Regional Centre Local Wastewater Servicing Capacity Analysis (LoWSCA)

Final Report

Prepared by
GM BluePlan for:

The Halifax Regional Water Commission

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1 Introduction

Halifax Regional Water Commission (HRWC), along with the Project Steering Committee comprising of the Municipality's staff and Halifax Water employees retained GM BluePlan to undertake 'The Regional Centre Local Wastewater Servicing Capacity Analysis' (LoWSCA "low-scar") project. This tactical level project will support the strategic level Regional Centre Plan, currently being undertaken by Halifax Regional Municipality (HRM).

1.1 Background

This study focuses on the Regional Centre, which is the urban core of the Halifax Regional Municipality (HRM), and is composed of the Halifax Peninsula and Dartmouth within the Circumferential Highway 111 and has a total land area of 33 square kilometers. HRM is currently working on the Regional Centre Plan which is a strategic corporate initiative that will guide the development of the Regional Centre for the next 25 years.

The Regional Centre Local Wastewater Servicing Capacity Analysis is a critical step in the infrastructure and development planning process undertaken by HRWC and HRM. This project will support HRM's objectives to promote and enable higher density development supported by adequate wastewater servicing as well as HRWC's objective to understand and track the existing system capacity and future system capacity needs.

The LoWSCA is intended to provide a capacity analysis of the local pipe infrastructure between the intensification area and the nearest Regional infrastructure.

In parallel with this study, Halifax Water is currently undertaking the West Region Wastewater Infrastructure Plan (WRWIP). This is a Regional infrastructure based study to identify the preferred servicing solution for the West Region. The WRWIP study builds on the Regional Wastewater Functional Plan (RWWFP). There are several synergies between the WRWIP and LoWSCA, in particular the flow monitor data and hydraulic model used is the same and the planning data provided by HRM, Regionally and by intensification pocket has been consolidated to ensure consistency.

1.2 Study Area

HRM is the capital of Nova Scotia and occupies an area of 5,577 square kilometers. HRM is the largest municipality in Atlantic Canada, with a total population of c.410,000 in 2014. The urban center around the harbor of HRM has a total population of 297,943 currently accounts for 70% of HRM's population.

The Regional Centre of HRM is the study area for this project and is defined as Peninsular Halifax and Dartmouth inside the arc of Highway 111 (The Circumferential). Within the study area, HRM has identified six (6) target intensification areas ('Pockets'), four in Halifax and two in Dartmouth, as follows and shown on Figure 1:

1. Spring Garden Road, Halifax
2. Quinpool Road, Halifax
3. Young Street, Halifax
4. Agricola & Gottingen Street, Halifax
5. Canal Street, Dartmouth
6. Wyse Road, Dartmouth

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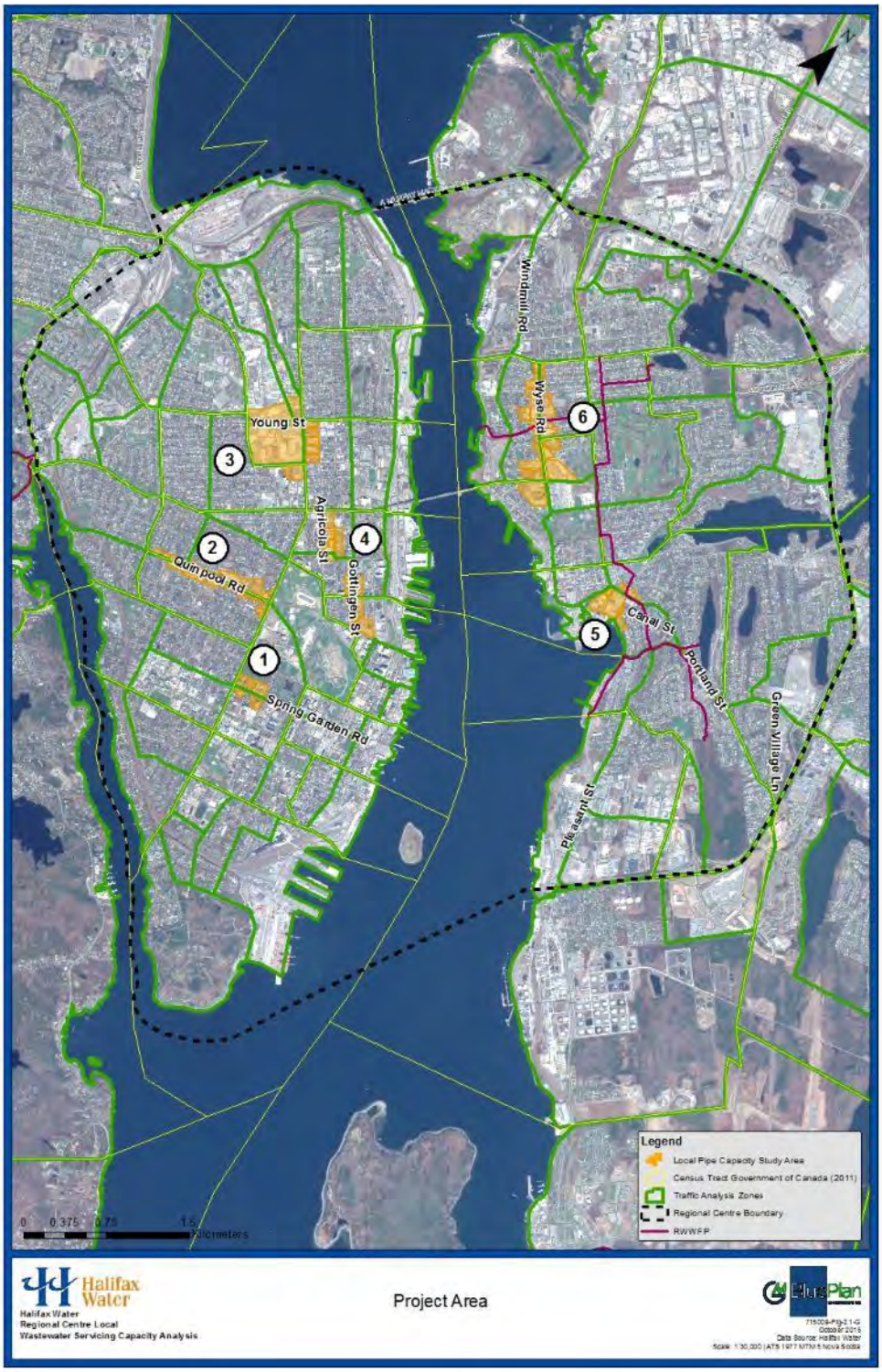


Figure 1: Project Study Area and Six Intensification 'Pockets'

2 Aims and Objective

The main aim of this project is to provide existing and future scenario capacity analysis of the local sewer pipe infrastructure in the six target intensification areas and to provide preferred solutions to the identified capacity issues. It is assumed for the purpose of this study that the nearest Regional infrastructure has sufficient capacity and is excluded from the scope of this analysis.

To achieve the study aim, the objectives of the study are:

- Review all relevant background information and data;
- Interpret and analyze flow monitoring data;
- Update and calibrate the hydraulic model;
- Assess existing and future servicing capacity;
- Evaluate and cost servicing alternatives;
- Develop a project level costed capital plan.

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3 Project Team

3.1 Core Team

The core team comprises Halifax Water staff, Halifax Regional Municipality staff and GM BluePlan Staff.

Project Governance and key contacts are as follows:

Project Sponsor	Jamie Hannam, Halifax Water
Steering Committee	**Halifax Water:** David Blades, Valerie Williams, Jamie Hannam, Susheel Arora, David Ellis, Kevin Gray **HRM:** Peter Duncan – duncanp@halifax.ca – Planning and Development, Jacob Ritchie – ritchij@halifax.ca - Urban Design Manager Luc Ouellet – ouellel@halifax.ca - Senior Planning Paul Burgess – burgesp@halifax.ca - Program Engineer
Project Manager (Halifax Water)	Meghan Woszczynski meghanw@halifaxwater.ca
Project Team (Halifax Water)	Kevin Gray, David Blades keving@halifaxwater.ca, david.blades@halifaxwater.ca
Extended Team (including external consultants)	GM BluePlan Engineering. Project Manager: James Jorgensen james.jorgensen@gmblueplan.ca

3.2 Stakeholders

Additional stakeholders have been identified as follows:

Nova Scotia Environment (NSE)	One of the core functions of the NSE is the protection of the environment. As such, the LWSCA will comply with the NSE's regulations. The NSE will also be consulted through the life of the analysis.
Nova Scotia Utility And Review Board (NSUARB)	Halifax Water falls under the jurisdiction of the NSUARB and must comply with its policies. The strategy provided by the analysis will therefore comply with the NSUARB's policies.
Development Community	The proposed strategy will provide security and supply servicing to the 6 target growth areas.
Others	Stakeholders such as the Urban Development Institute and Consumer Advocate will have their concerns considered through on-going consultation.

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4 Background Review and Consultation

4.1 Documents, Policy and Regulation

The following sections provide a brief review of pertinent information relevant to the LoWSCA study. It is noted that the RWWFP completed a thorough review of similar information, including Federal, Provincial and Municipal policy. To avoid duplication the RWWFP technical memorandum information is provided in Appendix A.

4.1.1 Wastewater System Effluent Regulations (WSER)

The WSER are the federal level regulations that affect all wastewater systems. For Halifax Water's wastewater systems, these regulations are the primary externally enforced regulations that must be adhered to. They focus on monitoring and understanding the operation of key wastewater discharge facilities. The regulations were based on the former CCME guidelines. They focus on monitoring and understanding discharges to the environment. The regulations are not particularly relevant to local level infrastructure and are therefore have limited impact to the LoWSCA project.

4.1.2 Halifax Water's Rules and Regulations

Halifax Water's Schedule of Rates, Rules and Regulations for Water, Wastewater and Stormwater Services, May 1st 2015, ('The Regulations') are primarily focused on rates, billing, charges, metering and service provision. The full document is available on the Halifax Water website: http://www.halifax.ca/hrwc/_assets/documents/HRWCRegRDCSWConsolidated.pdf

Of relevance to this study there are three key points noted, as follows:

Section 40. relates to the capacity assessment of systems and the ability of HRWC to enforce a limit to discharges to those systems:

> *"40. In the event the Commission deems that the Wastewater and/or Stormwater Systems, or any portion thereof, have insufficient capacity to accept existing or proposed Wastewater and/or Stormwater flows, the Commission may require that the amount of flow which can be discharged into the Wastewater and/or Stormwater Systems be limited according to such terms and conditions as the Commission may approve."*

Section 61, (6a) relates to the ability of HRWC to require a development applicant to provide a hydraulic analysis of the existing and proposed development, including the related downstream systems:

> *"61.(6) (a) the applicant may be required to provide a hydraulic analysis of the proposed Wastewater and/or Stormwater generation and existing downstream system capacity to determine the suitability of the Service Connection for a proposed new use"*

Attachment 3 is HRWC's Capital Cost Contribution Policy. This charge structure has now been largely superseded by the Regional Development Charge. However, the policy contains useful information on approaches to allocate costs to growth and non-growth and how oversizing infrastructure costs can be allocated.

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4.1.3 *Halifax Water's Design and Construction Specifications, 2016*

This document, available on HRWC website (http://www.halifax.ca/hrwc/documents/2-2016DesignandConstructionSpecifications.pdf) outlines the design and construction requirement for water, wastewater and stormwater system. It was updated in April 2016 and reflects the changes recommended through the design criteria review completed as part of the WRWIP project. These same criteria were used in the modelling and capacity assessment of the future growth scenario for the LoWSCA. The key criteria, extracted from Section 5.2.1.3 Wastewater Hydraulic Design of the document, are as follows:

> The flow Q (l/s), in the wastewater sewer system used for pipe sizing shall be as follows:
>
> $Q = [1.25 \times (a \times M)] + b$ (for sizing gravity wastewater systems)
>
> $M = 1 + 14 / (4 + (p^{0.5}))$
>
> where:
>
> | | |
> |---|---|
> | 1.25 | is a safety factor. |
> | (a x M) + b | is the peak design flow. |
> | a x M | is the peak dry weather flow. |
> | a | identified here as the average dry weather flow. The allowance is 300 litres (0.30 m^3) per person per day for residential development |
> | M | is the peaking factor as derived from the Harmon Formula. The minimum permissible peaking factor shall be 2.0 |
> | b | is the future degradation of pipe long-term infiltration/inflow allowance. The allowable is 0.28 litres / gross hectare / second (24 m^3 per gross hectare/day). |
> | P | is the design population in thousands. |

4.1.4 *The Halifax Regional Municipality Charter*

The charter is "the primary legislation under which the municipality operates". It contains 20 parts, 3 of which have been deemed pertinent to the Analysis; PART XIV Sewers, PART VIII Planning and Development and PART IX Subdivision.

PART XIV of the Charter, entitled "Sewers", defines the legislative rights and obligations of the municipality with regards to its sewer system. It defines the policy for standards and specifications, the law regarding building service connection, the requirement for flow interceptors and the requirement to connect to the municipal sewer amongst other decrees. It also defines the By-law for wastewater management districts.

PART VIII of the Charter, entitled "Planning and Development", establishes the prerogative of the Municipality to plan within its jurisdiction. For example, it delineates the steps to be taken for the adoption

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of planning documents and the amendments of land-use by-laws. It clearly establishes the right of the Municipality to adopt municipal planning strategies (section 227).

PART IX, entitled “Subdivision”, allows for the establishment of infrastructure charges for new or expanded wastewater or stormwater facilities.

4.1.5 Halifax Wet Weather Flow Study, 2009

The Halifax Wet Weather Flow Study was completed by CBCL Limited in 2009. The purpose was to provide a wastewater management plan for the sewer system which discharges to the Halifax WWTF.

The study sought to identify a means of managing overflows from the collection system and thereby mitigate the impact on the receiving environment. It determined which of the available CSO/SSO control techniques can be most effective. The Wet Weather Overflow Reduction Plan Recommendations included:

- Long-term plan (next 25 to 100 years);
    - Complete sewer separation in all sewersheds where combined sewers exist
    - Implement extraneous flow reduction measures
    - Provide separate storm systems, deep enough to accept foundation drainage from all buildings, in serviced areas where they do not currently exist including areas serviced by sanitary sewers only
    - Provide measures to reduce negative impacts on receiving waters from stormsewer discharges if they are found to impair the desired uses of the receiving waters
- In the short term (over the next 10 years) it is recommended that measures are taken to improve the efficiency of the interceptor systems by regulating the quantities of flows from areas serviced by combined sewers into the interceptors and reduce overflowing from the interceptors

4.1.6 Regional Wastewater Functional Plan (RWWFP), 2012

The RWWFP identified a preferred wastewater servicing strategy for the entire region. The study provided a feasible, project level costed strategy that would allow the system to service the projected population increase to a 2043 planning horizon. The strategy focused only on regional infrastructure and did not assess local pipe level assets. The RWWFP team worked with the Integrated Resource Plan team to ensure consistency across the two studies.

4.1.7 Integrated Resource Plan (IRP), 2012

The IRP was completed in 2012. The purpose of the IRP was to combine all individual studies, such as the RWWFP and Water Master Plan, and identify Halifax Water’s capital and operational and maintenance costs for its water, wastewater and stormwater infrastructure and to determine its resource needs and costs for the period spanning 2012-2046. The IRP requirements were categorized into by three areas; Growth, Regulatory Compliance and Asset Renewal.

4.1.8 Regional Development Charge (RDC), 2014

The RDC used the outputs from the RWWFP and the IRP to create Halifax Water’s first RDC. Through the application, review and public hearing process several items were highlighted that would require ongoing assessment and would be subject to more detailed level analysis. The WRWIP and LoWSCA projects.

4.1.9 West Region Wastewater Infrastructure Plan (WRWIP), Ongoing

The West Region Wastewater Infrastructure Plan (WRWIP) aims to define the planning and policy basis and provide a plan for the infrastructure required to achieve the regional strategy. This study builds on a

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previously completed Master Plan study (The RWWFP) which identified a conceptual level preferred servicing strategy for Halifax Water's regional wastewater infrastructure.

The WRWIP study includes a revision of baseline assumptions, population projections, a long term planning and cost estimation framework as well as hydraulic model update, calibration and analyses. Moreover, the WRWIP will provide an analysis of future demands and capacity constraints along with the recommended infrastructure siting, alignments and designs. The WRWIP project also reviewed and recommended changes to HRWC's design criteria, which have since been updated in the Design and Construction Specifications, and formally defined the level of service that the wastewater system should provide, outlined in the Sewer System Evaluation Guidelines (SSEG), described below.

The WRWIP will also provide a detailed cost analyses for infrastructure projects in the form of a capital project analysis.

4.1.10 Sewer System Evaluation Guidelines (SSEG), 2016

The purpose of the Sewer Systems Evaluation Guidelines is to establish the appropriate capacity requirement for the combined sewer system. The guidelines define how to complete development application capacity evaluations for combined and sanitary sewers, which can be easily and consistently completed by developers or their consultants. The guidelines should also document the appropriate Level of Service for existing customers connected to the combined sewer system, as well as the acceptability of upsizing or separating existing combined sewers to support development growth serviced by the combined sewer system. The approach to capacity and level of service evaluation must consider the current hydraulic modelling tools available, taking into account that an all-pipe model is not currently available.

The SSEG also include guidance on the Level of Service that should be expected for HRWC's combined sewer system. As an initial, quick assessment of capacity it is suggested that a local combined sewer should be capable to pass forward six times Dry Weather Flow plus infiltration (6DWF+I). This approach is consistent with practice in the U.K. and also complements Halifax Water's capacity expectations for the trunk interceptor sewers, which convey 4DWF. This approach is only recommended as an initial assessment to provide decision support. It is expected that a full hydraulic analysis be completed using HRWC's hydraulic model. In this case the Level of Service expected of the combined sewer is to convey a 5 year design storm without causing flooding or surcharge.

It is expected that the guidelines will be incorporated into Halifax Water's Design and Construction Specifications.

4.1.11 Other Data and Information

Additional data and information requested and received included:

- Operational performance commentary for the wastewater systems within the Pockets, including any reported or known flooding issues. There are no known flooding issues within the pockets. However, downstream of Young Street, near to Young Street CSO there is a manhole that is known to experience significant surcharge and sometimes flooding.
- System configuration clarifications including the sewer configuration around Lyle Street in the Wyse Road pocket.
- Future planned works that may be relevant including the likely Little Albro lake separation project. This work is ongoing and the results and recommendations are unknown. When complete, it should be reviewed in line with the recommendations set out in this study.

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- Water meter data was received for the Kings Wharf area, located in Dartmouth, in order to determine the relative occupancy of the new buildings at the site. The data was reviewed to establish if a portion of the projected future population for this area was, in fact, already there and should therefore be removed from the projected population allocation. Based on the water meter data and consultation with HRM and HRWC it was agreed that occupancy rates were minimal and that no reduction to the planning population data was required.
- Unit cost for estimating cost of infrastructure projects was reviewed by the project team. In addition and cost of property connections for use in separation projects was identified.

4.2 Flow Monitoring and SCADA Data

SCADA data related to the overflows was received. Whist the LoWSCA study does not consider the impact on regional infrastructure the SCADA data was used to assist with the calibration of the hydraulic model.

Flow monitoring was completed in the fall of 2015. Flow monitor locations were selected based on the spatial areas and system configuration of the six target development area pockets. Each pocket had a minimum of two flow monitors located, with a total of 15 monitors installed. In addition, 21 flow monitors installed for the ongoing WRWIP Project were available and were utilized. Figure 1 in Appendix B shows the location of the flow monitors, differentiated between their primary installation driver, the LoWSCA or WRWIP project.

The flow monitor data was reviewed weekly to ensure quality. The data was analyzed to identify the per capita, dry and wet weather flows, which was used to calibrate the hydraulic model. Appendix B includes a technical memo that provides a summary of the flow survey that was completed as part of the West Region Wastewater Infrastructure Plan (WRWIP) and the Local Wastewater Servicing Capacity Analysis (LoWSCA) projects. A summary of the flow monitors and their specifications, in addition to a map of their locations, is provided.

The memo also outlines the analysis methodology and presents the analysis results, which was completed using the Wastewater Inflow and Infiltration Flow Analysis Tool (WiiFAT). The WiiFAT was used to import flow monitoring and precipitation data, collected from October to November 2015, and complete a full suite of analyses that was then input into the hydraulic model and used to assist with model calibration.

4.3 Low Impact Design (LID)

At present there is no regulations in HRM in relation to implementation of LID's. A thorough review of LIDs has been completed to provide insight into the feasibility of such solutions and to better understand how regulation can be used to ensure appropriate implementation and ensure ongoing adequate maintenance.



Public side LID solutions are generally supported by HRWC and HRM. An example of this is the new public library in Halifax (right) which features a green roof to retain stormwater and prevent it entering the sewer system. However, public owned opportunities are limited and many LID solutions require implementation on private lands and buildings. Private side maintenance of LID solutions is a major concern for Halifax Water as ongoing performance cannot be guaranteed. Future guidelines or regulation will need to address this concern and provide mechanism to enable the ongoing guarantee of performance. The best practice review, contained in Appendix C, provides

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information on such a framework that may help HRM and HRWC decide upon a suitable regulatory framework structure.

4.4 Existing Hydraulic Model

The existing PCSWMM hydraulic models were reviewed for use in this study. The models were separate networks for Halifax, Herring Cove, Mill Cove, BLT, Dartmouth and Burnside. The models were previously calibrated for use with the RWWFP. It was noted that at that time limited flow monitor data was available and the model was calibrated to achieve consistency with the discharge frequency of overflows, as recorded by SCADA information.

The existing models were skeletal consisting of only major trunk and large size sewers and facilities. As shown in Figure 2 below, the existing models did not adequately represent the wastewater system within or downstream of the pocket intensification areas. This was the same for the Dartmouth and Burnside models. Figure 2 also shows the flow monitor locations and in many cases the pipe that had the flow monitor installed was not represented in the model.

Detailed description of the updates to the new hydraulic model are provided in Section 6.

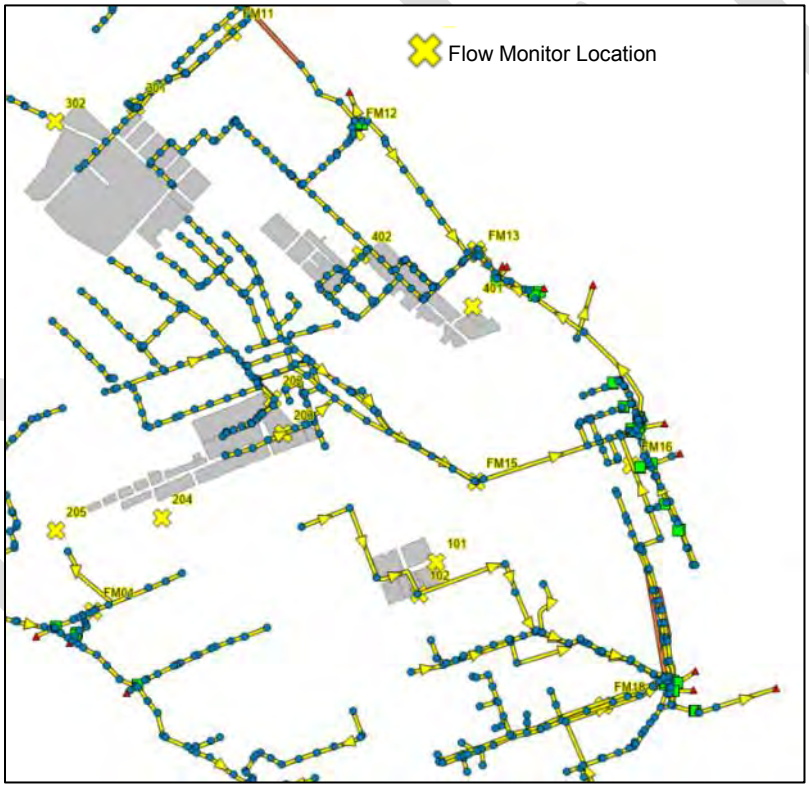


Figure 2: Existing Halifax Hydraulic Model Network

4.5 Background Review Summary

The review of background information included previous studies and reports, policy, regulations, design criteria, best practices and HRWC's existing hydraulic model. It is noted that the ongoing WRWIP project has defined, documented and recommended updates to HRWC's design criteria and Level of Service definition. This information is very relevant to this study and can be summarized as follows:

Design Criteria:

- Per capita sanitary flow 300 L/cap/d. peaked using Harmon formula. 1.25 safety factor applied.
- I/I allowance 0.28 L/s/ha for greenfield or suburban development. No allowance applied to intensification development

Level of Service:

- The combined and sanitary sewers will convey a 1in5 year design event without causing flooding or excessive surcharging.

Regulations:

Other relevant issues were reviewed and considered, but none were considered to be significant impacts to the project. Discussion with the project steering team and discussion and information from Nova Scotia environment confirmed that there are no pending or anticipated new regulations or policies that will affect the local sewer infrastructure.

Previous Reports:

No previous reports were of significant relevance for this project. Construction projects and previous capacity assessments that are directly relevant were reviewed and analyzed as part of the SSEG and were used to support the development of the evaluation guidelines and definition of the Level of Service.

LIDs:

LID features and installations are known to provide benefits when correctly applied. The review found many positive examples. However, greatest effectiveness appears to be when private development installations are incorporated and managed to ensure ongoing performance is maintained. This requires policy, and ideally, a legislative framework to be in place. It is recommended that HRWC and HRM review the best practice examples and begin defining a framework that will work best for the region and it's fairly unique administrative and utility organizational structure.

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5 Planning Data

5.1 Introduction

There were two methods adopted for allocation of population for the Halifax Model and Dartmouth Model. Although the WRWIP and the LoWSCA projects were mutually exclusive, they cover the same geographical area and share similar growth data and information. To be able to provide a growth model with comparable growth allocation for both the projects the following population allocation method was adopted.

The basic approach was to apply the more geographically focused LoWSCA growth to the six study areas (4 Halifax peninsula and 2 Dartmouth) and then amend the growth projections for the existing growth polygons used for the previous RWWFP and current WRWIP projects so that the total growth population allocated in the hydraulic models is equal to the new Traffic Survey Zone (TSZ) populations provided by HRM. The project team agreed this approach represents the most accurate growth scenario with focus on intensification in the six pockets. All growth was added to the model, including the non-peninsula growth in order to best represent the impacts of growth and ensure consistency in solutions between the LoWSCA and WRWIP projects.

Planning data was provided by HRM and consisted of two key data sets:

- Region wide existing and future residential and employment estimates spatially allocated by Traffic Survey Zones (TSZ). The spatial extent of the TSZ's are shown on Figure 1, above.
- Intensification (Pocket) area existing and future residential and employment estimates spatially allocated by property parcel, an example of which is shown on Figure 3, below.

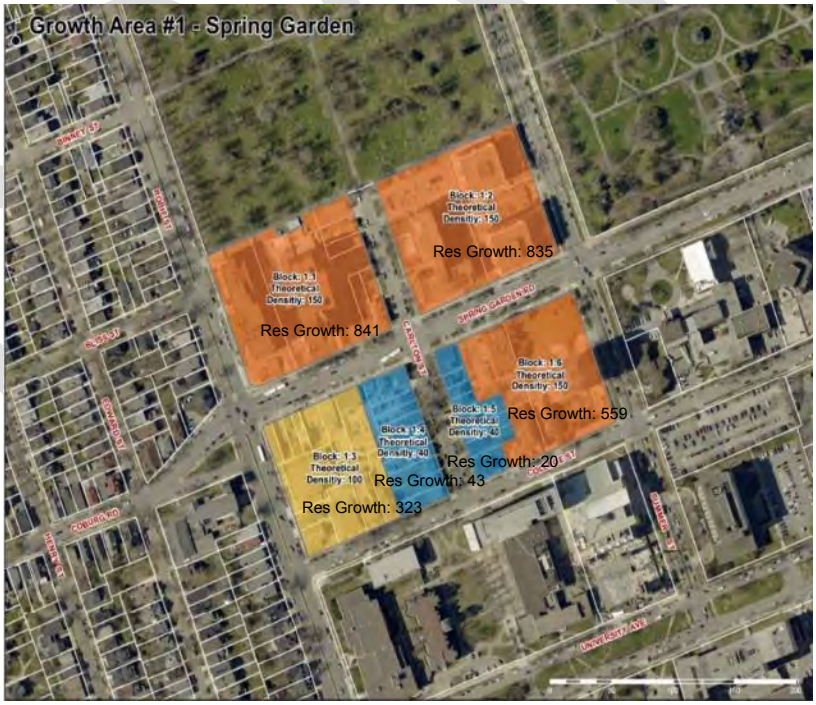


Figure 3: Example of projected growth allocation by parcel for intensification areas

5.2 Population Equivalent

HRM's projected growth, spatially allocated to Traffic Survey Zones (TSZ), was provided with residential population and employee numbers for every five year period. As a first step for this study the allocation of these two values were added to provide a Population Equivalent (PE) number. This PE value was used for both the allocation methods. For modelling purposes the residential and employment shares the same per capita flow allocation (300l/c/d). TSZ's that had populations year 2011 less than year 2046 were considered to have growth. The TSZs with negative growth were ignored during the allocation process.

An approach to allocate the population projections to the hydraulic models was agreed with the project team. Full details of the approach are included in Appendix D.

5.3 Population Allocation Summary Table

Table 1, below, show the TSZ growth and the LoWSCA growth for Halfax and Dartmouth.

Table 1: Halifax and Dartmouth Population Growth

Area	Total TSZ Growth	LoWSCA allocation of TSZ
Halifax Peninsula Growth	36,639	26,184
Halifax Non-Peninsula	59,820	0
Halifax Total Growth	*96,459*	*0*
Dartmouth Peninsula Growth-LoWSCA	3043	11,512
Dartmouth Non-Peninsula	40,172	0
Dartmouth Total Growth	*43,215*	*0*
TOTAL (Halifax & Dartmouth)	139,674	37,696

A summary of the 37,696 LoWSCA pocket growth is provided in Table 2 below. The table shows the areas of the blocks, the target unit density and the associated units and populations. Detailed breakdown of the pockets, parcel by parcel is provided in Section 7.

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Table 2: Intensification Pocket Area Summary of Growth Projections

Area	Gross Area (Ha)	Gross Area (Acres)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per acre)	Target unit density (per hectare)	Total Future # of Units (Full Build Out)	PPU	Total Future Residential Population Build out	Total Future Employment Population Build out	Predicted Future Density (people per acre)	Net Residential Growth Population	Net Employment Growth Population	Net Residential and Employment Growth
Growth Area #1 - Spring Garden Rd.	4.95	12.24	385	657	105	1,556	1,285	1.95	3,005	377	230	2,620	(280)	2,340
Growth Area #2 - Quinpool Rd.	15.00	37.07	1,199	376	85	3,162	3,163	1.95	5,923	743	187	4,723	367	5,090
Growth Area #3 - Young St.	31.90	78.82	404	2,061	101	2,767	8,025	1.95	15,903	1,997	223	15,498	(63)	15,435
Growth Area #4 - Agricola St. & Gottingen St.	12.41	30.66	595	994	70	2,446	2,168	1.95	4,361	547	155	3,766	(446)	3,319
Growth Area #5 - Canal St.	7.80	19.26	132	183	74	914	1,425	1.95	3,244	407	162	3,112	224	3,336
Growth Area #6 - Wyse Rd.	20.76	64.74	646	318	71	3,706	4,623	1.95	8,120	1,019	156	7,474	701	8,176
TOTALS/Averages	92.82	242.79	3,363	4,592	84	14,554	20,691		40,560	5,094	185	37,196	502	37,696

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6 Model Development

In summary the following activities were completed to prepare and ultimately use the model to undertake the growth impact analysis:

1. The Halifax, Dartmouth and Burnside models were updated using HRWC GIS information
2. The updated model networks and facilities were reviewed with HRWC to ensure accuracy
3. The Halifax, BLT and Herring Cove models were combined into one model network to allow for all west region growth to be allocated within the same model
4. The Burnside and Dartmouth models were combined into one model as Wyse Road spanned across the two, previously separate, models.
5. The models were calibrated using the recorded flow monitor data. Three rainfall events were used, recorded between October and November 2015.
6. The calibrated models were verified by comparing the results of overflow events with SCADA observed data. Historic flooding locations was reviewed to validate the pipe performance.
7. The models were simulated and used to complete the existing system capacity analysis.
8. The models were loaded with the growth populations and simulated to complete the future system capacity analysis.
9. The models were used to assess solutions and identify flow rates to understand requirement for flow separation and LID implementation.

6.1 Addition and Update of Local Infrastructure

The existing models were built out using HRWC GIS information to include all local pipes within and downstream of the intensification pockets. Figure 4 shows the existing Halifax model (left) in comparison to the updated model with local infrastructure (right) which has all local pipes represented. The figure also shows the flow monitor locations.

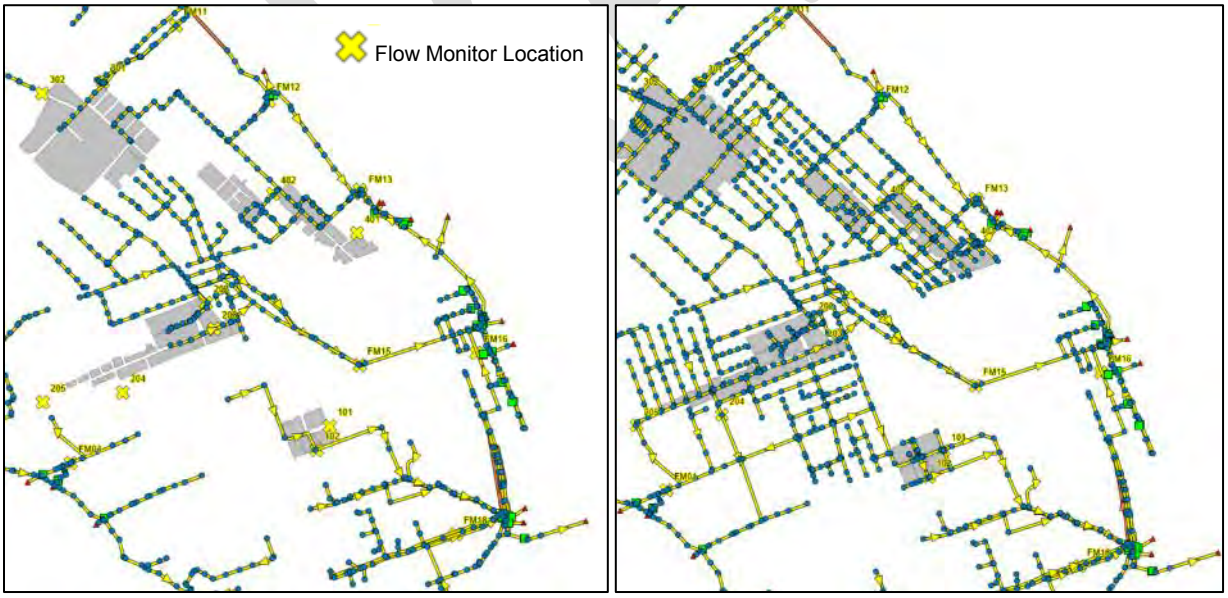


Figure 4: Existing and Updated Halifax Hydraulic Model

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6.2 Calibration of Hydraulic Models

The hydraulic models were calibrated with flow monitor data recorded during Fall 2015. Three rainfall events were used to calibrate the model:

Critical Event ID	Start of Event	End of Event	Peak 1-hr (mm)	Total Depth (mm)	Return Period (years)
CE-1	10/13/2015 9:55	10/13/2015 14:55	21	30	1.9
CE-2	10/29/2015 7:30	10/29/2015 18:55	10	49	0.9
CE-4	11/21/2015 6:55	11/23/2015 1:00	13	93	0.9

The largest event (CE-1) had an equivalent return period of approximately 1in2 years, which is considered very good for calibration purposes. It was a short, intense event. The other two events comfortably met best practice criteria for use as calibration events. Event CE-4 was a prolonged event spanning two days. It was not very intense but did deliver a significant volume of rainfall. The variation of the events, short and prolonged, provide a good test for the hydraulic model to respond to various event types.

In general the calibrated model produced a good fit with the observed data. The location of the flow monitors used and the wet weather calibration graphs are provided in Appendix E. The analysis and data QA/QC of the flow monitor data is provided in Appendix B.

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6.3 Growth Population Loading of Hydraulic Model

In order to apply the growth to the hydraulic model 'dummy' growth nodes were added to the model and named based on the growth area and block number. Each block where growth was identified has an associated node in the model, as shown on the Spring Garden example in Figure 5 below.



Figure 5: Spring Garden Growth Nodes in the Hydraulic Model

The node was loaded based on the agreed design criteria. Within the model a diurnal profile was used to peak the average dry weather flow loading. A summary of the approach is provided below and Figure 6 shows the approach graphically.

- 300 L/cap/d used and applied with a consistent, generic diurnal profile that has a peaking factor of three (see top right of Figure 6).
- 0.20l/s/ha as inflow (applied using a unit hydrograph, see top and bottom right of Figure 6)
- 0.08l/s/ha as infiltration (applied as constant rate, see bottom left of Figure 6)
- No I/I allowance applied for intensification growth.

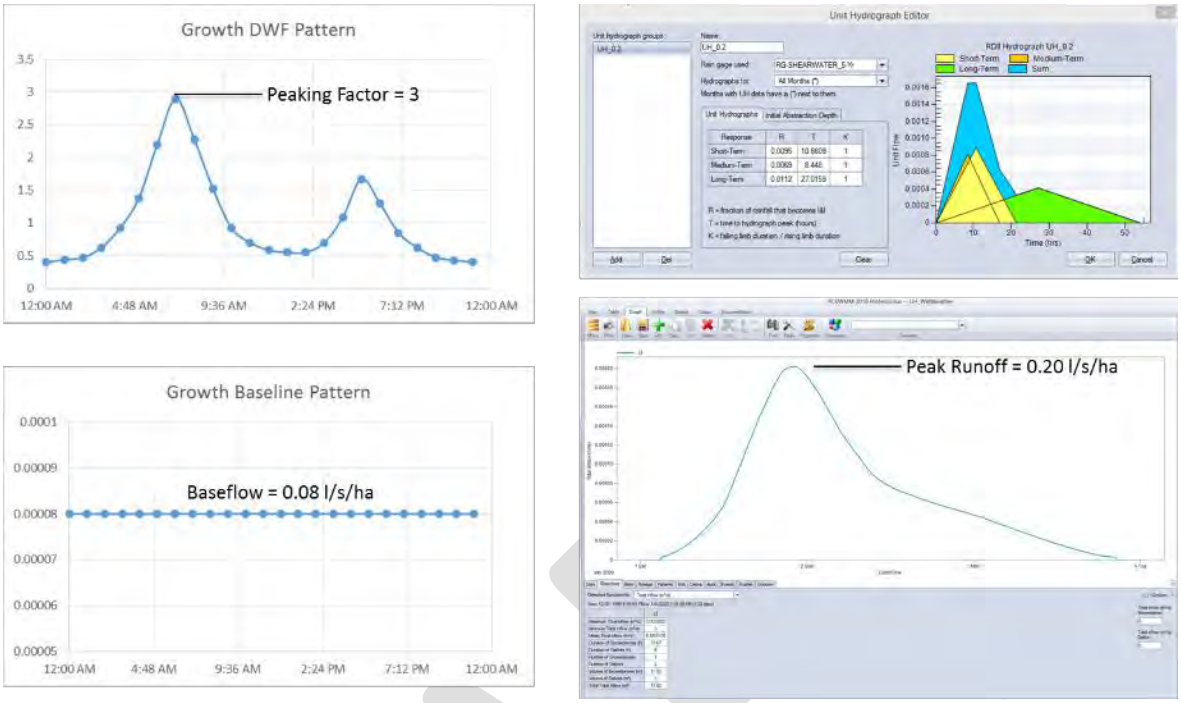


Figure 6: Graphical Illustration of Growth Application in the Hydraulic Model

6.4 Free Discharges

The scope of the LoWSCA project relates only to local infrastructure. To model the impact of growth on the local infrastructure the model analysis stops at the point of connection to Regional trunk sewer or facility. To ensure that the Regional infrastructure is not the cause of constraints in the local system the model was modified to disconnect the local infrastructure from Regional, as shown in the example below, Figure 7.



Figure 7: Example of 'Dummy' Outfall to Separate Local from Regional Infrastrucure Impacts

7 Capacity Analysis and Servicing Options

7.1 Growth Area Analysis Packages

The growth area memos are provided as individual, standalone packages. Within each memo is a description of the area as it is today, the proposed growth numbers and type of proposed development, an existing and future capacity analysis with trigger points, an evaluation of alternatives with costing, and recommendations.

7.2 Capacity Analysis

The capacity analysis was completed for each separated pocket, however taking into consideration any that are upstream and the impacts of their servicing alternatives. The local network assessed includes all infrastructure from the pocket to the nearest Regional infrastructure. This analysis was be completed using a 1-in-5 year design storm, in-line with the Sewer System Evaluation Guidelines. Constraints were identified using q/Q > 1, and each was properly assessed to eliminate those that were a result of modelling noise, such as subcatchment loading or a flat pipe that does not actually cause surcharge. The model was also set up with free outfalls at the Regional infrastructure to ensure that any surcharging within the local system is not a result of undersized pumping stations or other regional infrastructure.

The capacity analysis was completed for existing and future scenarios to determine whether or not upgrades were triggered by growth.

7.3 Evaluation of Alternatives

Multiple alternatives were evaluated to resolve the constraints that were identified in the capacity analysis as follows:

Upsizing of combined sewers with consideration for:

- Different alignments
- Options for twinning
- Diversion

Upsizing existing sewers may be the most cost effective alternative if it is a small segment that is creating a bottle neck. Although it resolves upstream constraints, it may trigger more upsizing downstream as more flows are conveyed; this includes high peak discharges and greater discharge volume at CSOs.

Sewer separation was considered and evaluated for each growth pocket. It was assumed that a new storm sewer system would be constructed and the existing combined would be converted into a sanitary sewer system, which can also act as a relief in some areas as required. This also allows for a multiple phase approach by separating roads and parking lots, then disconnecting properties. There is also less risk with missing a property disconnection.

Multiple scenarios were considered for each pocket:

- Minimum separation to resolve constraints
    - Partial (roads)
    - Full (roads + lots)
- Complete separation
    - Partial (roads)
    - Full (roads + lots)

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The proposed stormsewers were sized with future separation projects in mind. Once major trunk sewers are in place, it may become more feasible to separate areas further upstream and connect to the new stormsewer network.

The benefits of sewer separation include the removal of peak flow (L/s) and total volume (m^3) from the combined sewer system. These benefits were calculated for a 1-in-5 year design storm.

- Peak flow was calculated using the rational method with the following variables:
  - 90 mm/hr intensity
  - 0.7 coefficient for roads
  - 0.4 coefficient for lots
- Total volume was calculated using:
  - 89.8 mm total depth in 24 hours (1-in-5 year storm from Shearwater IDF)
  - 100% of road area
  - 40% of lot area

Opportunities for **non-infrastructure solutions** were also considered, such as attenuation through low impact development and on-site storage.

The amount of flow reduction, to eliminate the need for sewer upgrades, was assessed to determine the effectiveness of sewer separation and non-infrastructure solutions. The theoretical capacity of the constrained pipes was calculated in addition to the flows that would be conveyed had the sewers been upgraded. These flows were compared against the estimated benefits of other alternatives.

7.4 Costing

Costing was completed using a costing template and adheres to Halifax Waters Cost Estimation Framework. Unit rates were supported by historic, local, rate review and agreed by Halifax Water staff.

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8 Quinpool Road, Halifax: Capacity Analysis and Solution Development

Figure 8, below shows the location of the target development area. In total, six property parcels or blocks are identified that correspond to the descriptions in Table 3.

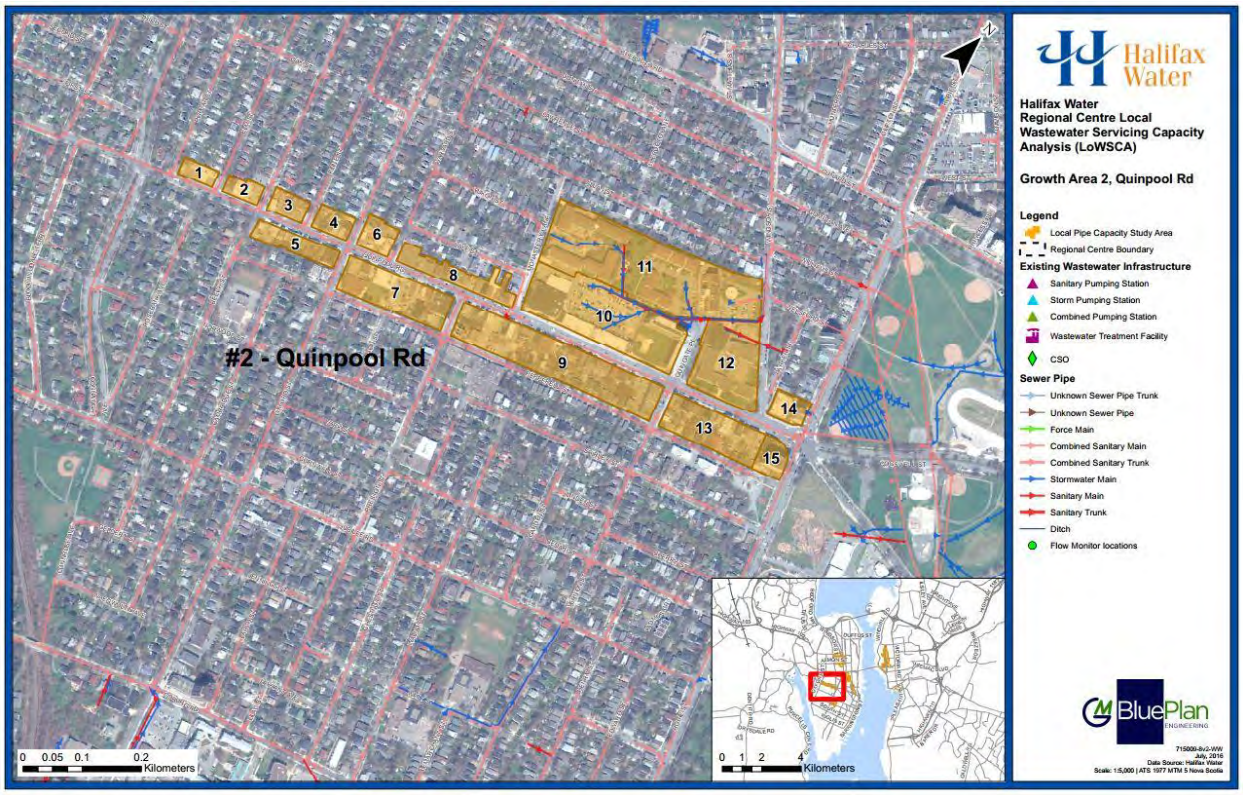


Figure 8: Quinpool Road Development Area

8.1 Quinpool Road Growth and Area Description

Quinpool Road is a mixed use road that is a key traffic through route. The area is predominantly two and three story buildings with commercial ground floor and residential above. There are several development sites, including a 3.5 acre old high school site. It is expected that the area will remain predominantly low/medium rise buildings but with increased density throughout. The East end, toward Robie St. would likely be the focus of the highest density developments. The surrounding area is relatively affluent, driving high land costs.

Table 3 below shows the growth projections, block by block, for the Quinpool Road area.

Table 3: Quinpool Road Block by Block Growth Projections

Area	Block #	Existing Use	Gross Area (Ha)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per hectare)	Total Future # of Units (Build Out)	Net Residential Growth Population	Net Employment Growth Population
#2 Quinpool Rd.	1	Restaurants, professional services offices	0.18	10	5	99	18	25	(1)
	2	Restaurants, professional services offices	0.20	12	5	99	20	26	(0)
	3	Restaurants, professional services offices	0.25	16	6	99	25	33	(0)
	4	Restaurants, professional services offices	0.26	18	7	99	26	33	(1)
	5	Restaurants, movie theatre, professional services offices	0.45	20	10	99	45	67	1
	6	Gas station, restaurants	0.30	21	8	173	52	81	4
	7	Synagogue, church on Preston, institutional, banks, MacDonald's, National chain past Oxford.	1.15	16	27	173	200	373	22
	8	Gas station, restaurants, smaller on this side of the street.	0.63	43	17	173	109	170	10
	9		2.27	65	52	173	393	703	44
	10	Grocery store, mall, Canadian tire, residential - 4-6 storey	2.48	279	65	247	612	914	85
	11		3.76	425	98	124	464	481	16
	12	Grocery store, mall, Canadian tire, residential - 4-6 storey	1.43	161	37	371	531	873	92
	13	Tall buildings	1.05	60	24	247	260	447	40
	14	Tall buildings	0.28	39	7	494	137	228	26
	15	Tall buildings	0.30	17	7	494	147	269	29
		Total	**15.00**	**1,200**	**377**	**3,163**	**3,163**	**4,724**	**367**

8.2 Capacity Analysis

8.2.1 Existing Constraints

Having completed the existing conditions modelling it is evident that the current infrastructure Level of Service does not meet the 5-year design storm standard. The current level of service that is being provided to the existing customers corresponds to a 2-year design storm. There are existing constraints within the Quinpool catchment under 5-year design storm conditions, causing surcharge and flooding. These constraints must be resolved before development can occur, as outlined in the Sewer System Evaluation Guidelines.

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The red segments in Figure 9 highlight the sewers that are under capacity (q/Q > 1) within the Quinpool and Spring Garden catchments under a 1in5 years design event. This figure presents the sewer network for Spring Garden in addition to Quinpool because a portion of the Quinpool flows impact the capacity of the downstream network passing through Spring Garden.

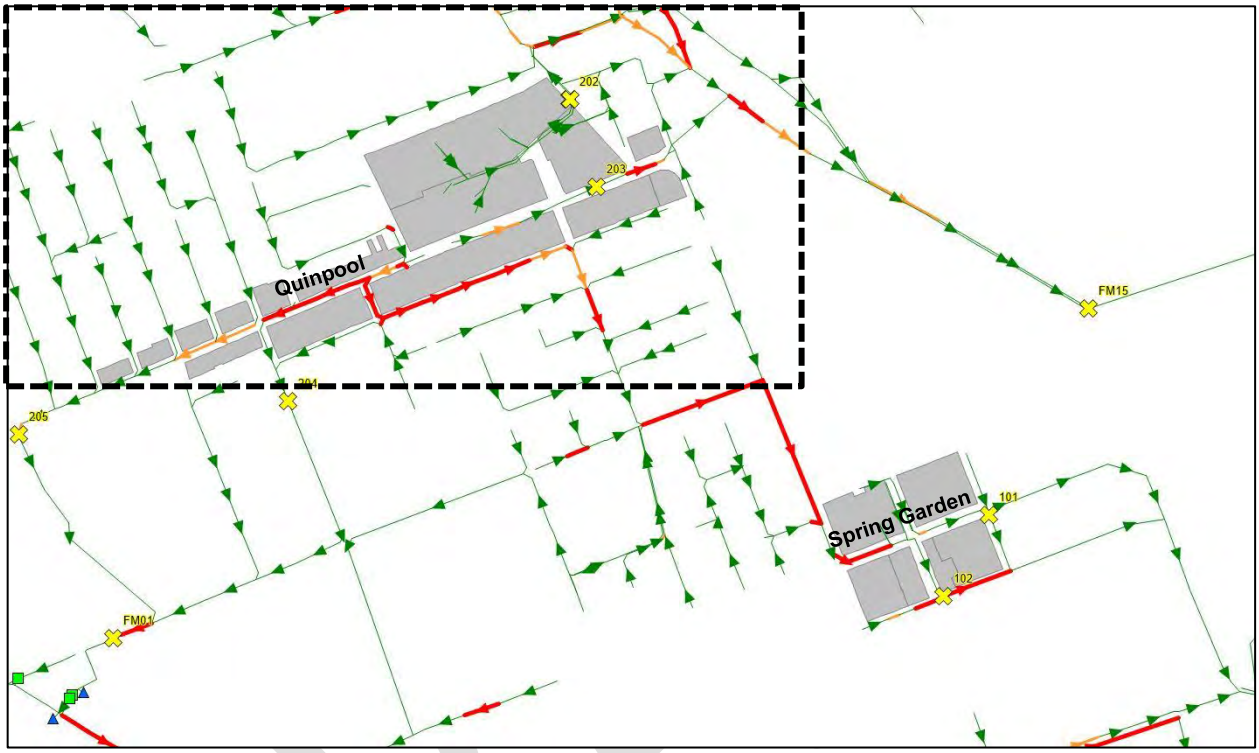


Figure 9: Quinpool Road and Spring Garden Existing Constraints (1in5yr)

Figure 10 focuses on the constraints within the Quinpool pocket. The area can be broken into three hydraulically separate sections that convey flow to different sections of the wastewater system, as shown on the figure.

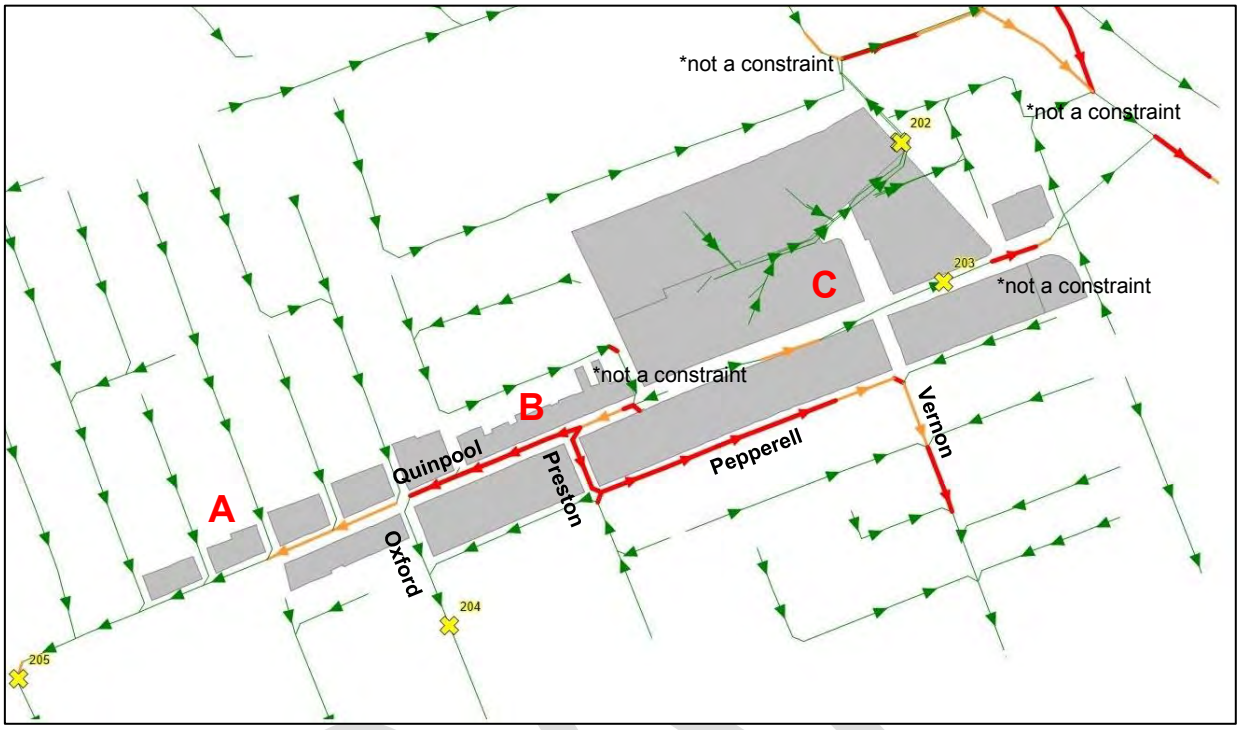


Figure 10: Quinpool Road Existing Constraints (1in5year)

As per Figure 10 there are existing constraints along Quinpool Rd., and the Preston-Pepperell-Vernon segment, under 5-year design storm conditions. To accommodate growth, either upsizing of the combined sewers or a reduction in flows is required.

8.2.2 *Impacts of Growth*

Following the completion of the growth impact modelling the impacts of growth were identified. The Quinpool area is split into 3 primary subcatchments, where 'A' flows to the left, 'B' flows down, and 'C' flows to the right. The proposed growth and their impacts on their respective sub-catchment are summarized as follows:

- Subcatchment 'A': small growth of 3 L/s does not trigger any constraints
- Subcatchment 'B': growth of 12 L/s causes surcharge and flooding to worsen, but does not trigger any new constraints
- Subcatchment 'C': growth of 49 L/s does not trigger any constraints

8.2.3 *Trigger Points*

The following summarizes the trigger points for each subcatchment:

- Subcatchment 'A': has a theoretical trigger point of 100 L/s (~ 5,700 people).
- Subcatchment 'B': predicted to surcharge and flood along Quinpool Rd. under a 5-year design storm therefore there is no trigger point.
- Subcatchment 'C': has a theoretical trigger point of 80 L/s (~ 4,600 people) along Quinpool, and 70 L/s (~ 4,000 people) within Blocks 10, 11, and 12.

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8.3 Evaluation of Alternatives

8.3.1 Alternative: Infrastructure Upgrades

Figure 11 and Figure 12 present the alignments for two alternatives that would provide sufficient capacity for future growth and resolve the system constraints as a standalone single solution, providing a level of service corresponding to a 1-in-5 year design storm. Alternative solutions were also explored, as outlined below.

8.3.1.1 Alternative 1 – Diverting Flow along Quinpool Rd.



Figure 11: Quinpool Road Infrastructure Upgrade Alternative 1

The proposed upgrades include approximately 210 meters of combined sewer; 525 mm diameter sewer along Quinpool Rd. from MH1876 to MH1985. This alternative requires that the invert of the Preston Rd. sewer at MH1876 be offset so that flows are diverted towards Oxford St.

8.3.1.2 Alternative 2 – Diverting Flow along Preston Rd.



Figure 12: Quinpool Road Infrastructure Upgrade Alternative 2

The proposed upgrades include approximately 620 meters of combined sewer; 525 mm diameter sewer along Preston-Pepperell-Vernon, from MH1876 to MH1907. This alternative requires that the invert of the Quinpool Rd. sewer at MH1876 be offset so that flows are diverted towards Preston Rd. This alternative would increase flows towards Spring Garden, which already has existing constraints (see Growth Area Memo for Spring Garden).

An assessment of the downstream sewers was completed for both alternatives.

- Alternative 1: Oxford St. has ~ 1000 L/s of available capacity, beginning at the 600 mm connection to Quinpool Rd.
- Alternative 2: Preston-Pepperell-Vernon has ~ 150 L/s of available capacity, until it connects to a 900 mm much further downstream.

After the assessment of the two alignments, diverting flows towards Oxford St. is the preferred sewer upsizing alternative.

8.3.2 Alternative: Opportunities for Removal of Flow

The theoretical capacities of the constrained sewers were calculated and compared against the modelled flows when upgrades are applied. The comparison suggests that a reduction of approximately 200 L/s is required to eliminate the need for sewer upgrades.

Upstream of the sewer constraints is a relatively small area and primarily residential. It would be unlikely that non-infrastructure solutions such as inflow and infiltration reduction, flow attenuation, or other low

impact development strategies would remove sufficient flow, which equates to approximately 40% of the existing flow.

8.3.3 Alternative: Sewer Separation

Two sewer separation scenarios were assessed; one representing the minimum amount of separation that would eliminate the need for sewer upgrades, and the other representing complete separation of the Quinpool pocket; Figure 13 and Figure 14 present the two alignments.

8.3.3.1 Minimum Sewer Separation (left)



Figure 13: Quinpool Road Minimum Sewer Separation

The minimum sewer separation alternative would include approximately 1,500 meters of stormwater sewer following Quinpool-Bloomingdale-Jubilee and discharge into the Northwest Arm. This alignment would require a new outfall, which would provide a reduction in CSO discharge, or connection to the regional infrastructure at the downstream CSO.

8.3.3.2 Complete Sewer Separation (right)



Figure 14: Quinpool Road Complete Sewer Separation

The complete sewer separation alternative would include an additional 2,500 meters of stormwater sewer that will follow primarily Bell Rd. and Sackville St. This alignment would also require a new outfall, or connection to the regional infrastructure at the Sackville CSO.

Table 4 summarizes the potential benefits of the two sewer separation scenarios in terms of peak flow and total volume removed from the combined sewer system during a 5-year design storm.

Table 4: Comparison of Sewer Separation Scenarioss

Separation Scenario	Peak Flow Removed (L/s)			Total Volume Removed (m^3)		
	Roads	Lots	Total	Roads	Lots	Total
Minimum (left)	397	448	845	2,061	1,220	3,281
Complete (right)	748	1,012	1,760	3,879	2,754	6,633

It should be noted that the peak flow is an estimate of peak runoff, and therefore is at the site level. This total peak flow removed will be less downstream due to time of concentration within the system, and therefore will not be the reduction in peak flows at the regional infrastructure.

The minimum sewer separation alternative (left) has the potential to remove an amount of flow large enough to eliminate the need for combined sewer upsizing (required flow reduction estimated at 200 L/s).

The additional separation of Quinpool (right) will not have any impact on the existing constraints, however would provide the opportunity to collect flows from all of the existing stormwater sewers that are currently connected to the combined system on Bell St, as well as future separation projects. If a new outfall were constructed, it would have a significant impact on the Sackville CSO. The trunk sewer upstream of the Sackville CSO currently conveys a peak flow of approximately 6,400 L/s, and a volume of 700,000 m^3 during a 1-in-5 year design storm.

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8.4 Alternative Cost Estimates

The follow Table 5 summarizes the costs associated with each alternative reviewed.

Table 5: Quinpool Road Alternative Cost Estimates

Scenario	Cost
Sewer Upgrades	0.37 M
Minimum Sewer Separation (left)	3.63 M
New Outfall	?
Complete Sewer Separation (right)	10.16 M
New Outfall	?

8.5 Recommendations and Preferred Option Cost Estimate

Based on the analysis undertaken and consideration of the alternatives our recommendations are as follows:

- Diverting flows along Quinpool Rd. is preferred over diverting them towards Spring Garden
- Minor sewer upgrades along Quinpool Rd. will resolve the existing constraints
- Opportunities for non-infrastructure solutions are minimal given the small size of the upstream catchment (mostly residential neighborhood)
- Minimum separation alternative removes sufficient flow to eliminate the need for sewer upgrades however is much more costly
- The preferred alternative is to upgrade
- The complete separation of the pocket, primarily the right half, would have significant impacts on the Sackville CSO.
    - This separation would allow for the collection of the sewers already separated along Bell St.
    - This would be a very costly project and would require a new outfall
    - It is recommended that a more detailed study be completed to assess the feasibility

Table 6, below, provides details and costs of the preferred option projects for Quinpool Road area.

Table 6: Quinpool Road Preferred Option Projects and Costs

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)
Quinpool	1	Q1	525 mm combined sewer upgrade along Quinpool Rd.	Halifax	Combined Sewer	525 mm	211	$365,000

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9 Spring Garden, Halifax: Capacity Analysis and Solution Development

Figure 15, below shows the location of the target development area. In total, six property parcels or blocks are identified that correspond the descriptions in Table 7.

