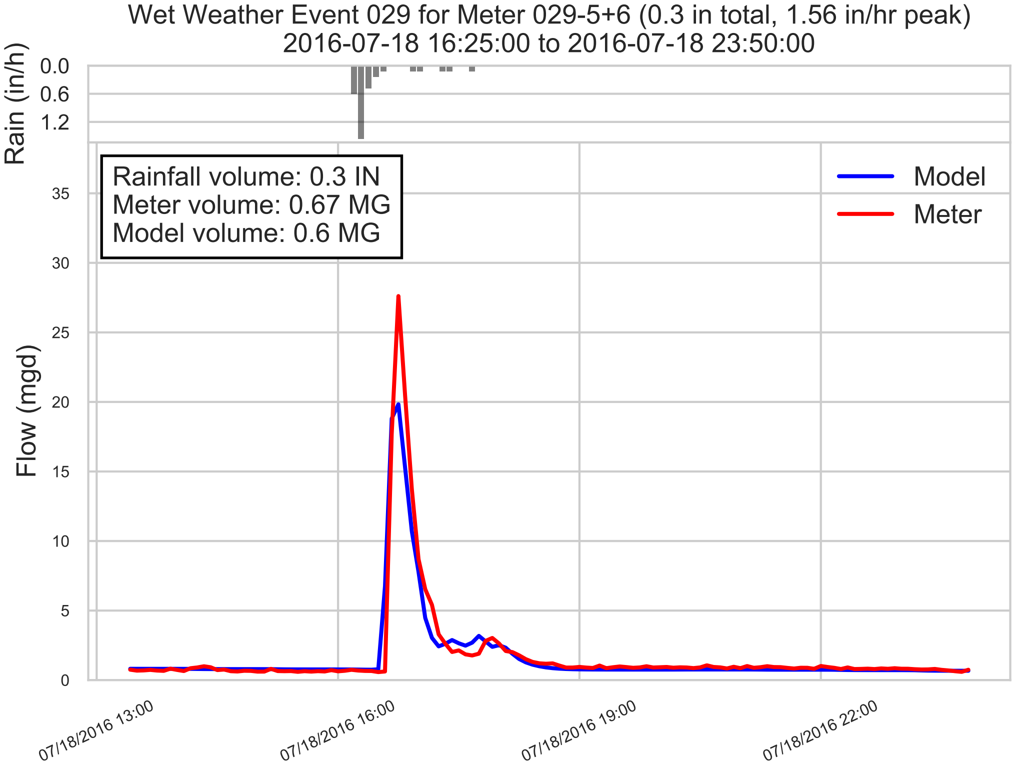

Wet Weather Event 026 for Meter 029-5+6 (0.14 in total, 0.84 in/hr peak)
2016-07-01 21:09:00 to 2016-07-02 05:50:00
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
0
2
4
6
8
10
12
14
Rainfall volume: 0.14 IN
Meter volume: 0.36 MG
Model volume: 0.24 MG
Model
Meter
07/01/2016 19:00
07/01/2016 22:00
07/02/2016 01:00
07/02/2016 04:00

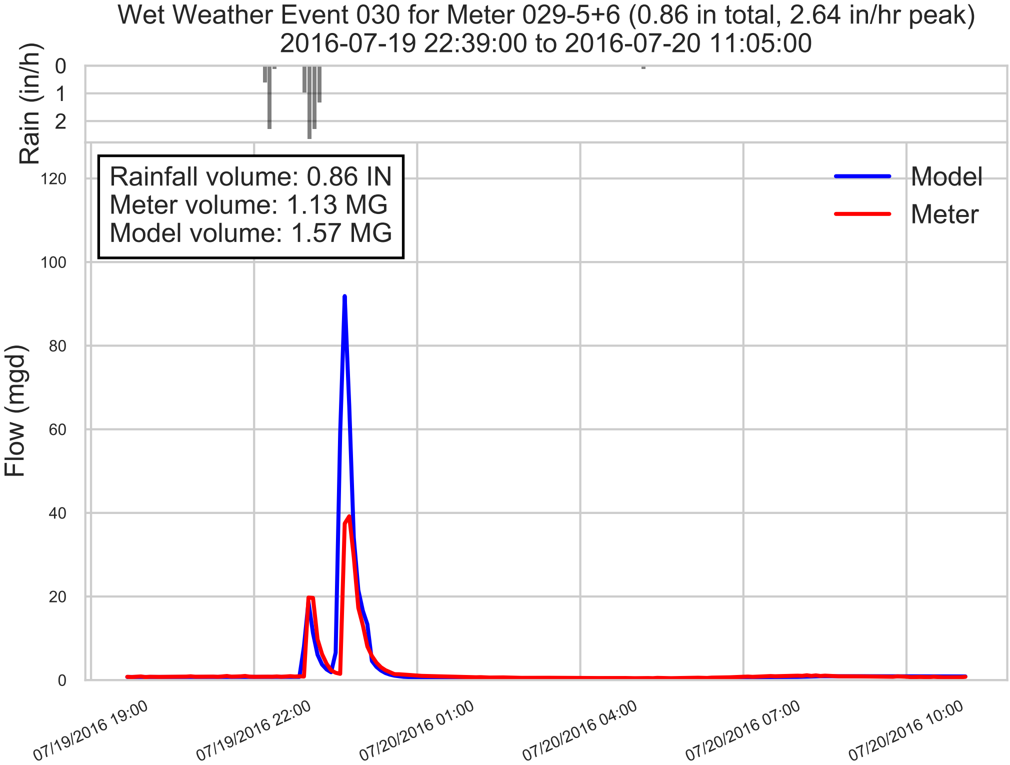


Wet Weather Event 027 for Meter 029-5+6 (0.88 in total, 1.44 in/hr peak)
2016-07-04 13:50:00 to 2016-07-05 12:04:00
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.88 IN
Meter volume: 1.82 MG
Model volume: 1.51 MG
Model
Meter
Flow (mgd)
25
20
15
10
5
0
07/04/2016 11:00
07/04/2016 14:00
07/04/2016 17:00
07/04/2016 20:00
07/04/2016 23:00
07/05/2016 02:00
07/05/2016 05:00
07/05/2016 08:00
07/05/2016 11:00

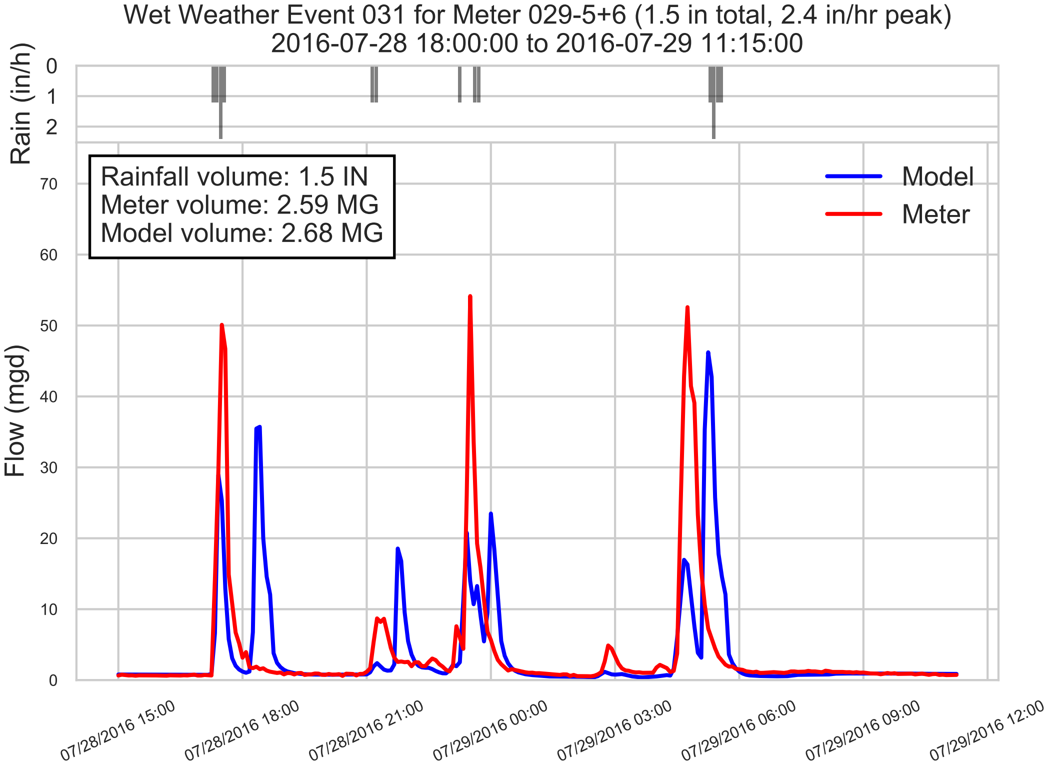


Wet Weather Event 028 for Meter 029-5+6 (0.28 in total, 1.56 in/hr peak)
2016-07-08 15:24:00 to 2016-07-08 21:45:00
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.28 IN
Meter volume: 0.42 MG
Model volume: 0.43 MG
Model
Meter
Flow (mgd)
25
20
15
10
5
0
07/08/2016 13:00
07/08/2016 16:00
07/08/2016 19:00
07/08/2016 22:00

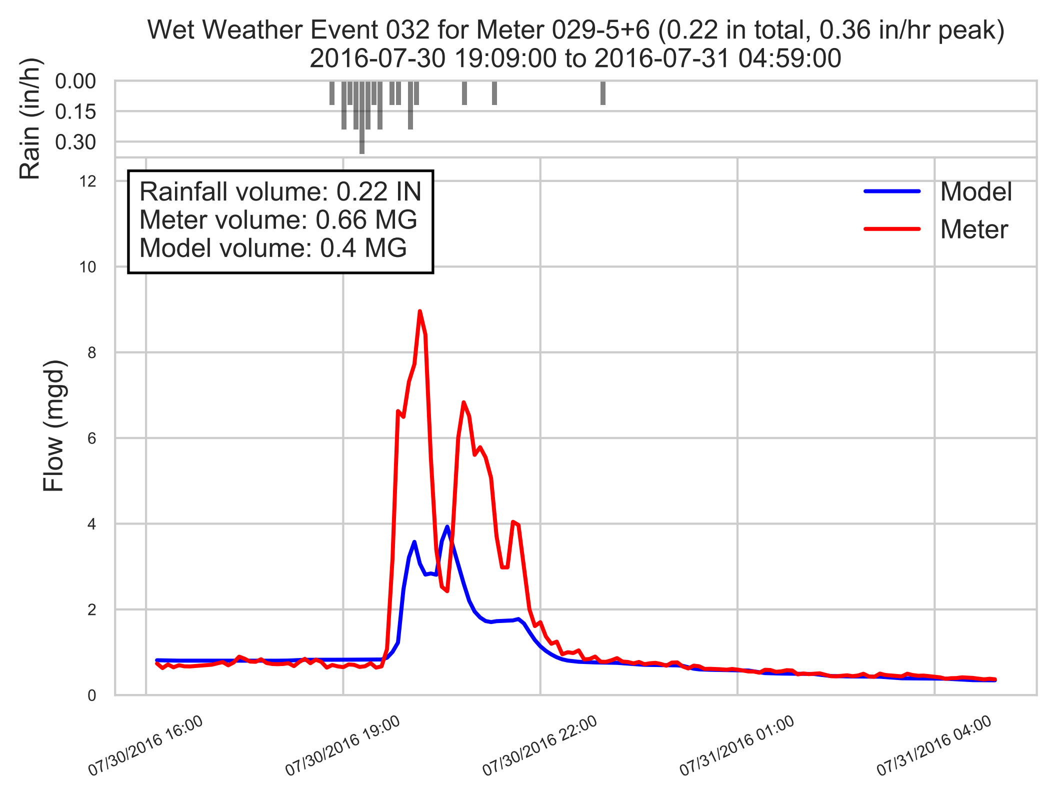

Wet Weather Event 029 for Meter 029-5+6 (0.3 in total, 1.56 in/hr peak)
2016-07-18 16:25:00 to 2016-07-18 23:50:00
Rain (in/h)
0.0
0.6
1.2
Rainfall volume: 0.3 IN
Meter volume: 0.67 MG
Model volume: 0.6 MG
Model
Meter
Flow (mgd)
35
30
25
20
15
10
5
0
07/18/2016 13:00
07/18/2016 16:00
07/18/2016 19:00
07/18/2016 22:00



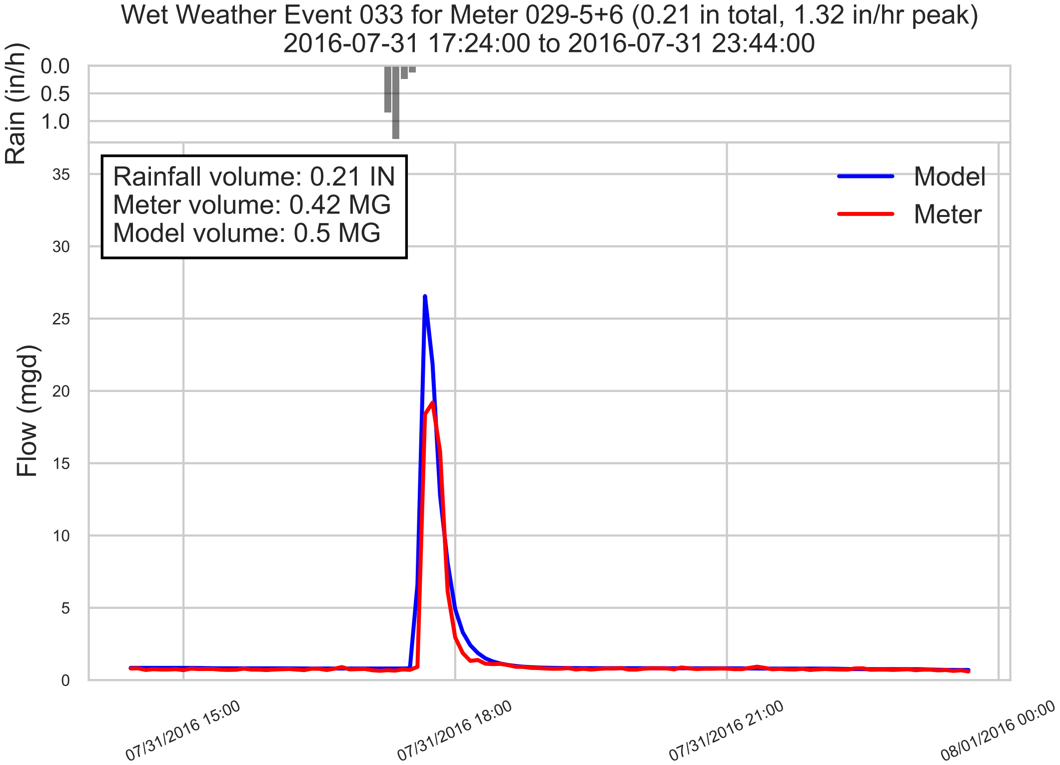
Wet Weather Event 030 for Meter 029-5+6 (0.86 in total, 2.64 in/hr peak)
2016-07-19 22:39:00 to 2016-07-20 11:05:00
Rain (in/h)
0
1
2
Rainfall volume: 0.86 IN
Meter volume: 1.13 MG
Model volume: 1.57 MG
Model
Meter
Flow (mgd)
120
100
80
60
40
20
0
07/19/2016 19:00
07/19/2016 22:00
07/20/2016 01:00
07/20/2016 04:00
07/20/2016 07:00
07/20/2016 10:00



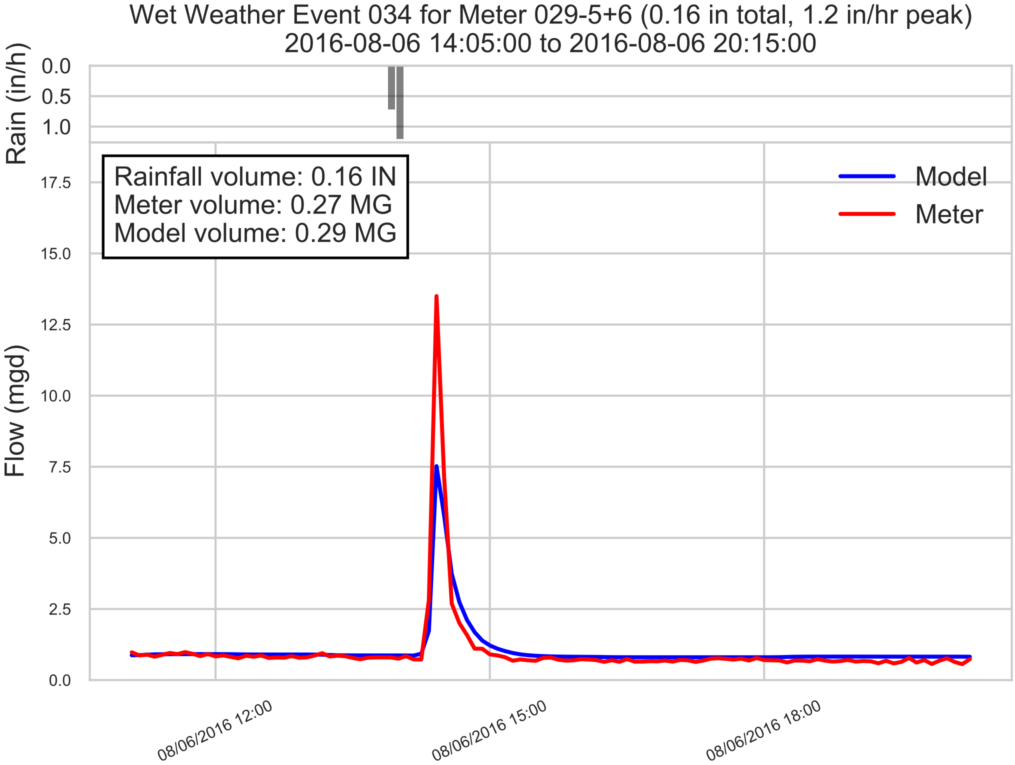
Wet Weather Event 031 for Meter 029-5+6 (1.5 in total, 2.4 in/hr peak)
2016-07-28 18:00:00 to 2016-07-29 11:15:00
Rain (in/h)
0
1
2
Rainfall volume: 1.5 IN
Meter volume: 2.59 MG
Model volume: 2.68 MG
Model
Meter
Flow (mgd)
70
60
50
40
30
20
10
0
07/28/2016 15:00
07/28/2016 18:00
07/28/2016 21:00
07/29/2016 00:00
07/29/2016 03:00
07/29/2016 06:00
07/29/2016 09:00
07/29/2016 12:00



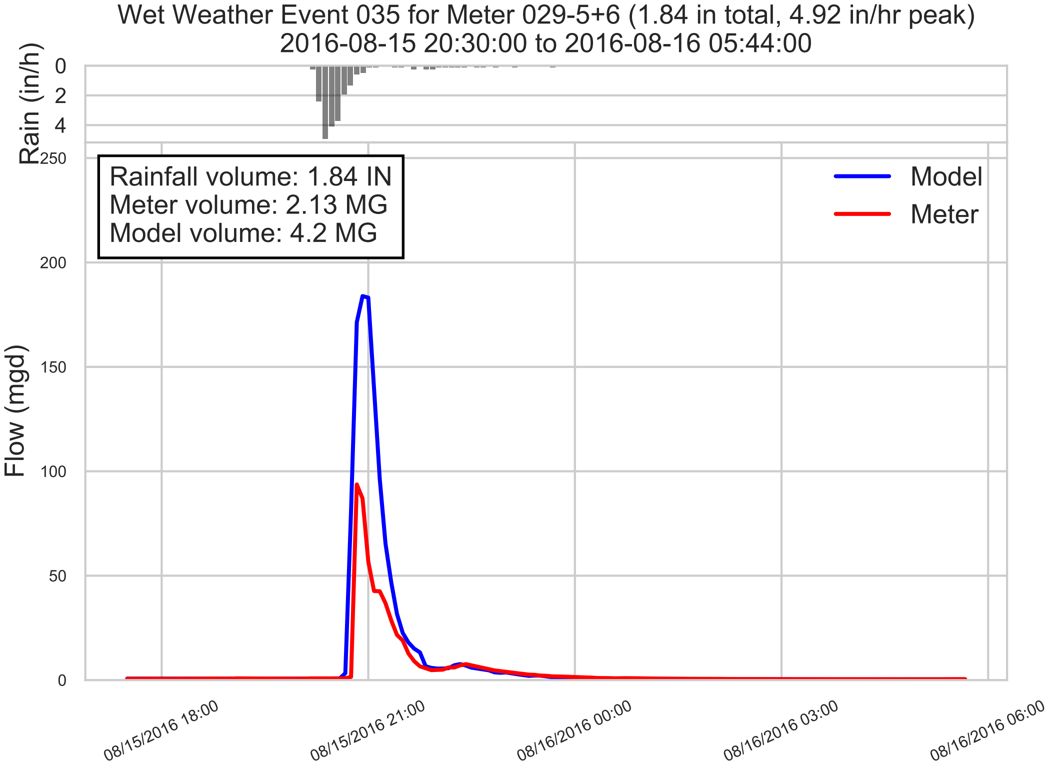
Wet Weather Event 032 for Meter 029-5+6 (0.22 in total, 0.36 in/hr peak)
2016-07-30 19:09:00 to 2016-07-31 04:59:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.22 IN
Meter volume: 0.66 MG
Model volume: 0.4 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
07/30/2016 16:00
07/30/2016 19:00
07/30/2016 22:00
07/31/2016 01:00
07/31/2016 04:00

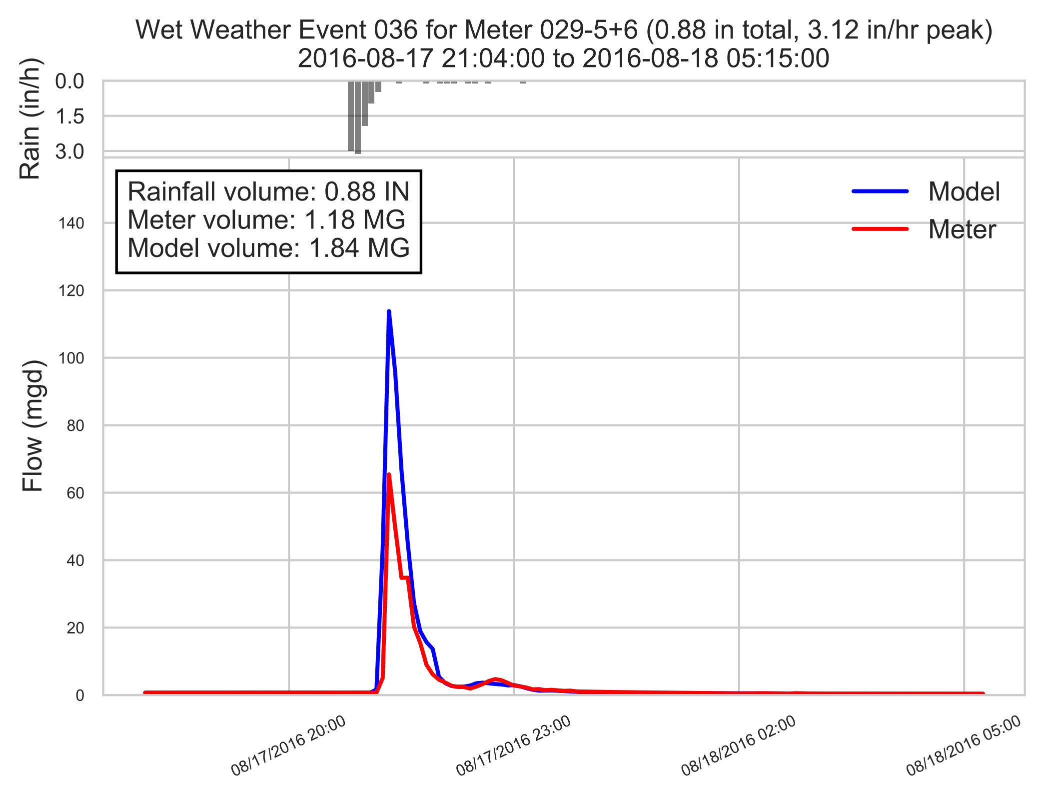


Wet Weather Event 033 for Meter 029-5+6 (0.21 in total, 1.32 in/hr peak)
2016-07-31 17:24:00 to 2016-07-31 23:44:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.21 IN
Meter volume: 0.42 MG
Model volume: 0.5 MG
Model
Meter
Flow (mgd)
35
30
25
20
15
10
5
0
07/31/2016 15:00
07/31/2016 18:00
07/31/2016 21:00
08/01/2016 00:00

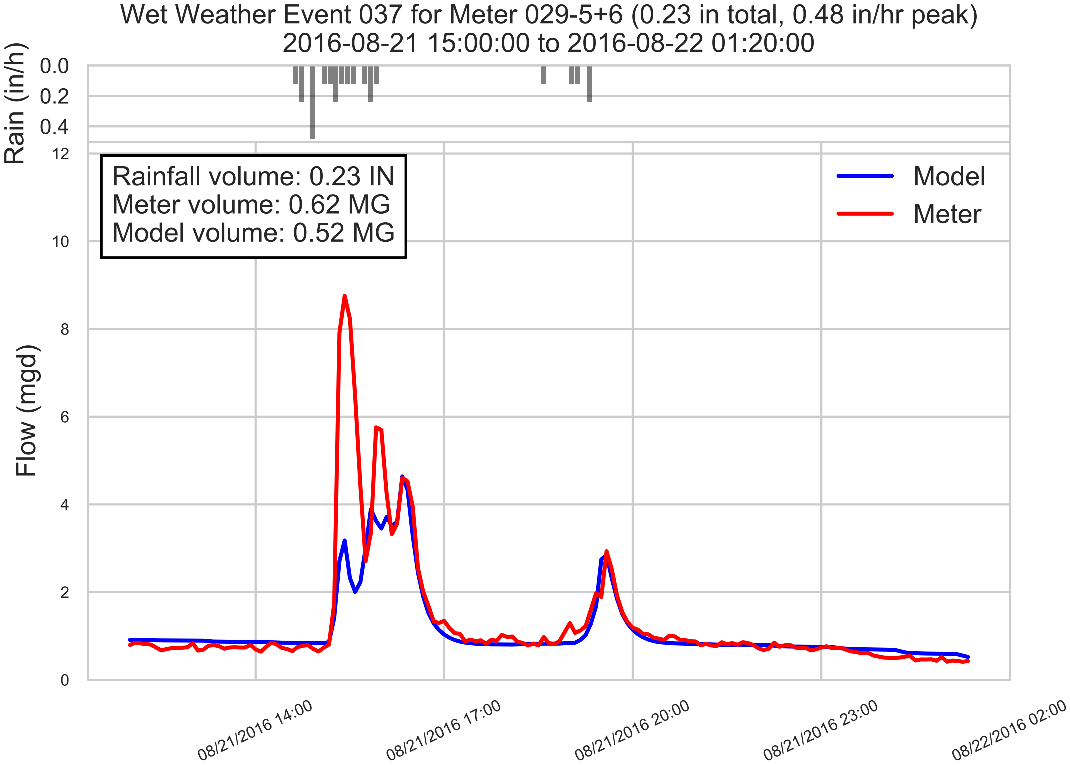


Wet Weather Event 034 for Meter 029-5+6 (0.16 in total, 1.2 in/hr peak)
2016-08-06 14:05:00 to 2016-08-06 20:15:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.16 IN
Meter volume: 0.27 MG
Model volume: 0.29 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
08/06/2016 12:00
08/06/2016 15:00
08/06/2016 18:00

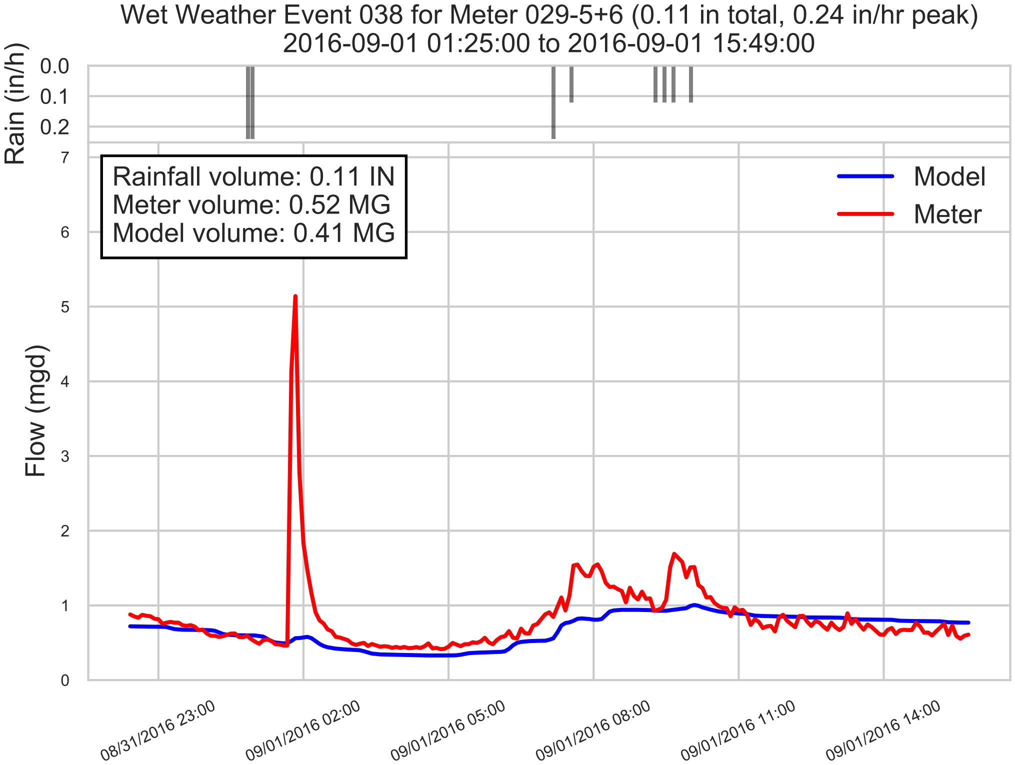

Wet Weather Event 035 for Meter 029-5+6 (1.84 in total, 4.92 in/hr peak)
2016-08-15 20:30:00 to 2016-08-16 05:44:00
Rain (in/h)
0
2
4
250
200
150
100
50
0
Flow (mgd)
Rainfall volume: 1.84 IN
Meter volume: 2.13 MG
Model volume: 4.2 MG
Model
Meter
08/15/2016 18:00
08/15/2016 21:00
08/16/2016 00:00
08/16/2016 03:00
08/16/2016 06:00

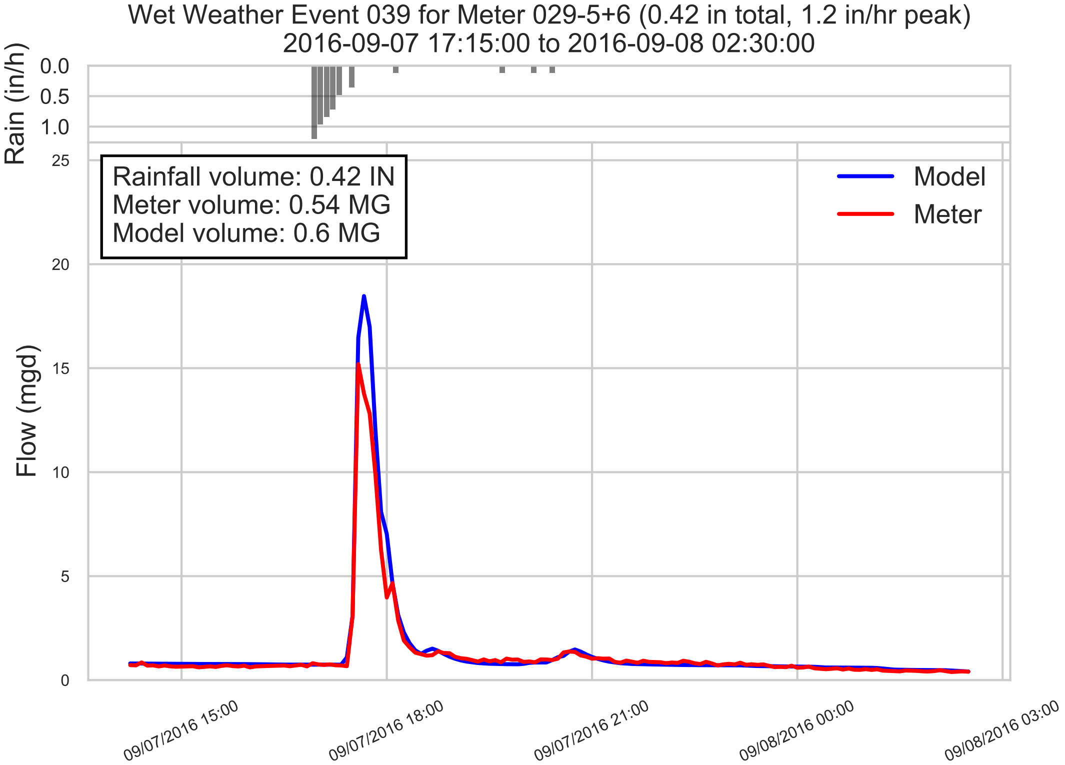


Wet Weather Event 036 for Meter 029-5+6 (0.88 in total, 3.12 in/hr peak)
2016-08-17 21:04:00 to 2016-08-18 05:15:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.88 IN
Meter volume: 1.18 MG
Model volume: 1.84 MG
Model
Meter
Flow (mgd)
140
120
100
80
60
40
20
0
08/17/2016 20:00
08/17/2016 23:00
08/18/2016 02:00
08/18/2016 05:00

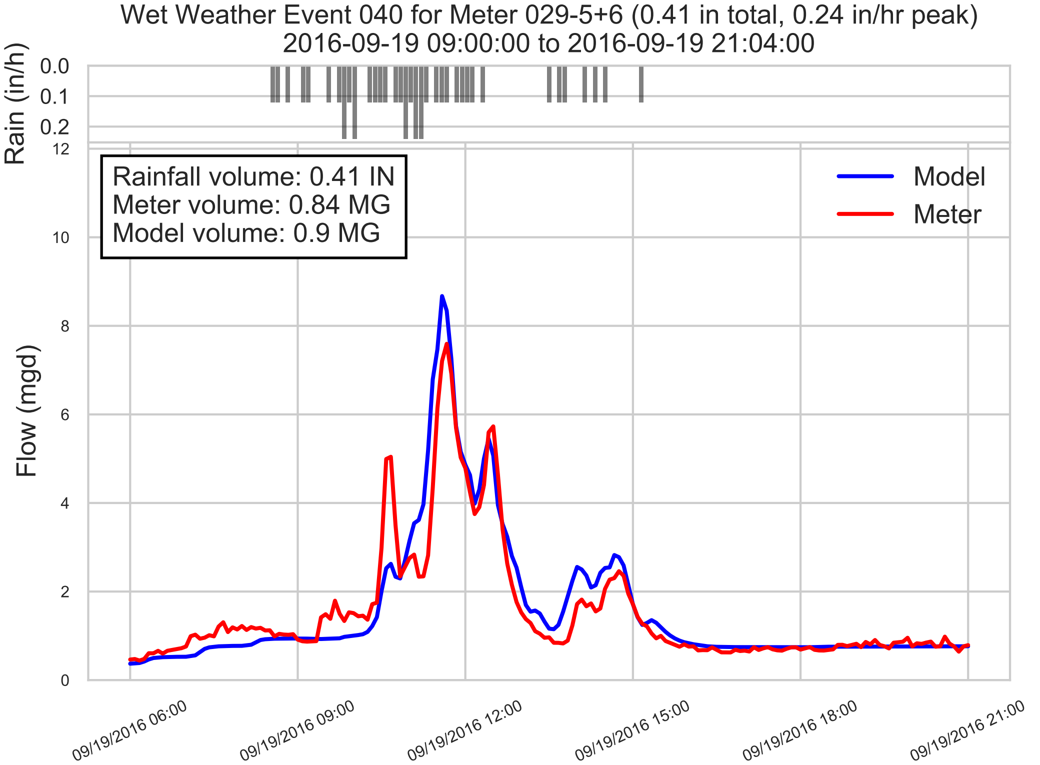


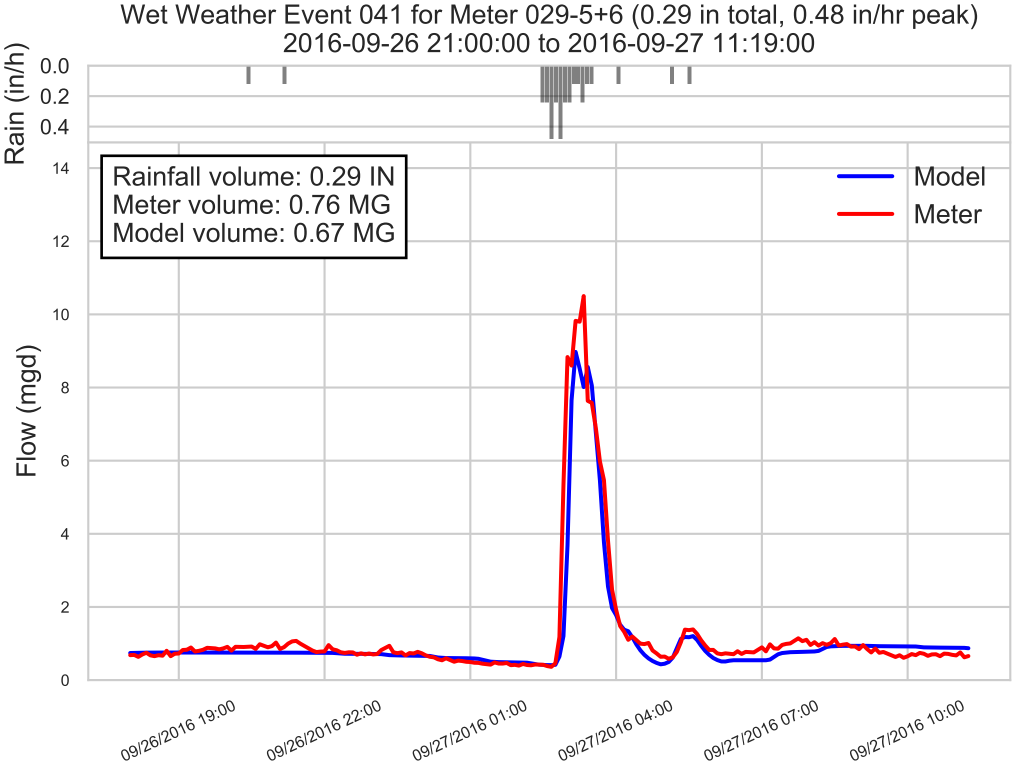
Wet Weather Event 037 for Meter 029-5+6 (0.23 in total, 0.48 in/hr peak)
2016-08-21 15:00:00 to 2016-08-22 01:20:00
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
12
10
8
6
4
2
0
Rainfall volume: 0.23 IN
Meter volume: 0.62 MG
Model volume: 0.52 MG
Model
Meter
08/21/2016 14:00
08/21/2016 17:00
08/21/2016 20:00
08/21/2016 23:00
08/22/2016 02:00


Wet Weather Event 038 for Meter 029-5+6 (0.11 in total, 0.24 in/hr peak)
2016-09-01 01:25:00 to 2016-09-01 15:49:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.11 IN
Meter volume: 0.52 MG
Model volume: 0.41 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
08/31/2016 23:00
09/01/2016 02:00
09/01/2016 05:00
09/01/2016 08:00
09/01/2016 11:00
09/01/2016 14:00

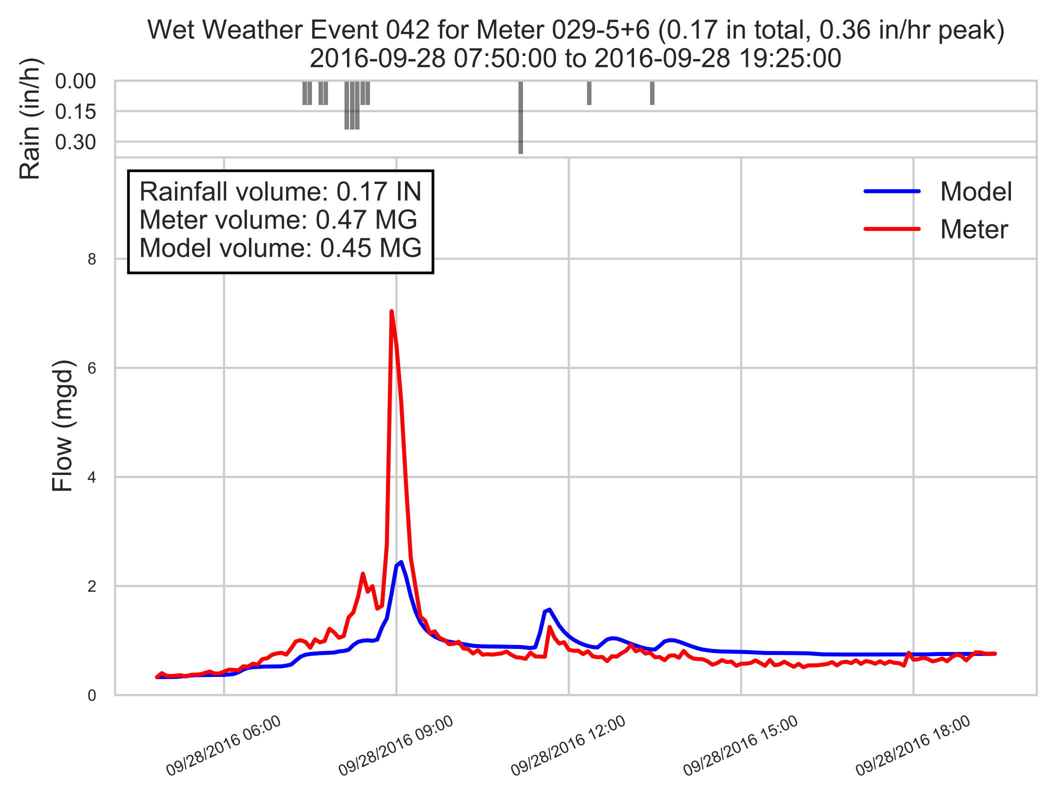


Wet Weather Event 039 for Meter 029-5+6 (0.42 in total, 1.2 in/hr peak)
2016-09-07 17:15:00 to 2016-09-08 02:30:00
Rain (in/h)
0.0
0.5
1.0
Flow (mgd)
25
20
15
10
5
0
Rainfall volume: 0.42 IN
Meter volume: 0.54 MG
Model volume: 0.6 MG
Model
Meter
09/07/2016 15:00
09/07/2016 18:00
09/07/2016 21:00
09/08/2016 00:00
09/08/2016 03:00

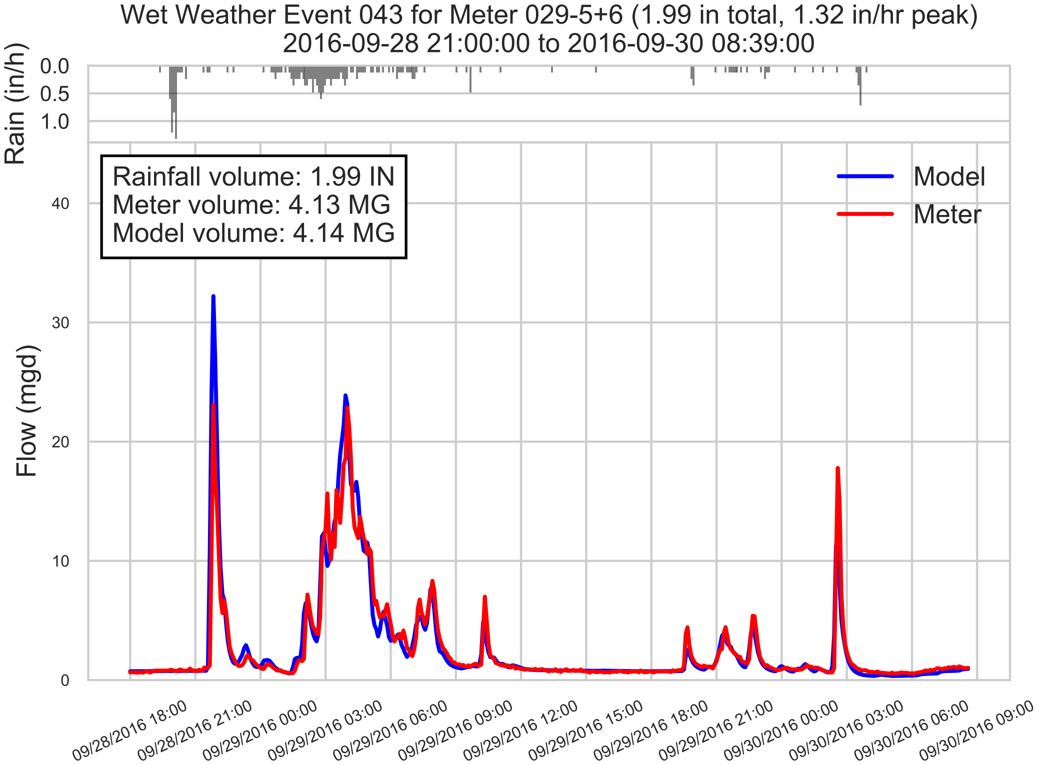

Wet Weather Event 040 for Meter 029-5+6 (0.41 in total, 0.24 in/hr peak)
2016-09-19 09:00:00 to 2016-09-19 21:04:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
12
10
8
6
4
2
0
Rainfall volume: 0.41 IN
Meter volume: 0.84 MG
Model volume: 0.9 MG
Model
Meter
09/19/2016 06:00
09/19/2016 09:00
09/19/2016 12:00
09/19/2016 15:00
09/19/2016 18:00
09/19/2016 21:00



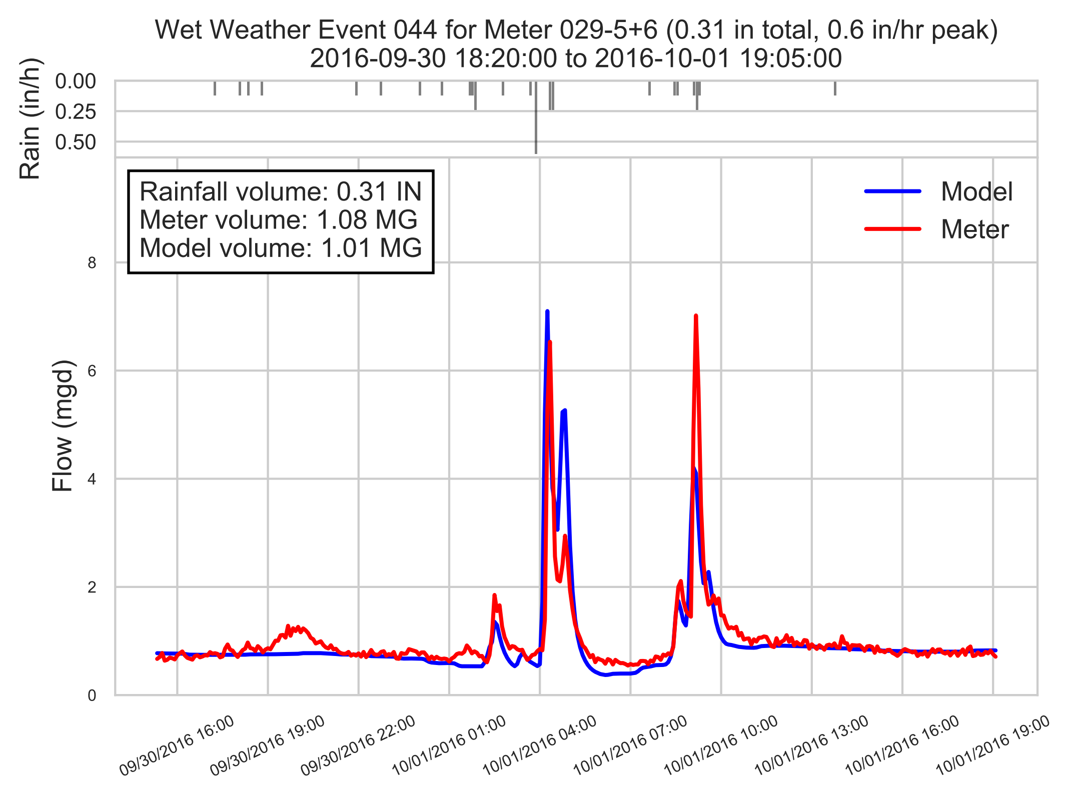
Wet Weather Event 041 for Meter 029-5+6 (0.29 in total, 0.48 in/hr peak)
2016-09-26 21:00:00 to 2016-09-27 11:19:00
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
14
12
10
8
6
4
2
0
Rainfall volume: 0.29 IN
Meter volume: 0.76 MG
Model volume: 0.67 MG
Model
Meter
09/26/2016 19:00
09/26/2016 22:00
09/27/2016 01:00
09/27/2016 04:00
09/27/2016 07:00
09/27/2016 10:00



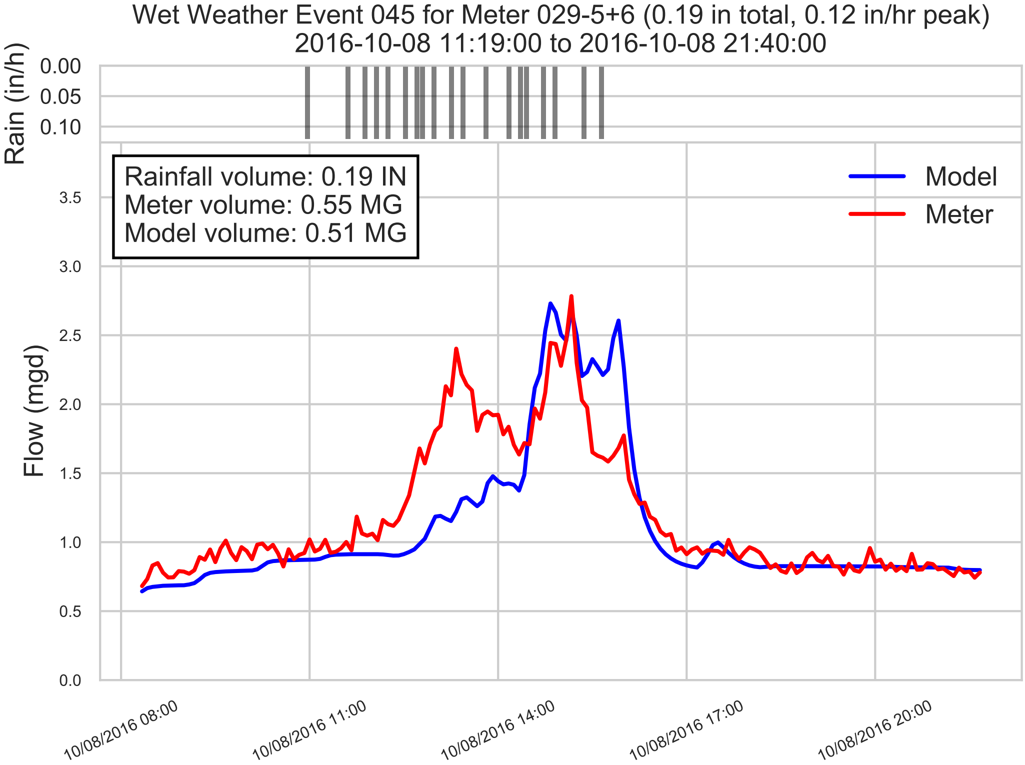
Wet Weather Event 042 for Meter 029-5+6 (0.17 in total, 0.36 in/hr peak)
2016-09-28 07:50:00 to 2016-09-28 19:25:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.17 IN
Meter volume: 0.47 MG
Model volume: 0.45 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
09/28/2016 06:00
09/28/2016 09:00
09/28/2016 12:00
09/28/2016 15:00
09/28/2016 18:00

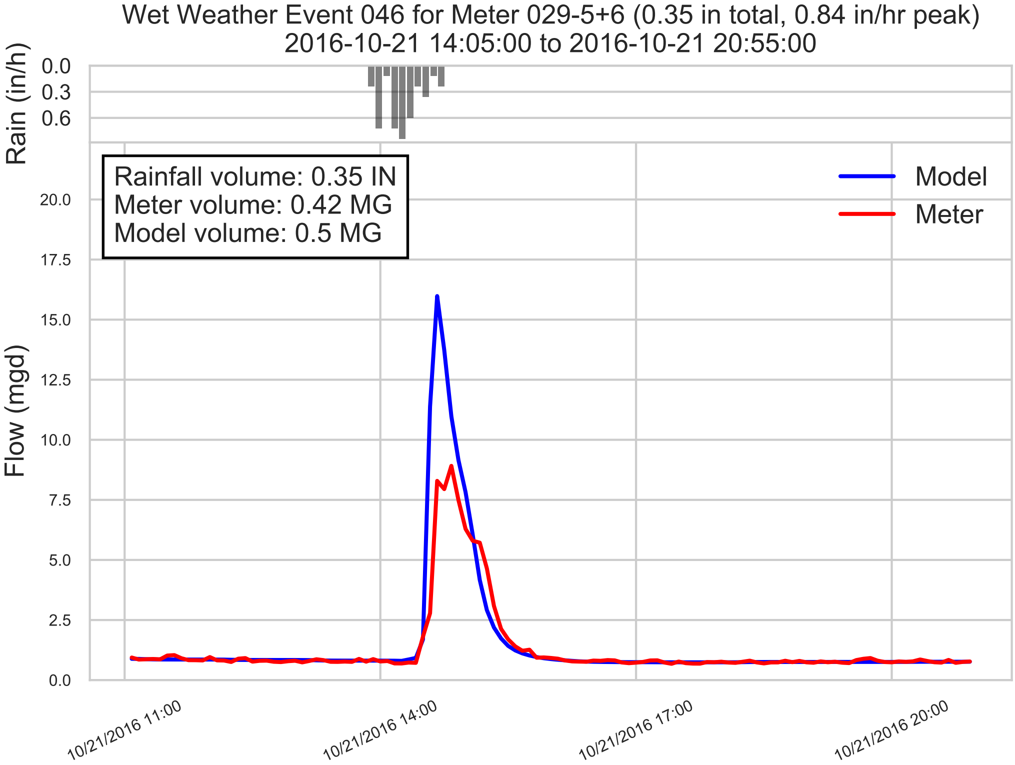


Wet Weather Event 043 for Meter 029-5+6 (1.99 in total, 1.32 in/hr peak)
2016-09-28 21:00:00 to 2016-09-30 08:39:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.99 IN
Meter volume: 4.13 MG
Model volume: 4.14 MG
Model
Meter
Flow (mgd)
40
30
20
10
0
09/28/2016 18:00
09/28/2016 21:00
09/29/2016 00:00
09/29/2016 03:00
09/29/2016 06:00
09/29/2016 09:00
09/29/2016 12:00
09/29/2016 15:00
09/29/2016 18:00
09/29/2016 21:00
09/30/2016 00:00
09/30/2016 03:00
09/30/2016 06:00
09/30/2016 09:00

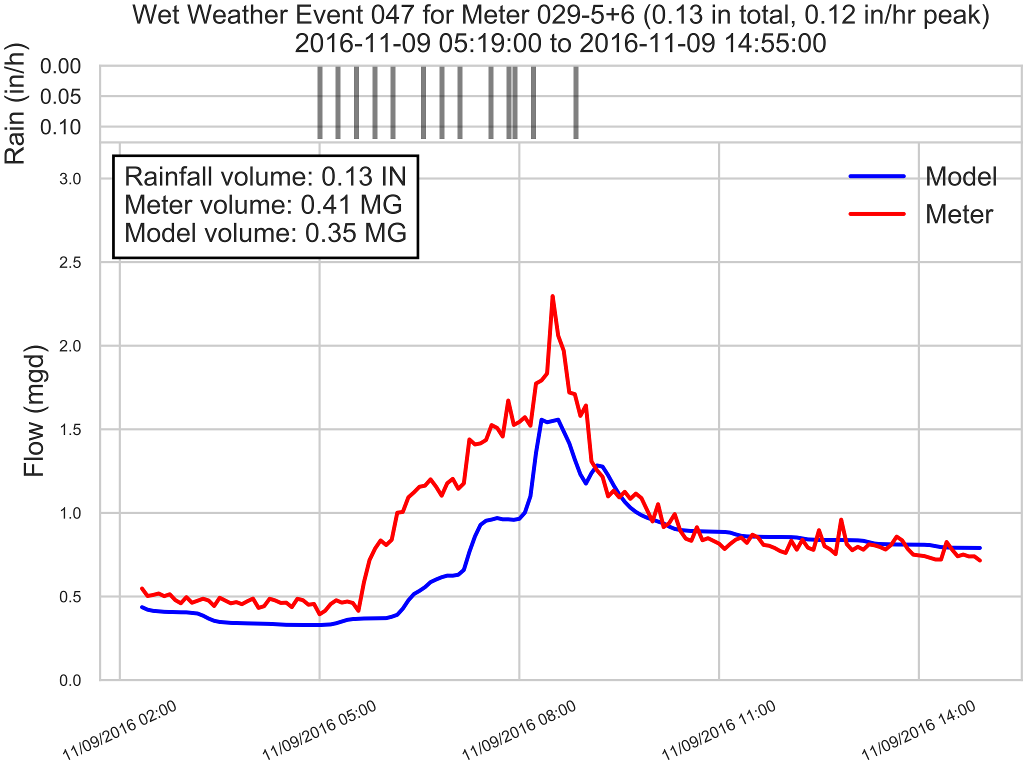


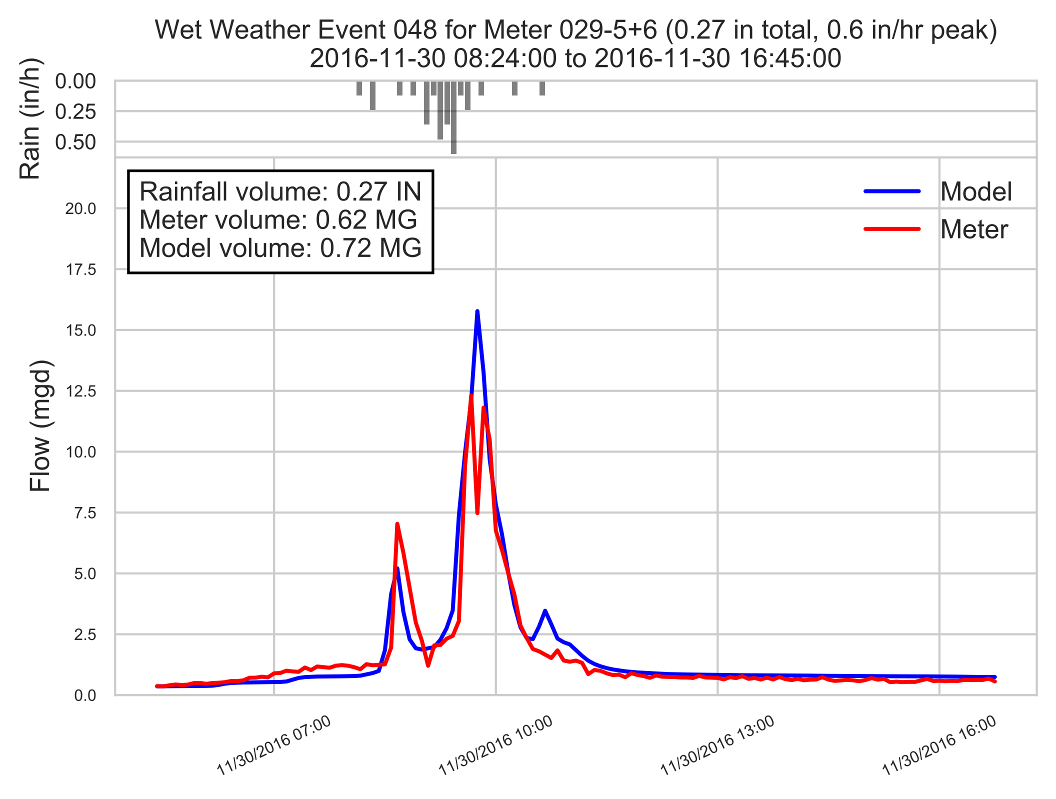
Wet Weather Event 044 for Meter 029-5+6 (0.31 in total, 0.6 in/hr peak)
2016-09-30 18:20:00 to 2016-10-01 19:05:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.31 IN
Meter volume: 1.08 MG
Model volume: 1.01 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
09/30/2016 16:00
09/30/2016 19:00
09/30/2016 22:00
10/01/2016 01:00
10/01/2016 04:00
10/01/2016 07:00
10/01/2016 10:00
10/01/2016 13:00
10/01/2016 16:00
10/01/2016 19:00

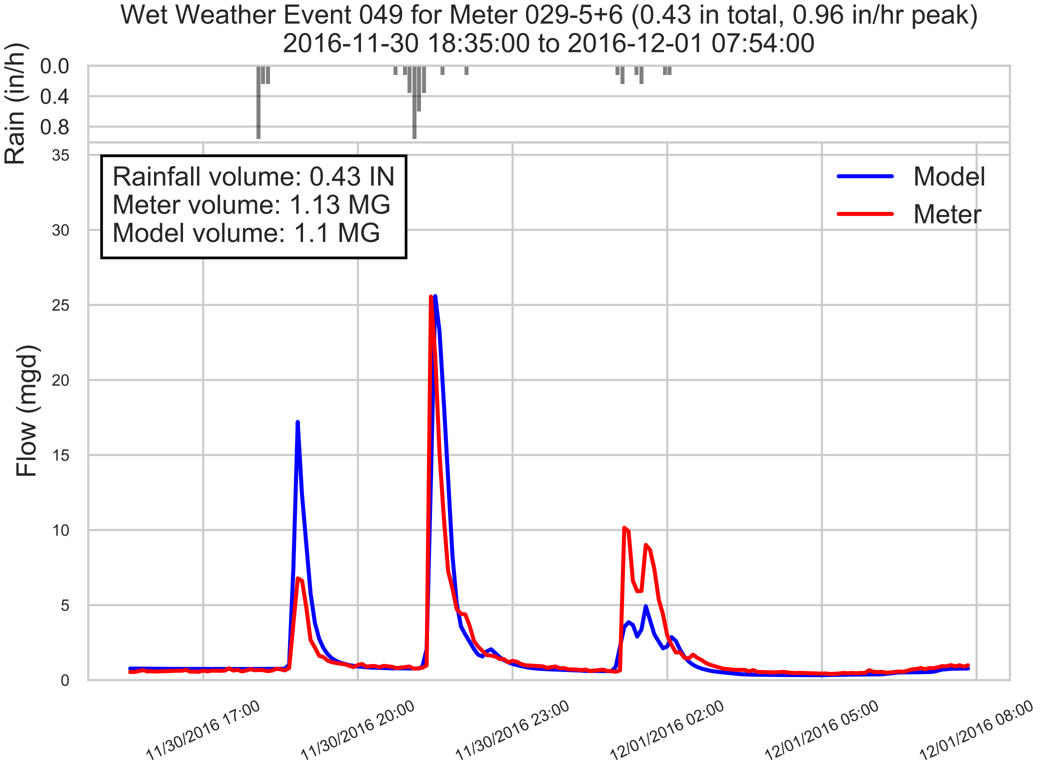

Wet Weather Event 045 for Meter 029-5+6 (0.19 in total, 0.12 in/hr peak)
2016-10-08 11:19:00 to 2016-10-08 21:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.19 IN
Meter volume: 0.55 MG
Model volume: 0.51 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/08/2016 08:00
10/08/2016 11:00
10/08/2016 14:00
10/08/2016 17:00
10/08/2016 20:00



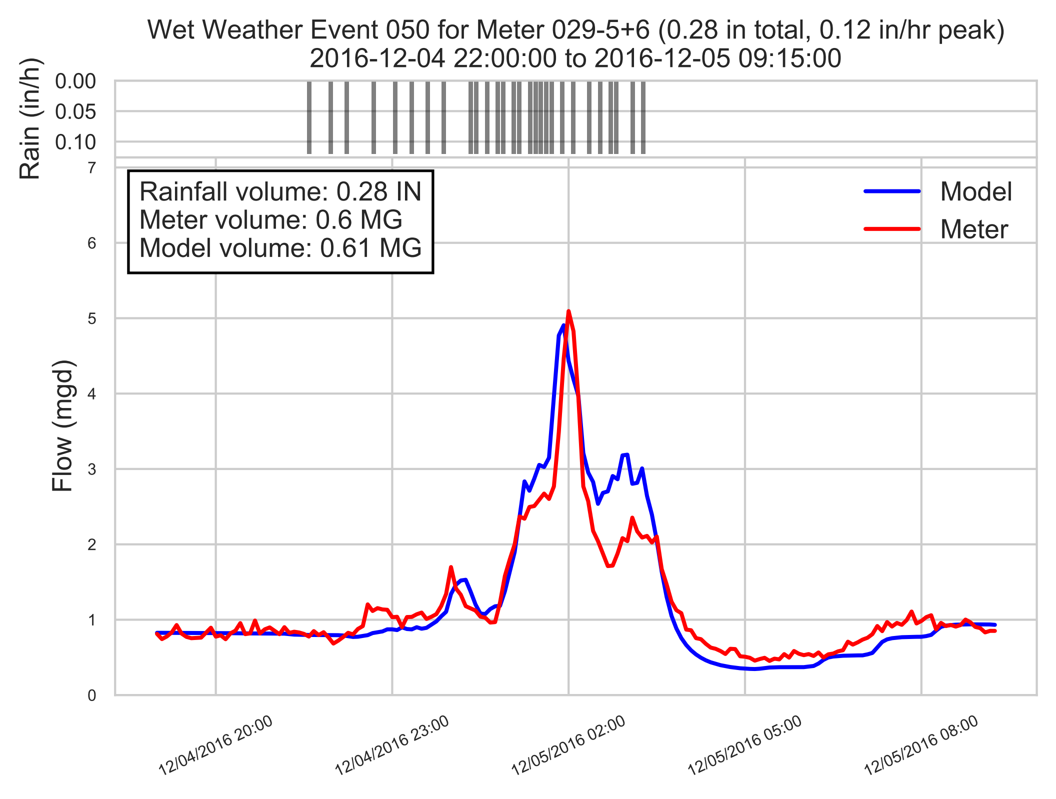
Wet Weather Event 046 for Meter 029-5+6 (0.35 in total, 0.84 in/hr peak)
2016-10-21 14:05:00 to 2016-10-21 20:55:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.35 IN
Meter volume: 0.42 MG
Model volume: 0.5 MG
Model
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
10/21/2016 11:00
10/21/2016 14:00
10/21/2016 17:00
10/21/2016 20:00


Wet Weather Event 047 for Meter 029-5+6 (0.13 in total, 0.12 in/hr peak)
2016-11-09 05:19:00 to 2016-11-09 14:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.13 IN
Meter volume: 0.41 MG
Model volume: 0.35 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/09/2016 02:00
11/09/2016 05:00
11/09/2016 08:00
11/09/2016 11:00
11/09/2016 14:00

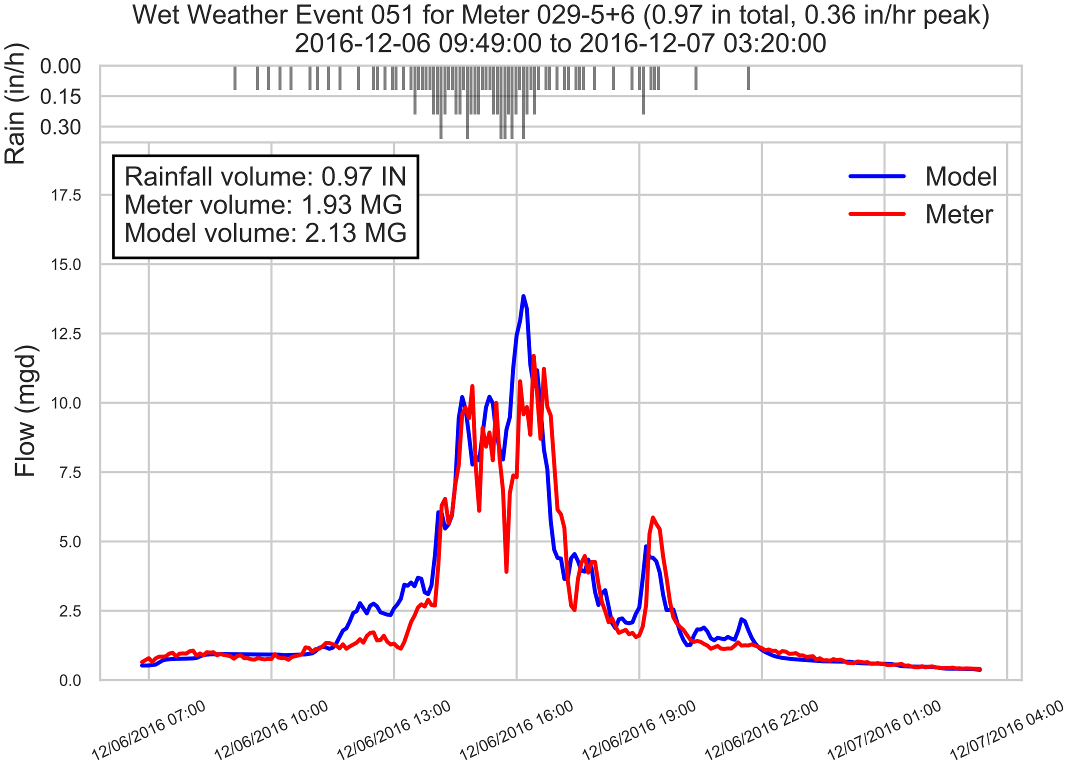

Wet Weather Event 048 for Meter 029-5+6 (0.27 in total, 0.6 in/hr peak)
2016-11-30 08:24:00 to 2016-11-30 16:45:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.27 IN
Meter volume: 0.62 MG
Model volume: 0.72 MG
Model
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
11/30/2016 07:00
11/30/2016 10:00
11/30/2016 13:00
11/30/2016 16:00



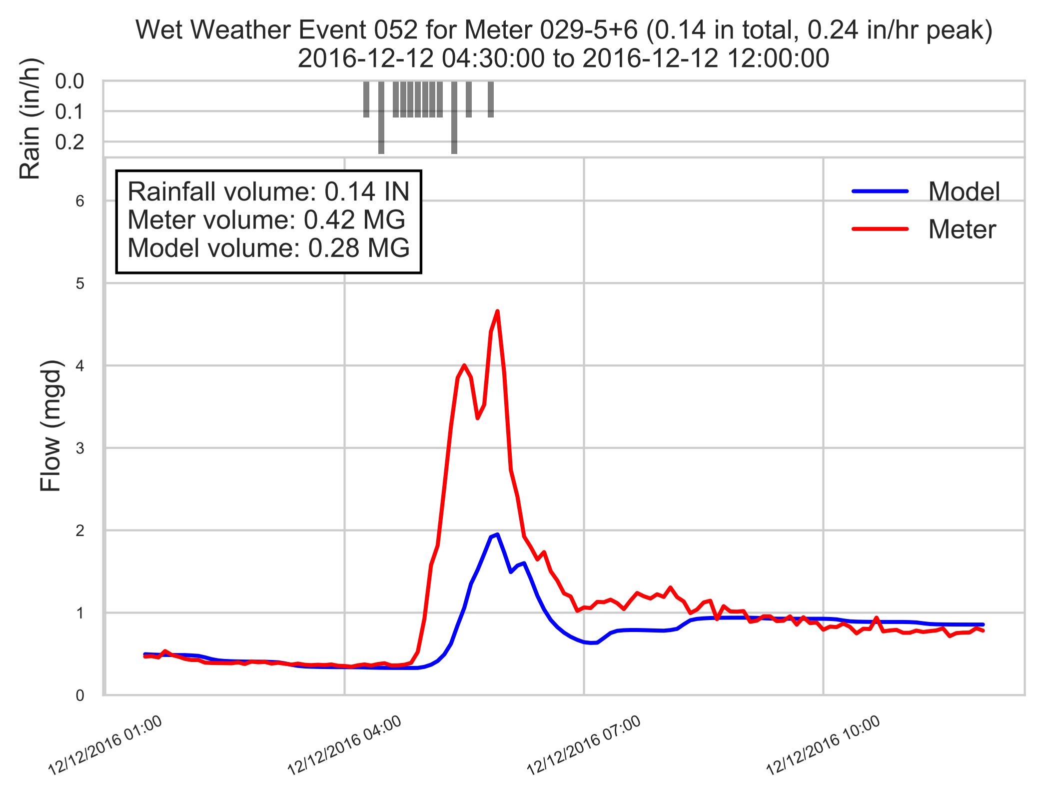
Wet Weather Event 049 for Meter 029-5+6 (0.43 in total, 0.96 in/hr peak)
2016-11-30 18:35:00 to 2016-12-01 07:54:00
Rain (in/h)
0.0
0.4
0.8
Flow (mgd)
0
5
10
15
20
25
30
35
Rainfall volume: 0.43 IN
Meter volume: 1.13 MG
Model volume: 1.1 MG
Model
Meter
11/30/2016 17:00
11/30/2016 20:00
11/30/2016 23:00
12/01/2016 02:00
12/01/2016 05:00
12/01/2016 08:00



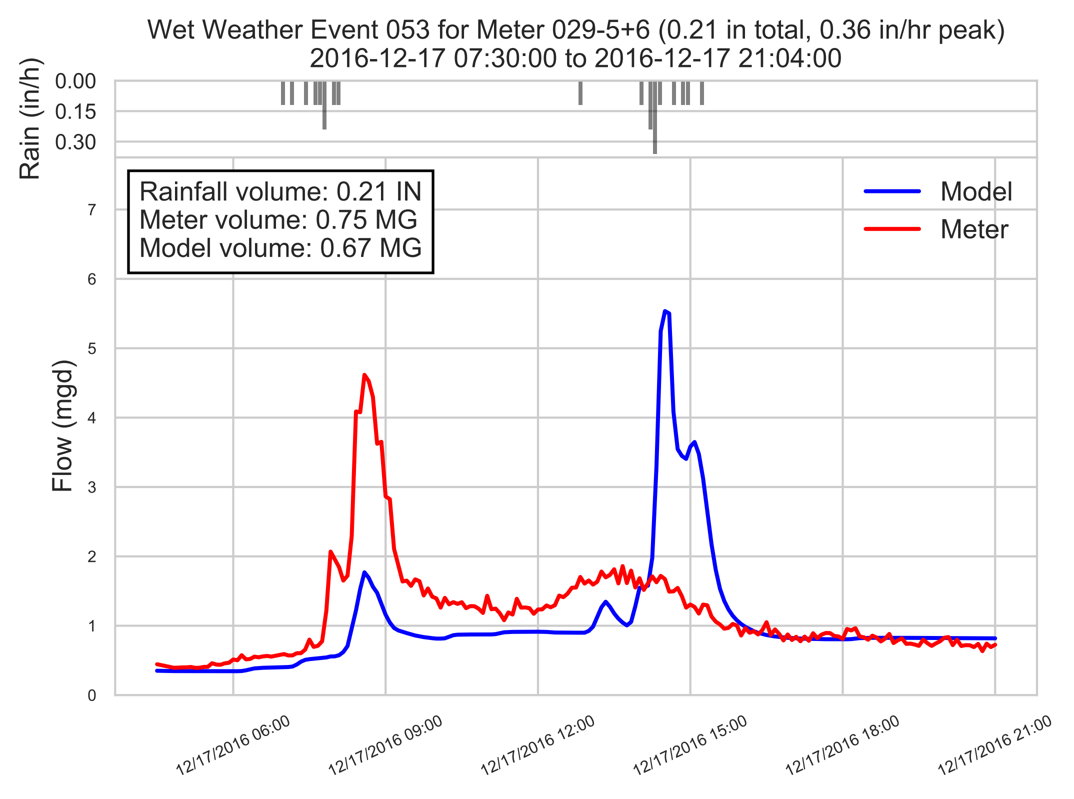
Wet Weather Event 050 for Meter 029-5+6 (0.28 in total, 0.12 in/hr peak)
2016-12-04 22:00:00 to 2016-12-05 09:15:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0
1
2
3
4
5
6
7
Rainfall volume: 0.28 IN
Meter volume: 0.6 MG
Model volume: 0.61 MG
Model
Meter
12/04/2016 20:00
12/04/2016 23:00
12/05/2016 02:00
12/05/2016 05:00
12/05/2016 08:00

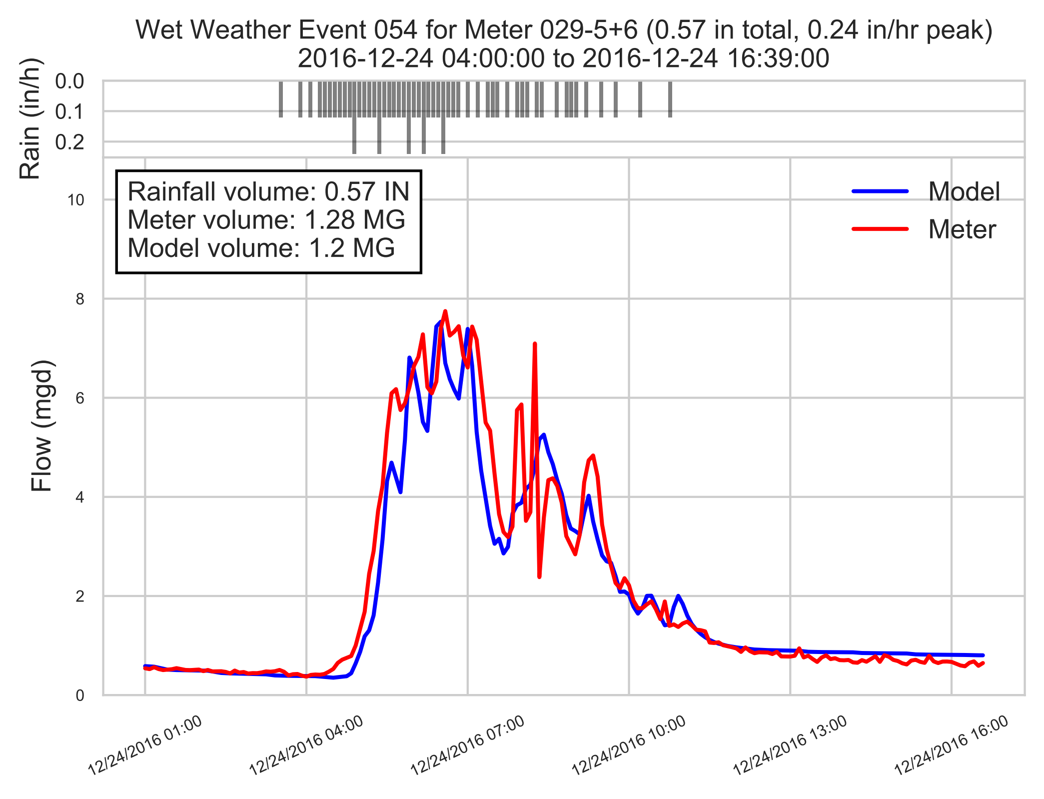


Wet Weather Event 051 for Meter 029-5+6 (0.97 in total, 0.36 in/hr peak)
2016-12-06 09:49:00 to 2016-12-07 03:20:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.97 IN
Meter volume: 1.93 MG
Model volume: 2.13 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
12/06/2016 07:00
12/06/2016 10:00
12/06/2016 13:00
12/06/2016 16:00
12/06/2016 19:00
12/06/2016 22:00
12/07/2016 01:00
12/07/2016 04:00

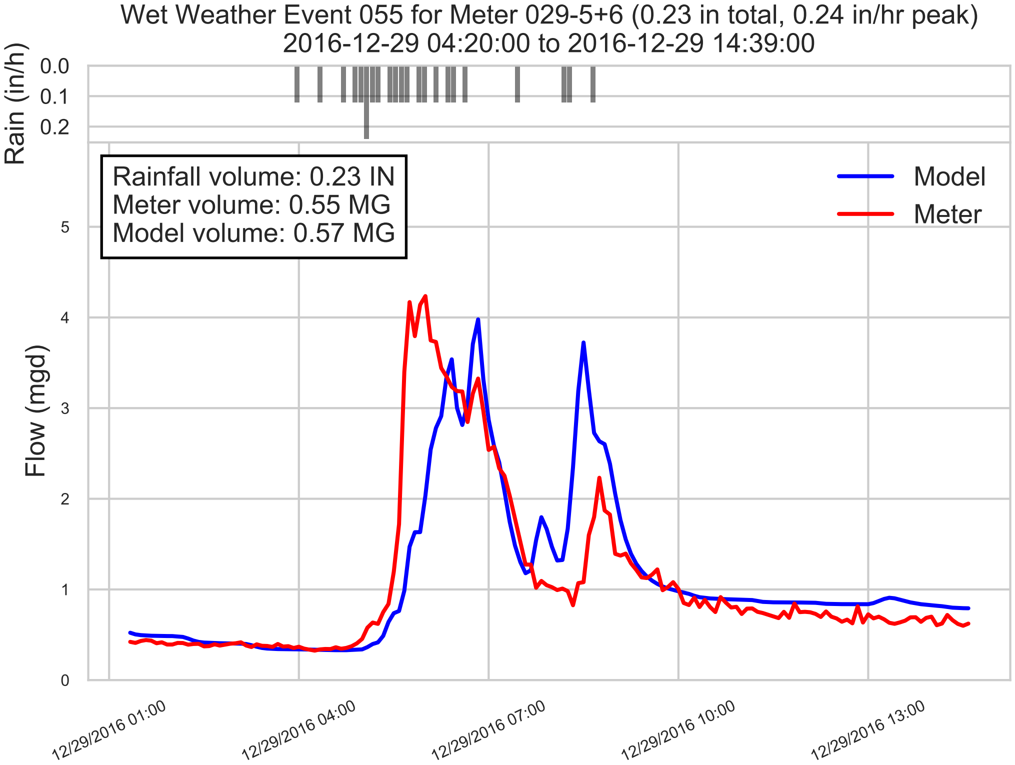


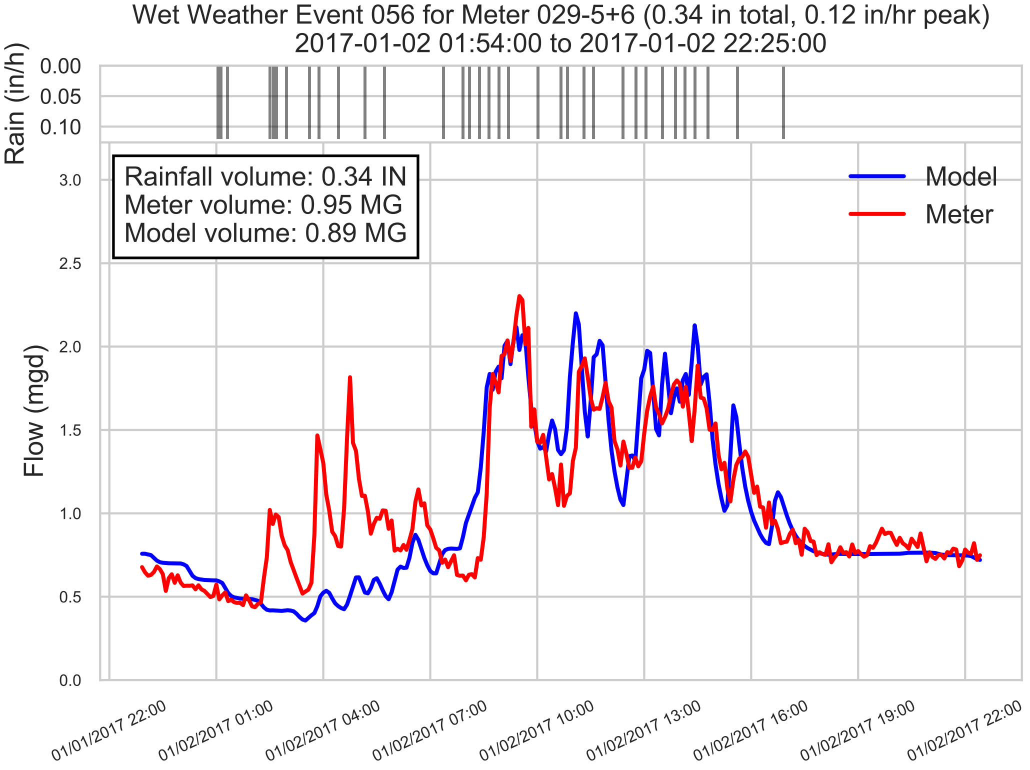
Wet Weather Event 052 for Meter 029-5+6 (0.14 in total, 0.24 in/hr peak)
2016-12-12 04:30:00 to 2016-12-12 12:00:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.14 IN
Meter volume: 0.42 MG
Model volume: 0.28 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
12/12/2016 01:00
12/12/2016 04:00
12/12/2016 07:00
12/12/2016 10:00


Wet Weather Event 053 for Meter 029-5+6 (0.21 in total, 0.36 in/hr peak)
2016-12-17 07:30:00 to 2016-12-17 21:04:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.21 IN
Meter volume: 0.75 MG
Model volume: 0.67 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
12/17/2016 06:00
12/17/2016 09:00
12/17/2016 12:00
12/17/2016 15:00
12/17/2016 18:00
12/17/2016 21:00

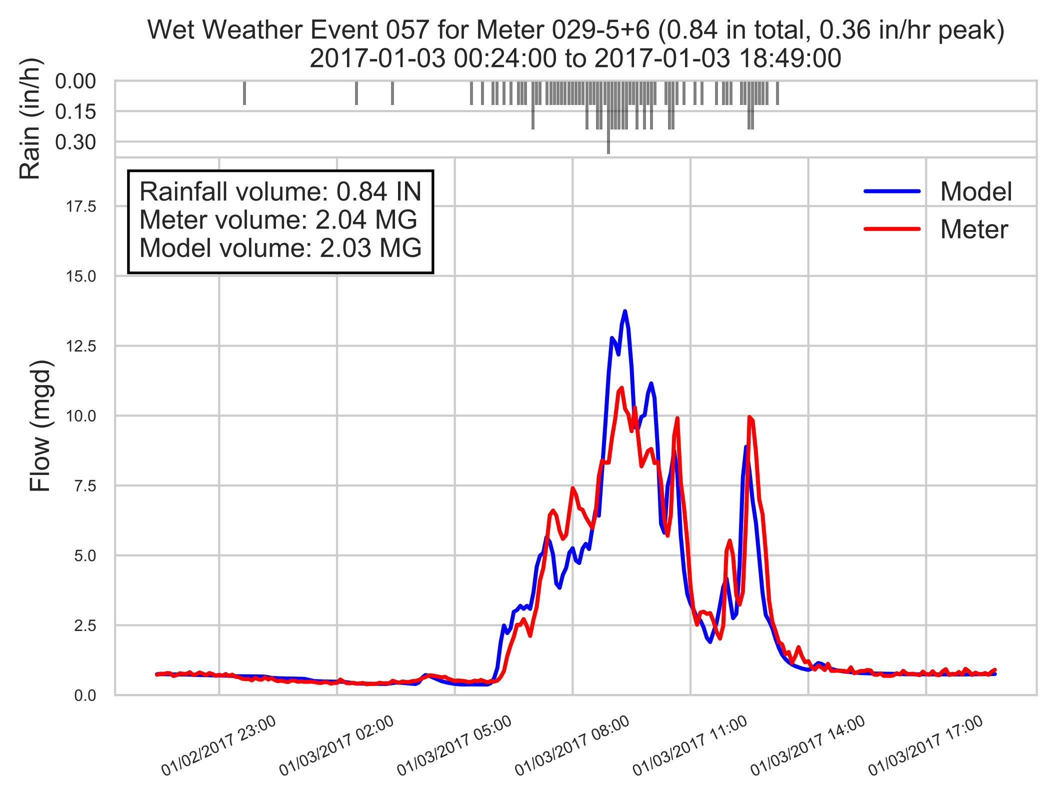


Wet Weather Event 054 for Meter 029-5+6 (0.57 in total, 0.24 in/hr peak)
2016-12-24 04:00:00 to 2016-12-24 16:39:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.57 IN
Meter volume: 1.28 MG
Model volume: 1.2 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12/24/2016 01:00
12/24/2016 04:00
12/24/2016 07:00
12/24/2016 10:00
12/24/2016 13:00
12/24/2016 16:00

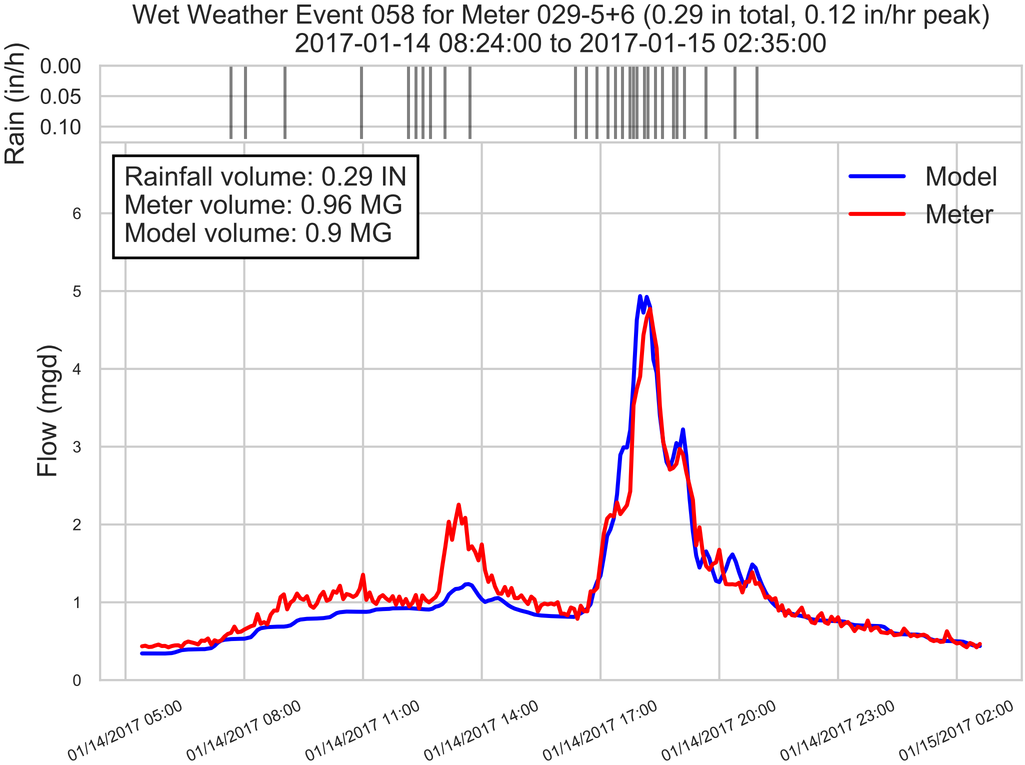

Wet Weather Event 055 for Meter 029-5+6 (0.23 in total, 0.24 in/hr peak)
2016-12-29 04:20:00 to 2016-12-29 14:39:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.23 IN
Meter volume: 0.55 MG
Model volume: 0.57 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
12/29/2016 01:00
12/29/2016 04:00
12/29/2016 07:00
12/29/2016 10:00
12/29/2016 13:00



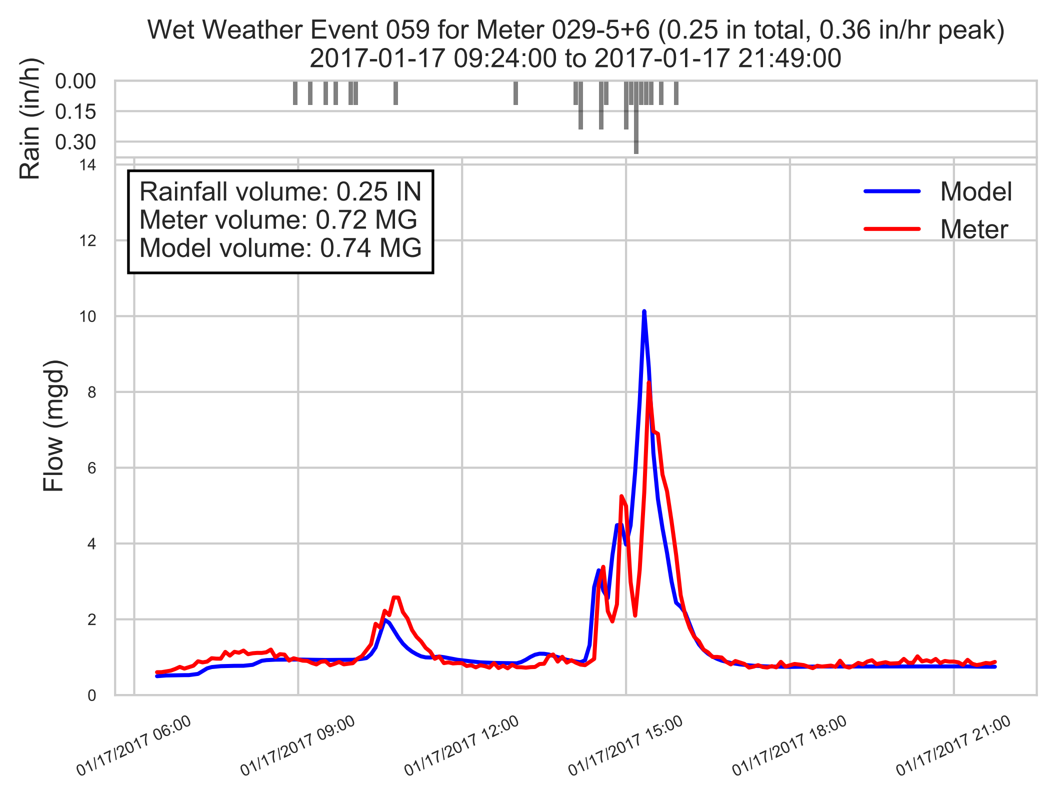
Wet Weather Event 056 for Meter 029-5+6 (0.34 in total, 0.12 in/hr peak)
2017-01-02 01:54:00 to 2017-01-02 22:25:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.34 IN
Meter volume: 0.95 MG
Model volume: 0.89 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
01/01/2017 22:00
01/02/2017 01:00
01/02/2017 04:00
01/02/2017 07:00
01/02/2017 10:00
01/02/2017 13:00
01/02/2017 16:00
01/02/2017 19:00
01/02/2017 22:00



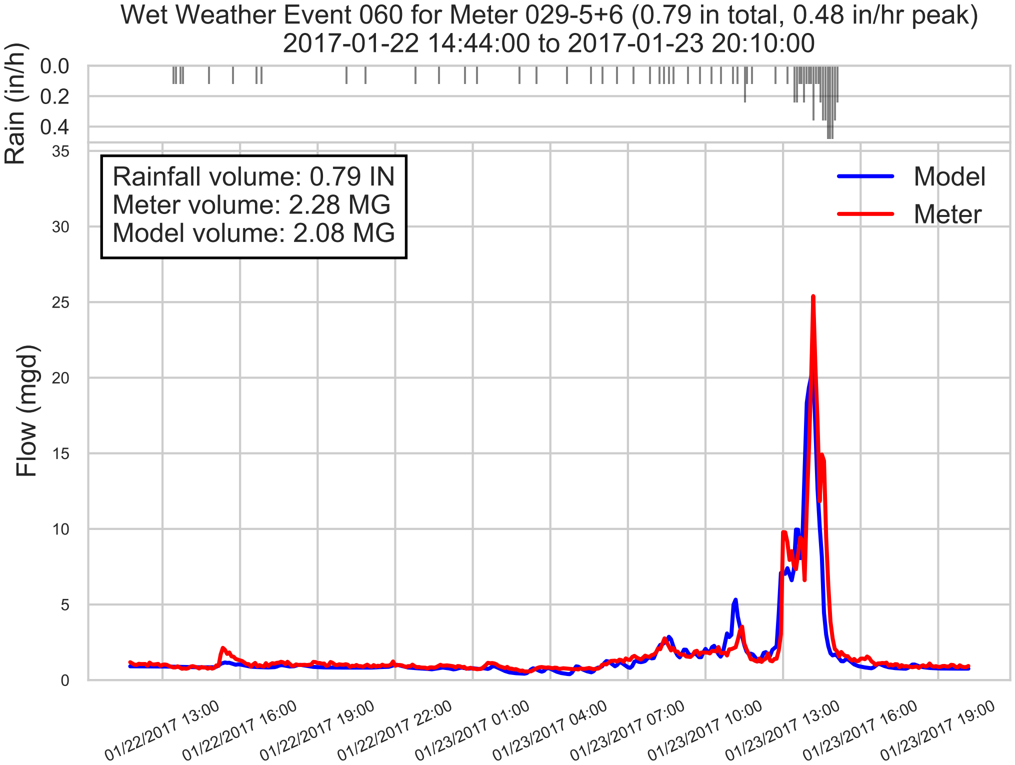
Wet Weather Event 057 for Meter 029-5+6 (0.84 in total, 0.36 in/hr peak)
2017-01-03 00:24:00 to 2017-01-03 18:49:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.84 IN
Meter volume: 2.04 MG
Model volume: 2.03 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
01/02/2017 23:00
01/03/2017 02:00
01/03/2017 05:00
01/03/2017 08:00
01/03/2017 11:00
01/03/2017 14:00
01/03/2017 17:00



Wet Weather Event 058 for Meter 029-5+6 (0.29 in total, 0.12 in/hr peak)
2017-01-14 08:24:00 to 2017-01-15 02:35:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.29 IN
Meter volume: 0.96 MG
Model volume: 0.9 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
01/14/2017 05:00
01/14/2017 08:00
01/14/2017 11:00
01/14/2017 14:00
01/14/2017 17:00
01/14/2017 20:00
01/14/2017 23:00
01/15/2017 02:00



Wet Weather Event 059 for Meter 029-5+6 (0.25 in total, 0.36 in/hr peak)
2017-01-17 09:24:00 to 2017-01-17 21:49:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.25 IN
Meter volume: 0.72 MG
Model volume: 0.74 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
01/17/2017 06:00
01/17/2017 09:00
01/17/2017 12:00
01/17/2017 15:00
01/17/2017 18:00
01/17/2017 21:00



Wet Weather Event 060 for Meter 029-5+6 (0.79 in total, 0.48 in/hr peak)
2017-01-22 14:44:00 to 2017-01-23 20:10:00
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
35
30
25
20
15
10
5
0
Rainfall volume: 0.79 IN
Meter volume: 2.28 MG
Model volume: 2.08 MG
Model
Meter
01/22/2017 13:00
01/22/2017 16:00
01/22/2017 19:00
01/22/2017 22:00
01/23/2017 01:00
01/23/2017 04:00
01/23/2017 07:00
01/23/2017 10:00
01/23/2017 13:00
01/23/2017 16:00
01/23/2017 19:00

Appendix B: Monitoring Timeseries for Entire Pre-Construction Metering Time Period

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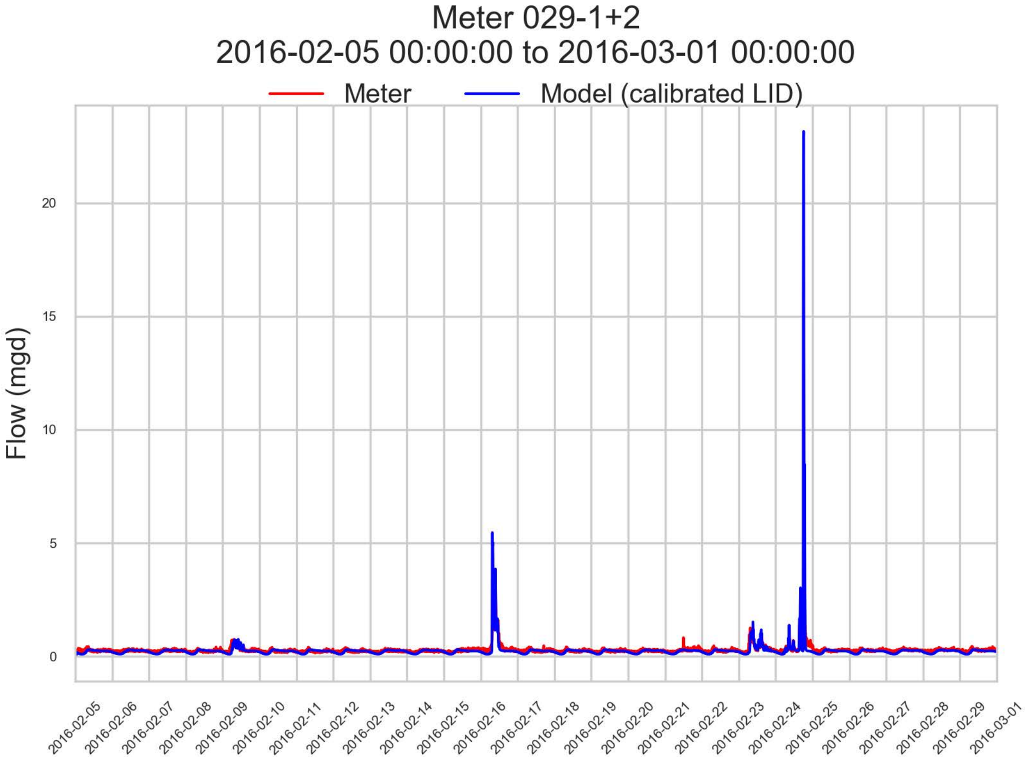
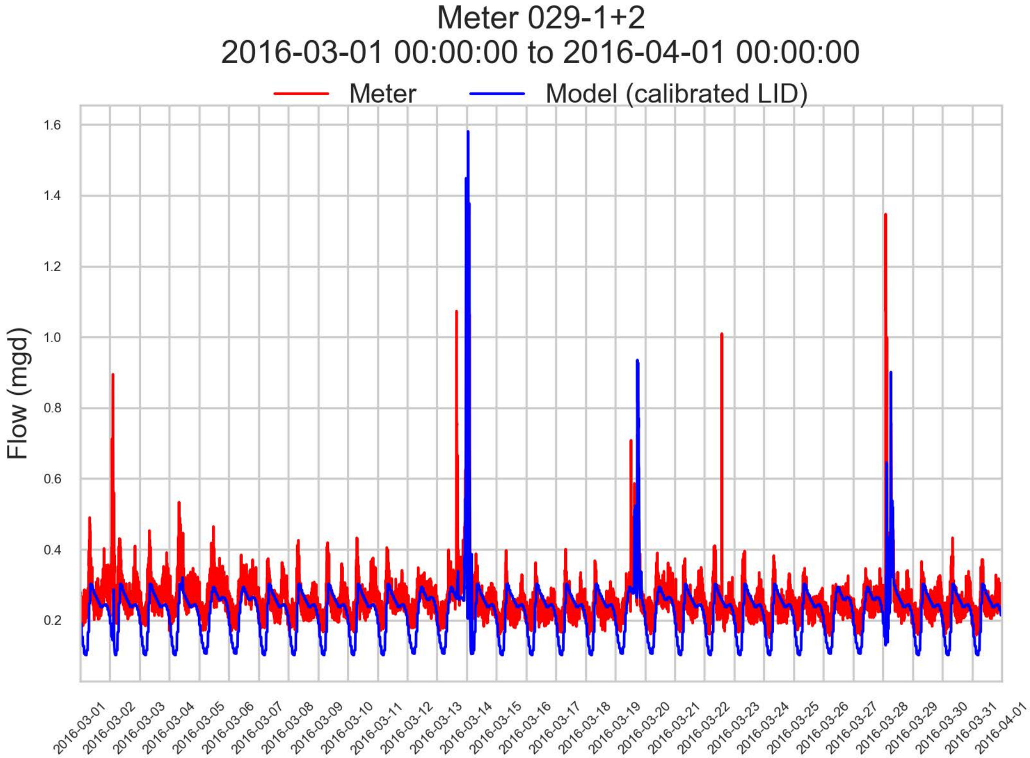
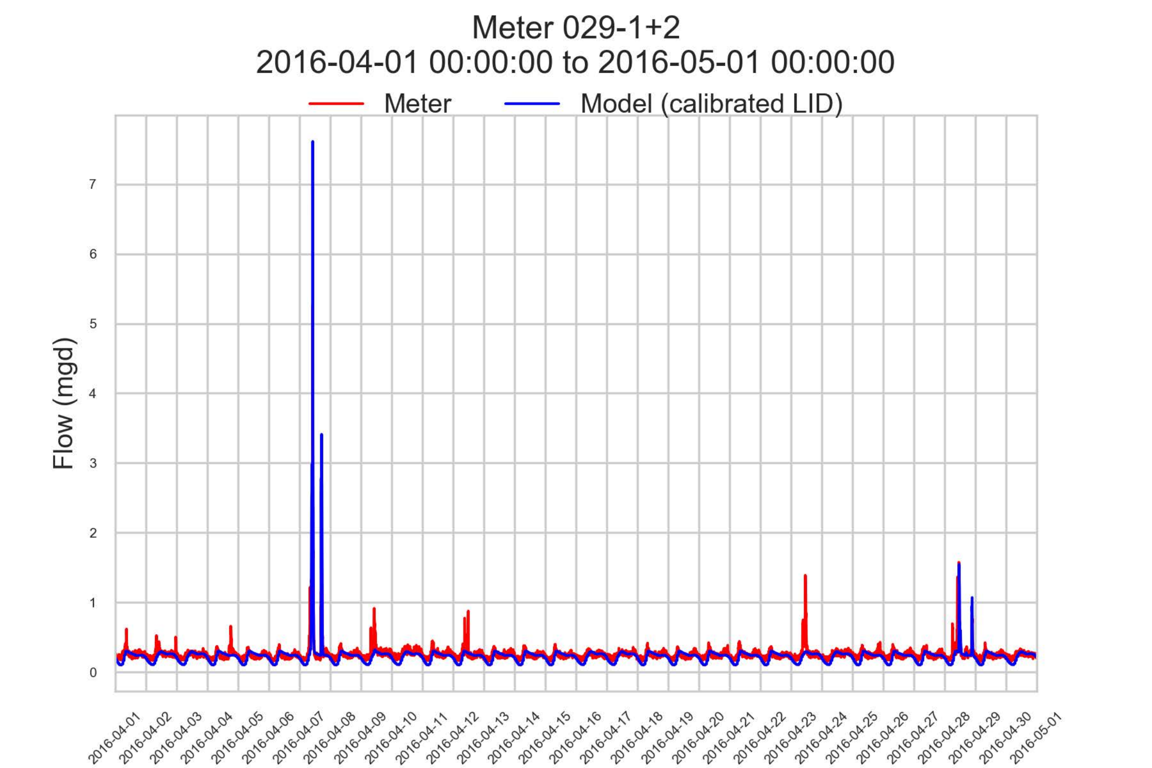
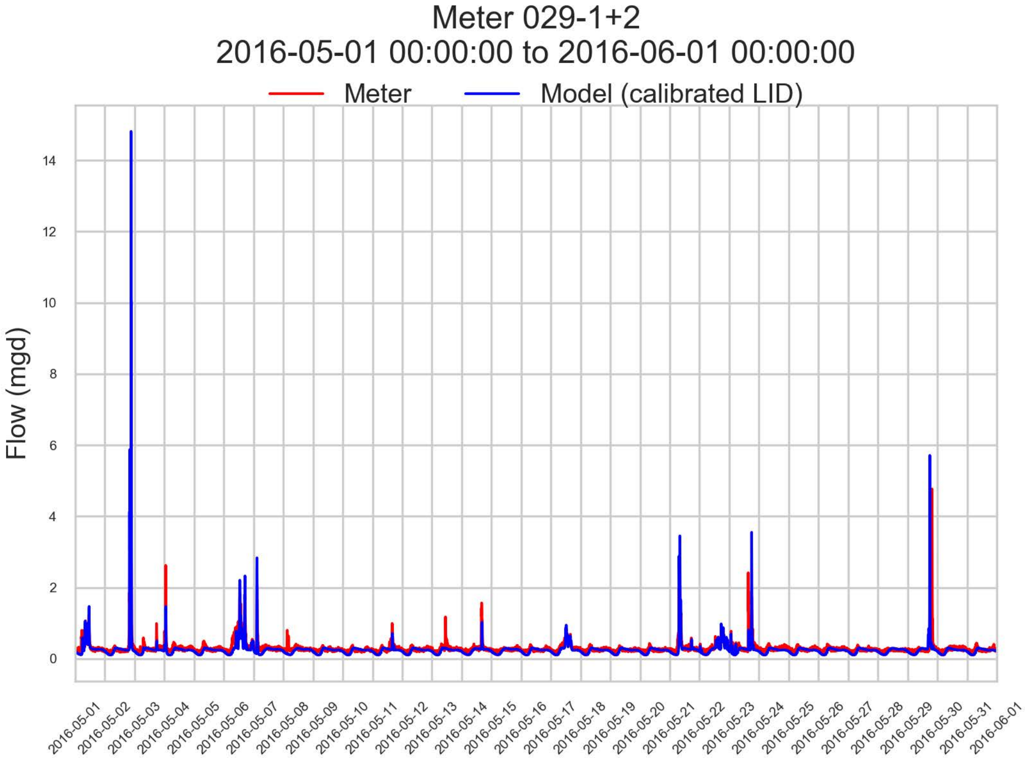

Meter 029-1+2
2016-02-05 00:00:00 to 2016-03-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
2016-02-05
2016-02-06
2016-02-07
2016-02-08
2016-02-09
2016-02-10
2016-02-11
2016-02-12
2016-02-13
2016-02-14
2016-02-15
2016-02-16
2016-02-17
2016-02-18
2016-02-19
2016-02-20
2016-02-21
2016-02-22
2016-02-23
2016-02-24
2016-02-25
2016-02-26
2016-02-27
2016-02-28
2016-02-29
2016-03-01



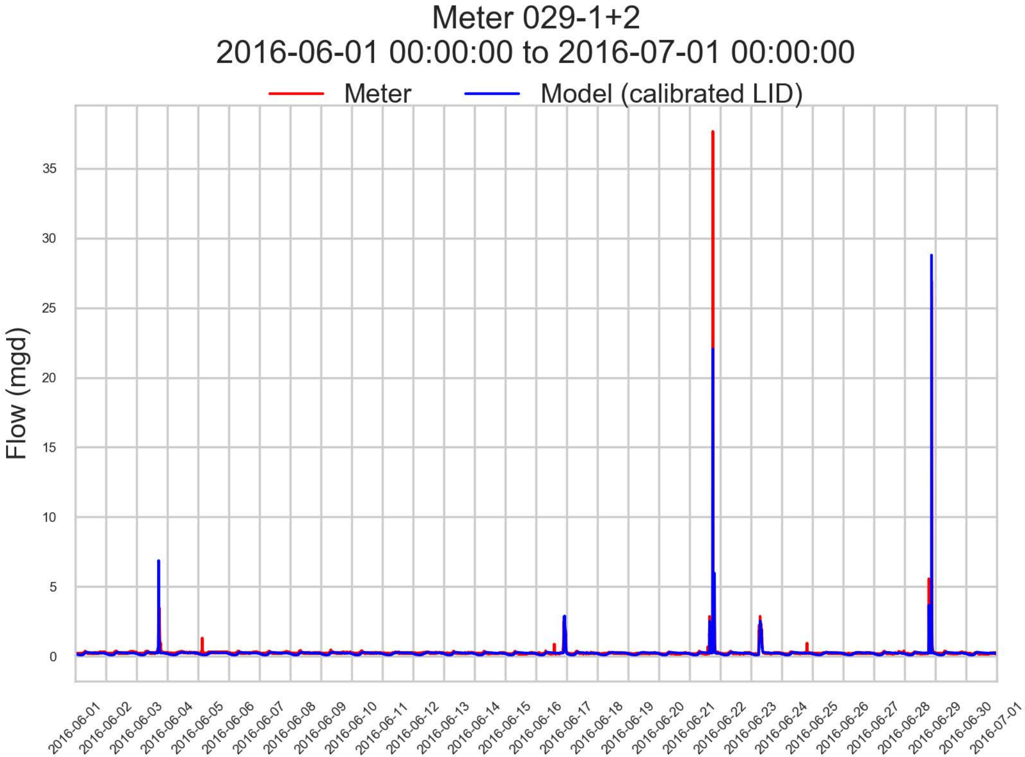
Meter 029-1+2
2016-03-01 00:00:00 to 2016-04-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
2016-03-01
2016-03-02
2016-03-03
2016-03-04
2016-03-05
2016-03-06
2016-03-07
2016-03-08
2016-03-09
2016-03-10
2016-03-11
2016-03-12
2016-03-13
2016-03-14
2016-03-15
2016-03-16
2016-03-17
2016-03-18
2016-03-19
2016-03-20
2016-03-21
2016-03-22
2016-03-23
2016-03-24
2016-03-25
2016-03-26
2016-03-27
2016-03-28
2016-03-29
2016-03-30
2016-03-31
2016-04-01



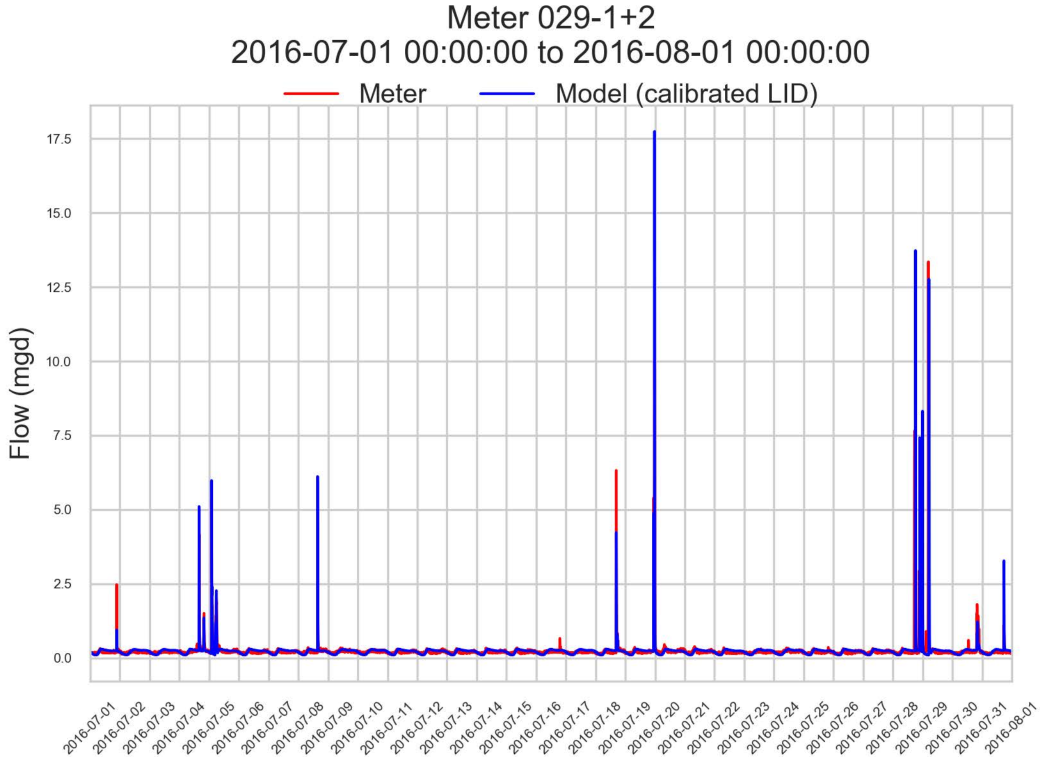
Meter 029-1+2
2016-04-01 00:00:00 to 2016-05-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
7
2016-04-01
2016-04-02
2016-04-03
2016-04-04
2016-04-05
2016-04-06
2016-04-07
2016-04-08
2016-04-09
2016-04-10
2016-04-11
2016-04-12
2016-04-13
2016-04-14
2016-04-15
2016-04-16
2016-04-17
2016-04-18
2016-04-19
2016-04-20
2016-04-21
2016-04-22
2016-04-23
2016-04-24
2016-04-25
2016-04-26
2016-04-27
2016-04-28
2016-04-29
2016-04-30
2016-05-01



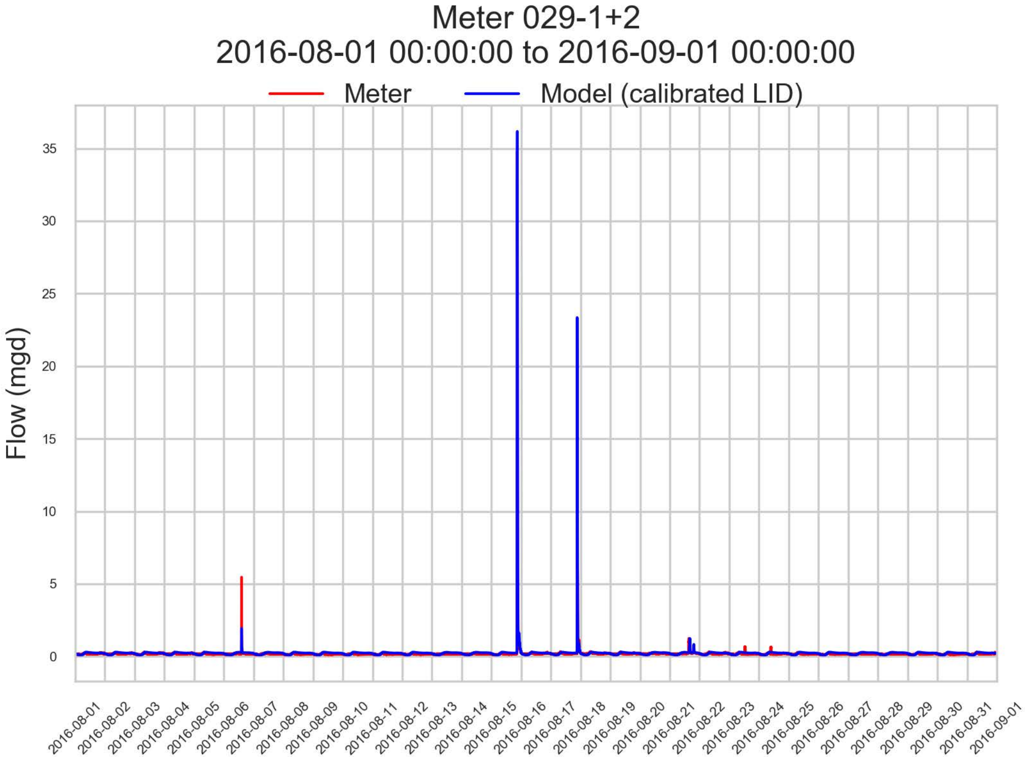
Meter 029-1+2
2016-05-01 00:00:00 to 2016-06-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
14
2016-05-01
2016-05-02
2016-05-03
2016-05-04
2016-05-05
2016-05-06
2016-05-07
2016-05-08
2016-05-09
2016-05-10
2016-05-11
2016-05-12
2016-05-13
2016-05-14
2016-05-15
2016-05-16
2016-05-17
2016-05-18
2016-05-19
2016-05-20
2016-05-21
2016-05-22
2016-05-23
2016-05-24
2016-05-25
2016-05-26
2016-05-27
2016-05-28
2016-05-29
2016-05-30
2016-05-31
2016-06-01



Meter 029-1+2
2016-06-01 00:00:00 to 2016-07-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
30
35
2016-06-01
2016-06-02
2016-06-03
2016-06-04
2016-06-05
2016-06-06
2016-06-07
2016-06-08
2016-06-09
2016-06-10
2016-06-11
2016-06-12
2016-06-13
2016-06-14
2016-06-15
2016-06-16
2016-06-17
2016-06-18
2016-06-19
2016-06-20
2016-06-21
2016-06-22
2016-06-23
2016-06-24
2016-06-25
2016-06-26
2016-06-27
2016-06-28
2016-06-29
2016-06-30
2016-07-01



Meter 029-1+2
2016-07-01 00:00:00 to 2016-08-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2016-07-01
2016-07-02
2016-07-03
2016-07-04
2016-07-05
2016-07-06
2016-07-07
2016-07-08
2016-07-09
2016-07-10
2016-07-11
2016-07-12
2016-07-13
2016-07-14
2016-07-15
2016-07-16
2016-07-17
2016-07-18
2016-07-19
2016-07-20
2016-07-21
2016-07-22
2016-07-23
2016-07-24
2016-07-25
2016-07-26
2016-07-27
2016-07-28
2016-07-29
2016-07-30
2016-07-31
2016-08-01


Meter 029-1+2
2016-08-01 00:00:00 to 2016-09-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
30
35
2016-08-01
2016-08-02
2016-08-03
2016-08-04
2016-08-05
2016-08-06
2016-08-07
2016-08-08
2016-08-09
2016-08-10
2016-08-11
2016-08-12
2016-08-13
2016-08-14
2016-08-15
2016-08-16
2016-08-17
2016-08-18
2016-08-19
2016-08-20
2016-08-21
2016-08-22
2016-08-23
2016-08-24
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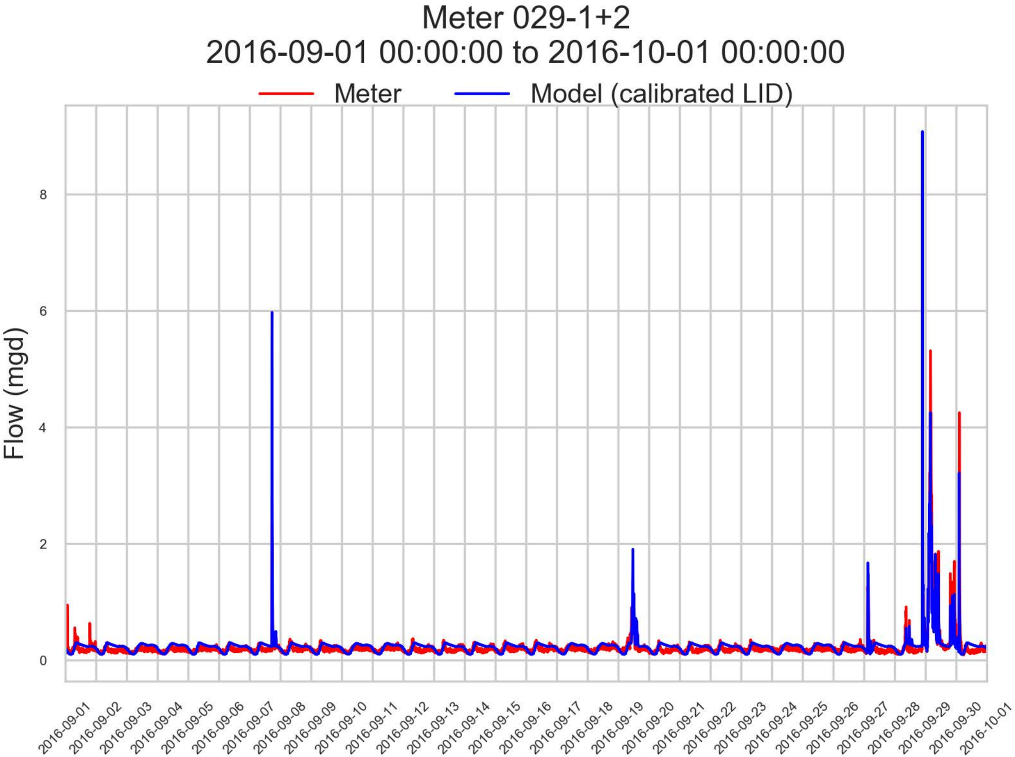
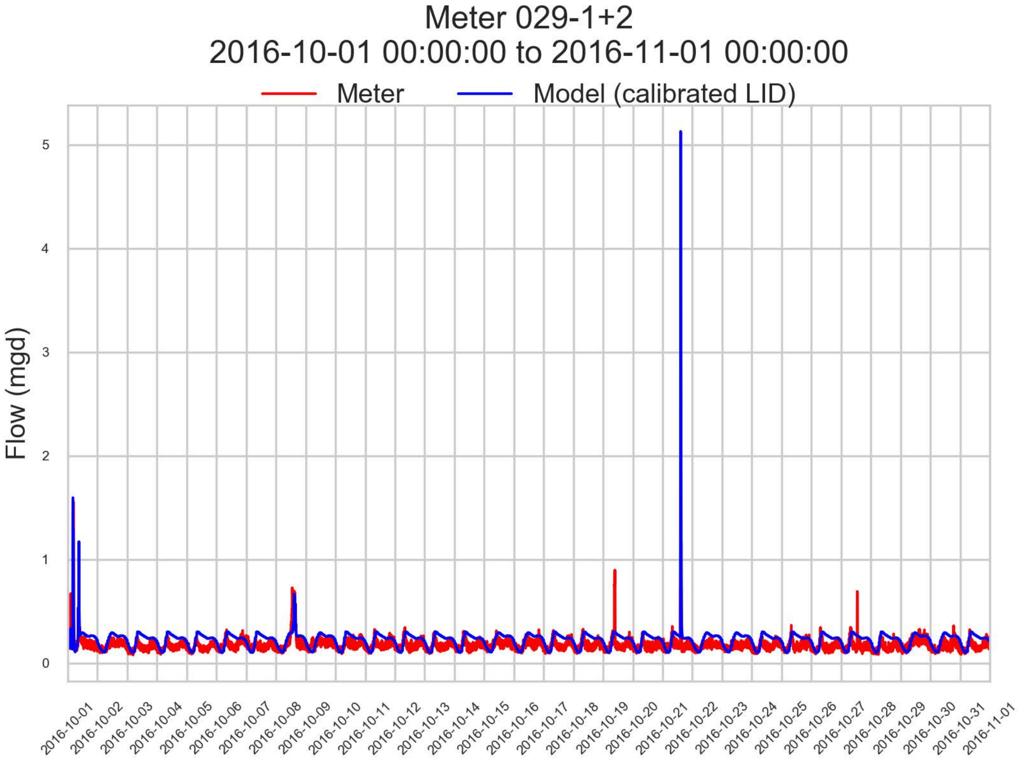
2016-08-26
2016-08-27
2016-08-28
2016-08-29
2016-08-30
2016-08-31
2016-09-01



Meter 029-1+2
2016-09-01 00:00:00 to 2016-10-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
2016-09-01
2016-09-02
2016-09-03
2016-09-04
2016-09-05
2016-09-06
2016-09-07
2016-09-08
2016-09-09
2016-09-10
2016-09-11
2016-09-12
2016-09-13
2016-09-14
2016-09-15
2016-09-16
2016-09-17
2016-09-18
2016-09-19
2016-09-20
2016-09-21
2016-09-22
2016-09-23
2016-09-24
2016-09-25
2016-09-26
2016-09-27
2016-09-28
2016-09-29
2016-09-30
2016-10-01



Meter 029-1+2
2016-10-01 00:00:00 to 2016-11-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
2016-10-01
2016-10-02
2016-10-03
2016-10-04
2016-10-05
2016-10-06
2016-10-07
2016-10-08
2016-10-09
2016-10-10
2016-10-11
2016-10-12
2016-10-13
2016-10-14
2016-10-15
2016-10-16
2016-10-17
2016-10-18
2016-10-19
2016-10-20
2016-10-21
2016-10-22
2016-10-23
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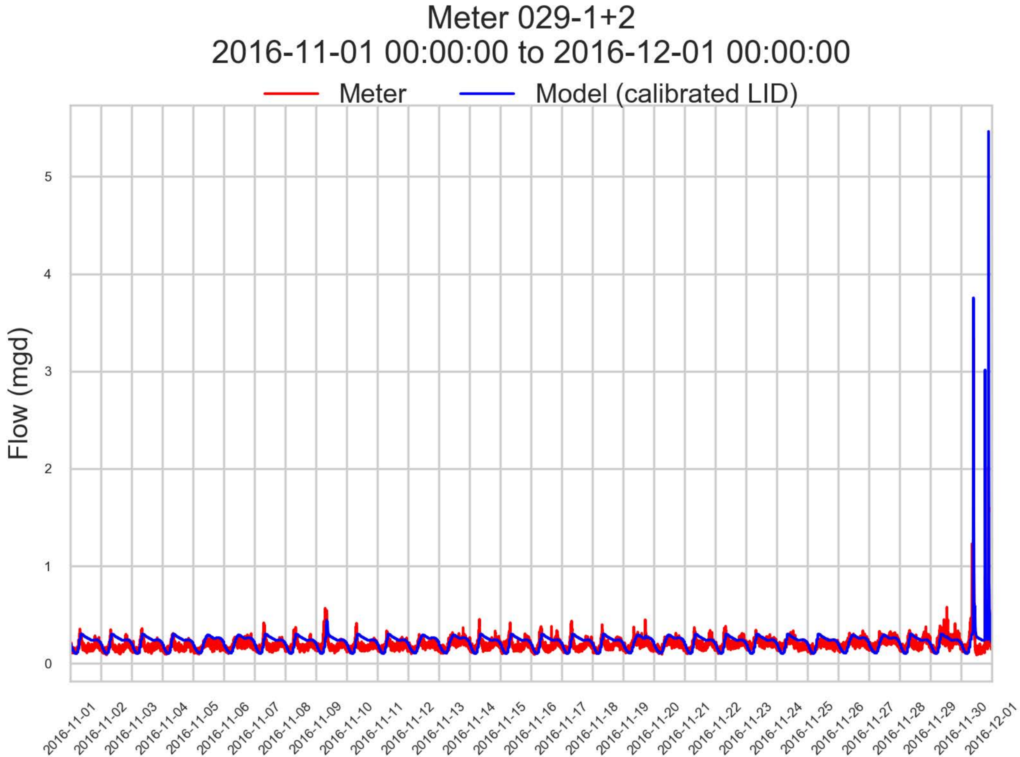
2016-10-28
2016-10-29
2016-10-30
2016-10-31
2016-11-01



Meter 029-1+2
2016-11-01 00:00:00 to 2016-12-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
2016-11-01
2016-11-02
2016-11-03
2016-11-04
2016-11-05
2016-11-06
2016-11-07
2016-11-08
2016-11-09
2016-11-10
2016-11-11
2016-11-12
2016-11-13
2016-11-14
2016-11-15
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2016-11-17
2016-11-18
2016-11-19
2016-11-20
2016-11-21
2016-11-22
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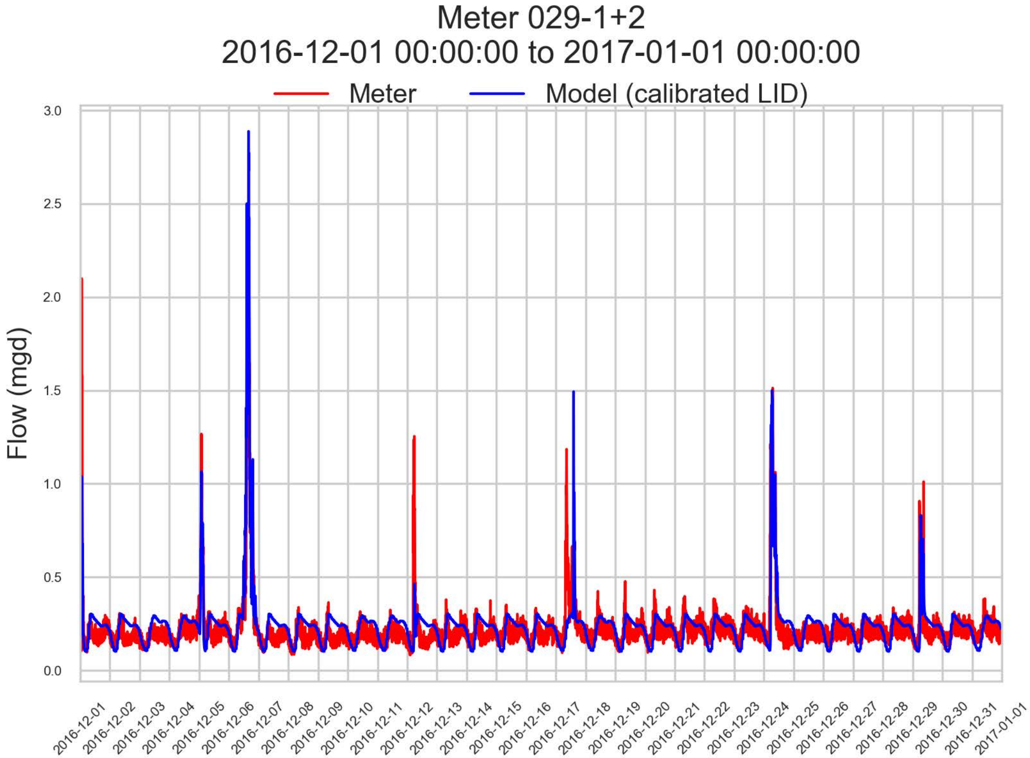
2016-11-29
2016-11-30
2016-12-01



Meter 029-1+2
2016-12-01 00:00:00 to 2017-01-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
2016-12-01
2016-12-02
2016-12-03
2016-12-04
2016-12-05
2016-12-06
2016-12-07
2016-12-08
2016-12-09
2016-12-10
2016-12-11
2016-12-12
2016-12-13
2016-12-14
2016-12-15
2016-12-16
2016-12-17
2016-12-18
2016-12-19
2016-12-20
2016-12-21
2016-12-22
2016-12-23
2016-12-24
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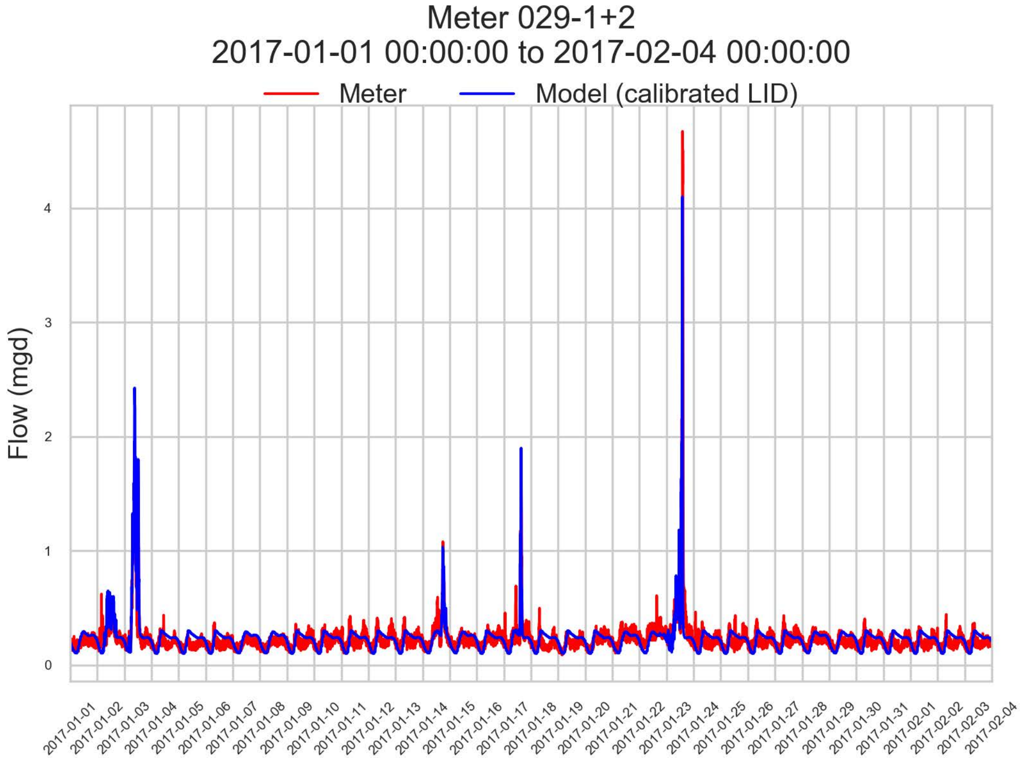
2016-12-30
2016-12-31
2017-01-01


Meter 029-1+2
2017-01-01 00:00:00 to 2017-02-04 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
2017-01-01
2017-01-02
2017-01-03
2017-01-04
2017-01-05
2017-01-06
2017-01-07
2017-01-08
2017-01-09
2017-01-10
2017-01-11
2017-01-12
2017-01-13
2017-01-14
2017-01-15
2017-01-16
2017-01-17
2017-01-18
2017-01-19
2017-01-20
2017-01-21
2017-01-22
2017-01-23
2017-01-24
2017-01-25
2017-01-26
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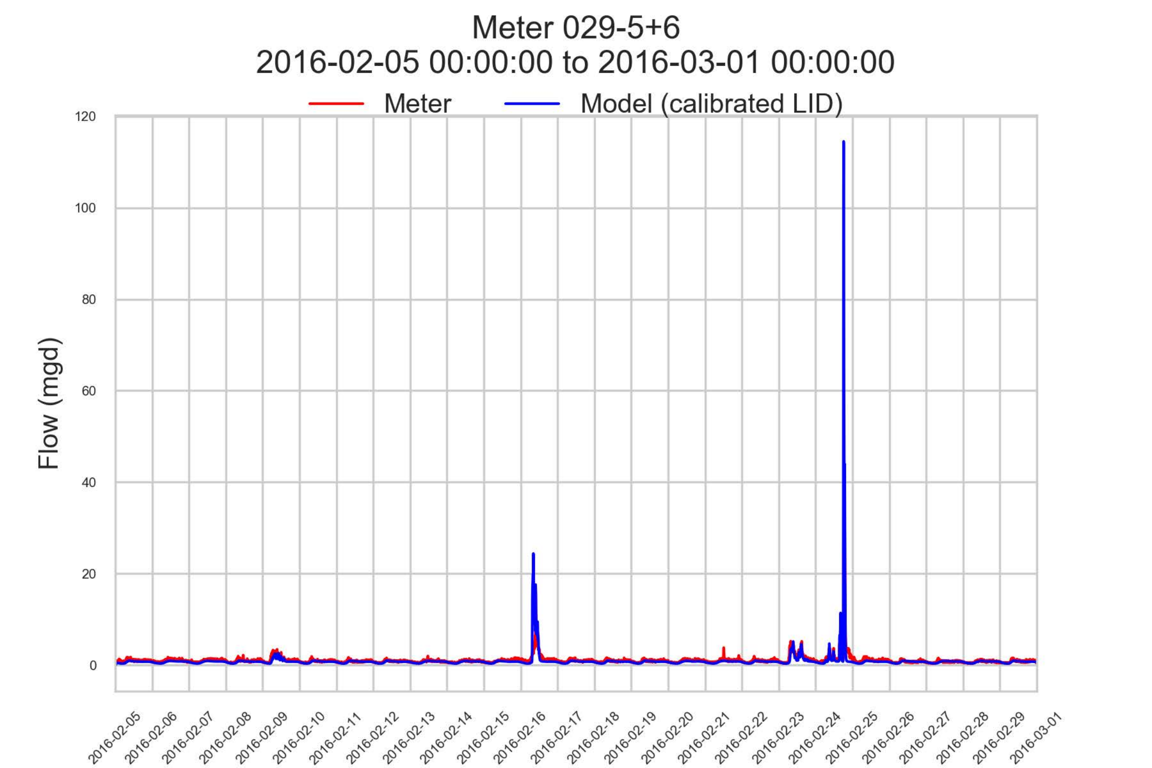
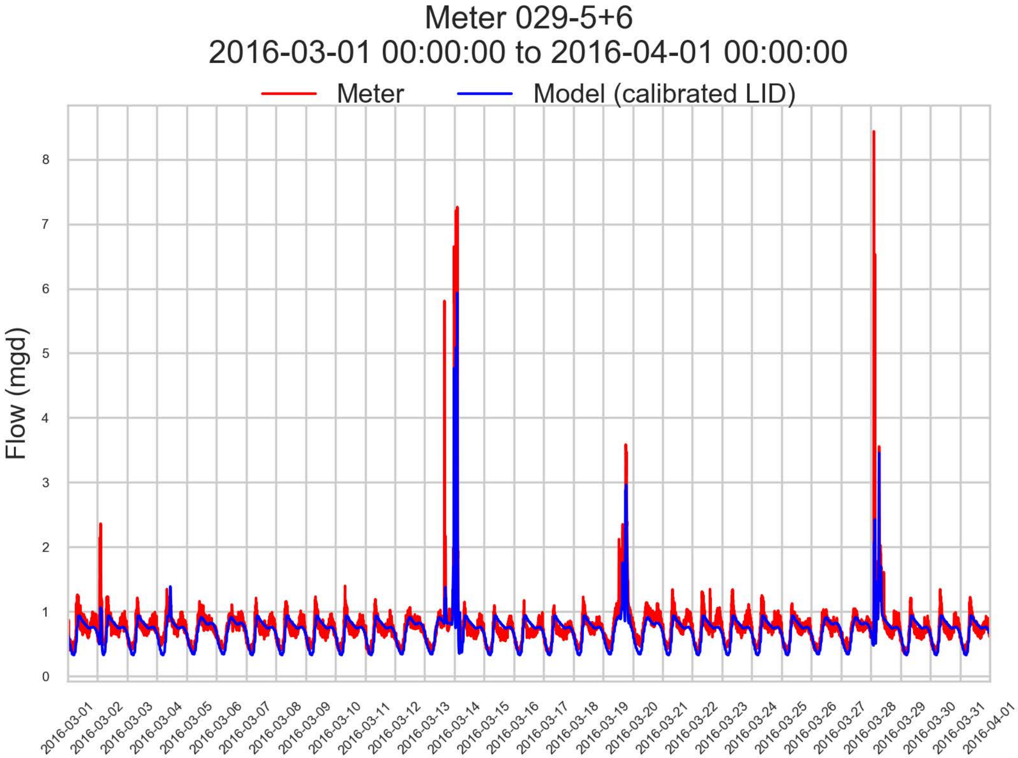
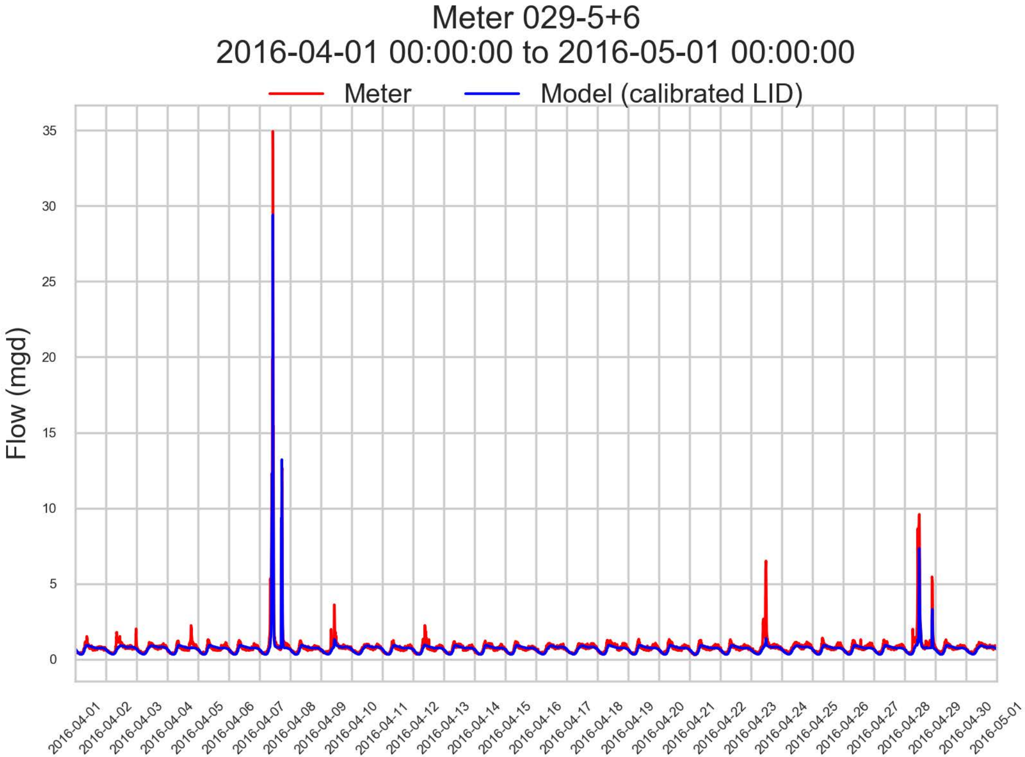
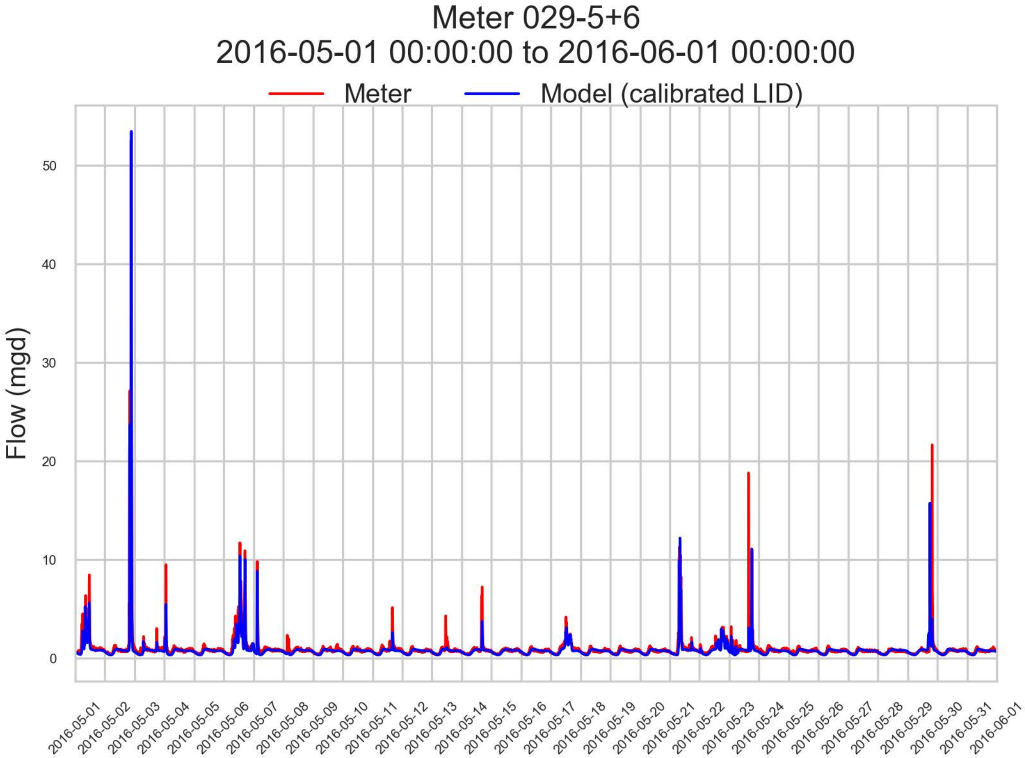
2017-01-30
2017-01-31
2017-02-01
2017-02-02
2017-02-03
2017-02-04