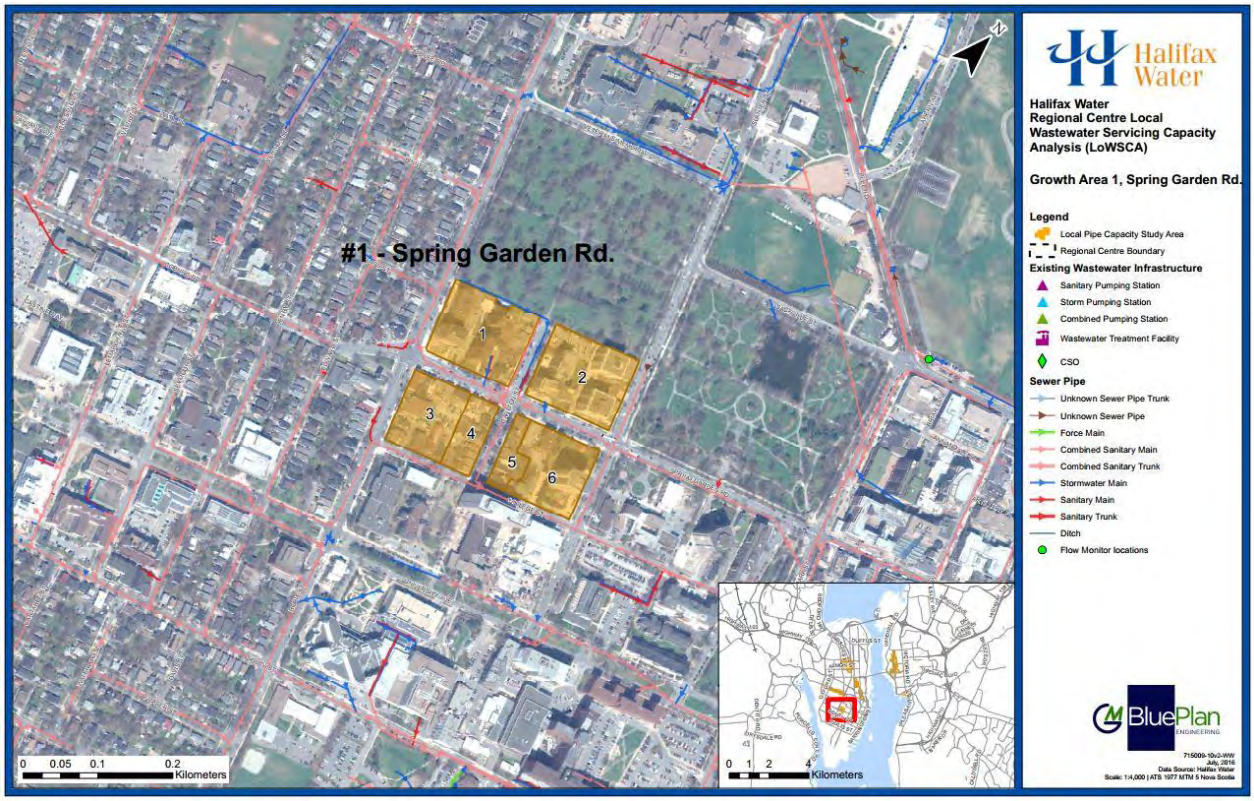


Figure 15: Spring Garden Development Area

9.1 Spring Garden Growth and Area Description

Spring Garden area is a currently developed area. Its location commands high land values. Block 1 and 2 currently feature an 18 and 12 story building, respectively. It is not expected to achieve a significantly higher population density although there is density potential for an additional c.2600 population. Blocks 3, 4, 5 and 6 are currently low rise and mainly residential with some ground floor commercial. The area is in close proximity to green space, adding to the desirability of the area. System knowledge in this area, prior to detailed hydraulic modelling capacity assessment, identified that this area may be nearing or at capacity and even modest increases in density would likely create issues.

Table 7 below shows the growth projections, block by block, for the Spring Garden area.

Table 7: Spring Garden Block by Block Growth Projections

Area	Block #	Existing Use	Gross Area (Ha)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per hectare)	Total Future # of Units (Build Out)	Net Residential Growth Population	Net Employment Growth Population
#1 Spring Garden Rd.	1	Some residential. Ground floor retail. Professional centre and residential. 18-storey building.	1.25	60	165	370.66	462	841	(52)
	2	Ground floor commercial, one side mostly residential. 12-storey building and other buildings. Few new buildings.	1.24	59	164	371	459	835	(52)
	3	Low rise building, commercial with some residential above ground level storey	0.83	76	109	247	204	323	(59)
	4	Mostly residential	0.42	39	56	99	42	43	(46)
	5	Mostly residential	0.29	35	39	99	28	20	(32)
	6	Mostly residential	0.93	116	124	371	346	559	(39)
		Total	**4.95**	**385**	**658**	**1,557**	**1,285**	**2,621**	**(280)**

9.2 Capacity Analysis

9.2.1 Existing Constraints

Having completed the existing conditions modelling it is evident that the current infrastructure Level of Service does not meet the 5-year design storm standard. The current level of service that is being provided to the existing customers corresponds to a 2-year design storm. There are existing constraints within the Spring Garden catchment under 5-year design storm conditions, causing surcharge and flooding. These constraints must be resolved before development can occur, as outlined in the Sewer System Evaluation Guidelines.

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The red pipe segments in Figure 16 highlight the sewers that are under capacity (q/Q > 1) within the Quinpool and Spring Garden catchments under a 5-year design storm. This figure presents the sewer network for Quinpool in addition to Spring Garden because a portion of these flows are conveyed through the same trunk and impact the available capacity within Spring Garden.

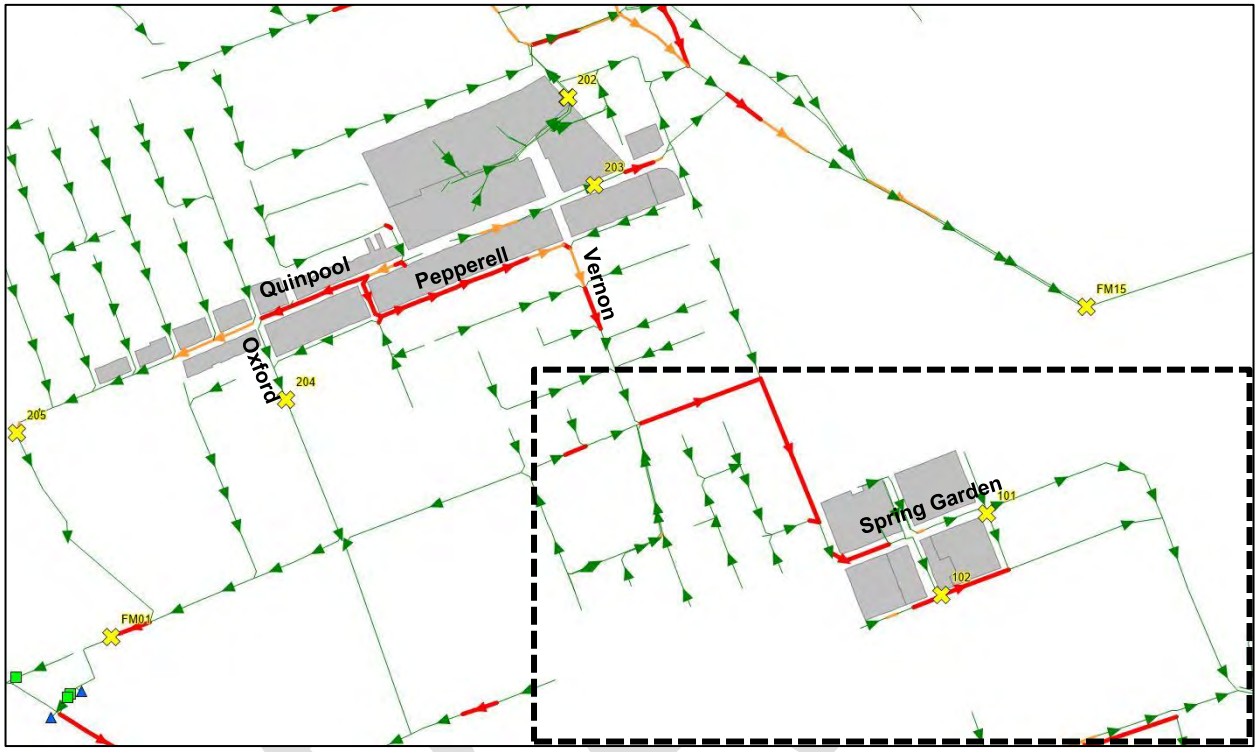


Figure 16: Spring Garden and Quinpool Existing Capacity Constraints (1in5yr)

As per Section 8 it should be noted that the preferred solution for the Quinpool area is to divert the flows along Quinpool Rd. towards the available capacity along Oxford St. (see the Growth Area Analysis for Quinpool, Section 8). Although this eliminates the constraints along Pepperell and Vernon, it does not resolve those along Jubilee, Robie, and within the Spring Garden pocket.

Figure 17 focuses on the constraints within the Spring Garden pocket.

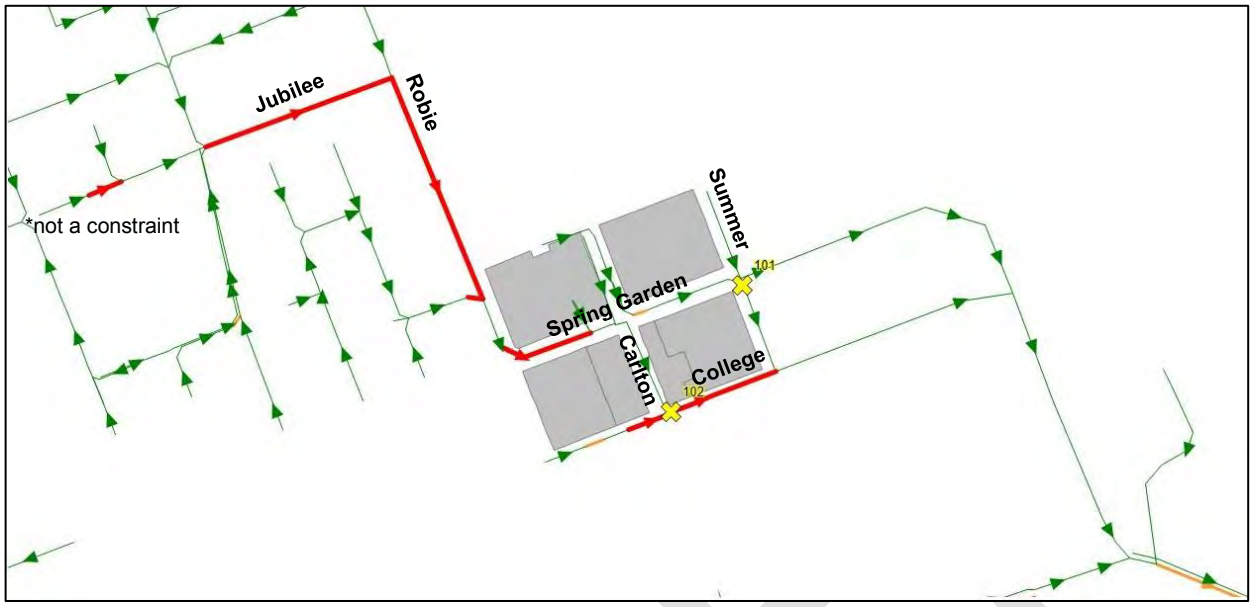


Figure 17: Spring Garden Existing Capacity Constraints (1in5yr)

There are existing constraints along the trunk network upstream, and through, Spring Garden under 5-year design storm conditions. To accommodate growth, upsizing of the combined sewers is required, however there may be opportunity to implement sewer separation, as there is an existing 1200 mm storm sewer downstream of the pocket along South Park St., north of South St. Sewer separation could potentially eliminate any existing constraints within the combined sewer system.

9.2.2 Impacts of Growth

Having completed the future conditions modelling the proposed growth within the Spring Garden blocks equates to approximately 30 L/s. These growth flows would cause further surcharging and flooding, however do not trigger any new constraints; they are marginal in comparison to the existing flows of up to 2,700 L/s (~ 1%).

9.2.3 Trigger Points

The existing system is already predicted to surcharge and flood along Spring Garden, Carlton, and College under a 5-year design storm. Therefore, blocks 1, 3, 4, and 5 do not have a trigger point. Block 2 however, can theoretically accommodate another 150 L/s (~ 8,500 people), as long the flows are connected to the Summer St. sewer.

9.3 Evaluation of Alternatives

The preferred alternative identified in the Growth Area Memo for Quinpool was considered while evaluating the alternatives for Spring Garden; divert flow along Quinpool Rd., reducing existing flow to Spring Garden by an estimated 100 L/s during a 1-in-5 year design storm.

The following section outlines the servicing alternatives for Spring Garden.

9.3.1 Alternative: Infrastructure Upgrades

Figure 18 presents the alignment for the proposed upgrades that would provide sufficient capacity for future growth and resolve the system constraints to provide a level of service corresponding to a 1-in-5 year design storm.

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Figure 18: Spring Garden Potential Sewer Upgrade Alignment

The proposed upgrades include approximately 1,000 meters of combined sewer; 900 mm diameter sewer upstream of Spring Garden from MH1615 to MH1593 (along Jubilee–Robie), and 1050 mm diameter sewer through Spring Garden from MH1593 to MH1375 (along Robie–Spring Garden–Carlton–College).

There is opportunity to twin the section along Robie and Spring Garden, which could provide additional benefits such as the opportunity for future sewer separation, smaller sewer upgrades (if there is no plan for future separation), and make the overall construction process more feasible by.

The upsizing of this segment will increase the conveyance to the Pier A CSO, and it is estimated that the peak flow, just upstream of the CSO, will increase from 6,500 L/s to 7,100 L/s under a 1-in-5 year design storm.

9.3.2 Alternative: Opportunities for Removal of Flow

The theoretical capacities of the constrained sewers were calculated and compared against the modelled flows when upgrades are applied. The comparison suggests that a reduction of approximately 1,000 L/s is required to eliminate the need for sewer upgrades.

Given the size of the upstream network, there could be opportunities to remove flows from the existing system using non-infrastructure solutions such as inflow and infiltration reduction. However, the magnitude of the required flow reduction is much too large for this to be considered a solution.

Flow attenuation through Low Impact Development is possible within the Spring Garden pocket as there is a lot of non-residential blocks suitable for storage and controlling runoff. Although attenuation is feasible and should be considered when developing within Spring Garden, it would have to remove between 90-100% of the stormwater runoff to effectively eliminate the need for sewer upgrades; for this reason it is not an effective solution on its own.

9.3.3 Alternative: Sewer Separation

There is a great opportunity for sewer separation by utilizing the existing 1,200 mm Ø stormwater sewer along South Park St., north of South St. Two scenarios were assessed; one representing the minimum amount of separation that would eliminate the need for sewer upgrades, and the other representing complete separation of the Spring Garden pocket; Figure 19 and Figure 20 present the two alignments.

9.3.3.1 Minimum Sewer Separation

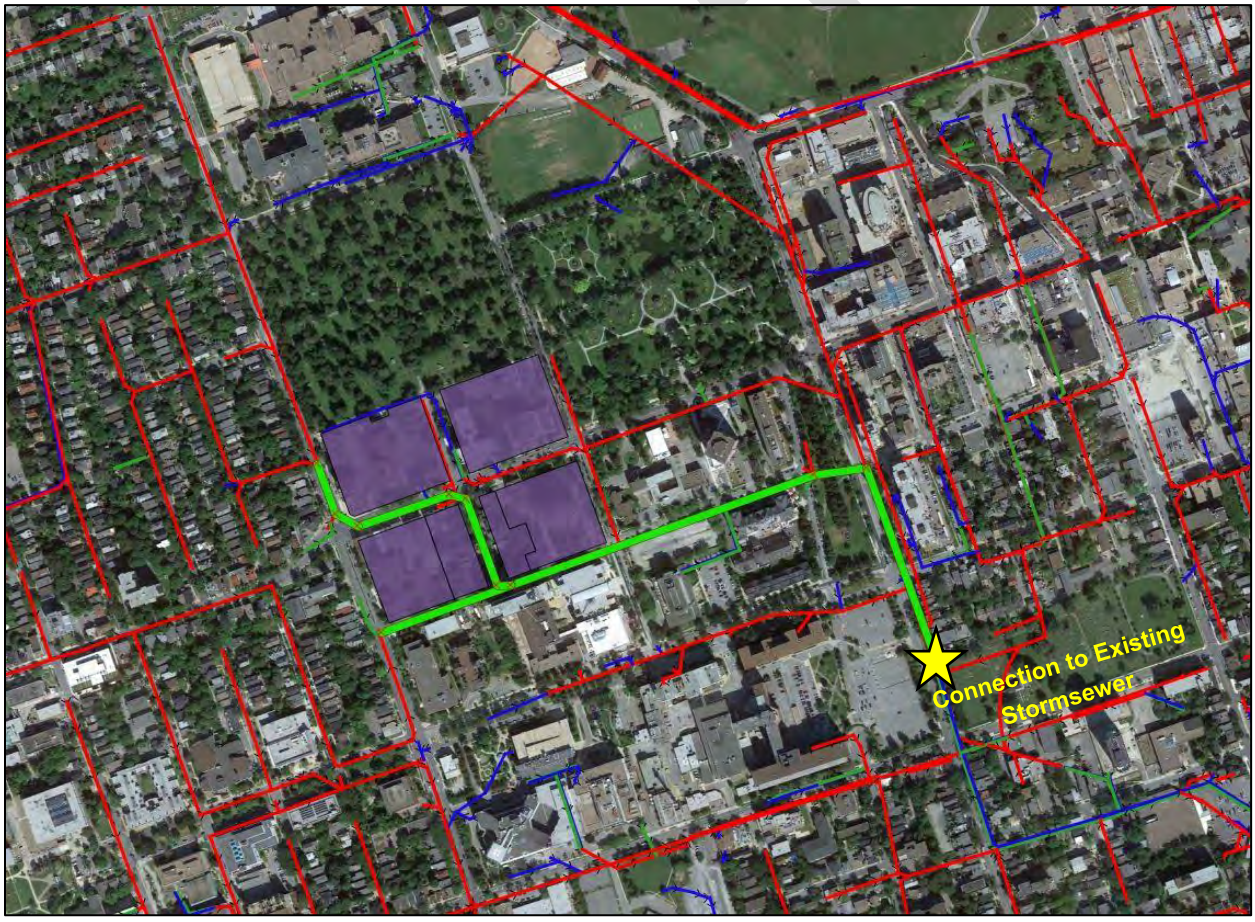


Figure 19: Spring Garden Minimum Sewer Separation Requirements

The minimum sewer separation alternative would include approximately 1,200 meters of stormwater sewer following Robie-Spring Garden-Carlton-College-South Park and connecting to the existing stormsewer on South Park St. north of South St.

9.3.3.2 Complete Sewer Separation

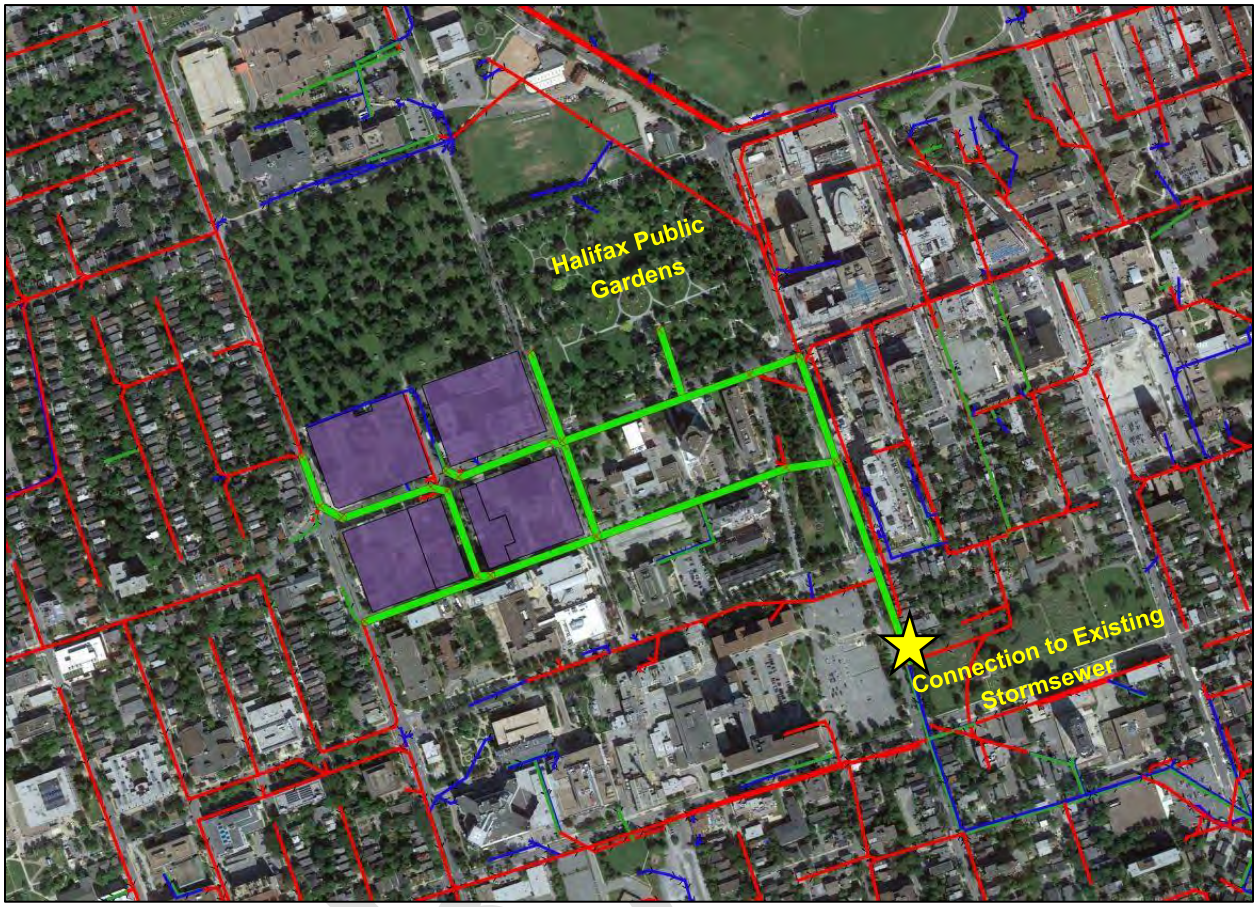


Figure 20: Spring Garden Complete Sewer Separation Requirements

The complete sewer separation alternative would include an additional 2,100 meters of stormwater sewer.

Table 8 summarizes the potential benefits of the two sewer separation scenarios in terms of peak flow and total volume removed from the combined sewer system during a 5-year design storm.

Table 8: Comparison of Sewer Separation Scenarios

Separation Scenario	Peak Flow Removed (L/s)			Total Volume Removed (m^3)		
	Roads	Lots	Total	Roads	Lots	Total
Minimum	238	872	**1,110**	1,233	2,376	3,609
Complete	444	1,190	1,634	2,304	3,240	5,544

It should be noted that the peak flow is an estimate of peak runoff, and therefore is at the site level. This total peak flow removed will be less downstream due to time of concentration within the system. However, it is a relatively short segment that is being assessed so it is still a conservative estimate.

The minimum sewer separation alternative has the potential to remove an amount of flow large enough to eliminate the need for combined sewer upsizing (required flow reduction estimated at 1,000 L/s). Separation of the remaining components of the pocket would have a marginal impact on the existing capacity

constraints since the majority are downstream. However, complete separation of the pocket provides opportunity to separate the Halifax Public Gardens. Although it is not part of the Spring Garden pocket, separating further upstream along Robie, up to Jubilee, should be considered, as it would significantly increase the opportunity to remove flows from the existing combined sewers within Spring Garden.

The existing stormwater network is connected to a major combined trunk sewer, which discharges to the Pier A CSO. Separation of Spring Garden could have a significant impact on the Pier A CSO, which currently discharges at 6,900 L/s and a volume of 600,000 m^3 during a 1-in-5 year design storm. However, a new outfall would be required to disconnect the storm network from Pier A, which could be very costly as it would likely require tunnelling under the railway tracks. This would require further analysis to determine the additional costs of a new outfall.

9.4 Alternative Cost Estimates

The follow Table 9 summarizes the costs associated with each alternative reviewed.

Table 9: Spring Garden Alternative Cost Estimates

Scenario	Cost
Sewer Upgrades	3.43 M
Minimum Sewer Separation	4.02 M
Complete Sewer Separation	5.90 M
New Outfall	?

9.5 Recommendations and Preferred Option Cost Estimate

Based on the analysis undertaken and consideration of the alternatives our recommendations are as follows:

- Sewer upgrades of the major trunk through Spring Garden are required
    - Opportunities for twinning along Robie and Spring Garden
    - Increases flow to the Pier A CSO
- There are opportunities for implementation of non-infrastructure solutions such as I/I reduction (large upstream catchment), and LID through storage (type of land use within the spring garden pocket) however it would be unlikely that these solutions would remove sufficient flow to eliminate the need for sewer upgrades
- Separation provides a wider range of benefits including opportunity for future separation projects of upstream networks, removal of flow from combined sewer system, and potential to reduce discharge at the Pier A CSO (with the construction of a new outfall)
    - The minimum sewer separation scenarios has the potential to remove sufficient flows from the combined sewer system eliminating the need for sewer upgrades.
    - Complete sewer separation allows for the disconnection of the Halifax Public Gardens
- Costs are similar between the sewer upgrades and the minimum sewer separation
- The minimum sewer separation scenario is the preferred alternative
- It is recommended that the separation be sized with future connections in mind

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- It is also recommended that further separation be considered, such as the Public Gardens and along Robie, as this will only increase the level of service

It is also recommended that further studies be conducted on the opportunities for a new outfall (currently would have to tunnel under the rail tracks)

Table 10, below, provides details and costs of the preferred option projects for Spring Garden Road area.

Table 10: Spring Garden Road Preferred Option Projects and Costs

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)
Spring Garden	2	SG1	New 450 mm storm sewer along College St.	Halifax	Storm Sewer	450 mm	159	$258,000
Spring Garden	3	SG2	New 900 mm storm sewer along Robie-Spring Garden-Carlton-College	Halifax	Storm Sewer	900 mm	780	$2,403,000
Spring Garden	4	SG3	New 1200 mm storm sewer along South Park St. connecting into existing 1200 mm storm sewer	Halifax	Storm Sewer	1200 mm	252	$1,083,000
							TOTAL	**$3,744,000**

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10 Young Street, Halifax: Capacity Analysis and Solution Development

Figure 31, below shows the location of the target development area. In total, six property parcels or blocks are identified that correspond the descriptions in Table 11.

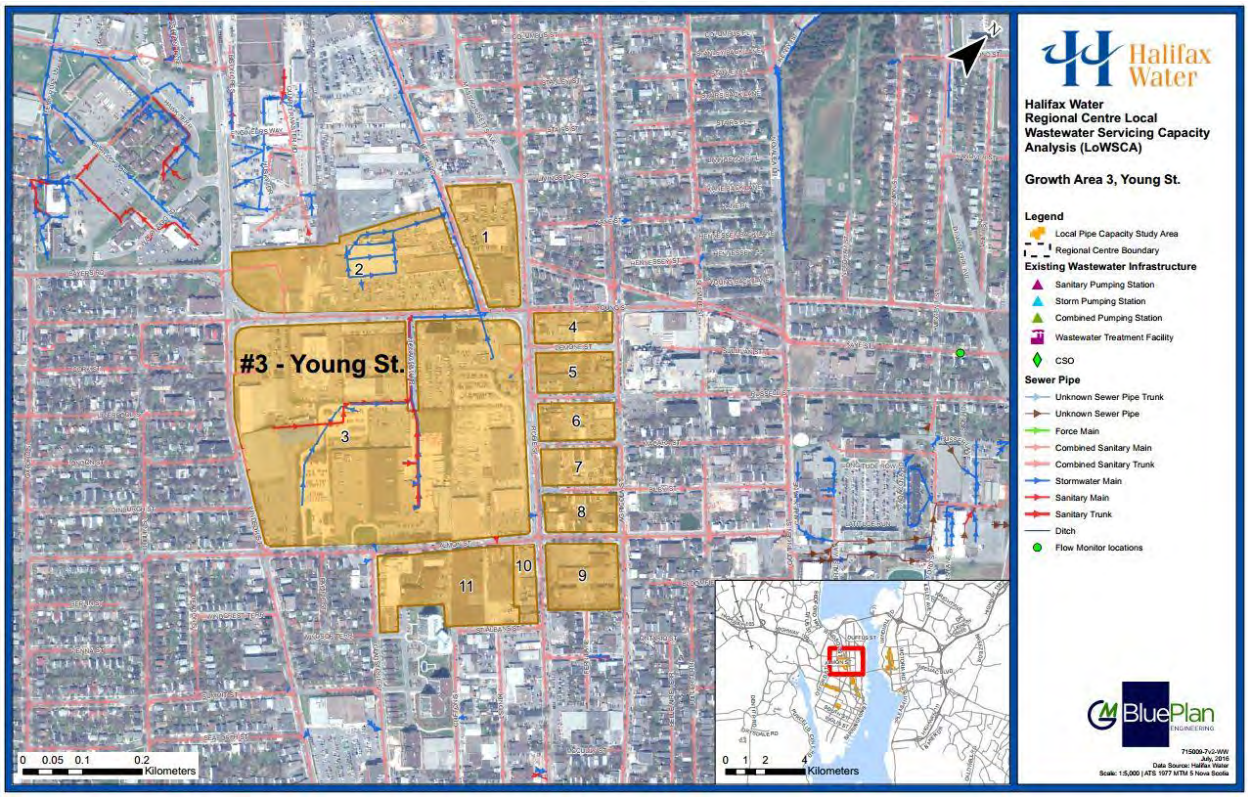


Figure 21: Young Street Development Area

10.1 Young Street Growth and Area Description

The Young Street area represents the largest potential growth of all the six pockets. The existing area is fully developed and features three large land owners that could create significant redevelopment potential. The Canada Post sorting facility, the HRM arena and Eastlink lands represent the majority of the defined spatial area. There are existing development applications for this area including an 18 story building and two 14 story buildings. It is thought that this area, due to the large parcels, has good potential for stormwater management solutions. Transportation links in the area have been subject to discussion and the widening of Bear Road had been tabled.

Table 11 below shows the growth projections, block by block, for the Young Street area.

Table 11: Young Street Block by Block Growth Projections

Area	Block #	Existing Use	Gross Area (Ha)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per hectare)	Total Future # of Units (Build Out)	Net Residential Growth Population	Net Employment Growth Population
#3 Young St.	1		1.75	-	16	247.11	431.80	842.00	90.15
	2		4.80	12	44	247.11	1,186.88	2,301.92	246.98
	3	Canada post, the Form Arena. East side is under developed from a planning perspective.	17.13	-	1,498	247.11	4,233.70	8,255.71	(461.55)
	4		0.65	12	56	172.97	111.84	205.60	(28.80)
	5	Application submitted for High-rise building - one is currently being built	0.85	14	74	247.11	209.49	394.97	(22.58)
	6	Application submitted for High-rise building	0.79	-	69	247.11	194.64	379.55	(21.01)
	7		0.76	27	67	247.11	188.28	340.10	(20.48)
	8		0.75	14	66	247.11	186.38	349.91	(19.91)
	9		1.34	28	117	247.11	330.00	615.40	(35.72)
	10		0.47	46	8	247.11	116.94	182.25	20.32
	11		2.61	252	48	370.66	965.83	1,631.53	188.68
		Total	**31.90**	**405**	**2,061**	**2,767.58**	**8,025.06**	**15,498.95**	**(63.93)**

10.2 Capacity Analysis

The Young Street blocks are subdivided into two areas based on their downstream network: A (~ 41 L/s) and B (~ 153 L/s), as shown on Figure 22.

- A includes Blocks 1-6
- B includes Blocks 7-11

10.2.1 Existing Constraints

Having completed the existing conditions modelling it is evident that the current infrastructure Level of Service does not meet the 5-year design storm standard. The current level of service that is being provided to the existing customers within these blocks corresponds to a 2-year design storm. There are existing constraints under 5-year design storm conditions, causing surcharge and flooding. These constraints must be resolved before development can occur, as outlined in the Sewer System Evaluation Guidelines.

The red pipe segments in Figure 22 highlight the sewers that are considered to be under capacity (q/Q > 1) within the Young St. catchments under a 1in5 year design storm. After a review of each of the red segment, those that were not considered an actual constraint are marked with an 'N'. The area upstream of the Almon and Gottingen intersection was not assessed as it is not part of the growth area.

The existing constraints include:

- Stormwater segment along Kempt

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- Multiple sewers within the Almon and Robie area
- Gottingen segment from Almon to North
- There is also known flooding to occur at a manhole along Kaye just upstream of the Young St. CSO.

There is confidence with the assessment of capacity within area 'B', as flow monitors 301 and 302 provide insight to existing flows along Kempt and Young. However, there were no flow monitors within area 'A', the closest being FM-12, which was located just upstream of the North St. CSO. Although this monitor was well calibrated, the upstream catchment is very large and the precise origin of the flow is unclear. In addition, a portion of the flows at the North and Gottingen flow split are conveyed towards Agricola & Gottingen; the precise characteristics of the flow split are unknown.

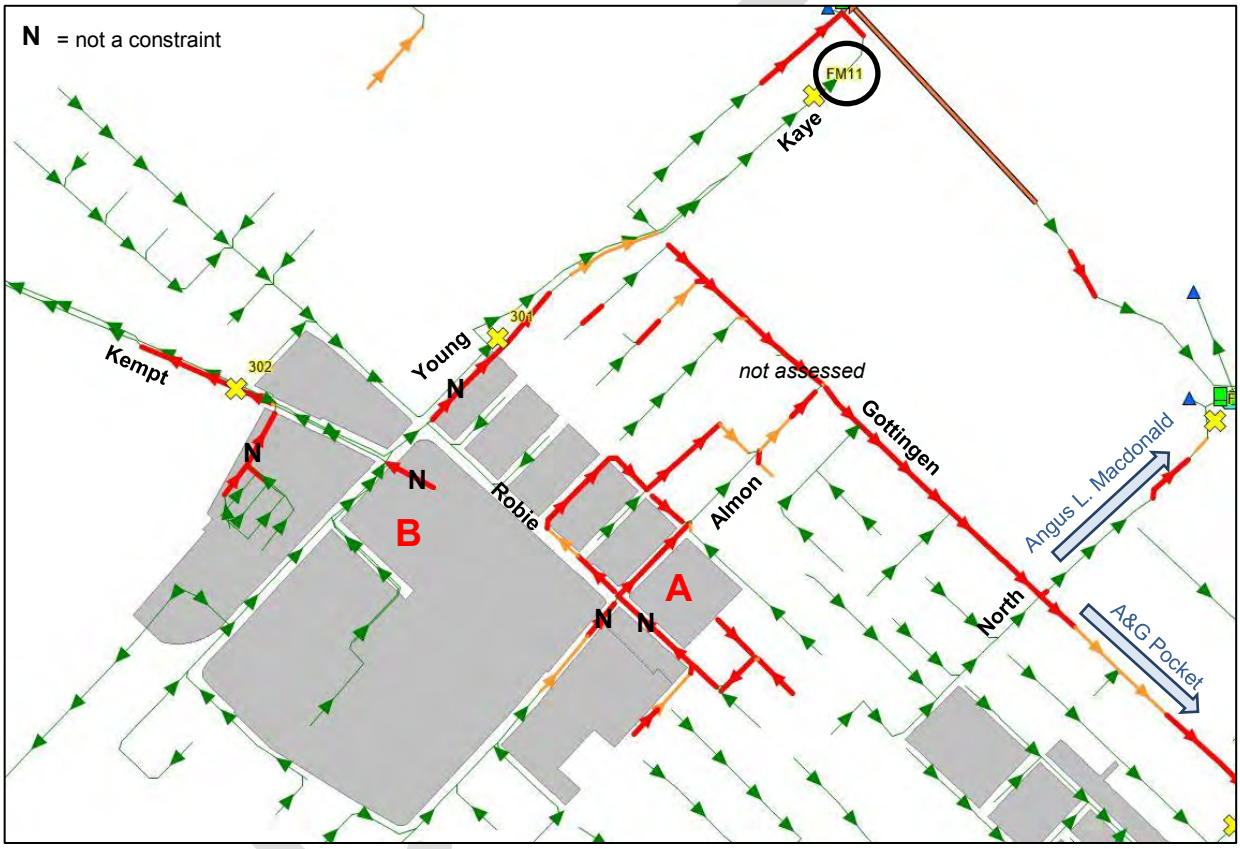


Figure 22: Young Street Existing Capacity Constraints (1in5year)

10.2.2 Impacts of Growth

The proposed growth within the Young Street blocks equates to approximately 41 L/s (A) and 153 L/s (B).

- The growth flows in (A) will cause further surcharging and flooding, however do not trigger any new constraints; they are marginal in comparison to the existing flows of up to 2,500 L/s (~ 2%).
- The growth flows in (B) will trigger upgrades along Young just downstream of Robie. These flows will also worsen the known downstream flooding along Kaye; the growth flows are significant, approximately 30% of the forecasted flows.

10.2.3 Trigger Points

The existing system for (A) is already predicted to surcharge and flood along Almon therefore these blocks do not have a trigger point. For the blocks in (B), the theoretical trigger point is 90 L/s (~ 5,000 people).

10.3 Evaluation of Alternatives

To accommodate growth, upsizing of combined sewers in (A) is required, in addition to the segment along Young. However, there may be opportunity to implement sewer separation, as there is an existing storm sewer network along Kempt, off of Young St. Sewer separation could potentially eliminate any existing constraints within the combined sewer system for both (A) and (B).

When evaluating each alternative, the conveyance of flows to the Agricola & Gottingen pocket via the North-Gottingen flow split was taken into consideration.

10.3.1 Alternative: Infrastructure Upgrades

The following sections present the different alignments for proposed sewer upgrades that would provide sufficient capacity for future growth, and resolve the system constraints to provide a level of service corresponding to a 1-in-5 year design storm.

10.3.1.1 Pocket A Alternative 1 – towards Angus L. Macdonald

Figure 23 shows the upgrades required for 'Pocket A' for the given alignment.

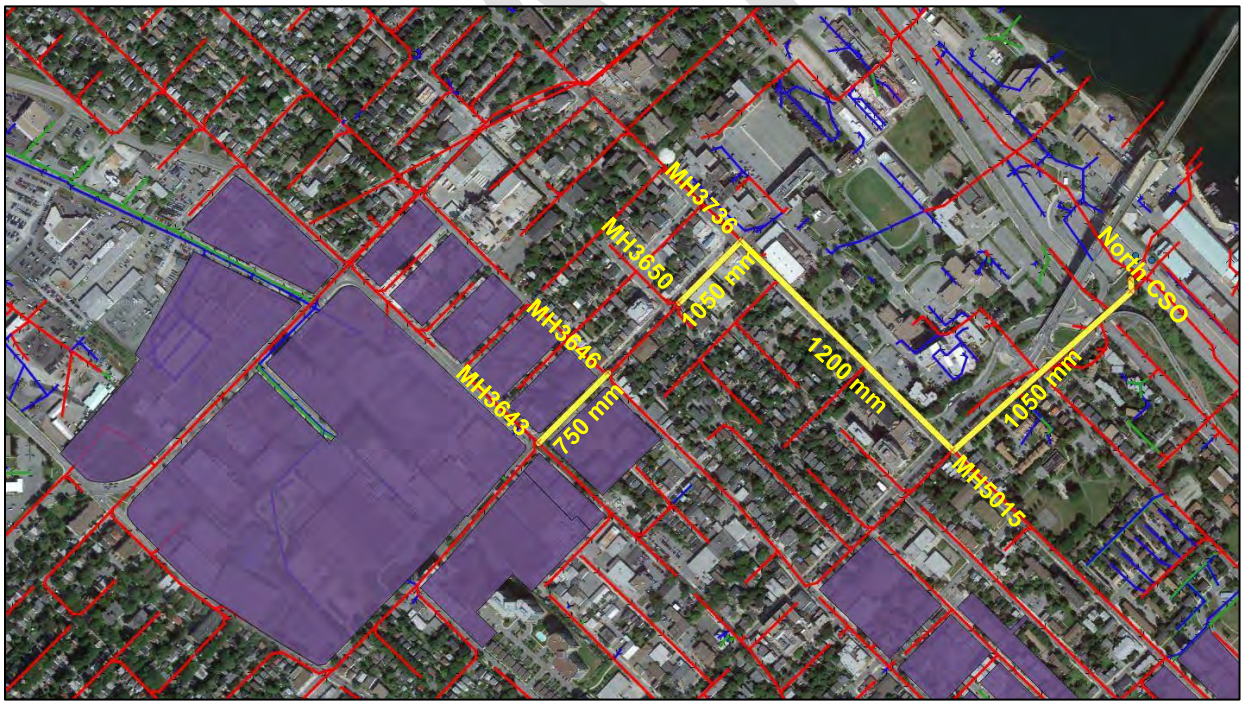


Figure 23: Young Street Infrastructure Upgrade 'Pocket A' Alternative 1

The proposed upgrades include approximately 1,130 meters of combined sewer. This alignment will require an offset of the sewer along Gottingen, south of North, to divert flows towards the North CSO. This will increase the conveyance to the North CSO from 2,600 L/s to 4,300 L/s under a 1-in-5 year design storm. The proposed 1050 mm segment along North St. will also likely require tunneling for 225 m, which will significantly increase construction cost.

This alignment will likely increase the capacity within the Agricola & Gottingen area depending on the amount of diverted flows; the peak flows through Gottingen are expected to decrease by 500 L/s. This also impacts the Upwater CSO, downstream of Gottingen, with a decrease in peak inflow from 2,300 to 1,750 L/s.

10.3.1.2 Pocket A Alternative 2 – towards Agricola & Gottingen

Figure 24 shows the upgrades required for 'Pocket A' for the given alignment.

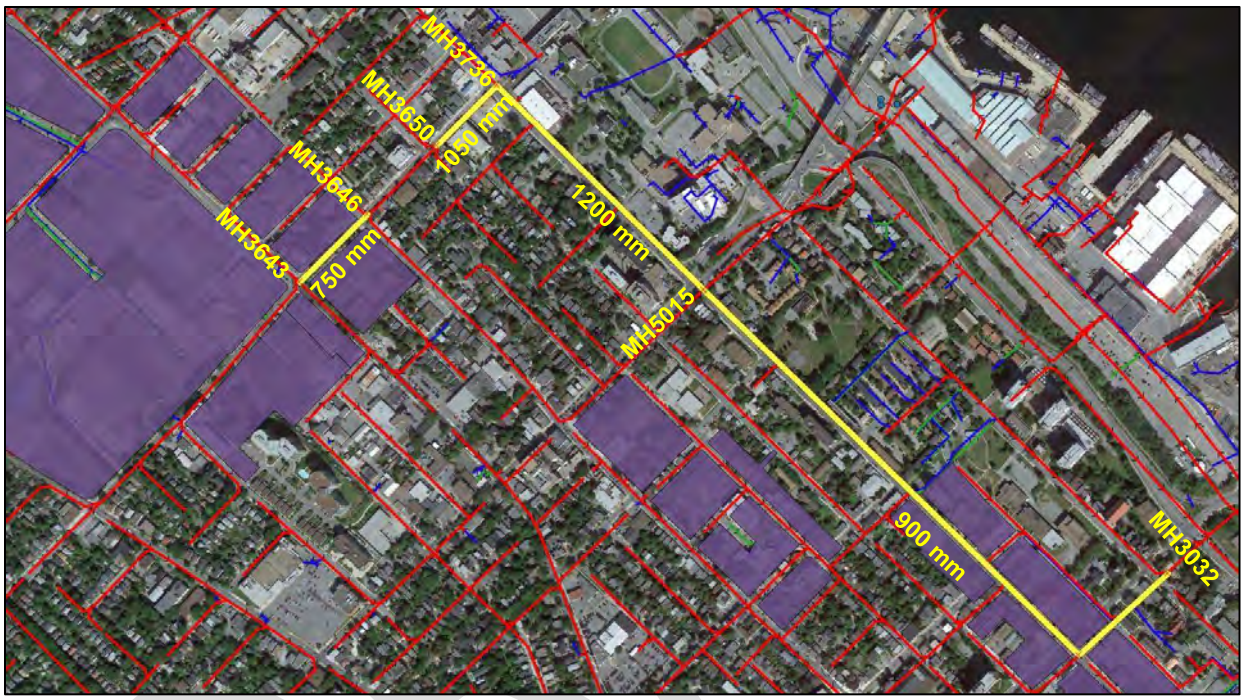


Figure 24: Young Street Infrastructure Upgrade 'Pocket A' Alternative 2

The proposed upgrades include approximately 1,600 meters of combined sewer. This alignment will increase the conveyance through Agricola & Gottingen and subsequently the conveyance to the Upwater CSO; the peak flows downstream of Agricola & Gottingen are estimated to increase from 2,300 L/s to 3,200 L/s as a result of this alignment, under a 1-in-5 year design storm. The inflow to the North St. CSO will still increase but marginally (~ 50 L/s)

The required upgrades along Gottingen may provide additional capacity for the Agricola & Gottingen pocket.

10.3.1.3 Pocket B – combined sewer upgrades

Figure 25 shows the combined sewer upgrades required to service 'Pocket B'



Figure 25: Young Street Combined Sewer Infrastructure Upgrade Pocket B Alternative

The proposed upgrades include approximately 220 meters of combined sewer along Young St. These upgrades may marginally increase the discharge at the Young CSO.

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10.3.1.4 Pocket B – storm sewer upgrades

Figure 26 shows the storm sewer upgrades required to service 'Pocket B'



Figure 26: Young Street Storm Sewer Infrastructure Upgrade Pocket B Alternative

The proposed upgrades include approximately 210 meters of storm sewer along Kempt. If future separation of Young St. is considered, these upgrades should be sized accordingly.

10.3.2 Alternative: Opportunities for Removal of Flow

The theoretical capacities of the constrained sewers were calculated and compared against the modelled flows when upgrades are applied. The comparison suggests that the following reductions in peak flow are required to eliminate the need for sewer upgrades:

- 1,500 L/s in pocket (A)
- 200 L/s in the combined system of pocket (B)

There is opportunity in pocket (A) to remove flows using on-site storage and low impact development. The blocks have a lot of impermeable area that can be redeveloped in such a way that reduces runoff and removes a large portion of wet weather flows. Although storage and LID practices are recommended within these blocks, as they are redeveloped, it is not likely going to eliminate the need for sewer upgrades along Almon and Gottingen; required reduction is approximately 50% of the existing flows.

There is a great opportunity to remove a large amount of flows within Young St. Block 3. It is a large piece of land with a lot impermeable area that can be redeveloped with considerations for storage and LID practices. It is likely that sufficient flows would be removed to eliminate the need for sewer upgrades, however these practices and methods of flow attenuation must be monitored to ensure that they continue to perform at a level that does not trigger constraints and surcharging in the future. Further investigation would be necessary to determine the site requirements to meet the desired reduction.

10.3.2.1 New Connection Point for Young Block 3

Although flow attenuation through storage or LID would likely eliminate the need for upgrades along Young St., changing the connection of Block 3 storm sewers would provide a more reliable solution. As previously discussed, LID practices will require ongoing monitoring to ensure consistent removal of flows. By changing the connection point, ~ 300 L/s will be removed from the existing combined sewers, eliminating the need for upgrades along Young St (Figure 27).

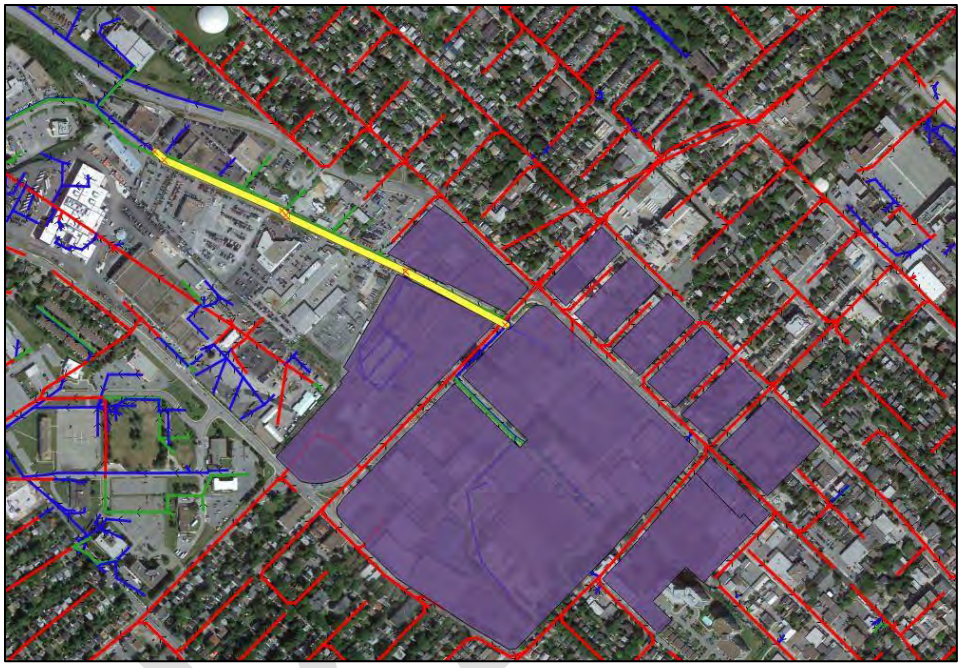


Figure 27: Young Street New Storm Sewer Connection

This option would require upgrades to the existing stormsewers, however a portion of them are already required (see 10.3.1.4) and could be upsized.

10.3.3 Alternative: Sewer Separation

There is a good opportunity for sewer separation by utilizing the existing stormwater network along Kempt. In total, three scenarios were assessed:

- Separating of pocket A and connecting into existing storm network along Kempt
- Separation of pocket A and conveying flows along Young-Kaye towards Young CSO
- Separation of pocket A and conveying flows towards Gottingen-North flow split.

10.3.3.1 Separation of Pocket A (Alternative 1) – connect into existing storm network off Young

Figure 28 shows the potential to separate the Young Street area and connect it to the existing stormsewer.



Figure 28: Young Street 'Pocket A' Sewer Separation Alternative 1

This alignment would fully separate the Young St. pocket and connect into the Kempt stormwater network. This would require major upgrades to the stormwater sewers. By utilizing the existing storm network, no new outfalls are required.

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10.3.4 Separation of Pocket A (Alternative 2) – towards Young CSO via Young-Kaye alignment

Figure 29 shows the potential to separate the Young Street area and divert a new stormsewer towards the harbour.



Figure 29: Young Street 'Pocket A' Sewer Separation Alternative 2

This alignment would fully separate the Young St. pocket and convey flows along Young and Kaye to the Young CSO. This alignment would require a new outfall at the Young CSO, or connection into the existing combined trunk sewer. This alterative would provide greater relief to the known surcharge and flooding issues just upstream of the Young CSO, along Kaye, in comparison to Alternative 1. However, this constraint must be further investigated to determine the exact cause and whether or not sewer separation can resolve the issue.

10.3.4.1 Separation of Pocket A (Alternative 3) – towards North-Gottingen flow split

Figure 30 shows the potential to separate the Young Street area and divert a new stormsewer south to the large diameter sewers that split north of Gottingen Pocket.



Figure 30: Young Street 'Pocket A' Sewer Separation Alternative 3

This option was considered but not assessed. It would provide enough separation to eliminate the required upgrades however would likely cause much more disturbance during construction, and much higher construction costs. The alignment would continue in a similar manner to the two upgrade scenarios, either along North or Gottingen.

Table 12 summarizes the potential benefits of the sewer separation scenarios that were assessed, in terms of peak flow and total volume removed from the combined sewer system during a 5-year design storm.

Table 12: Young Street Sewer Separation Scenario Comparison

Separation Scenario	Peak Flow Removed (L/s)			Total Volume Removed (m^3)		
	Roads	Lots	Total	Roads	Lots	Total
Connection to Existing	529	1,167	1,696	2,745	5,297	8,042
Conveyance to Harbour	691	1,167	1,858	3,582	5,297	8,879
Reduction within (A)	260	968	**1,228**	1,350	4,392	5,742

It should be noted that the peak flow is an estimate of peak runoff, and therefore is at the site level. This total peak flow removed will be less downstream due to time of concentration within the system. However, it is a relatively short segment that is being assessed so it is still a conservative estimate.

Both alternatives will have the same impact on the sewer constraints with (A). Separation would likely eliminate needs for upgrades along Almon and has the potential to eliminate the required upgrades along Gottingen (further analysis would be required to provide more confidence, including flow monitoring within the Young St. pocket). Separation would also eliminate the need for combined sewer upgrades along Young.

10.4 Alternative Cost Estimates

The follow Table 13 summarizes the costs associated with each alternative reviewed.

Table 13: Young Street Alternative Cost Estimates

Scenario	Cost
Sewer Upgrades – Pocket A (Alternative 1) via North St.	6.96 M
Sewer Upgrades – Pocket A (Alternative 2) via Gottingen	5.42 M
Sewer Upgrades – Pocket B (Young St.)	0.40 M
Sewer Upgrades – Pocket B (Kempt St.)	0.69 M
Change Connection of Young Block 3 Storm	1.54 M[1]
Sewer Separation (Alternative 1) – Connect to Existing	6.59 M
Sewer Separation (Alternative 2) – via Young-Kaye to Harbour	7.21 M
New Outfall	?

[1] This is $850,000 in addition to the sewer upgrades already required along Kempt Road.

[2] If Sewer Separation Alternative 1 and the change in connection of Block 3 occurs, larger storm sewer upgrades would be required in some areas at an additional cost of $134,000.

10.5 Recommendations and Preferred Option Cost Estimate

There are significant existing constraints within the Young St. pocket under a 1-in-5 year design storm. Many alternatives and alignments were reviewed including infrastructure upgrades, sewer separation, and LID solutions. The preferred strategy, based on cost, feasibility, and overall benefit to the existing system, includes the following:

- Full separation of the Young St. pocket, conveying the stormwater flows towards Young St. and connecting to the existing stormwater network along Kempt St. (~ 2,100 meters)
    - This strategy would also require upgrades to the existing stormwater network (~ 1,050 meters)
- This strategy would provide the opportunity to disconnect the storm sewers associated with Block 3 from the combined sewers along Young St., so that the flows are diverted along the existing storm sewers.
- This strategy should eliminate the need for all required sewer upsizing that was identified in the infrastructure upgrades scenarios
    - This will not only limit, but decrease the conveyance to the Young St. CSO, North St. CSO, and Upwater CSO.
- This strategy will also improve the conditions along Kaye, where there is known flooding right upstream of the Young St. CSO, although further studies would be required.

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Table 14, below, provides details and costs of the preferred option projects for Young Street area.

Table 14: Young Street Preferred Option Projects and Costs

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)
Young	5	Y1	New 375 mm storm sewers (roughly 6 equal in length) connecting to Robie St.	Halifax	Storm Sewer	375 mm	774	$1,155,000
Young	6	Y2	New 450 mm storm sewers along Almon St. and Young St.	Halifax	Storm Sewer	450 mm	866	$1,397,000
Young	7	Y3	New 600 mm storm sewer along Robie St.	Halifax	Storm Sewer	600 mm	461	$876,000
Young	8	Y4	New 825 mm storm sewer along Kempt	Halifax	Storm Sewer	825 mm	182	$520,000
Young	9	Y5	New 900 mm storm sewer along Kempt	Halifax	Storm Sewer	900 mm	449	$1,383,000
Young	10	Y6	New 750 mm storm sewer along Kempt	Halifax	Storm Sewer	750 mm	420	$1,116,000
							TOTAL	**$6,447,000**

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11 Agricola & Gottingen Street, Halifax: Capacity Analysis and Solution Development

Figure 31, below shows the location of the target development area. In total, six property parcels or blocks are identified that correspond to the descriptions in Table 15.



Figure 31: Agricola & Gottingen Street Development Area

11.1 Agricola & Gottingen Street Growth and Area Description

This currently developed area is targeted for relatively modest growth given the spatial extents of the area. There is a social housing development area east of Gottingen St. and community groups have suggested some resistance to high rise developments. The south of the area has the greatest potential to accommodate higher density high rise and proposals have been received for a 15 story high rise building. Land prices in this area are increasing, as is true for the whole downtown area.

Table 15 below shows the growth projections, block by block, for the Agricola & Gottingen Street area.

Table 15: Agricola & Gottingen St Block by Block Growth Projections

Area	Block #	Existing Use	Gross Area (Ha)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per hectare)	Total Future # of Units (Build Out)	Net Residential Growth Population	Net Employment Growth Population
#4 Agricola St. & Gottingen St.	1	Liquor store, breweries. New build - 1 storey.	1.57	111	57	173	272	420	9
	2	Mix commercial and residential	0.90	39	32	124	111	178	(5)
	3	Increased density	1.07	25	39	124	132	232	(6)
	4		0.57	30	21	124	70	107	(4)
	5		0.81	41	29	124	100	154	(5)
	6	230 units. The diamond and the met. Maitland.	0.80	33	29	173	138	235	5
	7		0.84	122	30	173	146	162	5
	8		0.85	25	31	247	211	387	21
	9		1.11	16	41	247	275	520	27
	10		0.62	69	110	173	108	141	(84)
	11		0.97	7	171	173	167	319	(130)
	12	Currently being developed	0.59	67	105	247	147	220	(69)
	13		1.29	8	228	247	320	616	(150)
	14		0.41	3	72	99	40	75	(62)
		Total	**12.41**	**595**	**995**	**2,446**	**2,168**	**3,767**	**(447)**

11.2 Capacity Analysis

11.2.1 Existing Constraints

Having completed the existing conditions modelling it is evident that the current level of service that is being provided to the existing customers corresponds to a 5-year design storm for the blocks north of Cornwallis, and a 2-year design storm for the blocks south of Cornwallis. There are existing constraints within the south of Cornwallis sub-catchment under 5-year design storm conditions, causing surcharge and flooding. These constraints must be resolved before development can occur, as outlined in the Sewer System Evaluation Guidelines.

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The red pipe segments in Figure 32 highlight the sewers that are under capacity (q/Q > 1) within the Agricola and Gottingen catchment under a 1in5 year design storm. The majority of the red segments are not real constraints, they are shown in the model as constraints as a results of subcatchment loadings or flat sewers that have a very low theoretical flow capacity; there is not any flooding or significant surcharge.

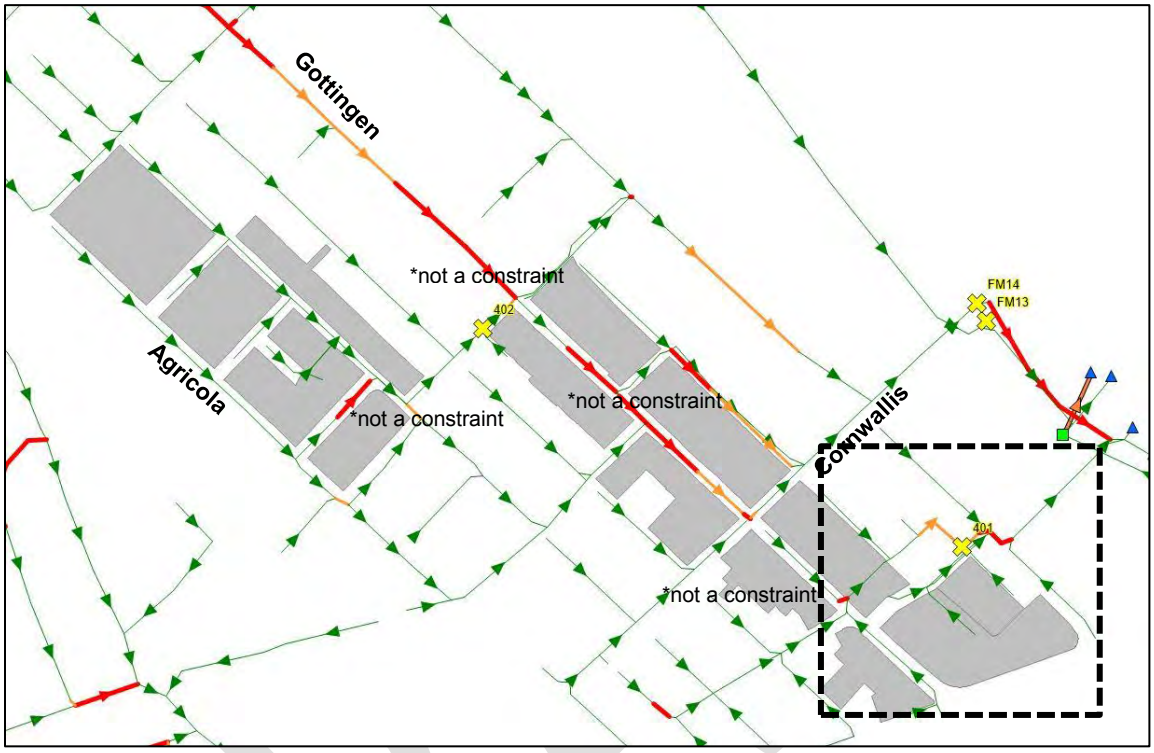


Figure 32: Agricola & Gottingen Street Existing Constraints (1in5year)

It should be noted that a portion of the Young St. pocket is upstream of these blocks. There is a flow split at Gottingen St. and North St., where primary flow is towards the Harbour along North, and relief is provided via Gottingen. The preferred servicing alternative of the Young St. pocket will impact the required upgrades along Gottingen; refer to Growth Area Memo for Young St. for further details.

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Figure 33 focuses on the constraints within the Gottingen pocket.

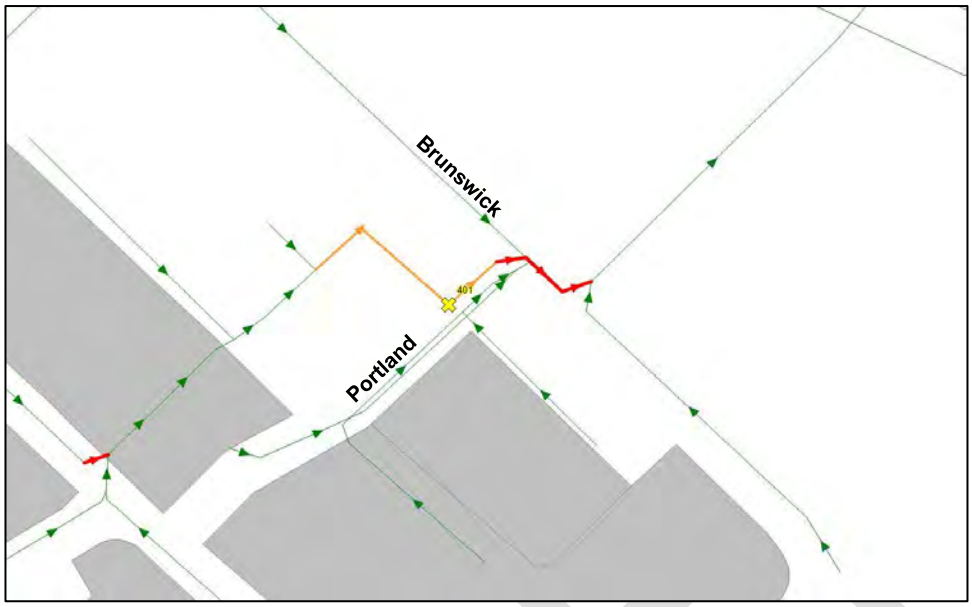


Figure 33: Gottingen Street Existing Constraints (1in5year)

There are existing constraints downstream of flow monitor 401, primarily along Brunswick. These segments are very flat, creating a bottleneck within this catchment. This results in backup and flooding under a 5-year design storm condition. To accommodate growth, upsizing of the combined sewers is required, however there may be opportunity to implement sewer separation, as there is an existing 450 mm storm sewer south of the pocket along Cogswell St.

11.2.2 Impacts of Growth

The proposed growth within the block south of Cornwallis equates to approximately 12 L/s. These growth flows would cause further surcharging and flooding along Brunswick, however do not trigger any new constraints; they are marginal in comparison to the existing flows of up to 1,800 L/s (< 1%).

There is enough capacity within the Agricola and Gottingen system, north of Cornwallis, to service the proposed growth within these blocks, which equates to approximately 30 L/s.

It should be noted that the impacts of growth within Agricola and Gottingen were assessed in isolation of the Young St. pocket. If flows along Gottingen Rd. are increased or decreased due to the servicing of the Young St., the impacts of growth within Agricola and Gottingen may change.

11.2.3 Trigger Points

The existing system is already predicted to surcharge and flood along Brunswick St. under a 5-year design storm, therefore the blocks south of Cornwallis do not have a trigger point. However, the remaining blocks within Agricola and Gottingen area can theoretically accommodate:

- 40 L/s within the Agricola area (~ 2,300 people)
- 60 L/s within the Gottingen area (~ 3,400 people) – *in isolation of Agricola blocks.*
    - Theoretical available capacity within Gottingen would increase to 120 L/s (~ 6,800 people) with the implementation of the preferred Young St. alternative (see Growth Area Memo – Young St.)

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It should be noted that these trigger points are calculated in isolation of the servicing strategies for Young St. If flows along Gottingen Rd. are increased or decreased due to the servicing of the Young St. pocket, these trigger points will change.

11.3 Evaluation of Alternatives

11.3.1 Alternative: Infrastructure Upgrades

Figure 34 presents the alignment for the proposed upgrades that would provide sufficient capacity for future growth and resolve the system constraints, providing a level of service corresponding to a 1-in-5 year design storm.

The proposed upgrades include approximately 65 meters of combined sewer; 900 mm diameter sewer along Brunswick from MH3072 to MH3065 and 750 mm diameter sewer along Portland from MH3065 to MH48737.

The upsizing of this segment will increase the conveyance to the Upwater CSO, and it is estimated that the peak flows downstream of the upgrades will increase from to 1,500 to 1,900 L/s under a 1-in-5 year design storm.



Figure 34: Agricola & Gottingen Street Infrastructure Upgrades (1in5year)

11.3.2 Alternative: Opportunities for Removal of Flow

The theoretical capacities of the constrained sewers were calculated and compared against the modelled flows when upgrades are applied. The comparison suggests that a reduction of approximately 1,500 L/s is required to eliminate the need for sewer upgrades; this is a result of the slope of this segment and the resulting theoretical capacity.

Given the size of the upstream network, and the type of development (primarily residential), it is unlikely that non-infrastructure solutions such as inflow and infiltration reduction, low impact development, or flow attenuation, will remove sufficient flows to eliminate the need for sewer upgrades; the percentage of flow reduction that is required is too large (> 75%).

11.3.3 Alternative: Sewer Separation

There is a good opportunity for sewer separation by utilizing the existing 450 mm stormwater sewer along Cogswell St., south of the Gottingen pocket. Three scenarios were assessed:

- Alternative 1: south of Cornwallis connecting into existing stormwater sewer and north of Cornwallis discharges to Harbour via Cornwallis
    - Scenario 1a: separation of south pocket that could potentially eliminate the need for sewer upgrades
    - Scenario 1b: separation of north pocket toward Harbour
- Alternative 2: complete separation whereby the entire Agricola and Gottingen pocket connects to existing stormwater sewer.

11.3.3.1 Alternative 1a – Separation of South Pocket (connection to existing)

Figure 35 shows a separation alternative that connects the newly separated area to an existing storm sewer.

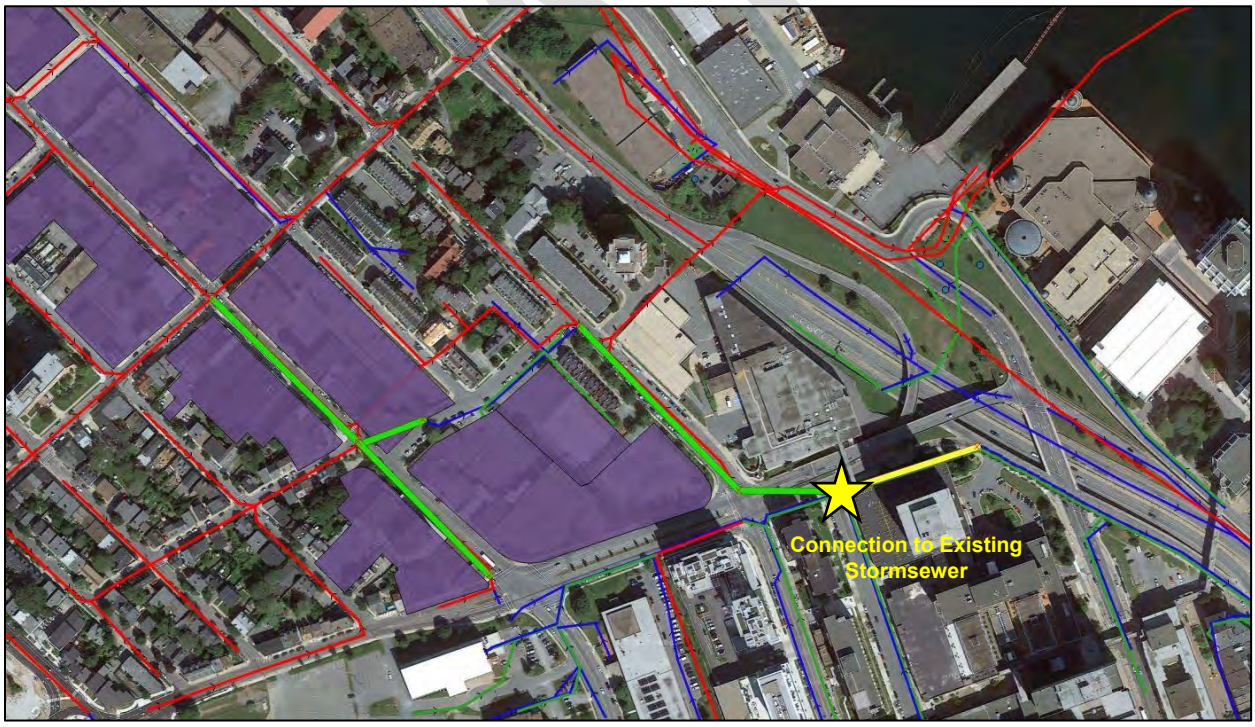


Figure 35: Agricola & Gottingen Street Sewer Separation Alternative 1a

The blocks south of Cornwallis would be separated and connected to the existing stormwater sewer along Cogswell. Minor upgrades would be required within the existing stormsewer network.

11.3.3.2 Alternative 1b – Separation of North Pocket (to Harbour)

Figure 36 shows a separation alternative that diverts the newly separated area towards the Harbour.

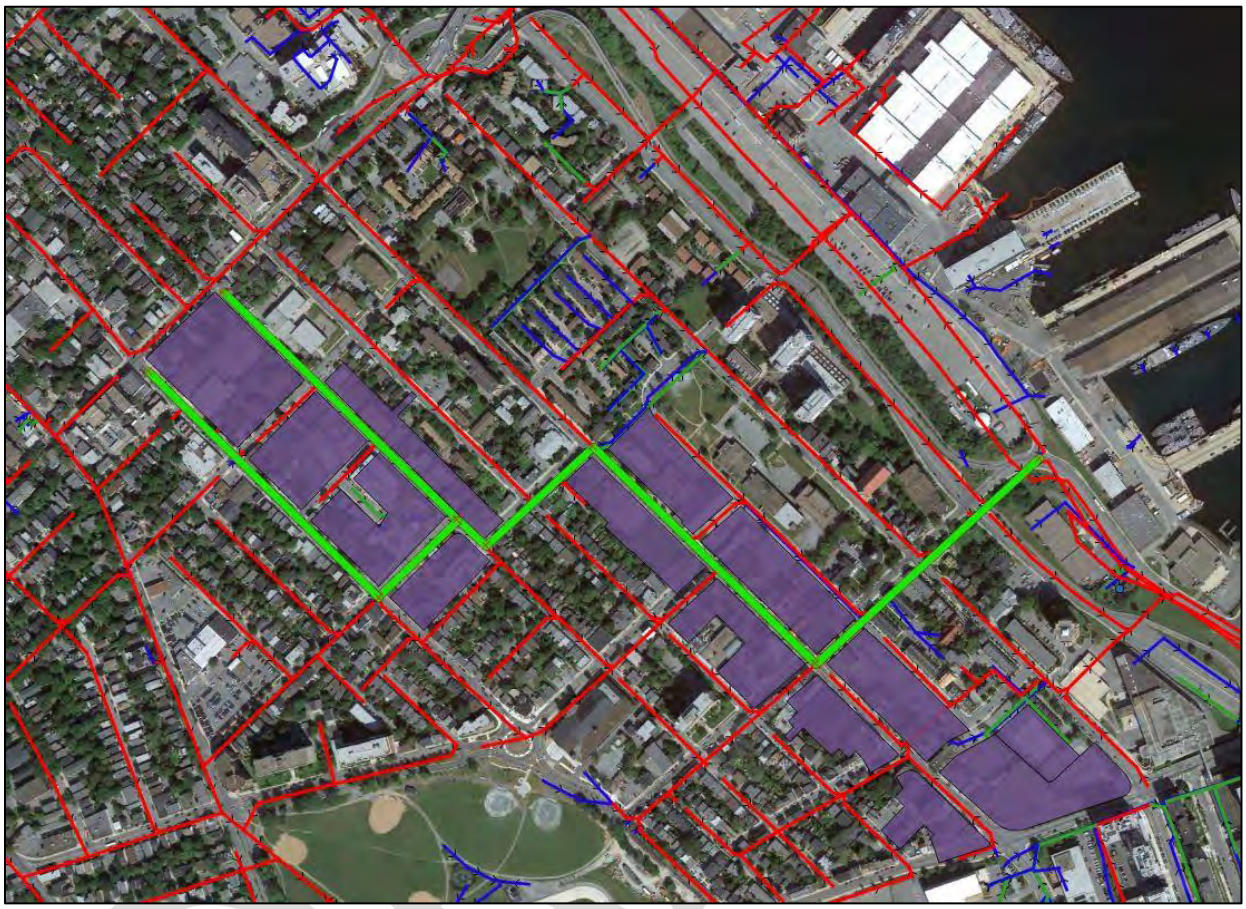


Figure 36: Agricola & Gottingen Street Sewer Separation Alternative 1b

The blocks north of Cornwallis would be separated and conveyed to a trunk along Cornwallis towards the Harbour. A new outfall would be required or a connection into the existing combined trunk sewer.

11.3.3.3 Alternative 2 – Complete Separation (connection to existing)

Figure 37 shows an alternative that separates the entire Agricola and Gottingen pocket area.



Figure 37: Agricola & Gottingen Street Sewer Separation Alternative 2

The blocks north of Cornwallis would be separated and connected to the pocket south of Cornwallis. The entire separation of Agricola and Gottingen would connect to the existing stormwater sewer along Cogswell. Upgrades would be required to the existing stormsewer network both within the Gottingen blocks and downstream of the connection point.

Table 16 summarizes the potential benefits of the different sewer separation pockets, in terms of peak flow and total volume removed from the combined sewer system during a 5-year design storm.

Table 16: Agricola & Gottingen Sewer Separation Scenarios Comparison

Separation Scenario	Peak Flow Removed (L/s)			Total Volume Removed (m^3)		
	Roads	Lots	Total	Roads	Lots	Total
South Pocket	187	431	618	972	1,566	2,538
North Pocket (to harbour)	290	985	1,275	1,503	3,575	5,078
North Pocket (to existing)	220	985	1,205	1,143	3,575	4,718

It should be noted that the peak flow is an estimate of peak runoff, and therefore is at the site level. This total peak flow removed will be less downstream due to time of concentration within the system, and therefore will not be the reduction in peak flows at the regional infrastructure.

Sewer separation of the south pocket would not reduce peak flows sufficiently to eliminate the need for sewer upgrades (required flow reduction estimated at 1,500 L/s). However, there are opportunities to separate this pocket and the existing stormwater sewer along Cogswell making the separation project more feasible, including the stormwater outfall that is already in place. Although sewer upgrades are still required, sewer separation of the south pocket should still be considered as it may reduce the size of upgrades and will reduce the CSO discharge at Upwater CSO.

Complete separation of the blocks north of Cornwallis would provide additional relief to the Upwater CSO. If considered, it is recommended that it be connected to the existing stormwater network through the south pocket, as this alternative does not require a new outfall (only minor sewer upgrades).

11.4 Alternative Cost Estimates

The follow Table 5 summarizes the costs associated with each alternative reviewed.

Table 17: Agricola & Gottingen Alternative Cost Estimates

Scenario	Cost
Sewer Upgrades	0.19 M
Sewer Separation – Alternative 1 (south)	1.25 M
Sewer Separation – Alternative 1 (north)	3.56 M
New Outfall (end of Cornwallis)	?
Sewer Separation – Alternative 2 (south)	2.26 M
Sewer Separation – Alternative 2 (north)	2.65 M

11.5 Recommendations and Preferred Option Cost Estimate

- Approximately 65 meters of sewer upgrades would be sufficient to resolve the existing constraints
- Removal of ~ 1500 L/s would be required to eliminate the need for sewer upgrades
- Non-infrastructure solutions would not provide sufficient reduction in flows due to the size of the upstream catchment and type of development. The reduction would equate to over 60% of the existing flow in the sewers along Brunswick.
- Separation of the south pocket does not provide adequate reduction in flows within the combined sewer system to eliminate the need for sewer upgrades.
    - However there is great opportunity for a separation project due to the existing stormwater network south on Cogswell.
    - It is recommended that if separation of the south pocket were to occur, that it be sized with the intention of connecting the pockets north of Cornwallis.
- Full separation of the north would not impact the existing constraints
    - If considered, it is recommended that it be connected to the existing stormwater system through the south pocket instead of to the harbour via Cornwallis.
    - This eliminates the need for a new outfall
- The preferred alternative is to upgrade the sewers along Portland and Brunswick

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- In addition, complete a feasibility study to separate the south pocket and connect into the existing stormwater sewer along Cogswell.

Table 18, below, provides details and costs of the preferred option projects for Agricola and Gottingen area.

Table 18: Agricola and Gottingen Preferred Option Projects and Costs

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)
Agricola & Gottingen	11	AG1	750 mm combined sewer upgrade along Portland	Halifax	Combined Sewer	750 mm	35	$93,000
Agricola & Gottingen	12	AG2	900 mm combined sewer upgrade along Brunswick	Halifax	Combined Sewer	900 mm	30	$93,000
							TOTAL	**$186,000**

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12 Canal Street, Dartmouth: Capacity Analysis and Solution Development

Figure 38, below shows the location of the target development area. In total, six property parcels or blocks are identified that correspond to the descriptions in Table 19.



Figure 38: Canal Street Development Area

12.1 Canal Street Growth and Area Description

This area is the subject of the Dartmouth Cove Master Plan. There is identified redevelopment potential within the area. Nearby to this area 1500 units on Kings Wharf have been approved and building has started, with some of the buildings already completed. The location poses some development obstacles including its low level in relation to sea level. Flows from this area convey to Old Ferry Road PS, which is regional infrastructure although has known capacity issues. Daylighting of the piped water channel has been widely discussed but no plans have been approved to achieve this.

Table 19 below shows the growth projections, block by block, for the Canal Street area.

Table 19: Canal Street Block by Block Growth Projections

Area	Block #	Existing Use	Gross Area (Ha)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per hectare)	Total Future # of Units (Build Out)	Net Residential Growth Population	Net Employment Growth Population
#5 Canal St.	1	8 storey office building + Marina and diving school, curling club	2.43	6	57	247	600	1,164	90
	2		2.89	8	68	247	713	1,383	107
	3	Ship building/finishing yard.	0.70	2	17	124	87	167	5
	4		0.89	87	21	173	153	212	17
	5		0.89	28	21	124	110	186	6
		Total	**7.80**	**258**	**309**	**914**	**1,426**	**3,112**	**224**

12.2 Capacity Analysis

12.2.1 Existing Constraints

Having completed the existing conditions modelling it is evident that the current level of service that is being provided to the existing customers corresponds to a 5-year design storm. There are no existing constraints to the local sewers although the trunk system does have constraints

The hydraulic model in this area used two flow monitors for calibration thus not all pipe flows can be confirmed, especially in regard to the accuracy around flow splits in the area. However, growth projections are very modest and only 2l/s are loaded to this eastern area.

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The red segments in Figure 39 highlight the sewers that are under capacity (q/Q > 1) within the Canal St. pocket, both local and regional infrastructure. The major trunk sewers along Maitland and Portland appear to have constraints but are not part of the local analysis.



Figure 39: Canal Street Existing Contraints (1in5year)

12.2.2 Impacts of Growth

The proposed growth within the Canal St. blocks equates to approximately 24 L/s, 18 L/s of which are located in the two largest blocks. These growth flows do not trigger any new constraints; they are marginal in comparison to the existing flows (~2%).

12.2.3 Trigger Points

There are no existing constraints within the pocket therefore trigger points for the blocks were identified:

- Block 1: approximately 60 L/s (~ 3,400 people)
- Blocks 2-5: approximately 200 L/s (~ 11,500 people)

12.3 Evaluation of Alternatives

An evaluation of infrastructure upgrades was not required as there are no constraints with the loading of the proposed growth. However, opportunities to remove flow and possible sewer separation alternatives were still considered.

12.3.1 Sewer Separation

The majority of Block 1 and 2 are already separated, however there is a good opportunity to separate the remaining area of Block 1 and 2, and to include separation of Block 3 and 4. The proposed alignment in Figure 40 would allow for complete separation of the pocket and connect into the existing sewer along Canal St.



Figure 40: Canal Street Sewer Separation Alternative

Table 20 summarizes the potential benefits of the sewer separation alignment in terms of peak flow and total volume removed from the combined sewer system during a 5-year design storm.

Table 20: Canal Street Benefit of Sewer Separation

Separation Scenario	Peak Flow Removed (L/s)			Total Volume Removed (m^3)		
	Roads	Lots	Total	Roads	Lots	Total
Portland	69	234	303	360	850	1,210

It should be noted that the peak flow is an estimate of peak runoff, and therefore is at the site level. This total peak flow removed will be less downstream due to time of concentration within the system. However, it is a relatively short segment that is being assessed so it is still a conservative estimate.

12.4 Alternative Cost Estimates

The follow Table 21 summarizes the costs associated with each alternative reviewed.

Table 21: Canal Street Alternative Cost Estimate

Scenario	Cost
Sewer Separation	0.62 M

12.5 Recommendations and Preferred Option Cost Estimate

The existing system has sufficient capacity to accommodate all of the proposed growth within the Canal St. pocket, therefore infrastructure upgrades are not required. There is however opportunity for sewer separation as there is an existing 600 mm storm sewer along Canal St. It is recommended that, although not required for growth, considerations be made to implement the proposed sewer separation alternative. The ~ 350 m of storm sewer will provide opportunities to connect any future separation within the growth pockets, and utilize the existing stormwater infrastructure.

Table 22, below, provides details and costs of the preferred option projects for Agricola and Gottingen area.

Table 22: Canal Street Preferred Option Projects and Costs

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)
Canal	23	C1	New 375 mm storm sewer along Portland St.	Dartmouth	Storm Sewer	375 mm	91	$136,000
Canal	24	C2	New 600 mm storm sewer along Canal St. connecting into existing 600 mm storm sewer	Dartmouth	Storm Sewer	600 mm	252	$480,000
							TOTAL	**$616,000**

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13 Wyse Road, Dartmouth: Capacity Analysis and Solution Development

Figure 38, below shows the location of the target development area. In total, six property parcels or blocks are identified that correspond to the descriptions in Table 23.



Figure 41: Wyse Road Development Area

13.1 Wyse Road Growth and Area Description

Wyse Road is large spatial area spanning various sewer connection points. It has been identified as a potential redevelopment area for some time although its low economic status has stifled real interest. More recently land prices have seen increases and developer interest has heightened and some redevelopment has occurred. There is currently a large public housing location east of the study area. The intent would be to add buildings that provide potential for medium density (8 story max) buildings.

Table 23 below shows the growth projections, block by block, for the Wyse Road area.

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Table 23: Wyse Road Block by Block Growth Projections

Area	Block #	Existing Use	Gross Area (Ha)	Existing Residential Population (2015)	Existing Employment Population (2015)	Target unit density (per hectare)	Total Future # of Units (Build Out)	Net Residential Growth Population	Net Employment Growth Population
#6 Wyse Rd.	1		0.26	11	2	99	26	1.95	50
	2		0.17	7	1	99	17	1.95	33
	3		0.18	5	1	99	18	1.95	34
	4		0.87	82	6	99	86	1.95	167
	5		0.22	6	2	99	22	1.95	43
	6	Some residential	5.20	111	40	124	642	1.95	1,253
	7	Car dealership	1.84	15	14	124	227	1.95	443
	8	Some development interest. Application submitted	0.32	11	2	124	39	1.95	77
	9	Some development interest. Application submitted	0.25	7	2	124	30	1.95	59
	10	Application submitted for 90 units	0.79	10	6	247	196	1.95	383
	11	Former public housing, now rentals	4.05	214	66	99	400	1.95	780
	12		1.47	78	24	99	146	1.95	284
	13		0.68	36	11	99	67	1.95	132
	14		0.68	-	11	247	167	1.95	326
	15	Shopping centre, Gas station	3.43	-	56	247	849	1.95	1,655
	16	Lots of interest. Vacant. All owned by one person.	0.35	5	3	494	171	1.95	334
	17	Lots of interest. Vacant. All owned by one person.	0.98	15	7	99	97	1.95	189
	18		0.57	-	4	173	99	1.95	193
	19		0.53	-	4	494	263	1.95	513
	20	Holiday Inn, office building - 12 storey, bridge office, strip mall. Will consider a tall building here.	3.07	30	50	173	531	1.95	1,035
	21		0.29	-	5	247	71	1.95	139
		Total	**20.76**	**646**	**318**	**3,707**	**4,624**	**1.95**	**8,121**

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13.2 Capacity Analysis

The Wyse Rd. pocket is can be split up into three primary sub-catchments, which are labelled in Figure 42

13.2.1 Existing Constraints

The current level of service that is being provided to the existing customers does not meet the 1in5 year design storm level of service and corresponds to a 2-year design storm. There are existing constraints within the Wyse Rd. catchment under 5-year design storm conditions, causing surcharge and flooding. These constraints must be resolved before development can occur, as outlined in the Sewer System Evaluation Guidelines.

The red segments in Figure 42 highlight the sewers that are under capacity (q/Q > 1) within the three sub-catchments of the Wyse Rd. pocket under a 1in5 year design storm. The majority of the constraints are downstream of the blocks, causing surcharging within the study area.

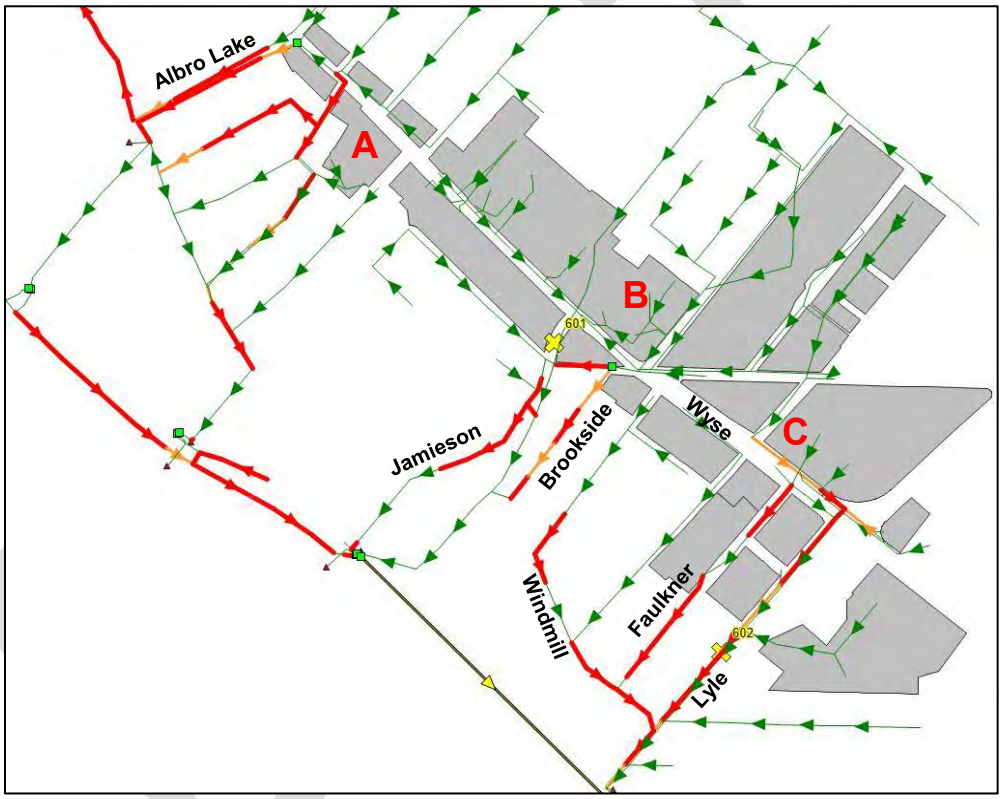


Figure 42: Wyse Road Existing Constraints and Subcatchments

To accommodate growth, upsizing of the combined sewers is required, however there may be opportunity to implement sewer separation, as there are a lot of existing separate sewers throughout the Wyse Rd. blocks, including a 750 mm diameter stormsewer along Lyle, and a storm sewer network downstream of Albro Lake Rd.

13.2.2 Impacts of Growth

The proposed growth within the Wyse Rd. blocks equates to approximately 80 L/s, however the majority of it is located in the Wyse-Lyle corner of the study area.

- (A) – 3 L/s
- (B) – 12 L/s
- (C) – 65 L/s

All of the growth flows would cause further surcharging and flooding.

13.2.3 Trigger Points

The existing system is already predicted to surcharge along Lyle, Windmill, Jamieson, and Albro Lake, all of which are downstream sewers for the Wyse Rd. pocket. Therefore, there are no trigger points for these blocks as the existing constraints must be resolved before any growth can occur.

13.3 Evaluation of Alternatives

13.3.1 Alternative: Infrastructure Upgrades

Figure 43 presents the alignment for the proposed upgrades that would provide sufficient capacity for future growth and resolve the system constraints to provide a level of service corresponding to a 1-in-5 year design storm.



Figure 43: Wyse Road Infrastructure Upgrade Alternative

The proposed upgrades for sub-catchment (B) include approximately 160 meters of combined sewer; 375 mm upgrades along Ropewalk (MH19270 to MH19283), and 450 mm upgrades along Jamieson (MH19283

to MH19284). The invert of the sewer downstream of MH19291, along Jamieson, would be offset to divert the flows to the 1200 mm trunk rather than continue along Jamieson. This would eliminate the need for upsizing the remainder of Jamieson. The invert of the most upstream sewer on Brookside would also be offset to divert flows along Ropewalk; this would prevent construction through this neighbourhood and minimize the extent of upgrades.

The proposed upgrades for sub-catchment (A) include approximately 1,100 meters of combined sewer; the alignment includes upgrades along Windmill (MH14551 to MH14563), along Lyle (MH14553 to MH18806), and along Wyse (MH18806 to MH18811).

The proposed upgrades for sub-catchment A include an adjustment of inverts to divert flows towards Albro Lake Rd. rather than along Howe St. This should resolve the constraints that are downstream of Wyse Rd. and Howe; Figure 44 marks the location of the diversion.

The existing constraints identified along Albro Lake - Windmill are likely a result of modelling noise and do not appear to be real constraints. However, flow monitoring data was not available within this area therefore there is less confidence with the results. Further investigation into this part of the system is recommended to have a better understanding of the actual flows and conditions.



Figure 44: Location of Proposed Flow Split Alteration

13.3.2 Alternative: Sewer Separation

A large portion of the Wyse Rd. pocket is already partially separated. There is good opportunity for advancing the sewer separation within these blocks by utilizing the existing 750 mm stormwater sewer along Lyle St. and the exising stormwater network downstream of Albro Lake Rd. Separation of all three sub-catchments was assessed and are highlighted in Figure 45.

- The separation of (A) would require approximately 600 meters of storm sewer and would connect into the 600 mm sewer along Windmill Rd.

- The separation of (B) would require approximately 800 meters of storm sewer along Wyse and Jamieson. This provides the added benefit of connecting all of the existing separate sewers upstream of the Wyse-Jamieson intersection, which would eliminate the need for sewer upgrades along Jamieson.
- The separation of (C) would require approximately 300 meters of storm sewer along Wyse Rd. and connect into the existing 750 mm storm sewer along Lyle. This would complete the separation of the blocks within sub-catchment (C), however would not eliminate the need for sewer upgrades along Lyle.
- Either the separation along Albro Lake or Jamieson should be sized with consideration for the separation of Albro Lake. Depending on where that connection will be made, the sewer sizes may vary.

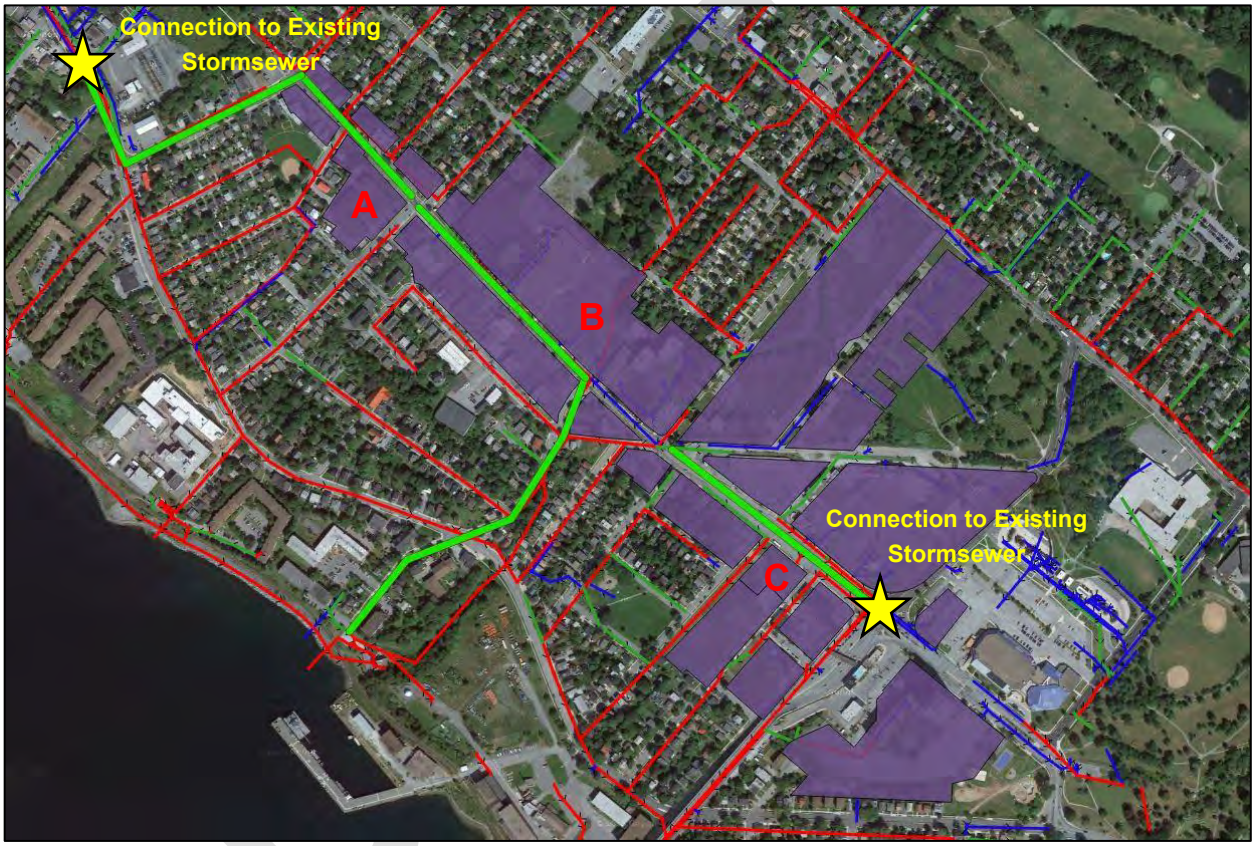


Figure 45: Wyse Road Sewer Separation Alternative

Table 24 summarizes the potential benefits of the three separation scenarios in terms of peak flow and total volume removed from the combined sewer system during a 5-year design storm.

Table 24: Wyse Road Sewer Separation Alternative Comparision

Separation Scenario	Peak Flow Removed (L/s)			Total Volume Removed (m^3)		
	Roads	Lots	Total	Roads	Lots	Total
A - Albro Lake Rd	139	155	294	720	702	1,422
B - Jamieson	222	1,262	1,484	1,152	5,729	6,881
C - Wyse	161	183	344	837	833	1,670

It should be noted that the peak flow is an estimate of peak runoff, and therefore is at the site level. This total peak flow removed will be less downstream due to time of concentration within the system. However, they are relatively short segments that are being assessed so it is still a conservative estimate.

13.4 Alternative Cost Estimates

The follow Table 25 summarizes the costs associated with each alternative reviewed.

Table 25: Wyse Road Alternative Cost Estimates

Sewer Upgrades	Cost
B - Jamieson	0.25 M
A - Windmill	0.66 M
A - Lyle/Wyse	1.32 M
Sewer Separation	**Cost**
A - Albro Lake Rd.	1.25 M
B - Jamieson	2.69 M
New Outfall	?
C - Wyse	0.67 M

13.5 Recommendations and Preferred Option Cost Estimate

The Wyse Rd. pocket was sub-divided into three areas; as shown in Figure 42. The conclusions and recommendations for each area are as follows:

- The growth blocks within (A) have minimal growth (~ 3 L/s) and do not trigger any new constraints. The existing constraints along Howe can be resolved with a diversion strategy at the Howe-Wyse intersection, diverting flows along the 600 mm sewer towards Albro Lake Rd.
- Infrastructure upgrades are recommended within (B), along Ropewalk and Jamieson. Although separation would provide additional benefits to the overall system, and should still be considered in the future, the preferred strategy is to upgrade ~ 160 meters of combined sewers and divert flows to the 1200 mm trunk, away from the remaining downstream sewers along Jamieson.
- Infrastructure upgrades are recommended within (C), along Windmill, Lyle, and Wise Rd. Separation of a small segment is also recommended along Wyse Rd., as there is opportunity to connect to the existing 750 mm storm sewer along Lyle St.

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- It is recommended that future separation projects be considered, primarily around the separation of Lake Albro. The separation strategy for the lake will impact the strategies and alignments for separation of the (A) and (B) pockets.

Table 26, below, provides details and costs of the preferred option projects for Wyse Road area.

Table 26: Wyse Road Preferred Option Projects and Costs

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)
Wyse	13	W1	375 mm combined sewer upgrade along Ropewalk Ln (with diversion at MH19270)	Dartmouth	Combined Sewer	375 mm	81	$121,000
Wyse	14	W2	450 mm combined sewer upgrade along Jamieson - south of Rosedale Dr. (with diversion at MH19291)	Dartmouth	Combined Sewer	450 mm	79	$127,000
Wyse	15	W3	300 mm combined sewer upgrade along Wyse Rd. (from Angus L. Macdonald to Green Rd.)	Dartmouth	Combined Sewer	300 mm	169	$238,000
Wyse	16	W4	600 mm combined sewer upgrade along Lyle Street (from Wyse Rd. to Windmill Rd.)	Dartmouth	Combined Sewer	600 mm	422	$803,000
Wyse	17	W5	750 mm combined sewer upgrade along Lyle (from Windmill Rd. to Shore Rd.)	Dartmouth	Combined Sewer	750 mm	106	$282,000
Wyse	18	W6	450 mm combined sewer upgrade along Windmill (from Dawson to Pelzant)	Dartmouth	Combined Sewer	450 mm	210	$339,000
Wyse	19	W7	525 mm combined sewer upgrade along Windmill (from Faulkner to Dawson)	Dartmouth	Combined Sewer	525 mm	95	$165,000
Wyse	20	W8	600 mm combined sewer upgrade along Windmill (from Lyle to Faulkner)	Dartmouth	Combined Sewer	600 mm	83	$158,000
Wyse	21	W9	Diversion at MH19371 (Howe St. and Wyse Rd. intersection)	Dartmouth	Combined Sewer			$50,000
Wyse	22	W10	New 450 mm storm sewer along Wyse Rd. connecting into existing 750 mm storm sewer along Lyle	Dartmouth	Storm Sewer	450 mm	330	$533,000
							TOTAL	**$2,816,000**

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14 Development Capacity Tracking Tool (DCTT)

A Development Capacity Tracking Tool (DCTT) was developed as part of the Regional Centre Local Wastewater Servicing Capacity Analysis (LoWSCA) project. The aim of the DCTT is to provide users with the ability to track proposed, approved, and/or built development, and quickly assess the performance of the existing system under different development scenarios. Outputs from the tool may include, but are not limited to:

- Tracking development over time and whether or not it is proposed, approved, built but not included in base flows, or built and included in base flows.
- Identifying where and how much available capacity exists within the system, in terms or population, units, or hectares for Greenfield development.
- Identifying trigger points for capital upgrades for different 'what if' scenarios.
- Prioritizing areas with greatest development potential and those with limitations.

Objectives that were used to meet the aim of the tool were:

- Ensure everything is fully dynamic so that inputs, such as people per unit, units per hectare, and per capita rates, can be changed and all results automatically updated.
- Provide considerations for different development types, such as intensification versus Greenfield development, and apartments versus detached housing.
- Provide considerations for proposed, approved, and built development; this allows for continuous tracking of development as they move through different phases.
- Use modelling results for existing flow conditions.
- Results from the tool can be mapped as an output.
- Tool can be easily updated by any user.

When assessing capacity, it is important that the tool is used as an initial assessment not the absolute answer for infrastructure decisions. Modelling and capacity assessment exercises should still be used in the evaluation of proposed developments.

Appendix F provides an outline of the methodology that was used in the development of the DCTT in addition to a set of user guidelines, for general use or future updates. The final section of the memo presents preliminary results for two scenarios, LoWSCA proposed development under a 2-Year and a 5-Year design storm for both the Halifax Peninsula and Dartmouth areas.

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15 Recommended Capital Plan & Cost Estimates

Table 27 shows a summary of the preferred solution costs by area

Table 28 provides the full project level capital program for each of the six target intensification pocket areas.

Table 27: Preferred Solution Summary Costs by Area

Area	Cost ($)
Quinpool Road	$365,000
Spring Garden	$3,744,000
Young Street	$6,447,000
Agricola & Gottingen Street	$186,000
Wyse Road	$2,816,000
Canal Street	$616,000
Total	**$14,174,000**

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Table 28: Detailed Capital Program for All Target Pockets

Region	Capital Plan Project No.	Area Project ID	Project Description	System	Project Type	Diameter (mm)	Length (m)	Total Cost $ (2016)	Growth Blocks Serviced	Comment
Quinpool	1	Q1	525 mm combined sewer upgrade along Quinpool Rd.	Halifax	Combined Sewer	525 mm	211	$365,000	6, 7, 8	MH1876 - offset invert of sewer along Preston
Spring Garden	2	SG1	New 450 mm storm sewer along College St.	Halifax	Storm Sewer	450 mm	159	$258,000	Entire Pocket	
Spring Garden	3	SG2	New 900 mm storm sewer along Robie-Spring Garden-Carlton-College	Halifax	Storm Sewer	900 mm	780	$2,403,000		
Spring Garden	4	SG3	New 1200 mm storm sewer along South Park St. connecting into existing 1200 mm storm sewer	Halifax	Storm Sewer	1200 mm	252	$1,083,000		Connects into existing 1200mm diameter storm sewer on South Park St., north of South St.
Young	5	Y1	New 375 mm storm sewers (roughly 6 equal in length) connecting to Robie St.	Halifax	Storm Sewer	375 mm	774	$1,155,000	Entire Pocket	
Young	6	Y2	New 450 mm storm sewers along Almon St. and Young St.	Halifax	Storm Sewer	450 mm	866	$1,397,000		
Young	7	Y3	New 600 mm storm sewer along Robie St.	Halifax	Storm Sewer	600 mm	461	$876,000		Connects into MH3695. Disconnect Block 3 storm sewers from MH3682 (combined)
Young	8	Y4	New 825 mm storm sewer along Kempt	Halifax	Storm Sewer	825 mm	182	$520,000	Entire Pocket	
Young	9	Y5	New 900 mm storm sewer along Kempt	Halifax	Storm Sewer	900 mm	449	$1,383,000		
Young	10	Y6	New 750 mm storm sewer along Kempt	Halifax	Storm Sewer	750 mm	420	$1,116,000		
Agricola & Gottingen	11	AG1	750 mm combined sewer upgrade along Portland	Halifax	Combined Sewer	750 mm	35	$93,000	10, 11, 12, 13, 14	
Agricola & Gottingen	12	AG2	900 mm combined sewer upgrade along Brunswick	Halifax	Combined Sewer	900 mm	30	$93,000		
Wyse	13	W1	375 mm combined sewer upgrade along Ropewalk Ln (with diversion at MH19270)	Dartmouth	Combined Sewer	375 mm	81	$121,000	6, 7, 8, 11, 12, 13	MH19270 - offset invert of sewer along Brookside, divert flows along Ropewalk
Wyse	14	W2	450 mm combined sewer upgrade along Jamieson - south of Rosedale Dr. (with diversion at MH19291)	Dartmouth	Combined Sewer	450 mm	79	$127,000		MH19291 - offset invert of sewer along Jamieson, divert flows towards 1200mm trunk
Wyse	15	W3	300 mm combined sewer upgrade along Wyse Rd. (from Angus L. Macdonald to Green Rd.)	Dartmouth	Combined Sewer	300 mm	169	$238,000	12, 13, 14, 15, 18, 19, 20, 21	
Wyse	16	W4	600 mm combined sewer upgrade along Lyle Street (from Wyse Rd. to Windmill Rd.)	Dartmouth	Combined Sewer	600 mm	422	$803,000		
Wyse	17	W5	750 mm combined sewer upgrade along Lyle (from Windmill Rd. to Shore Rd.)	Dartmouth	Combined Sewer	750 mm	106	$282,000		
Wyse	18	W6	450 mm combined sewer upgrade along Windmill (from Dawson to Pelzant)	Dartmouth	Combined Sewer	450 mm	210	$339,000	9, 10, 16, 17, 18, 19	
Wyse	19	W7	525 mm combined sewer upgrade along Windmill (from Faulkner to Dawson)	Dartmouth	Combined Sewer	525 mm	95	$165,000		
Wyse	20	W8	600 mm combined sewer upgrade along Windmill (from Lyle to Faulkner)	Dartmouth	Combined Sewer	600 mm	83	$158,000		
Wyse	21	W9	Diversion at MH19371 (Howe St. and Wyse Rd. intersection)	Dartmouth	Combined Sewer	-	-	$50,000	1, 2, 3, 4, 5	MH19371 - offset invert of sewer along towards Howe, divert flow along 600mm towards Albro Lake Rd. *assumed cost*
Wyse	22	W10	New 450 mm storm sewer along Wyse Rd. connecting into existing 750 mm storm sewer along Lyle	Dartmouth	Storm Sewer	450 mm	330	$533,000	10,14, 15, 16, 19	connects into existing 750mm along Lyle St., collects existing separated sewers from Block 15
Canal	23	C1	New 375 mm storm sewer along Portland St.	Dartmouth	Storm Sewer	375 mm	91	$136,000	1, 2, 4, 5	
Canal	24	C2	New 600 mm storm sewer along Canal St. connecting into existing 600 mm storm sewer	Dartmouth	Storm Sewer	600 mm	252	$480,000		connects into existing 600mm storm sewer along Canal St.
GRAND TOTAL								**$14,174,000**		

Appendix A RWWFP Technical Memo - Policy and Legislation

AECOM
105 Commerce Valley Drive West, Floor 7 905 886 7022 tel
Markham, ON, Canada L3T 7W3 905 886 9494 fax
www.aecom.com

Memorandum

To	Steve Murphy, CBCL	Page	1 of 61
CC	Ray Rice, AECOM		
Subject	Review of Halifax Water's Policies, Procedures and Legislation		
From	James Jorgensen		
Date	November, 2011	Project Number	60145704 (AECOM) 101001.00 (CBCL)

Executive Summary

This memorandum summarizes the review of current policies, procedures, and legislation affecting wastewater service delivery for Halifax Water (HW). A review of other municipalities was also undertaken to draw on experiences and policies that may be beneficial to Halifax Water.

The objectives of this document include:

- Provide direction for planning and identify wastewater servicing issues which may impact growth options
- Provide direction and guidelines for development and evaluation of servicing alternatives for the Regional Functional Wastewater Master Plan
- Identify policies that can reasonably be implemented
- Identify policies that can stand the test of time. It is anticipated that best practices and criteria can be updated over time while the context and intent of the policy should remain valid without requiring revision.

The document reviews current guidance and best practice at Federal, Provincial and Municipal levels, highlighting the relevance of each to HW. The review continues, looking at practices in other regions. Following this review the document highlights the primary policy statements that feature as common, key concerns within the reviewed information and have relevance to HW's long term wastewater planning objectives.

There is a plethora of existing policies and regulations that are directly applicable to Halifax Water. Perhaps the most significant of these is the Canada-wide Strategy for the Management of Municipal Wastewater Effluent (CCME). If fully adopted this strategy has implications for all aspects of HW's waste water system, from overflows to treatment facilities. The strategy seeks to impose relatively strict limits on effluent discharges that will require significant upgrading of HW's current infrastructure in order to achieve. Beyond asset improvements the strategy also calls for the development of monitoring procedures to provide a measurement of compliance.

Other policies and strategies used elsewhere, as described in this report, could be modified to HW's requirements and play an important role in supporting the attainment of the CCME requirements.

As evidenced below, other regions have employed a variety of strategies in order to improve their asset performance. Chesapeake Bay (Maryland Dept of the Environment) serves as one such example where a diversity of regulatory and planning programs has been introduced to reduce the input of pollutants to surface and ground waters. In 2009 the state introduced the 'Sanitary Sewer Overflow Enforcement Initiative' to address unauthorized discharges of sewage. Part of this initiative

sets out significant financial penalties, up to $32,000 per day, enforceable under state and federal law for unauthorized discharges. HW should be mindful of the potential to be subject to similar strict enforcement in the future and prepare now, though the development of their Master Plans to be prepared for any such regulatory change in the future.

Other case studies included highlight the level of engineering intervention that can be required to meet regulatory compliance, such as the Thames Water London Tideway project which is being implemented to improve the water quality of the Thames River that flows through London. The Water Company is currently failing to comply with the European Union Urban Waste Water Treatment Directive. The total costs of the improvements are estimated to be £5 billion ($8 billion C. dollars).

Finally, the document compiles the review findings into a policy matrix which defines the ten most pertinent policies or objectives relevant to HW. Each policy statement or objective is categorised and contains defined aims or practices that HW can focus on in order to achieve the overall objective. In total there are forty-seven aims/practices spread over the ten policy statements/objectives. For each practice, where applicable, a metric is defined in order to provide a mechanism to assess progress and attainment of the objectives. The ten policy statements are as follows:

1. Optimize the use of the existing wastewater system/network.
2. Minimize the long term life cycle costs of the wastewater system through revised design standards.
3. Monitor wastewater systems to identify water quality/waste loading issues and system capacity/quantity limitations.
4. Manage wastewater flows in the combined sewer system to minimize overflows to the environment and property.
5. Manage wastewater flows in the sanitary sewer system to minimize overflows to the environment and property.
6. Optimize available system capacity.
7. Regulate allowable flow into the wastewater system.
8. Meet effluent discharge limits as defined by NSE and consistent with the CCME for all wastewater treatment facilities.
9. Ensure new development does not impact the frequency, volume, and quality of combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs).
10. Ensure HRM and Halifax Water policies for growth are consistent.

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1. Introduction

This memorandum summarizes the review of current policies, procedures, and legislation affecting wastewater service delivery for Halifax Water (HW). A review of other world class municipalities was also undertaken to draw on experiences and policies that may be beneficial to Halifax Water.

The objectives of this document include:

- Provide direction for planning and identify wastewater servicing issues which may impact growth options
- Provide direction and guidelines for development and evaluation of servicing alternatives for the wastewater Master Plan
- Set policies that can reasonably be implemented
- Set policies that can stand the test of time. It is anticipated that best practices and criteria can be updated over time while the context and intent of the policy should remain valid without requiring revision.

The document reviews current guidance and best practice at Federal, Provincial and Municipal levels, highlighting the relevance of each to HW. The review continues, looking at practices in other regions. Following this review the document highlights the primary policy statements that feature as common, key concerns within the reviewed information and have relevance to HW's long term wastewater planning objectives.

Finally, the document compiles the review findings into a policy matrix which defines the ten most pertinent policies or objectives relevant to HW. Each policy statement or objective is categorised and contains defined aims or practices that HW can focus on in order to achieve the overall objective. In total there are forty-seven aims/practices spread over the ten policy statements/objectives. For each practice, where applicable, a metric is defined in order to provide a mechanism to assess progress and attainment of the objectives. The ten policy statements are as follows:

1. Optimize the size and extent of the wastewater system/network.
2. Minimize the long term life cycle costs of the wastewater system through revised design standards.
3. Monitor wastewater systems to identify water quality/waste loading issues and system capacity/quantity limitations.
4. Manage wastewater flows in the combined sewer system to minimize overflows to the environment and property.
5. Manage wastewater flows in the sanitary sewer system to minimize overflows to the environment and property.
6. Optimize available system capacity.
7. Regulate allowable flow into the wastewater system.
8. Meet effluent discharge limits as defined by NSE approvals to operate for all wastewater treatment facilities.
9. Ensure new development does not impact the frequency, volume, and quality of combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs).
10. Ensure HRM and Halifax Water policies for growth are consistent.

1.1 Summary of Existing Practice – Halifax Water

Halifax Water is the municipal water, wastewater and stormwater utility serving residents of the Halifax Regional Municipality (HRM). It is an entity incorporated under the Halifax Regional Water Commission Act, authorized to own and operate water, stormwater and wastewater facilities for the benefit of the residents of HRM.

Community wastewater discharges and system connections into the Halifax Water regional collections system are subject to the *Schedule of Rules and Regulations for Water, Wastewater and Stormwater Services* (Schedule "B") and the *Schedule of Rules and Regulations for Wastewater Service* (Schedule "C"). These rules and regulations are in place to regulate the direct and indirect discharge of wastewater, drainage, substances and contaminants into any wastewater facility or sewer. The rules and regulations are intended to protect public health and the environment, and to ensure the proper operation and maintenance of the existing wastewater collection system.

1.2 Programs already in place by Halifax Water

- Stormwater Inflow Reduction (SIR) program
  - Initiated in 2009
  - Designed to address HRM's most serious wastewater operational problems
  - Includes investigation, testing, inspecting and follow-up visits to public and private parts of the wastewater system
  - Current resourcing: one team conducting approximately 300 inspections per year; no resources allocated to implementation or monitoring.
- Source Control / P2 Program (Pollution Prevention division)
  - Regulates discharges into municipal wastewater and stormwater systems
  - Inspects all ICI locations within HRM serviced sewersheds
  - Primary contact for agencies during incidents involving releases or spills
  - Will be bringing forth changes to existing Rules and Regulations (Schedule "B" and "C") to reflect improved language and control measures in model sewer use by-law
  - Current resourcing: two teams conducting approximately 400 inspections per year
- Asset Management Program (Engineering & IS)
  - Asset management (AM) assessment – awarded to CH2M Hill and completed in June 2011
  - AM office put in place – August 2011
  - AM Roadmap implementation over the next 5 years pending available funding
  - Ongoing infrastructure inventories and condition assessments to be completed
- Capital Renewal (Engineering & IS)
  - Annual capital project implementation for asset renewal, rehabilitation, and replacement
  - Water, wastewater, and stormwater infrastructure in addition to SCADA, GIS, IT, and operational upgrades
  - Current annual investment level of approximately $25 million
- Operations and Maintenance (Wastewater/Stormwater Collection division)
  - Cleaning of sewers and pumping stations, repair and maintenance, CCTV inspection, assist with infrastructure inventory

- Other wastewater/stormwater collection programs and activities (various departments)
  - Development approvals
  - Integrated Resource Plan (IRP)
  - Drainage investigations
  - Energy efficiency projects

1.3 Background on System

Halifax Regional Municipality has an extensive wastewater collection system that consists of over 2,000 km of pipe, 37,000 manholes 13 wastewater treatment facilities, 3 Halifax Harbour Solutions wastewater treatment facilities, 160 pumping stations, and 10 retention/holding tanks. The system consists of both combined wastewater and stormwater areas as well as separated sewer areas. In 2007, HRM's wastewater and stormwater assets were transferred to Halifax Water.

Given the fact that HRM is surrounded by a series of harbours, basins, and lakes, Halifax Water has endeavoured to continuously improve and upgrade the wastewater collection system in an attempt to address wastewater overflows to these bodies. Since the merger, Halifax Water has funded operation and capital expenditures from revenue with minimal assistance from the municipal government and limited funding sources from federal and provincial infrastructure programs.

Summary review of relevant policies, procedures and legislation

2. Federal Policy

- Canadian Environmental Protection (CEPA) Act, 1999
  - Governs the release of toxic substances into the environment and enables regulations to control or eliminate use of these substances
- Fisheries Act
  - Protects Canadian waters against the deposit of harmful substances into fish habitats
  - However, there is currently no regulation applicable to the release of Municipal Waste Water Effluent (MWWE), although this is pending.
- Canada-wide Strategy for the Management of Municipal Wastewater Effluent, CCME
  - Provides a harmonized and collectively agreed-to regulatory framework for municipal wastewater effluent management in Canada

2.1 CEPA, 1999 – Inorganic Chloramines and Chlorinated Wastewater Effluents in Municipal Wastewater Effluent

- Notice published on December 4, 2004, under Part 4 of the CEPA, 1999 requiring the preparation and implementation of pollution prevention plans for inorganic chloramines and chlorinated wastewater effluents
- Applicable to WWTFs with:
  - Average effluent flow greater than or equal to 5000 m^3/d during either 2004 or 2005
  - Total Residual Chlorine concentration greater than 0.02 mg/L
- Implementation required by December 31, 2010

2.2 Canada-wide Strategy for the Management of Municipal Wastewater Effluent (CCME)

- The Canada Wastewater Systems Effluent Regulations (WSER) are the principal instrument that Environment Canada is using to implement the Canadian Council of Ministers of the Environment (CCME) Canada-wide Strategy for the Management of Municipal Wastewater that was endorsed in 2009.
- *CCME Objective:* to achieve regulatory clarity in managing municipal wastewater effluent under a harmonized framework that is protective of human health and the environment.
- To achieve the above goal, the Strategy focuses on two outcomes:
  1. Improved human health and environmental protection
  2. Improved clarity about the way municipal wastewater effluent is managed and regulated
- Improved Human Health & Environmental Protection
  - National Performance Standards (NPS) for Waste Water Treatment Facilities (WWTF's):
    1. Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) – 25 mg/L
    2. Total Suspended Solids (TSS) – 25 mg/L [1]
    3. Total Residual Chlorine (TRC) – 0.02 mg/L
    4. Un-ionized ammonia <=1.25 mg/L at 15 ˚C

  - Effluent Discharge Objectives (EDOs)
    5. Established through site-specific Environmental Risk Assessments (ERAs) that includes initial characterization of the effluent and considers the characteristics of the receiving environment and mixing
- Within one (1) year, jurisdictions will determine the initial risk level for WWTFs that do not meet the NPSs. Timelines for compliance of NPS based on level of risk are:
  - High risk: 10 years
  - Medium risk: 20 years
  - Low risk: 30 years
- Within seven (7) years, WWTFs will submit action plans where prioritization of actions is required
- Within eight (8) years, an Environmental Risk Assessment will be completed for all WWTFs and site-specific EDOs established where necessary
- A one (1) year initial characterization will be completed as part of the risk assessment
- All new and upgraded WWTFs will meet the NPSs immediately.
- Reduction at Source
  - Eliminate or reduce pollutants entering the wastewater system from all sources
  - Model Sewer Use Bylaw provides guidance to municipalities to control what is discharged to wastewater systems (source control)
- Toxicity
  - Medium and large sized wastewater facilities required to conduct whole effluent toxicity testing (> 2500 m3/d)
- Combined and Sanitary Sewer Overflows
  - Ensure that CSOs and SSOs will not increase in frequency due to development, unless it occurs as part of an approved long-term management plan
  - No CSO discharge during dry weather, except during spring thaw and emergencies
  - Removal of floatable materials where feasible
  - Within seven (7) years, the national overflow standards for CSOs and SSOs must be met and a long term plans to reduce CSOs and capture substances will be in place
- Monitoring and Reporting
  - National Performance Standards (NPS) and toxicity to be regularly monitored
  - EDO monitoring based on frequency set by jurisdiction
  - Results of monitoring related to NPSs, EDOs, and CSOs will be reported to the public at least once per year
  - Environmental monitoring at watershed level
  - Within three (3) years, all facilities will begin to monitor effluent quality. WWTFs must monitor for compliance with NPSs and any EDOs
  - Within five (5) years, a mechanism will be developed under CCME for monitoring the receiving environment at a watershed level
  - Within three (3) years, all facilities will meet public reporting requirements as per jurisdictional requirements
- Governance
  - Improved clarity about the way municipal wastewater effluent is managed and regulated
  - Harmonization of regulatory requirements important to establish a one-window approach to governance so WWTF owners and operators deal with a single regulatory agency

  - Regulatory clarity will be achieved through consistent implementation of performance standards in a harmonized regulatory framework
  - Within three (3) years, jurisdictions will incorporate requirements into their respective regulatory frameworks and develop implementation plans
- Key Activities relating to the CCME:
  - Harmonization of the Regulatory Framework
  - Coordinated Science and Research
    - Review of the state of knowledge on science and technology
    - Assess the need for action regarding emerging issues
  - Environmental Risk Management Model
- Develop and implement the concept of an Environmental Risk Management Model (ERMM)
  - Integrate list of pollutants, achievable/desirable performance standards and characteristics of site specific receiving environment
  - Include management of nitrogen and phosphorus
- CCME CSO/SSO Long-Term Control Plan currently in draft form
  - Based on the United States Environmental Protection Agency: CSO Long-Term Control Plan Template for Small Communities
  - See Section 3.6: Nova Scotia Environment for further details on how the NSE anticipates the CCME will define the assessment of sewer overflows.

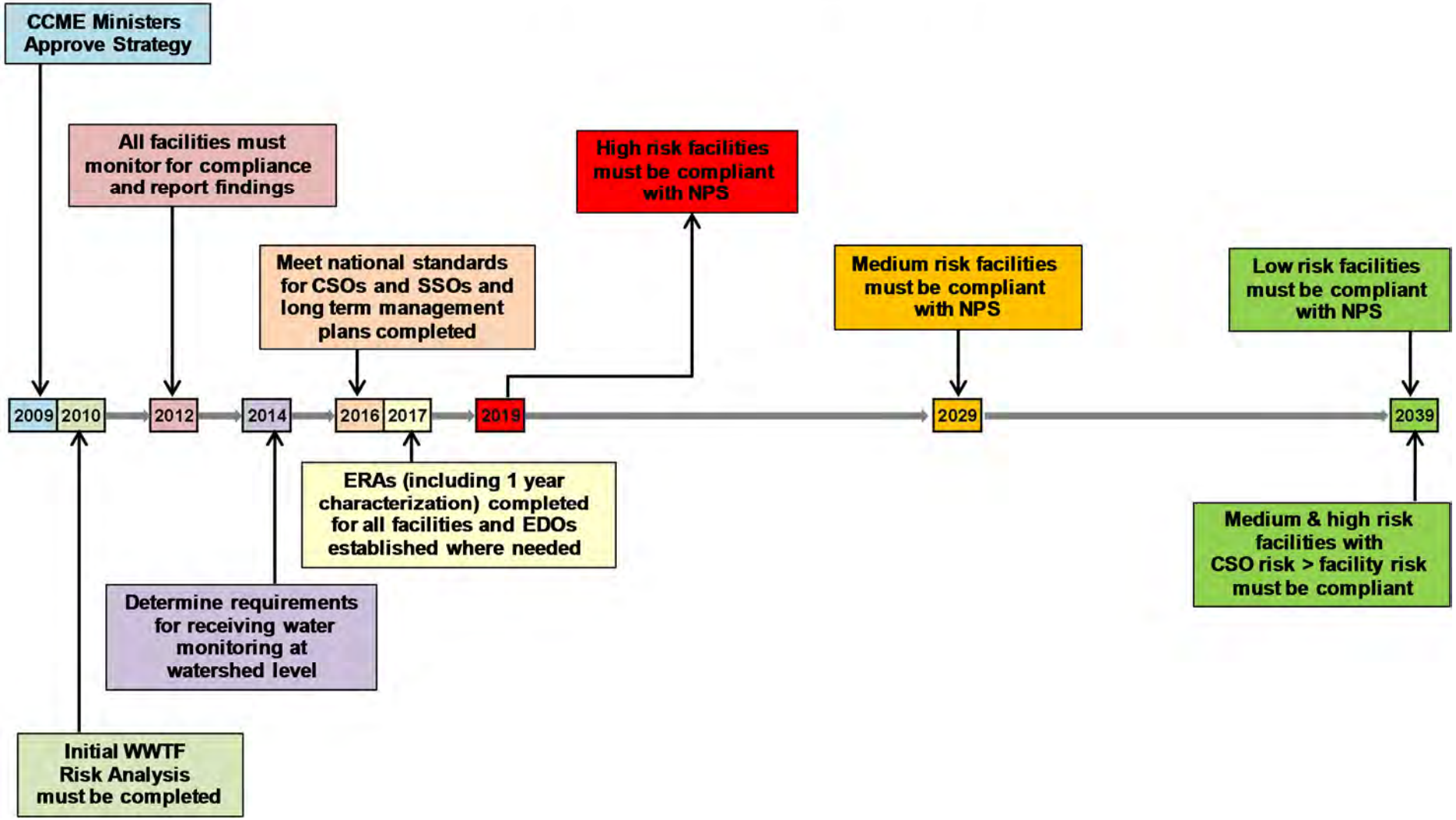
2.3 Implications of CCME Strategy

- Compliance is expected to be fully achieved through risk-based implementation timelines that extend over 30 years. However, a significant proportion of wastewater systems not currently meeting the standards are anticipated to be high risk. These would be required to meet the standards within 10 years. This approach provides time for owners and operators of systems requiring infrastructure upgrades to plan, finance, and implement cost-effective measures to meet the required standards.
- Implications of Canada-wide Strategy for the Management of Municipal Wastewater Effluent for Halifax Water:
  - Facilities currently using chlorine disinfection may not meet the national TRC standards and will require dechlorination upgrades or conversion to UV disinfection
  - Aerotech biosolids processing and dewatering facilities may also need upgrading to handle increased biosolids load with increased treatment level
  - Compliance with National Performance Standards (NPS) may require upgrading of the following facilities to secondary treatment levels:
    - Halifax WWTF
    - Dartmouth WWTF
    - Herring Cove WWTF
      (Halifax, Dartmouth and Herring Cove plants are advanced primary plants with design effluent quality limits that are generally lower than normal primary treatment but are still likely to be higher than the NPS's)
    - Eastern Passage WWTF (The Eastern Passage WWTF is currently scheduled to undergo an upgrade to a secondary facility. The construction contract has recently been signed for this project.)