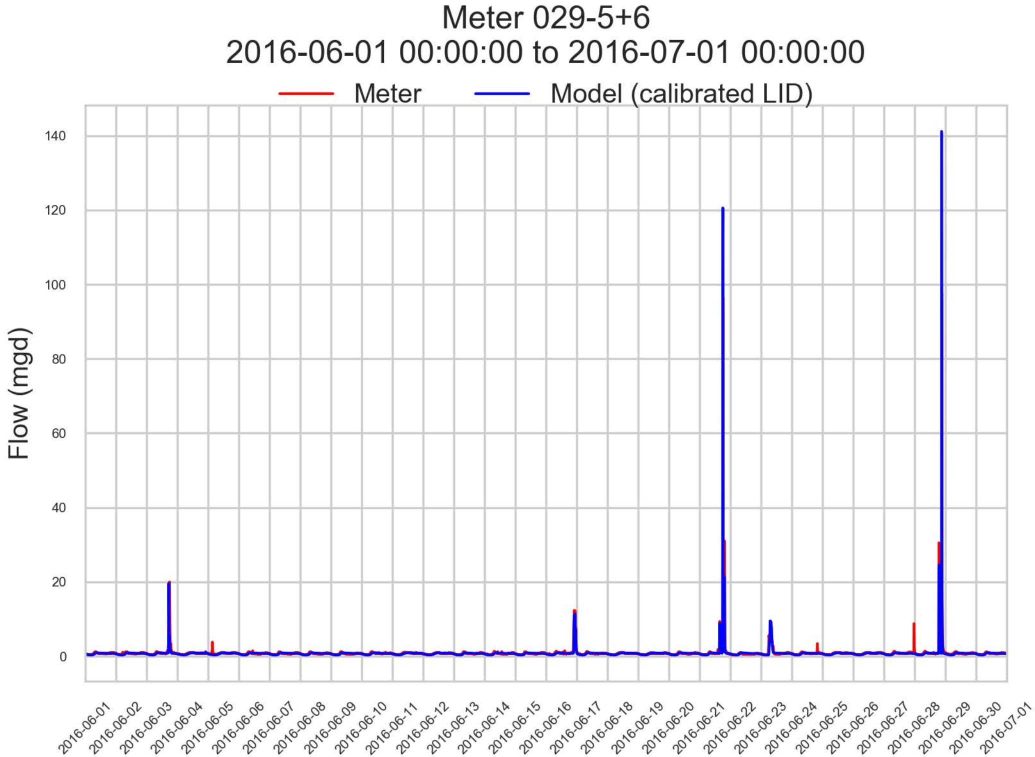


Meter 029-5+6
2016-02-05 00:00:00 to 2016-03-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
20
40
60
80
100
120
2016-02-05
2016-02-06
2016-02-07
2016-02-08
2016-02-09
2016-02-10
2016-02-11
2016-02-12
2016-02-13
2016-02-14
2016-02-15
2016-02-16
2016-02-17
2016-02-18
2016-02-19
2016-02-20
2016-02-21
2016-02-22
2016-02-23
2016-02-24
2016-02-25
2016-02-26
2016-02-27
2016-02-28
2016-02-29
2016-03-01


Meter 029-5+6
2016-03-01 00:00:00 to 2016-04-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
7
8
2016-03-01
2016-03-02
2016-03-03
2016-03-04
2016-03-05
2016-03-06
2016-03-07
2016-03-08
2016-03-09
2016-03-10
2016-03-11
2016-03-12
2016-03-13
2016-03-14
2016-03-15
2016-03-16
2016-03-17
2016-03-18
2016-03-19
2016-03-20
2016-03-21
2016-03-22
2016-03-23
2016-03-24
2016-03-25
2016-03-26
2016-03-27
2016-03-28
2016-03-29
2016-03-30
2016-03-31
2016-04-01


Meter 029-5+6
2016-04-01 00:00:00 to 2016-05-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
35
30
25
20
15
10
5
0
2016-04-01
2016-04-02
2016-04-03
2016-04-04
2016-04-05
2016-04-06
2016-04-07
2016-04-08
2016-04-09
2016-04-10
2016-04-11
2016-04-12
2016-04-13
2016-04-14
2016-04-15
2016-04-16
2016-04-17
2016-04-18
2016-04-19
2016-04-20
2016-04-21
2016-04-22
2016-04-23
2016-04-24
2016-04-25
2016-04-26
2016-04-27
2016-04-28
2016-04-29
2016-04-30
2016-05-01


Meter 029-5+6
2016-05-01 00:00:00 to 2016-06-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
10
20
30
40
50
2016-05-01
2016-05-02
2016-05-03
2016-05-04
2016-05-05
2016-05-06
2016-05-07
2016-05-08
2016-05-09
2016-05-10
2016-05-11
2016-05-12
2016-05-13
2016-05-14
2016-05-15
2016-05-16
2016-05-17
2016-05-18
2016-05-19
2016-05-20
2016-05-21
2016-05-22
2016-05-23
2016-05-24
2016-05-25
2016-05-26
2016-05-27
2016-05-28
2016-05-29
2016-05-30
2016-05-31
2016-06-01



Meter 029-5+6
2016-06-01 00:00:00 to 2016-07-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
20
40
60
80
100
120
140
2016-06-01
2016-06-02
2016-06-03
2016-06-04
2016-06-05
2016-06-06
2016-06-07
2016-06-08
2016-06-09
2016-06-10
2016-06-11
2016-06-12
2016-06-13
2016-06-14
2016-06-15
2016-06-16
2016-06-17
2016-06-18
2016-06-19
2016-06-20
2016-06-21
2016-06-22
2016-06-23
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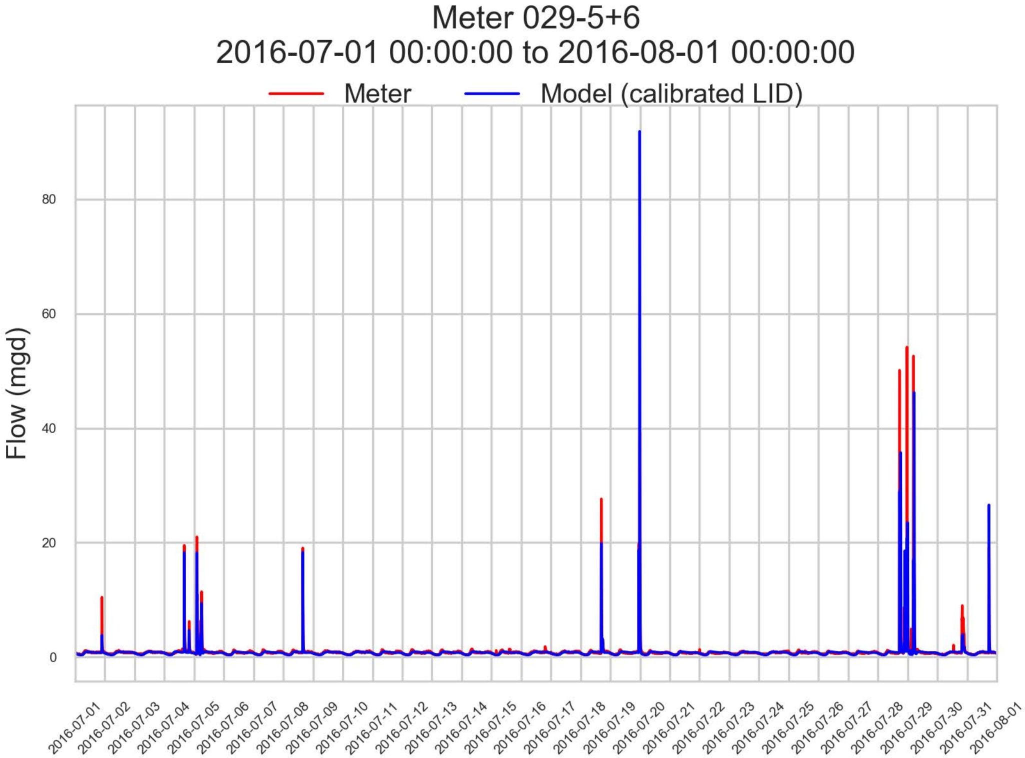
2016-06-29
2016-06-30
2016-07-01


Meter 029-5+6
2016-07-01 00:00:00 to 2016-08-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
20
40
60
80
2016-07-01
2016-07-02
2016-07-03
2016-07-04
2016-07-05
2016-07-06
2016-07-07
2016-07-08
2016-07-09
2016-07-10
2016-07-11
2016-07-12
2016-07-13
2016-07-14
2016-07-15
2016-07-16
2016-07-17
2016-07-18
2016-07-19
2016-07-20
2016-07-21
2016-07-22
2016-07-23
2016-07-24
2016-07-25
2016-07-26
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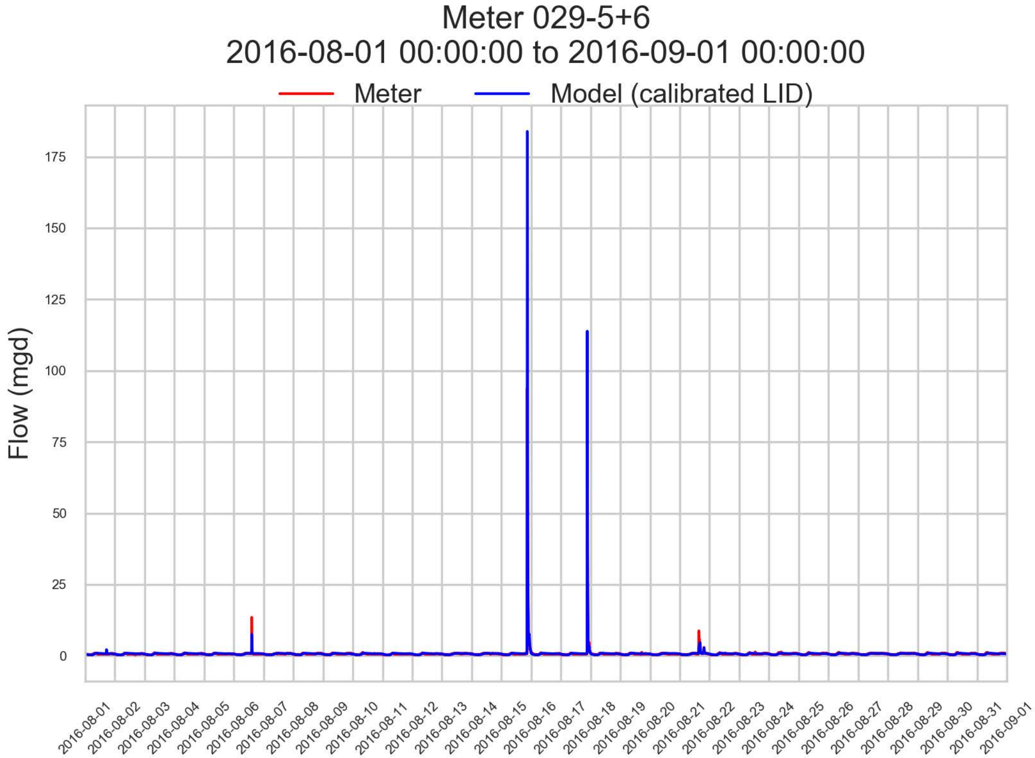
2016-07-28
2016-07-29
2016-07-30
2016-07-31
2016-08-01



Meter 029-5+6
2016-08-01 00:00:00 to 2016-09-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
175
150
125
100
75
50
25
0
2016-08-01
2016-08-02
2016-08-03
2016-08-04
2016-08-05
2016-08-06
2016-08-07
2016-08-08
2016-08-09
2016-08-10
2016-08-11
2016-08-12
2016-08-13
2016-08-14
2016-08-15
2016-08-16
2016-08-17
2016-08-18
2016-08-19
2016-08-20
2016-08-21
2016-08-22
2016-08-23
2016-08-24
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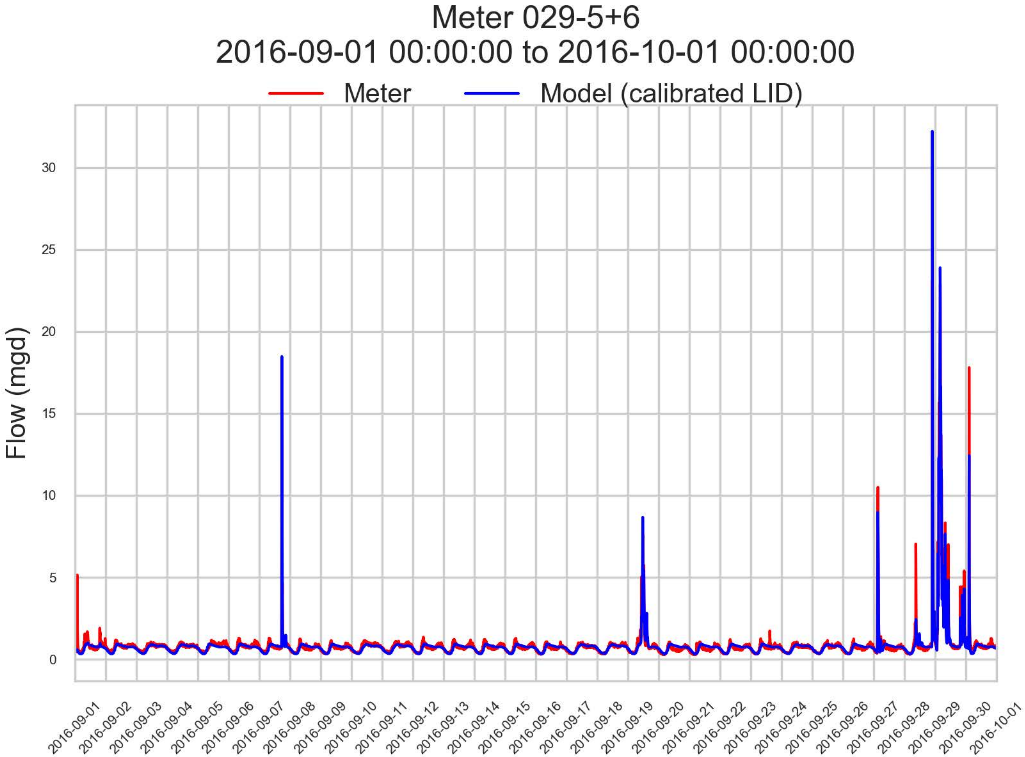
2016-08-26
2016-08-27
2016-08-28
2016-08-29
2016-08-30
2016-08-31
2016-09-01


Meter 029-5+6
2016-09-01 00:00:00 to 2016-10-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
30
2016-09-01
2016-09-02
2016-09-03
2016-09-04
2016-09-05
2016-09-06
2016-09-07
2016-09-08
2016-09-09
2016-09-10
2016-09-11
2016-09-12
2016-09-13
2016-09-14
2016-09-15
2016-09-16
2016-09-17
2016-09-18
2016-09-19
2016-09-20
2016-09-21
2016-09-22
2016-09-23
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2016-09-26
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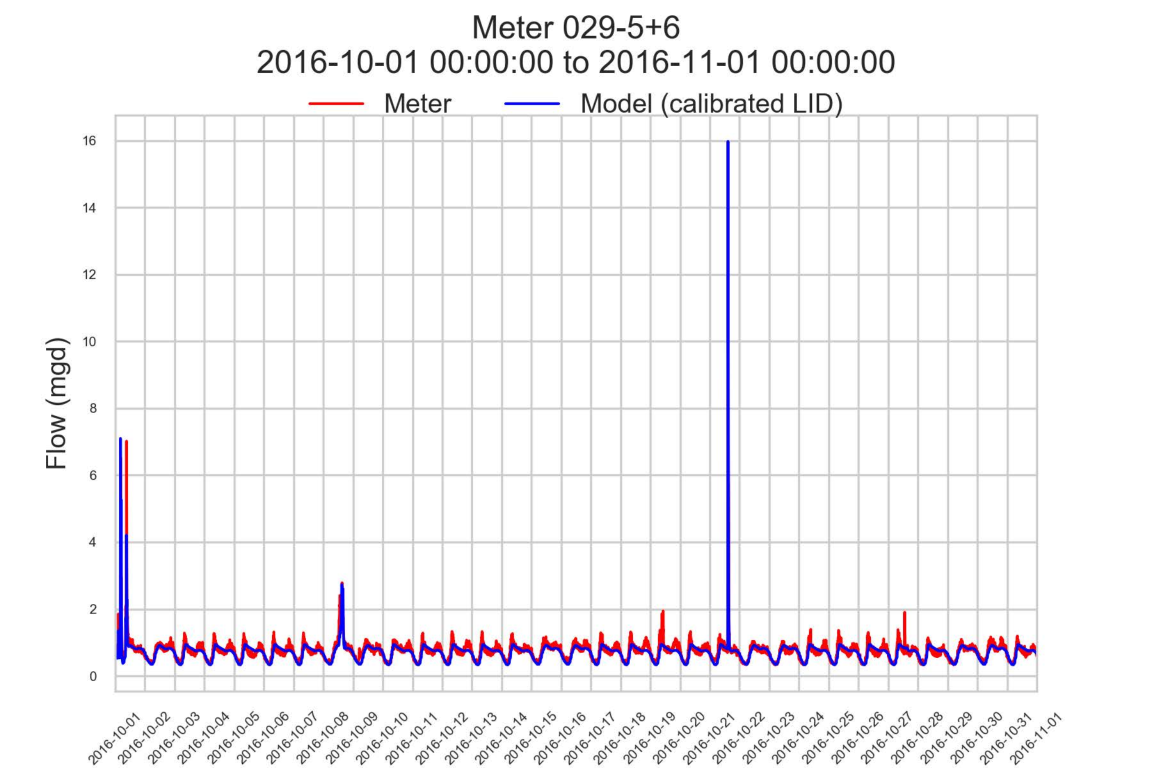
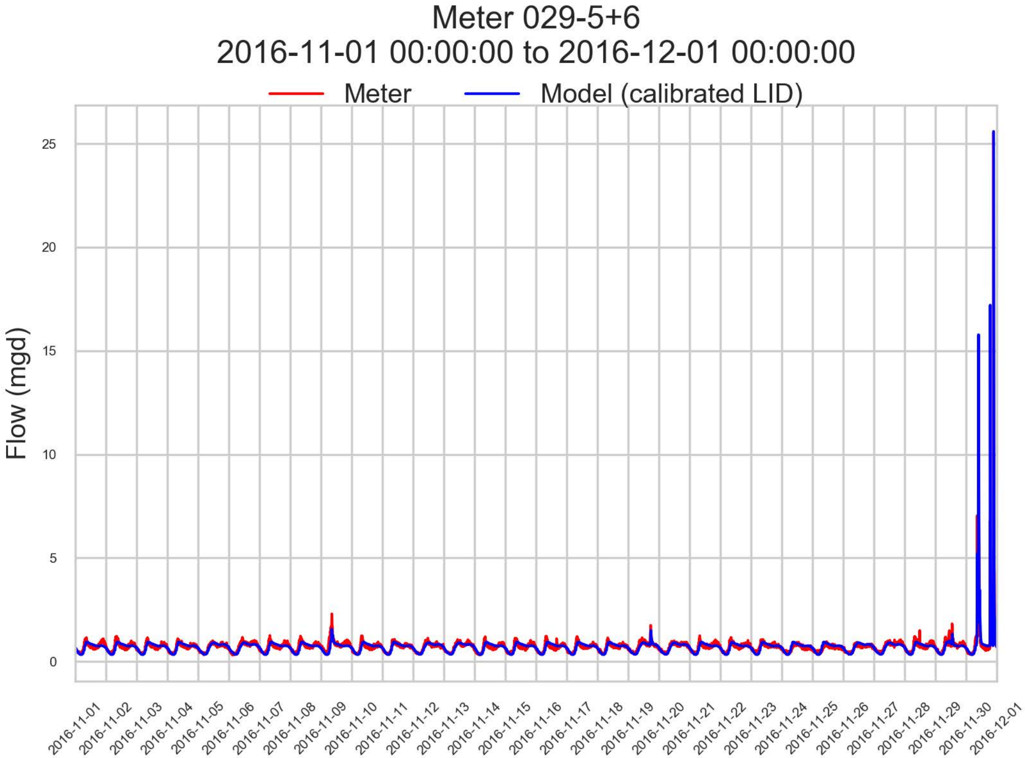
2016-09-29
2016-09-30
2016-10-01


Meter 029-5+6
2016-10-01 00:00:00 to 2016-11-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
14
16
2016-10-01
2016-10-02
2016-10-03
2016-10-04
2016-10-05
2016-10-06
2016-10-07
2016-10-08
2016-10-09
2016-10-10
2016-10-11
2016-10-12
2016-10-13
2016-10-14
2016-10-15
2016-10-16
2016-10-17
2016-10-18
2016-10-19
2016-10-20
2016-10-21
2016-10-22
2016-10-23
2016-10-24
2016-10-25
2016-10-26
2016-10-27
2016-10-28
2016-10-29
2016-10-30
2016-10-31
2016-11-01


Meter 029-5+6
2016-11-01 00:00:00 to 2016-12-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
2016-11-01
2016-11-02
2016-11-03
2016-11-04
2016-11-05
2016-11-06
2016-11-07
2016-11-08
2016-11-09
2016-11-10
2016-11-11
2016-11-12
2016-11-13
2016-11-14
2016-11-15
2016-11-16
2016-11-17
2016-11-18
2016-11-19
2016-11-20
2016-11-21
2016-11-22
2016-11-23
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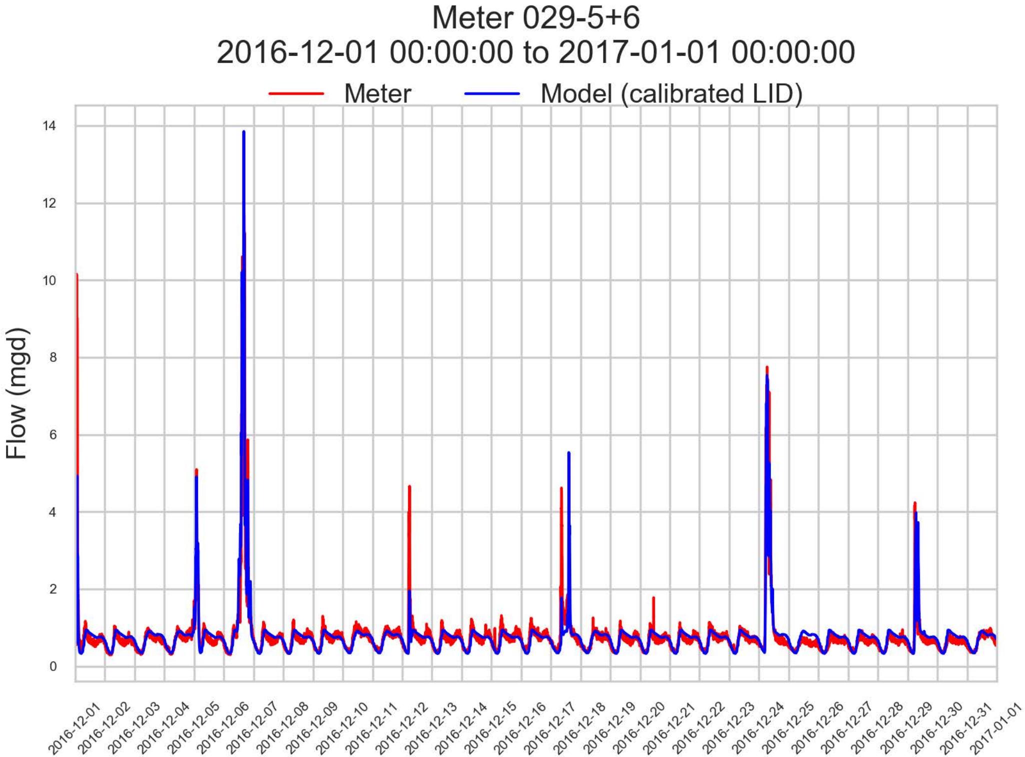
2016-11-28
2016-11-29
2016-11-30
2016-12-01



Meter 029-5+6
2016-12-01 00:00:00 to 2017-01-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
14
12
10
8
6
4
2
0
2016-12-01
2016-12-02
2016-12-03
2016-12-04
2016-12-05
2016-12-06
2016-12-07
2016-12-08
2016-12-09
2016-12-10
2016-12-11
2016-12-12
2016-12-13
2016-12-14
2016-12-15
2016-12-16
2016-12-17
2016-12-18
2016-12-19
2016-12-20
2016-12-21
2016-12-22
2016-12-23
2016-12-24
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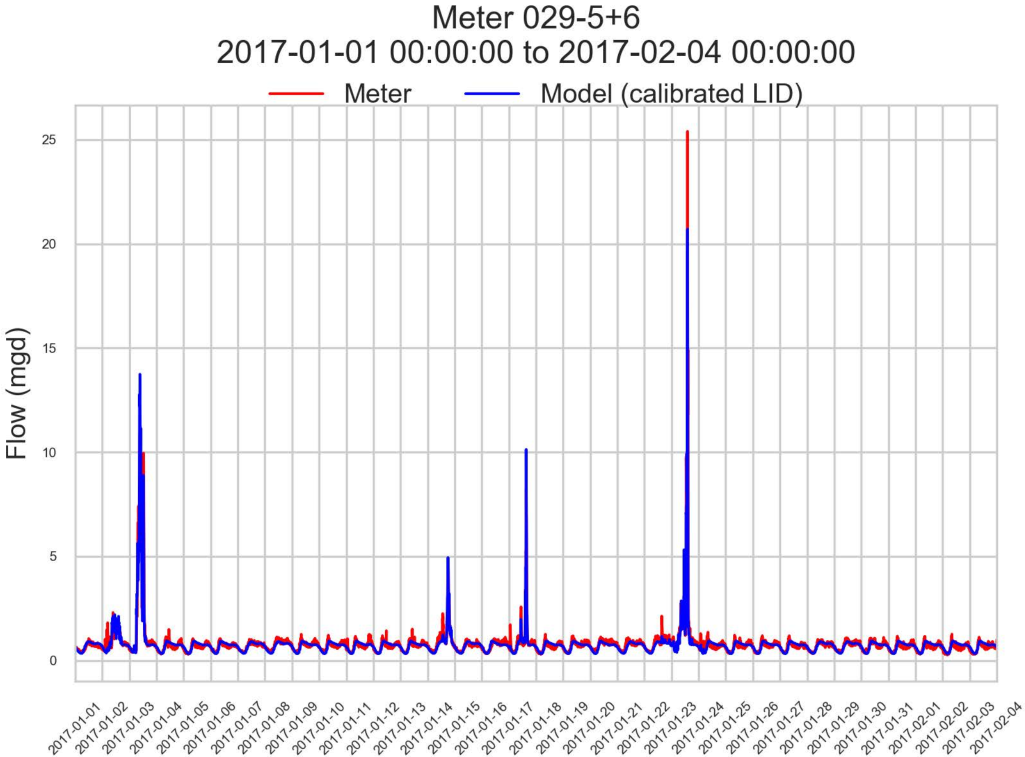
2016-12-26
2016-12-27
2016-12-28
2016-12-29
2016-12-30
2016-12-31
2017-01-01



Meter 029-5+6
2017-01-01 00:00:00 to 2017-02-04 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
2017-01-01
2017-01-02
2017-01-03
2017-01-04
2017-01-05
2017-01-06
2017-01-07
2017-01-08
2017-01-09
2017-01-10
2017-01-11
2017-01-12
2017-01-13
2017-01-14
2017-01-15
2017-01-16
2017-01-17
2017-01-18
2017-01-19
2017-01-20
2017-01-21
2017-01-22
2017-01-23
2017-01-24
2017-01-25
2017-01-26
2017-01-27
2017-01-28
2017-01-29
2017-01-30
2017-01-31
2017-02-01
2017-02-02
2017-02-03
2017-02-04

Appendix C: Post-Construction Event Hydrographs

(Note: The y-axis varies in scale between the individual plots)

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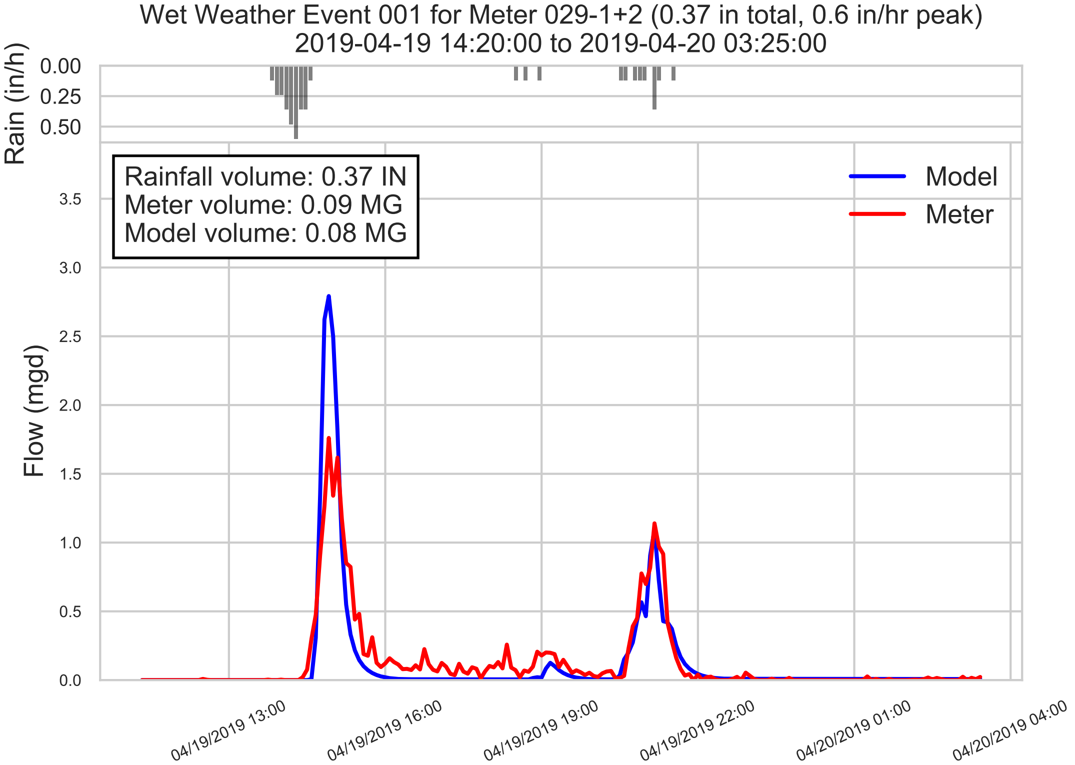
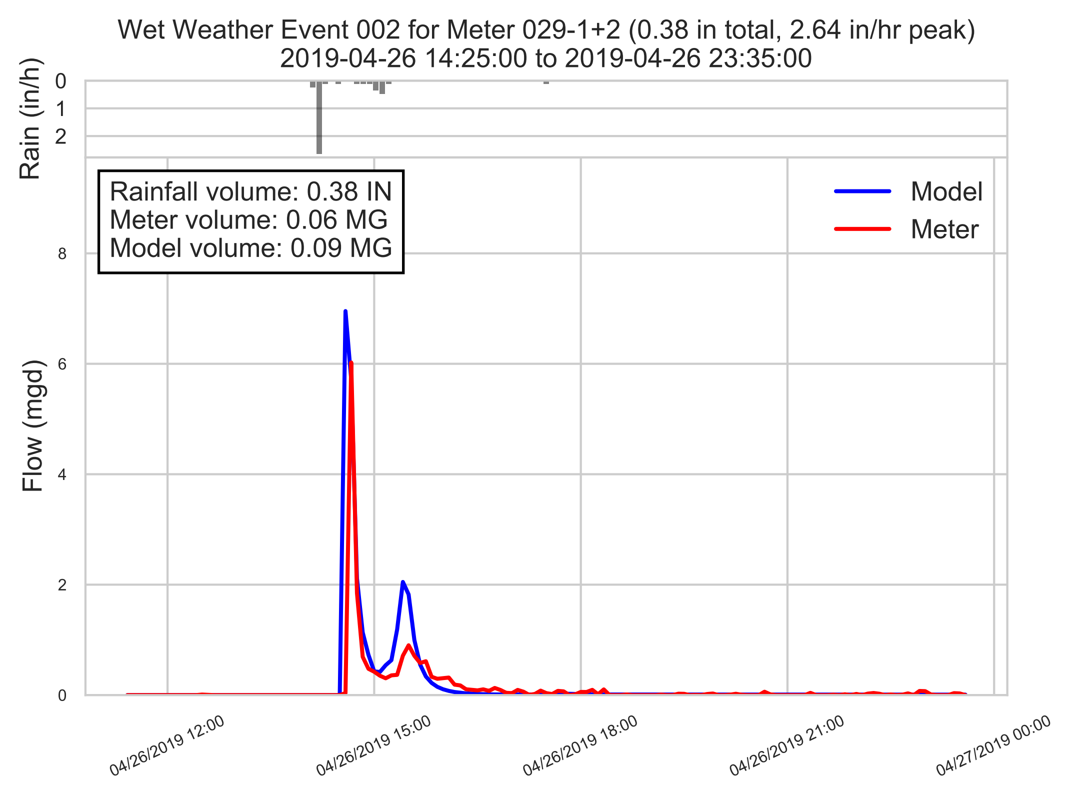
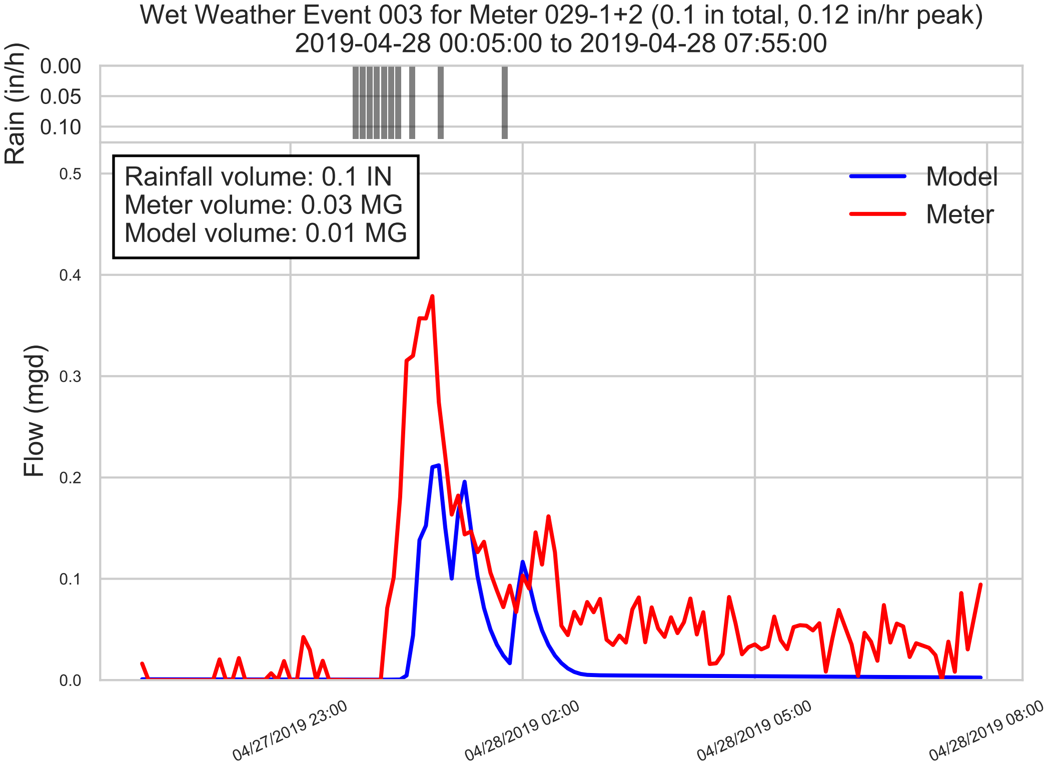
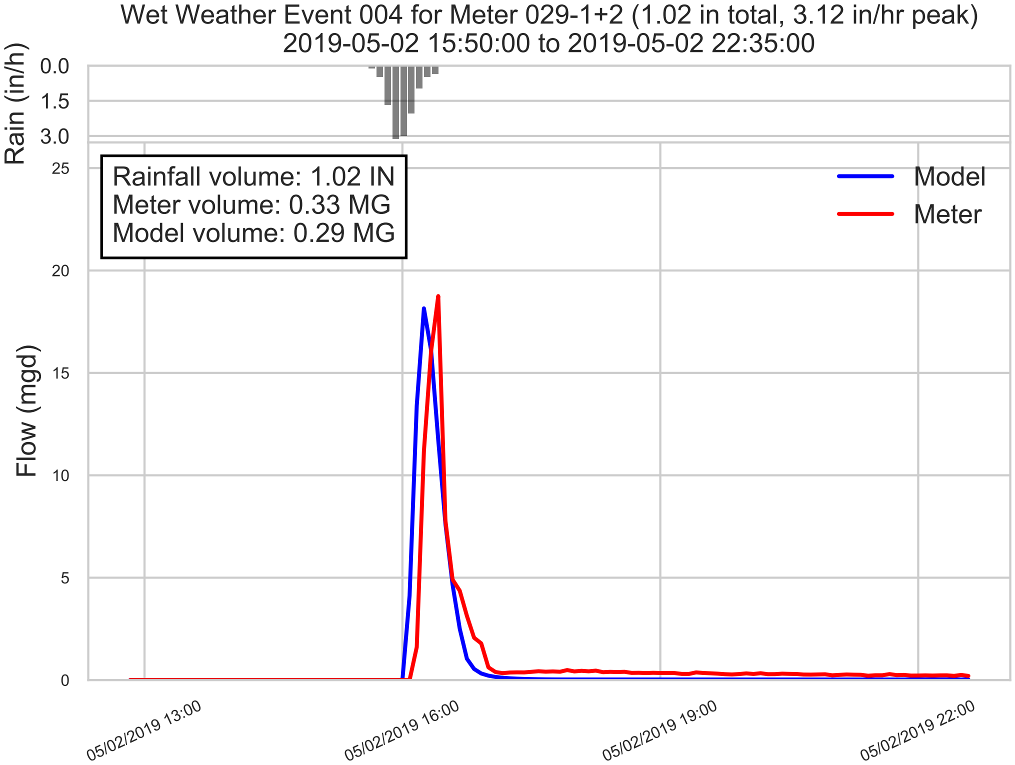
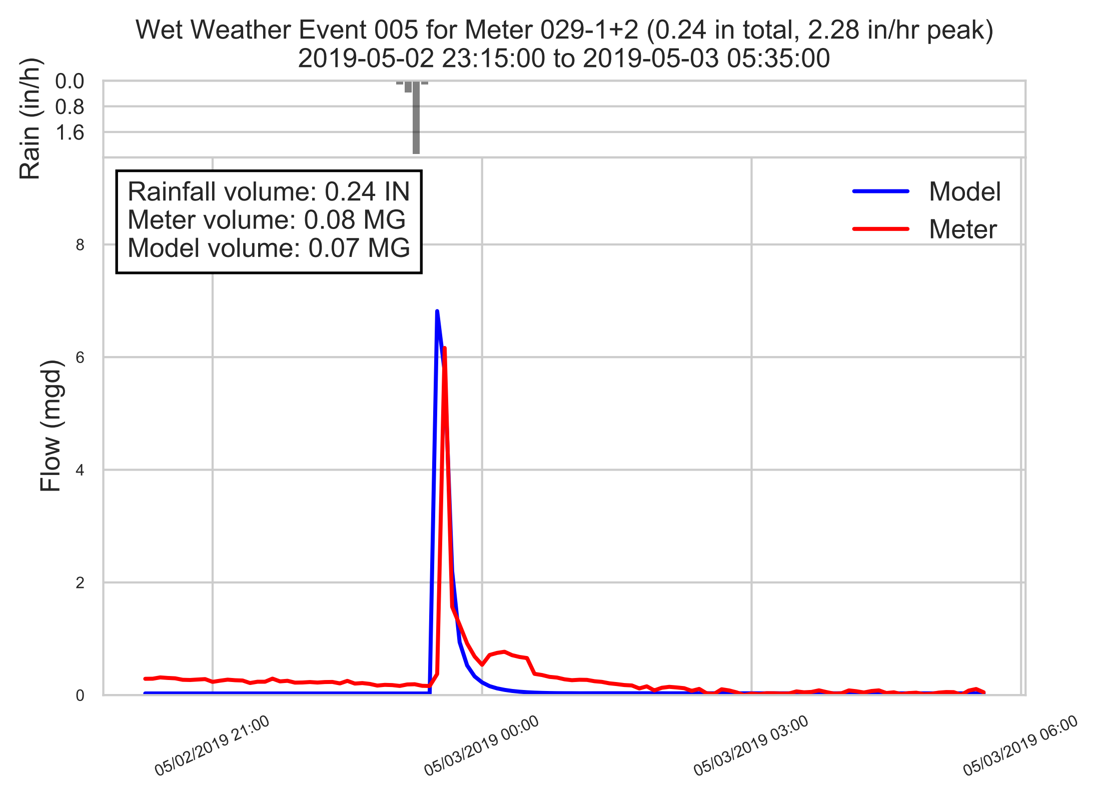
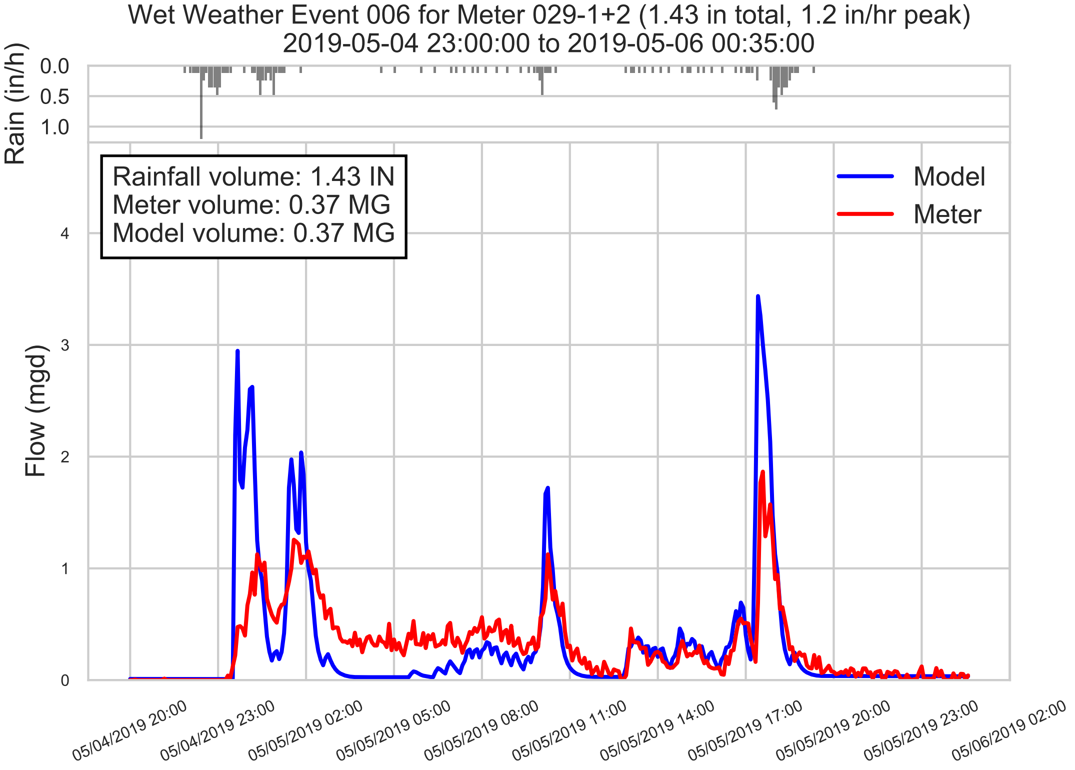

Wet Weather Event 001 for Meter 029-1+2 (0.37 in total, 0.6 in/hr peak)
2019-04-19 14:20:00 to 2019-04-20 03:25:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.37 IN
Meter volume: 0.09 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
04/19/2019 13:00
04/19/2019 16:00
04/19/2019 19:00
04/19/2019 22:00
04/20/2019 01:00
04/20/2019 04:00

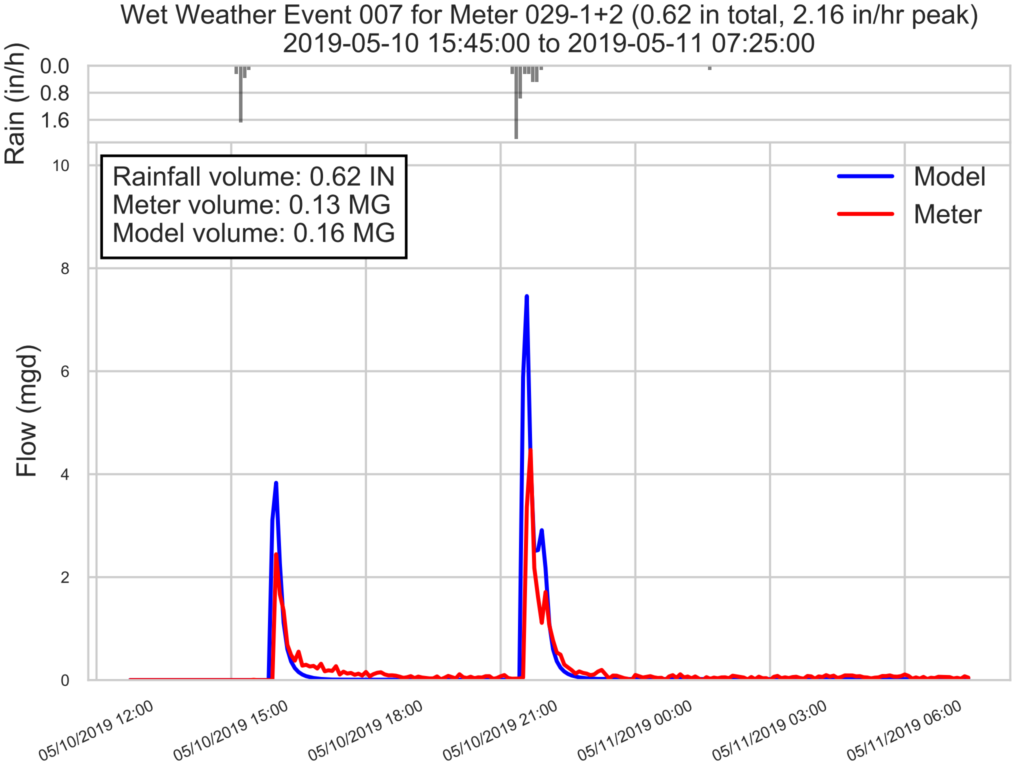

Wet Weather Event 002 for Meter 029-1+2 (0.38 in total, 2.64 in/hr peak)
2019-04-26 14:25:00 to 2019-04-26 23:35:00
Rain (in/h)
0
1
2
Rainfall volume: 0.38 IN
Meter volume: 0.06 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
8
6
4
2
0
04/26/2019 12:00
04/26/2019 15:00
04/26/2019 18:00
04/26/2019 21:00
04/27/2019 00:00


Wet Weather Event 003 for Meter 029-1+2 (0.1 in total, 0.12 in/hr peak)
2019-04-28 00:05:00 to 2019-04-28 07:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.1 IN
Meter volume: 0.03 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
04/27/2019 23:00
04/28/2019 02:00
04/28/2019 05:00
04/28/2019 08:00

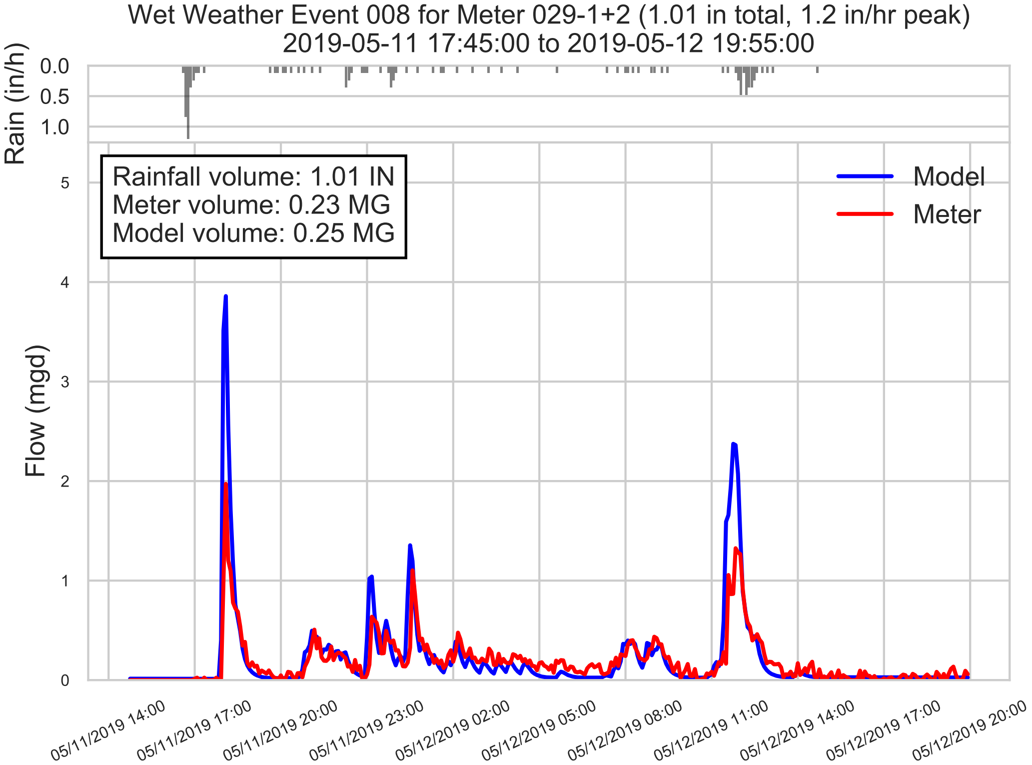

Wet Weather Event 004 for Meter 029-1+2 (1.02 in total, 3.12 in/hr peak)
2019-05-02 15:50:00 to 2019-05-02 22:35:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.02 IN
Meter volume: 0.33 MG
Model volume: 0.29 MG
Model
Meter
Flow (mgd)
25
20
15
10
5
0
05/02/2019 13:00
05/02/2019 16:00
05/02/2019 19:00
05/02/2019 22:00


Wet Weather Event 005 for Meter 029-1+2 (0.24 in total, 2.28 in/hr peak)
2019-05-02 23:15:00 to 2019-05-03 05:35:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.24 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
8
6
4
2
0
05/02/2019 21:00
05/03/2019 00:00
05/03/2019 03:00
05/03/2019 06:00

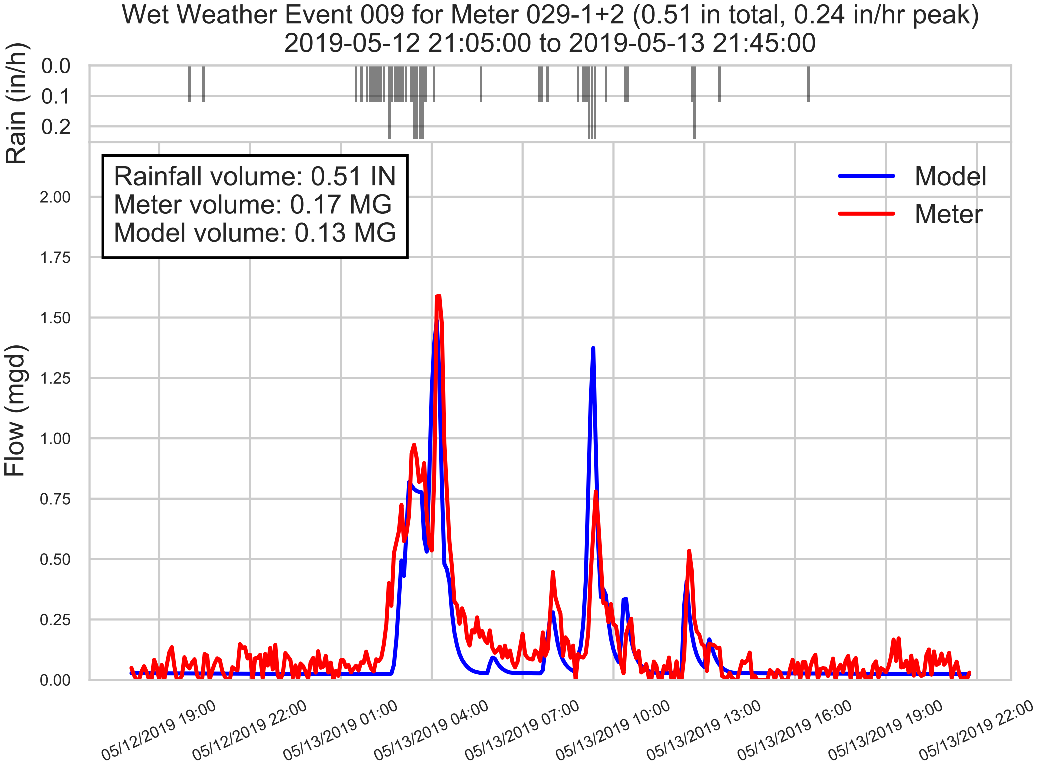

Wet Weather Event 006 for Meter 029-1+2 (1.43 in total, 1.2 in/hr peak)
2019-05-04 23:00:00 to 2019-05-06 00:35:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.43 IN
Meter volume: 0.37 MG
Model volume: 0.37 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
05/04/2019 20:00
05/04/2019 23:00
05/05/2019 02:00
05/05/2019 05:00
05/05/2019 08:00
05/05/2019 11:00
05/05/2019 14:00
05/05/2019 17:00
05/05/2019 20:00
05/05/2019 23:00
05/06/2019 02:00



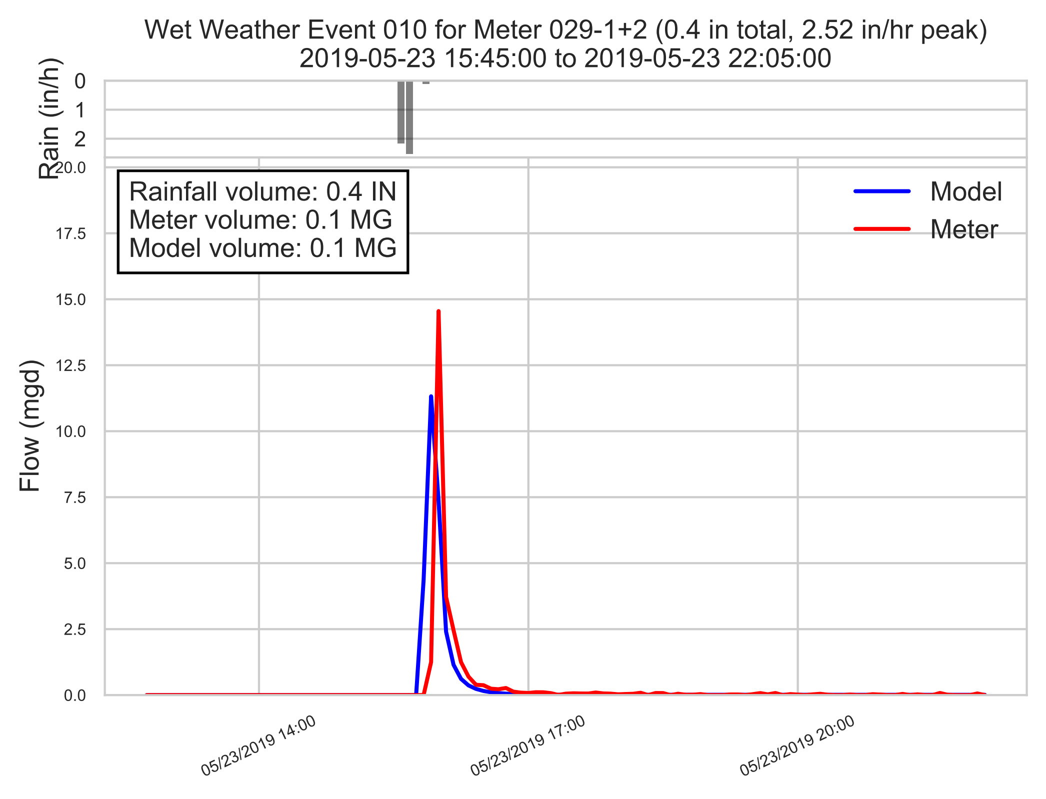
Wet Weather Event 007 for Meter 029-1+2 (0.62 in total, 2.16 in/hr peak)
2019-05-10 15:45:00 to 2019-05-11 07:25:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.62 IN
Meter volume: 0.13 MG
Model volume: 0.16 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
05/10/2019 12:00
05/10/2019 15:00
05/10/2019 18:00
05/10/2019 21:00
05/11/2019 00:00
05/11/2019 03:00
05/11/2019 06:00

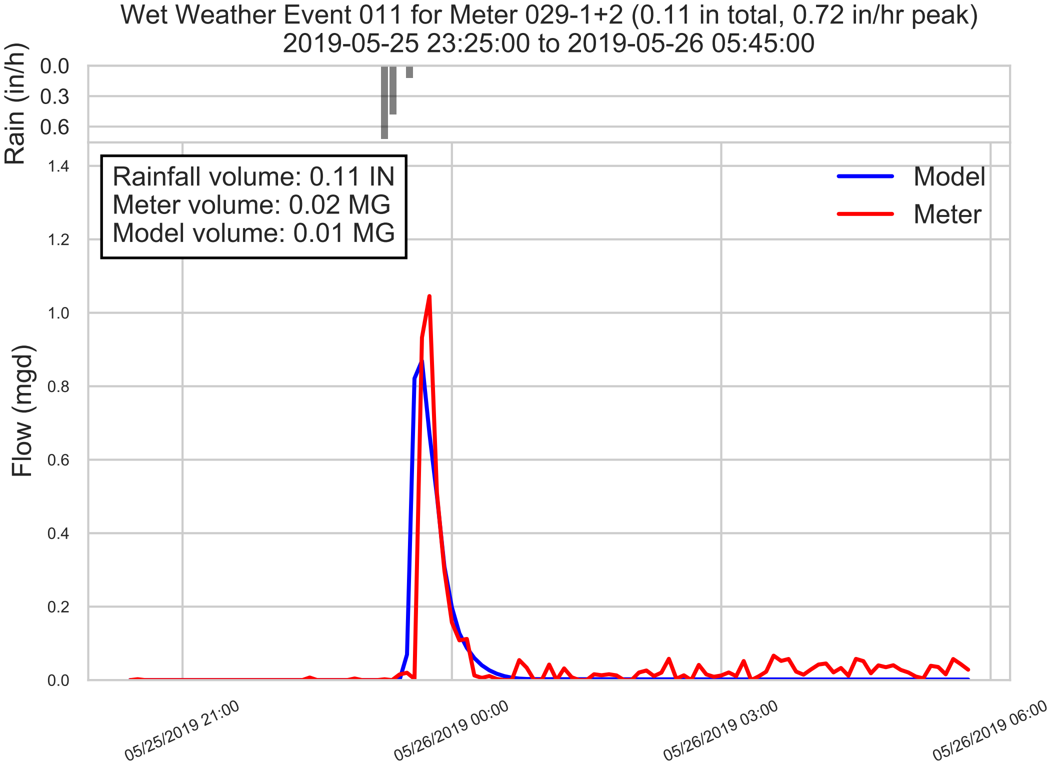


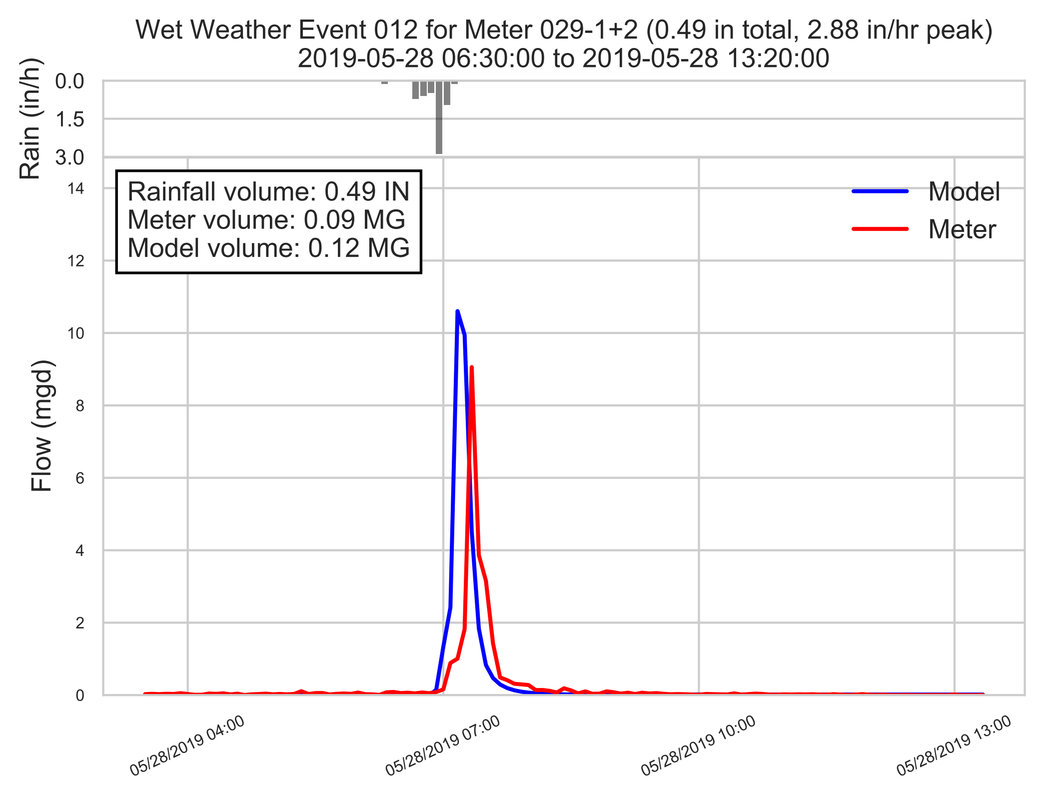
Wet Weather Event 008 for Meter 029-1+2 (1.01 in total, 1.2 in/hr peak)
2019-05-11 17:45:00 to 2019-05-12 19:55:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.01 IN
Meter volume: 0.23 MG
Model volume: 0.25 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
05/11/2019 14:00
05/11/2019 17:00
05/11/2019 20:00
05/11/2019 23:00
05/12/2019 02:00
05/12/2019 05:00
05/12/2019 08:00
05/12/2019 11:00
05/12/2019 14:00
05/12/2019 17:00
05/12/2019 20:00

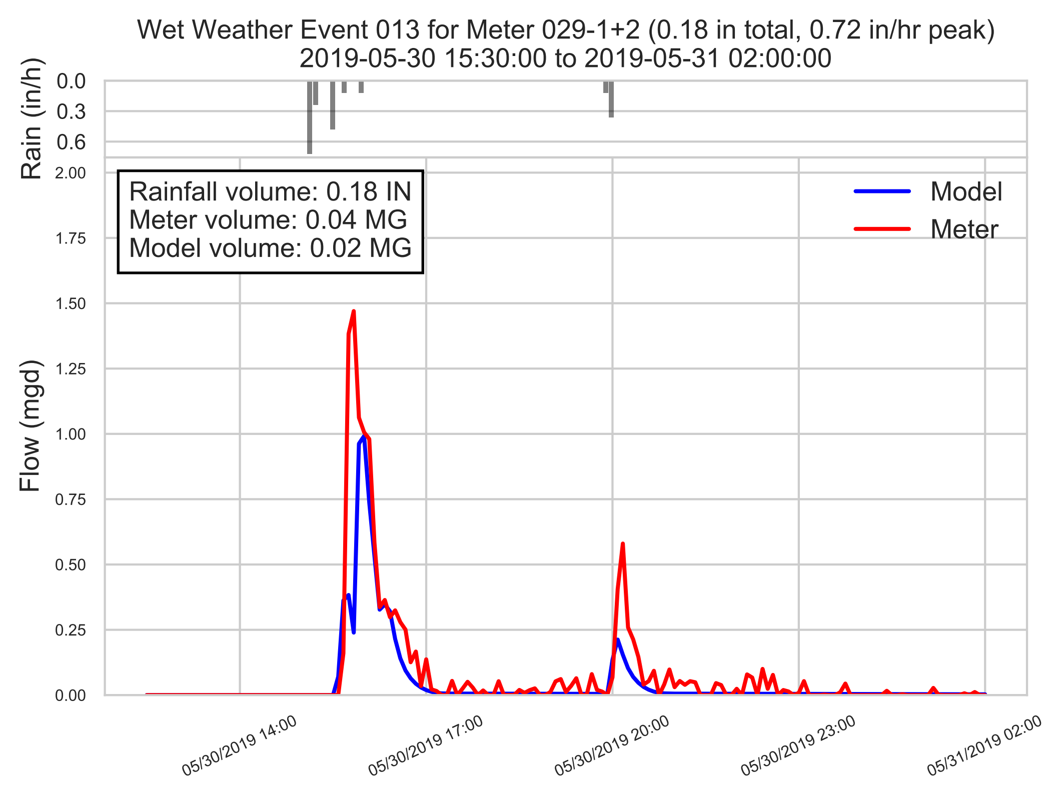


Wet Weather Event 009 for Meter 029-1+2 (0.51 in total, 0.24 in/hr peak)
2019-05-12 21:05:00 to 2019-05-13 21:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.51 IN
Meter volume: 0.17 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
05/12/2019 19:00
05/12/2019 22:00
05/13/2019 01:00
05/13/2019 04:00
05/13/2019 07:00
05/13/2019 10:00
05/13/2019 13:00
05/13/2019 16:00
05/13/2019 19:00
05/13/2019 22:00

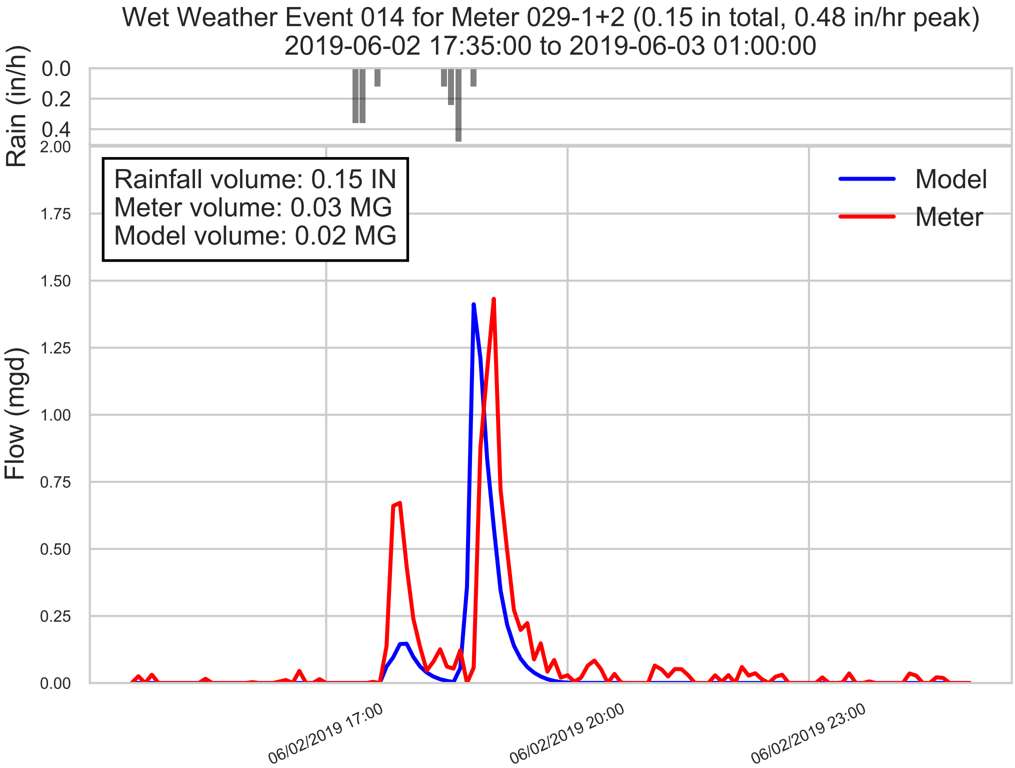

Wet Weather Event 010 for Meter 029-1+2 (0.4 in total, 2.52 in/hr peak)
2019-05-23 15:45:00 to 2019-05-23 22:05:00
Rain (in/h)
0
1
2
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Flow (mgd)
Rainfall volume: 0.4 IN
Meter volume: 0.1 MG
Model volume: 0.1 MG
Model
Meter
05/23/2019 14:00
05/23/2019 17:00
05/23/2019 20:00

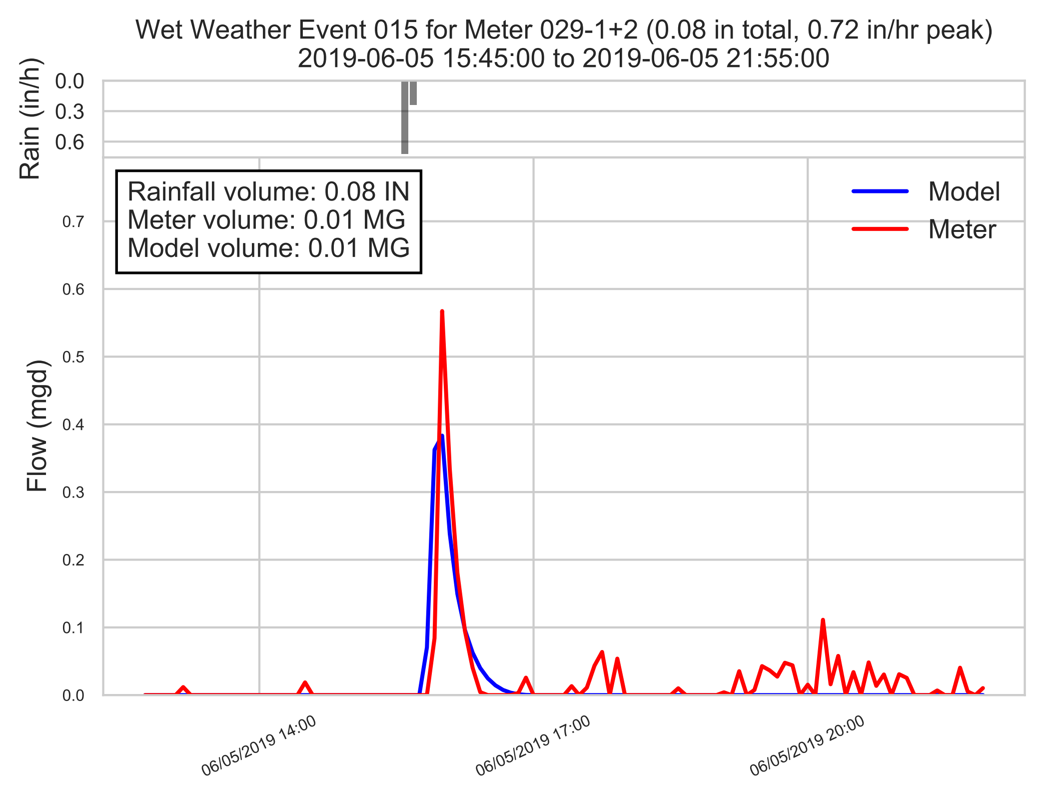

Wet Weather Event 011 for Meter 029-1+2 (0.11 in total, 0.72 in/hr peak)
2019-05-25 23:25:00 to 2019-05-26 05:45:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.11 IN
Meter volume: 0.02 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
05/25/2019 21:00
05/26/2019 00:00
05/26/2019 03:00
05/26/2019 06:00


Wet Weather Event 012 for Meter 029-1+2 (0.49 in total, 2.88 in/hr peak)
2019-05-28 06:30:00 to 2019-05-28 13:20:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.49 IN
Meter volume: 0.09 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
05/28/2019 04:00
05/28/2019 07:00
05/28/2019 10:00
05/28/2019 13:00

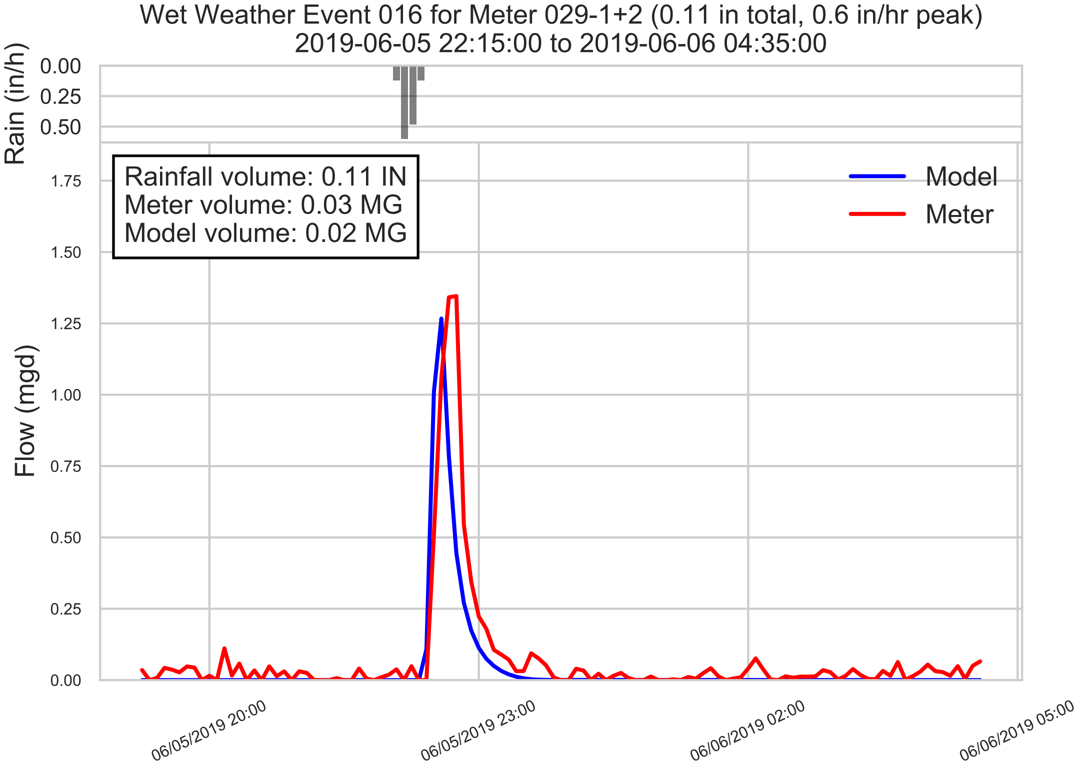


Wet Weather Event 013 for Meter 029-1+2 (0.18 in total, 0.72 in/hr peak)
2019-05-30 15:30:00 to 2019-05-31 02:00:00
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall volume: 0.18 IN
Meter volume: 0.04 MG
Model volume: 0.02 MG
Model
Meter
05/30/2019 14:00
05/30/2019 17:00
05/30/2019 20:00
05/30/2019 23:00
05/31/2019 02:00

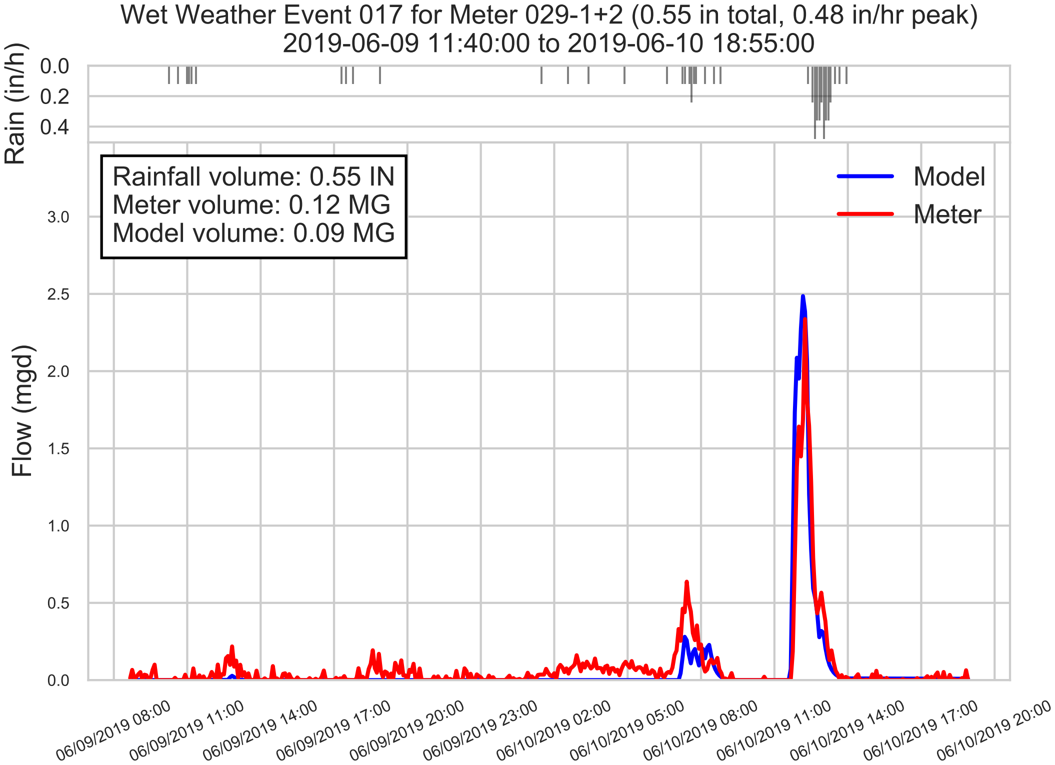

Wet Weather Event 014 for Meter 029-1+2 (0.15 in total, 0.48 in/hr peak)
2019-06-02 17:35:00 to 2019-06-03 01:00:00
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall volume: 0.15 IN
Meter volume: 0.03 MG
Model volume: 0.02 MG
Model
Meter
06/02/2019 17:00
06/02/2019 20:00
06/02/2019 23:00



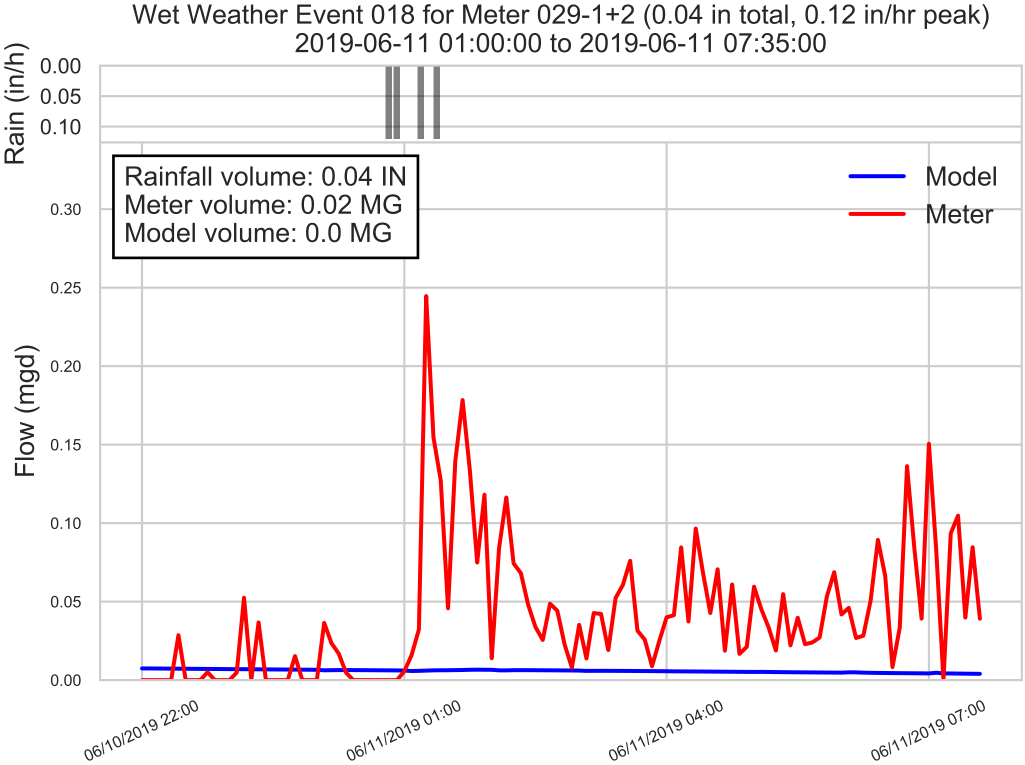
Wet Weather Event 015 for Meter 029-1+2 (0.08 in total, 0.72 in/hr peak)
2019-06-05 15:45:00 to 2019-06-05 21:55:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.08 IN
Meter volume: 0.01 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
06/05/2019 14:00
06/05/2019 17:00
06/05/2019 20:00

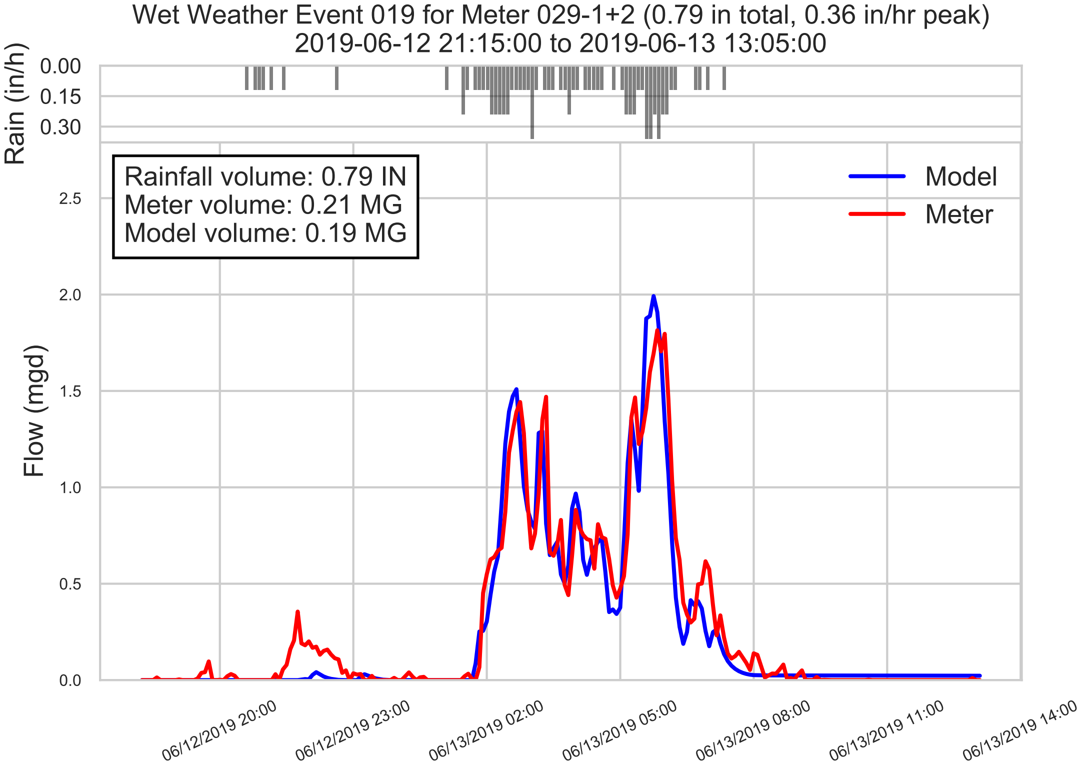


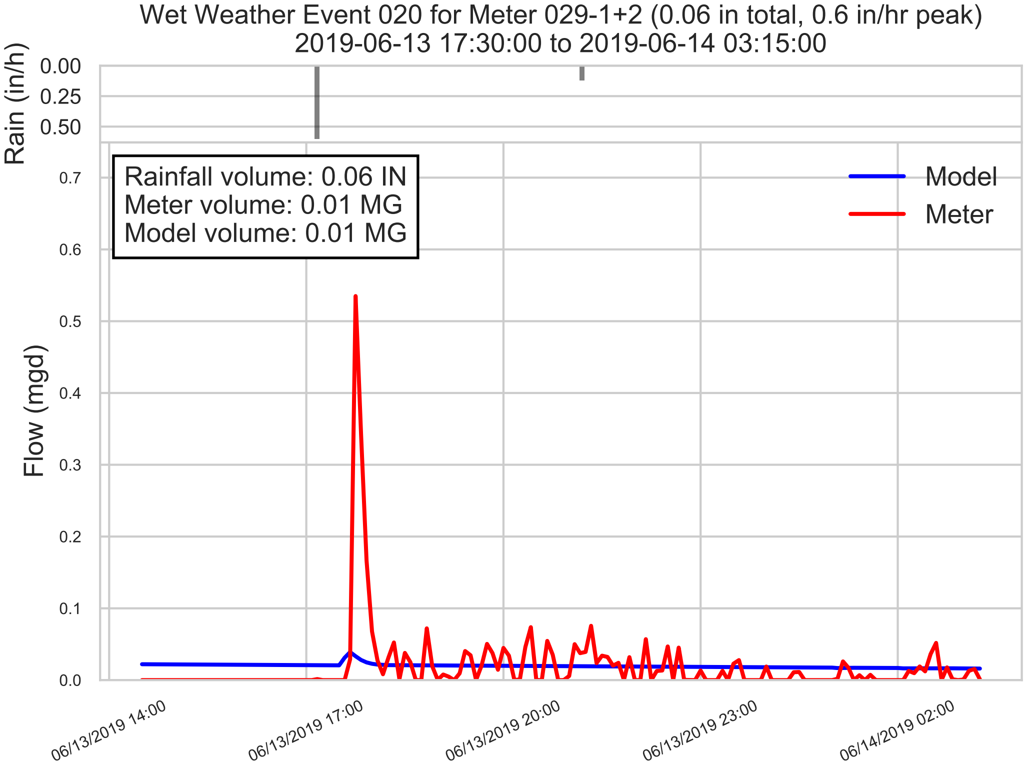
Wet Weather Event 016 for Meter 029-1+2 (0.11 in total, 0.6 in/hr peak)
2019-06-05 22:15:00 to 2019-06-06 04:35:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.11 IN
Meter volume: 0.03 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
06/05/2019 20:00
06/05/2019 23:00
06/06/2019 02:00
06/06/2019 05:00



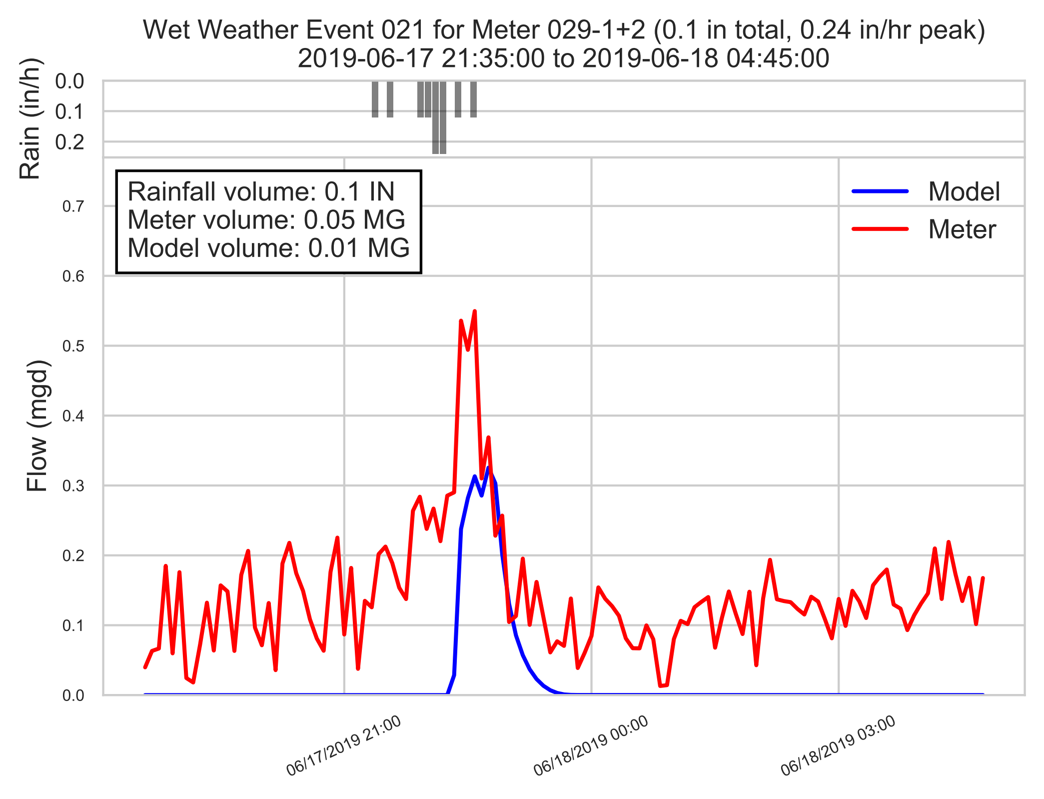
Wet Weather Event 017 for Meter 029-1+2 (0.55 in total, 0.48 in/hr peak)
2019-06-09 11:40:00 to 2019-06-10 18:55:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.55 IN
Meter volume: 0.12 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06/09/2019 08:00
06/09/2019 11:00
06/09/2019 14:00
06/09/2019 17:00
06/09/2019 20:00
06/09/2019 23:00
06/10/2019 02:00
06/10/2019 05:00
06/10/2019 08:00
06/10/2019 11:00
06/10/2019 14:00
06/10/2019 17:00
06/10/2019 20:00

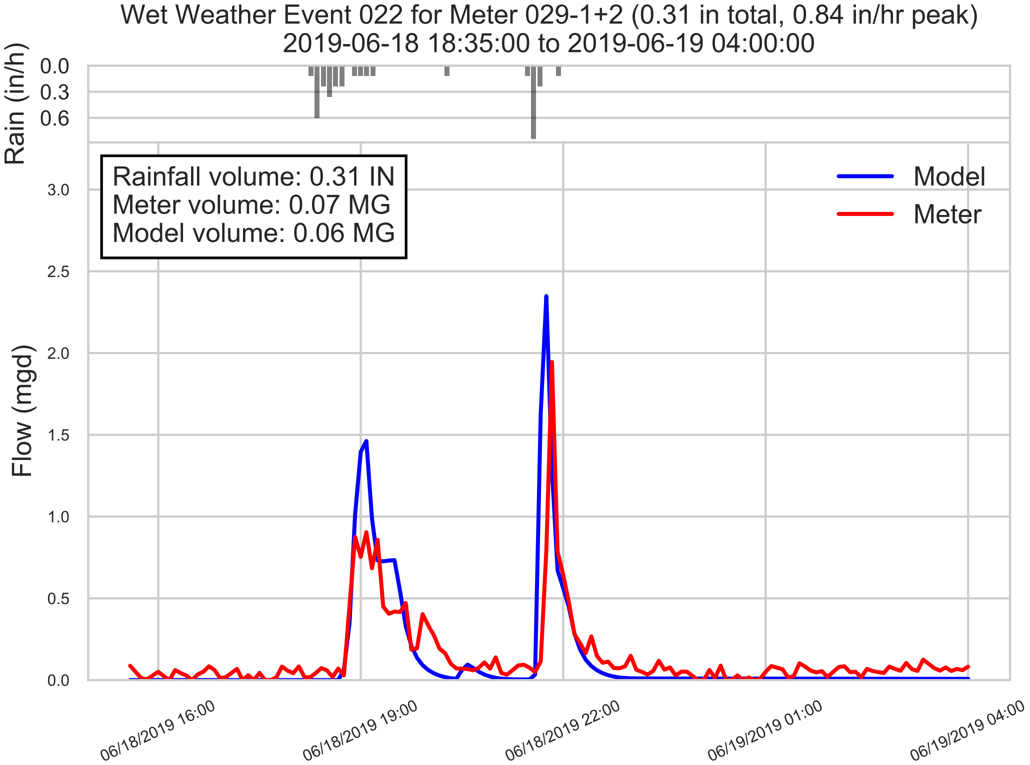

Wet Weather Event 018 for Meter 029-1+2 (0.04 in total, 0.12 in/hr peak)
2019-06-11 01:00:00 to 2019-06-11 07:35:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.04 IN
Meter volume: 0.02 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
06/10/2019 22:00
06/11/2019 01:00
06/11/2019 04:00
06/11/2019 07:00


Wet Weather Event 019 for Meter 029-1+2 (0.79 in total, 0.36 in/hr peak)
2019-06-12 21:15:00 to 2019-06-13 13:05:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.79 IN
Meter volume: 0.21 MG
Model volume: 0.19 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
06/12/2019 20:00
06/12/2019 23:00
06/13/2019 02:00
06/13/2019 05:00
06/13/2019 08:00
06/13/2019 11:00
06/13/2019 14:00

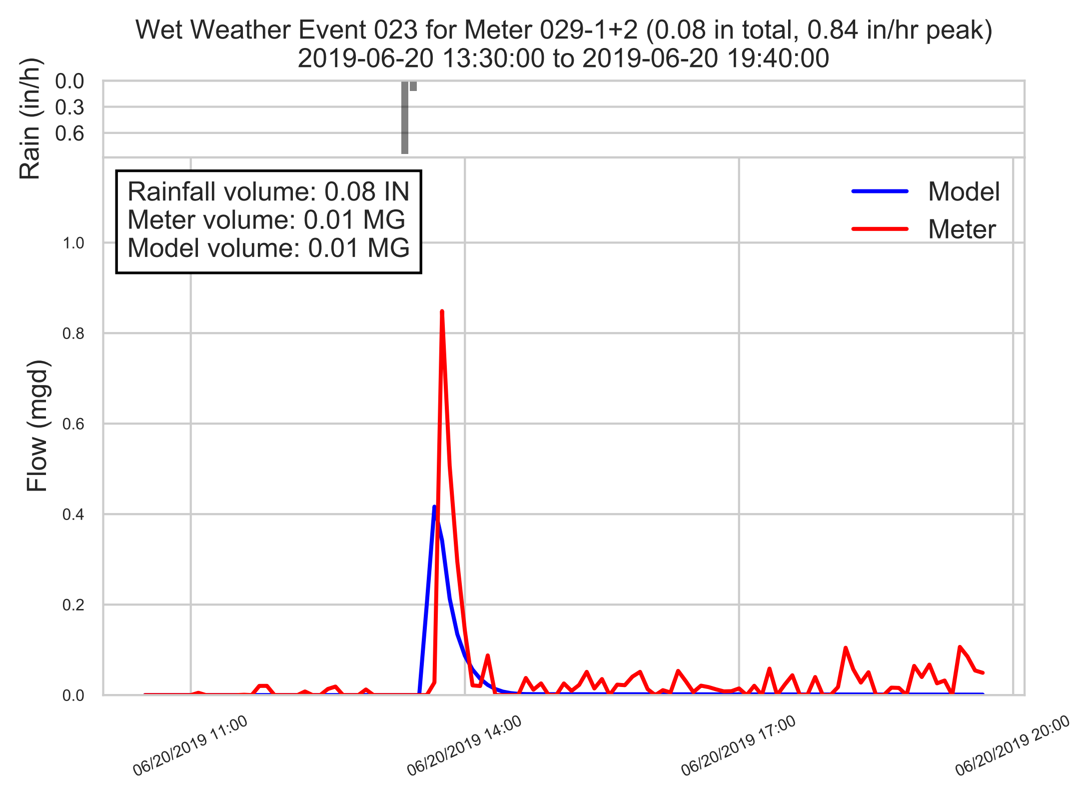


Wet Weather Event 020 for Meter 029-1+2 (0.06 in total, 0.6 in/hr peak)
2019-06-13 17:30:00 to 2019-06-14 03:15:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.06 IN
Meter volume: 0.01 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
06/13/2019 14:00
06/13/2019 17:00
06/13/2019 20:00
06/13/2019 23:00
06/14/2019 02:00

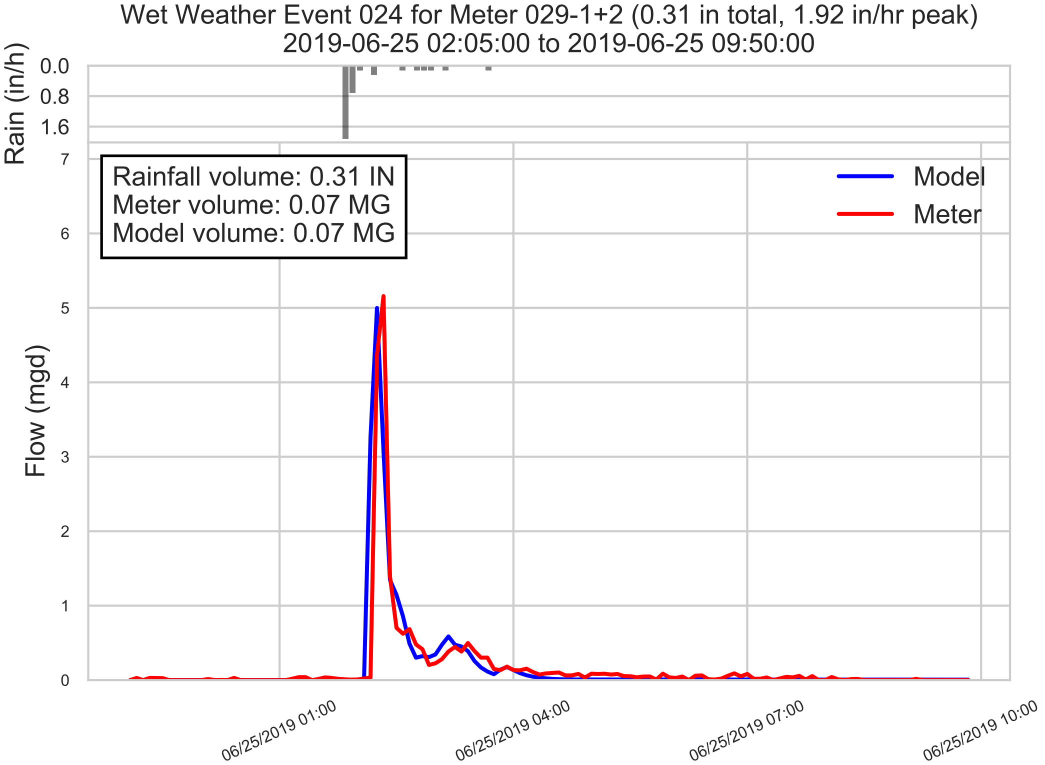

Wet Weather Event 021 for Meter 029-1+2 (0.1 in total, 0.24 in/hr peak)
2019-06-17 21:35:00 to 2019-06-18 04:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.1 IN
Meter volume: 0.05 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
06/17/2019 21:00
06/18/2019 00:00
06/18/2019 03:00

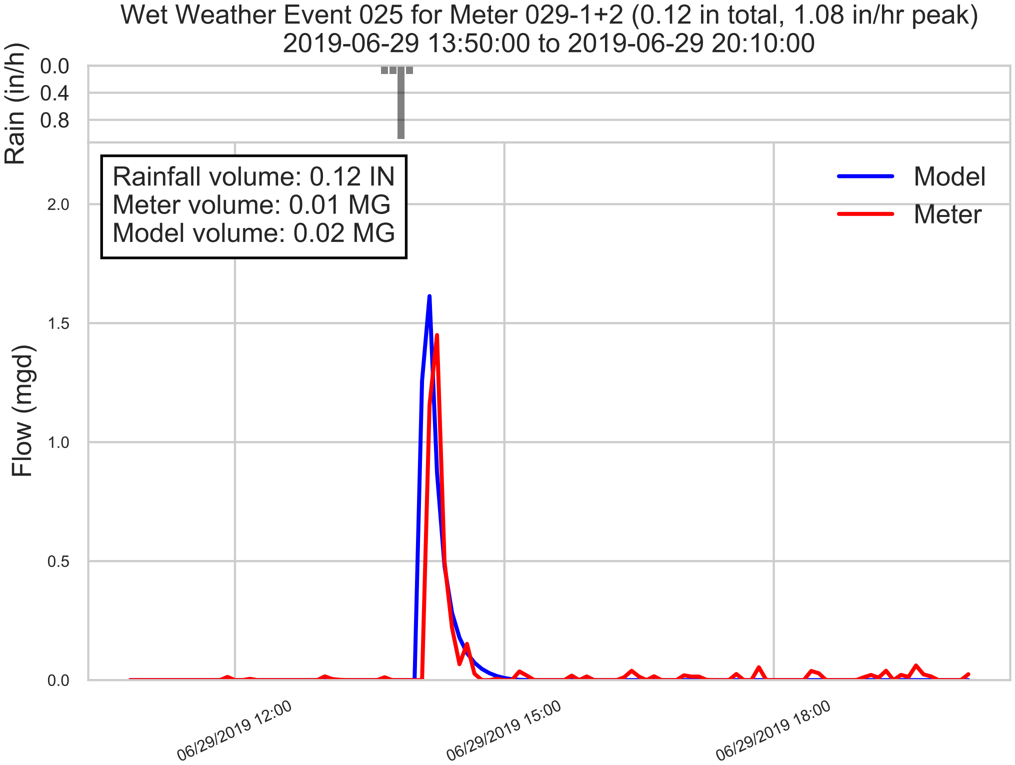


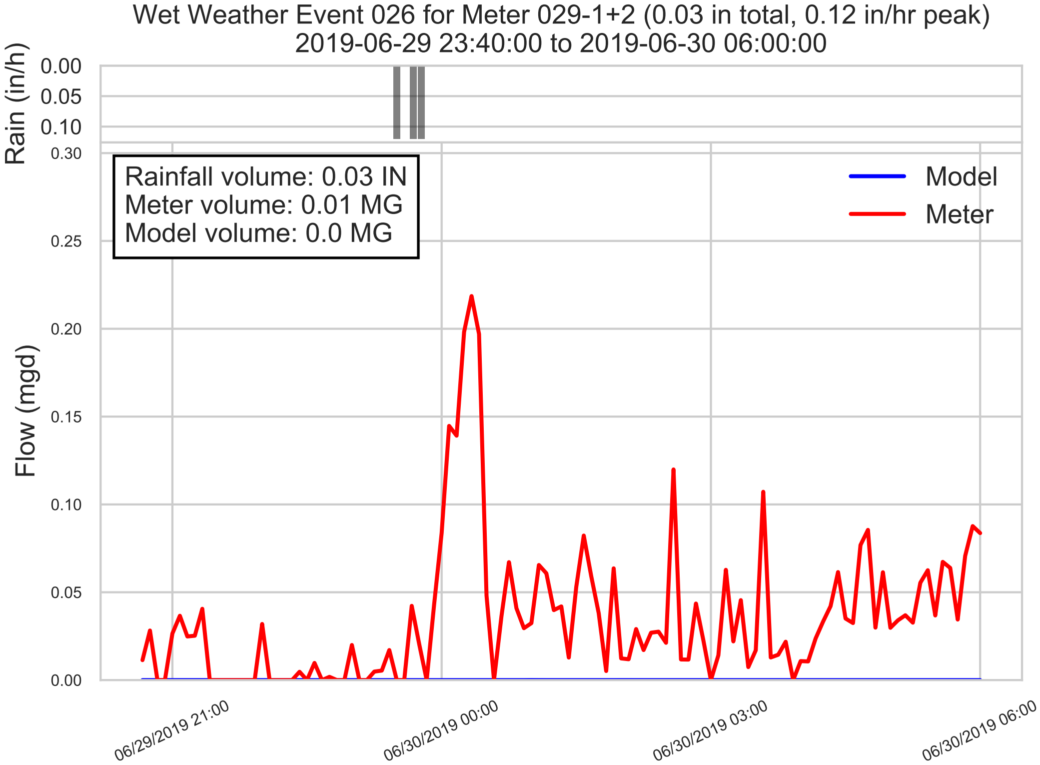
Wet Weather Event 022 for Meter 029-1+2 (0.31 in total, 0.84 in/hr peak)
2019-06-18 18:35:00 to 2019-06-19 04:00:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.31 IN
Meter volume: 0.07 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06/18/2019 16:00
06/18/2019 19:00
06/18/2019 22:00
06/19/2019 01:00
06/19/2019 04:00



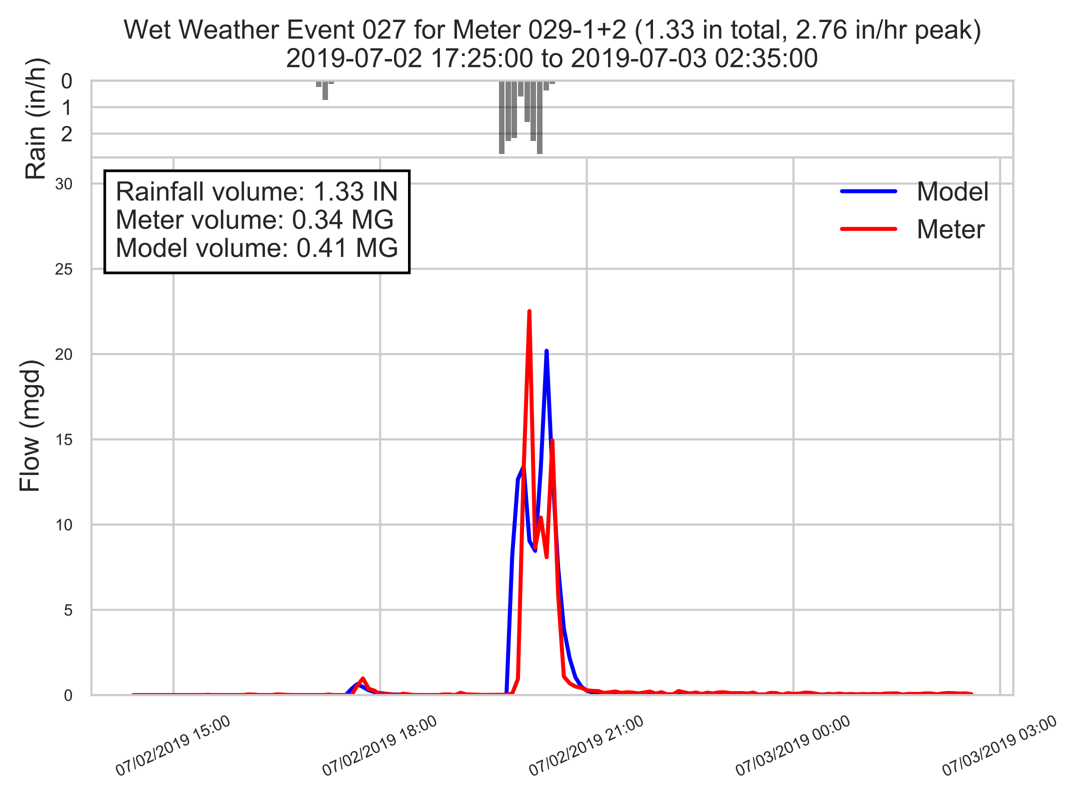
Wet Weather Event 023 for Meter 029-1+2 (0.08 in total, 0.84 in/hr peak)
2019-06-20 13:30:00 to 2019-06-20 19:40:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.08 IN
Meter volume: 0.01 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
06/20/2019 11:00
06/20/2019 14:00
06/20/2019 17:00
06/20/2019 20:00

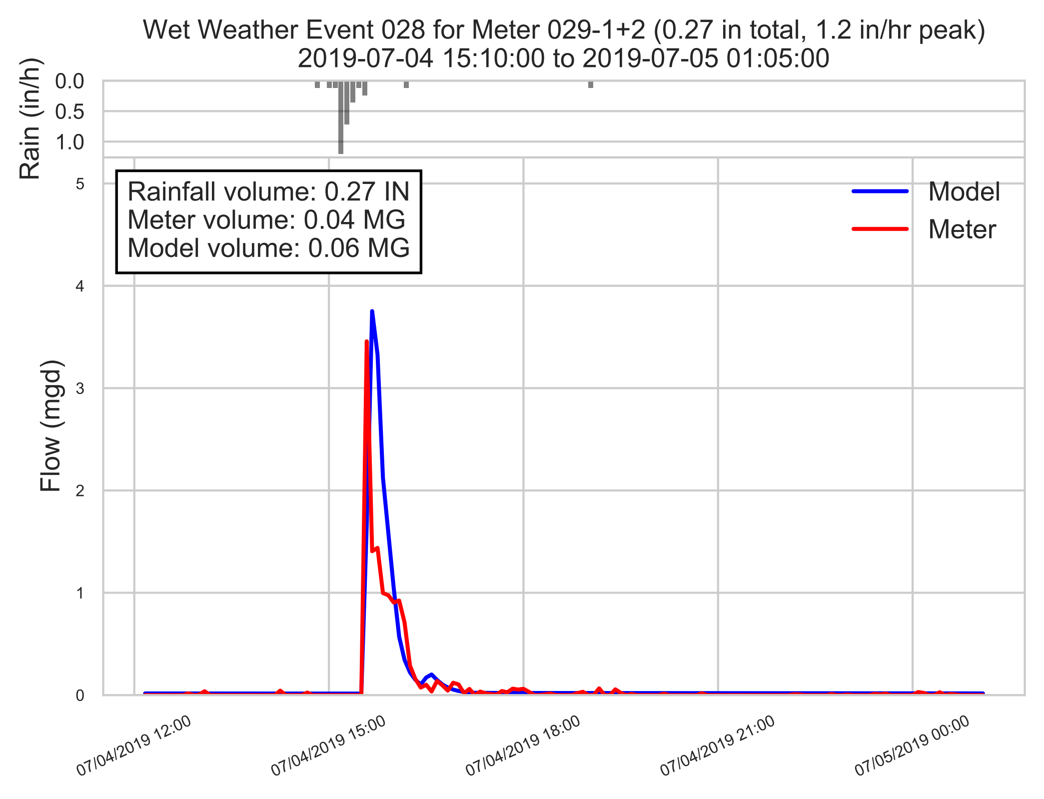

Wet Weather Event 024 for Meter 029-1+2 (0.31 in total, 1.92 in/hr peak)
2019-06-25 02:05:00 to 2019-06-25 09:50:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
7
6
5
4
3
2
1
0
Rainfall volume: 0.31 IN
Meter volume: 0.07 MG
Model volume: 0.07 MG
Model
Meter
06/25/2019 01:00
06/25/2019 04:00
06/25/2019 07:00
06/25/2019 10:00


Wet Weather Event 025 for Meter 029-1+2 (0.12 in total, 1.08 in/hr peak)
2019-06-29 13:50:00 to 2019-06-29 20:10:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.12 IN
Meter volume: 0.01 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
06/29/2019 12:00
06/29/2019 15:00
06/29/2019 18:00

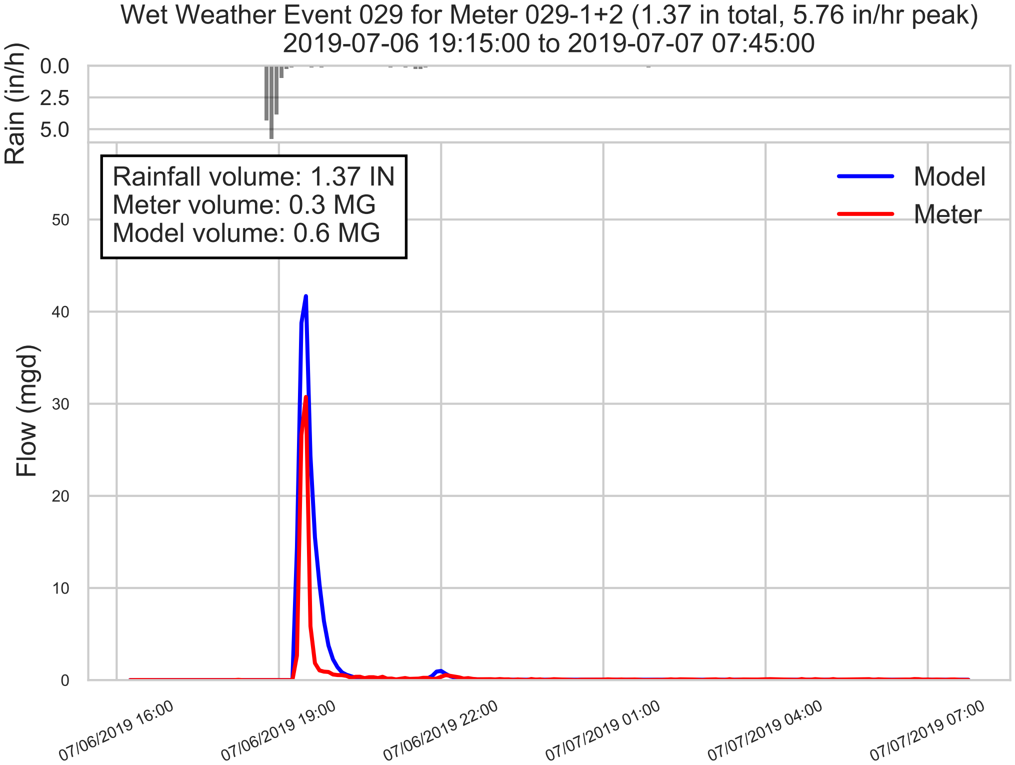


Wet Weather Event 026 for Meter 029-1+2 (0.03 in total, 0.12 in/hr peak)
2019-06-29 23:40:00 to 2019-06-30 06:00:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall volume: 0.03 IN
Meter volume: 0.01 MG
Model volume: 0.0 MG
Model
Meter
06/29/2019 21:00
06/30/2019 00:00
06/30/2019 03:00
06/30/2019 06:00

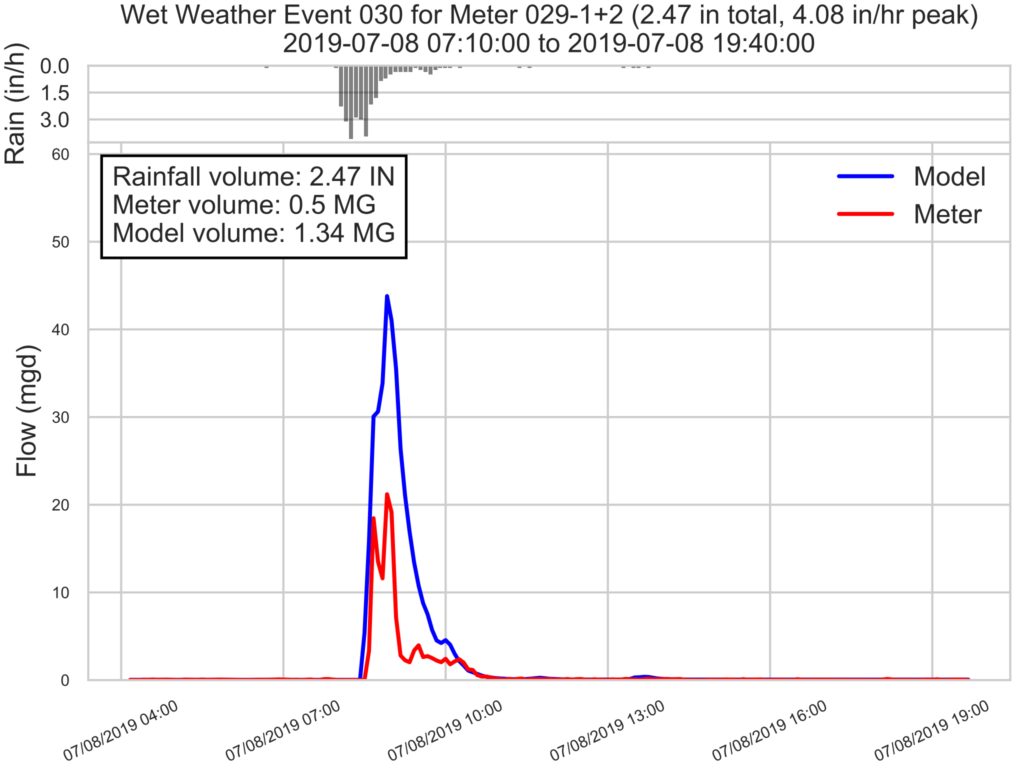

Wet Weather Event 027 for Meter 029-1+2 (1.33 in total, 2.76 in/hr peak)
2019-07-02 17:25:00 to 2019-07-03 02:35:00
Rain (in/h)
0
1
2
Rainfall volume: 1.33 IN
Meter volume: 0.34 MG
Model volume: 0.41 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
07/02/2019 15:00
07/02/2019 18:00
07/02/2019 21:00
07/03/2019 00:00
07/03/2019 03:00



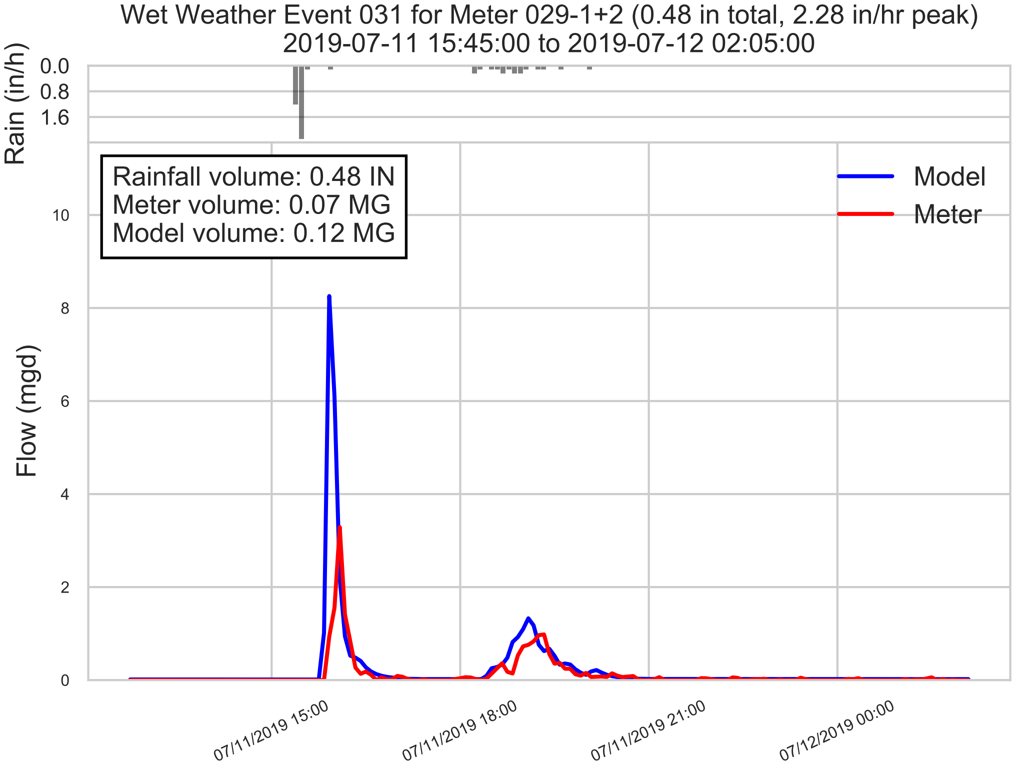
Wet Weather Event 028 for Meter 029-1+2 (0.27 in total, 1.2 in/hr peak)
2019-07-04 15:10:00 to 2019-07-05 01:05:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.27 IN
Meter volume: 0.04 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
07/04/2019 12:00
07/04/2019 15:00
07/04/2019 18:00
07/04/2019 21:00
07/05/2019 00:00

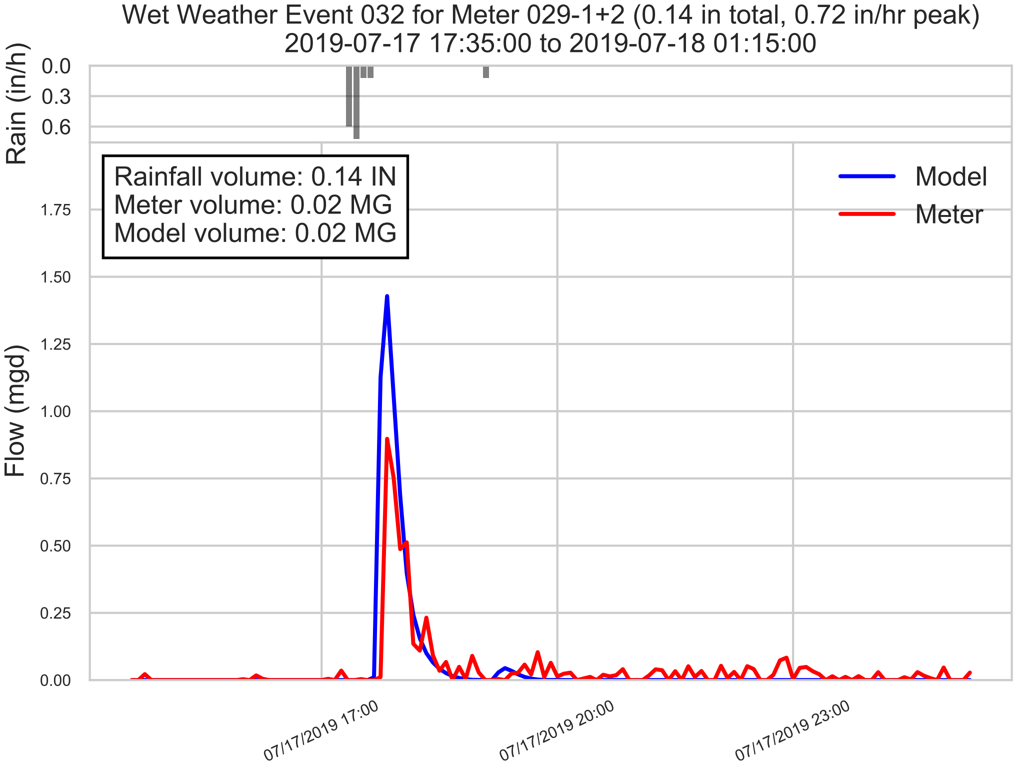


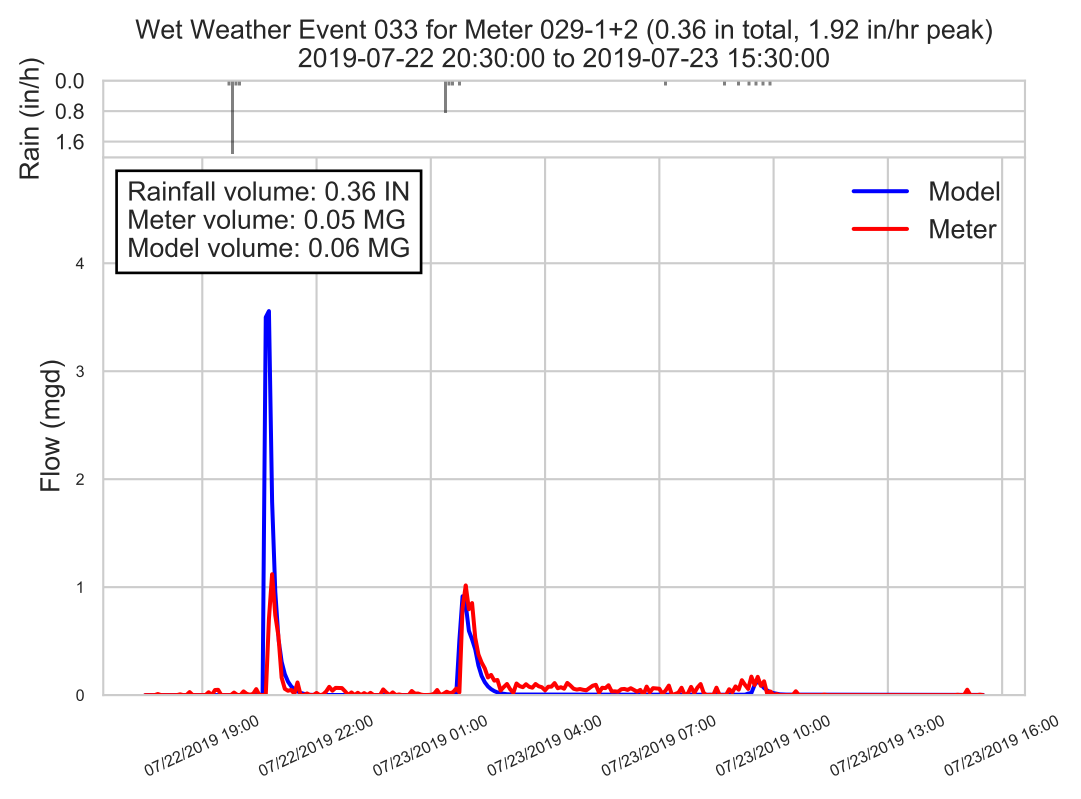
Wet Weather Event 029 for Meter 029-1+2 (1.37 in total, 5.76 in/hr peak)
2019-07-06 19:15:00 to 2019-07-07 07:45:00
Rain (in/h)
0.0
2.5
5.0
Rainfall volume: 1.37 IN
Meter volume: 0.3 MG
Model volume: 0.6 MG
Model
Meter
Flow (mgd)
50
40
30
20
10
0
07/06/2019 16:00
07/06/2019 19:00
07/06/2019 22:00
07/07/2019 01:00
07/07/2019 04:00
07/07/2019 07:00



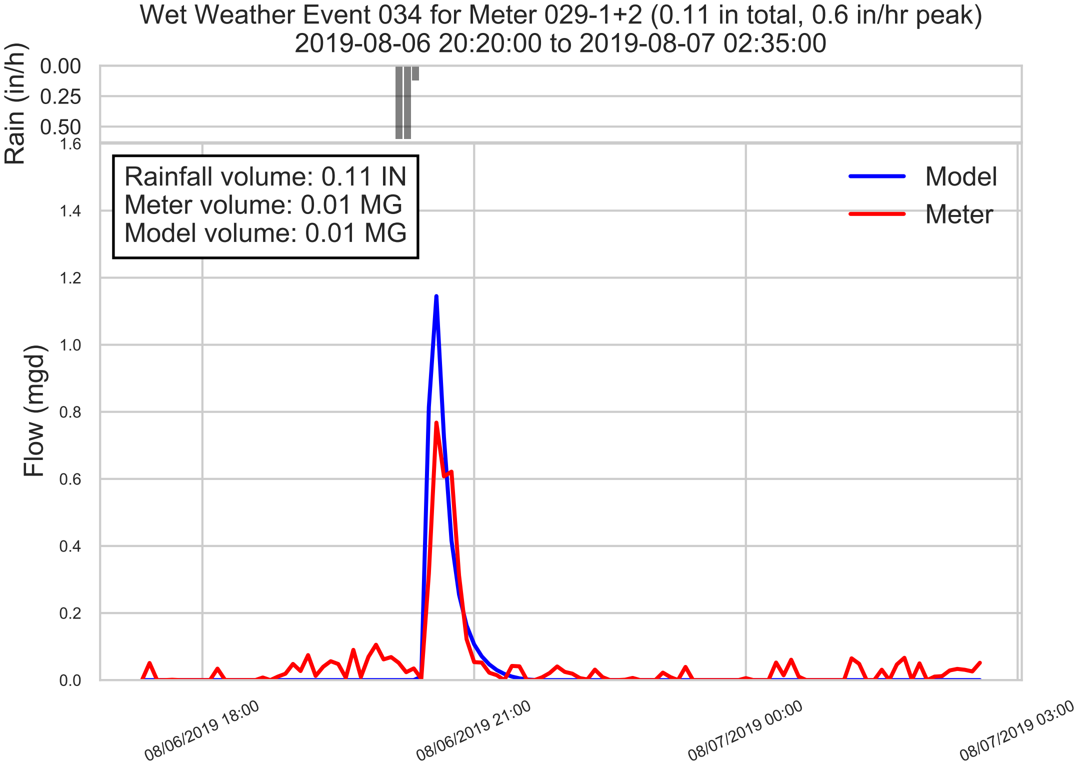
Wet Weather Event 030 for Meter 029-1+2 (2.47 in total, 4.08 in/hr peak)
2019-07-08 07:10:00 to 2019-07-08 19:40:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
0
10
20
30
40
50
60
Rainfall volume: 2.47 IN
Meter volume: 0.5 MG
Model volume: 1.34 MG
Model
Meter
07/08/2019 04:00
07/08/2019 07:00
07/08/2019 10:00
07/08/2019 13:00
07/08/2019 16:00
07/08/2019 19:00


Wet Weather Event 031 for Meter 029-1+2 (0.48 in total, 2.28 in/hr peak)
2019-07-11 15:45:00 to 2019-07-12 02:05:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.48 IN
Meter volume: 0.07 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
07/11/2019 15:00
07/11/2019 18:00
07/11/2019 21:00
07/12/2019 00:00

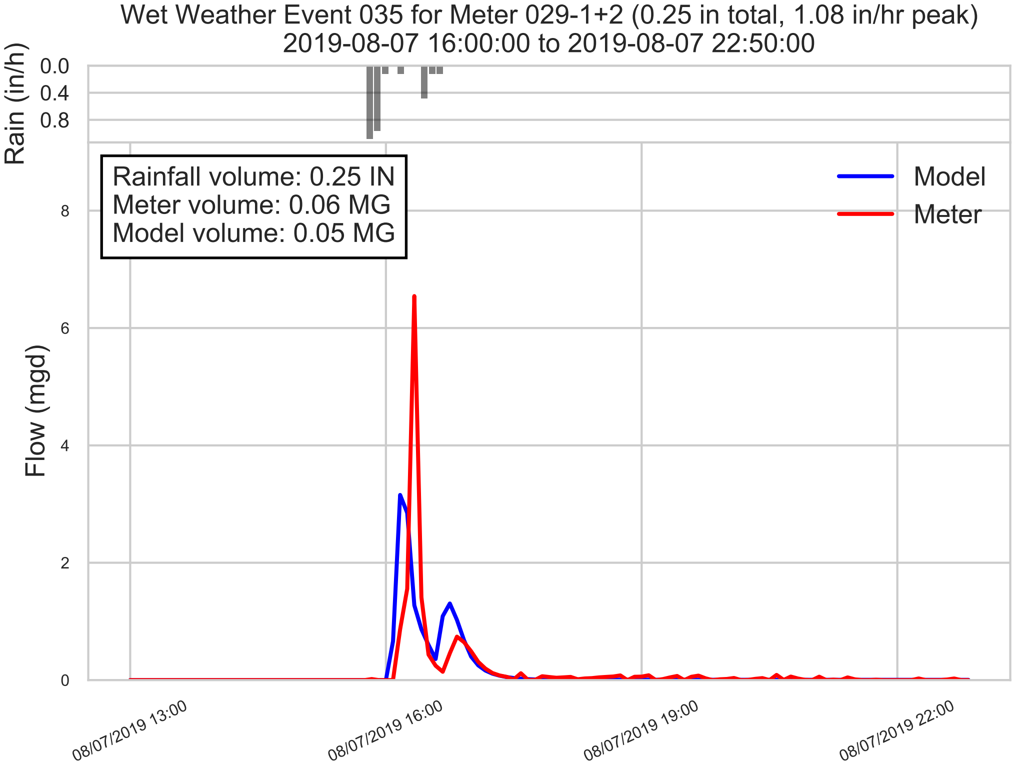

Wet Weather Event 032 for Meter 029-1+2 (0.14 in total, 0.72 in/hr peak)
2019-07-17 17:35:00 to 2019-07-18 01:15:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.14 IN
Meter volume: 0.02 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
07/17/2019 17:00
07/17/2019 20:00
07/17/2019 23:00

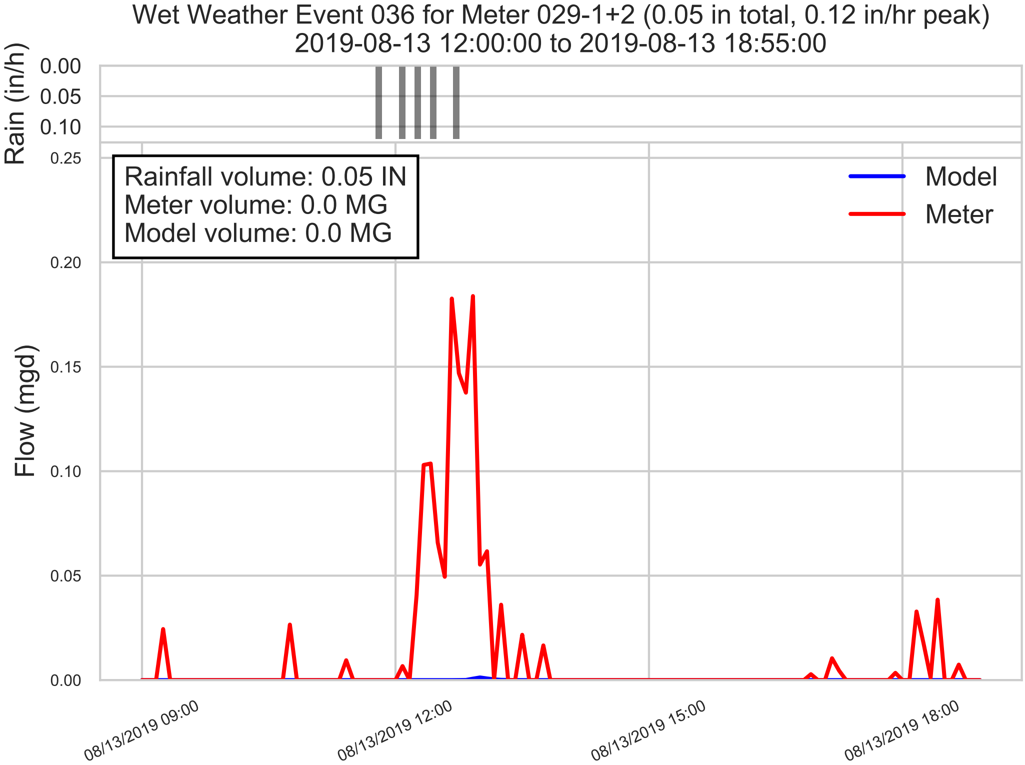


Wet Weather Event 033 for Meter 029-1+2 (0.36 in total, 1.92 in/hr peak)
2019-07-22 20:30:00 to 2019-07-23 15:30:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.36 IN
Meter volume: 0.05 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
4
3
2
1
0
07/22/2019 19:00
07/22/2019 22:00
07/23/2019 01:00
07/23/2019 04:00
07/23/2019 07:00
07/23/2019 10:00
07/23/2019 13:00
07/23/2019 16:00

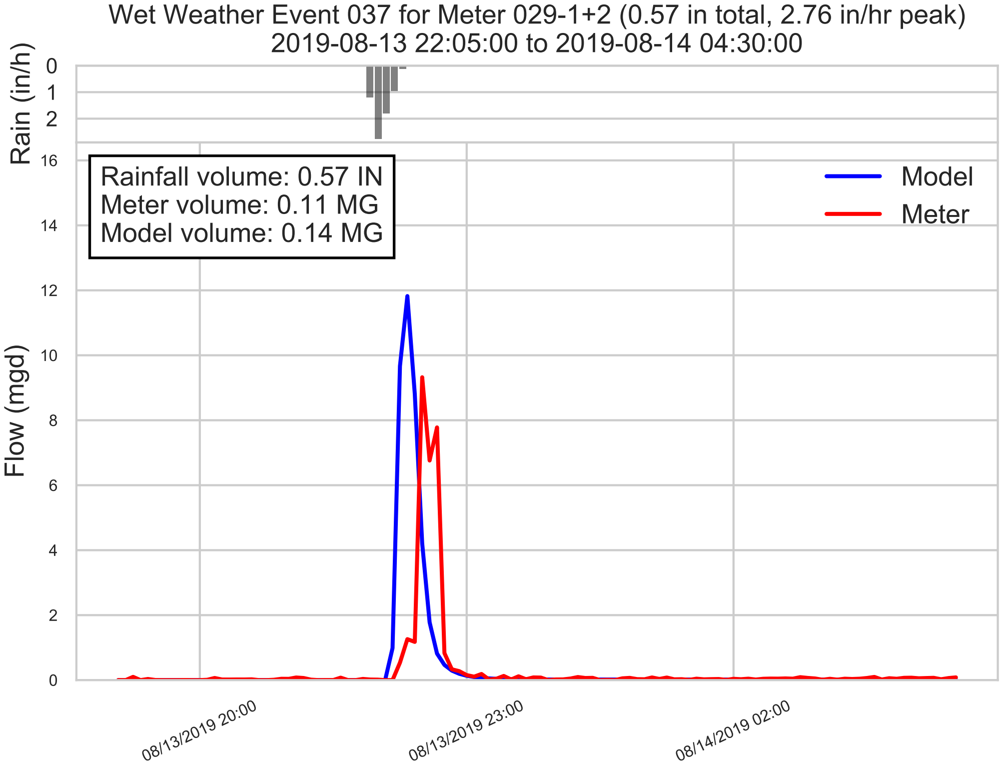


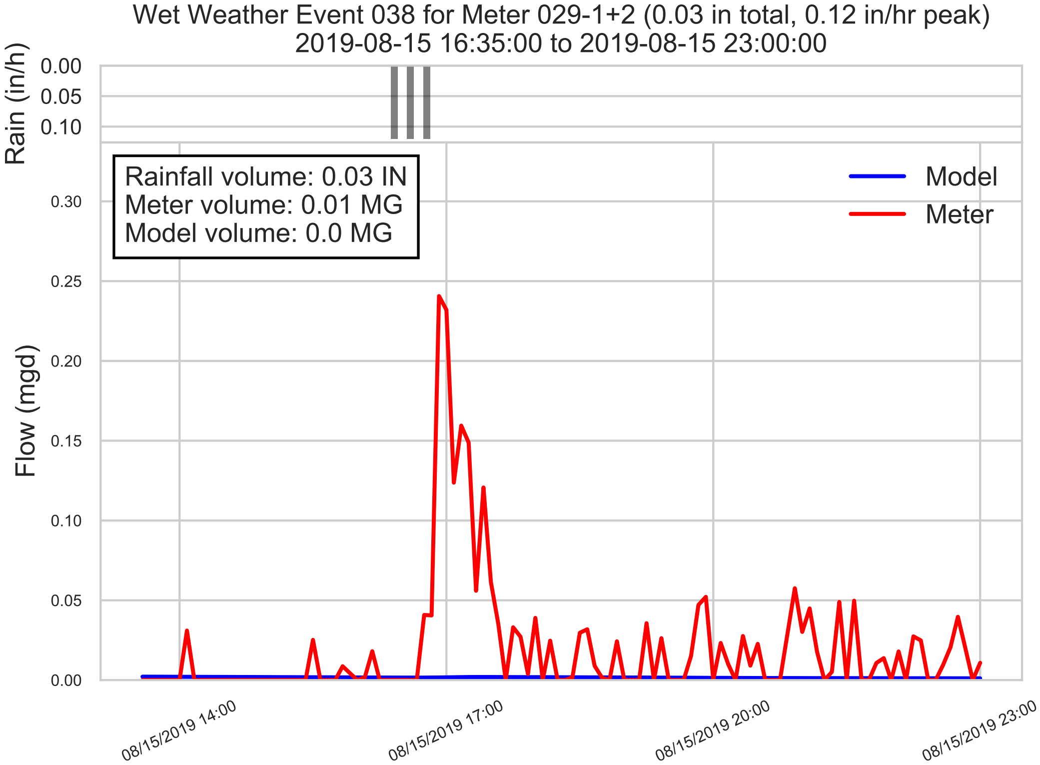
Wet Weather Event 034 for Meter 029-1+2 (0.11 in total, 0.6 in/hr peak)
2019-08-06 20:20:00 to 2019-08-07 02:35:00
Rain (in/h)
0.00
0.25
0.50
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Rainfall volume: 0.11 IN
Meter volume: 0.01 MG
Model volume: 0.01 MG
Model
Meter
08/06/2019 18:00
08/06/2019 21:00
08/07/2019 00:00
08/07/2019 03:00