- Figure 1, below, shows HW's timeline to achieve compliance with the CCME strategy, However, given that the CCME and Fisheries Regulations have not been formally adopted the timeline outlined may be subject to change

- CCME Strategy requires that effluent from all WWTFs be screened for a broad list of parameters which may have impacts on receiving waters
- Provincial jurisdictions may decide to impose standards beyond the basic NPS
- A one-year characterization must be completed for all facilities as part of an ERA

Figure1: Halifax Water's CCME Strategy Compliance Timeline



2.4 Receiving Water Environmental Risk Analysis (ERA)

- Receiving water ERAs must be conducted for all WWTFs since jurisdictions will use these analyses to determine if additional effluent discharge objectives (EDOs) are required
- ERAs will determine environmental concentrations of discharged substances outside of the defined mixing zone in the receiving waters
- Initial budget allocation was provided in FY 2009/10 ($100,000) for the AerotechWWTF and the ERA for the Beechville/Lakeside/Timberlea WWTF was recently awarded for $150,000 - $200,000
- ERA for Eastern Passage was completed as part of current upgrade
- WWTF risk analysis under CCME produces the following unofficial results:

WWT Facility	Compliant	Reason	Risk	Timeframe
• Halifax [1] • Dartmouth [1] • Herring Cove [1]	NO	High BOD/TSS	• Medium • Medium • Low	20 years 20 years 30 years
Eastern Passage	NO	High BOD/TSS	Upgrade initiated.	
Lakeside-Timberlea [2]	NO	High TRC	Low	30 years
AeroTech [3]	NO	High BOD/TSS	Medium	20 years
Belmont [4]	NO	High TRC	To be decommissioned.	
Frame [5]	NO	High TRC	Low	30 years
Lockview-MacPherson (Fall River) [6]	YES	N/A	Low	N/A
Middle Musquodoboit	YES	N/A	Low	N/A
North Preston	YES	N/A	Low	N/A
Springfield Lake [7]	NO	High TRC	Low	30 years
Steeves (Wellington) [8]	NO	High TRC	Low	30 years
Uplands Park [9]	YES	N/A	Low	N/A
Mill Cove	YES	N/A	Medium	N/A

Notes below:

[1]Facilities were designed as advanced primary facilities with EDOs for BOD/TSS of 50/40 mg/L. As part of the CCME Strategy, systems with CSO discharges must also consider the risk inherent in the CSOs, and if the CSO risk score on a sewershed basis exceeds the risk score for the facility, then both CSOs and facility must be compliant within 30 years. CSO risk analyses to be carried out for Halifax and Dartmouth. Herring Cove is low risk.
[2] WWTF currently at the maximum capacity allowed by NSE due to limited dilution of discharge in receiving waters. Future study to examine options for dealing with growth, including reduction of chlorine or upgrade to UV disinfection.
[3] Further study of options required due to significant receiving water limitations.
[4] Flows will be diverted to Eastern Passage WWTF as part of Eastern Passage upgrade.
[5] Upgrade planned which will include conversion to UV disinfection.
[6] Fall River community is the subject of an HRM planning study for future growth (completed in 2009). Study will consider options for future wastewater treatment to accommodate projected growth. Result of study called for limited growth in the community but no growth in WWTF flows. Fall River WWTF also being assessed by Halifax Water for facility optimization and enhancement of treatment process – no growth anticipated as a result of the HRM planning exercise due to assimilative capacity of the receiving stream.
[7] Upgrade will need to be planned to dechlorinate or to convert to UV disinfection.
[8] Upgrade to UV disinfection is planned.
[9] Upgrade to UV disinfection is complete (2011). Will ultimately be decommissioned and flows re-directed to Halifax WWTF with the development of Bedford West.

3. Provincial Policy

3.1 Atlantic Canada Wastewater Guidelines Manual (Environment Canada 2006)

- Atlantic Canada Wastewater Guidelines Manual
- Adopted in 2003, superseding Nova Scotia guidelines established in 1992.
- Reference for the collection, treatment and disposal of sanitary sewage
- Sewage Flows:
  - Residential – average day flow 340 L/cap/d, peaked using Harmon or Babbit Formulas (min. 2)
  - ICI – generally use population equivalent of 85 persons / ha; individual flow rates also provided within manual (Table 2.1).
  - I&I Allowance:
    - area allowance: from 0.14 to 0.28 L/s per gross ha
    - length and diameter of pipe allowance: from 0.24 to 0.48 m^3/cm of pipe diameter/km length of pipe per day
- No universal effluent discharge limits in place for existing facilities
- Prior to the Atlantic Canada guidelines, generic objectives based on receiving water were as follows:

Category	BOD 5 (mg/L)	Suspended Solids (mg/L)	Fecal Coliforms (#/100 mL)
Fresh, limited dilution	5	5	200
Fresh, with dilution	10	10	200
Brackish waters or restricted bays	20	20	1,000
Open ocean	30	30	5,000

- Since then, site-specific effluent guidelines are required based on assessment of dilution ratio; a measure of a receiving water's assimilative capacity and should be based on the 7 consecutive day average low streamflow occurring once in 20 years(7Q20) and the peak hourly effluent discharge rate.
- A receiving water assessment is recommended for all new WWTFs and mandatory when discharges > 200 m^3/d or dilution ratios exceed 7Q20 in the receiving water
- Receiving water studies focus on:
  - Assessment of water quality
  - Factors affecting mixing
  - Sampling of indigenous aquatic biota may also be required
- Limits are based on assimilative capacity of the receiving water, taking into account water uses

- See Table E2, below, for wastewater effluent requirements:

TABLE E.2 EFFLUENT REQUIREMENTS (See Note 4 and 5)

POINT OF DISCHARGE	FECAL COLIFORM MPN/100ml	REQUIRED EFFLUENT QUALITY $CBOD_5$/SS mg/L (See note 2&3)
Fresh water lakes low flow streams (5-10 times dilution) (See note 1)	200	0-20/0-20 (dependant upon results of receiving water assessment)
Rivers and estuaries	200	20/20
Open coastline(Not applicable in N.B)	200	25/25

NOTES

1) Low flow streams may require periods of no discharge.
2) Effluent quality may be stipulated as a result of a receiving water assessment.
3) Nutrient removal may also be specifically required.
4) See section 1.2.1 for effluent discharge requirements
5) Table E.2 not applicable to N.L. Refer to Newfoundland and Labrador Regulation 65/03 *Environmental Control Water and Sewage Regulations, 2003*

Source: Atlantic Canada Waste Water Guidelines Manual, 2006.

- WW effluent discharge is limited/restricted for low flow receiving waters based on limited dilution, such as the Nine Mile River and Johnson River; could conflict with CCME standards.
- The Nova Scotia Environment Policy concerning dilution requirements for receiving waters, as shown above in Table E2, has implications for WWTF discharges. The policy limits/restricts WWTP effluent discharge in low flow streams where sufficient dilution is unavailable. This policy could conflict with CCME regulations, and is currently presenting concerns at the Aerotech and Laskeside Timberlea WWTP's which currently discharge to low flow streams.
- All new sewer systems be designed as separate sewers
- Requirements for CSO treatment specified by the regulatory agency having jurisdiction
- Reduce, where possible and practical, the frequency and duration of CSOs to minimize impacts on receiving water
- Chlorination unless waived by the regulatory agencies
- Alarmed and equipped to indicate frequency and duration of overflows, and designed to permit manual flow measurement
- All overflows should be recorded and reported to the regulatory agencies

3.2 Environment Act, 1995

- Water and Wastewater Facility Regulations (amended to N.S. Reg. 140/2000)
- Activities Designation Regulations (N.S. Reg. 47/95)
- On-Site Sewage Disposal Systems Regulations [also made under the Health Act] (amended to N.S. Reg. 129/2001)

- On-Site Services Advisory Board Regulations [also made under the Health Act] (N.S. Reg. 149/2002)
- Emergency Spill Regulations, N.S. Reg. 59/95

3.3 Water and Wastewater Facility Regulations, N.S. Reg. 60/95

- Water and wastewater treatment facility classifications according to a specific points system and by service population
- Operator certification education and experience requirements
- Financial assistance for municipal sewage studies
- Monitoring requirements for public drinking water supplies

3.4 Activities Designation Regulations, N.S. Reg. 47/95

- Identifies certain activities which require regulatory approval from the Minister or an Administrator designated by the Minister
- Section 7(2), Division III (Municipal Waste Approvals), Part 1 (Sewage/Storm Drainage/Seepage), designates the construction, operation, or reclamation of a sewage works as an activity, and includes:
  - sewage collection system and pumping stations
  - retention or storage facilities
  - treatment facilities
  - Outfalls
- Section 26 of the Regulations also designates the “construction, operation or reclamation of an industrial composting facility” as an activity

3.5 Emergency Spill Regulations, N.S. Reg. 59/95

- Regulations for unauthorized release of designated contaminants
- Reporting requirements
- Training and powers of emergency responders
- Wastewater is listed as a designated contaminant under “Unauthorized sewage discharge into fresh water or sensitive marine water”

3.6 Nova Scotia Environment (NSE)

- The NSE regulates activities relating to: Capacity, Effluent Quality, Monitoring & Reporting and Biosolids Quality, Water Strategy, Stormwater approvals, Watercourse alterations, Wetlands Conservation Policy, Floodplain delineation and management and Erosion and Sediment Control Guidelines.
- Generally, Nova Scotia Environment (NSE) intends to retain alignment with the CCME strategy in that they want no increased overflows due to development without an approved overflow management plan.
- NSE wants municipalities to record the frequency of overflows over the next 5 years. Municipalities should review trends and identify the mitigation plan (to be submitted to NSE for approval by 2017).
- NSE has begun discussions regarding the prioritization of combined sewer overflows (CSOs) versus sanitary sewer overflows (SSOs). NSE favors a risk based prioritization method based on risk to health and the environment.

- From a federal perspective, the new wastewater regulations will require an estimation of the volume of overflow or actual flow measurement. NSE recognizes this is not practical for all Nova Scotia municipalities and for some overflow locations. Where the recording of actual data is unfeasible and estimation of overflow impacts will be required, the use of hydraulic modeling for estimating purposes may be permitted.
- Overflows should be ranked based on a scoring system and risk categorized high, medium and low priority.
- NSE is not in favor of an overflow credit scenario where increases in overflow at one location are offset by decreases at another.
- NSE anticipates that CCME overflow compliance will be assessed at an asset level, not at a collective sewershed level.

4. Municipal Local Policy

4.1 Halifax Regional Water Commission Act, 2007 (Bill No. 83)

http://halifax.ca/hrwc/documents/HalifaxWaterAct1-RoyalAssentDec13-07.pdf

- Gives responsibility of water, wastewater and stormwater systems to HRWC

4.2 Halifax Regional Municipality Charter, 2008 (Bill No. 179)

http://nslegislature.ca/legc/bills/60th_2nd/3rd_read/b179.htm

- The purpose of the act is to give broad authority to the Council, including broad authority to pass by-laws, and respect its right to govern the Municipality in whatever ways the Council considers appropriate within the jurisdiction given to it. Responsibilities include those relating to the provision, maintenance and regulation of water and wastewater systems.

4.3 Atlantic Canada Wastewater Guidelines Manual (Environment Canada 2006)

- See above

4.4 Schedule "B" Rules and Regulations for Stormwater Service

http://halifax.ca/hrwc/documents/ScheduleBRulesRegulations_Stormwater2009.pdf
http://www.halifax.ca/regionalplanning/documents/ServiceRequirementsScheduleBupdatedMay272010.pdf

4.5 Schedule "B" Rules and Regulations for Airport/Areotech System

http://halifax.ca/hrwc/documents/AirportAerotechRulesandRegs-effectiveDec1-08.pdf

4.6 Schedule "C" Rules and Regulations for Wastewater Service:

http://halifax.ca/hrwc/documents/ScheduleCRulesRegulations_Wastewater.pdf

- Amended by Orders dated April 3, 2008 and March 30, 2009
- Commission reserves the right to undertake testing for cross connections to the wastewater system from time to time
- Details on installation of property owner's plumbing, pipes, fittings, vents, fixtures and other devices for conveying, distributing, controlling or handling wastewater
- Details on the design and construction of wastewater building service connections
- Descriptive list of substances that no person shall discharge into wastewater facilities, sewage or wastewater
- Reporting requirements
- Extra strength and volume surcharge agreements

4.7 Halifax Regional Municipality (HRM): Regional Municipal Planning Strategy

http://www.halifax.ca/regionalplanning/documents/Regional_SBL_001.pdf
http://www.halifax.ca/regionalplanning/documents/Regional_MPS.pdf

- The Regional Municipality Planning Strategy (MPS) is a guide for the future development of the Halifax Regional Municipality (HRM)

- Goal is to achieve a shared vision of the future of HRM, a vision of healthy, vibrant and sustainable communities
- Plan provides a sound basis for decision-making over the next 25 years, and will be reviewed regularly
- The plan will be implemented through four (4) broad types of policy:
  - Secondary planning strategies
  - Land use regulations
  - Background studies
  - Functional plans

  Infrastructure charges will be applied in accordance with the provisions of the HRM Charter
- HRM is in the process of reviewing the Regional Municipal Planning Strategy (commonly known as the Regional Plan) and is proposing to develop a new Municipal Planning Strategy and Land Use By-law for the Regional Centre. Both of these projects place a high emphasis on improved design, sustainability practices/ principles and bringing people into the Regional Centre to live, work and play.
- The *Regional Plan*, adopted by Council in 2006, forms a comprehensive guide for the future growth and development of HRM. It presents a coordinated and integrated approach for achieving sustainable and balanced growth in a way intended to preserve the environment, maintain a strong economy, emphasize the provision of transit services, and promote communities that would be compact, well planned, vibrant and healthy. The Plan has enjoyed many great successes and remains a strong and well-conceived blueprint for growth. It has led to several notable initiatives such as the *Economic Strategy* and *HRMbyDesign*.
- The Economic Strategy 2011-16 (*A Greater Halifax*) is a five-year plan to grow the economy of the city and the entire region. The plan stresses two fundamental objectives: helping to build better lives for the people who live and work here and aligning our resources and efforts to make our city a place where more people will want to live and work in the future.
- Understanding that the conditions affecting the objectives of the Economic Strategy and other initiatives change over time, the Regional Plan was written as a living document intended to be responsive to emerging challenges and opportunities. It therefore contains within it a mechanism requiring that it be formally reviewed and updated every five years. The first of these five year reviews will commence in the fall of 2011, and is expected to last for approximately 12 months. Because the overall policy framework and intent of the 2006 Plan remains sound, the review is proposed to be an issue or theme-based process as opposed to a rewrite of the entire document.
- The 2006 Regional Plan mandated the creation of the “Regional Centre Urban Design Study” to guide future growth in the Regional Centre. This study, now known as ‘HRM by Design’, has two major phases. The Downtown Halifax Plan, which was adopted by Council in 2009 and the Centre Plan. The Centre Plan applies to the entire Regional Centre with the exception of Downtown Halifax, which has already been completed in Phase 1.
- The objective of the Centre Plan is to provide an enduring vision for the HRM’s Regional Centre by addressing the nature, intensity and quality of development in the public and private realms. This will result in an urban design strategy, built from guidelines, and an implementation framework to direct development to be in keeping with the spirit and intent of the Regional Plan. The study will also address issues such as open space, streetscapes, residential infill, architectural design and development approval processes. The primary

deliverable of the Centre Plan will be a new Regional Centre Municipal Planning Strategy and Land Use By-law.

- The five year review of the Regional Plan is timely as the world has changed a great deal in the five years since the Regional Plan's adoption. We now face new challenges, as well as an intensification of previous challenges. Much more is known today about the impact of development on climate change and sea level rise. Energy and resource scarcity is more acutely felt. The cost of providing municipal services to dispersed, low-density development is considerably higher and continues to increase. The linkages between public health and development patterns are more clearly understood. The cost of building and maintaining roads has increased dramatically, while at the same time the transit and active transportation needs of HRM residents have evolved and expanded considerably.
- The growth of residential units exceeded the targets set in the 2006 Regional Plan for both suburban and rural areas, but however has failed to reach the target established for the Regional Centre. A great deal of work is anticipated in order to meet the urban target. Throughout the past five years, the community's understanding of fundamental issues of sustainability, and therefore, their expectations of HRM for handling them, has become much more sophisticated. The Regional Plan's position on each of these issues will be examined as part of the review process, with resultant definitive actions an essential component of the Centre Plan process.
- The five year Regional Plan Review project is not a re-writing of the Plan; but rather an evaluation and updating of the Plan goals and objectives. One such component is the targeted settlement pattern split for new units (25% Urban, 50% Suburban & 25% Rural) as established in the Regional Plan. Actual permits issued over the past 5 yrs. are 16% Urban, 56% Suburban & 28% Rural.

4.8 Regional Subdivision By-Law

http://www.halifax.ca/planning/map.html

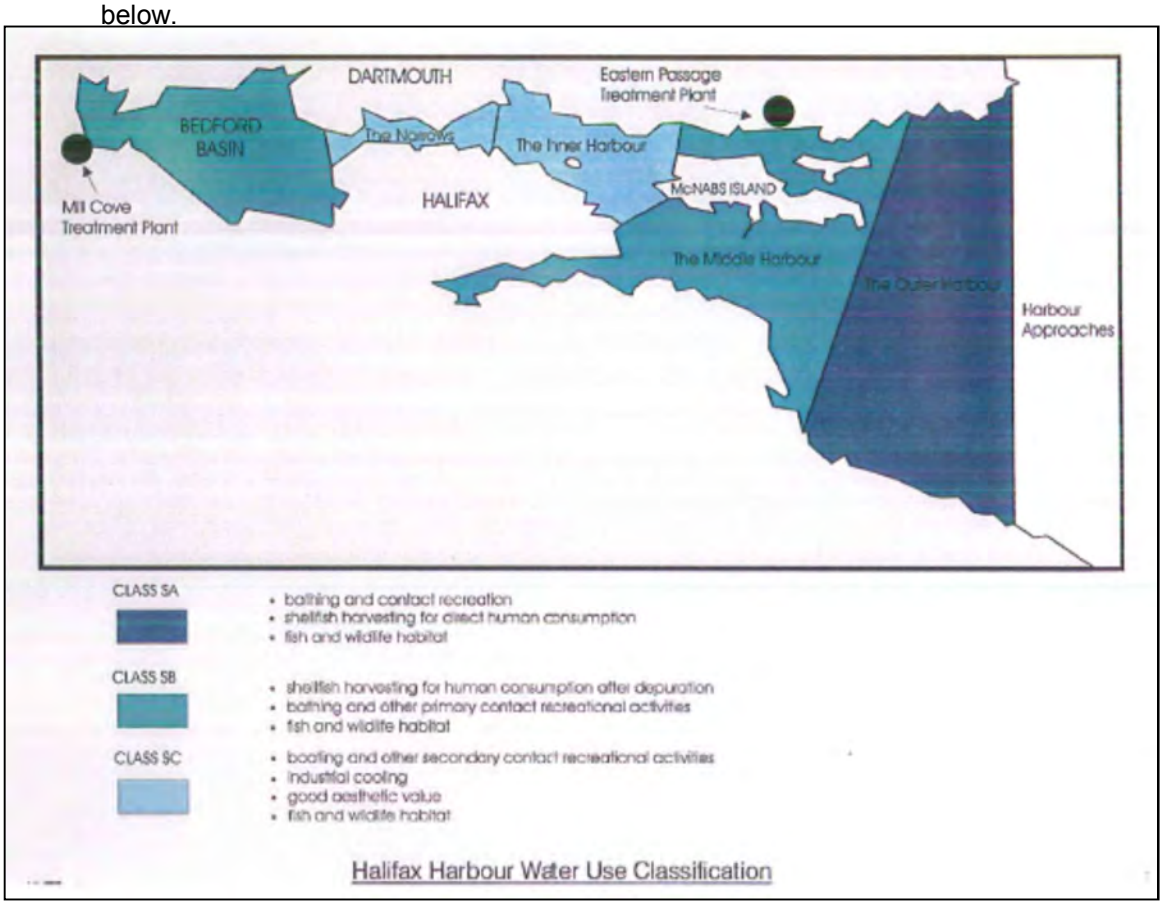
- Adopted by HRM on May 22, 2010
- Infrastructure charges – final subdivision shall be paid by the subdivider in accordance with Schedules "F", "G", "L", "M", and "N"
- Where a proposed subdivision is to be serviced by a wastewater, stormwater, or water distribution system the concept plan is to be accompanied by eight copies of a concept plan servicing schematic, prepared by a Professional Engineer in accordance with the Municipal Service Systems Design Guidelines

4.9 Harbour Specific Water Quality Objectives

- Halifax Harbour Task Force (HHTF) established criteria in 1990 that outlined water quality objectives and prioritized sections of the Harbour:
- HHTF classifications are:
  - Class SA:
    - applicable to the Outer Harbour
    - defines uses such as bathing and contact recreation, shellfish harvesting for direct human consumption and fish and wildlife habitat
  - Class SB:
    - Applicable to the Middle Harbour, Northwest Arm and Bedford Basin

  - defines uses such as recreation use, shellfish harvesting for human consumption after depuration (cleansing) and fish and wildlife habitat
- Class SC:
  - Applicable to the Inner Harbour and Narrows
  - defines uses for boating and other secondary contact recreational activities (e.g. shoreline hiking), industrial cooling, good esthetics, and fish and wildlife habitat

- Fecal Coliform Bacteria Objectives:
  - 14 fecal coliform per 100 mL (shellfish harvesting water quality standard)
  - 200 faecal coliform per 100 mL (swimming water quality standard)
- In 1998 the Halifax Harbour Solutions Advisory committee amended the classification zones to ensure that the North West Arm be classified as SB, from SC, as shown on the figure below.



Halifax Harbour Water Use Classification

There are water quality issues in Halifax Harbour and it is clear that the above standards are regularly exceeded. This is highlighted by a water quality study undertaken by the Department of Fisheries and Oceans, Bedford Institute of Oceanography, a hyperlink to which is provided on Halifax Water's own website (http://www2.mar.dfo-mpo.gc.ca/science/ocean/BedfordBasin/HHWQMP/FecalColiforms.pdf). In 2008 the new WWTF's came online. Apart from a failure of Halifax WWTF in 2009, more recent sampling in 2010, when all three new WWTF have been operating at full capacity, has shown vast improvements in water quality. A full summary report of water quality is available on the Halifax water website (http://www.halifax.ca/harboursol/documents/HHWQMPFinalSummaryReport.pdf)

5. Review of Other World Class Municipalities

Case study examples were reviewed for i) policies, procedures, and legislation relevant to wastewater service delivery and ii) wastewater design criteria, drawing on the parallel conditions they share with Halifax Regional Municipality. The municipalities reviewed for the purposes of this study include:

- Ontario Ministry of Environment
- Capital Regional District, BC
- City of Hamilton, ON
- Thames Water, England
- Boston Harbour, USA
- Chesapeake Bay, USA
- Sydney Water, Australia

Halifax Regional Municipality, like other world class municipalities, spent hundreds of years discharging untreated domestic and industrial wastewater into coastal waters. Recognizing the vast repercussions of this practice, the Region has since attempted to restore the water quality by constructing new wastewater treatment facilities (WWTFs) as part of the Harbour Solutions Project. Specifically, the WWTFs built as part of the HSP were: Halifax, Dartmouth and Herring Cove.

5.1 Ontario Ministry of Environment, CSO Control

In 1994, Ontario's Ministry of Environment introduced a new provincial standard for water quality protection, Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters – or "F-5" for short. Procedure F-5-5 accompanies the standard and defines key guidelines and objective for municipalities to follow.

F-5-5's water quality objectives are some of the best in the world (E. Coli: 100 cfu/100 mL). F-5-5 also requires municipalities to develop pollution prevention strategies as well as "end-of-pipe" solutions.

In principal, the procedure is well founded and its objectives are succinct and transparent. However, some studies have criticized the procedure as being too ambitious and containing "no clear timelines or consistent enforcement mechanisms to induce municipalities to meet these standards. It lacks the force of true regulation" (Water Keepers F-5 Report, 2004).

This example serves to highlight the need to create policies that are achievable and that have the support of the organisations that are required to attain them, whilst ensuring benefit to the environment and safety to humans.

- Goals of Procedure F-5-5 are to:
  - Eliminate occurrence of dry weather overflows
  - Minimize potential for impacts on human health and aquatic life resulting from CSOs
  - Achieve, as a minimum, compliance with body contact recreational water quality objectives (Ontario Water Quality Objectives for E. coli at beaches impacted by CSOs for at least 95% of the four-month period (June 1 to September 30) for an average year

- Minimum level of treatment for wet weather flows above dry weather flows is primary treatment or equivalent (30% BOD_5 removal and 50% TSS removal)
- For beach protection, additional controls above the minimum CSO controls include:
  - no violation of the beach water quality objective, E. coli of 100 coliform per 100 mL as a result of CSOs for at least 95% of the four-month season (June 1 to September 30)
  - No more than two overflows per season for an average year with the combined total duration of the CSOs at any single CSO location being less than 48 hours

5.2 Capital Regional District (CRD), British Columbia

This following text highlights the primary policy statements adopted by the district. The statements are founded on goals which compliment those of Halifax Water; protect public health and the environment and provide effective, affordable and collaborative management. Thus, the policies can be used as guidance in the formulation of HW's own policies.

- Greater Vancouver Regional District's (GVRD) Liquid Waste Management Plant (LWMP) was approved under the BC Waste Management Act in April 2002. In 2010, metrovancourver published its latest Integrated Liquid Waste and Resource Management Plan. Its key purpose is to improve water quality by addressing impacts of wastewater discharges into receiving waters, with the ultimate goals to:
  - Protect public health and the environment
  - Use liquid waste as a resource
  - Effective, affordable and collaborative management

- The plan set outs management areas for each of the above goals. Within the management areas a set of strategies are listed that will be implemented in order to achieve the goal. Full details of all the strategies are contained in the full report (MetroVancouver, 2010)
- The following is a brief summary of the key strategies of relevance to HW and their wastewater system, especially CSOs and WWTF compliance:
- Work with municipalities to review historical data and adjust as necessary the average inflow and infiltration allowance for regional trunk sewers and wastewater treatment plants, and develop associated target allowances for municipal sewer catchments associated with a 1:5 year return frequency storm event for sanitary sewers to a level that ensures environmental and economic sustainability. (TBC 2013)
- Review progress in reducing inflow and infiltration every four years
- Prohibit the construction of new combined sewer systems other than those functioning as part of a strategy to reduce combined sewer overflows or to manage stormwater quality. (Ongoing)
- Replace combined regional trunk sewers with separated sanitary and storm sewers. (Ongoing)
- Work with municipalities to develop and implement municipal-regional sanitary overflow management plans which will: prevent sanitary overflows resulting from heavy rain and snowmelt occurring less than once every five years (for a 24 hour duration event); reduce emergency overflows due to power outages; and identify locations and schedules for appropriate system capacity improvements, wet weather containment, and point treatment and discharge to receiving waters of chronic overflows. (TBC 2013)

- Develop and implement operational plans for sewerage and wastewater treatment facilities to ensure infrastructure reliability and optimal performance. (Ongoing)
- Operate wastewater treatment plants which have secondary level to meet requirements specified in each facility's Operating Certificate and the Canada-wide Strategy for the Management of Municipal Wastwater Effluent (CWS-MMWE) National Performance Standards for wastewater effluent, including. (Ongoing)
- Monthly average maximum Carbonaceous Biochemical Oxygen Demand (CBOD5): 25 mg/L and; Monthly average maximum Total Suspended Solids (TSS): 25 mg/L.
- Maintain interim maximum daily concentration limits for wastewater effluent and operate the plants to meet requirements specified in each facility's Operating Certificate. (Ongoing)
- Create incentives to reduce inflow and infiltration by adjusting Tier I sewerage cost allocation formulae within each sewerage area from an average dry weather flow basis (25th percentile) to average wet weather flow (75th percentile) with appropriate adjustments for combined sewerage areas. Tier II cost allocation would remain unchanged. (TBC 2010)

5.3 City of Hamilton, Ontario

Similarly to the policies of the CRD, above, the following policies adopted by the City of Hamilton serve as a source of reference to Halifax Water when reviewing their own policy objectives.

The City of Hamilton has eight Wastewater Servicing Policies, as follows:

1. Provision of separate sanitary and storm sewer systems shall be considered a priority for all new growth areas
2. The City of Hamilton shall implement a sewer use bylaw that will set the maximum permissible limits on the criteria for discharge into municipal sewers.
3. The City of Hamilton shall provide adequate reliability and security in wastewater pumping systems.
4. The City of Hamilton shall endeavour to meet or exceed the Ministry of Environment Procedure F-5-5 and Human Health Risk Assessment Protocol (HH-RAP), taken from the United State Environmental Protection Agency (EPA) for CSO control.
5. The City of Hamilton shall meet the Hamilton Harbour Remedial Action Plan (RAP) initial loading objectives and work towards the refinement and achievement of the final stage loading objectives
6. The City of Hamilton shall meet or exceed the requirements of the Certificate of Approval and the appropriate legislated treatment criteria.
7. The City of Hamilton shall utilize reasonable design and costing criteria for establishing and evaluation servicing scenarios
8. The City of Hamilton shall ensure that there is a Biosolids Management Plan that addresses the needs of all residents within the City boundary

- Specifically relating to CSOs the City has generally attempted to follow the F-5-5 procedure. However, much work still needs to be done in order to achieve the aims. In part, this example highlights the need for such targets to be lawfully enforceable; amongst other policy statements, the following minimum targets are cited as key objectives:
  - One CSO event or less for discharges to sensitive environmental and/or recreational areas
  - Two CSO events or less for discharges to recreational beaches
  - At least 90% treatment of all wet weather flow volume on a sewerage system wide basis.

5.4 Chesapeake Bay

The Chesapeake Bay case study highlights a variety of strategies aimed at preserving and improving a large waterbody surrounded by developed, urban areas; similar to the scenarios that Halifax Water is faced with.

Chesapeake Bay is a large body of water situated on the Atlantic coast of the United States, adjacent to the State of Maryland. In 2000, the State of Maryland signed Chesapeake 2000, an Agreement for the restoration of the Chesapeake Bay. In regards to water quality protection and restoration, several policies were outlined, each with treatment objectives, timelines, and program contacts.

In 2005, a regulation became effective addressing reporting and public notification of sewage overflows and bypasses. In 2009, the Maryland Department of the Environment also implemented an enforcement initiative to address unauthorized SSO discharges. Under State and federal law, penalties for sewage overflow range from $1,000 to $32,500 per day for each overflow.

Point source discharges are regulated in Maryland by the Office of Environmental Programs (OEP) as part of the federally mandated National Pollutant Discharge Elimination System (NPDES) which is administered by the U.S. Environmental Protection Agency (EPA). The OEP monitoring program for point source discharges was developed to meet the specific requirements of NPDES and EPA. The entire program is based on establishing and enforcing specific discharge permits. As part of its regulatory responsibility, OEP issues discharge permits and reviews monitoring data to assure compliance with the permits.

Several types of monitoring approaches are taken for municipal sewage discharges. The most comprehensive monitoring is carried out by the dischargers themselves. Daily sampling and records of effluent parameters and operational indices are generally required. To verify this self monitoring, OEP personnel conduct periodic compliance monitoring at varying frequencies depending on permit conditions, discharge volume and type of treatment process used. Onsite reviews of plant operation are also conducted regularly by OEP engineers.

The Maryland Department of the Environment (MDE) implements a variety of regulatory and planning programs to reduce the input of pollutants to surface and ground waters of the State. Reduction of nutrients from both point- and non-point sources is the focus of the permit requirements, along with control of bacterial pollution from sewage treatment plants and toxic materials from any source. The following items represent a selection of the programs most relevant to the waste water system:

Bay Restoration Fund
The Bay Restoration Fund is a dedicated fund, financed by wastewater treatment plant users, that is used to upgrade Maryland's wastewater treatment plants with enhanced nutrient removal (ENR) technology so they are capable of achieving wastewater effluent quality of 3 mg/l total nitrogen and 0.3 mg/l total phosphorus. In addition, a similar fee paid by septic system users is utilized to upgrade onsite systems and implement cover crops to reduce nitrogen loading to the Bay.

TMDL
Total Maximum Daily Loads (TMDLs) are a requirement, found in 303(d), of the federal Clean Water Act that became law in 1972. TMDLs are a tool for implementing State water quality standards. They are based on the relationship between pollution sources and in-stream water quality standards.

Fish and Shellfish
MDE's Fish and Shellfish programs monitor the quality of shellfish harvesting waters, and testing edible fish tissue to certify that fish are safe for human consumption. Certain fish in contaminated waters can accumulate high enough levels of toxic substances. When consumed frequently over a lifetime these may increase the consumers' risk of adverse health effects. In these cases, MDE issues fish consumption advisories to limit consumption of certain fish species. MDE also works with the county health departments to monitor water quality at Maryland beaches.

Environmental Boards
The Environmental Boards are comprised of four State licensing boards, established by the General Assembly. Also located within the Water Management Administration, the Boards were created to license and certify individuals as environmental sanitarians; superintendents and operators of waterworks, wastewater works, industrial wastewater works, wastewater collection systems and waste water distribution systems; well drillers, water conditioner and water pump installers; and marine contractors.

Compliance
MDE staff are always on call during the regular workweek and on weekends, holidays and after normal working hours, to ensure that all environmental emergencies are promptly addressed.

Water Management Permits
MDE's Water Management Administration (WMA) issues permits to protect Maryland's water resources by controlling industrial and municipal wastewater discharges. Surface water discharges are regulated through combined State and federal permits under the National Pollutant Discharge Elimination System (NPDES). Groundwater discharges are regulated through State issued groundwater permits.

Sediment, Stormwater and Dam Safety
The Sediment, Stormwater and Dam Safety Program concentrates on controlling runoff increases and mitigating water quality degradation associated with new development. This section provides guidance on how to prevent sediment and stormwater runoff, or "nonpoint source" pollution.

Sanitary Sewer Overflow Enforcement Initiative

On March 28, 2005, a new regulation (COMAR 26.08.10, Overflows and Bypasses) that addresses reporting and public notification about sewage overflows and bypasses became effective.

The Department is implementing a new enforcement initiative effective January 1, 2009 as a further step in its efforts to address unauthorized discharges of pollutants resulting from sanitary sewer overflows. The Department has taken numerous enforcement actions independently and jointly with the Environmental Protection Agency (EPA) and citizen groups over the last ten years that included orders for system upgrades and penalties for unlawful discharges.

Under the new enforcement initiative, MDE will begin to assess penalties for all sewage overflows, with the exception of permitted combined sewer overflows, unless the owner or operator of the system can clearly demonstrate that the overflow was beyond their control and in spite of taking all

reasonable steps to properly operate, maintain and improve sewer system infrastructure. Under State and federal law, penalties for sewage overflows can range from $1,000 to $32,500 per day respectively for each overflow. The Department may also issue orders requiring improvements to prevent and eliminate sewer overflows from systems with repeated overflows from the same pump station, manhole or sewer line, large volume overflows or overflows that are due to poor system maintenance, operation or design.

5.5 Boston Harbour

Boston Harbour is a mature example of the strategies employed to achieve large scale water quality improvements.

Severe pollution problems in Boston Harbour prompted large scale improvements to the wastewater network. Highlighting parallels with Halifax Water, Boston's WWTF were required to be upgraded to secondary treatment in order to achieve compliance. Boston is an example of large scale WWTF upgrading. For HW this example serves as a template for what may be expected, albeit on a smaller scale, should HW opt for large WWTF sites as opposed to more smaller scale WWTF's.

In the 1980s, Boston Harbour was recognized as the most contaminated harbour in North America due to the vast volumes of raw wastewater discharged to the Harbour. In December 1985 and as a result of several suits filed against the Metropolitan District Commission (responsibility later assumed by the Massachusetts Water Resources Authority (MWRA)), US Federal Court set forth a ruling detailing the schedule by which the MWRA was to complete the harbour clean-up. As a result of this ruling, one of the largest public works projects in US history was started eventually costing $3.8 billion dollars and lasting over 20 years. Thus, wastewater treatment was upgraded to primary treatment followed by secondary treatment and source control measures were put in place.

At the present time, the demand for sewer expansion to communities outside the service area is low. Much of the growth in the metropolitan Boston area is being driven toward "smart growth" policies leading to redevelopment of previously occupied sites in areas likely to be served by existing sewers.

The National Pollutant Discharge Elimination System **(**NPDES) Program was created by the Clean Water Act of 1972. NPDES regulates point source dischargers such as wastewater treatment plants and CSO facilities. The essential component of the permits is the submission of monthly Discharge Monitoring Reports (DMR) to EPA and Department for Environmental Protection (DEP). The DMRs include the results from effluent monitoring and biotoxicity.

Any entity that is subject to governmental regulation must be ready to deal with regulatory change. To comply with the 'BEACH Act', Massachusetts has issued new draft water quality criteria that include new bacteria standards. The ability of treatment facilities to meet these standards has not been evaluated nationally (or state-wide). The EPA has developed recommended nutrient criteria (usually phosphorus) for most freshwater "ecoregions", including the eastern coastal plain which includes most of Massachusetts. States are encouraged to develop sitespecific nutrient criteria, but Massachusetts has not.

- SSO Rule: EPA and DEP will continue to focus on reduction and/or elimination of SSOs.
- Blending: A previous blending policy which would have specifically allowed blending was withdrawn by EPA, due to pressure from environmental groups that wanted blending prohibited. EPA is drafting a new blending policy that will certainly include limitations on blending.

5.6 Thames Water, London

This example provides an insight to the level of intervention that can be required to meet environmental regulations and compliance in a major global city that has historically neglected to implement an effective long term plan. Instead of incremental improvements the City of London is facing massive engineering tasks in order to facilitate compliance and provide a wastewater system suitable to serve the city now and in the future.

There are 57 overflows, which discharge combined sewage into the Thames River 50 to 60 times a year. London's wastewater system, which dates back to the mid-1800s, was designed to overflow into Thames River to avoid flooding streets and homes with sewage during heavy rainfall.

When the sewers fill to capacity after heavy rainfall, any excess sewage is discharged into the river via these overflows, to prevent flooding to buildings and streets. Around 39 million tonnes of untreated sewage is discharged annually, and as little as 2mm of rainfall can trigger a discharge. Without tackling this, ten years from now the 39 million tonnes of sewage is forecast to rise to 70 million tonnes.

Thames Water is working with the multiple partners to support the London Thames Tideway Improvements. The improvements include the upgrading of five WWTF and the construction of two tunnels that will divert combined sewage to Beckton wastewater treatment facility. They are also focusing on source control, particularly cross connections. One of Thames Water's proposals is to include a survey of illicit connections as part of the survey carried out at the time of sale of a property.

European Union guidelines are also being violated by overflows into the Thames River. The volume and frequency of untreated wastewater that overflows into the Thames River is in contravention of the European Urban Wastewater Treatment Directive.

In the case of London, several CSO control measures were ruled out due to excessive costs or inadequate effectiveness, as follows:

- Sustainable Urban Drainage Systems (SUDS): are intended to reduce rainwater from entering the wastewater system in the first place and include measures such as green roofs, detention pond, rainwater harvesting, etc. SUDS was determined as not practical or cost-effective for London due to the high density development and underlying geology.
- Combined Sewer Separation: was considered, however cost estimates for the construction of a new separated sewer system totalled between £12 billion and £20 billion and the disruption to central London would be significant.
- Bubblers and skimmer boats: are currently used by the municipal water authority to reduce the impact of untreated sewage discharges on the ecology of the Thames river and are intended to tackle the symptom, not the cause. Therefore, the widespread and continued use of this equipment was not considered sustainable.

In 2000, the Thames Tideway Strategic Study was set up to consider the environmental impact of storm discharges to the tidal River Thames, and to propose potential solutions that would ensure

compliance with the requirements of the EU Urban Wastewater Treatment Directive concerning the collection, treatment and discharge of urban wastewater.

Thames Water, the Environment Agency, the Greater London Authority, Department for Environemnt, Food and Rural Affairs (Defra) and the water regulator, Ofwat (as an observer) all contributed to the study, which was independently chaired by engineering consultant Professor Chris Binnie.

The study concluded that preventing discharges from combined sewer overflows alone would not be enough to achieve new water quality standards. It was agreed that London's major sewage treatment works would also need to be expanded as they needed to treat considerably more wastewater.

In line with the recommendations of the Thames Tideway Strategic Study Thames Water are developing three separate schemes to address these problems:

In summer 2010, Thames Water started a £675m project to modernise and extend London's five major sewage treatment works to increase the amount of sewage the sites can treat, greatly reducing the need for storm discharges to the river.

The Lee Tunnel is the first of two tunnels, which will collectively capture an average of 39 million tonnes of sewage a year from the 35 most polluting combined sewer overflows. The £635m 4 mile long Lee Tunnel will help prevent more than 16 million tonnes of sewage mixed with rainwater overflowing into the River Lee each year, by capturing it and transferring it to Beckton Sewage Treatment Works, which is being expanded by 60 per cent to enable it to deal with the increased volumes. Tunnelling work is due to begin in January 2012 and is likely to progress at a rate of 17 metres a day. Tunnelling is expected to finish in late 2013

The proposed Thames Tunnel is the final and most challenging piece of the overall plan to tackle sewage discharges into the River Thames in London. The Thames Tunnel is a sewer the width of three London buses, which will run up to 20 miles from west to east London, up to 75 metres below ground, broadly following the route of the River Thames.

Initial construction of the Thames Tunnel is provisionally scheduled to start in 2013 and finish in 2020. Thames Water estimates the total costs of building the Thames Tunnel to be £3.6bn ($5.7bn C). This will require average household bills to rise by slightly more than £1 a week by 2018; Thames Water has c.14 million customers.

5.7 Sydney Water, Australia

Southwest Growth Centre Servicing Plans

This case study has been included to emphasize the need to establish strong policies and direction. Options for improvement and upgrade can take many forms and without a clear strategy in place the evaluation of options can become prolonged. As shown below different management, groups and organisations can bring new ideas and debates regarding strategies for improvement. Whilst it is important to adequately consider all feasible alternatives for upgrade a clear direction statement from the client organisation can serve to streamline the optioneering process. This case study is ongoing.

Mid 2007. Servicing strategy for early release areas in place.

The early release areas in the South West Growth Centre included Edmondson Park, Oran Park and Turner Road. Servicing for the early release areas was largely based on available capacity in existing Sydney Water water and wastewater infrastructure. The servicing strategy also included provision of recycled water to all new houses. Provision of recycled water enabled the new homes met the BASIX regulatory requirements for water efficiency.

October 2007. South West Growth Centre Area Plan.
In October 2007, the South West Growth Centre Area Plan was completed by GHD for Sydney Water. (Between January and October 2007, GHD completed six separate planning studies on the SW Growth Centre for Sydney Water). The preferred servicing option comprised:

- 3 IDAL sewage treatment plants (STPs) located in the general vicinities of Kemps Creek, Lowes Creek and South Creek served generally by gravity systems connecting properties to the STPS.
- Networked drinking and recycled water systems providing dual reticulation for use throughout the South West Growth Centre
- Integration of the recycled water network with surrounding recycled water systems to facilitate the efficient use of the product and surplus wastewater management.

Water supply was to be provided from the existing Prospect and Macarthur Water Filtration Plan systems.

May 2009. Effluent Management from the North West and South West Growth Centres
In 2009, Sydney Water was concerned that the costs of recycled water provision were not affordable and commissioned work to compare the relative economic and environmental merits of excluding non-potable recycling of water as part of the servicing strategy. GHD were commissioned to do this work.

The work highlighted the environmental challenges of effluent discharge to South Creek and the Hawkesbury Nepean River due to new growth. A range of options was evaluated ranging from ultra filtration/reverse osmosis plants to implementation of on-site systems.

The analysis triggered ongoing regulatory discussions with the (now) Office of Environment and Heritage regarding permissible nutrient loads into the Hawkesbury Nepean catchment.

Subsequent to the options analysis by GHD, SKM was commissioned to assess the environmental impacts of discharges from new STPs into the upper reaches of South Creek, an ephemeral stream.

May 2011. Review of Sydney Water's servicing strategies
In 2011, the newly appointed Strategic Planning Manager for Sydney Water commissioned a review of Sydney Water's servicing approach, seeking a vision of possible futures and a roadmap by which it could be achieved. Bonacci Water supported by MWH was the successful tenderer.

Bonacci disputed Sydney Water's preferred option for servicing the South West Growth Centre. Rather than three STPs, Bonacci suggested that the optimal solution was for 15-20 membrane bioreactor plants. Smaller scale solutions were seen to provide for flexibility of development, improve

affordability, provide opportunity for private sector involvement and remove the need for lumpy investment by Sydney Water.

In response, Sydney Water proposed to form a cross functional team including Sydney Water staff and external business and technical analysts to determine the preferred servicing option and procurement strategy for the South West Growth Centre.

A request for professional services tender was issued on 12 September 2011 to develop procurement strategies for the South West Growth Centre and Priority Sewerage Program. The story continues...

6. Guiding Principles Policy Paper

6.1 Implications for Halifax Water

- How does the current situation related to policies, procedures and legislation affect Halifax Water and its wastewater system?
  - Need to establish regulatory clarity
  - CCME Standards may not be appropriate for all WWTFs, particularly those with more sensitive receiving waters
- Are there any current conflicting policies, procedures, and legislation?
  - Nova Scotia Environment (NSE) Policy limits/restricts wastewater effluent discharge in low flow streams where there is insufficient dilution. This policy could conflict with CCME Standards and are currently presenting concerns at the Aerotech and Lakeside WWTFs, which currently discharge to low flow streams (Johnson River and Nine Mile River, respectively)
- Describe the feasibility/risks of implementing policies, procedures, and legislation from other jurisdictions (i.e. Vancouver CRD)

Based on the review of Federal, Provincial and Municipal policies and discussion with HW and associated stakeholders, the following 'long list' of guiding principals were developed. These principles form the foundation for the key policy recommendations that follow in the policy matrix, which serves as a prioritised 'short list' of policies considered to be the most pertinent and relevant to HW.

6.2 Guiding Policy Statements

- Optimize available use of existing wastewater infrastructure
- Minimize or eliminate the use of wastewater pumping stations and forcemains
- Minimize the long term operating and maintenance costs of the wastewater system
- Within the timescales and framework of an approved CSO management plan, new development shall maintain or improve current levels of service
  - No negative impacts on existing wastewater effluent discharges
  - Serviced by a municipal separated wastewater and stormwater collection system
  - No increase in frequency and concentration of CSOs and SSOs
- Existing combined systems shall be replaced by separated systems over time
- Prioritize higher risk facilities (based on CCME Standards)
- Wastewater systems shall be designed and constructed to minimize infiltration and inflow conditions
- Existing sources of infiltration and inflow shall be identified and reduced where feasible
- Due to the nature of the Region's wastewater systems and the location of the system and facilities near the Halifax Harbour, adopt Harbour Solutions-specific criteria (similar to other Harbour communities, e.g. Hamilton)
- Under the Regional Wastewater Functional Plan, the goals related to strategies for wastewater servicing, wet weather control and wastewater treatment include:
  - Provide capacity to service projected growth
  - Priority to provide compliance under existing conditions
  - Maintain compliance in line with anticipated growth
  - Maximize volume to be treated through full secondary and tertiary treatment

  - Reduce discharge of untreated combined and eliminate sanitary sewer overflows
  - use beach closures as one measure for the benchmark for success
- Harmonize planning and servicing policies
- Do not permit partial servicing for new development
- Growth areas within Halifax Regional Municipality shall be designated with consideration given to the provision of municipal water and wastewater
- Ensure that the design of water and wastewater infrastructure recognizes the potential for growth beyond the time horizon of the Regional Plan (2026)
- Maintain sufficient reserve capacity in its water and wastewater infrastructure and facilities to provide operational flexibility and meet potential changes in servicing conditions
- Continue to and increase the amount of monitoring of wastewater system conditions and production/wastewater collection flow information
- Implement a sewer use bylaw that will set the maximum permissible limits on the criteria for discharge into municipal sewers
- Provide adequate reliability and security in wastewater pumping stations
- Endeavor to meet or exceed the Nova Scotia Environment regulatory effluent discharge requirements which are permit specific for each treatment facility on the basis of receiving water (fresh or salt water) and the corresponding level of treatment
- Meet or exceed the requirements of appropriate legislated treatment criteria
- Utilize reasonable design and costing criteria for evaluating servicing scenarios
- Ensure that there is a up-to-date Biosolids Management Plan that addresses the needs of all residents within the Regional boundary

6.3 Level of Service for the Regional Waste Water Functional Plan

The preferred solutions and associated capital program will identify infrastructure required to service the 2046 regional growth and will be focussed on maintaining current wet weather conditions in terms of frequency and volume of overflows. Based on a typical year analysis the functional plan solutions will not result in additional frequency or volume of overflow discharges.

CCME Canada-wide Strategy for the Management of Municipal Wastewater (CSMMW) specifies expected national standards for CSOs and SSOs. In summary:

For CSOs the strategy prescribes:

- *No increase in CSO frequency due to development or redevelopment, unless it occurs as part of an approved CSO management plan.*
- *No CSO discharge during dry weather, except during spring thaw and emergencies.*
- *Floatable materials will be removed, where feasible.*

And for SSOs:

All SSOs should be monitored and reported, at least on an occurrence basis. Since SSOs should not occur, the objective is elimination through corrective measures. As a minimum:

- *SSO frequencies should not increase due to development or redevelopment; and*
- *SSOs should not occur during dry weather, except during spring thaw and emergencies.*

(CCME, 2008)

The primary intent of the RWWFP is to provide solutions that, in light of growth, maintain the current level of service, particularly in regard to overflow spill frequency and volume performance. However, where opportunities exist options will be promoted that provide improvement beyond the current level

of service. Such improvements may provide a reduction in overflow spill frequency and/or volume and will also include recommendations for the provision of baffles and/or screening where such equipment is currently absent.

Consideration of growth horizons
The original RWWFP time horizon is 2026. However, currently available growth projections extend to 2046, aligned with the horizon of the concurrent Integrated Resource Plan (IRP) study. It has been agreed that the planned growth to 2046 will be considered when developing options under the RWWFP.

Priority of Solutions and implementation
As previously noted, the CCME strategy specifies several expected performance statements. As well, Halifax Water intends to have a priority framework for solutions, which can be simply summarized as:

1: Sanitary Sewer Overflows
2: Combined Sewer Overflows discharging into sensitive waters
3: Combined Sewer Overflows

Based on this information Halifax Water will adhere to this guidance when prioritizing solutions.

Following the above categorization process, all overflows should be scored based on the draft “criteria for calculation of risk level of individual CSO locations”, as shown in Table 6.1, below This approach will provide a further level of resolution and allow Halifax Water to tailor solutions in a risk based, timely manner.

% of Total dry weather flow found in the sewer at this location (or % of combined sewer served at this location)	≥ 50%	30 points
	≥ 25%	20 points
	≥ 10%	10 points
	< 10%	5 points
Frequency of CSO events (Excluding exceptional emergency events)	> 1 event/year during dry weather	50 points
	> 25 events/year	30 points
	> 15 events/year	20 points
	> 5 events/year	10 points
	5 events/year or less	0 points
Receiving environment type and affected uses - all that apply	Drinking water intake within 500 metres downstream	25 points
	Drinking water intake within 500 - 2000 metres downstream	15 points
	Shellfish harvesting area (past or present) within 500 metres	20 points
	Endangered species/fish spawning area within 500 metres downstream	10 points
	Area used for contact recreation within 500 metres downstream	20 points
	Area used for contact recreation within 500 - 2000 metres downstream	10 points
	Fish consumption advisory	5 points
	Discharge into lake, reservoir, marine estuary or enclosed bay	10 points
Industrial input		15 points

Table 6.1: Draft Criteria for Calculation of Risk Level of Individual CSO Locations (CCME, 2008)

7. Recommended Primary Policies, Practices and Metrics

7.1 Policy Matrix Structure

Following the generation of the above 'long list' of guiding principles, they were reviewed and prioritised to form a succinct, concise set of policy statements that will provide a framework for HW to work within. The recommended policy matrix is shown below.

The following sections describe the ten core policies established as the focus of the Regional Wastewater Functional Plan.

The ten core policies form distinct objectives to act as guiding principles for HW to strive to achieve, as follows:

1. Optimize the use of the existing wastewater system/network.
2. Minimize the long term life cycle costs of the wastewater system through revised design standards.
3. Monitor wastewater systems to identify water quality/waste loading issues and system capacity/quantity limitations.
4. Manage wastewater flows in the combined sewer system to minimize overflows to the environment and property.
5. Manage wastewater flows in the sanitary sewer system to minimize overflows to the environment and property.
6. Optimize available system capacity.
7. Regulate allowable flow into the wastewater system.
8. Meet effluent discharge limits as defined by NSE and consistent with the CCME for all wastewater treatment facilities.
9. Within the timescales and framework of an approved CSO management plan, ensure new development does not impact the frequency, volume, and quality of combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs).
10. Ensure HRM and Halifax Water policies for growth are consistent

In order to achieve each overall policy objectives most policies have been broken down into a series of aims or practices which define the activities required to achieve the policy objective. In total there are 43 practices identified.

To monitor progress and attainment of the policies each practice has a defined metric. Some of this information will already be recorded, however some may not and procedures and data recording processes will need to be established to allow for the population of these fields.

For each policy, individual practice and associated metric the relevance to baseline, regulatory and growth strategy has been identified.

7.2 Recommended policies matrix table:

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
A	Optimize the use of the existing wastewater system/network.	X	X	X	A.1	Minimize or eliminate the use of wastewater pumping stations and forcemains based on full life cycle cost (LCC) analysis.	X		X	standards and enforcement	A.1.1	# of pumping stations per capita/pumping costs per captia.
					A.2	Identify, obtain, and preserve strategic servicing corridors to optimize the wastewater network (may include integrated corridors for multiple utilities / uses).	X		X		A.2.1	Complete specific strategic sewer analysis.
											A.2.2	Monitor network operation.
											A.2.3	% of network depicted by model and frequency of model updates
					A.3	Carry out master planning to determine master servicing needs including trunk servicing, timing, cost apportionment, and service boundaries.	X	X	X		A.3.1	Regular updating of master plan and evidence of completing recommendations therein.
					A.4	Develop master servicing strategies that consider phasing decisions including the need for interim versus ultimate servicing scenarios and outlines responsibilities for construction, operations and maintenance of interim facilities prior to the master planned infrastructure being in service.		X	X		A.4.1	Specifically address within Master Planning document
					A.5	Amalgamate proposed infrastructure to minimize the length and number of pipes in a given corridor.	X		X		A.5.1	Reduction in pipe length per capita
					A.6	Manage infrastructure to ensure wastewater treatment facility (WWTF) performance is maintained.	X	X	X		A.6.1	WWTF process and compliance monitoring

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
					A.7	Maintain sufficient reserve capacity in HW's wastewater infrastructure and facilities to provide operational flexibility and meet potential changes in servicing conditions and the introduction of more stringent provincial treatment requirements in the future.		X	X	need a quantifiable limit or "buffer" on capacity	A.7.1	WWTF process and compliance monitoring. Flow to full treatment analysis.
B	Minimize the long term life cycle costs of the wastewater system through revised design standards.	X			B.1	Implement revised minimum sewer grades to improve flushing.	X				B.1.1	% reduction in length of shallow grade sewers
					B.2	Regular review and update of the wastewater design standards and requirements.	X	X	X		B.2.1	Annual updates
					B.3	Implement revised sanitary sewer design calculation.	X	X	X		B.3.1	
C	Monitor wastewater systems to identify water quality/waste loading issues and system capacity/quantity limitations.	X	X	X	C.1	Continue the wastewater characterization and monitoring program in order to define the existing issues.	X	X			C.1.1	% of ERAs completed/year
					C.2	Develop an enhanced monitoring program that includes real-time data capture and analysis.	X	X			C.2.1	Availability and recording of relevant data
											C.2.2	% of network being monitored or modeled
					C.3	Develop method for tracking /demonstrating the success of wet weather management initiatives.	X	X			C.3.1	Fund project to develop and implement.
											C.3.2	% of funding for wet weather monitoring/programs
					C.4	Develop a flow monitoring master plan that outlines the optimal locations for flow meters and rain gauges, confirms the goals, objectives and outcomes of the program, and is integrated with other technical analysis tools such as PI and the	X	X	X		C.4.1	Fund project to develop and implement. Staged measure from desktop study to survey to implementation

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
						hydraulic model.					C.4.2	% of master plan complete
											C.4.3	% of network integration with PI/model
					C.5	Monitor both plant and overall system performance.	X	X			C.5.1	Implement monitoring. Record and make data available
											C.5.2	Assess Compliance metrics
D	Manage wastewater flows in the combined sewer system to minimize overflows to the environment and property.	X	X	X	D.1	Using storage and real-time controls, manage and regulate flows to all interceptor sewers from combined service areas to ensure that all intercepted flows are delivered to the wastewater treatment facility or comply with current permit requirements.	X				D.1.1	Set appropriate metrics to allow for phased implementation with short, medium, and long term targets.
					D.2	Reduce volumes and frequency of discharge of untreated combined sewer overflows.	X	X	X		D.2.1	Monitor overflows (in priority) and assess data.
											D.2.2	# of CSO and SSO events per year.
					D.3	Eliminate existing combined sewer overflows (CSOs) that occur during dry weather conditions.	X	X			D.3.1	Endeavour to capture and treat all dry weather flows plus 90% of wet weather flows above dry weather flow volume.
					D.4	Provide screening for CSOs	X	X			D.4.1	# of CSO's without screening.
					D.5	Continue to monitor wastewater system conditions and flow information using real-time monitoring and sampling to track system flows	X		X	establish modelling group	D.5.1	WWTF compliance monitoring and network monitoring.

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
						and discharge quality over time.				ultimately link to quality	D.5.2	% of network monitored or modeled
					D.6	Over time, reduce combined sewer overflows (CSOs) with priority given to health and environmental impacts: a) where overflow impacts special environmental zones (Northwest Arm, Black Rock, etc) b) where overflow impacts recreational water use areas c) at all other identified CSO locations	X	X			D.6.1	# of CSO and SSO events per year (CCME MWWES parameter) TARGET = TBD
											D.6.2	# of public health and environmental regulatory infractions resulting in written warning and/or conviction
					D.7	Utilize beach closures and body contact recreational water quality objectives as the benchmark for success in minimizing impacts on water quality.	X	X		establish LOS parameters specific to Halifax enterococci is considered the best indicator for marine waters	D.7.1	Strive to keep beaches open for at least 95% of days during summer period (June 1 to September 30) - achieve body contact recreational water quality objective of 200 E. coli per 100 mL (initial) and gradually increase target to achieve 100 E. coli per 100 mL.
											D.7.2	# of public health and environmental regulatory infractions resulting in a written warning TARGET = 0 - 2 (max)
											D.7.3	# of public health and environmental regulatory infractions resulting in a conviction TARGET = 0

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
					D.8	Develop a long term sewer separation program based on full life cycle cost (LCC) analysis to capitalize on construction synergies over time.					D.8.1	Project funding and completion
											D.8.2	% of combined sewer converted to separated sewers
E	Manage wastewater flows in the sanitary sewer system to minimize overflows to the environment and property.	X	X	X	E.1	Install storm sewers where none currently exist in areas serviced by separate sanitary sewers. Promote separation where feasible	X	X			E.1.1	Storm sewer length per capita.
											E.1.2	# of separation schemes funded
					E.2	Eliminate sanitary sewer overflows (SSOs) with priority given to health and environmental impacts: a) under dry weather conditions b) under wet weather conditions where overflow impacts recreational water use areas c) under wet weather conditions at all other identified SSO locations	X	X			E.2.1	# of SSO's per capita.
											E.2.2	# of SSO's in proximity to sensitive areas.
											E.2.3	# of SSOs events per year and per recreational season
					E.3	Maintain any existing holding tanks and dynamic controls until all combined areas have been replaced by separate sanitary and storm sewers.	X	X		long term; ongoing I/I may be an issue	E.3.1	Assessment of operational maintenance budget.
					E.4	Continue to upgrade the sanitary sewer system to reduce I&I and the potential for SSOs by: a) overall system management b) regulatory requirements c) stormwater inflow reduction (SIR) program d) stormwater management restrictions e) cross connection elimination f) emerging I/I mitigation practices.	X	X			E.4.1	Expenditure trend analysis relating to I&I reduction % investment for I/I reduction programs
											E.4.2	Reduction in SSOs (frequency & volume)

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
											E.4.3	# of cross connections eliminated
					E.5	Utilize beach closures and body contact recreational water quality objectives as the benchmark for success in minimizing impacts on water quality.	X	X			E.5.1	# of beach closure days/year based on rolling average of 4 years.
					E.6	Develop an SSO management plan to eliminate SSOs over time.	X	X			E.6.1	# of SSO assets per capita.
											E.6.2	# of SSO events per year or recreational season
F	Optimize available system capacity.	X		X	F.1	Fully utilize capacity and optimize system controls of existing wastewater infrastructure.	X		X		F.1.1	% reduction in new wastewater mains due to optimization
					F.2	Existing sources of infiltration and inflow shall be identified and reduced by implementing extraneous flow reduction measures.	X	X	X	this is a whole program	F.2.1	WWTF flow data analysis
					F.3	Where overflows need to be avoided, temporary storage of the wet weather flows can be provided (e.g. surface level storage tanks or deep tunnel storage).	X	X	X		F.3.1	
					F.4	Use master planning to identify opportunities for cross-sewershed flow exchanges.	X	X	X		F.4.1	
					F.5	Optimize management of excess flows between collection and treatment systems.	X	X	X		F.5.1	% diverted/increased flows @ treatment facility
G	Regulate allowable flow into the wastewater system.	X	X	X	G.1	Implement Rules and Regulations that will set the maximum permissible limits on the criteria for discharge quantity into municipal sewers relative to size and load.	X	X	X		G.1.1	Ratio of discharge volume to receiving sewer volume
											G.1.2	Ratio of discharge concentration to receiving sewer concentration

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
					G.2	Enhance education and outreach program.	X	X	X		G.2.1	# of education documents issued
											G.2.2	# of hits to website
H	Meet effluent discharge limits as defined by NSE and consistent with the CCME for all wastewater treatment facilities.	X	X	X	H.1	Prioritize upgrades of treatment facilities identified as higher risk.		X		- freshwater vs. saltwater - quantity vs. frequency	H.1.1	% of budget allocated/spent on WWTF compliance projects
					H.2	Maximize volume to be treated through full secondary and tertiary treatment (long term).		X			H.2.1	Percentage of wastewater treatment facilities meeting discharge regulations of their permits; we must own the system for one year to include as a measure (does not include HHSP plants) TARGET = 80%
											H.2.2	Adopt levels of acceptable Harbour-specific wastewater criteria, identified through the Halifax Harbour Solutions Project.
					H.3	Ensure that a Biosolids Management Plan that addresses the requirements of the NSE guidelines is maintained and updated.	X	X	X		H.3.1	Biosolids residual handling: % of samples having a minimum solids content of 25% for HHSP and 18% for Aerotech TARGET = 95%
I	Within the timescales and framework of an approved CSO management plan, ensure new development does not impact the frequency, volume, and quality of combined sewer overflows (CSOs) or sanitary		X	X	I.1	New wastewater systems shall be designed and constructed to minimize extraneous flows.			X	- relies on good design standards, construction methods & inspection	I.1.1	Review design specification and ensure completion of as built CCTV survey.
											I.1.2	Length of new sewers CCTV'ed per year

	POLICY/OBJECTIVE (guiding principles, goals, or objectives)	Baseline	Regulatory	Growth		PRACTICES/AIMS (how we will meet the policy)	Baseline	Regulatory	Growth	Comments		METRICS (how we will measure our success)
	sewer overflows (SSOs).				I.2	Produce and maintain an approved CSO management plan, including details to mitigate the impact of new development on the operation of sewer overflows.					I.2.1	Complete and maintain waste water master plan
J	Ensure HRM and Halifax Water policies for growth are consistent.	X	X	X	J.1	Adopt area-specific wastewater design criteria for master planning purposes, taking into account historical flows and other related studies and analyses.	X	X	X		J.1.1	Inclusion of design criteria review as part of master plan
					J.2	Plan for wastewater capacity to service projected growth as defined in HRM's Regional Plan. Ensure that planning establishes population projections or opportunity areas to allow or better projections.			X	availability charge (need to establish baseline for availability charge)	J.2.1	% growth driven capital projects per year?
											J.2.2	Length of main or value of assets constructed to support growth?
					J.3	Ensure that the design of water and wastewater infrastructure recognizes the potential for growth beyond the time horizon of HRM's Regional Plan (related to CCC policies).			X		J.3.1	# of kilometers or value of assets identified beyond Regional Plan horizon of 2026
					J.4	New development shall maintain or improve current levels of service.			X		J.4.1	Compliance monitoring and trend analysis
					J.5	Ensure policies align with HRM policy to promote growth within the urban core.		X	X		J.5.1	Assessment of targeted settlement pattern split for new units: 25% Urban, 50% Suburban & 25% Rural
					J.6	Review all policies every 5 years in line with HRM master plan review.		X			J.6.1	Undertake policy review as part of HRM master plan review.