Wet Weather Event 035 for Meter 029-1+2 (0.25 in total, 1.08 in/hr peak)
2019-08-07 16:00:00 to 2019-08-07 22:50:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.25 IN
Meter volume: 0.06 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
8
6
4
2
0
08/07/2019 13:00
08/07/2019 16:00
08/07/2019 19:00
08/07/2019 22:00

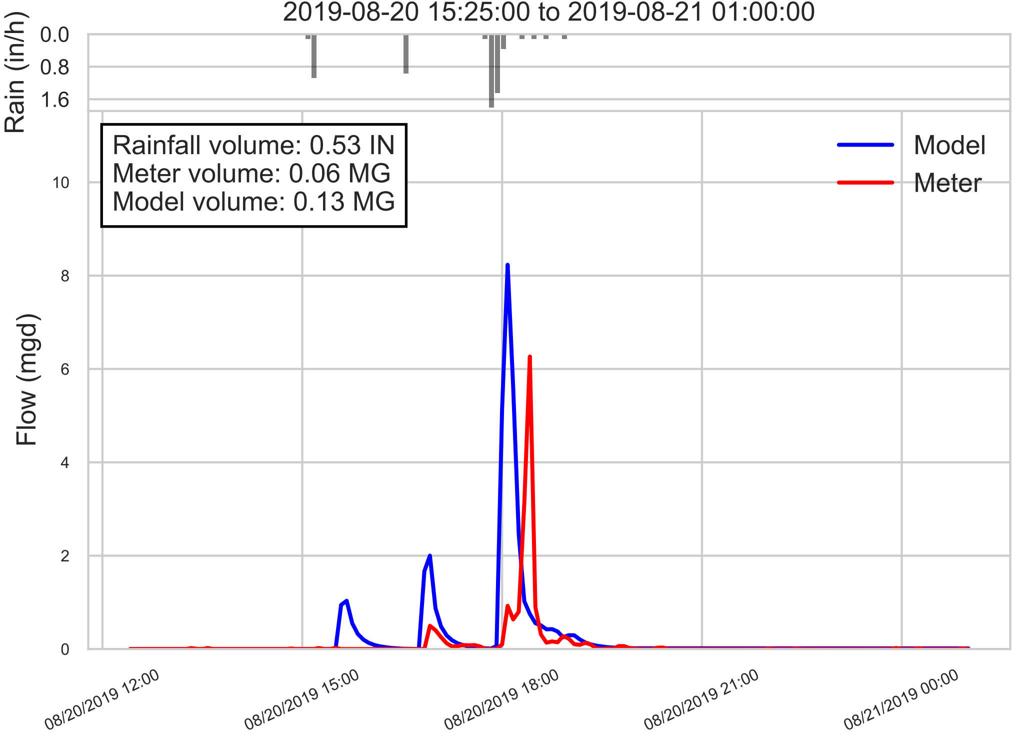


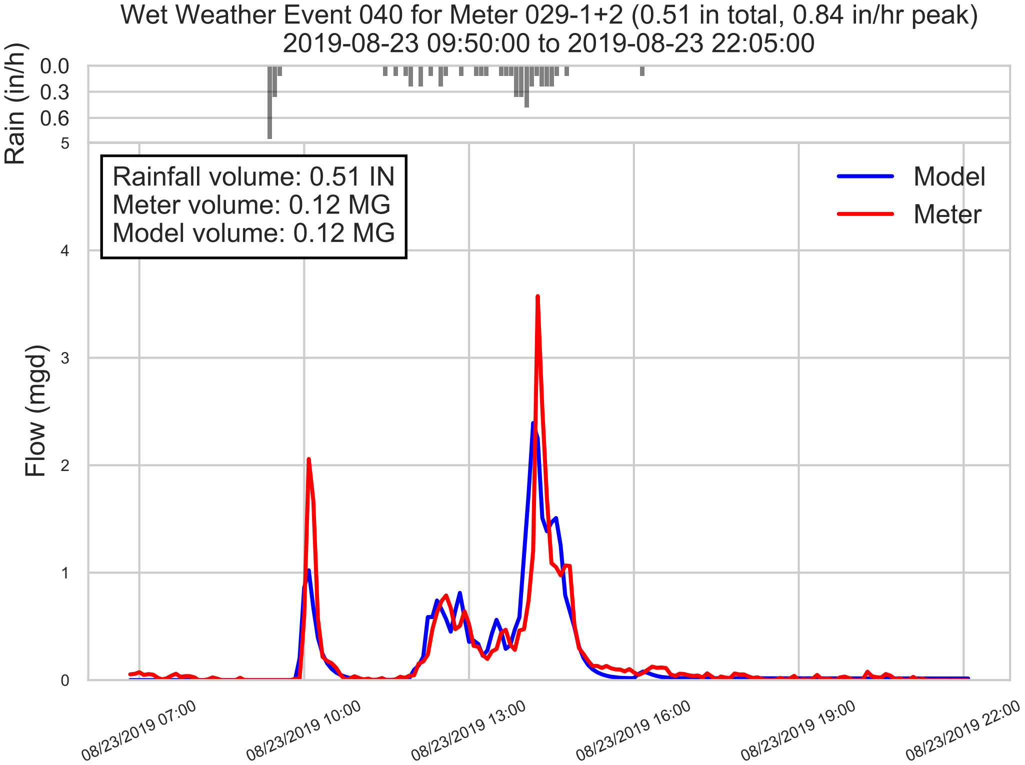
Wet Weather Event 036 for Meter 029-1+2 (0.05 in total, 0.12 in/hr peak)
2019-08-13 12:00:00 to 2019-08-13 18:55:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall volume: 0.05 IN
Meter volume: 0.0 MG
Model volume: 0.0 MG
Model
Meter
08/13/2019 09:00
08/13/2019 12:00
08/13/2019 15:00
08/13/2019 18:00

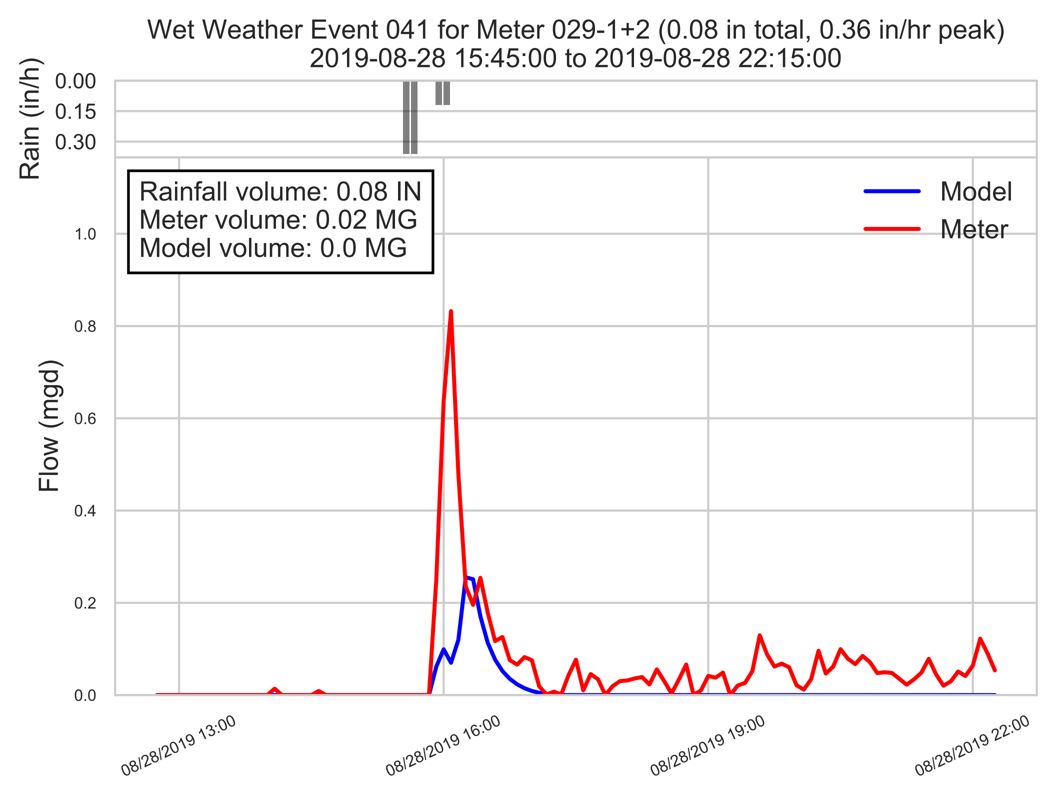

Wet Weather Event 037 for Meter 029-1+2 (0.57 in total, 2.76 in/hr peak)
2019-08-13 22:05:00 to 2019-08-14 04:30:00
Rain (in/h)
0
1
2
Flow (mgd)
16
14
12
10
8
6
4
2
0
Rainfall volume: 0.57 IN
Meter volume: 0.11 MG
Model volume: 0.14 MG
Model
Meter
08/13/2019 20:00
08/13/2019 23:00
08/14/2019 02:00


Wet Weather Event 038 for Meter 029-1+2 (0.03 in total, 0.12 in/hr peak)
2019-08-15 16:35:00 to 2019-08-15 23:00:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.03 IN
Meter volume: 0.01 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
08/15/2019 14:00
08/15/2019 17:00
08/15/2019 20:00
08/15/2019 23:00

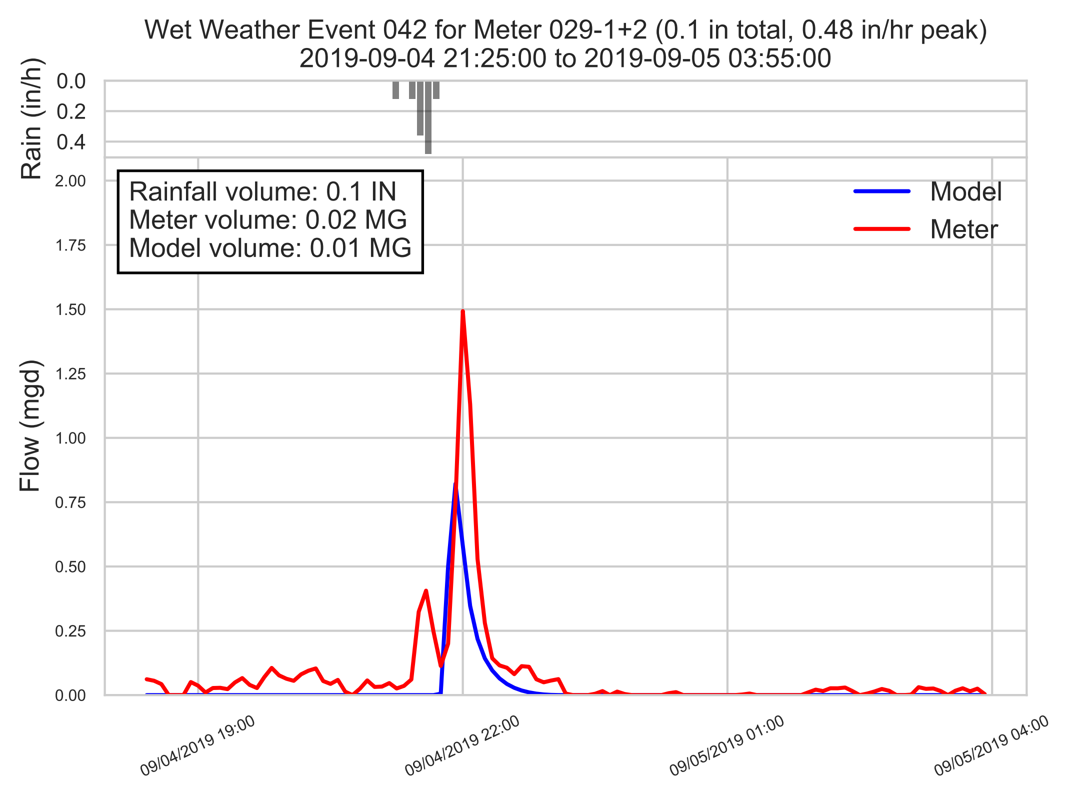
Wet Weather Event 039 for Meter 029-1+2 (0.53 in total, 1.8 in/hr peak)
2019-08-20 15:25:00 to 2019-08-21 01:00:00

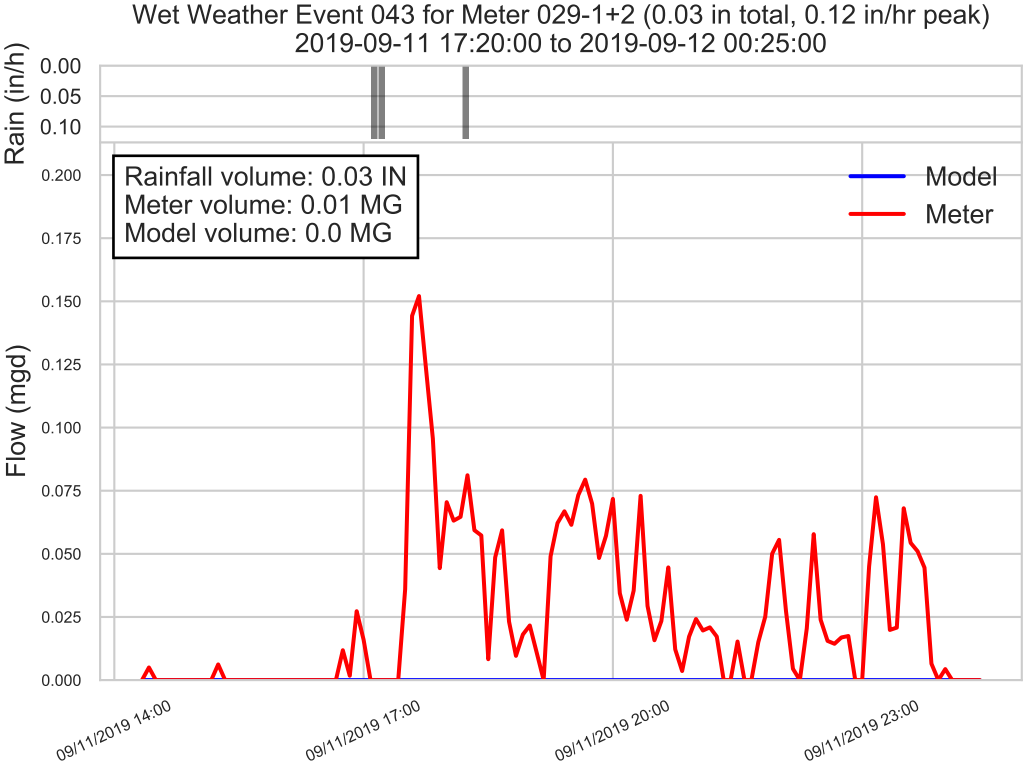


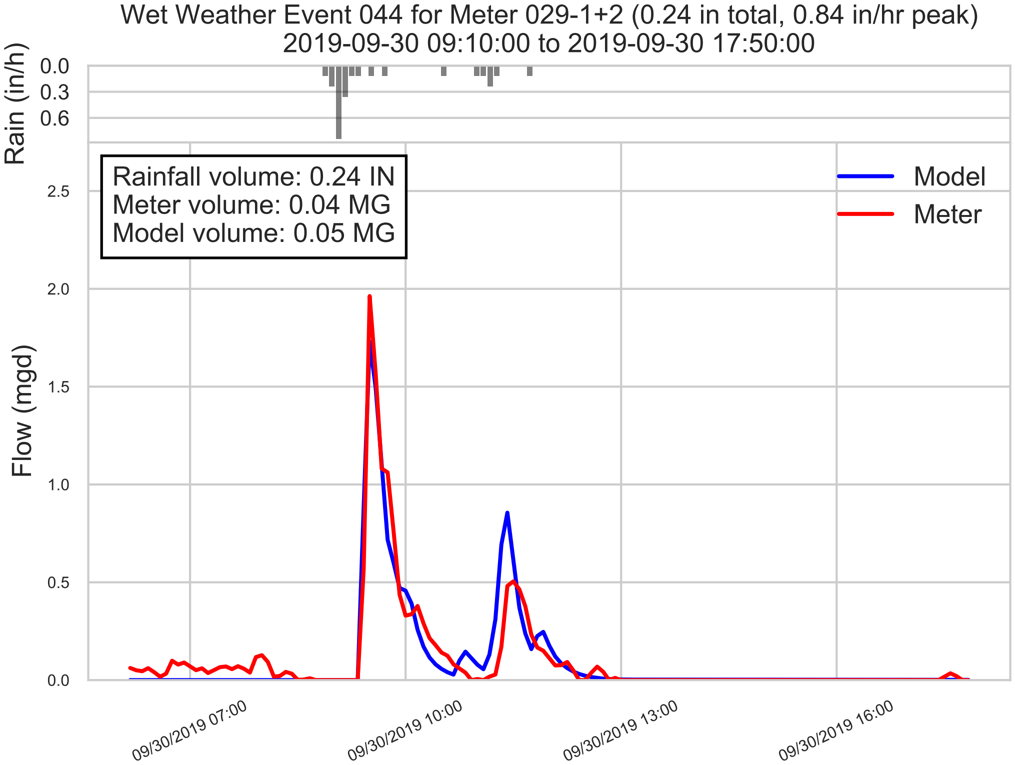

Wet Weather Event 040 for Meter 029-1+2 (0.51 in total, 0.84 in/hr peak)
2019-08-23 09:50:00 to 2019-08-23 22:05:00
Rain (in/h)
0.0
0.3
0.6
5
4
3
2
1
0
Flow (mgd)
Rainfall volume: 0.51 IN
Meter volume: 0.12 MG
Model volume: 0.12 MG
Model
Meter
08/23/2019 07:00
08/23/2019 10:00
08/23/2019 13:00
08/23/2019 16:00
08/23/2019 19:00
08/23/2019 22:00



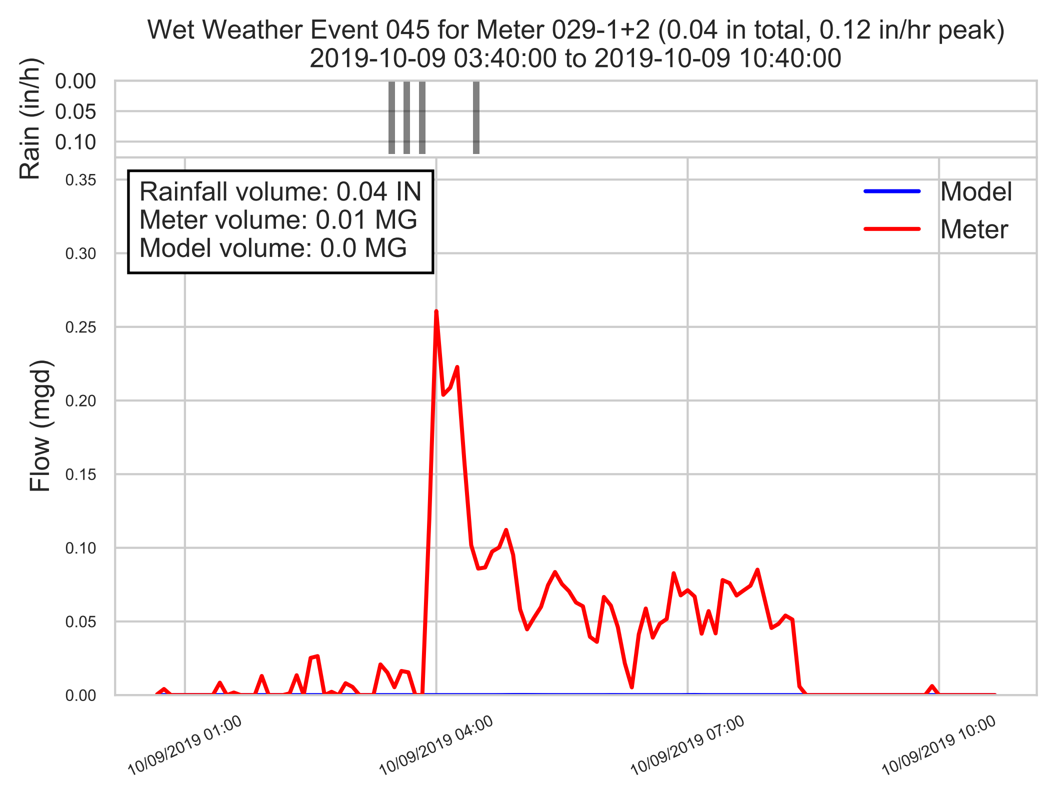
Wet Weather Event 041 for Meter 029-1+2 (0.08 in total, 0.36 in/hr peak)
2019-08-28 15:45:00 to 2019-08-28 22:15:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.08 IN
Meter volume: 0.02 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
08/28/2019 13:00
08/28/2019 16:00
08/28/2019 19:00
08/28/2019 22:00


Wet Weather Event 042 for Meter 029-1+2 (0.1 in total, 0.48 in/hr peak)
2019-09-04 21:25:00 to 2019-09-05 03:55:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.1 IN
Meter volume: 0.02 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
09/04/2019 19:00
09/04/2019 22:00
09/05/2019 01:00
09/05/2019 04:00

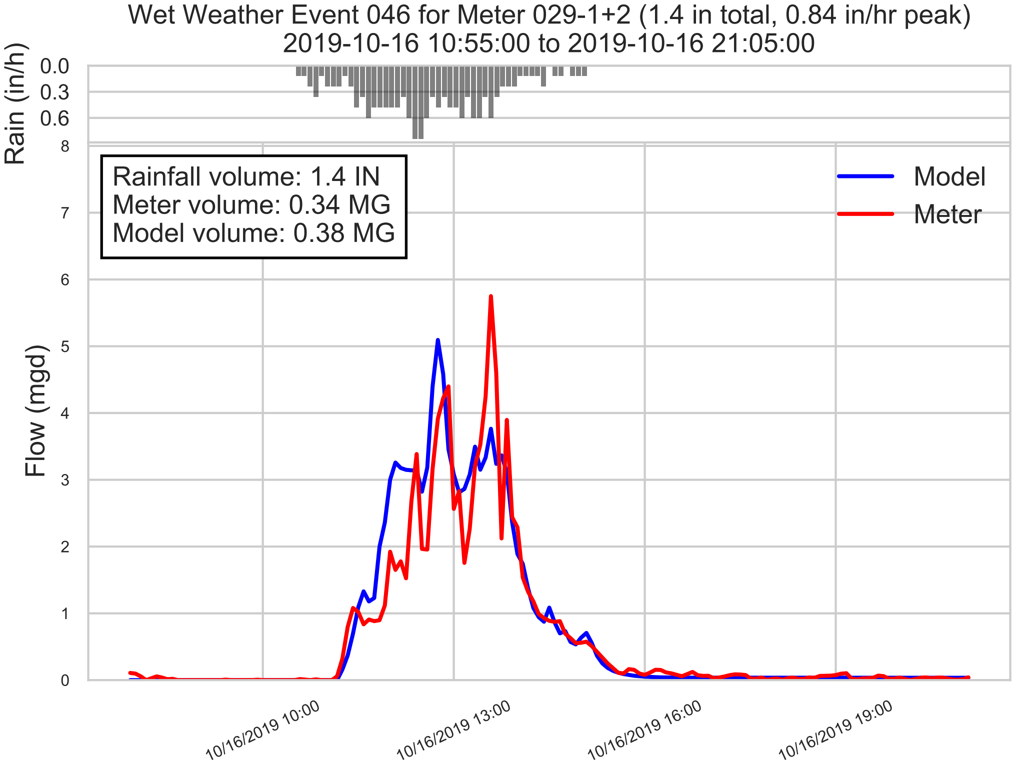

Wet Weather Event 043 for Meter 029-1+2 (0.03 in total, 0.12 in/hr peak)
2019-09-11 17:20:00 to 2019-09-12 00:25:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.03 IN
Meter volume: 0.01 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
09/11/2019 14:00
09/11/2019 17:00
09/11/2019 20:00
09/11/2019 23:00



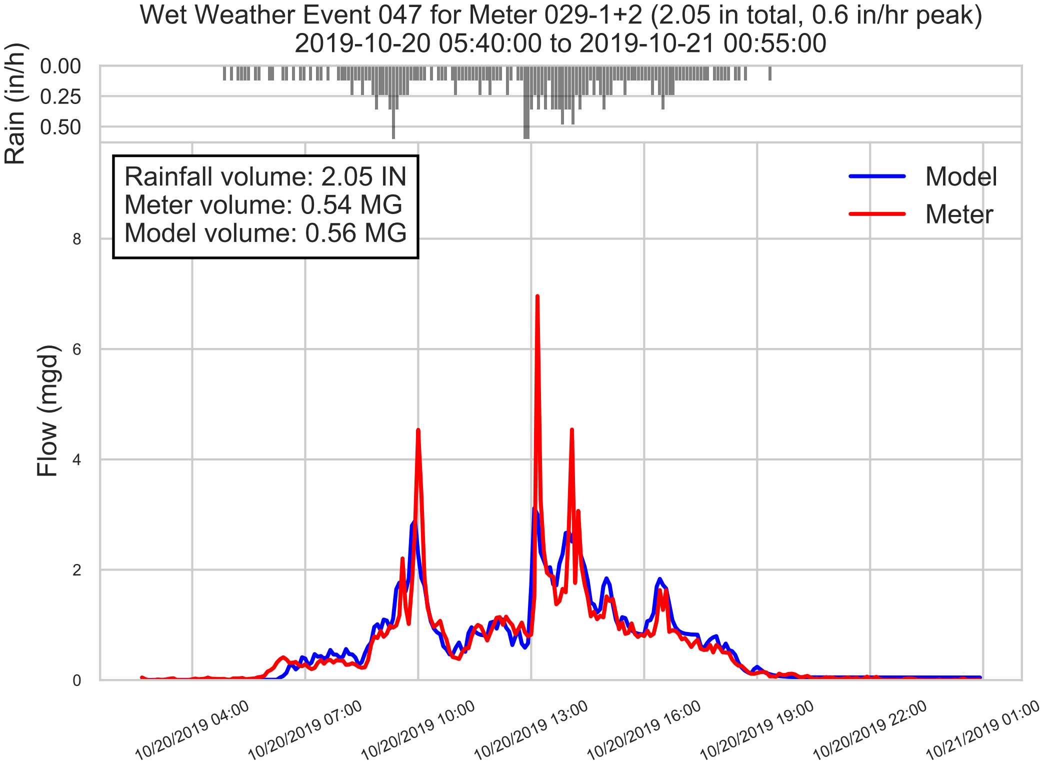
Wet Weather Event 044 for Meter 029-1+2 (0.24 in total, 0.84 in/hr peak)
2019-09-30 09:10:00 to 2019-09-30 17:50:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.24 IN
Meter volume: 0.04 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
09/30/2019 07:00
09/30/2019 10:00
09/30/2019 13:00
09/30/2019 16:00



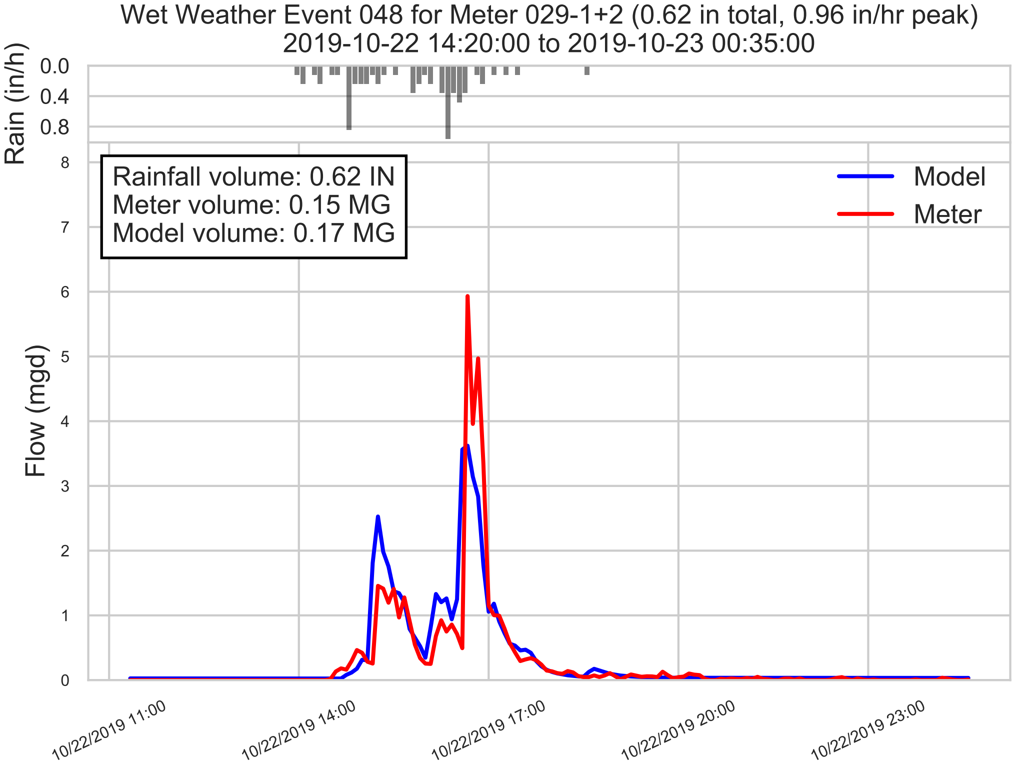
Wet Weather Event 045 for Meter 029-1+2 (0.04 in total, 0.12 in/hr peak)
2019-10-09 03:40:00 to 2019-10-09 10:40:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Rainfall volume: 0.04 IN
Meter volume: 0.01 MG
Model volume: 0.0 MG
Model
Meter
10/09/2019 01:00
10/09/2019 04:00
10/09/2019 07:00
10/09/2019 10:00



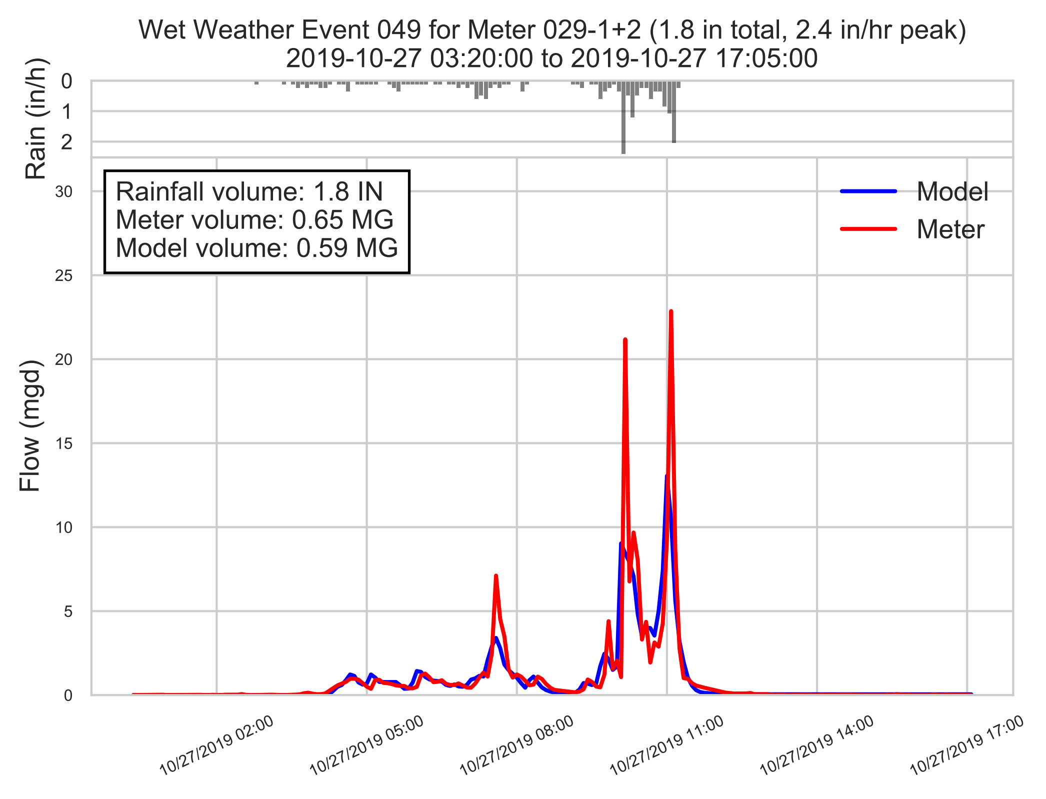
Wet Weather Event 046 for Meter 029-1+2 (1.4 in total, 0.84 in/hr peak)
2019-10-16 10:55:00 to 2019-10-16 21:05:00
Rain (in/h)
0.0
0.3
0.6
8
7
6
5
4
3
2
1
0
Flow (mgd)
Rainfall volume: 1.4 IN
Meter volume: 0.34 MG
Model volume: 0.38 MG
Model
Meter
10/16/2019 10:00
10/16/2019 13:00
10/16/2019 16:00
10/16/2019 19:00



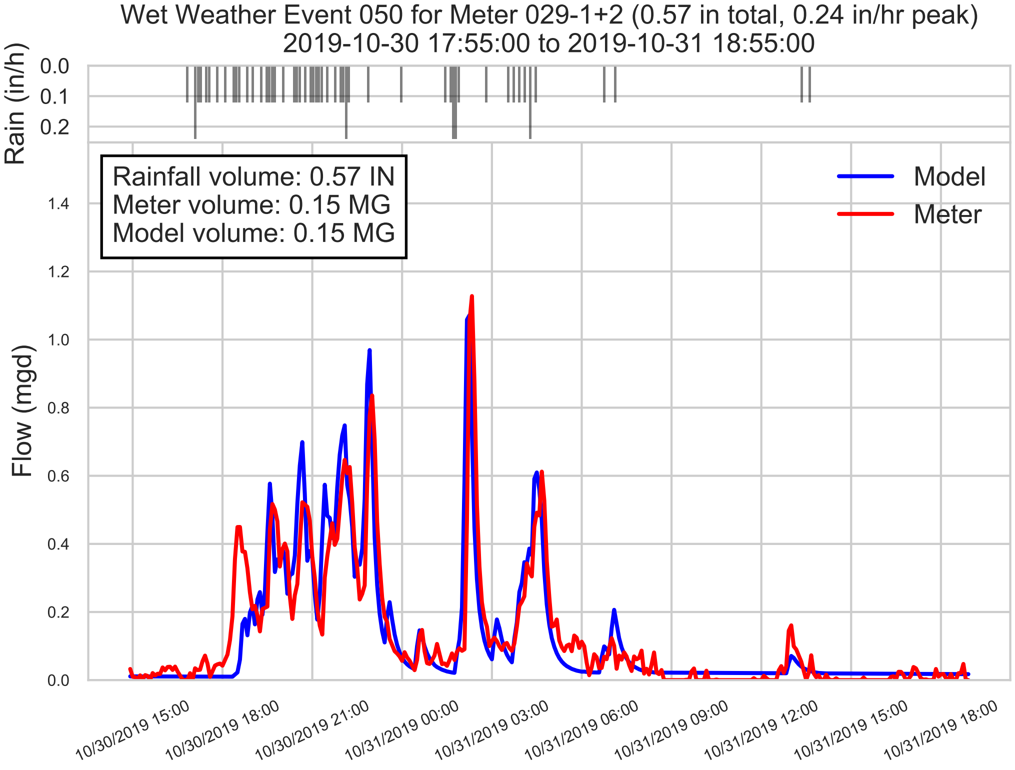
Wet Weather Event 047 for Meter 029-1+2 (2.05 in total, 0.6 in/hr peak)
2019-10-20 05:40:00 to 2019-10-21 00:55:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 2.05 IN
Meter volume: 0.54 MG
Model volume: 0.56 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10/20/2019 04:00
10/20/2019 07:00
10/20/2019 10:00
10/20/2019 13:00
10/20/2019 16:00
10/20/2019 19:00
10/20/2019 22:00
10/21/2019 01:00



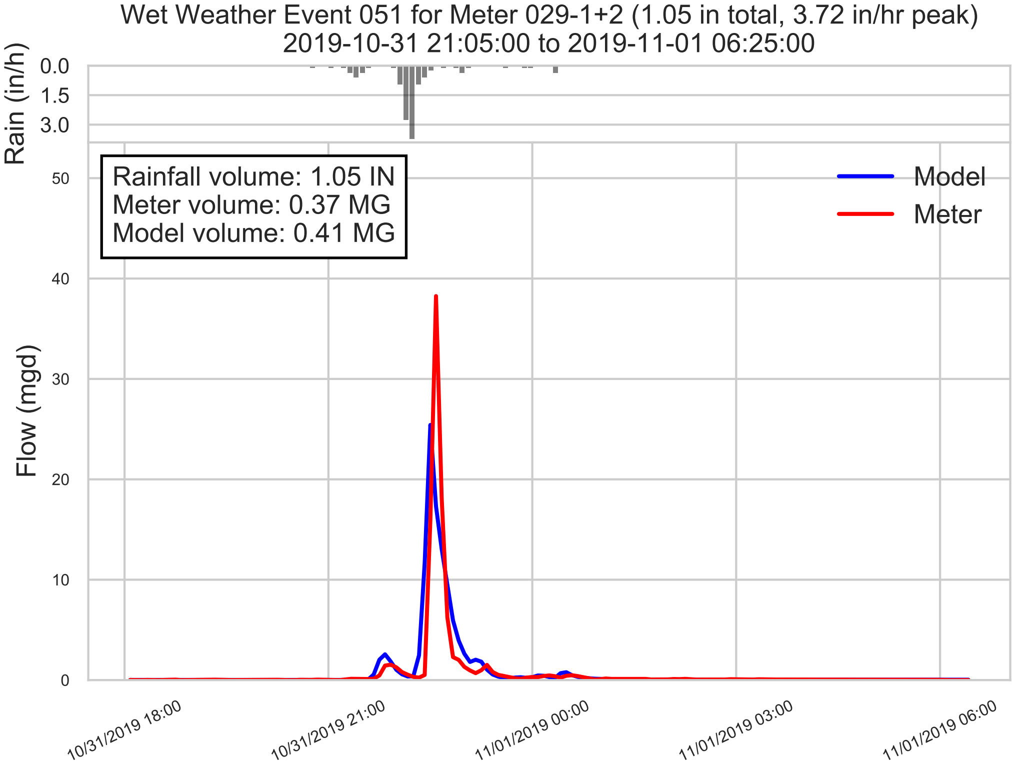
Wet Weather Event 048 for Meter 029-1+2 (0.62 in total, 0.96 in/hr peak)
2019-10-22 14:20:00 to 2019-10-23 00:35:00
Rain (in/h)
0.0
0.4
0.8
Flow (mgd)
0
1
2
3
4
5
6
7
8
Rainfall volume: 0.62 IN
Meter volume: 0.15 MG
Model volume: 0.17 MG
Model
Meter
10/22/2019 11:00
10/22/2019 14:00
10/22/2019 17:00
10/22/2019 20:00
10/22/2019 23:00

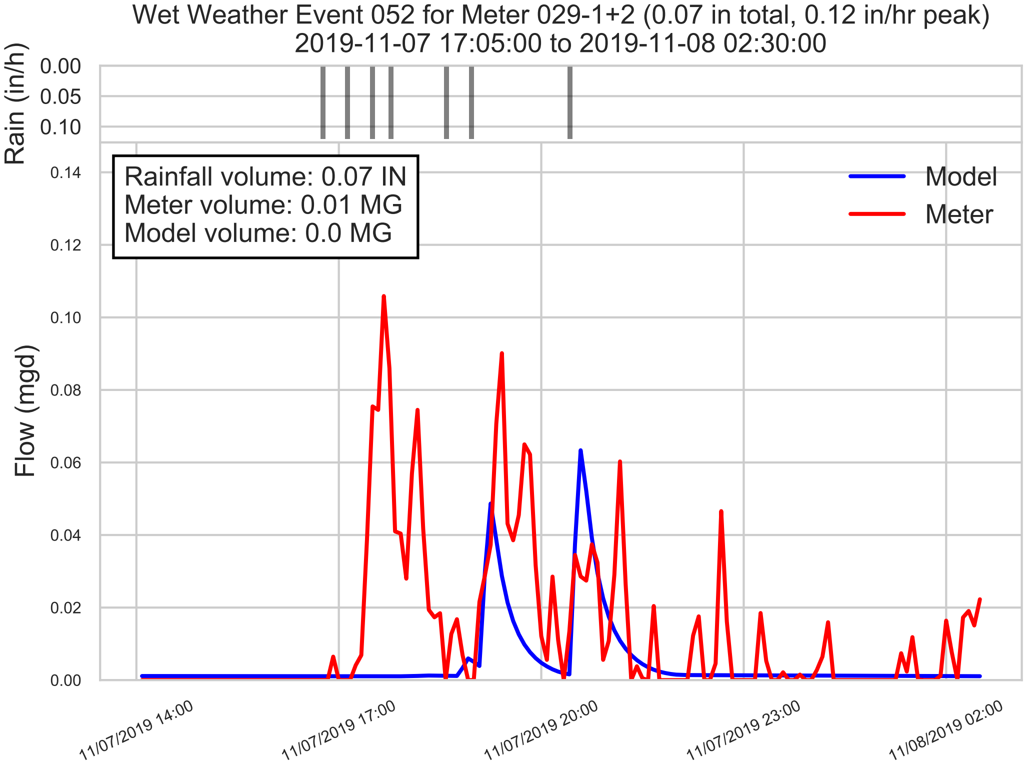


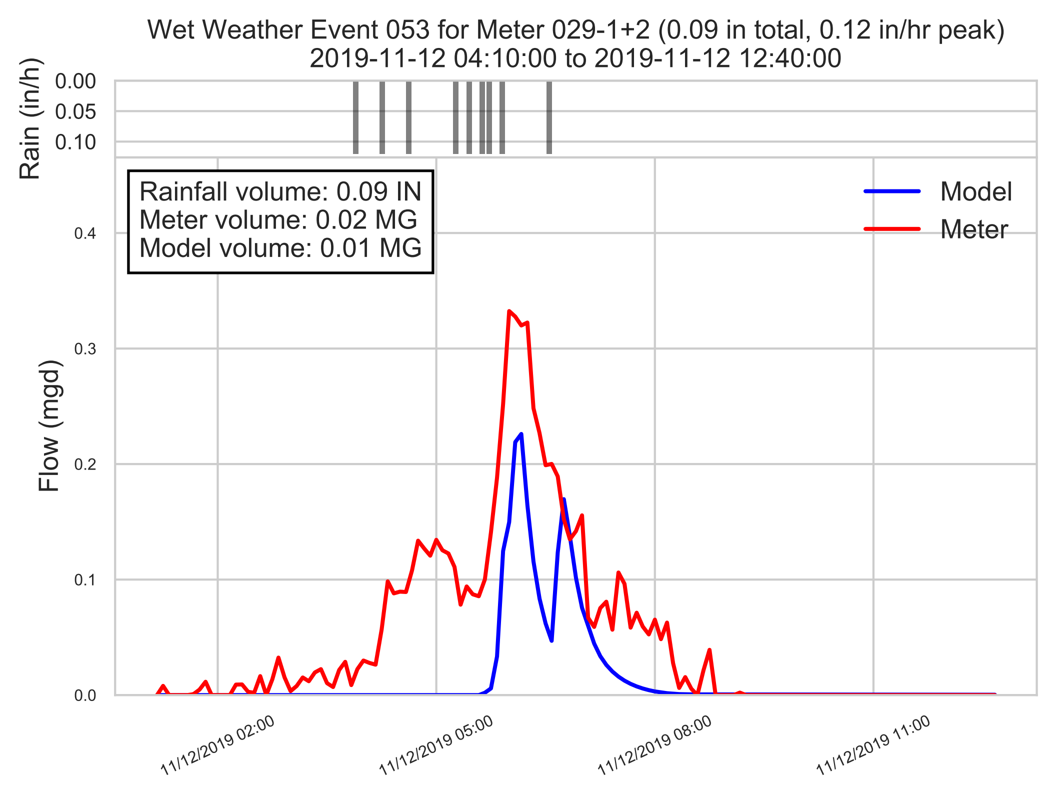
Wet Weather Event 049 for Meter 029-1+2 (1.8 in total, 2.4 in/hr peak)
2019-10-27 03:20:00 to 2019-10-27 17:05:00
Rain (in/h)
0
1
2
Rainfall volume: 1.8 IN
Meter volume: 0.65 MG
Model volume: 0.59 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
10/27/2019 02:00
10/27/2019 05:00
10/27/2019 08:00
10/27/2019 11:00
10/27/2019 14:00
10/27/2019 17:00

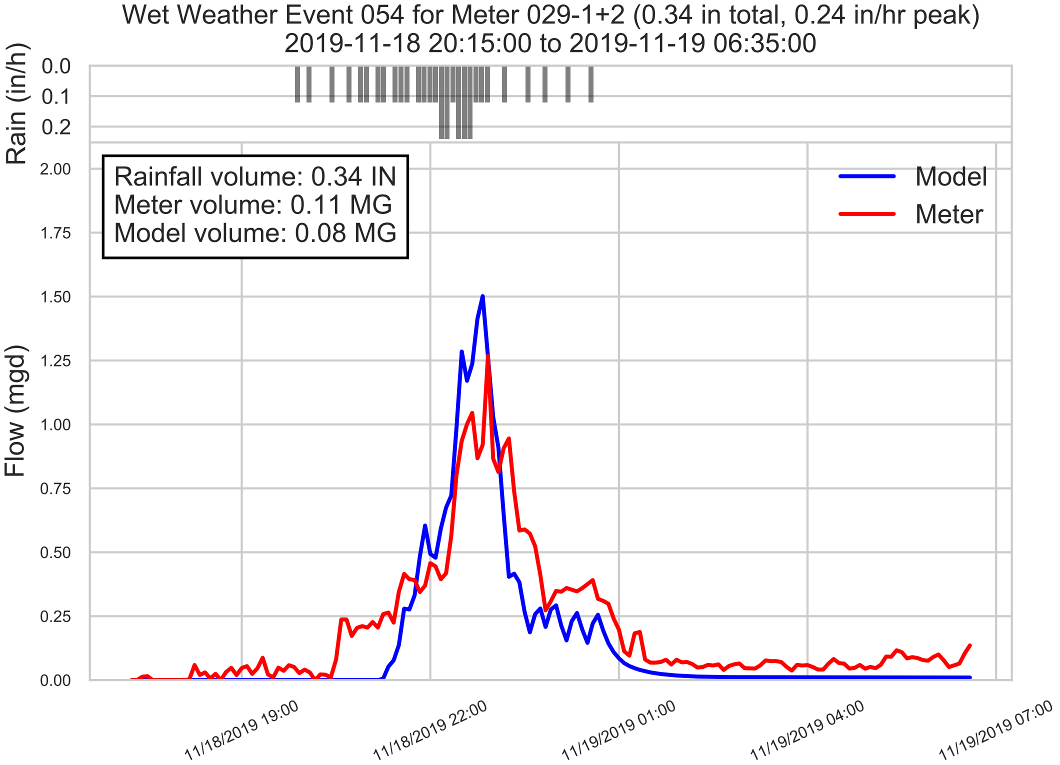


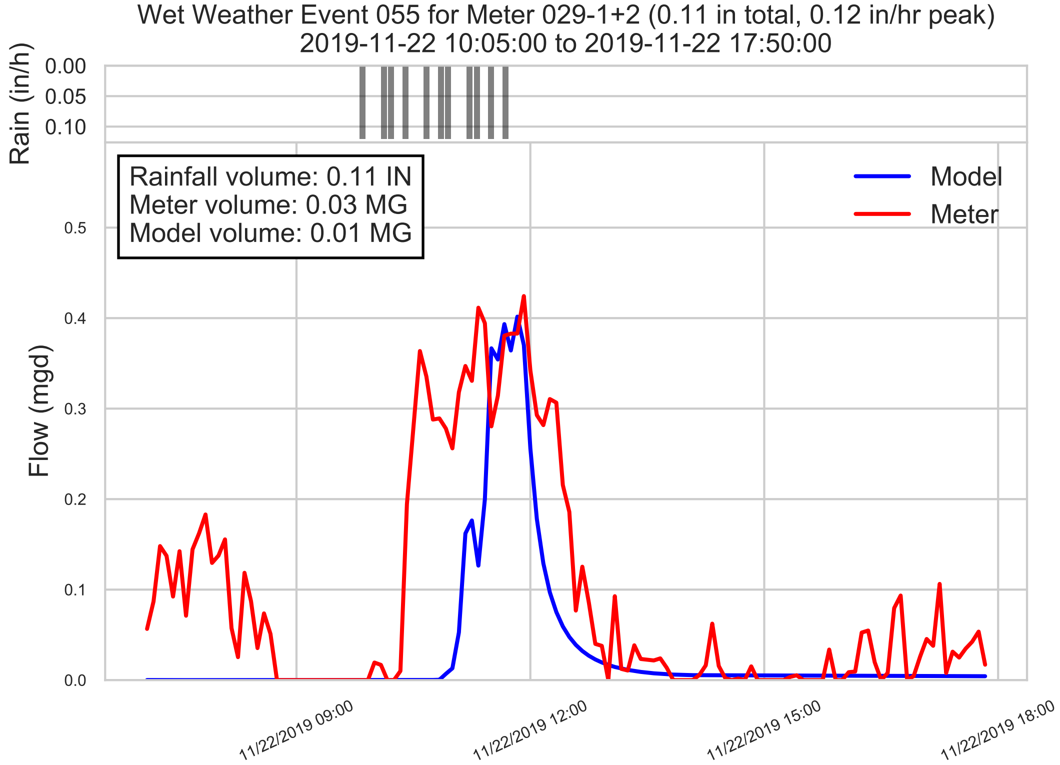
Wet Weather Event 050 for Meter 029-1+2 (0.57 in total, 0.24 in/hr peak)
2019-10-30 17:55:00 to 2019-10-31 18:55:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.57 IN
Meter volume: 0.15 MG
Model volume: 0.15 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10/30/2019 15:00
10/30/2019 18:00
10/30/2019 21:00
10/31/2019 00:00
10/31/2019 03:00
10/31/2019 06:00
10/31/2019 09:00
10/31/2019 12:00
10/31/2019 15:00
10/31/2019 18:00


Wet Weather Event 051 for Meter 029-1+2 (1.05 in total, 3.72 in/hr peak)
2019-10-31 21:05:00 to 2019-11-01 06:25:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.05 IN
Meter volume: 0.37 MG
Model volume: 0.41 MG
Model
Meter
Flow (mgd)
50
40
30
20
10
0
10/31/2019 18:00
10/31/2019 21:00
11/01/2019 00:00
11/01/2019 03:00
11/01/2019 06:00

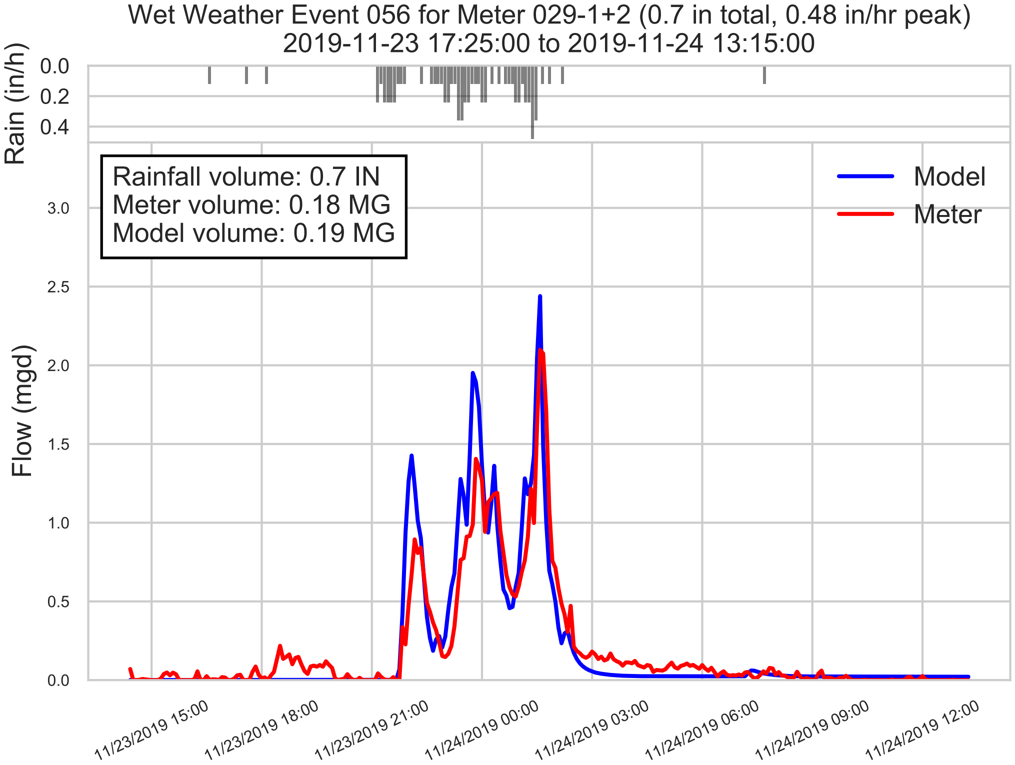

Wet Weather Event 052 for Meter 029-1+2 (0.07 in total, 0.12 in/hr peak)
2019-11-07 17:05:00 to 2019-11-08 02:30:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.07 IN
Meter volume: 0.01 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
11/07/2019 14:00
11/07/2019 17:00
11/07/2019 20:00
11/07/2019 23:00
11/08/2019 02:00


Wet Weather Event 053 for Meter 029-1+2 (0.09 in total, 0.12 in/hr peak)
2019-11-12 04:10:00 to 2019-11-12 12:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.09 IN
Meter volume: 0.02 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
11/12/2019 02:00
11/12/2019 05:00
11/12/2019 08:00
11/12/2019 11:00

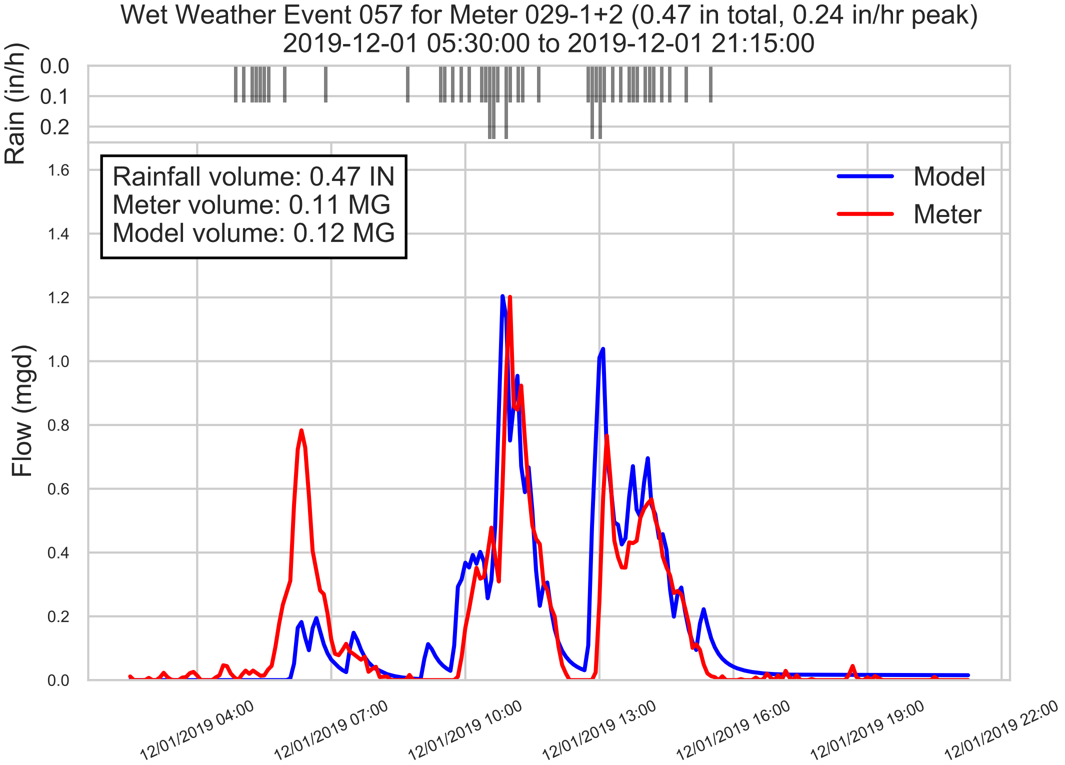

Wet Weather Event 054 for Meter 029-1+2 (0.34 in total, 0.24 in/hr peak)
2019-11-18 20:15:00 to 2019-11-19 06:35:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall volume: 0.34 IN
Meter volume: 0.11 MG
Model volume: 0.08 MG
Model
Meter
11/18/2019 19:00
11/18/2019 22:00
11/19/2019 01:00
11/19/2019 04:00
11/19/2019 07:00

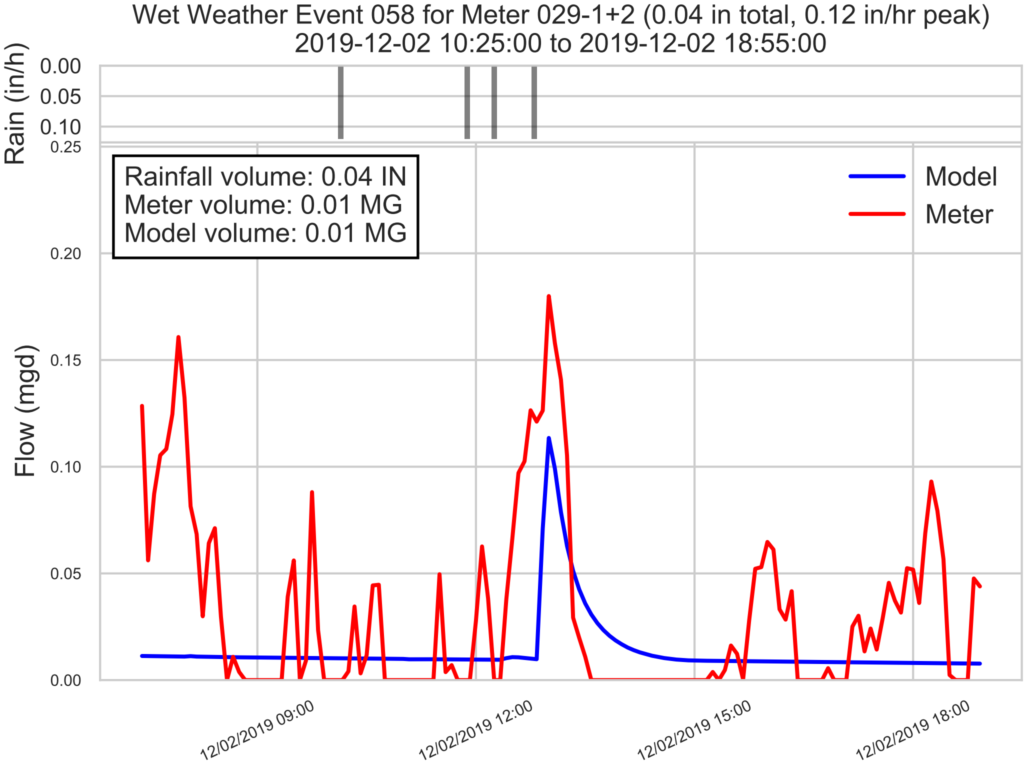


Wet Weather Event 055 for Meter 029-1+2 (0.11 in total, 0.12 in/hr peak)
2019-11-22 10:05:00 to 2019-11-22 17:50:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.11 IN
Meter volume: 0.03 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.5
0.4
0.3
0.2
0.1
0.0
11/22/2019 09:00
11/22/2019 12:00
11/22/2019 15:00
11/22/2019 18:00

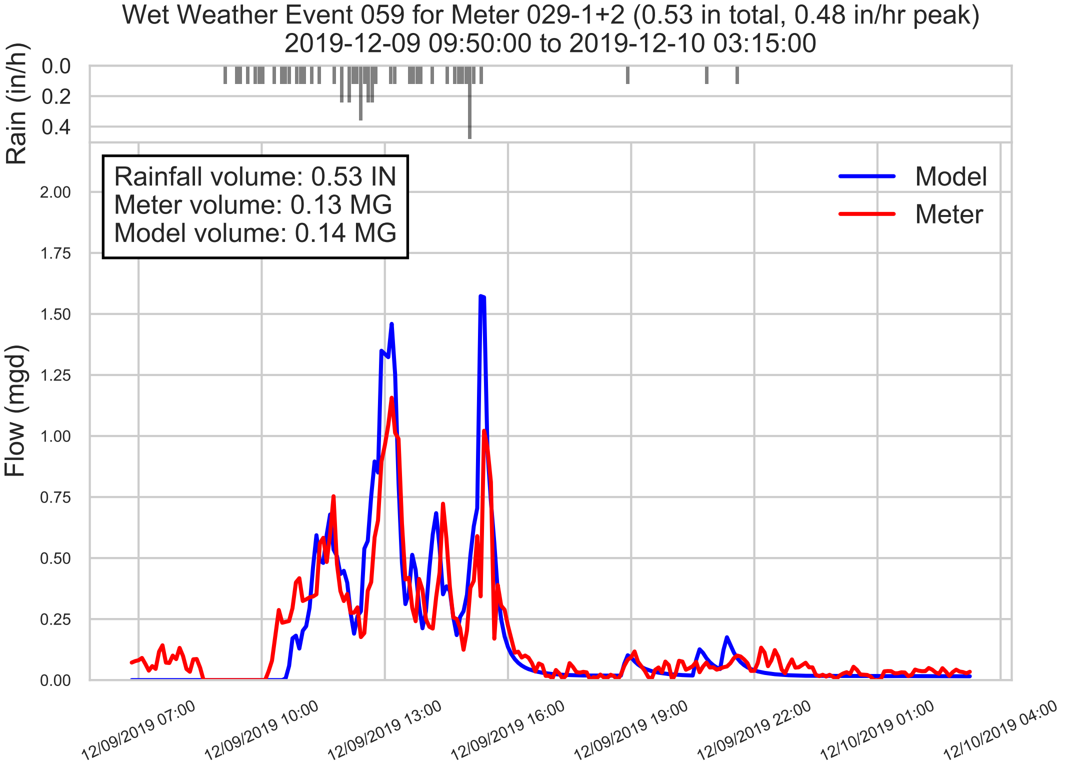


Wet Weather Event 056 for Meter 029-1+2 (0.7 in total, 0.48 in/hr peak)
2019-11-23 17:25:00 to 2019-11-24 13:15:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.7 IN
Meter volume: 0.18 MG
Model volume: 0.19 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/23/2019 15:00
11/23/2019 18:00
11/23/2019 21:00
11/24/2019 00:00
11/24/2019 03:00
11/24/2019 06:00
11/24/2019 09:00
11/24/2019 12:00

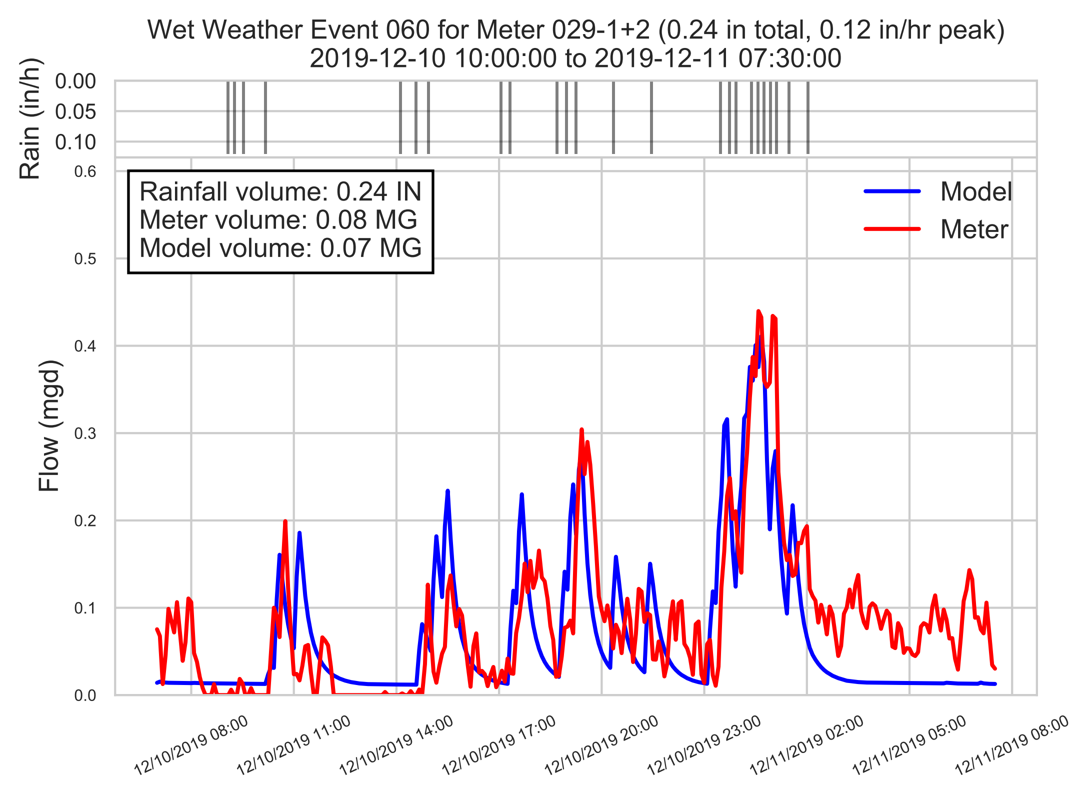

Wet Weather Event 057 for Meter 029-1+2 (0.47 in total, 0.24 in/hr peak)
2019-12-01 05:30:00 to 2019-12-01 21:15:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.47 IN
Meter volume: 0.11 MG
Model volume: 0.12 MG
Model
Meter
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/01/2019 04:00
12/01/2019 07:00
12/01/2019 10:00
12/01/2019 13:00
12/01/2019 16:00
12/01/2019 19:00
12/01/2019 22:00



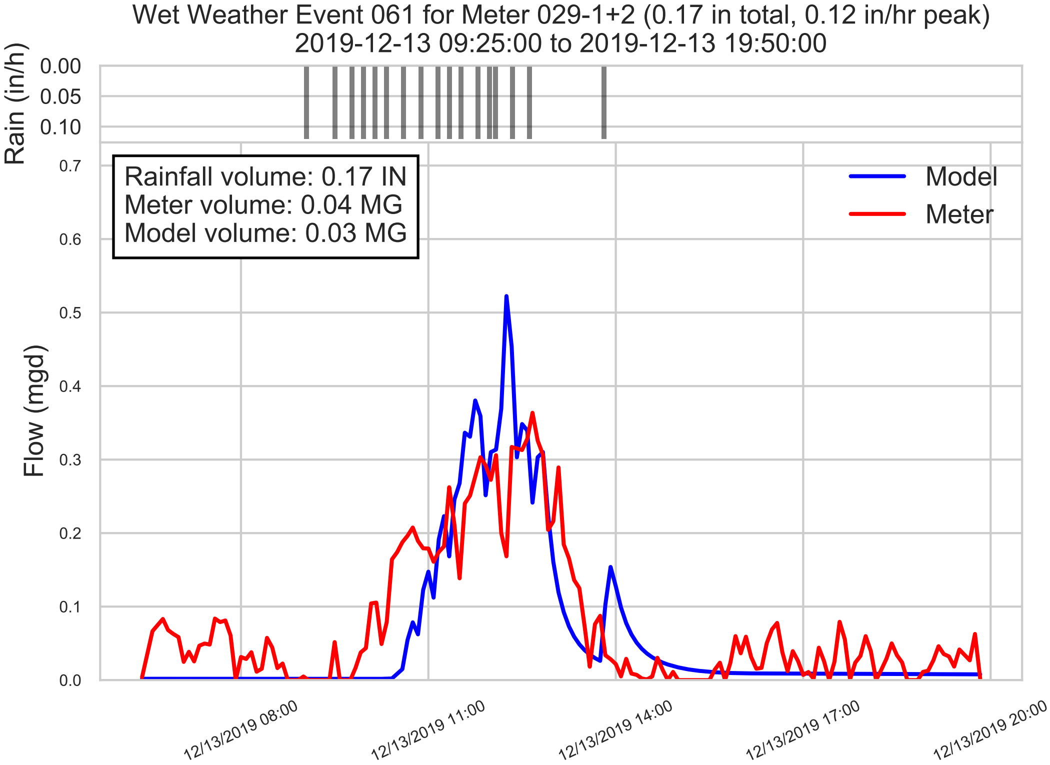
Wet Weather Event 058 for Meter 029-1+2 (0.04 in total, 0.12 in/hr peak)
2019-12-02 10:25:00 to 2019-12-02 18:55:00
Rain (in/h)
0.00
0.05
0.10
0.25
0.20
0.15
0.10
0.05
0.00
Flow (mgd)
Rainfall volume: 0.04 IN
Meter volume: 0.01 MG
Model volume: 0.01 MG
Model
Meter
12/02/2019 09:00
12/02/2019 12:00
12/02/2019 15:00
12/02/2019 18:00

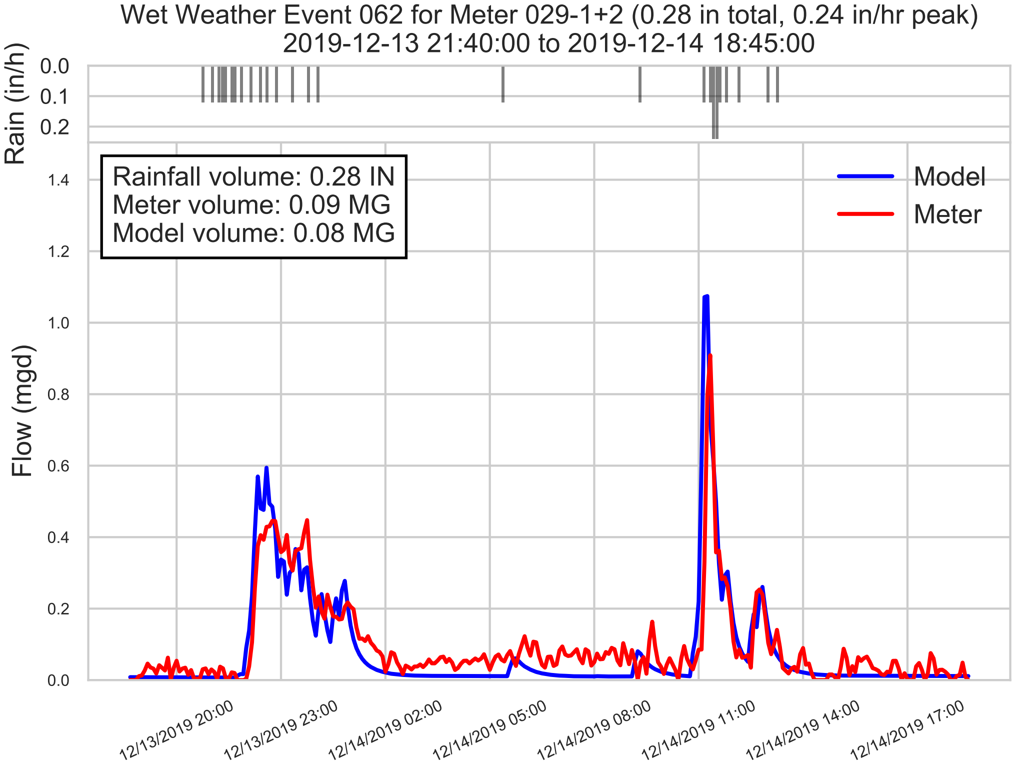


Wet Weather Event 059 for Meter 029-1+2 (0.53 in total, 0.48 in/hr peak)
2019-12-09 09:50:00 to 2019-12-10 03:15:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.53 IN
Meter volume: 0.13 MG
Model volume: 0.14 MG
Model
Meter
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
12/09/2019 07:00
12/09/2019 10:00
12/09/2019 13:00
12/09/2019 16:00
12/09/2019 19:00
12/09/2019 22:00
12/10/2019 01:00
12/10/2019 04:00

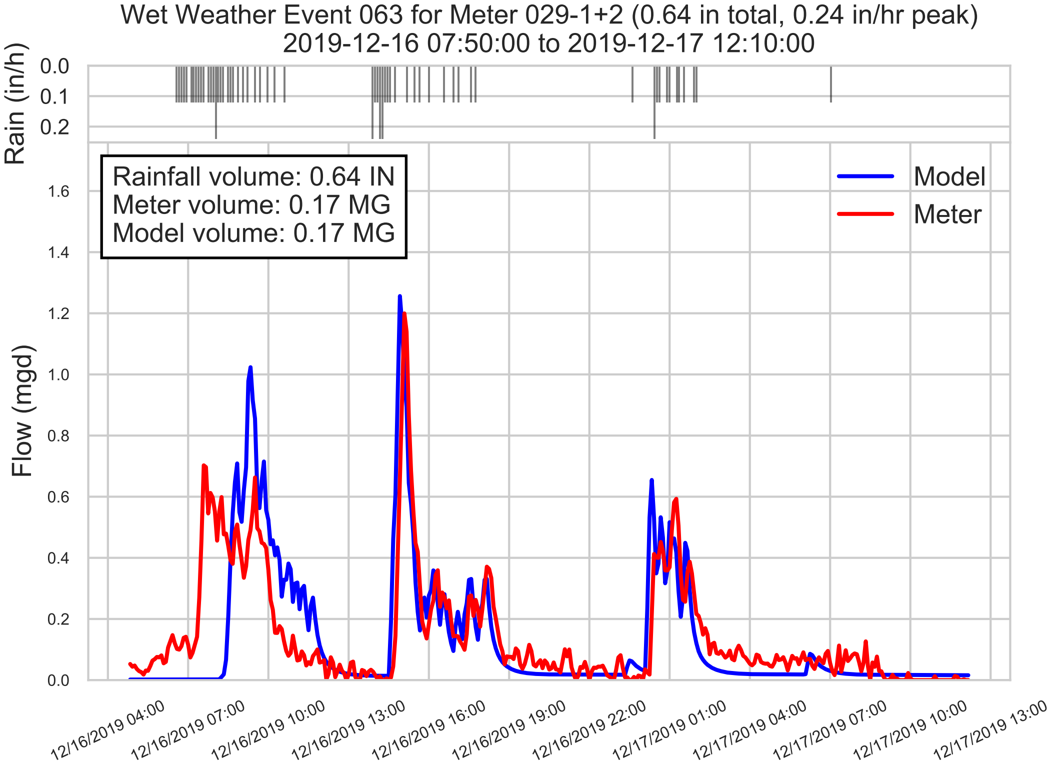


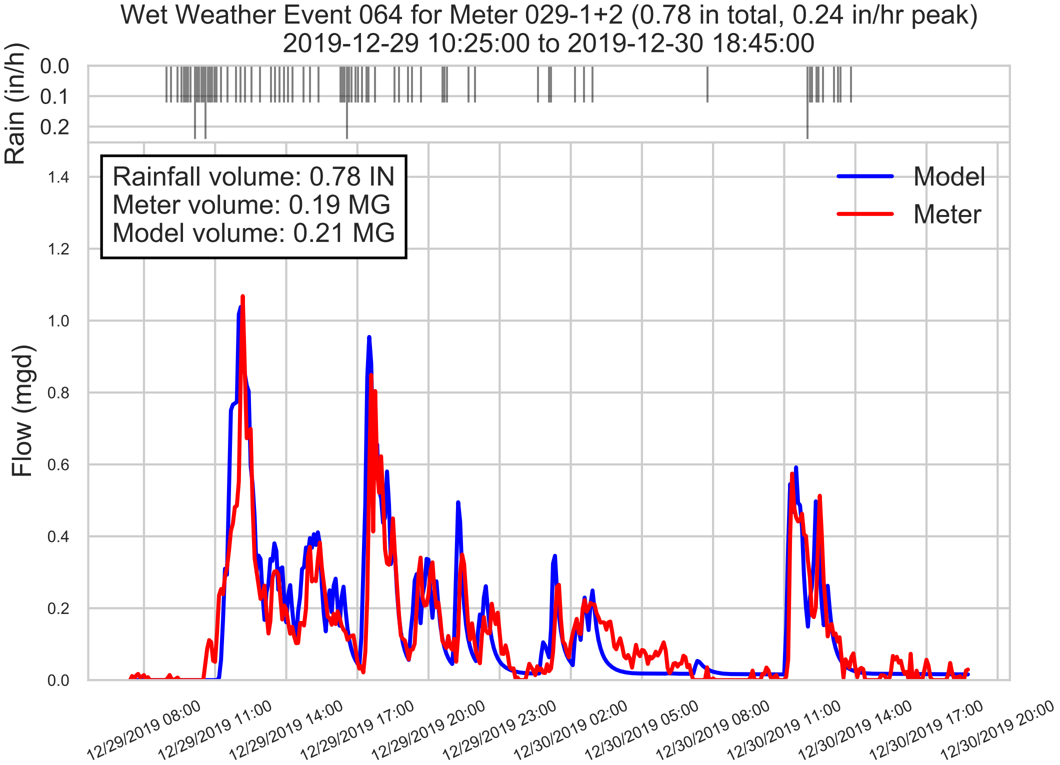
Wet Weather Event 060 for Meter 029-1+2 (0.24 in total, 0.12 in/hr peak)
2019-12-10 10:00:00 to 2019-12-11 07:30:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.24 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
12/10/2019 08:00
12/10/2019 11:00
12/10/2019 14:00
12/10/2019 17:00
12/10/2019 20:00
12/10/2019 23:00
12/11/2019 02:00
12/11/2019 05:00
12/11/2019 08:00

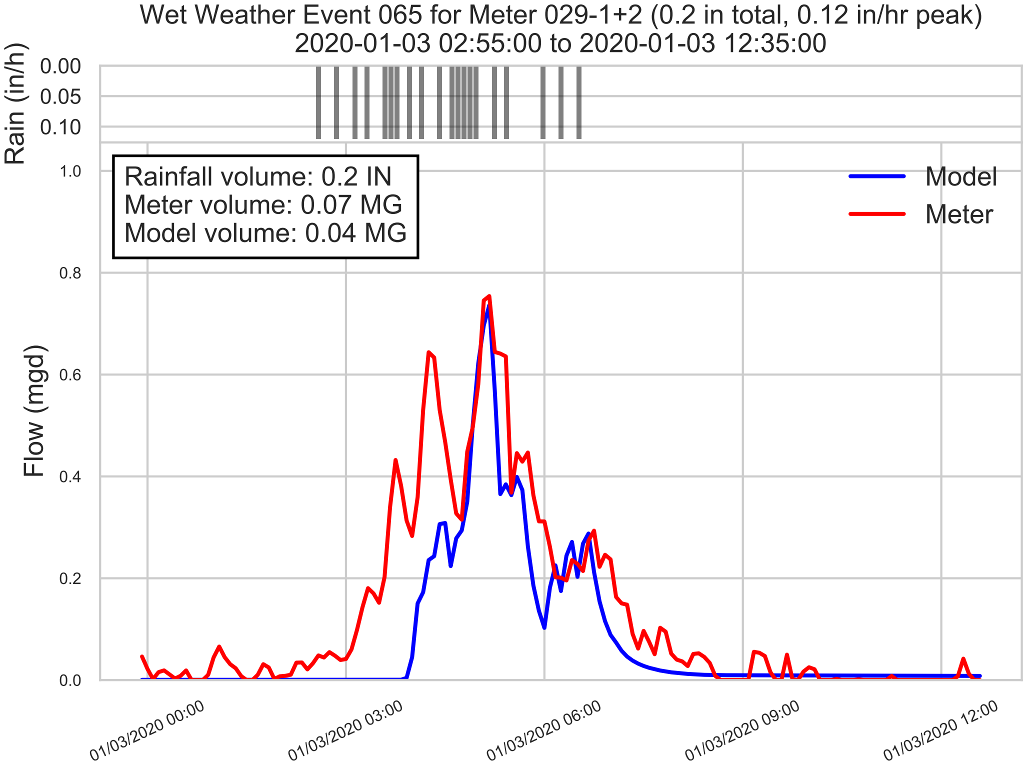

Wet Weather Event 061 for Meter 029-1+2 (0.17 in total, 0.12 in/hr peak)
2019-12-13 09:25:00 to 2019-12-13 19:50:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Rainfall volume: 0.17 IN
Meter volume: 0.04 MG
Model volume: 0.03 MG
Model
Meter
12/13/2019 08:00
12/13/2019 11:00
12/13/2019 14:00
12/13/2019 17:00
12/13/2019 20:00

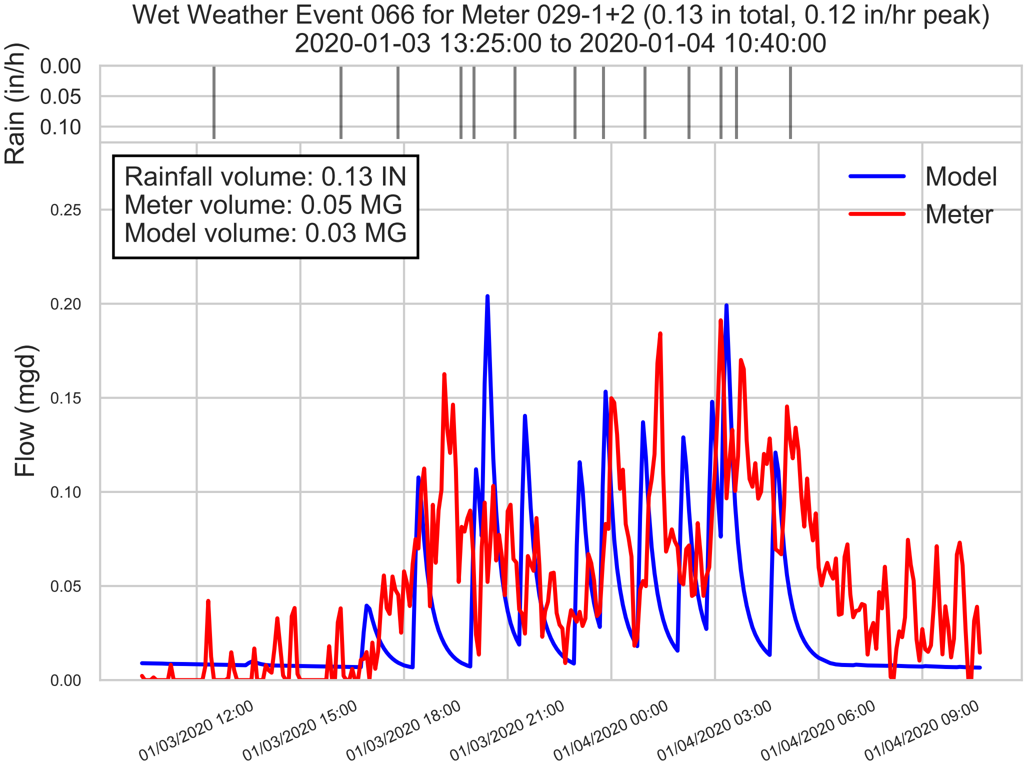


Wet Weather Event 062 for Meter 029-1+2 (0.28 in total, 0.24 in/hr peak)
2019-12-13 21:40:00 to 2019-12-14 18:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.28 IN
Meter volume: 0.09 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/13/2019 20:00
12/13/2019 23:00
12/14/2019 02:00
12/14/2019 05:00
12/14/2019 08:00
12/14/2019 11:00
12/14/2019 14:00
12/14/2019 17:00

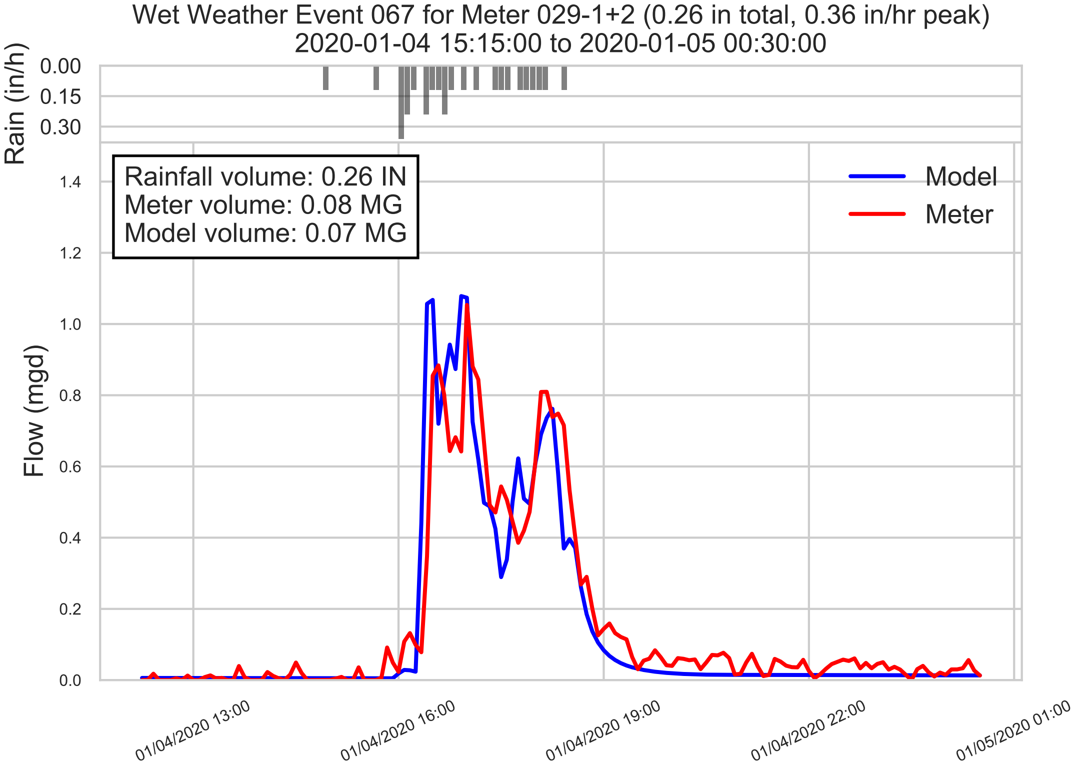

Wet Weather Event 063 for Meter 029-1+2 (0.64 in total, 0.24 in/hr peak)
2019-12-16 07:50:00 to 2019-12-17 12:10:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.64 IN
Meter volume: 0.17 MG
Model volume: 0.17 MG
Model
Meter
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/16/2019 04:00
12/16/2019 07:00
12/16/2019 10:00
12/16/2019 13:00
12/16/2019 16:00
12/16/2019 19:00
12/16/2019 22:00
12/17/2019 01:00
12/17/2019 04:00
12/17/2019 07:00
12/17/2019 10:00
12/17/2019 13:00


Wet Weather Event 064 for Meter 029-1+2 (0.78 in total, 0.24 in/hr peak)
2019-12-29 10:25:00 to 2019-12-30 18:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.78 IN
Meter volume: 0.19 MG
Model volume: 0.21 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
12/29/2019 08:00
12/29/2019 11:00
12/29/2019 14:00
12/29/2019 17:00
12/29/2019 20:00
12/29/2019 23:00
12/30/2019 02:00
12/30/2019 05:00
12/30/2019 08:00
12/30/2019 11:00
12/30/2019 14:00
12/30/2019 17:00
12/30/2019 20:00

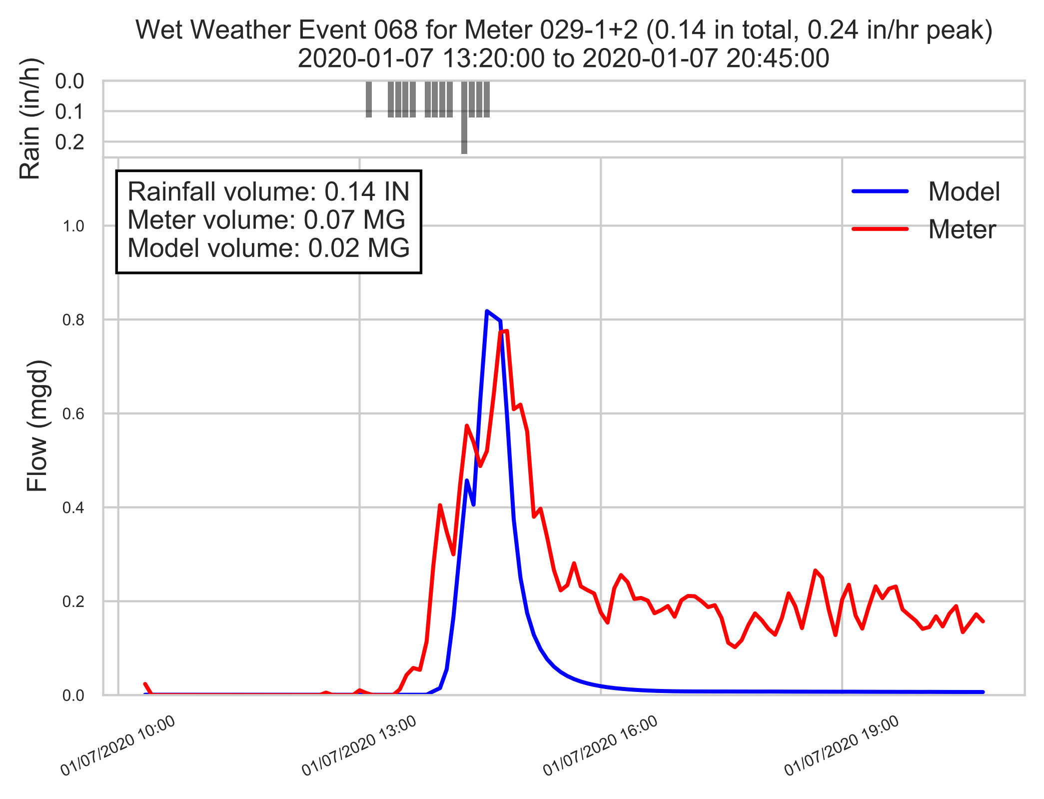

Wet Weather Event 065 for Meter 029-1+2 (0.2 in total, 0.12 in/hr peak)
2020-01-03 02:55:00 to 2020-01-03 12:35:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.07 MG
Model volume: 0.04 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
01/03/2020 00:00
01/03/2020 03:00
01/03/2020 06:00
01/03/2020 09:00
01/03/2020 12:00



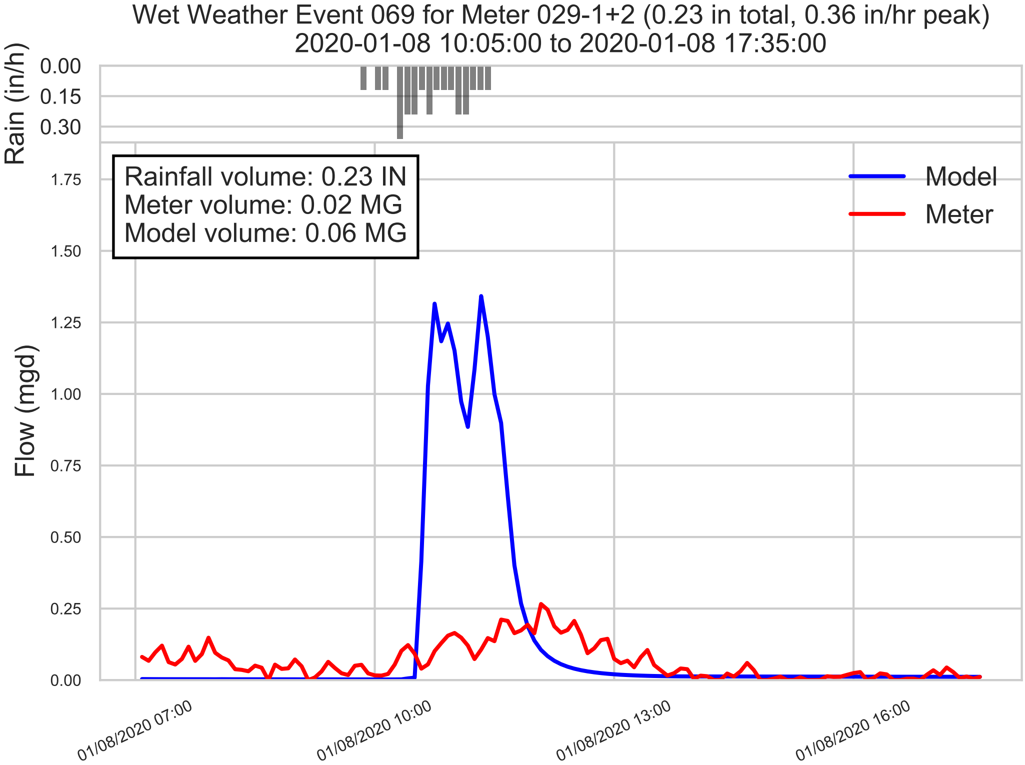
Wet Weather Event 066 for Meter 029-1+2 (0.13 in total, 0.12 in/hr peak)
2020-01-03 13:25:00 to 2020-01-04 10:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.13 IN
Meter volume: 0.05 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
0.25
0.20
0.15
0.10
0.05
0.00
01/03/2020 12:00
01/03/2020 15:00
01/03/2020 18:00
01/03/2020 21:00
01/04/2020 00:00
01/04/2020 03:00
01/04/2020 06:00
01/04/2020 09:00

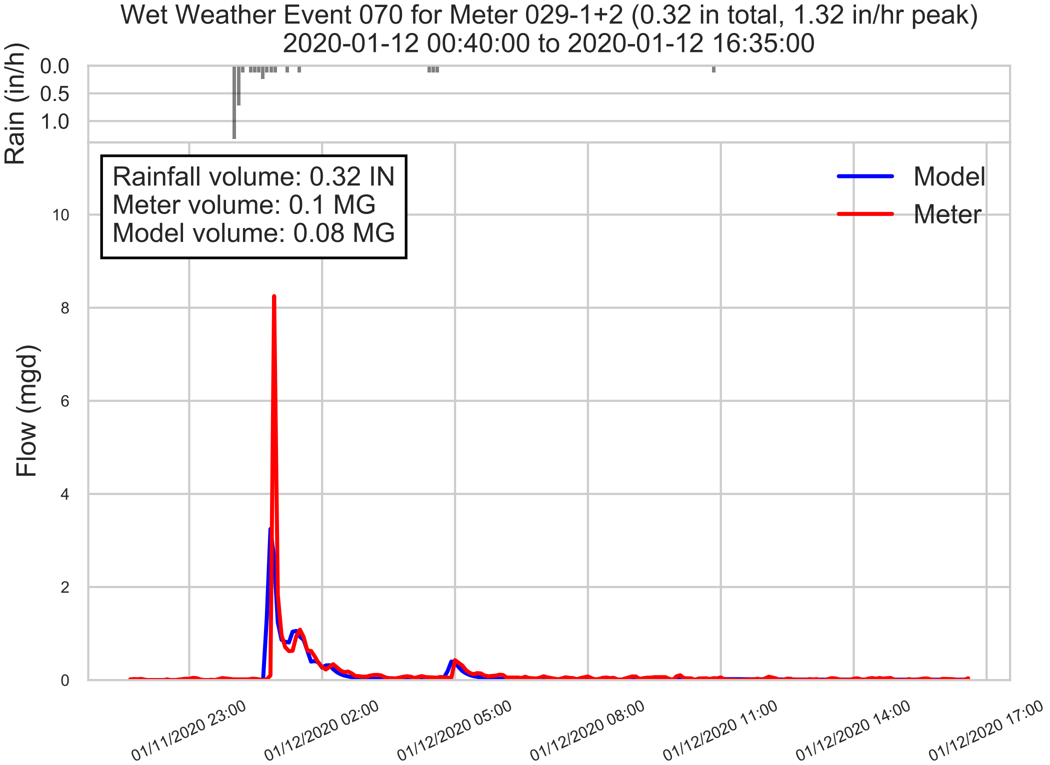


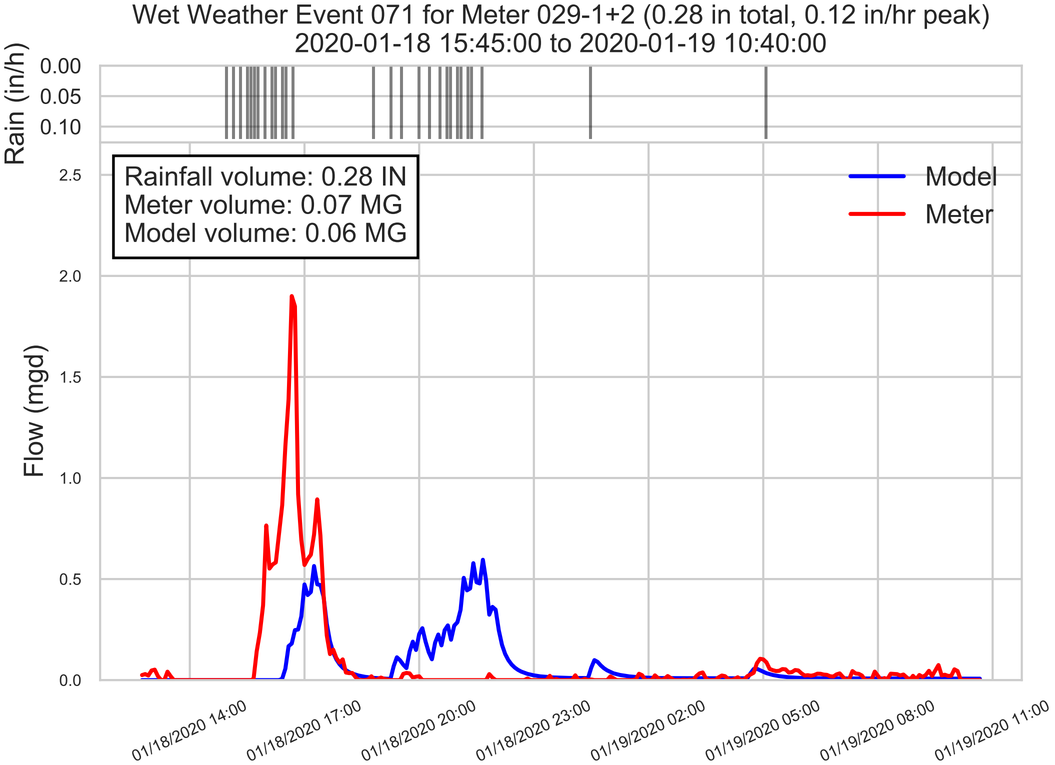
Wet Weather Event 067 for Meter 029-1+2 (0.26 in total, 0.36 in/hr peak)
2020-01-04 15:15:00 to 2020-01-05 00:30:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.26 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
01/04/2020 13:00
01/04/2020 16:00
01/04/2020 19:00
01/04/2020 22:00
01/05/2020 01:00

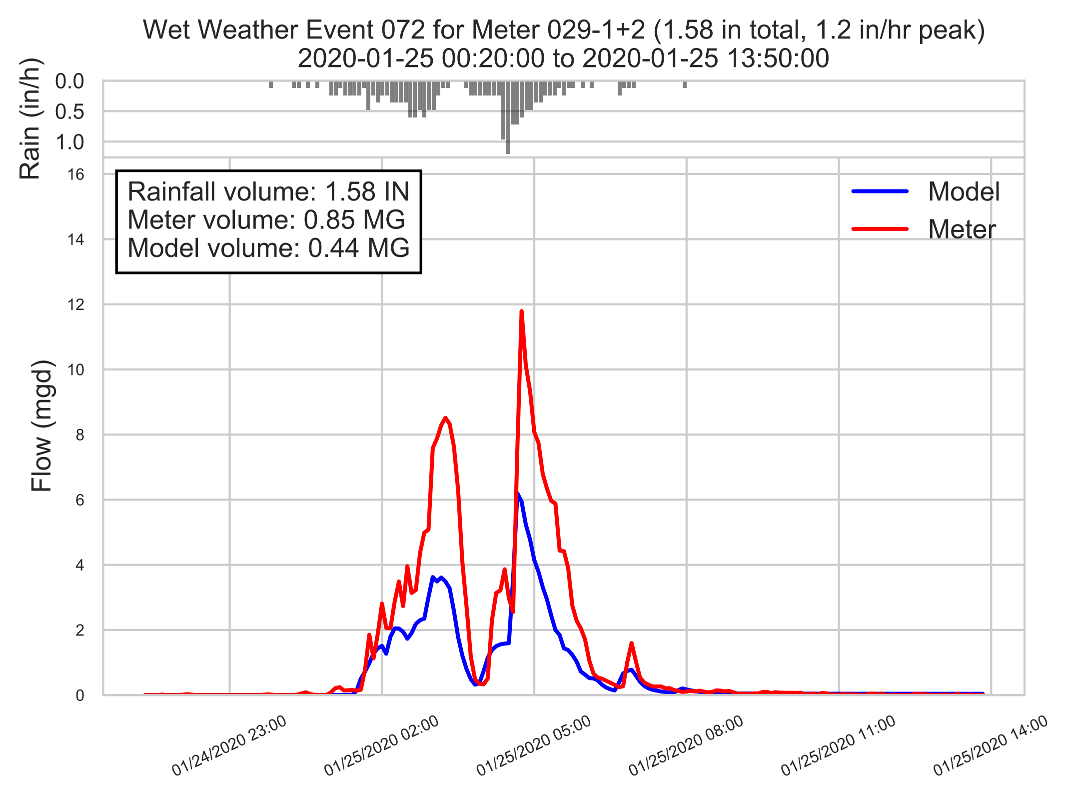


Wet Weather Event 068 for Meter 029-1+2 (0.14 in total, 0.24 in/hr peak)
2020-01-07 13:20:00 to 2020-01-07 20:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.14 IN
Meter volume: 0.07 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
01/07/2020 10:00
01/07/2020 13:00
01/07/2020 16:00
01/07/2020 19:00

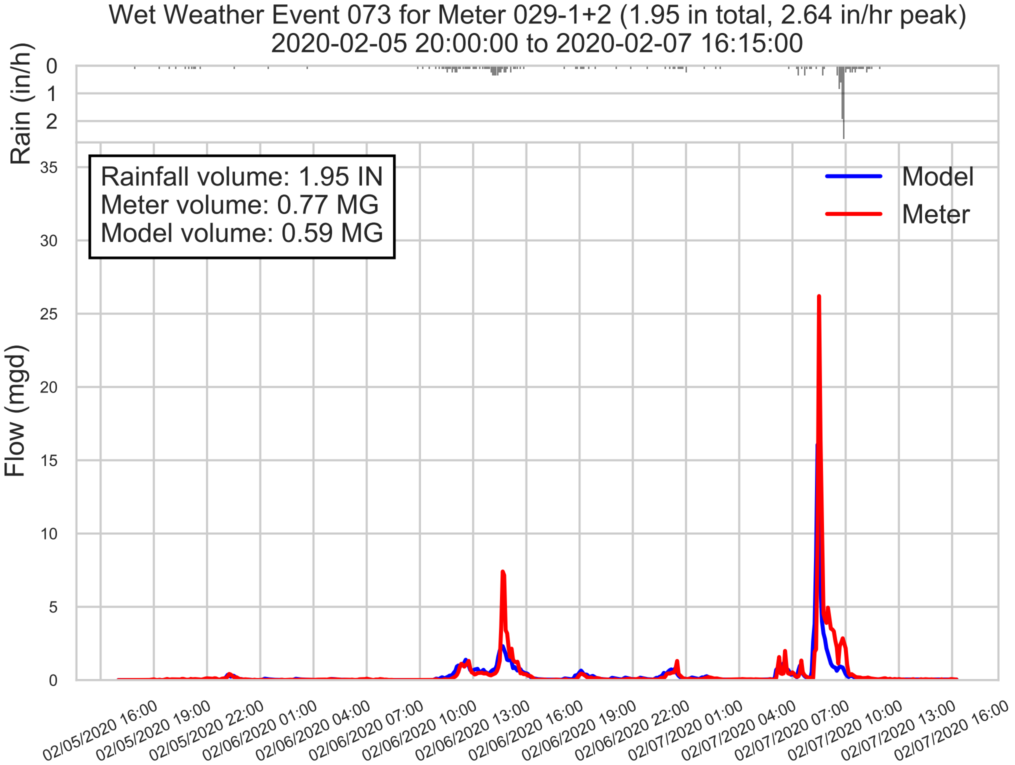

Wet Weather Event 069 for Meter 029-1+2 (0.23 in total, 0.36 in/hr peak)
2020-01-08 10:05:00 to 2020-01-08 17:35:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.23 IN
Meter volume: 0.02 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
01/08/2020 07:00
01/08/2020 10:00
01/08/2020 13:00
01/08/2020 16:00

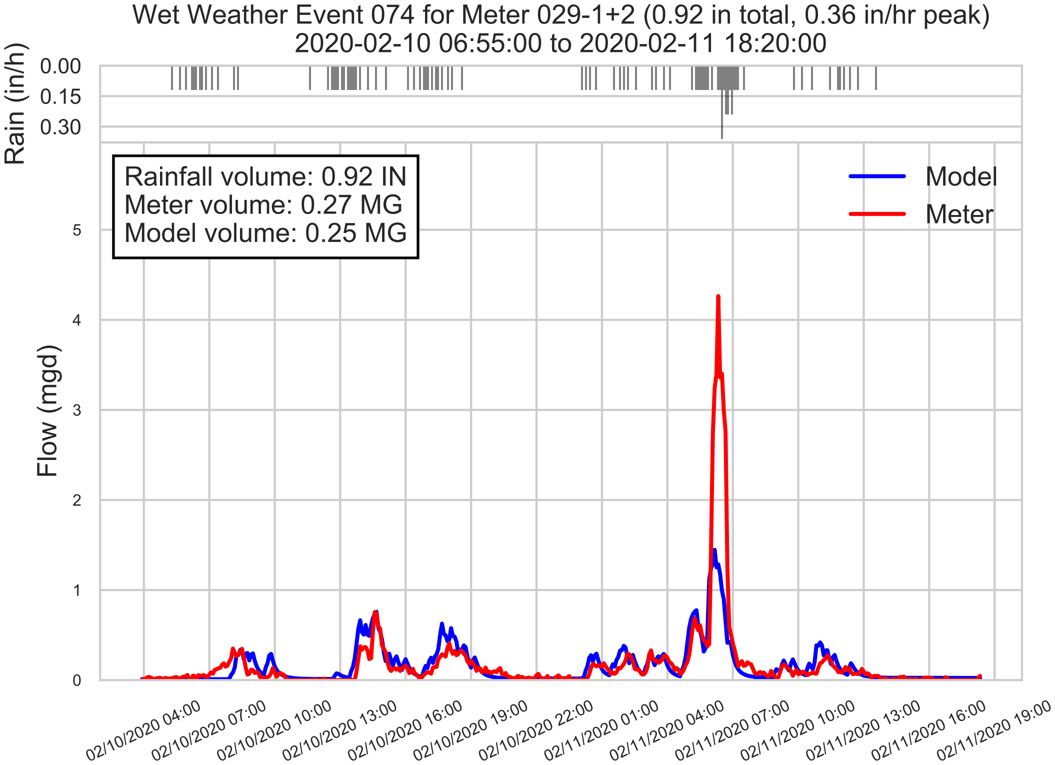

Wet Weather Event 070 for Meter 029-1+2 (0.32 in total, 1.32 in/hr peak)
2020-01-12 00:40:00 to 2020-01-12 16:35:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.32 IN
Meter volume: 0.1 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
01/11/2020 23:00
01/12/2020 02:00
01/12/2020 05:00
01/12/2020 08:00
01/12/2020 11:00
01/12/2020 14:00
01/12/2020 17:00


Wet Weather Event 071 for Meter 029-1+2 (0.28 in total, 0.12 in/hr peak)
2020-01-18 15:45:00 to 2020-01-19 10:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.07 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
01/18/2020 14:00
01/18/2020 17:00
01/18/2020 20:00
01/18/2020 23:00
01/19/2020 02:00
01/19/2020 05:00
01/19/2020 08:00
01/19/2020 11:00

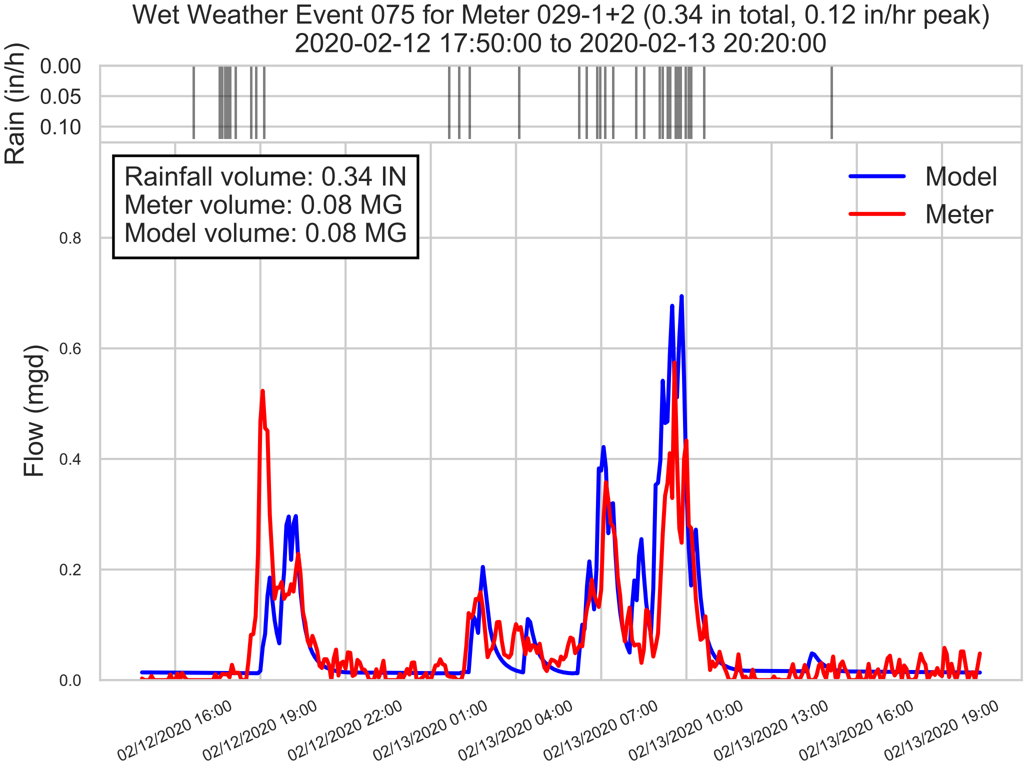


Wet Weather Event 072 for Meter 029-1+2 (1.58 in total, 1.2 in/hr peak)
2020-01-25 00:20:00 to 2020-01-25 13:50:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.58 IN
Meter volume: 0.85 MG
Model volume: 0.44 MG
Model
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
01/24/2020 23:00
01/25/2020 02:00
01/25/2020 05:00
01/25/2020 08:00
01/25/2020 11:00
01/25/2020 14:00

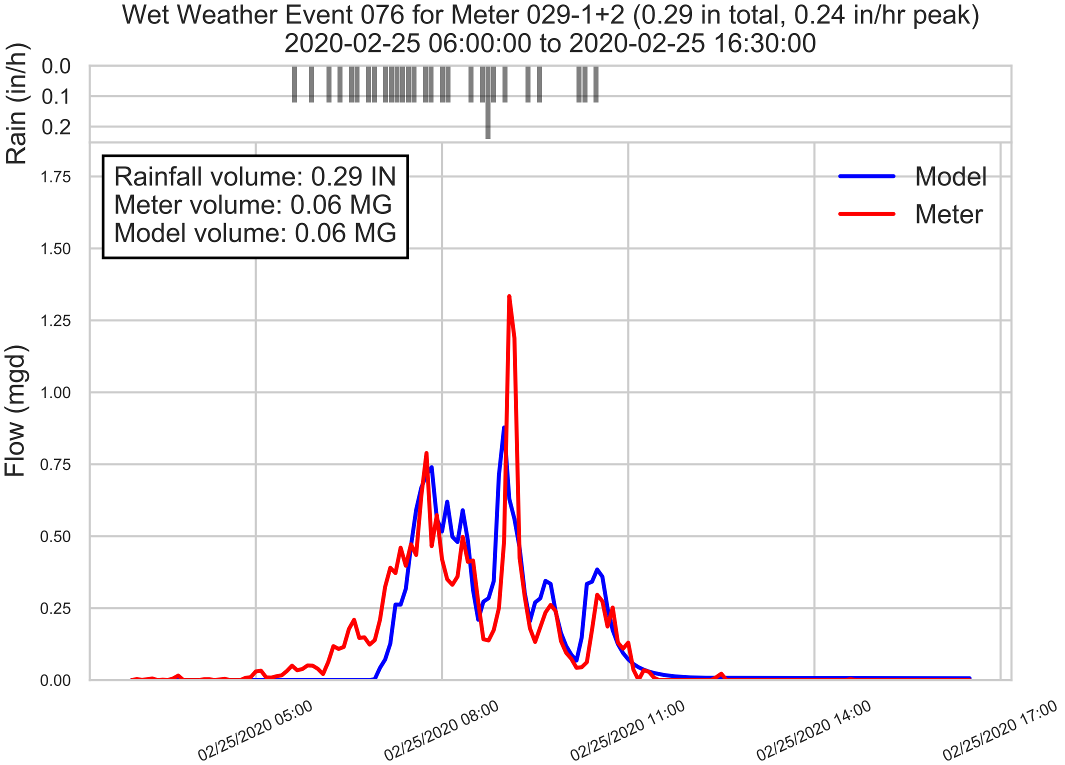

Wet Weather Event 073 for Meter 029-1+2 (1.95 in total, 2.64 in/hr peak)
2020-02-05 20:00:00 to 2020-02-07 16:15:00
Rain (in/h)
0
1
2
Flow (mgd)
35
30
25
20
15
10
5
0
Rainfall volume: 1.95 IN
Meter volume: 0.77 MG
Model volume: 0.59 MG
Model
Meter
02/05/2020 16:00
02/05/2020 19:00
02/05/2020 22:00
02/06/2020 01:00
02/06/2020 04:00
02/06/2020 07:00
02/06/2020 10:00
02/06/2020 13:00
02/06/2020 16:00
02/06/2020 19:00
02/06/2020 22:00
02/07/2020 01:00
02/07/2020 04:00
02/07/2020 07:00
02/07/2020 10:00
02/07/2020 13:00
02/07/2020 16:00



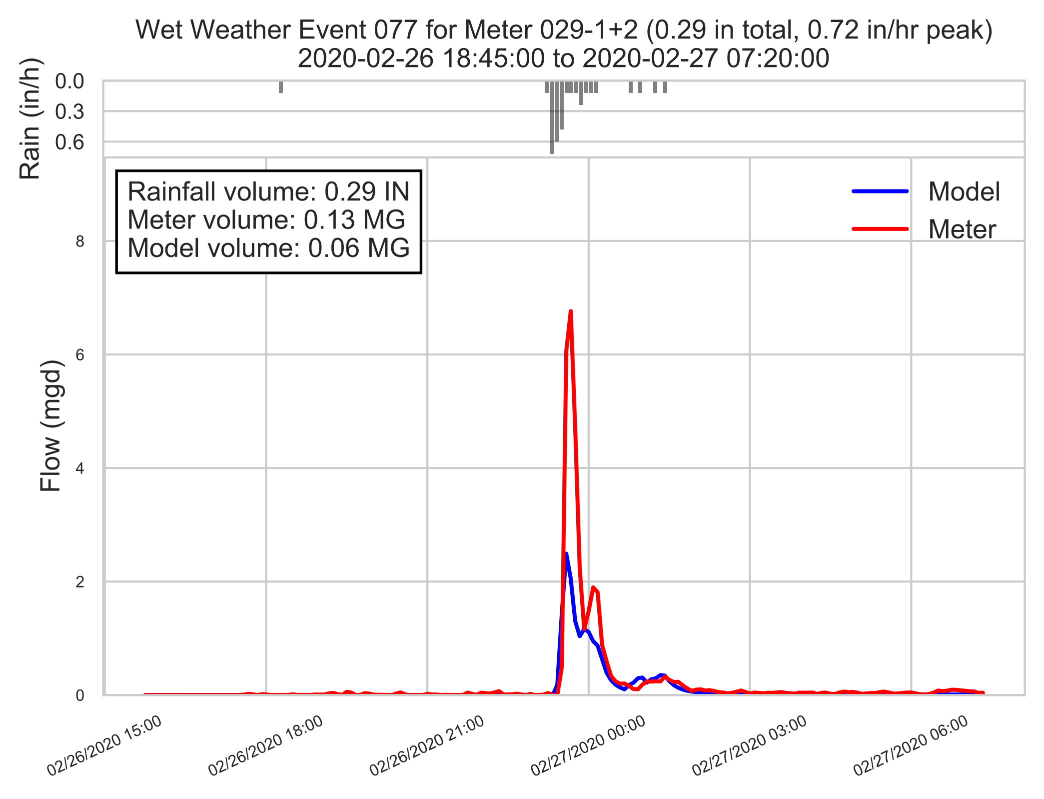
Wet Weather Event 074 for Meter 029-1+2 (0.92 in total, 0.36 in/hr peak)
2020-02-10 06:55:00 to 2020-02-11 18:20:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.92 IN
Meter volume: 0.27 MG
Model volume: 0.25 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
02/10/2020 04:00
02/10/2020 07:00
02/10/2020 10:00
02/10/2020 13:00
02/10/2020 16:00
02/10/2020 19:00
02/10/2020 22:00
02/11/2020 01:00
02/11/2020 04:00
02/11/2020 07:00
02/11/2020 10:00
02/11/2020 13:00
02/11/2020 16:00
02/11/2020 19:00



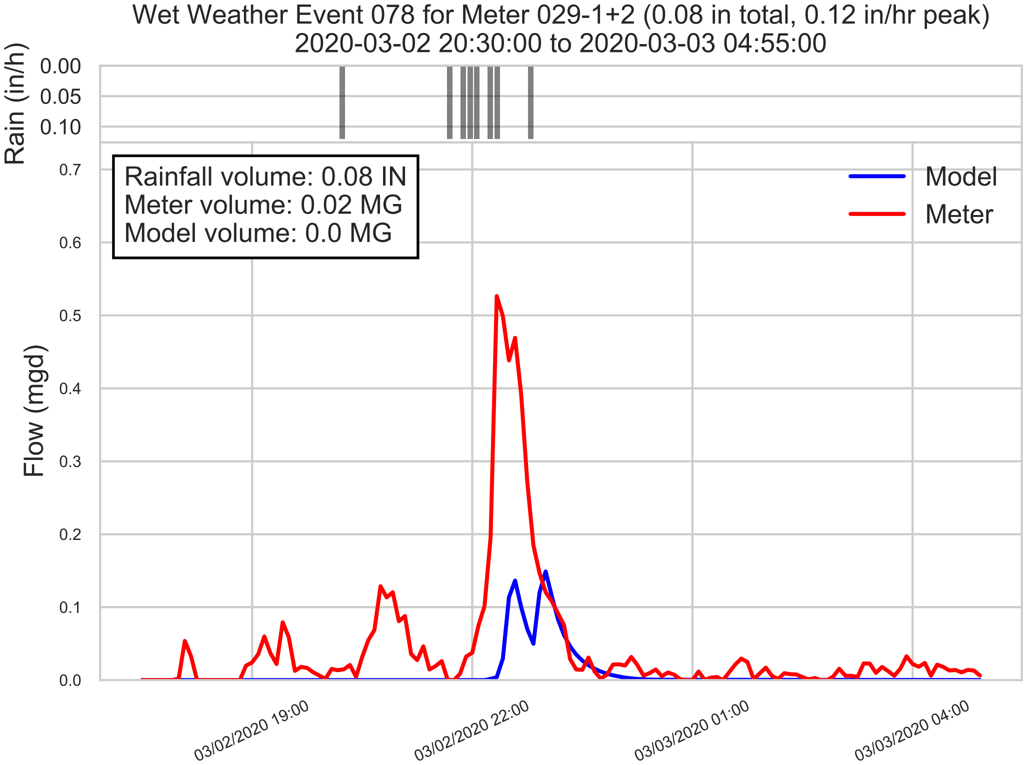
Wet Weather Event 075 for Meter 029-1+2 (0.34 in total, 0.12 in/hr peak)
2020-02-12 17:50:00 to 2020-02-13 20:20:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.34 IN
Meter volume: 0.08 MG
Model volume: 0.08 MG
Model
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
02/12/2020 16:00
02/12/2020 19:00
02/12/2020 22:00
02/13/2020 01:00
02/13/2020 04:00
02/13/2020 07:00
02/13/2020 10:00
02/13/2020 13:00
02/13/2020 16:00
02/13/2020 19:00



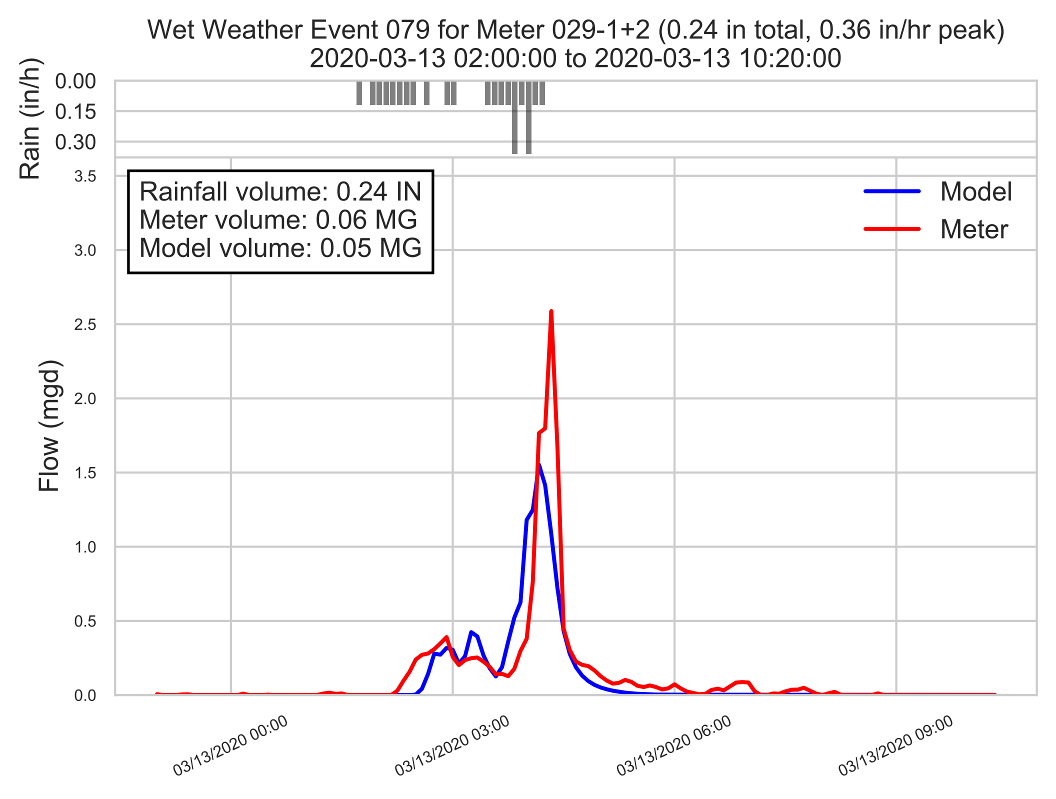
Wet Weather Event 076 for Meter 029-1+2 (0.29 in total, 0.24 in/hr peak)
2020-02-25 06:00:00 to 2020-02-25 16:30:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.06 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
02/25/2020 05:00
02/25/2020 08:00
02/25/2020 11:00
02/25/2020 14:00
02/25/2020 17:00



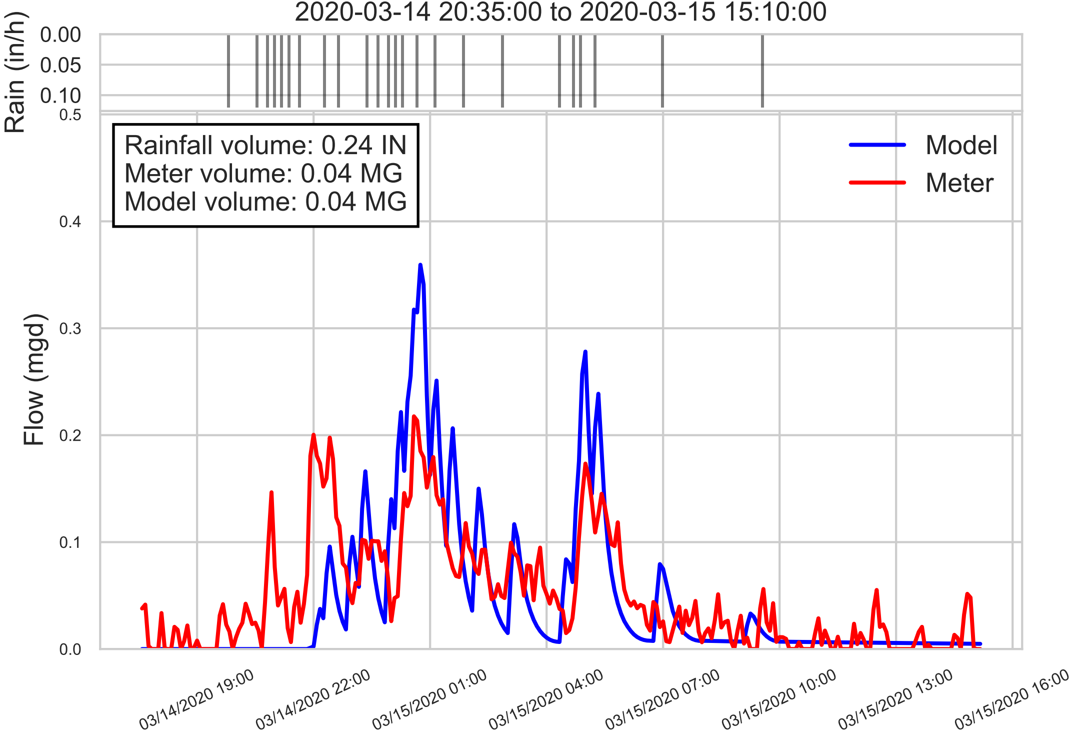
Wet Weather Event 077 for Meter 029-1+2 (0.29 in total, 0.72 in/hr peak)
2020-02-26 18:45:00 to 2020-02-27 07:20:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.29 IN
Meter volume: 0.13 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
8
6
4
2
0
02/26/2020 15:00
02/26/2020 18:00
02/26/2020 21:00
02/27/2020 00:00
02/27/2020 03:00
02/27/2020 06:00

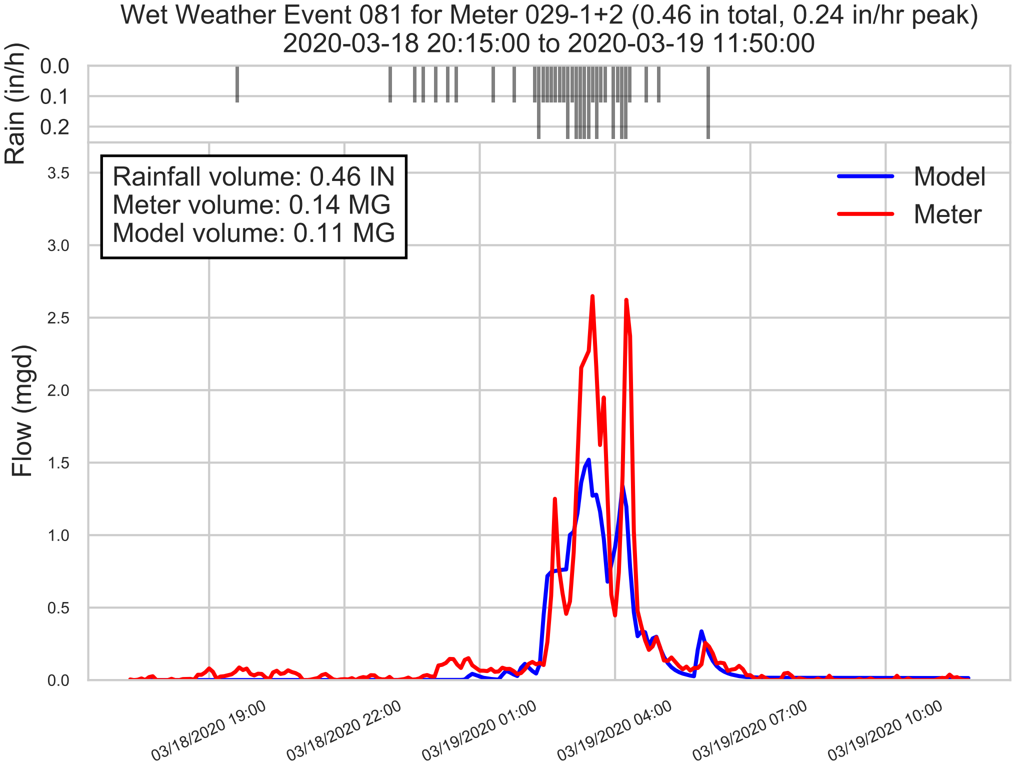


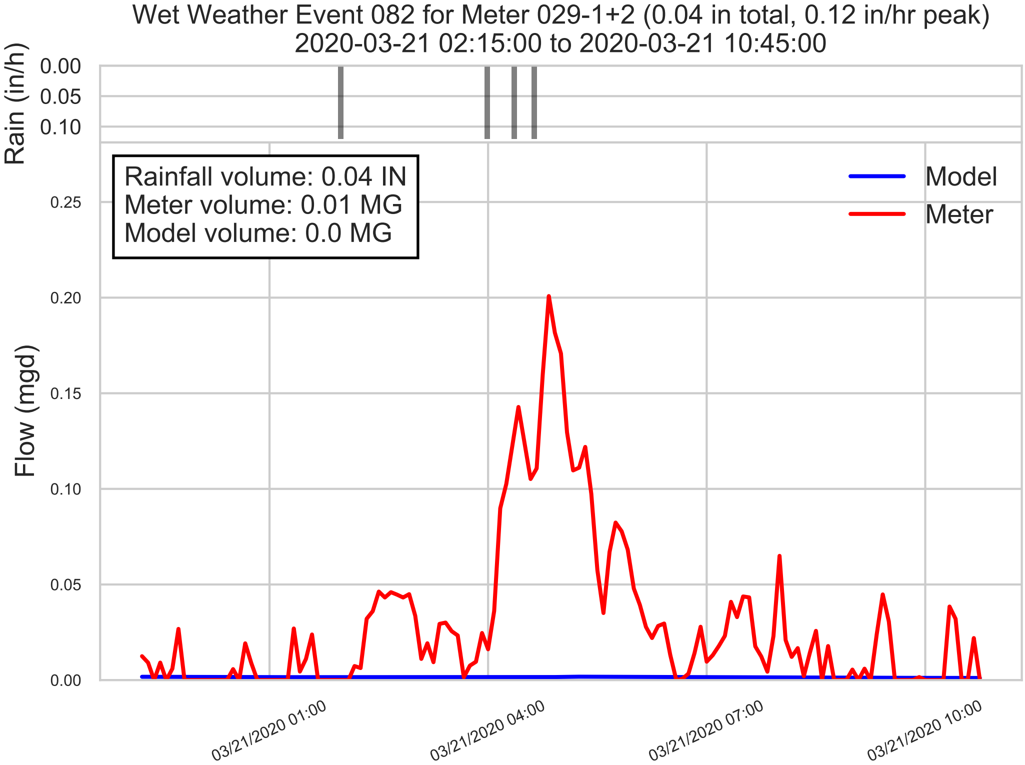
Wet Weather Event 078 for Meter 029-1+2 (0.08 in total, 0.12 in/hr peak)
2020-03-02 20:30:00 to 2020-03-03 04:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.08 IN
Meter volume: 0.02 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
03/02/2020 19:00
03/02/2020 22:00
03/03/2020 01:00
03/03/2020 04:00


Wet Weather Event 079 for Meter 029-1+2 (0.24 in total, 0.36 in/hr peak)
2020-03-13 02:00:00 to 2020-03-13 10:20:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.24 IN
Meter volume: 0.06 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
03/13/2020 00:00
03/13/2020 03:00
03/13/2020 06:00
03/13/2020 09:00

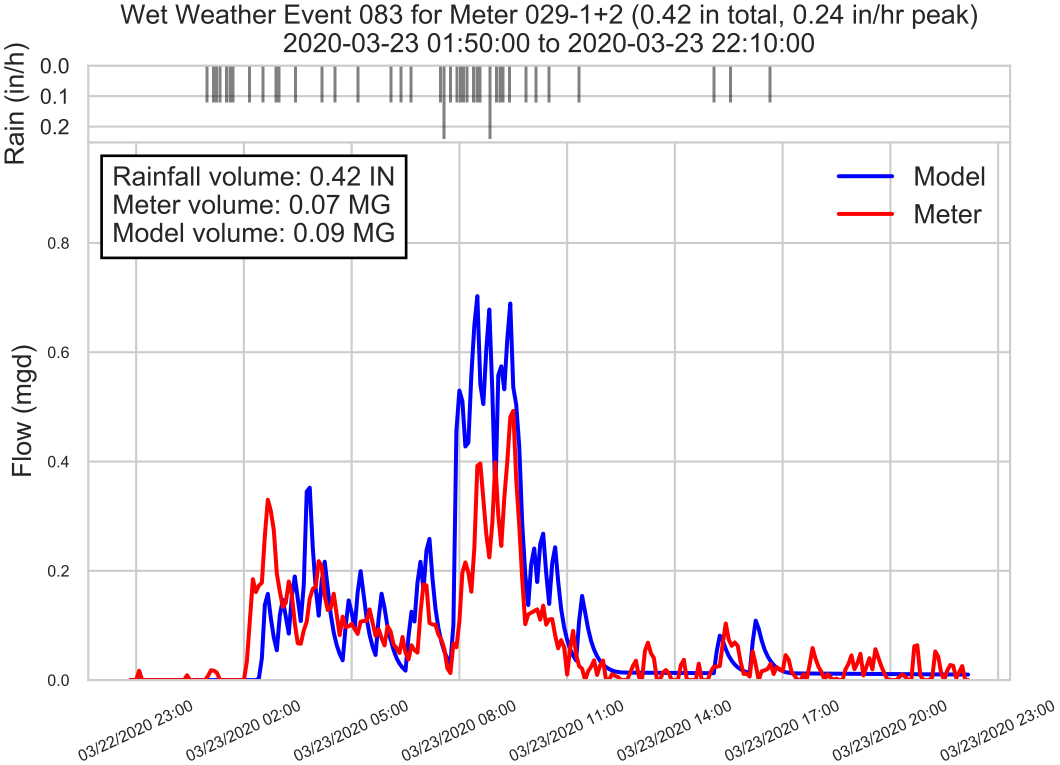
Wet Weather Event 080 for Meter 029-1+2 (0.24 in total, 0.12 in/hr peak)
2020-03-14 20:35:00 to 2020-03-15 15:10:00

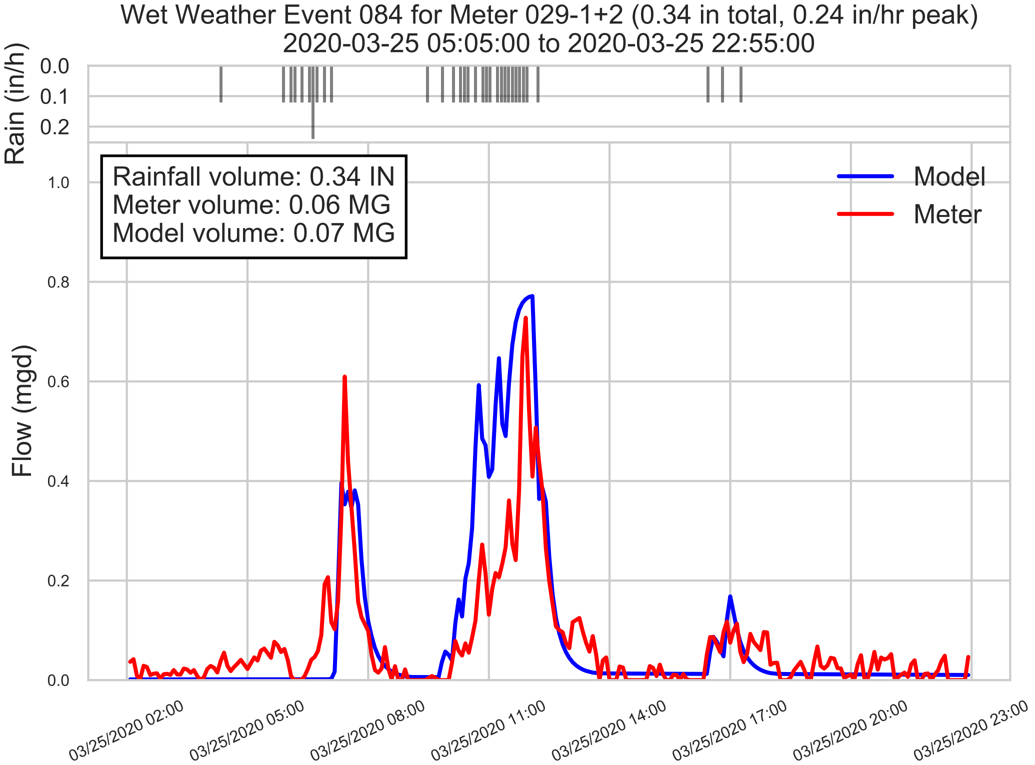



Wet Weather Event 081 for Meter 029-1+2 (0.46 in total, 0.24 in/hr peak)
2020-03-18 20:15:00 to 2020-03-19 11:50:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.46 IN
Meter volume: 0.14 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
03/18/2020 19:00
03/18/2020 22:00
03/19/2020 01:00
03/19/2020 04:00
03/19/2020 07:00
03/19/2020 10:00

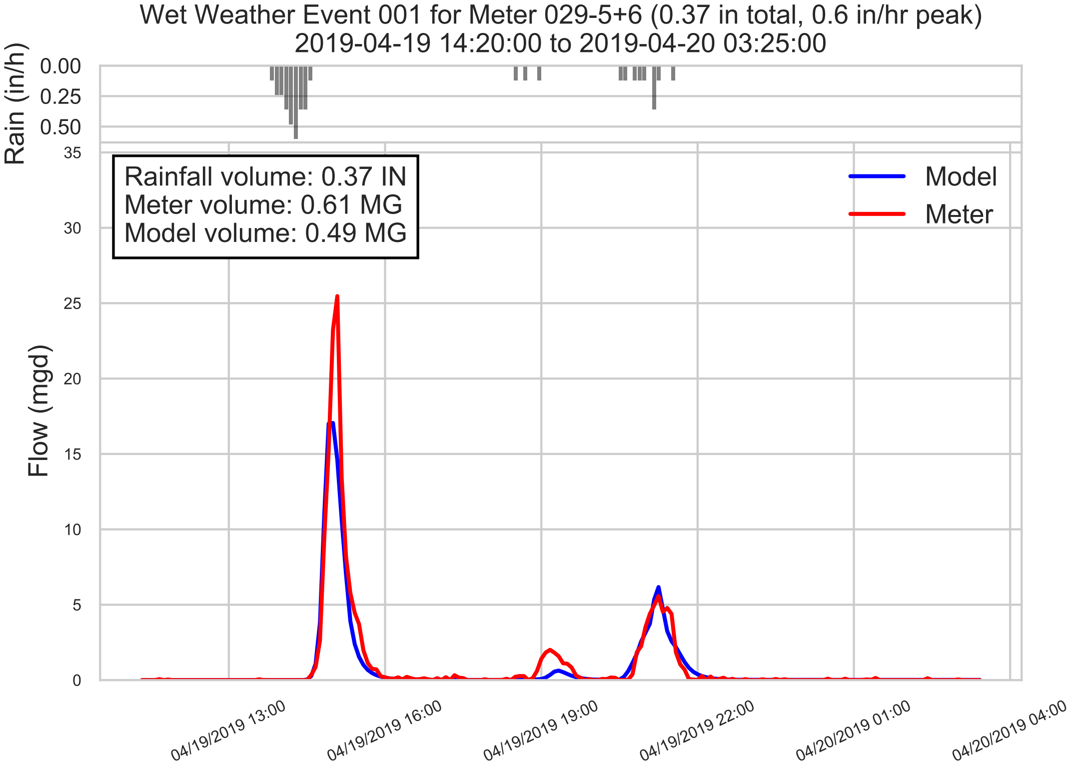


Wet Weather Event 082 for Meter 029-1+2 (0.04 in total, 0.12 in/hr peak)
2020-03-21 02:15:00 to 2020-03-21 10:45:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.04 IN
Meter volume: 0.01 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.25
0.20
0.15
0.10
0.05
0.00
03/21/2020 01:00
03/21/2020 04:00
03/21/2020 07:00
03/21/2020 10:00