7.3 Primary Policy A - Optimize the use of the existing wastewater system/network.

This is a broad, expansive policy that covers many aspects of the waste water system. Essentially, it is centered on optimizing and maximizing the use of existing infrastructure, prior to the upgrading, expansion or installation of new infrastructure.

The investment in the existing infrastructure, coupled with the cost and social or environmental impacts of constructing new facilities, should be considered where capacity already exist.

However, should existing infrastructure exist and have available capacity, considering servicing alternatives should evaluate the ability to utilize this capacity versus new infrastructure to determine the most cost-effective and technically-viable solution.

The availability of calibrated models will be an important tool in achieving this policy.

It is also recognized that other planning criteria may outweigh the desirability to maximize every facet of the current systems.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.3.1 Policy Practice A.1 - Minimize or eliminate the use of wastewater pumping stations and forcemains based on full life cycle cost (LCC) analysis.

Policy Practice Metric A.1.1 - Number of pumping stations per capita/pumping costs per capita.

7.3.2 Policy Practice A.2 - Identify, obtain, and preserve strategic servicing corridors to optimize the wastewater network (may include integrated corridors for multiple utilities / uses).

Policy Practice Metric A.2.1 - Complete specific strategic sewer analysis.

Policy Practice Metric A.2.2 - Monitor network operations

Policy Practice Metric A.2.3 - % of network depicted by model. Frequency of model updates.

7.3.3 Policy Practice A.3 - Carry out master planning to determine master servicing needs including trunk servicing, timing, cost apportionment, and service boundaries.

Policy Practice Metric A.3.1 - Regular updating of master plan and evidence of completing recommendations therein.

7.3.4 Policy Practice A.4 - Develop master servicing strategies that consider phasing decisions including the need for interim versus ultimate servicing scenarios and outlines responsibilities for construction, operations and maintenance of interim facilities prior to the master planned infrastructure being in service.

Policy Practice Metric A.4.1 – Specifically address within Master Planning document

7.3.5 Policy Practice A.5 - Amalgamate proposed infrastructure to minimize the length and number of pipes in a given corridor.

Policy Practice Metric A.5.1 - Reduction in pipe length per capita

7.3.6 Policy Practice A.6 - Manage infrastructure to ensure wastewater treatment facility (WWTF) performance is maintained.

Policy Practice Metric A.6.1 - WWTF process and compliance monitoring

7.3.7 Policy Practice A.7 - Maintain sufficient reserve capacity in Halifax Regional Municipality's wastewater infrastructure and facilities to provide operational flexibility and meet potential changes in servicing conditions and the introduction of more stringent provincial treatment requirements in the future.

Policy Practice Metric A.7.1 - WWTF process and compliance monitoring. Flow to full treatment analysis.

7.4 Primary Policy B - Minimize the long term life cycle costs of the wastewater system through revised design standards.

When reviewing and revising design standards it is important to consider likely future changes to the operation and use of the wastewater system, such as a potential reduction in DWF per capita as a result of water conservation measures. A balance between designing for the current and future scenarios needs to be established that provides outputs with headroom without detriment to the short term financial goal of HW.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.4.1 Policy Practice B.1 - Implement revised minimum sewer grades to improve flushing.

Policy Practice Metric B.1.1 – % reduction in length of shallow grade sewers

7.4.2 Policy Practice B.2 - Regular review and update of the wastewater design standards and requirements.

Policy Practice Metric B.2.1 – Annual updates

7.4.3 Policy Practice B.3 - Implement revised sanitary sewer design calculation.

7.5 Primary Policy C - Monitor wastewater systems to identify water quality/waste loading issues and system capacity/quantity limitations.

It is essential that relevant system data be recorded and maintained in a useable format to support day to day planning, analysis, operations and maintenance of the water and wastewater systems.

From a planning, design and compliance perspective, system data and historical information will provide the basis for establishing and using planning and design criteria. Effective use of recorded data can be utilized to quickly identify potential water quality issues. For example, monitoring overflows which can provide a real time assessment of system operations. Sewer flow monitoring and the use of hydraulic models, combined with the information contained in master plans can be used to identify capacity issues, both now and in the future.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.5.1 Policy Practice C.1 - Continue the wastewater characterization and monitoring program in order to define the existing issues.

Policy Practice Metric C.1.1 – % of ERAs completed/year

7.5.2 Policy Practice C.2 - Develop an enhanced monitoring program that includes real-time data capture and analysis.

Policy Practice Metric C.2.1 – Availability and recording of relevant dat. % of network being monitored or modeled

Policy Practice Metric C.2.2 – % of network being monitored or modeled

7.5.3 Policy Practice C.3 - Develop method for tracking /demonstrating the success of wet weather management initiatives.

Policy Practice Metric C.3.1 – Fund project to develop and implement.

Policy Practice Metric C.3.2 – % of funding for wet weather monitoring/programs

7.5.4 Policy Practice C.4 - Develop a flow monitoring master plan that outlines the optimal locations for flow meters and rain gauges, confirms the goals, objectives and outcomes of the program, and is integrated with other technical analysis tools such as PI and the hydraulic model.

Policy Practice Metric C.4.1 – Fund project to develop and implement. Staged measure from desktop study to survey to implementation.

Policy Practice Metric C.4.2 – % of master plan complete.

Policy Practice Metric C.4.3 – % of network integration with PI/model.

7.5.5 Policy Practice C.5 - Monitor both plant and overall system performance.

Policy Practice Metric C.5.1 – Implement monitoring. Record and make data available.

Policy Practice Metric C.5.2 – Assess Compliance metrics

7.6 Primary Policy D - Manage wastewater flows in the combined sewer system to minimize overflows to the environment and property.

There are many approaches to the management of wastewater flows to minimize overflows and property flooding. It is expected that no one approach will be sufficient but rather a suite of methodologies to address the various mechanisms and processes related to overflows and flooding from the wastewater system will be used. Methods may focus on the causes of overflow, such as incapacity of combined sewers etc or methods to mitigate the effect of overflows, such as overflow screening and pre treatment.

It is important to ensure that investment in this area is directed to assets that pose the greatest risk. To establish this, priority work is required to understand the likelihood or frequency of overflows and flooding occurring and the consequence or effect of when it does. This risk based approach will deliver the greatest benefits in the short term whilst providing a framework for capital investment in the future.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.6.1 Policy Practice D.1 - Using storage and real-time controls, manage and regulate flows to all interceptor sewers from combined service areas to ensure that all intercepted flows are delivered to the wastewater treatment facility or comply with current permit requirements.

Policy Practice Metric D.1.1 - Set appropriate metrics to allow for phased implementation and short, medium, and long term targets.

7.6.2 Policy Practice D.2 - Reduce volumes of discharge of untreated combined sewer overflows.

Policy Practice Metric D.2.1 - Monitor overflows (in priority) and assess data.

Policy Practice Metric D.2.2 - No of CSO and SSO events per year

7.6.3 Policy Practice D.3 - Eliminate existing combined sewer overflows (CSOs) that occur during dry weather conditions.

Policy Practice Metric D.3.1 - Endeavour to capture and treat all dry weather flows plus 90% of wet weather flows above dry weather flow volume.

7.6.4 Policy Practice D.4 - Provide screening for CSOs

Policy Practice Metric D.4.1 - # of CSO's without screening.

7.6.5 Policy Practice D.5 - Continue to monitor wastewater system conditions and flow information using real-time monitoring and sampling to track system flows and discharge quality over time.

Policy Practice Metric D.5.1 - WWTF compliance monitoring and network monitoring.

Policy Practice Metric D.5.2 – % of network monitored or modeled.

7.6.6 Policy Practice D.6 - Over time, reduce combined sewer overflows (CSOs) with priority given to health and environmental impacts:

a) where overflow impacts special environmental zones (Northwest Arm, Black Rock, etc)

b) where overflow impacts recreational water use areas

c) at all other identified CSO locations

Policy Practice Metric D.6.1 - Number of CSO and SSO events per year (CCME MWWES parameter). TARGET = TBD

Policy Practice Metric D.6.2 – Number of public health and environmental regulatory infractions resulting in written warning and/or conviction

7.6.7 Policy Practice D.7 - Utilize beach closures and body contact recreational water quality objectives as the benchmark for success in minimizing impacts on water quality.

Policy Practice Metric D.7.1 - strive to keep beaches open for at least 95% of days during summer period (June 1 to September 30). Achieve body contact recreational water quality objective of 200 E. coli per 100 mL (initial) and gradually increase target to achieve 100 E. coli per 100 mL.Enterococci is considered the best indicator for marine waters.

Policy Practice Metric D.7.2 - Number of public health and environmental regulatory infractions resulting in a written warning. TARGET = 0 - 2 (max)

Policy Practice Metric D.7.3 - Number of public health and environmental regulatory infractions resulting in a conviction. TARGET = 0

7.6.8 Policy Practice D.8 – Develop a long tem sewer separatiuon program based on full life cycle cost (LCC) analysis to capitalize on construction synergies over time.

Policy Practice Metric D.8.1 – Project funding and completion. % of combined sewer converted to separated sewers.

Policy Practice Metric D.8.2 – % of combined sewer converted to separated sewers

7.7 Primary Policy E - Manage wastewater flows in the sanitary sewer system to minimize overflows to the environment and property.

As per primary policy D, this policy contains a similar rational. However the occurrence of overflows from the sanitary system can be considered more significant due to the nature of the effluent. From an environmental and system operation perspective such overflows are more serious and can suggest fundamental system performance issues that need to be addressed.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.7.1 Policy Practice E.1 - Install storm sewers where none currently exist in areas serviced by separate sanitary sewers. Promote separation where feasible

Policy Practice Metric E.1.1 - Storm sewer length per capita. # of separation schemes funded.

Policy Practice Metric E.1.2 – Number of separation schemes funded

7.7.2 Policy Practice E.2 - Eliminate sanitary sewer overflows (SSOs) with priority given to health and environmental impacts:

a) under dry weather conditions

b) under wet weather conditions where overflow impacts recreational water use areas

c) under wet weather conditions at all other identified SSO locations

Policy Practice Metric E.2.1 - Number of SSO's per capita.

Policy Practice Metric E.2.2 - Number of SSO's in proximity to sensitive areas.

Policy Practice Metric E.2.3 - Number of SSOs events per year and per recreational season

7.7.3 Policy Practice E.3 - Maintain any existing holding tanks and dynamic controls until all combined areas have been replaced by separate sanitary and storm sewers.

Policy Practice Metric E.3.1 – Assessment of operational maintenance budget.

7.7.4 Policy Practice E.4 - Continue to upgrade the sanitary sewer system to reduce I&I and the potential for SSOs by:

a) overall system management

b) regulatory requirements

c) stormwater inflow reduction (SIR) program

d) stormwater management restrictions

e) cross connection elimination

f) emerging I/I mitigation practices.

Policy Practice Metric E.4.1 - Expenditure trend analysis relating to I&I reduction. % investment for I/I reduction programs

Policy Practice Metric E.4.2 - Reduction in SSOs (frequency & volume)

Policy Practice Metric E.4.3 - Number of cross connections eliminated

7.7.5 Policy Practice E.5 - Utilize beach closures and body contact recreational water quality objectives as the benchmark for success in minimizing impacts on water quality.

Policy Practice Metric E.5.1 - Number of beach closure days/year based on rolling average of 4 years.

7.7.6 Policy Practice E.6 - Develop an SSO management plan to eliminate SSOs over time.

Policy Practice Metric E.6.1 - Number of SSO's per capita.

Policy Practice Metric E.6.2 - Number of SSO events per year or recreational season

7.8 Primary Policy F – Optimize available system capacity.

In utilizing existing capacity of infrastructure, there needs to be a balance struck in maximizing the use of the existing infrastructure while maintaining reserve capacity and ensuring acceptable operation conditions are sustained. The maximum acceptable criteria should not be exceeded including pipe velocities, operating pressures, sewer pipe surcharging conditions, and firm pumping capacitates. The use of existing infrastructure should not compromise the level of service being provided to existing customers.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.8.1 Policy Practice F.1 - Fully utilize capacity and optimize system controls of existing wastewater infrastructure

Policy Practice Metric F.1.1 - % reduction in new wastewater mains due to optimization

7.8.2 Policy Practice F.2 - Existing sources of infiltration and inflow shall be identified and reduced by implementing extraneous flow reduction measures.

Policy Practice Metric F.2.1 – WWTF flow data analysis

7.8.3 Policy Practice F.3 - Where overflows need to be avoided, temporary storage of the wet weather flows can be provided (e.g. surface level storage tanks or deep tunnel storage).

Policy Practice Metric F.3.1 -

7.8.4 Policy Practice F.4 - Use master planning to identify opportunities for cross-sewershed flow exchanges.

Policy Practice Metric F.4.1 -

7.8.5 Policy Practice F.5 - Optimize management of excess flows between collection and treatment systems.

Policy Practice Metric F.5.1 - % diverted/increased flows @ treatment facility

7.9 Primary Policy G - Regulate allowable flow into the wastewater system.

There are several significant wastewater system input sources. In terms of regulating permissible flows it is first important to have a firm understanding of the receiving assets. Industrial effluent discharges need to be carefully managed in order to provide a service to industry without compromising system serviceability. Domestic users also need to be educated in terms of what allowance is permissible.

In order to achieve this policy goal the following practice with associated metric has been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.9.1 Policy Practice G.1 - Implement Rules and Regulations that will set the maximum permissible limits on the criteria for discharge quantity into municipal sewers relative to size and load.

Policy Practice Metric G.1.1 - Ratio of discharge volume to receiving sewer volume

Policy Practice Metric G.1.2 - Ratio of discharge concentration to receiving sewer concentration

7.9.2 Policy Practice G.2 - Enhance education and outreach program

Policy Practice Metric G.2.1 - Number of education documents issued

Policy Practice Metric G.2.2 - Number of hits to website

7.10 Primary Policy H - Meet effluent discharge limits as defined by NSE and consistent with the CCME for all wastewater treatment facilities.

Effluent discharge quality should be routinely monitored. Where problems are identified they should be prioritised using a risk based approach to allocate asset investment and improvement. It is important to establish a professional and open working relationship with NSE, working together to realise improvements.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.10.1 Policy Practice H.1 - Prioritize upgrades of treatment facilities identified as higher risk.

Policy Practice Metric H.1.1 – % of budget allocated/spent on WWTF compliance projects

7.10.2 Policy Practice H.2 - Maximize volume to be treated through full secondary and tertiary treatment (long term).

Policy Practice Metric H.2.1 – Percentage of wastewater treatment facilities meeting discharge regulations of their permits; we must own the system for one year to include as a measure (does not include HHSP plants). TARGET = 80%

Policy Practice Metric H.2.2 – Adopt levels of acceptable Harbour-specific wastewater criteria, identified through the Halifax Harbour Solutions Project.

7.10.3 Policy Practice H.3 - Ensure that a Biosolids Management Plan that addresses the requirements of the NSE guidelines is maintained and updated.

Policy Practice Metric H.3.1 - Biosolids residual handling: % of samples having a minimum solids content of 25% for HHSP and 18% for Aerotech. TARGET = 95%

7.11 Primary Policy I – Within the timescales and framework of an approved CSO management plan, ensure new development does not impact the frequency, volume, and quality of combined sewer overflows (CSOs) or sanitary sewer overflows (SSOs).

Concise design guidance and detailed hydraulic modelling are key aspects to the successful attainment of this ongoing objective. Evaluation studies prior to installation of new wastewater systems should be of sufficient detail to understand such things like groundwater, water table and soil types. This information should affect design decisions to ensure that a suitable specification is generated that will minimise extraneous flows to enter the new system.

In order to achieve this policy goal the following practice with associated metric has been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.11.1 Policy Practice I.1 – New wastewater systems shall be designed and constructed to minimize extraneous flows.

Policy Practice Metric I.1.1 - Review design specification and ensure completion of as built CCTV survey

Policy Practice Metric I.1.2 - Length of new sewers CCTV'ed per year

7.11.2 Policy Practice I.2 – Produce an maintain an approved CSO management plan, including details to mitigate the impact of new development on the operation of sewer overflows.

Policy Practice Metric I.2.1 - Complete and maintain waste water master plan

7.12 Primary Policy J - Ensure HRM and Halifax Water policies for growth are consistent.

Taking account of HRM policies and procedures as well as establishing close working relationships are important aspect of this policy. An important use of the master plan is to facilitate this close working relationship by providing understanding of the requirements of each organisation. The HRM regional plan should form a key document when assessing growth whilst being conscious of the need to plan for growth beyond the time horizon of the official plan.

In order to achieve this policy goal the following practices with associated metrics have been defined. These provide manageable, specific tasks that can be measured against progress and success:

7.12.1 Policy Practice J.1 – Adopt area-specific wastewater design criteria for master planning purposes, taking into account historical flows and other related studies and analyses.

Policy Practice Metric J.1.1 – Inclusion of design criteria review as part of master plan

7.12.2 Policy Practice J.2 – Plan for wastewater capacity to service projected growth as defined in HRM's Regional Plan.

Policy Practice Metric J.2.1 – % growth driven capital projects per year

Policy Practice Metric J.2.2 – Length of main or value of assets constructed to support growth

7.12.3 Policy Practice J.3 – Ensure that the design of water and wastewater infrastructure recognizes the potential for growth beyond the time horizon of HRM's Regional Plan (related to CCC policies).

Policy Practice Metric J.3.1 – Number of kilometres or value of assets identified beyond Regional Plan horizon of 2026

7.12.4 Policy Practice J.4 – New development shall maintain or improve current levels of service.

Policy Practice Metric J.4.1 – Compliance monitoring and trend analysis

7.12.5 Policy Practice J.5 - Ensure policies align with HRM policy to promote growth within the urban core.

Policy Practice Metric J.5.1 - Assessment of targeted settlement pattern split for new units: 25% Urban, 50% Suburban & 25% Rural

7.12.6 Policy Practice J.6 - Review all policies every 5 years in line with HRM regional plan review.

Policy Practice Metric J.6.1 - Undertake policy review as part of HRM regional plan review.

References

Boston Harbour Master Plan, 2006:
http://www.mwra.state.ma.us/publications/masterplan/2006/wastewater.pdf

Canadian Council of Ministers of the Environment (CCME), (2008) Canada-wide Strategy for the Management of Municipal Wastewater Effluent (CSMMWE) Environmental Risk Management: Framework and Guidance.

Chambers P.A., M. Allard, S.L. Walker, J. Marsalek, J. Lawrence, M. Servos, J. Busnarda, K.S. Munger, K. Adare, C. Jefferson, R.A. Kent and M.P. Wong. 1997. The impacts of municipal wastewater effluents on Canadian waters: a review. *Water Quality Research Journal of Canada 32: 659-71*.

Chesapeake Bay Monitoring Programme: Pollutant Inputs, 2011:
http://www.dnr.state.md.us/bay/monitoring/mon_mngmt_actions/chapter8.html

City of Hamilton Water and Wastewater Master Plan, Report II – Policy Paper, January 2007

Department of Fisheries and Oceans, Bedford Institute of Oceanography. Water Quality of Halifax Harbour. http://www2.mar.dfo-mpo.gc.ca/science/ocean/BedfordBasin/HHWQMP/FecalColiforms.pdf

Greater London Authority, 2011, Dealing with Waste Water in London
http://www.london.gov.uk/priorities/environment/water-management/wastewater

Halifax Regional Water Commission. 2011. Schedule “B” – Schedule of Rules and Regulations for Water, Wastewater and Stormwater Services.
http://www.halifax.ca/hrwc/PoliciesAndRegulations.html

Halifax Regional Water Commission. 2011. Schedule “C” – Schedule of Rules and Regulations for Water, Wastewater and Stormwater Services.
http://halifax.ca/hrwc/documents/ScheduleCRulesRegulations_Wastewater.pdf

Halifax Regional Water Commission Act. 2007. Bill No. 83. An Act Respecting the Halifax Regional Water Commission.
http://nslegislature.ca/legc/bills/60th_2nd/3rd_read/b083.htm

Halifax Regional Municipality Charter. 2008. Bill No. 179. An Act Respecting the Halifax Regional Municipality.
http://nslegislature.ca/legc/bills/60th_2nd/3rd_read/b179.htm

Halifax Water. 2011. General Information on Utility (www.halifax.ca/hrwc) [last accessed 4 June 2011].

Halifax Water, Water Quality summary report:
http://www.halifax.ca/harboursol/documents/HHWQMPFinalSummaryReport.pdf

Maryland Department of the Environment, 2011, Water Programs (Chesapeake Bay): http://www.mde.state.md.us/programs/water/pages/programs/waterprograms/index.aspx

Metro Vancouver. Integrated Liquid Waste and Resource Management Plan, May 2010. http://www.metrovancouver.org/about/publications/Publications/ILWRMP.pdf

Thames Tunnel Consultation Document, 2011: http://www.thamestunnelconsultation.co.uk/our-proposed-solution.aspx\

Thames Water. London Tideway Improvements Website, 2011: http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/2833.htm

Water Keepers F-5 Report, 2004. http://www.waterkeeper.ca/lok/documents/F55_report.pdf

Appendix B Flow Monitor Data Analysis

Date:	April 21, 2016	File:	714058
To:	Halifax Water		
From:	GM BluePlan Engineering		
Project:	West Region Wastewater Infrastructure Plan (WRWIP)		
Subject:	WiiFAT Flow Monitoring Data Analysis		

TECHNICAL MEMO

Overview

This technical memo provides a summary of the flow survey that was completed as part of the West Region Wastewater Infrastructure Plan (WRWIP) and the Local Wastewater Servicing Capacity Analysis (LoWSCA) projects. A summary of the flow monitors and their specifications, in addition to a map of their locations, is provided in Appendix A.

This memo also outlines the analysis methodology and presents the analysis results, which was completed using the Wastewater Inflow and Infiltration Flow Analysis Tool (WiiFAT), developed by GM BluePlan. The WiiFAT was used to import flow monitoring and precipitation data, collected from October to November 2015, and complete a full suite of analyses, as outlined below.

Flow Monitoring Analysis Methodology

Identification of Critical Precipitation Events

Precipitation data, collected by a rain gauge located at the Halifax Water Wastewater Treatment Facility, was used to identify and summarize all precipitation events during the flow monitoring period. The precipitation events were then filtered down to just critical events, which are identified as having a minimum of 5 mm of total precipitation and a minimum peak 1-hour intensity of 20 mm/hr. The Region's IDF information was used to quantify a return period for each critical event.

Review of Velocity-Depth Scatter Graph

The relationship of the flow monitor velocity and depth data was used to evaluate the performance of the flow monitor in addition to the assessment of pipe flow conditions. The scatter graphs can be used to identify issues with the flow monitor hardware and understand flow characteristics, such as surcharge, of the pipe flow.

Dry Weather Flow Analysis

Precipitation data was used to identify and summarize dry weather days, from which five weekdays and four weekend days were selected. The selected dry weather days were used to assess and calculate dry weather flow variables, graph the 24-hour average dry weather flow diurnal curve, and determine the hourly dry weather flow factors used for the dry weather flow model calibration.

Quantification of Rainfall Derived Inflow and Infiltration (RDII)

The flow monitoring data, precipitation data, and the results from the dry weather flow analysis were used to quantify the catchment's response, RDII, to the critical precipitation events. Key RDII variables were calculated including the Unit Peak RDII (L/s/ha) and the Volumetric Runoff Coefficient (Cv). The Cv is defined as the rainfall that entered the sanitary system as a percentage of the total rain that fell on the catchment area. Wet weather flow graphs were developed to illustrate the different flow components, during the precipitation events, in isolation.

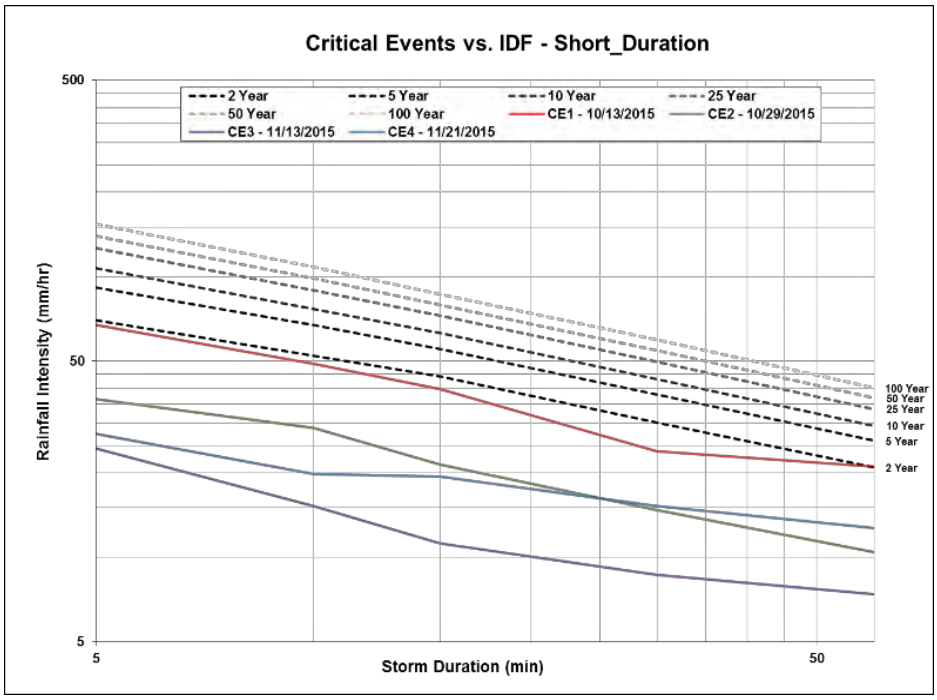
Flow Monitoring Acronyms

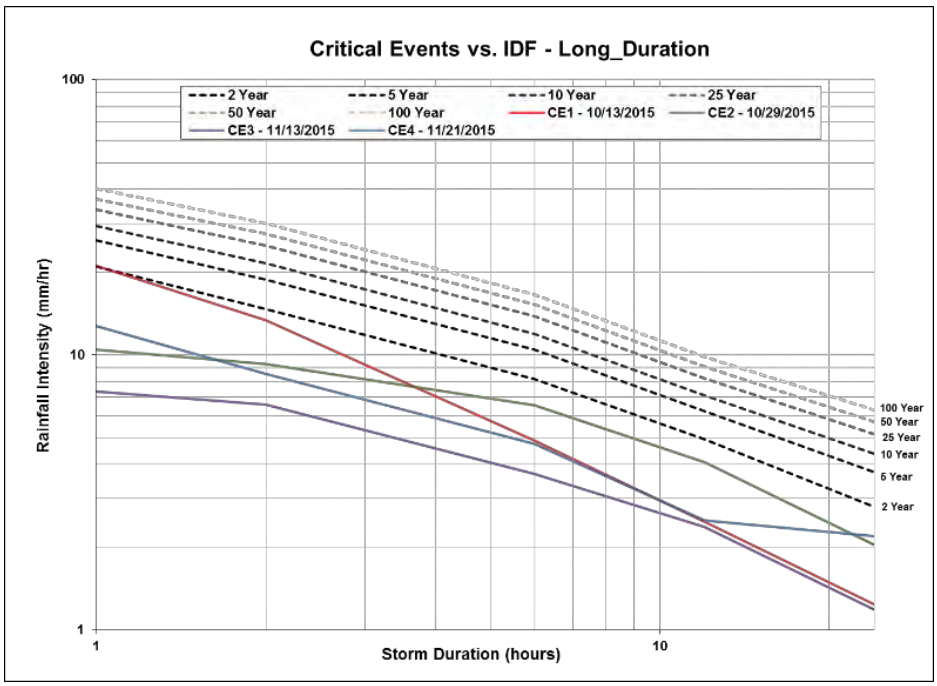
ADWF	average dry weather flow = average sanitary flow + BGWI
BGWI	base groundwater infiltration
CO	combined sewer
SAN	sanitary sewer
ST	storm sewer

Identification of Critical Precipitation Events

Over the course of the flow monitoring period, four (4) critical events were observed; the table below summarizes the critical events and the figures compare the intensities against the Region's IDF curves for short and long durations.

Critical Event ID	Start of Event	End of Event	Peak 1-hr (mm)	Total Depth (mm)	Return Period (years)
CE-1	10/13/2015 9:55	10/13/2015 14:55	21	30	1.9
CE-2	10/29/2015 7:30	10/29/2015 18:55	10	49	0.9
CE-3	11/13/2015 0:50	11/13/2015 12:15	7	29	0.2
CE-4	11/21/2015 6:55	11/23/2015 1:00	13	93	0.9





1. Dry Weather Flow Analysis

The following table summarizes the key dry weather flow variables. Additional dry weather flow results and figures are provided in Appendix B, including the 24-hour ADWF diurnal curves.

Flow Monitor ID	Sewer Type	ADWF (L/s)	Unit BGWI (L/s/ha)	Per Capita Sanitary Flow (L/day)
FM-1	CO	17.0	0.19	111
FM-2	SAN	76.9	0.03	302
FM-3	CO	19.8	0.09	127
FM-4	SAN	68.5	0.17	203
FM-5	SAN	10.0	0.02	378
FM-6	SAN	39.8	0.06	301
FM-7	CO	11.5	0.04	204
FM-8	CO	51.6	0.29	363
FM-9	CO	27.7	0.35	429
FM-10	CO	11.8	0.22	129
FM-11	CO	19.8	0.23	345
FM-12	CO	21.9	0.42	156
FM-13	CO	307.3	0.05	416
FM-14	CO	25.0	0.25	138
FM-15	CO	58.3	0.18	227
FM-16	CO	319.6	0.15	194
FM-17	CO	0.9	0.02	141
FM-18	SAN	90.4	0.07	249
FM-20	SAN	81.5	0.13	240
FM-21	SAN	37.1	0.02	130
FM-22	SAN	131.1	0.02	333
FM-101	CO	2.1	0.13	212
FM-102	CO	6.4	0.05	107
FM-201	SAN	1.9	0.05	121
FM-202	ST	*NA*	*NA*	*NA*
FM-203	CO	0.3	0.06	211
FM-204	CO	5.8	0.21	358
FM-205	CO	8.6	0.21	182
FM-301	CO	4.3	0.06	351
FM-302	ST	*NA*	*NA*	*NA*
FM-401	CO	7.4	0.23	424
FM-402	CO	1.5	0.07	107
FM-501	SAN	141.4	0.01	533
FM-502	CO	0.2	0.02	129
FM-601	CO	43.7	0.22	198
FM-602	CO	6.0	0.48	84

2. Quantification of Rainfall Derived Inflow and Infiltration (RDII)

The following table summarizes the key RDII variables that correspond to each critical event. The figures in Appendix B illustrate the catchment's response to each critical event, including the different flow components in isolation.

Flow Monitor ID	Sewer Type	Unit Peak RDII (L/s/ha)				Event Cv (%)			
		1	2	3	4	1	2	3	4
FM-1	CO	7.53	7.97	3.68	7.47	14	19	15	30
FM-2	SAN	0.75	0.24	0.37	0.62	1	3	1	3
FM-3	CO	0.68	0.78	0.41	1.01	5	7	6	15
FM-4	SAN	*NA*	0.50	0.18	0.97	*NA*	7	4	14
FM-5	SAN	0.10	0.29	0.15	0.48	1	1	1	3
FM-6	SAN	0.83	0.76	0.38	0.98	4	4	5	15
FM-7	CO	4.08	1.88	1.78	4.03	11	3	10	17
FM-8	CO	39.93	35.19	10.23	41.88	74	83	87	129
FM-9	CO	12.99	11.32	0.38	4.79	9	2	3	4
FM-10	CO	14.25	7.53	3.95	8.02	35	28	29	51
FM-11	CO	2.50	1.47	1.07	2.11	2	2	2	3
FM-12	CO	38.99	21.48	20.43	37.85	49	64	86	78
FM-13	CO	0.58	0.57	0.57	0.56	12	9	9	16
FM-14	CO	*NA*	3.31	2.42	3.61	*NA*	8	11	16
FM-15	CO	15.13	8.21	6.29	10.98	23	31	29	54
FM-16	CO	0.72	0.62	0.93	0.96	9	6	12	23
FM-17	CO	12.87	13.51	6.51	5.87	9	15	21	3
FM-18	SAN	1.27	1.12	1.20	1.14	48	22	20	24
FM-20	SAN	0.66	0.74	0.41	0.89	14	12	9	19
FM-21	SAN	0.15	0.22	*NA*	*NA*	2	2	*NA*	*NA*
FM-22	SAN	0.18	0.58	0.14	0.63	2	4	3	8
FM-101	CO	13.64	7.90	5.05	9.78	17	15	16	22
FM-102	CO	18.20	11.57	5.12	11.68	25	22	20	33
FM-201	SAN	0.58	0.60	0.31	0.80	4	2	2	5
FM-202	ST	52.50	34.70	27.69	33.84	32	53	60	57
FM-203	CO	21.14	18.27	10.10	19.20	28	33	35	32
FM-204	CO	58.74	31.59	18.95	24.51	56	87	132	144
FM-205	CO	22.74	9.51	5.43	8.11	25	29	35	32
FM-301	CO	10.69	6.50	*NA*	*NA*	22	18	*NA*	*NA*
FM-302	ST	14.29	7.37	3.49	8.33	11	11	13	14
FM-401	CO	*NA*	19.52	11.37	26.11	*NA*	33	42	57
FM-402	CO	8.73	4.62	4.94	13.38	5	3	4	6
FM-501	SAN	0.36	0.63	0.25	0.35	5	6	5	9
FM-502	CO	13.58	11.06	5.26	16.73	11	22	14	38
FM-601	CO	14.76	3.19	1.92	5.32	26	24	33	36
FM-602	CO	38.57	24.61	8.22	27.56	54	41	43	58

3. Statistical Analysis for Key Outputs

A statistical analysis was completed for two key outputs to identify the average value, extent of variability, an appropriate range of values, and potential outliers.

- Per Capita Sanitary Flow (L/cap/d): dependent on the accuracy of the population number.
- Peak Unit RDII (L/s/ha): dependent on the accuracy of the catchment area.

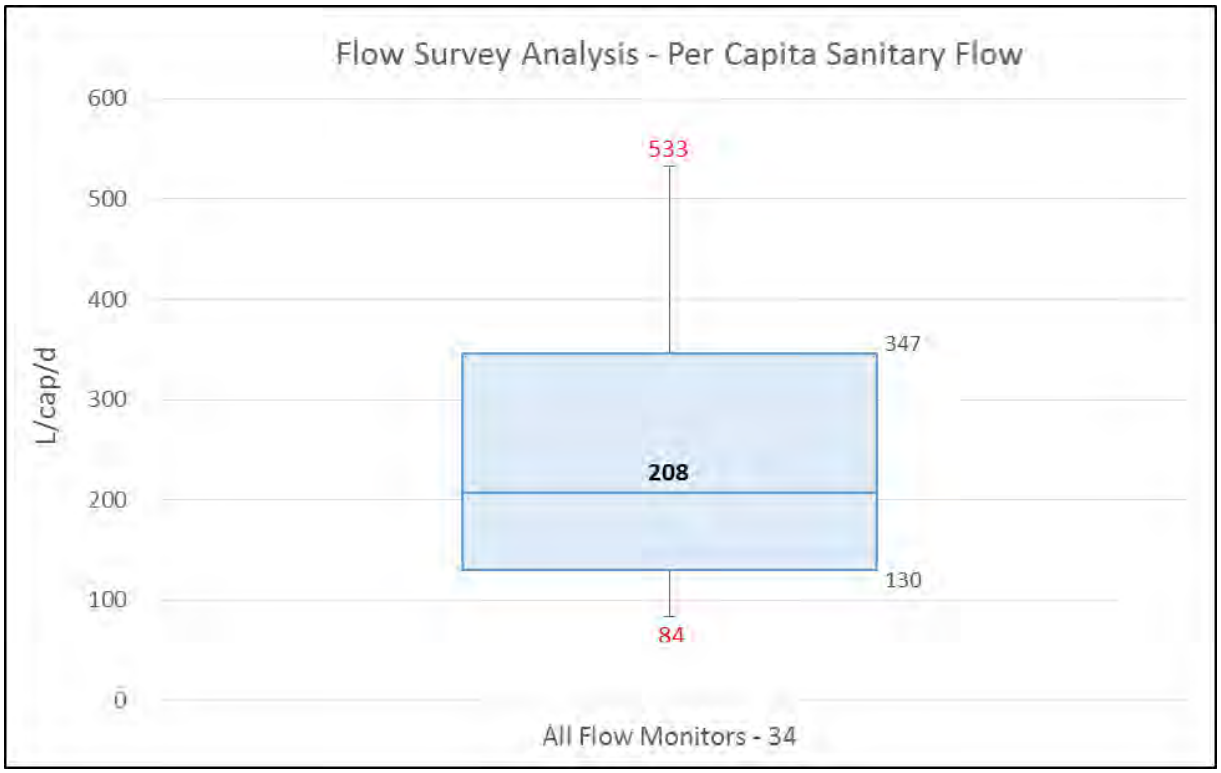
Statistical Analysis: Box-and-Whisker Plot

The statistical analysis that was used is a box-and-whisker plot; a graphical method of presenting the degree of dispersion and skewness of data points centered on a dataset's quartiles (the box) and upper and lower limits (the whiskers).

The lower limit of the box represents the 25th percentile, the upper limit of the box represents the 75th percentile, and the interior band is the median. The whiskers represent the lowest and highest data points within 1.5 Inter Quartile Range (IQR) of the first and third quartiles respectively; where the IQR is equal to the height of the box (Q3-Q1). Any data points outside of the whiskers are considered outliers.

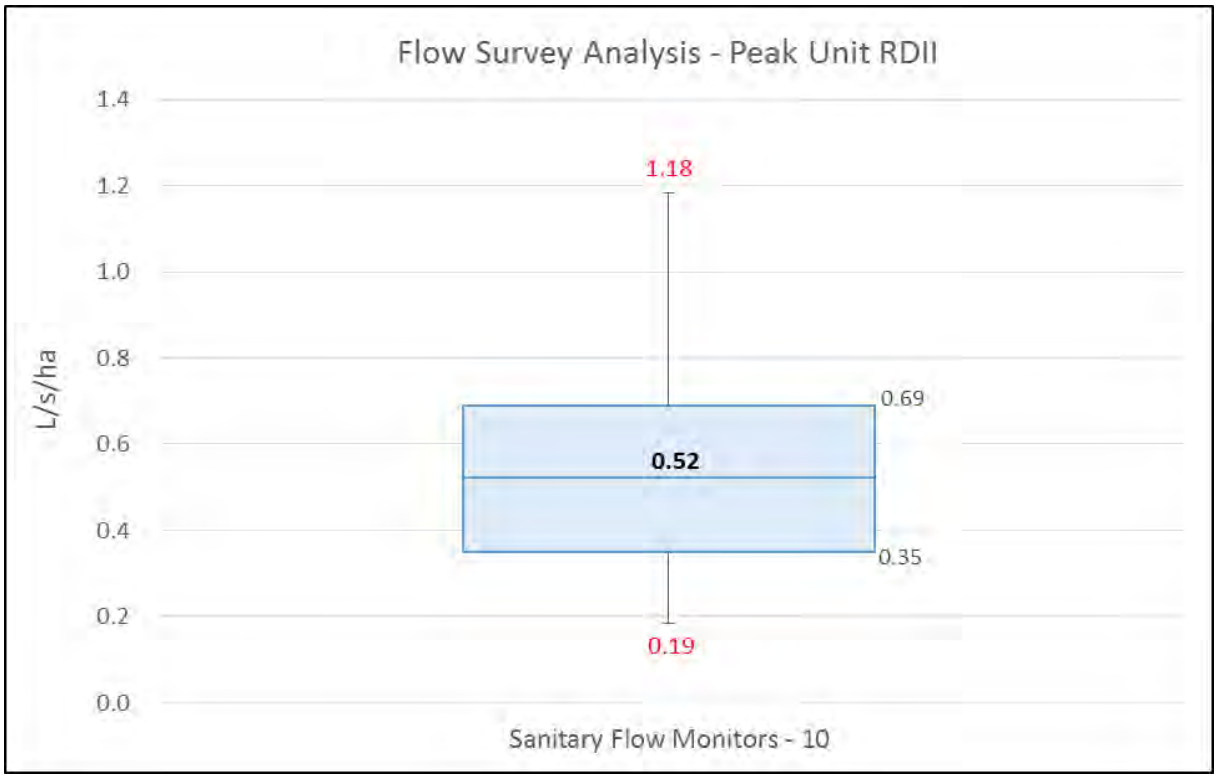
Per Capita Sanitary Flow

The average per capita sanitary flow rate was estimated as part of the dry weather flow analysis. With probable outliers removed, the per capita sanitary flow rates range from ***84 - 533 L/cap/d*** with an average of ***208 L/cap/d***; the central 50% ranges from 130 - 347 L/cap/d.

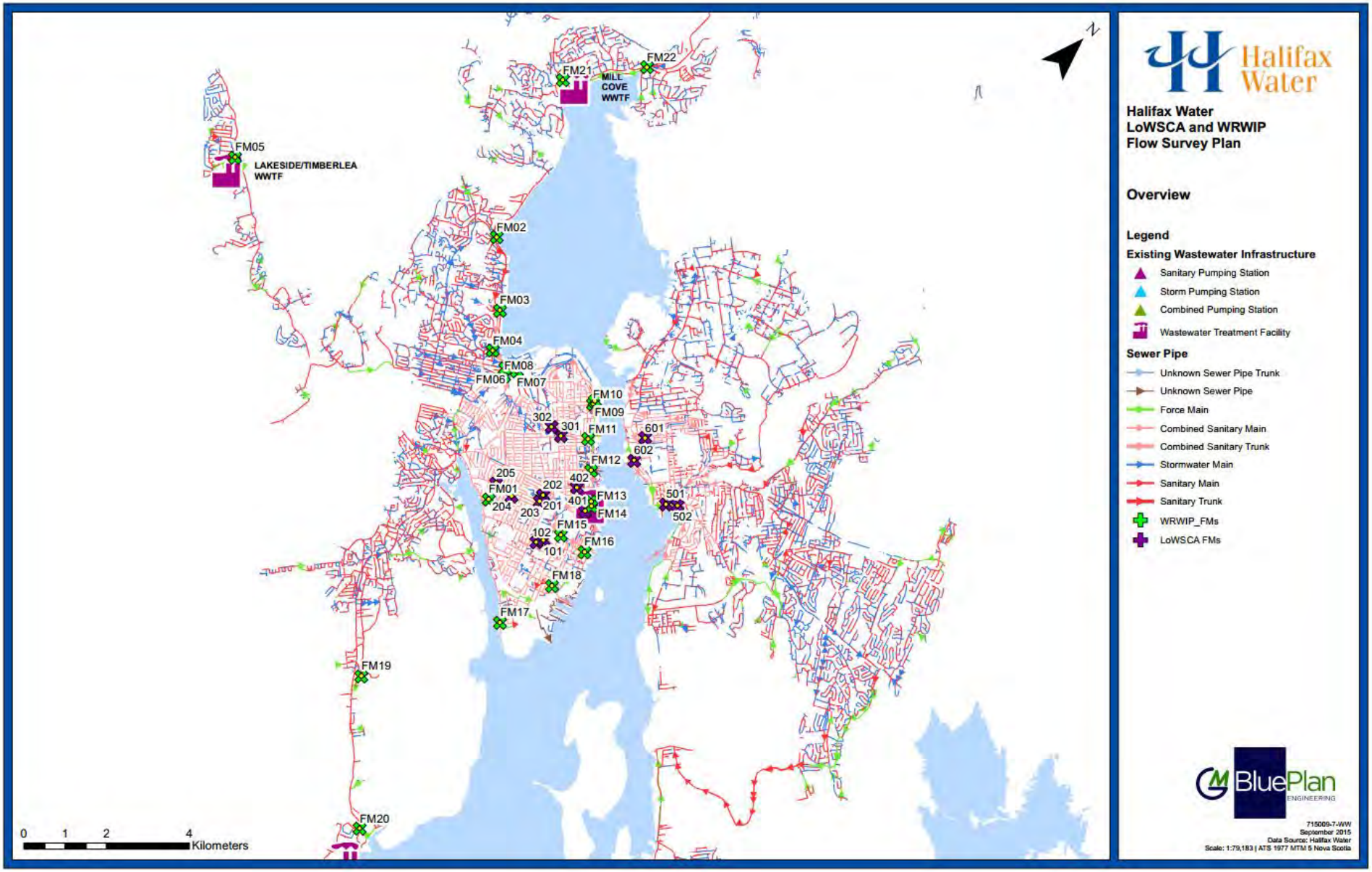


Peak Unit RDII

An extraneous flow analysis, quantification of RDII rates, was completed as part of the wet weather analysis. This analysis summarizes each catchment's response to four critical precipitation events. The statistical analysis was completed for flow monitors located in sanitary sewers only (10 number). With probable outliers removed, the peak unit RDII rates range from ***0.19 - 1.18 L/s/ha*** with an average of ***0.52 L/s/ha.***



Appendix A: Flow Monitor Locations and Site Information


FM22
FM21
MILL COVE WWTF
FM05
LAKESIDE/TIMBERLEA WWTF
FM02
FM03
FM04
FM08
FM06
FM07
FM10
FM09
FM11
302
301
601
602
FM12
205
FM01
204
202
201
203
402
401
FM13
FM14
501
502
FM15
102
101
FM16
FM18
FM17
FM19
FM20
0 1 2 4 Kilometers
Halifax Water
Halifax Water
LoWSCA and WRWIP
Flow Survey Plan
Overview
Legend
Existing Wastewater Infrastructure
Sanitary Pumping Station
Storm Pumping Station
Combined Pumping Station
Wastewater Treatment Facility
Sewer Pipe
Unknown Sewer Pipe Trunk
Unknown Sewer Pipe
Force Main
Combined Sanitary Main
Combined Sanitary Trunk
Stormwater Main
Sanitary Main
Sanitary Trunk
WRWIP_FMs
LoWSCA FMs
BluePlan ENGINEERING
715009-7-WW
September 2015
Data Source: Halifax Water
Scale: 1:79,183 | ATS 1977 MTM 5 Nova Scotia

Flow Monitor ID	Sewer System	Location	Manhole Number	Flow Monitoring Period	Pipe Size (mm)	Catchment Area (ha)	Equivalent Population
FM-1	CO	Jubilee/Fairfield	1146	Oct. 7 – Nov. 24	900	66	3,405
FM-2	SAN	Bedford	11042	Sep. 29 – Dec. 1	1,500	650	17,065
FM-3	CO	Bedford/Seton	7110	Sep. 29 – Nov. 27	750	142	4,828
FM-4	SAN	Off Bedford	9039	Oct. 28 – Nov. 30	750	255	10,452
FM-5	SAN	Rosewood	52083	Sep. 29 – Dec. 1	600	144	1,558
FM-6	SAN	Ramp Rd	4354	Sep. 30 – Nov. 27	600	245	7,199
FM-7	CO	Bayne Street	4485	Sep. 30 – Nov. 26	900	67	3,793
FM-8	CO	DS of Lakeside PS Diversion	4369	Sep. 30 – Dec. 1	600	34	9,887
FM-9	CO	Duffus/Barrington	4953	Oct. 6 – Nov. 25	900	43	2,557
FM-10	CO	Barrington	4972	Oct. 4 – Nov. 25	1,200	39	2,380
FM-11	CO	Kaye/Vincent	3952	Oct. 9 – Nov. 26	500	60	1,484
FM-12	CO	Valour	49590	Sep. 30 – Nov. 30	750	39	3,038
FM-13	CO	Upper Water/Valour	49418	Oct. 9 – Nov. 30	1350	1,377	48,757
FM-14	CO	WWTF Halifax Plant	3047	Oct. 6 – Nov. 30	900	75	4,150
FM-15	CO	Sackville/Bell	2027	Oct. 8 – Nov. 30	1,800	129	13,123
FM-16	CO	Hollis/Salter	49808	Oct. 8 – Nov. 30	900	897	80,730
FM-17	CO	Chain Rock	441	Oct. 6 – Nov. 30	1,500	22	330
FM-18	SAN	Inglis/Mitchell	49818	Oct. 4 – Nov. 25	750	402	21,054
FM-20	SAN	Lancaster/Tribune	14366	Oct. 6 – Nov. 30	750	346	13,301
FM-21	SAN	Incoming to Mill Cove WWTF	33724	Sep. 29 – Nov. 10	900	655	17,605
FM-22	SAN	Fish Hatchery PS	23016	Sep. 29 – Dec. 1	1,200	2,098	25,000
FM-101	CO	Spring Garden/Summer	1676	Oct. 7 – Nov. 25	450	8	439
FM-102	CO	College/Carlton	1374	Oct. 7 – Nov. 25	900	53	2,830
FM-201	SAN	Windsor/Welsford	2314	Oct. 8 – Nov. 24	300	7	1,134
FM-202	ST	Windsor/Welsford	2313	Oct. 8 – Nov. 24	750	7	*NA*
FM-203	CO	Quinpool	2348	Oct. 8 – Nov. 24	350	2	86
FM-204	CO	Quinpool/Oxford	1513	Oct. 8 – Nov. 24	600	11	868
FM-205	CO	Quinpool/Bloomingdale	1523	Oct. 7 – Nov. 24	900	26	1,527
FM-301	CO	Young/Agricola	3772	Oct. 4 – Nov. 2	600	39	470
FM-302	ST	Kempt/Livingstone	3827	Sep. 30 – Nov. 26	375	24	*NA*
FM-401	CO	Brunswick/Portland	3070	Oct. 27 – Nov. 26	500	13	894
FM-402	CO	Buddy Day/Gottingen	3336	Oct. 8 – Nov. 26	400	13	403
FM-501	SAN	Canal	18738	Oct. 9 – Nov. 27	1,050	1,810	18,878
FM-502	CO	Maitland	1852	Oct. 5 – Nov. 27	600	5	88
FM-601	CO	Jamieson/Wyse	19279	Oct. 9 – Nov. 24	1,500	102	9,078
FM-602	CO	Lyle/Williams	18823	Oct. 3 – Nov. 27	375	11	934

Appendix B: WiiFAT Outputs

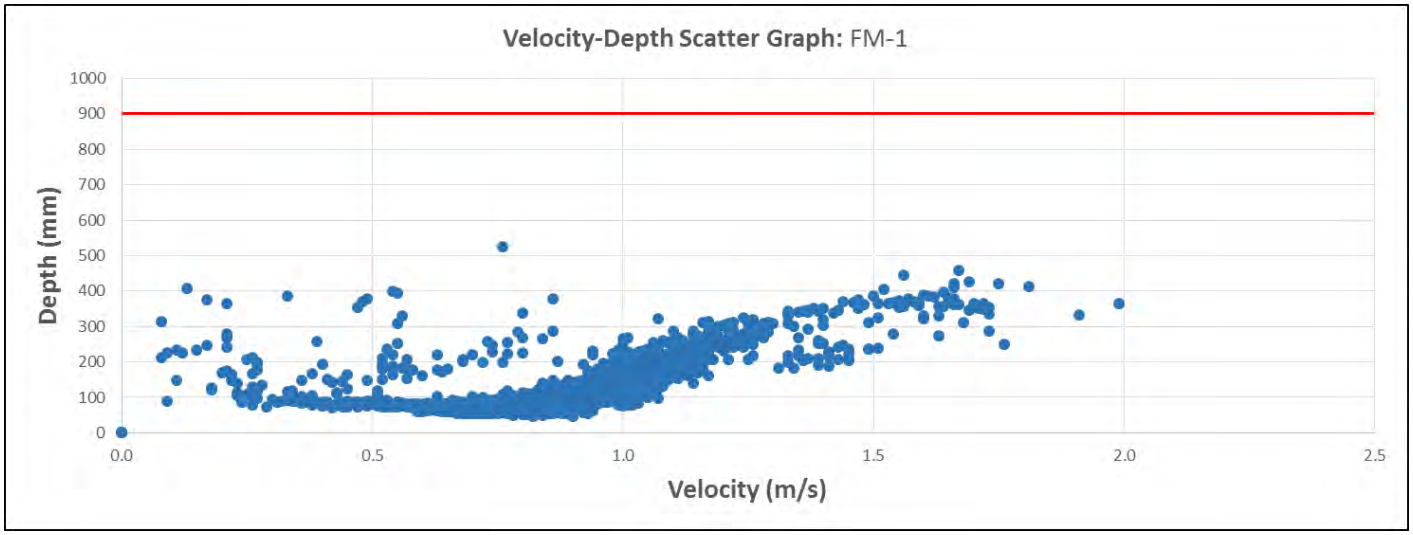
Table of Contents – Flow Monitors

Page #

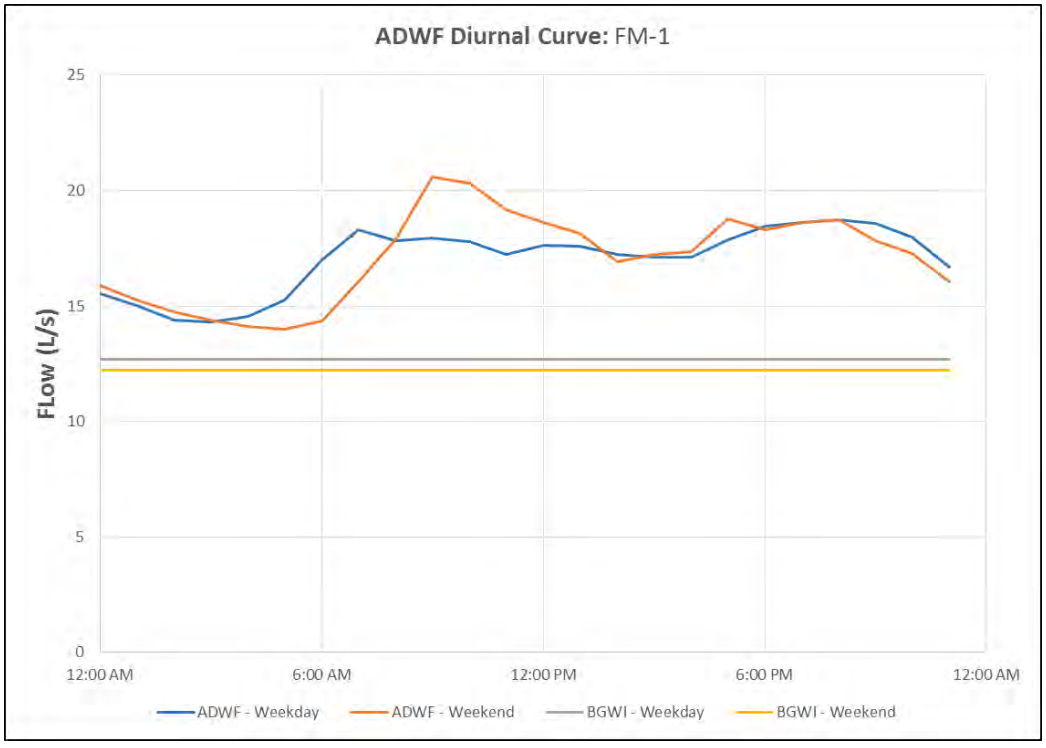
FM-1 12
FM-2 16
FM-3 20
FM-4 24
FM-5 28
FM-6 32
FM-7 36
FM-8 40
FM-9 44
FM-10 48
FM-11 52
FM-12 56
FM-13 60
FM-14 64
FM-15 68
FM-16 72
FM-17 76
FM-18 80
FM-20 84
FM-21 88
FM-22 91
FM-101 95
FM-102 99
FM-201 103
FM-202 107
FM-203 111
FM-204 115
FM-205 119
FM-301 123
FM-302 126
FM-401 130
FM-402 134
FM-501 138
FM-502 142
FM-601 146
FM-602 150

FM-1

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.66	0.75
0.54	0.62
0.40	0.51
0.38	0.44
0.43	0.39
0.60	0.37
0.99	0.44
1.29	0.78
1.18	1.16
1.21	1.71
1.17	1.66
1.04	1.42
1.13	1.31
1.13	1.21
1.05	0.96
1.02	1.02
1.02	1.05
1.19	1.34
1.33	1.24
1.37	1.31
1.39	1.34
1.36	1.14
1.21	1.03
0.92	0.78

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	17.0	17.1	L/s
MNF	14.3	14.0	L/s
BGWI	12.7	12.2	L/s
Unit BGWI	0.19	0.19	L/s/ha
Sanitary Flow	4.4	4.9	L/s
Per Capita Sanitary Flow	110.6	124.1	L/cap/d
Peak DWF	18.7	20.6	L/s

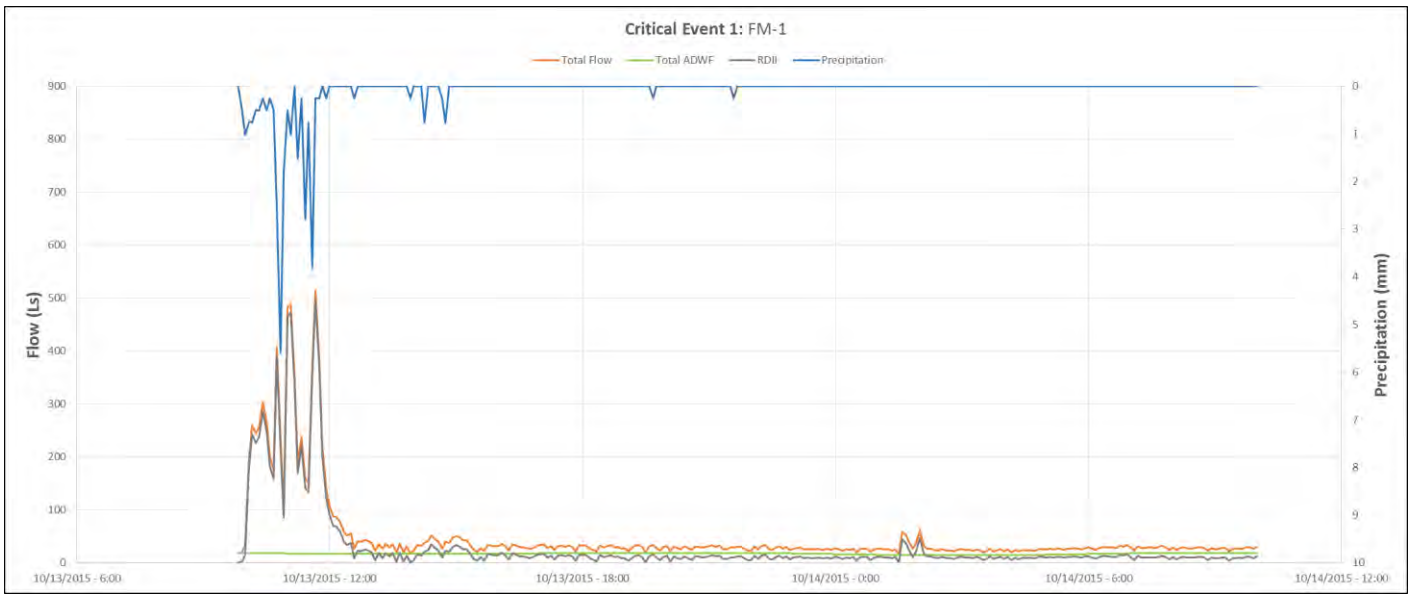
Quantification of RDII

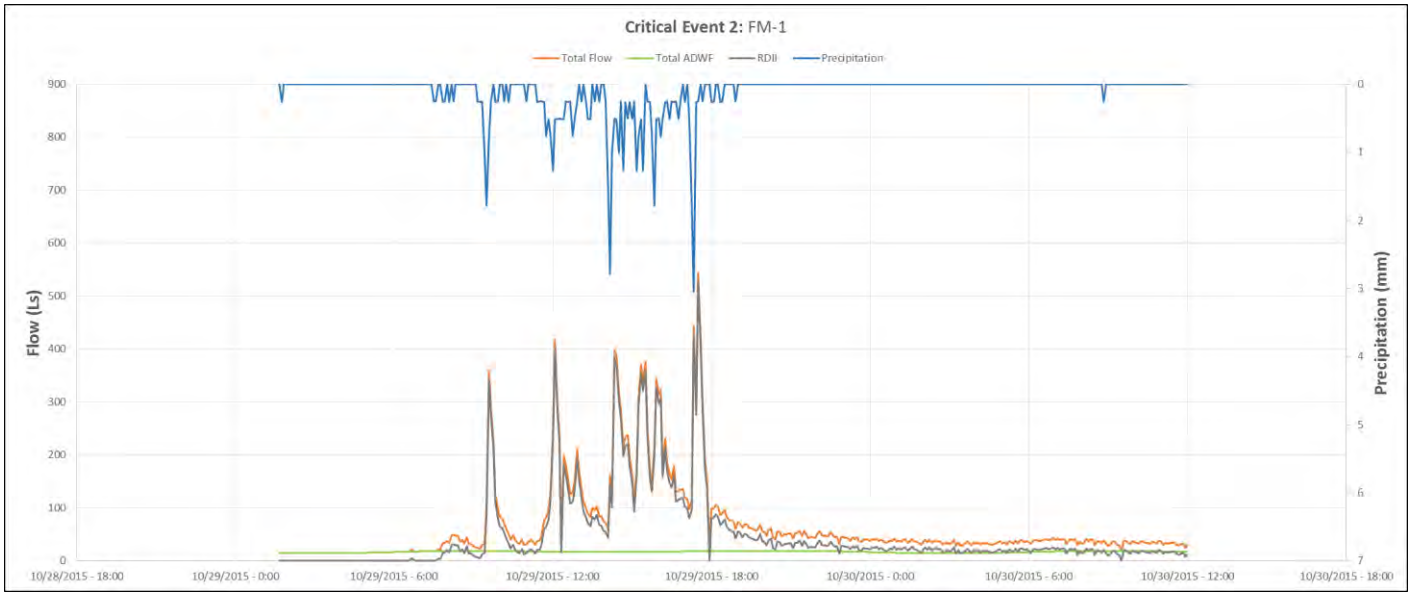
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	497	14%	7.53
CE2	10/29/2015	10	49	526	19%	7.97
CE3	11/13/2015	7	29	243	15%	3.68
CE4	11/21/2015	13	93	493	30%	7.47

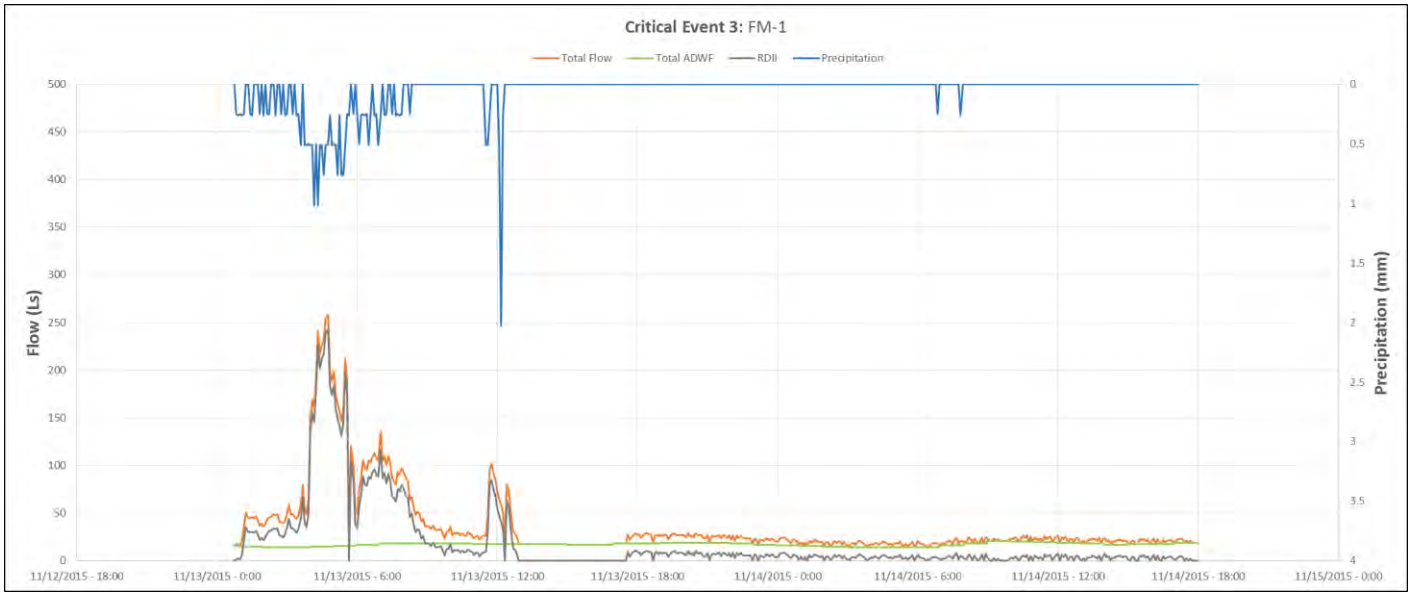
Estimated Peak Wet Weather Design Flows (L/s)

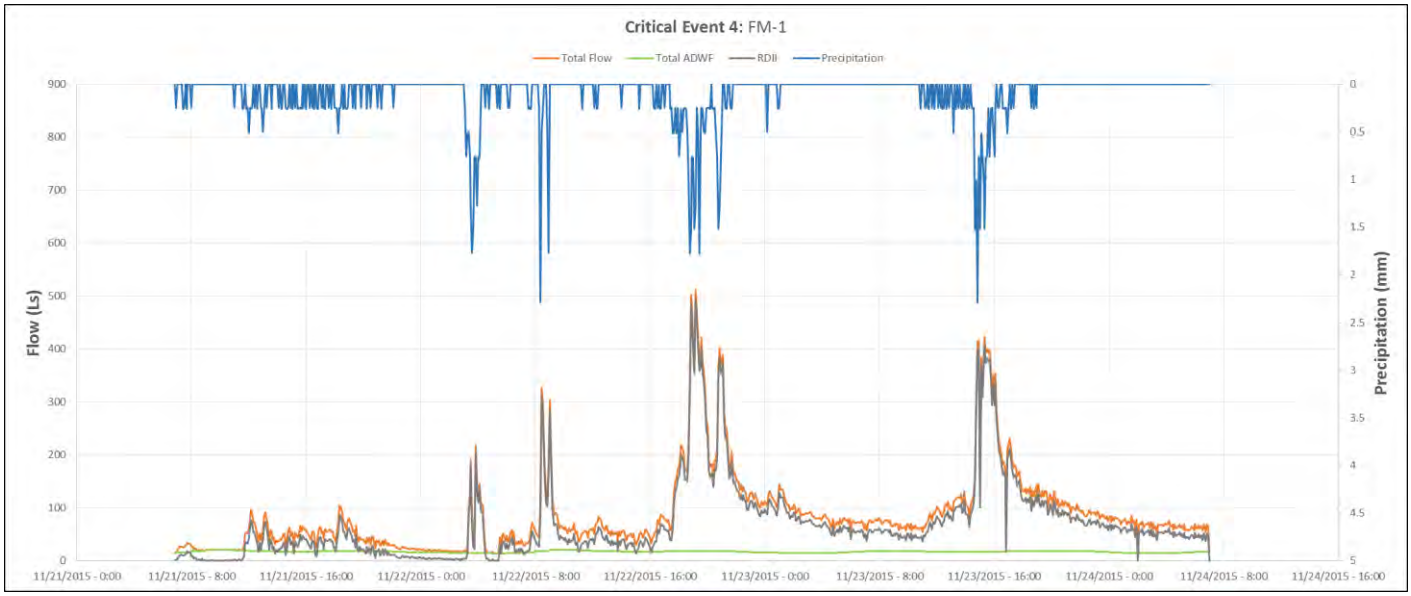
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	49	715	909	1040	1205	1326	1447

Wet Weather Flow Graphs



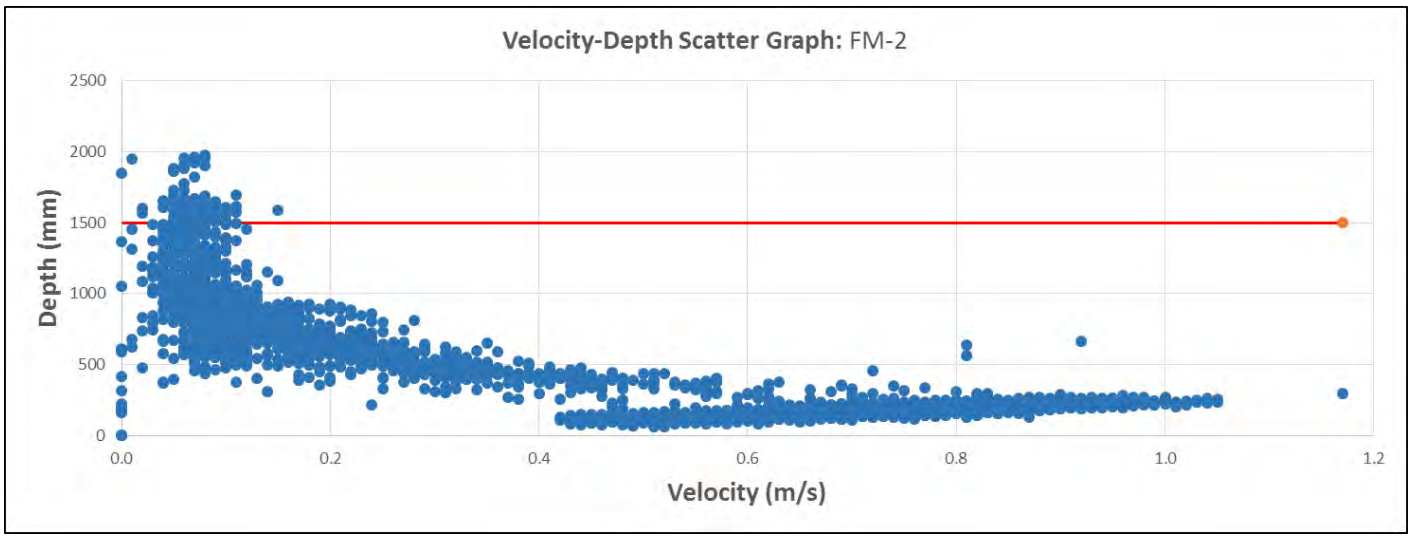



Critical Event 3: FM-1
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

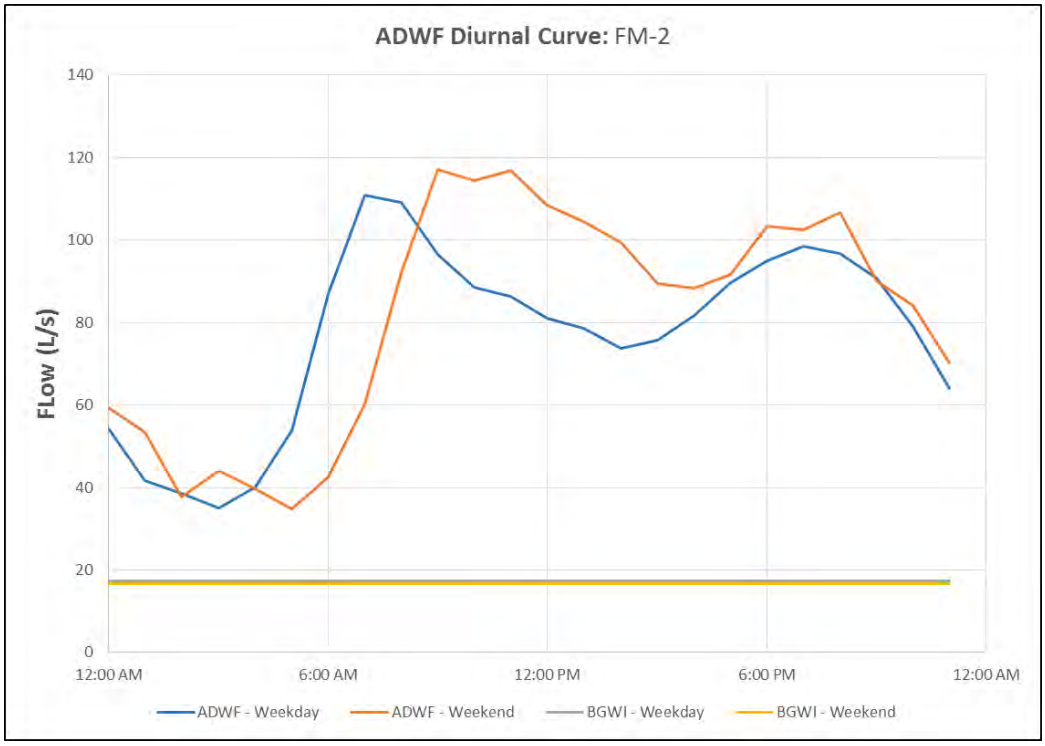

Critical Event 4: FM-1
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 8:00
11/21/2015 - 16:00
11/22/2015 - 0:00
11/22/2015 - 8:00
11/22/2015 - 16:00
11/23/2015 - 0:00
11/23/2015 - 8:00
11/23/2015 - 16:00
11/24/2015 - 0:00
11/24/2015 - 8:00
11/24/2015 - 16:00

FM-2

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.62	0.66
0.41	0.57
0.36	0.33
0.30	0.42
0.38	0.36
0.61	0.28
1.17	0.40
1.57	0.68
1.54	1.17
1.33	1.55
1.20	1.51
1.16	1.55
1.07	1.42
1.03	1.36
0.95	1.28
0.98	1.13
1.08	1.11
1.21	1.16
1.30	1.34
1.36	1.33
1.33	1.39
1.23	1.14
1.03	1.04
0.78	0.83

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	76.9	81.3	L/s
MNF	35.1	34.8	L/s
BGWI	17.3	16.6	L/s
Unit BGWI	0.03	0.03	L/s/ha
Sanitary Flow	59.7	64.7	L/s
Per Capita Sanitary Flow	302.1	327.5	L/cap/d
Peak DWF	110.8	117.1	L/s

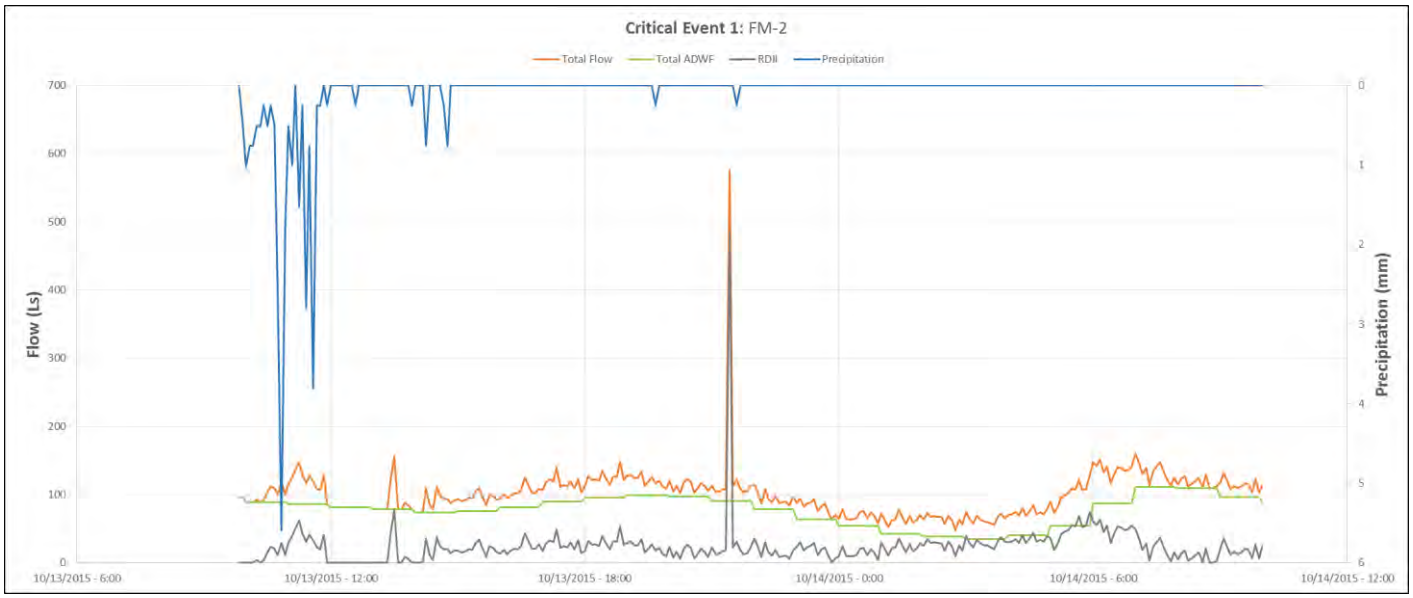
Quantification of RDII

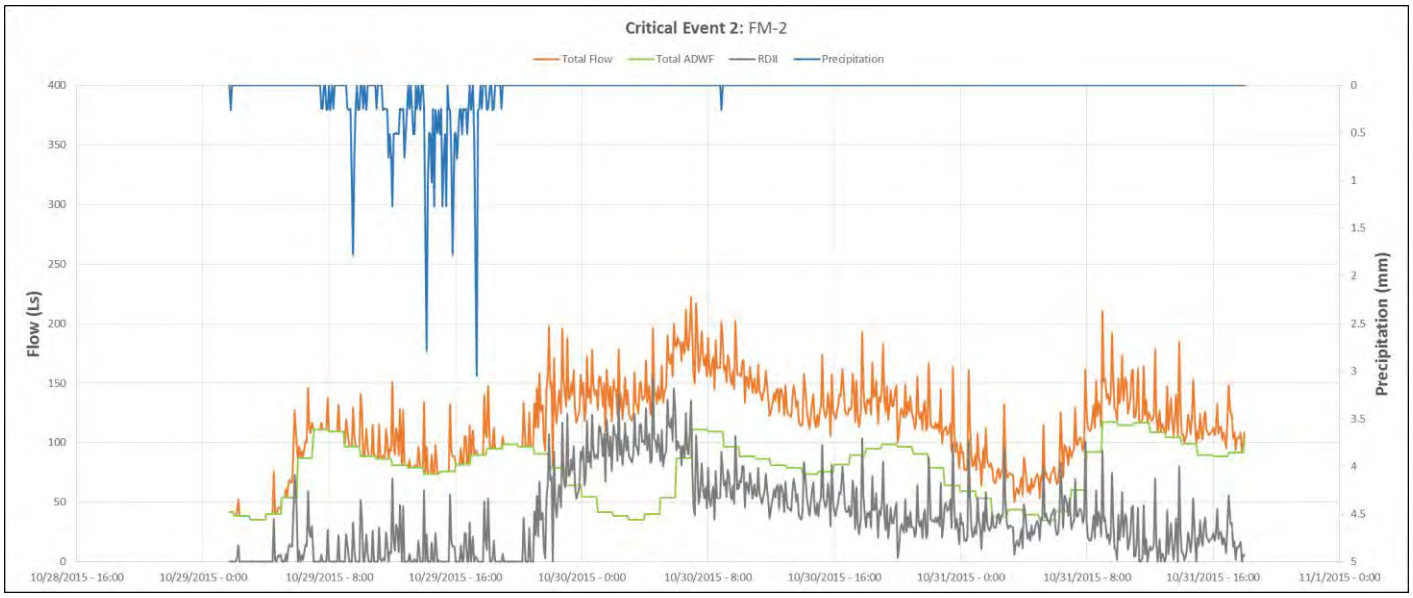
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	485	2.1	1%	0.75
CE2	10/29/2015	10	49	156	8.6	3%	0.24
CE3	11/13/2015	7	29	238	1.7	1%	0.37
CE4	11/21/2015	13	94	405	17.1	3%	0.62

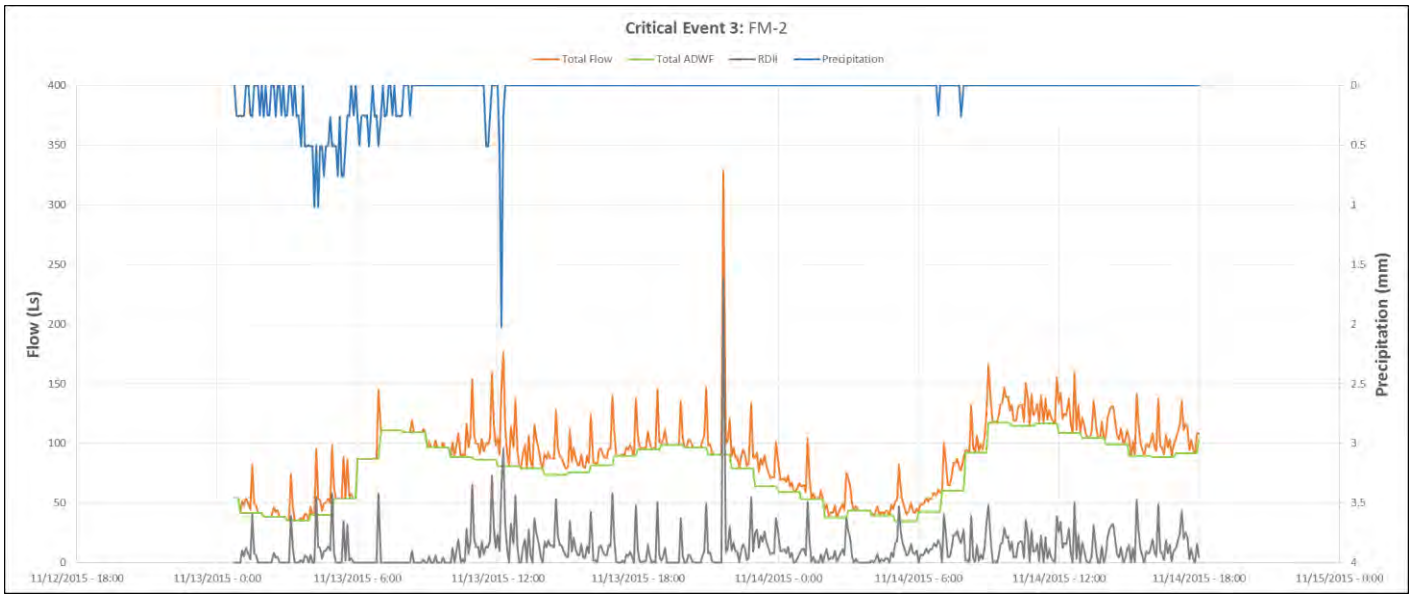
Estimated Peak Wet Weather Design Flows (L/s)

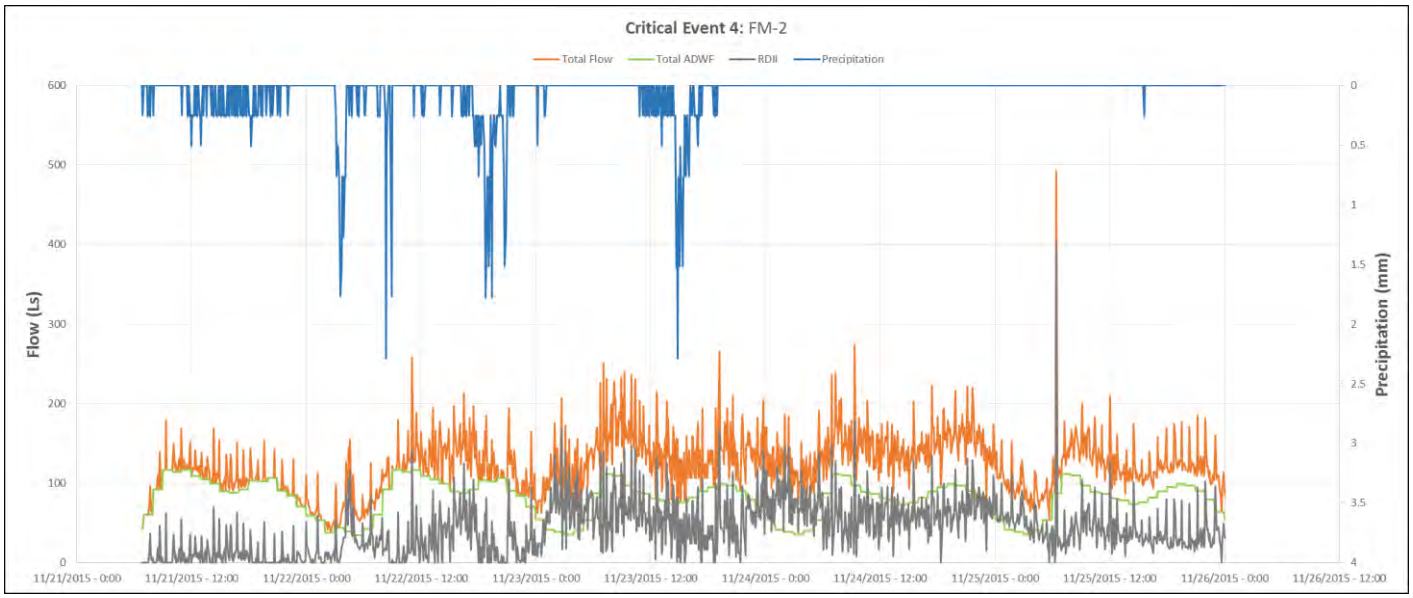
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	401	449	540	598	670	728	780

Wet Weather Flow Graphs



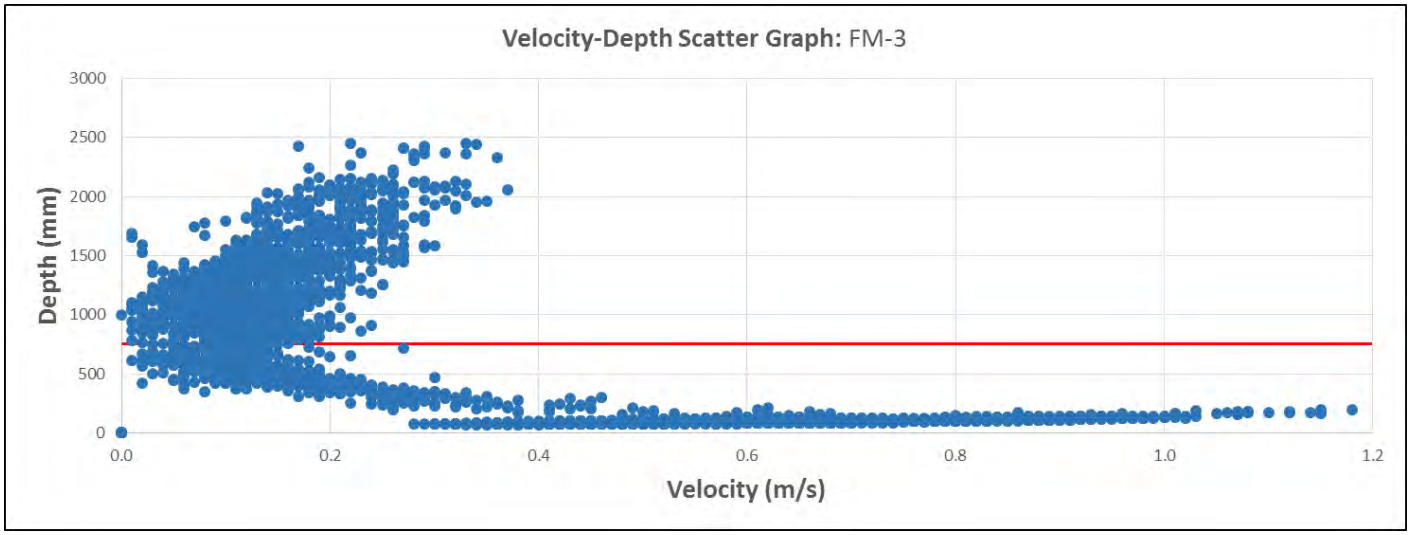



Critical Event 3: FM-2
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
50
100
150
200
250
300
350
400
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

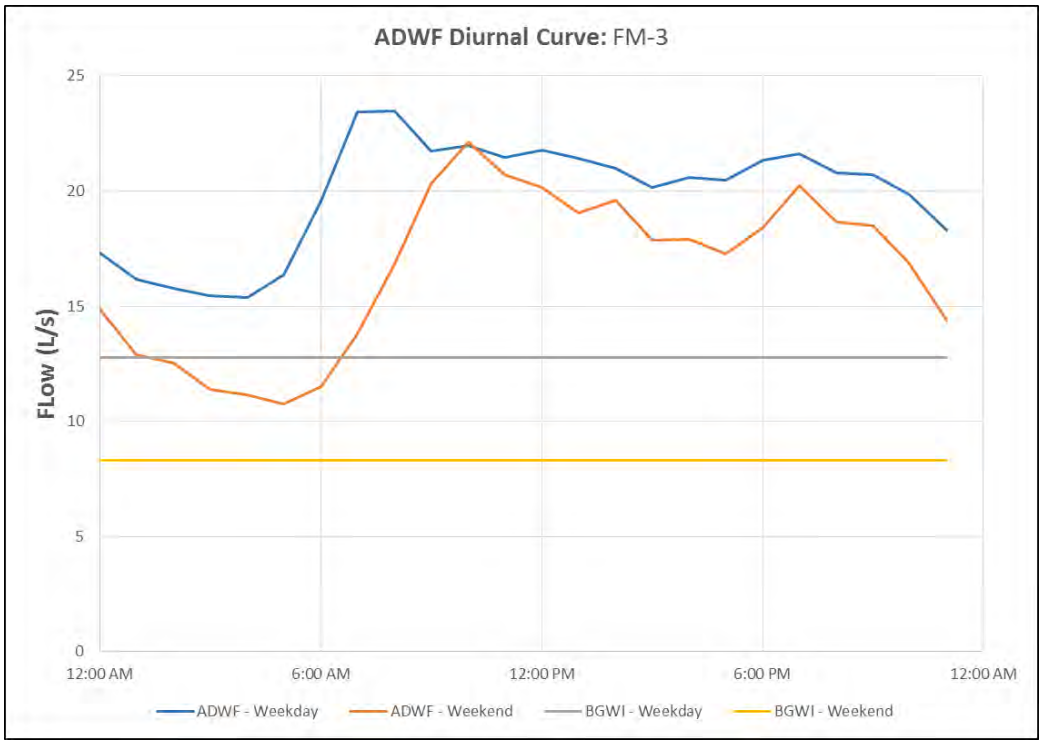

Critical Event 4: FM-2
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
100
200
300
400
500
600
0.5
1
1.5
2
2.5
3
3.5
4
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00
11/26/2015 - 0:00
11/26/2015 - 12:00

FM-3

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly F actors



Weekday (factor)	Weekend (factor)
0.64	0.79
0.48	0.56
0.42	0.51
0.38	0.37
0.37	0.34
0.51	0.30
0.96	0.39
1.51	0.66
1.51	1.03
1.27	1.45
1.30	1.67
1.23	1.50
1.27	1.44
1.22	1.30
1.16	1.37
1.05	1.16
1.11	1.16
1.09	1.08
1.21	1.22
1.25	1.44
1.14	1.25
1.13	1.23
1.00	1.03
0.78	0.74

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	19.8	16.6	L/s
MNF	15.4	10.8	L/s
BGWI	12.8	8.3	L/s
Unit BGWI	0.09	0.06	L/s/ha
Sanitary Flow	7.1	8.3	L/s
Per Capita Sanitary Flow	126.6	147.9	L/cap/d
Peak DWF	23.5	22.1	L/s

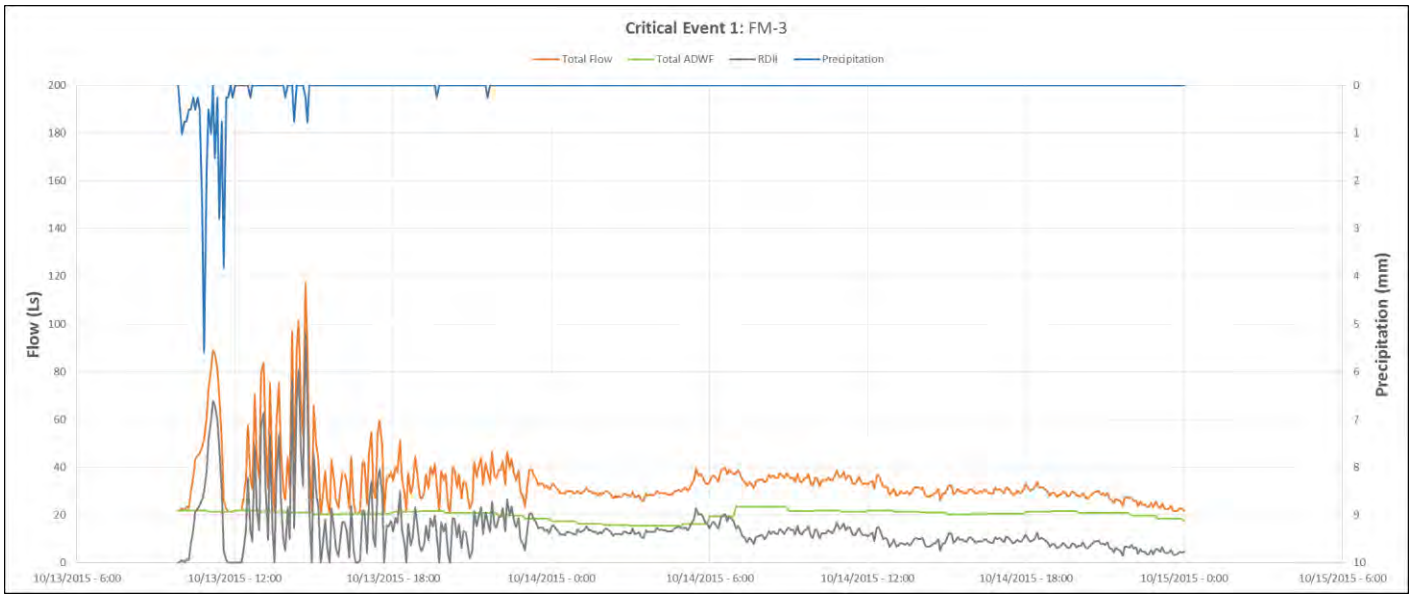
Quantification of RDII

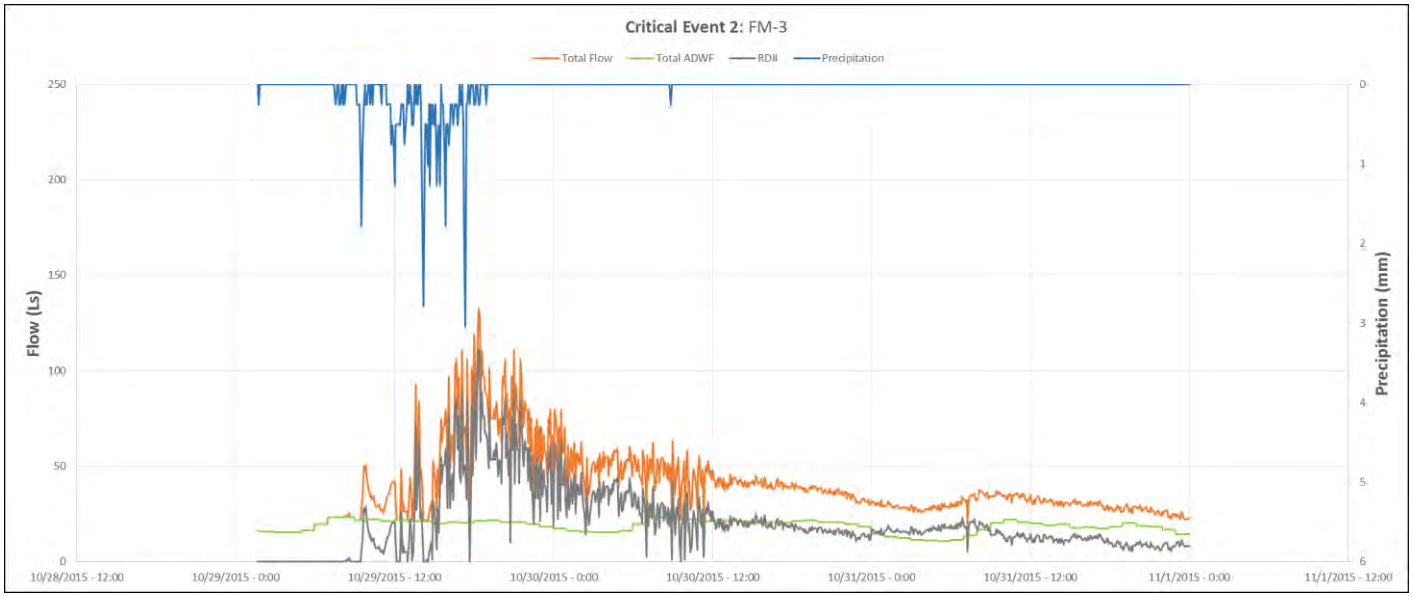
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	96	1.9	5%	0.68
CE2	10/29/2015	10	49	111	5.2	7%	0.78
CE3	11/13/2015	7	29	59	2.5	6%	0.41
CE4	11/22/2015	13	63	143	13.4	15%	1.01

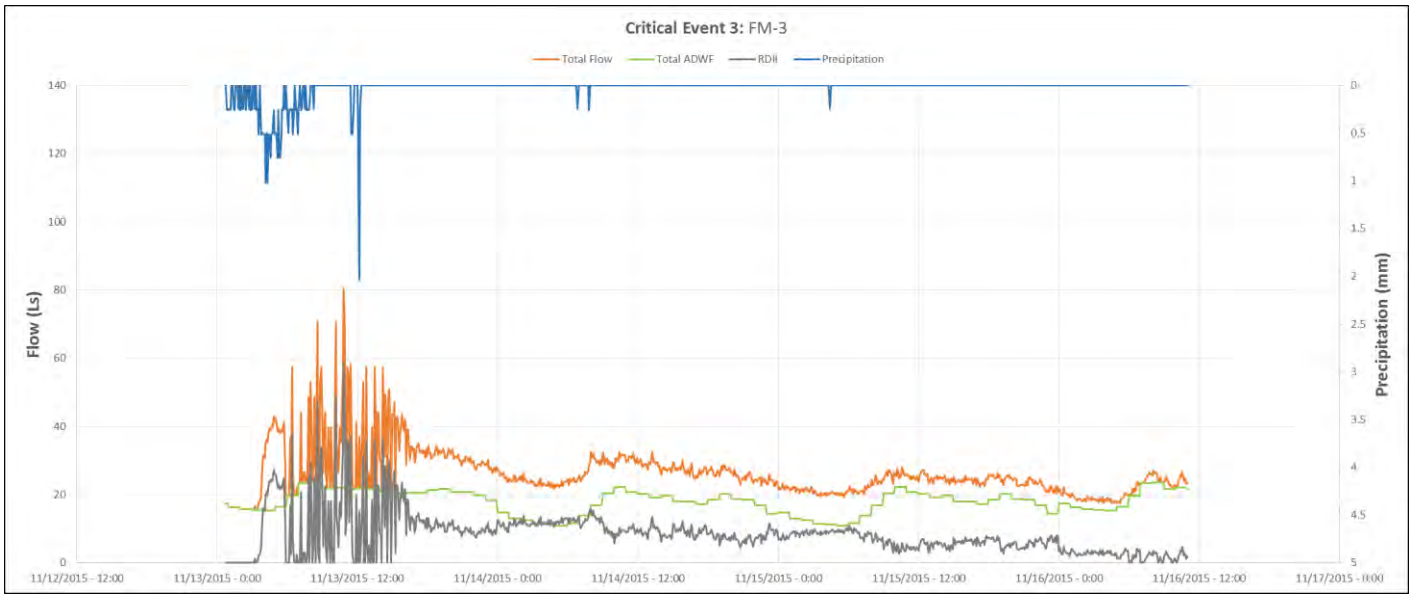
Estimated Peak Wet Weather Design Flows (L/s)

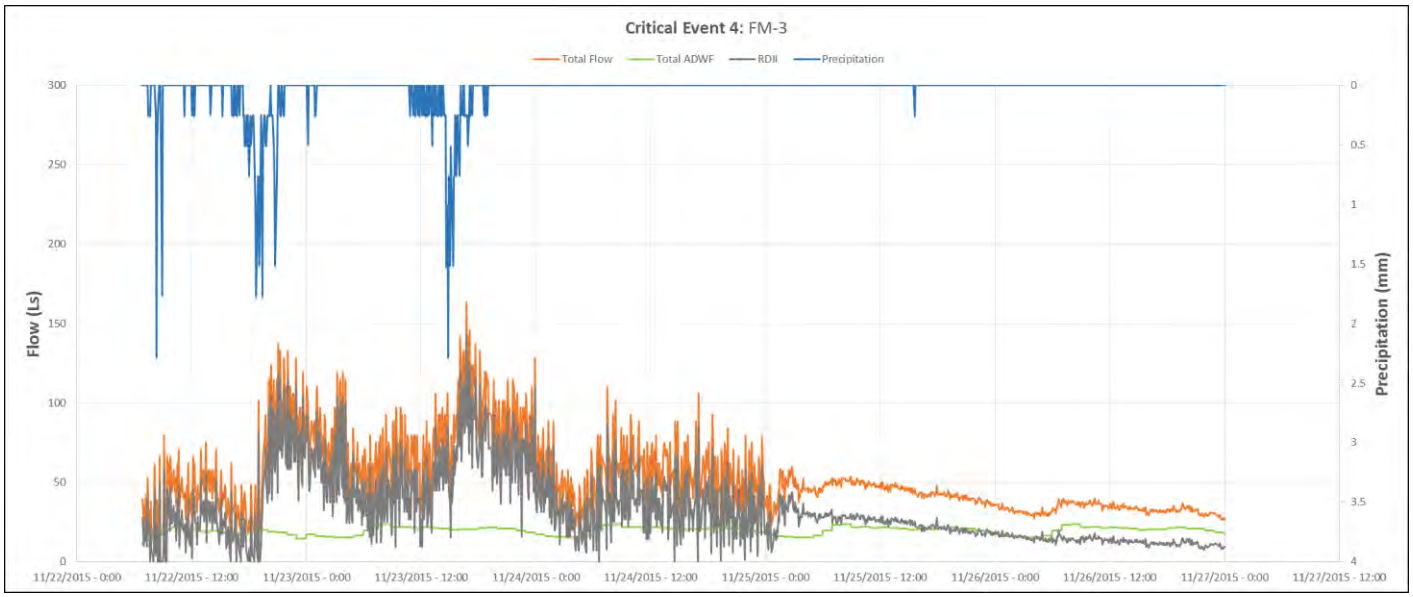
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	75	165	205	232	266	290	316

Wet Weather Flow Graphs



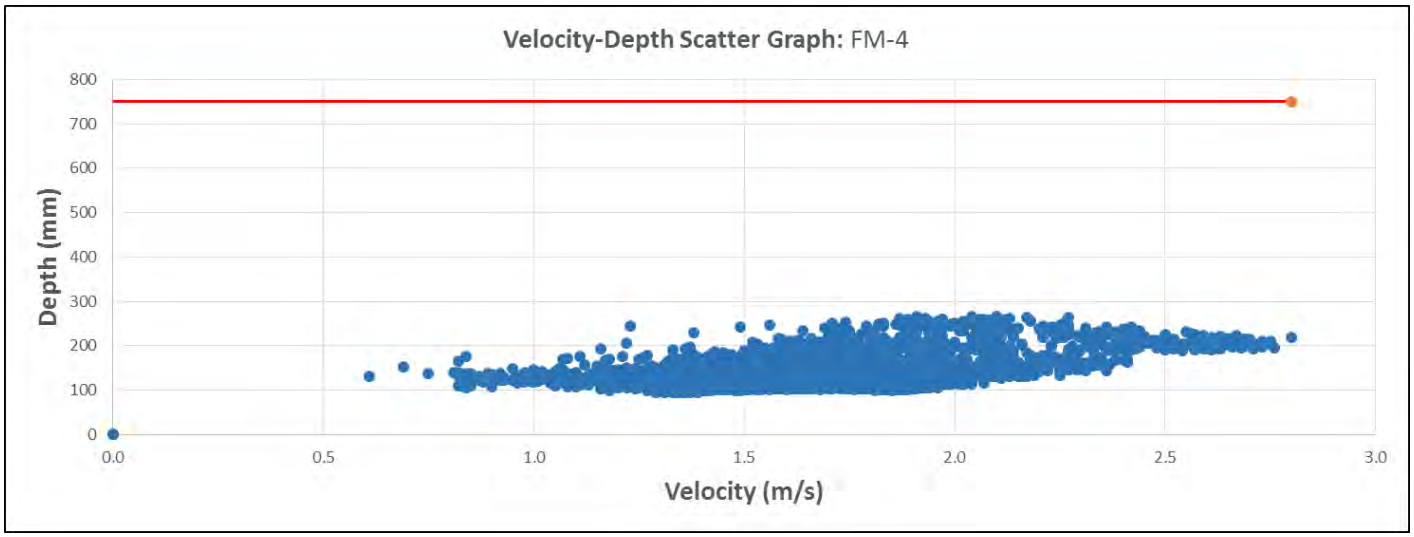



Critical Event 3: FM-3
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
140
120
100
80
60
40
20
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/12/2015 - 12:00
11/13/2015 - 0:00
11/13/2015 - 12:00
11/14/2015 - 0:00
11/14/2015 - 12:00
11/15/2015 - 0:00
11/15/2015 - 12:00
11/16/2015 - 0:00
11/16/2015 - 12:00
11/17/2015 - 0:00

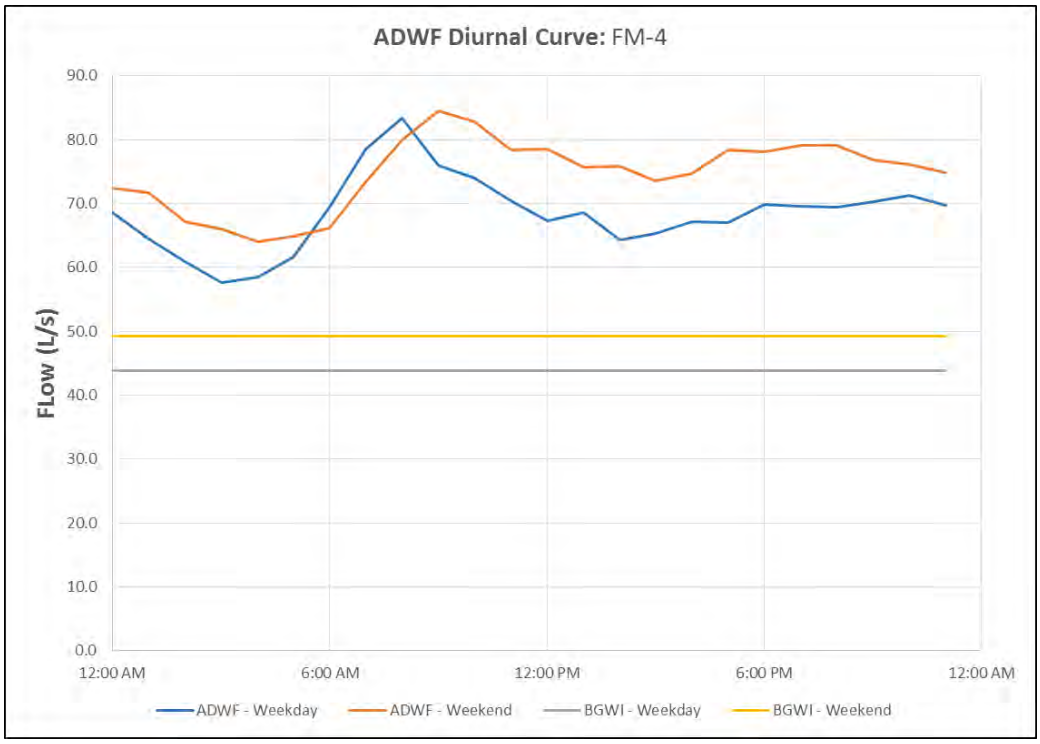

Critical Event 4: FM-3
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
4
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00
11/26/2015 - 0:00
11/26/2015 - 12:00
11/27/2015 - 0:00
11/27/2015 - 12:00

FM-4

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
1.01	0.91
0.84	0.88
0.69	0.71
0.56	0.66
0.59	0.58
0.72	0.62
1.04	0.66
1.41	0.95
1.61	1.21
1.31	1.39
1.22	1.32
1.08	1.14
0.95	1.15
1.00	1.04
0.83	1.05
0.87	0.95
0.95	1.00
0.94	1.14
1.06	1.13
1.04	1.17
1.04	1.18
1.07	1.09
1.12	1.06
1.05	1.01

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	68.5	74.7	L/s
MNF	57.7	64.0	L/s
BGWI	43.9	49.2	L/s
Unit BGWI	0.17	0.19	L/s/ha
Sanitary Flow	24.5	25.4	L/s
Per Capita Sanitary Flow	202.9	210.3	L/cap/d
Peak DWF	83.4	84.6	L/s

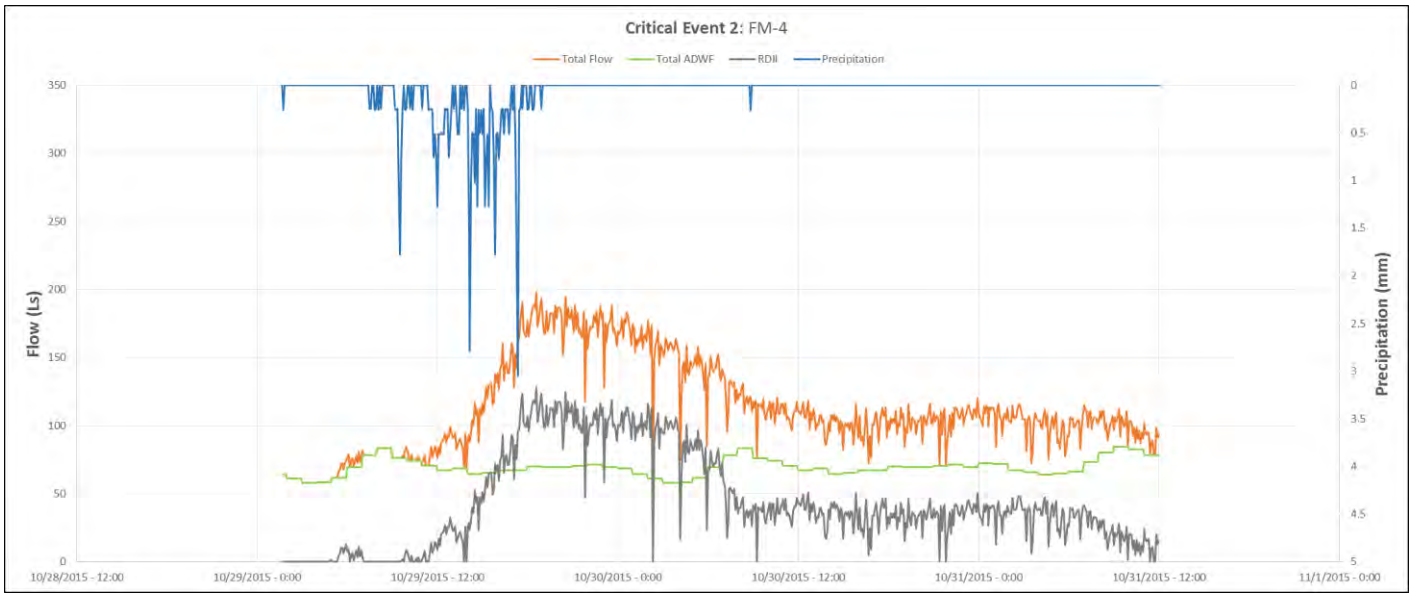
Quantification of RDII

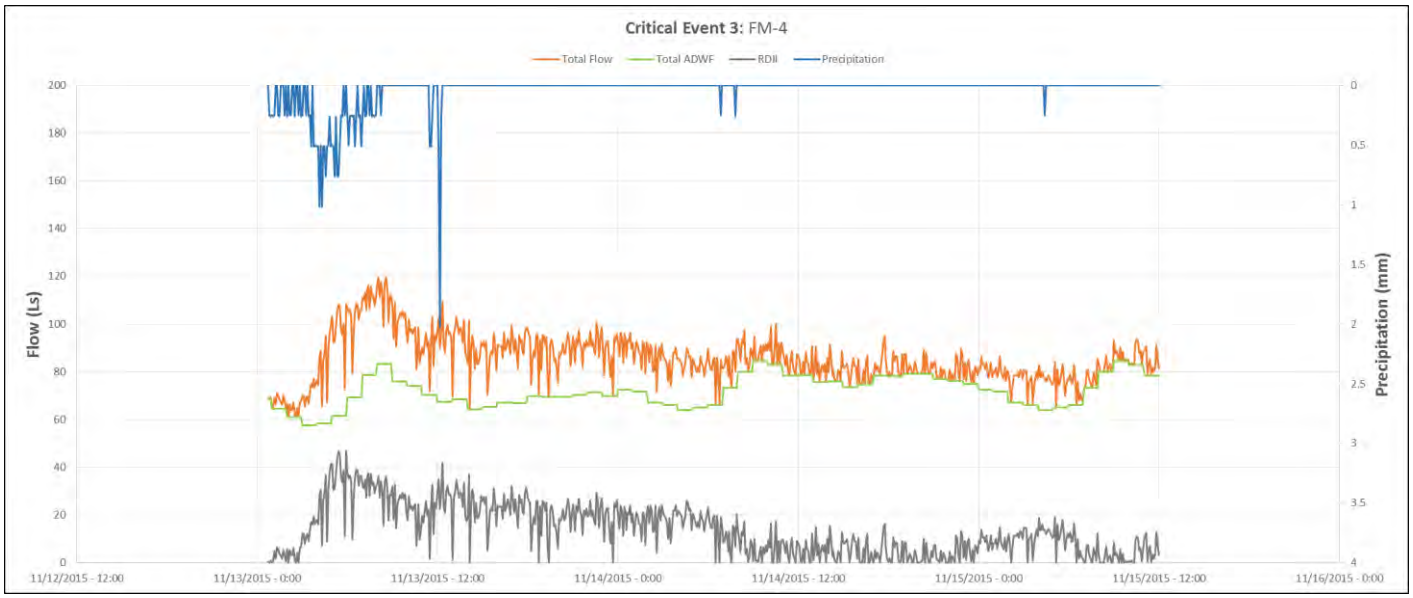
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE2	10/29/2015	10	49	128	9.1	7%	0.50
CE3	11/13/2015	7	29	47	2.9	4%	0.18
CE4	11/21/2015	13	94	247	34.3	14%	0.97

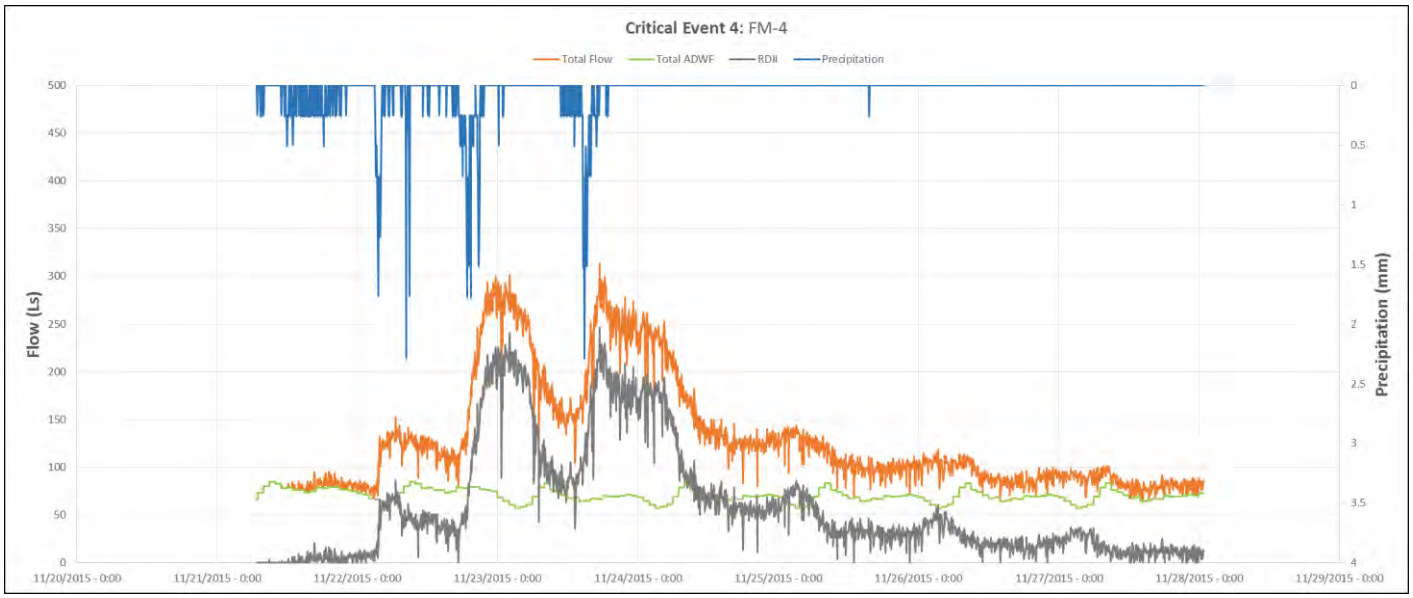
Estimated Peak Wet Weather Design Flows (L/s)

Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	217	281	334	373	419	452	487

Wet Weather Flow Graphs

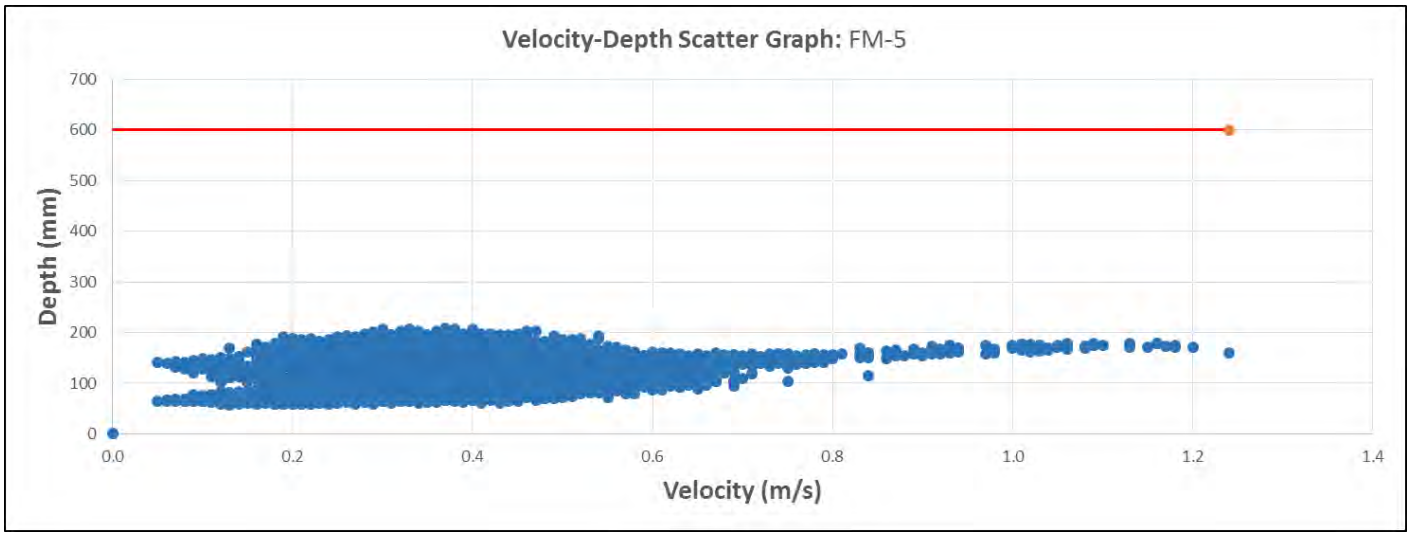



Critical Event 3: FM-4
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 12:00
11/13/2015 - 0:00
11/13/2015 - 12:00
11/14/2015 - 0:00
11/14/2015 - 12:00
11/15/2015 - 0:00
11/15/2015 - 12:00
11/16/2015 - 0:00

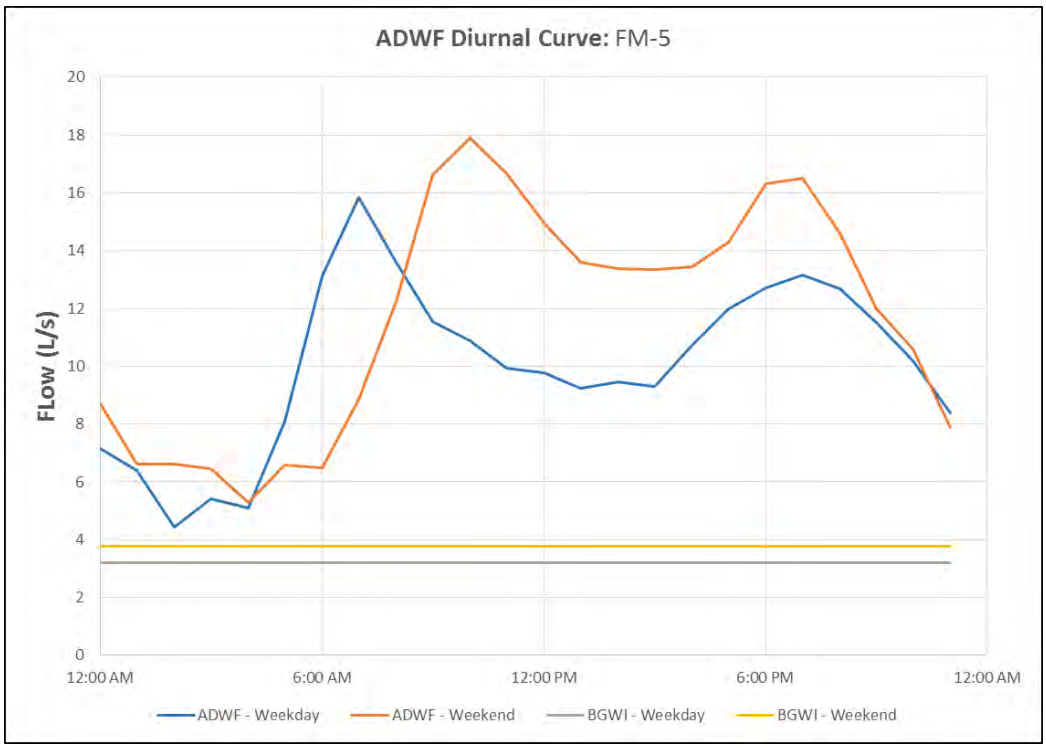

Critical Event 4: FM-4
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/20/2015 - 0:00
11/21/2015 - 0:00
11/22/2015 - 0:00
11/23/2015 - 0:00
11/24/2015 - 0:00
11/25/2015 - 0:00
11/26/2015 - 0:00
11/27/2015 - 0:00
11/28/2015 - 0:00
11/29/2015 - 0:00

FM-5

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.58	0.62
0.47	0.36
0.18	0.36
0.33	0.34
0.28	0.19
0.72	0.36
1.45	0.34
1.85	0.64
1.52	1.07
1.22	1.63
1.12	1.79
0.99	1.63
0.96	1.42
0.88	1.24
0.92	1.22
0.89	1.21
1.10	1.23
1.29	1.33
1.39	1.59
1.46	1.61
1.39	1.37
1.22	1.04
1.03	0.87
0.76	0.52

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	10.0	11.7	L/s
MNF	4.4	5.3	L/s
BGWI	3.2	3.8	L/s
Unit BGWI	0.02	0.03	L/s/ha
Sanitary Flow	6.8	7.9	L/s
Per Capita Sanitary Flow	378.1	438.0	L/cap/d
Peak DWF	15.8	17.9	L/s