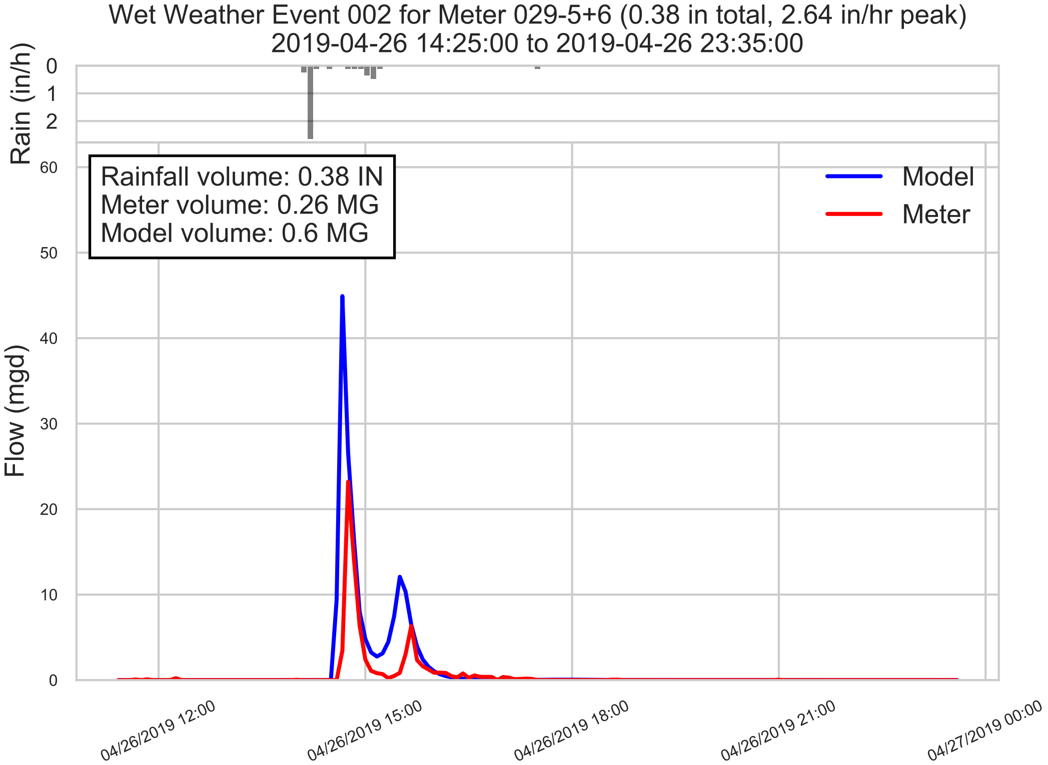

Wet Weather Event 083 for Meter 029-1+2 (0.42 in total, 0.24 in/hr peak)
2020-03-23 01:50:00 to 2020-03-23 22:10:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.42 IN
Meter volume: 0.07 MG
Model volume: 0.09 MG
Model
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
03/22/2020 23:00
03/23/2020 02:00
03/23/2020 05:00
03/23/2020 08:00
03/23/2020 11:00
03/23/2020 14:00
03/23/2020 17:00
03/23/2020 20:00
03/23/2020 23:00



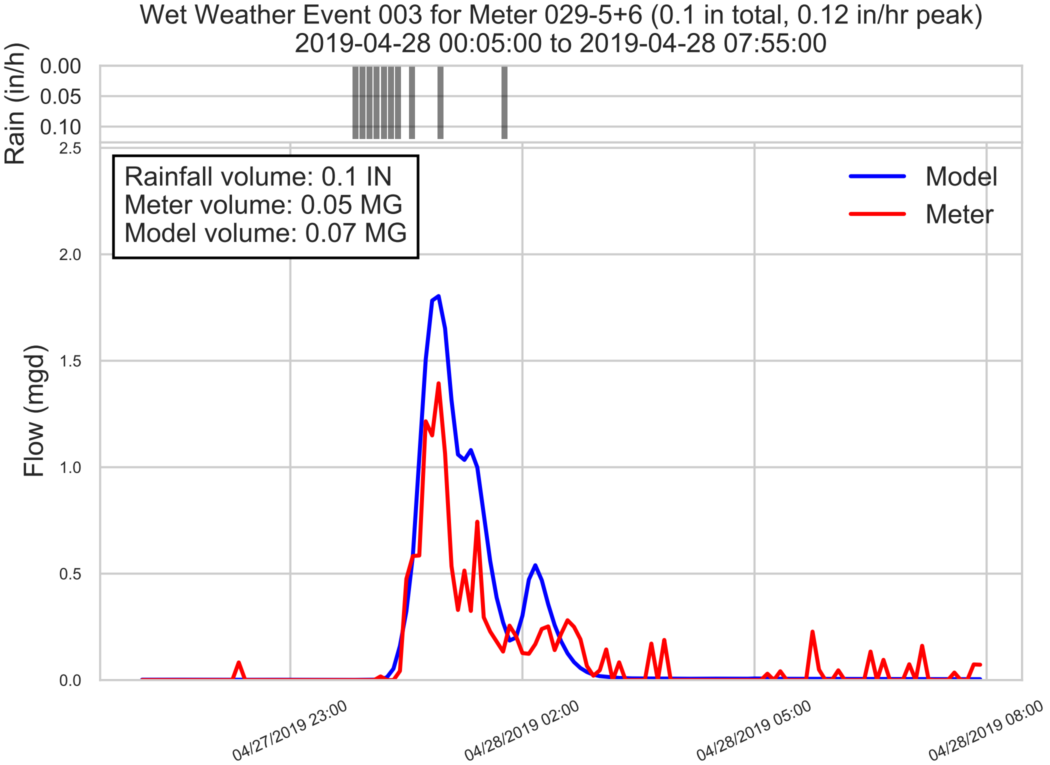
Wet Weather Event 084 for Meter 029-1+2 (0.34 in total, 0.24 in/hr peak)
2020-03-25 05:05:00 to 2020-03-25 22:55:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.34 IN
Meter volume: 0.06 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
03/25/2020 02:00
03/25/2020 05:00
03/25/2020 08:00
03/25/2020 11:00
03/25/2020 14:00
03/25/2020 17:00
03/25/2020 20:00
03/25/2020 23:00



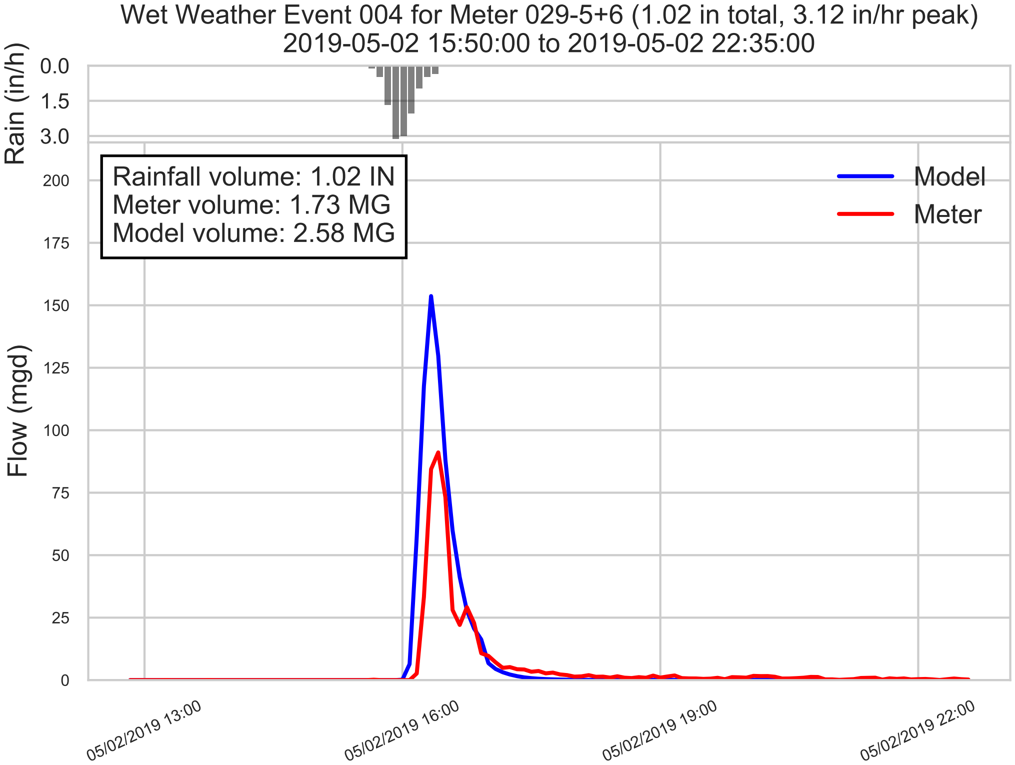
Wet Weather Event 001 for Meter 029-5+6 (0.37 in total, 0.6 in/hr peak)
2019-04-19 14:20:00 to 2019-04-20 03:25:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.37 IN
Meter volume: 0.61 MG
Model volume: 0.49 MG
Model
Meter
Flow (mgd)
35
30
25
20
15
10
5
0
04/19/2019 13:00
04/19/2019 16:00
04/19/2019 19:00
04/19/2019 22:00
04/20/2019 01:00
04/20/2019 04:00

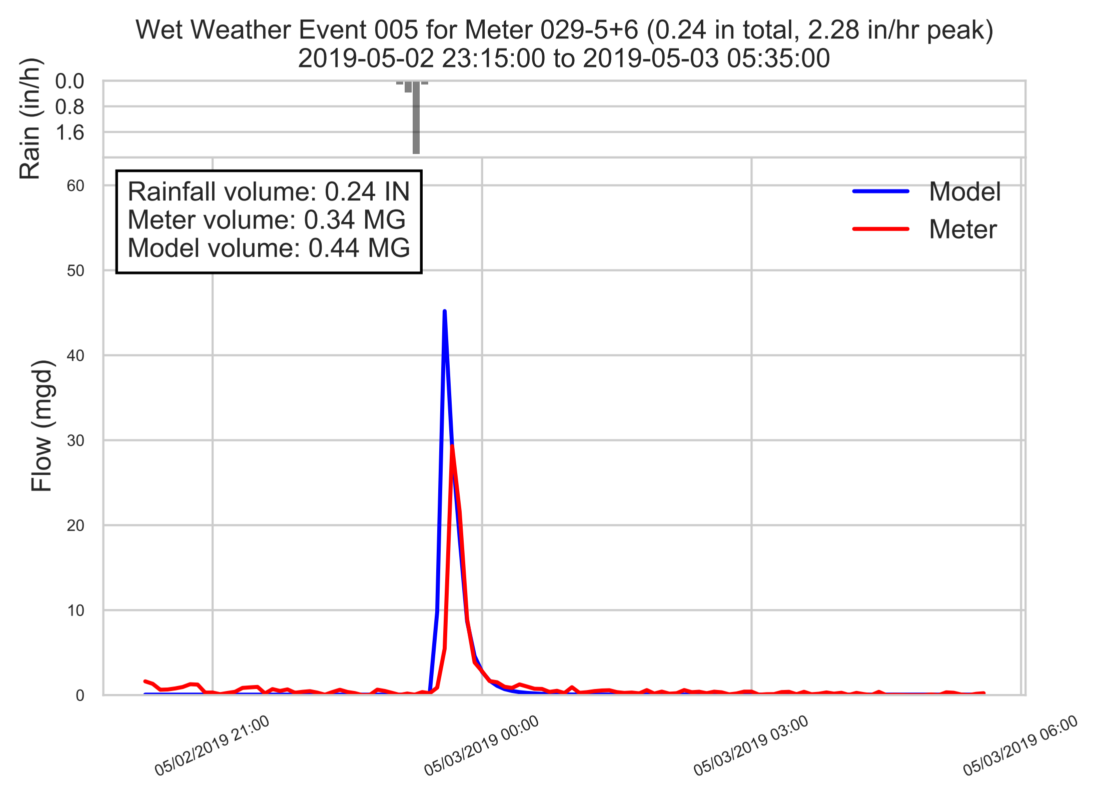


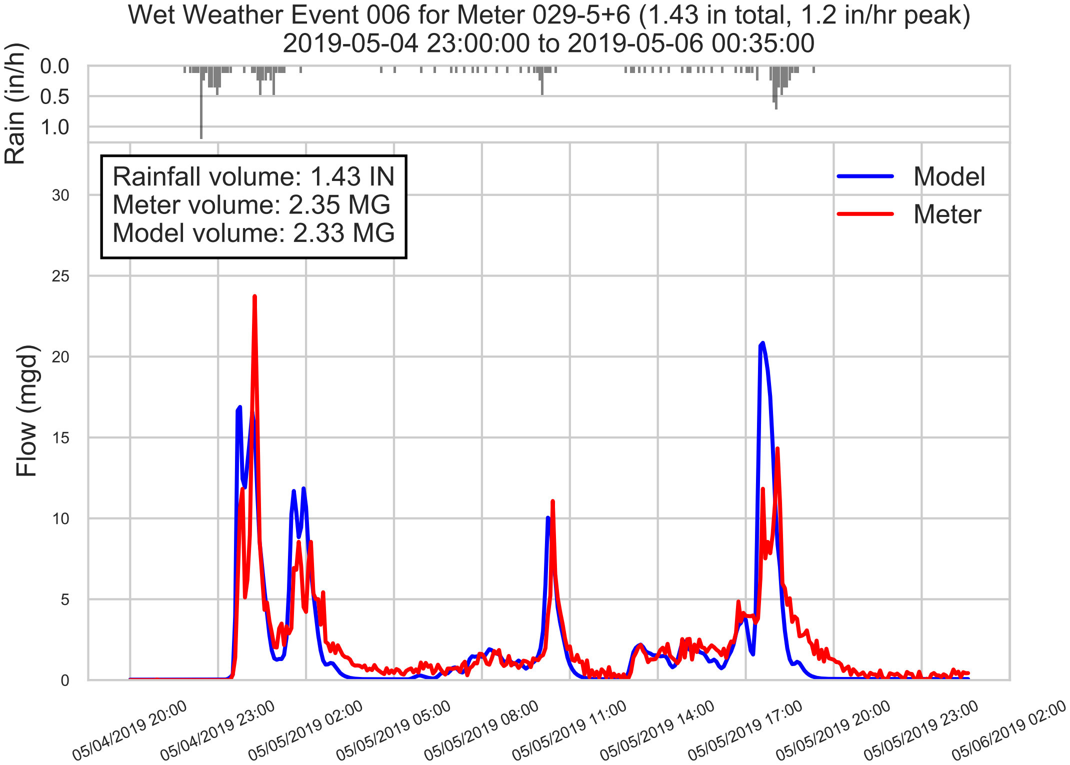
Wet Weather Event 002 for Meter 029-5+6 (0.38 in total, 2.64 in/hr peak)
2019-04-26 14:25:00 to 2019-04-26 23:35:00
Rain (in/h)
0
1
2
Rainfall volume: 0.38 IN
Meter volume: 0.26 MG
Model volume: 0.6 MG
Model
Meter
Flow (mgd)
60
50
40
30
20
10
0
04/26/2019 12:00
04/26/2019 15:00
04/26/2019 18:00
04/26/2019 21:00
04/27/2019 00:00



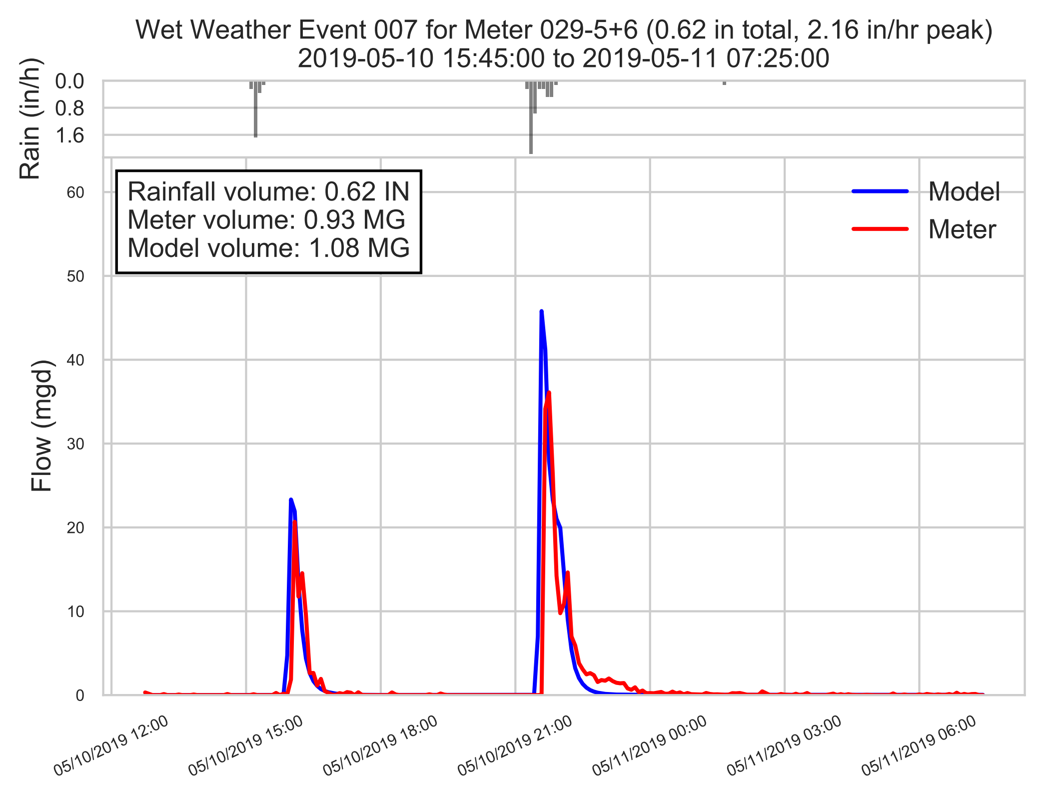
Wet Weather Event 003 for Meter 029-5+6 (0.1 in total, 0.12 in/hr peak)
2019-04-28 00:05:00 to 2019-04-28 07:55:00
Rain (in/h)
0.00
0.05
0.10
2.5
2.0
1.5
1.0
0.5
0.0
Flow (mgd)
Rainfall volume: 0.1 IN
Meter volume: 0.05 MG
Model volume: 0.07 MG
Model
Meter
04/27/2019 23:00
04/28/2019 02:00
04/28/2019 05:00
04/28/2019 08:00

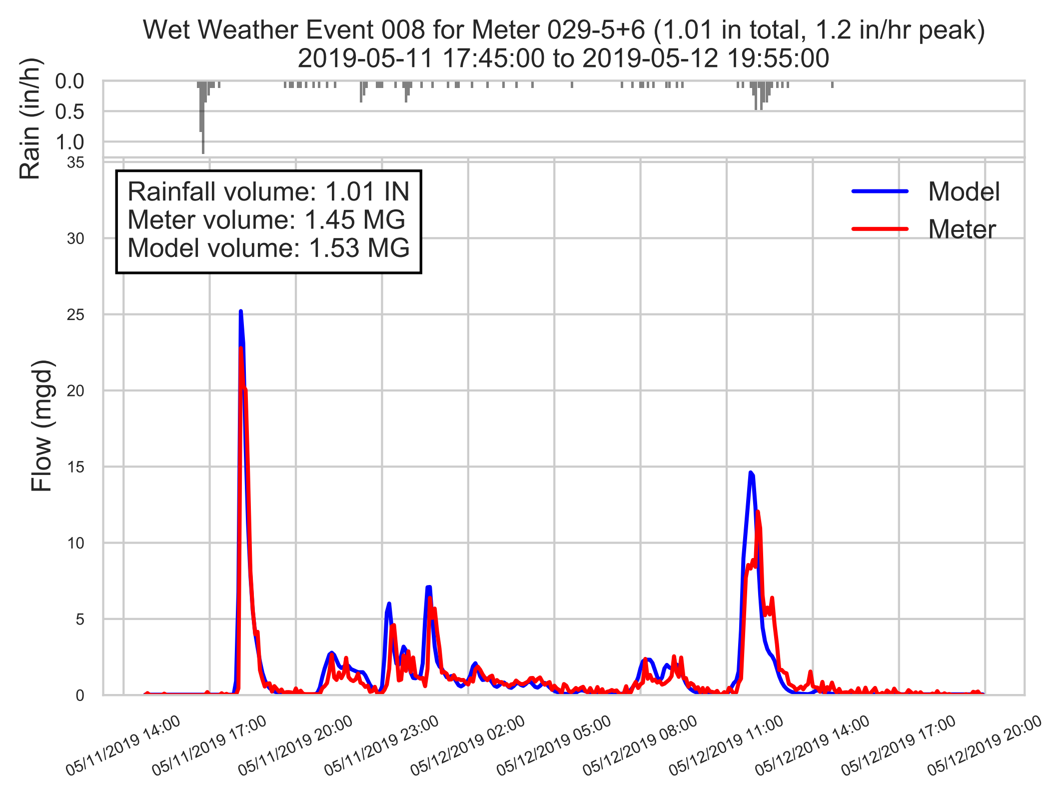

Wet Weather Event 004 for Meter 029-5+6 (1.02 in total, 3.12 in/hr peak)
2019-05-02 15:50:00 to 2019-05-02 22:35:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 1.02 IN
Meter volume: 1.73 MG
Model volume: 2.58 MG
Model
Meter
Flow (mgd)
200
175
150
125
100
75
50
25
0
05/02/2019 13:00
05/02/2019 16:00
05/02/2019 19:00
05/02/2019 22:00


Wet Weather Event 005 for Meter 029-5+6 (0.24 in total, 2.28 in/hr peak)
2019-05-02 23:15:00 to 2019-05-03 05:35:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.24 IN
Meter volume: 0.34 MG
Model volume: 0.44 MG
Model
Meter
Flow (mgd)
60
50
40
30
20
10
0
05/02/2019 21:00
05/03/2019 00:00
05/03/2019 03:00
05/03/2019 06:00

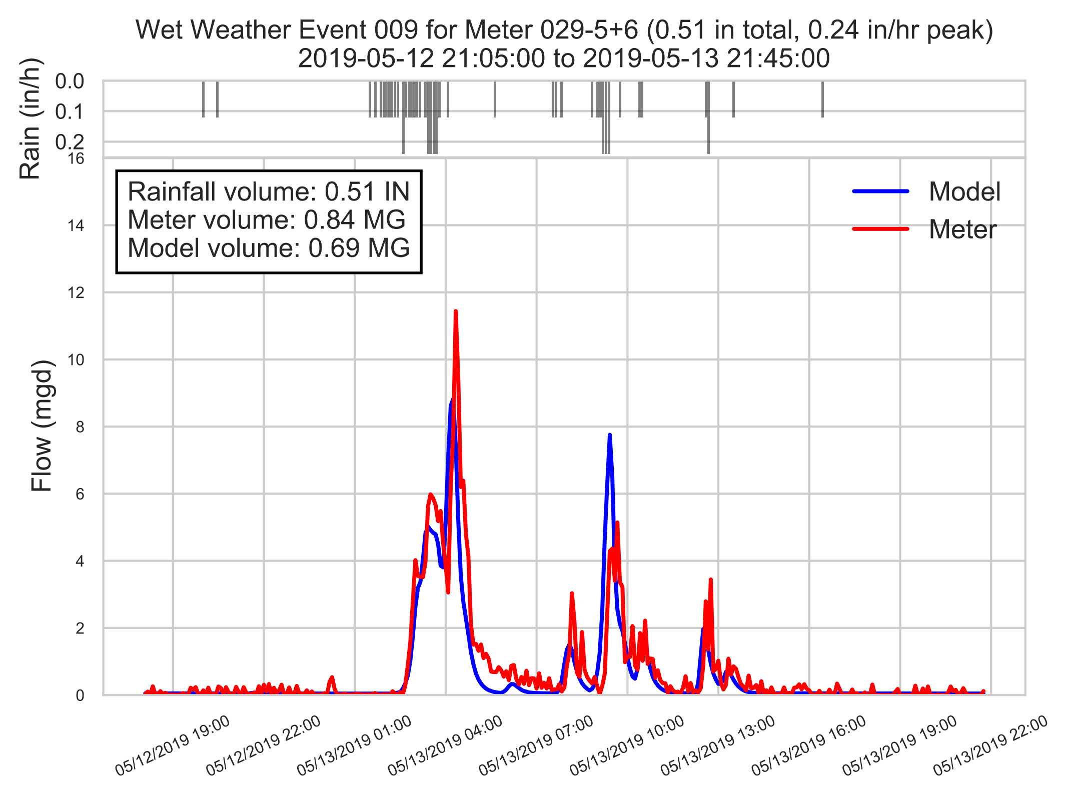


Wet Weather Event 006 for Meter 029-5+6 (1.43 in total, 1.2 in/hr peak)
2019-05-04 23:00:00 to 2019-05-06 00:35:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.43 IN
Meter volume: 2.35 MG
Model volume: 2.33 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
05/04/2019 20:00
05/04/2019 23:00
05/05/2019 02:00
05/05/2019 05:00
05/05/2019 08:00
05/05/2019 11:00
05/05/2019 14:00
05/05/2019 17:00
05/05/2019 20:00
05/05/2019 23:00
05/06/2019 02:00

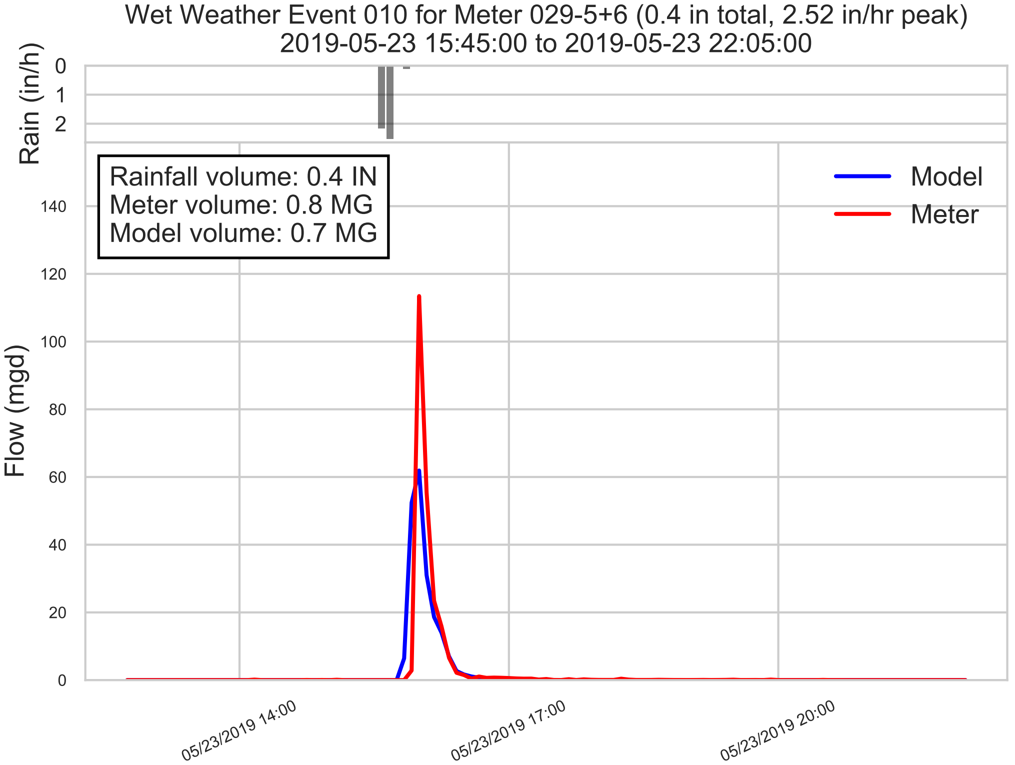

Wet Weather Event 007 for Meter 029-5+6 (0.62 in total, 2.16 in/hr peak)
2019-05-10 15:45:00 to 2019-05-11 07:25:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.62 IN
Meter volume: 0.93 MG
Model volume: 1.08 MG
Model
Meter
Flow (mgd)
60
50
40
30
20
10
0
05/10/2019 12:00
05/10/2019 15:00
05/10/2019 18:00
05/10/2019 21:00
05/11/2019 00:00
05/11/2019 03:00
05/11/2019 06:00

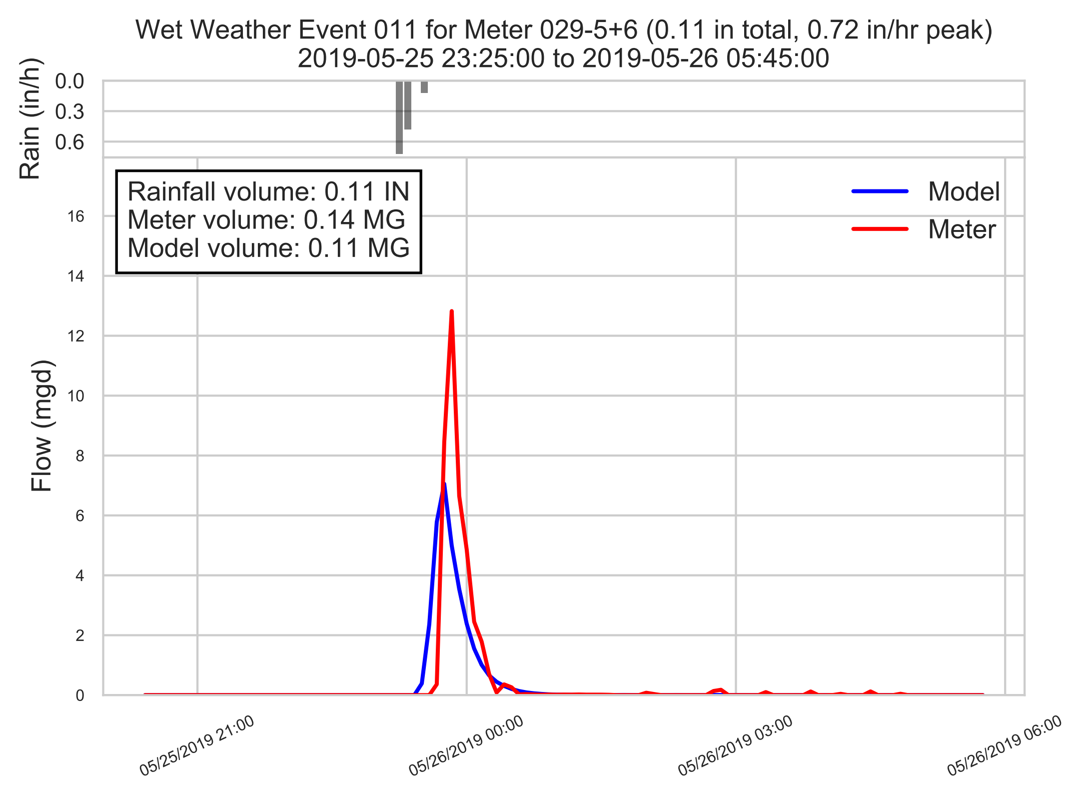


Wet Weather Event 008 for Meter 029-5+6 (1.01 in total, 1.2 in/hr peak)
2019-05-11 17:45:00 to 2019-05-12 19:55:00
Rain (in/h)
0.0
0.5
1.0
Flow (mgd)
0
5
10
15
20
25
30
35
Rainfall volume: 1.01 IN
Meter volume: 1.45 MG
Model volume: 1.53 MG
Model
Meter
05/11/2019 14:00
05/11/2019 17:00
05/11/2019 20:00
05/11/2019 23:00
05/12/2019 02:00
05/12/2019 05:00
05/12/2019 08:00
05/12/2019 11:00
05/12/2019 14:00
05/12/2019 17:00
05/12/2019 20:00

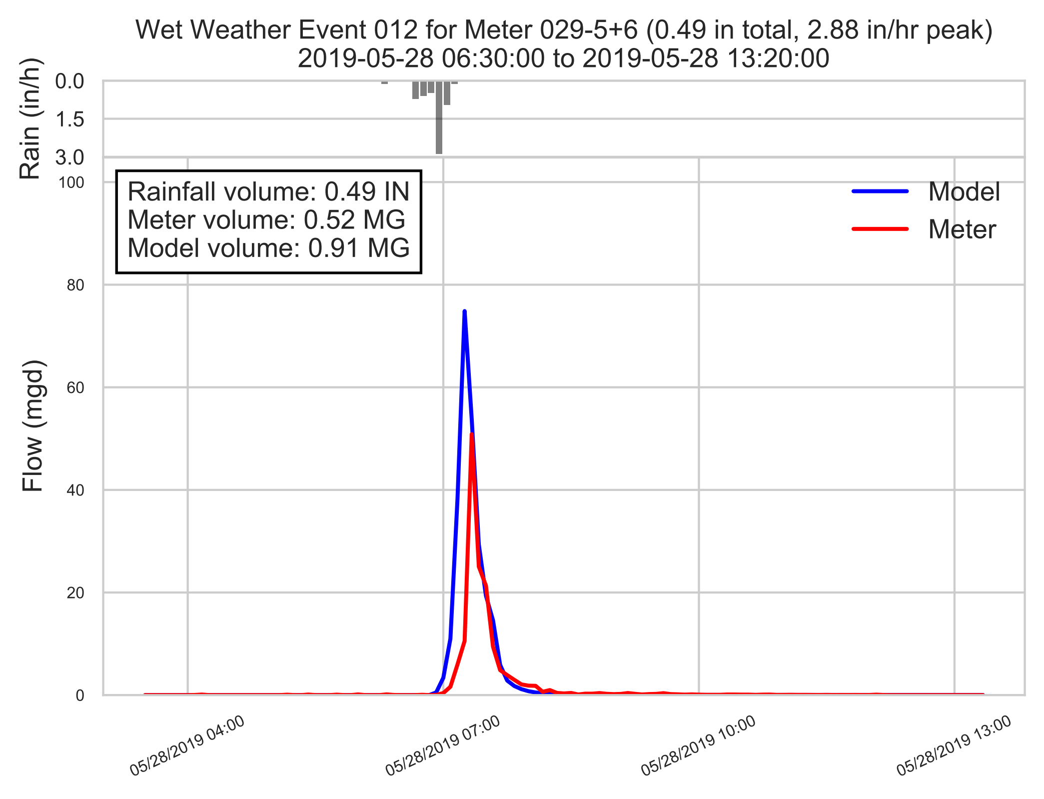


Wet Weather Event 009 for Meter 029-5+6 (0.51 in total, 0.24 in/hr peak)
2019-05-12 21:05:00 to 2019-05-13 21:45:00
Rain (in/h)
0.0
0.1
0.2
Flow (mgd)
16
14
12
10
8
6
4
2
0
Rainfall volume: 0.51 IN
Meter volume: 0.84 MG
Model volume: 0.69 MG
Model
Meter
05/12/2019 19:00
05/12/2019 22:00
05/13/2019 01:00
05/13/2019 04:00
05/13/2019 07:00
05/13/2019 10:00
05/13/2019 13:00
05/13/2019 16:00
05/13/2019 19:00
05/13/2019 22:00

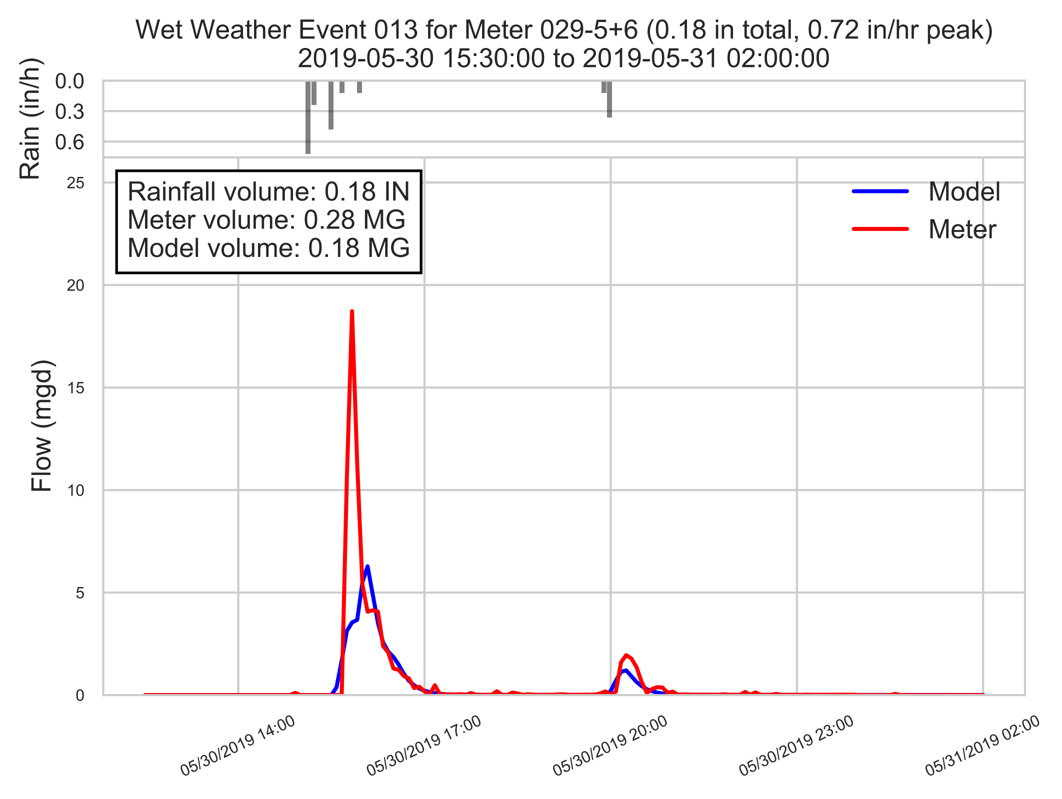

Wet Weather Event 010 for Meter 029-5+6 (0.4 in total, 2.52 in/hr peak)
2019-05-23 15:45:00 to 2019-05-23 22:05:00
Rain (in/h)
0
1
2
Rainfall volume: 0.4 IN
Meter volume: 0.8 MG
Model volume: 0.7 MG
Model
Meter
Flow (mgd)
140
120
100
80
60
40
20
0
05/23/2019 14:00
05/23/2019 17:00
05/23/2019 20:00



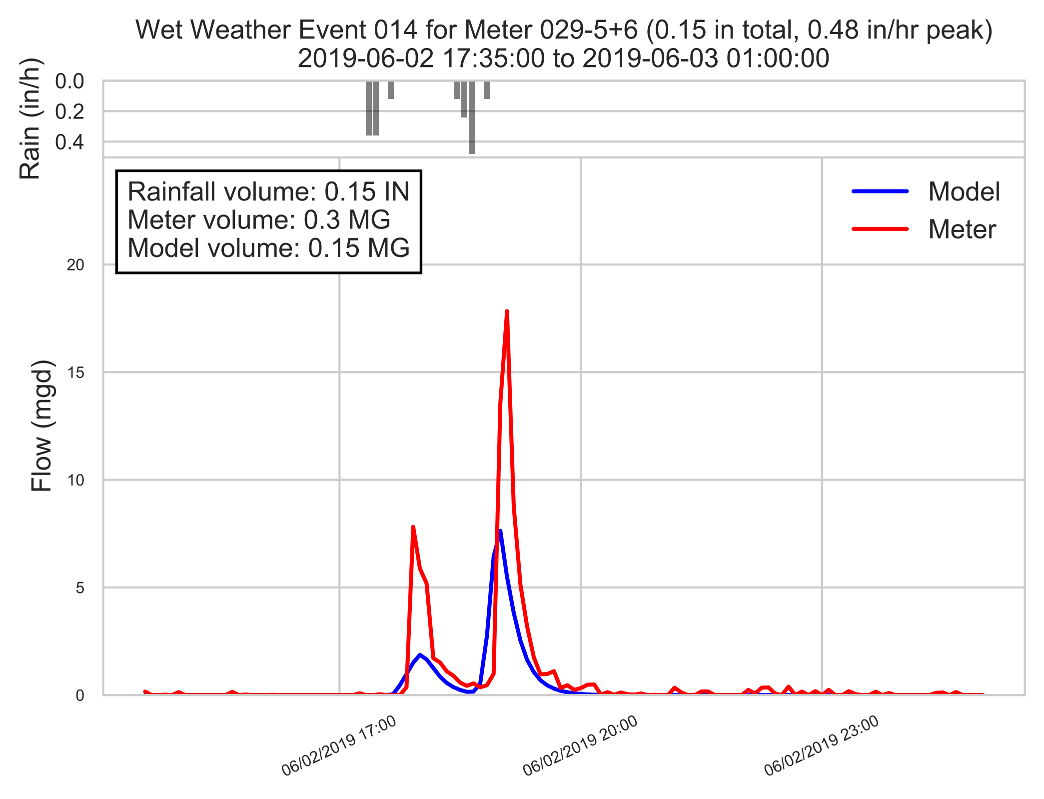
Wet Weather Event 011 for Meter 029-5+6 (0.11 in total, 0.72 in/hr peak)
2019-05-25 23:25:00 to 2019-05-26 05:45:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.11 IN
Meter volume: 0.14 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
05/25/2019 21:00
05/26/2019 00:00
05/26/2019 03:00
05/26/2019 06:00

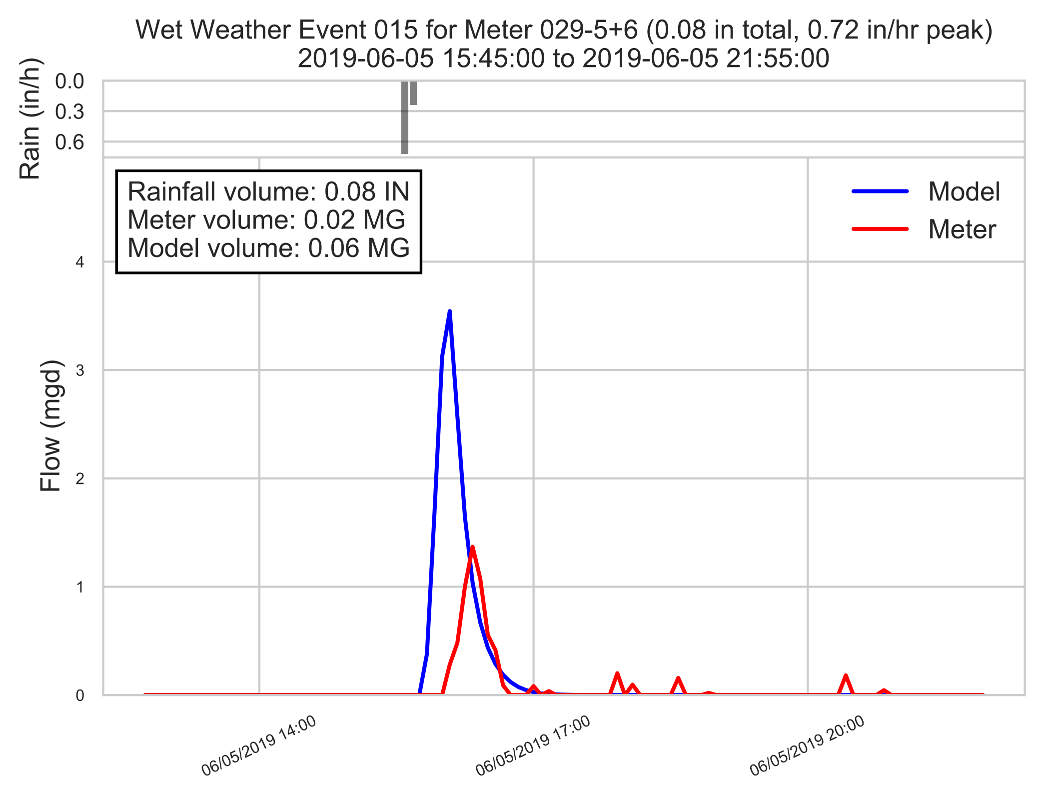


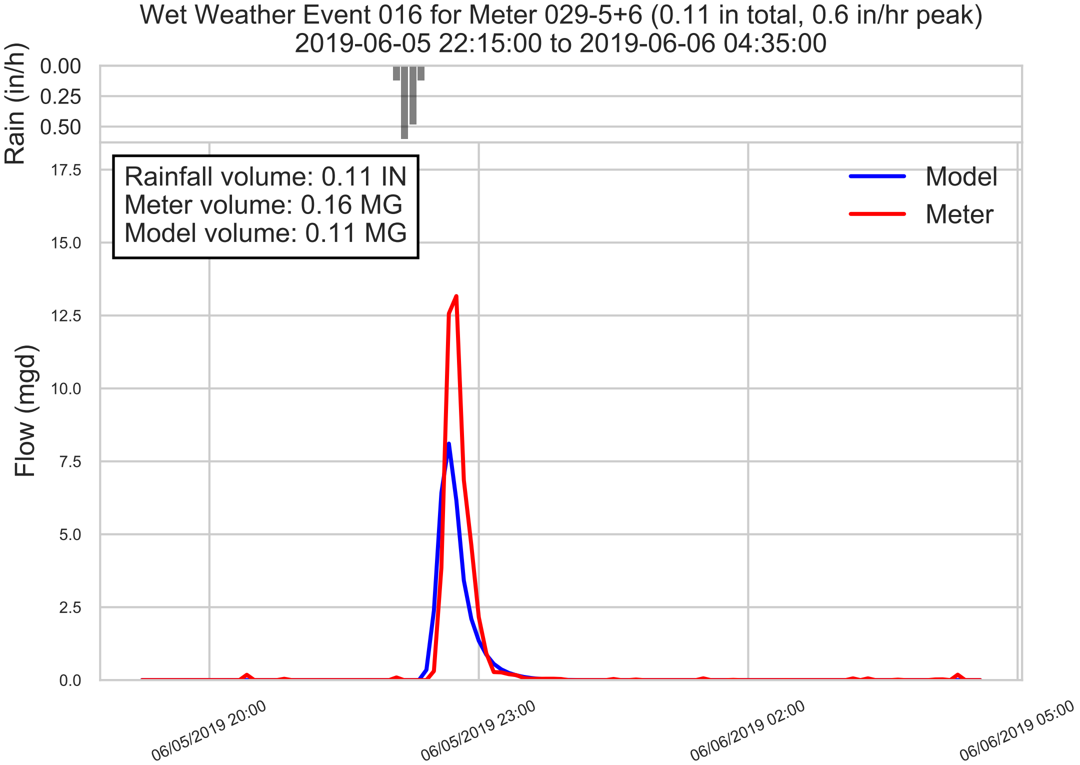
Wet Weather Event 012 for Meter 029-5+6 (0.49 in total, 2.88 in/hr peak)
2019-05-28 06:30:00 to 2019-05-28 13:20:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 0.49 IN
Meter volume: 0.52 MG
Model volume: 0.91 MG
Model
Meter
Flow (mgd)
100
80
60
40
20
0
05/28/2019 04:00
05/28/2019 07:00
05/28/2019 10:00
05/28/2019 13:00



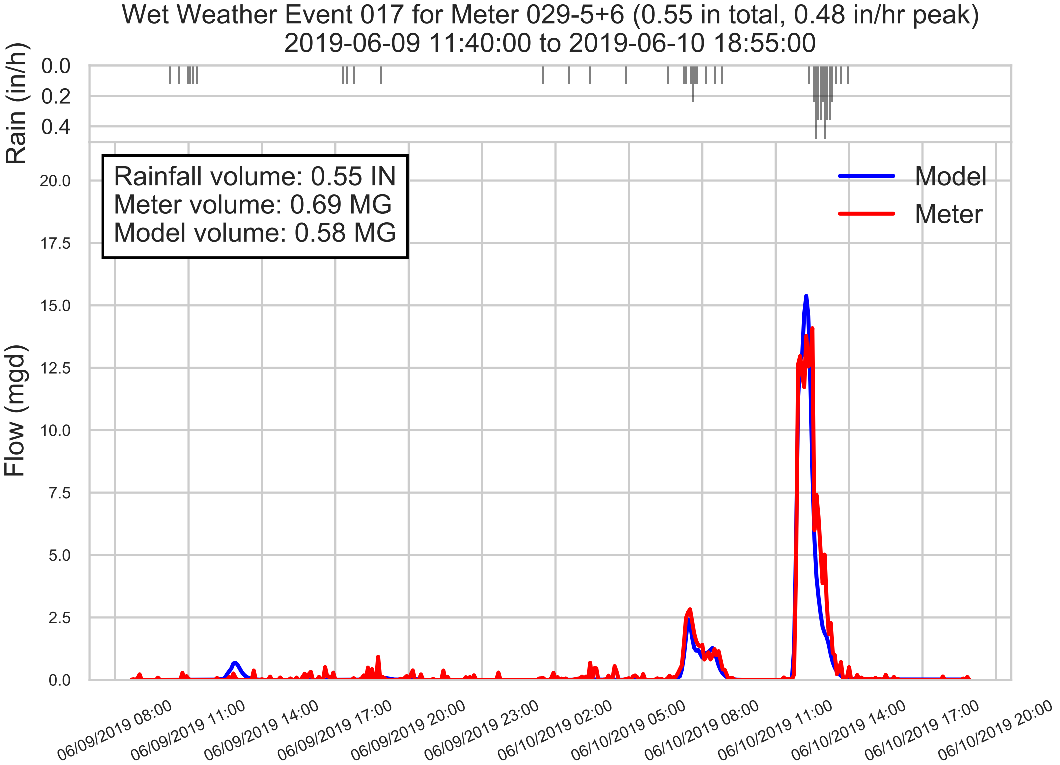
Wet Weather Event 013 for Meter 029-5+6 (0.18 in total, 0.72 in/hr peak)
2019-05-30 15:30:00 to 2019-05-31 02:00:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.18 IN
Meter volume: 0.28 MG
Model volume: 0.18 MG
Model
Meter
Flow (mgd)
25
20
15
10
5
0
05/30/2019 14:00
05/30/2019 17:00
05/30/2019 20:00
05/30/2019 23:00
05/31/2019 02:00


Wet Weather Event 014 for Meter 029-5+6 (0.15 in total, 0.48 in/hr peak)
2019-06-02 17:35:00 to 2019-06-03 01:00:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.15 IN
Meter volume: 0.3 MG
Model volume: 0.15 MG
Model
Meter
Flow (mgd)
20
15
10
5
0
06/02/2019 17:00
06/02/2019 20:00
06/02/2019 23:00

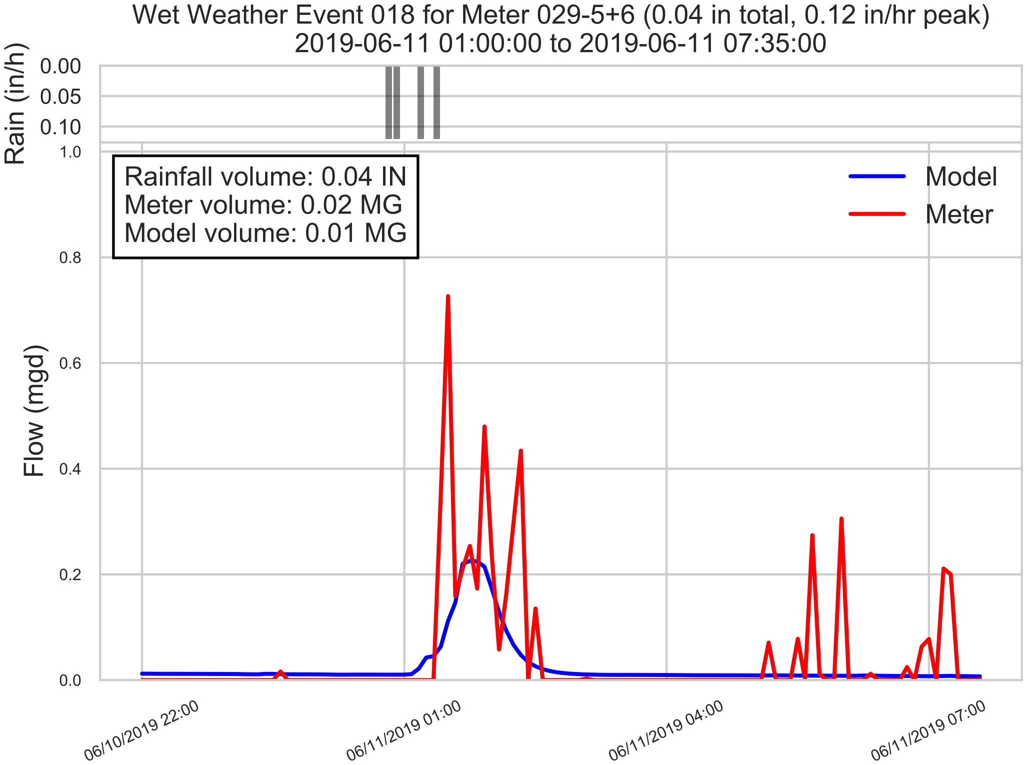

Wet Weather Event 015 for Meter 029-5+6 (0.08 in total, 0.72 in/hr peak)
2019-06-05 15:45:00 to 2019-06-05 21:55:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.08 IN
Meter volume: 0.02 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
4
3
2
1
0
06/05/2019 14:00
06/05/2019 17:00
06/05/2019 20:00



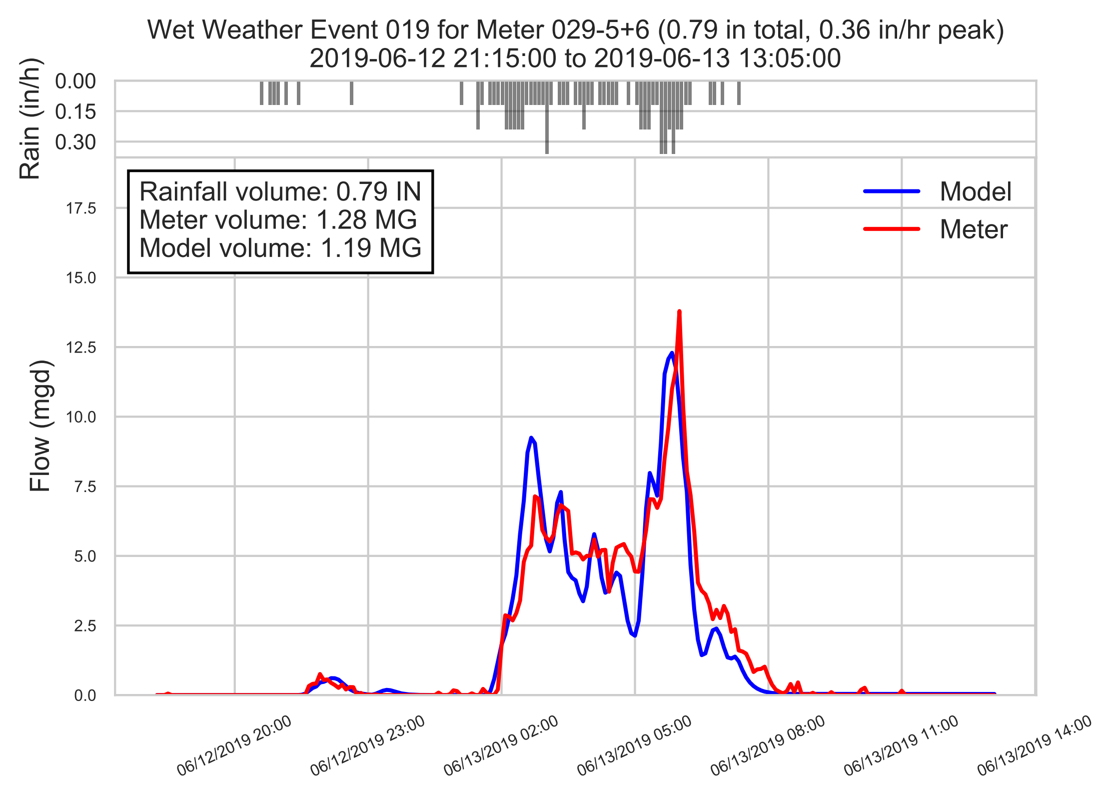
Wet Weather Event 016 for Meter 029-5+6 (0.11 in total, 0.6 in/hr peak)
2019-06-05 22:15:00 to 2019-06-06 04:35:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.11 IN
Meter volume: 0.16 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
06/05/2019 20:00
06/05/2019 23:00
06/06/2019 02:00
06/06/2019 05:00



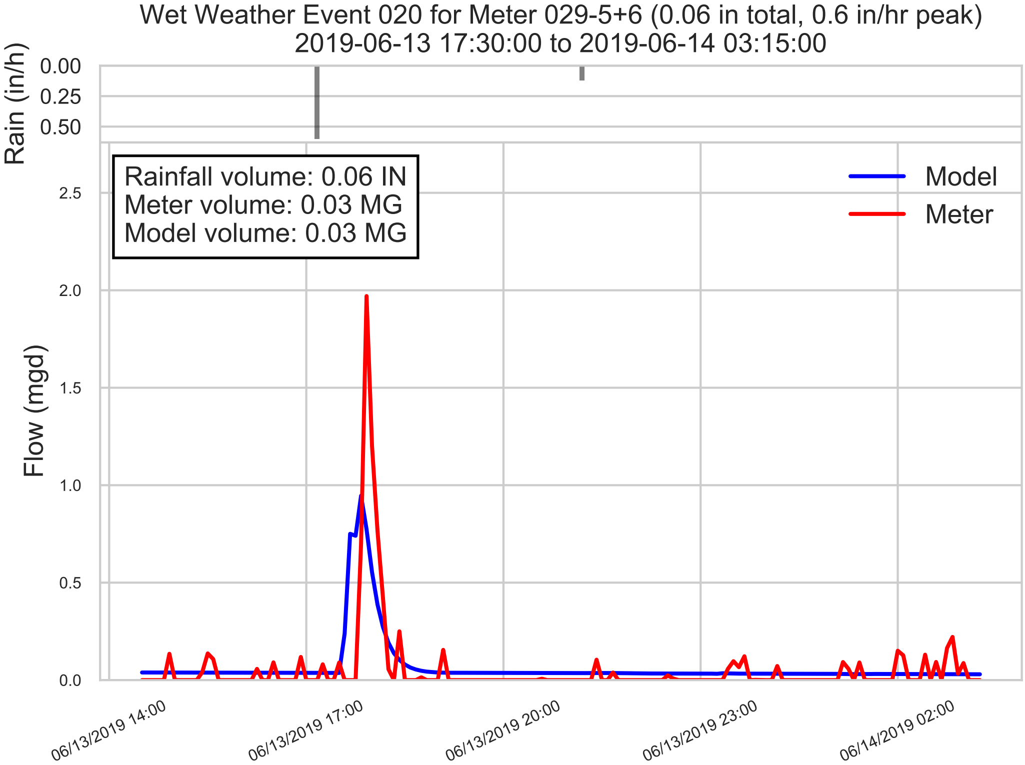
Wet Weather Event 017 for Meter 029-5+6 (0.55 in total, 0.48 in/hr peak)
2019-06-09 11:40:00 to 2019-06-10 18:55:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.55 IN
Meter volume: 0.69 MG
Model volume: 0.58 MG
Model
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
06/09/2019 08:00
06/09/2019 11:00
06/09/2019 14:00
06/09/2019 17:00
06/09/2019 20:00
06/09/2019 23:00
06/10/2019 02:00
06/10/2019 05:00
06/10/2019 08:00
06/10/2019 11:00
06/10/2019 14:00
06/10/2019 17:00
06/10/2019 20:00



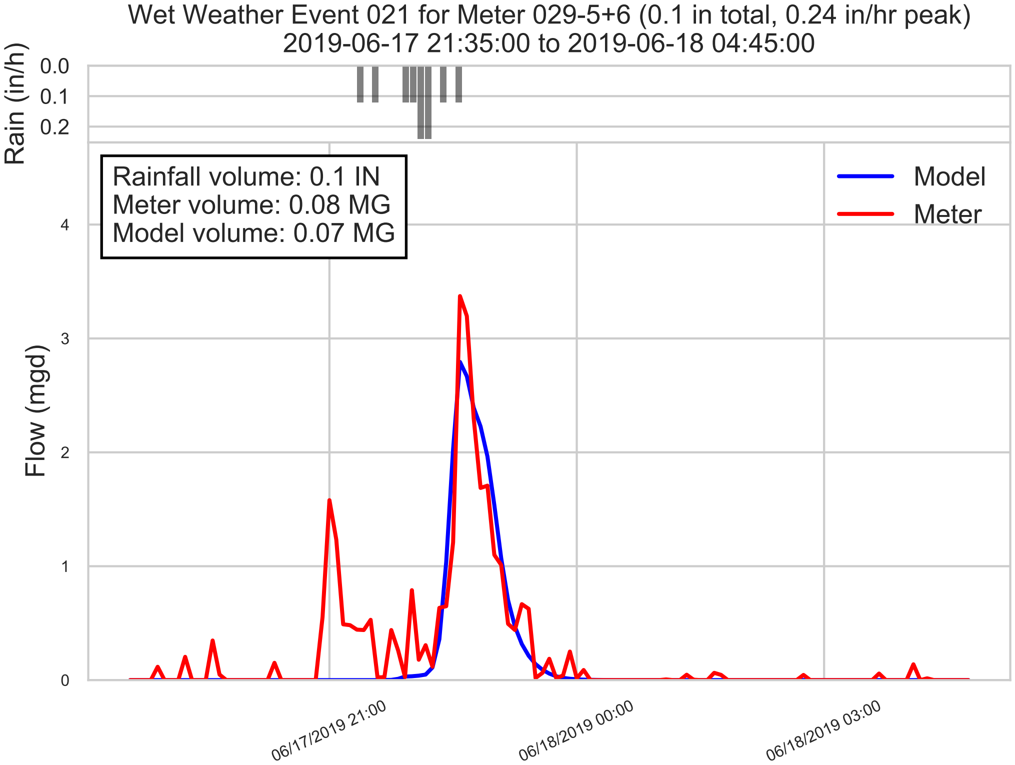
Wet Weather Event 018 for Meter 029-5+6 (0.04 in total, 0.12 in/hr peak)
2019-06-11 01:00:00 to 2019-06-11 07:35:00
Rain (in/h)
0.00
0.05
0.10
1.0
0.8
0.6
0.4
0.2
0.0
Flow (mgd)
Rainfall volume: 0.04 IN
Meter volume: 0.02 MG
Model volume: 0.01 MG
Model
Meter
06/10/2019 22:00
06/11/2019 01:00
06/11/2019 04:00
06/11/2019 07:00

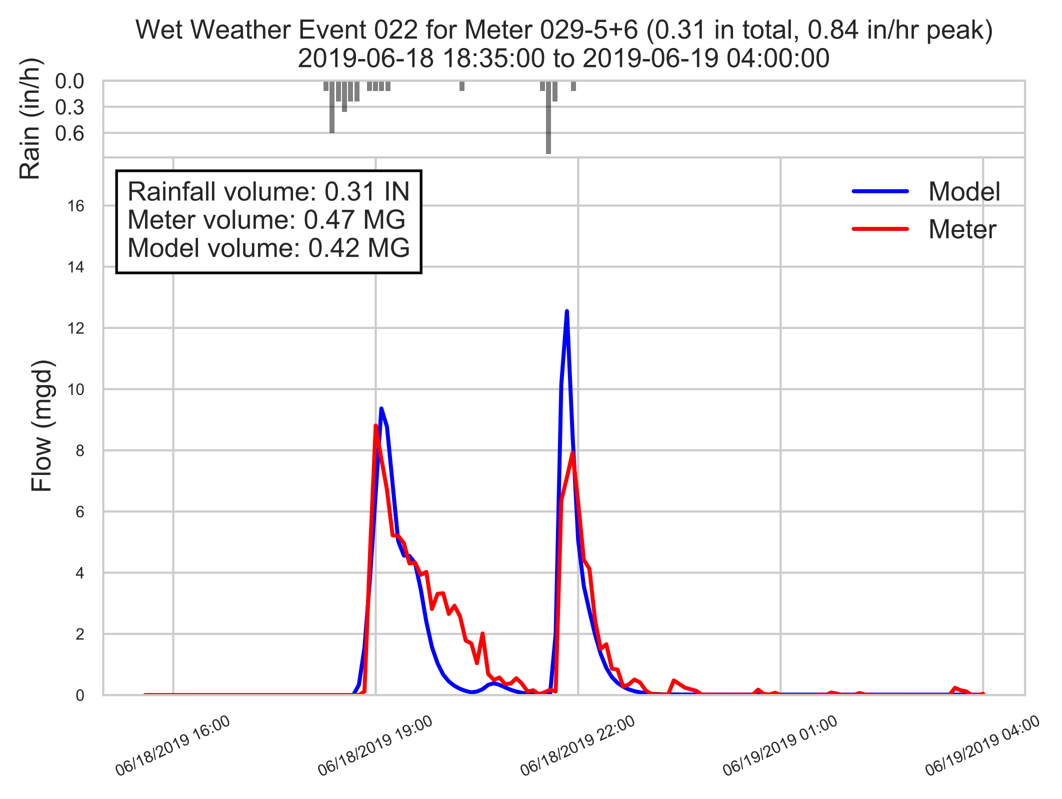


Wet Weather Event 019 for Meter 029-5+6 (0.79 in total, 0.36 in/hr peak)
2019-06-12 21:15:00 to 2019-06-13 13:05:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.79 IN
Meter volume: 1.28 MG
Model volume: 1.19 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
06/12/2019 20:00
06/12/2019 23:00
06/13/2019 02:00
06/13/2019 05:00
06/13/2019 08:00
06/13/2019 11:00
06/13/2019 14:00

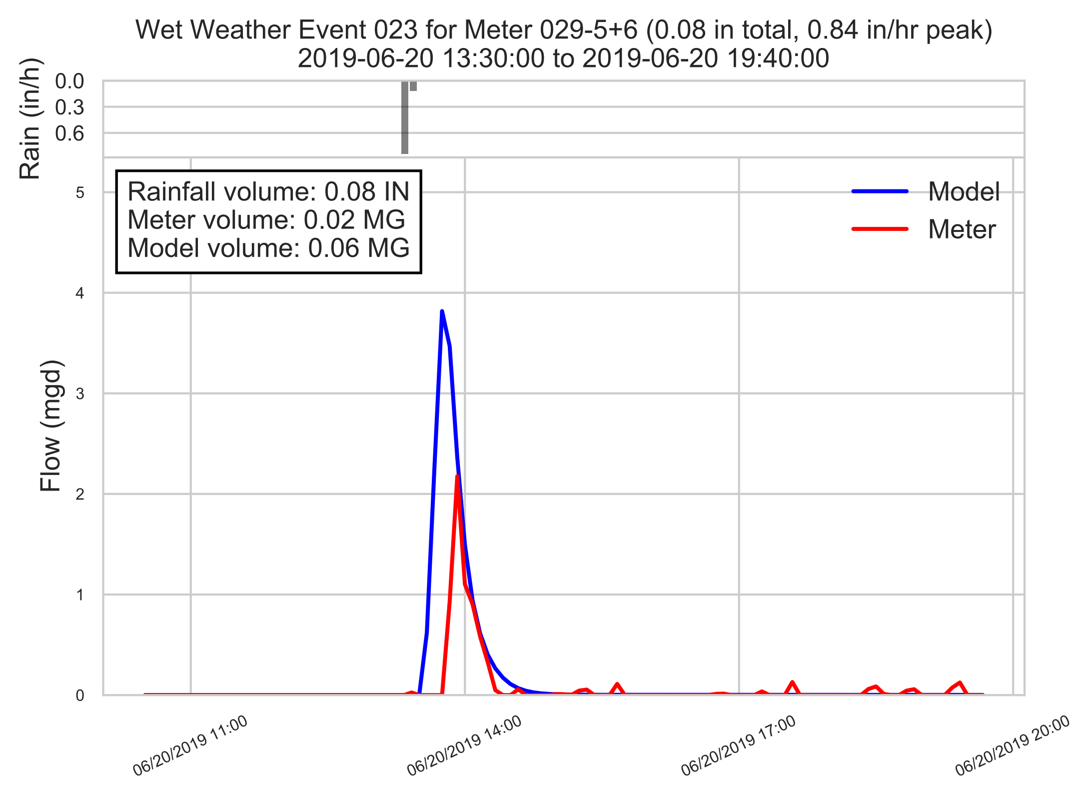


Wet Weather Event 020 for Meter 029-5+6 (0.06 in total, 0.6 in/hr peak)
2019-06-13 17:30:00 to 2019-06-14 03:15:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.06 IN
Meter volume: 0.03 MG
Model volume: 0.03 MG
Model
Meter
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
06/13/2019 14:00
06/13/2019 17:00
06/13/2019 20:00
06/13/2019 23:00
06/14/2019 02:00

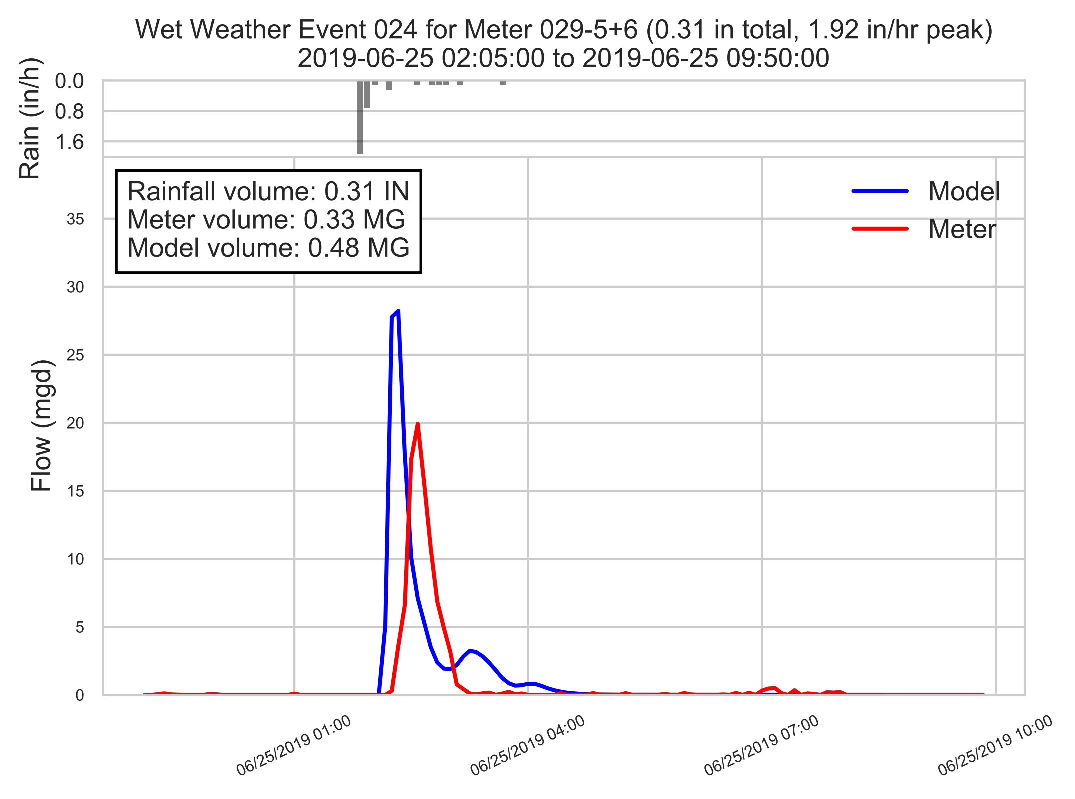

Wet Weather Event 021 for Meter 029-5+6 (0.1 in total, 0.24 in/hr peak)
2019-06-17 21:35:00 to 2019-06-18 04:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.1 IN
Meter volume: 0.08 MG
Model volume: 0.07 MG
Model
Meter
Flow (mgd)
4
3
2
1
0
06/17/2019 21:00
06/18/2019 00:00
06/18/2019 03:00



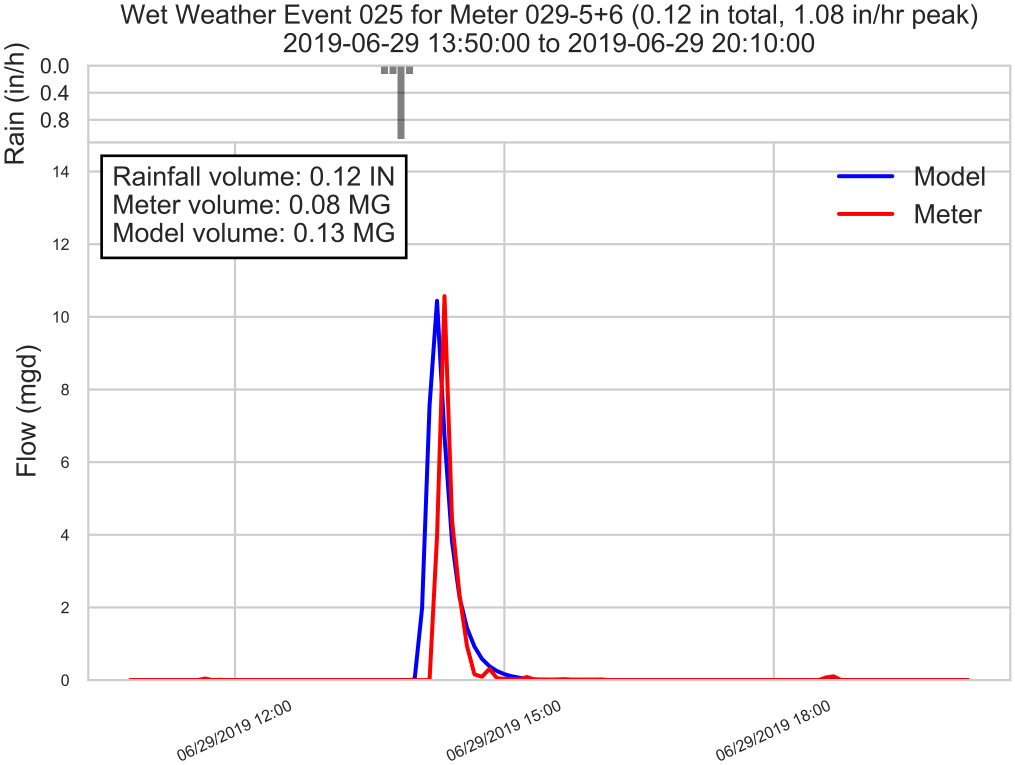
Wet Weather Event 022 for Meter 029-5+6 (0.31 in total, 0.84 in/hr peak)
2019-06-18 18:35:00 to 2019-06-19 04:00:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.31 IN
Meter volume: 0.47 MG
Model volume: 0.42 MG
Model
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
06/18/2019 16:00
06/18/2019 19:00
06/18/2019 22:00
06/19/2019 01:00
06/19/2019 04:00

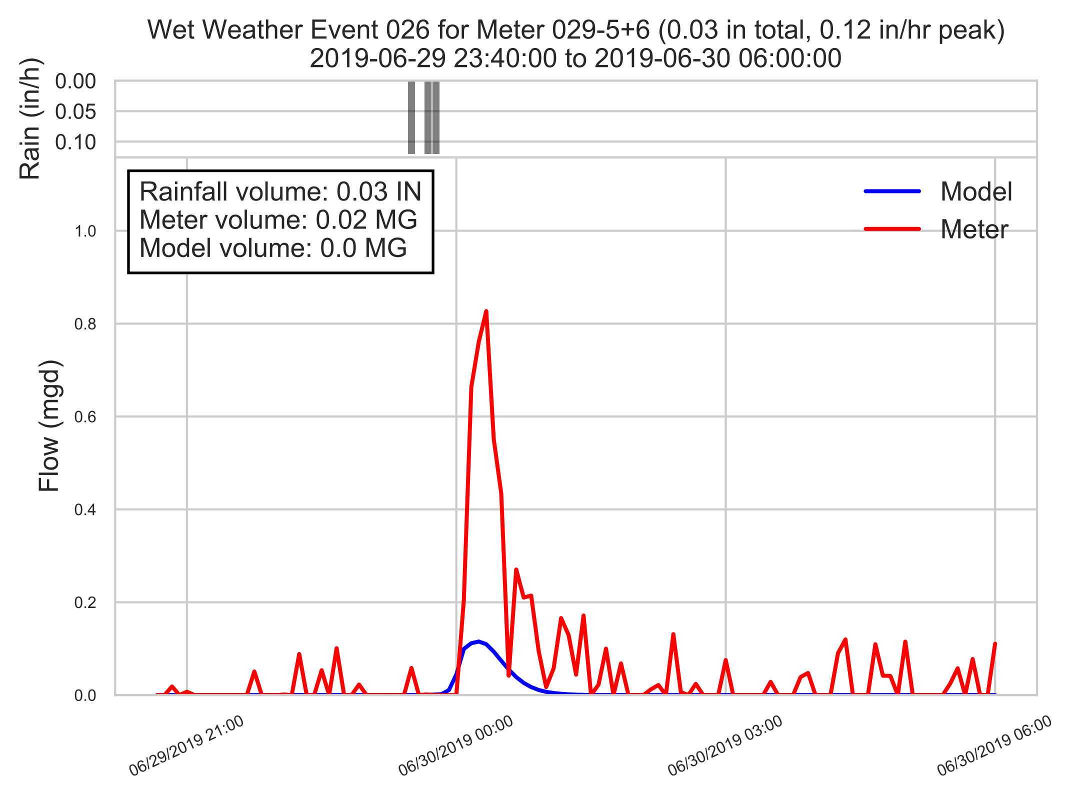


Wet Weather Event 023 for Meter 029-5+6 (0.08 in total, 0.84 in/hr peak)
2019-06-20 13:30:00 to 2019-06-20 19:40:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.08 IN
Meter volume: 0.02 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
06/20/2019 11:00
06/20/2019 14:00
06/20/2019 17:00
06/20/2019 20:00

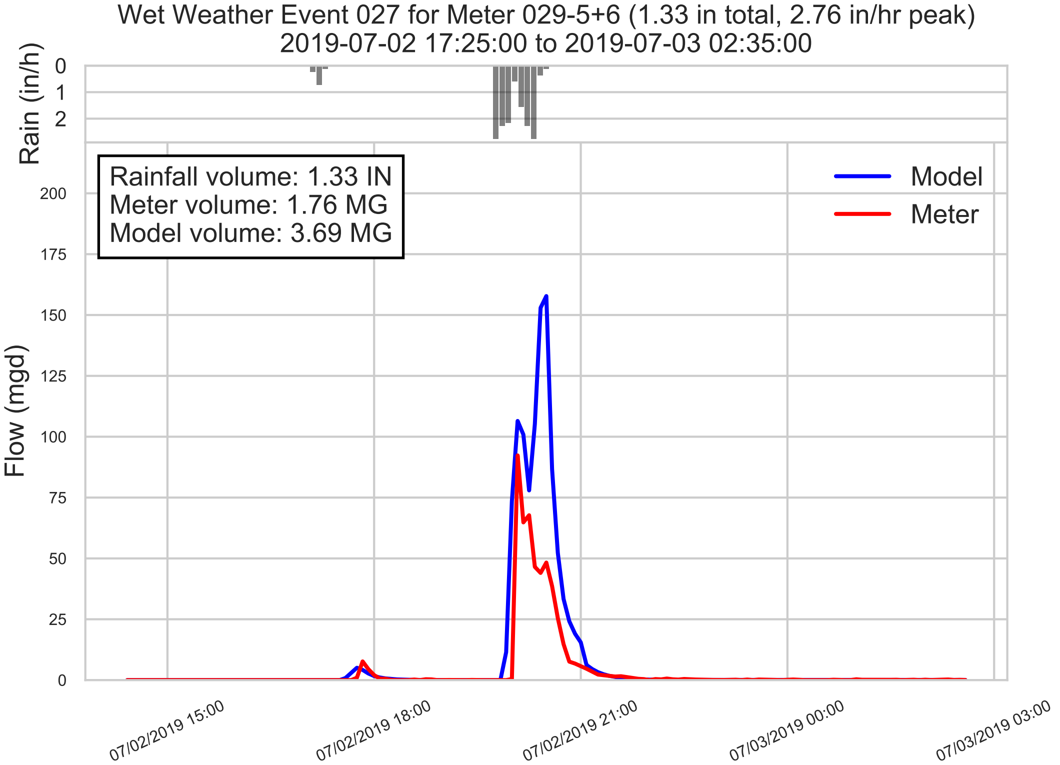


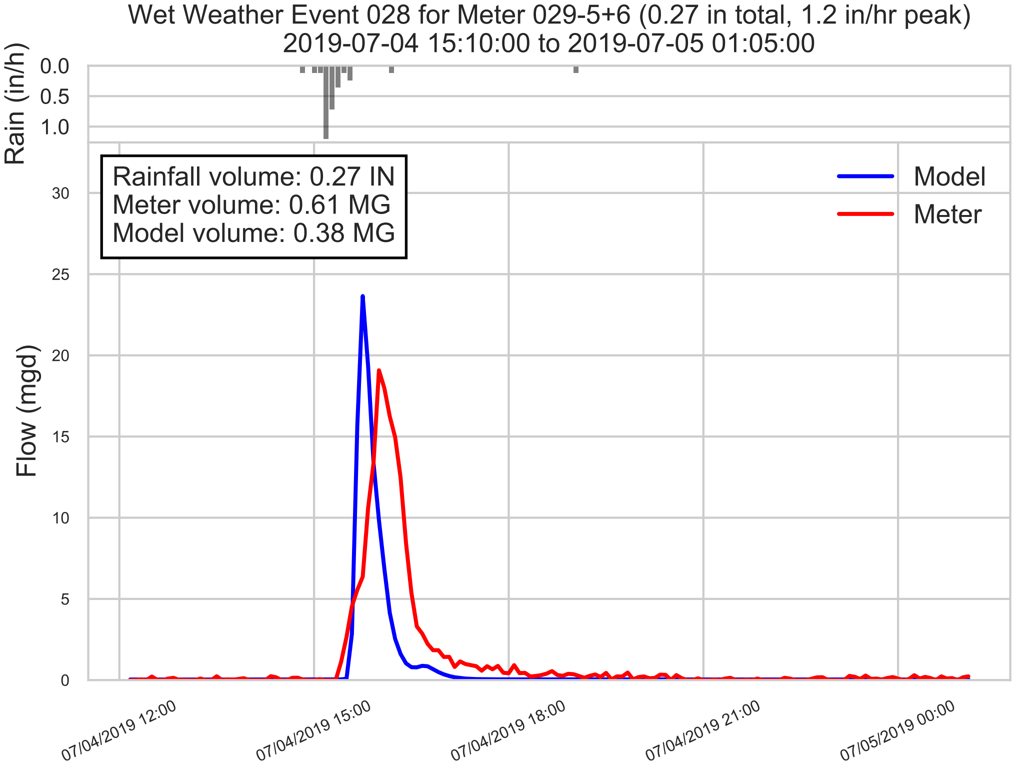
Wet Weather Event 024 for Meter 029-5+6 (0.31 in total, 1.92 in/hr peak)
2019-06-25 02:05:00 to 2019-06-25 09:50:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.31 IN
Meter volume: 0.33 MG
Model volume: 0.48 MG
Model
Meter
Flow (mgd)
35
30
25
20
15
10
5
0
06/25/2019 01:00
06/25/2019 04:00
06/25/2019 07:00
06/25/2019 10:00

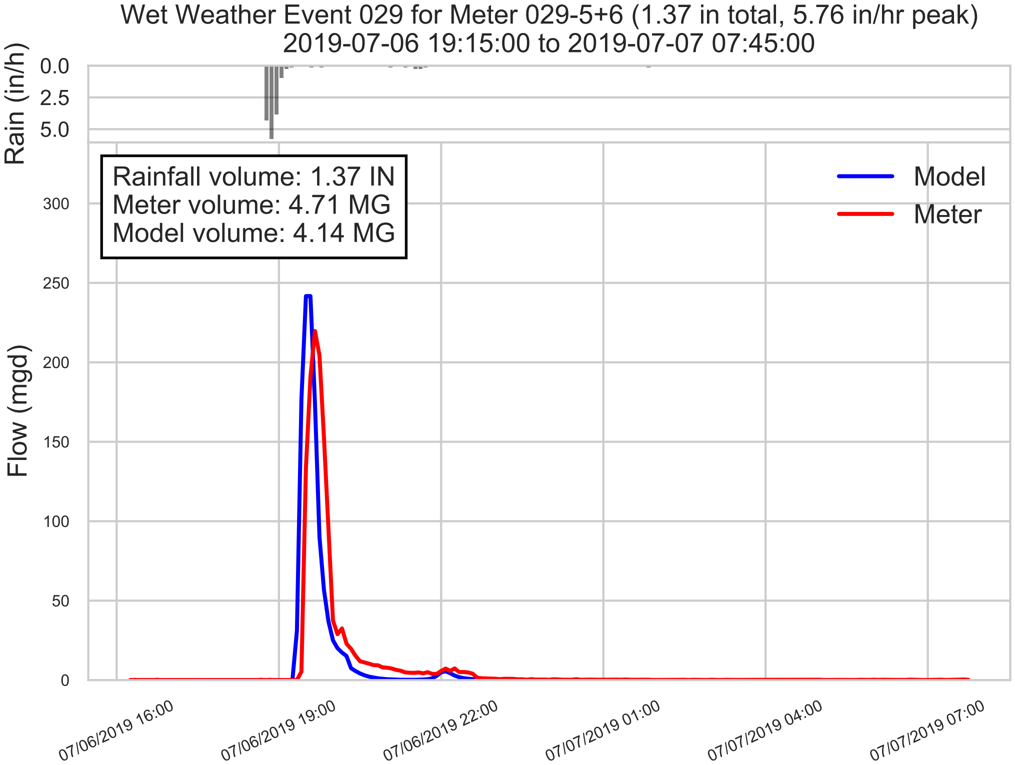

Wet Weather Event 025 for Meter 029-5+6 (0.12 in total, 1.08 in/hr peak)
2019-06-29 13:50:00 to 2019-06-29 20:10:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.12 IN
Meter volume: 0.08 MG
Model volume: 0.13 MG
Model
Meter
Flow (mgd)
14
12
10
8
6
4
2
0
06/29/2019 12:00
06/29/2019 15:00
06/29/2019 18:00



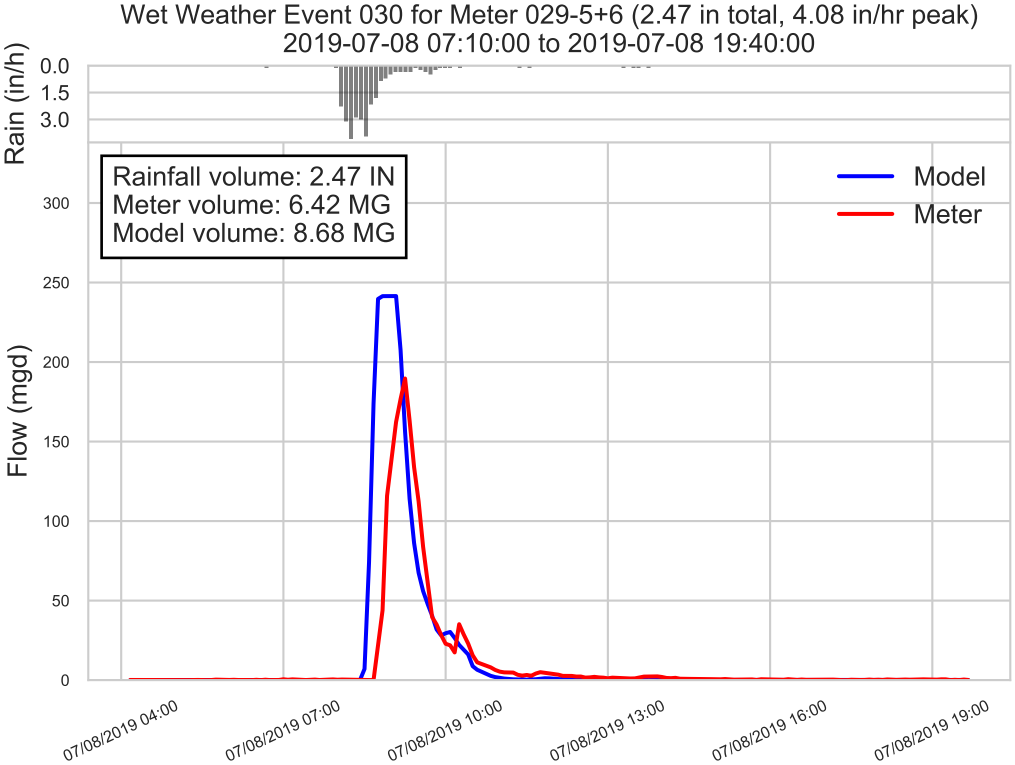
Wet Weather Event 026 for Meter 029-5+6 (0.03 in total, 0.12 in/hr peak)
2019-06-29 23:40:00 to 2019-06-30 06:00:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.03 IN
Meter volume: 0.02 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
06/29/2019 21:00
06/30/2019 00:00
06/30/2019 03:00
06/30/2019 06:00


Wet Weather Event 027 for Meter 029-5+6 (1.33 in total, 2.76 in/hr peak)
2019-07-02 17:25:00 to 2019-07-03 02:35:00
Rain (in/h)
0
1
2
Rainfall volume: 1.33 IN
Meter volume: 1.76 MG
Model volume: 3.69 MG
Model
Meter
Flow (mgd)
200
175
150
125
100
75
50
25
0
07/02/2019 15:00
07/02/2019 18:00
07/02/2019 21:00
07/03/2019 00:00
07/03/2019 03:00

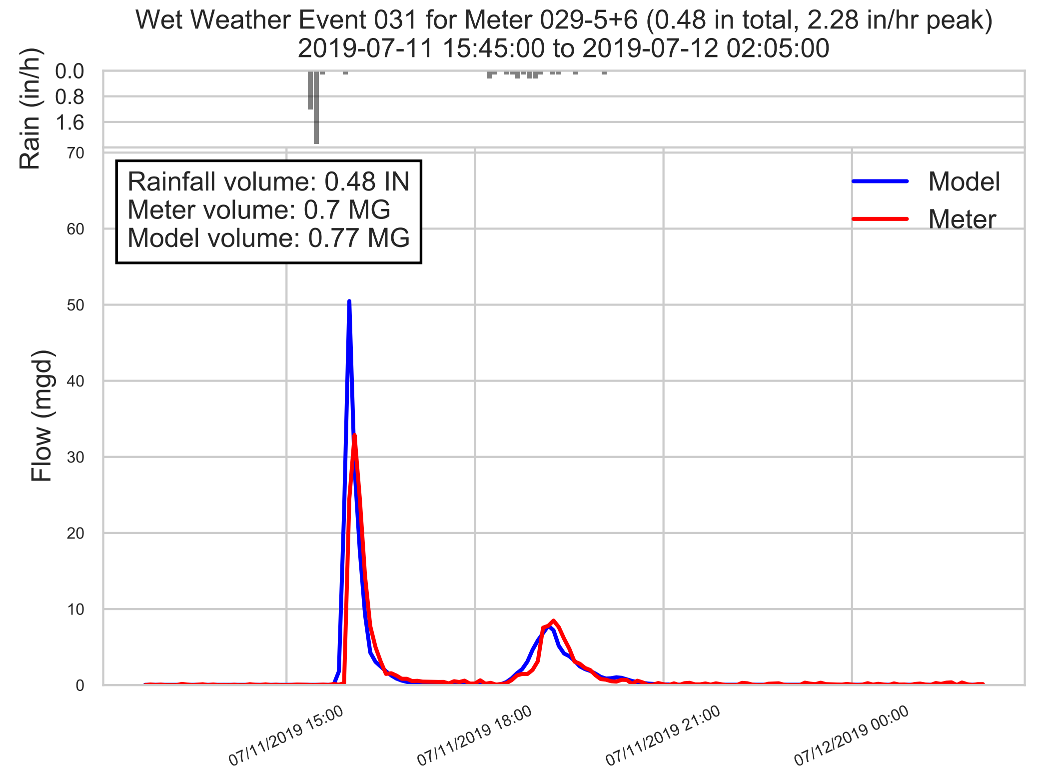

Wet Weather Event 028 for Meter 029-5+6 (0.27 in total, 1.2 in/hr peak)
2019-07-04 15:10:00 to 2019-07-05 01:05:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.27 IN
Meter volume: 0.61 MG
Model volume: 0.38 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
07/04/2019 12:00
07/04/2019 15:00
07/04/2019 18:00
07/04/2019 21:00
07/05/2019 00:00



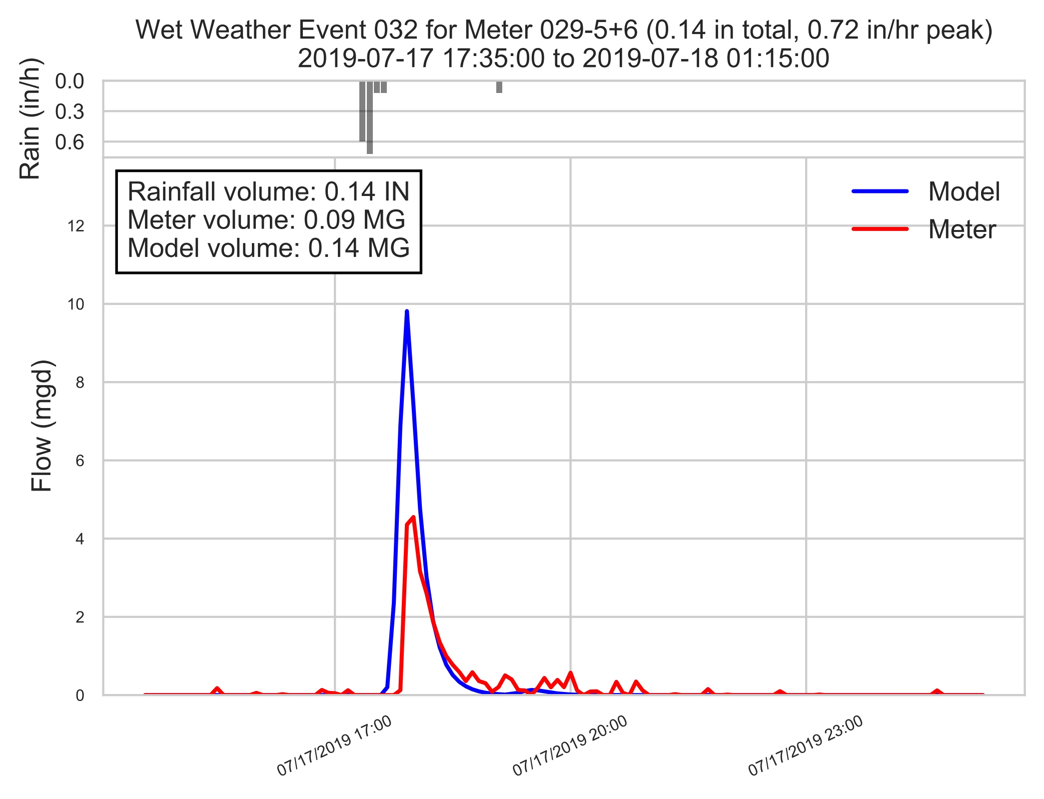
Wet Weather Event 029 for Meter 029-5+6 (1.37 in total, 5.76 in/hr peak)
2019-07-06 19:15:00 to 2019-07-07 07:45:00
Rain (in/h)
0.0
2.5
5.0
Rainfall volume: 1.37 IN
Meter volume: 4.71 MG
Model volume: 4.14 MG
Model
Meter
Flow (mgd)
300
250
200
150
100
50
0
07/06/2019 16:00
07/06/2019 19:00
07/06/2019 22:00
07/07/2019 01:00
07/07/2019 04:00
07/07/2019 07:00

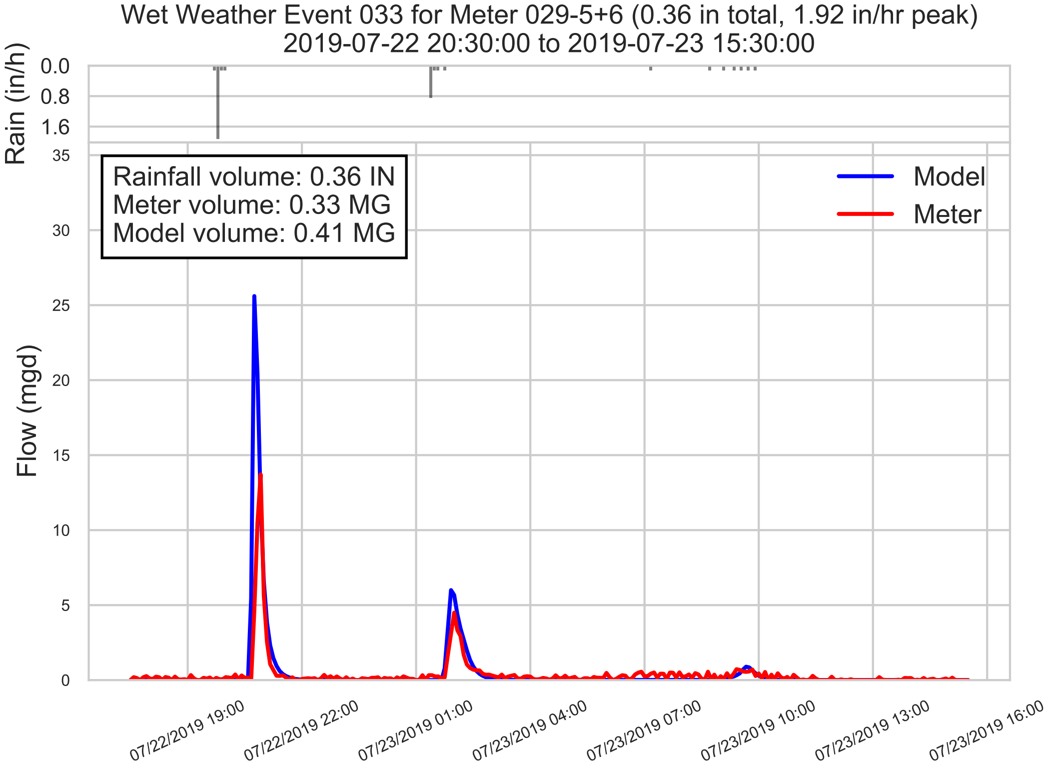


Wet Weather Event 030 for Meter 029-5+6 (2.47 in total, 4.08 in/hr peak)
2019-07-08 07:10:00 to 2019-07-08 19:40:00
Rain (in/h)
0.0
1.5
3.0
Rainfall volume: 2.47 IN
Meter volume: 6.42 MG
Model volume: 8.68 MG
Model
Meter
Flow (mgd)
300
250
200
150
100
50
0
07/08/2019 04:00
07/08/2019 07:00
07/08/2019 10:00
07/08/2019 13:00
07/08/2019 16:00
07/08/2019 19:00

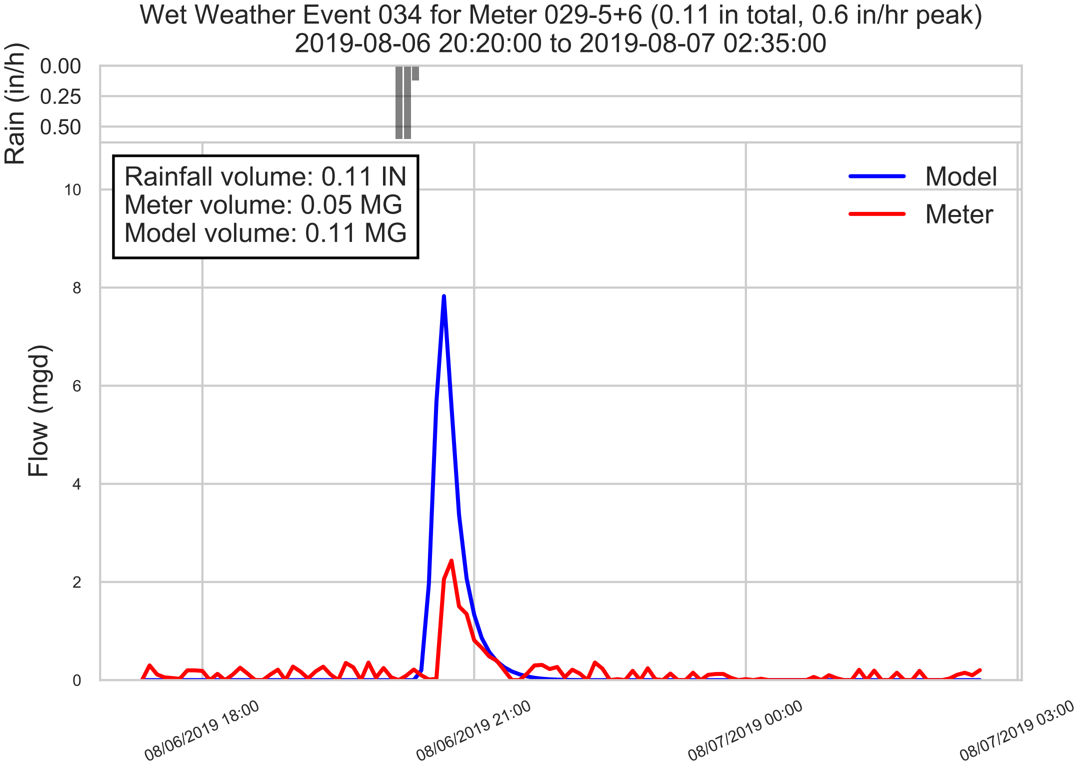


Wet Weather Event 031 for Meter 029-5+6 (0.48 in total, 2.28 in/hr peak)
2019-07-11 15:45:00 to 2019-07-12 02:05:00
Rain (in/h)
0.0
0.8
1.6
70
60
50
40
30
20
10
0
Flow (mgd)
Rainfall volume: 0.48 IN
Meter volume: 0.7 MG
Model volume: 0.77 MG
Model
Meter
07/11/2019 15:00
07/11/2019 18:00
07/11/2019 21:00
07/12/2019 00:00

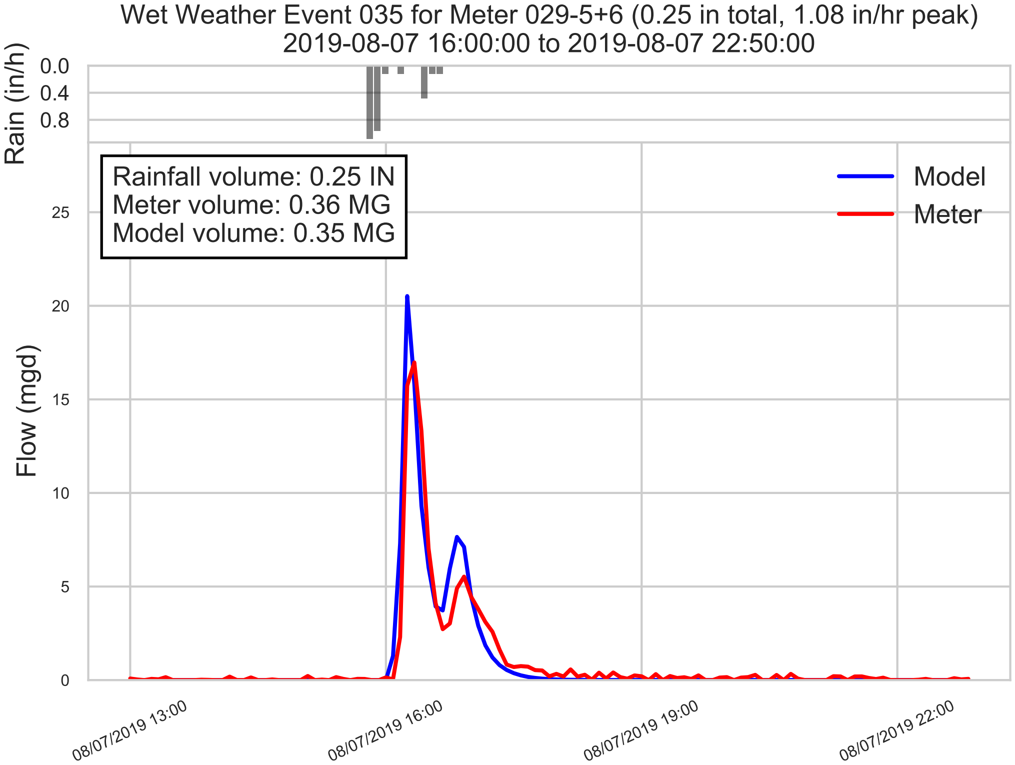

Wet Weather Event 032 for Meter 029-5+6 (0.14 in total, 0.72 in/hr peak)
2019-07-17 17:35:00 to 2019-07-18 01:15:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.14 IN
Meter volume: 0.09 MG
Model volume: 0.14 MG
Model
Meter
Flow (mgd)
12
10
8
6
4
2
0
07/17/2019 17:00
07/17/2019 20:00
07/17/2019 23:00

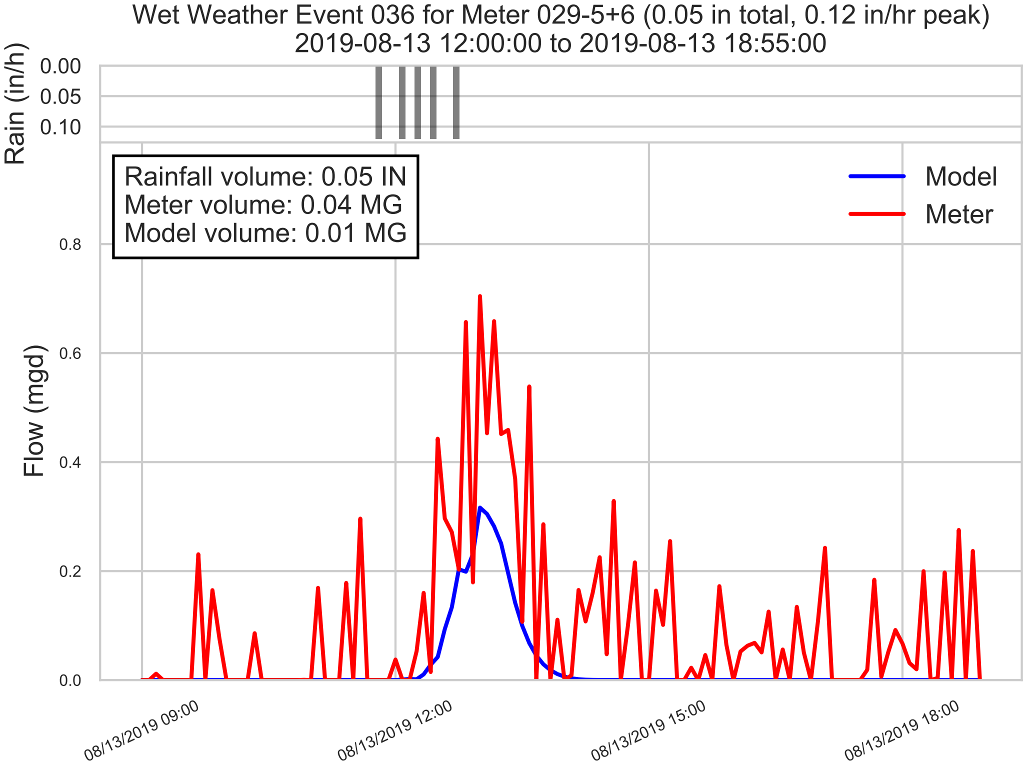


Wet Weather Event 033 for Meter 029-5+6 (0.36 in total, 1.92 in/hr peak)
2019-07-22 20:30:00 to 2019-07-23 15:30:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
35
30
25
20
15
10
5
0
Rainfall volume: 0.36 IN
Meter volume: 0.33 MG
Model volume: 0.41 MG
Model
Meter
07/22/2019 19:00
07/22/2019 22:00
07/23/2019 01:00
07/23/2019 04:00
07/23/2019 07:00
07/23/2019 10:00
07/23/2019 13:00
07/23/2019 16:00

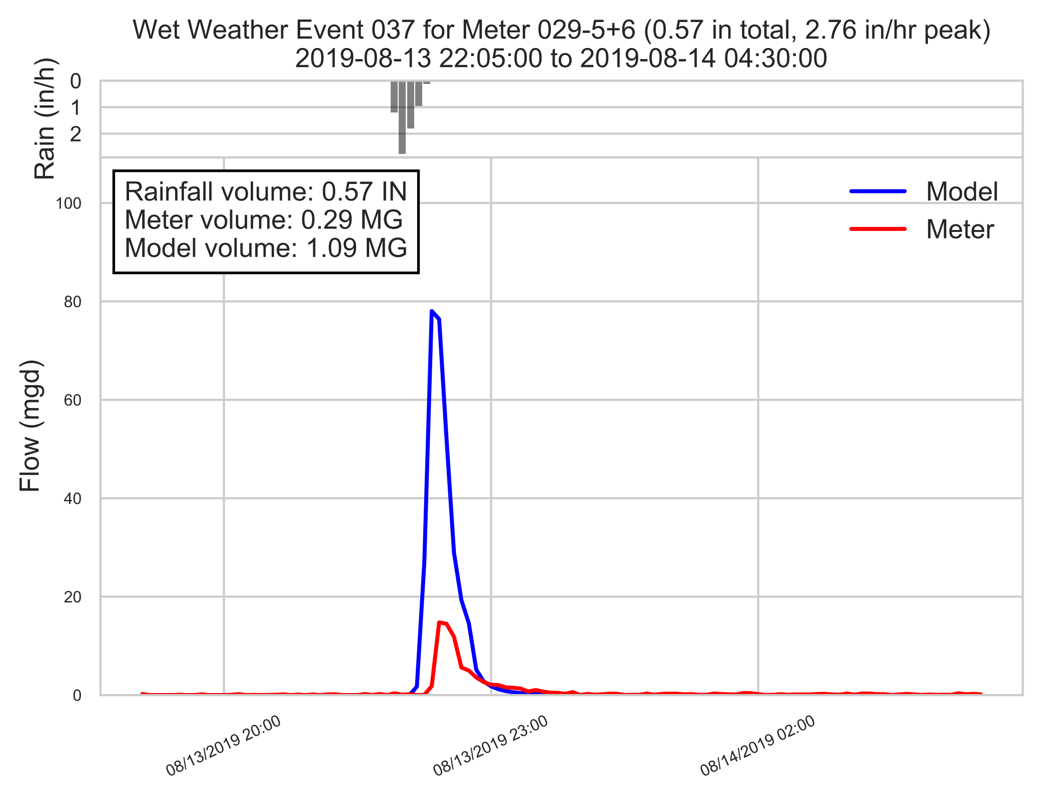


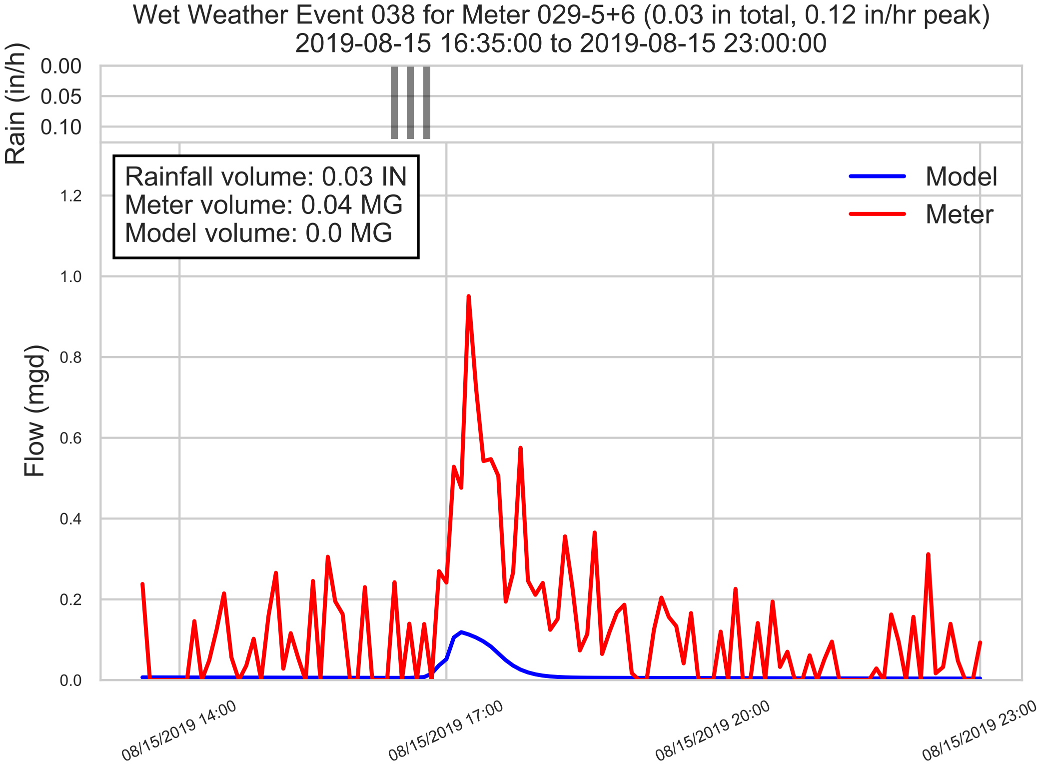
Wet Weather Event 034 for Meter 029-5+6 (0.11 in total, 0.6 in/hr peak)
2019-08-06 20:20:00 to 2019-08-07 02:35:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 0.11 IN
Meter volume: 0.05 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
08/06/2019 18:00
08/06/2019 21:00
08/07/2019 00:00
08/07/2019 03:00

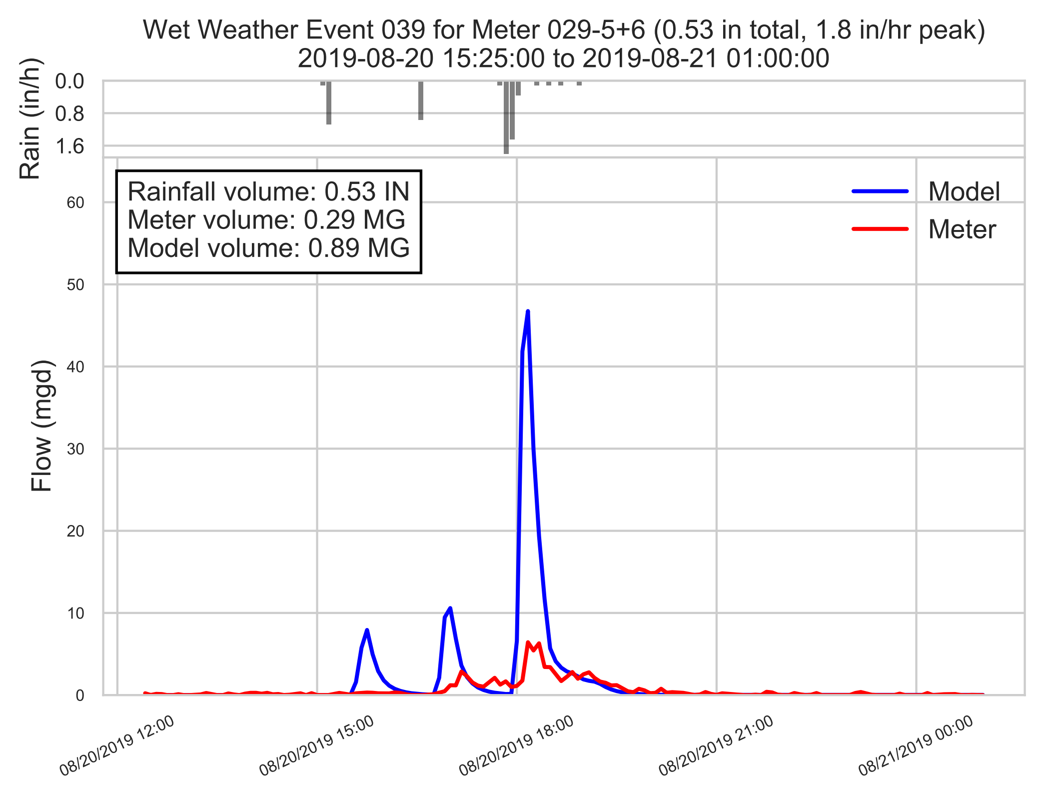

Wet Weather Event 035 for Meter 029-5+6 (0.25 in total, 1.08 in/hr peak)
2019-08-07 16:00:00 to 2019-08-07 22:50:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.25 IN
Meter volume: 0.36 MG
Model volume: 0.35 MG
Model
Meter
Flow (mgd)
0
5
10
15
20
25
08/07/2019 13:00
08/07/2019 16:00
08/07/2019 19:00
08/07/2019 22:00



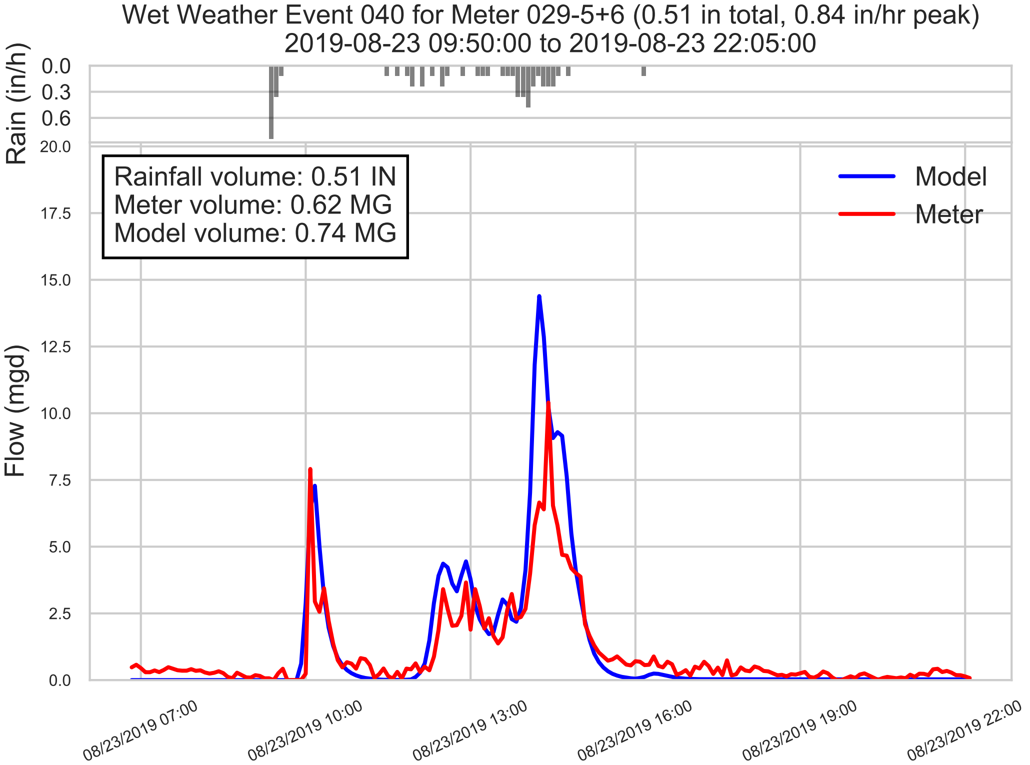
Wet Weather Event 036 for Meter 029-5+6 (0.05 in total, 0.12 in/hr peak)
2019-08-13 12:00:00 to 2019-08-13 18:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.05 IN
Meter volume: 0.04 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
0.8
0.6
0.4
0.2
0.0
08/13/2019 09:00
08/13/2019 12:00
08/13/2019 15:00
08/13/2019 18:00


Wet Weather Event 037 for Meter 029-5+6 (0.57 in total, 2.76 in/hr peak)
2019-08-13 22:05:00 to 2019-08-14 04:30:00
Rain (in/h)
0
1
2
Rainfall volume: 0.57 IN
Meter volume: 0.29 MG
Model volume: 1.09 MG
Model
Meter
Flow (mgd)
100
80
60
40
20
0
08/13/2019 20:00
08/13/2019 23:00
08/14/2019 02:00

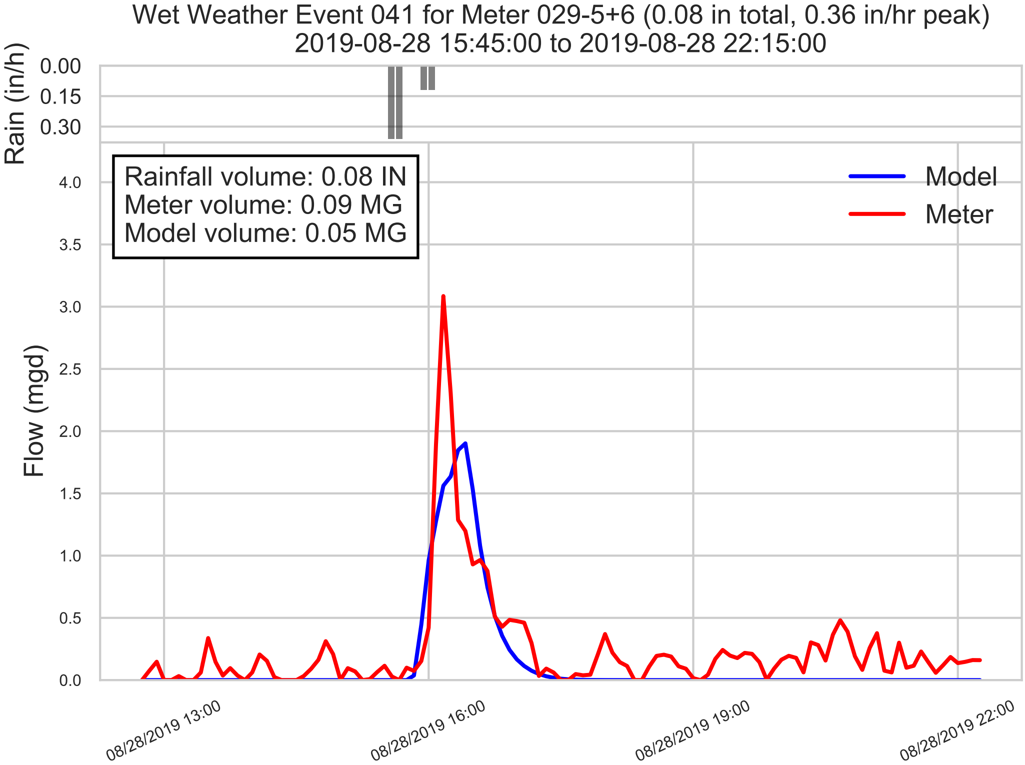

Wet Weather Event 038 for Meter 029-5+6 (0.03 in total, 0.12 in/hr peak)
2019-08-15 16:35:00 to 2019-08-15 23:00:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.03 IN
Meter volume: 0.04 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
08/15/2019 14:00
08/15/2019 17:00
08/15/2019 20:00
08/15/2019 23:00



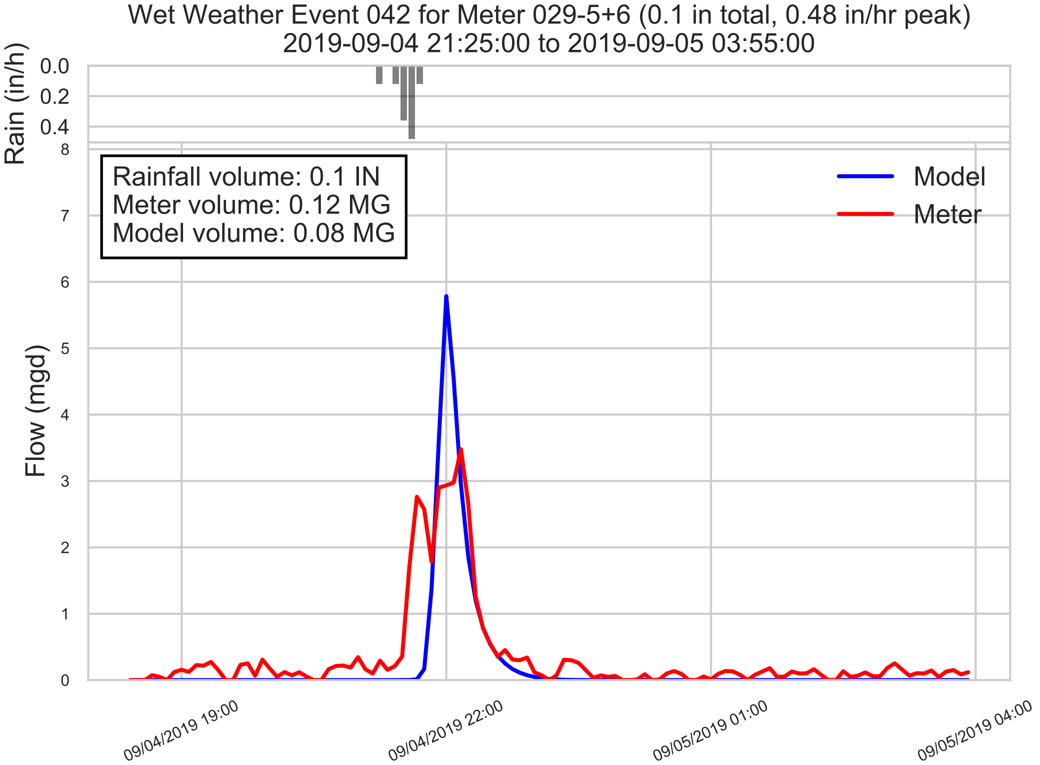
Wet Weather Event 039 for Meter 029-5+6 (0.53 in total, 1.8 in/hr peak)
2019-08-20 15:25:00 to 2019-08-21 01:00:00
Rain (in/h)
0.0
0.8
1.6
Rainfall volume: 0.53 IN
Meter volume: 0.29 MG
Model volume: 0.89 MG
Model
Meter
Flow (mgd)
0
10
20
30
40
50
60
08/20/2019 12:00
08/20/2019 15:00
08/20/2019 18:00
08/20/2019 21:00
08/21/2019 00:00



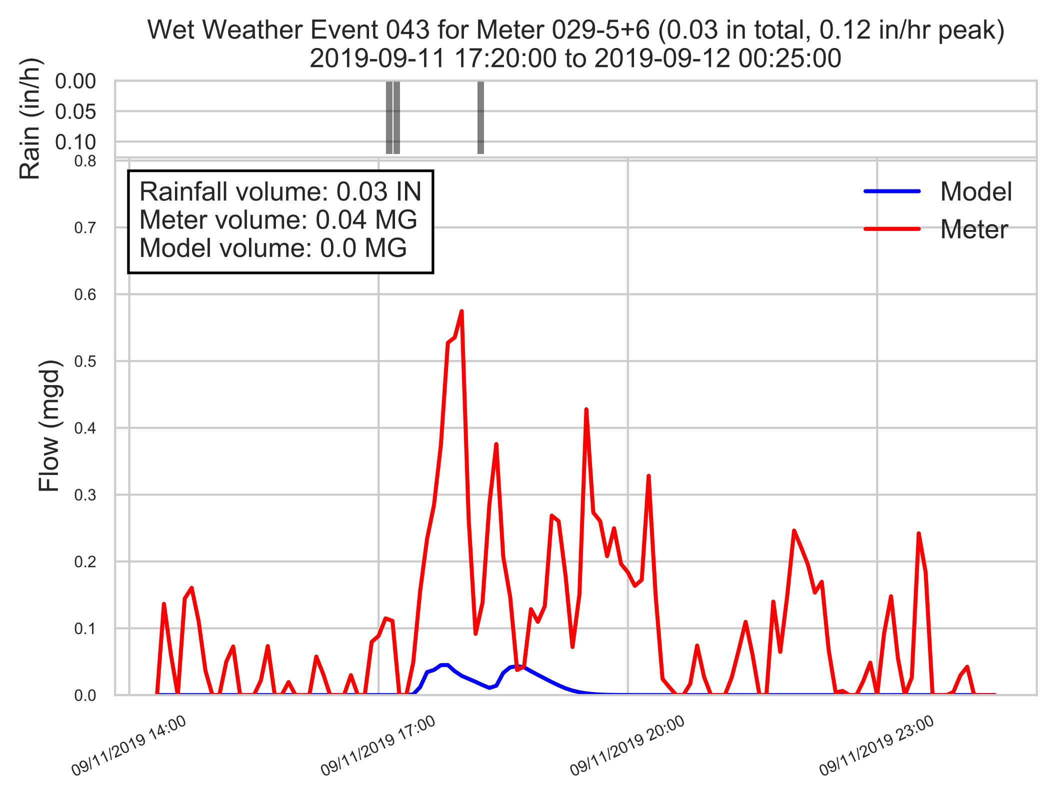
Wet Weather Event 040 for Meter 029-5+6 (0.51 in total, 0.84 in/hr peak)
2019-08-23 09:50:00 to 2019-08-23 22:05:00
Rain (in/h)
0.0
0.3
0.6
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Flow (mgd)
Rainfall volume: 0.51 IN
Meter volume: 0.62 MG
Model volume: 0.74 MG
Model
Meter
08/23/2019 07:00
08/23/2019 10:00
08/23/2019 13:00
08/23/2019 16:00
08/23/2019 19:00
08/23/2019 22:00

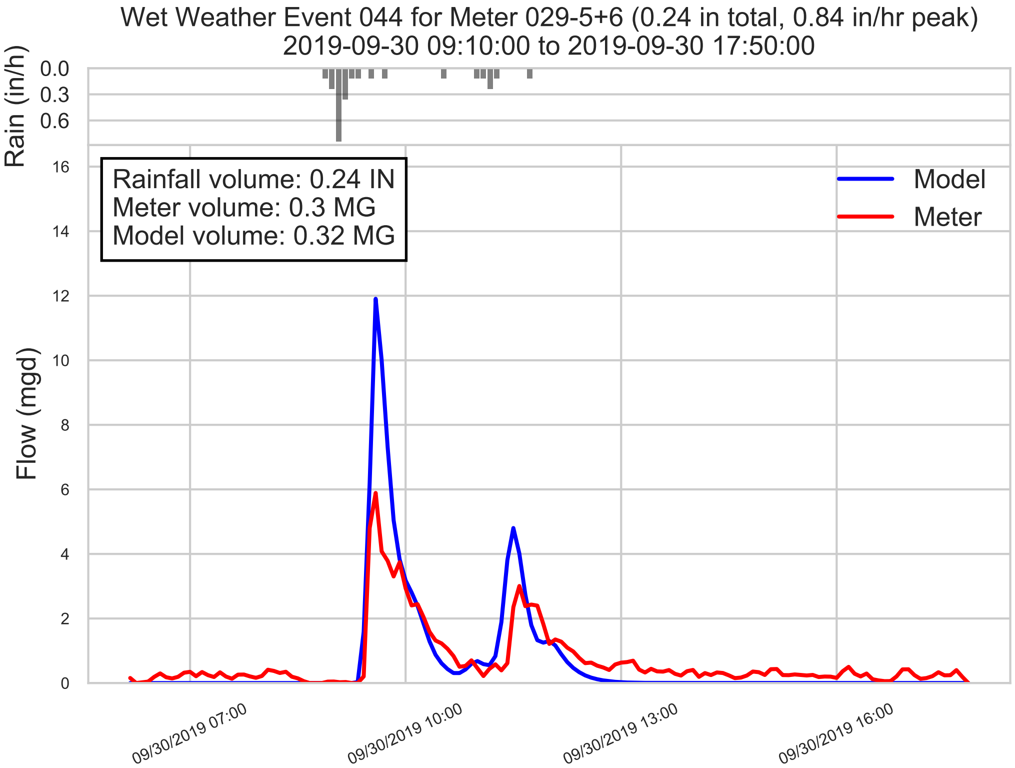


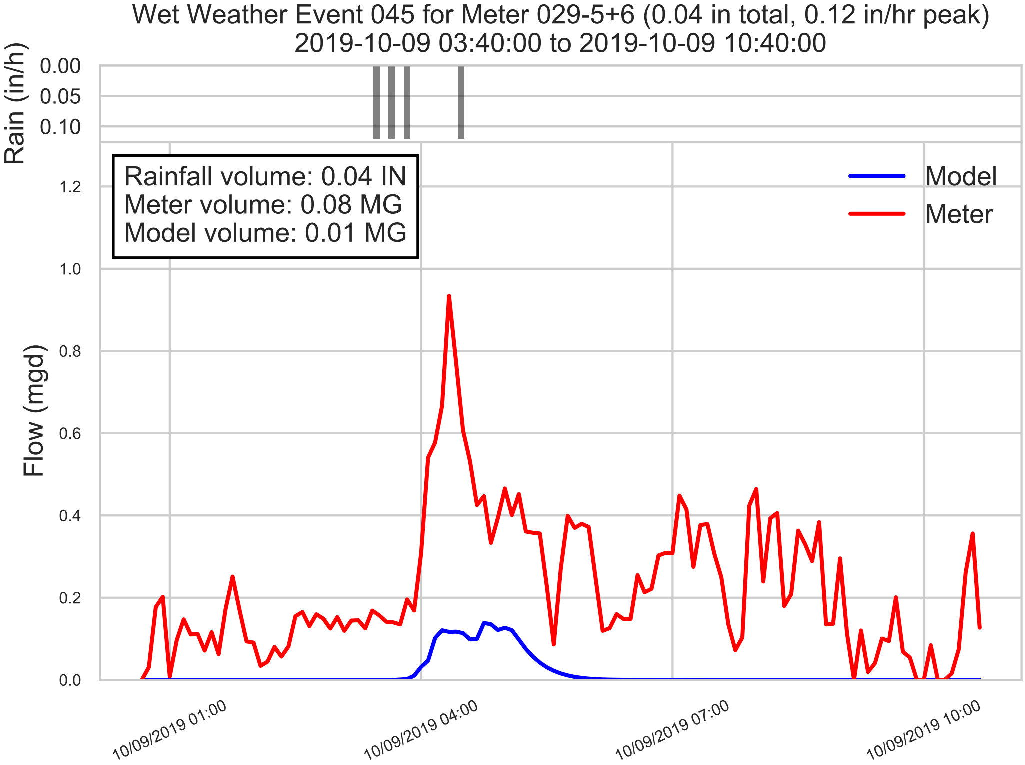
Wet Weather Event 041 for Meter 029-5+6 (0.08 in total, 0.36 in/hr peak)
2019-08-28 15:45:00 to 2019-08-28 22:15:00
Rain (in/h)
0.00
0.15
0.30
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall volume: 0.08 IN
Meter volume: 0.09 MG
Model volume: 0.05 MG
Model
Meter
08/28/2019 13:00
08/28/2019 16:00
08/28/2019 19:00
08/28/2019 22:00

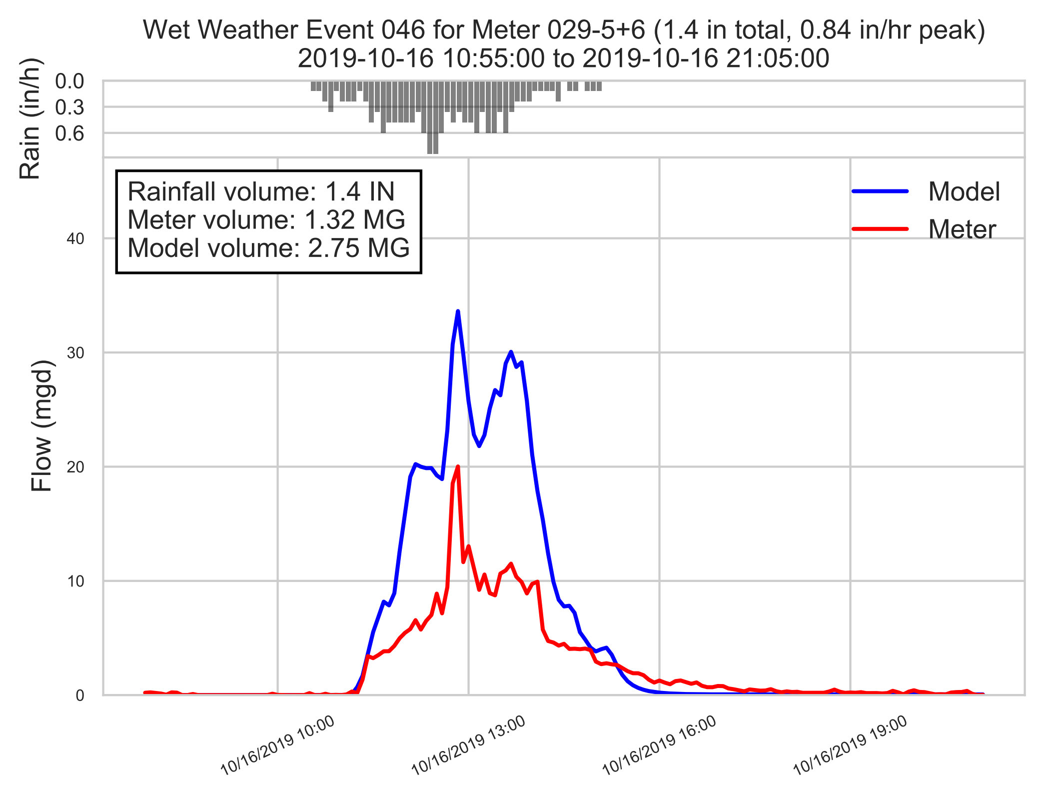


Wet Weather Event 042 for Meter 029-5+6 (0.1 in total, 0.48 in/hr peak)
2019-09-04 21:25:00 to 2019-09-05 03:55:00
Rain (in/h)
0.0
0.2
0.4
Flow (mgd)
Rainfall volume: 0.1 IN
Meter volume: 0.12 MG
Model volume: 0.08 MG
Model
Meter
8
7
6
5
4
3
2
1
0
09/04/2019 19:00
09/04/2019 22:00
09/05/2019 01:00
09/05/2019 04:00

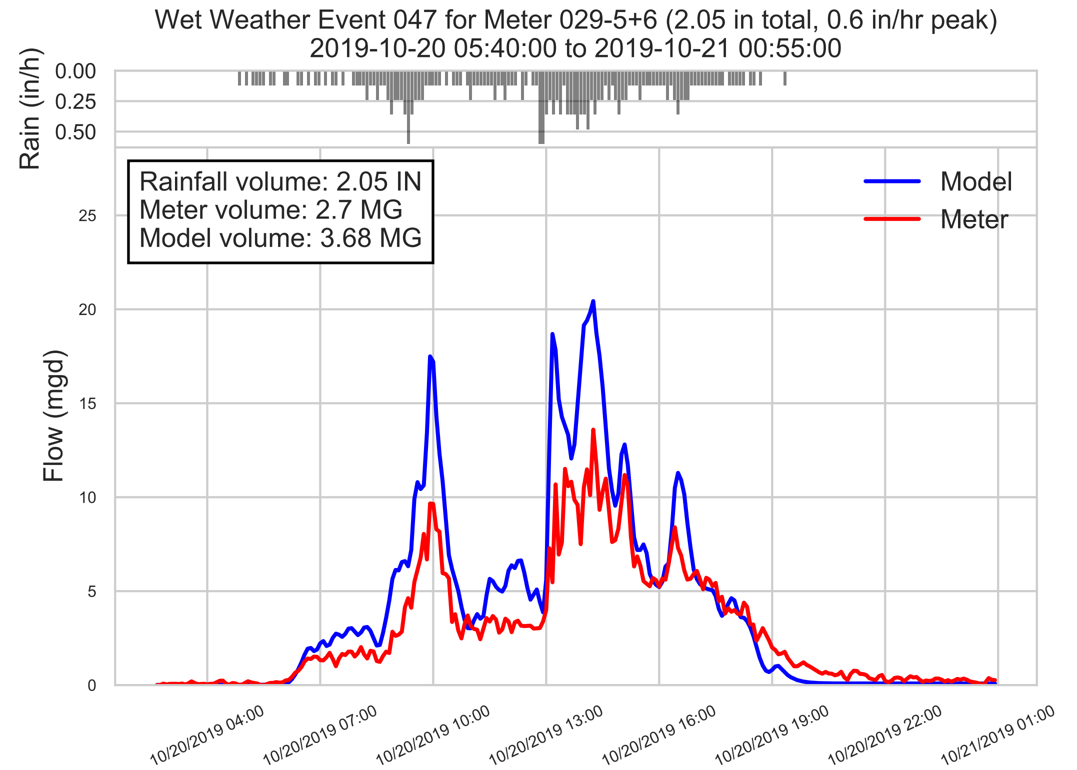

Wet Weather Event 043 for Meter 029-5+6 (0.03 in total, 0.12 in/hr peak)
2019-09-11 17:20:00 to 2019-09-12 00:25:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.03 IN
Meter volume: 0.04 MG
Model volume: 0.0 MG
Model
Meter
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
09/11/2019 14:00
09/11/2019 17:00
09/11/2019 20:00
09/11/2019 23:00

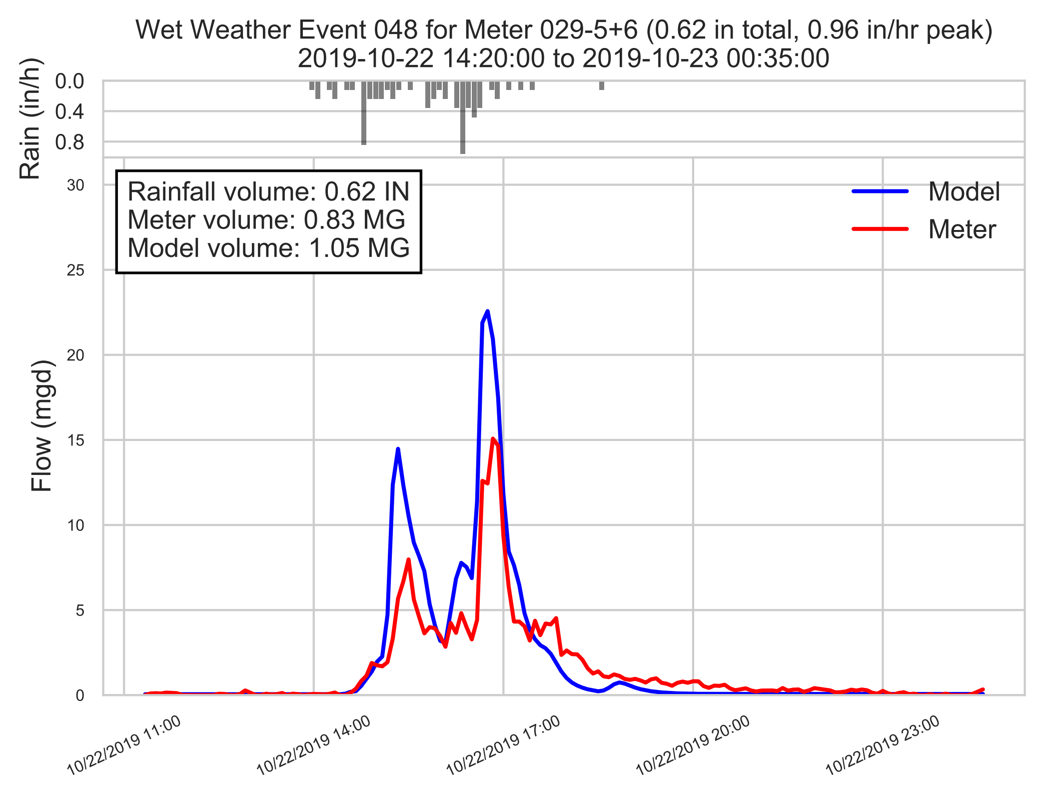

Wet Weather Event 044 for Meter 029-5+6 (0.24 in total, 0.84 in/hr peak)
2019-09-30 09:10:00 to 2019-09-30 17:50:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.24 IN
Meter volume: 0.3 MG
Model volume: 0.32 MG
Model
Meter
Flow (mgd)
16
14
12
10
8
6
4
2
0
09/30/2019 07:00
09/30/2019 10:00
09/30/2019 13:00
09/30/2019 16:00


Wet Weather Event 045 for Meter 029-5+6 (0.04 in total, 0.12 in/hr peak)
2019-10-09 03:40:00 to 2019-10-09 10:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.04 IN
Meter volume: 0.08 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10/09/2019 01:00
10/09/2019 04:00
10/09/2019 07:00
10/09/2019 10:00

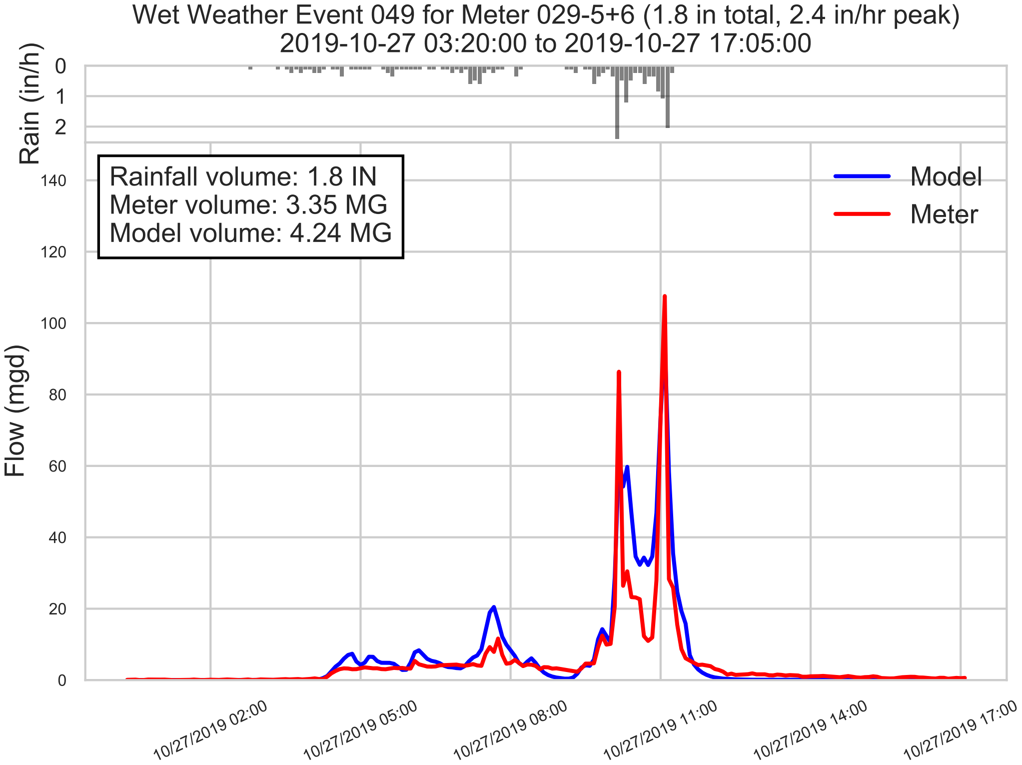


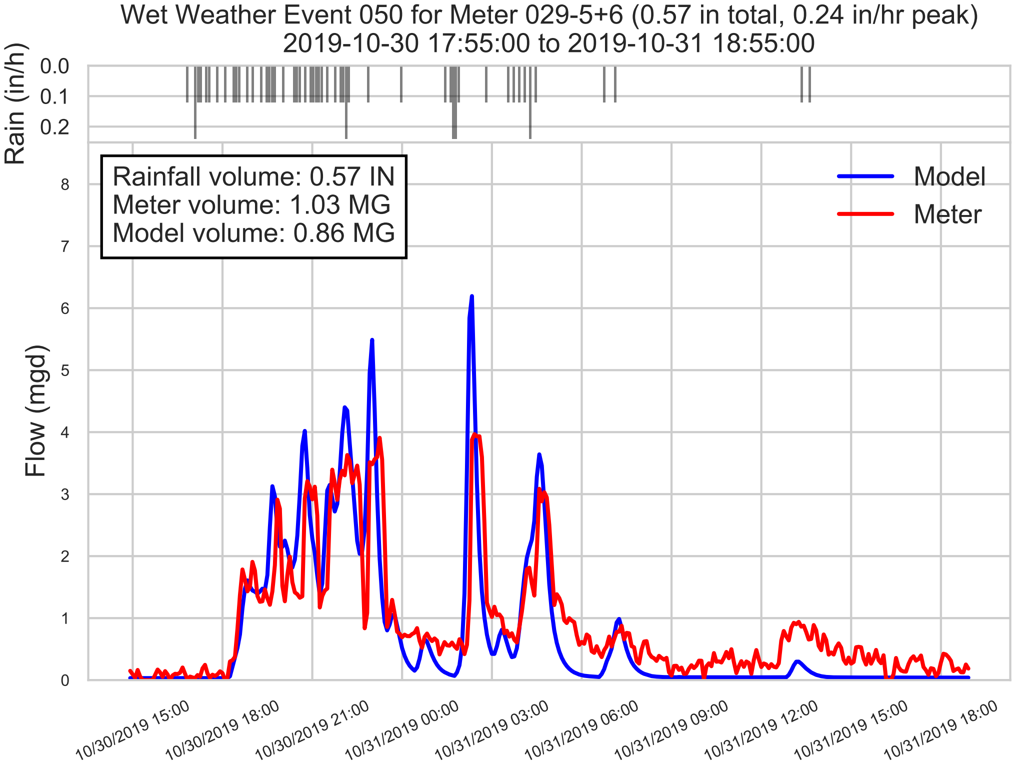
Wet Weather Event 046 for Meter 029-5+6 (1.4 in total, 0.84 in/hr peak)
2019-10-16 10:55:00 to 2019-10-16 21:05:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 1.4 IN
Meter volume: 1.32 MG
Model volume: 2.75 MG
Model
Meter
Flow (mgd)
40
30
20
10
0
10/16/2019 10:00
10/16/2019 13:00
10/16/2019 16:00
10/16/2019 19:00

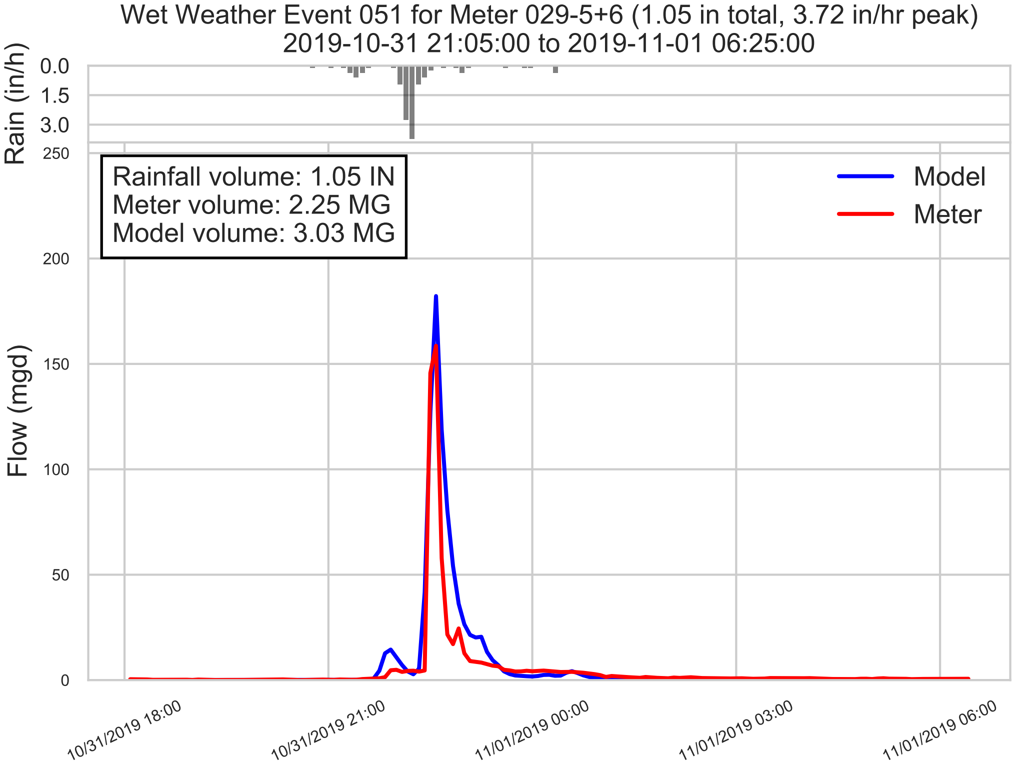

Wet Weather Event 047 for Meter 029-5+6 (2.05 in total, 0.6 in/hr peak)
2019-10-20 05:40:00 to 2019-10-21 00:55:00
Rain (in/h)
0.00
0.25
0.50
Rainfall volume: 2.05 IN
Meter volume: 2.7 MG
Model volume: 3.68 MG
Model
Meter
Flow (mgd)
0
5
10
15
20
25
10/20/2019 04:00
10/20/2019 07:00
10/20/2019 10:00
10/20/2019 13:00
10/20/2019 16:00
10/20/2019 19:00
10/20/2019 22:00
10/21/2019 01:00



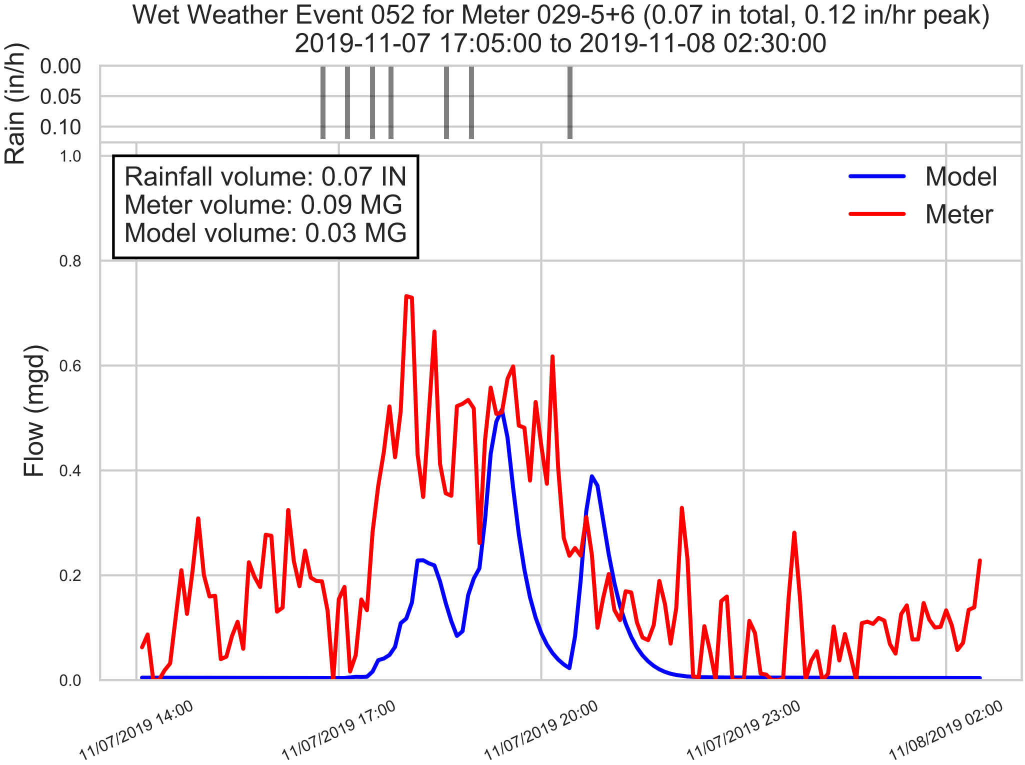
Wet Weather Event 048 for Meter 029-5+6 (0.62 in total, 0.96 in/hr peak)
2019-10-22 14:20:00 to 2019-10-23 00:35:00
Rain (in/h)
0.0
0.4
0.8
Rainfall volume: 0.62 IN
Meter volume: 0.83 MG
Model volume: 1.05 MG
Model
Meter
Flow (mgd)
30
25
20
15
10
5
0
10/22/2019 11:00
10/22/2019 14:00
10/22/2019 17:00
10/22/2019 20:00
10/22/2019 23:00


Wet Weather Event 049 for Meter 029-5+6 (1.8 in total, 2.4 in/hr peak)
2019-10-27 03:20:00 to 2019-10-27 17:05:00
Rain (in/h)
0
1
2
Rainfall volume: 1.8 IN
Meter volume: 3.35 MG
Model volume: 4.24 MG
Model
Meter
Flow (mgd)
140
120
100
80
60
40
20
0
10/27/2019 02:00
10/27/2019 05:00
10/27/2019 08:00
10/27/2019 11:00
10/27/2019 14:00
10/27/2019 17:00

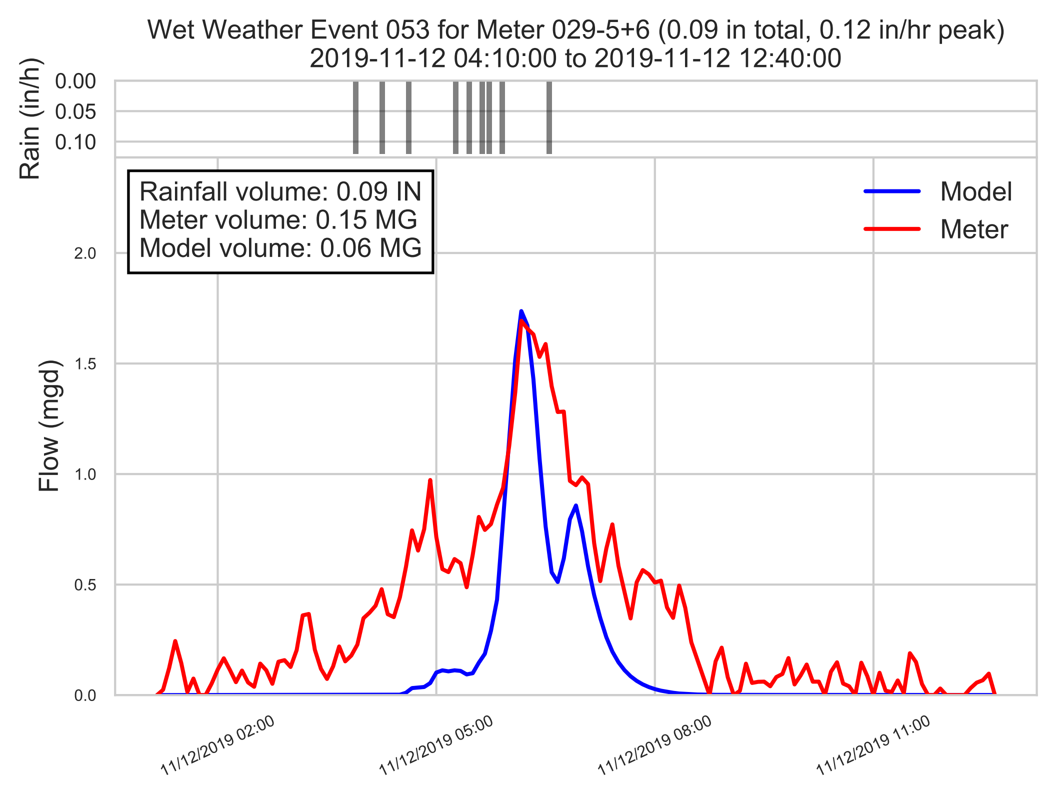

Wet Weather Event 050 for Meter 029-5+6 (0.57 in total, 0.24 in/hr peak)
2019-10-30 17:55:00 to 2019-10-31 18:55:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.57 IN
Meter volume: 1.03 MG
Model volume: 0.86 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
10/30/2019 15:00
10/30/2019 18:00
10/30/2019 21:00
10/31/2019 00:00
10/31/2019 03:00
10/31/2019 06:00
10/31/2019 09:00
10/31/2019 12:00
10/31/2019 15:00
10/31/2019 18:00



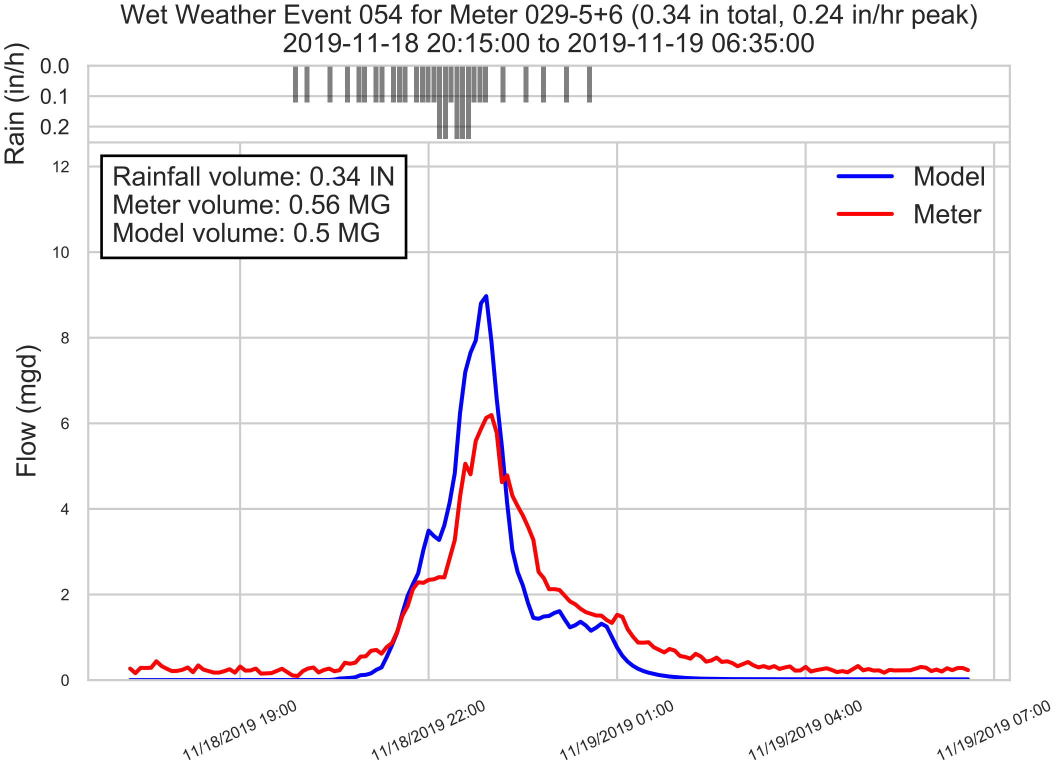
Wet Weather Event 051 for Meter 029-5+6 (1.05 in total, 3.72 in/hr peak)
2019-10-31 21:05:00 to 2019-11-01 06:25:00
Rain (in/h)
0.0
1.5
3.0
250
200
150
100
50
0
Flow (mgd)
Rainfall volume: 1.05 IN
Meter volume: 2.25 MG
Model volume: 3.03 MG
Model
Meter
10/31/2019 18:00
10/31/2019 21:00
11/01/2019 00:00
11/01/2019 03:00
11/01/2019 06:00



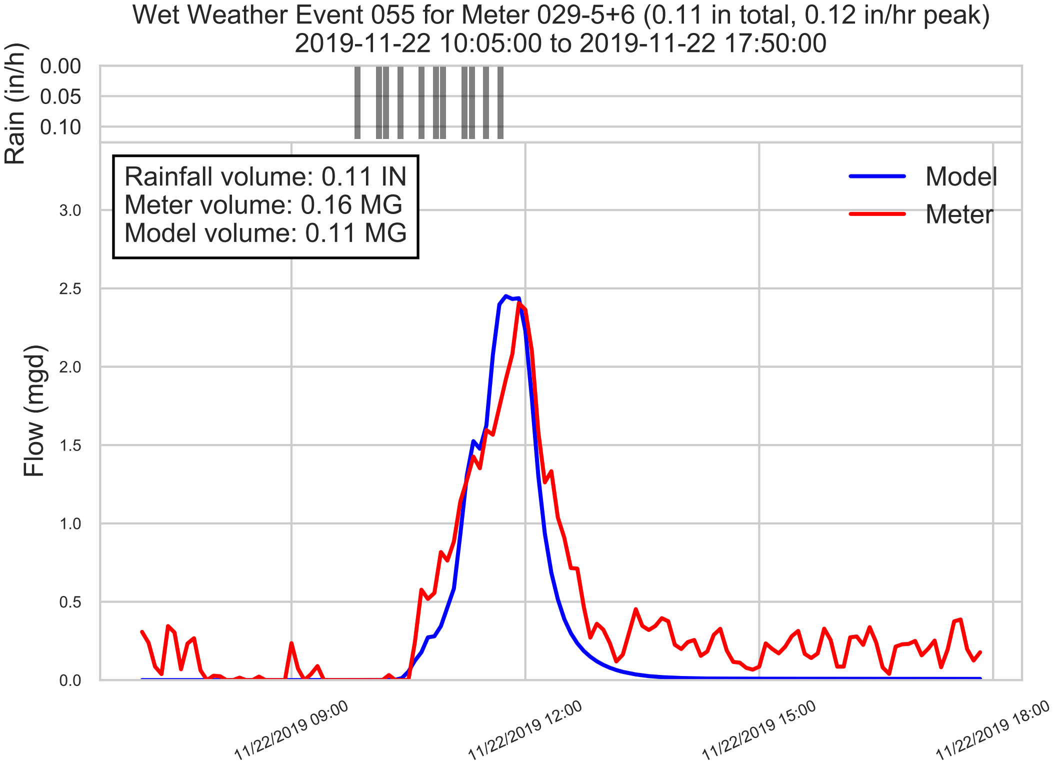
Wet Weather Event 052 for Meter 029-5+6 (0.07 in total, 0.12 in/hr peak)
2019-11-07 17:05:00 to 2019-11-08 02:30:00
Rain (in/h)
0.00
0.05
0.10
Flow (mgd)
1.0
0.8
0.6
0.4
0.2
0.0
Rainfall volume: 0.07 IN
Meter volume: 0.09 MG
Model volume: 0.03 MG
Model
Meter
11/07/2019 14:00
11/07/2019 17:00
11/07/2019 20:00
11/07/2019 23:00
11/08/2019 02:00



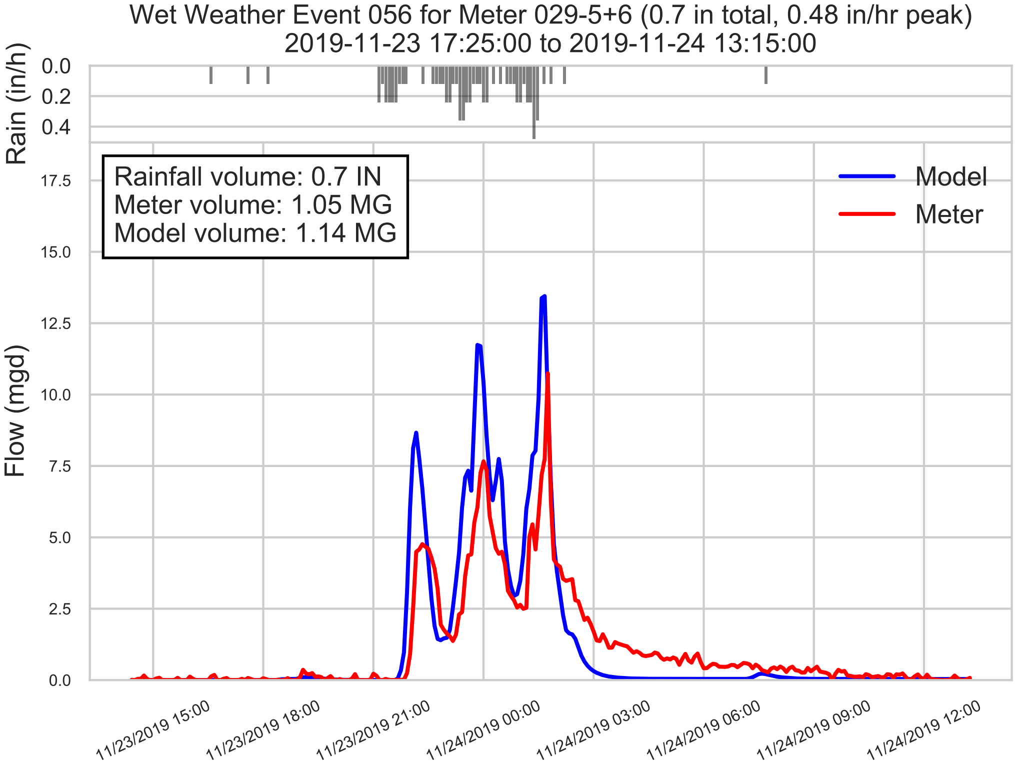
Wet Weather Event 053 for Meter 029-5+6 (0.09 in total, 0.12 in/hr peak)
2019-11-12 04:10:00 to 2019-11-12 12:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.09 IN
Meter volume: 0.15 MG
Model volume: 0.06 MG
Model
Meter
Flow (mgd)
2.0
1.5
1.0
0.5
0.0
11/12/2019 02:00
11/12/2019 05:00
11/12/2019 08:00
11/12/2019 11:00



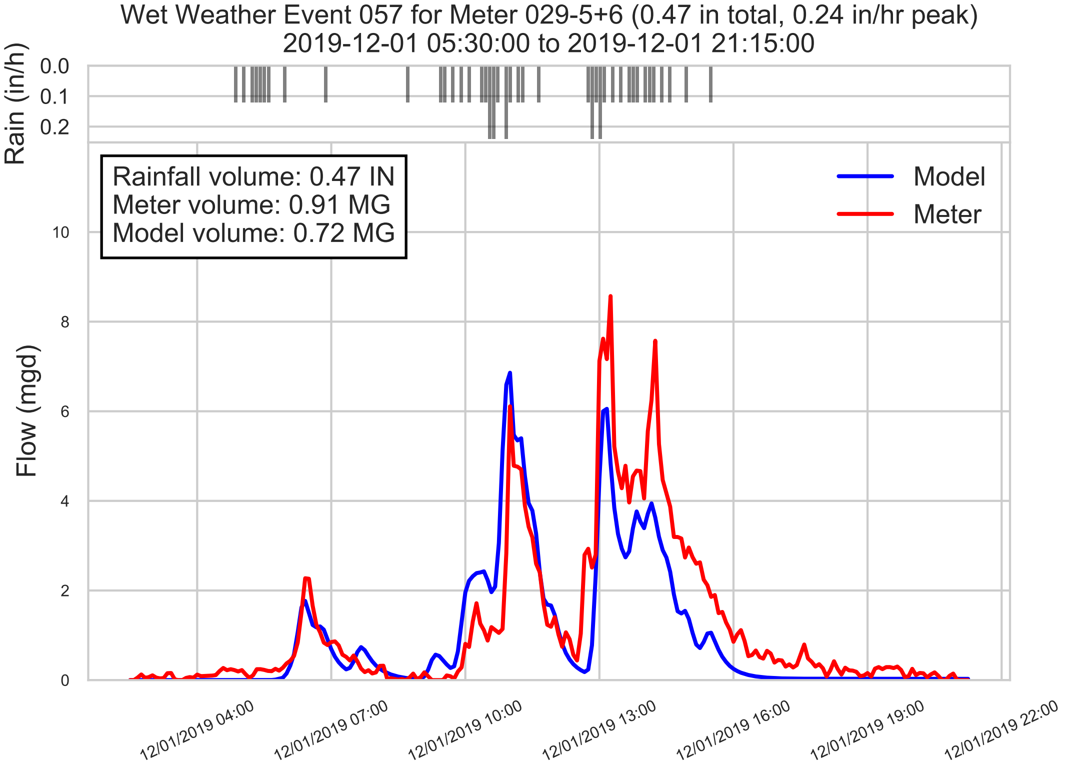
Wet Weather Event 054 for Meter 029-5+6 (0.34 in total, 0.24 in/hr peak)
2019-11-18 20:15:00 to 2019-11-19 06:35:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.34 IN
Meter volume: 0.56 MG
Model volume: 0.5 MG
Model
Meter
Flow (mgd)
12
10
8
6
4
2
0
11/18/2019 19:00
11/18/2019 22:00
11/19/2019 01:00
11/19/2019 04:00
11/19/2019 07:00



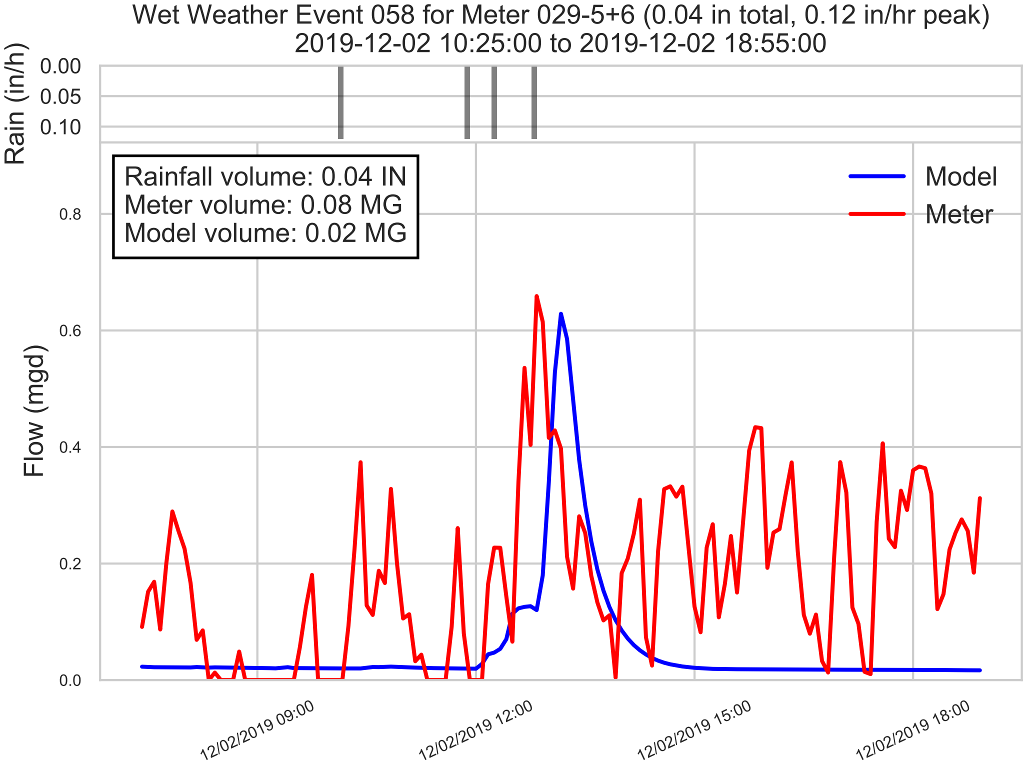
Wet Weather Event 055 for Meter 029-5+6 (0.11 in total, 0.12 in/hr peak)
2019-11-22 10:05:00 to 2019-11-22 17:50:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.11 IN
Meter volume: 0.16 MG
Model volume: 0.11 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/22/2019 09:00
11/22/2019 12:00
11/22/2019 15:00
11/22/2019 18:00

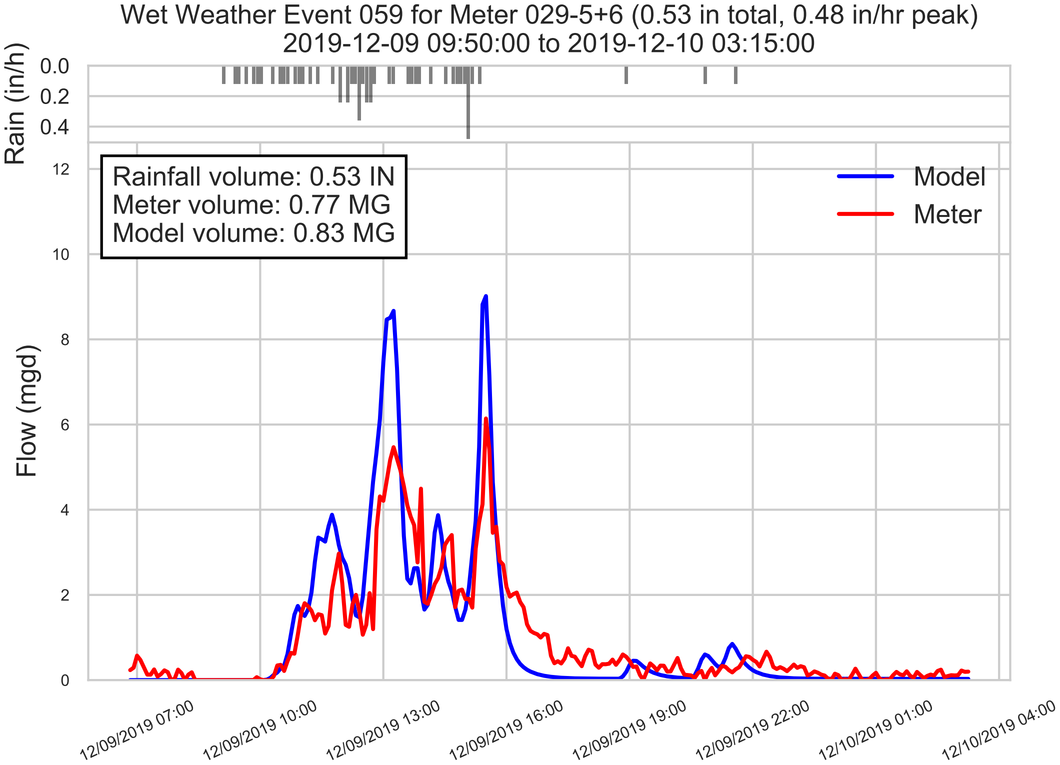


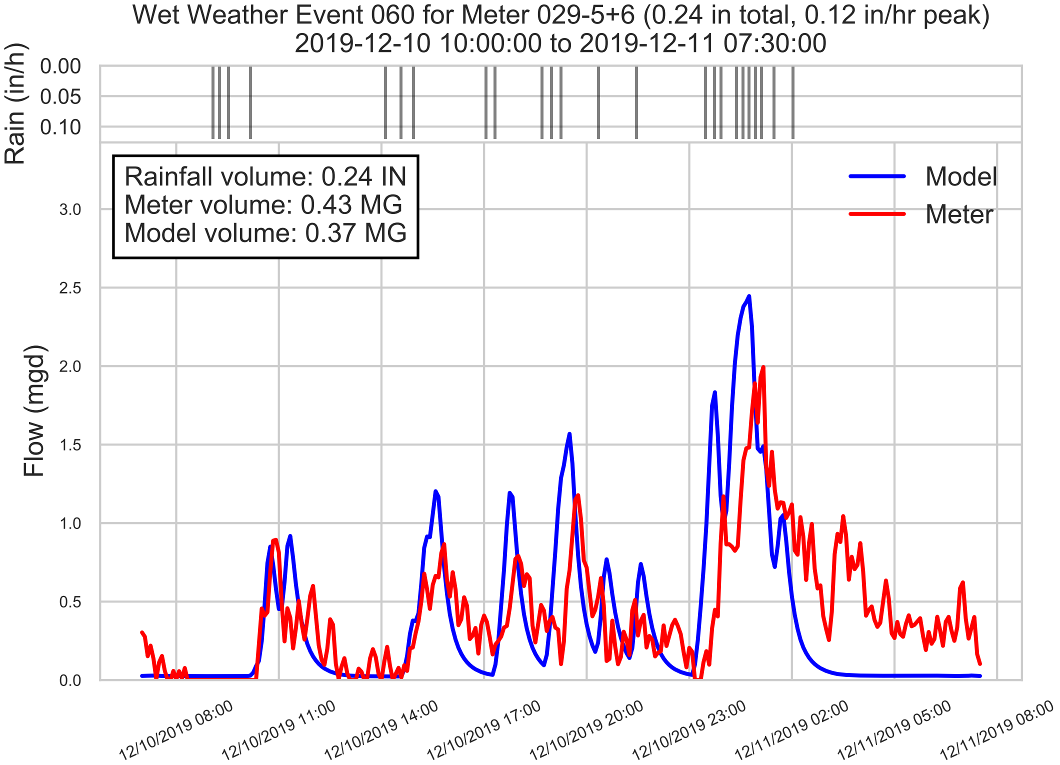
Wet Weather Event 056 for Meter 029-5+6 (0.7 in total, 0.48 in/hr peak)
2019-11-23 17:25:00 to 2019-11-24 13:15:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.7 IN
Meter volume: 1.05 MG
Model volume: 1.14 MG
Model
Meter
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
11/23/2019 15:00
11/23/2019 18:00
11/23/2019 21:00
11/24/2019 00:00
11/24/2019 03:00
11/24/2019 06:00
11/24/2019 09:00
11/24/2019 12:00



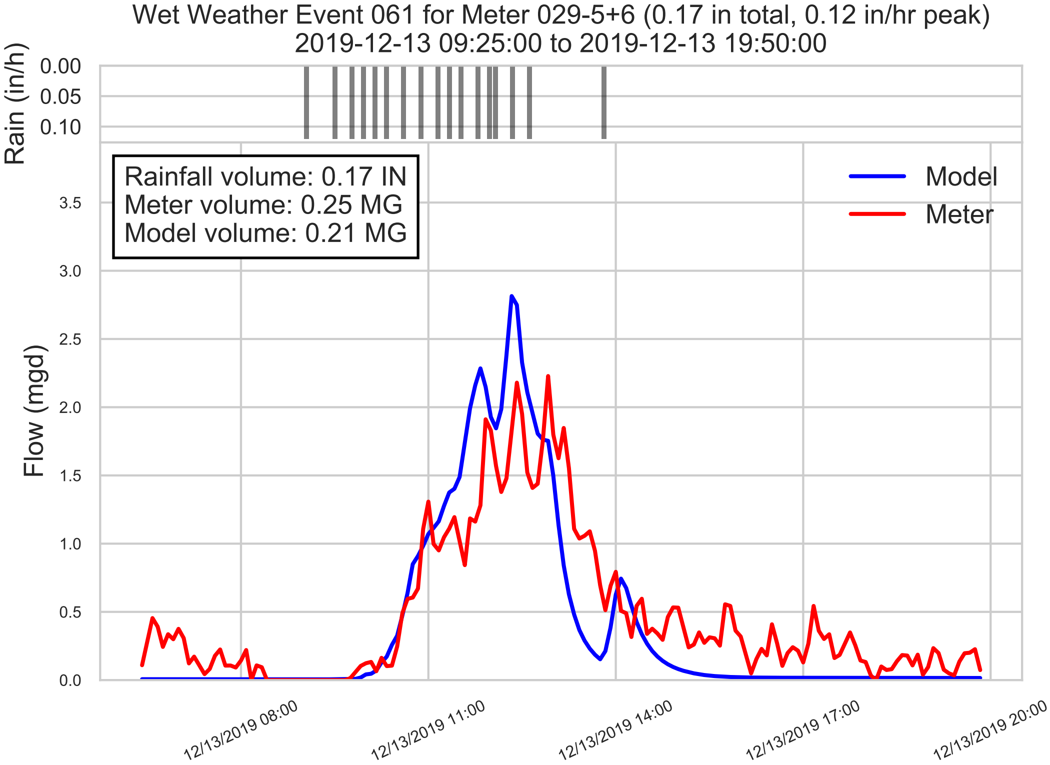
Wet Weather Event 057 for Meter 029-5+6 (0.47 in total, 0.24 in/hr peak)
2019-12-01 05:30:00 to 2019-12-01 21:15:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.47 IN
Meter volume: 0.91 MG
Model volume: 0.72 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12/01/2019 04:00
12/01/2019 07:00
12/01/2019 10:00
12/01/2019 13:00
12/01/2019 16:00
12/01/2019 19:00
12/01/2019 22:00


Wet Weather Event 058 for Meter 029-5+6 (0.04 in total, 0.12 in/hr peak)
2019-12-02 10:25:00 to 2019-12-02 18:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.04 IN
Meter volume: 0.08 MG
Model volume: 0.02 MG
Model
Meter
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
12/02/2019 09:00
12/02/2019 12:00
12/02/2019 15:00
12/02/2019 18:00

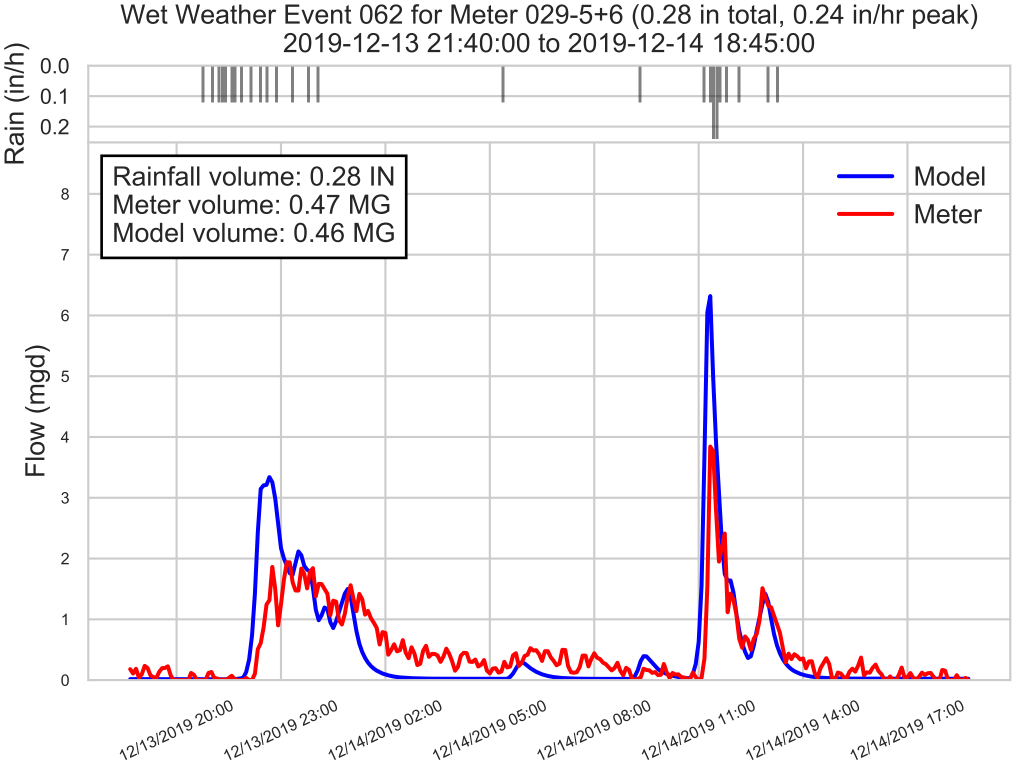

Wet Weather Event 059 for Meter 029-5+6 (0.53 in total, 0.48 in/hr peak)
2019-12-09 09:50:00 to 2019-12-10 03:15:00
Rain (in/h)
0.0
0.2
0.4
Rainfall volume: 0.53 IN
Meter volume: 0.77 MG
Model volume: 0.83 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
12/09/2019 07:00
12/09/2019 10:00
12/09/2019 13:00
12/09/2019 16:00
12/09/2019 19:00
12/09/2019 22:00
12/10/2019 01:00
12/10/2019 04:00



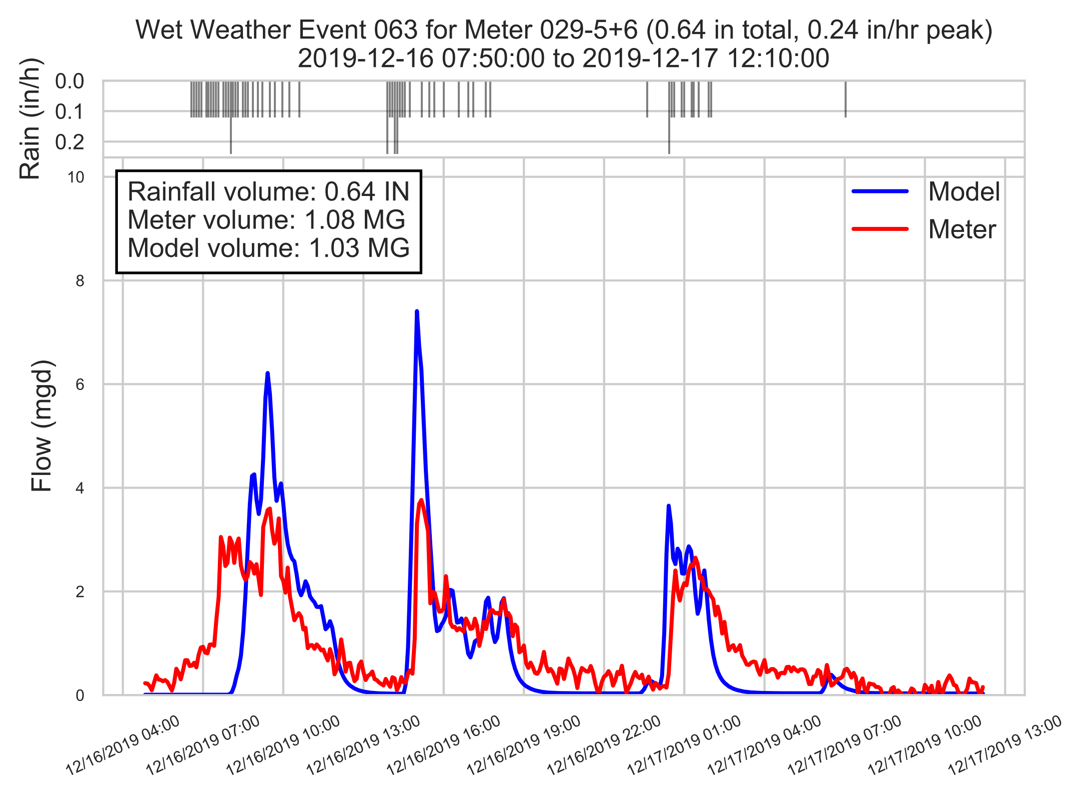
Wet Weather Event 060 for Meter 029-5+6 (0.24 in total, 0.12 in/hr peak)
2019-12-10 10:00:00 to 2019-12-11 07:30:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.24 IN
Meter volume: 0.43 MG
Model volume: 0.37 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/10/2019 08:00
12/10/2019 11:00
12/10/2019 14:00
12/10/2019 17:00
12/10/2019 20:00
12/10/2019 23:00
12/11/2019 02:00
12/11/2019 05:00
12/11/2019 08:00



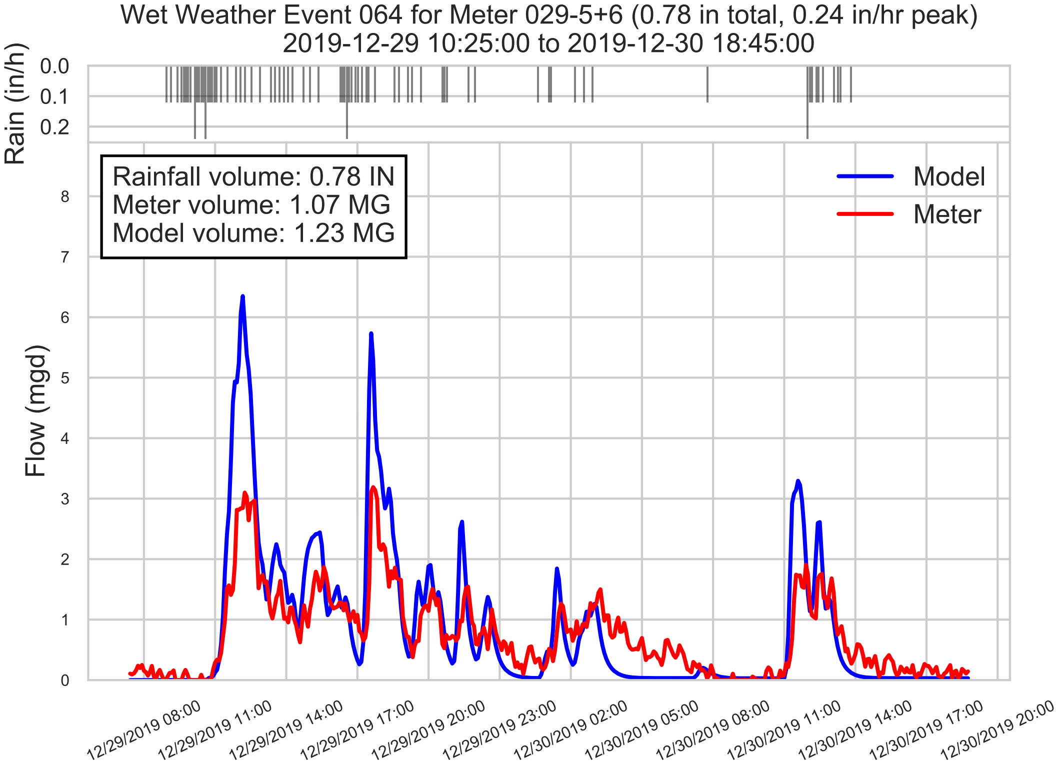
Wet Weather Event 061 for Meter 029-5+6 (0.17 in total, 0.12 in/hr peak)
2019-12-13 09:25:00 to 2019-12-13 19:50:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.17 IN
Meter volume: 0.25 MG
Model volume: 0.21 MG
Model
Meter
Flow (mgd)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/13/2019 08:00
12/13/2019 11:00
12/13/2019 14:00
12/13/2019 17:00
12/13/2019 20:00

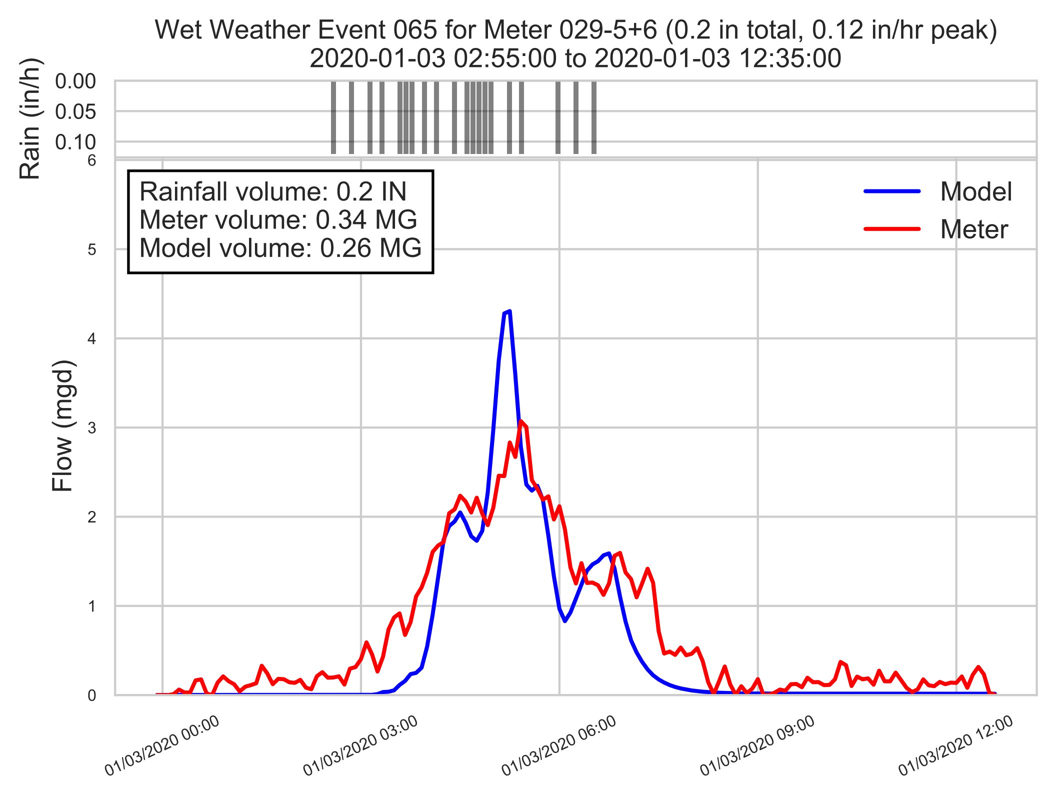


Wet Weather Event 062 for Meter 029-5+6 (0.28 in total, 0.24 in/hr peak)
2019-12-13 21:40:00 to 2019-12-14 18:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.28 IN
Meter volume: 0.47 MG
Model volume: 0.46 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
12/13/2019 20:00
12/13/2019 23:00
12/14/2019 02:00
12/14/2019 05:00
12/14/2019 08:00
12/14/2019 11:00
12/14/2019 14:00
12/14/2019 17:00

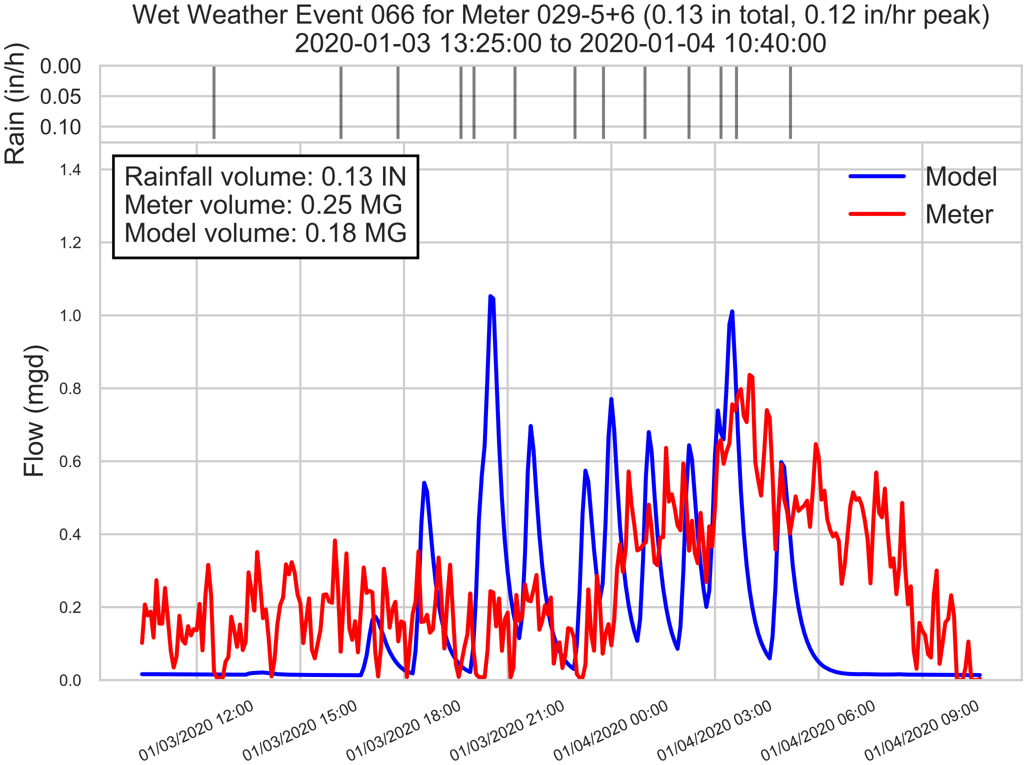


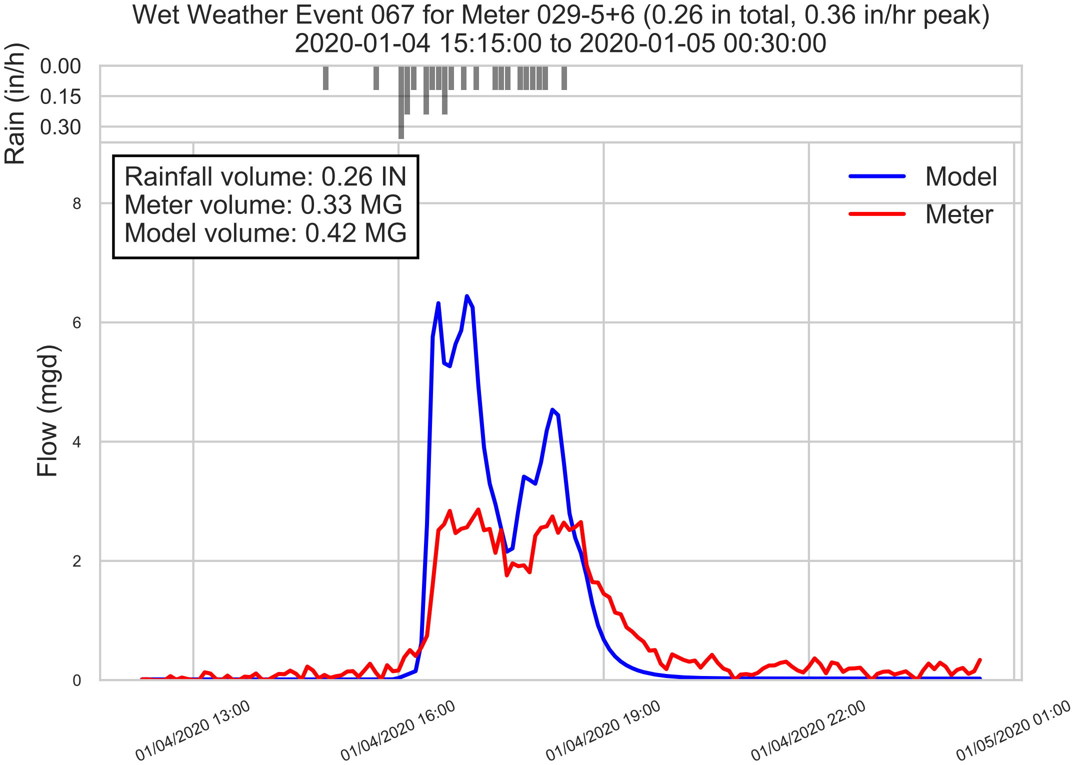
Wet Weather Event 063 for Meter 029-5+6 (0.64 in total, 0.24 in/hr peak)
2019-12-16 07:50:00 to 2019-12-17 12:10:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.64 IN
Meter volume: 1.08 MG
Model volume: 1.03 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
12/16/2019 04:00
12/16/2019 07:00
12/16/2019 10:00
12/16/2019 13:00
12/16/2019 16:00
12/16/2019 19:00
12/16/2019 22:00
12/17/2019 01:00
12/17/2019 04:00
12/17/2019 07:00
12/17/2019 10:00
12/17/2019 13:00

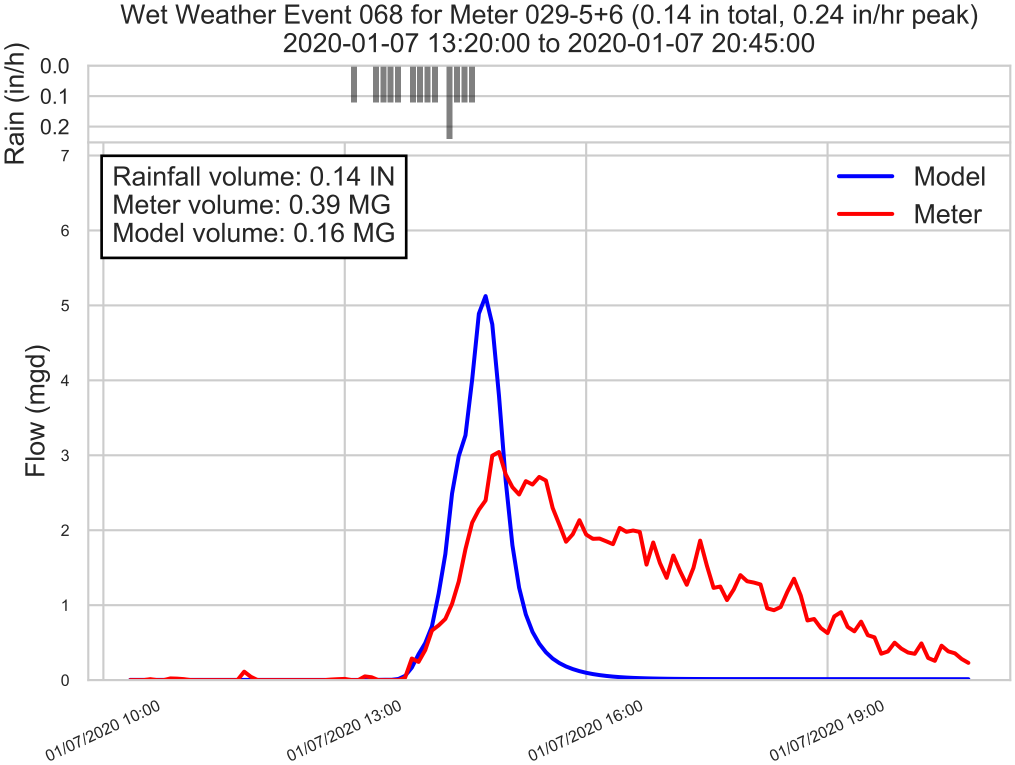

Wet Weather Event 064 for Meter 029-5+6 (0.78 in total, 0.24 in/hr peak)
2019-12-29 10:25:00 to 2019-12-30 18:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.78 IN
Meter volume: 1.07 MG
Model volume: 1.23 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
8
12/29/2019 08:00
12/29/2019 11:00
12/29/2019 14:00
12/29/2019 17:00
12/29/2019 20:00
12/29/2019 23:00
12/30/2019 02:00
12/30/2019 05:00
12/30/2019 08:00
12/30/2019 11:00
12/30/2019 14:00
12/30/2019 17:00
12/30/2019 20:00

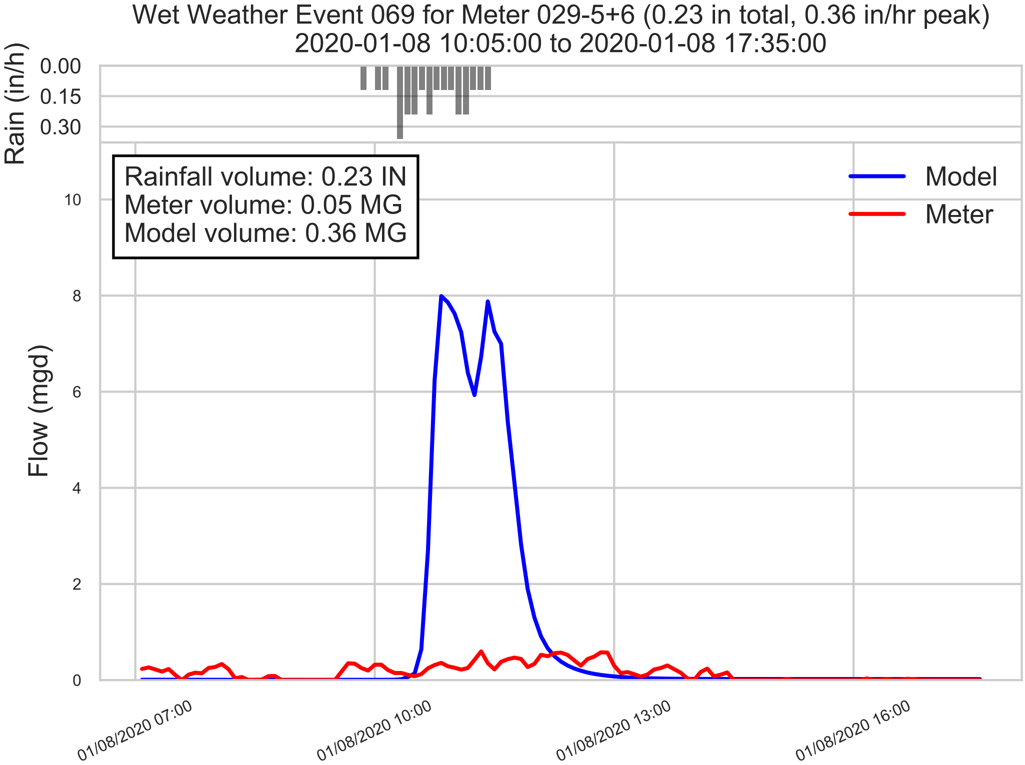


Wet Weather Event 065 for Meter 029-5+6 (0.2 in total, 0.12 in/hr peak)
2020-01-03 02:55:00 to 2020-01-03 12:35:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.2 IN
Meter volume: 0.34 MG
Model volume: 0.26 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
01/03/2020 00:00
01/03/2020 03:00
01/03/2020 06:00
01/03/2020 09:00
01/03/2020 12:00

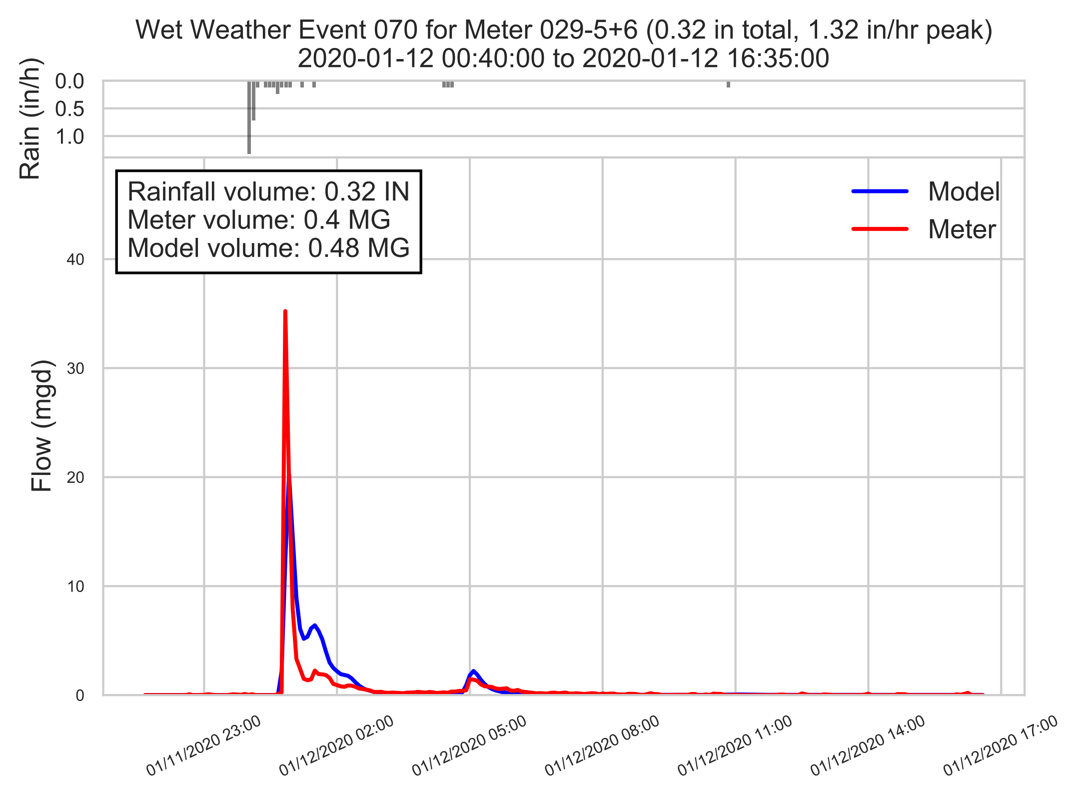

Wet Weather Event 066 for Meter 029-5+6 (0.13 in total, 0.12 in/hr peak)
2020-01-03 13:25:00 to 2020-01-04 10:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.13 IN
Meter volume: 0.25 MG
Model volume: 0.18 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
01/03/2020 12:00
01/03/2020 15:00
01/03/2020 18:00
01/03/2020 21:00
01/04/2020 00:00
01/04/2020 03:00
01/04/2020 06:00
01/04/2020 09:00


Wet Weather Event 067 for Meter 029-5+6 (0.26 in total, 0.36 in/hr peak)
2020-01-04 15:15:00 to 2020-01-05 00:30:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.26 IN
Meter volume: 0.33 MG
Model volume: 0.42 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
01/04/2020 13:00
01/04/2020 16:00
01/04/2020 19:00
01/04/2020 22:00
01/05/2020 01:00

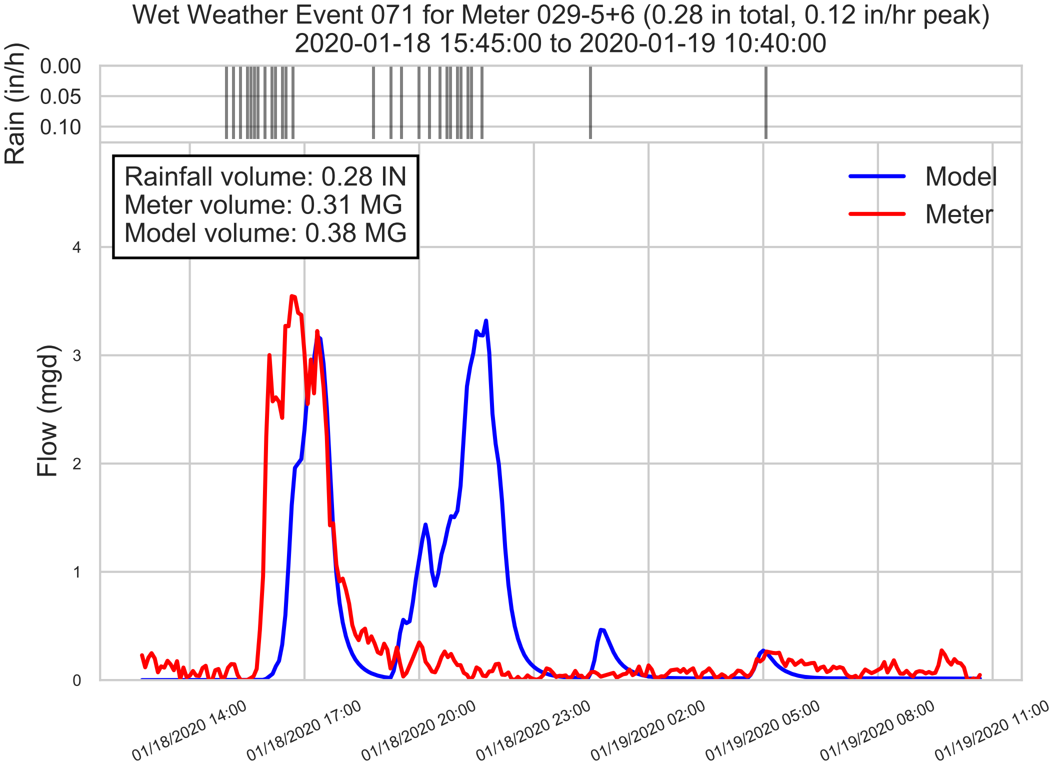

Wet Weather Event 068 for Meter 029-5+6 (0.14 in total, 0.24 in/hr peak)
2020-01-07 13:20:00 to 2020-01-07 20:45:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.14 IN
Meter volume: 0.39 MG
Model volume: 0.16 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
7
01/07/2020 10:00
01/07/2020 13:00
01/07/2020 16:00
01/07/2020 19:00



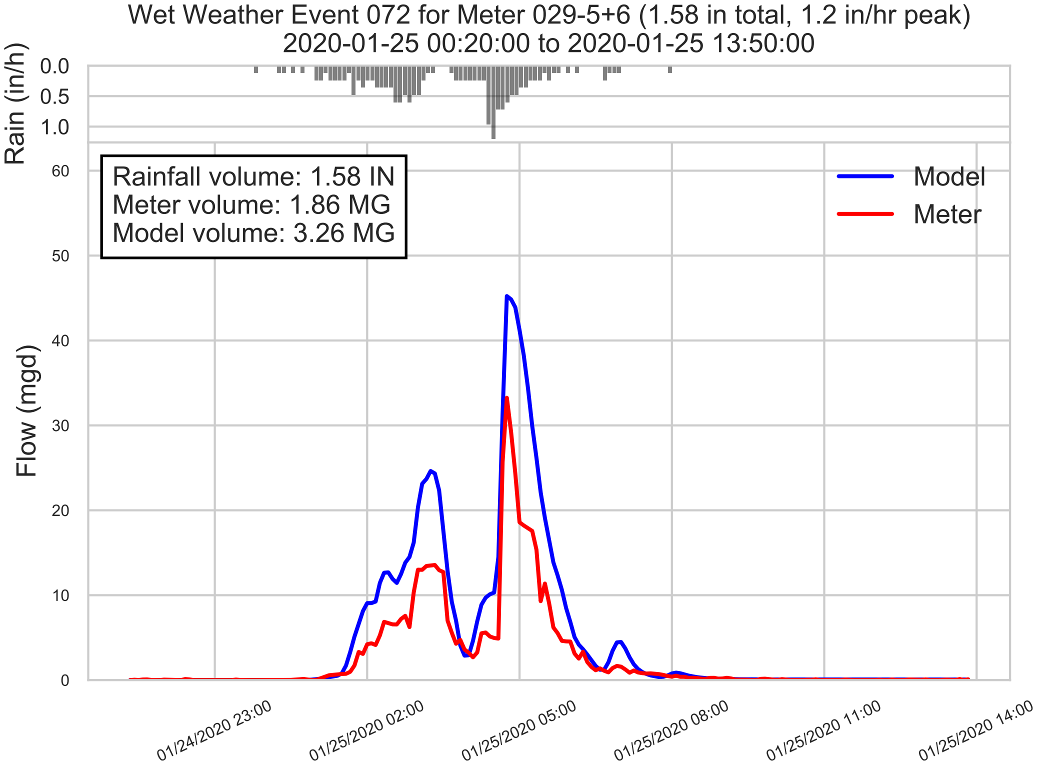
Wet Weather Event 069 for Meter 029-5+6 (0.23 in total, 0.36 in/hr peak)
2020-01-08 10:05:00 to 2020-01-08 17:35:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.23 IN
Meter volume: 0.05 MG
Model volume: 0.36 MG
Model
Meter
Flow (mgd)
10
8
6
4
2
0
01/08/2020 07:00
01/08/2020 10:00
01/08/2020 13:00
01/08/2020 16:00



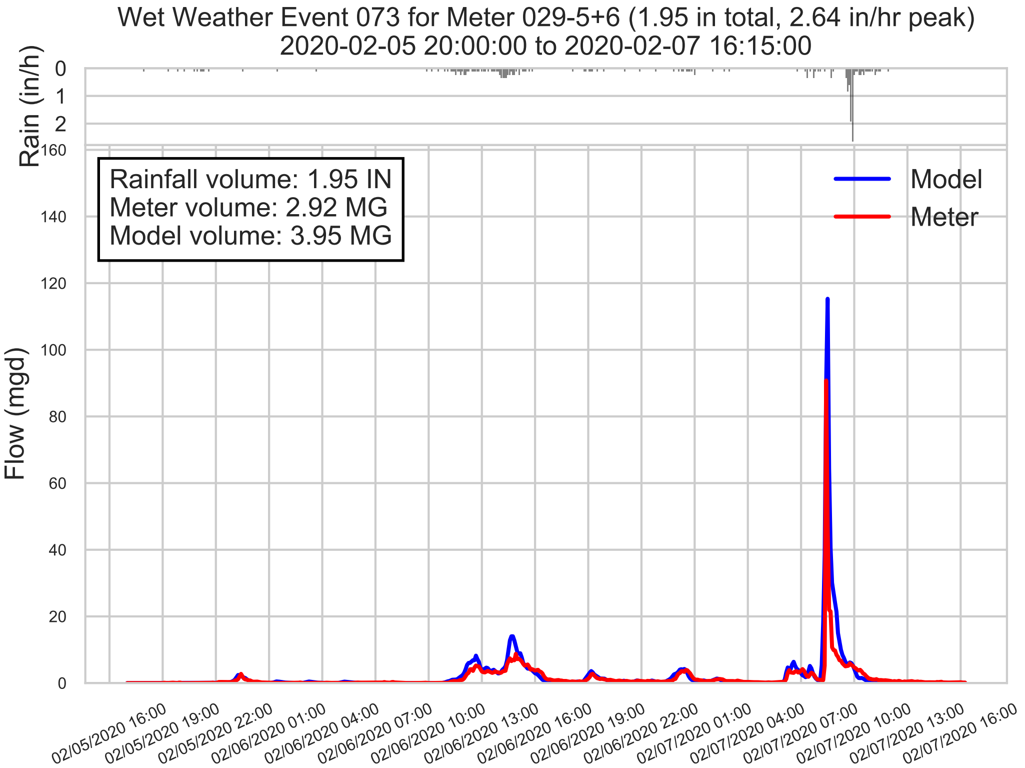
Wet Weather Event 070 for Meter 029-5+6 (0.32 in total, 1.32 in/hr peak)
2020-01-12 00:40:00 to 2020-01-12 16:35:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 0.32 IN
Meter volume: 0.4 MG
Model volume: 0.48 MG
Model
Meter
Flow (mgd)
40
30
20
10
0
01/11/2020 23:00
01/12/2020 02:00
01/12/2020 05:00
01/12/2020 08:00
01/12/2020 11:00
01/12/2020 14:00
01/12/2020 17:00



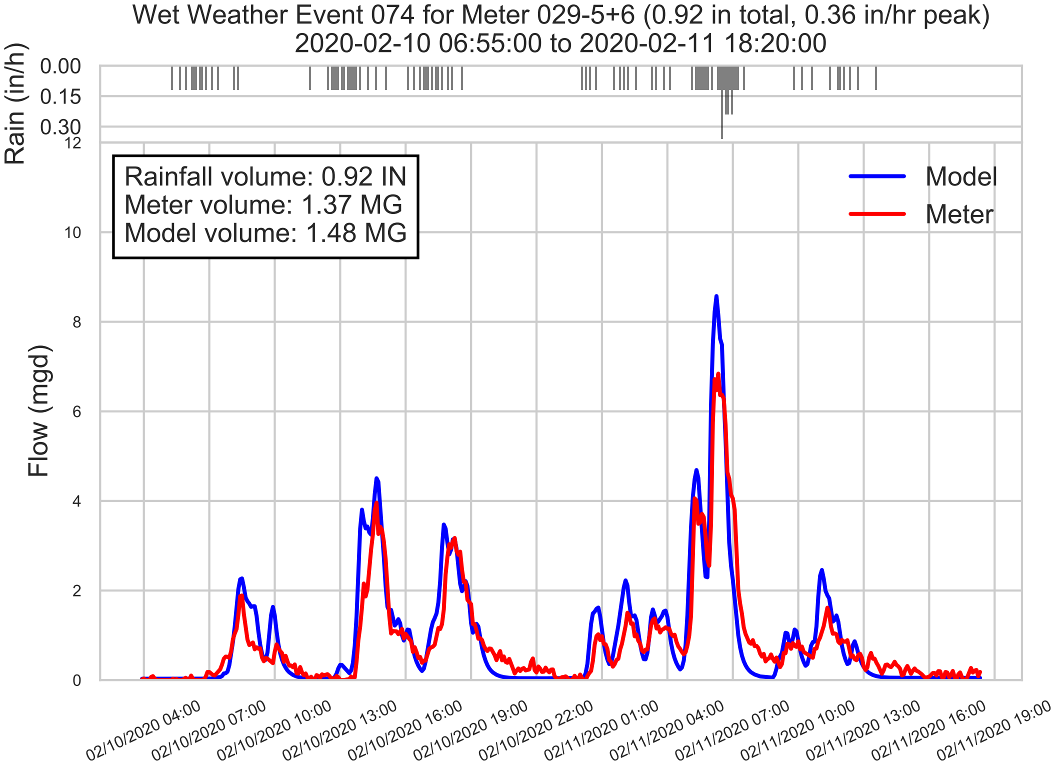
Wet Weather Event 071 for Meter 029-5+6 (0.28 in total, 0.12 in/hr peak)
2020-01-18 15:45:00 to 2020-01-19 10:40:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.28 IN
Meter volume: 0.31 MG
Model volume: 0.38 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
01/18/2020 14:00
01/18/2020 17:00
01/18/2020 20:00
01/18/2020 23:00
01/19/2020 02:00
01/19/2020 05:00
01/19/2020 08:00
01/19/2020 11:00



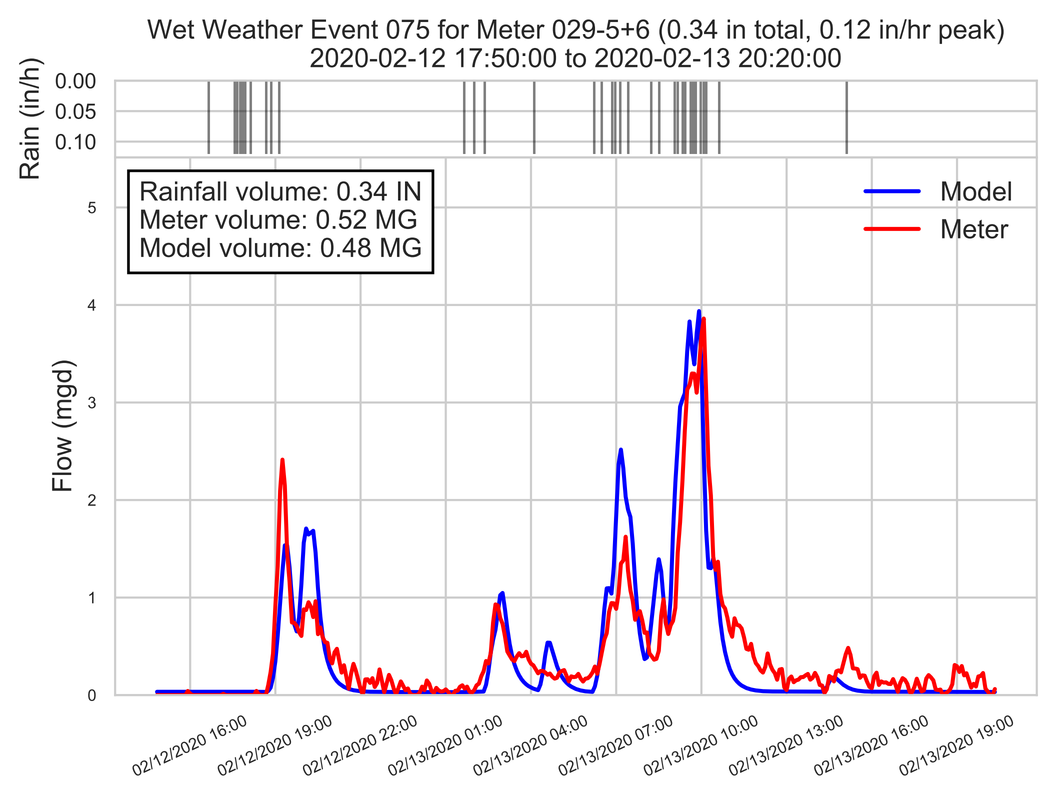
Wet Weather Event 072 for Meter 029-5+6 (1.58 in total, 1.2 in/hr peak)
2020-01-25 00:20:00 to 2020-01-25 13:50:00
Rain (in/h)
0.0
0.5
1.0
Rainfall volume: 1.58 IN
Meter volume: 1.86 MG
Model volume: 3.26 MG
Model
Meter
Flow (mgd)
60
50
40
30
20
10
0
01/24/2020 23:00
01/25/2020 02:00
01/25/2020 05:00
01/25/2020 08:00
01/25/2020 11:00
01/25/2020 14:00



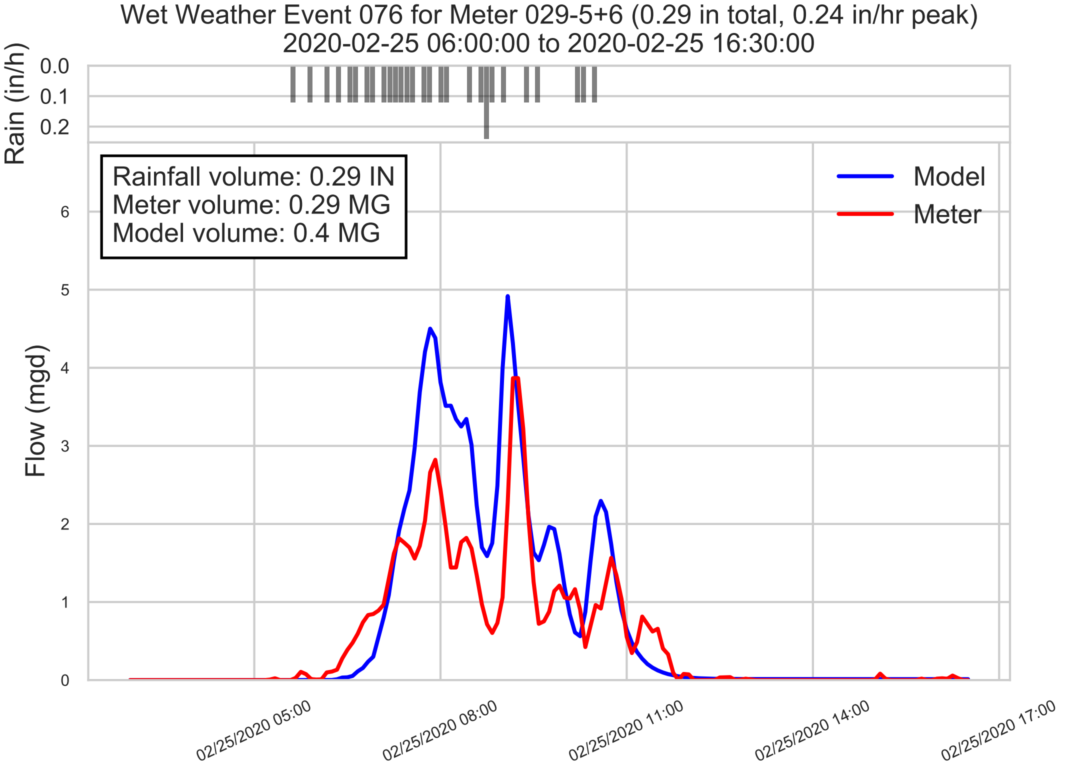
Wet Weather Event 073 for Meter 029-5+6 (1.95 in total, 2.64 in/hr peak)
2020-02-05 20:00:00 to 2020-02-07 16:15:00
Rain (in/h)
0
1
2
Flow (mgd)
160
140
120
100
80
60
40
20
0
Rainfall volume: 1.95 IN
Meter volume: 2.92 MG
Model volume: 3.95 MG
Model
Meter
02/05/2020 16:00
02/05/2020 19:00
02/05/2020 22:00
02/06/2020 01:00
02/06/2020 04:00
02/06/2020 07:00
02/06/2020 10:00
02/06/2020 13:00
02/06/2020 16:00
02/06/2020 19:00
02/06/2020 22:00
02/07/2020 01:00
02/07/2020 04:00
02/07/2020 07:00
02/07/2020 10:00
02/07/2020 13:00
02/07/2020 16:00



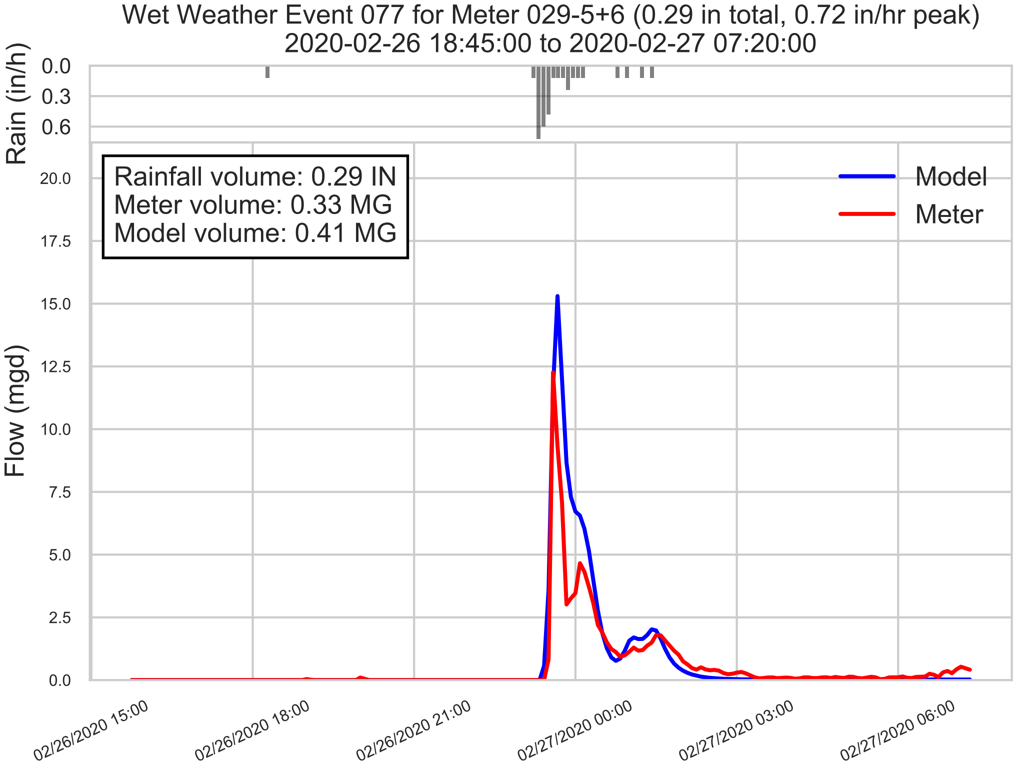
Wet Weather Event 074 for Meter 029-5+6 (0.92 in total, 0.36 in/hr peak)
2020-02-10 06:55:00 to 2020-02-11 18:20:00
Rain (in/h)
0.00
0.15
0.30
12
10
8
6
4
2
0
Flow (mgd)
Rainfall volume: 0.92 IN
Meter volume: 1.37 MG
Model volume: 1.48 MG
Model
Meter
02/10/2020 04:00
02/10/2020 07:00
02/10/2020 10:00
02/10/2020 13:00
02/10/2020 16:00
02/10/2020 19:00
02/10/2020 22:00
02/11/2020 01:00
02/11/2020 04:00
02/11/2020 07:00
02/11/2020 10:00
02/11/2020 13:00
02/11/2020 16:00
02/11/2020 19:00

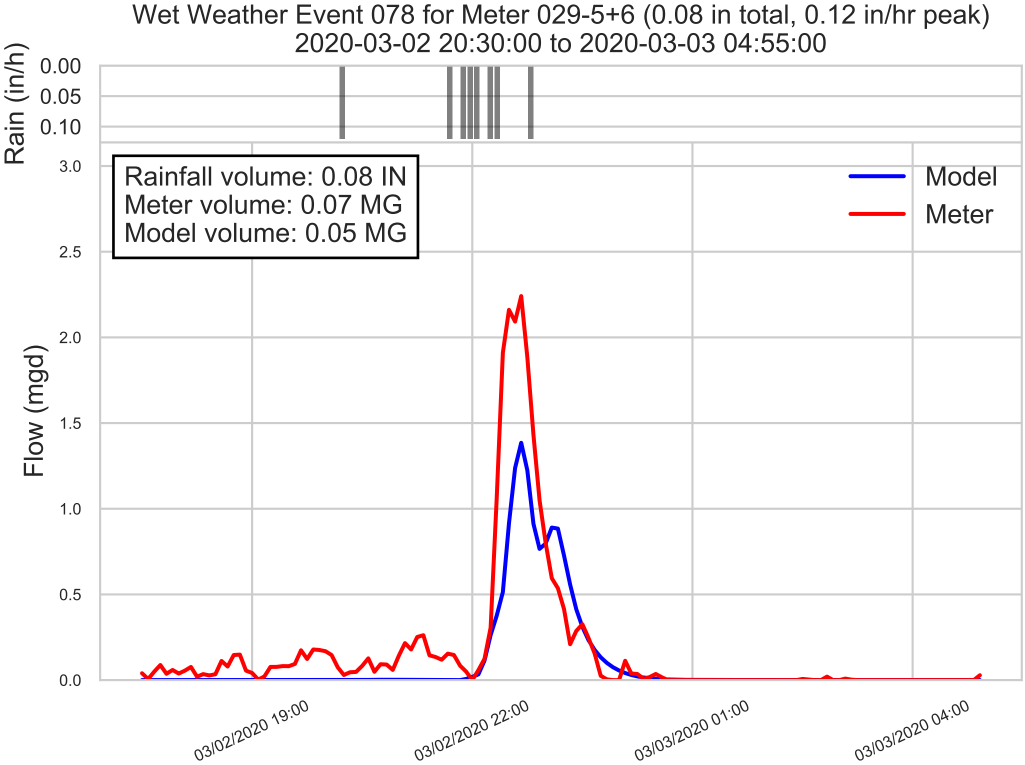


Wet Weather Event 075 for Meter 029-5+6 (0.34 in total, 0.12 in/hr peak)
2020-02-12 17:50:00 to 2020-02-13 20:20:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.34 IN
Meter volume: 0.52 MG
Model volume: 0.48 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
02/12/2020 16:00
02/12/2020 19:00
02/12/2020 22:00
02/13/2020 01:00
02/13/2020 04:00
02/13/2020 07:00
02/13/2020 10:00
02/13/2020 13:00
02/13/2020 16:00
02/13/2020 19:00

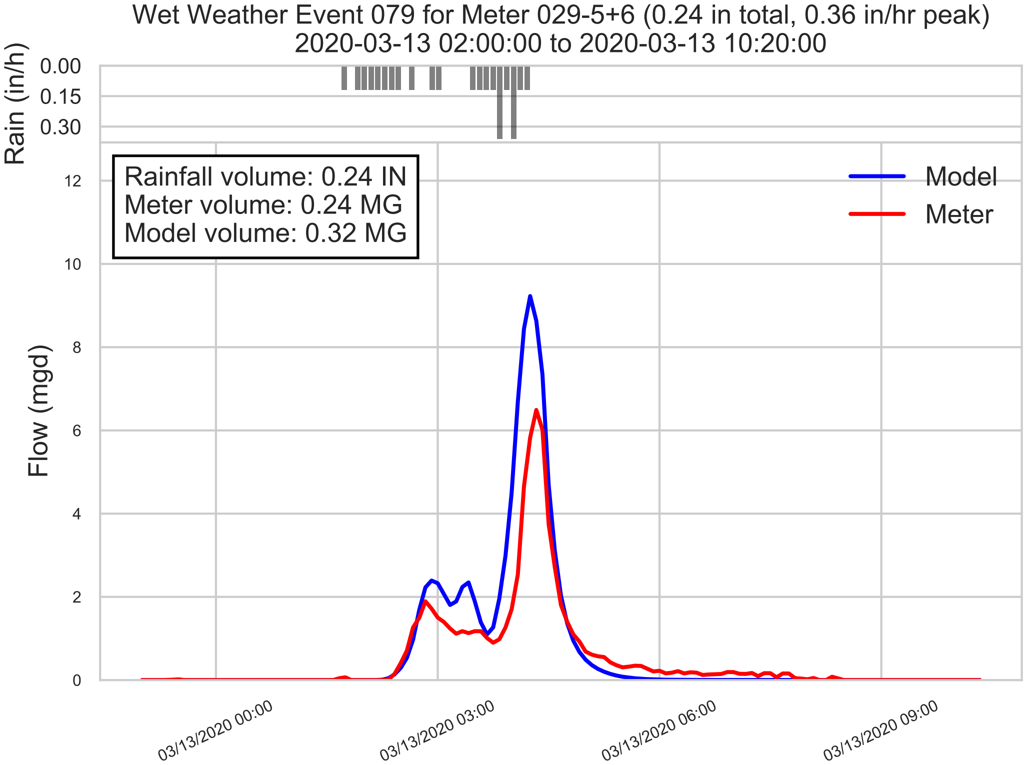


Wet Weather Event 076 for Meter 029-5+6 (0.29 in total, 0.24 in/hr peak)
2020-02-25 06:00:00 to 2020-02-25 16:30:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.29 IN
Meter volume: 0.29 MG
Model volume: 0.4 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
02/25/2020 05:00
02/25/2020 08:00
02/25/2020 11:00
02/25/2020 14:00
02/25/2020 17:00

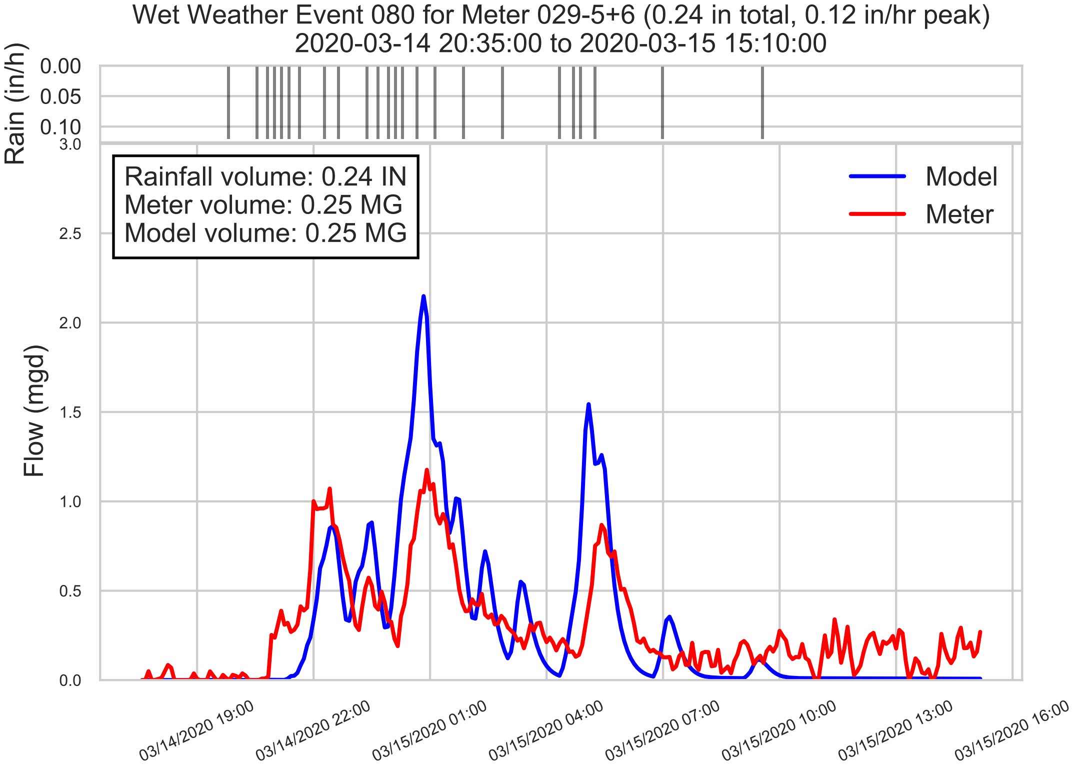

Wet Weather Event 077 for Meter 029-5+6 (0.29 in total, 0.72 in/hr peak)
2020-02-26 18:45:00 to 2020-02-27 07:20:00
Rain (in/h)
0.0
0.3
0.6
Rainfall volume: 0.29 IN
Meter volume: 0.33 MG
Model volume: 0.41 MG
Model
Meter
Flow (mgd)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
02/26/2020 15:00
02/26/2020 18:00
02/26/2020 21:00
02/27/2020 00:00
02/27/2020 03:00
02/27/2020 06:00

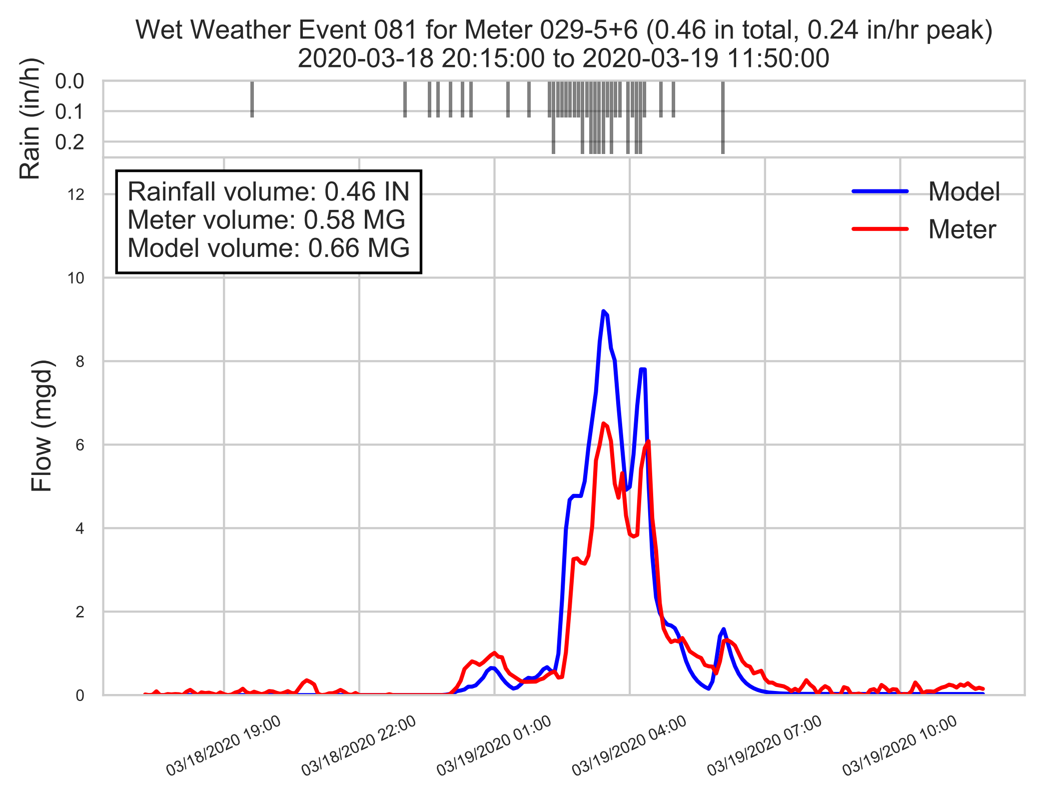


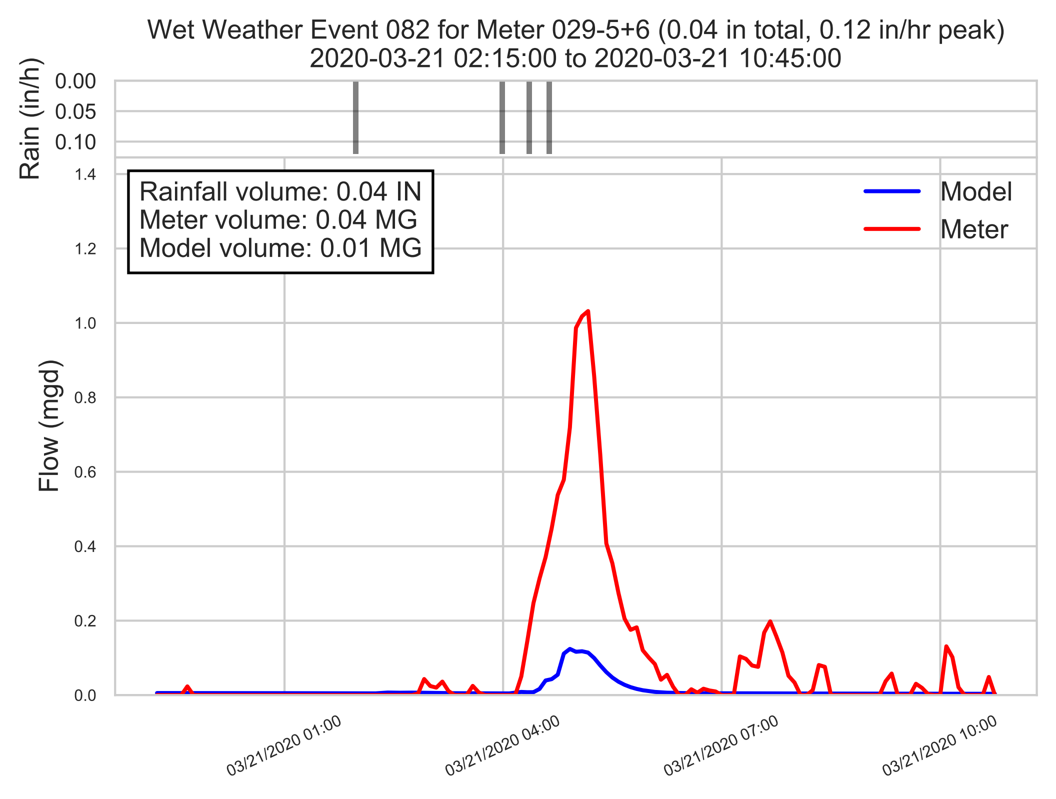
Wet Weather Event 078 for Meter 029-5+6 (0.08 in total, 0.12 in/hr peak)
2020-03-02 20:30:00 to 2020-03-03 04:55:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.08 IN
Meter volume: 0.07 MG
Model volume: 0.05 MG
Model
Meter
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
03/02/2020 19:00
03/02/2020 22:00
03/03/2020 01:00
03/03/2020 04:00



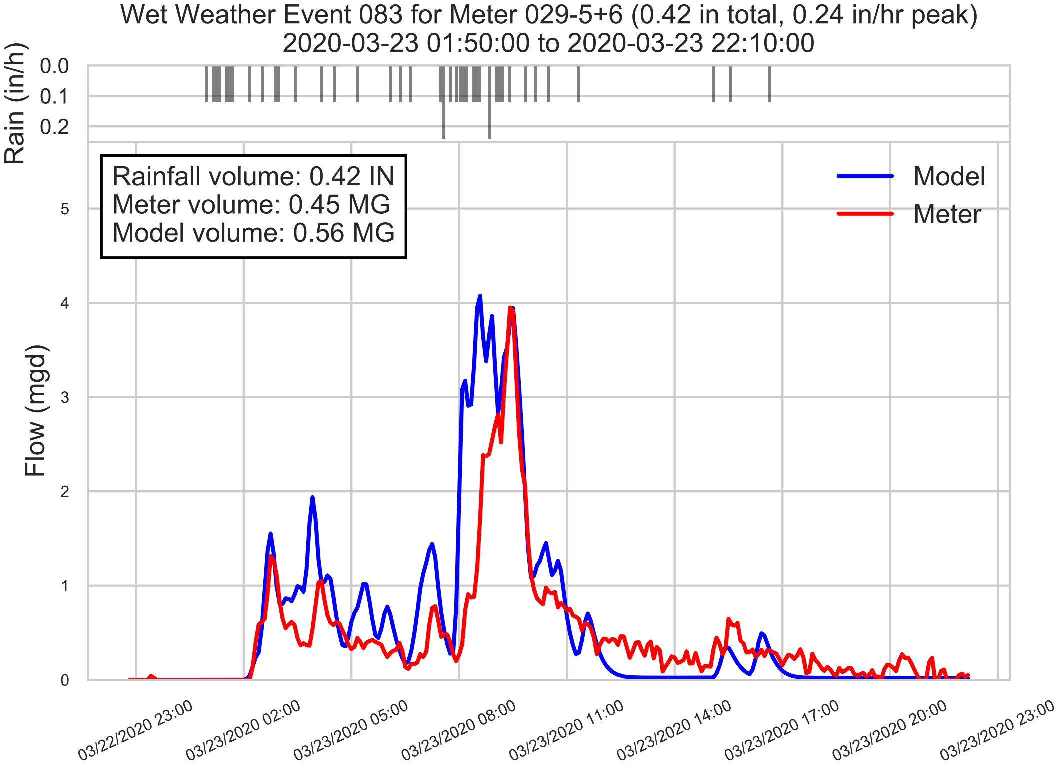
Wet Weather Event 079 for Meter 029-5+6 (0.24 in total, 0.36 in/hr peak)
2020-03-13 02:00:00 to 2020-03-13 10:20:00
Rain (in/h)
0.00
0.15
0.30
Rainfall volume: 0.24 IN
Meter volume: 0.24 MG
Model volume: 0.32 MG
Model
Meter
Flow (mgd)
0
2
4
6
8
10
12
03/13/2020 00:00
03/13/2020 03:00
03/13/2020 06:00
03/13/2020 09:00


Wet Weather Event 080 for Meter 029-5+6 (0.24 in total, 0.12 in/hr peak)
2020-03-14 20:35:00 to 2020-03-15 15:10:00
Rain (in/h)
0.00
0.05
0.10
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (mgd)
Rainfall volume: 0.24 IN
Meter volume: 0.25 MG
Model volume: 0.25 MG
Model
Meter
03/14/2020 19:00
03/14/2020 22:00
03/15/2020 01:00
03/15/2020 04:00
03/15/2020 07:00
03/15/2020 10:00
03/15/2020 13:00
03/15/2020 16:00

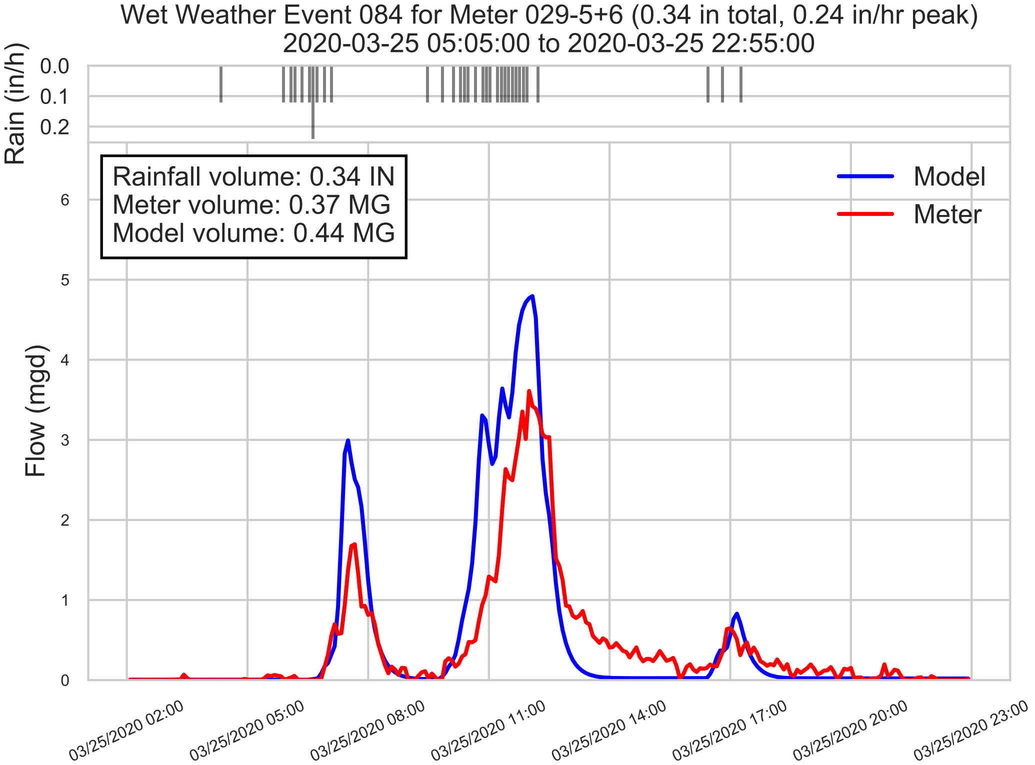

Wet Weather Event 081 for Meter 029-5+6 (0.46 in total, 0.24 in/hr peak)
2020-03-18 20:15:00 to 2020-03-19 11:50:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.46 IN
Meter volume: 0.58 MG
Model volume: 0.66 MG
Model
Meter
Flow (mgd)
12
10
8
6
4
2
0
03/18/2020 19:00
03/18/2020 22:00
03/19/2020 01:00
03/19/2020 04:00
03/19/2020 07:00
03/19/2020 10:00



Wet Weather Event 082 for Meter 029-5+6 (0.04 in total, 0.12 in/hr peak)
2020-03-21 02:15:00 to 2020-03-21 10:45:00
Rain (in/h)
0.00
0.05
0.10
Rainfall volume: 0.04 IN
Meter volume: 0.04 MG
Model volume: 0.01 MG
Model
Meter
Flow (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
03/21/2020 01:00
03/21/2020 04:00
03/21/2020 07:00
03/21/2020 10:00



Wet Weather Event 083 for Meter 029-5+6 (0.42 in total, 0.24 in/hr peak)
2020-03-23 01:50:00 to 2020-03-23 22:10:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.42 IN
Meter volume: 0.45 MG
Model volume: 0.56 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
03/22/2020 23:00
03/23/2020 02:00
03/23/2020 05:00
03/23/2020 08:00
03/23/2020 11:00
03/23/2020 14:00
03/23/2020 17:00
03/23/2020 20:00
03/23/2020 23:00


Wet Weather Event 084 for Meter 029-5+6 (0.34 in total, 0.24 in/hr peak)
2020-03-25 05:05:00 to 2020-03-25 22:55:00
Rain (in/h)
0.0
0.1
0.2
Rainfall volume: 0.34 IN
Meter volume: 0.37 MG
Model volume: 0.44 MG
Model
Meter
Flow (mgd)
0
1
2
3
4
5
6
03/25/2020 02:00
03/25/2020 05:00
03/25/2020 08:00
03/25/2020 11:00
03/25/2020 14:00
03/25/2020 17:00
03/25/2020 20:00
03/25/2020 23:00

Appendix D: Monitoring Timeseries for Entire Post-Construction Metering Time Period

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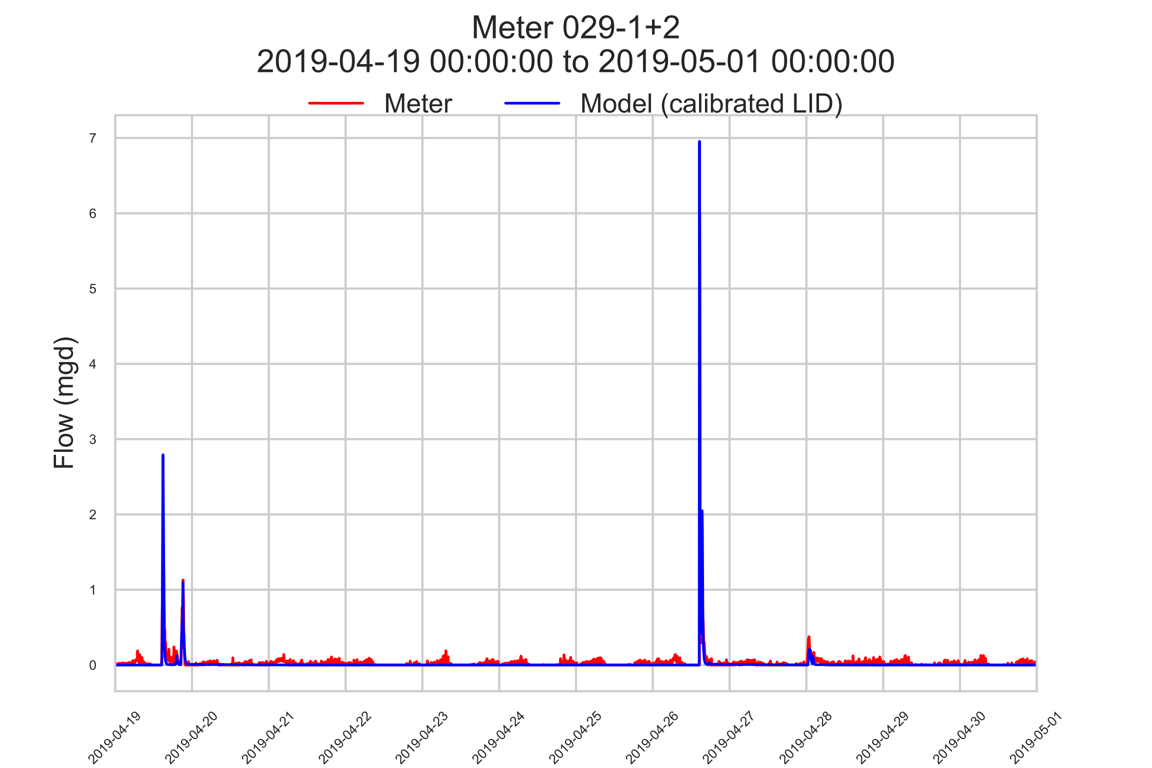
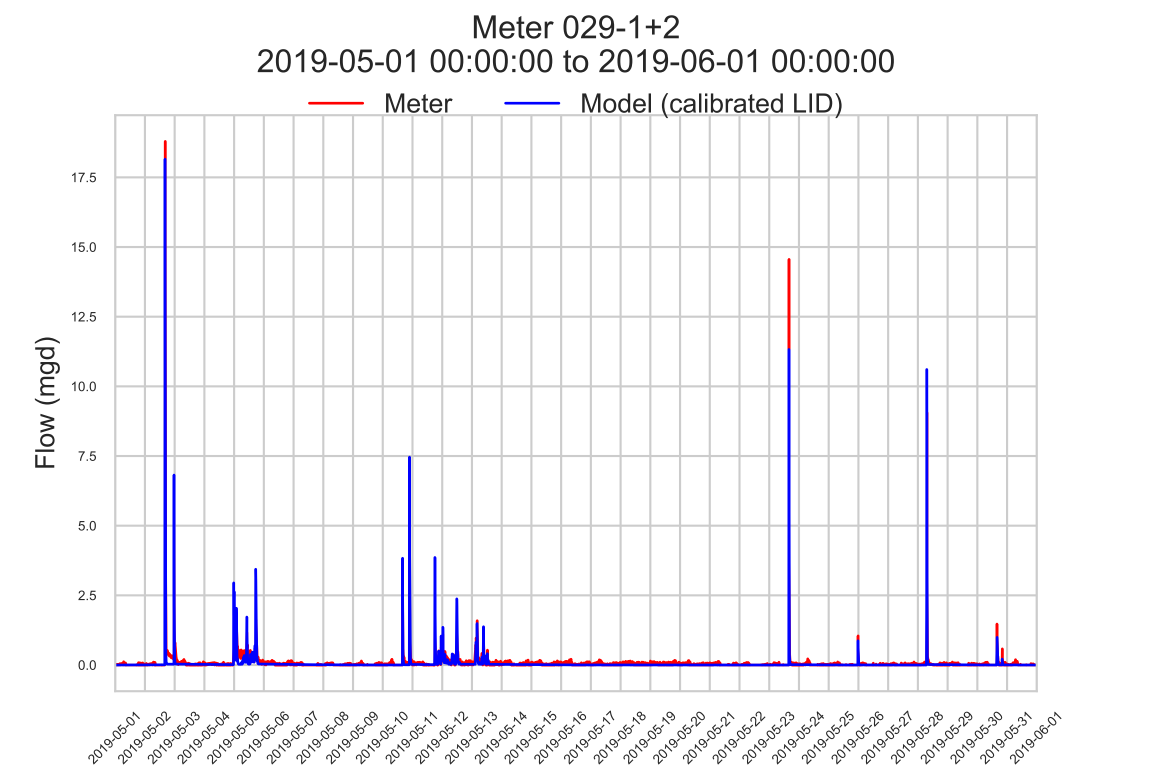


Meter 029-1+2
2019-04-19 00:00:00 to 2019-05-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
6
7
2019-04-19
2019-04-20
2019-04-21
2019-04-22
2019-04-23
2019-04-24
2019-04-25
2019-04-26
2019-04-27
2019-04-28
2019-04-29
2019-04-30
2019-05-01



Meter 029-1+2
2019-05-01 00:00:00 to 2019-06-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
2019-05-01
2019-05-02
2019-05-03
2019-05-04
2019-05-05
2019-05-06
2019-05-07
2019-05-08
2019-05-09
2019-05-10
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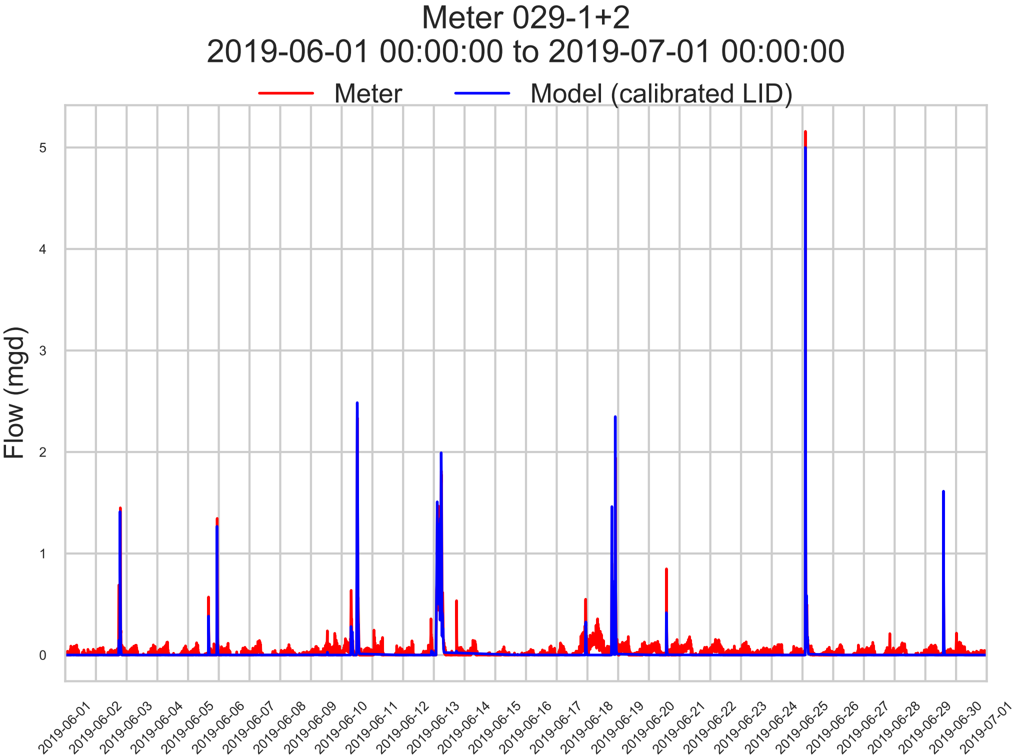
2019-06-01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2019-06-01 00:00:00 to 2019-07-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
1
2
3
4
5
2019-06-01
2019-06-02
2019-06-03
2019-06-04
2019-06-05
2019-06-06
2019-06-07
2019-06-08
2019-06-09
2019-06-10
2019-06-11
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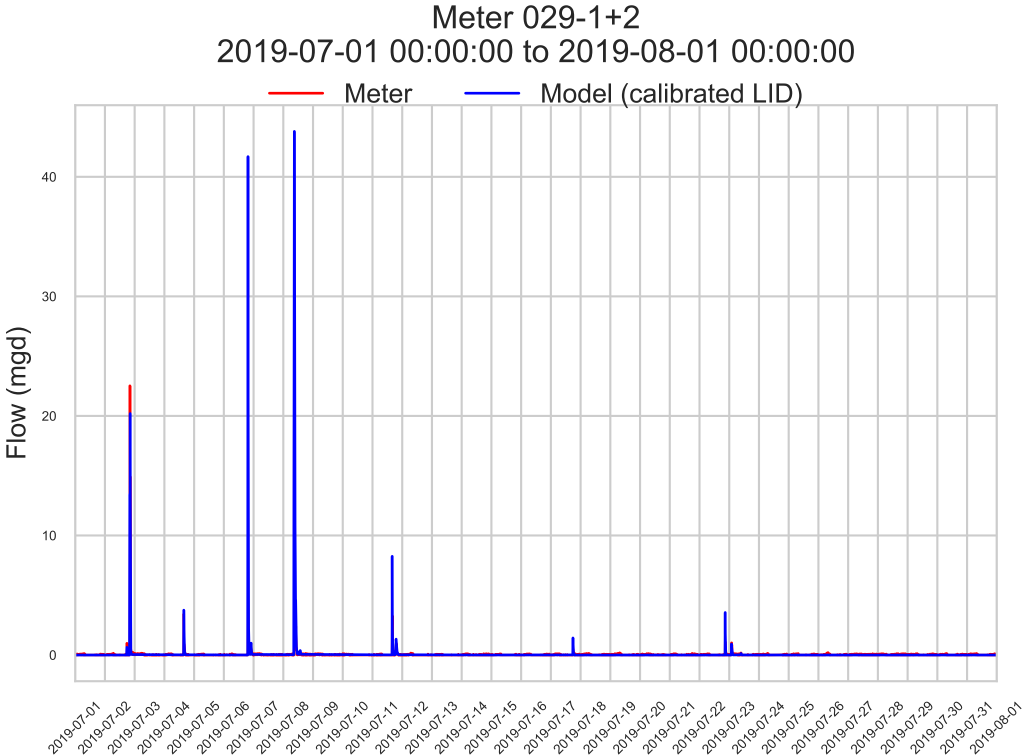

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2019-07-01 00:00:00 to 2019-08-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
10
20
30
40
2019-07-01
2019-07-02
2019-07-03
2019-07-04
2019-07-05
2019-07-06
2019-07-07
2019-07-08
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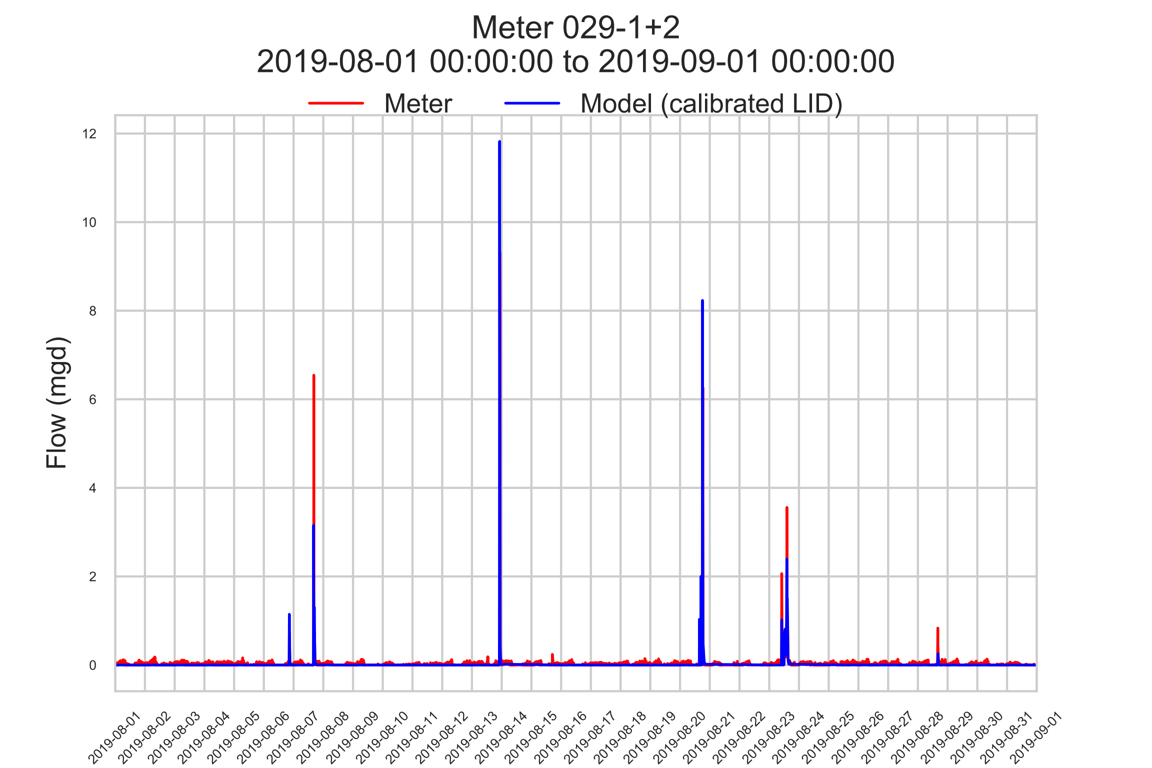
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2019-08-01 00:00:00 to 2019-09-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2019-08-01
2019-08-02
2019-08-03
2019-08-04
2019-08-05
2019-08-06
2019-08-07
2019-08-08
2019-08-09
2019-08-10
2019-08-11
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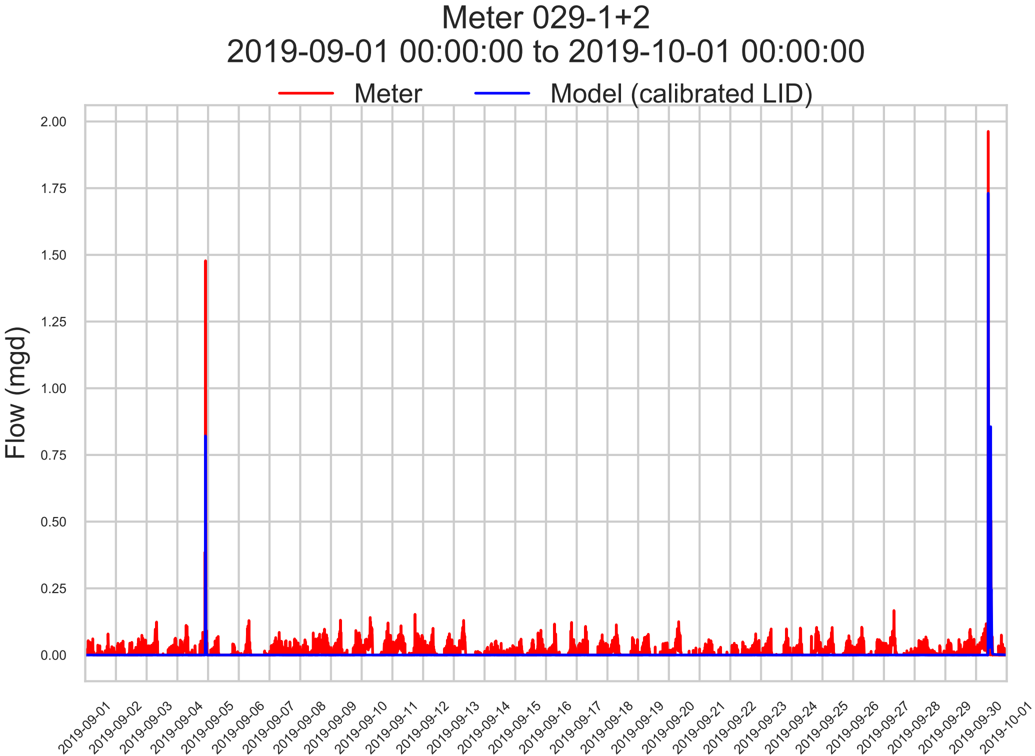
2019-09-01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2019-09-01 00:00:00 to 2019-10-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2019-09-01
2019-09-02
2019-09-03
2019-09-04
2019-09-05
2019-09-06
2019-09-07
2019-09-08
2019-09-09
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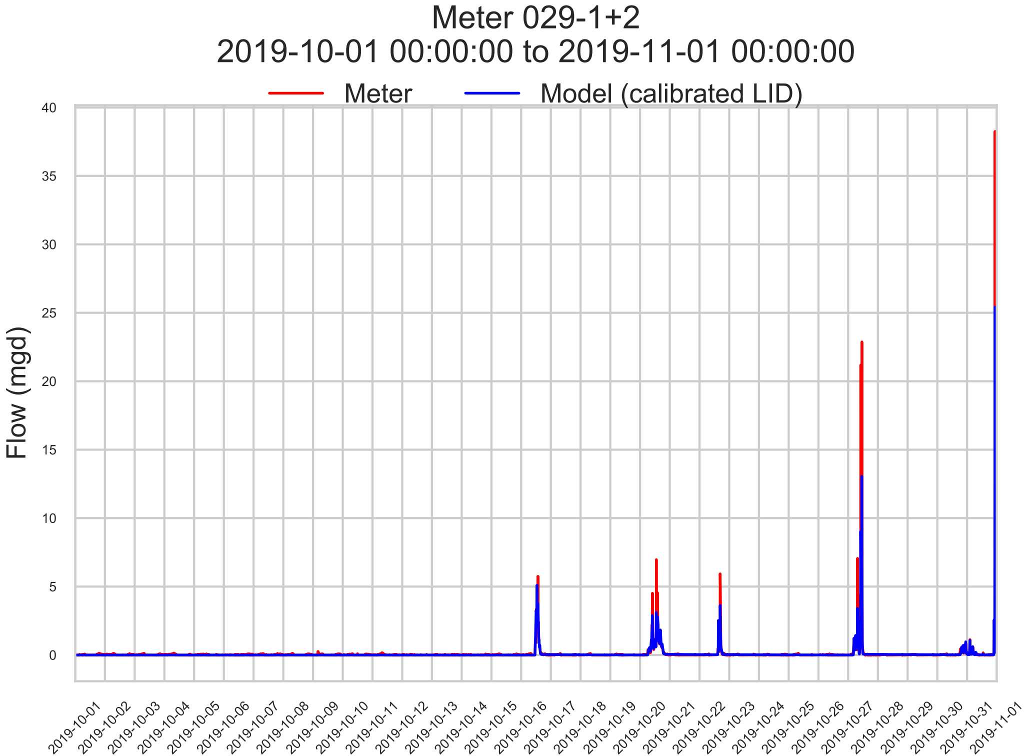
2019-10-01



Meter 029-1+2
2019-10-01 00:00:00 to 2019-11-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
30
35
40
2019-10-01
2019-10-02
2019-10-03
2019-10-04
2019-10-05
2019-10-06
2019-10-07
2019-10-08
2019-10-09
2019-10-10
2019-10-11
2019-10-12
2019-10-13
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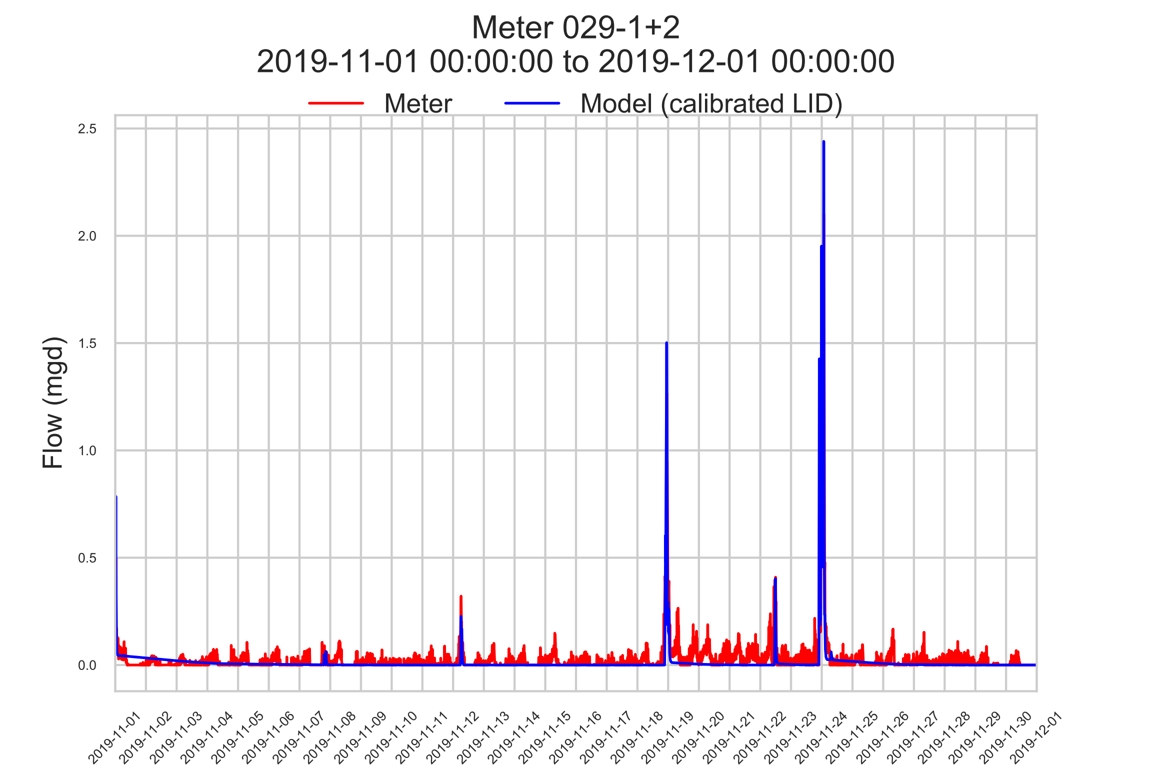
2019-10-31
2019-11-01



Meter 029-1+2
2019-11-01 00:00:00 to 2019-12-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
2019-11-01
2019-11-02
2019-11-03
2019-11-04
2019-11-05
2019-11-06
2019-11-07
2019-11-08
2019-11-09
2019-11-10
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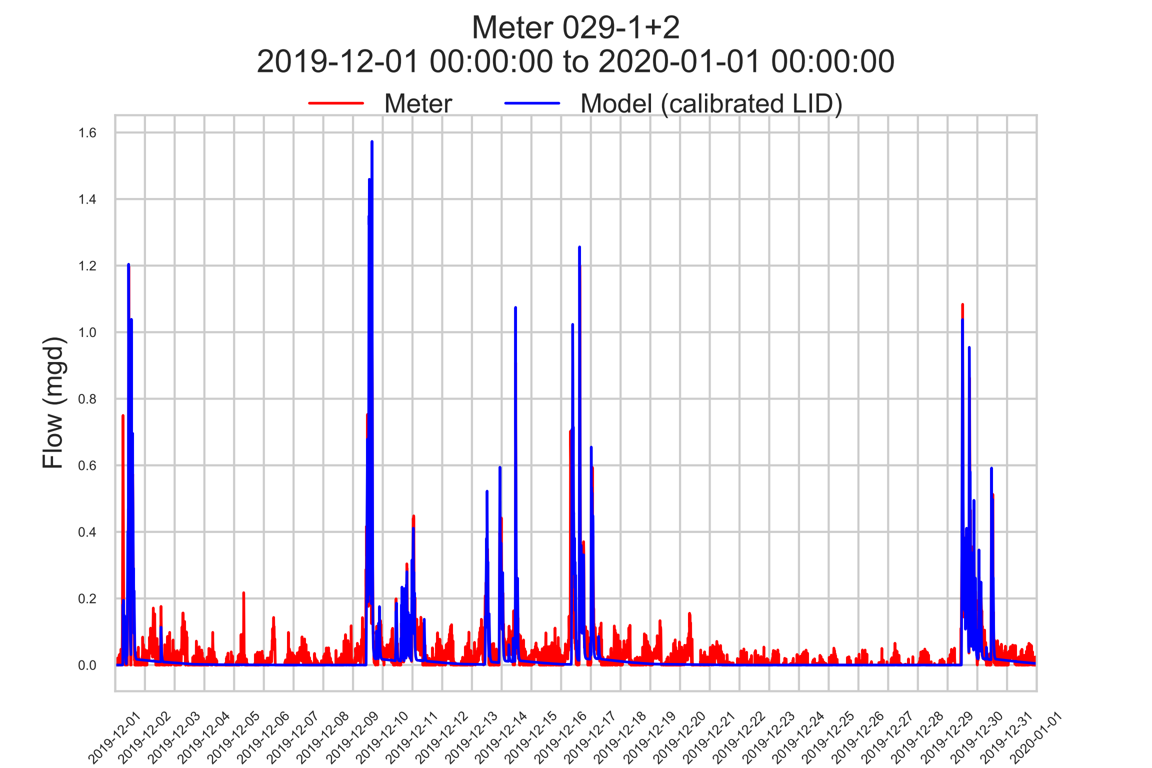

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Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
2019-12-01
2019-12-02
2019-12-03
2019-12-04
2019-12-05
2019-12-06
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2019-12-08
2019-12-09
2019-12-10
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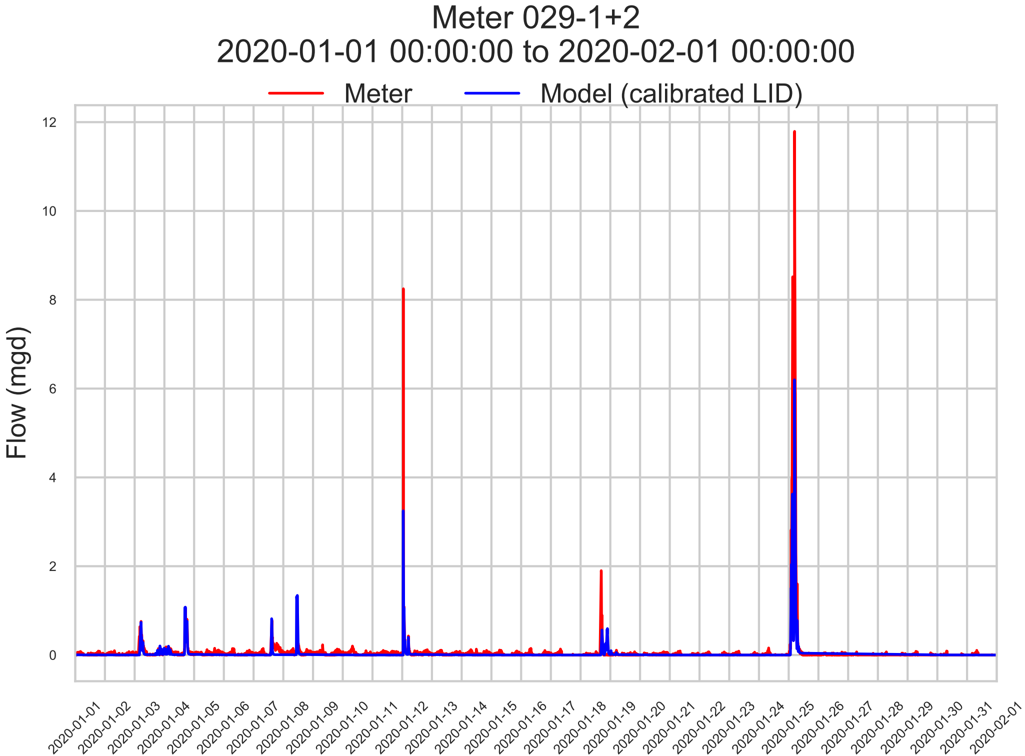
2019-12-31
2020-01-01