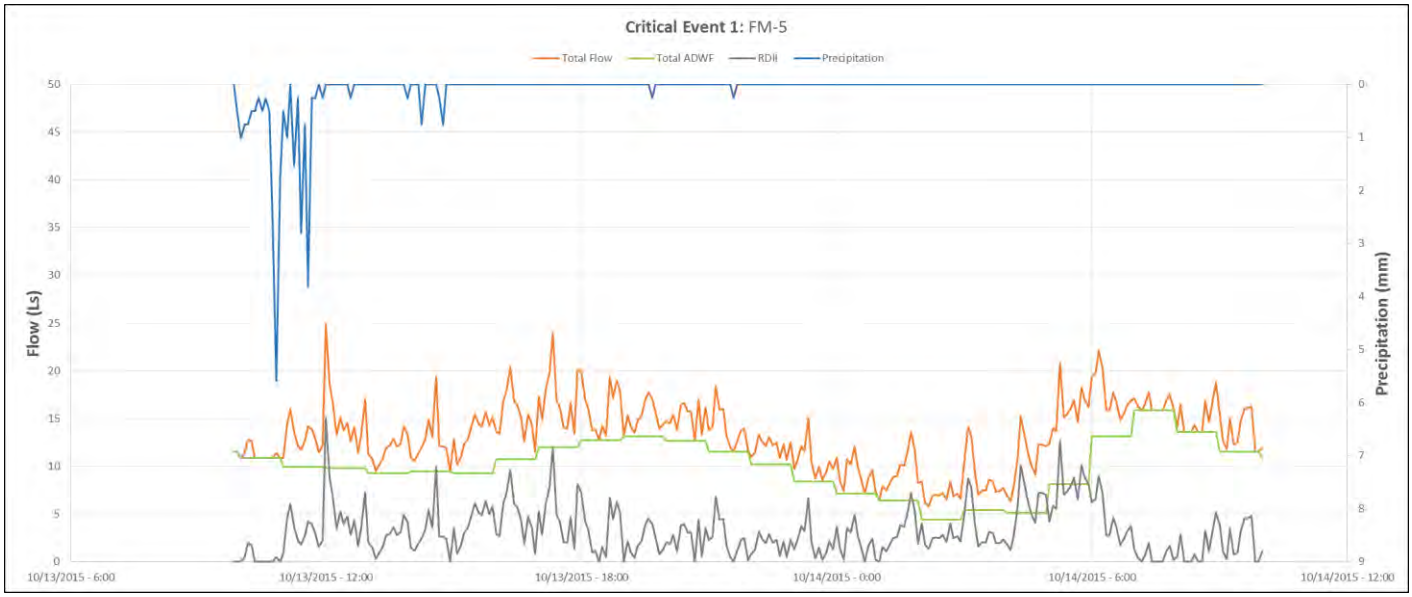
Quantification of RDII

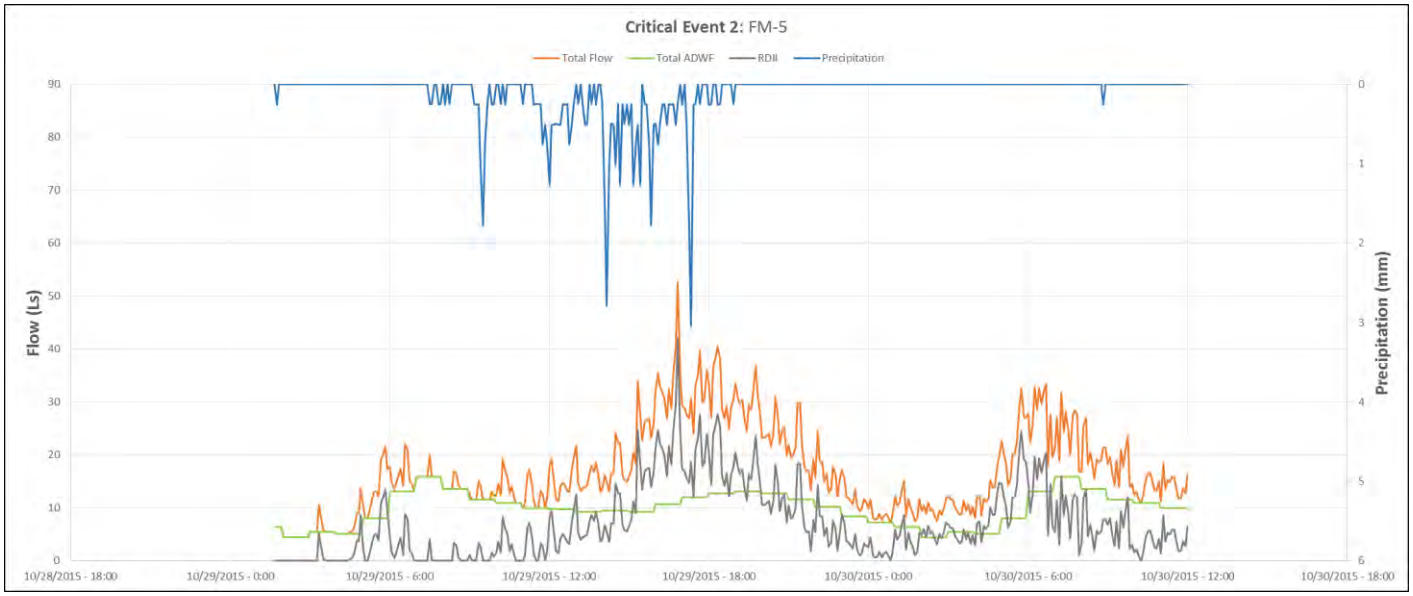
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	15	0.3	1%	0.10
CE2	10/29/2015	10	49	42	0.9	1%	0.29
CE3	11/13/2015	7	29	22	0.4	1%	0.15
CE4	11/21/2015	13	93	70	4.3	3%	0.48

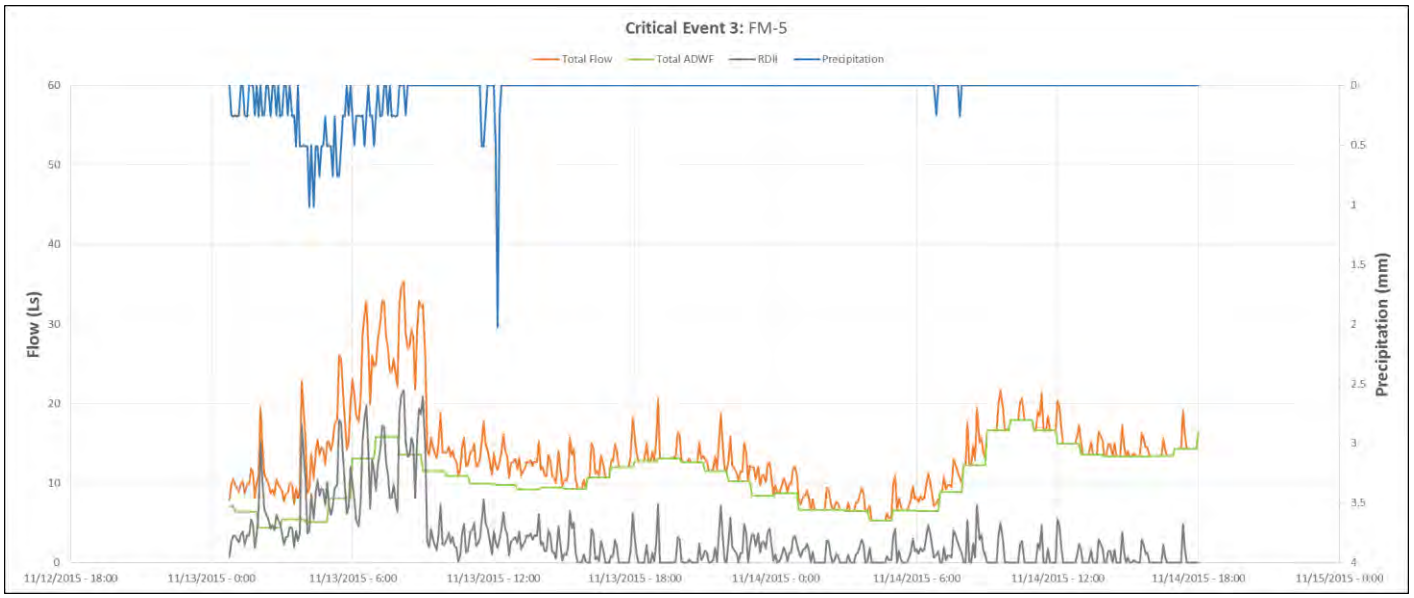
Estimated Peak Wet Weather Design Flows (L/s)

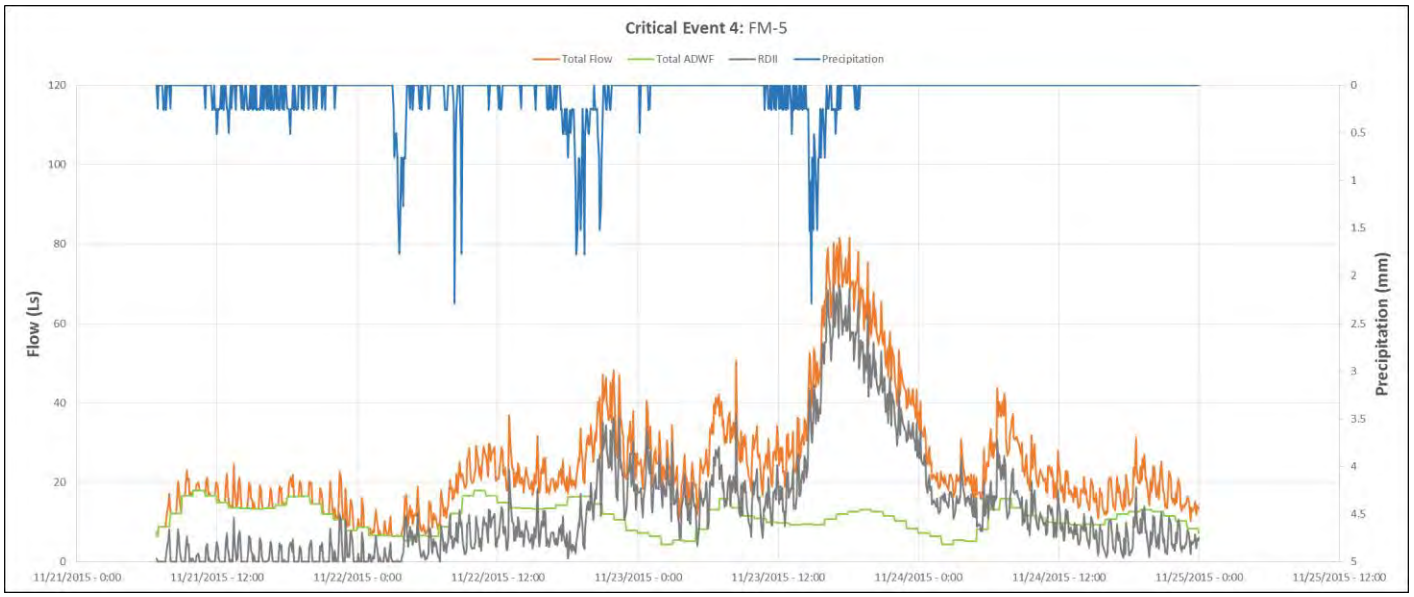
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	67	78	96	107	122	132	142

Wet Weather Flow Graphs



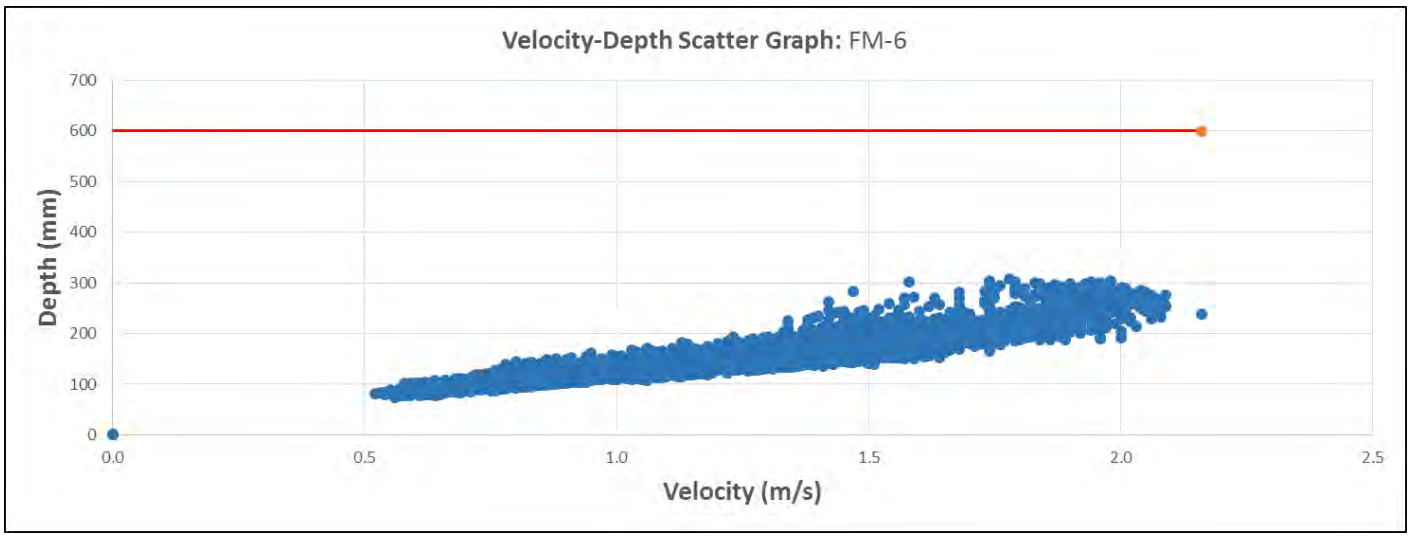



Critical Event 3: FM-5
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

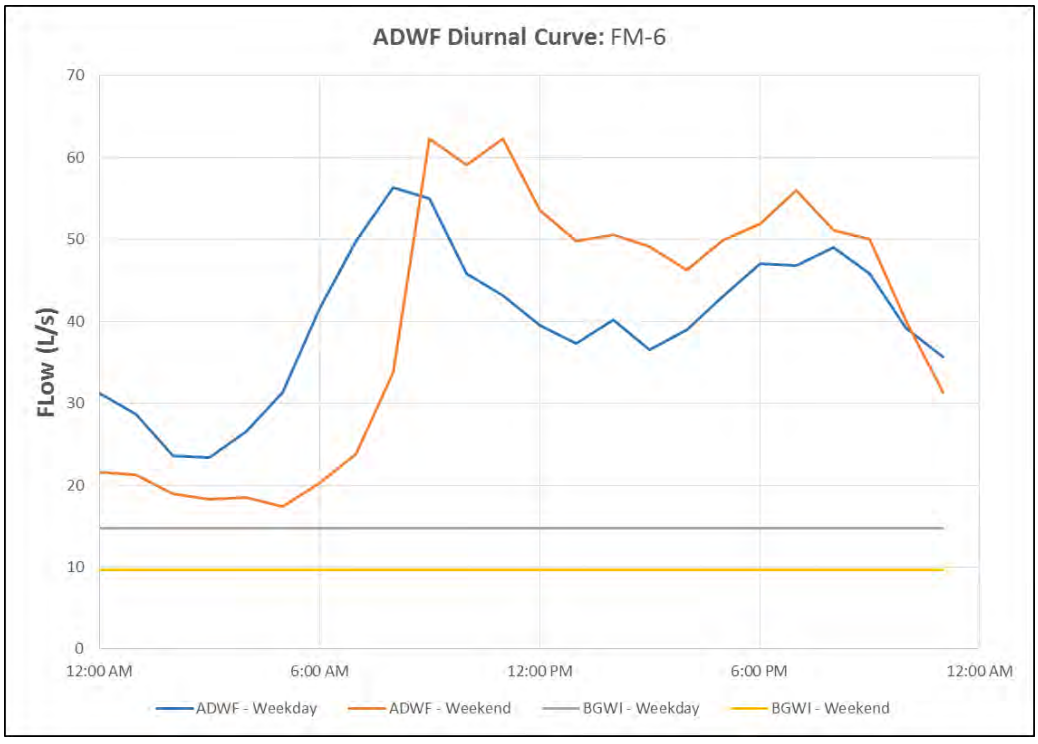

Critical Event 4: FM-5
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00

FM-6

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.66	0.40
0.56	0.39
0.35	0.31
0.35	0.29
0.47	0.29
0.66	0.26
1.07	0.35
1.40	0.47
1.66	0.80
1.60	1.74
1.24	1.63
1.13	1.74
0.99	1.45
0.90	1.33
1.01	1.35
0.87	1.31
0.97	1.21
1.13	1.33
1.29	1.40
1.28	1.53
1.37	1.37
1.24	1.33
0.98	1.00
0.84	0.72

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	39.8	39.9	L/s
MNF	23.4	17.4	L/s
BGWI	14.7	9.6	L/s
Unit BGWI	0.06	0.04	L/s/ha
Sanitary Flow	25.1	30.3	L/s
Per Capita Sanitary Flow	300.8	363.3	L/cap/d
Peak DWF	56.3	62.3	L/s

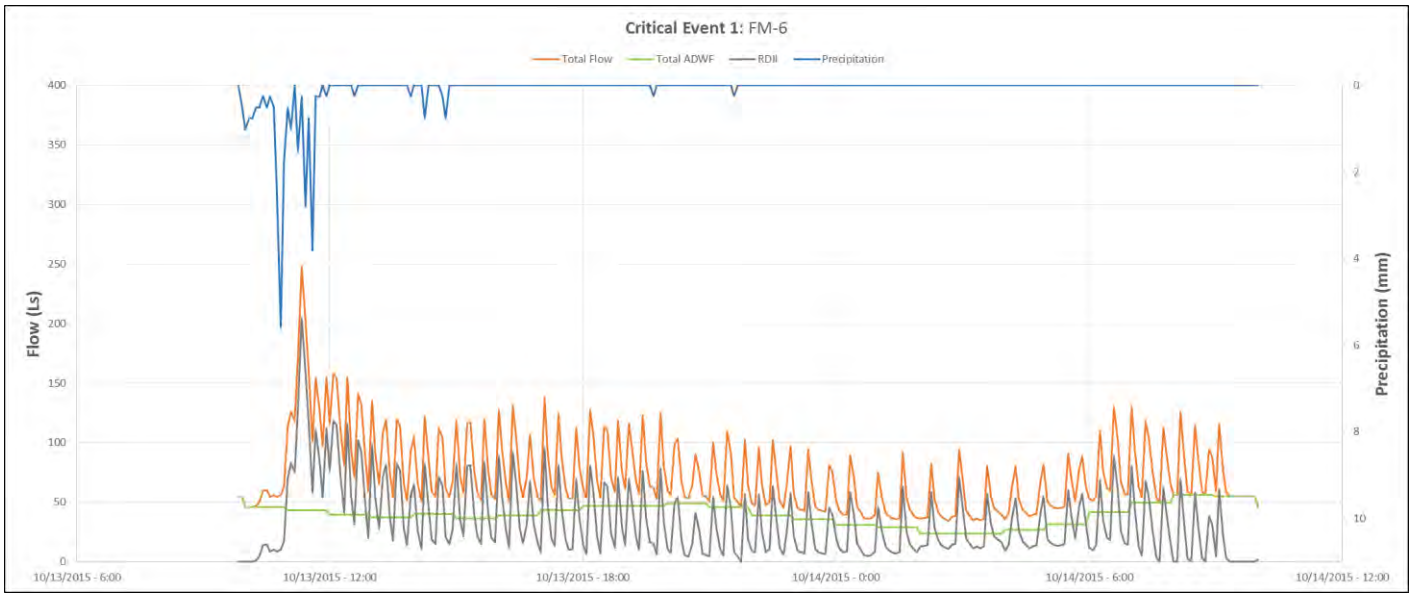
Quantification of RDII

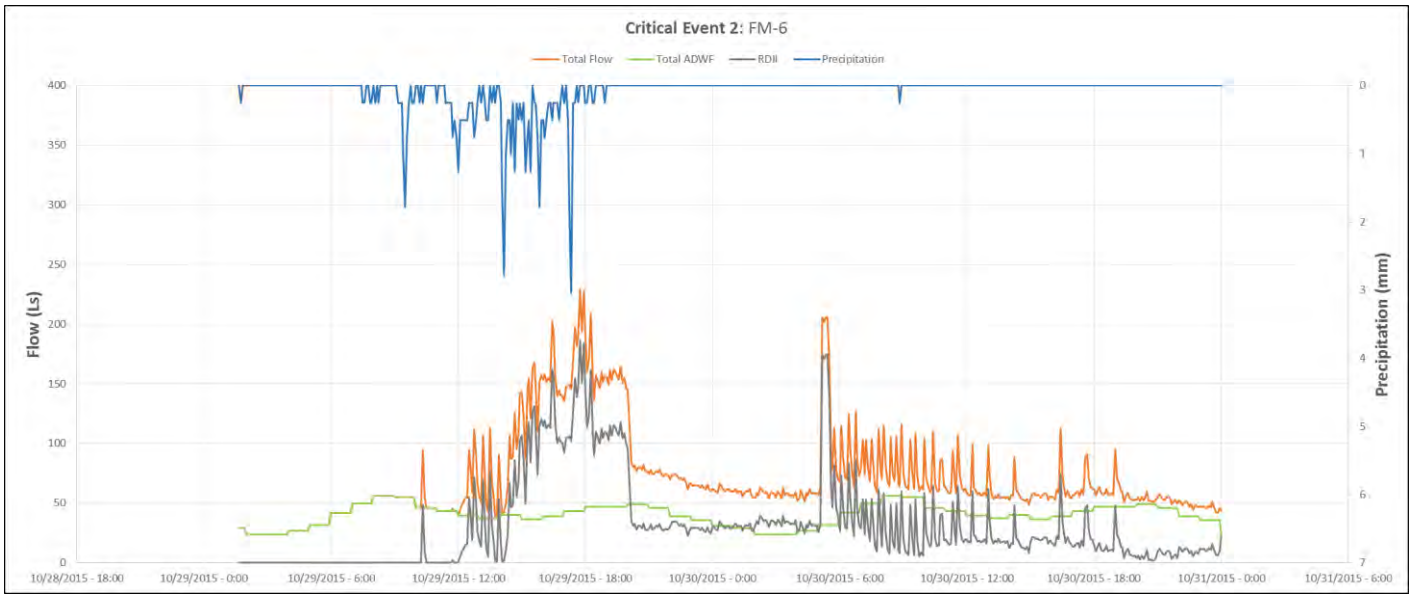
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	204	2.9	4%	0.83
CE2	10/29/2015	10	49	186	5.2	4%	0.76
CE3	11/13/2015	7	29	94	3.7	5%	0.38
CE4	11/21/2015	13	94	241	34.6	15%	0.98

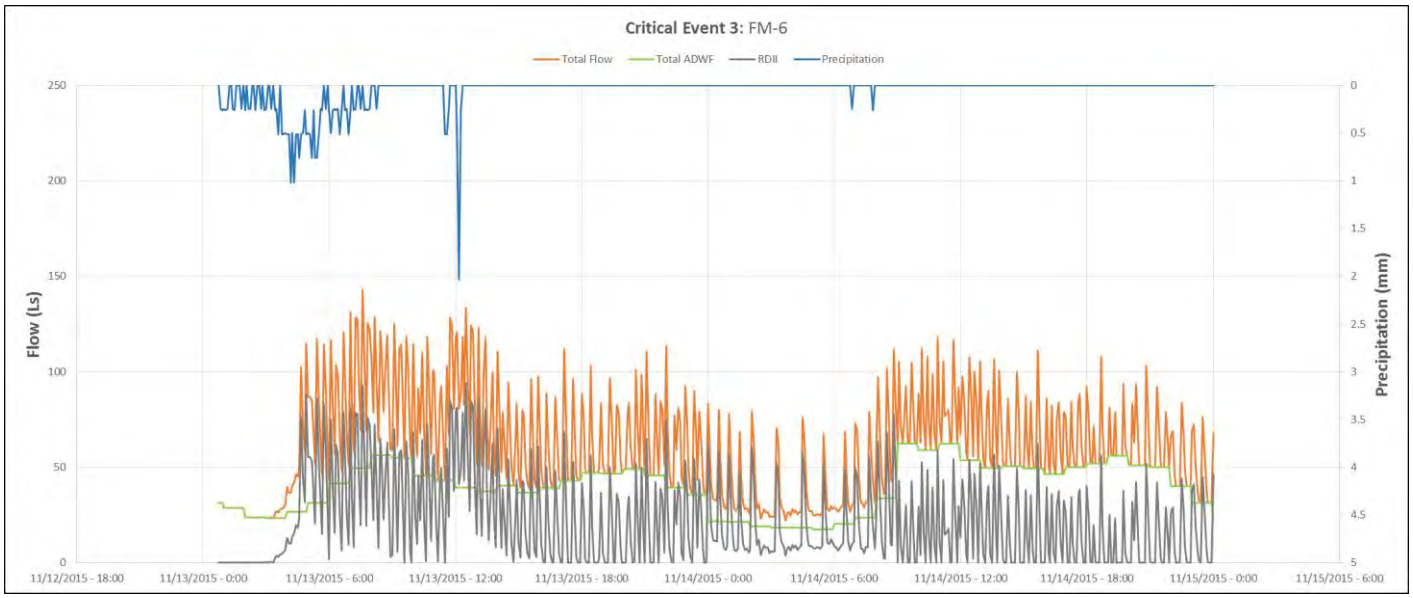
Estimated Peak Wet Weather Design Flows (L/s)

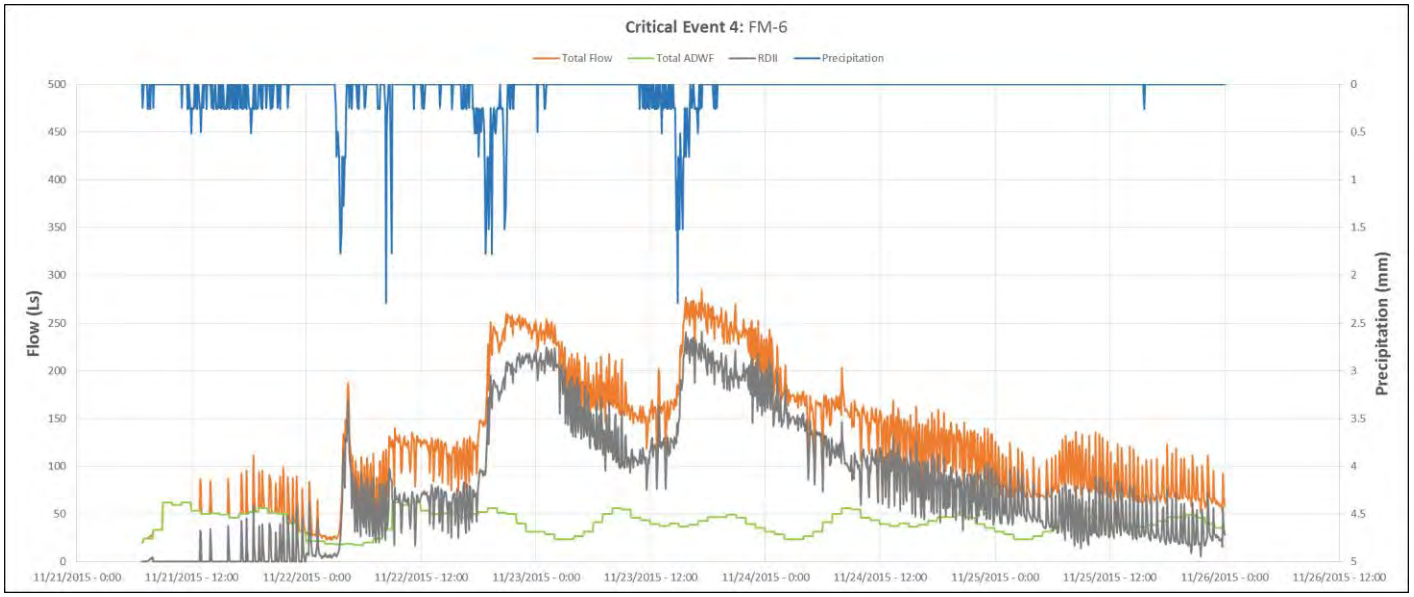
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	174	356	440	493	565	616	667

Wet Weather Flow Graphs



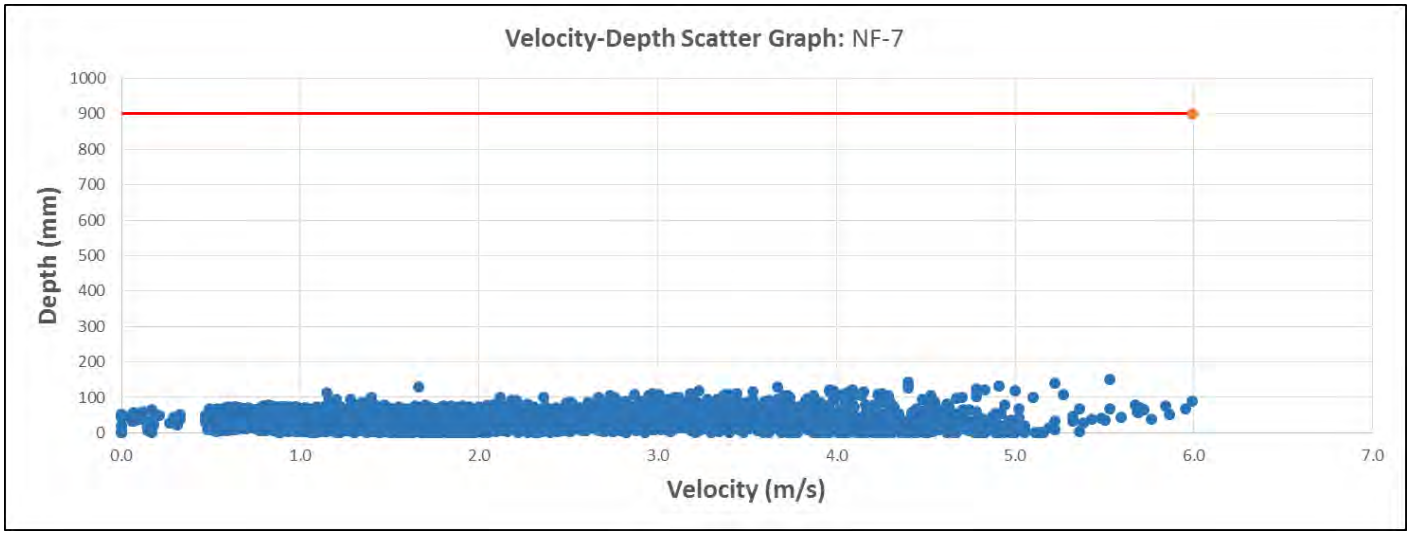



Critical Event 3: FM-6
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00

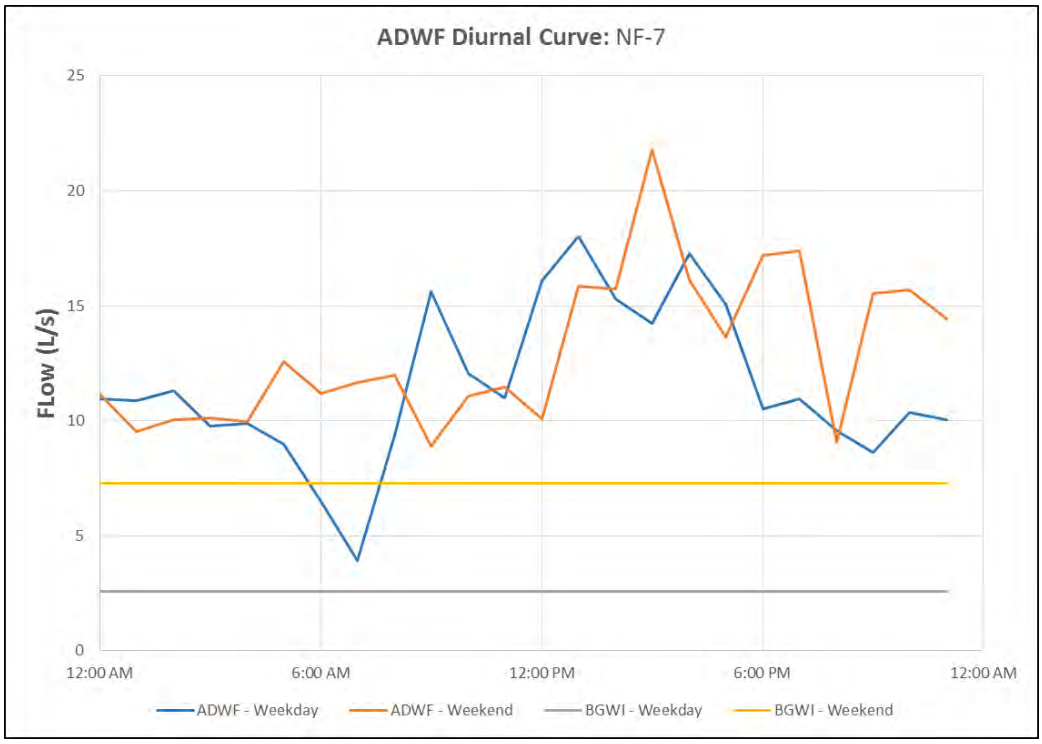

Critical Event 4: FM-6
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
500
450
400
350
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00
11/26/2015 - 0:00
11/26/2015 - 12:00

FM-7

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.94	0.68
0.93	0.39
0.98	0.48
0.81	0.50
0.82	0.47
0.72	0.92
0.44	0.69
0.15	0.77
0.76	0.82
1.46	0.28
1.06	0.66
0.94	0.73
1.51	0.49
1.73	1.49
1.43	1.48
1.30	2.52
1.64	1.54
1.40	1.11
0.89	1.73
0.94	1.76
0.78	0.31
0.68	1.44
0.87	1.47
0.84	1.25

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	11.5	13.0	L/s
MNF	3.9	8.9	L/s
BGWI	2.6	7.3	L/s
Unit BGWI	0.04	0.11	L/s/ha
Sanitary Flow	8.9	5.7	L/s
Per Capita Sanitary Flow	203.6	131.0	L/cap/d
Peak DWF	18.0	21.8	L/s

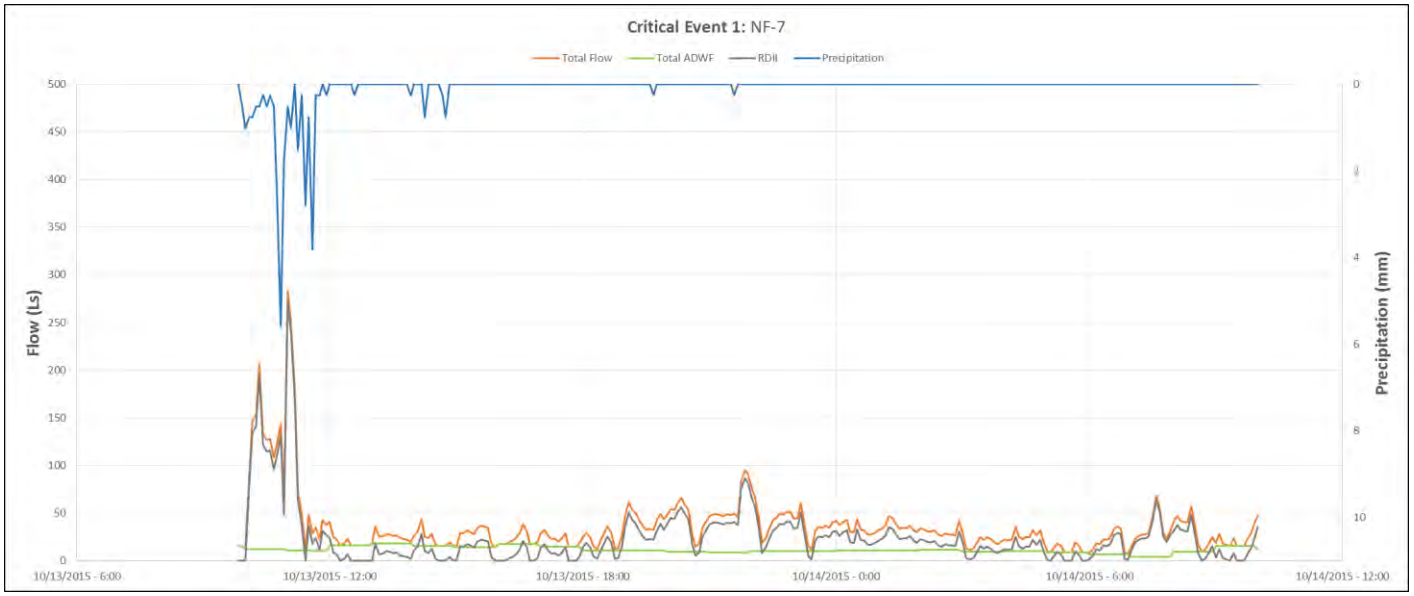
Quantification of RDII

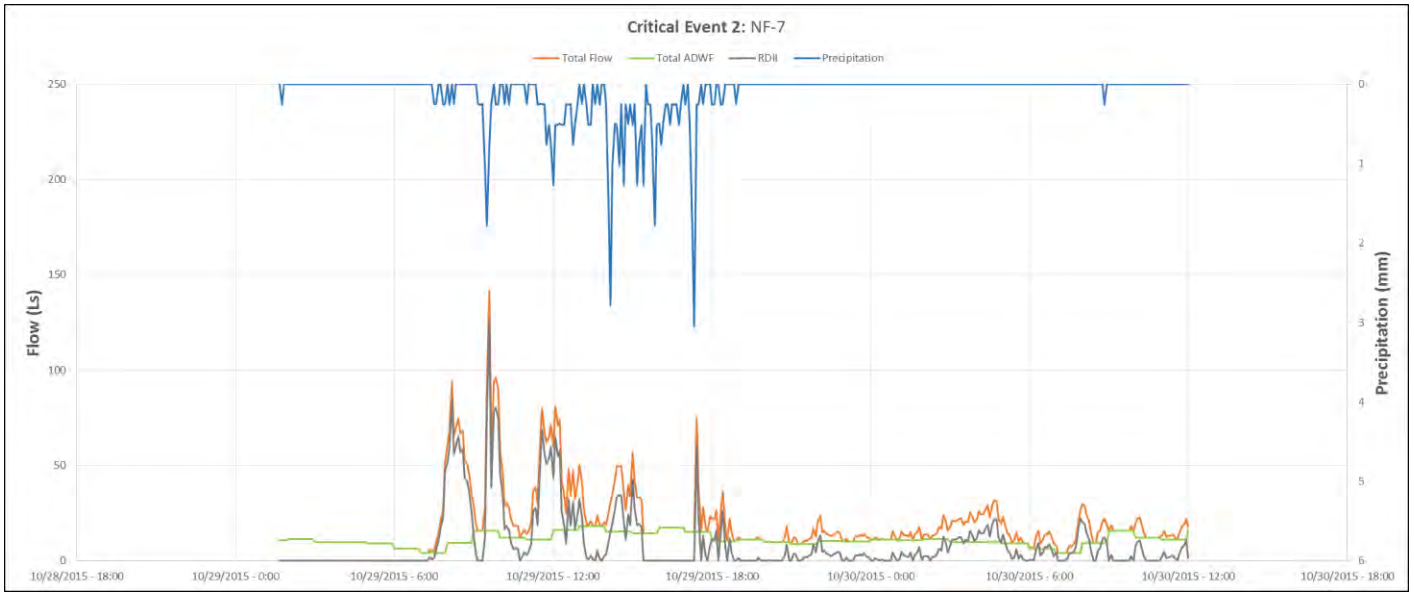
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	273	2.1	11%	4.08
CE2	10/29/2015	10	49	126	1.1	3%	1.88
CE3	11/13/2015	7	29	119	2.0	10%	1.78
CE4	11/21/2015	13	93	269	10.6	17%	4.03

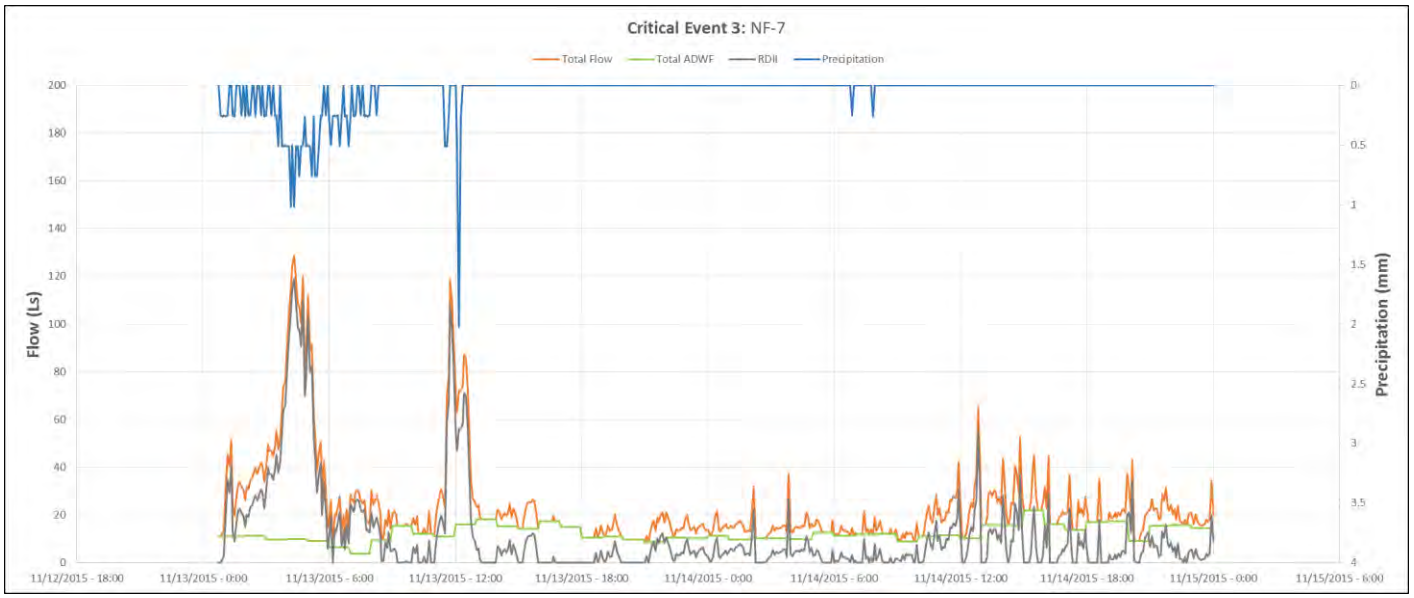
Estimated Peak Wet Weather Design Flows (L/s)

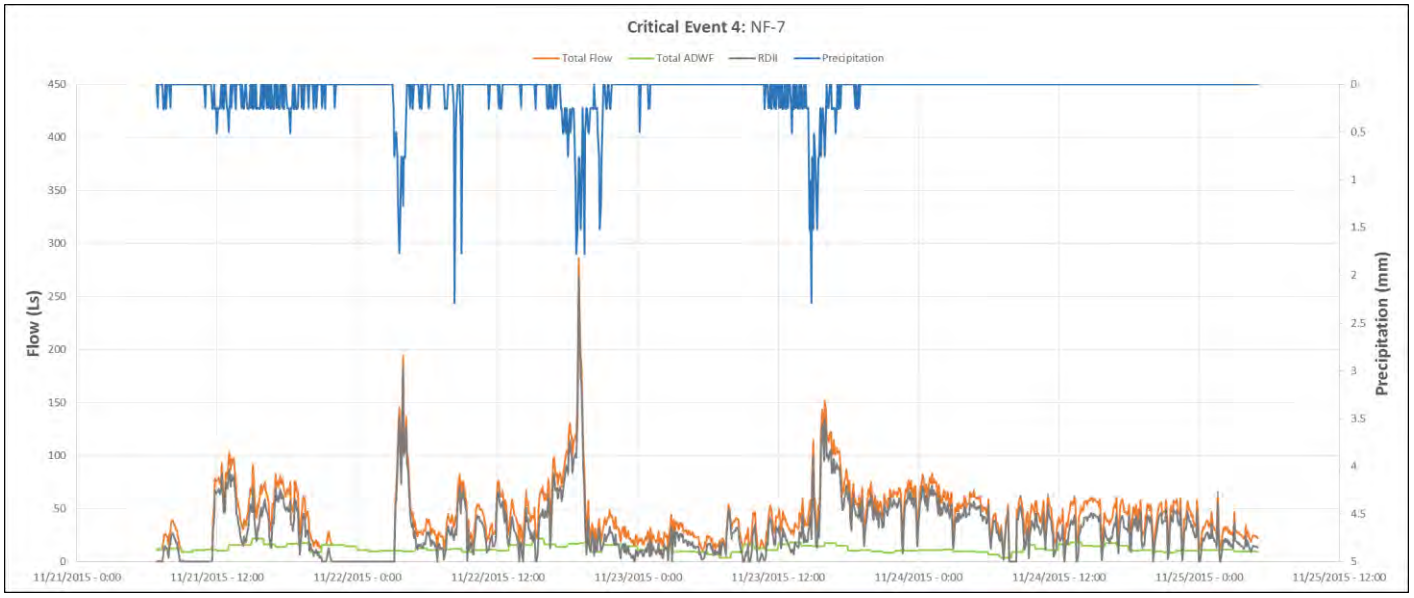
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	74	243	297	333	378	412	446

Wet Weather Flow Graphs



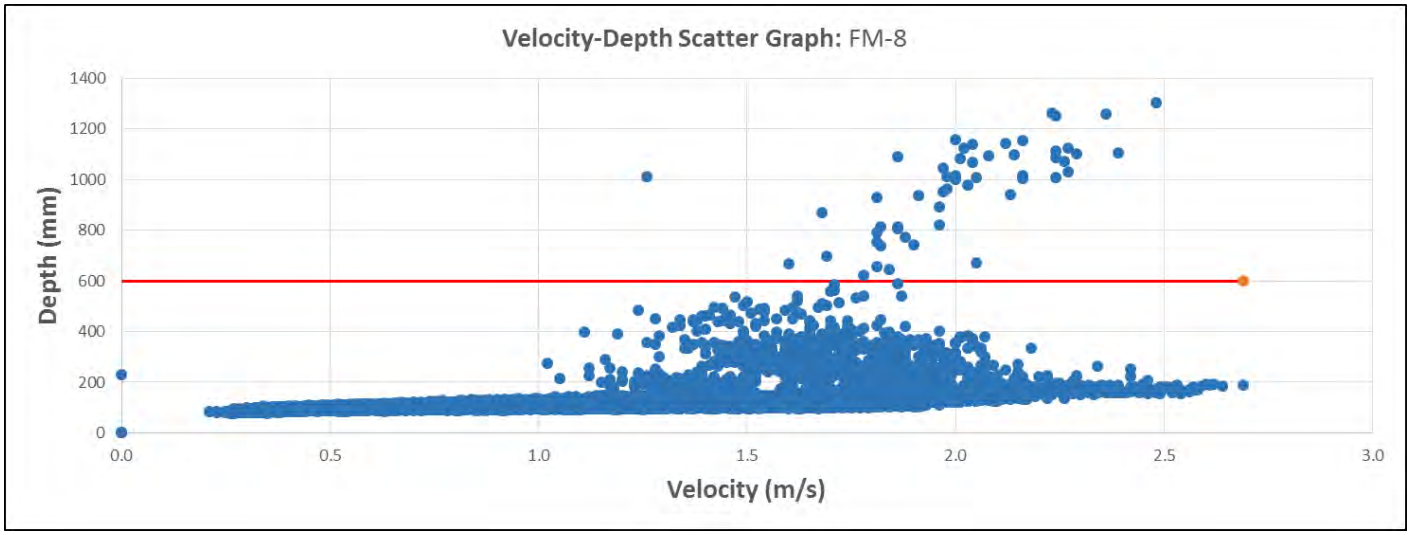



Critical Event 3: NF-7
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00

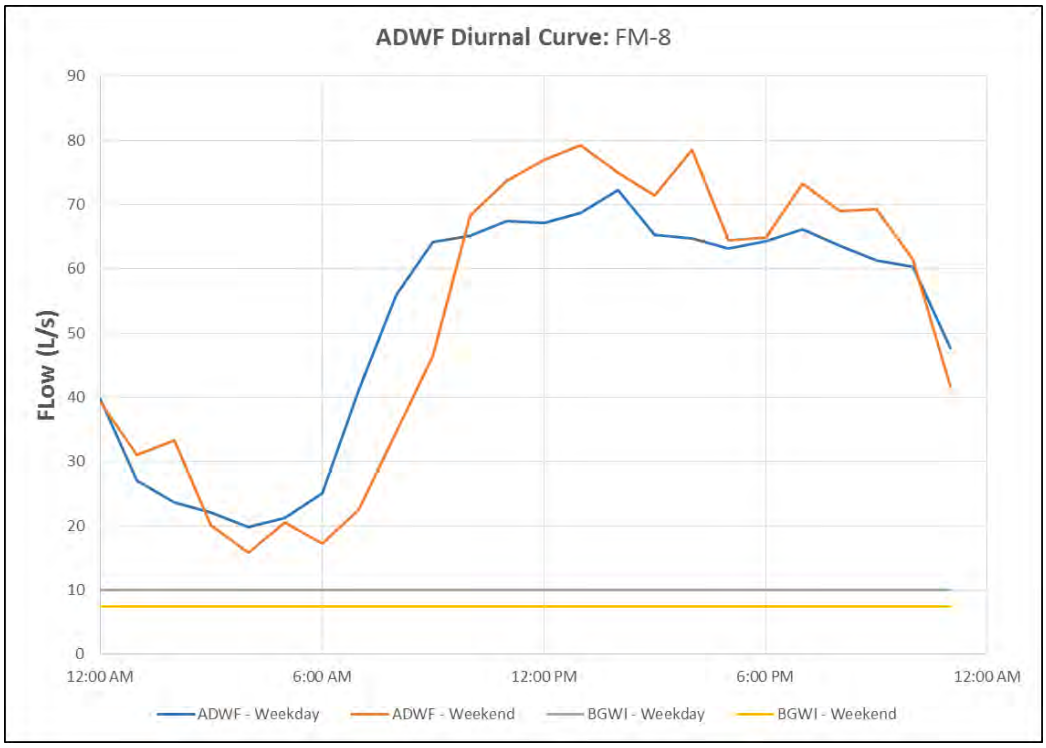

Critical Event 4: NF-7
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00

FM-8

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.71	0.71
0.41	0.53
0.33	0.58
0.29	0.28
0.24	0.19
0.27	0.29
0.36	0.22
0.75	0.34
1.10	0.61
1.30	0.87
1.33	1.37
1.38	1.49
1.37	1.56
1.41	1.61
1.50	1.52
1.33	1.44
1.32	1.60
1.28	1.28
1.31	1.29
1.35	1.48
1.29	1.38
1.23	1.39
1.21	1.21
0.91	0.77

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	51.6	52.0	L/s
MNF	19.9	15.8	L/s
BGWI	10.0	7.5	L/s
Unit BGWI	0.29	0.22	L/s/ha
Sanitary Flow	41.6	44.5	L/s
Per Capita Sanitary Flow	363.3	389.0	L/cap/d
Peak DWF	72.3	79.2	L/s

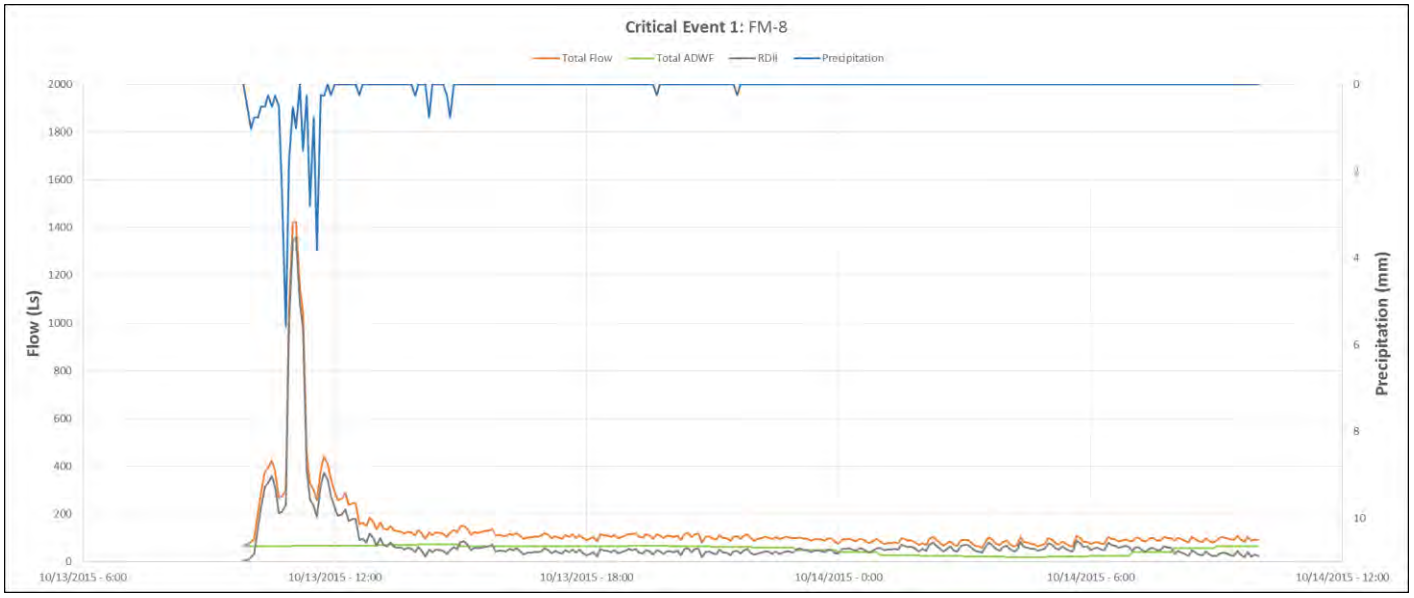
Quantification of RDII

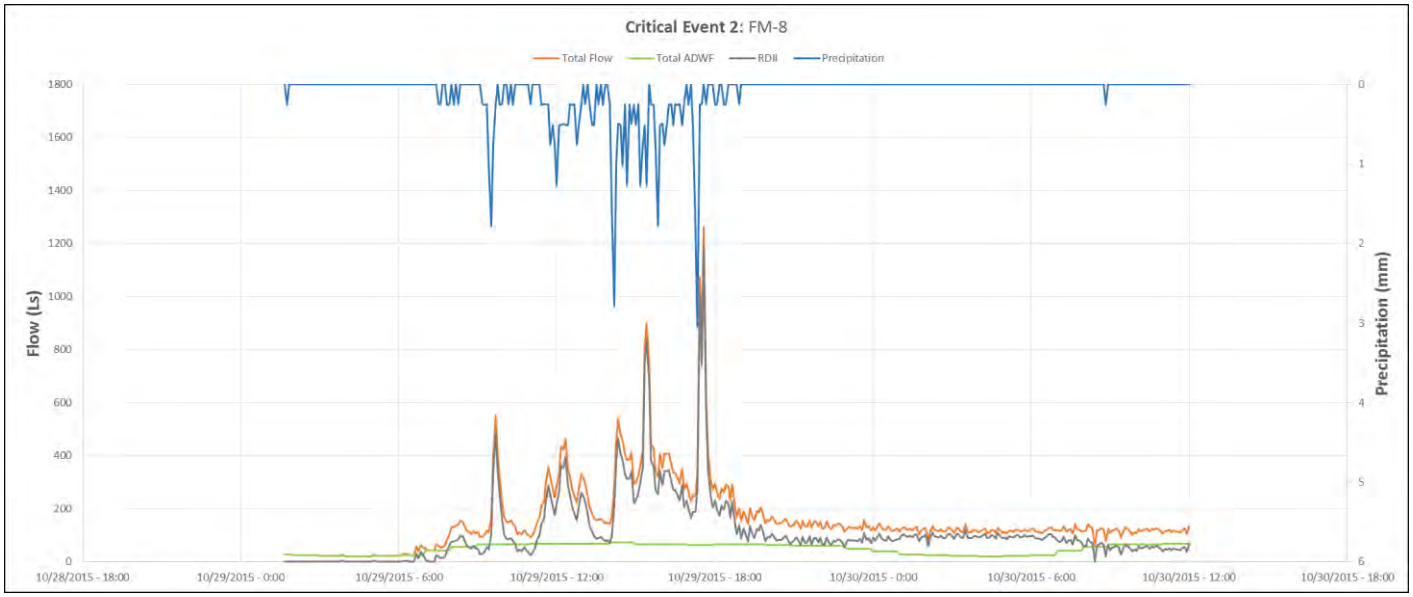
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	1358	7.4	74%	39.93
CE2	10/29/2015	10	49	1196	13.9	83%	35.19
CE3	11/13/2015	7	29	348	8.6	87%	10.23
CE4	11/21/2015	13	93	1424	40.8	129%	41.88

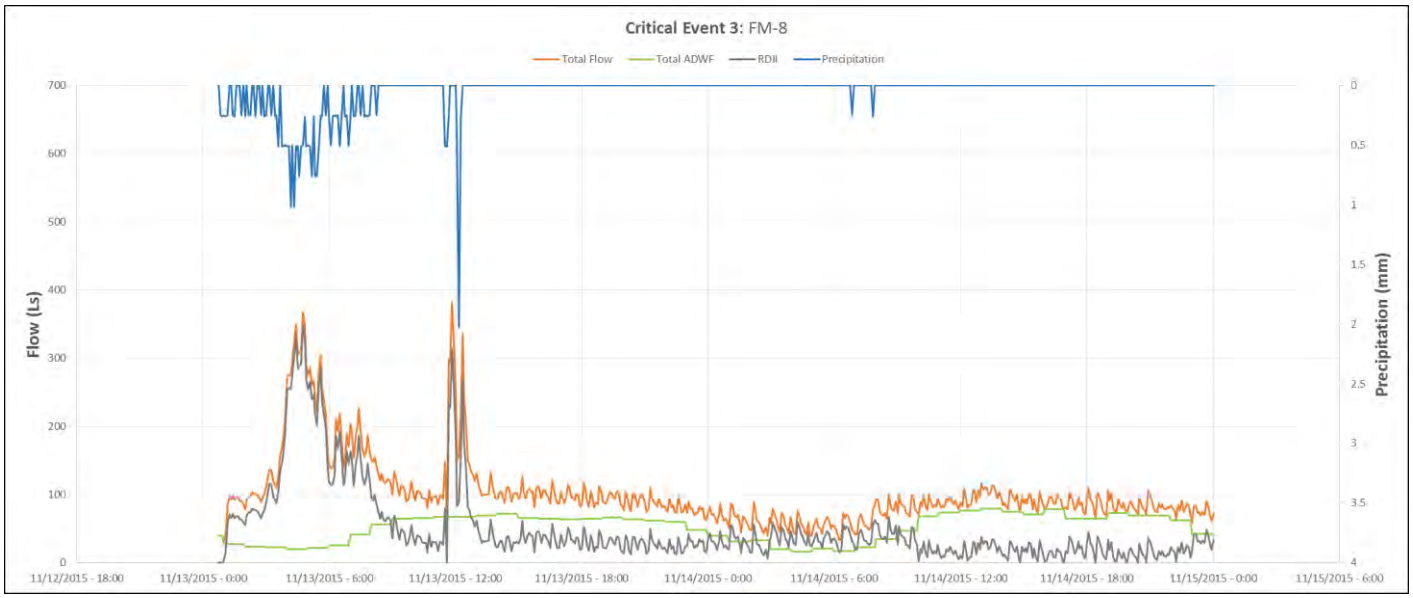
Estimated Peak Wet Weather Design Flows (L/s)

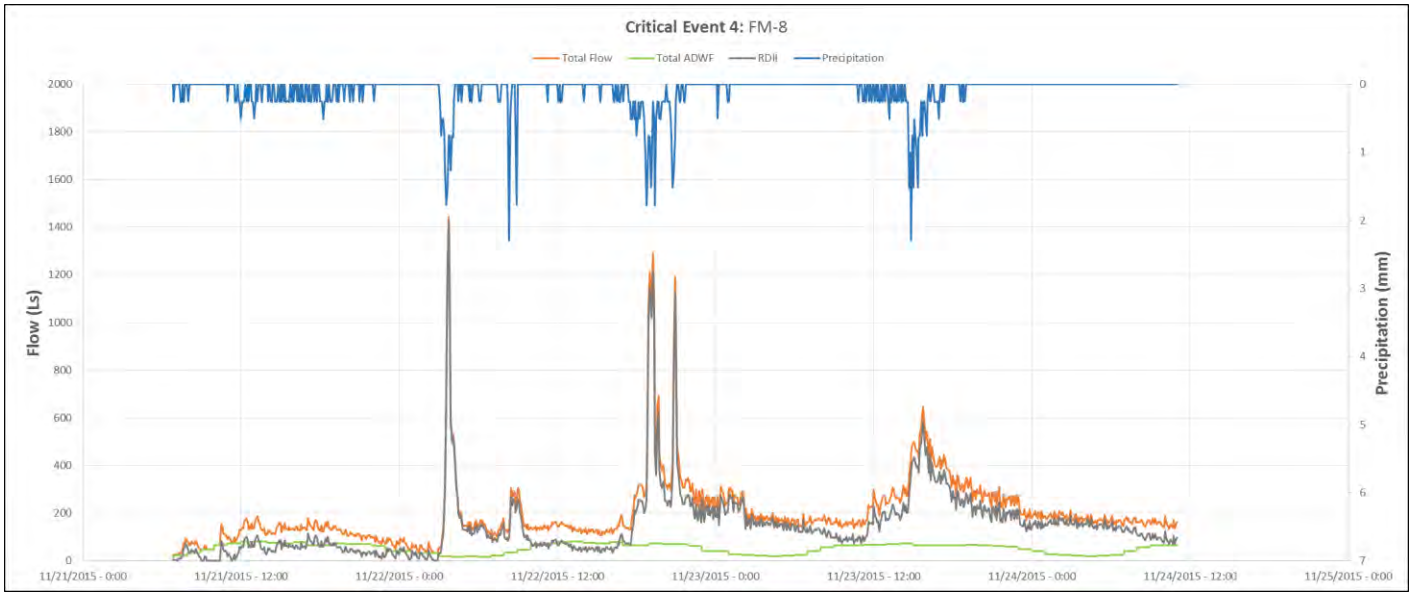
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	344	1039	1273	1429	1627	1773	1920

Wet Weather Flow Graphs



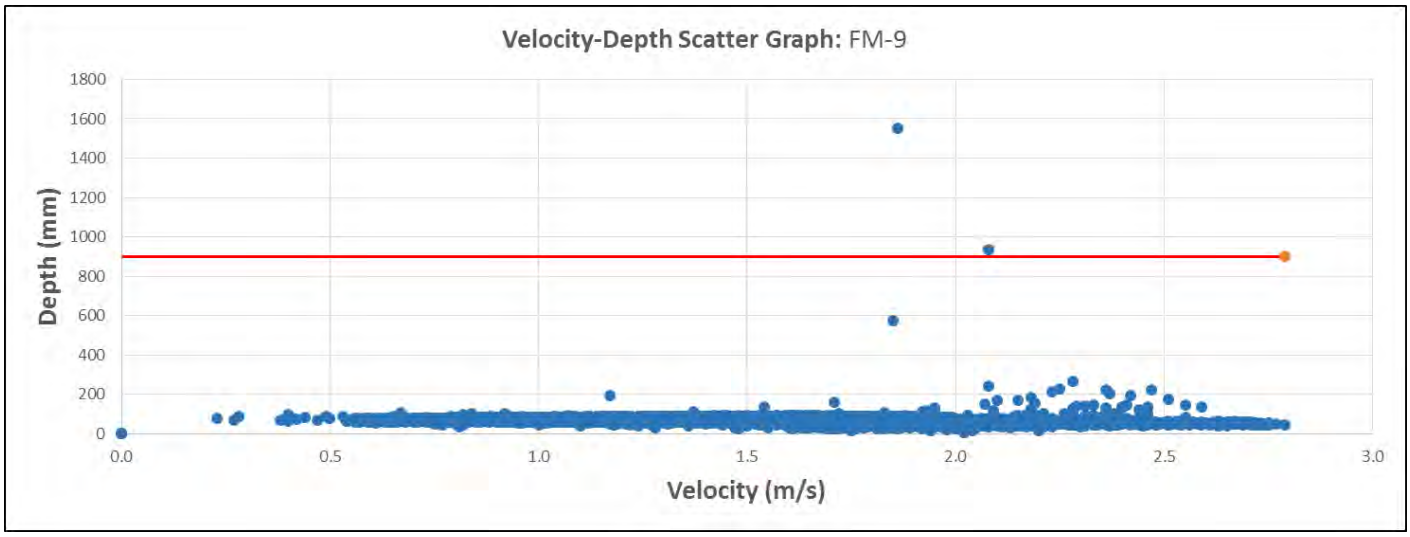



Critical Event 3: FM-8
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
100
200
300
400
500
600
700
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00