Meter 029-1+2
2020-01-01 00:00:00 to 2020-02-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2020-01-01
2020-01-02
2020-01-03
2020-01-04
2020-01-05
2020-01-06
2020-01-07
2020-01-08
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2020-01-10
2020-01-11
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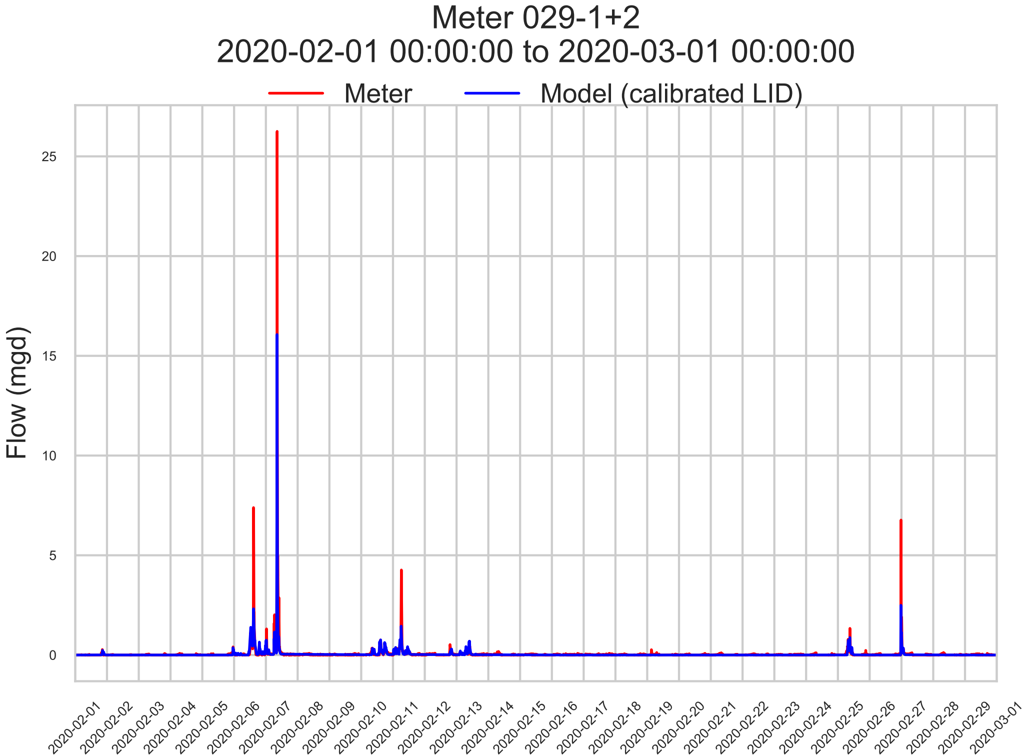
Meter 029-1+2
2020-02-01 00:00:00 to 2020-03-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
2020-02-01
2020-02-02
2020-02-03
2020-02-04
2020-02-05
2020-02-06
2020-02-07
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2020-02-09
2020-02-10
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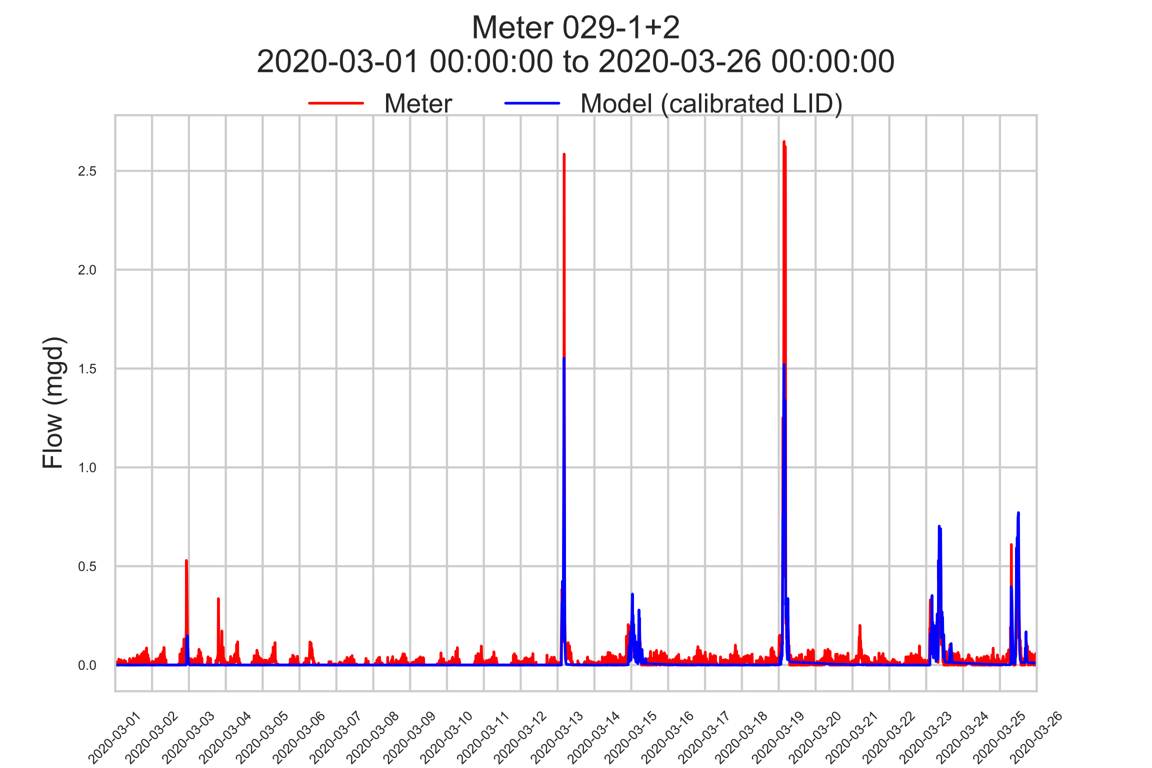

Meter 029-1+2
2020-03-01 00:00:00 to 2020-03-26 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0.0
0.5
1.0
1.5
2.0
2.5
2020-03-01
2020-03-02
2020-03-03
2020-03-04
2020-03-05
2020-03-06
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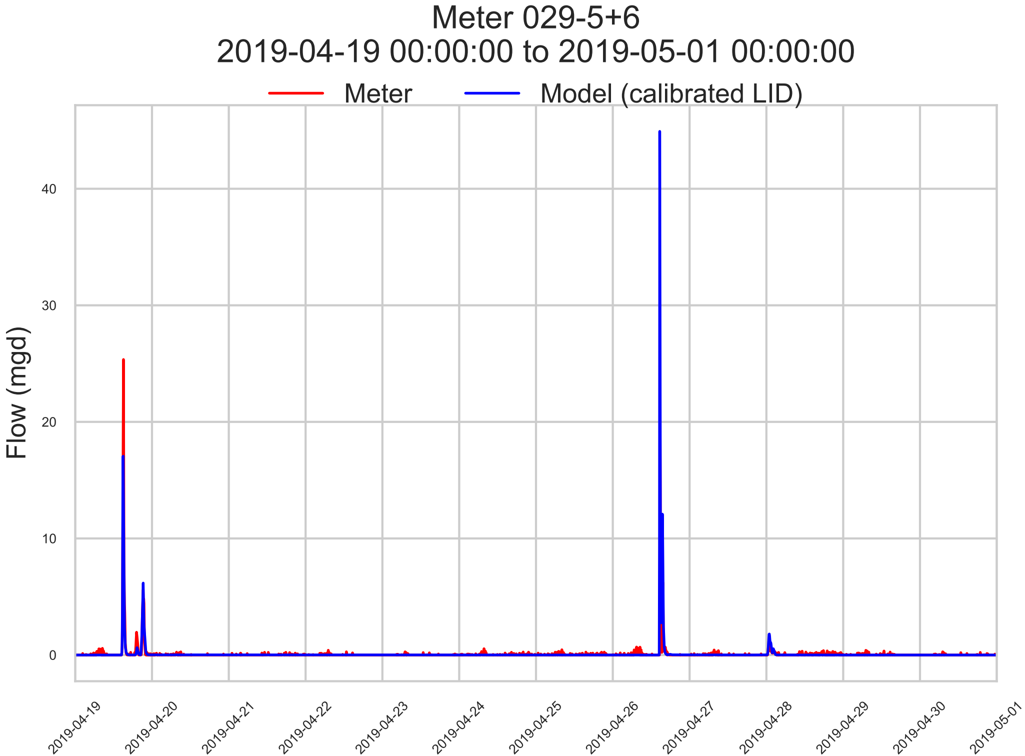
2020-03-26



Meter 029-5+6
2019-04-19 00:00:00 to 2019-05-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
10
20
30
40
2019-04-19
2019-04-20
2019-04-21
2019-04-22
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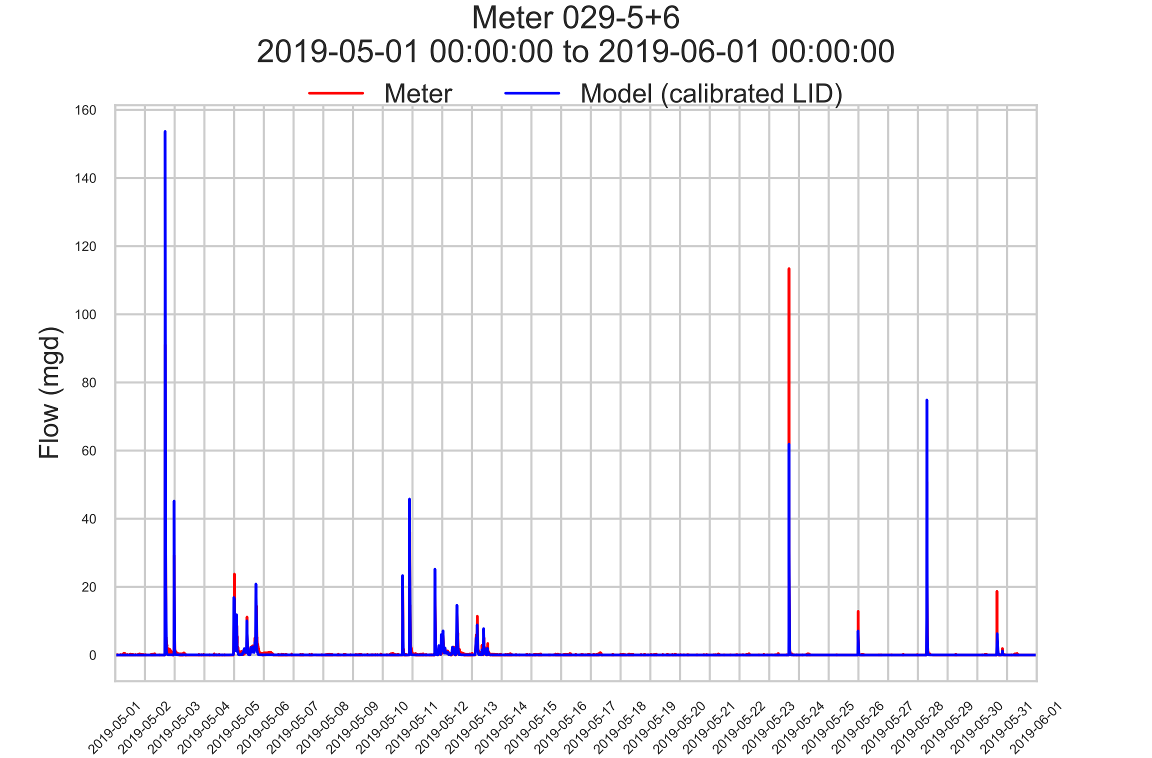
2019-04-30
2019-05-01



Meter 029-5+6
2019-05-01 00:00:00 to 2019-06-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
20
40
60
80
100
120
140
160
2019-05-01
2019-05-02
2019-05-03
2019-05-04
2019-05-05
2019-05-06
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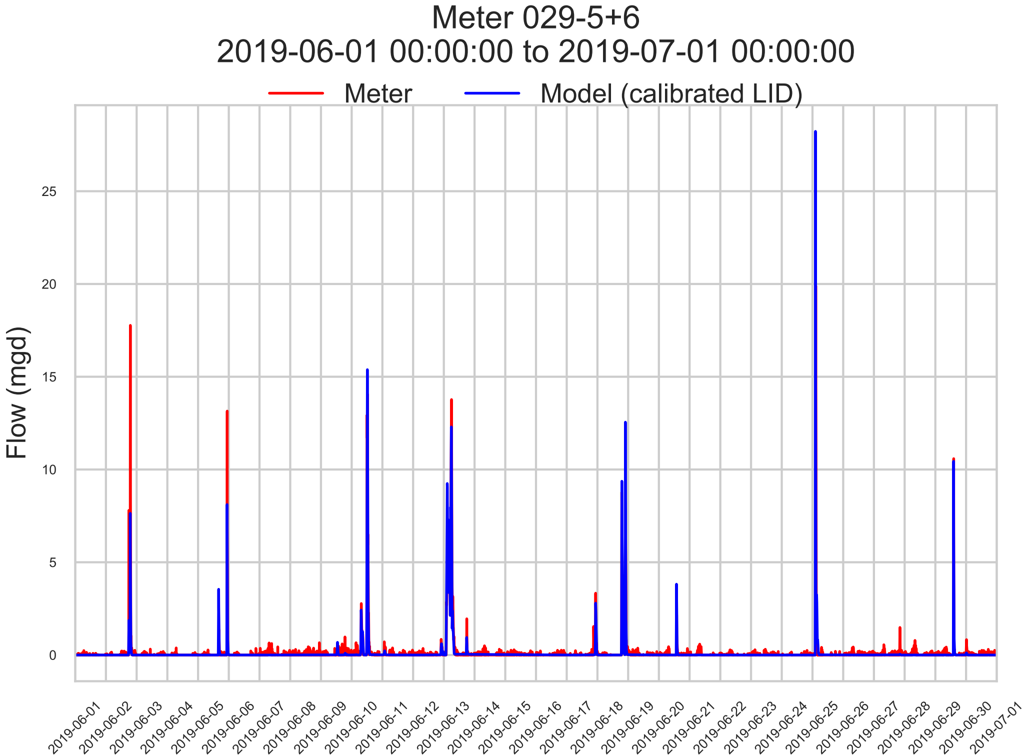
2019-06-01


Meter 029-5+6
2019-06-01 00:00:00 to 2019-07-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
5
10
15
20
25
2019-06-01
2019-06-02
2019-06-03
2019-06-04
2019-06-05
2019-06-06
2019-06-07
2019-06-08
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2019-06-10
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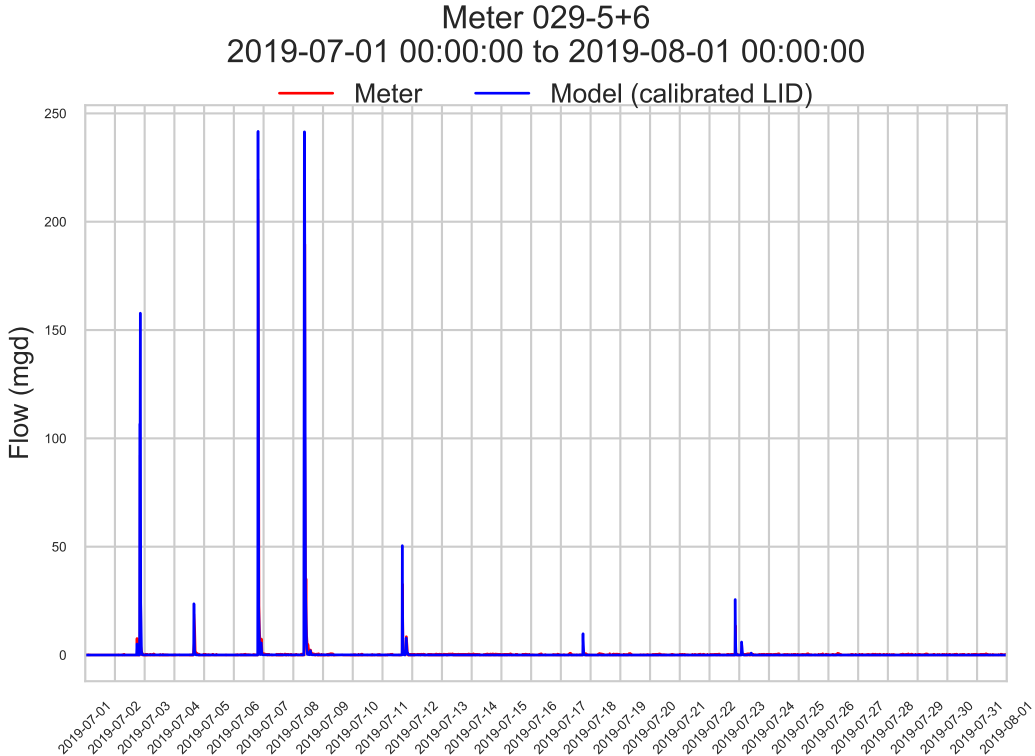
2019-07-01



Meter 029-5+6
2019-07-01 00:00:00 to 2019-08-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
50
100
150
200
250
2019-07-01
2019-07-02
2019-07-03
2019-07-04
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2019-07-06
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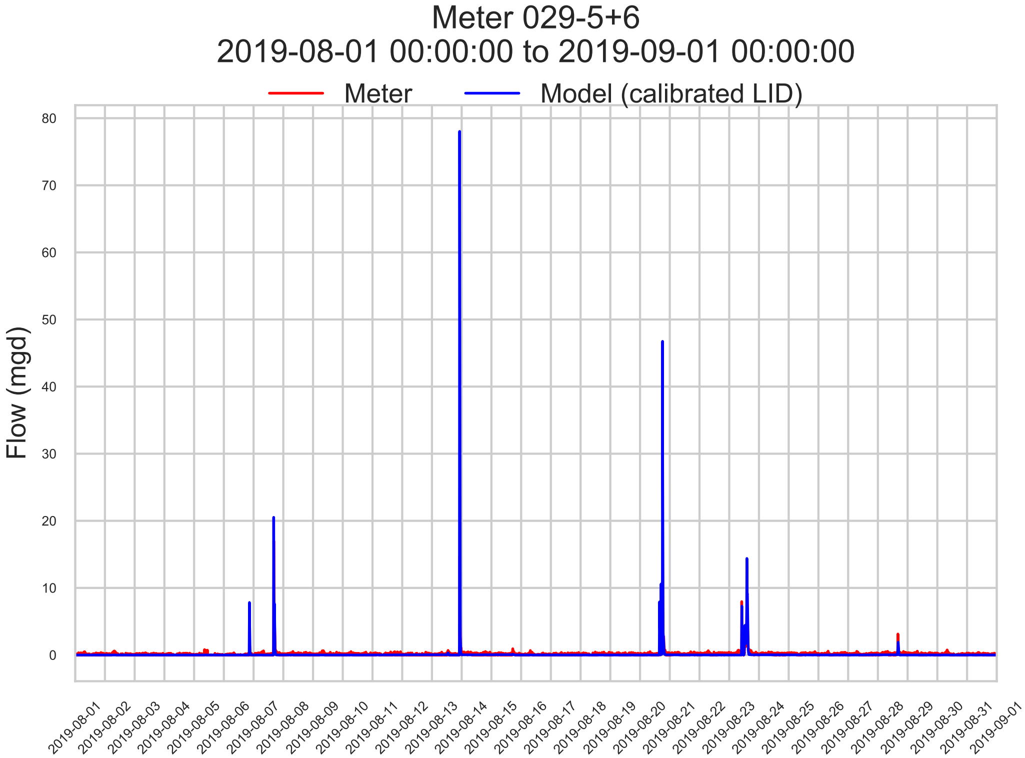

Meter 029-5+6
2019-08-01 00:00:00 to 2019-09-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
10
20
30
40
50
60
70
80
2019-08-01
2019-08-02
2019-08-03
2019-08-04
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2019-08-06
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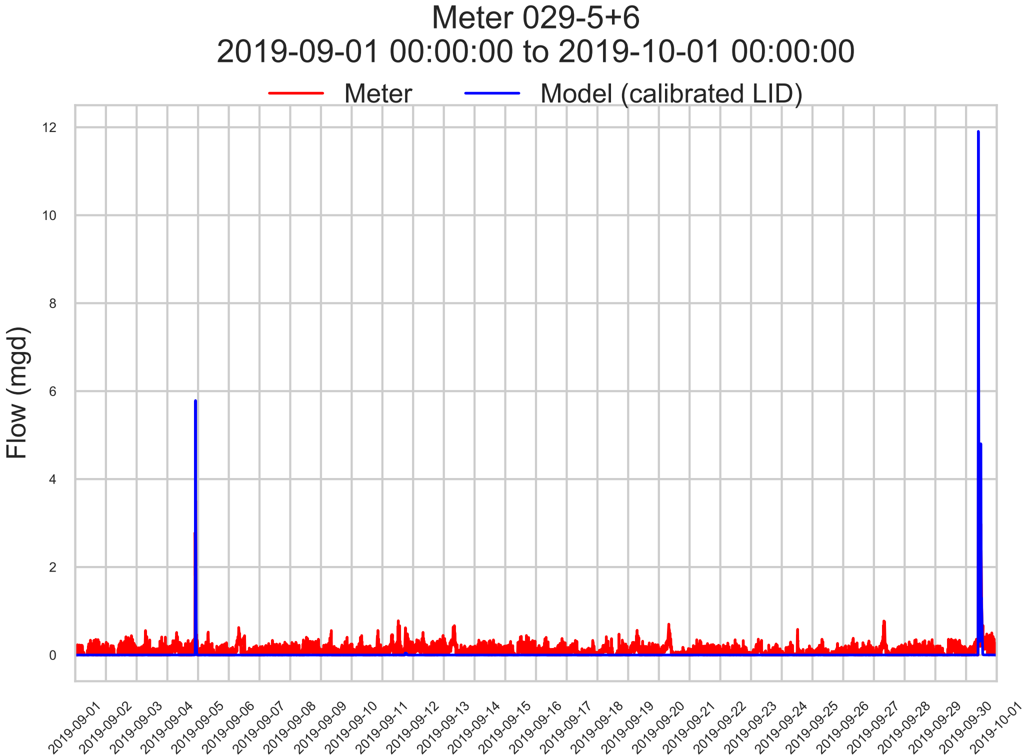

Meter 029-5+6
2019-09-01 00:00:00 to 2019-10-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
2019-09-01
2019-09-02
2019-09-03
2019-09-04
2019-09-05
2019-09-06
2019-09-07
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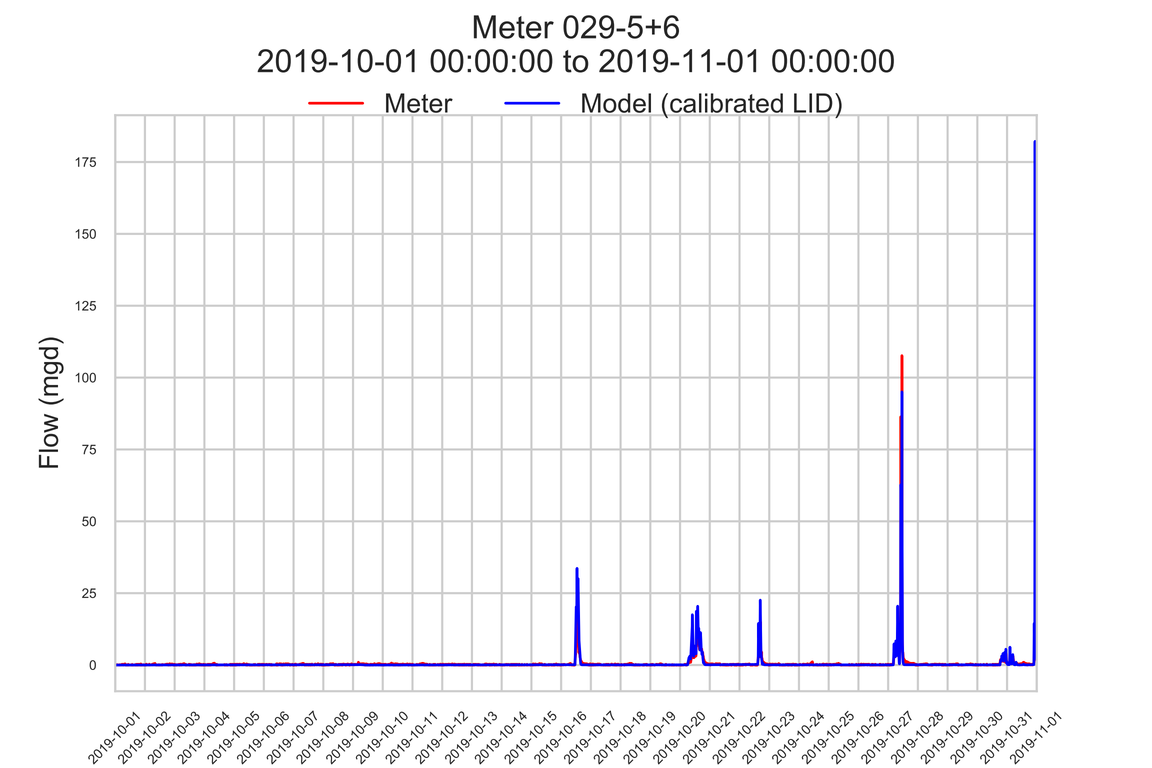
2019-10-01


Meter 029-5+6
2019-10-01 00:00:00 to 2019-11-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
25
50
75
100
125
150
175
2019-10-01
2019-10-02
2019-10-03
2019-10-04
2019-10-05
2019-10-06
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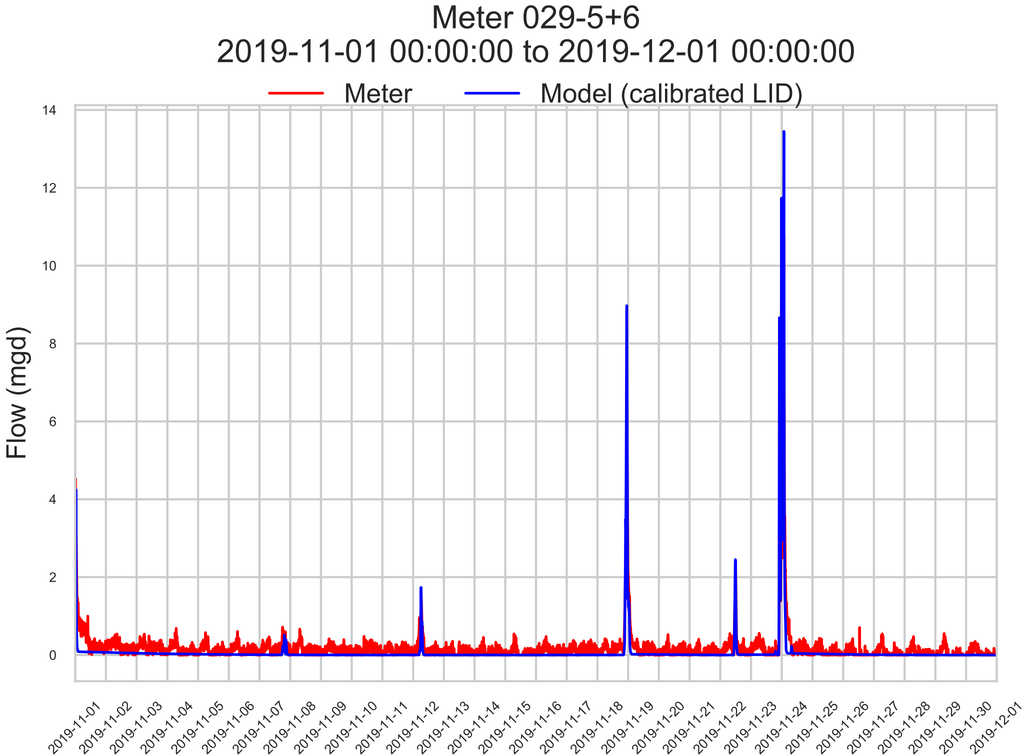
2019-11-01


Meter 029-5+6
2019-11-01 00:00:00 to 2019-12-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
10
12
14
2019-11-01
2019-11-02
2019-11-03
2019-11-04
2019-11-05
2019-11-06
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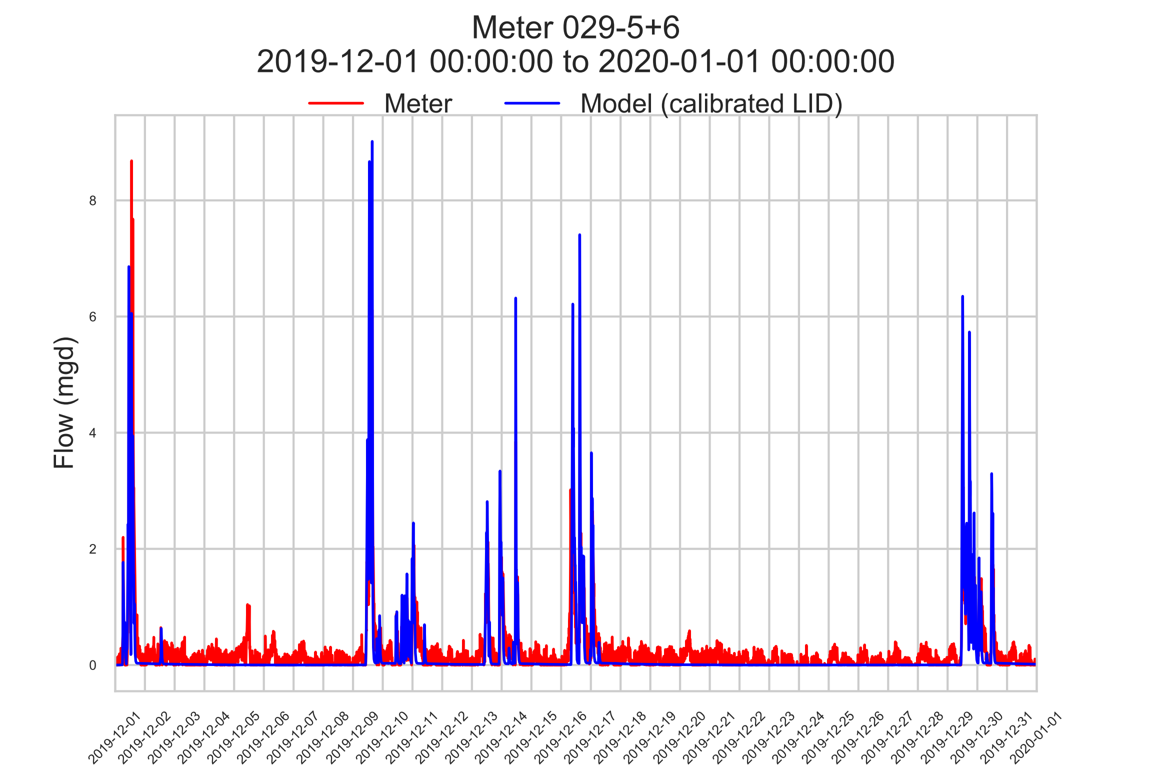
2019-11-30
2019-12-01



Meter 029-5+6
2019-12-01 00:00:00 to 2020-01-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
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2019-12-01
2019-12-02
2019-12-03
2019-12-04
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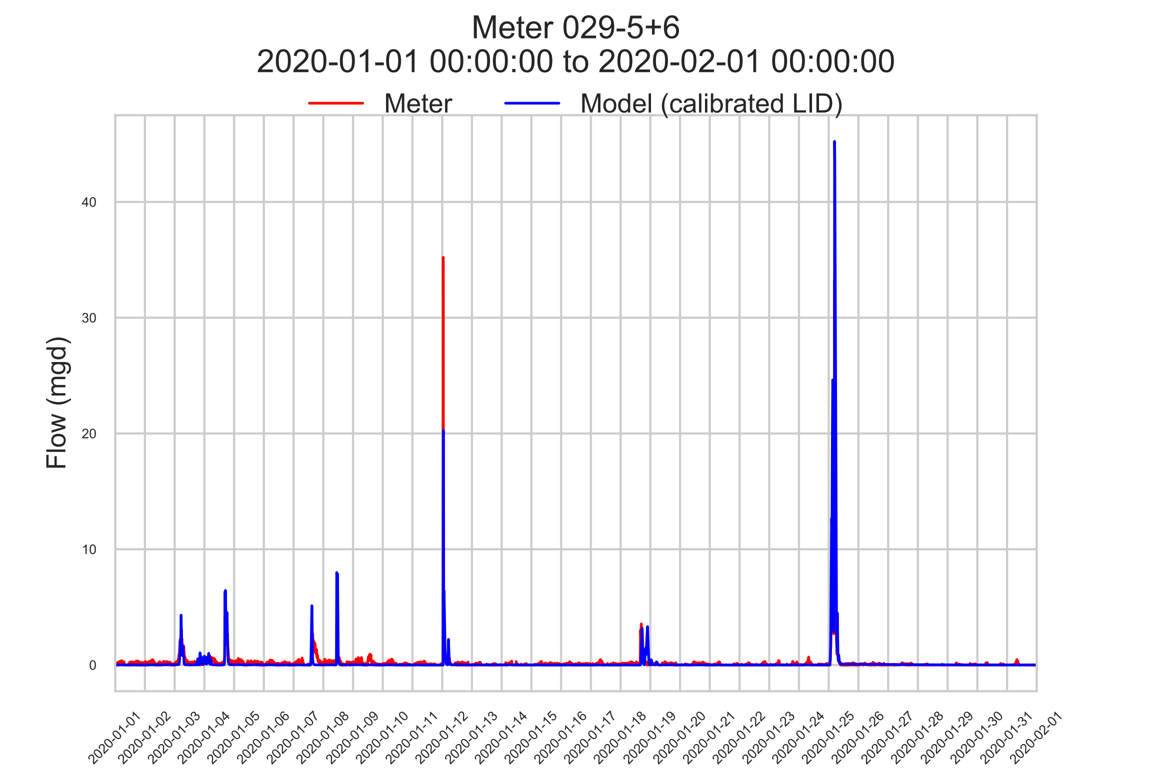
2020-01-01



Meter 029-5+6
2020-01-01 00:00:00 to 2020-02-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
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20
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2020-01-01
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2020-01-14
2020-01-15
2020-01-16
2020-01-17
2020-01-18
2020-01-19
2020-01-20
2020-01-21
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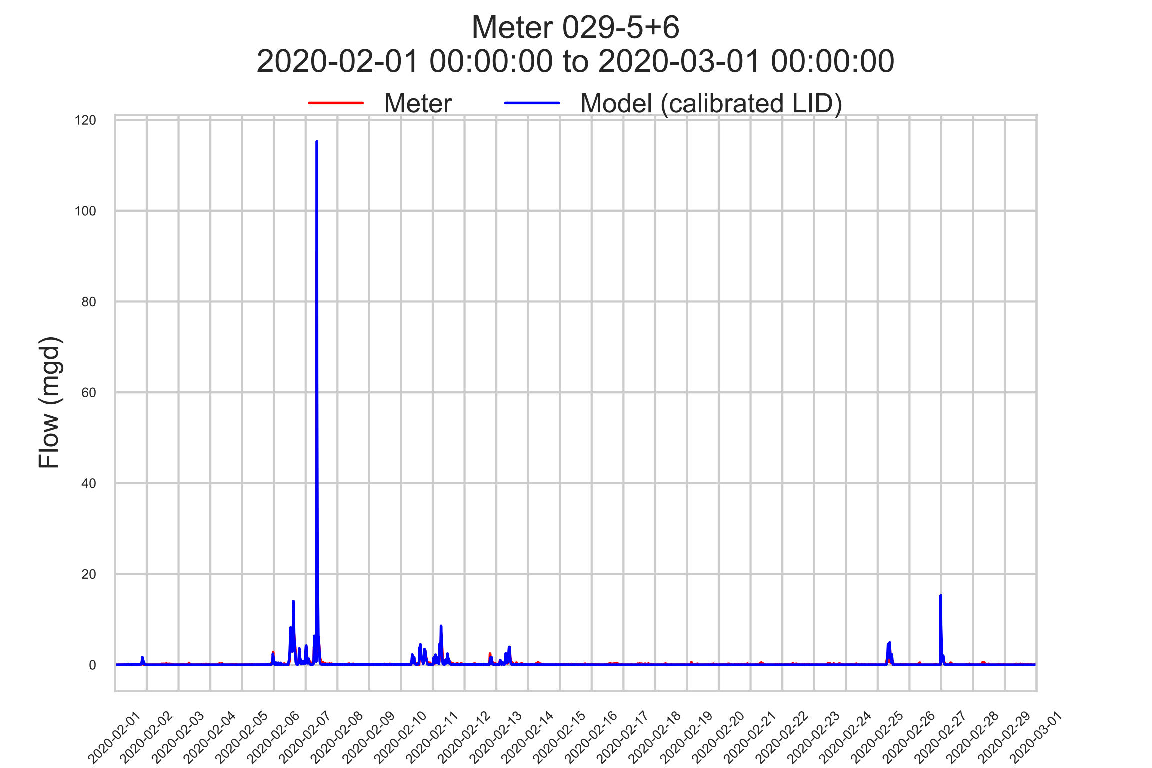
2020-01-31
2020-02-01


Meter 029-5+6
2020-02-01 00:00:00 to 2020-03-01 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
20
40
60
80
100
120
2020-02-01
2020-02-02
2020-02-03
2020-02-04
2020-02-05
2020-02-06
2020-02-07
2020-02-08
2020-02-09
2020-02-10
2020-02-11
2020-02-12
2020-02-13
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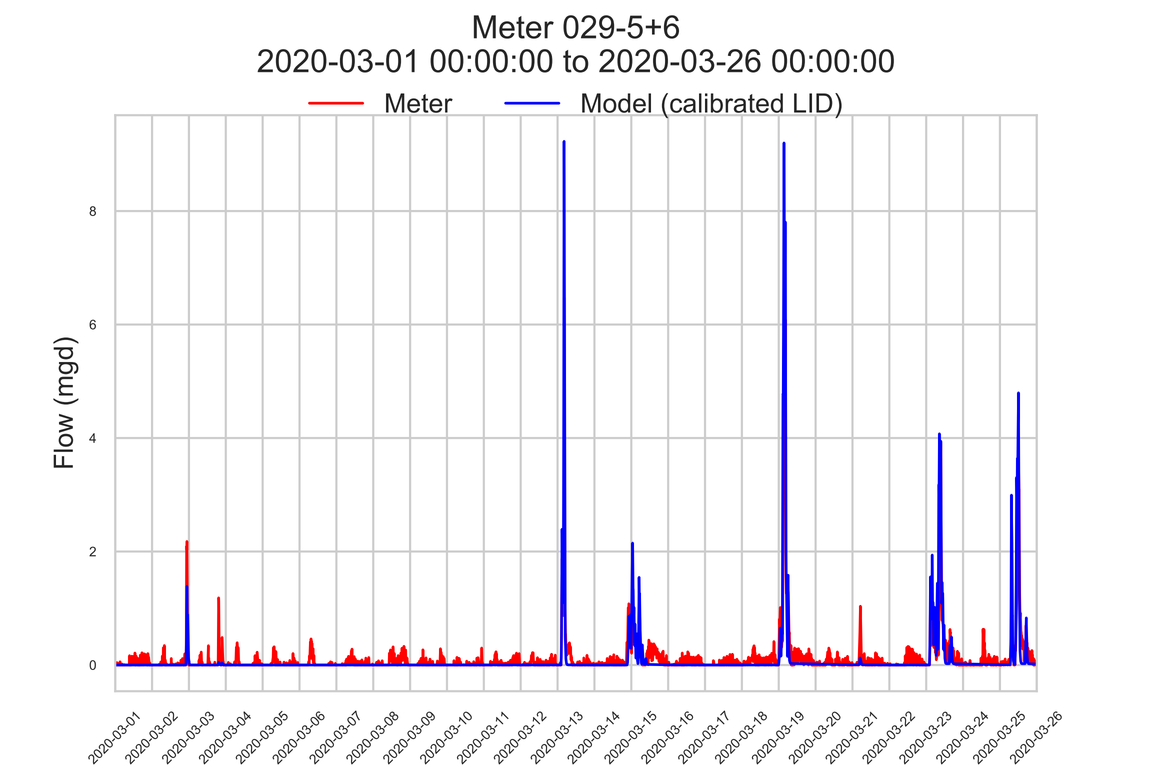
2020-02-29
2020-03-01


Meter 029-5+6
2020-03-01 00:00:00 to 2020-03-26 00:00:00
Meter
Model (calibrated LID)
Flow (mgd)
0
2
4
6
8
2020-03-01
2020-03-02
2020-03-03
2020-03-04
2020-03-05
2020-03-06
2020-03-07
2020-03-08
2020-03-09
2020-03-10
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2020-03-19
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2020-03-22
2020-03-23
2020-03-24
2020-03-25
2020-03-26

Appendix G

2020 Green Infrastructure Survey Results

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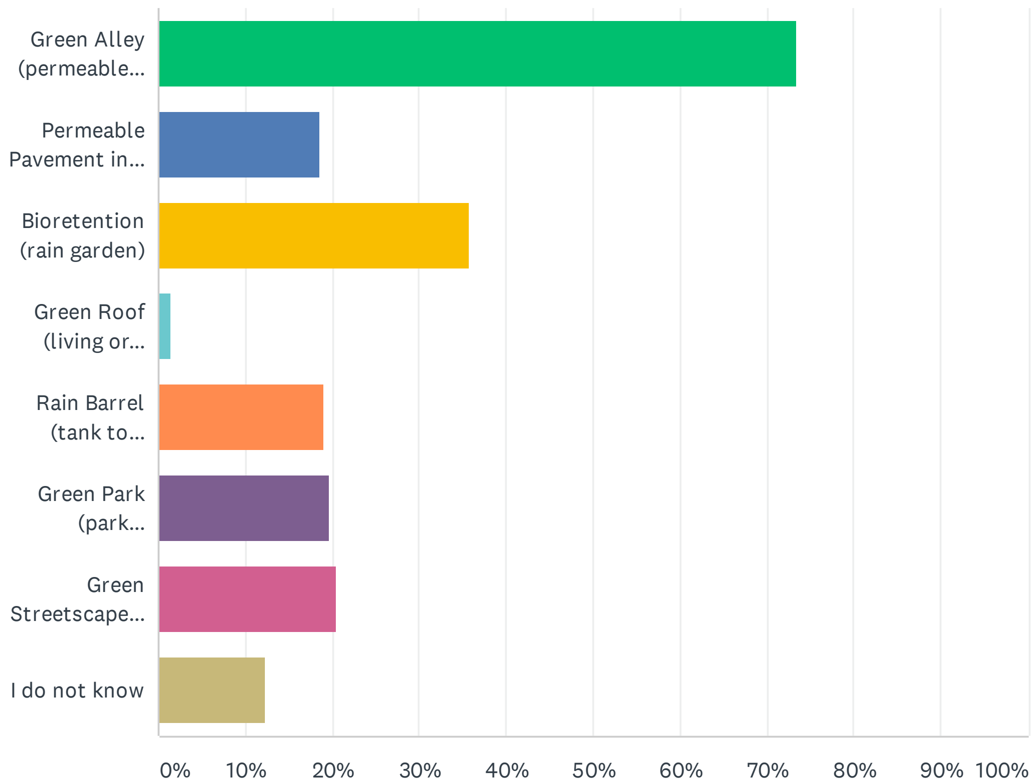
Q1 What type of green infrastructure has been installed in your neighborhood? (Check all the apply.)

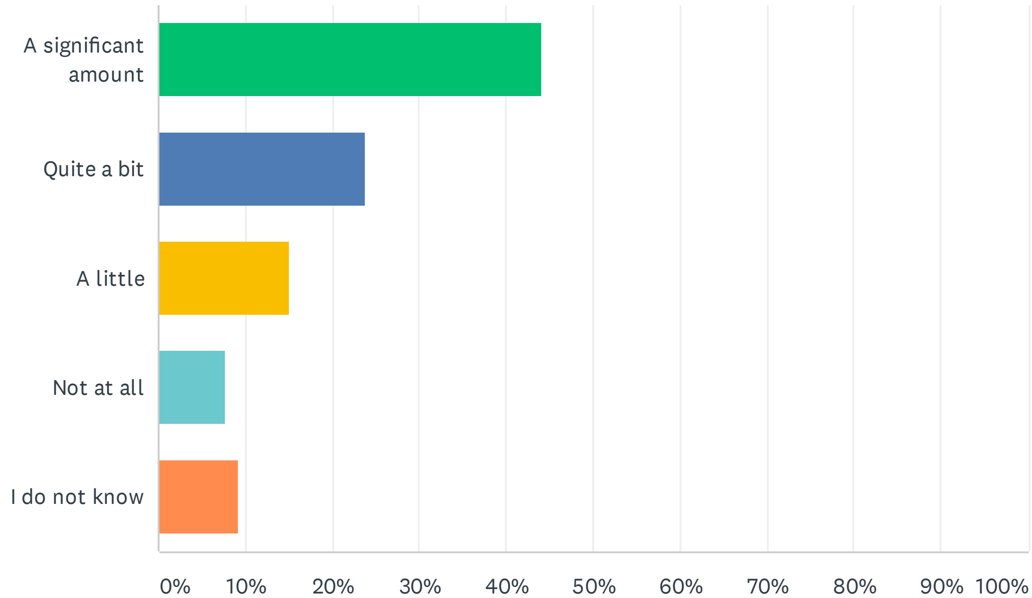
Answered: 204 Skipped: 2



ANSWER CHOICES	RESPONSES	
Green Alley (permeable pavers/permeable asphalt)	73.53%	150
Permeable Pavement in Parking Lane (permeable asphalt)	18.63%	38
Bioretention (rain garden)	35.78%	73
Green Roof (living or vegetated roof)	1.47%	3
Rain Barrel (tank to capture and store rainwater)	19.12%	39
Green Park (park containing green infrastructure/stormwater management features)	19.61%	40
Green Streetscape (block containing green infrastructure/stormwater management features)	20.59%	42
I do not know	12.25%	25
Total Respondents: 204		

Q2 Would you like more green infrastructure in your neighborhood?

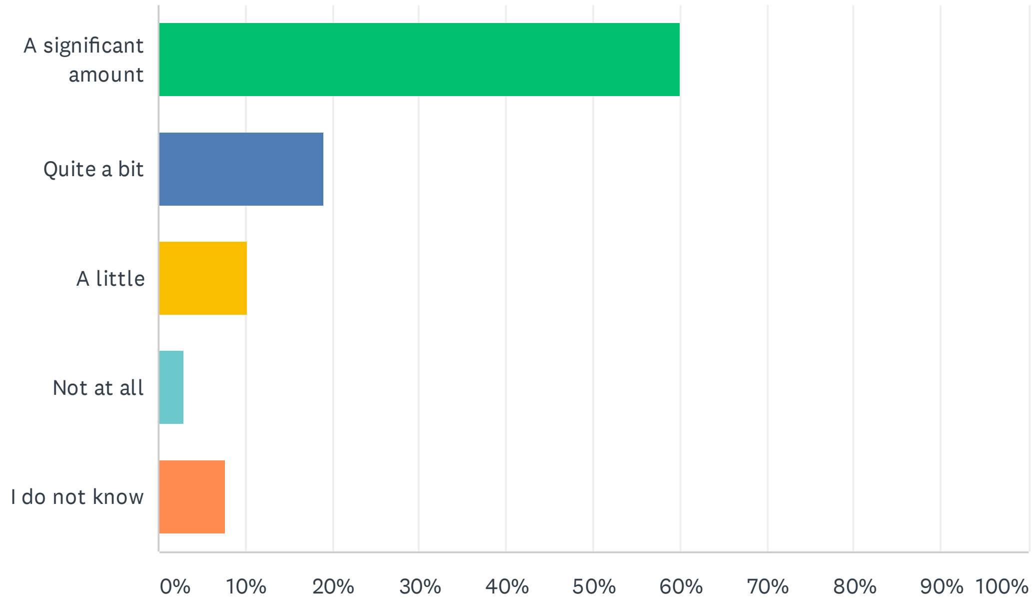
Answered: 206 Skipped: 0



ANSWER CHOICES	RESPONSES	
A significant amount	44.17%	91
Quite a bit	23.79%	49
A little	15.05%	31
Not at all	7.77%	16
I do not know	9.22%	19
TOTAL		206

Q3 Would you like more green infrastructure in the District?

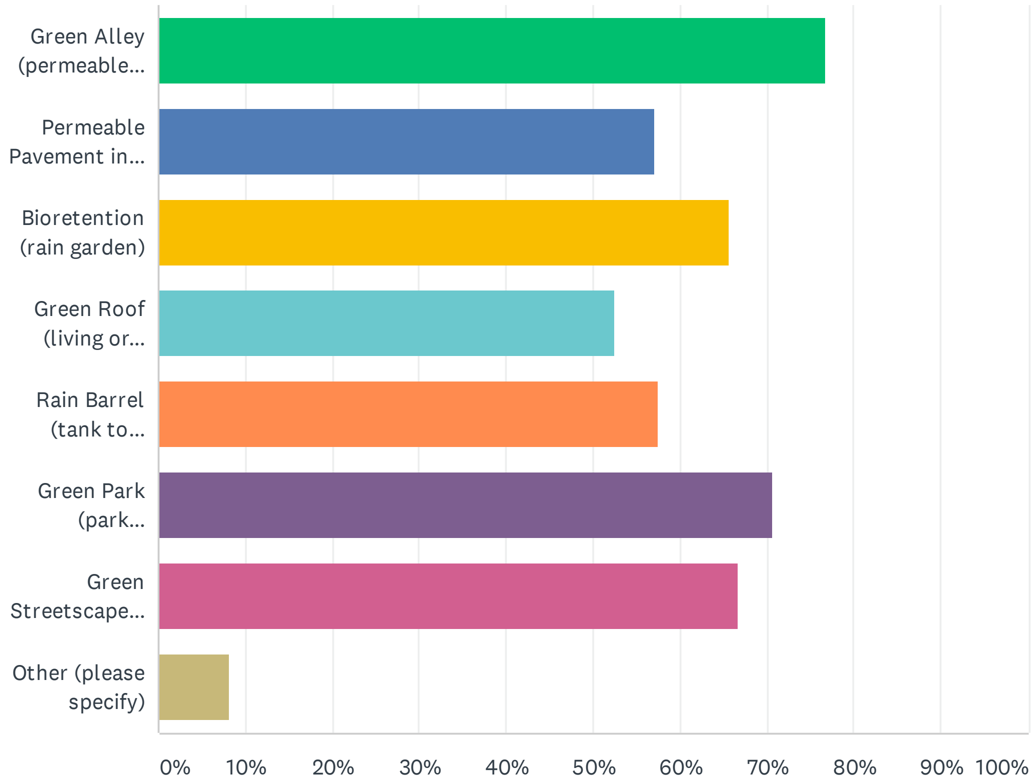
Answered: 205   Skipped: 1



ANSWER CHOICES	RESPONSES	
A significant amount	60.00%	123
Quite a bit	19.02%	39
A little	10.24%	21
Not at all	2.93%	6
I do not know	7.80%	16
TOTAL		205

Q4 Which type of green infrastructure would you like to see more of in the District? (Check all the apply.)

Answered: 198 Skipped: 8

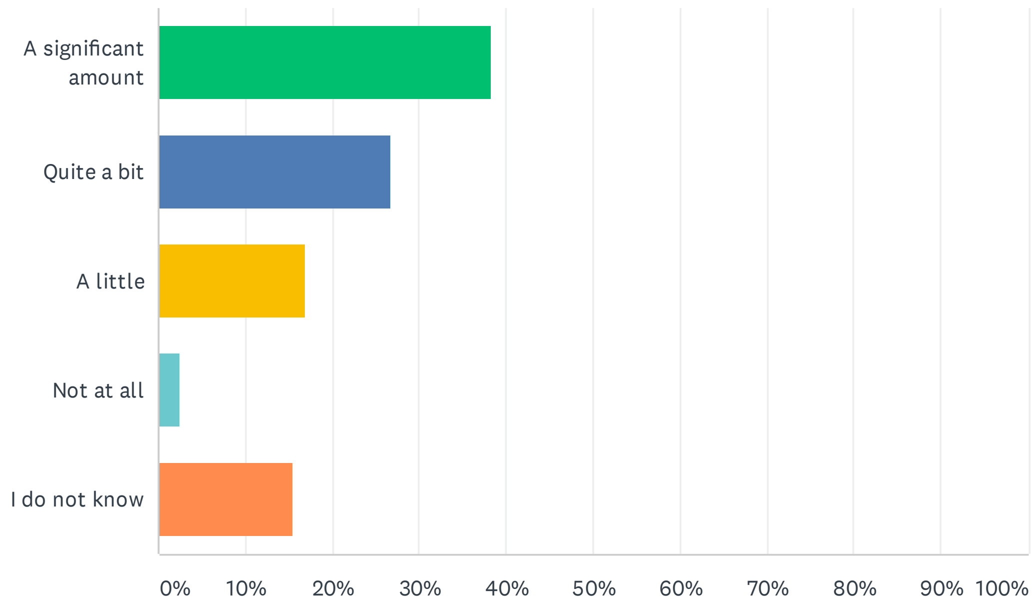


ANSWER CHOICES	RESPONSES	
Green Alley (permeable pavers/permeable asphalt)	76.77%	152
Permeable Pavement in Parking Lane (permeable asphalt)	57.07%	113
Bioretention (rain garden)	65.66%	130
Green Roof (living or vegetated roof)	52.53%	104
Rain Barrel (tank to capture and store rainwater)	57.58%	114
Green Park (park containing green infrastructure/stormwater management features)	70.71%	140
Green Streetscape (block containing green infrastructure/stormwater management features)	66.67%	132
Other (please specify)	8.08%	16
Total Respondents: 198		

#	OTHER (PLEASE SPECIFY)	DATE
1	stream daylighting	4/1/2020 7:56 PM
2	Athletic fields under the control of DCPS, DPR, and private entities that DO NOT USE artificial tuff	4/1/2020 2:18 PM
3	require solar on every new roof, and incentivize installation where appropriate on existing roofs.. . . . irrespective of historic designation! COmmunication dishes exist, and not as important and reducing use of fossil fuels	4/1/2020 10:28 AM
4	Solar/Wind generating power sources for utilities (e.g., traffic lights, street lights; Metro bus stops); permeable pavers used for cross walks; additional green infrastructure that not only manages rain/storm water, but also mitigates mosquito populations/vector-borne diseases in the summer	3/31/2020 4:00 PM
5	Terrible question. Depends on cost to ratepayers and on thorough environmental analyses of specific projects with advance neighborhood input, consistent with the NEPA review process. This was not followed in connection with the green alleys project in our neighborhood and resulted in a wasteful process, among other things. Our alleys had been redone not long ago so were in good repair. Other nearby alleys in terrible repair should have been targeted.	3/31/2020 3:33 PM
6	Replacement of rusted pipes. My water has lots of rust which is very unhealthy for my challenged health and destroys certain items items in my home.	3/31/2020 3:30 PM
7	Anything to make the city look better. However, I would also like to see less constructions on the street. Construction is almost everywhere in DC. Why can't one project be completed then move on to another area. It's crazy with the detours a person has to take to get around DC because of the construction.	3/31/2020 3:26 PM
8	I like rain tank on my roof for my use.	2/25/2020 2:38 PM
9	More tree planting, and practices to support tresses as SWM BMPs	2/14/2020 5:40 PM
10	More trash barrels on the streets R.O.W - particularly near public spaces. Also, perhaps combined trash/recycle barrels.	1/27/2020 11:28 AM
11	?	1/27/2020 9:29 AM
12	At the end of the 1900 block of 39th St. NW	1/23/2020 4:27 PM
13	None	1/23/2020 3:30 PM
14	more waste and recycling receptacles to reduce trash and litter getting into GI infrastructure and storm drains	1/18/2020 12:54 PM
15	Grey water and compost systems for sure!	1/17/2020 2:25 PM
16	pocket wetlands	1/15/2020 8:52 PM

Q5 Does the green infrastructure installed bring a benefit to your neighborhood?

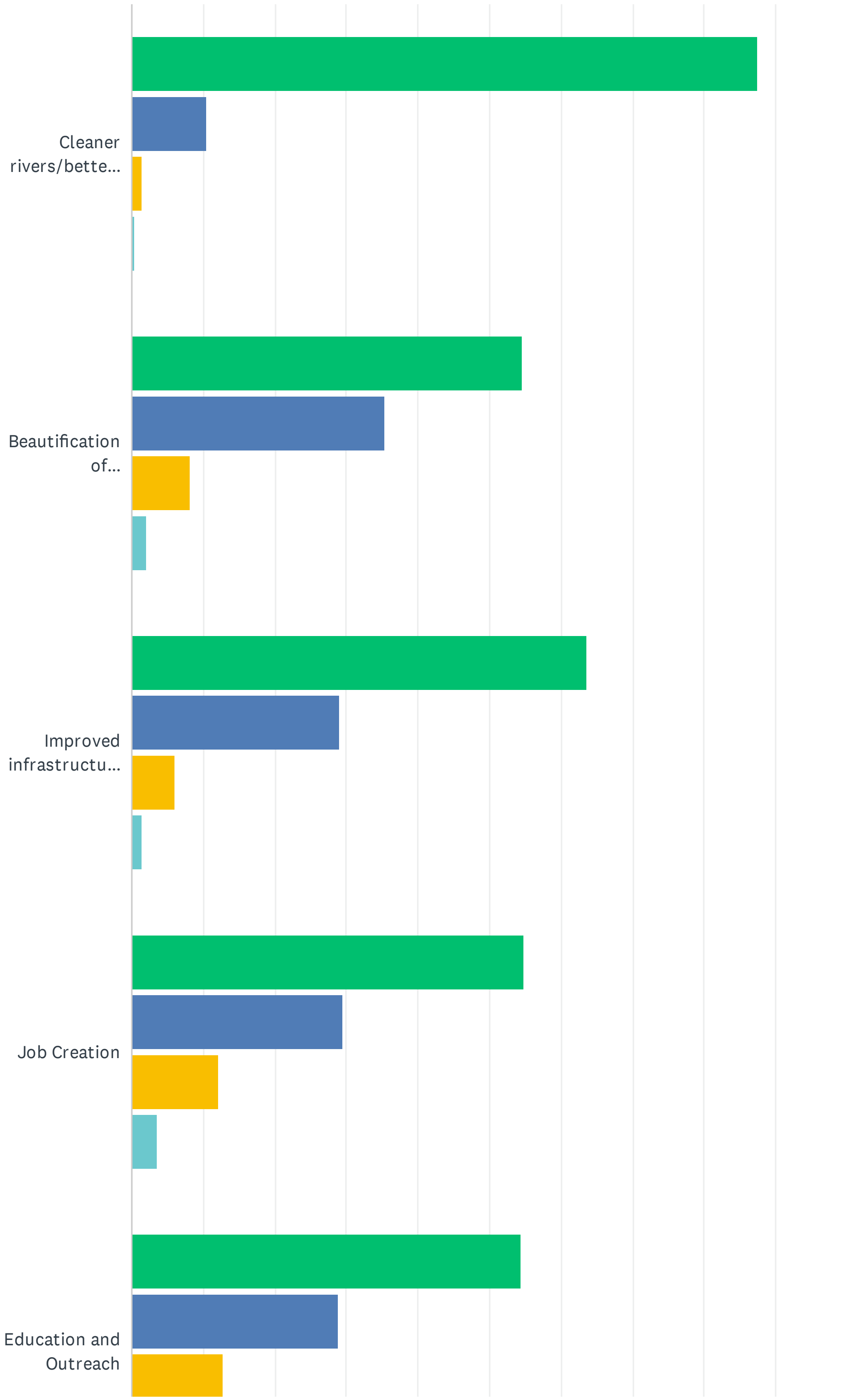
Answered: 201 Skipped: 5

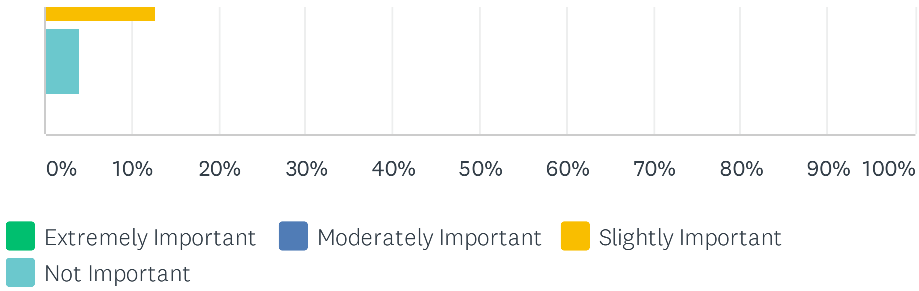


ANSWER CHOICES	RESPONSES	
A significant amount	38.31%	77
Quite a bit	26.87%	54
A little	16.92%	34
Not at all	2.49%	5
I do not know	15.42%	31
TOTAL		201

Q6 Rate importance of green infrastructure benefits to you.

Answered: 201 Skipped: 5

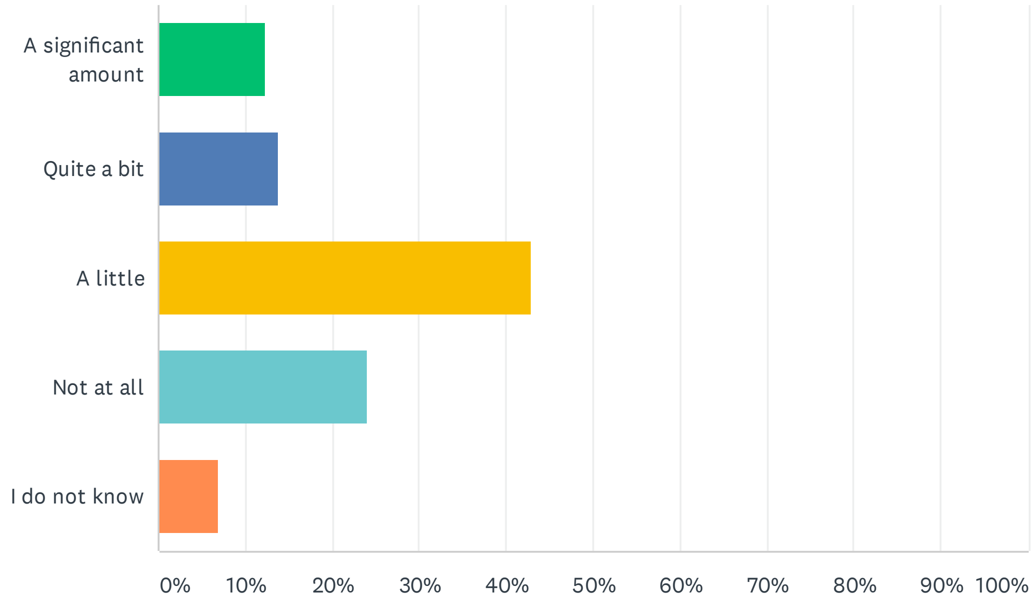




	EXTREMELY IMPORTANT	MODERATELY IMPORTANT	SLIGHTLY IMPORTANT	NOT IMPORTANT	TOTAL	WEIGHTED AVERAGE
Cleaner rivers/better water quality	87.50% 175	10.50% 21	1.50% 3	0.50% 1	200	3.85
Beautification of neighborhoods	54.55% 108	35.35% 70	8.08% 16	2.02% 4	198	3.42
Improved infrastructure (i.e. repaved alleys)	63.50% 127	29.00% 58	6.00% 12	1.50% 3	200	3.54
Job Creation	54.82% 108	29.44% 58	12.18% 24	3.55% 7	197	3.36
Education and Outreach	54.31% 107	28.93% 57	12.69% 25	4.06% 8	197	3.34

Q7 How disruptive was the construction of green infrastructure to your day-to-day life?

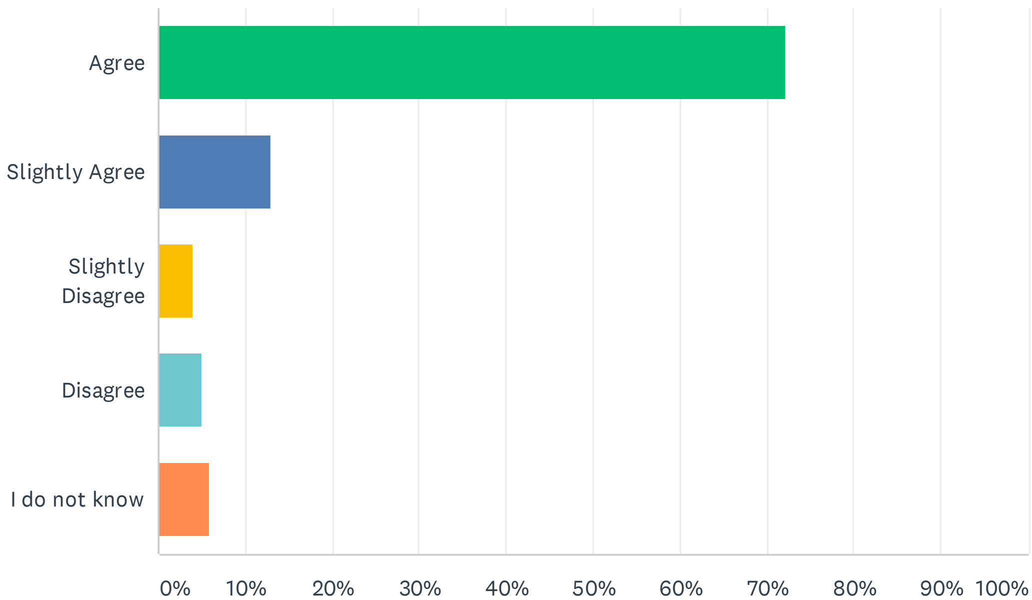
Answered: 203 Skipped: 3



ANSWER CHOICES	RESPONSES	
A significant amount	12.32%	25
Quite a bit	13.79%	28
A little	42.86%	87
Not at all	24.14%	49
I do not know	6.90%	14
TOTAL		203

Q8 Do you agree with the following statement: The benefit of green infrastructure outweighs the disruption of construction.

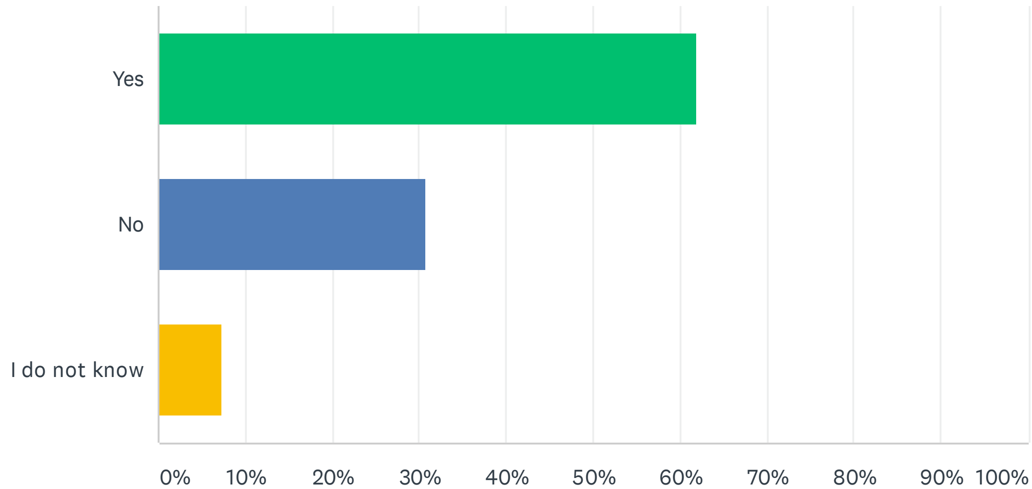
Answered: 202 Skipped: 4



ANSWER CHOICES	RESPONSES	
Agree	72.28%	146
Slightly Agree	12.87%	26
Slightly Disagree	3.96%	8
Disagree	4.95%	10
I do not know	5.94%	12
TOTAL		202

Q9 Do you agree with the following statement: I was aware that DC Water was bringing green infrastructure to my neighborhood before construction started.

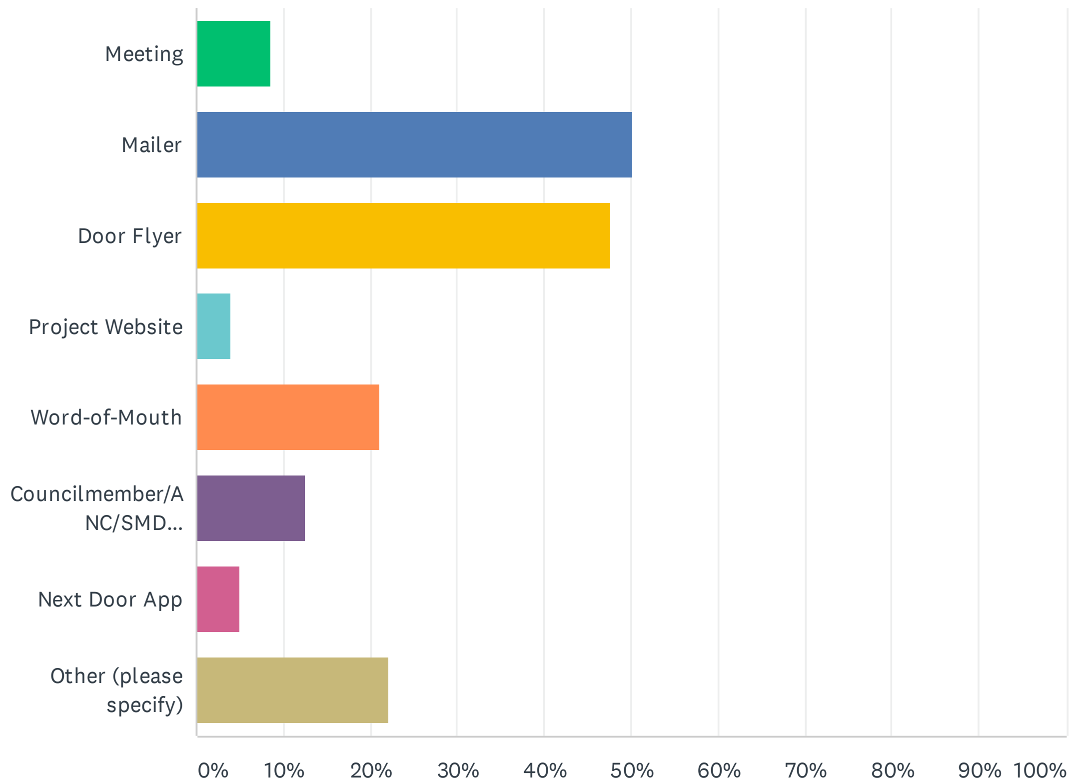
Answered: 202 Skipped: 4



ANSWER CHOICES	RESPONSES	
Yes	61.88%	125
No	30.69%	62
I do not know	7.43%	15
TOTAL		202

Q10 How did you find out that green infrastructure was coming to your neighborhood? (Check all that apply).

Answered: 199 Skipped: 7



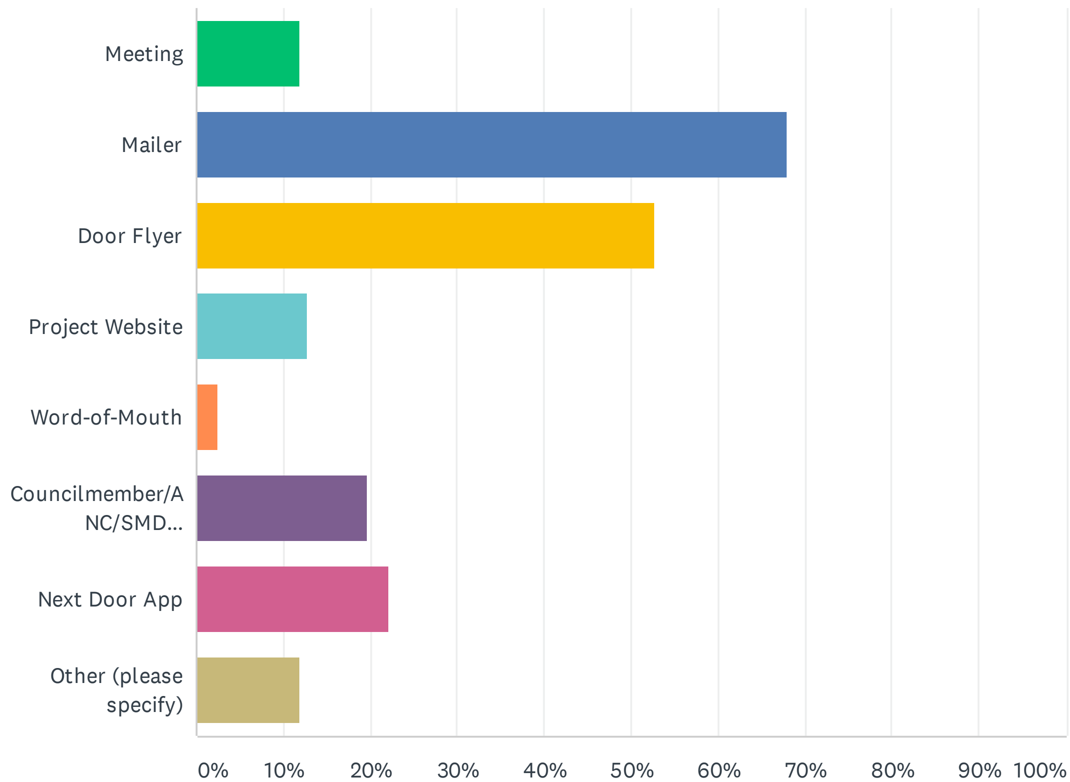
ANSWER CHOICES	RESPONSES	
Meeting	8.54%	17
Mailer	50.25%	100
Door Flyer	47.74%	95
Project Website	4.02%	8
Word-of-Mouth	21.11%	42
Councilmember/ANC/SMD Representative	12.56%	25
Next Door App	5.03%	10
Other (please specify)	22.11%	44
Total Respondents: 199		

#	OTHER (PLEASE SPECIFY)	DATE
1	We looked outside and saw the alley was blocked	4/3/2020 5:13 AM
2	I didn't find out until work began	4/1/2020 3:13 PM
3	Asked surveyors what they were doing	4/1/2020 11:18 AM
4	I never knew.	4/1/2020 10:34 AM
5	different social networks	4/1/2020 10:28 AM
6	Email	4/1/2020 10:25 AM
7	Just moved to the neighborhood	4/1/2020 9:57 AM
8	Infrastructure was complete prior to my moving to this neighborhood.	4/1/2020 8:03 AM
9	Found out due to receipt of this survey	3/31/2020 8:17 PM
10	Honestly I do not remember the specifics but I knew it was happening.	3/31/2020 7:08 PM
11	No notification to date.	3/31/2020 6:20 PM
12	Phone call from DCWATER	3/31/2020 4:21 PM
13	The just started tearing up our alley without notice, though when I complained to my council member, DC WASA claimed they put a notice on our door. We did not receive any such notice.	3/31/2020 3:41 PM
14	No door flyer or meaningful notice at a stage where we could be involved. Process violated federal and DC NEPA and the public meetings were ridiculous. It was cynical wasteful treatment of the affected public. Happy to expand on this if you contact me.	3/31/2020 3:33 PM
15	When they started working and caused many cracks in my home which drained my savings to repair some, but was never reimbursed. Really unconscionable since it created a big financial hardship for me. Really unjust.	3/31/2020 3:30 PM
16	I found out when they were doing it and parking all their equipment on my property where I couldn't even move my trash cans	3/31/2020 3:26 PM
17	THE DAY IT STARTED I ASKED A JOB SITE SUPERVISOR WHAT WAS HAPPENING	3/31/2020 3:11 PM
18	Construction started	3/31/2020 3:10 PM
19	The alley was re-done an after the fact my neighbor told me about the "green" part of it. In fact, I was not even notified that the work was being done and my car was blocked int my driveway for 2 weeks without notice.	3/31/2020 3:00 PM
20	walking by and seeing it	3/31/2020 2:50 PM
21	Just finding out	3/31/2020 2:49 PM
22	seeing construction as it happens	2/25/2020 3:03 PM
23	DC Water attended annual picnic	2/13/2020 9:50 AM
24	The team showed up in an alley.	2/6/2020 10:24 AM
25	This Survey	1/30/2020 9:49 AM
26	Some features were in place when I moved here.	1/27/2020 11:28 AM
27	Saw Crews Working	1/27/2020 10:58 AM
28	Local website: www.burleith.org	1/27/2020 10:52 AM
29	?	1/27/2020 9:29 AM
30	Literally this flyer	1/23/2020 5:03 PM
31	This Survey	1/23/2020 5:01 PM
32	Community association Group	1/23/2020 4:54 PM

33	Trucks & Workers disrupting alley with no notice.	1/23/2020 4:13 PM
34	Seeing the results after construction	1/23/2020 4:03 PM
35	I didn’t know. I thought the construction had something to do with the bus depot.	1/23/2020 1:05 AM
36	flyers on the trees	1/20/2020 10:12 PM
37	yard signs	1/20/2020 6:23 PM
38	I was not alerted. I just heard them working in the alley.	1/19/2020 11:38 AM
39	Found out about it when construction began	1/18/2020 3:27 PM
40	pamphlet in the water bill	1/18/2020 12:53 PM
41	wasn't aware before alley work began	1/15/2020 5:47 PM
42	Already present	1/15/2020 1:05 AM
43	Listserv	1/14/2020 7:33 AM
44	Annual Burleith piicnic. You had a table with info	1/13/2020 2:51 PM

Q11 What is your preferred way to receive information about construction projects in your neighborhood? (Check two methods).

Answered: 203 Skipped: 3

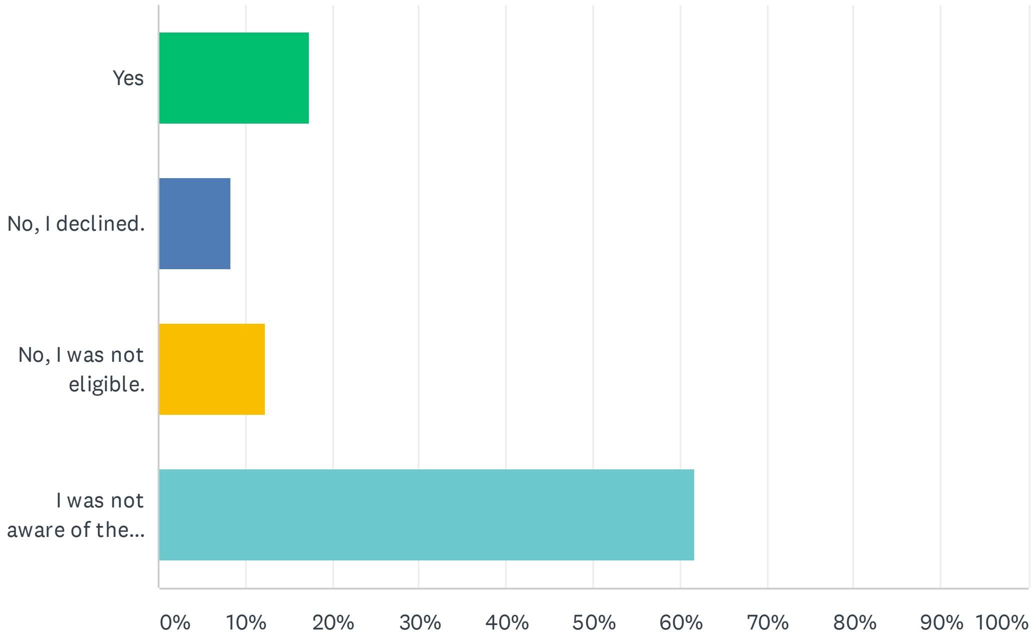


ANSWER CHOICES	RESPONSES	
Meeting	11.82%	24
Mailer	67.98%	138
Door Flyer	52.71%	107
Project Website	12.81%	26
Word-of-Mouth	2.46%	5
Councilmember/ANC/SMD Representative	19.70%	40
Next Door App	22.17%	45
Other (please specify)	11.82%	24
Total Respondents: 203		

#	OTHER (PLEASE SPECIFY)	DATE
1	Email	4/3/2020 5:13 AM
2	email	4/1/2020 3:13 PM
3	Email or text	4/1/2020 10:34 AM
4	email	4/1/2020 10:28 AM
5	Email	4/1/2020 10:25 AM
6	Email !!! send emails or add to neighbor list	4/1/2020 8:54 AM
7	Email	3/31/2020 8:17 PM
8	Email would be best if possible.	3/31/2020 6:20 PM
9	411 notifications	3/31/2020 3:39 PM
10	We do not want to be told of construction projects like green infrastructure after decisions have been made. This is a terrible question that misses the point. You must make sure citizens are informed and participate in the decision process while it is still in the decision stage.	3/31/2020 3:33 PM
11	I would prefer a mailer or even a voicemail	3/31/2020 3:26 PM
12	Email	3/31/2020 3:11 PM
13	Email would be great	3/31/2020 3:00 PM
14	email	2/25/2020 3:03 PM
15	email	2/14/2020 5:40 PM
16	email	2/4/2020 1:28 PM
17	News (TV)	1/30/2020 9:49 AM
18	Prefer any communication that does not generate litter - NO to mailers & flyers and even signage that is not removed after event.	1/27/2020 11:28 AM
19	co,,umity Blogs like Popville, Greater Greater Washington	1/27/2020 10:58 AM
20	Community Representative	1/23/2020 4:54 PM
21	email	1/20/2020 7:08 PM
22	the water bill notice was effective	1/18/2020 12:53 PM
23	Listserv	1/14/2020 7:33 AM
24	Email	1/13/2020 8:05 PM

Q12 Did you participate in DC Water's Downspout Disconnection and Rain Barrel Program (Drain the Rain)?

Answered: 201 Skipped: 5



ANSWER CHOICES	RESPONSES	
Yes	17.41%	35
No, I declined.	8.46%	17
No, I was not eligible.	12.44%	25
I was not aware of the program	61.69%	124
TOTAL		201

Q13 Additional Comments:

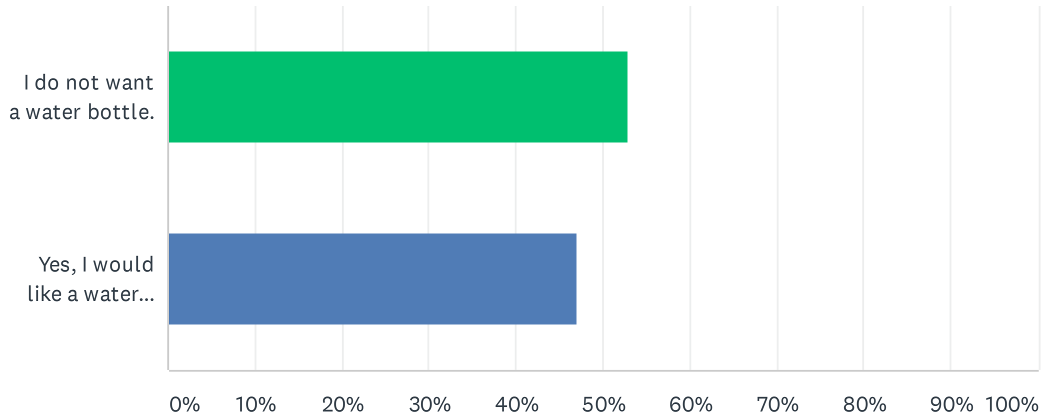
Answered: 33   Skipped: 173

#	RESPONSES	DATE
1	Wished you would installed permeable pavers throughout the entire alley.	4/3/2020 5:13 AM
2	i declined to participate in the downspout disconnection program because they did not offer rain barrels that would fit in the area near my downspout. A broader selection of rain barrel sizes and shapes would be helpful.	4/1/2020 4:28 PM
3	I would like to have an assessment of the community -- Cloisters West -- for water retention methods.	4/1/2020 10:28 AM
4	As much as I like my new alley, the permeable pavers/alley that was put in behind my house was EXTREMELY DISRUPTIVE. The door flyers kept coming and changing the dates. The last date on the last door flyer came and went. No construction. Then out of the blue work started and lasted over 6 weeks. It was insane. I couldn't get in and out of my driveway, which is a problem because as a healthcare worker, my schedule was insane and street parking was really hard to come by during those 6 weeks. Additionally, I had to call the project manager multiple times because THERE WAS NO PLAN IN PLACE FOR TRASH PICKUP. The PM said the construction workers were supposed to move our bins for us, but that rarely happened, and trash and recycling was piling up. It was gross. AND the trash/recycle trucks would completely skip our alley because the part that wasn't under construction was still blocked by their trucks. It was infuriating. Rats are gross. Our alley was nasty. I was so pissed one day I dumped my trash in their machines because despite the notes I tried to leave them and the calls I constantly had to make, no one was picking up our trash. GROSS. So next time you start a project, have a trash plan in place. Tell the residents the plan and MAKE SURE THE WORKERS DO WHAT THEY'RE SUPPOSED TO. AND YOU SHOULD LET US KNOW THE ACTUAL DATE YOU ARE GOING TO START AND A PROJECTED END DATE. 6 Weeks for half a fucking alley is ridiculous. Love the end result, but come on, be more efficient.	4/1/2020 1:00 AM
5	I just found out about the rain barrel program and would like to participate.	3/31/2020 7:25 PM
6	I have never seen such poorly managed construction. Unfortunately, as a water user I get to pay for this.	3/31/2020 4:15 PM
7	If there is construction that disrupts street parking, lift parking restrictions on or around the block(s) (e.g., temporarily suspend ticketing of vehicles parked in front of no parking signs near construction areas at night) to reduce frustration to residents living near construction areas)	3/31/2020 4:00 PM
8	Ever since our alley was "improved," we have noticed significant disruption to the water table in our area. We have noticed significant settling of the ground of our back yard and, for the first time in 14 years of living in this house, we have started to have water back up into our basement during heavy rains. It comes from the floor and interior basement walls and is not the result of running water traveling to the house. We are being forced to expend significant money to have a sump pump installed, whereas prior to the "improvements" this was not necessary.	3/31/2020 3:41 PM
9	I was told that I was not eligible, however, most of my neighbors have a Rain Barrel. I'd like for someone to re-visit my home at [redacted] and consider installing a Rain Barrel for my home. Thank you.	3/31/2020 3:39 PM
10	This project was carried out without legal compliance with notice and comment requirements. It was performed by Fort Myer Construction company, known for a history of misconduct, corruption and poor performance. I was assured there would be adequate oversight of their work. There was not. They knocked into a streetlight on 36th St. NW where it intersects with the alley between Whitehaven and T. This lamp post remains leaning. I have photos of the equipment that did the damage. Moreover, the green alley on the west side of 35th Place NW, just south of Whitehaven, has badly cracked in less than a year. Clearly substandard work. The company (Fort Myer) needs to correct these things at their expense and the public needs assurance this is happening. Also, no one needs a free water bottle. DC Water is a terrible company and our rates are ridiculous. Stop doing things like offering free water bottles that we pay for. And explain to the public how the generous programs for free or reduced water charges work. Isn't that generosity being paid for by the rest of us???	3/31/2020 3:33 PM
11	When work done at the city's request result in damage to property, we should not have to should the expense, especially seniors on very limited income. Very limited. And I may lose my home.	3/31/2020 3:30 PM
12	The construction during this process left the tree box area in front of my house and half of the 5200 2nd Street NW block a total mess. There are dangerous lumps on the soil and soil erosion	3/31/2020 3:27 PM

	at the curb side. Many of us complained about this to your organization and DDOT. I personally had email communication with Ms. Zander but all you guys did was pass the buck and pass me back and forth between agencies. And nothing has happened. It is still a big mess.	
13	I don't know why I wasn't made aware of the participation in the DC Water Downspout since I see several houses on my block who has them. I read all mailers received from the DC Government.	3/31/2020 3:26 PM
14	Space saving rain barrels should be incorporated into the program for those with smaller lawns.	3/31/2020 2:57 PM
15	re: #12, they were talking to a neighbor about it when I was outside and I said sure let me know and I never heard back	3/31/2020 2:50 PM
16	We participate in River Smart Homes. We have 3 barrels.	2/6/2020 10:24 AM
17	I signed up for this last time & never received a call or mail materials	2/6/2020 10:07 AM
18	Tried, but to complicated. I paid for my water barrel	2/6/2020 9:52 AM
19	Still Considering	2/6/2020 9:28 AM
20	In the process of Participating.	1/30/2020 9:57 AM
21	Neighbors who did participate said barrel leaked & flooded basement.	1/30/2020 9:52 AM
22	I am interested	1/30/2020 9:29 AM
23	Everything is good	1/27/2020 11:19 AM
24	We have a rain barrel	1/27/2020 9:18 AM
25	Through my neighbor	1/23/2020 4:54 PM
26	I applied, no response	1/23/2020 4:21 PM
27	We would like to participate - Rain Barrel!	1/23/2020 4:13 PM
28	I was previously a participant in the RiverSmart program so already had rain barrels.	1/16/2020 12:30 AM
29	I would love to participate in any rain barrel programs	1/15/2020 10:51 PM
30	While the communication about the construction was associated with the green alley project was good, the communication about maintenance has been poor. Indeed, to my surprise, there was a crew blocking the alley and kicking up dust using a heavy machine last summer for which there was no notice. If that kind of intrusive maintenance is going to happen, there needs to be some notice so that neighbors know not to be in their backyards or so that they can move their cars.	1/15/2020 9:45 AM
31	First, the team in our neighborhood - Glover Park - was wonderful. They were always pleasant, informative, and did their best to minimize disruption. It was a long project though - lots of weather delays. I would be all for more green infrastructure if we know more about the benefits. My understanding is that this was pretty experimental. I'd like to know more about the costs and benefits of this versus other options to be greener and change behavior. Can a few select blocks and alleys make a big difference? If yes, please bring more. The pavers make the neighborhood look better. I fear the rain gardens could become trash pits. I hope not.	1/14/2020 11:29 PM
32	Renter	1/14/2020 11:06 AM
33	My only complaint during construction of the green alley was the pavers were higher than the prior surface and my back gate wouldn't open. No one from the construction team was aware of the problem. I had to hire someone to come change my back gate door so I would have access to the alley.	1/13/2020 4:19 PM

Q14 A free water bottle is available for completing this survey. If you would like a free water bottle, select yes and enter your contact information.

Answered: 204 Skipped: 2



ANSWER CHOICES	RESPONSES	
I do not want a water bottle.	52.94%	108
Yes, I would like a water bottle.Provide Address and Email/Phone Number (required to receive water bottle):	47.06%	96
TOTAL		204

#	YES, I WOULD LIKE A WATER BOTTLE.PROVIDE ADDRESS AND EMAIL/PHONE NUMBER (REQUIRED TO RECEIVE WATER BOTTLE):	DATE
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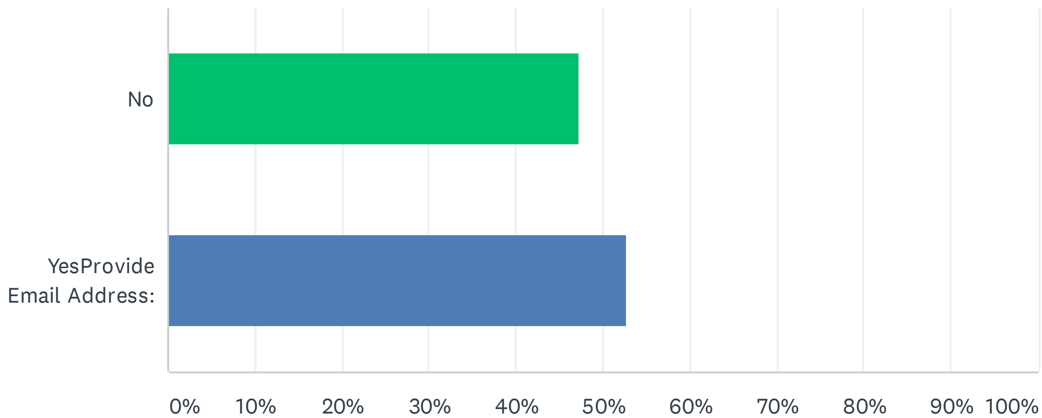
Q15 Would you like us to include you in future emails/updates? If so, select yes and enter your email address.

Answered: 199   Skipped: 7



ANSWER CHOICES	RESPONSES	
No	47.24%	94
YesProvide Email Address:	52.76%	105
TOTAL		199

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Q16 Name (optional)

Answered: 62 Skipped: 144

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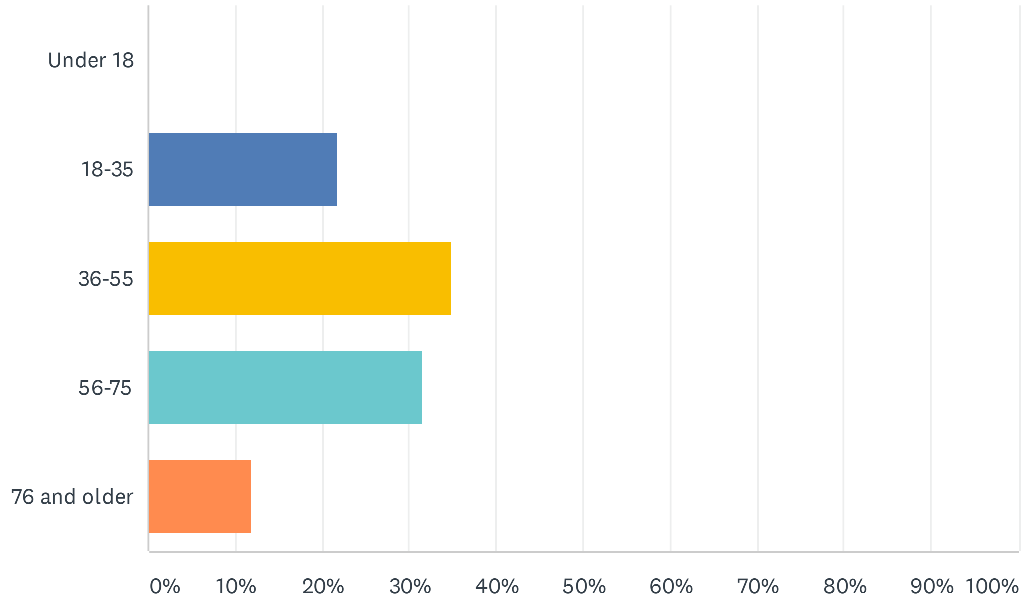
Q17 What is your age range? (optional)

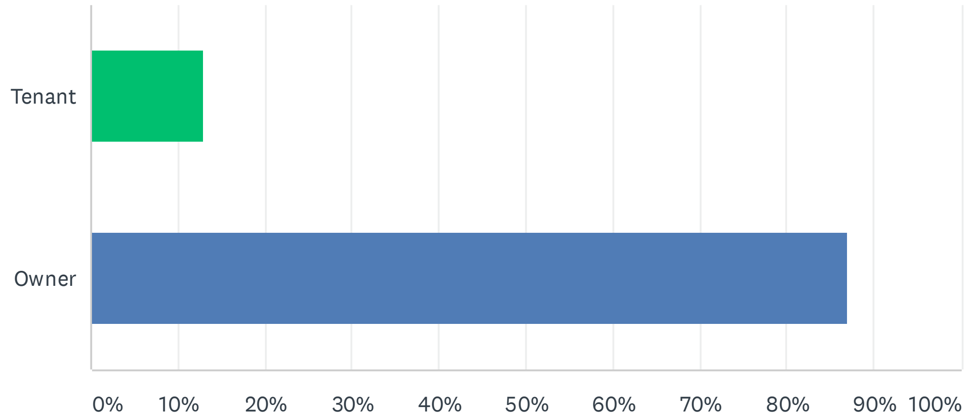
Answered: 203   Skipped: 3



ANSWER CHOICES	RESPONSES	
Under 18	0.00%	0
18-35	21.67%	44
36-55	34.98%	71
56-75	31.53%	64
76 and older	11.82%	24
TOTAL		203

Q18 Are you a tenant or owner at this property? (optional)

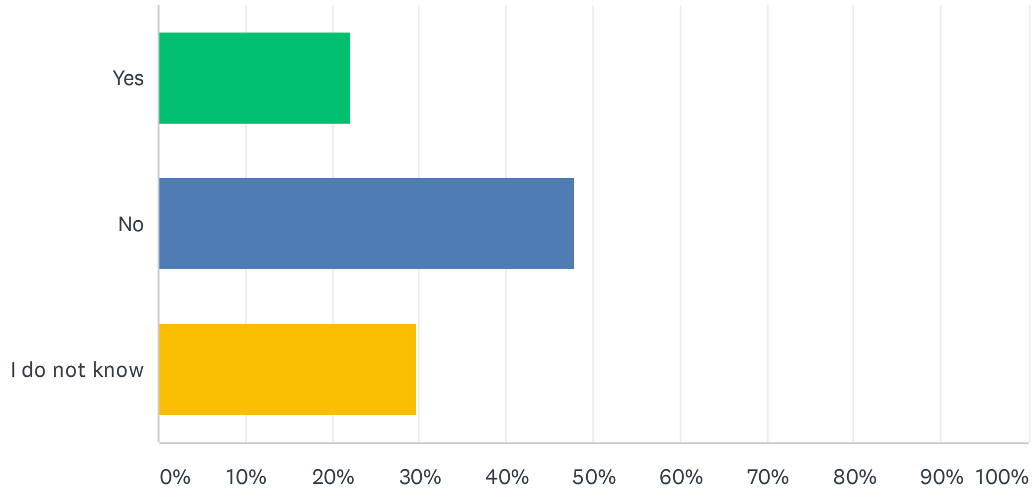
Answered: 200 Skipped: 6



ANSWER CHOICES	RESPONSES	
Tenant	13.00%	26
Owner	87.00%	174
TOTAL		200

Q19 Have you participated in DOEE’s RiverSmart Program? (optional)

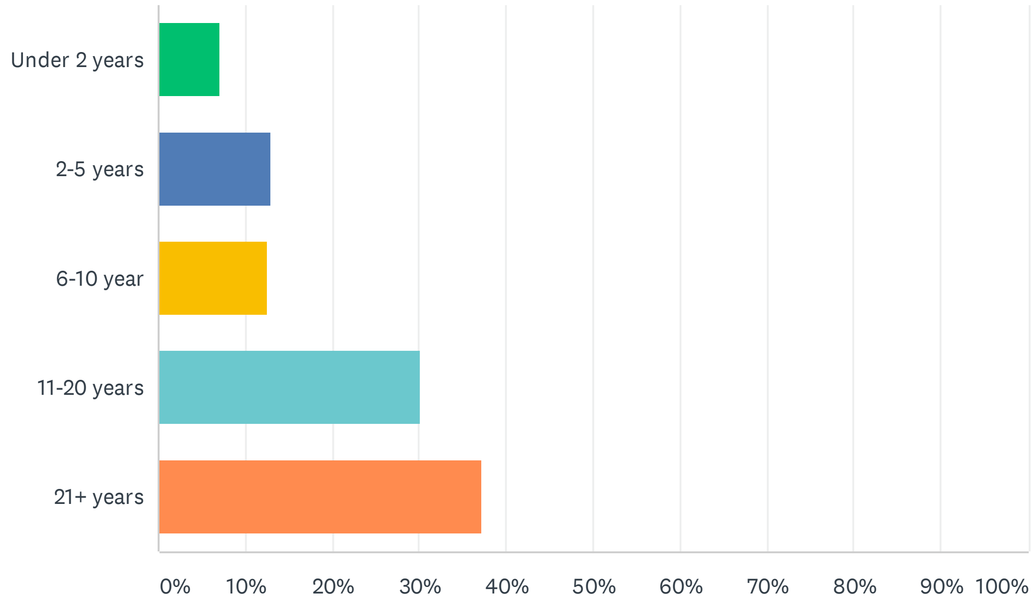
Answered: 198 Skipped: 8



ANSWER CHOICES	RESPONSES	
Yes	22.22%	44
No	47.98%	95
I do not know	29.80%	59
TOTAL		198

Q20 How long have you lived in the District? (optional)

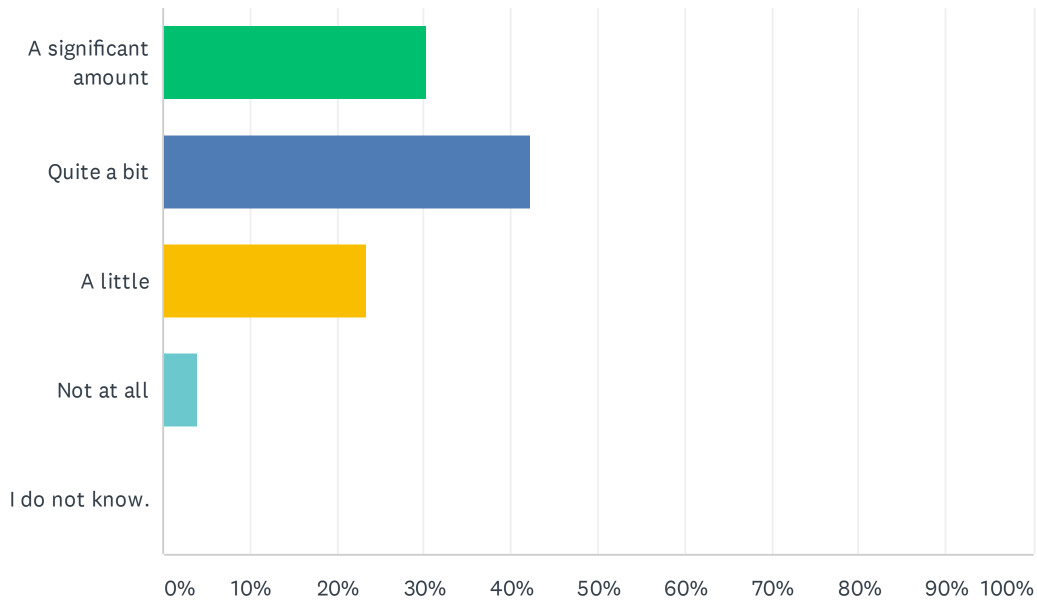
Answered: 199 Skipped: 7



ANSWER CHOICES	RESPONSES	
Under 2 years	7.04%	14
2-5 years	13.07%	26
6-10 year	12.56%	25
11-20 years	30.15%	60
21+ years	37.19%	74
TOTAL		199

Q21 Do you consider environmental impacts when making decisions and purchases? (optional)

Answered: 201   Skipped: 5



ANSWER CHOICES	RESPONSES	
A significant amount	30.35%	61
Quite a bit	42.29%	85
A little	23.38%	47
Not at all	3.98%	8
I do not know.	0.00%	0
TOTAL		201

Appendix H

Utility Protection Guidelines

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DC WATER GREEN INFRASTRUCTURE
UTILITY PROTECTION GUIDELINES

PURPOSE
The DC Water Green Infrastructure Utility Protection Guidelines (Guidelines) provide guidance on the design and construction of green infrastructure adjacent or connected to DC Water utilities. The Guidelines provide information related to the following practices: street tree planting, trees and tree box filters; bioretention and bioswales; permeable pavements and pavers; alleys with bioretention; and underdrains adjacent to catch basins. DC Water utilities adjacent to, crossing, or connected to these green infrastructure practices include water mains, sewers, water services, sewer laterals, meters, shutoffs, valve boxes, cleanouts, hydrants and other structures.

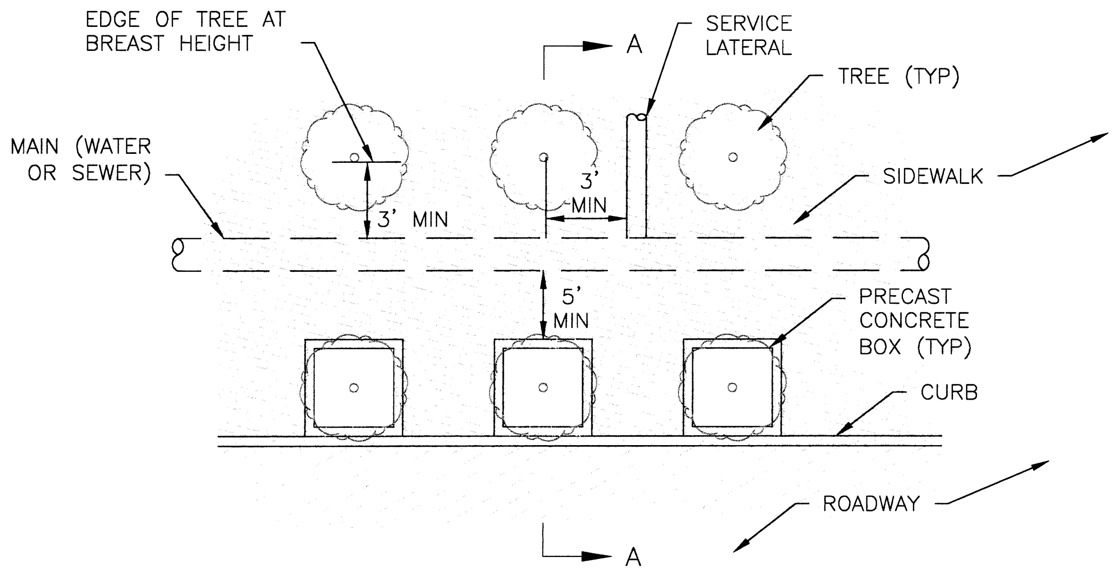
DEVELOPMENT
The development of these Guidelines included consultation with other agencies, analysis of similar guidelines in other localities and a review of local regulations (including the District of Columbia Municipal Separate Storm Sewer System permit). The specific requirements outlined herein reflect the due diligence performed as part of the development process.

USE
This document should be used by professionals to assist in the design, siting and installation of green infrastructure without conflicting with DC Water-owned utilities. In addition to these Guidelines, users of this document should follow all applicable local and federal regulations associated with their project. Waivers from these Guidelines are subject to review and approval from DC Water. Granting of waivers is at the sole discretion of DC Water.

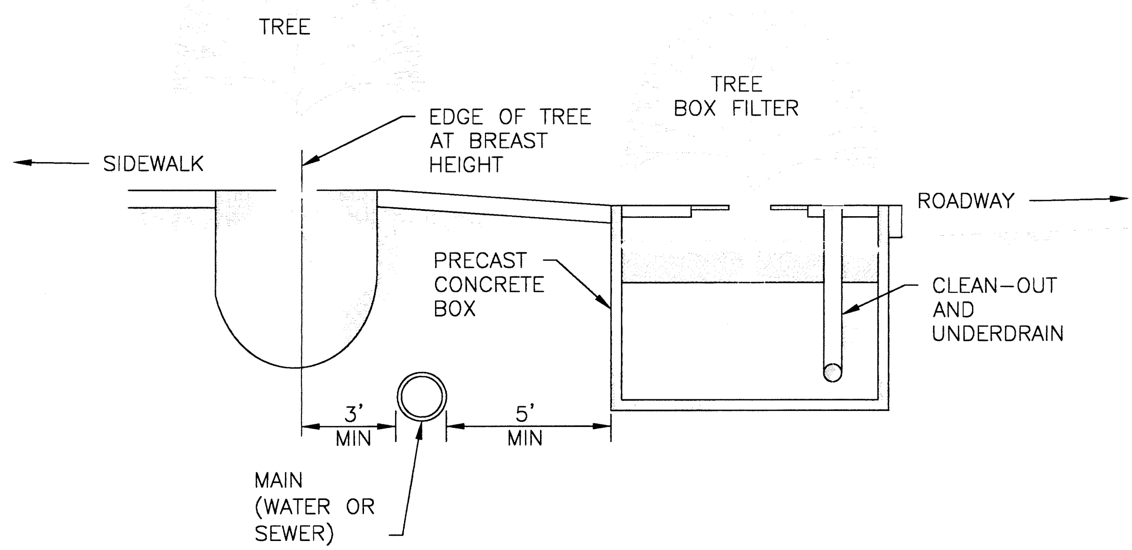
These guidelines represent a living document and will be updated as necessary to reflect the most current science and technology available.

AUTHORITY
DCMR – 12 (Construction Codes), Section 102.2 – Public Works Standards: Work performed in public space, not specifically addressed in the Construction Codes, shall conform to the pertinent standards of the District of Columbia Department of Transportation (DDOT) and the District of Columbia Water and Sewer Authority.

GENERAL
Proprietary materials removed by utility work performed by DC Water will be replaced with standard construction materials that have flow transmission capability (i.e. #57 stone). Structural / proprietary devices, including but not limited to, structural soil framing systems, precast concrete boxes, and cast in place walls, shall not be placed within 5' horizontally of the outer edge of DC Water utilities.



PLAN

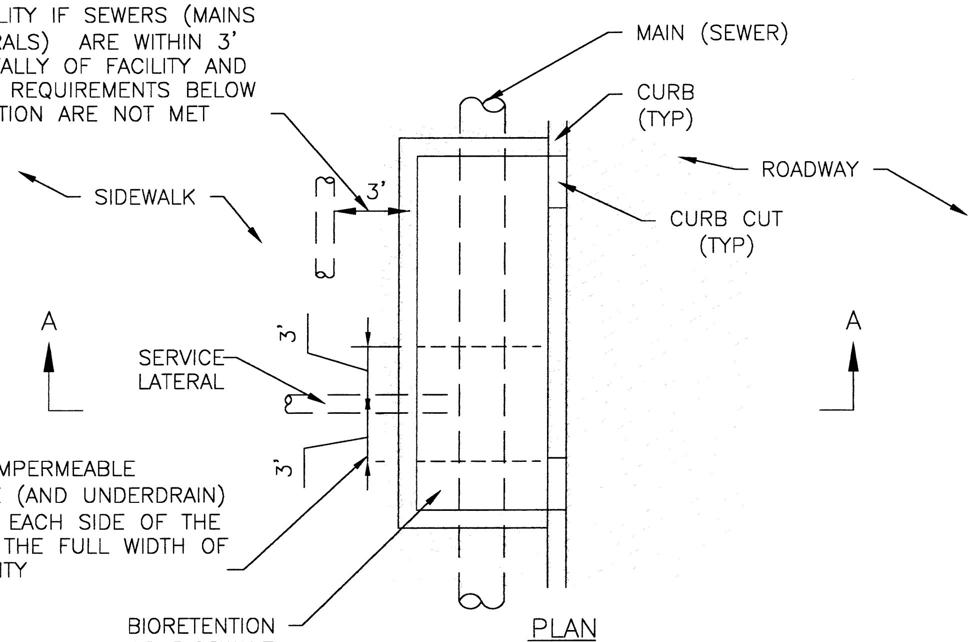


SECTION A–A

NOTES:

1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. HORIZONTAL CLEARANCE IS 3' MIN FOR TREES FROM OUTER EDGE OF TREE AT BREAST HEIGHT TO OUTER EDGE OF UTILITY. WHEN MIN DISTANCE CANNOT BE MET, EXCEPTIONS MAY BE GRANTED IF THE UTILITY IS GREATER THAN 15' BELOW FINISHED GRADE, OR OTHERWISE APPROVED BY DC WATER.

APPROVED DATE: 7-19-13 CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL WATER AND SEWER CLEARANCES FOR TREES



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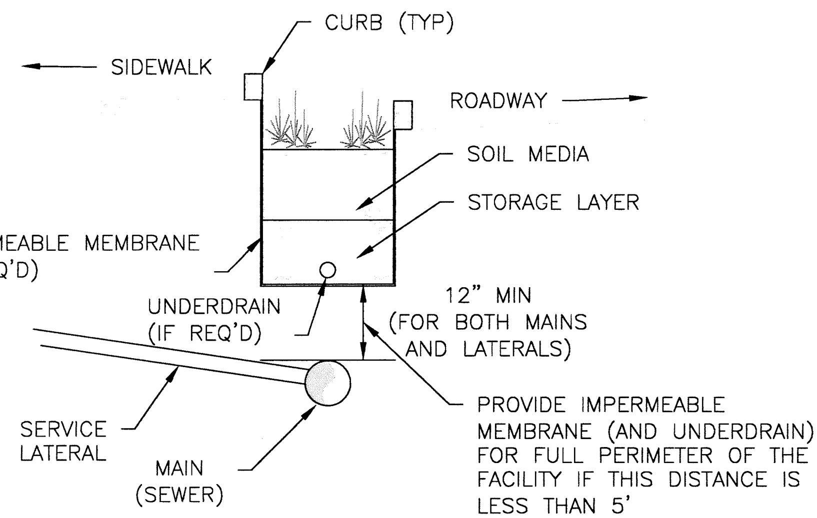
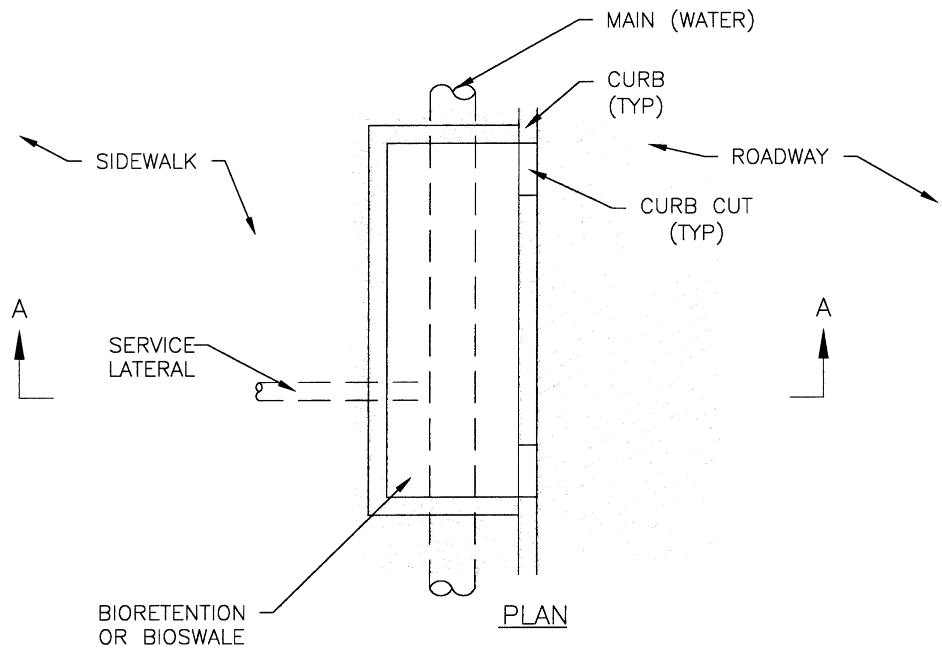
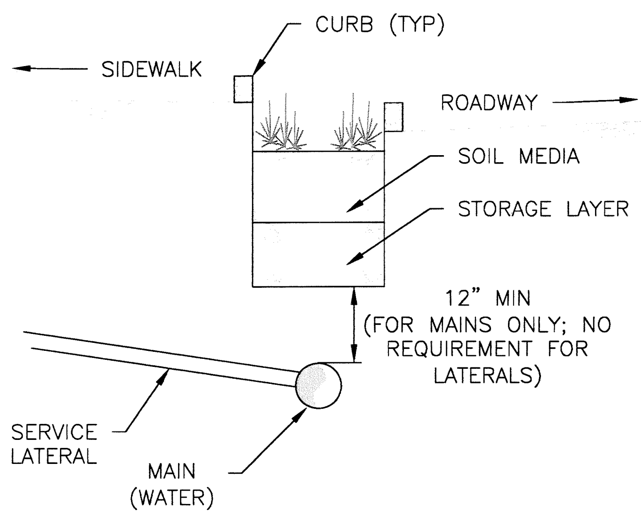


SECTION A–A

NOTES:
1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. BIORETENTION OR BIOSWALES SHALL NOT DISTURB PIPE BEDDING AS IDENTIFIED IN DC WATER'S DESIGN MANUAL.
3. LINING SEWERS AND LATERALS FROM MANHOLE TO MANHOLE IS REQUIRED IF THE IMPERMEABLE MEMBRANE (AND UNDERDRAIN) IS NOT USED.

APPROVED DATE: 7-19-13 Ensaw CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL SEWER CLEARANCES FOR BIORETENTION AND BIOSWALES

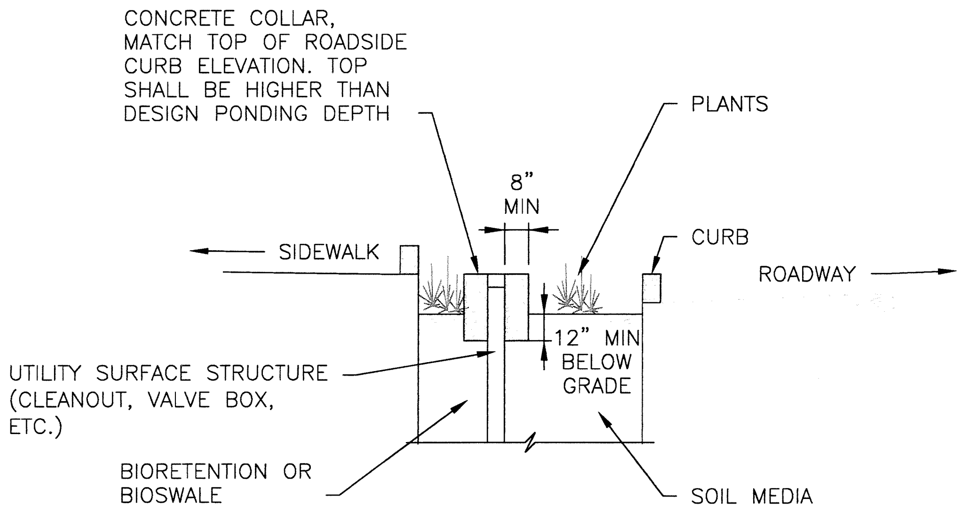




NOTES:

1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. BIORETENTION OR BIOSWALES SHALL NOT DISTURB PIPE BEDDING AS IDENTIFIED IN DC WATER'S DESIGN MANUAL.
3. WATER SERVICE PIPES GREATER THAN 2" IN DIAMETER SHALL BE CONSIDERED AS WATER MAINS.
4. WATER SERVICE LATERALS SHALL NOT BE EXPOSED AND HAVE 18" SOIL COVER, MIN.

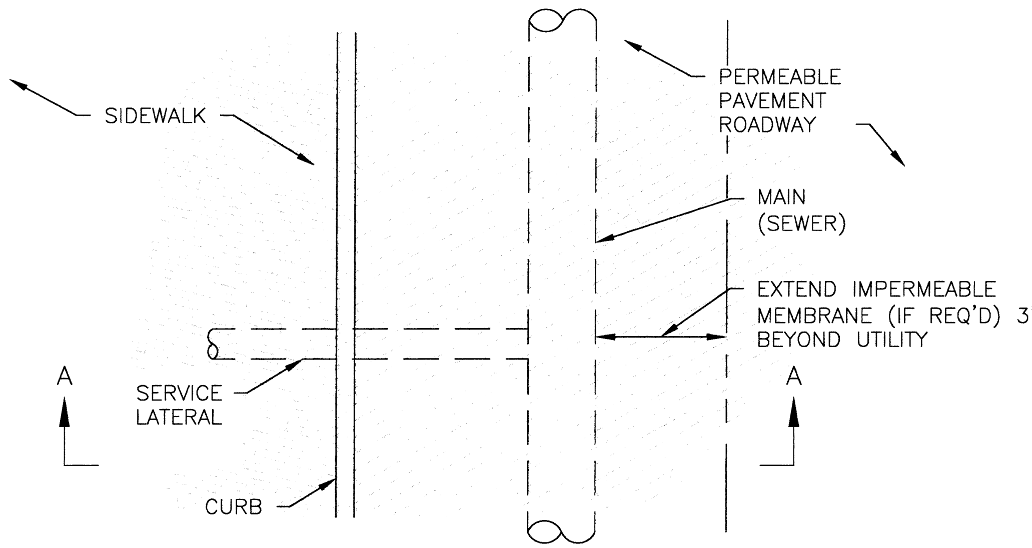
APPROVED DATE: 7-19-13 Zenaw CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL WATER CLEARANCES FOR BIORETENTION AND BIOSWALES



SECTION

NOTE:
GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.

APPROVED DATE: 7-19-13 CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL UTILITY SURFACE STRUCTURES FOR BIORETENTION AND BIOSWALES



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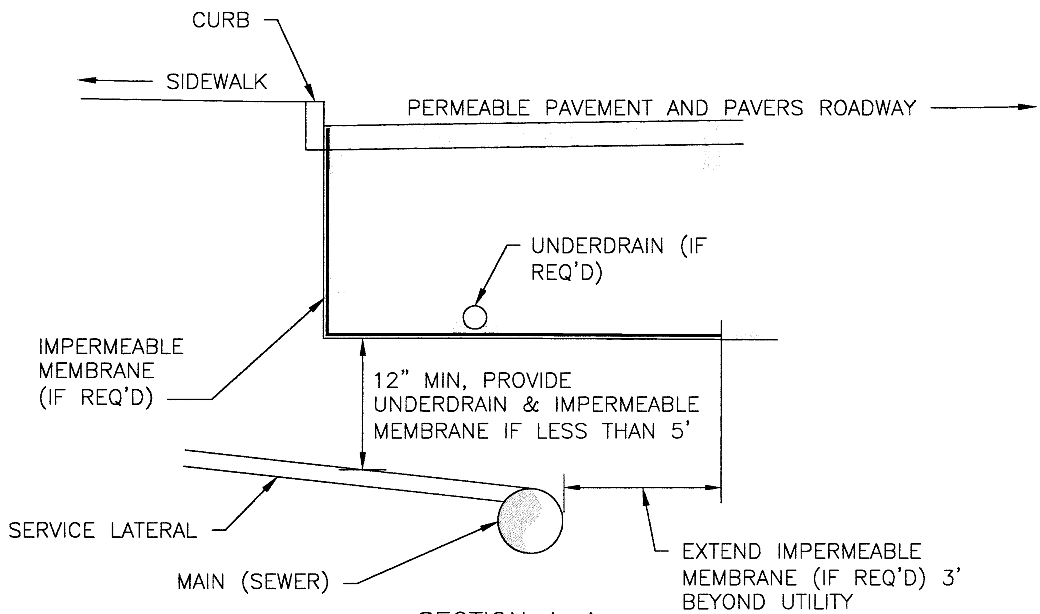
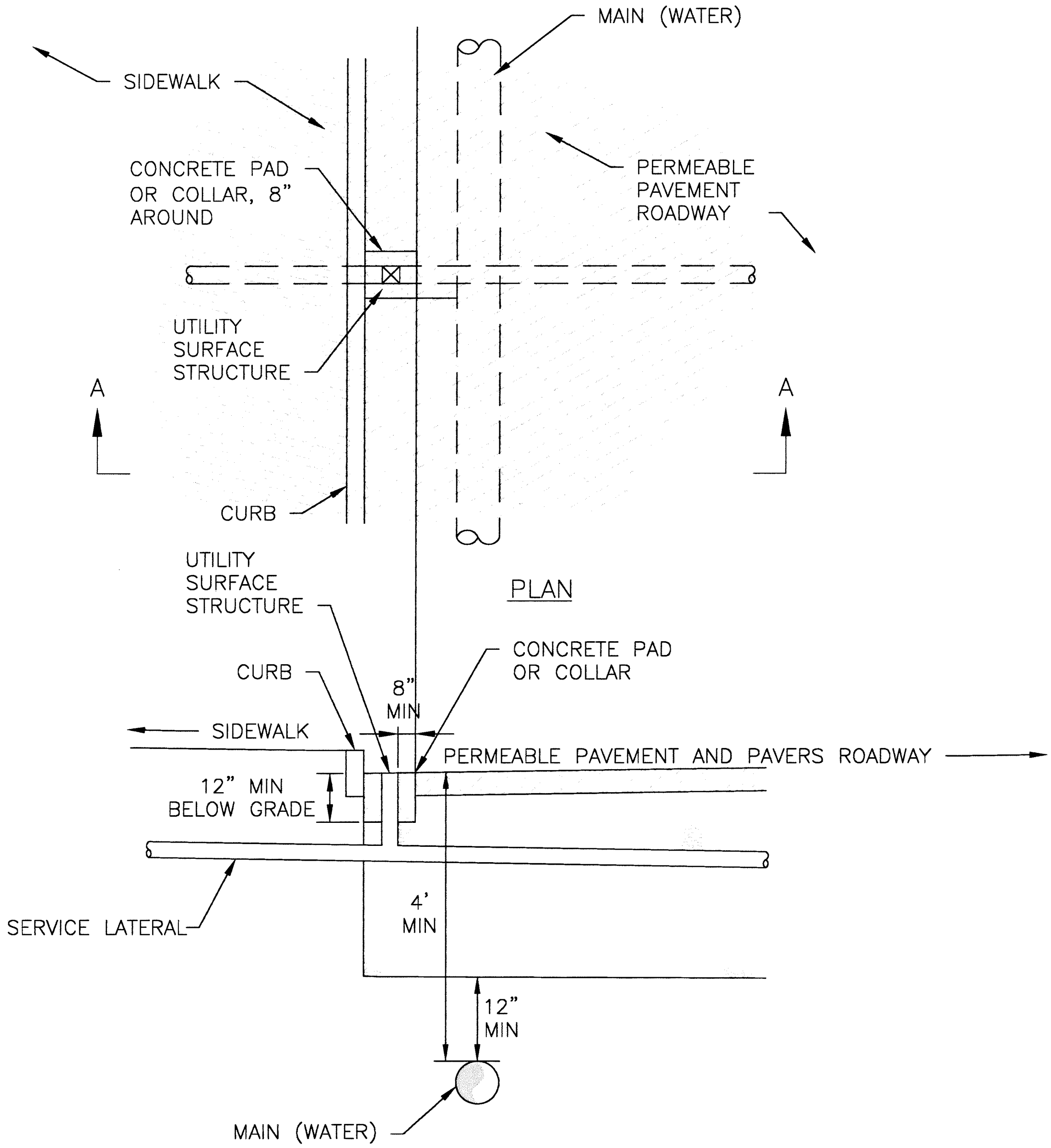


SECTION A–A

NOTES:

1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. PERMEABLE PAVEMENT AND PAVER SYSTEMS SHALL NOT DISTURB PIPE BEDDING AS IDENTIFIED IN DC WATER'S DESIGN MANUAL.
3. LINING SEWERS AND LATERALS FROM MANHOLE TO MANHOLE IS REQUIRED IF THE IMPERMEABLE MEMBRANE (AND UNDERDRAIN) IS NOT USED.

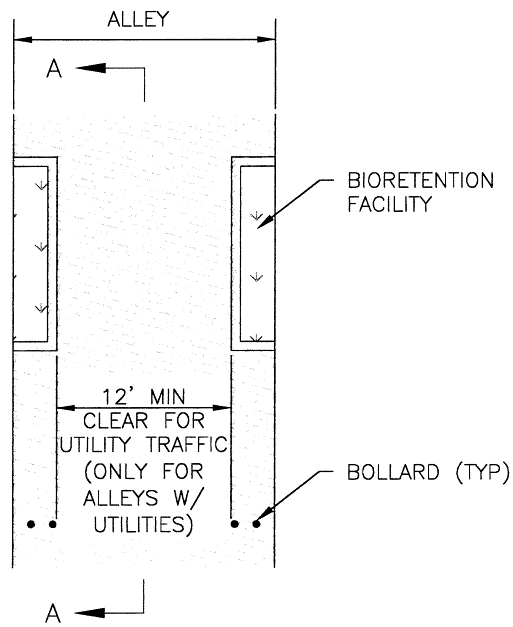
APPROVED DATE: 7-19-13 CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL SEWER CLEARANCES FOR PERMEABLE PAVEMENTS AND PAVERS



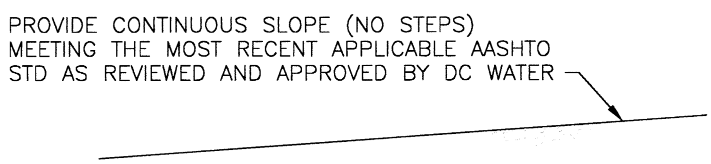
SECTION A–A

NOTES:
1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. PERMEABLE PAVEMENT AND PAVER SYSTEMS SHALL NOT DISTURB PIPE BEDDING AS IDENTIFIED IN DC WATER'S DESIGN MANUAL.
3. WATER SERVICE PIPES GREATER THAN 2" IN DIAMETER SHALL BE CONSIDERED AS WATER MAINS.

APPROVED, DATE: 7-19-13 CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL WATER CLEARANCES FOR PERMEABLE PAVEMENTS AND PAVERS



PLAN

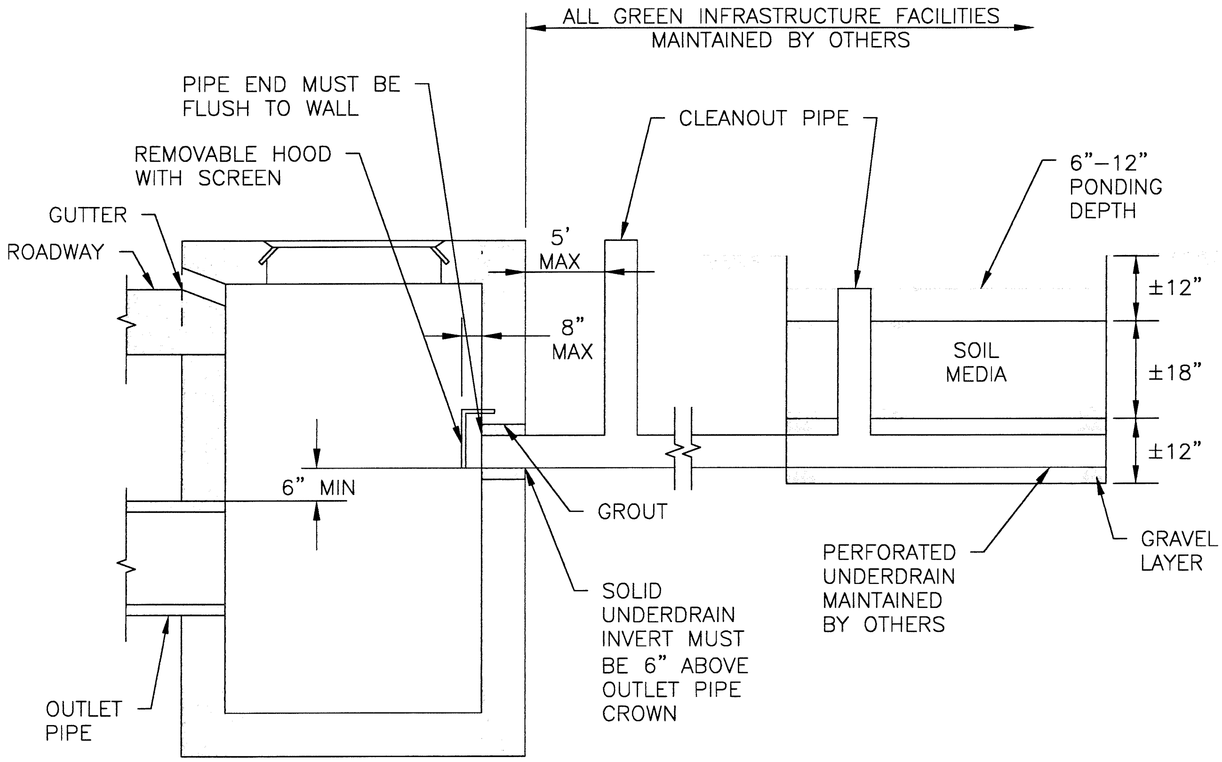


SECTION A–A

NOTE:

1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. THIS DETAIL IS ONLY APPLICABLE FOR ALLEYS WITH WATER AND SEWER UTILITIES.
3. LARGE STRUCTURES WITH FOUNDATIONS SHALL NOT BE PLACED WITHIN 5' OF DC WATER UTILITIES.

APPROVED DATE: 7-19-13 Emon CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL WATER AND SEWER CLEARANCES FOR ALLEYS WITH BIORETENTION



SECTION

NOTES:
1. GREEN INFRASTRUCTURE MEASURES SHALL MEET OTHER APPLICABLE DDOT, DDOE AND DC WATER STANDARDS.
2. THE PREFERRED LOCATIONS FOR CONNECTING UNDERDRAINS ARE AT MANHOLES AND SEWERS.
3. UNDERDRAIN CONNECTIONS TO CATCH BASINS ARE ONLY ALLOWED IF THE GREEN INFRASTRUCTURE FACILITY IS GREATER THAN 20' FROM AN EXISTING MANHOLE OR SEWER LINE OR IF TOTAL SURFACE AREA OF ALL GREEN INFRASTRUCTURE MEASURES IS LESS THAN 250 SQ FT.
4. CATCH BASIN CONNECTIONS FROM UNDERDRAINS SERVICING PRIVATE PROPERTY ARE PROHIBITED.
5. CLAY DAMS OR OTHER APPROVED WATERSTOPS SHALL BE PROVIDED AT 100' INTERVALS (MINIMUM ONE) ALONG THE LENGTH OF THE UNDERDRAIN TO PREVENT MIGRATION OF WATER ALONG THE LENGTH OF THE PIPE.
6. CLEAN OUTS SHALL BE PLACED AT 100 FOOT INTERVALS (MINIMUM ONE MUST BE LOCATED AT A MAX OF 5' FROM CATCH BASIN).
7. DC WATER IS NOT RESPONSIBLE FOR CLOGGING OF THE UNDERDRAIN OR FOR CLEANING.
8. THE UNDERDRAIN SYSTEM SHALL BE DESIGNED TO FILTER INCOMING WATER TO PREVENT THE MIGRATION OF SILT AND OR TURBIDITY TO THE SEWER SYSTEM.
9. UNDERDRAINS SHALL BE LOW-FLOW, SUBSURFACE PIPES THAT DRAIN ONLY THE GREEN INFRASTRUCTURE MEASURE.

APPROVED DATE: 7-19-13 CHIEF ENGINEER	REVISION NO.: 1 DATE: 07/19/13 PREPARED BY: DCCR CHECKED BY: J. CASSIDY	STANDARD DETAIL WATER AND SEWER CLEARANCES FOR UNDERDRAINS ADJACENT TO CATCH BASINS

Appendix I

National Green Infrastructure Certification Program (NGICP)

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NATIONAL
GREEN
INFRASTRUCTURE
CERTIFICATION
PROGRAM
ngicp

Water Environment Federation
the water quality people®

BODY OF KNOWLEDGE

Initiated under the leadership of DC Water and the Water Environment Federation, the National Green Infrastructure Certification Program (NGICP) sets national certification standards for green infrastructure (GI) construction, inspection and maintenance workers. Designed to meet international best-practice standards, the certification advances the establishment of sustainable communities by promoting GI as an environmentally and economically beneficial stormwater management option, supporting the development of proficient green workforces and establishing a career path for skilled GI workers.

INTRODUCTION

The Body of Knowledge (BoK) is a document that lists the resources that were identified, reviewed and selected as reference materials for the technical basis of the National Green Infrastructure Certification Program (NGICP). Tables 1 through 6 represent the recommended foundational reference list to be used during the development of the NGICP. Table 7 represents a comprehensive list of all resources that were identified and reviewed.

The intended purpose of this list is to act as a "library" of prescreened reference material that is specifically applicable as knowledge needed to conduct tasks related to the construction, inspection and maintenance of green infrastructure systems. This material will be helpful as foundational references for individuals who are writing and reviewing the NGICP curricula, training materials, exam items and for certification candidates who are preparing to take the exam.

BACKGROUND

The District of Columbia Water and Sewer Authority (DC Water) and the Water Environment Federation (WEF), along with a group of partner organizations from all over the United States, are leading the development of a National Green Infrastructure Certification Program (NGICP) for construction, inspection and maintenance workers. The goal of this certification program is to provide a nationally recognized credential for individuals who install, inspect and maintain green infrastructure (GI) systems. In addition, the program will help support community-based job creation in U.S. cities investing in green infrastructure and create a skilled work force that has the needed knowledge to properly install, inspect and maintain these systems to ensure long-term, reliable performance.

The national green infrastructure certification is intended as an entry-level credential that will verify that certified individuals possess a well-rounded foundational knowledge about what green infrastructure is, how it is intended to function and how to properly install, maintain and visually verify its proper operation. The national program must focus on common aspects of green infrastructure that will be true in any region of the United States, regardless of climate, soil types, specific local regulations, etc. Specific regional aspects of green infrastructure must be addressed separately.

For the purposes of the NGICP, green infrastructure is defined as an approach to stormwater management that combines a variety of different technologies and practices that use natural systems or engineered systems that mimic natural processes to filter and store stormwater to protect local surface water quality. The certification program will address GI practices such as bioretention (rain gardens, bioswales, tree/planter boxes, tree trenches), green and blue roofs, permeable pavements, dry wells, rainwater harvesting (rain barrels, cisterns, rainwater harvesting systems), stormwater wetlands, as well as others. These practices help to capture and filter stormwater, holding it until it can be infiltrated or evapotranspirated or slowly released to gray infrastructure systems, managing the water locally in order to reduce flow to local stormwater or combined sewer systems and reducing the volume of water flowing directly to local waterways. Green infrastructure protects local surface water quality, reduces combined sewer overflows (CSOs), helps meet Municipal Separate Storm Sewer System (MS4) requirements, as well as provides additional triple-bottom-line (environmental, social and economic) benefits in the areas where they are correctly installed and properly maintained.

REVIEW OF MATERIALS

Materials reviewed include manuals, presentations (PPT), webcasts, related technical memorandums, books and outreach material such as on-line videos, brochures and factsheets. In addition, existing GI training materials from other utilities and related documents from other industry trade groups/organizations were also reviewed.

Although these materials were read through to ensure that they are applicable as foundational knowledge for GI construction, inspection and maintenance tasks, the technical accuracy of these materials has not been verified. The fact that they are included in this body of knowledge document in no way implies that these materials are endorsed, approved or verified in any way. The individual users must practice due diligence in the use and application of this information.

The materials are grouped by type – training material, jurisdiction, industry/trade group/organization, books, factsheets/brochures/forms/checklists and videos/webcasts. Several of the most applicable reference documents related to the core competencies identified as important to workers carrying out tasks in constructing, inspecting and maintaining green infrastructure are listed under each type.

1. REVIEW OF EXISTING GI TRAINING MATERIAL

The existing GI training materials reviewed included training materials produced by San Francisco Public Utilities Commission (SFPUC), Washington State Department of Ecology, Onondaga County, NY, Department of Energy and Environment (DOEE) District of Columbia and Alliance for the Chesapeake Bay. Also reviewed were PowerPoint slide presentations from workshops conducted by Northeast Ohio Stormwater Training Council (NEOSWTC) in 2014 and 2015. **Table 1** (page 9) provides a summary of existing GI training materials that are considered as additional resources for the NGICP.

There are highlights from several references that are particularly useful as background documents for the NGICP:

The SFPUC has developed a GI Construction Training Guidebook and four training modules (PowerPoint slide presentations):

- **Course 1.1** – Introduction to GI Construction
- **Course 1.2** – GI Site Management
- **Course 2.1** – Bioretention Planter Construction
- **Course 2.2** – Permeable Pavement Construction

This material was developed in 2015 and is being used by SFPUC to train local contractors working on their GI construction projects. It also includes a PDF titled "Tailgate Talks" that briefly discusses the construction/installation and maintenance of bioretention planters and permeable pavements.

The Washington State Department of Ecology's "Low Impact Development Operations and Training" PowerPoint slide presentation provides information about the following GI practices – bioretention, permeable pavement and green roofs. It includes diagrams and maintenance standards/procedures for each of the GI practices covered.

The "Green Infrastructure Maintenance Training" PowerPoint presentation by Onondaga County, NY, provides diagrams and maintenance information about the following GI practices – porous pavements, green roofs, rain gardens, green streets (vegetated curb extensions, sidewalk planters), cisterns/rain barrels, infiltration beds (dry well, infiltration bed, infiltration trench/tree trench). This material is presented as Appendix D of the Save the Rain Program's Green Infrastructure Maintenance Manual.

The materials from the NEOSWTC workshop in 2014 and 2015 provides extensive information and a variety of photos of the maintenance aspects of the following GI practices, as presented by:

- Bill Hunt of North Carolina State University (NCSU): swales, green roofs, cisterns and rainwater harvesting, bioretention, permeable pavement and parking lot best management practices (BMPs) (such as permeable pavement, sand filters and manufactured products)
- Brian Prunty, Stormwater Specialist, Summit Soil & Water Conservation District: Operations & Maintenance for Bioretention Stormwater Practices (Part 1 & 2)
- Roger Gettig, Director of Horticulture and Conservation: Plants for Rain Gardens and Bioretention

The Philadelphia Water Department developed a Green Infrastructure Maintenance Manual in 2014 that contains procedures for specific maintenance tasks. Each protocol provides information on required training, equipment/materials, health and safety issues and a detailed procedure for executing the tasks. Appendices provide supplementary reference materials including health and safety procedures, a comprehensive listing of typical maintenance personnel classifications and additional guidance on site access and permits. The GI practices addressed in this manual include stormwater tree trenches, rain gardens, stormwater planters, stormwater wetlands, bioswales, stormwater tree planters, rain barrels/cisterns, green roofs, pervious paving and blue roofs. They also have published a Plant Identification Manual in 2014 that provides concise information and photos for hundreds of plants and trees that are commonly used in GI practices.

2. JURISDICTIONAL STANDARDS/GUIDELINES (MANUALS, TECHNICAL BULLETINS, CONSTRUCTION AND DESIGN GUIDANCE DOCUMENTS)

Several jurisdictions within the United States and Canada provided information on low impact development (LID) practices, operation and maintenance (O&M) of various GI types, GI design standards, stormwater management manuals, technical bulletins, construction and design guidance documents, etc. These documents represent critical regional information but they include detailed information that is too localized to be widely applicable in the National GI Certification Program. Therefore, they provide important local information but the majority of the information is not suitable to be used as specific references to support the NGICP. **Table 2** (page 10) provides a summary of all reference materials (by jurisdiction) that are considered as additional resources for the NGICP.

The following utilities'/governments'/jurisdictions' standards and guidelines have been identified and collected in this Body of Knowledge:

- Bay Area Stormwater Management Agencies Association (BASMAA)
- Blue Water Baltimore
- Chesapeake Stormwater Network
- City of Atlanta, Watershed Department
- City of Columbus, OH
- City of New Orleans
- City of Omaha, NE
- City of Portland, OR
- City of Santa Barbara, CA
- City of Tucson, AZ
- Clean Water Services, OR
- Contra Costa Clean Water Program, CA
- Credit Valley Conservation, Canada
- DC Water
- Delta Institute, IL
- Department of Natural Resources and Environmental Control, DE
- District of Columbia's Department of Energy and the Environment
- District of Columbia's Department of Transportation
- Fairfax County Public Works and Environmental Services, VA
- Georgia Environmental Protection Division
- Louisiana Department of Environmental Quality
- Metropolitan Nashville—Davidson County, TN
- Metropolitan Sewer District of Louisville, KY
- Metropolitan St. Louis Sewer District, MO Department of Natural Resources
- Michigan Department of Environmental Quality
- Minnesota Pollution Control Agency
- Montgomery County, Maryland Department of Environmental Protection
- New York Department of Environmental Protection
- New York State

- North Carolina Department of Environment and Natural Resources
- Northeast Ohio Stormwater Training Council
- Northern Virginia Regional Commission
- Onondoga County, NY
- Pennsylvania Department of Environmental Protection
- Philadelphia Water Department
- Pima County, AZ
- Prince George's County, MD
- Seattle Public Utilities
- Southern California Stormwater Monitoring Coalition
- Tennessee Department of Environment and Conservation
- Urban Drainage and Flood Control District, CO
- U.S. Army Corps of Engineers
- U.S. Department of Transportation, Federal Highway Administration
- U.S. Environmental Protection Agency (USEPA)
- Virginia Department of Environmental Quality
- Washington State Department of Ecology
- West Virginia Department of Environmental Protection

3. INDUSTRY/TRADE GROUP/ORGANIZATION REVIEW

Table 3 (page 15) provides a summary of references from Industry/trade groups/organizations that were reviewed as potential additional resources for the NGICP. Several references with useful information on installation, inspection and maintenance aspects of GI are highlighted here.

The Interlocking Concrete Pavement Institute (ICPI) publishes a document titled, "Industry Guidelines for Permeable Interlocking Concrete Pavement in the United States and Canada". It is a PowerPoint presentation that can be downloaded. Also, at their website, www.icpi.org, they have a section dedicated to permeable pavers: there are resources useful for the NGICP that can be accessed by clicking on "Installation" and "Maintenance". On the permeable paver maintenance page, they have a downloadable document titled, "ICPI Inspector's Guide for PICP Installation and Maintenance".

The National Asphalt Pavement Association (NAPA) publishes a booklet labeled Information Series 131 that is titled, "Porous Asphalt Pavements for Stormwater Management: Design, Construction and Maintenance Guide". It was updated in 2008. This booklet can be purchased ($30 nonmember price) and downloaded from NAPA's website by following this link: https://store.asphaltpavement.org. Although approximately half of the 24-page guide booklet is dedicated to design aspects, this is still a valuable reference for porous pavement for the NGICP because it includes labeled cross sections of typical porous pavement, a step-by-step overview of the construction sequence and a brief discussion of post-construction and on-going maintenance considerations. There is also a materials discussion. It is focused on specifications for materials, which is more detailed than necessary for the NGICP.

The National Ready Mixed Concrete Association (NRMCA) has information regarding pervious concrete available at www.perviouspavement.org. This site has information pertinent to the NGICP that can be found by clicking on the "Benefits" button, the "Construction" button, the "Inspection and Maintenance" button and the "Materials" button at the top of the page.

In addition to the above, information on stormwater products was also collected from manufacturers of stormwater products used in various GI practices. They include:

- Chambers that replace the conventional stormwater retention/detention systems such as ponds, swales, pipe and stone trenches or beds, or concrete structures. These chambers may also be used as drywells
- An engineered biofiltration device with components similar to bioretention in pollutant removal and application but has been optimized for high volume/flow treatment in a compact system
- An engineered soil that meet typical specifications for road sub-base while allowing tree root growth (for use under porous pavements and with street trees)
- A prefabricated modular bioretention system made from high-quality precast concrete, that uses physical, chemical and biological processes to remove sediment, metals, nutrients, petroleum hydrocarbons, gross solids and trash from stormwater runoff
- A tree box filter that provides exceptional stormwater treatment capable of removing fine sediment and dissolved pollutants
- A modular stormwater detention system, which is an underground structural precast concrete system provides many solutions for detention, retention, infiltration, treatment and harvesting

- An all-inclusive stormwater runoff control system that manages water volume in addition to protecting water quality by providing integrated pretreatment, combined with the advantages and versatility of structural precast concrete modules (vaults) with the aesthetics and performance of permeable interlocking concrete pavers to provide a stand-alone, low maintenance, LID green solution for stormwater retention, detention, reuse, ground water recharge and flood management

4. FACTSHEETS/BROCHURES/FORMS/CHECKLISTS

A number of brief technical documents were reviewed that include factsheets, brochures forms and checklists on O&M of the specific GI types included in the NGICP. Any one or two page document that provided a description of the GI type including maintenance details was considered to be a factsheet. Brochures included more illustrations and were primarily targeted for outreach. **Table 4** (page 16) provides a summary of these brief two to ten page documents that are considered as additional resources for the NGICP.

The references from Montgomery County, MD, include factsheets that provide information on maintenance activities and the time frame during which they should be performed, including some very useful trouble shooting tips for the following GI practices – green roof, porous pavement, swales, rain gardens, rain barrels, dry wells and vegetated stormwater facilities, a brochure that describes the planting design for bioretention and rain gardens, and a guide for permeable pavements that provides information on the design, installation and maintenance aspects.

The factsheets from the City of Alexandria, VA, provided information on routine maintenance tasks and frequency for the following GI practices – bioretention, permeable pavement, rainwater harvesting, constructed wetlands, vegetated roofs and urban bioretention areas.

The City of Lancaster's "Green Infrastructure Plan" includes an Appendix of factsheets on various GI technologies that provides a description, benefits, cost and maintenance information for the following GI practices – rain gardens, bioswales, tree boxes, bioretention planters, permeable pavements, green roofs and rain barrels.

Washington State Department of Ecology's inspection forms for bioretention and permeable pavements provide helpful insight into items to be checked at each of these facility types.

The references from Rutgers University included factsheets on maintenance of rain gardens, tree boxes and permeable pavements. Specifically, there was good information on how to keep rain gardens free from mosquitoes.

Milwaukee Metropolitan Sewerage District's (MMSD) factsheet provides useful information about equipment needs for maintenance of GI practices. This is in DRAFT form and has not been made final yet.

The factsheets from Minnehaha Creek Watershed District cover several different types of BMPs (such as filtration practices, infiltration basins and trenches, rain gardens, swales and permeable pavements) and maintenance information applicable to all of them.

The references from the University of New Hampshire Stormwater Center include inspection checklists and maintenance factsheets for pavements and bioretention systems/tree filters, to provide regular inspection and maintenance guidance. There are also several design guidelines that also have maintenance topics and recommended inspection information at the end of the document. These documents can be downloaded from the Center's website at http://www.unh.edu/unhsc/.

The Interlocking Concrete Pavement Institute's (ICPI) "Inspector's Guide for PICP Installation & Maintenance" consists of a checklist intended to assist in identifying critical items that should be checked during construction, immediately after construction prior to acceptance and then during on-going maintenance inspections.

The Seattle Public Utilities has published a checklist titled "Natural Drainage Systems Landscape Maintenance Categories (LMC) and Characteristics" that provides a list of items to verify during maintenance activities for various GI practices.

The Metropolitan St. Louis Sewer District's brochures provide useful information on inspection and maintenance of porous pavements, planter boxes and rain gardens. The checklists for pervious pavement and bioretention inspection, to be used during inspection, consists of a list of items that should be checked during routine maintenance inspection.

The factsheet on Bioretention Soil Mix, found as a resource on the Washington State University-sponsored www.12000raingardens.org website, was produced by Cedar Grove Landscape and Construction services and outlines bioretention soil mix specifications and recommendations for bioretention swales and rain gardens.

The factsheets from Fairfax County Public Works and Environmental Services, provides information on the maintenance of the following GI practices – bioretention practices, permeable pavement, rainwater harvesting, tree box filters, soil compost amendments, vegetated swales, vegetated roofs and wet and dry stormwater ponds. There is also a recommended plant list available for plantings in bioretention area in Fairfax County.

The factsheets from University of Delaware Co-operative Extension provides useful information related to design, installation and maintenance of rain gardens and green roofs.

The City of Omaha Stormwater Program has published inspection forms for rain gardens, bioretention system and permeable pavers and pervious pavement, which can be used as a tool in evaluating that specific GI facility and also serve as a document of maintenance.

Rain garden information on design, plant selection and maintenance topics included:

- "A Resident's Reference Guide to Creating a Rain Garden" from Kansas City Water Services
- The "Rain Garden Care (Brochure)" from Milwaukee Metropolitan Sewerage District

The factsheets authored by M. Cahill found on the Oregon State University Stormwater Solution's website provide detailed information on design, construction and maintenance of the following GI practices — stormwater planters, dry wells and swales.

The USEPA has published stormwater technology factsheets on bioretention, vegetated swales, constructed wetlands and porous pavements, that provide information regarding the cost, performance, design criteria, operation and maintenance for each of those GI practices.

The factsheets from BASMAA provide information on the feasibility, design checklist, maintenance considerations and typical materials including an example application, for the following GI practices – pervious pavements, rain gardens, and rain barrels and cisterns.

The "Stormwater Treatment BMP Inspection Data Collection Form" published by Santa Clara Valley Urban Runoff Pollution Prevention Program can be used for many GI practices ranging from biofiltration (vegetated swale, green roof, planter boxes, bioretention) to detention (constructed wetland) to structural GI practices such as porous pavements.

5. OTHERS (VIDEOS, WEBCASTS)

Several webcasts and videos were also identified as valuable resources to help identify common maintenance tasks for various GI practices and inspection considerations. **Table 5** (page 19) provides a summary of videos/webcasts that are considered as additional resources for NGICP.

The references from Chesapeake Stormwater include:

- Videos that are geared towards construction, inspection and maintenance of Low Impact Development (LID) stormwater practices for local governments and contractors
- A PowerPoint slide presentation (PDF) that provides information on "Analyzing the Bioretention Construction Sequence"
- A webcast on "Bioretention Design, Installation and Maintenance"

The videos by DDOE, as part of the RiverSmart Program, provide information on maintenance of green roofs and rain barrels.

The DVD titled "Getting Polluted Runoff under Control" by Stormwater PA and GreenTreks Network includes two videos – one targeting homeowners and the other one on GI (gives big picture – water cycle, how living roofs, rain gardens, etc. can transform cityscapes into oases of green and help with stormwater management). This DVD is available for purchase through Stormwater PA's website.

The video by Metropolitan St. Louis Sewer District on rain gardens and planter boxes provides information on the installation and maintenance topics.

The video titled "Rainscapes Rain Garden" by Montgomery County, MD, describes the reasons for installing RainScape projects in general and rain gardens in particular. The video titled "How Green Streets Work" features the Department of Environmental Protection's Green Street program and discusses some of the community based practices used to collect, treat and allow rainwater from hard surfaces to absorb into the ground.

The webcasts by USEPA include the following:

- Greening Your Backyard: Water Efficiency and Stormwater Solutions for Homeowners and Communities
- Green Infrastructure in Arid Communities
- Best Practices for Green Infrastructure Operation & Maintenance
- Getting More Green from your Stormwater Infrastructure

The slides and transcripts for the above webcasts are available on USEPA's website for download.

REFERENCES

The following tables are categorized by type of reference (manuals, books, outreach and technical bulletins) and also by GI category (design, construction and maintenance). Notes on which sections of each document are most relevant, also are included.

TABLE 1

Provides a summary of existing GI training materials that are considered as additional resources for the NGICP.

TABLE 2

Provides a summary of all jurisdictional reference materials that are considered as additional resources for the NGICP. They include GI design standards, stormwater management manuals, technical bulletins, construction and design guidance documents, etc.

TABLE 3

Provides a summary of references from industry/trade groups/ organizations that were reviewed as potential additional resources for the NGICP.

TABLE 4

Provides a summary of factsheets, brochures, forms and checklists on O&M (of the specific GI types included in the NGICP) that are considered as additional resources for the NGICP.

TABLE 5

Provides a summary of videos/webcasts (related to inspection and maintenance of GI practices) that are considered as additional resources for the NGICP.

TABLE 6

Provides a list of books that were considered as additional resources.

TABLE 7

Represents a complete list of all the references/resources that were researched and reviewed for consideration as additional resources for the development of the NGICP. This table is categorized by author/publisher and GI type covered.

TABLE 1
GI TRAINING MATERIALS

CONSTRUCTION

Title	Author/ Publisher	Year	Notes
San Francisco Green Infrastructure Construction Training Guidebook	San Francisco Public Utilities Commission	2015	The guide has factsheets on bioretention planter construction, permeable pavement construction.
Course 1.1 – Introduction to Green Infrastructure Construction		2015	PPT/Slides
Course 1.2 – Green Infrastructure Site Management		2015	PPT/Slides
Course 2.1 – Bioretention Planter Construction		2015	PPT/Slides
Course 2.2 – Permeable Pavement Construction		2015	PPT/Slides
Tailgate Talks		2015	

MAINTENANCE

Title	Author/ Publisher	Year	Notes
Low Impact Development Operations and Maintenance Training	Washington State Department of Ecology		PPT/slides that talk about bioretention, permeable pavement, green roof (each section includes: diagram, how it works, maintenance standards & procedures by component (for each GI type)).
Save the Rain Program Green Infrastructure Maintenance Training	Onondaga County, NY	2012	This training material includes GI technology factsheets for porous pavement, rain garden, vegetated roof, tree trenches, cistern/rain barrel, in addition to maintenance procedures and a list of commonly used plants in bioretention.
Grassy Swales (& Bioswales) Maintenance	Bill Hunt of NCSU	2015	These are PPT/slides (by various authors) from Northeast Ohio Stormwater Training Council (NEOSWTC) workshops held in 2014 and 2015.
Green Roofs Maintenance		2015	
Cisterns & Rainwater Harvesting Maintenance		2015	
Bioretention Maintenance (Part 1 and 2)		2015	
Permeable Pavement Maintenance (Part 1 and 2)		2015	
Parking Lot BMPs (Part 1 and 2)		2014	
Operations & Maintenance for Bioretention Stormwater Practices (Part 1 & 2)	Brian Prunty, Stormwater Specialist, Summit Soil & Water Conservation District	2014	
Plants for Rain Gardens and Bioretention	Roger Gettig, Director of Horticulture and Conservation	2014	

TABLE 2
MATERIALS FROM VARIOUS JURISDICTIONS

Jurisdiction	Document	Year	Category	Comments/Notes
Bay Area Stormwater Management Agencies Association	Start at the Source: Design Guidance Manual for Stormwater Quality	1999		Permeable pavements (based on types of materials used), dry wells, rain barrels/cisterns, grass/vegetated swales (maintenance, grass selection).
Bay Area Stormwater Management Agencies Association (& WRA Consultants)	Regional Bioretention Soil Guidance & Model Specification	2010		This report provides model soil guidance and specification with a goal of providing a long-term infiltration rate of 5 to 10 inches per hour, providing stormwater treatment and supporting plant health.
Blue Water Baltimore	Routine Maintenance for Rain Gardens		Maintenance	This document provides detailed information on routine maintenance of rain gardens including plant care and infiltration maintenance.
City of Atlanta, Watershed Department	Green Infrastructure Stormwater Management Practices for Small Commercial Development	2014	Design	Chapter 7 addresses mostly design guidelines for bioretention, infiltration trenches, bioswales, permeable pavement, stormwater planters, subsurface infiltration, rainwater harvesting/cisterns, green roofs. Very little information on maintenance & inspection.
	Green Infrastructure for Single Family Residences	2012	Design, Construction & Maintenance	Information presented very concisely – design, construction & maintenance of cisterns, dry wells, vegetated filter strips, modified French drains, permeable pavers, rain gardens.
City of Columbus, OH	Stormwater Strategic Plan — Green Infrastructure Design & Implementation Guidelines	2015	Design, Inspection & Maintenance	The intent of this manual is to provide the user with considerations for the placement and design of GI in right-of-way (ROW) and retrofit of existing urban environments, including standard component designs within GI facilities such as inlets, area protection, plantings, underdrains, overflow structures and outlets. Includes information on construction, inspection & maintenance. The chapters on storage media and permeable surfaces provide good NGICP-related information.
City of Omaha, NE	Bioretention Gardens: A Manual for Contractors in the Omaha Region to Design and Install Bioretention Gardens	2016	Design, Construction, Maintenance	This manual provides important knowledge to help design, build and maintain a viable rain garden. Along with regional specific information there are also details about site assessment, garden design, drainage and soil management, effective selection and use of plants, and the relative costs associated with bioretention implementation.
City of Portland, OR	Stormwater Management Manual	2014		The most relevant sections in this manual are: Appendix F.3 – top soil specifications, F.4 – plant templates and plan lists, G.3 – green street design, maintenance indicators and corrective action for green roofs, swales, planters, dry wells and permeable pavement (Chapter 3).
City of Santa Barbara	Stormwater BMP Guidance Manual	2013	Construction, O&M	Chapter 5 – rain gardens, rain barrels, soil amendments; Chapter 6 – bioretention (advantages, limitations, design criteria, plant/filter media, O&M), vegetated swale filters, rain barrels, planter boxes, green roofs.
City of Tucson	Water Harvesting Guidance Manual	2006		Water harvesting techniques – microbasins, French drains, gabions, water tanks, etc. Pages 16-17 include an inspection & maintenance table.
Chesapeake Stormwater Network (serving the regional interstate watershed of Chesapeake Bay)	CSN Technical Bulletin No. 10 Bioretention Illustrated: A Visual Guide for Constructing, Inspecting, Maintaining, and Verifying the Bioretention Practice	2013	Design, Construction, O&M, Inspection	Focuses mainly on Bioretention (Design, Construction, Inspection & Maintenance), Appendix A – Visual Indicator Profile Sheets for Bioretention Inspections, Appendix B – Visual indicators for Grass Channels, Filter Strips/Sheet flow to Buffer, Permeable Pavement, Subsurface Infiltration.
	Maintenance Matters Now! The Changing World of BMP Inspection	2014	Maintenance	PPT/slides – a part of the Chesapeake Bay Stormwater Training Partnership and includes photos of GI practices (visual inspection – right and wrong pics), similar to the technical bulletin.
Clean Water Services	Low Impact Development Approaches (LIDA) Handbook	2009	Design, Maintenance	In this handbook, Chapter 4 provides information on application/limitations, design factors & maintenance of the following GI practices — porous pavement, green roof, rain garden, vegetated swale, constructed wetland. And detailed autocad drawing files are included in the Appendix.

TABLE 2

MATERIALS FROM VARIOUS JURISDICTIONS

Jurisdiction	Document	Year	Category	Comments/Notes
Contra Costa Clean Water Program	Stormwater C.3 Guidebook	2012	Design	Through the Contra Costa Clean Water Program, Contra Costa municipalities have prepared a Stormwater C.3 Guidebook to assist applicants through the process of submittals and reviews. Appendix B provides information on soils, plantings & irrigation for bioretention. Design sheets are also included for pervious pavements, bioretention, dry wells, cisterns and planter boxes.
Credit Valley Conservation	Low Impact Development Construction Guide – Version 1.0	2012	Construction, Maintenance	Bioretention soil specifications – page 54; Appendix B – LID Landscape Design Guide, concepts (siting, design, construction/installation, maintenance) related to general LID practices. Information on pervious pavers.
Delta Institute	Green Infrastructure Designs – Scalable Solutions to Local Challenges	2015	Design, Construction & Maintenance	This publication covers the following GI practices – bioswales, rain gardens, stormwater planters and permeable pavement. It provides nice diagrams including CAD files.
District Department of the Environment (DDOE)	Stormwater Management Guidebook for the DDOE (now called Department of Energy and Environment (DOEE))	2013	Design, Construction, Maintenance	Chapter 3 includes feasibility, detailed design calculations, plan views, information on pretreatment, conveyance, material specifications, sizing, construction sequencing and maintenance. Appendices include construction & maintenance checklists.
District of Columbia – Department of Transportation	Green Infrastructure Standards	2014	Design (drawings), Maintenance, Plant selection for bioretention	Supplement to Design & Engineering Manual. Includes GI Plant list and GI Maintenance schedules.
DC Water	Technical Memorandum #6 Green Infrastructure Technologies	2012	Construction, O&M	Contains construction, O&M, good schematics and photos.
	DC Water Green Infrastructure Utility Protection Guidelines	2013	Construction	This document provides guidance on the design and construction of GI adjacent or connected to DC Water utilities. Includes plan views of GI types.
	DC Clean Rivers (DCCR) GI Design Standards	2015	Design, Construction, O&M	DRAFT Version.
Delaware Department of Natural Resources and Environmental Control (DNREC)	Green Infrastructure Primer for Delaware	2016	Construction & Maintenance	This guide provides information on the benefits and types of GI. It has pertinent information on construction & maintenance of rain gardens, vegetated swales, tree boxes/tree trenches, rain barrels, cisterns, green roofs.
Fairfax County Public Works and Environmental Services	Public Facilities Manual	2011	Design, Construction & Maintenance	Chapter 6 is particularly useful since it covers the design, construction specification and maintenance of constructed wetlands, bioretention, vegetated swales, tree box filters, vegetated roofs, rainwater harvesting and permeable pavement.
	Fairfax County Maintenance Contractor Awareness Training	2015	Maintenance	Includes 5 training presentations that are available for download: http://www.fairfaxcounty.gov/dpwes/stormwater/maintenance-training.htm Part I: Overview; Part II: Above Ground Facilities; Part III: Above Ground Facilities; Part IV: Below Ground Facilities; Part V: Vegetative Practice.
Flexible Pavements of Ohio	Technical Bulletin: Porous Asphalt Pavement	2012	Design, Construction & Maintenance	This document provides information on design consideration, construction and maintenance of porous asphalt pavement.
Louisiana Department of Environmental Quality (DEQ)	Stormwater BMP Guidance Tool (A Stormwater Best Management Practices Guide for Orleans and Jefferson Parishes)	2010		Includes overview and diagram for planter boxes, green roofs, cisterns/rain barrels, biofiltration BMPs and permeable pavement. It is mostly focused on design aspects, very little on inspection/maintenance.
Metropolitan Nashville – Davidson County, TN	LID Manual	2016	Design, Construction & Maintenance	

TABLE 2
MATERIALS FROM VARIOUS JURISDICTIONS

Jurisdiction	Document	Year	Category	Comments/Notes
Metropolitan Sewer District of Louisville, KY	Green Infrastructure Design Manual	2015	Design, Operation & Maintenance	A new addition to the MSD Design Manual is Chapter 18, Green Management Practices (GMP) Manual. It provides information on site feasibility, design criteria, O&M, benefits & limitations, etc., for bioswales, rain gardens, constructed wetlands, green roofs, blue roofs, permeable pavers, porous concrete, porous asphalt, planters, tree boxes, rainwater harvesting, in the form of factsheets. Note: This manual is being updated and a revised version will be available in summer of 2016.
Metropolitan St. Louis Sewer District	Landscape Guide for Stormwater Best Management Practice Design	2012		In this guide, Section 3 provides information on native species, invasive species, site preparation, planting design, plant selection and installation and management. Section 4 presents more specific guidance on landscaping criteria and plant selection for the following BMP design types: wet ponds, wetlands, infiltration basins and dry swales, surface sand filters, bioretention and organic filters. Section 7 lists various plants specific for each BMP type outlined.
Michigan Department of Environmental Quality	Low Impact Development Manual for Michigan	2008	O&M	Structural BMPs – rain gardens, planter boxes, green roofs, vegetated swales, pervious pavement.
Mid-America Regional Council & American Public Works Association (Kansas City Metro Area)	Manual of Best Management Practices For Stormwater Quality	2012	Inspection & Maintenance	Good figures and tables. Describes maintenance and inspection for rain gardens, bioretention, permeable pavements and green roofs. Figures 4-23, 8-7, 8-28 are helpful. Tables covering typical maintenance activity and frequency are included.
Minnesota Pollution Control Agency	Minnesota Stormwater Manual	2008		This manual together with the electronic wiki webpage provides a well-rounded introduction to stormwater management.
Missouri Department of Natural Resources	Missouri Guide to Green Infrastructure	2012	Inspection & Maintenance	This guide addresses economic costs and benefits to developers and municipalities, as well as environmental benefits. This is not a technical manual. Chapter 6 addresses siting & safety consideration, maintenance, benefits & includes inspection & maintenance checklist.
Montgomery County, MD	Rainscapes Projects Manual		Design, Construction & Maintenance	This technical manual provides information on design, construction/installation and maintenance of the following types of GI practices - green roofs, rain barrels/cisterns, permeable pavers, rain gardens and dry wells.
	Raingardens for Rainscapes			This technical manual provides information on the design, construction/installation and maintenance of rain gardens.
NY Department of Environmental Protection	Guidelines for Design & Construction of Stormwater Management Systems	2012	Design, Construction, O&M	Chapter 4 includes rooftop systems (green & blue roofs) – siting considerations, design, construction, O&M (includes inspection & troubleshooting).
Northern Virginia Regional Commission	Maintaining Stormwater Systems – A Guidebook for Private Owners and Operators in Northern Virginia	2007	Inspection & Maintenance	This guidebook provides information on stormwater systems & their components including inspection/maintenance/troubleshooting guide for rain gardens, vegetated swale, green roof & permeable pavement.
North Carolina State University (published by NC Co-operative Extension)	Low Impact Development – A Guidebook for North Carolina	2009	Design & Maintenance	Bioretention, permeable pavement, cisterns & water harvesting, swales, green roofs.
Northeast Ohio Stormwater Training Council	Maintaining Stormwater Control Measures Guidance for Private Owners & Operators	2015	Inspection & Maintenance	Addresses inspection and maintenance of GI practices – permeable pavements, green roofs, bioretention area/rain gardens etc. Includes good illustrations.
Onondaga County, NY	Save the Rain Program Green Infrastructure Maintenance Manual	2013	O&M	Appendix A – Detailed Green Infrastructure Standard Maintenance Procedures, Appendix E – Factsheets.

TABLE 2
MATERIALS FROM VARIOUS JURISDICTIONS

Jurisdiction	Document	Year	Category	Comments/Notes
Oregon State University Stormwater Solutions	Field Guide: Maintaining Rain Gardens, Swales and Stormwater Planters	2013	Maintenance	This field guide provides information needed to properly maintain rain gardens, swales, stormwater planters, and other facilities. Topics covered include erosion, sedimentation, vegetation and weeds, structures, trash and debris, safety. The field manual covers the most common maintenance activities that workers will need to remedy and provides lots of photos as a guide.
Philadelphia Water Department	Green Infrastructure Maintenance Manual Development Process Plan	2012	Maintenance	Chapter 4 – National Inventory of Maintenance Practices and Procedures, Info on maintenance task/data sheet template (Appendix II and III), Inventory of Maintenance Practices and Procedures by GSI Practice (Appendix VI), page 3 – definitions of various GI practices.
	Stormwater Management Guidance Manual	2015	Construction, Inspection & Maintenance	Chapters 4, 5, 6 address the following topics – bioretention, porous pavement, green roofs, cisterns, blue roofs.
	Green Stormwater Infrastructure Maintenance Manual	2014	Maintenance	This document contains standard operating procedures for executing specific maintenance tasks. Each protocol provides information on required training, equipment/materials, health and safety issues, including a detailed procedure for executing tasks. Appendices provide supplementary reference materials including health and safety procedures, a comprehensive listing of typical maintenance personnel classifications, and additional guidance on site access and permits. The GI practices addressed in this manual include stormwater tree trenches, rain gardens, stormwater planters, stormwater wetlands, bioswales, stormwater tree planters, rain barrels/cisterns, green roofs, pervious paving, blue roofs.
	Plant Identification Manual	2014		This provides concise plant information along with a photo of each type.
Pima County & City of Tucson, AZ	Low Impact Development & Green Infrastructure Guidance Manual	2015	Design, Construction, O&M	Appendix G – plant list, design criteria, site selection, and construction. Includes a maintenance summary related to general GI practices.
Prince George's County, MD	Bioretention Manual	2007	Construction & Inspection	The manual provides information on bioretention types, applications, landscaping techniques & practices, construction & inspection including guidance on sizing, location & design.
	Prince George's County Stormwater Design Manual	2014	Design, Construction, O&M	Mostly design information presented. Chapter 14 includes inspection requirement during construction. Chapter 10 includes some O&M information for rainwater harvesting, rain gardens, swales, green roofs, permeable pavements, dry wells.
Seattle Public Utilities	Green Stormwater Infrastructure Manual Volume V: Operations & Maintenance	2015	Maintenance	Topics of interest for curriculum development include – equipment needs, materials required, maintenance during construction period. Appendices include planting guidance for Trees & vegetation (G), Maintenance checklists (E).
	City of Seattle Stormwater Manual – Volume 3: Project Stormwater Control	2015	Maintenance	Chapter 2 provides information on the various BMP categories. Chapter 5 includes information on description, performance mechanism, applicability, site considerations, design criteria, BMP sizing, construction requirements and O&M for dry wells, rain gardens, permeable pavement, rainwater harvesting and swales.
Southern California Stormwater Monitoring Coalition	LID for Southern California	2010	Design, O&M	Chapter 4 - bioretention, pervious pavement, green roofs, BMP factsheets, soil amendments, dry wells, infiltration basins, trenches, vegetated swales.
Tennessee Department of Environment & Conservation	Tennessee Permanent Stormwater Management and Design Guidance Manual	2014		Chapter 5 addresses the following topics – bioretention, green roofs, permeable pavement, rainwater harvesting, and bioswales in Appendices C, D, E and F.
University of Minnesota	An Introduction to Stormwater Practices Maintenance – Vegetated & Biological Stormwater Practices Maintenance		Maintenance	Excellent PPT targeted towards maintenance, with great visuals.

TABLE 2

MATERIALS FROM VARIOUS JURISDICTIONS

Jurisdiction	Document	Year	Category	Comments/Notes
U.S. Army Corps of Engineers	Army Low Impact Development Technical User Guide	2013	Design, Construction & Maintenance	The guide addresses the following GI practices – bioretention, vegetated swales, permeable pavements, rainwater harvesting, green roofs. Chapter 5 covers the description, types, components, design criteria, materials, construction considerations, maintenance of the GI practices.
U.S. Department of Transportation, Federal Highway Administration	Porous Asphalt Pavements with Stone Reservoirs (Technical Brief -FHWA-HIF-15-009)	2015	Design, Construction & Maintenance	This technical brief provides an overview of the benefits, limitations and applications of porous asphalt pavements with stone reservoirs. Design, construction and maintenance aspects are all discussed.
USEPA	Green Roofs for Stormwater Runoff Control	2009		This report evaluates green roofs as a stormwater management tool. The influence of media type, media depth and drought during plant establishment on plant growth and long-term management of media pH were investigated.
	Green Infrastructure Case Studies	2010		This case study report describes a dozen cities and counties that are using green infrastructure approaches to reduce imperviousness and preserve natural open space throughout a watershed and at the neighborhood scale, as well as adding green infrastructure practices at the site level.
Urban Drainage and Flood Control District, Denver, CO	Urban Storm Drainage Criteria Manual Volume 3	Updated 2010	Maintenance	BMP maintenance – bioretention, green roofs, permeable pavement, grass buffers and swales.
Virginia Department of Environmental Quality (DEQ)	Virginia Stormwater BMP Clearing House		Design, Inspection, Maintenance	This clearing house website provides design standards & specifications for all stormwater BMPs approved for use in Virginia.
Washington State Department of Ecology	Western Washington Low Impact Development (LID) Operation & Maintenance (O&M)	2013	O&M	Maintenance standards and procedures, equipment & materials, skills and staffing. Compost amended soils information on page 81.
Washington Department of Ecology & Washington State University Extension	Rain Garden Handbook for Western Washington	2013	Design, Installation & Maintenance	A guide for design, maintenance and installation.
Watershed Management Group – Funded by USEPA & Arizona DEA	Green Infrastructure for Southwestern Neighborhoods – Version 1.2 Revised October 2012	2012	Maintenance	Design, construction, maintenance (site selection, soils, O&M, plan view diagrams) – mainly in arid climate.

TABLE 3
INDUSTRY/TRADE GROUPS/ORGANIZATIONS MATERIALS

Organization	Source Document	Type	Category	Comments/Notes
Contech Engineered Solutions	Filterra Solutions Brochure	Brochure	Installation & Maintenance	These documents provide installation and maintenance information on an engineered biofiltration device. It can be used in different configurations in both new construction and urban retrofits as well as streetscapes, urban areas, parking lots, roof drains, etc.
	Filterra Operations & Maintenance Guide	Manual/Guide	Installation & Maintenance	
CULTEC, Inc.	CULTEC Plastic Chamber as Dry Well	Brochure		This brochure provides information on benefits and specifications for use in a dry well.
	CULTEC stormwater product booklet	Booklet	Installation & Maintenance	These documents provide information on product features, benefits, components, specifications, installation and drawings.
Interlocking Concrete Pavement Institute (ICPI)	Industry Guidelines for Permeable Interlocking Concrete Pavement in the United States and Canada	PPT/slides	Design, Construction & Maintenance	Includes good visuals.
Oldcastle Stormwater Solutions	BioMod Modular Bioretention Brochure	Brochure		This brochure describes the BioMod modular bioretention system and provides information on benefits, application, design and configurations.
	BioMod Modular Maintenance Manual	Booklet	Maintenance	This brochures provides information on general specifications for maintenance of BioMod modular bioretention system.
	TreePod Biofilter	Brochure		This brochure provides information on its application, capabilities and design.
	StormCapture Harvesting & Reuse Brochure	Brochure		This brochure provides information on StormCapture harvesting system.
	StormCapture Installation Manual	Booklet	Installation	This brochure provides information on the installation process.
	StormCapture Maintenance Manual	Booklet	Maintenance	This brochure provides information on maintenance.
	PermeCapture Brochure	Brochure		This brochure provides information on benefits, application & performance.
Urban Horticulture Institute, Cornell University (CU)	CU-Structural Soil – A Comprehensive Guide	Guide		Overview on using CU-Structural Soil® to support trees, turf and porous pavement.
	Using Porous Asphalt and CU-Structural Soil	Booklet		Booklet details how the combination of porous asphalt and CU-Structural Soil™ reduces runoff and improves water quality.

TABLE 4

FACTSHEETS/BROCHURES/CHECKLISTS/FORMS

Source Document	Organization	Type	Category	Comments/Notes
Pervious Pavement (Stormwater Control for Small Projects)	Bay Area Stormwater Management Agencies Associations	Factsheet	Design, Installation & Maintenance	This factsheet provides information on feasibility, maintenance considerations, typical materials & example applications and a design checklist.
Rain Gardens (Stormwater Control for Small Projects)		Factsheet	Design, Installation & Maintenance	This factsheet provides information on feasibility, maintenance considerations, how to plan & install and a design checklist.
Rain Barels & Cisterns (Stormwater Control for Small Projects)		Factsheet	Design, Installation & Maintenance	This factsheet provides information on feasibility, operation & maintenance, components and a design checklist.
Bioretention Area Maintenance Schedule and Guidelines	City of Alexandria, VA	Factsheet	Maintenance	Routine maintenance task & frequency.
Permeable Pavement Maintenance Schedule and Guidelines		Factsheet	Maintenance	
Rainwater Harvesting Maintenance Schedule and Guidelines		Factsheet	Maintenance	
Urban Bioretention Area Maintenance Schedule and Guidelines		Factsheet	Maintenance	
Vegetated Roof Maintenance Schedule and Guidelines		Factsheet	Maintenance	
Constructed Wetlands Maintenance Schedule and Guidelines		Factsheet	Maintenance	
Bioretention System Annual Evaluation Form	City of Omaha Stormwater Program	Inspection Form	Inspection & Maintenance	This form can be used as a tool in evaluating bioretention system, as well as act as a document of maintenance.
Permeable Pavers & Pervious Pavement Annual Evaluation Form				This form can be used as a tool in evaluating permeable pavers and pervious pavement, as well as a document of maintenance.
Rain Garden Annual Evaluation Form				This form can be used as a tool in evaluating your rain garden, as well as a document of maintenance.
Bioretention Practices	Fairfax County Public Works and Environmental Services	Factsheet	Maintenance	
Permeable Pavement		Factsheet	Maintenance	
Rainwater Harvesting		Factsheet	Maintenance	
Tree Box Filters		Factsheet	Maintenance	
Soil Compost Amendments		Factsheet	Maintenance	
Vegetated Roofs		Factsheet	Maintenance	
Vegetated Swales		Factsheet	Maintenance	
Wet and Dry Stormwater Ponds		Factsheet	Maintenance	
Recommended Plant List for Bioretention Facilities		Plant List		
A Resident's Reference Guide to Creating a Rain Garden	Kansas City Water Services	Brochure	Design	Rain garden design & plant selection information.
City of Lancaster Green Infrastructure Plan: Appendix A – Green Infrastructure Technology Fact Sheets	City of Lancaster, PA	Brochure	Description, Maintenance, Benefits, Cost	Includes information on rain gardens, bioswales, tree boxes, bioretention planters, permeable pavements, green roofs, rain barrels.

TABLE 4
FACTSHEETS/BROCHURES/CHECKLISTS/FORMS

Source Document	Organization	Type	Category	Comments/Notes
Factsheet on Stormwater Planters	M. Cahill, D.C. Godwin and M. Sowles	Factsheet	Design, Construction & Maintenance	This factsheet provides detailed information on design, construction & maintenance.
Factsheet on Dry Wells		Factsheet	Design, Construction & Maintenance	This factsheet provides detailed information on design, construction & maintenance.
Factsheet on Swales		Factsheet	Design, Construction & Maintenance	This factsheet provides detailed information on design, construction & maintenance.
Porous Pavement Ownership and Maintenance	Metropolitan St. Louis Sewer District	Brochure	Inspection & Maintenance	
Rain Garden Ownership and Maintenance		Brochure	Inspection & Maintenance	
Planter Box Ownership & Maintenance		Brochure	Inspection & Maintenance	
Bioretention Maintenance Inspection Checklist		Checklist	Inspection	
Pervious Pavement Maintenance Inspection Checklist		Checklist	Inspection	
Rain Garden Care	Milwaukee Metropolitan Sewerage District	Brochure		
Stormwater Tree Factsheet		Factsheet		
DRAFT Green Infrastructure Maintenance and Equipment Needs		Factsheet	Maintenance	
Inspection Guide (Filtration Practices, Infiltration Basins and Trenches, Bioretention (Rain Gardens), and Swales)	Minnehaha Creek Watershed District	Factsheet (Inspection Guide)	Inspection	
Inspection Guide for Permeable Pavers		Factsheet (Inspection Guide)	Inspection	
Green Roof Maintenance	Montgomery County	Factsheet	Description, Maintenance	Maintenance activities, frequency and troubleshooting tips.
Porous Pavement Maintenance		Factsheet		
Rain Garden/Bioswale Maintenance		Factsheet		
Swale Maintenance		Factsheet		
Vegetated Stormwater Facility Maintenance		Factsheet		
Buried Dry Well Maintenance		Factsheet		
Rain Barrels		Factsheet		
Planting Design for Bioretention & Rain Gardens		Brochure	Design	
Permeable Pavement Design Template		Guide	Design, Installation & Maintenance	This guidebook provides information on the design, installation and maintenance of permeable pavements.
Inspector's Guide for Permeable Interlocking Concrete Pavers (PICP) Installation & Maintenance	PICP Institute	Checklist	Inspection	This PICP inspector's guide for project construction and maintenance consists of a checklist developed from the ICPI PICP manual and the PICP certificate course.
Green Infrastructure Practices: An Introduction to Permeable Pavement	Rutgers University	Factsheet	Maintenance	Types, benefits, maintenance.
Rain Gardens and Mosquitoes		Factsheet	Maintenance	How to keep rain gardens free from mosquitoes.
An Introduction to Green Infrastructure Practices				Introduction/benefits/types.
Green Infrastructure Practices: Tree Boxes		Factsheet	Maintenance	Fact Sheet FS1209, includes information on installation, maintenance of tree boxes.

TABLE 4

FACTSHEETS/BROCHURES/CHECKLISTS/FORMS

Source Document	Organization	Type	Category	Comments/Notes
Stormwater Treatment BMP Inspection Data Collection Form	Santa Clara Valley Urban Runoff Pollution Prevention Program	Form	Inspection & Maintenance	
Natural Drainage Systems Landscape Maintenance Categories (LMC) and Characteristics Checklist	Seattle Public Utilities	Checklist	Maintenance	
Rain Gardens	University of Delaware Co-operative Extension	Factsheet	Design, Installation & Maintenance	This factsheet provides information related to design, installation and maintenance.
Green Roofs		Factsheet	Design, Installation & Maintenance	This factsheet provides information related to design, installation and maintenance.
Rainwater Harvesting		Factsheet		
Regular Inspection and Maintenance Guidance for Porous Pavements	University of New Hampshire Stormwater Center	Factsheet & Checklist	Inspection & Maintenance	Inspection checklist and maintenance activities.
Regular Inspection and Maintenance Guidance for Bioretention Systems/Tree Filters		Factsheet & Checklist	Inspection & Maintenance	Inspection checklist and maintenance activities.
USEPA Stormwater Technology Factsheet (Vegetated Swales)	USEPA	Factsheet	Design, Operation & Maintenance	Cost, performance, design criteria, operation & maintenance.
USEPA Stormwater Technology Factsheet (Constructed Wetlands)		Factsheet	Design, Operation & Maintenance	Cost, performance, design criteria, operation & maintenance.
USEPA Stormwater Technology Factsheet (Porous Pavement)		Factsheet	Design, Operation & Maintenance	Cost, performance, design criteria, operation & maintenance.
USEPA Stormwater Technology Factsheet (Bioretention)		Factsheet	Design, Operation & Maintenance	Cost, performance, design criteria, operation & maintenance.
Bioretention Inspection Form	Washington State Department of Ecology	Forms		
Permeable Pavement Inspection Form		Forms		
Bioretention Soil Mix	Found as a resource on the 12,000 Rain Gardens program webpage	Factsheet		This factsheet helps understand the composition of soil mixes for bioretention.

TABLE 5

VIDEOS/WEBCASTS

Title	Source	Type	Category	Comments/Notes
A Guide to Proper Construction Techniques for Contractors, Local Governments and Involved Homeowners	Chesapeake Stormwater (Videos)	Construction	https://youtu.be/efu1LfF1rio?list=PLvAwYhXd7L0I_Fmj2HsMXMqdN5MU6OWfh	Covers construction practices and the importance of following the construction sequence.
Inspecting LID Stormwater Practices: A Guide to Proper LID Inspection Practices for Local Governments and Contractors		Inspection	https://youtu.be/eAFuMro0gvA?list=PLvAwYhXd7L0I_Fmj2HsMXMqdN5MU6OWfh	Offers tips on how to conduct routine and more formal inspections of LID-type stormwater management practices such as bioretention, bioswales and permeable pavement.
Stormwater BMP and LID Maintenance: A Guide to Proper Maintenance Practices for Local Government Staff and Landscapers		Maintenance	https://www.youtube.com/watch?v=coFbdMB-q0U&feature=youtu.be&list=PLvAwYhXd7L0I_Fmj2HsMXMqdN5MU6OWfh	Discusses routine maintenance of LID-type stormwater management practices including commonly encountered maintenance problems and offers potential solutions for remediating them.
Analyzing the Bioretention Construction Sequence	Chesapeake Stormwater (PDF of PPT/slides)	Construction	http://chesapeakestormwater.net/wp-content/uploads/downloads/2013/10/Bioretention-Construction-Sequence.pdf	
Bioretention Design, Installation and Maintenance	Chesapeake Stormwater (Webcast)	Design, Installation & Maintenance	http://chesapeakestormwater.net/2010/04/bioretention-design-installation-and-maintenance/	
RiverSmart Rooftops in Washington, DC	DDOE (Videos)	Construction & Maintenance	https://vimeo.com/122354242	
RiverSmart Homes – Rain Barrel Maintenance		Maintenance	https://vimeo.com/85290827	
MSD Rain Garden and Planter Box Maintenance	Metropolitan St. Louis Sewer District (Video)	Maintenance	https://www.youtube.com/watch?v=nK4x1rtyMds&feature=youtu.be	
Getting Polluted Runoff Under Control	Stormwater PA and GreenTreks Network (DVD/Videos)		This DVD can be purchased at: http://www.greentreks.tv/?tag=green-building	The videos targeting homeowners and the one on GI gives useful big picture information on water cycle, how living roofs, rain gardens, etc., green stormwater management).
Greening Your Backyard: Water Efficiency and Stormwater Solutions for Homeowners and Communities	USEPA		https://www.youtube.com/watch?v=WOMLB2kLYVA&feature=youtu.be	This webcast provides information to homeowners and communities about some of the latest tools and information on water efficiency and stormwater solutions.
Green Infrastructure for Arid Communities			Webcast slides and transcript can be found at: https://www.epa.gov/green-infrastructure/green-infrastructure-arid-communities	This webcast showcases how green infrastructure practices and the many associated benefits can be effective not only in wetter climates, but also for those communities in arid and semi-arid regions around the nation that have different precipitation patterns and water demand challenges.
Best Practices for Green Infrastructure O&M			Webcast slides and transcript can be found at: https://www.epa.gov/green-infrastructure/best-practices-green-infrastructure-om-webcast	This webcast provides a general overview of best practices to consider when creating a green infrastructure O&M plan.
Getting More Green from your Stormwater Infrastructure			Webcast slides and transcript can be found at: https://www.epa.gov/green-infrastructure/getting-more-green-your-stormwater-infrastructure-webcast	This webcast showcases different ways of communicating both cost savings and benefits related to green infrastructure.

TABLE 6
BOOKS

Organization	Source Document	ISBN	Comments/Notes
Green Roof Plants: A Resource & Planting Guide	Edmund Snodgrass & Lucie Snodgrass	ISBN-13: 978-0-88192-787-0	Great plant identification guide, focuses primarily on green roof plants.
Permeable Interlocking Concrete Pavements	David R. Smith	ISBN 978-1-4507-8440-5	Design, specifications, construction, maintenance.

TABLE 7
REFERENCES, DOCUMENTS AND TRAINING MATERIALS FOR GREEN STORMWATER INFRASTRUCTURE

#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
1	Start at the Source: Design Guidance Manual for Stormwater Quality	Bay Area Stormwater Management Agencies Association	✓	✓			✓	✓	
2	Pervious Pavement (Stormwater Control for Small Projects)		✓	✓					
3	Rain Gardens (Stormwater Control for Small Projects)								
4	Rain Barrels & Cisterns (Stormwater Control for Small Projects)							✓	
5	Regional Bioretention Soil Guidance & Model Specification	Bay Area Stormwater Management Agencies Association (& WRA Consultants)	✓						
6	Routine Maintenance for Rain Gardens	Blue Water Baltimore	✓						
7	Stormwater Management Guidebook for the DC DOEE	Center for Watershed Protection	✓	✓	✓			✓	✓
8	A Guide to Proper Construction Techniques for Contractors, Local Governments and Involved Homeowners	Chesapeake Stormwater							
9	Inspecting LID Stormwater Practices: A Guide to Proper LID Inspection Practices for Local Governments and Contractors		✓	✓					
10	Stormwater BMP and LID Maintenance: A Guide to Proper Maintenance Practices for Local Government Staff and Landscapers								
11	Bioretention Design, Installation and Maintenance Webcast		✓						
12	Analyzing the Bioretention Construction Sequence		✓						
13	CSN Technical Bulletin No. 10 Bioretention Illustrated: A Visual Guide for Constructing, Inspecting, Maintaining, and Verifying the Bioretention Practice		✓	✓					
14	Maintenance Matters Now! The changing world of BMP Inspection								
15	Low Impact Development Construction Guide – Version 1.0	Credit Valley Conservation	✓	✓					

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TABLE 7
REFERENCES, DOCUMENTS AND TRAINING MATERIALS FOR GREEN STORMWATER INFRASTRUCTURE

#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
16	Post-Construction Stormwater Management	City of Alexandria, VA							
17	Bioretention Area Maintenance Schedule and Guidelines								
18	Permeable Pavement Maintenance Schedule and Guidelines			✓					
19	Rainwater Harvesting Maintenance Schedule and Guidelines							✓	
20	Sheet Flow to Vegetated Filter Areas and Conserved Open Space Maintenance Schedule and Guidelines								
21	Urban Bioretention Area Maintenance Schedule and Guidelines		✓						
22	Vegetated Roof Maintenance Schedule and Guidelines				✓				
23	Constructed Wetlands Maintenance Schedule and Guidelines								✓
24	Green Infrastructure Stormwater Management Practices for Small Commercial Development	City of Atlanta, Watershed Department, GA	✓	✓	✓			✓	
25	Green Infrastructure for Single Family Residences		✓	✓	✓		✓	✓	
26	Stormwater Strategic Plan – Green Infrastructure Design & Implementation Guidelines	City of Columbus, OH		✓					
27	LID Guidance Manual	City of Flagstaff, AZ							
28	Permeable Pavement Factsheet	City of Omaha Stormwater Program, NE		✓					
29	Bioretention Systems Factsheet		✓						
30	Bioretention System Annual Evaluation Form		✓						
31	Permeable Pavers & Pervious Pavement Annual Evaluation Form			✓					
32	Rain Garden Annual Evaluation Form		✓						
33	Bioretention Gardens: A Manual for Contractors in the Omaha Region to Design and Install Bioretention Gardens		✓						
34	Stormwater Management Manual	City of Portland, OR	✓	✓	✓		✓		
35	Stormwater BMP Guidance Manual	City of Santa Barbara, CA	✓		✓				
36	Water Harvesting Guidance Manual	City of Tucson, AZ						✓	
37	Low Impact Development Approaches (LIDA) Handbook	Clean Water Services, OR	✓	✓	✓				✓
38	Stormwater Maintenance Training for Municipal Employees in Northeast Ohio	Cleveland, OH	✓	✓	✓			✓	
39	Filterra® Solutions Brochure	Contech Engineered Solutions	✓						
40	Filterra® Operation & Maintenance Guide		✓						
41	Stormwater C.3 Guidebook	Contra Costa Clean Water Program, CA	✓	✓			✓	✓	
42	CULTEC Plastic Chamber as Dry Well	CULTEC, Inc							
43	CULTEC Stormwater Product Booklet								
44	Industry Guidelines for Permeable Interlocking Concrete Pavement in the United States and Canada	David R. Smith of ICPI		✓					
45	Green Infrastructure Primer for Delaware	Delaware Department of Natural Resources and Environmental Control (DNREC)	✓		✓			✓	

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#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
46	Green Infrastructure Designs – Scalable Solutions to Local Challenges	Delta Institute, IL	✓	✓					
47	Green Infrastructure Standards	District of Columbia – Department of Transportation	✓	✓					
48	Technical Memorandum #6 – Green Infrastructure Technologies	DC Water	✓	✓	✓	✓		✓	
49	DC Water Green Infrastructure Utility Protection Guidelines		✓	✓					
50	DCCR GI Design Standards (Draft)		✓	✓	✓			✓	
51	Riversmart Homes (Training materials)	District Department of the Environment (DDOE)*** and Alliance for the Chesapeake Bay	✓						
52	Low Impact Development (LID) Construction and Maintenance Guidance Manual	District Department of the Environment (DDOE)*** and LID center	✓	✓	✓		✓	✓	
53	RiverSmart Rooftops in Washington, DC	District Department of the Environment (DDOE)**			✓				
54	RiverSmart Homes – Rain Barrel Maintenance		✓						
55	RiverSmart Homes		✓	✓				✓	
56	Stormwater Management Guidebook								
57	Green Roof Plants: A Resource & Planting Guide	Edmund Snodgrass & Lucie Snodgrass			✓				
58	Bioretention Practices	Fairfax County, VA							
59	Permeable Pavement		✓						
60	Rainwater Harvesting		✓					✓	
61	Tree Box Filters								
62	Soil Compost Amendments								
63	Vegetated Roofs				✓				
64	Wet and Dry Stormwater Management Ponds								
65	Vegetated Swales		✓						
66	Public Facilities Manual (Chapter 6) – Fairfax County		✓	✓	✓			✓	✓
67	Fairfax County Maintenance Contractor Awareness Training		✓	✓	✓				✓
68	Recommended Plant List for Bioretention Facilities								
69	40-hrs Stormwater Inspection Team Training Materials (Internal)								
70	Technical Bulletin: Porous Asphalt Pavement, (Rev. 16 July 2012)	Flexible Pavements of Ohio		✓					
71	Georgia Stormwater Management Manual	Georgia Environmental Protection Division (and Atlanta Regional Commission)							
72	Change the Game with Green Infrastructure – Retrofits of Existing Detention Basin may be Orders of Magnitude More Cost-Effective than New BMP Construction: A Preliminary Report	Goodrich et al.							
73	Cost-Effective Stormwater Management Retrofit Device								

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*** Now called Department of Energy and Environment (DOEE)

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#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
74	Green Roof Design 101: Introductory Course, Second Edition Participant's Manual	Green Roofs for Healthy Cities			✓				
75	Green Roof Waterproofing and Drainage 301: Participant's Manual				✓				
76	Strategic Green Infrastructure Planning	Green Infrastructure Center Inc.							
77	Permeable Interlocking Concrete Pavements (Fourth Edition)	Interlocking Concrete Pavement Institute		✓					
78	Inspector's Guide for PICP Installation & Maintenance			✓					
79	A Resident's Reference Guide to Creating a Rain Garden	Kansas City Water Services	✓						
80	Green Infrastructure Pilot Through The Seasons		✓	✓					
81	City of Lancaster Green Infrastructure Plan: Appendix A – Green Infrastructure Technology Fact Sheets	City of Lancaster and Pennsylvania DCNR	✓	✓	✓		✓	✓	
82	Construction Field Guide	Louisville and Jefferson County Metropolitan Sewer District							
83	Stormwater BMP Guidance Tool	Louisiana Department of Environmental Quality (LDEQ)	✓	✓	✓				
84	LID for Southern California	Low Impact Development Center	✓	✓	✓		✓		
85	Maryland Stormwater Design Manual (Volumes 1 and 2)	Maryland Department of the Environment							
86	Factsheet on Stormwater Planters	M. Cahill, D.C. Godwin and M. Sowles	✓						
87	Factsheet on Dry Wells						✓		
88	Factsheet on Swales		✓						
89	2016 LID Manual	Metropolitan Nashville–Davidson Co	✓	✓	✓			✓	
90	Green Infrastructure Design Manual	Metropolitan Sewer District of Louisville, KY	✓	✓	✓	✓		✓	✓
91	Chapter 18 of the GI Design Manual (Draft)		✓	✓	✓	✓		✓	✓
92	Qualified Post-Construction Inspector (QPCI) Exam								
93	Qualified Post-Construction Inspector Training Program								
94	Porous Pavement Ownership & Maintenance	Metropolitan St. Louis Sewer District		✓					
95	Rain Garden Ownership & Maintenance		✓						
96	Planter Box Ownership & Maintenance		✓						
97	Bioretention Maintenance Inspection Checklist		✓						
98	Pervious Pavement Maintenance Inspection Checklist			✓					
99	MSD Rain Garden and Planter Box Maintenance		✓						
100	Landscape Guide for Stormwater BMP Design		✓						✓
101	Low Impact Development Manual for Michigan	Michigan Department of Environmental Quality	✓	✓	✓				
102	Manual of Best Management Practices For Stormwater Quality	Mid-America Regional Council And American Public Works Association	✓	✓	✓				

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#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
103	MMSD Stormwater Tree Factsheet	Milwaukee Metropolitan Sewerage District	✓						
104	Rain Garden Care		✓						
105	Green Infrastructure Maintenance and Equipment Needs (Draft)		✓	✓	✓			✓	✓
106	Inspection Guide (Filtration Practices, Infiltration Basins and Trenches, Bioretention (Raingardens), and Swales)	Minnehaha Creek Watershed District	✓						
107	Inspection Guide for Permeable Pavers			✓					
108	Minnesota Stormwater Manual	Minnesota Pollution Control Agency	✓	✓	✓		✓	✓	✓
109	Missouri Guide to Green Infrastructure	Missouri Department of Natural Resources							
110	Factsheet on Green Roof Maintenance	Montgomery County			✓				
111	Factsheet on Porous Pavement Maintenance			✓					
112	Factsheet on Rain Garden/ Bioswale Maintenance		✓						
113	Factsheet on Swale Maintenance		✓						
114	Factsheet on Vegetated Stormwater Facility Maintenance		✓						
115	Factsheet on Buried Dry Well Maintenance						✓		
116	Factsheet on Rain Barrels		✓					✓	
117	RainScapes Rain Garden Video		✓						
118	How Green Streets Work		✓						
119	Site Assessment for a Rain Garden		✓						
120	Planting Design for Bioretention & Rain Gardens		✓						
121	Permeable Pavement Design Template			✓					
122	Raingardens for Rainscapes		✓						
123	Rainscapes Projects Manual		✓	✓				✓	
124	Grassy Swales (& Bioswales) Maintenance	NEOSWTC (Workshop Materials 2015)	✓						
125	Green Roofs Maintenance				✓				
126	Cisterns & Rainwater Harvesting Maintenance							✓	
127	Bioretention Maintenance (Part 1 and 2)		✓	✓					
128	Permeable Pavement Maintenance (Part 1 and 2)								
129	Parking Lot BMPs (Part 1 and 2)	NEOSWTC (Workshop Materials 2014)							
130	Operations & Maintenance for Bioretention Stormwater Practices (Part 1 & 2)		✓						
131	Plants for Rain Gardens and Bioretention								
132	High Performance Landscape Guidelines	New York City Department of Parks & Recreation	✓	✓	✓	✓	✓		
133	Guidelines for Design & Construction of Stormwater Management Systems	New York Department of Environmental Protection			✓	✓			
134	New York State Stormwater Management Design Manual	New York State Department of Environmental Conservation							
135	Maintaining Stormwater Systems – A Guidebook for Private Owners and Operators in Northern Virginia	Northern Virginia Regional Commission	✓	✓	✓				

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REFERENCES, DOCUMENTS AND TRAINING MATERIALS FOR GREEN STORMWATER INFRASTRUCTURE

#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
136	Stormwater Best Management Practices Manual	North Carolina Department of Environment and Natural Resources							
137	Stormwater BMP Inspection & Maintenance Certification – Participant's Manual	North Carolina State University	✓						✓
138	Low Impact Development A Guidebook for North Carolina	North Carolina Cooperative Extension		✓	✓			✓	✓
139	Maintaining Stormwater Control Measures Guidance for Private Owners & Operators	Northeast Ohio Storm Water Training Council	✓	✓	✓			✓	
140	BioMod Modular Bioretention Brochure	Oldcastle Stormwater Solutions	✓						
141	BioMod Modular Maintenance Manual		✓						
142	TreePod Biofilter		✓						
143	StormCapture Harvesting & Reuse Brochure							✓	
144	StormCapture Installation Manual							✓	
145	StormCapture Maintenance Manual							✓	
146	PermeCapture Brochure			✓					
147	Save the Rain Program Green Infrastructure Maintenance Manual	Onondaga County, NY	✓	✓	✓		✓	✓	
148	Save the Rain Program Green Infrastructure Maintenance Training		✓	✓	✓			✓	
149	Field Guide: Maintaining Rain Gardens, Swales and Stormwater Planters	Oregon State University Stormwater Solutions	✓						
150	Pennsylvania Stormwater Best Management Practices Manual	Pennsylvania Department of Environmental Protection							
151	Green Infrastructure Maintenance Manual Development Process Plan	Philadelphia Water Department	✓	✓	✓			✓	
152	Stormwater Management Guidance Manual		✓	✓	✓	✓		✓	
153	Plant Identification Manual		✓						
154	Green Stormwater Infrastructure Maintenance Manual		✓	✓	✓	✓		✓	✓
155	Low Impact Development & Green Infrastructure Guidance Manual	Pima County & City of Tucson, AZ	✓	✓			✓	✓	
156	Prince George's County Stormwater Design Manual	Prince George's County, MD	✓	✓	✓		✓		
157	Bioretention Manual		✓						
158	Green Infrastructure Practices: An Introduction to Permeable Pavement	Rutgers University		✓					
159	Rain Gardens & Mosquitoes		✓						
160	An Introduction to Green Infrastructure Practices								
161	Green Infrastructure Practices: Tree Boxes		✓						

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#	Title	Author/Publisher	Bioretention*	Porous/ Permeable Pavements	Green Roofs	Blue Roofs	Dry Wells	Rainwater Harvesting**	Stormwater/ Constructed Wetland
162	GI Construction Training Program	San Fransisco Public Utilities Commission							
	Green Infrastructure Construction Guide Book		✓	✓					
	Course 1.1 – Introduction to Green Infrastructure Construction								
	Course 1.2 – Green Infrastructure Site Management								
	Course 2.1 – Bioretention Planter Construction		✓						
	Course 2.2 – Permeable Pavement Construction			✓					
	Tailgate Talks		✓	✓					
163	Stormwater Treatment BMP Inspection Data Collection Form	Santa Clara Valley Urban Runoff Pollution Prevention Program	✓	✓	✓				✓
164	Natural Drainage Systems Landscape Maintenance Categories (LMC) and Characteristics Checklist	Seattle Public Utilities							
165	City of Seattle Stormwater Manual Volume 3: Project Stormwater Control		✓	✓			✓	✓	
166	Green Stormwater Infrastructure Manual – Volume 5: Operations and Maintenance		✓	✓					
167	Low Impact Development (LID) for Southern California	Southern California Stormwater Monitoring Coalition							
168	Site Design Procedures for Better Stormwater Management	Stormwater PA							
169	Getting Polluted Runoff Under Control	Stormwater PA and GreenTreks Network	✓		✓				
170	Tennessee Permanent Stormwater Management and Design Guidance Manual	Tennessee Dept of Environment and Conservation Division of Water Resources	✓	✓	✓			✓	
171	Porous Asphalt Pavements with Stone Reservoirs	U.S. Department of Transportation, Federal Highway Administration		✓					
172	Army Low Impact Development Technical User Guide	U.S. Army Corps of Engineers	✓	✓	✓			✓	
173	Rain Gardens	University of Delaware Co-operative Extension	✓						
174	Green Roofs				✓				
175	Rainwater Harvesting							✓	
176	An Introduction to Stormwater Practices Maintenance – Vegetated & Biological Stormwater Practices Maintenance	University of Minnesota	✓						✓
177	Regular Inspection & Maintenance Guidance for Bioretention System/Tree Filters	University of New Hampshire Stormwater Center	✓						
178	Regular Inspection & Maintenance Guidance for Porous Pavements			✓					
179	Rain Garden Educator's Kit	University of Wisconsin-Extension Basin Education Program & Wisconsin DNR							
180	Urban Storm Drainage Criteria Manual Volume 3	Urban Drainage and Flood Control District, Denver, CO	✓	✓					
181	CU-Structural Soil – A Comprehensive Guide	Urban Horticulture Institute, Cornell University	✓						
182	Using Porous Asphalt and CU-Structural Soil			✓					

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183	Post-Construction Performance Standards & Water Quality-Based Requirements	USEPA							
184	Stormwater Technology Factsheet (Bioretention)		✓						
185	USEPA Stormwater Technology Factsheet (Vegetated Swales)		✓						
186	USEPA Stormwater Technology Factsheet (Constructed Wetlands)								✓
187	USEPA Stormwater Technology Factsheet (Porous Pavement)			✓					
188	Performance of Stormwater Retention Ponds and Constructed Wetlands in Reducing Microbial Concentrations								✓
189	Green Roofs for Stormwater Runoff Control				✓				
190	Green Infrastructure Case Studies								
191	Greening Your Backyard: Water Efficiency and Stormwater Solutions for Homeowners and Communities		✓					✓	
192	Green Infrastructure for Arid Communities								
193	Best Practices for Green Infrastructure O&M								
194	Getting More Green from your Stormwater Infrastructure								
195	Virginia Stormwater BMP Clearing House	Virginia Department of Environmental Quality							
196	Low Impact Development Operations and Maintenance Training	Washington State Department of Ecology	✓	✓	✓				
197	Bioretention Inspection Form								
198	Permeable Pavement Inspection Form			✓					
199	Western Washington Low Impact Development (LID) Operation and Maintenance (O&M)		✓	✓	✓		✓		
200	Washington State Low Impact Development Training Plan								
201	Rain Garden Handbook for Western Washington	Washington State Department of Ecology & WSU Extension	✓						
202	Green Infrastructure Implementation	Water Environment Federation	✓	✓	✓	✓		✓	
203	Green Infrastructure for Southwestern Neighborhoods	Watershed Management Group (Funded by USEPA and Arizona Department of Environmental Quality)							
204	West Virginia Stormwater Management and Design Guidance Manual	West Virginia Department of Environmental Protection	✓	✓	✓			✓	✓
205	Bioretention Soil Mix	12,000 Rain Gardens Program webpage	✓						
206	Sustainable Stormwater Kit	Found as a resource on the ASLA website							

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THANK YOU!

WEF thanks the NGICP Program Partners for their assistance in building the Body of Knowledge. The Body of Knowledge document is an outcome of a collective effort of various subject matter experts (SMEs) in the field of stormwater and GI. We are thankful to the Technical Advisory Group (TAG) members and the Governing Body members for their time and commitment in reviewing this document and providing comments.

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Appendix J

MS4 Practices in Piney Branch from DOEE Database

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MS4 Practices in Piney Branch form DOEE Database

OBJECTID	X	Y	BMP_ID_NUMBER	BMP_TYPE	BMP_SUB_TYPE	UNDERDRAIN	INSTALLATION_DATE	CONTRIBUTING_DRAINAGE_AREA_FT2	POST_PROJECT_NATURAL_FT2	POST_PROJECT_COMPACTED_FT2	POST_PROJECT_IMPERVIOUS_FT2	POST_PROJECT_BMP_AREA_FT2	POST_PROJECT_VEHICULAR_FT2	PRE_PROJECT_NATURAL_FT2	PRE_PROJECT_COMPACTED_FT2	PRE_PROJECT_IMPERVIOUS_FT2	PRE_PROJECT_BMP_AREA_FT2	PRE_PROJECT_VEHICULAR_FT2	STORAGE_VOLUME_FT3	ELIGIBLE STORAGE VOLUME (FT3	X_COORDINATE	Y_COORDINATE
196	-77.0337	39	320-0-2	Storage		FALSE	2003-01-05	144620		60113	84507				144620				5904	5904	397079	142544.2
5	-77.0113	39	527-0-2	Storage		FALSE	2004-04-19	22814			22814								817	817	399020.9	144009.1
13	-77.0169	39	609-0-1	Bioretention	Standard	TRUE	2004-09-05	18295			17465	830							1411	1411	398535.8	145185.8
195	-77.0169	39	609-0-2	Bioretention	Standard	TRUE	2004-09-05	9148			8434	714							196	196	398535.8	145196.9
75	-77.0145	38.9	671-0-1	Storage		FALSE	2004-12-16	87537		31799	45738	10000							23753	20081	398741.6	141963.4
4	-77.0315	38.9	747-0-2	Storage		FALSE	2005-04-04	121968			121968				121968				5266	5266	397269	140401.7
78	-77.0085	39	725-0-1	Filtering Systems		FALSE	2005-05-16	10604			10604								344	344	399263.4	142932.2
121	-77.0333	38.9	1265-0-1	Filtering Systems		FALSE	2005-09-21	4792			4792		4792						198	198	397113.4	141722.7
237	-77.0146	39	721-0-1	Infiltration		FALSE	2005-10-21	8825		5273	3552								152	152	398737.5	144089.4
226	-77.0171	39	1080-0-1	Filtering Systems		FALSE	2006-11-09	23522		2178	21344								528	528	398518	143132.2
239	-77.0330	38.9	1143-0-2	Storage		FALSE	2006-12-22	75796		7406	68390								2985	2985	397138.8	140046.5
94	-77.0330	38.9	1048-0-2	Storage		FALSE	2007-01-31	4160			4160								150	150	397138.9	140446.1
208	-77.0141	38.9	1425-0-1	Filtering System		FALSE	2007-04-02	7675			7675	7675							243	243	398775.6	141612.1
48	-77.0176	39	1323-0-1	Infiltration		FALSE	2007-08-30	4500			4500								98	98	398474.9	144131.2
184	-77.0176	39	1323-0-2	Infiltration		FALSE	2007-08-30	4500			4500								98	98	398474.9	144142.3
136	-77.0320	38.9	1161-0-1	Proprietary practice		FALSE	2007-10-04	43124		871	42253								1762	1762	397225.5	140190.8
71	-77.0360	38.9	97-0-1	Infiltration		FALSE	2008-05-19	32099		1979	30120		11575						1364	1364	396883.3	141767.4
228	-77.0248	38.9	1457-0-1	Filtering Systems		FALSE	2008-07-16	43560			43560								853	853	397850.1	140978.7
69	-77.0318	38.9	1039-0-2	Storage		FALSE	2008-10-01	21780		3920	17860								769	769	397242.9	140113.1
203	-77.0120	39	1477-0-2	Storage		FALSE	2008-11-15	8799			8799								461	461	398960.1	143154.3
29	-77.0243	38.9	1609-0-1	Proprietary practice		FALSE	2009-01-18	18731		871	17860		7405						902	902	397893.3	140734.5
211	-77.0329	38.9	1629-0-1	Filtering Systems		FALSE	2009-01-24	74215		3985	70230		5402						2700	2700	397147.7	140590.4
235	-77.0178	39	1715-0-1	Permeable pavement	Enhanced	TRUE	2009-06-26	103900			0	103900							22351	22351	398457.6	144375.5
241	-77.0258	38.9	1735-0-2	Green roof		FALSE	2009-07-10	5573			0	5573							743	743	397763.5	141456.1
122	-77.0166	39	2765-0-2	Bioretention	Standard	TRUE	2009-11-04	30601		5395	23601	1605							1896	1896	398561.7	144608.6
157	-77.0170	39	2765-0-1	Bioretention	Standard	TRUE	2009-11-04	22699		10513	11800	386							566	566	398527	144608.6
158	-77.0237	38.9	1543-0-1	Green roof		FALSE	2010-09-29	4356			2756	1600							631	631	397945.3	140634.6
53	-77.0236	38.9	1543-0-2	Filtering Systems		FALSE	2010-09-29	2178			2178								192	192	397954	140656.8
9	-77.0253	38.9	1850-0-1	Green roof		FALSE	2010-12-30	9577			0	9577							3990	2654	397806.8	141256.3
183	-77.0250	38.9	1850-0-2	Storage		FALSE	2010-12-30	24159			24159								864	864	397832.8	141278.5
154	-77.0263	39	2672-0-1	Permeable pavement	Standard	TRUE	2011-03-10	50094			0	50094							10019	10019	397720.7	143421
240	-77.0315	38.9	2953-0-1	Bioretention	Standard	TRUE	2011-06-19	15247		6460	8277	510							765	765	397269.5	141889.2
39	-77.0343	38.9	2738-0-1	Permeable pavement	Standard	TRUE	2011-08-20	57499			0	57499							11995	11995	397026.1	140224.1
6	-77.0243	38.9	2692-0-1	Proprietary practice		FALSE	2011-10-19	12197		12197	0								560	560	397893.4	140834.4
58	-77.0330	38.9	2714-0-1	Bioretention	Standard	TRUE	2011-10-27	3485		812	2178	495			871	2614			133	133	397139	140679.2
216	-77.0252	38.9	2721-0-4	Bioretention	Standard	TRUE	2012-03-15	9801		1990	7319	492							983	983	397815.6	141622.6
47	-77.0250	38.9	2721-0-3	Bioretention	Standard	TRUE	2012-03-15	18906		4584	13417	905							1809	1809	397832.8	141411.7
191	-77.0248	38.9	2721-0-1	Bioretention	Standard	TRUE	2012-03-15	6360		4023	2178	159							317	317	397850.1	141289.6
170	-77.0262	38.9	2036-0-1	Permeable pavement	Standard	TRUE	2012-06-24	22050			7686	14364	14364						1200	1200	397728.9	141633.7
206	-77.0324	38.9	2882-0-1	Dry swale		FALSE	2012-07-21	33106		19442	2614	11050							303	303	397191.4	141645
218	-77.0267	38.9	3243-0-1	Green roof		FALSE	2012-11-08	5763			0	5763							769	769	397685.3	140923.3
81	-77.0220	38.9	3142-0-2	Storage		FALSE	2012-11-20	157687		99064	58623		31251						3473	3473	398093	141900
1	-77.0244	38.9	3014-0-1	Green roof		FALSE	2012-12-07	11676			3926	7750							1168	1168	397884.6	140612.4
46	-77.0343	38.9	3078-0-1	Proprietary practice		FALSE	2013-05-14	29403		9016.92	20386.08		424						754	754	397026.1	140079.8
7	-77.0288	38.9	3163-0-1	Permeable pavement	Standard	TRUE	2013-08-30	13454		3159	0	10295			1520	11934			5405	3313	397503.1	140557
54	-77.0269	39	3280-0-3	Proprietary practice		FALSE	2014-05-01	61420		5228	56192								3438	3438	397668.8	143665.2
242	-77.0264	39	3280-0-2	Proprietary practice		FALSE	2014-05-01	87991		19166	68825		11761						3636	3636	397712.1	143776.2
110	-77.0276	39	3280-0-1	Bioretention	Standard	TRUE	2014-05-01	36000			32290	3710							928	928	397608.1	143720.7
30	-77.0324	39	1654-0-1	Filtering Systems		FALSE	2014-07-03	5327		3395	1932		200						218	218	397192	143443.3
77	-77.0323	39	1654-0-2	Filtering Systems		FALSE	2014-07-03	5327		3395	1932		200						218	218	397200.7	143443.3
151	-77.0344	38.9	3373-0-1	Green roof		FALSE	2014-07-20	3978			1074	2904							579	579	397017.4	140068.7

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OBJECTID	X	Y	BMP_ID_NUMBER	BMP_TYPE	BMP_SUB_TYPE	UNDERDRAIN	INSTALLATION_DATE	CONTRIBUTING_DRAINAGE_AREA_FT2	POST_PROJECT_NATURAL_FT2	POST_PROJECT_COMPACTED_FT2	POST_PROJECT_IMPERVIOUS_FT2	POST_PROJECT_BMP_AREA_FT2	POST_PROJECT_VEHICULAR_FT2	PRE_PROJECT_NATURAL_FT2	PRE_PROJECT_COMPACTED_FT2	PRE_PROJECT_IMPERVIOUS_FT2	PRE_PROJECT_BMP_AREA_FT2	PRE_PROJECT_VEHICULAR_FT2	STORAGE_VOLUME_FT3	ELIGIBLE STORAGE VOLUME (FT3	X_COORDINATE	Y_COORDINATE
57	-77.0227	38.9	3528-0-1	Filtering Systems		FALSE	2014-08-13	11278		3275	8003								364.38	364.38	398032	140623.5
131	-77.0263	38.9	3291-0-1	Green roof		FALSE	2014-09-24	32495			29620	2875							3128	3128	397720.1	141145.3
231	-77.0253	38.9	3291-0-3	Green roof		FALSE	2014-09-24	32686			29620	3066							1778	1778	397806.8	141156.4
55	-77.0148	39	3448-0-2	Filtering Systems		FALSE	2014-10-09	49924		11948	37976		18300						4500	4500	398717.4	142843.5
14	-77.0137	39	3448-0-1	Bioretention	Standard	TRUE	2014-10-09	22560		10760	11548	252							754	754	398812.7	142843.5
3	-77.0154	39	3353-0-1	Proprietary practice		FALSE	2015-01-21	19994			19994		6795						851	851	398665.7	145230.2
41	-77.0319	38.9	3502-0-1	Filtering Systems		FALSE	2015-05-24	8138			8138								370	370	397234.8	141944.7
98	-77.0313	39	3573-0-2	Storage		FALSE	2015-06-21	39291			39291								864	864	397287.1	142755.1
126	-77.0313	39	3573-0-1	Proprietary practice		FALSE	2015-06-21	25169			25169		21337						1005	1005	397287.1	142766.2
130	-77.0272	39	3587-0-1	Filtering Systems		FALSE	2015-07-30	2084			2084								288	288	397642.7	143432.1
200	-77.0320	38.9	792580	Bioretention	Enhanced	FALSE	2015-10-19	34873		27884	6013	976							3829	3829	397226.1	141645
99	-77.0317	38.9	792579	Green roof		FALSE	2015-10-19	609			609								38	38	397252.1	141645
33	-77.0270	38.9	3680-0-27	Permeable pavement	Standard	TRUE	2015-10-24	1907			0	1907							1668	528	397659.6	141866.9
60	-77.0271	38.9	3680-0-51	Bioretention	Standard	TRUE	2015-10-24	4724			912	3812							3335	1309	397650.9	141844.7
125	-77.0284	38.9	3680-0-13	Bioretention	Standard	TRUE	2015-10-24	1742			1243	499							887	483	397538.2	141889.1
91	-77.0271	38.9	3680-0-6	Bioretention	Standard	TRUE	2015-10-24	3767			2942	825							1469	1044	397650.9	141778.1
236	-77.0280	38.9	3680-0-3	Bioretention	Standard	TRUE	2015-10-24	3029			2396	633							1126	839	397572.9	141900.2
173	-77.0270	38.9	3680-0-11	Bioretention	Standard	TRUE	2015-10-24	1549			1281	268							477	429	397659.6	141789.2
153	-77.0278	38.9	3680-0-5	Bioretention	Standard	TRUE	2015-10-24	2877			2439	438							779	779	397590.2	141822.5
26	-77.0282	38.9	3680-0-1	Bioretention	Standard	TRUE	2015-10-24	2568			2245	323							574	574	397555.6	141911.3
61	-77.0268	38.9	3680-0-28	Permeable pavement	Standard	TRUE	2015-10-24	3153			1376	1777							622	622	397676.9	141855.8
162	-77.0271	38.9	3680-0-10	Bioretention	Standard	TRUE	2015-10-24	1374			1097	277							246	246	397650.9	141800.3
124	-77.0282	38.9	3680-0-4	Bioretention	Standard	TRUE	2015-10-24	4254			3882	372							662	662	397555.6	141889.1
103	-77.0280	38.9	3680-0-30	Permeable pavement	Standard	TRUE	2015-10-24	7765			6476	1289							1128	1128	397572.9	141844.7
10	-77.0263	38.9	3680-0-7	Bioretention	Standard	TRUE	2015-10-24	1890			1787	103							183	183	397720.2	141689.2
222	-77.0269	38.9	3680-0-50	Bioretention	Standard	TRUE	2015-10-24	13972			12428	1544							1351	1351	397668.2	141755.8
97	-77.0277	38.9	3680-0-20	Permeable pavement	Standard	TRUE	2015-10-24	3073			2592	481							253	253	397598.9	141900.2
20	-77.0273	38.9	3680-0-29	Permeable pavement	Standard	TRUE	2015-10-24	9493			8605	888							777	777	397633.6	141900.2
215	-77.0277	38.9	3680-0-49	Bioretention	Standard	TRUE	2015-10-24	27613			25127	2486							2176	2176	397598.9	141844.7
147	-77.0269	38.9	3680-0-14	Bioretention	Standard	TRUE	2015-10-24	12430			11923	507							902	902	397668.2	141722.5
163	-77.0275	38.9	3680-0-48	Bioretention	Standard	TRUE	2015-10-24	7846			7251	595							521	521	397616.3	141911.3
197	-77.0264	38.9	3680-0-9	Bioretention	Standard	TRUE	2015-10-24	3048			2942	106							189	189	397711.6	141789.1
135	-77.0270	38.9	3680-0-24	Permeable pavement	Standard	TRUE	2015-10-24	10169			9514	655							573	573	397659.6	141800.3
223	-77.0276	38.9	3680-0-31	Permeable pavement	Standard	TRUE	2015-10-24	19511			18704	807							989	989	397607.5	141800.3
138	-77.0268	38.9	3680-0-52	Bioretention	Standard	TRUE	2015-10-24	3681			3260	421							147	147	397676.9	141789.1
36	-77.0262	38.9	3680-0-8	Bioretention	Standard	TRUE	2015-10-24	9195			9027	168							299	299	397728.9	141689.2
95	-77.0271	38.9	3680-0-12	Bioretention	Standard	TRUE	2015-10-24	7690			7553	137							244	244	397650.9	141911.3
80	-77.0273	38.9	3680-0-22	Permeable pavement	Standard	TRUE	2015-10-24	19511			19260	251							252	252	397633.5	141778.1
166	-77.0251	39	3791-0-4	Permeable pavement	Standard	TRUE	2015-11-20	138441		25881	41288	71272			72760	73840			14254	14254	397824.8	143809.5
134	-77.0251	39	3791-0-1	Filtering Systems		FALSE	2015-11-20	23355		5302	18053					86319			2160	2160	397824.8	143831.7
18	-77.0257	39	3791-0-2	Storage		FALSE	2015-11-20	86094		9045	77049		54162						3346	3346	397772.8	143643
172	-77.0296	38.9	680115	Bioretention	Enhanced	FALSE	2015-12-14	22614			22614								4392	4392	397435.9	141852
89	-77.0285	38.9	680174	Engineered treepits	Standard	TRUE	2015-12-14	24297		2827	19054	2416							4349	4349	397530.4	141701.6
159	-77.0292	38.9	680116	Bioretention	Standard	TRUE	2015-12-14	81247		27490	50341	3416							12665	12665	397464.7	141791.7
23	-77.0283	38.9	680117	Dry swale		FALSE	2015-12-14	46960		46960	0								3167	3167	397545.6	141874.4
34	-77.0296	38.9	680085	Bioretention	Standard	TRUE	2015-12-14	7998		5678	1534	786							510	510	397438.4	141704.7
123	-77.0296	38.9	680084	Bioretention	Enhanced	FALSE	2015-12-14	7184		5476	656	1052							430	430	397437	141871.1
52	-77.0284	38.9	680086	Dry swale		FALSE	2015-12-14	7879		6421	1458								430	430	397534.8	141886.7
21	-77.0296	38.9	680144	Bioretention	Standard	TRUE	2015-12-14	0			0								1413	1413	397438.5	141711.6
37	-77.0167	39	2894-0-1	Filtering Systems		FALSE	2015-12-15	1693			1693		5448						247.5	247.5	398552.7	142799.1
101	-77.0269	38.9	3681-0-1	Permeable pavement	Standard	TRUE	2015-12-23	77874			70063	7811							8072	8072	397668.2	141700.3

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38	-77.0278	38.9	3681-0-2	Proprietary practice		FALSE	2015-12-23	38768			38768								3410	3410	397590.2	141800.3
84	-77.0277	38.9	3833-0-2	Permeable pavement	Standard	TRUE	2016-03-18	2605		1100	491	1014	1014						397	397	397598.6	140812.3
92	-77.0324	38.9	3561-0-1	Proprietary practice		FALSE	2016-03-18	8712		1307	7405								326	326	397191.2	141067.7
106	-77.0277	38.9	3833-0-1	Infiltration		FALSE	2016-03-18	6567		1979	4588								210	210	397598.6	140812.3
2	-77.0182	39	3560-0-1	Green roof		FALSE	2016-06-09	4560			0	4560							380	380	398423.1	145241.4
171	-77.0357	38.9	761173	Infiltration trench		FALSE	2016-08-24	439		169	132	138			439				229.7	99	396903	140023.4
105	-77.0357	38.9	761172	Infiltration trench		FALSE	2016-08-24	727		190	318	219			727				364.5	177	396903.3	140023.4
129	-77.0357	38.9	761169	Intensive green roof		FALSE	2016-08-24	901			180	721			901				362	250	396903.3	140023.4
8	-77.0357	38.9	761174	Pervious concrete	Enhanced	FALSE	2016-08-24	86			68	18				86			19	19	396903.3	140023.4
49	-77.0357	38.9	761168	Intensive green roof		FALSE	2016-08-24	1026			205	821			1026				217	217	396903.3	140023.4
189	-77.0357	38.9	761170	Infiltration basin		FALSE	2016-08-24	104			89	15			104				21.3	21.3	396903.3	140023.4
87	-77.0357	38.9	761167	Extensive green roof		FALSE	2016-08-24	1518			304	1214				1518			216	216	396903.3	140023.4
28	-77.0357	38.9	761171	Infiltration trench		FALSE	2016-08-24	1007		18	939	50			1007				70.9	70.9	396903.3	140023.4
156	-77.0145	39	3755-0-5	Permeable pavement	Enhanced	TRUE	2016-09-01	2131			1276	855							182	182	398743.7	145119.2
68	-77.0152	39	3755-0-7	Permeable pavement	Enhanced	TRUE	2016-09-01	3929			1815	2114							335	335	398683.1	145097
143	-77.0150	39	3755-0-3	Permeable pavement	Enhanced	TRUE	2016-09-01	2876			700	2176							245	245	398700.4	145163.6
45	-77.0146	39	3755-0-4	Permeable pavement	Enhanced	TRUE	2016-09-01	3205			1830	1375							273	273	398735.1	145141.4
79	-77.0150	39	3755-0-8	Permeable pavement	Enhanced	TRUE	2016-09-01	4470			2195	2275							380	380	398700.4	145085.9
66	-77.0147	39	3755-0-6	Permeable pavement	Enhanced	TRUE	2016-09-01	3215			2360	855							266	266	398726.4	145130.3
50	-77.0151	39	3755-0-2	Storage		FALSE	2016-09-01	73601			73601		28815						2007	2007	398691.7	145097
232	-77.0085	38.9	2687-0-1	Proprietary practice		FALSE	2016-09-14	15246			15246		8276						709	709	399263.4	142310.6
15	-77.0213	38.9	1058899	Infiltration trench		FALSE	2016-11-21	1963			1963					1963			487	487	398150.5	140625.4
82	-77.0213	38.9	1058900	Pervious concrete	Enhanced	FALSE	2016-11-21	3473			2333	1140				3473			593	593	398150.5	140600.4
229	-77.0277	38.9	778699	Infiltration		FALSE	2016-11-21	9374		3324	6050								430.64	430.64	397595.5	141328
164	-77.0262	38.9	1032179	Pervious concrete	Enhanced	FALSE	2017-04-06	187	0	0	0	187		0	0	187	0		83	52	397727.5	141714
140	-77.0262	38.9	1032178	Infiltration trench		FALSE	2017-04-06	2603		377	2121	105			0	2603	0		365	365	397727.5	141707.7
202	-77.0261	38.9	1032177	Extensive green roof		FALSE	2017-04-06	1809	0	0	0	1809		0	0	1809	0		239	239	397737.8	141707.7
179	-77.0139	39	4617-48-1	Traditional bioretention	Standard	TRUE	2017-07-21	4971	0	1050	3566	355	2093	0	1105	3866	0	947	773	773	398797	143212
19	-77.0128	39	4617-36-1	Permeable pavers	Enhanced	FALSE	2017-07-21	5463	0	890	3284	1289	0	0	690	4773	0	0	562	562	398895	143166
31	-77.0105	39	4617-43-1	Permeable pavers	Enhanced	FALSE	2017-07-21	637	0	93	401	143	0	0	46	591	0	0	66	66	399092	143217
93	-77.0104	39	4617-44-1	Permeable pavers	Enhanced	FALSE	2017-07-21	653	0	47	454	152	0	0	39	614	0	0	67	67	399102	143169
56	-77.0065	39	4617-37-1	Permeable pavers	Enhanced	FALSE	2017-07-21	2734	0	250	1802	682	0	0	200	2534	0	0	276	276	399434	143166
161	-77.0159	39	4617-46-1	Traditional bioretention	Standard	TRUE	2017-07-21	10101	0	2596	7264	241	5240	0	1988	8113	0	5240	364	364	398624	143162
139	-77.0140	39	4617-47-1	Traditional bioretention	Standard	TRUE	2017-07-21	15769	0	4522	11140	107	3784	0	3778	11991	0	3312	111	111	398784	143211
152	-77.0146	39	987983	Stormwater planters	Standard	TRUE	2017-08-28	3150			2400	750			3150				134	134	398735.7	142885.3
175	-77.0143	39	987984	Stormwater planters	Standard	TRUE	2017-08-28	2150			1800	350			2150				66	66	398757.4	142885.7
238	-77.0231	38.9	1275429	Infiltration trench		FALSE	2018-02-15	7523		637	5986	900			1169	6354			1248.5	1248.5	397996.7	141595.6
233	-77.0135	38.9	1177940	Pervious concrete	Enhanced	FALSE	2018-03-29	16			3	13			6	10			15.5	4	398829.3	141660.6
150	-77.0134	38.9	1177909	Pervious concrete	Standard	TRUE	2018-03-29	2317		301	175	1841			1930	387	0		652	602	398838.5	141722.3
115	-77.0135	38.9	1177910	Pervious concrete	Enhanced	FALSE	2018-03-29	776		290	336	150			419	357			179.1	177	398829.9	141722.3
165	-77.0134	38.9	1177911	Traditional bioretention	Enhanced	FALSE	2018-03-29	2454		557	1822	75			1222	1232			105	105	398838.5	141722.3
225	-77.0302	38.9	983601	Pervious concrete	Enhanced	FALSE	2018-05-09	3311	0	244	2230	837		0	1814	1497	0		1308	885	397380.5	140684.3
224	-77.0299	38.9	983602	Traditional bioretention	Enhanced	FALSE	2018-05-09	3039	0	632	2315	92		0	1763	1276	0		131	131	397411.1	140680.3
59	-77.0260	38.9	1185604	Permeable pavers	Enhanced	FALSE	2018-05-25	204	0	28	0	176		0	2	202	0		74.89	53	397742.9	141972.4
67	-77.0261	38.9	1185579	Permeable pavers	Enhanced	FALSE	2018-05-25	204	0	28	0	176		0	204	0	0		74.89	53	397740	141999.2
70	-77.0260	38.9	1185599	Permeable pavers	Enhanced	FALSE	2018-05-25	204	0	28	0	176		0	153	51	0		74.89	53	397743.2	141980.8
185	-77.0261	38.9	1185589	Permeable pavers	Enhanced	FALSE	2018-05-25	204	0	28	0	176		0	74	130	0		74.89	53	397741.9	141990.4
198	-77.0260	38.9	1185594	Permeable pavers	Enhanced	FALSE	2018-05-25	204	0	28	0	176		0	184	20	0		74.89	53	397744.2	141982.2
213	-77.0261	38.9	1185584	Permeable pavers	Enhanced	FALSE	2018-05-25	204	0	28	0	176		0	89	115	0		74.89	53	397741.4	141994
24	-77.0261	38.9	1185581	Permeable pavers	Enhanced	FALSE	2018-05-25	208	0	32	0	176		0	158	50	0		74.89	53	397740.7	141997
108	-77.0261	38.9	1185586	Permeable pavers	Enhanced	FALSE	2018-05-25	208	0	32	0	176		0	149	59	0		74.89	53	397741.6	141991.9

MS4 Practices in Piney Branch form DOEE Database

OBJECTID	X	Y	BMP_ID_NUMBER	BMP_TYPE	BMP_SUB_TYPE	UNDERDRAIN	INSTALLATION_DATE	CONTRIBUTING_DRAINAGE_AREA_FT2	POST_PROJECT_NATURAL_FT2	POST_PROJECT_COMPACTED_FT2	POST_PROJECT_IMPERVIOUS_FT2	POST_PROJECT_BMP_AREA_FT2	POST_PROJECT_VEHICULAR_FT2	PRE_PROJECT_NATURAL_FT2	PRE_PROJECT_COMPACTED_FT2	PRE_PROJECT_IMPERVIOUS_FT2	PRE_PROJECT_BMP_AREA_FT2	PRE_PROJECT_VEHICULAR_FT2	STORAGE_VOLUME_FT3	ELIGIBLE STORAGE VOLUME (FT3	X_COORDINATE	Y_COORDINATE
149	-77.0260	38.9	1185596	Permeable pavers	Enhanced	FALSE	2018-05-25	208	0	32	0	176		0	198	10	0		74.89	53	397743.2	141981.4
168	-77.0260	38.9	1185591	Permeable pavers	Enhanced	FALSE	2018-05-25	208	0	32	0	176		0	142	66	0		74.89	53	397742.9	141985.7
169	-77.0260	38.9	1185606	Permeable pavers	Enhanced	FALSE	2018-05-25	208	0	32	0	176		0	4	204	0		74.89	53	397745.1	141966.7
201	-77.0260	38.9	1185601	Permeable pavers	Enhanced	FALSE	2018-05-25	208	0	32	0	176		0	28	180	0		74.89	53	397743.8	141977.7
17	-77.0263	38.9	1185603	Dry swale		FALSE	2018-05-25	523	0	260	218	45		0	298	225	0		146.46	111	397722.3	141973.7
111	-77.0262	38.9	1185608	Dry swale		FALSE	2018-05-25	523	0	260	218	45		0	409	114	0		146.46	111	397725.4	141965.6
141	-77.0263	38.9	1185588	Dry swale		FALSE	2018-05-25	523	0	260	218	45		0	355	168	0		146.46	111	397719	141990.2
146	-77.0263	38.9	1185598	Dry swale		FALSE	2018-05-25	523	0	260	218	45		0	506	17	0		146.46	111	397720.9	141979.3
160	-77.0263	38.9	1185593	Dry swale		FALSE	2018-05-25	523	0	260	218	45		0	523	0	0		146.46	111	397720.6	141981.9
176	-77.0263	38.9	1185583	Dry swale		FALSE	2018-05-25	523	0	260	218	45		0	523	0	0		146.46	111	397718	141993.3
32	-77.0261	38.9	1185600	Infiltration trench		FALSE	2018-05-25	492	0	27	450	15		0	327	165	0		42.08	42.08	397739.3	141981.2
40	-77.0261	38.9	1185605	Infiltration trench		FALSE	2018-05-25	492	0	27	450	15		0	55	437	0		42.08	42.08	397739.3	141973.9
117	-77.0261	38.9	1185595	Infiltration trench		FALSE	2018-05-25	492	0	27	450	15		0	373	119	0		42.08	42.08	397740	141983.4
142	-77.0261	38.9	1185590	Infiltration trench		FALSE	2018-05-25	492	0	27	450	15		0	103	389	0		42.08	42.08	397738.7	141990
177	-77.0261	38.9	1185585	Infiltration trench		FALSE	2018-05-25	492	0	27	450	15		0	115	377	0		42.08	42.08	397738.5	141993.9
205	-77.0261	38.9	1185580	Infiltration trench		FALSE	2018-05-25	492	0	27	450	15		0	492	0	0		42.08	42.08	397737	141999.6
16	-77.0261	38.9	1185592	Infiltration trench		FALSE	2018-05-25	503	0	16	472	15		0	217	286	0		42.08	42.08	397740.5	141983.2
64	-77.0261	38.9	1185587	Infiltration trench		FALSE	2018-05-25	503	0	16	472	15		0	105	398	0		42.08	42.08	397739.7	141991.5
96	-77.0261	38.9	1185582	Infiltration trench		FALSE	2018-05-25	503	0	16	472	15		0	322	181	0		42.08	42.08	397738.1	141996.3
116	-77.0261	38.9	1185602	Infiltration trench		FALSE	2018-05-25	503	0	16	472	15		0	116	387	0		42.08	42.08	397739.6	141976.5
128	-77.0261	38.9	1185607	Infiltration trench		FALSE	2018-05-25	503	0	16	472	15		0	43	460	0		42.08	42.08	397741.1	141965.2
167	-77.0261	38.9	1185597	Infiltration trench		FALSE	2018-05-25	503	0	16	472	15		0	503	0	0		42.08	42.08	397740.7	141980.2
83	-77.0212	38.9	1179005	Infiltration trench		FALSE	2018-06-06	1629	0	577	1052	0		0	1629	0	0		255	255	398158.5	140585.5
100	-77.0214	38.9	1179004	Infiltration trench		FALSE	2018-06-06	3373			3373					3373			441	441	398146.7	140605
119	-77.0107	39	1171335	Traditional bioretention	Enhanced	TRUE	2018-08-02	5944		127	4868	949			5944				1665	1630	399073.1	143072.3
62	-77.0107	39	1171334	Porous asphalt	Standard	TRUE	2018-08-02	4260		232	0	4028	4028		4260				191	191	399073.1	143072.3
204	-77.0230	38.9	1174621	Permeable pavers	Enhanced	FALSE	2018-09-12	1839			1155	684			1839				416.1	416.1	398006	140623.5
194	-77.0230	38.9	1174622	Infiltration trench		FALSE	2018-09-12	3030		313	2167	550			3030				527.1	527.1	398006	140645.7
180	-77.0197	39	1301001	Intensive green roof		FALSE	2018-09-24	283			35	248				283			74	74	398294.7	143216.8
114	-77.0197	39	1300998	Intensive green roof		FALSE	2018-09-24	262			38	224				262			67	67	398294.7	143216.8
181	-77.0197	39	1301000	Intensive green roof		FALSE	2018-09-24	181			31	150				181			45	45	398294.7	143216.8
63	-77.0197	39	1300999	Intensive green roof		FALSE	2018-09-24	103			20	83				103			25	25	398294.7	143216.8
192	-77.0197	39	1300997	Intensive green roof		FALSE	2018-09-24	1483			367	1116				1483			355.63	355.63	398294.7	143216.8
199	-77.0197	39	1300996	Intensive green roof		FALSE	2018-09-24	2977			1400	1577				2977			502.54	502.54	398294.7	143216.8
104	-77.0289	38.9	1255706	Extensive green roof		FALSE	2018-10-05	18345	0	0	1387	16958		0	178	18167	0		3475	3475	397494.4	141404.3
243	-77.0289	38.9	1255737	Traditional bioretention	Standard	TRUE	2018-10-05	11085	0	3527	7426	132		0	4367	6718	0		138	138	397493.2	141429.2
210	-77.0210	38.9	1380285	Traditional bioretention	Standard	TRUE	2018-10-30	2646		813	1419	414			1227	1419			877	626	398177.3	140679.6
133	-77.0214	38.9	1380314	Traditional bioretention	Standard	TRUE	2018-10-30	4051		269	3351	431			700	3351			1025.92	1025.92	398143.7	140676
188	-77.0212	38.9	1380344	Traditional bioretention	Standard	TRUE	2018-10-30	2646		425	1959	262			687	1959			632.3	632.3	398166.1	140748.8
35	-77.0212	38.9	1380313	Traditional bioretention	Standard	TRUE	2018-10-30	3393			3078	315			315	3078			834.75	834.75	398159	140679.6
214	-77.0214	38.9	1380254	Traditional bioretention	Standard	TRUE	2018-10-30	4141			3799	342			292	3849			949	949	398143.8	140753.1
74	-77.0216	38.9	1380315	Traditional bioretention	Standard	TRUE	2018-10-30	2308			2112	196			196	2112			519.4	519.4	398127.8	140729.3
25	-77.0215	38.9	1380316	Traditional bioretention	Standard	TRUE	2018-10-30	2341			2143	198			198	2143			524.82	524.82	398132.8	140708.6
182	-77.0217	38.9	1380317	Porous asphalt	Standard	TRUE	2018-10-30	8575		265	1476	6834			580	7995			1793.9	1793.9	398117.8	140689.8
145	-77.0280	39	723549	Green roof		FALSE	2019-01-16	182			9	173				182			118.3	50	397576.4	144000.2
102	-77.0279	39	723581	Green roof		FALSE	2019-01-16	1223			247	976				1223			667.3	339	397578.7	144046.1
244	-77.0279	39	723582	Bioretention	Standard	TRUE	2019-01-16	9574		1423	7496	655			3200	6374			1981.4	1981.4	397578.7	144046.1
187	-77.0280	39	723580	Green roof		FALSE	2019-01-16	1010			52	958				1010			190.2	190.2	397573.5	143998.3
72	-77.0280	39	723550	Green roof		FALSE	2019-01-16	444			40	404				444			80.3	80.3	397577	144010.5
127	-77.0330	38.9	1263377	Extensive green roof		FALSE	2019-03-17	1032			269	763			665	367			182.6	182.6	397140	140904.7
85	-77.0330	38.9	1263376	Extensive green roof		FALSE	2019-03-17	537			159	378			95	442			90.5	90.5	397140	140904.7

MS4 Practices in Piney Branch form DOEE Database

OBJECTID	X	Y	BMP_ID_NUMBER	BMP_TYPE	BMP_SUB_TYPE	UNDERDRAIN	INSTALLATION_DATE	CONTRIBUTING_DRAINAGE_AREA_FT2	POST_PROJECT_NATURAL_FT2	POST_PROJECT_COMPACTED_FT2	POST_PROJECT_IMPERVIOUS_FT2	POST_PROJECT_BMP_AREA_FT2	POST_PROJECT_VEHICULAR_FT2	PRE_PROJECT_NATURAL_FT2	PRE_PROJECT_COMPACTED_FT2	PRE_PROJECT_IMPERVIOUS_FT2	PRE_PROJECT_BMP_AREA_FT2	PRE_PROJECT_VEHICULAR_FT2	STORAGE_VOLUME_FT3	ELIGIBLE STORAGE VOLUME (FT3	X_COORDINATE	Y_COORDINATE
186	-77.0330	38.9	1263378	Extensive green roof		FALSE	2019-03-17	1433			478	955			440	993			228.5	228.5	397140	140904.7
109	-77.0330	38.9	1263408	Pervious concrete	Standard	TRUE	2019-03-17	1190			159	1031			800	390			180.6	180.6	397140	140904.7
148	-77.0330	38.9	1263379	Proprietary practice		FALSE	2019-03-17	1076			1076				206	870			0	0	397140	140904.7
217	-77.0083	39	1291500	Permeable pavers	Enhanced	FALSE	2019-03-21	330				330			330				201	91	399282	142775.2
230	-77.0083	39	1291502	Permeable pavers	Enhanced	FALSE	2019-03-21	411			87	324			411				197	114	399282	142755.2
178	-77.0080	39	1291499	Residential rain gardens	Enhanced	FALSE	2019-03-21	2931		720	2058	153			839	2092			239	239	399305	142773.5
174	-77.0312	38.9	1120597	Infiltration trench		FALSE	2019-04-05	1413		0	1273	140			0	1413			216	216	397292.8	141516.4
234	-77.0312	38.9	1120626	Infiltration trench		FALSE	2019-04-05	6168			5888	280				6168			924	924	397292.8	141516.4
227	-77.0312	38.9	1120568	Stormwater planters	Enhanced	TRUE	2019-04-05	6500		1317	4783	400			2493	4007			860	860	397292.8	141516.4
132	-77.0312	38.9	1120566	Infiltration trench		FALSE	2019-04-05	16279		1007	13872	1400			13288	2991			2163	2163	397292.8	141516.4
219	-77.0312	38.9	1120627	Extensive green roof		FALSE	2019-04-05	3034			1707	1327				3034			160	160	397292.9	141516.4
212	-77.0312	38.9	1120567	Extensive green roof		FALSE	2019-04-05	5375		0	3202	2173			1096	4279			263	263	397292.8	141516.4
51	-77.0328	39	1521607	Pervious concrete	Standard	TRUE	2019-04-10	1289		454	0	835			754	535			681.6	298	397159.1	143545.9
27	-77.0326	39	1521605	Pervious concrete	Standard	TRUE	2019-04-10	2201		775	7	1419			1444	757			1157.2	508	397171	143541.1
88	-77.0327	39	1521610	Pervious concrete	Standard	TRUE	2019-04-10	250		142		108			250				93.3	51	397167.2	143561.7
42	-77.0327	39	1521609	Pervious concrete	Standard	TRUE	2019-04-10	281		200		81			281				73	52	397164.9	143558.2
209	-77.0325	39	1521611	Pervious concrete	Standard	TRUE	2019-04-10	410		250	110	50			215	195			52	52	397183.1	143580
22	-77.0326	39	1521612	Extensive green roof		FALSE	2019-04-10	2972			1156	1816			1412	1560			402.5	402.5	397178.8	143561.3
113	-77.0342	38.9	1085505	Permeable pavers	Enhanced	FALSE	2019-05-23	1720		1300	0	420			1720				117.5	117.5	397038.7	141087.2
193	-77.0339	38.9	1085503	Infiltration trench		FALSE	2019-05-23	9163			9163					9163			931.6	931.6	397058.8	141092.2
107	-77.0270	38.9	1333927	Permeable pavers	Enhanced	FALSE	2019-05-30	17153		1688	11348	4117			1688	11348	4117		3294	3294	397657.6	141696.6
207	-77.0271	38.9	1333958	Traditional bioretention	Standard	TRUE	2019-05-30	19313		9454	8909	950			9422	9891			2608	2608	397650	141723
137	-77.0279	38.9	1333868	Intensive green roof		FALSE	2019-05-30	536			0	536				536			89	89	397585.8	141739.2
86	-77.0282	38.9	1333899	Permeable pavers	Standard	TRUE	2019-05-30	2360		189	611	1560				2360			366	366	397553.8	141758.6
190	-77.0277	38.9	1333867	Infiltration trench		FALSE	2019-05-30	34677			34677					34677			3410	3410	397601.8	141786.4
65	-77.0282	38.9	1333898	Extensive green roof		FALSE	2019-05-30	2658			886	1772				2658			245	245	397554.2	141717.5
11	-77.0270	38.9	1333929	Permeable pavers	Standard	TRUE	2019-05-30	35872		9622	23787	2463			11452	21957	2463		1971	1971	397658	141696.2
220	-77.0185	39	1379219	Permeable pavers	Standard	TRUE	2019-11-06	500	0	0	0	500		0	500	0	0		201	139	398398.6	144503.3
76	-77.0185	39	1379220	Traditional bioretention	Standard	TRUE	2019-11-06	31530	0	10950	18230	2350		0	14300	17230	0		6268	6268	398398.6	144503.3
73	-77.0197	39	1379218	Traditional bioretention	Standard	TRUE	2019-11-06	28600	0	3720	23900	980		0	4700	23900	0		6281	6281	398290.5	144411.8
120	-77.0193	39	1379159	Permeable pavers	Enhanced	FALSE	2019-11-06	12600	0	5300	1640	5660		0	12600	0	0		2280.4	2280.4	398330.6	144269.2
221	-77.0186	39	1379163	Traditional bioretention	Standard	TRUE	2019-11-06	5500	0	1800	3250	450		0	5500	0	0		1006	1006	398384.1	144368.9
144	-77.0195	39	1379161	Traditional bioretention	Standard	TRUE	2019-11-06	72700	0	17500	50200	5000		0	23800	48900	0		13665	13665	398306	144264.8
12	-77.0183	39	1379249	Permeable pavers	Enhanced	FALSE	2019-11-06	11600	0	8500	0	3100		0	11600	0	0		1410	1410	398416	144499.3
155	-77.0187	39	1379189	Porous asphalt	Standard	TRUE	2019-11-06	39570	0	2100	25670	11800		0	2100	37470	0		4754	4754	398382.1	144280.9
44	-77.0193	39	1379160	Intensive green roof		FALSE	2019-11-06	11950	0	0	6050	5900		0	7420	4530	0		1016.12	1016.12	398331.2	144297.7
118	-77.0279	38.9	1346683	Permeable pavers	Enhanced	FALSE	2020-01-10	458		325	45	88	0		397	61		0	51	51	397584.1	141219.2
112	-77.0289	38.9	1346651	Permeable pavers	Enhanced	FALSE	2020-01-10	2350		175	1527	648	648		1736	614			487	487	397492	141292.1
43	-77.0290	38.9	1346652	Permeable pavers	Enhanced	FALSE	2020-01-10	3967		317	2850	800			1307	2660			601	601	397484.4	141229
90	-77.0162	38.9	1445632	Permeable pavers	Enhanced	FALSE	2020-01-16	3604	0	305	2520	779		0	1051	2553	0		623	623	398596.8	142361.5
																		Volume (cu ft)	325,462	310,576		
																		Volume (mg)	2.4	2.3		

Appendix K

Model Documentation: Overflow & Green Infrastructure Modeling for Piney Branch Sewershed

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

Model Documentation: Overflow & Green Infrastructure Modeling for Piney Branch Sewershed

June 2020

Prepared for:

Prepared by:

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 20032

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Appendix

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1 Introduction

1.1 Background

The development and calibration of the combined sewer model used for the LTCP is documented in *Study Memorandum LTCP 5-4: CSS Model Documentation* that was published with the LTCP in 2001. The modeling conducted to evaluate both overflows and widespread green infrastructure implementation in the Piney Branch sewershed (NPDES outfall 049) uses a sub-model that was calibrated independently of the system-wide LTCP model using monitoring data related to the Structure 70 regulator improvements.

1.2 Model Documentation

The Piney Branch sewershed model is based upon the system-wide LTCP model. As with the RC-A and PR-A green infrastructure (GI) models, the Piney Branch model uses SWMM to simulate runoff and represent GI implementation. GI is represented on the model subshed level, and for the purposes of the Piney Branch model, only the design parameters of permeable pavement GI practice type is modeled; this was done in order to simplify model setup. The GI scenarios all included the equivalent GI-treated 24 impervious acres from RC-A, along with additional acreage per each scenario (for example, the 90-acre GI scenario is assumed to include RC-A acres, plus an additional 66 impervious acres treated by GI). A schematic of the "lumped practice" modeling approach is shown in Figure 1-1.

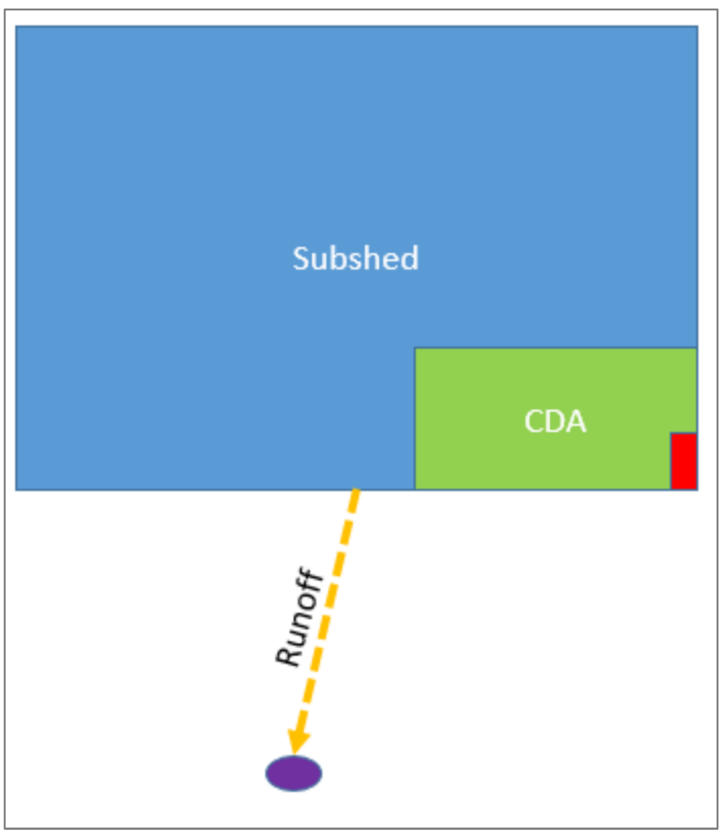

Figure 1-1. Lumped Practice Modeling Approach

1.3 Sewershed Changes Since Long Term Control Plan

The original Long Term Control Plan (LTCP) was developed by DC Water from 1999-2002. During the preparation of the LTCP, flow monitoring was performed at the Piney Branch outfall during 1999-2000. That flow monitoring was used to develop, calibrate and validate the collection system model which was ultimately used to determine the size of the storage facility included in the original LTCP, which was 9.5 million gallons. Since the development of the LTCP, several changes have occurred in the sewershed:

- Pursuant to the requirements of the LTCP Consent Decree, DC Water raised the weir at the diversion structure (Structure 70) for the Piney Branch CSO outfall. The purpose of the weir raising was to increase the capture of combined sewage by increasing the height of the weir. The weir was raised as high as practicable given the capacity of the downstream interceptors, without causing upstream flooding due to restriction of the Piney Branch outlet due to the weir raising.
- Since the original monitoring conducted at the outfall from 1999-2000, natural economic development has occurred in the sewershed. The District's stormwater regulations require mitigation of runoff for development and redevelopment that exceeds certain thresholds. As part of this redevelopment, stormwater controls constructed in the Piney Branch sewershed since 2002 have a storage volume of 2.3 million gallons.
- Rock Creek Project 1 and its associated projects comprising approximately 27 impervious acres was placed in operation on March 15, 2019. These practices were constructed over the previous 2 years and the net effect of these practices appear in the monitoring data collected.

The recent monitoring at the outfall performed since 2018 has captured the net effect of the above changes in the sewershed since the LTCP.

1.4 Scope and Modeling Objectives

The Piney Branch model was developed and calibrated to post improvements monitoring data that was collected in conjunction with the Structure 70 CSO regulator improvements. The resulting calibrated model reflects the structure improvements and the net effects of implementation of stormwater controls in the sewershed since 2002. Various permutations of the calibrated model were then developed to reflect the theoretical implementation of various acres of GI. The calibrated baseline (no GI) and GI scenarios were then applied to predict overflow frequencies and volumes for the LTCP average year period of 1988-1990. The resulting rankings of overflow events for various GI implementation levels were then used to establish storage volumes that would be necessary to achieve one overflow per year; these storages were configured in the model, and the resulting scenario results were used to predict overflow frequencies and volumes with storage in place.

- The Piney Branch monitoring period began on 2/22/2018. There was a period of two-plus months of monitoring while Structure 70 improvements and retrofits were being completed. That work ended on 5/7/2018.
- In May and June 2018, there were several large rain events that washed out stop logs that were installed as part of the regulator retrofits.
- The Structure 70 regulator improvements /post-retrofits completed on 10/4/2018.

- The Piney Branch model calibration period used was from 10/11/2018 (coinciding with the first rainfall event following the restoration of the structure) to 12/3/2019.
- The calibrated model was used to simulate the LTCP forecast period of 1988-1990.
- GI and storage scenarios were set up and simulated for the LTCP forecast period.

Table 1-1 provides an overview of all modeling timeframes.

Table 1-1. Piney Branch Modeling Timeframes

Modeling Purpose	Timeframe	Model Description
Rainfall Monitoring	2/22/18 – 12/3/19	Entire monitoring period
Post-Improvements Monitoring	10/11/18 – 12/3/19	Monitoring that covers full Structure 70 improvements/retrofits. Used as model calibration period.

2 Description of System

2.1 Piney Branch Sewershed

The Piney Branch sewershed consists of 2,333 acres, and is approximately 56% impervious. Its CSO outfall, 049, is regulated by Structure 70, which consists of three weirs at various crest levels. The structure improvements and retrofits included installing stop logs on two of three weirs to raise the effective weir crests.

2.2 Monitoring locations and data

The Piney Branch outfall monitoring that was conducted in 2018-2019 consisted of four meters, one in the East Rock Creek Diversion Sewer downstream of Structure 70, and one meter each at the their Structure 70 overflow weirs. Table 2-1 summarizes the Piney Branch meters.

Table 2-1: Piney Branch Flow Meters

Meter	Location
RCC 049-1	Structure 70 north weir
RCC 049-2	Structure 70 middle weir
RCC 049-3	Structure 70 south weir
RCC 049-4	East Rock Creek Diversion Sewer, downstream of Structure 70

Figure 2-1shows the locations of the Piney Branch meters at Structure 70, which is located just north of Piney Branch Parkway and east of Rock Creek.

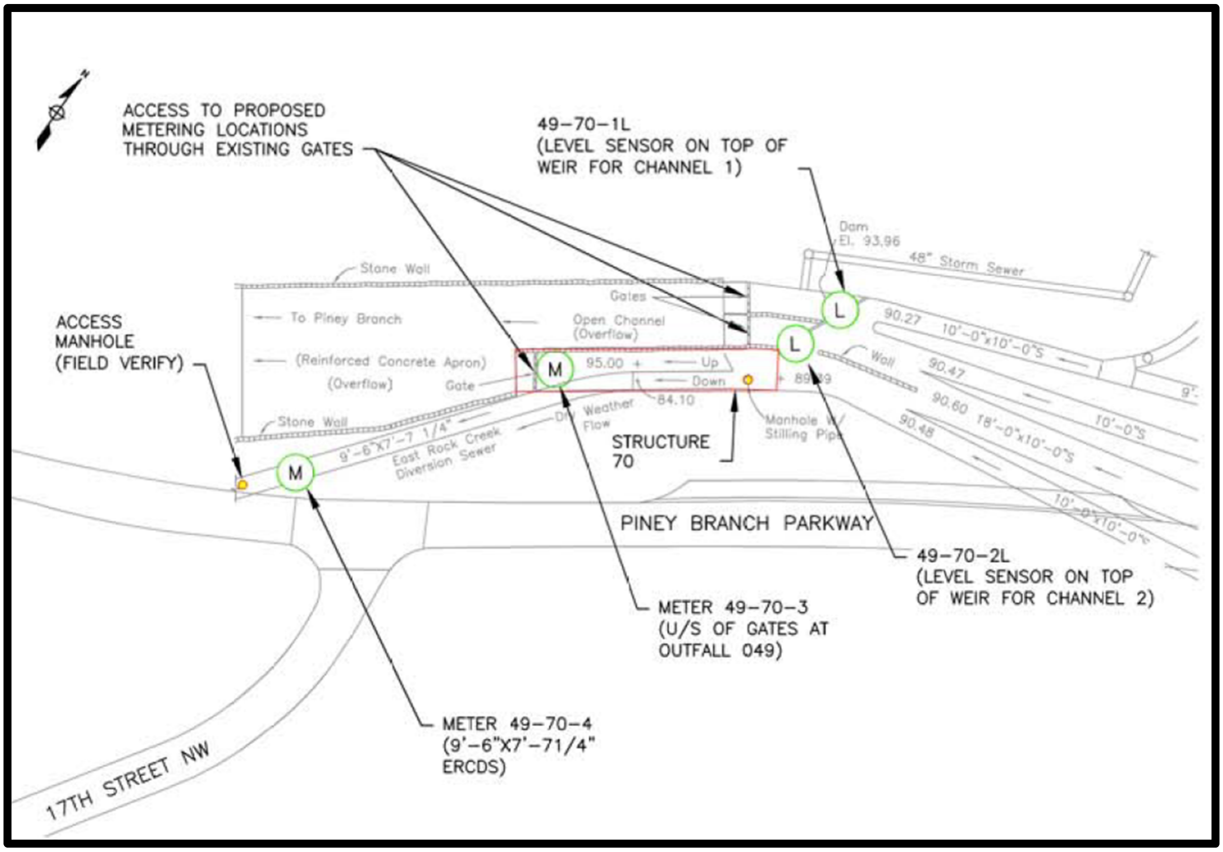

Figure 2-1: Piney Branch Meter Locations

2.3 Rainfall Monitoring

A rain gauge with a five-minute reporting interval was installed at the Washington Latin Public Charter School at 5200 2nd Street Northwest, which is located in the central portion of the Piney Branch sewershed. Table 2-2 summarizes the rainfall event totals for the monitoring periods.

Table 2-2: Total Rainfall During Pre- and Post-Construction Periods

Period	Total Rainfall (inches)	Number of Wet Weather events
2018-2019 entire monitoring period, 2/22/18 – 12/3/19	106.57	211
2018-2019 post-improvements/retrofit calibration period, 10/11/18 – 12/3/19	57.95	127

3 Model Calibration

The Piney Branch model calibration consisted of:

- adjustments to the model's dry weather flow inputs and runoff component to match total flow observed in the East Rock Creek Diversion Sewer, and;
- a reconfiguration of the representation of Structure 70 in the model, so that the post-improvements/retrofit conditions were represented correctly, and the predicted overflows could be calibrated to the observed overflows.

3.1 Calibration Results

Figure 3-1 through Figure 3-6 are 1-to-1 volume and peak flow plots and select individual event hydrographs for the East Rock Creek Diversion Sewer meter location and the sum of the Structure 70 overflow meters, comparing metered flows versus modeled predictions.

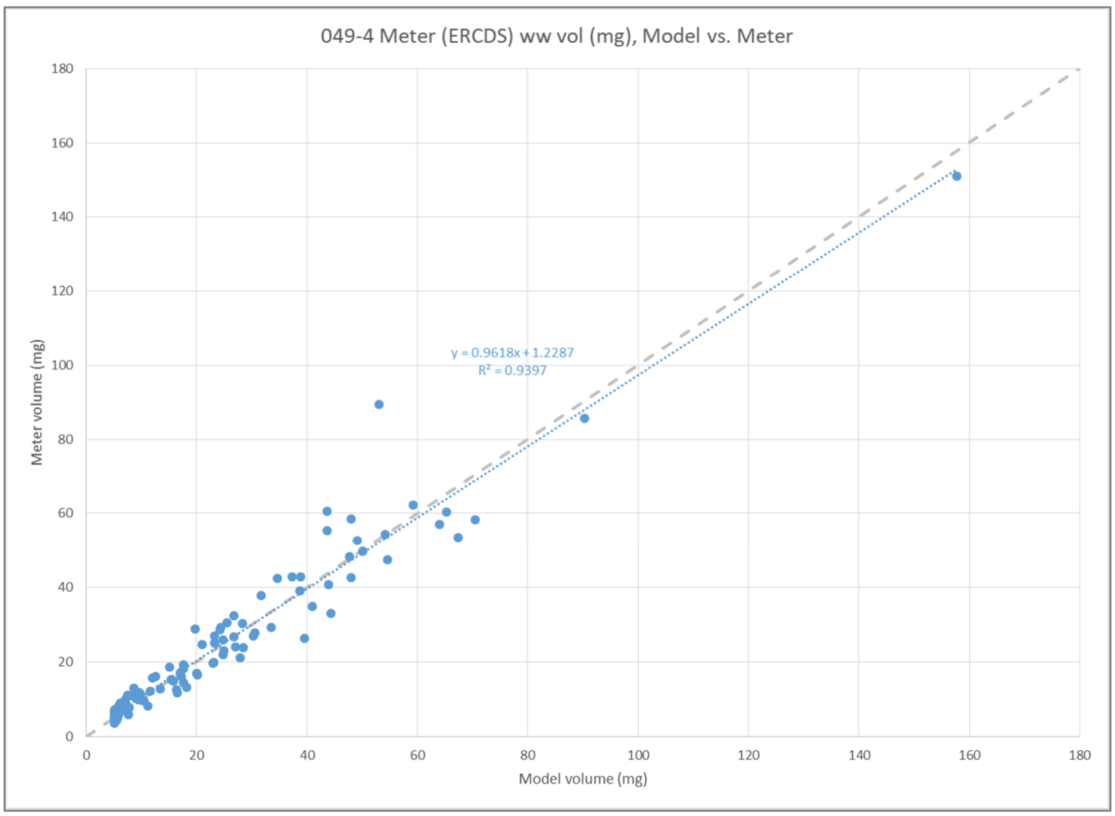

Figure 3-1: Piney Branch event volumes, 049-4 Meter (ERCDS)

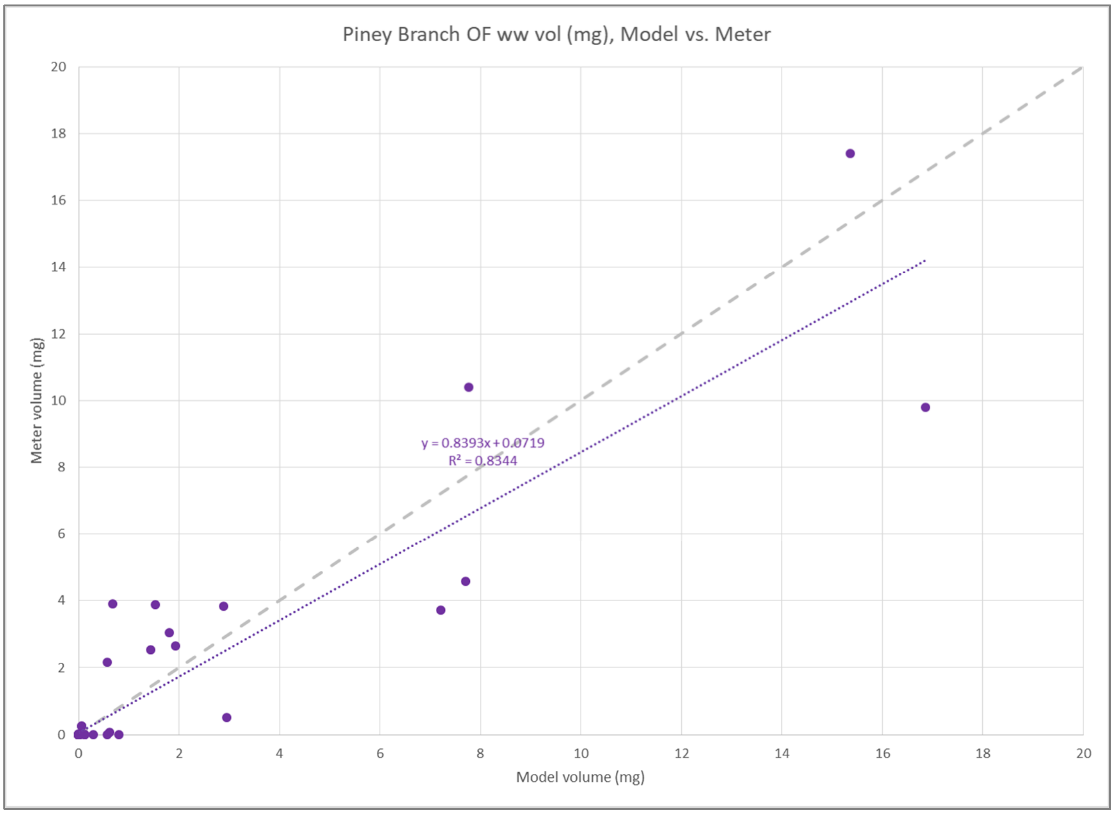

Figure 3-2: Piney Branch event volumes, all 049 overflow meters

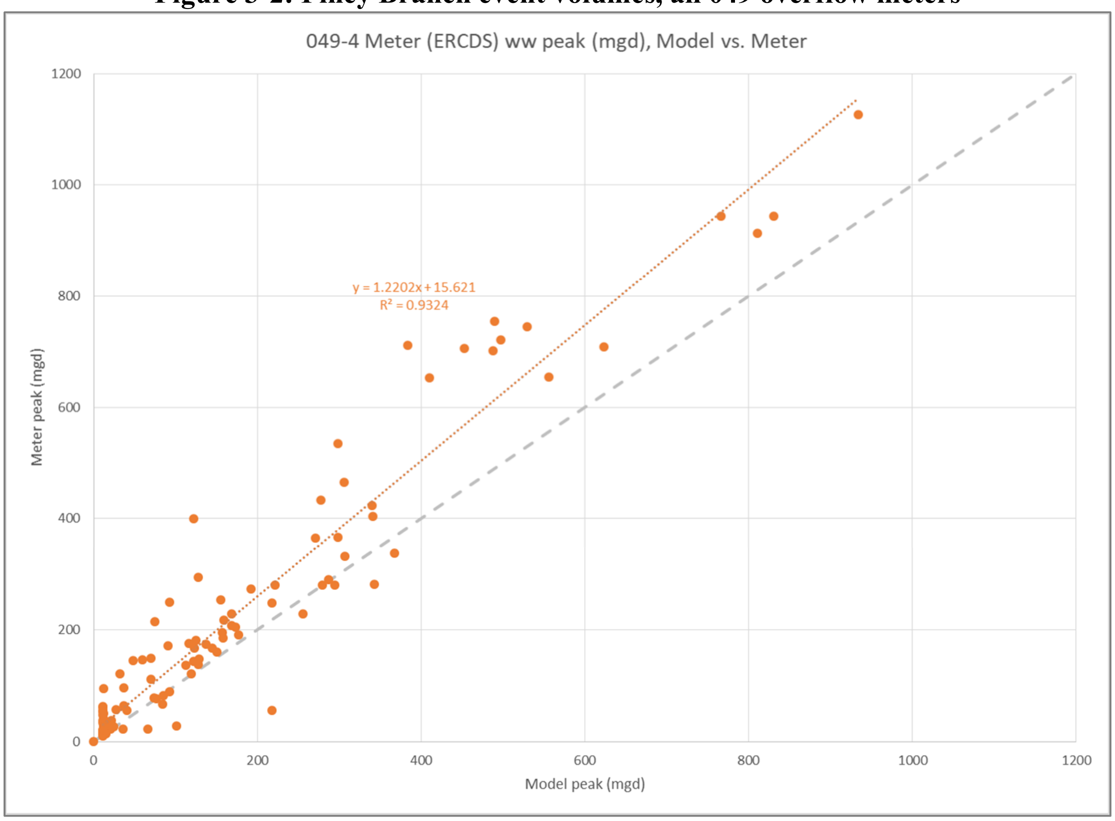

Figure 3-3. Piney Branch event peak flows, 049-4 meter (ERCDS)

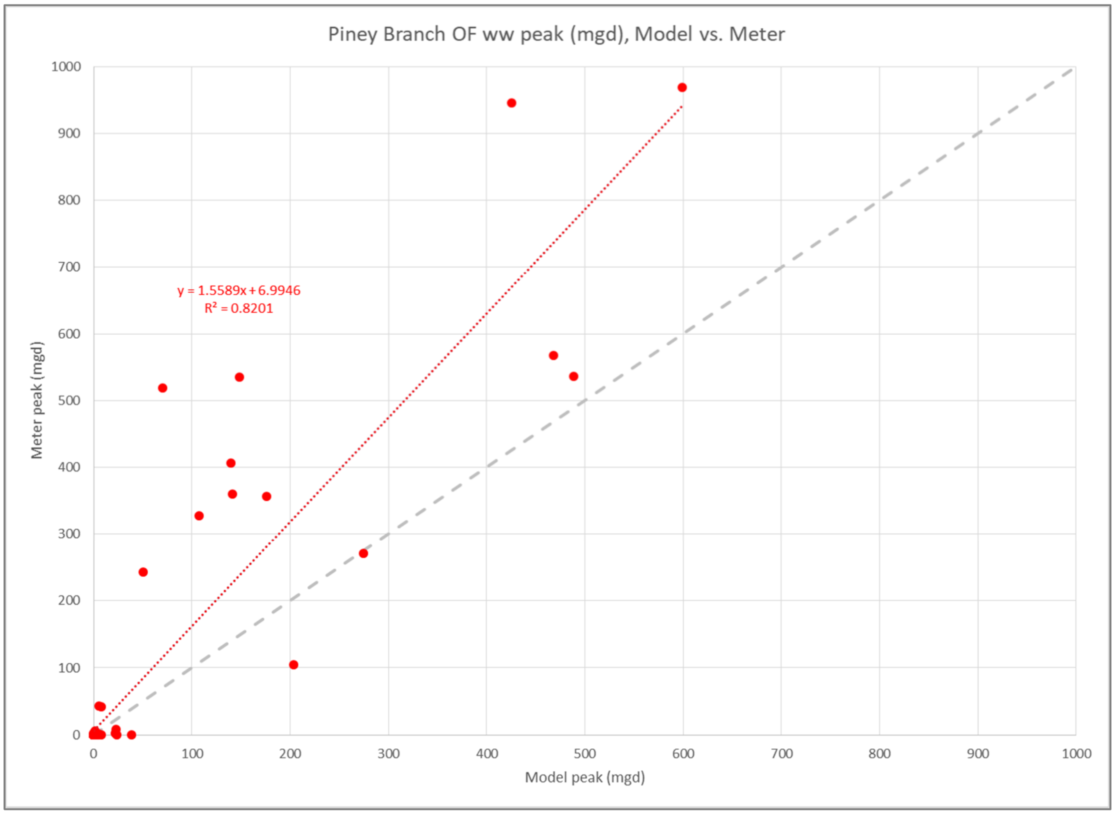

Figure 3-4. Piney Branch event peak flows, all 049 overflow meters

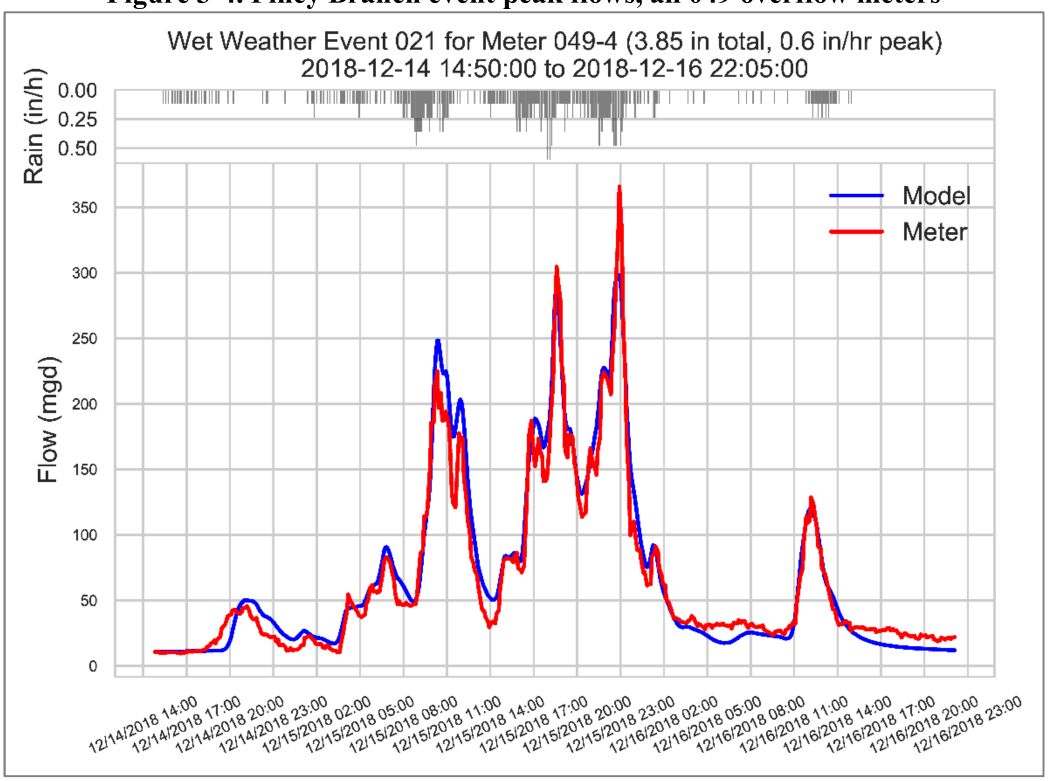

Figure 3-5: PR-A Piney Branch event hydrograph, 049-4 meter (ERCDS)

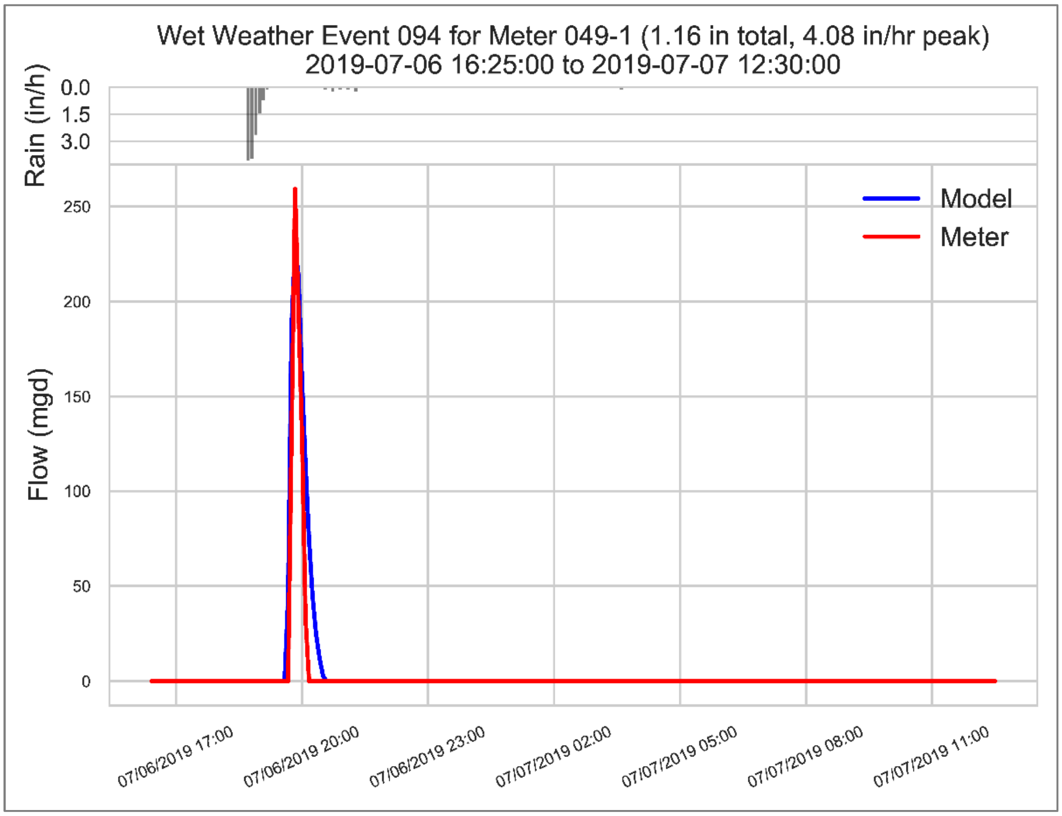

Figure 3-6: Piney Branch event hydrograph, 049-1 (Structure 70 north weir)

The calibrated model matches the overall volumes well, with the overflow volume match showing more scatter, as is typical with calibration to overflow meters. The overall modeled overflow volume exceeds metered overflow volume by 3.4% for the calibration period. The model tends to over-predict peak flows consistently. Table 3-1 summarizes the calibration-period volumes and overflow frequencies, by meter.

Table 3-1. Piney Branch Calibration Summary

		Meter		Model		
Meter	Location	Total Volume (mg)	Event Frequency	Total Volume (mg)	Event Frequency	OF events in common
049-1	North weir	37.56	20	38.22	26	*19*
049-2	Middle weir	23.46	15	23.77	17	*13*
049-3	South weir	8.00	13	9.38	17	*12*
all 049 OFs		*69.02*	*20*	*71.37*	*26*	*19*
049-4	ERCDS	2698.83	n/a	2643.66	n/a	

4 Green Infrastructure & Storage Scenarios

The calibrated Piney Branch model was applied for the LTCP forecast period of 1988-1990 to establish a baseline for average-year CSO predictions for Piney Branch / CSO 049 with the net sewershed changes due to stormwater retrofits since 2002 and the Structure 70 improvements completed. Model scenarios were then developed that evaluated:

- Various levels of GI implementation (zero, 50, 100 and 150 impervious acres treated), assumed for modeling purposes to be distributed throughout the Piney Branch sewershed. All GI scenarios assume that RC-A GI-treated acreage is being supplemented by additional GI-treated acres. RC-A practices are not explicitly modeled in the larger-scale Piney Branch model, but the acres treated by GI in RC-A are included in the totals for each GI scenario.
- To meet the regulatory target of one overflow per year, storages were based on the volume of the 4th overflow event highlighted in the table below for each of the baseline and GI scenarios for all of 1988-1990. The modeled storage element was located downstream of existing overflow weirs, and storage dewatering was set to 24 hours (i.e. a 2 million gallon storage element had a maximum dewatering rate set to 2 mgd).

Table 4-1. Piney Branch Overflow Frequency with GI and Storage

GI = 0, Storage = 0					GI = 50, Storage = 0				
OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)	OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)
1	76_B	5/4/1989	5/6/1989	5.8135	1	76_B	5/4/1989	5/6/1989	5.6903
2	102	11/15/1989	11/18/1989	3.1264	2	102	11/15/1989	11/18/1989	2.7831
3	150	8/5/1990	8/8/1990	2.9346	3	150	8/5/1990	8/8/1990	2.6457
4	162	10/18/1990	10/21/1990	2.7611	4	162	10/18/1990	10/21/1990	2.4012
5	30	7/26/1988	7/29/1988	2.2749	5	30	7/26/1988	7/29/1988	1.9540
6	75	4/28/1989	5/4/1989	1.7849	6	75	4/28/1989	5/4/1989	1.6094
7	151	8/8/1990	8/12/1990	1.3874	7	151	8/8/1990	8/12/1990	1.2956
8	96	9/24/1989	9/28/1989	1.1608	8	96	9/24/1989	9/28/1989	0.9895
9	97	10/1/1989	10/5/1989	1.0476	9	97	10/1/1989	10/5/1989	0.8900
10	80	5/22/1989	5/26/1989	0.9341	10	80	5/22/1989	5/26/1989	0.8222
11	88	7/19/1989	7/22/1989	0.9088	11	88	7/19/1989	7/22/1989	0.7338
12	106	12/30/1989	1/3/1990	0.8341	12	76_A	5/4/1989	5/6/1989	0.6837
13	76_A	5/4/1989	5/6/1989	0.7893	13	106	12/30/1989	1/3/1990	0.6596
14	126	4/14/1990	4/17/1990	0.7041	14	126	4/14/1990	4/17/1990	0.5360
15	147_A	7/11/1990	7/13/1990	0.5605	15	147_A	7/11/1990	7/13/1990	0.3935
16	169	12/20/1990	12/26/1990	0.3762	16	169	12/20/1990	12/26/1990	0.2992
17	85_A	7/3/1989	7/4/1989	0.1982	17	85_A	7/3/1989	7/4/1989	0.1420
18	79	5/15/1989	5/19/1989	0.1469	18	79	5/15/1989	5/19/1989	0.1066
19	51	11/27/1988	11/30/1988	0.1260	19	85_B	7/3/1989	7/6/1989	0.0738
20	85_B	7/3/1989	7/6/1989	0.1025	20	51	11/27/1988	11/30/1988	0.0704

GI = 0, Storage = 0					GI = 50, Storage = 0				
OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)	OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)
21	22	5/16/1988	5/22/1988	0.0972	21	22	5/16/1988	5/22/1988	0.0662
22	83	6/14/1989	6/19/1989	0.0938	22	83	6/14/1989	6/19/1989	0.0541
23	74	4/18/1989	4/21/1989	0.0635	23	74	4/18/1989	4/21/1989	0.0292
24	94	9/13/1989	9/16/1989	0.0146	24	94	9/13/1989	9/16/1989	0.0041
25	120	3/17/1990	3/22/1990	0.0130	25	120	3/17/1990	3/22/1990	0.0029
26	4	1/17/1988	1/22/1988	0.0119	26	123	4/1/1990	4/4/1990	0.0014
27	123	4/1/1990	4/4/1990	0.0093	27	4	1/17/1988	1/22/1988	0.0013
28	49	11/16/1988	11/19/1988	0.0063	28	49	11/16/1988	11/19/1988	0.0006
29	147_B	7/11/1990	7/15/1990	0.0030	29	147_B	7/11/1990	7/15/1990	0.0004
30	131	5/4/1990	5/7/1990	0.0021					
31	82	6/5/1989	6/11/1989	0.0010					
32	132	5/9/1990	5/13/1990	0.0004					

GI = 100, Storage = 0					GI = 150, Storage = 0				
OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)	OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)
1	76_B	5/4/1989	5/6/1989	5.5907	1	76_B	5/4/1989	5/6/1989	5.4458
2	102	11/15/1989	11/18/1989	2.4380	2	150	8/5/1990	8/8/1990	2.2025
3	150	8/5/1990	8/8/1990	2.3924	3	102	11/15/1989	11/18/1989	2.1821
4	162	10/18/1990	10/21/1990	2.0762	4	162	10/18/1990	10/21/1990	1.8455
5	30	7/26/1988	7/29/1988	1.6584	5	30	7/26/1988	7/29/1988	1.4564
6	75	4/28/1989	5/4/1989	1.4520	6	75	4/28/1989	5/4/1989	1.3424
7	151	8/8/1990	8/12/1990	1.2395	7	151	8/8/1990	8/12/1990	1.1503
8	96	9/24/1989	9/28/1989	0.8458	8	96	9/24/1989	9/28/1989	0.7411
9	97	10/1/1989	10/5/1989	0.7471	9	80	5/22/1989	5/26/1989	0.6533
10	80	5/22/1989	5/26/1989	0.7218	10	97	10/1/1989	10/5/1989	0.6504
11	76_A	5/4/1989	5/6/1989	0.5914	11	76_A	5/4/1989	5/6/1989	0.5273
12	88	7/19/1989	7/22/1989	0.5829	12	88	7/19/1989	7/22/1989	0.4879
13	106	12/30/1989	1/3/1990	0.5064	13	106	12/30/1989	1/3/1990	0.4070
14	126	4/14/1990	4/17/1990	0.3911	14	126	4/14/1990	4/17/1990	0.2944
15	147	7/11/1990	7/18/1990	0.2499	15	169	12/20/1990	12/26/1990	0.1867
16	169	12/20/1990	12/26/1990	0.2316	16	147	7/11/1990	7/18/1990	0.1619
17	85_A	7/3/1989	7/4/1989	0.0940	17	85_A	7/3/1989	7/4/1989	0.0640
18	79	5/15/1989	5/19/1989	0.0744	18	79	5/15/1989	5/19/1989	0.0550
19	85_B	7/3/1989	7/6/1989	0.0506	19	85_B	7/3/1989	7/6/1989	0.0354
20	22	5/16/1988	5/22/1988	0.0415	20	22	5/16/1988	5/22/1988	0.0271

GI = 100, Storage = 0					GI = 150, Storage = 0				
OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)	OF vol rank	Event-ID	Event Start	Event End	Model ww vol (mg)
21	51	11/27/1988	11/30/1988	0.0335	21	51	11/27/1988	11/30/1988	0.0144
22	83	6/14/1989	6/19/1989	0.0257	22	83	6/14/1989	6/19/1989	0.0134
23	74	4/18/1989	4/21/1989	0.0087	23	74	4/18/1989	4/21/1989	0.0009

Based on the foregoing, Table 4-2 provides the minimum gray storage volumes required to provide a degree of CSO control of one remaining overflow per average year of rainfall:

Table 4-2. Piney Branch Minimum Gray Storage Volumes

Green Infrastructure Implemented by DC Water (acres)	Minimum Storage Volume (million gallons)
0	2.76
50	2.40
100	2.07
150	1.85

The above minimum storage volumes are based on model output and do not include a safety factor. DC Water normally includes a safety factor in its designs to account for uncertainties in rainfall measurement, monitoring, modeling, construction, climate change and other factors. The safety factor and the final selected gray volume are included in the main body of the Practicability Report.

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Appendix A: Post Improvement Events Plots

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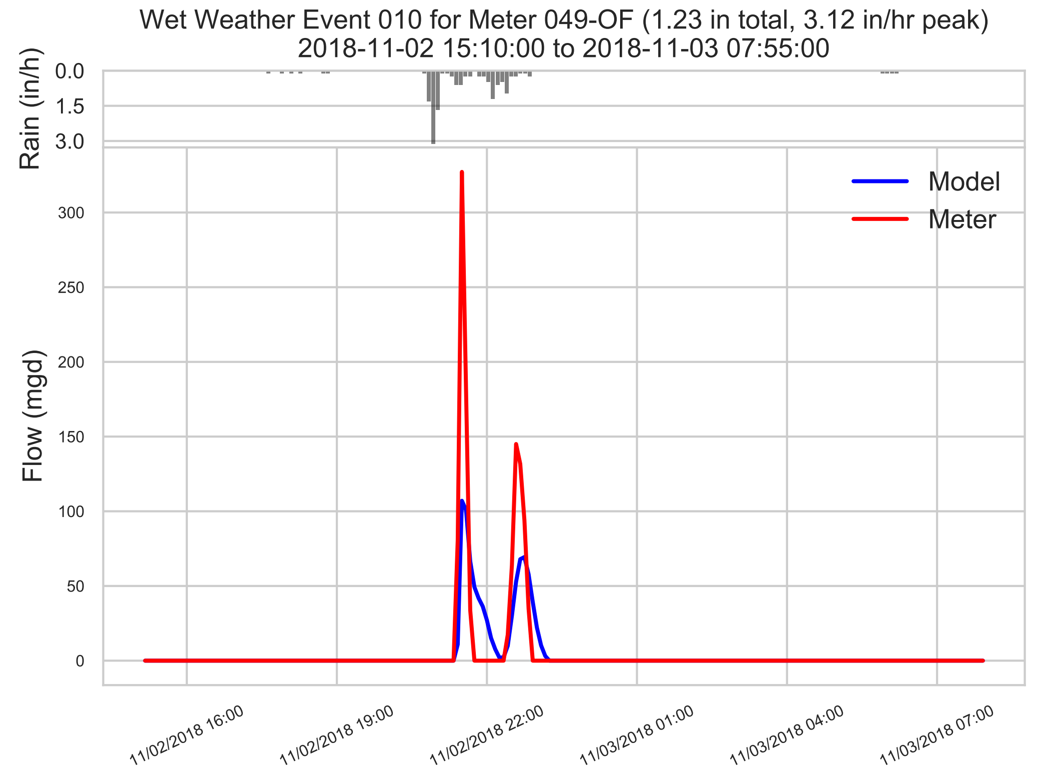
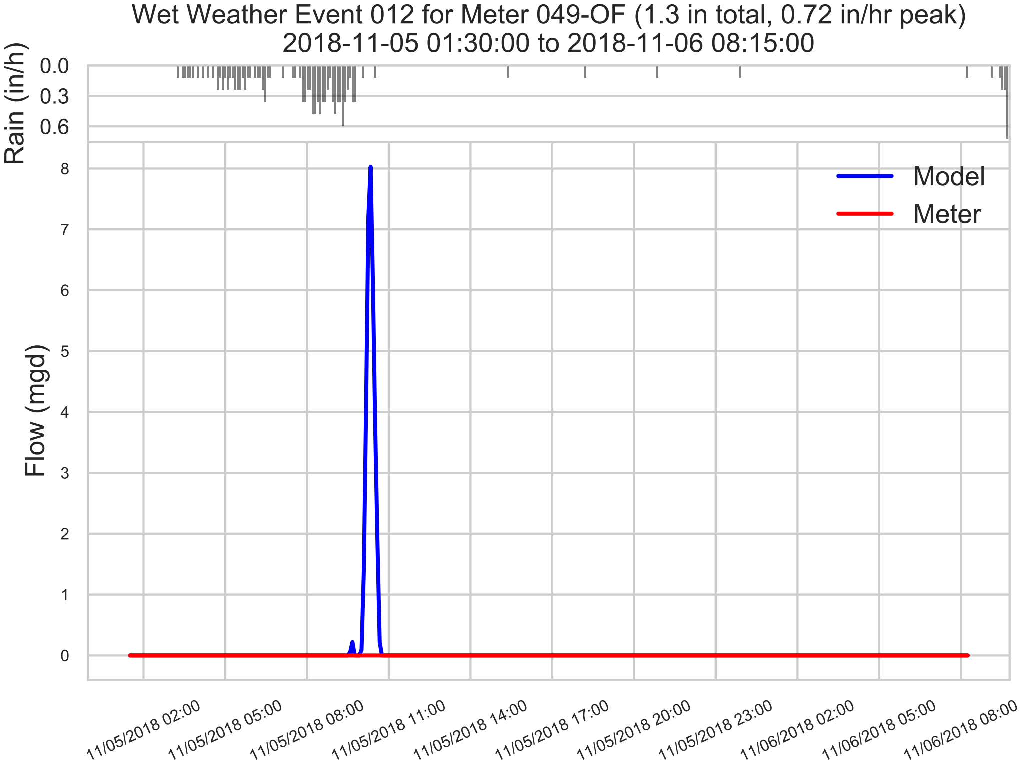
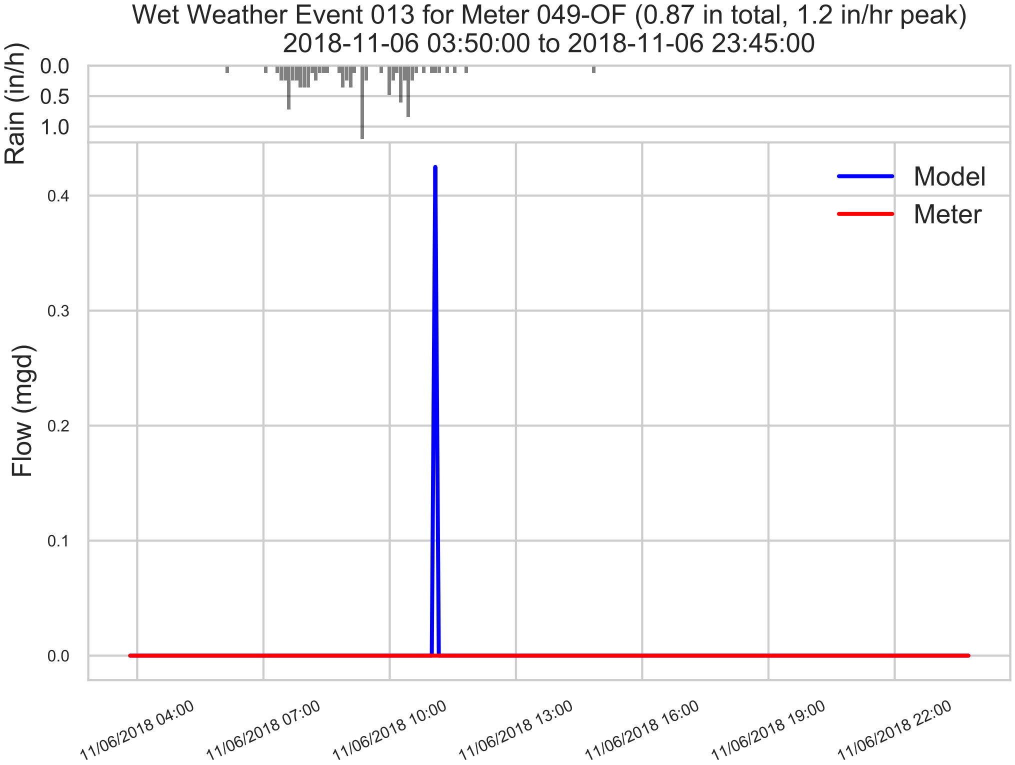
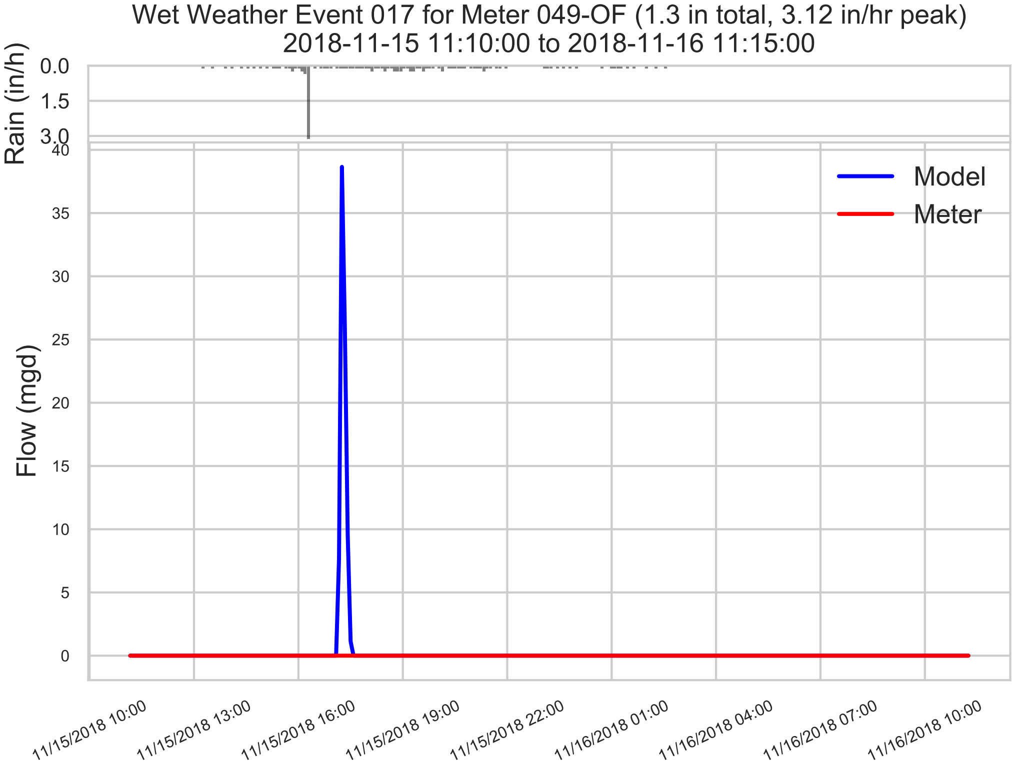


Wet Weather Event 010 for Meter 049-OF (1.23 in total, 3.12 in/hr peak)
2018-11-02 15:10:00 to 2018-11-03 07:55:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
300
250
200
150
100
50
0
Model
Meter
11/02/2018 16:00
11/02/2018 19:00
11/02/2018 22:00
11/03/2018 01:00
11/03/2018 04:00
11/03/2018 07:00

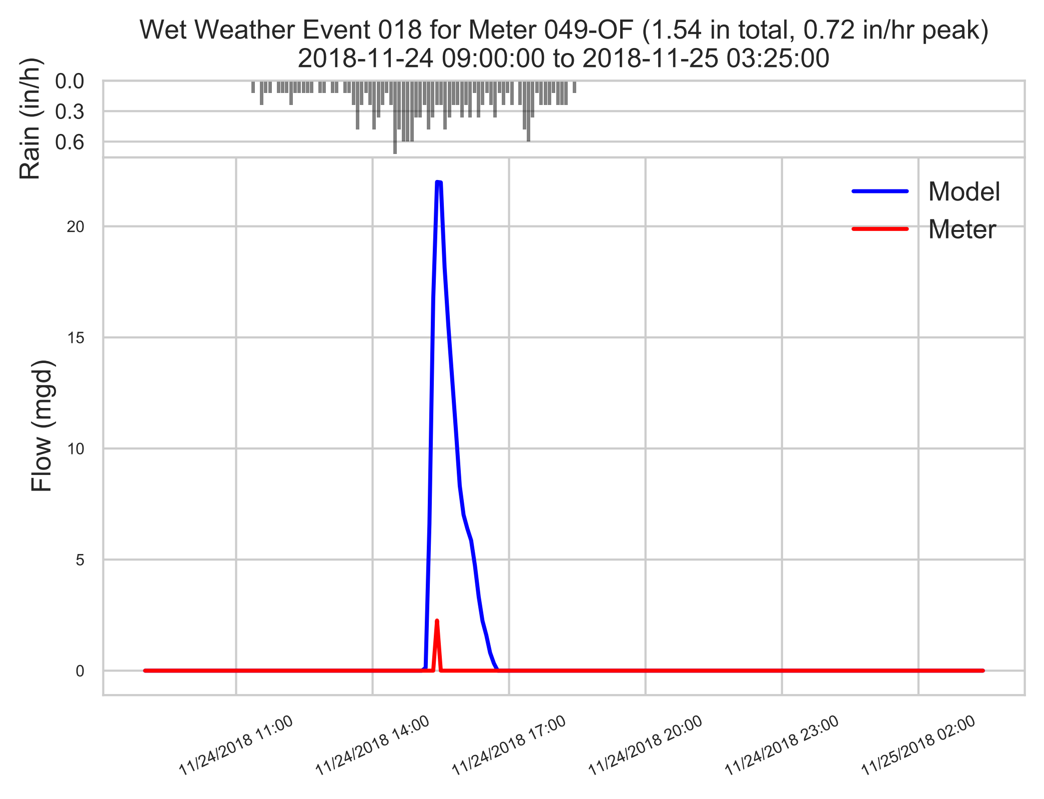


Wet Weather Event 012 for Meter 049-OF (1.3 in total, 0.72 in/hr peak)
2018-11-05 01:30:00 to 2018-11-06 08:15:00
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
8
7
6
5
4
3
2
1
0
Model
Meter
11/05/2018 02:00
11/05/2018 05:00
11/05/2018 08:00
11/05/2018 11:00
11/05/2018 14:00
11/05/2018 17:00
11/05/2018 20:00
11/05/2018 23:00
11/06/2018 02:00
11/06/2018 05:00
11/06/2018 08:00

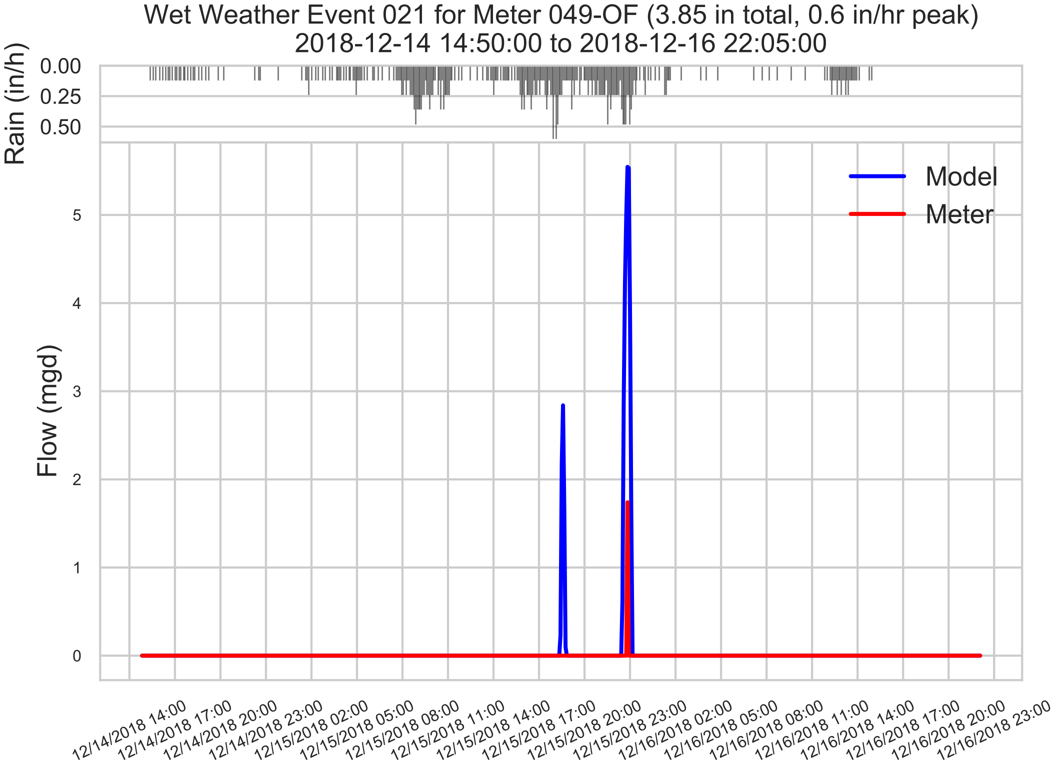

Wet Weather Event 013 for Meter 049-OF (0.87 in total, 1.2 in/hr peak)
2018-11-06 03:50:00 to 2018-11-06 23:45:00
Rain (in/h)
0.0
0.5
1.0
Flow (mgd)
0.4
0.3
0.2
0.1
0.0
Model
Meter
11/06/2018 04:00
11/06/2018 07:00
11/06/2018 10:00
11/06/2018 13:00
11/06/2018 16:00
11/06/2018 19:00
11/06/2018 22:00

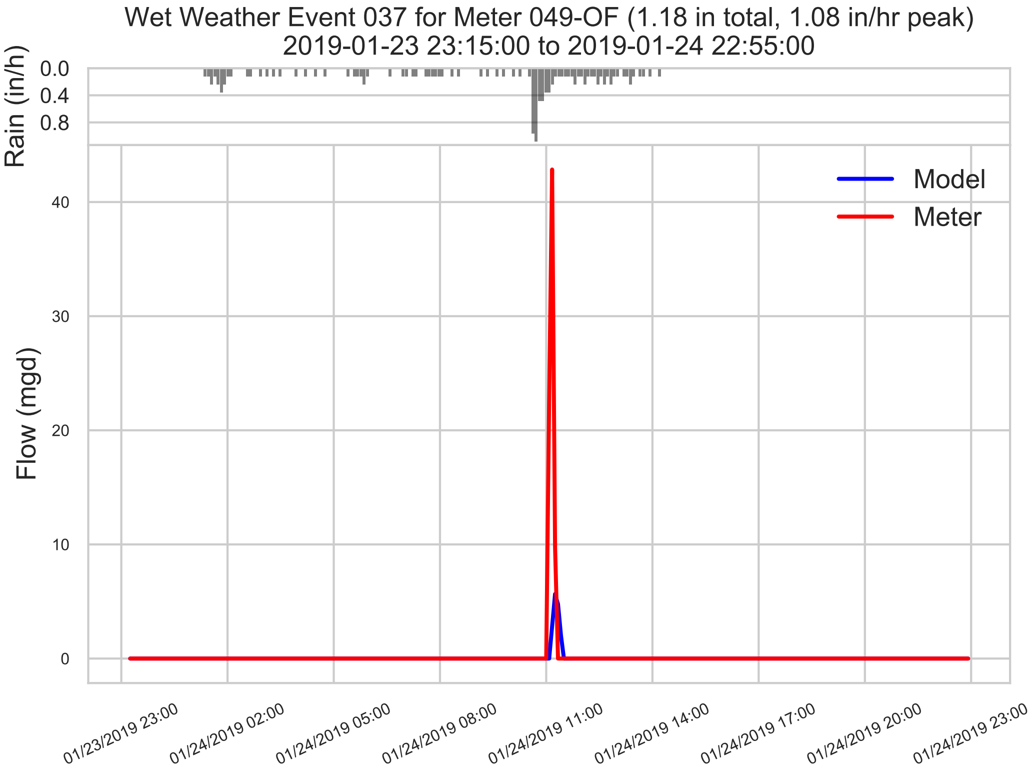


Wet Weather Event 017 for Meter 049-OF (1.3 in total, 3.12 in/hr peak)
2018-11-15 11:10:00 to 2018-11-16 11:15:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
40
35
30
25
20
15
10
5
0
Model
Meter
11/15/2018 10:00
11/15/2018 13:00
11/15/2018 16:00
11/15/2018 19:00
11/15/2018 22:00
11/16/2018 01:00
11/16/2018 04:00
11/16/2018 07:00
11/16/2018 10:00

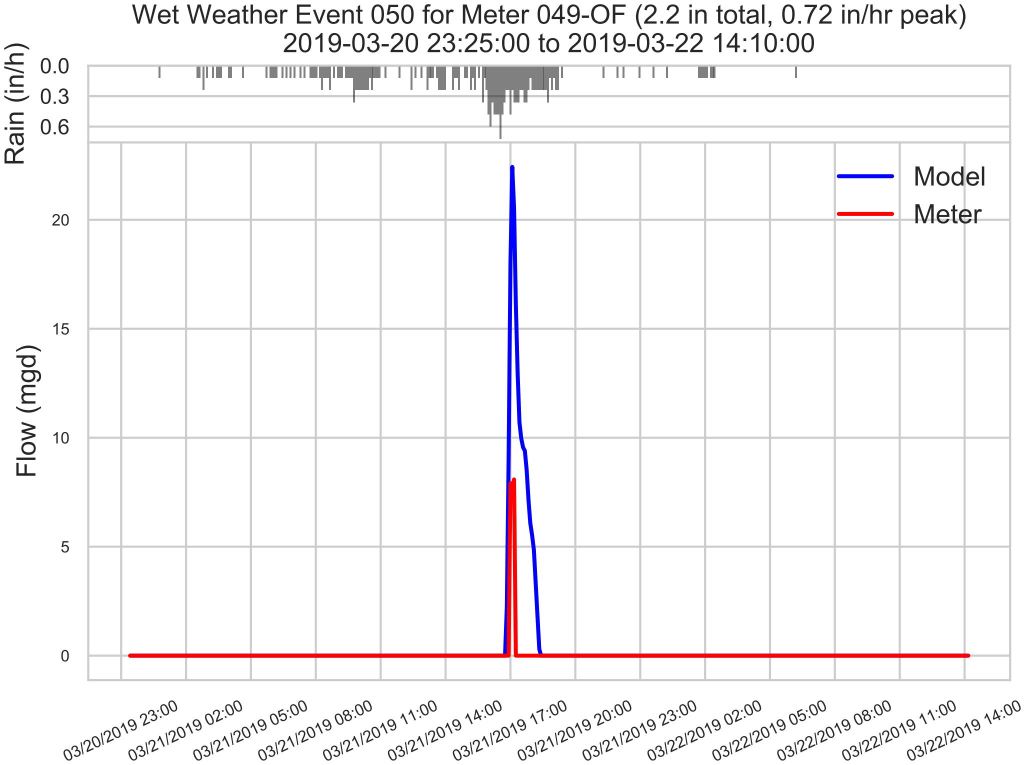


Wet Weather Event 018 for Meter 049-OF (1.54 in total, 0.72 in/hr peak)
2018-11-24 09:00:00 to 2018-11-25 03:25:00
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
20
15
10
5
0
Model
Meter
11/24/2018 11:00
11/24/2018 14:00
11/24/2018 17:00
11/24/2018 20:00
11/24/2018 23:00
11/25/2018 02:00

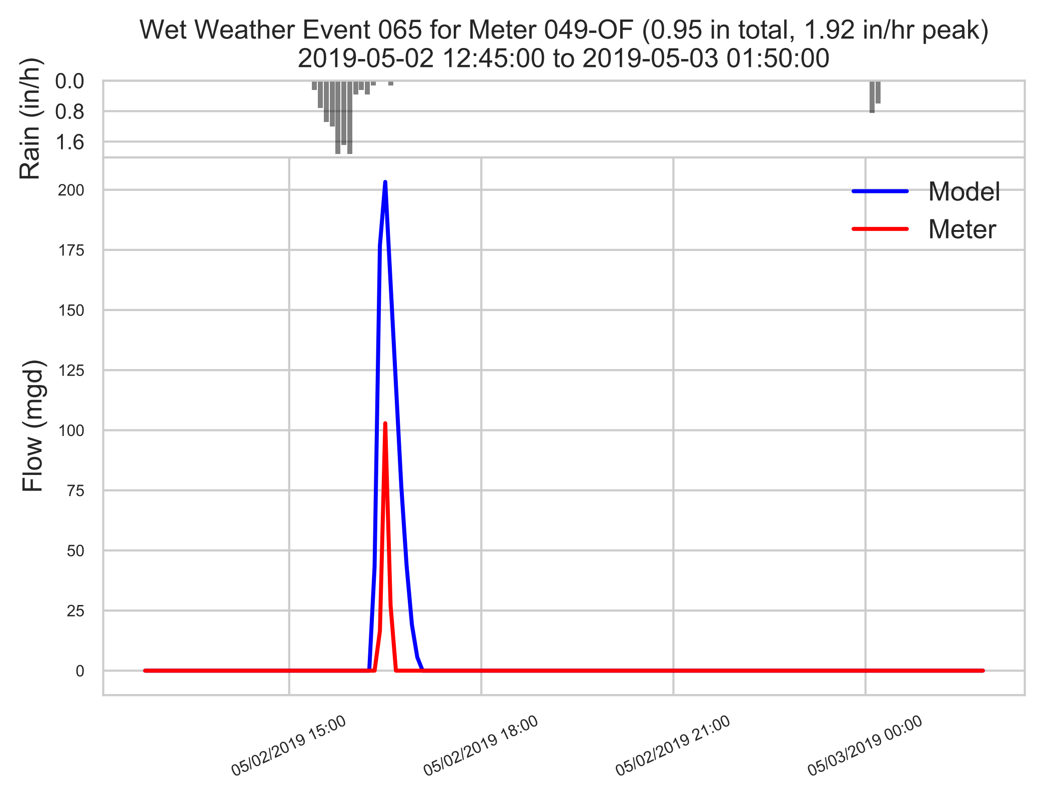

Wet Weather Event 021 for Meter 049-OF (3.85 in total, 0.6 in/hr peak)
2018-12-14 14:50:00 to 2018-12-16 22:05:00
Rain (in/h)
0.00
0.25
0.50
Flow (mgd)
0
1
2
3
4
5
Model
Meter
12/14/2018 14:00
12/14/2018 17:00
12/14/2018 20:00
12/14/2018 23:00
12/15/2018 02:00
12/15/2018 05:00
12/15/2018 08:00
12/15/2018 11:00
12/15/2018 14:00
12/15/2018 17:00
12/15/2018 20:00
12/15/2018 23:00
12/16/2018 02:00
12/16/2018 05:00
12/16/2018 08:00
12/16/2018 11:00
12/16/2018 14:00
12/16/2018 17:00
12/16/2018 20:00
12/16/2018 23:00



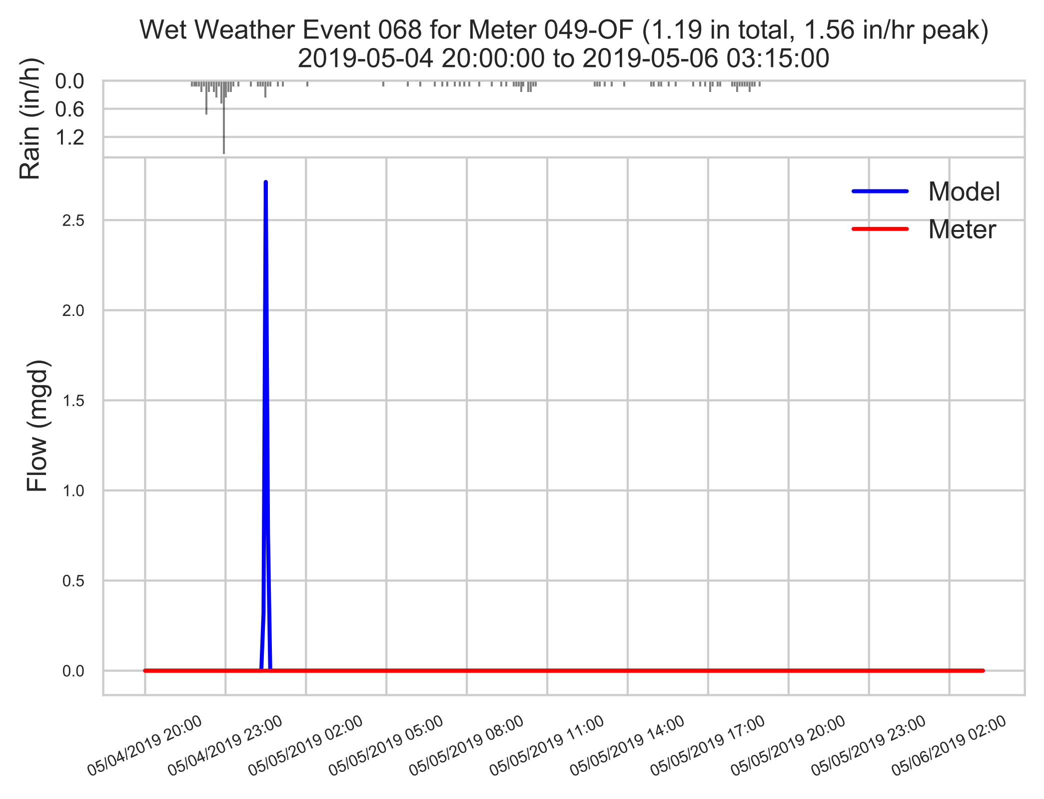
Wet Weather Event 037 for Meter 049-OF (1.18 in total, 1.08 in/hr peak)
2019-01-23 23:15:00 to 2019-01-24 22:55:00
Rain (in/h)
0.0
0.4
0.8
Flow (mgd)
40
30
20
10
0
Model
Meter
01/23/2019 23:00
01/24/2019 02:00
01/24/2019 05:00
01/24/2019 08:00
01/24/2019 11:00
01/24/2019 14:00
01/24/2019 17:00
01/24/2019 20:00
01/24/2019 23:00

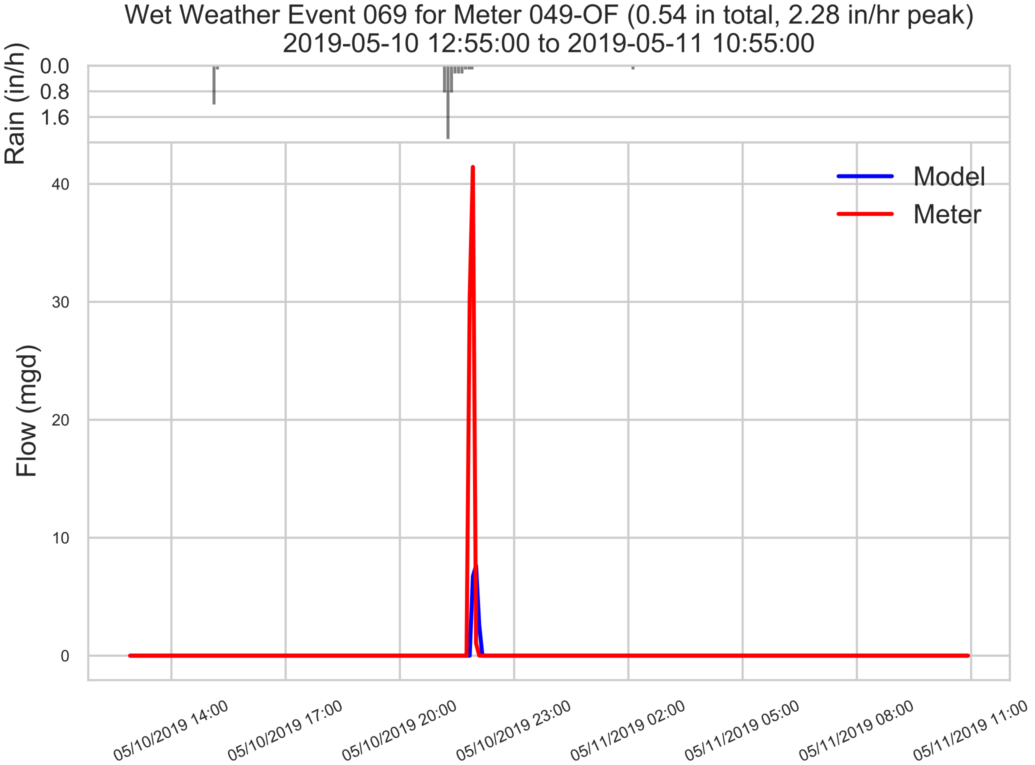


Wet Weather Event 050 for Meter 049-OF (2.2 in total, 0.72 in/hr peak)
2019-03-20 23:25:00 to 2019-03-22 14:10:00
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
0
5
10
15
20
Model
Meter
03/20/2019 23:00
03/21/2019 02:00
03/21/2019 05:00
03/21/2019 08:00
03/21/2019 11:00
03/21/2019 14:00
03/21/2019 17:00
03/21/2019 20:00
03/21/2019 23:00
03/22/2019 02:00
03/22/2019 05:00
03/22/2019 08:00
03/22/2019 11:00
03/22/2019 14:00

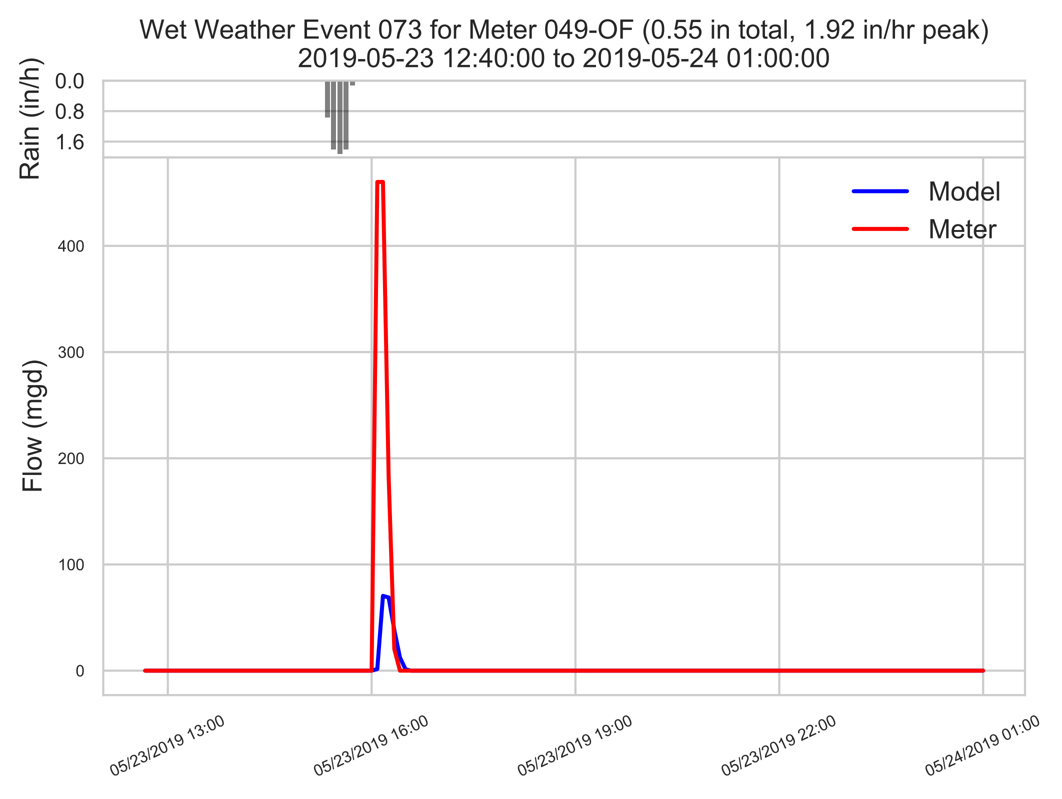


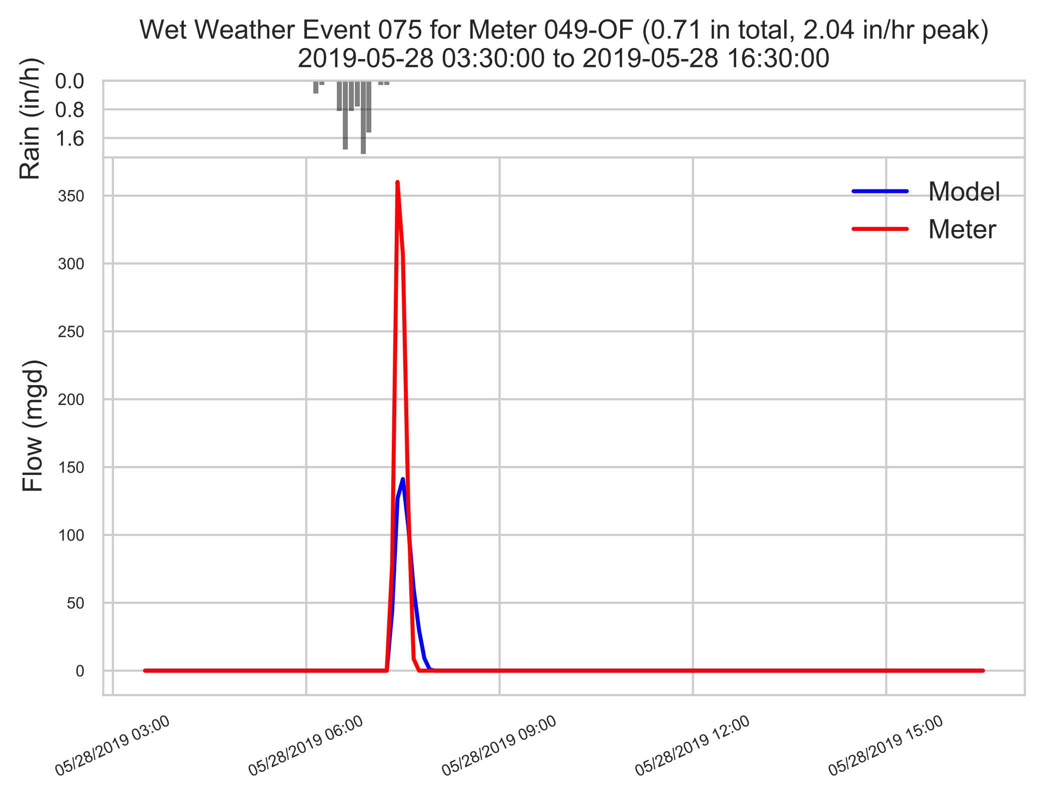
Wet Weather Event 065 for Meter 049-OF (0.95 in total, 1.92 in/hr peak)
2019-05-02 12:45:00 to 2019-05-03 01:50:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
200
175
150
125
100
75
50
25
0
Model
Meter
05/02/2019 15:00
05/02/2019 18:00
05/02/2019 21:00
05/03/2019 00:00


Wet Weather Event 068 for Meter 049-OF (1.19 in total, 1.56 in/hr peak)
2019-05-04 20:00:00 to 2019-05-06 03:15:00
Rain (in/h)
0.0
0.6
1.2
Flow (mgd)
2.5
2.0
1.5
1.0
0.5
0.0
Model
Meter
05/04/2019 20:00
05/04/2019 23:00
05/05/2019 02:00
05/05/2019 05:00
05/05/2019 08:00
05/05/2019 11:00
05/05/2019 14:00
05/05/2019 17:00
05/05/2019 20:00
05/05/2019 23:00
05/06/2019 02:00

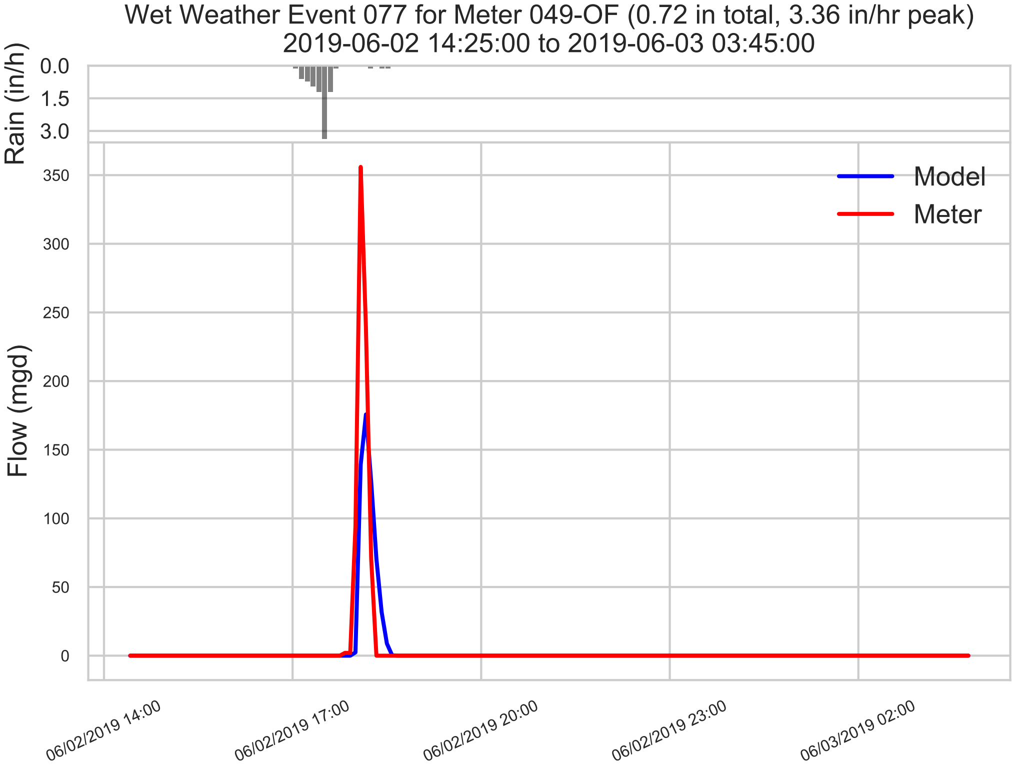


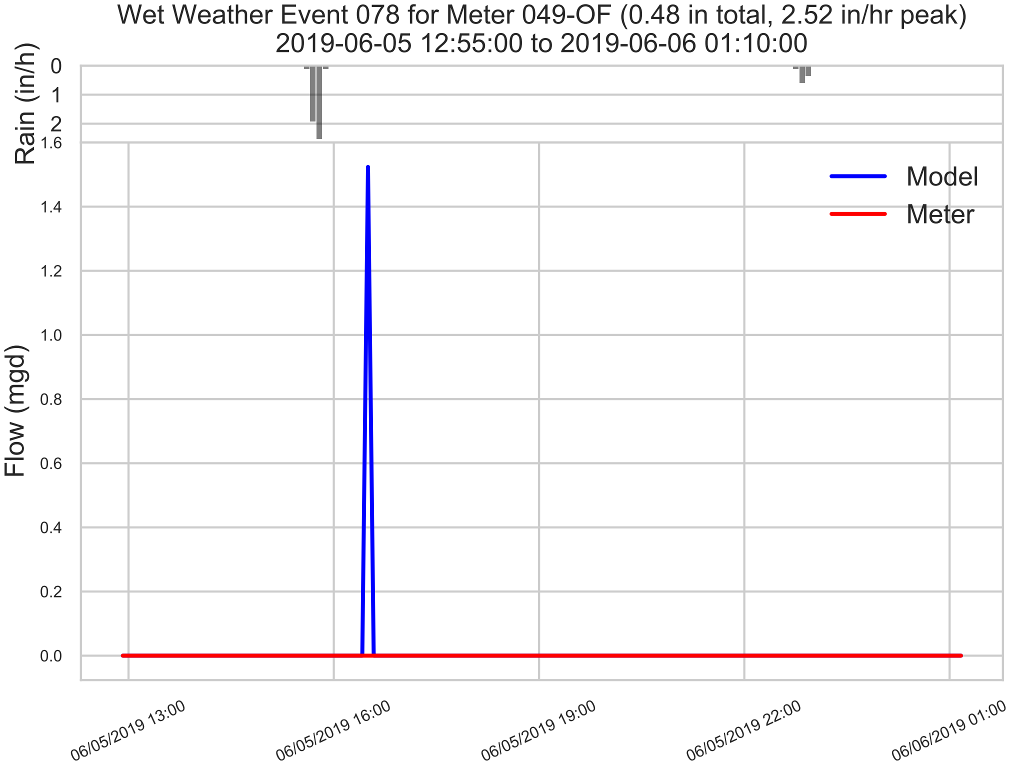
Wet Weather Event 069 for Meter 049-OF (0.54 in total, 2.28 in/hr peak)
2019-05-10 12:55:00 to 2019-05-11 10:55:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
40
30
20
10
0
Model
Meter
05/10/2019 14:00
05/10/2019 17:00
05/10/2019 20:00
05/10/2019 23:00
05/11/2019 02:00
05/11/2019 05:00
05/11/2019 08:00
05/11/2019 11:00

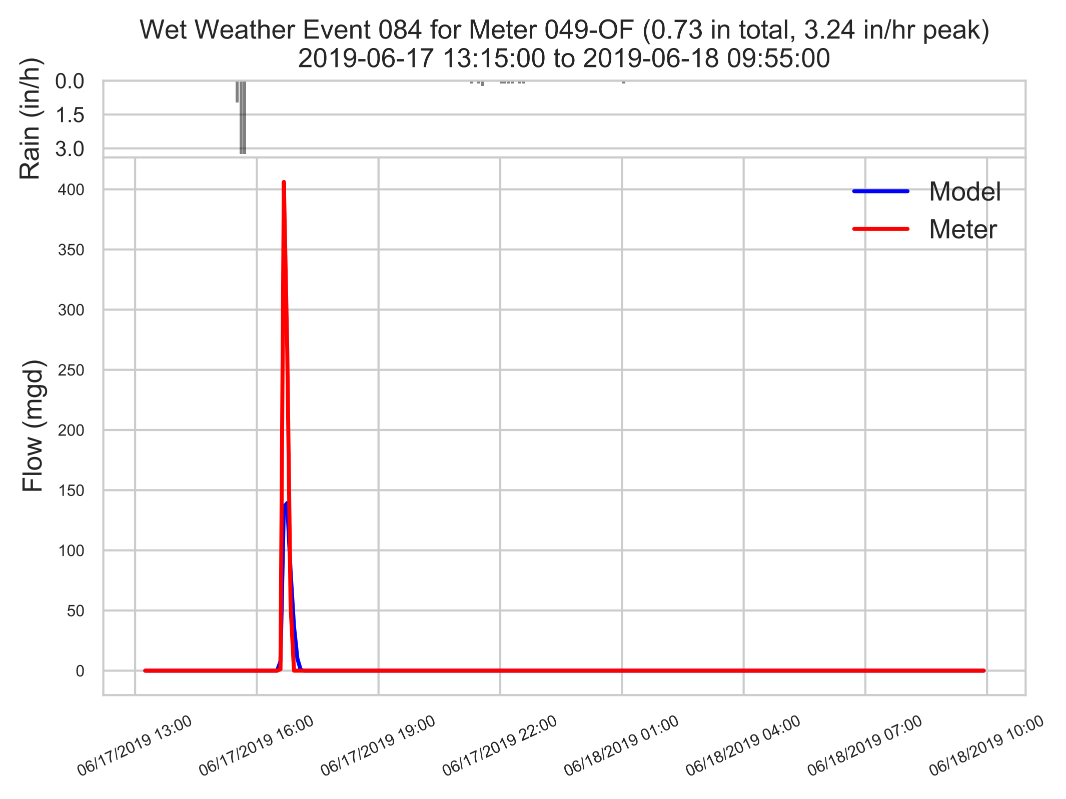

Wet Weather Event 073 for Meter 049-OF (0.55 in total, 1.92 in/hr peak)
2019-05-23 12:40:00 to 2019-05-24 01:00:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
400
300
200
100
0
Model
Meter
05/23/2019 13:00
05/23/2019 16:00
05/23/2019 19:00
05/23/2019 22:00
05/24/2019 01:00

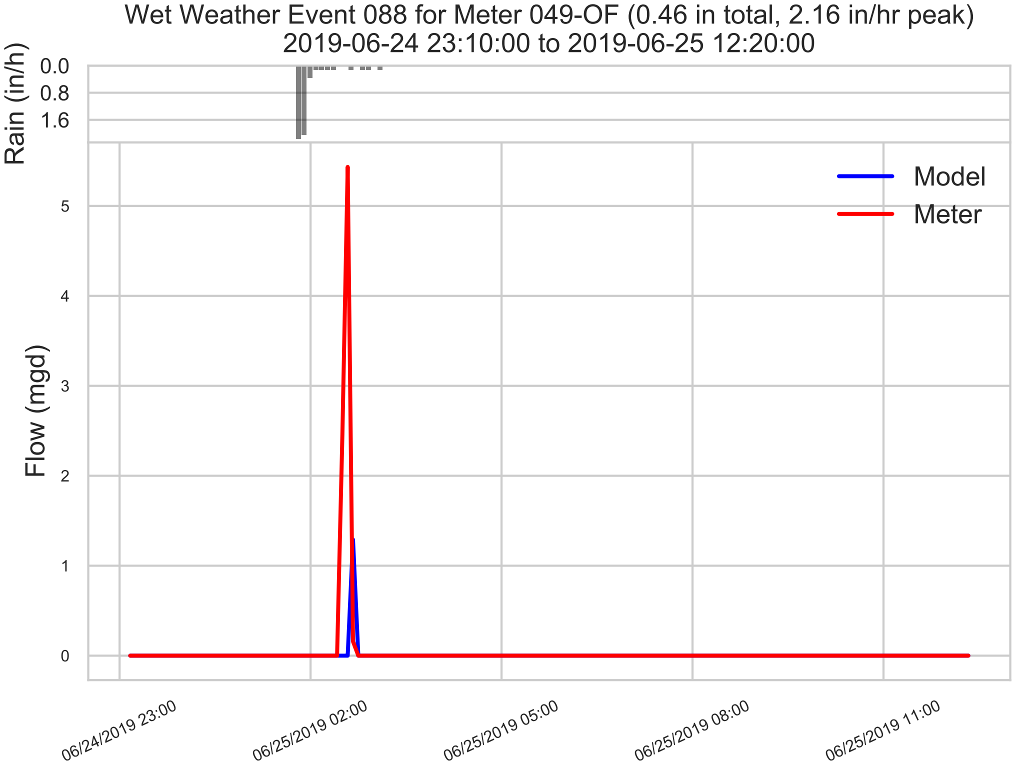


Wet Weather Event 075 for Meter 049-OF (0.71 in total, 2.04 in/hr peak)
2019-05-28 03:30:00 to 2019-05-28 16:30:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
350
300
250
200
150
100
50
0
Model
Meter
05/28/2019 03:00
05/28/2019 06:00
05/28/2019 09:00
05/28/2019 12:00
05/28/2019 15:00

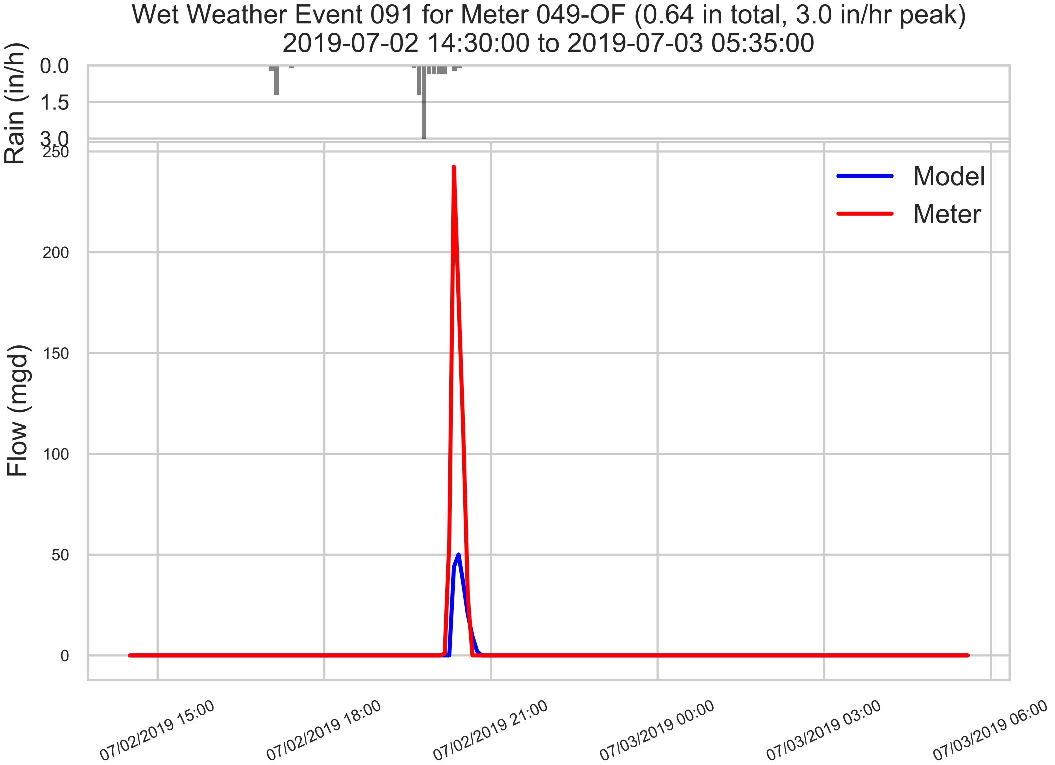

Wet Weather Event 077 for Meter 049-OF (0.72 in total, 3.36 in/hr peak)
2019-06-02 14:25:00 to 2019-06-03 03:45:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
350
300
250
200
150
100
50
0
Model
Meter
06/02/2019 14:00
06/02/2019 17:00
06/02/2019 20:00
06/02/2019 23:00
06/03/2019 02:00


Wet Weather Event 078 for Meter 049-OF (0.48 in total, 2.52 in/hr peak)
2019-06-05 12:55:00 to 2019-06-06 01:10:00
Rain (in/h)
0
1
2
Flow (mgd)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Model
Meter
06/05/2019 13:00
06/05/2019 16:00
06/05/2019 19:00
06/05/2019 22:00
06/06/2019 01:00

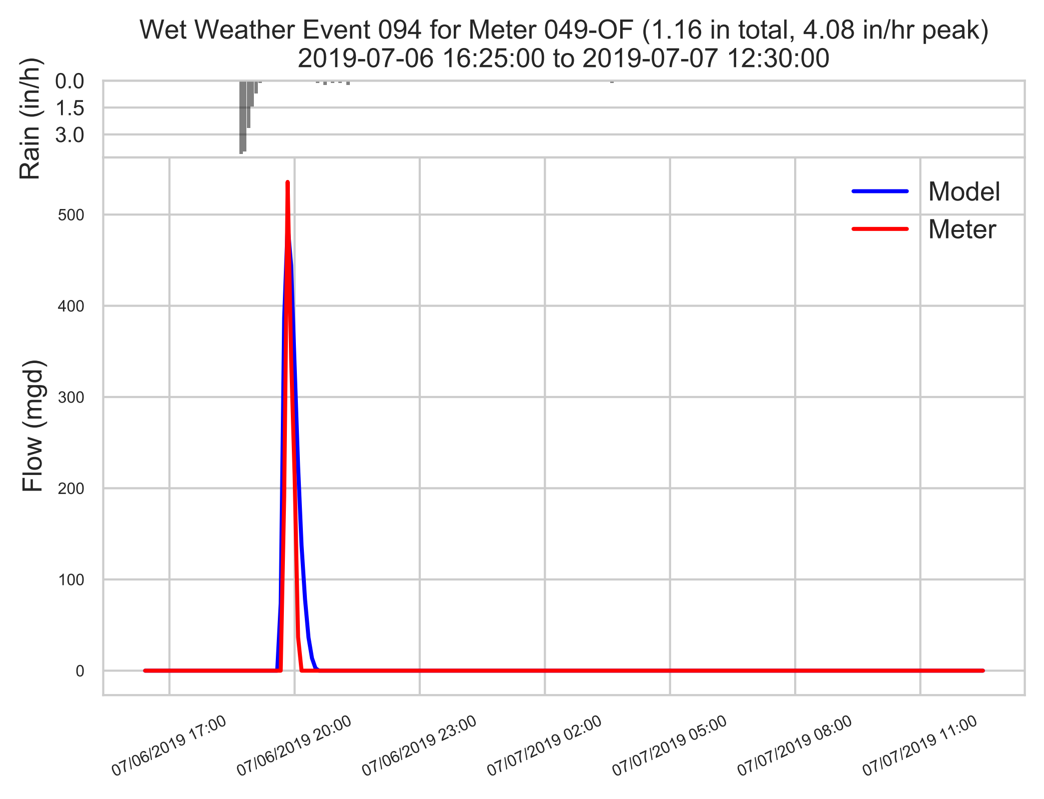

Wet Weather Event 084 for Meter 049-OF (0.73 in total, 3.24 in/hr peak)
2019-06-17 13:15:00 to 2019-06-18 09:55:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
400
350
300
250
200
150
100
50
0
Model
Meter
06/17/2019 13:00
06/17/2019 16:00
06/17/2019 19:00
06/17/2019 22:00
06/18/2019 01:00
06/18/2019 04:00
06/18/2019 07:00
06/18/2019 10:00



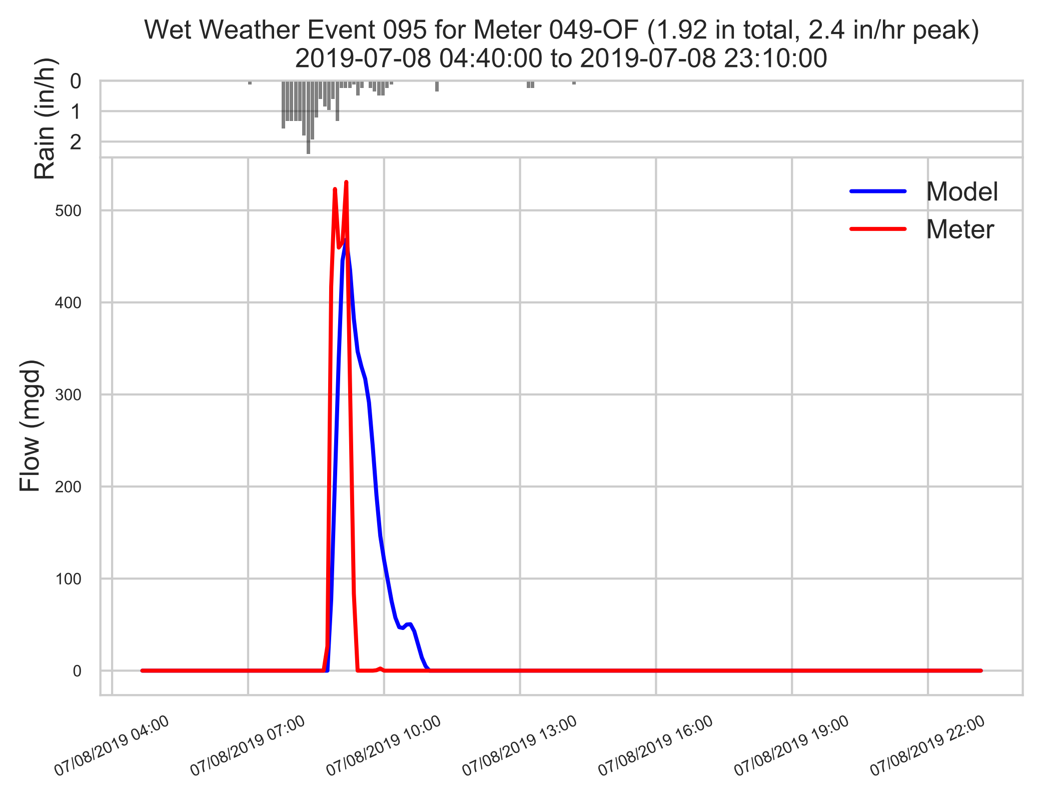
Wet Weather Event 088 for Meter 049-OF (0.46 in total, 2.16 in/hr peak)
2019-06-24 23:10:00 to 2019-06-25 12:20:00
Rain (in/h)
0.0
0.8
1.6
Flow (mgd)
0
1
2
3
4
5
Model
Meter
06/24/2019 23:00
06/25/2019 02:00
06/25/2019 05:00
06/25/2019 08:00
06/25/2019 11:00



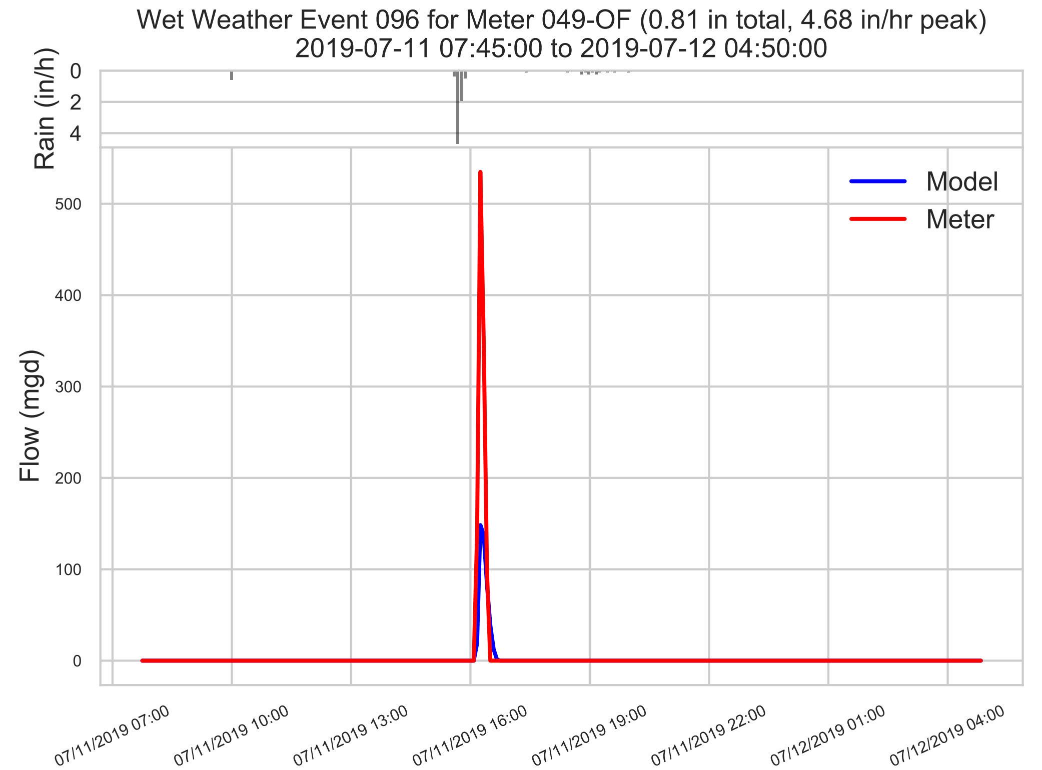
Wet Weather Event 091 for Meter 049-OF (0.64 in total, 3.0 in/hr peak)
2019-07-02 14:30:00 to 2019-07-03 05:35:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
250
200
150
100
50
0
Model
Meter
07/02/2019 15:00
07/02/2019 18:00
07/02/2019 21:00
07/03/2019 00:00
07/03/2019 03:00
07/03/2019 06:00



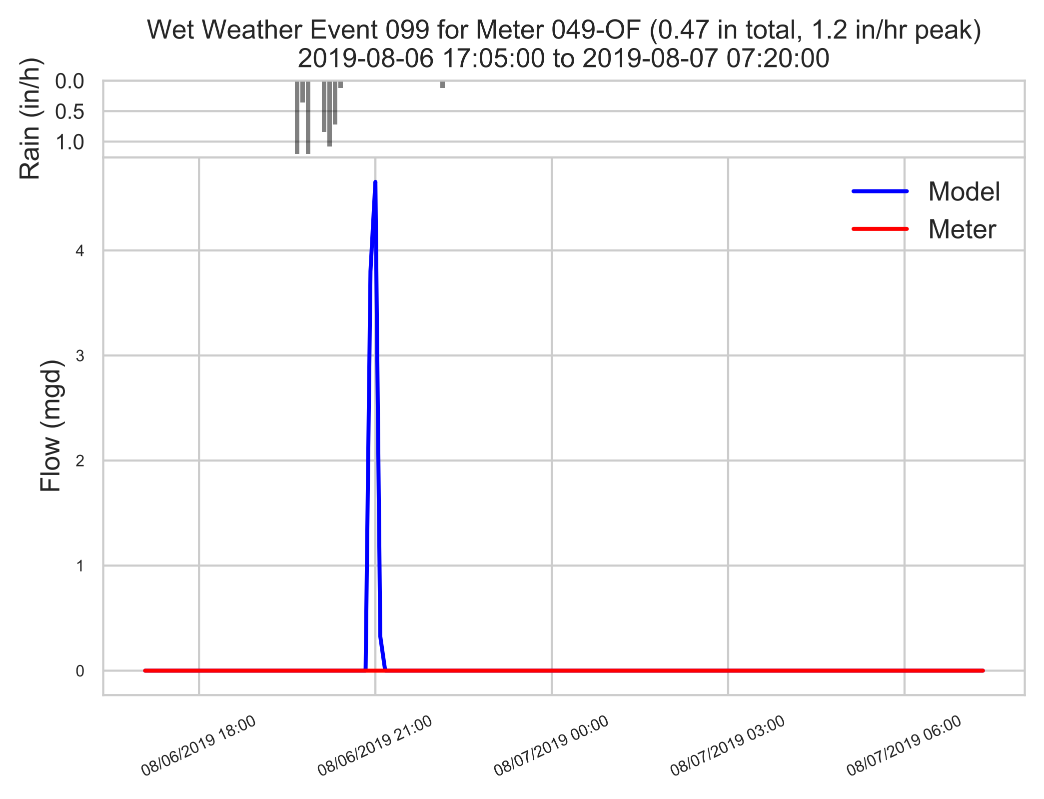
Wet Weather Event 094 for Meter 049-OF (1.16 in total, 4.08 in/hr peak)
2019-07-06 16:25:00 to 2019-07-07 12:30:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
500
400
300
200
100
0
Model
Meter
07/06/2019 17:00
07/06/2019 20:00
07/06/2019 23:00
07/07/2019 02:00
07/07/2019 05:00
07/07/2019 08:00
07/07/2019 11:00



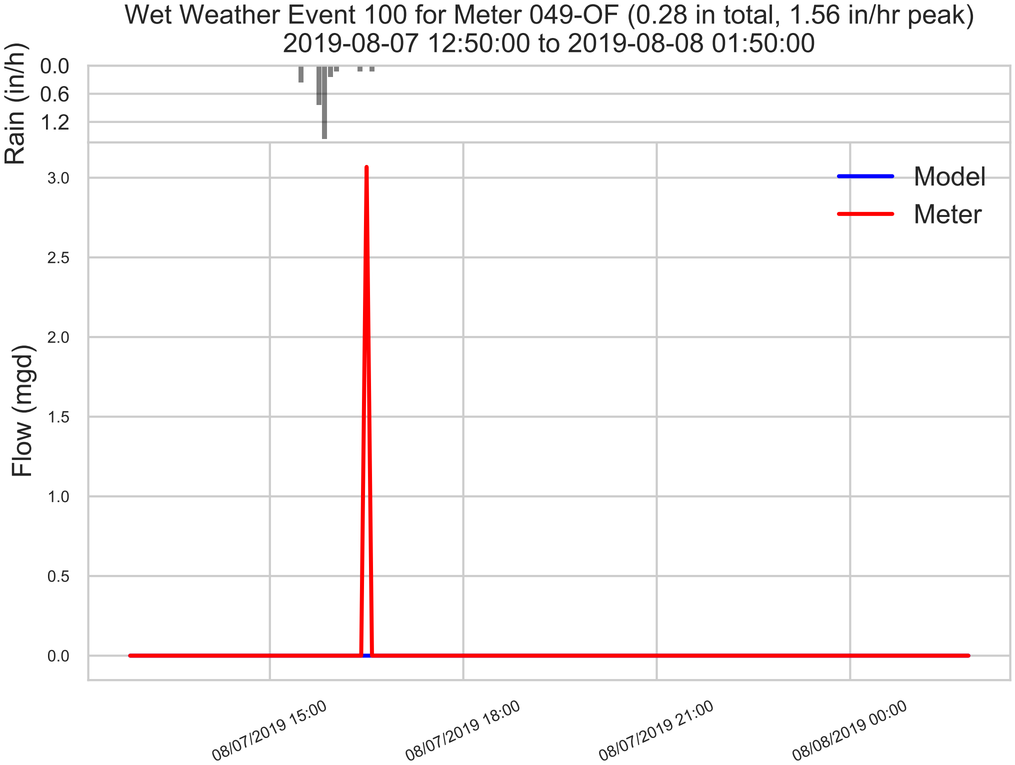
Wet Weather Event 095 for Meter 049-OF (1.92 in total, 2.4 in/hr peak)
2019-07-08 04:40:00 to 2019-07-08 23:10:00
Rain (in/h)
0
1
2
Flow (mgd)
500
400
300
200
100
0
Model
Meter
07/08/2019 04:00
07/08/2019 07:00
07/08/2019 10:00
07/08/2019 13:00
07/08/2019 16:00
07/08/2019 19:00
07/08/2019 22:00



Wet Weather Event 096 for Meter 049-OF (0.81 in total, 4.68 in/hr peak)
2019-07-11 07:45:00 to 2019-07-12 04:50:00
Rain (in/h)
0
2
4
Flow (mgd)
500
400
300
200
100
0
Model
Meter
07/11/2019 07:00
07/11/2019 10:00
07/11/2019 13:00
07/11/2019 16:00
07/11/2019 19:00
07/11/2019 22:00
07/12/2019 01:00
07/12/2019 04:00



Wet Weather Event 099 for Meter 049-OF (0.47 in total, 1.2 in/hr peak)
2019-08-06 17:05:00 to 2019-08-07 07:20:00
Rain (in/h)
0.0
0.5
1.0
Flow (mgd)
0
1
2
3
4
Model
Meter
08/06/2019 18:00
08/06/2019 21:00
08/07/2019 00:00
08/07/2019 03:00
08/07/2019 06:00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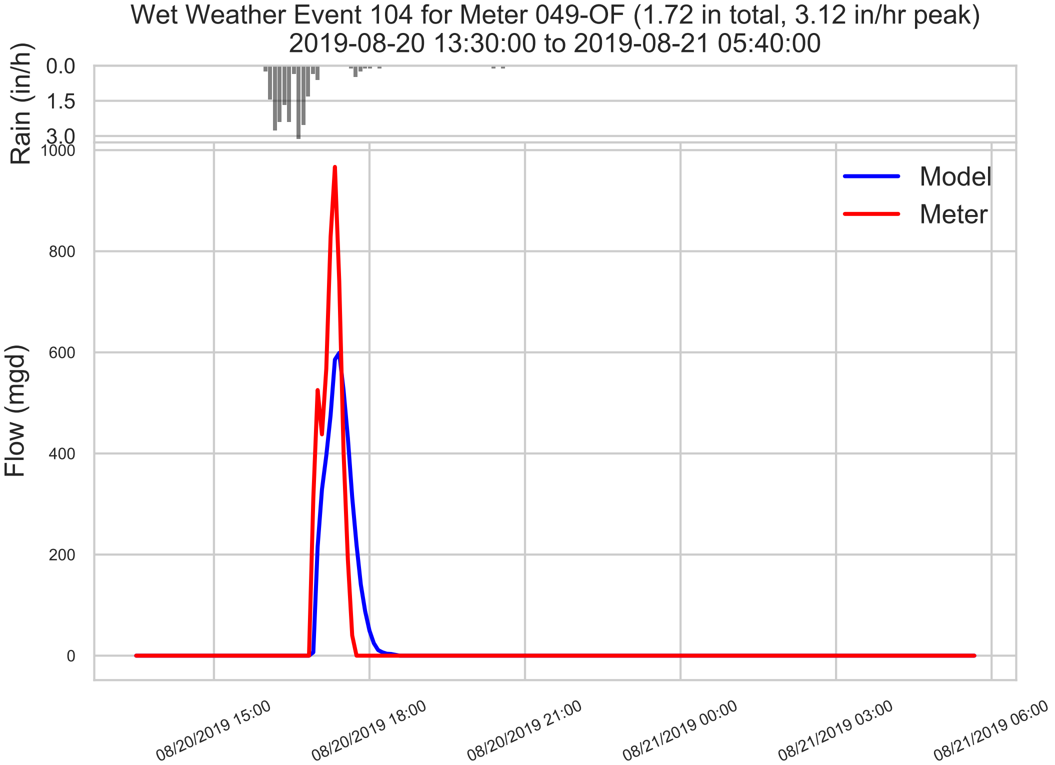
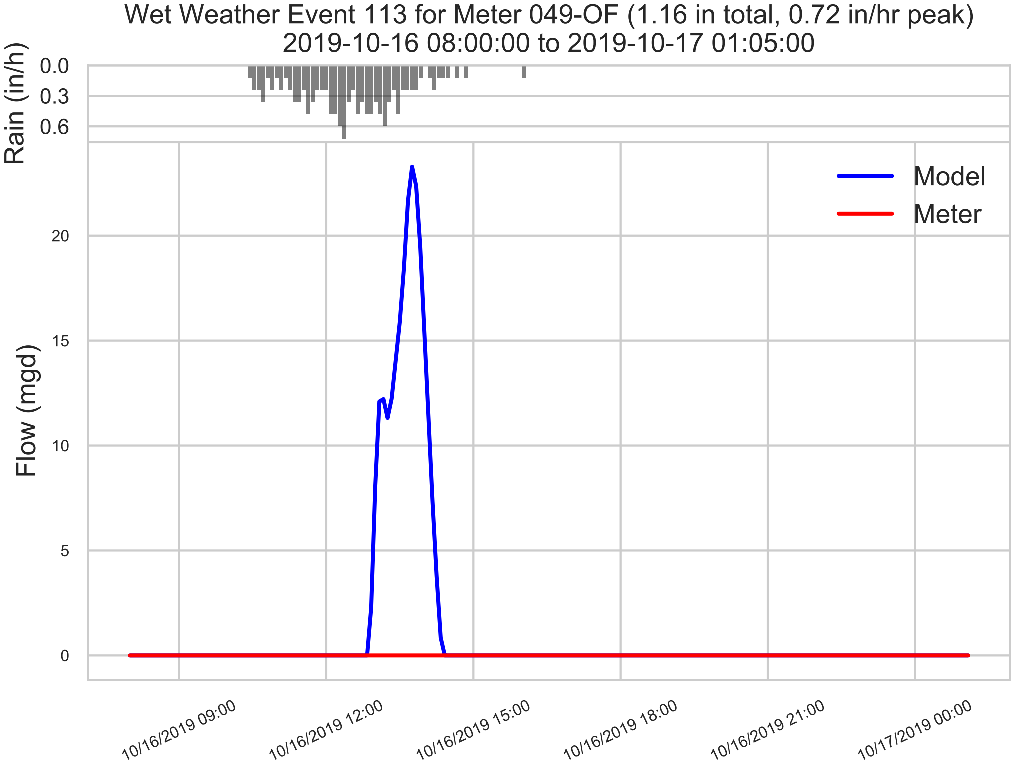
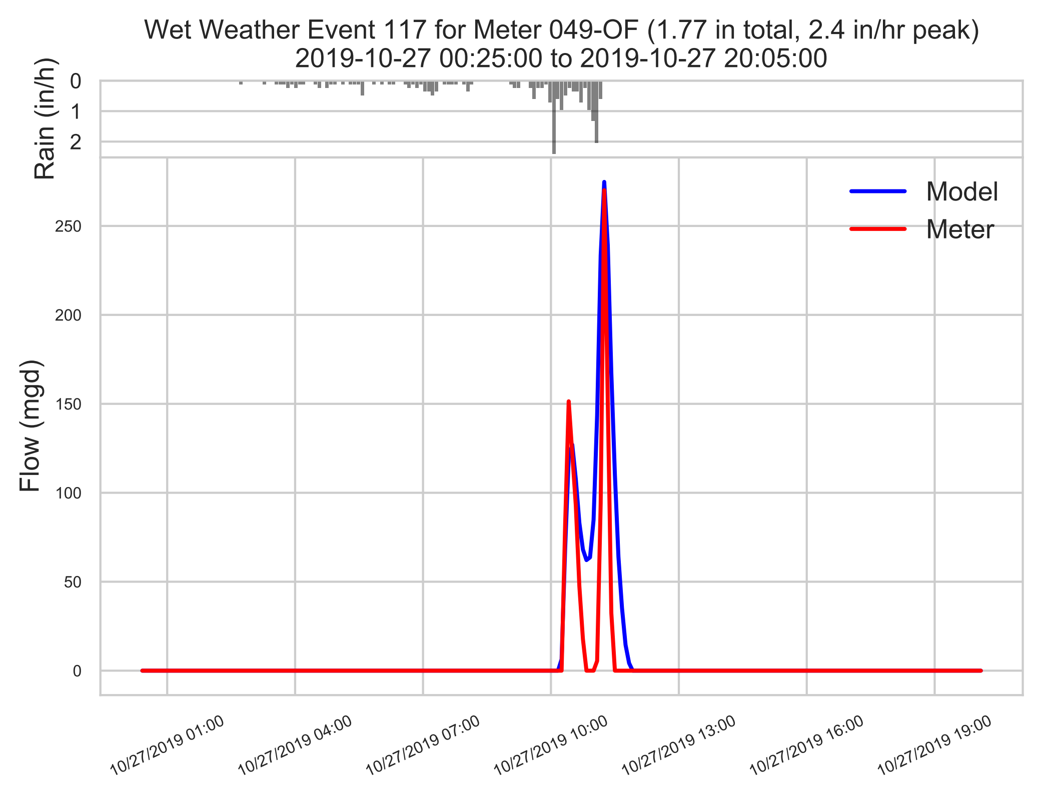
2019-08-07 12:50:00 to 2019-08-08 01:50:00
Rain (in/h)
0.0
0.6
1.2
Flow (mgd)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Model
Meter
08/07/2019 15:00
08/07/2019 18:00
08/07/2019 21:00
08/08/2019 00:00

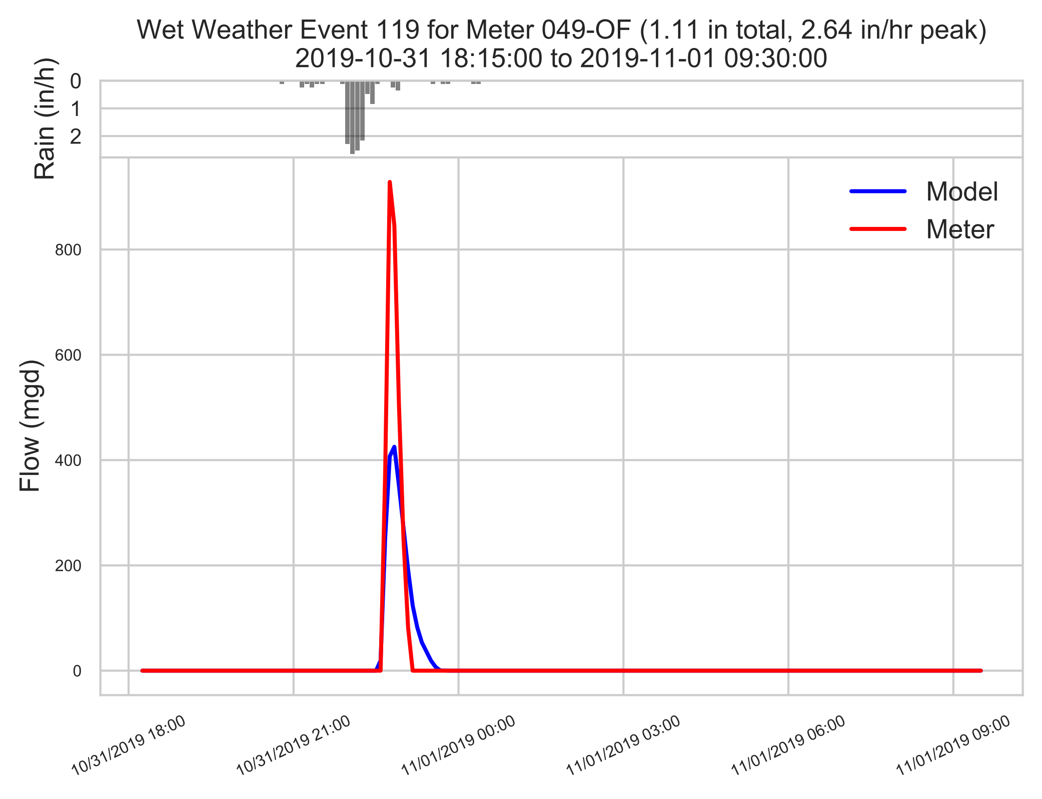


Wet Weather Event 104 for Meter 049-OF (1.72 in total, 3.12 in/hr peak)
2019-08-20 13:30:00 to 2019-08-21 05:40:00
Rain (in/h)
0.0
1.5
3.0
Flow (mgd)
1000
800
600
400
200
0
Model
Meter
08/20/2019 15:00
08/20/2019 18:00
08/20/2019 21:00
08/21/2019 00:00
08/21/2019 03:00
08/21/2019 06:00


Wet Weather Event 113 for Meter 049-OF (1.16 in total, 0.72 in/hr peak)
2019-10-16 08:00:00 to 2019-10-17 01:05:00
Rain (in/h)
0.0
0.3
0.6
Flow (mgd)
0
5
10
15
20
Model
Meter
10/16/2019 09:00
10/16/2019 12:00
10/16/2019 15:00
10/16/2019 18:00
10/16/2019 21:00
10/17/2019 00:00



Wet Weather Event 117 for Meter 049-OF (1.77 in total, 2.4 in/hr peak)
2019-10-27 00:25:00 to 2019-10-27 20:05:00
Rain (in/h)
0
1
2
Flow (mgd)
250
200
150
100
50
0
Model
Meter
10/27/2019 01:00
10/27/2019 04:00
10/27/2019 07:00
10/27/2019 10:00
10/27/2019 13:00
10/27/2019 16:00
10/27/2019 19:00



Wet Weather Event 119 for Meter 049-OF (1.11 in total, 2.64 in/hr peak)
2019-10-31 18:15:00 to 2019-11-01 09:30:00
Rain (in/h)
0
1
2
Flow (mgd)
0
200
400
600
800
Model
Meter
10/31/2019 18:00
10/31/2019 21:00
11/01/2019 00:00
11/01/2019 03:00
11/01/2019 06:00
11/01/2019 09:00

Appendix L

Economic Impact Analysis and Triple Bottom Line Assessment of CSO Control Alternatives in Rock Creek Watershed, Washington, D.C.

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Economic Impact Analysis and Triple Bottom Line Assessment of CSO Control Alternatives in Rock Creek Watershed, Washington D.C.

Prepared for DC Water and Greeley and Hansen

June 2020

Prepared by Corona Environmental Consulting, LLC

This report presents findings from the economic impact analysis (EIA) and triple bottom line (TBL) assessment conducted by Corona Environmental Consulting to evaluate the impacts and benefits of alternative combined sewer overflow (CSO) control strategies for the Rock Creek Watershed in Washington D.C. This report is organized as follows:

- Section 1 describes the CSO control alternatives evaluated
- Section 2 provides background on EIA and methods employed for this study, as well as a summary of results and key findings
- Section 3 describes the methods and results from the TBL assessment of green infrastructure (GI) strategies incorporated into some of the CSO control alternatives.

1. Rock Creek CSO Control Alternatives

Corona Environmental Consulting evaluated the economic impacts and TBL benefits associated with three CSO control alternatives for the Rock Creek watershed, as provided by DC Water. The three alternatives are each designed to manage 9.5 million gallons (MG) of stormwater runoff using various stormwater management practices. The alternatives consist of the following components:

- Alternative 1 includes additional gray infrastructure storage capacity of 9.5 MG
- Alternative 2 includes a mix of gray infrastructure and GI practices. Under this alternative DC Water will install 4.2 MG of gray infrastructure storage capacity. GI (including downspout disconnection) will manage 3.0 MG of stormwater runoff from 65 impervious acres within the watershed. Approximately 70% of the 65 acres managed though GI will be managed through permeable pavement installations; 30% will be managed through bioretention.
- Alternative 3 is similar to Alternative 2, with that only difference being that 50% of the 65 acres managed though GI will be managed through permeable pavement installations and 50% will be managed through bioretention.

Throughout this report, we refer to Alternatives 2 and 3 as “hybrid” alternatives because of their mix of gray infrastructure and GI practices. Table 1 provides a summary of each alternative, including a brief description of the stormwater management practices incorporated and associated volume managed, the timeline for construction, and total capital and annual operations and maintenance (O&M) costs.

2. Economic Impact Analysis

Background

When policymakers make decisions about public investments, they must always weigh competing priorities and different levels of return on investment for different uses of public funds. According to Green for All (2011), investments in water and other infrastructure are one of the most efficient methods of job creation. The report states that infrastructure investments create 16% more jobs, dollar-for-dollar, than a payroll tax holiday; nearly 40% more jobs than an across-the-board tax cut; and more than five times as many jobs as a temporary business tax cut (Green For All, 2011, based on Moody’s Analytics).

Table 1. Summary of CSO control alternatives evaluated for Rock Creek Watershed

	Alternative 1 – All Gray	Alternative 2 – Hybrid Green/Gray	Alternative 3 – Hybrid Green/Gray
Stormwater management practices (control volume)	Gray infrastructure storage capacity (9.5 MG)	• 65 new GI acres including downspout disconnections (3.0 MG) • Gray infrastructure storage (4.2 MG) • Credit for 71 acres of management from the MS4 area (2.3 MG)[a]	• 65 new GI acres including downspout disconnections (3.0 MG) • Gray infrastructure storage (4.2 MG) • Credit for 71 acres of management from the MS4 area (2.3 MG)[a]
Capital cost	$185 M	$134 M	$134 M
Construction timeline	2026 - 2028	2022 – 2027 (GI) 2026 – 2028 (Gray)	2022 – 2027 (GI) 2026 – 2028 (Gray)
Annual O&M[b]	$0.28 M/year	$1.13 M/year[c] (GI and gray components)	$1.13 M/year (GI and gray components)
Notes		30% of GI acres bioretention; 70% permeable pavement	50% of GI acres bioretention; 50% permeable pavement

a. No costs or further description of the MS4 credit of 71 acres was provided by DC Water; thus, this analysis does not include any economic impacts or TBL benefits from this component of the hybrid alternatives.
b. Annual O&M costs do not include major replacement/rehabilitation costs. These costs are integrated into the economic impact model, as discussed below.
c. Includes annual O&M for gray infrastructure components and 65 new greened acres only; does not include costs for existing 24 acres because these costs will be incurred under all alternatives.

There are two reasons for infrastructure's high job-creation potential. First, infrastructure investments are targeted toward areas in the economy with high excess capacity (i.e., market demand is below what the industry could potentially supply), such as the construction and landscaping industries and the associated suppliers. Second, tax cuts – especially those for high-income individuals – are more likely to be saved (especially in times of economic downturn), whereas worker-directed income (such as that resulting from infrastructure investment) is more likely to be put back into the economy (Green for All 2011).

Evidence suggests that compared to gray infrastructure, the wide-scale implementation of GI has the potential to create more positive local economic impacts. Gray civil engineering projects often require specialized skills, and firms performing these activities typically have these skill sets with their existing staff. Acquiring additional staff for a new project happens largely by hiring labor from competitors or other markets that are low on work. For the most part, these skilled laborers are also represented by trade unions, and are therefore already in the labor force. When a city water department implements a traditional infrastructure project in this manner, the net effect is that these already employed workers are simply bid away from other construction projects, resulting in a transfer of employment. In addition, many of the large engineering/ construction firms hired for this work may be located outside of the District.

In contrast, GI construction and O&M may require fewer highly trained and skilled employees. If GI jobs can be targeted to District residents who are not already employed or are underemployed, this can result in a net gain in employment in the local economy, providing significant economic and social benefits.

Key concepts

Corona performed an EIA to evaluate the job creation and other local economic benefits associated with spending on alternative CSO control strategies. An **EIA** estimates the change in local economic activity (for a specified region) caused by a business, organization, policy, program, project, activity, or other economic event. In the context of this analysis, the economic event is equal to DC Water's investments in infrastructure to reduce CSOs, including both capital and O&M expenditures. EIA traces how the economic activity associated with the event (e.g., spending by DC Water) ripples through the local economy, including how it results in changes in industry output, labor income, employment, and profits.

Corona used the IMPLAN model to evaluate the economic impacts associated with DC Water's investments in alternative CSO controls. IMPLAN is an economic impact model that uses actual dollar amounts of all business transactions occurring in a local economy (as reported each year by businesses and government agencies). IMPLAN contains this data for 546 industry sectors. IMPLAN allows users to assess the impacts of an economic event across three categories:

- ***Direct impacts*** are production changes associated with the immediate effects of an economic activity (in this case, spending by DC Water). For example, under the "all gray" infrastructure scenario for Rock Creek, DC Water would spend approximately $185 million to construct 9.5 million gallons of storage. For simplification, assume that the $185 million in spending all goes to a private construction firm. The construction firm would essentially be supplying $185 million worth of goods and services to DC Water. This additional activity by the construction firm, and associated changes in jobs, and in payments for wages, salaries, taxes, supplies, and services, represent the direct impacts of spending by DC Water.
- ***Indirect impacts*** are production changes resulting from various rounds of re-spending by industries that experience direct impacts. In the previous example, indirect effects result from the re-spending of the construction industry's receipts in backward-linked industries (i.e., industries supplying products and services to the construction industry). Changes in sales, jobs, and income in the concrete pipe industry, for example, represent indirect effects of associated with spending by the construction sector to construction gray CSO infrastructure. Businesses supplying products and services to the concrete pipe industry represent another round of indirect effects. Indirect spending will eventually affect, to varying degrees, many other economic sectors in the region.
- ***Induced effects*** are the changes in economic activity resulting from household spending of income earned directly or indirectly as a result of additional spending. For example, local construction

employees supported by the District's infrastructure investment spend their income in D.C. on housing, food, transportation, and the usual array of household product and service needs. The sales, income, and jobs that result from household spending of added wage, salary, or proprietor's income are known as induced effects. Indirect and induced effects are sometimes collectively called *secondary effects*.

The *total economic impact* is the sum of direct, indirect, and induced effects within a study region.

For each industry sector included in IMPLAN, the model contains information on the percentage of materials and services that the sector purchases locally (i.e., in the study region). The model also contains data on the percentage of individuals employed by local industries that live in the study region. The goods, services, and labor that are purchased or generated from outside of the study region are not reflected in the economic impact results for indirect and induced effects. Going back to the construction industry example, IMPLAN indicates that most of the materials associated with concrete products (e.g., concrete pipes) that are used in DC construction projects are not manufactured within the District. Thus, most of the spending on concrete products, and associated increase in sales and labor, would not be included in the indirect or induced impacts calculated in IMPLAN because they are not purchased locally.

IMPLAN calculates the change in key economic indicators associated with direct, indirect, and induced effects, including ***economic output, total value added, labor income, and employment,*** each described below.

Economic output represents the value of industry production. For manufacturing, this equals sales plus/minus inventory change. For sectors without inventory, output is total sales or revenue. Back to our simplified construction example, the $185 million in capital spending by DC Water under the gray infrastructure alternative represents an increase in economic output for the construction sector by that same amount (essentially an increase in sales for the industry of $185 million). Economic output for other sectors will also increase as the construction sector buys materials and supplies to construct the gray infrastructure. The change in economic output for sectors that supply the construction sector are categorized as indirect impacts.

As shown in Figure 1, economic output for an industry or sector is equal to the sum of 1) the amount that the industry spends on intermediate inputs; and 2) total value added. ***Total value added*** is equal to the sum of labor income, other property income, and any taxes on production and imports that the industry pays. ***Labor income*** is the sum of employee compensation (wages and benefits) and proprietor income (profit).

IMPLAN calculates ***employment*** associated with changes in economic output based on local data for relevant industries.

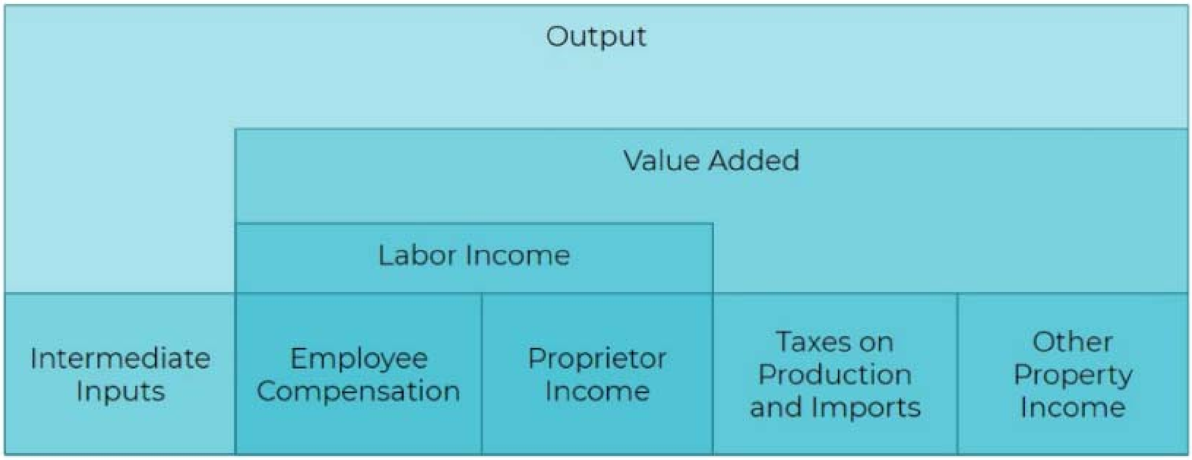

Figure 1. Components of economic output
Source: IMPLAN

Assumptions for EIA analysis

The EIA examines the impacts of spending on CSO control alternatives through 2060. The spending included in the analysis reflects capital spending for construction and associated design, planning, and management, as well as annual O&M spending through the last year of the analysis period. The study region is Washington DC; it does not include surrounding counties.

A key first step to conducting the EIA was to determine how the investments by DC Water will be spent under each alternative. While IMPLAN contains data on spending patterns for 546 economic sectors, there is no “green or gray infrastructure sector” included in IMPLAN. Thus, we selected a primary economic sector that best matches green and gray infrastructure capital construction spending, as follows:

- GI sector: Construction of new highways and streets
- Gray infrastructure sector: Construction of other new non-residential structures (excludes commercial buildings)

We then used data provided by DC Water (e.g., detailed costs and bid sheets for GI and gray infrastructure) to change the industry spending patterns for these sectors to better reflect the actual spending that will occur under each alternative.

Allocation of GI costs

Table 2 provides an example of the changes we made to the industry spending pattern for the IMPLAN sector “Construction of new highways and streets” to better account for GI construction spending. The percentage of spending across categories represents a weighted average of costs associated with permeable pavement and bioretention. These percentages were applied to the percentage of the overall budget that is allocated to direct construction, which accounts for approximately 43% of the total capital budget for GI (based on the bid sheets provided by DC Water). We excluded landscaping costs from this break out because we accounted for them elsewhere in the model. This is because the mix of labor to inputs for the landscaping sector is different than for the construction sector. We also separately modeled spending associated with downspout disconnections, allocating it to the sector “services to buildings.”

Table 2. GI construction spending pattern for IMPLAN Sector: Construction of new highways and streets[a]

Economic sector[b]	% of GI construction spending allocated to sector[c]
Construction of new highways and streets[d]	11.1%
Waste remediation	1.8%
Sand and gravel	2.3%
Asphalt paving mixtures and blocks	3.3%
Stone	9.0%
Other textile products	2.4%
Concrete blocks and bricks	2.8%
Ready mix concrete	1.8%
Water, sewage and other systems	5.0%
Plastics pipes and pipe fittings	2.6%
Ornamental and architectural metal products	1.5%
Employee compensation	29.1%
Proprietor income	2.1%

a. The percentages shown in Table 1 are based on a 70/30% split of permeable pavement to bioretention. This split varies across the two hybrid Rock Creek alternatives and the percentages are changed accordingly in IMPLAN.
b. The spending shown for economic sectors is for commodities/inputs only; employee compensation represents fully burdened labor costs.
c. Spending allocations do not total 100% because taxes and income from other property are not included.
d. The 11.1% of spending on GI construction allocated to the primary sector of construction of new highways and streets is allocated across this sector's typical inputs (i.e., the sector's typical spending pattern).

The remaining 56% of the capital construction budget (not including the 30% markup) was allocated across the different activities included in the bid sheets for the Rock Creek demonstration project (RC-A, on a percentage basis). This includes general conditions line items, landscaping, and other miscellaneous activities (e.g., contractor management labor costs, traffic control, permits, general site equipment rental). We allocated the 30% mark up on capital to the IMPLAN sector *architectural, engineering, and related services*. O&M and replacement/rehabilitation expenditures for bioretention were allocated to the *landscaping and horticultural services sector*; for permeable pavement these expenditures were allocated to *maintenance and repair construction of highways, streets, bridges, and tunnels*. Table 3 provides a summary of how all costs for GI components were allocated across IMPLAN sectors.

Table 3. GI spending by IMPLAN sector as a proportion of total cost

Spending category	IMPLAN Sector	Spending allocation
Capital Costs	Construction of new highways and streets (revised industry spending pattern to better reflect spending associated with direct construction of GI practices)	44%
	Landscaping and horticultural services	1.4%
	Construction of new highways and streets (general conditions)[a]	41%
	Architectural, engineering, and related services[b]	3.8%
	Employment and payroll of local government[c]	5.0%
	Maintenance and repair construction of highways, streets, bridges, and tunnels[d]	3.0%
	Water, sewage and other systems[e]	1.6%
Downspout disconnections	Services to buildings	100%
30% Markup	Architectural, engineering, and related services	100%
O&M and replacement/ rehabilitation	Landscaping and horticultural services	Varies based on percentage of permeable pavement and bioretention included in alternative
	Maintenance and repair construction of highways, streets, bridges, and tunnels	

a. Accounts for more general construction activities. We revised this sector in IMPLAN to account for a higher percentage of the general conditions budget spent on labor compared to the normal industry spending pattern.
b. Survey crew
c. Government permits
d. Traffic control
e. Utility protection, sewer disconnection, lead service line replacement

Allocation of gray infrastructure costs

As with GI, we changed the industry spending pattern for IMPLAN sector *Construction of other new non-residential structures* to better reflect spending for gray infrastructure. The allocation of costs for gray infrastructure was informed by similar work Corona's economists conducted in 2013 on the economic impacts of CSO alternatives. Table 4 shows the changes we made, demonstrating spending allocation in the IMPLAN "Construction of other new nonresidential structures" sector. For the gray infrastructure alternative, 100% of capital and replacement/rehabilitation costs were allocated through the industry spending pattern for construction of other new non-residential structures. The 30% capital markup was allocated to the *architectural, engineering and other related services* sector, while O&M spending for gray infrastructure is allocated to *engineering and other related services* sector, while O&M spending for gray infrastructure is allocated to the *water, sewage, and other systems* sector.

Table 4. Gray infrastructure construction spending pattern for IMPLAN Sector: Construction of other new non-residential structures.

Economic sector	% of gray construction spending allocated to sector
Concrete piping	8.7%
Ready mix concrete	1.2%
Water, sewage, and other systems	0.6%
Commercial and industrial machinery and equipment rental	2.7%
Wholesale - machinery, equipment and supplies	3.9%
Construction of other new non-residential structures (general construction inputs)[a]	22.5%
Employee compensation	55%
Proprietor income	3.9%

a. The 22.5% of spending allocated to the primary sector of construction of other new non-residential structures is allocated across this sector's typical inputs (i.e., it reflects the sector's typical spending pattern).

Household income adjustments: comparing apples to apples

The all gray infrastructure alternative (Alternative 1) has significantly higher capital costs than the hybrid alternatives (Alternatives 2 and 3); however, the O&M costs associated with the hybrid alternatives are much higher than for the gray-only alternative because GI is more expensive to maintain than underground gray storage. Over the analysis period (through 2060), despite having lower O&M and replacement/rehabilitation costs, Alternative 1 results in a higher level of spending by DC Water.

To be able to directly compare alternatives, we adjusted the model inputs to reflect equal spending across scenarios. To do this, we assume that the higher cost of installing gray infrastructure under Alternative 1 would be paid for by an additional increase in utility rates for households (over and above any rate increases that would occur under the GI alternatives). We therefore modeled the difference in costs as a savings to households under the less expensive alternatives. This is represented as a household income change in IMPLAN, which models how household savings are spent in the local DC economy. We allocated the savings over time under the hybrid alternatives across different income levels using income distribution data for DC from the U.S. Census American Community Survey. Table 5 shows total spending and associated household savings under each alternative, through 2060. All costs are shown in 2019 USD.

Table 5. Capital and O&M costs through 2060 under each CSO control alternative

	Alternative 1 – All Gray	Alternative 2 – Hybrid Green/Gray	Alternative 3 – Hybrid Green/Gray
Capital cost	$ 142,307,692	$103,000,000	$103,000,000
Capital markup (design, planning, construction management)	$ 42,692,308	$ 30,900,000	$30,900,000
O&M (through 2060)	$ 8,960,000	$ 39,586,733	$39,586,733
Replacement/rehabilitation (through 2060)	$ 17,220,000	$ 23,846,700	$22,826,700
Household savings		$ 13,846,567	$14,866,567
Total modeled spending	$ 211,180,000	$ 211,180,000	$ 211,180,000

a. No costs or further description of the MS4 credit of 71 acres was provided by DC Water; thus, this analysis does not include any economic impacts or TBL benefits from this component of the hybrid alternatives.

IMPLAN local labor assumptions

The IMPLAN model calculates local labor values based on a local commuting rate for the study region. The commuting rate varies by region but is constant across all business sectors within a region in IMPLAN. The commuting rate for DC is 63.4%, meaning that of all the labor utilized in a given project, 36.6% of the labor pool is assumed to be DC residents, while the remaining 63.4% commute in from elsewhere. For many of the jobs created by GI implementation, we adjusted the local labor rate to 51% based on information provided by DC Water. We did not adjust the local labor rate for the engineering jobs created by spending on design, planning, and construction management, nor for jobs created within the water, sewage, and other systems sector or for the specialized construction sector associated with building underground storage/tunnels. The effects of hiring local labor mostly show up in the "induced effects" because it represents additional spending by households within DC.

EIA results

This section presents the results of the EIA for the Rock Creek infrastructure alternatives, including impacts associated with spending on capital and O&M through 2060. All results are shown 2019 USD. We did not apply inflation or discount rates to present results in net present value (NPV) terms.

The much larger capital expenditures under the gray infrastructure alternative results in a greater initial economic impact compared to the hybrid alternatives. However, greater O&M spending for GI creates greater economic impact and creates greater opportunity for local jobs. **Overall, the hybrid alternatives**

create a greater economic impact across most economic indicators. This is despite the fact that the gray infrastructure alternative is more costly and that the household savings modeled under the hybrid alternatives create less of an effect on the local economy than infrastructure spending. **Per dollar spent by DC Water, the hybrid alternatives result in a 9% greater impact in terms of economic output, and an 11% to 15% greater employment impact, compared with the gray alternative.**

Local vs. non-local spending

The IMPLAN analysis confirms that not only will more jobs be created locally (i.e., within the District), but more money will likely be spent locally under the hybrid alternatives. Specifically, results indicate that for every dollar spent directly on stormwater management, the hybrid alternatives indirectly generate 15 - 16% more local spending (per dollar spent by DC Water) than the gray alternative. These estimates reflect the percentage of materials and labor purchased locally for all aspects of the project, including engineering, financial, construction, and landscaping services, and other related industries. The hybrid alternatives also have significantly greater induced effects in terms of total economic output – 61% to 64% greater per dollar spent by DC Water. This is in part due to the savings that DC households will realize under the hybrid alternatives because they are less expensive.

Employment

In IMPLAN, a job is defined as the annual average of monthly jobs in an industry (this is the same definition used nationally by the Quarterly Census of Employment and Wages, Bureau of Labor Statistics, and Bureau of Economic Analysis). Thus, one job lasting 12 months is equal to two jobs lasting six months each, and three jobs lasting four months each.

Table 6 shows the direct, indirect, and induced employment generated by infrastructure spending under each alternative. Hybrid alternatives offer higher levels of local employment across all three categories of effects compared to the gray alternative. This is likely due to the higher O&M requirements associated with GI throughout the project period (which creates local direct jobs), the higher percentage of local jobs created, and the increased local spending that occurs under the hybrid alternatives (which creates additional indirect and induced employment).

For direct effects, IMPLAN includes all employment created by direct spending, including jobs filled by non-residents, because these jobs occur in DC. We adjusted the direct effects to reflect DC Water's green jobs goal of filling 51% of GI-related construction and maintenance jobs with DC residents. The estimates below include the total direct jobs that would be created under each alternative, as well as the direct jobs that would likely be filled by local DC residents (in parentheses). Indirect and induced impacts reported by IMPLAN only includes jobs that are filled by DC residents.

Again, direct employment represents employment generated by the initial spending under each alternative. An example of a direct job would be a landscaper hired by DC Water to maintain a bioretention garden. The direct employment shown in Table 6 represents the employment associated with all aspects of the project, not only construction and O&M jobs. Indirect employment describes jobs created due to the re-spending of money by directly affected industries. An example of an indirect job would be one created due to increased spending by the landscaping industry (e.g., for bioretention landscaping) in an industry that supplies products and services to the landscaping industry. Induced employment represents employment generated as a result of increased spending by households that receive direct or indirect income as a result of a project or policy (e.g., now that the landscaper has a job, he/she spends a portion of the income from that job in the District's economy).

Table 6. Employment impacts (jobs created) through 2060, 2019 USD

Impact type	Alternative 1 - Gray	Alternative 2 – Hybrid	Alternative 3 – Hybrid
Direct effects	1,568 (575 local)[a]	1,542 (674 local)	1,599 (729 local)
Indirect effects	141	154	150
Induced effects	177	264	267
Total effects	**1,885 (892)**	**1,960 (1,092)**	**2,016 (1,147)**

a. Local jobs include jobs filled by local residents, assuming 51% of GI construction and maintenance jobs are filled locally.

Totals may not sum due to rounding.

Labor income

Table 7 shows the total labor income generated under each alternative. Total labor income includes all forms of employment income, including employee compensation (wages, benefits, and taxes paid by the employer) and proprietor income (which represents one form of profit). As shown, there is a higher level of labor income generated under the hybrid alternatives. The direct labor income-to-direct employment ratio is lower under the hybrid alternatives, indicating that individuals employed in the relevant industry sectors for these alternatives will earn less income and profit compared with those employed under the baseline alternative.

Table 7. Labor income impacts of Rock Creek infrastructure alternatives *($M, 2019 USD)*

Impact type	Alternative 1 - Gray	Alternative 2 – Hybrid	Alternative 3 – Hybrid
Direct effects	$126.4	$123.2	$120.1
Indirect effects	$16.2	$17.3	$16.8
Induced effects	$13.5	$20.2	$20.4
Total effects	**$156.2**	**$160.7**	**$157.4**

Totals may not sum due to rounding.

Total economic output

Table 8 presents the local (i.e., within the District) direct, indirect, and induced effects on economic output under the CSO control infrastructure alternatives. Economic output represents the value of industry production.[1] The economic output associated with each alternative is equivalent to the direct spending by DC Water under each alternative (including capital and O&M through 2060). As shown, the hybrid alternatives result in $3.4 to $4.4 million more in terms of economic output within the District compared

[1]. For manufacturers, this represents sales plus or minus the change in inventory. For service sectors, production is equal to sales. For retail and wholesale trade, output is equal to gross margin, not gross sales.

to the gray alternative even though they are less costly. This is due to the greater amount of goods, services, and labor purchased locally under these alternatives.

Table 8. Economic output impacts of Rock Creek infrastructure alternatives ($M, 2019 USD)

Impact type	Alternative 1 - Gray	Alternative 2 –Hybrid	Alternative 3 – Hybrid
Direct effects	$211.2	$197.3	$196.3
Indirect effects	$30.8	$33.5	$32.9
Induced effects	$30.9	$46.6	$47.1
Total effects	**$272.9**	**$277.4**	**$276.3**

Totals may not sum due to rounding.

Total value added

Total value added is defined as the difference between the total economic output of an industry and the cost of its intermediate inputs. It equals gross output (i.e., sales or receipts and other operating income, plus inventory change) minus intermediate inputs (i.e., consumption of goods and services purchased from other industries or imported). Value added consists of employee compensation (wages, benefits, taxes paid), any taxes on production and imports that the industry pays, and gross operating surplus (i.e., proprietor income and other profits).

Table 9 presents the total value added generated within the District under the gray and hybrid alternatives through 2060. As shown, the hybrid alternatives will result in at least $20 million in additional value added compared with the gray infrastructure alternative.

Table 9. Total value added impacts through 2060 ($M, 2019 USD)

Impact type	Alternative 1 - Gray	Alternative 2 –Hybrid	Alternative 3 – Hybrid
Direct effects	$92.4	$103.6	$104.9
Indirect effects	$21.2	$23.0	$22.5
Induced effects	$20.9	$31.5	$31.9
Total effects	**$134.5**	**$158.1**	**$159.4**

Totals may not sum due to rounding.
The significant difference in value added between the hybrid and gray alternatives is largely because value added for the construction sector associated with gray infrastructure spending has a negative value associated with property income in DC.

Impacted economic sectors

As described above, the CSO control alternatives result in different types of jobs and draw upon different services and inputs for implementation. Tables 10 through 12 show the top economic sectors impacted under the three alternatives, respectively, by employment impact. Results for each sector include total employment, labor income, value added, and economic output generated locally.

Table 10. Top 10 economic sectors impacted, by employment generated, Alternative 1 - Gray

Economic sector	Total employment (jobs)	Labor income ($M, 2019 USD)	Value added ($M, 2019 USD)	Economic output ($M, 2019 USD)
Construction of other new nonresidential structures (excludes buildings)	1,349	91.55	55.99	155.55
Architectural, engineering, and related services	211	28.17	32.73	50.50
Water, sewage and other treatment and delivery systems	24	2.55	6.26	9.11
Employment services	19	1.46	2.30	3.00
Other real estate	15	0.90	2.47	4.24
Full-service restaurants	14	0.55	0.84	1.24
Hospitals	13	1.41	1.66	2.76
Junior colleges, colleges, universities and professional schools	10	0.69	0.95	1.25
Limited-service restaurants	10	0.38	0.60	1.02
Services to buildings and dwellings	9	0.27	0.30	0.46
Retail – Building materials	8	0.66	1.14	1.43

Table 11 Top 10 economic sectors impacted, by employment generated, Alternative 2 – Hybrid Green/Gray

Economic sector	Total employment (jobs)	Labor income ($M, 2019 USD)	Value added ($M, 2019 USD)	Economic output ($M, 2019 USD)
Construction of other new nonresidential structures (excludes buildings)	598	$40.57	$24.81	$68.94
Maintenance and repair construction of highways, streets, bridges and tunnels	376	$24.95	$12.71	$34.27
Landscape and horticultural services	262	$5.04	$8.35	$14.78
Architectural, engineering, and related services	177	$23.60	$27.42	$42.30
Construction of new highways and streets	105	$18.24	$27.07	$33.40
Retail – Building material and garden equipment and supply stores	21	$1.75	$3.02	$3.77
Services to buildings and dwellings	22	$0.69	$0.76	$1.17
Employment services	19	$1.44	$2.28	$2.97
Water, sewage and other treatment and delivery systems	15	$1.57	$3.86	$5.62
Other real estate	17	$1.03	$2.84	$4.87
Hospitals	17	$1.82	$2.15	$3.56
Full-service restaurants	16	$0.65	$0.99	$1.46

Table 12. Top 10 economic sectors impacted, by employment generated, Alternative 3 – Hybrid Green/Gray

Economic sector	Total employment (jobs)	Labor income ($M, 2019 USD)	Value added ($M, 2019 USD)	Economic output ($M, 2019 USD)
Construction of other new nonresidential structures (excludes buildings)	598	$40.57	$24.81	$68.94
Landscape and horticultural services	430	$8.26	$13.69	$24.22
Maintenance and repair construction of highways, streets, bridges and tunnels	268	$17.78	$9.06	$24.42
Architectural, engineering, and related services	174	$23.23	$26.99	$41.64
Construction of other new nonresidential structures (excludes buildings)	103	$21.97	$30.70	$33.03
Services to buildings and dwellings	22	$0.70	$0.77	$1.19
Employment services	19	$1.48	$2.33	$3.04
Retail – Building material and garden equipment and supply stores	16	$1.38	$2.38	$2.97
Other real estate	18	$1.08	$2.98	$5.12
Employment and payroll of local government, hospitals and health services	15	$1.60	$1.97	$1.97
Water, sewage and other treatment and delivery systems	15	$1.57	$3.86	$5.62
Hospitals	17	$1.88	$2.21	$3.67

Many of the sectors shown in the tables below are the same due to the large amount of initial capital spending on gray infrastructure under all alternatives. However, the analysis of economic sectors impacted under the different alternatives further demonstrates that a greater percentage of jobs needed for GI implementation can be filled by District residents who are currently unemployed and/or underemployed. For example, most of the jobs within the economic sector "landscape and horticulture services," which will receive a large number of jobs under the hybrid alternatives due to GI implementation, generally require limited or no experience. By comparison, construction jobs, which represent one of the largest industry sectors generated for gray infrastructure, require a higher percentage of skilled laborers and are often crews hired from outside the District. In addition, many of the impacted sectors are sectors impacted by additional local spending that occurs under all alternatives.

Summary

Overall, given the same level of spending (or household savings), the hybrid alternatives results in a greater economic impact in the District compared to the gray alternative. This is primarily due to the increased utilization of local resources associated with GI, as well as the increase in local employment generated. Alternative 3 would result in the largest economic impact, supporting an estimated 2,016 jobs between 2022 and 2060, including direct, indirect, and induced employment. This compares to an estimated 1,885 jobs between 2026-2060 (including O&M beginning after construction is complete) under

Alternative 1. A higher percentage of the jobs under the hybrid alternatives will also likely be filled by unemployed/underemployed local residents, resulting in a larger net gain in employment rather than a transfer of employment.

Table 13 summarizes the total direct, indirect, and induced effects for employment, labor income, total value added, and economic output under the gray and hybrid alternatives. Again, results represent the same level of economic activity, including spending on infrastructure and household savings under the hybrid alternatives. Table 14 shows total economic impacts per million dollars spent by DC Water.

Table 13. Summary of economic impacts over design, construction, implementation, and O&M through 2060

Impact type	Alternative 1 - Gray	Alternative 2 – Hybrid Green/Gray	Alternative 3 – Hybrid Green/Gray
Employment (jobs)	1,885	1,960	2,016
Labor income ($M, 2019 USD)	$16.18	$17.27	$16.85
Total value added ($M, 2019 USD)	$134.46	$158.15	$159.38
Economic output ($M, 2019 USD)	$272.94	$277.37	$276.34

Table 14. Total economic impacts per million dollars spent by DC Water, 2019 USD

	Alternative 1 – All Gray	Alternative 2 – Hybrid Green/Gray		Alternative 3 – Hybrid Green/Gray	
Total spending (through 2060, $M)	$ 211.2	$ 197.3		$ 196.3	
	Impact / $M	**Impact /$M**	**% increase from gray**	**Impact / $M**	**% increase from gray**
Employment (jobs)	8.9	9.9	**11.3%%**	10.3	**15.0%**
Labor income	76,637	87,540	**14.2%**	85,824	**12.0%**
Total value added	636,710	801,417	**25.9%**	811,861	**27.5%**
Economic output	1,292,459	1,405,590	**8.8%**	1,407,633	**8.9%**

3. Triple Bottom Line Assessment of GI Co-Benefits

This section describes the methods and assumptions and presents results for the TBL assessment of co-benefits associated with the GI components of the two hybrid alternatives that DC Water is considering for the Rock Creek Watershed.

Background and Assumptions

Corona Environmental Consulting is currently developing an economic framework and tool (the Green Stormwater Infrastructure Benefits Valuation Framework and Tool) to help stormwater practitioners quantify and monetize the co-benefits of GI. The development of the Tool is being funded by the Water Research Foundation. We have applied the methodology developed for the Tool to quantify and monetize the co-benefits associated with bioretention and permeable pavement. Based on this methodology, the TBL analysis of GI co-benefits includes the following benefit categories:

- Energy Savings Wastewater Treatment
- Air Emissions Reduction
- Property Value Increase
- Heat Stress Reduction
- Recreation Improvement
- Carbon Emissions Reduction
- Ecosystem Value
- Avoided Social Costs of Green Jobs
- Avoided Gray Infrastructure Costs

The following sections describe the assumptions incorporated into the analysis for each benefit category. For applicable benefit categories (i.e. heat stress reduction), we note the changes to assumptions made based on feedback from DC Water.

General Assumptions
The following general assumptions apply as applicable across multiple benefit categories.

- Design storm depth: 1.2 inches
- District population (2018): 702,455 people
- Area of the District: 61.05 square miles

Energy savings from avoided wastewater treatment
This benefit includes the energy saved from diverting stormwater from wastewater collection, conveyance, and/or treatment systems. The benefit is calculated based on the total volume of stormwater infiltrated under each scenario based on a design storm depth of 1.2 inches and acres managed through GI implementation.

The benefit calculation applies national average energy intensity estimates (kWh/million gallons, MG) for avoided wastewater pumping and treatment, based on average flow rate at the WWTP. We assumed an average treatment volume of 300 MGD for DC Water's Blue Plains Advanced Wastewater Treatment Plant. We selected the average energy intensity of 3,300 kWh/MGD that was associated with an average flow rate range of 101-330 MGD from the national study.

Assumption summary:

- Average flow rate of Blue Plains Wastewater Treatment Plant: 300 MGD
- Associated average energy intensity: 3,300 kWh/MGD
- Average cost of electricity in the District: 11.6 cents/kWh

Air emissions reduction and related health benefits

This benefit includes the reduction in NOx, SO_2, and $PM_{2.5}$ emissions from power plants associated with the GI-related energy savings. This benefit is the result of the avoided energy use from avoided wastewater treatment.

To calculate the reduced emissions of NOx and SO_2, we applied emissions rates (pounds of pollutant/kWh) for the **RFC East** region (where DC is located) from the U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID). To estimate direct $PM_{2.5}$ emissions reductions, we used emissions rates from EPA's AVoided Emissions and geneRation Tool (AVERT). DC is located in the **Great Lakes/Mid-Atlantic** region in the AVERT tool.

To monetize emissions reductions benefits, we rely on data from U.S. EPA's Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE). In 2018, EPA used BenMAP-CE to calculate the benefit-per-ton of reducing $PM_{2.5}$ and $PM_{2.5}$ precursor emissions (including NOx and SO_2) in 17 industry sectors. Our analysis incorporates EPA's estimates for the electricity-generating sector to monetize the health-related benefits of emissions reductions (i.e., monetary value per ton associated with avoided mortality and morbidity risk).

<u>Assumption Summary</u>

Emissions rates (from EGRID/AVERT) for DC:

- NOx: 1.2 metric tons per year
- SO_2: 1.2 metric tons per year
- PM2.5: 0.21 metric tons per year

Value of emissions reduction (from BENMAP tool):

- NOx value: $10,792 per metric ton/ year
- SO2 value: $71,167 per metric ton/ year
- $PM_{2.5}$ value: $253,512 per metric ton/ year

Property value increases

This benefit estimates the potential property value increases associated with GI improvements based on studies of housing value from the literature.

The first step is to determine baseline property values within the GSI management area. We use data for single-family and multi-family residential properties from the U.S. Census American Community Survey (ACS). Specifically, we use the following ACS tables: "Aggregate Value by Units in Structure" and "Units in Structure" to estimate baseline property values for single-family homes and multi-family buildings.

We calculate the percentage of properties within the management area that would be affected by GI based on the area of GI practice installed (in this case bioretention because permeable pavement installations generally do not increase property values on their own unless they result or are part of a neighborhood beautification project/effort). Based on estimates form the literature, we assumed a "buffer zone" of 100 meters, meaning that GI projects would affect the value of properties within a 100-meter radius. We divided the total impacted area (GI area plus the buffer zone) by the management area (i.e.., are of Rock Creek watershed) to determine the percentage of properties affected by GI. Using this approach, the analysis finds that under Alternative 3 approximately 3.25% of properties within the Rock Creek Watershed would be affected by bioretention installations, while 1.95% would be affected under Alternative 2.

For the change in value due to GI, the literature provides a range of values for bioretention, rain gardens and biofiltration from 0.44% to 10%. We apply the approximate midpoint value of 4.25%, from a range around the midpoint of 3.5% to 5%, to the value of affected properties within the management area.

To reduce the potential for double counting, we only allow 50% of the estimated property value increase to be included in the calculations of total costs and benefits. This is because many of the other (separately calculated) benefits of GI are also reflected in increased property values. Using this approach, we are attempting to capture only the portion of property value increases due to enhanced aesthetics in the area.

Assumption Summary

- 4.25% property value increase associated with properties located next to bioretention
- Does not exclude any single-family or multi-family residential properties due to high baseline vegetation or of very high value.

Heat stress reduction

This benefit estimates the cooling effect of GSI and associated reductions in heat related fatalities and illnesses. Increases in cooling through GSI can come through increased reflectivity (albedo) of surfaces, and/or through increases in vegetation.

Based on feedback from DC Water, we will not consider there to be increased cooling associated with permeable pavement installed in the scenarios. DC Water is replacing existing asphalt with permeable pavement asphalt with the same albedo, and thus does not gain cooling benefit from these installations.

For the increase in vegetation from bioretention, we rely on estimates from the literature on the degrees of cooling associated with a 10% increase in vegetated area of the management area (these estimates are specific to DC). We consider a 5% increase in vegetation to be a lower bound needed to achieve cooling benefits from vegetative GSI.

Our approach utilizes city-specific relationships between deaths and extreme temperatures using historical (daily) mortality and weather data developed by US EPA as part of the Fourth National Climate Assessment, Climate Change Impacts and Risk Analysis. This study defines extremely hot days as those with a daily *minimum* temperature that is warmer than 99% of the days in the historical reference period and is at least 20°C (68°F). Statistical analysis is then used to estimate deaths that can be attributed to weather on those days.

While at first perhaps counterintuitive, extremely hot days are defined based on minimum temperatures because the urban heat island effect is often driven by days when hot temperatures do not cool off at night. During a heat event, people need the relief of lower nighttime temperatures to recover from compounding heat stress that builds throughout the day (Moriyama 1988, as cited by TPL 2016). However, the UHI effect often becomes more pronounced after sunset due to the slow release of heat from urban infrastructure (EPA 2008); thus, this relief does not always occur.

The EPA data provides us with the baseline relationship between deaths and extreme temperatures (i.e., minimum mortality temperatures, MMT) in DC. The next step is to link planned increases in GSI to reductions in urban temperatures. For this step, we rely on estimates from Sailor (2003), which links a 10% increase in vegetated acreage in DC to reductions in average daily temperatures.

Finally, to link temperature reductions to decreased mortalities, we perform the following steps:

- Calculate the change in the days each year when the District is over the MMT (i.e., subtract the change in temperature from Sailor et al. 2003 from the MMT for the historical reference period)
- Use the change in days over MMT to calculate a new average annual mortality rate
- Calculate annual lives saved from the project based on local/affected population.

EPA (2017) and Sailor (2003) tells us the reduction in mortalities that result from the reduction of the number of days with nighttime temperatures above the mortality threshold for DC. The number of avoided emergency room (ER) visits and hospitalizations are estimated based on data linking those to the number of heat deaths.

To monetize the reductions in heat-related fatalities we follow standard U.S. EPA methodology for estimating the value of mortality risk reductions. This is based on estimates of how much people are willing to pay for small reductions in their risks of dying from adverse health conditions. These WTP estimates for small reductions in mortality risks are often referred to as the "value of a statistical life" (VSL). The VSL estimate in 2019 dollars is $10,200,000. The value of an avoided hospital admission is $34,271, and the value of an avoided ER visit is $529.

We scale our benefit estimate to account for the actual increase in vegetated area in the management area (as a percentage of total area, not baseline vegetation) compared to the 10% estimate. For example, if the actual increase in vegetated acreage is 2%, we scale down the reduction in nighttime temperature reduction by 4/5. We also scale the benefit estimate to account for the ratio of the management area to the total population of DC.

Assumption Summary

- A 10% increase in vegetation leads to a 0.31 degree Fahrenheit reduction in the minimum nighttime temperature in DC
- Benefits are scaled to actual increase in bioretention as a percentage of management area relative to the 10% estimate.
- Value of an avoided premature mortality (VSL) is $10,200,000
- Value of an avoided hospital admission is $34,271
- Value of an avoided ER visit is $529

Recreation improvements
We estimate the increased recreational benefit associated with installation or substantial improvement of pocket parks. Pocket parks are typically about one-quarter acre in size and serve residents within a one-quarter to one-half-mile radius, depending on population density. We assume that 750 residents are within the area served by a pocket park, and that they visit 9 months out of the year.

We assume that one pocket park is substantially improved in the 30% bioretention scenario, and two pocket parks substantially improved in the 50% bioretention scenario.

We apply the Unit Day Value Method developed by the U.S. Army Corps of Engineers (ACOE) to estimate direct use values for additional recreational trips associated with improved pocket parks. The method uses a series of questions to assess the quality of the recreational experience and assign a value per trip. The resulting value per trip based on the answers listed to questions below is $8.80.

<u>Assumption Summary</u>

- Pocket parks are currently underutilized and will be revitalized under GI implementation
- 750 residents served by a pocket park
- Residents visit parks 9 months out of the year
- One pocket park is substantially improved in the 30% bioretention scenario
- Two pocket parks substantially improved in the 50% bioretention scenario.
- The assumptions we made for pocket park substantial improvements in DC include:
    - How many general recreation activities of normal quality will be provided by the project? General activities include picnicking, walking, bench-sitting, playground activity, bike riding,
        - Answer: Several (3-5)
    - What is the availability of similar recreational opportunities located nearby?
        - Answer: Many
    - To what degree does the site provides adequate services to support recreation?
        - Answer: Adequate
    - To what degree is the facility easily accessible?
        - Answer: Very High
    - How are the aesthetic qualities of the area including water and vegetation, air and water quality, scenery, and climate?
        - Answer: Average

Carbon emissions reduction
Carbon emissions reductions are based on two GI-related effects. First, the reduction in energy usage for wastewater treatment reduces power plant CO_2 emissions. Second, bioretention sequesters carbon.

To calculate avoided CO_2 emissions from power plants, we multiply total GSI-related energy savings by the non-baseload pollutant CO_2 emissions rate (lbs/metric ton) from the EGRID database for the RFC East region. The carbon dioxide equivalent emission rate from the RFC East region is 1,441 pounds per MWh. We apply for energy grid losses as reported by EPA, which account for the additional energy that must be produced to meet consumer demand.

To value avoided CO_2 emissions, we use the "social cost of carbon", which is currently $51 per metric ton assuming a 3% discount rate over time.

To value the carbon sequestered in bioretention, we use the square feet of bioretention installed, and apply a carbon sequestration rate from the literature of 13 kilograms CO_2e per square meter. We then value this sequestered carbon dioxide equivalent using the SCC.

Assumption Summary:

- 1,441 pounds per MWh emission rate of carbon dioxide equivalent in the RFC East EGRID region (which includes DC)
- 13 kg CO_2e sequestered per square meter of bioretention
- $51 per metric ton is the "social cost of carbon"

Ecosystem and biodiversity benefits

Evidence suggests that vegetated GI practices, including bioretention areas can contribute to the network of green spaces that support terrestrial ecosystems and biodiversity in urban and suburban settings. We value the ecosystem and biodiversity benefits starting with an estimate of wetland valuation studies from the literature. That value is $4,912 per acre. The literature shows that bioretention does not have the same ecosystem and biodiversity value as wetlands – so we scale the value for bioretention by using 2/5 of the wetland value, to $1,965 per acre.

Assumption Summary:

- The ecosystem and biodiversity value of bioretention is 2/5 of the value for wetlands, or $1,965 per acre.

Green job benefits

Jobs associated with large civil works and infrastructure projects are not typically counted in benefit-cost analysis. This is because the labor retained in such projects typically involves skilled workers who would be gainfully employed in other ventures (private or public investments), especially when the national or regional economy is running at near full employment. This means that there typically is a transfer of employment across potential activities rather than a real net gain in the number of jobs.

However, there are some exceptions that may apply to GI, and reasons for quantifying (and potentially monetizing this benefit). Specifically, there are likely to be social benefits (e.g., avoided social costs) when jobs can be steered to local citizens who are typically unemployed or under-employed, or otherwise living in poverty, due to a lack of education and training and other social circumstances. Thus, the benefits of providing these jobs include the avoided costs of social services that the City would provide on behalf of the same people if they remained unemployed. This is the approach Corona's economists applied in a 2009 study of the TBL benefits of GI in Philadelphia. Specifically, based on estimates from the literature, the 2009 study applied an avoided social cost of $10,000 (2009 USD) per unemployed worker, assuming a certain percentage of labor employed for GI programs would fall into this category.

Following this approach, we assume a 2019 USD value of $11,900 per unemployed or (updated form the 2009 estimate based on the consumer price index) and assumed that this benefit applies to approximately

30% of construction and maintenance workers hired. This benefit does not include jobs associated with GI design and engineering.

Assumption Summary:

- Avoided social costs applies to 30% of GI construction and maintenance jobs
- Avoided social costs amount to $11,900 per applicable worker
- Alternatives 2 and 3 support approximately 18 and 20 maintenance jobs per year ($1.4 million in annual spending on O&M)
- Total GI construction jobs amount to 150.6 and 155.6 under Alternatives 2 and 3, respectively (not including design/engineering jobs).

Avoided gray infrastructure costs

There are different ways to account for the gray infrastructure costs that GI projects will help to offset. When directly comparing a gray infrastructure alternative to a GI alternative, this benefit is accounted for by directly comparing the costs of each alternative. When evaluating a GI alternative on its own, avoided costs can be accounted for on the benefits side of the ledger. To account for this benefit, we subtract the present value costs of the gray infrastructure components included in Alternatives 2 and 3 (the hybrid alternatives) from the full present value costs of Alternative 1 (the gray infrastructure alternative). This net reduction in gray infrastructure costs can be included as a benefit of the hybrid alternatives when evaluating these projects individually (but not when they are being directly compared to Alternative 1).

TBL Co-Benefit Estimates and Comparison to Cost

Table 15 presents the annual co-benefit estimates for Alternatives 2 and 3, as well as for the Rock Creek demonstration project (RC-A, completed in 2019). The table includes both physical/quantitative estimates (e.g., energy savings in kWh, avoided emissions in metric tons per year) and the monetary value associated with each benefit.

Benefits are assumed to be constant over time and to accrue throughout the analysis period ending in the year 2060. The exception is heat stress reduction, which is estimated for the years 2020 and 2050, and is linearly interpolated for years between 2020 and 2050, as well as from 2050 to 2060. The totals shown in Table 15 reflects 2020 values (not 2050 values) for heat stress reduction benefits (avoided mortality, reduced emergency room visits, and reduced hospitalizations).

Table 15. Average annual co-benefit values by scenario (2019 USD)

Annual Triple Bottom Line Benefit	Alt. 2 - Hybrid	Alt. 3 - Hybrid	Rock Creek A
Energy use savings WW treatment (kWh/yr)	3,321	3,321	1,226
Value of energy use savings WW	$38,621	$38,621	$14,260
Reduced air emissions - NOx (metric tons/year)	1.81	1.81	0.67
Reduced air emissions - SO2	1.81	1.81	0.67
Reduced air emissions - PM2.5	0.32	0.32	0.12
Value of Reduced Air Emissions NOx	$19,508	$19,508	$7,203
Value of Reduced Air Emissions - SO2	$128,640	$128,640	$47,498
Value of Reduced Air Emissions PM2.5	$80,193	$80,193	$29,610
Annual average increase in Property Value - Single Family[a]	$553,259	$922,107	$136,193
Annual average increase in Property Value - Multifamily	$462,608	$771,020	$113,878
Number of Avoided Mortalities year 2020	0.0004	0.0007	0.0001
Number of Avoided Mortalities - year 2050	0.0009	0.0014	0.0002
Value of Avoided Mortalities - year 2020	$4,397	$7,329	$1,082
Value of Avoided Mortalities - year 2050	$8,794	$14,657	$2,165
Value of Reduced Emergency Room Visits - Year 2020	$12	$20	$3
Value of Reduced Emergency Room Visits - Year 2050	$24	$40	$6
Value of Reduced Hospitalizations - Year 2020	$140	$234	$35
Value of Reduced Hospitalizations - Year 2050	$281	$468	$69
Emission avoided due to energy savings (metric tons)	2,269	2,269	838
Value of avoided GHG emissions	$115,704	$115,704	$42,721
Carbon sequestration from bioretention (kg CO2 eq.)	55,512	92,520	13,665
Value of bioretention carbon sequestration	$2,831	$4,719	$697
Ecosystem value of bioretention areas	$1,659	$2,764	$408
Recreation value for substantially rehabilitated pocket parks	$75,636	$151,272	$0
Green jobs added – construction (30% of total GI construction jobs) [b]	25.1	25.9	----
Green jobs added - O&M (30% of total GI maintenance jobs)	5.5	6.0	----
Value of green jobs – construction *	$89,733	$92,593	----
Value of green jobs - O&M	$65,135	$71,922	----
Total ($)	**$1,548,363**	**$2,314,073**	**$393,589**

a. Annual property values reflect 50% of expected property value increases to avoid double counting
b. Only applicable for years in which GI construction occurs (2022-2027)

We calculated the present value of benefits for each option over time using a 3% discount rate. Using present value allows us to compare benefits across scenarios and to directly compare benefits to costs. The present value comparison is shown in Table 16. The present value of costs presented in Table 16 reflects the costs associated with the GI components of the hybrid alternatives only; the costs associated with the gray infrastructure components of the hybrid alternatives, as well as downspout disconnection, are not included in the table. In addition, the table does not show avoided gray infrastructure costs under these alternatives relative to Alternative 1.

Table 16. Summary of present value of co-benefits compared to costs, (2019 USD)

	Present Value of Benefits	**Present Value of Costs (GI only)**	**Benefits Compared to Costs**
Alternative 2 - Hybrid Green/Gray	$17,306,499	$68,103,754	0.25
Alternative 3 – Hybrid Green/Gray	$25,868,510	$67,819,680	0.38
Rock Creek A - Demonstration	$7,484,357	$ -- -	----

For both scenarios, the largest present value total for a benefit is property value increases, followed by air emissions reduction. Air emission reductions depend on the avoided energy use associated with reduced wastewater treatment due to capture of stormwater by GI. The present value benefits shown in Table 16 are larger for Alternative 3 than for Alternative 2 for several reasons. First, the property value increases are much greater under Alternative 3 because our analysis assumes that permeable pavement installations do not result in property value increases. Second, there are greater green job benefits in Alternative 3 compared to Alternative 2 because a greater proportion of bioretention requires more labor. Finally, there is greater recreation improvement benefit because Alternative 3 is assumed to improve two parks, whereas Alternative 2 is assumed to improve one park. Figure 2 shows the distribution of benefits for Alternative 2; Figure 3 shows the distribution of benefits for Alternative 3.

Figure 2. Distribution of co-benefit present value benefits (through 2060) for the Alternative 2

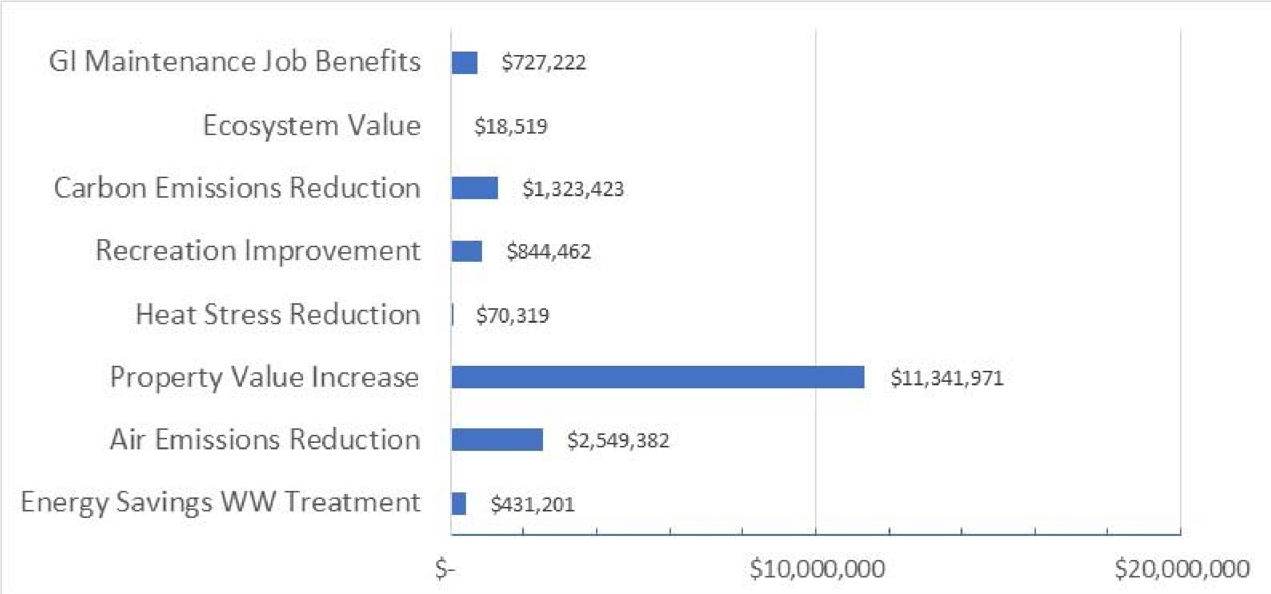

Figure 3. Distribution of co-benefit present value benefits (through 2060) for the Alternative 3

Benefits for the Rock Creek A demonstration project are shown for comparison in Figure 4. Recreation improvement benefit for this scenario is zero because we assumed no parks were substantially improved.

Figure 4. Distribution of co-benefit present values for the Rock Creek A demonstration project

In addition to the benefits presented above, the hybrid alternatives will avoid significant costs associated with gray infrastructure that would otherwise be implemented under Alternative 1. The present value costs of Alternative 1 (through 2060) amount to approximately $159.0 M. The present value costs associated with the gray infrastructure components of Alternatives 2 and 3 amount to $70.9 M over the same period. Thus, the hybrid alternatives will avoid approximately $88.1 M in gray infrastructure costs compared to Alternative 1. This more than offsets the present value GI costs of approximately $68 M under each hybrid alternative.

The present value of costs for each scenario including the gray scenarios is shown in Table 17. The table reports capital and O&M values for both the Gray and Green aspects of each scenario, when applicable, and the sum of capital and O&M. Downspout disconnection (DD) costs are reported separately for each scenario and are included in the total.

Table 17. Present Value Costs of All Rock Creek Alternatives ($M 2019 USD)

	Gray infrastructure component			GI components (Permeable pavement and bioretention)			DD[a]	Total
Alternative	**Capital**	**O&M/ replacement**	**Total**	**Capital**	**O&M/ replacement**	**Total**		
Alt 1 Gray	147.2	11.9	159.0					159.0
Alt 2 Hybrid	65.2	5.67	70.9	43.4	24.7	68.1	0.81	139.8
Alt 3 Hybrid	65.2	5.67	70.9	43.4	24.4	67.8	0.81	139.5

a. DD = Downspout Disconnection; implementation of downspout disconnections are assumed to occur from 2022 through 2023