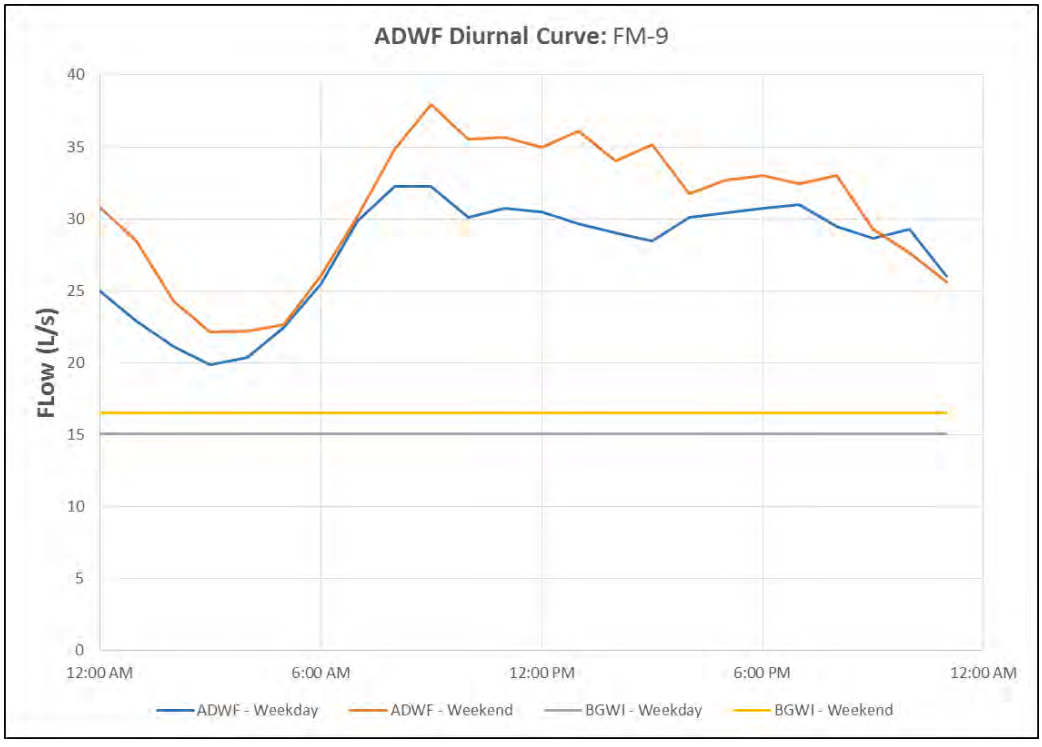

Critical Event 4: FM-8
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
1
2
3
4
5
6
7
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-9

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.79	1.01
0.62	0.84
0.48	0.55
0.38	0.39
0.42	0.40
0.58	0.43
0.82	0.67
1.17	0.96
1.35	1.30
1.36	1.51
1.19	1.34
1.23	1.35
1.21	1.30
1.15	1.38
1.10	1.24
1.06	1.32
1.18	1.08
1.21	1.14
1.24	1.17
1.25	1.12
1.14	1.16
1.07	0.90
1.12	0.79
0.86	0.64

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	27.7	30.7	L/s
MNF	19.9	22.1	L/s
BGWI	15.0	16.5	L/s
Unit BGWI	0.35	0.39	L/s/ha
Sanitary Flow	12.7	14.1	L/s
Per Capita Sanitary Flow	429.1	478.0	L/cap/d
Peak DWF	32.3	37.9	L/s

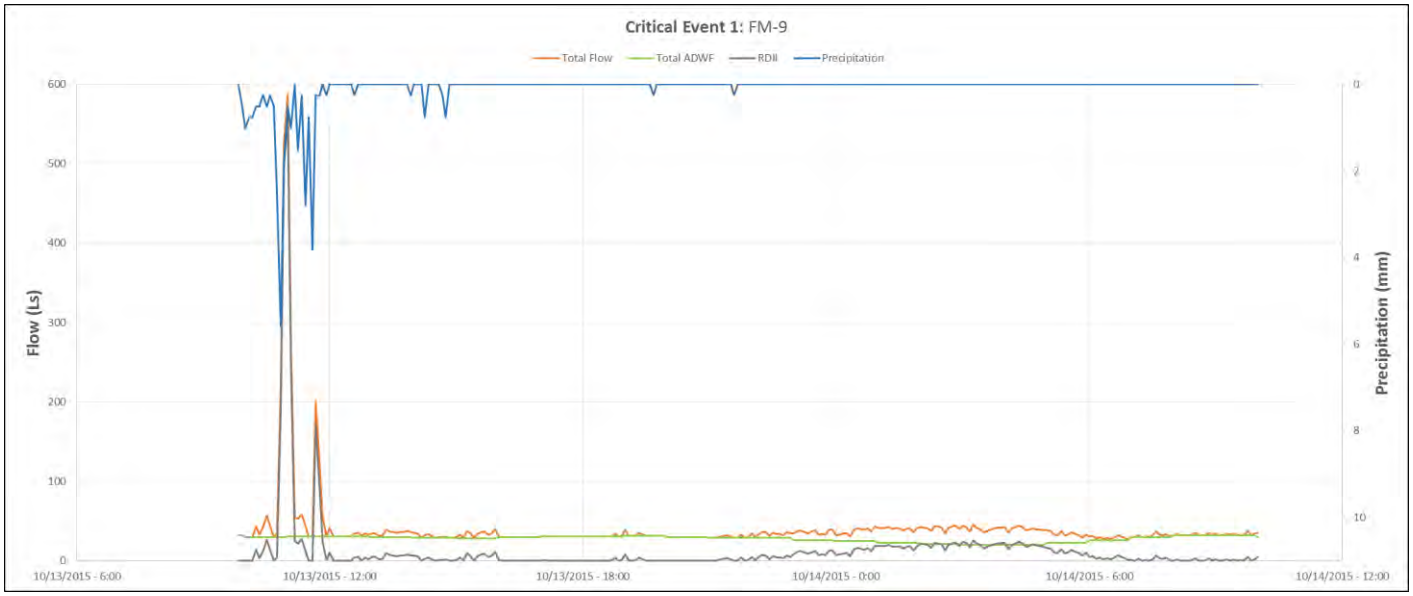
Quantification of RDII

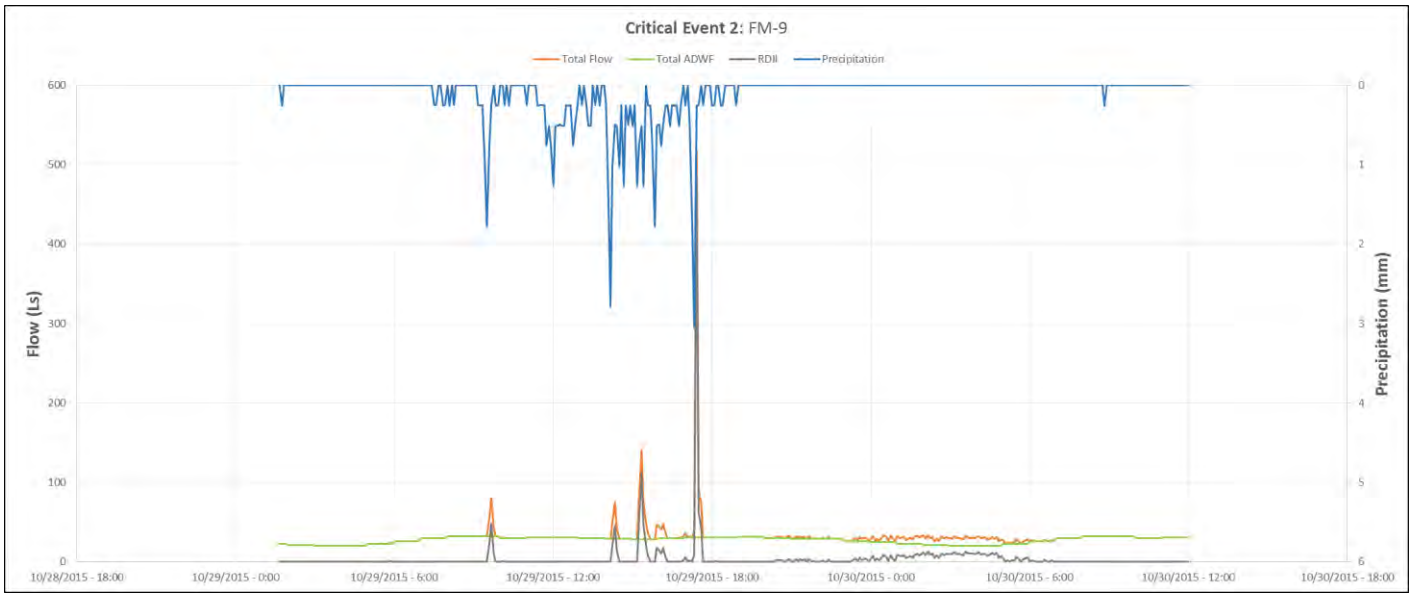
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	557	1.1	9%	12.99
CE2	10/29/2015	10	49	486	0.5	2%	11.32
CE3	11/13/2015	7	29	16	0.3	3%	0.38
CE4	11/21/2015	13	93	206	1.8	4%	4.79

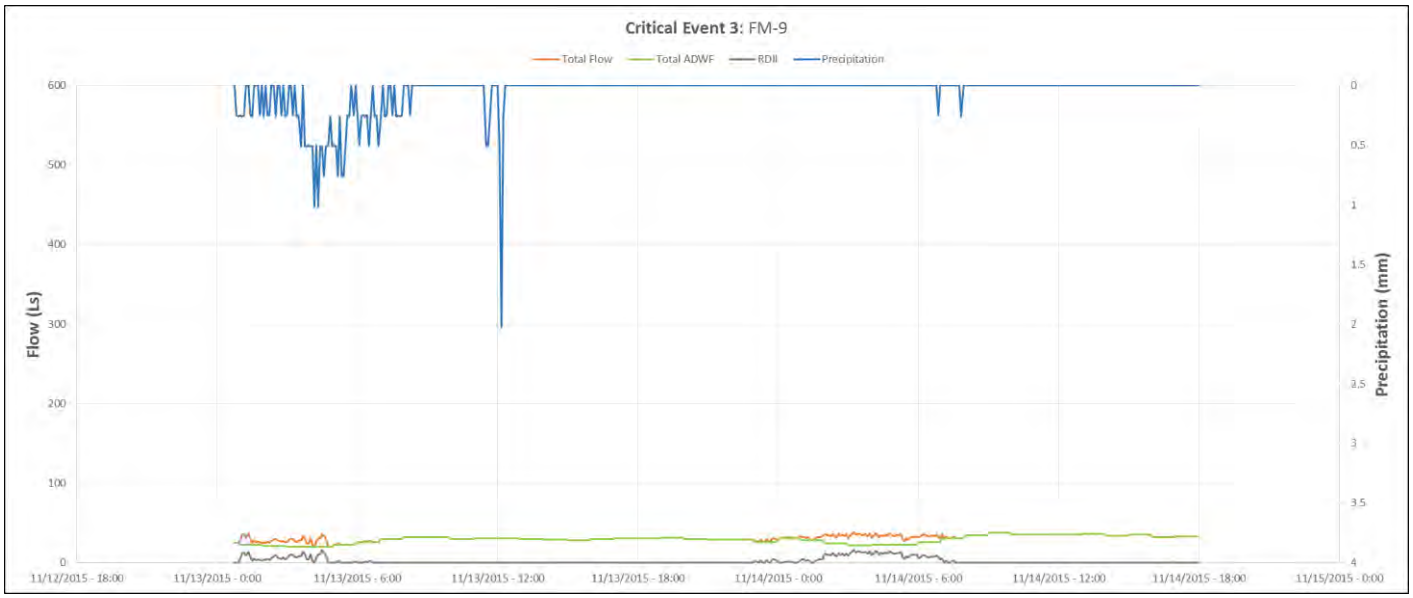
Estimated Peak Wet Weather Design Flows (L/s)

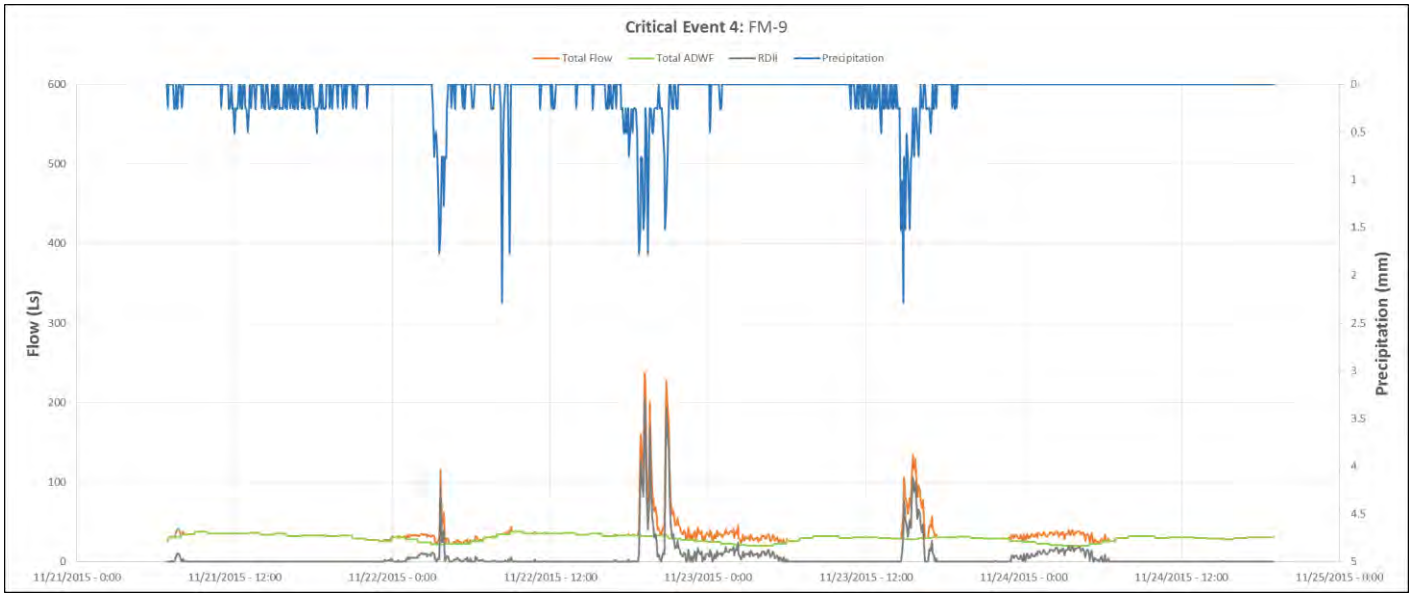
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	123	373	466	529	609	667	726

Wet Weather Flow Graphs



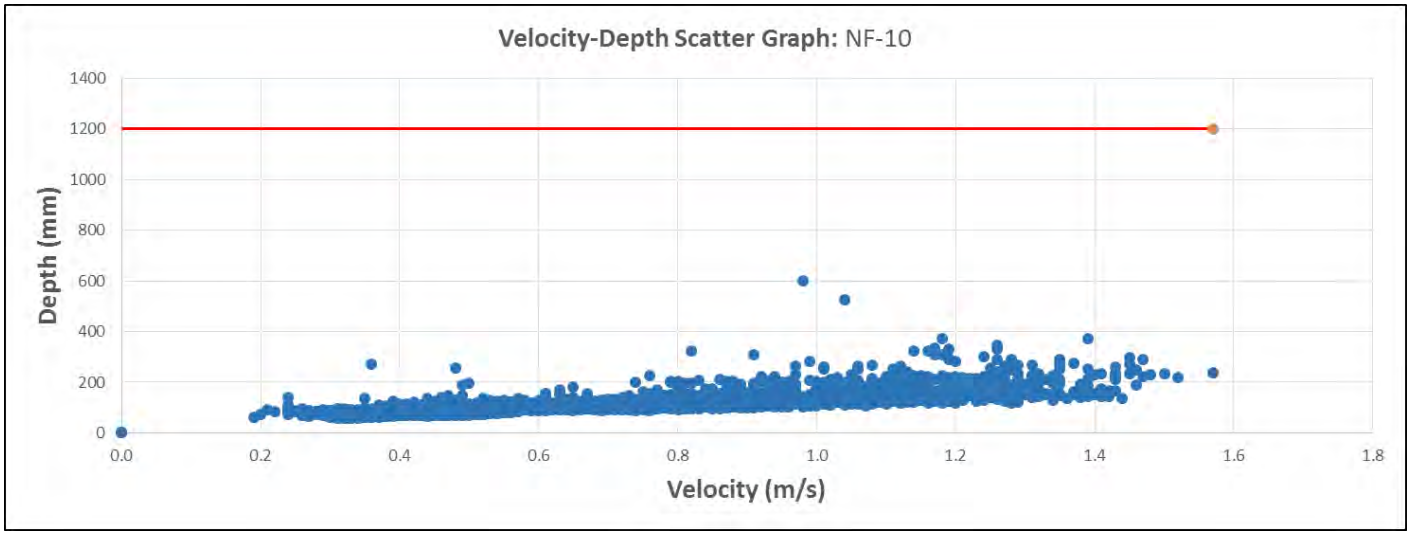



Critical Event 3: FM-9
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

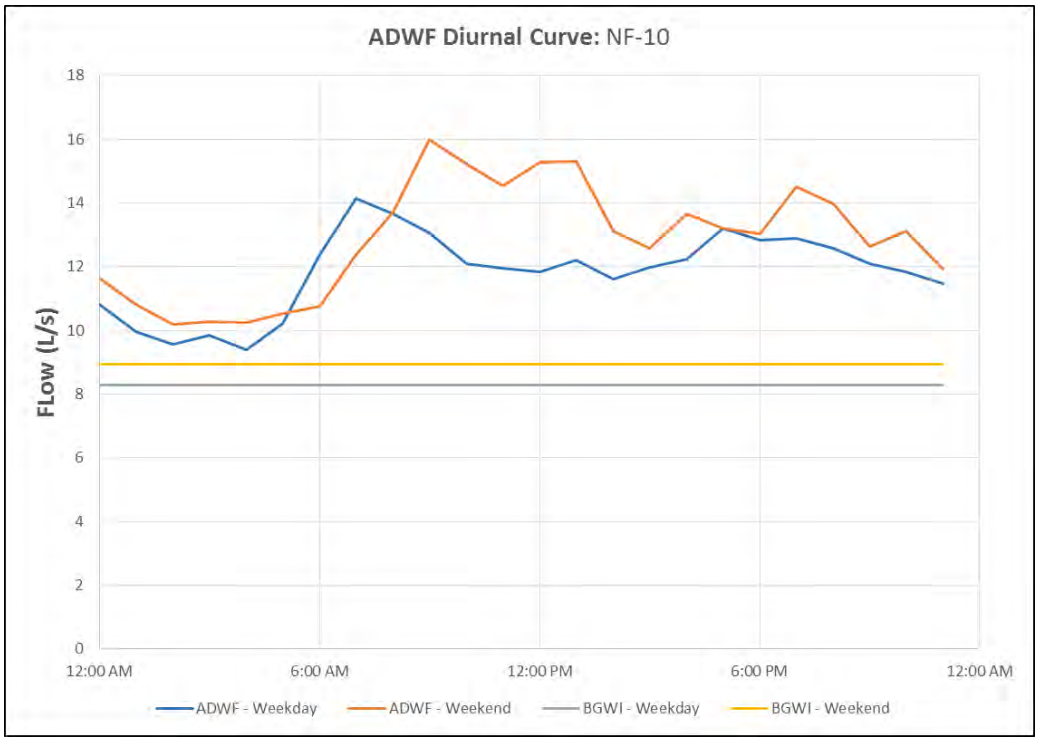

Critical Event 4: FM-9
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-10

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.71	0.69
0.47	0.48
0.36	0.32
0.44	0.34
0.31	0.33
0.54	0.41
1.16	0.46
1.66	0.88
1.52	1.22
1.35	1.79
1.07	1.60
1.03	1.43
1.00	1.62
1.10	1.62
0.94	1.07
1.04	0.93
1.12	1.20
1.39	1.09
1.29	1.04
1.30	1.42
1.21	1.29
1.07	0.94
1.01	1.07
0.90	0.76

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	11.8	12.9	L/s
MNF	9.4	10.2	L/s
BGWI	8.3	8.9	L/s
Unit BGWI	0.22	0.23	L/s/ha
Sanitary Flow	3.5	3.9	L/s
Per Capita Sanitary Flow	128.5	142.7	L/cap/d
Peak DWF	14.2	16.0	L/s

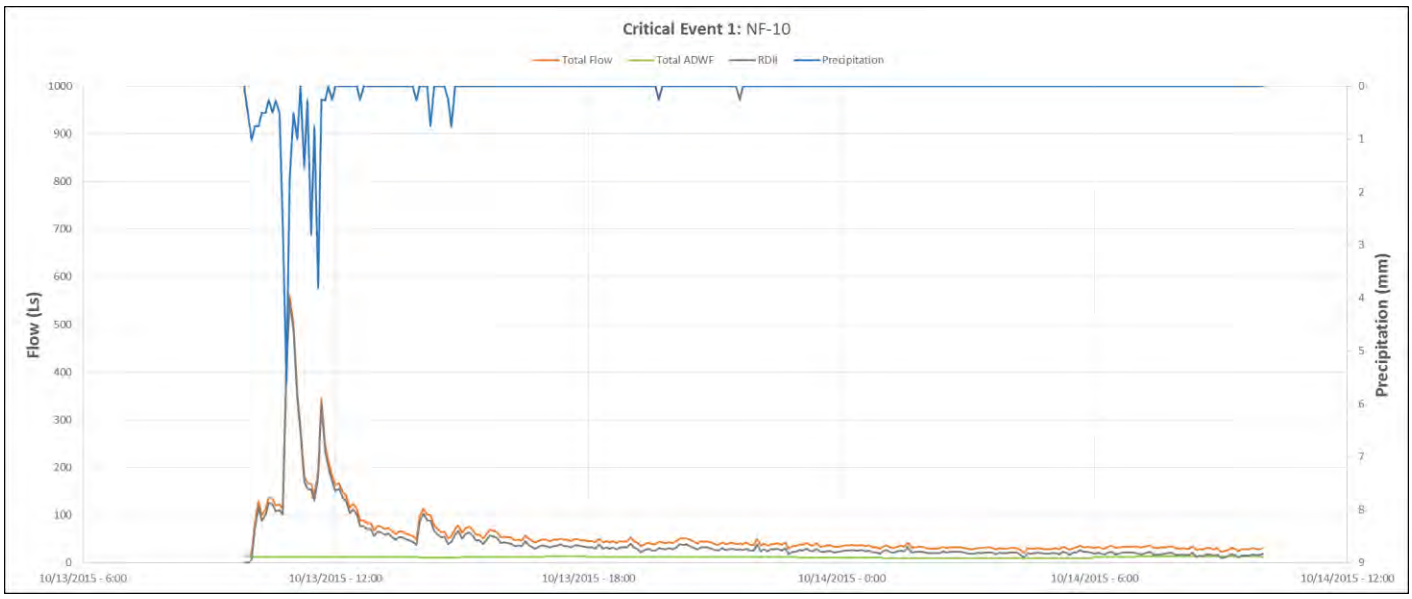
Quantification of RDII

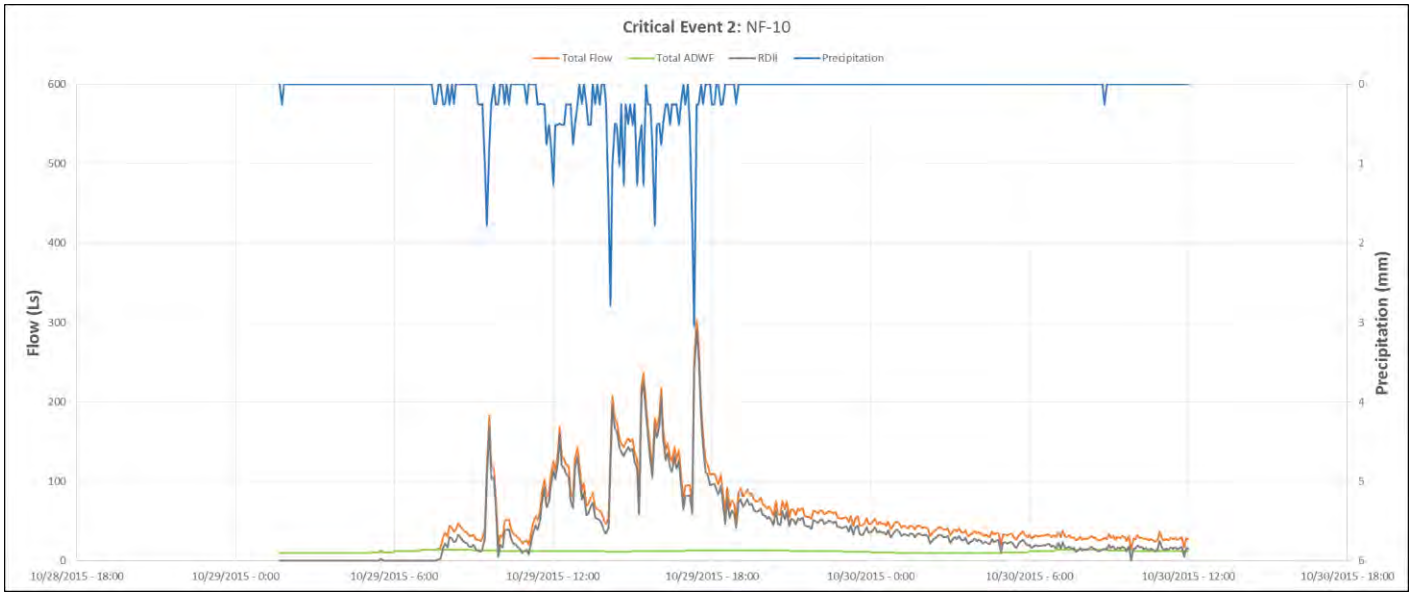
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	549	4.0	35%	14.25
CE2	10/29/2015	10	49	290	5.3	28%	7.53
CE3	11/13/2015	7	29	152	3.3	29%	3.95
CE4	11/21/2015	13	93	309	18.5	51%	8.02

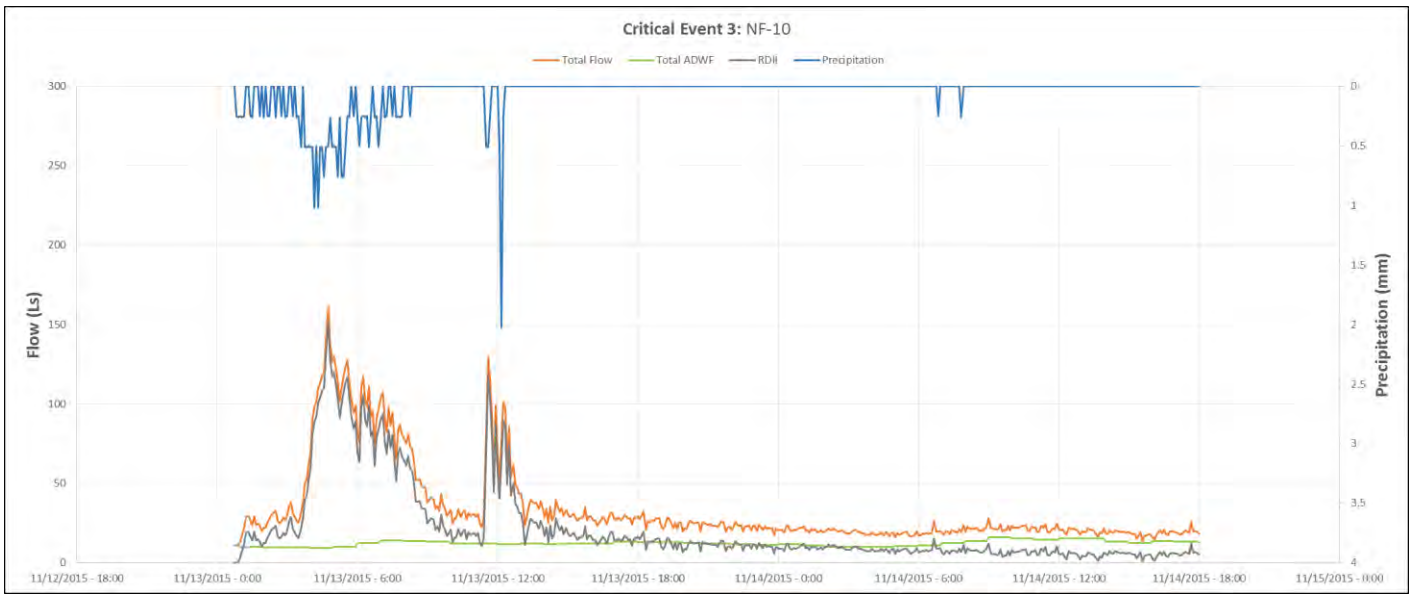
Estimated Peak Wet Weather Design Flows (L/s)

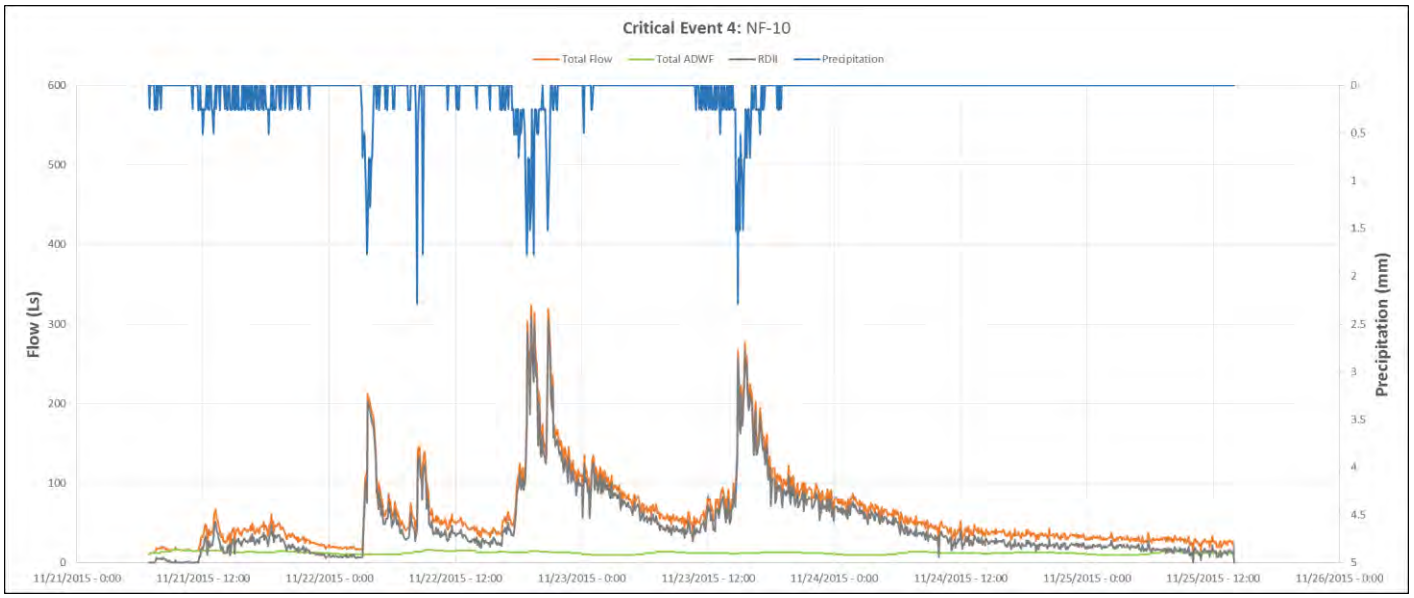
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	38	474	602	688	797	877	957

Wet Weather Flow Graphs



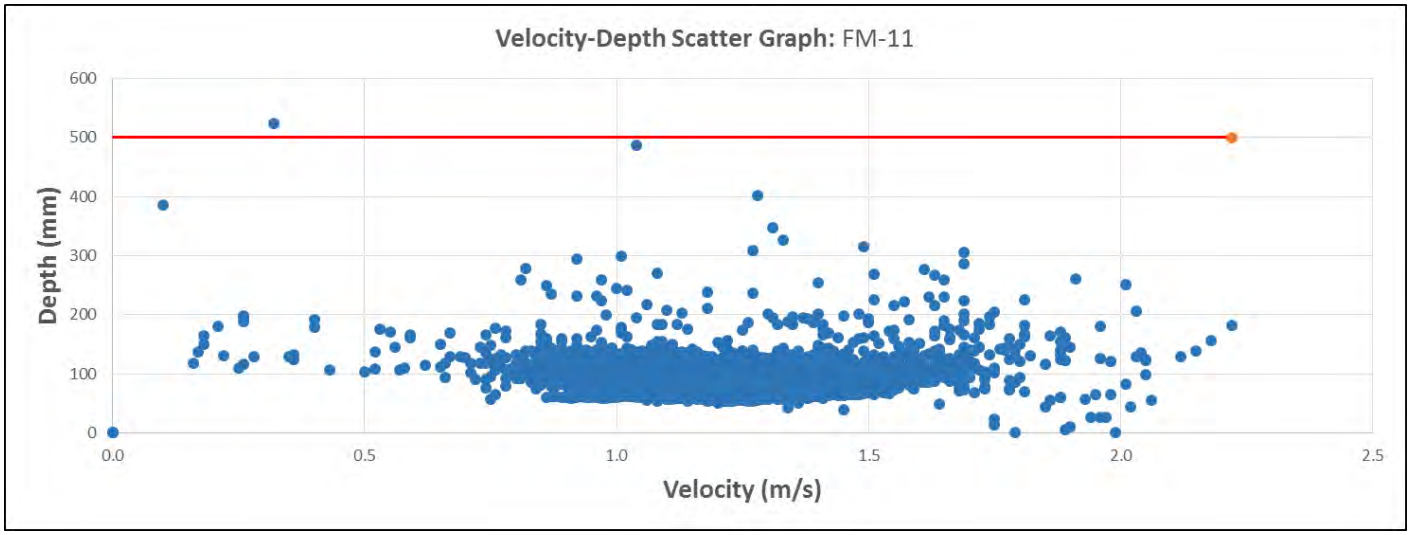



Critical Event 3: NF-10
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

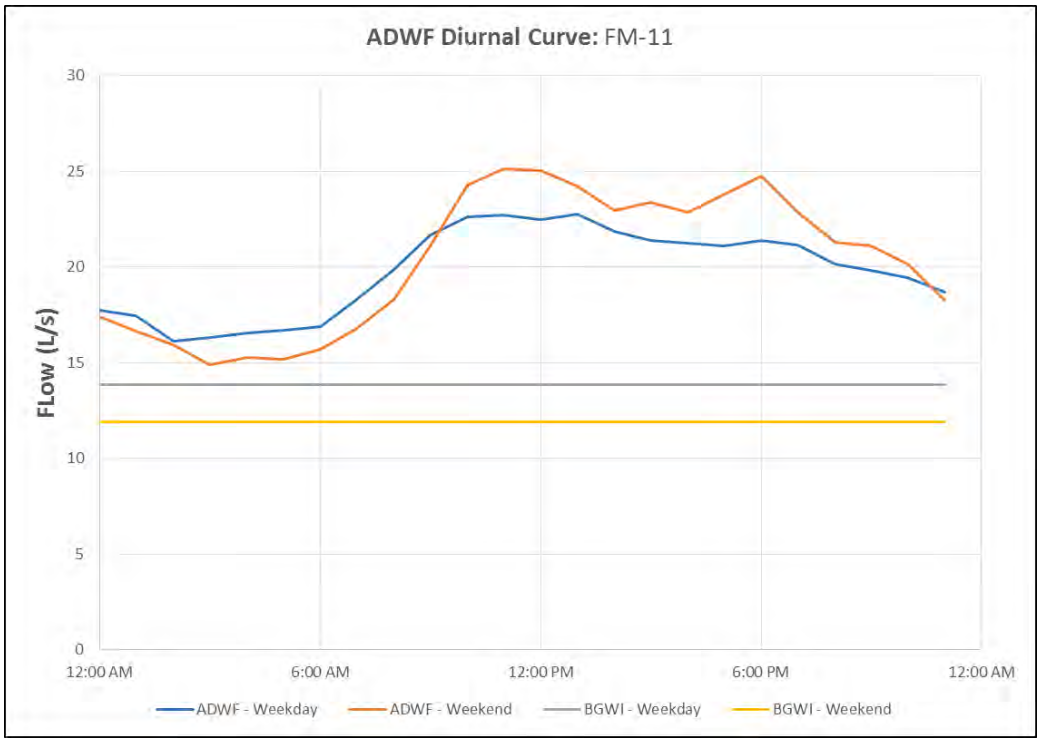

Critical Event 4: NF-10
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
600
500
400
300
200
100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00
11/26/2015 - 0:00

FM-11

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.66	0.65
0.61	0.56
0.39	0.48
0.41	0.35
0.46	0.40
0.48	0.39
0.51	0.45
0.75	0.58
1.02	0.76
1.33	1.10
1.48	1.47
1.50	1.58
1.46	1.57
1.50	1.47
1.35	1.32
1.27	1.37
1.25	1.30
1.23	1.42
1.27	1.53
1.23	1.30
1.06	1.12
1.01	1.09
0.95	0.98
0.82	0.76

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	19.8	20.3	L/s
MNF	16.1	14.9	L/s
BGWI	13.8	11.9	L/s
Unit BGWI	0.23	0.20	L/s/ha
Sanitary Flow	5.9	8.4	L/s
Per Capita Sanitary Flow	344.8	487.7	L/cap/d
Peak DWF	22.8	25.1	L/s

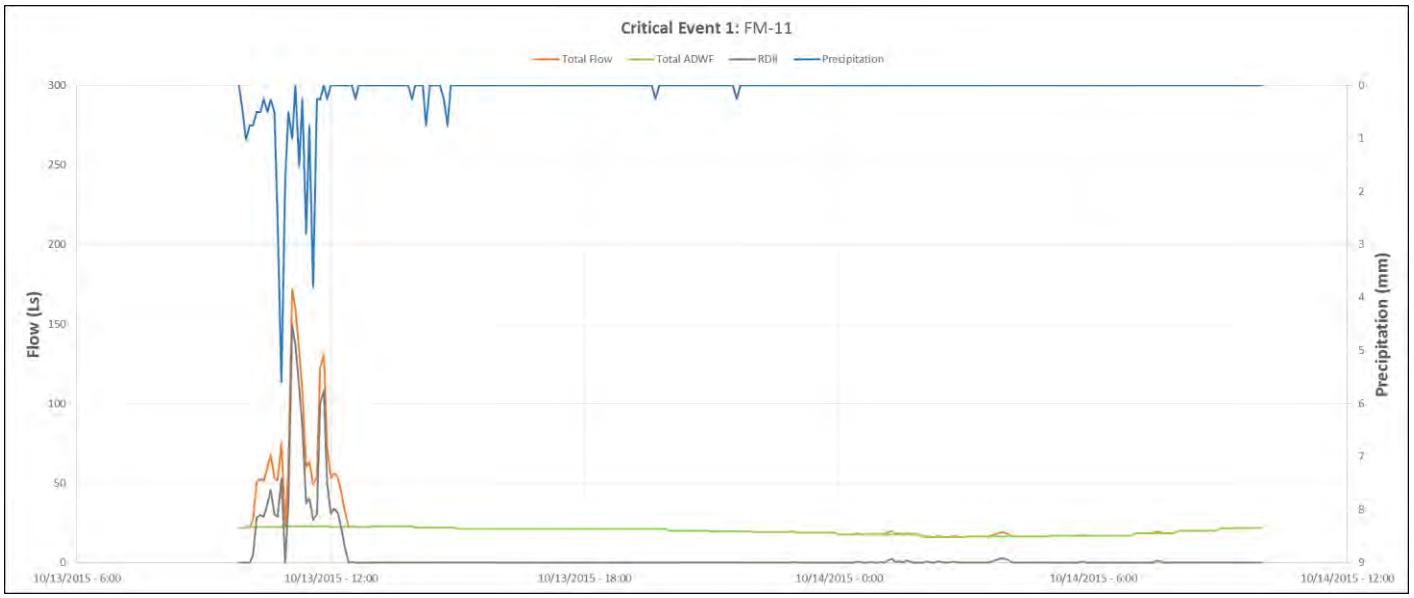
Quantification of RDII

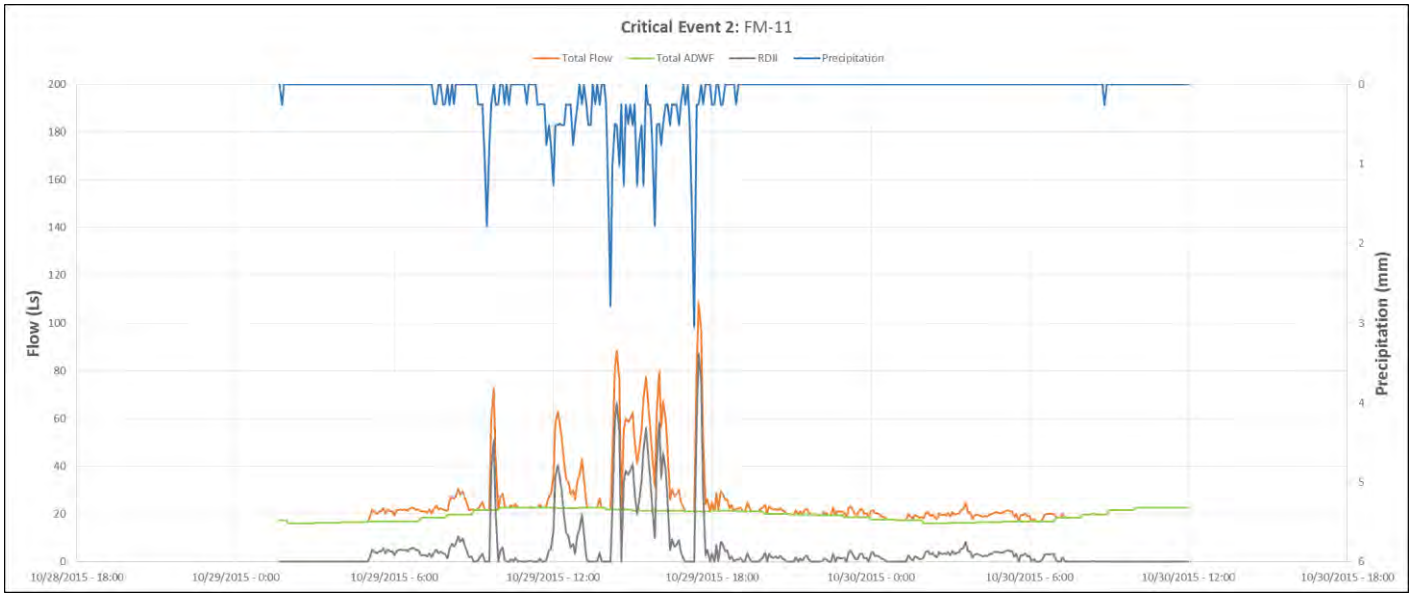
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	149	0.4	2%	2.50
CE2	10/29/2015	10	49	87	0.7	2%	1.47
CE3	11/13/2015	7	29	64	0.4	2%	1.07
CE4	11/21/2015	13	93	126	1.5	3%	2.11

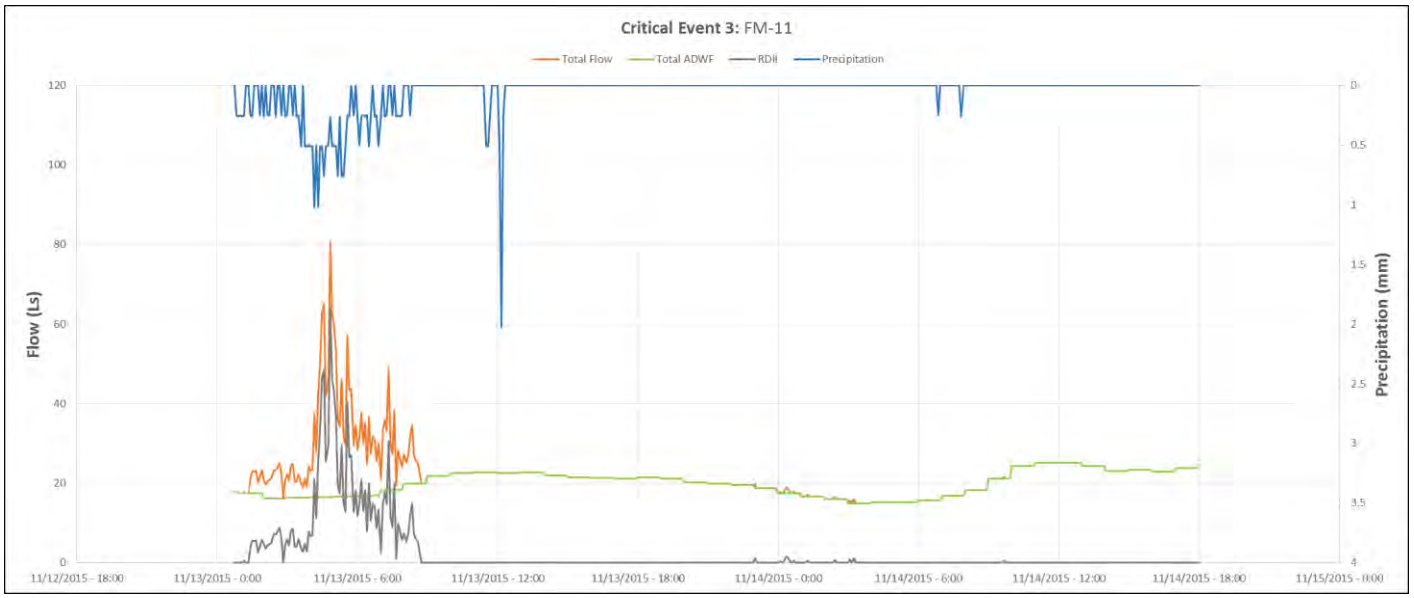
Estimated Peak Wet Weather Design Flows (L/s)

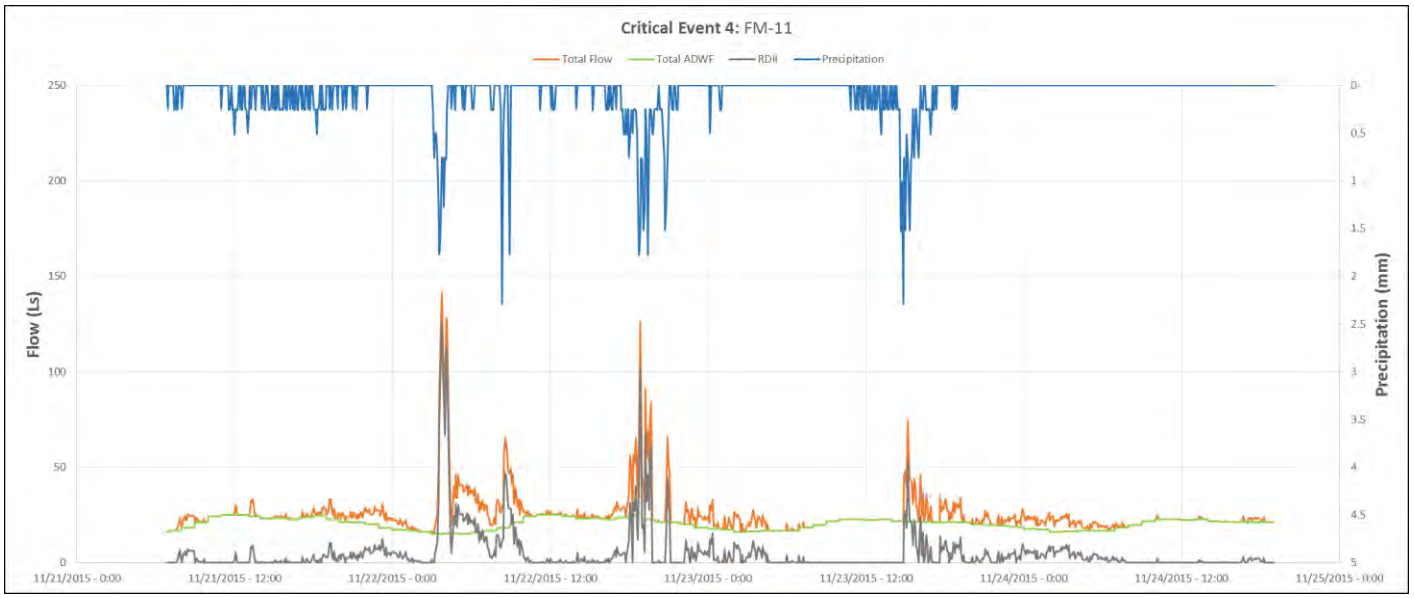
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	77	145	177	200	229	249	270

Wet Weather Flow Graphs



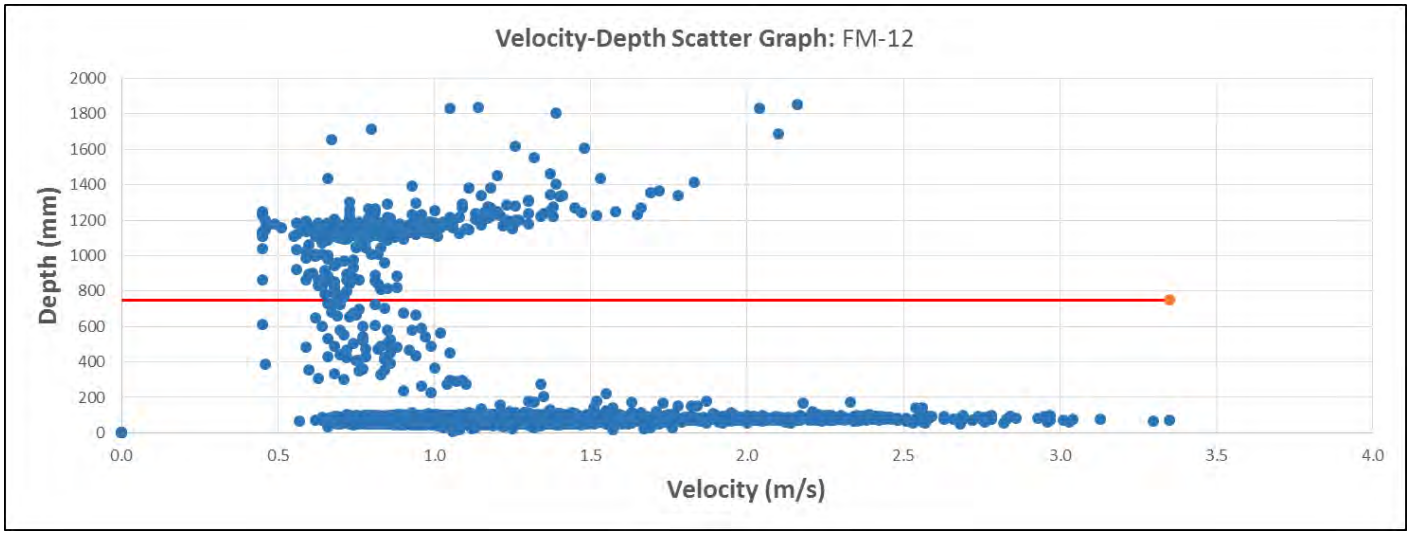



Critical Event 3: FM-11
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

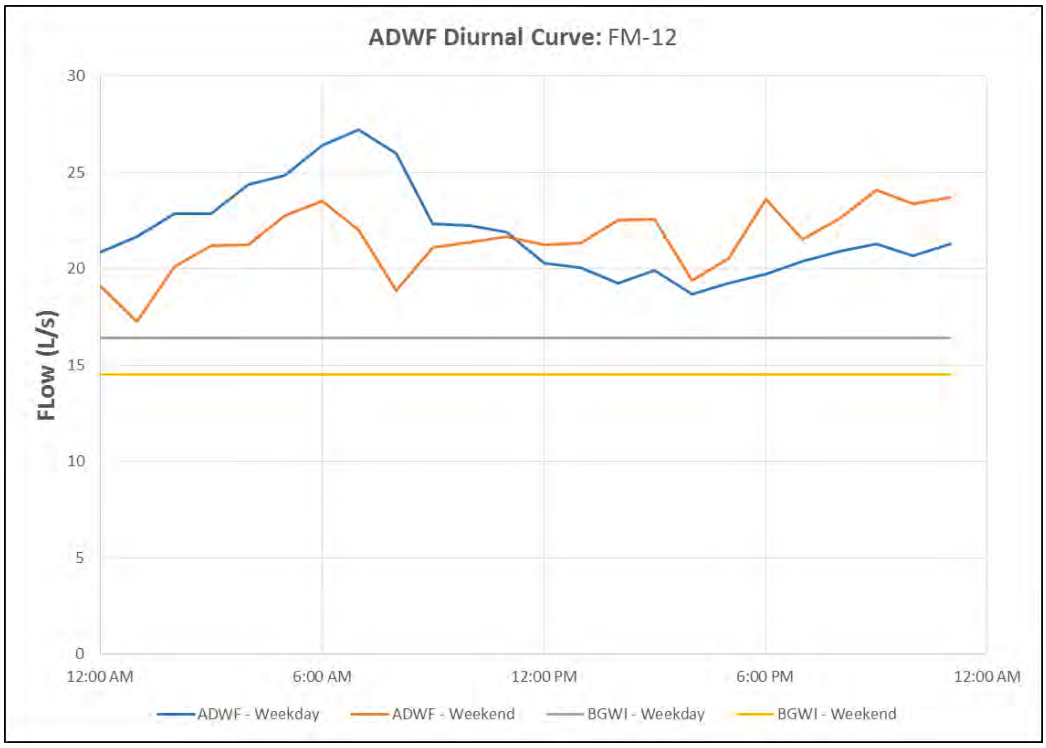

Critical Event 4: FM-11
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-12

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.81	0.65
0.96	0.39
1.18	0.79
1.18	0.95
1.45	0.96
1.54	1.18
1.83	1.28
1.97	1.07
1.75	0.62
1.08	0.94
1.06	0.98
1.00	1.02
0.71	0.96
0.67	0.97
0.52	1.14
0.64	1.15
0.42	0.69
0.52	0.86
0.61	1.30
0.72	1.00
0.82	1.15
0.89	1.37
0.78	1.26
0.89	1.31

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	21.9	21.5	L/s
MNF	18.7	17.3	L/s
BGWI	16.4	14.5	L/s
Unit BGWI	0.42	0.38	L/s/ha
Sanitary Flow	5.5	7.0	L/s
Per Capita Sanitary Flow	156.0	199.0	L/cap/d
Peak DWF	27.2	24.1	L/s

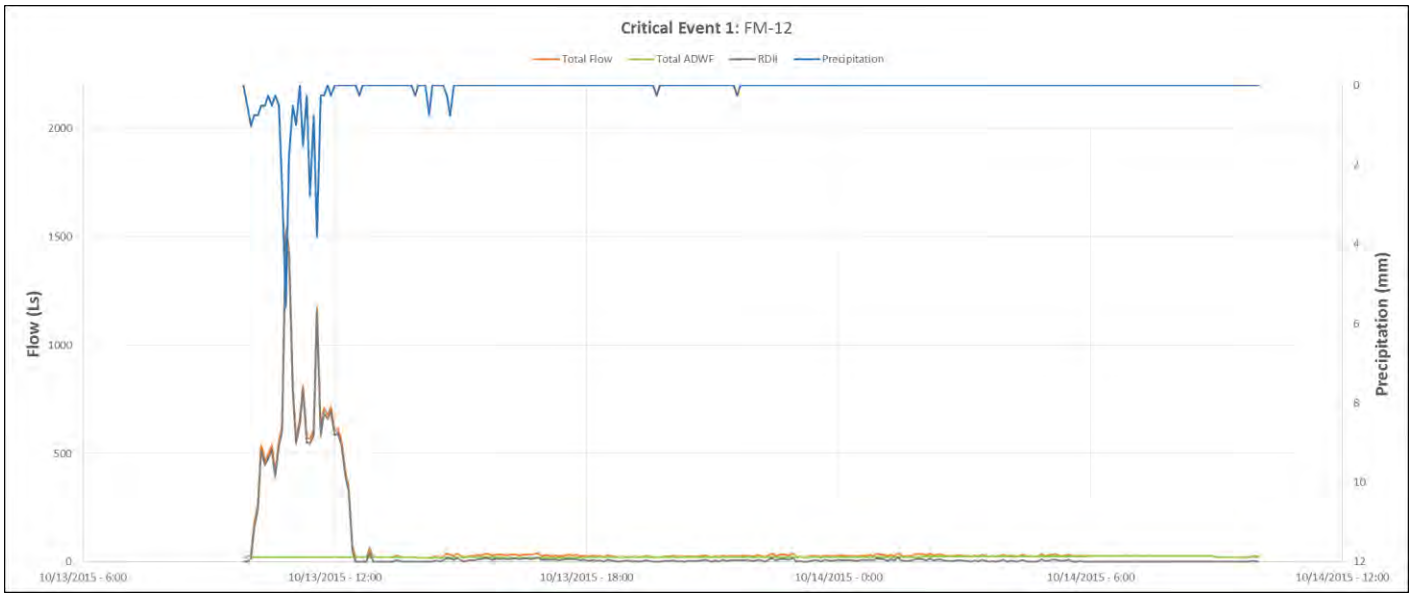
Quantification of RDII

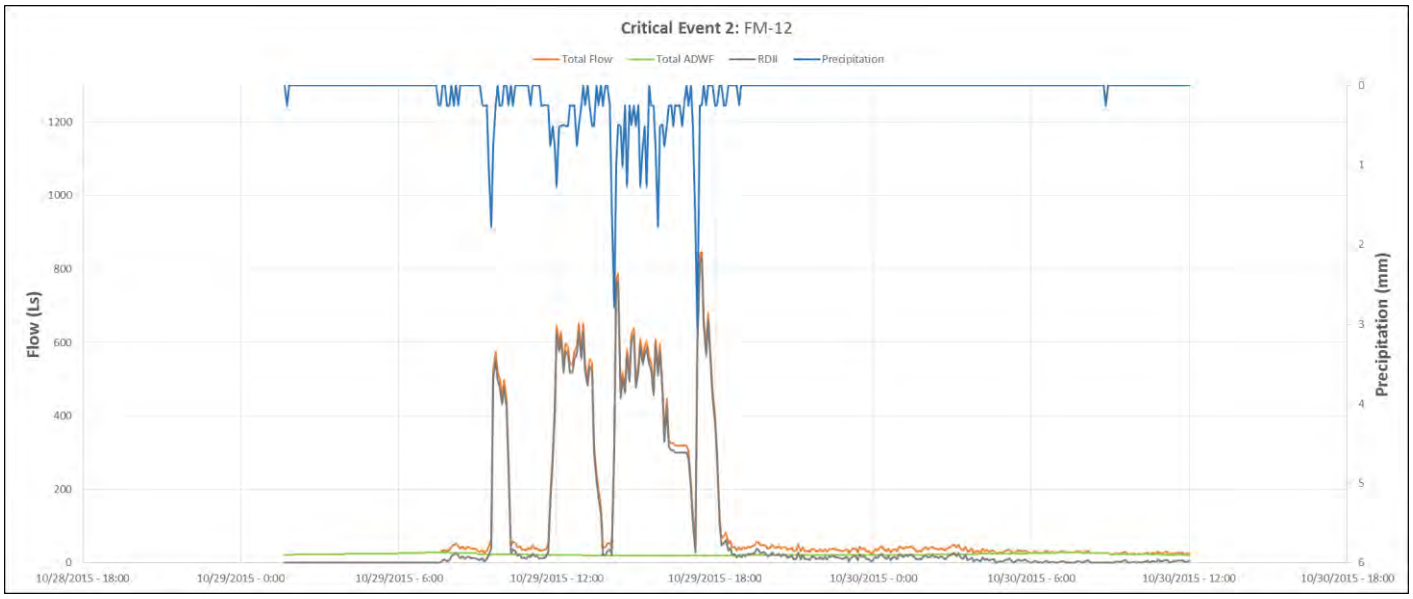
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	1509	5.7	49%	38.99
CE2	10/29/2015	10	49	831	12.1	64%	21.48
CE3	11/13/2015	7	29	791	9.6	86%	20.43
CE4	11/21/2015	13	93	1465	28.2	78%	37.85

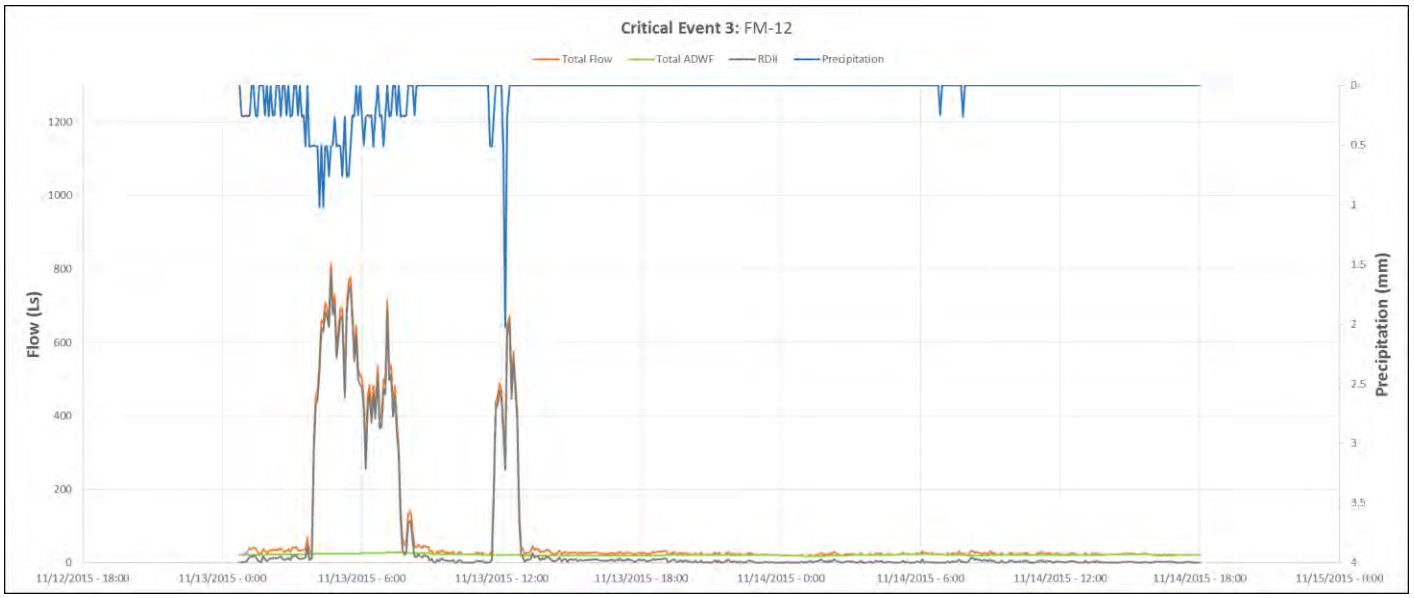
Estimated Peak Wet Weather Design Flows (L/s)

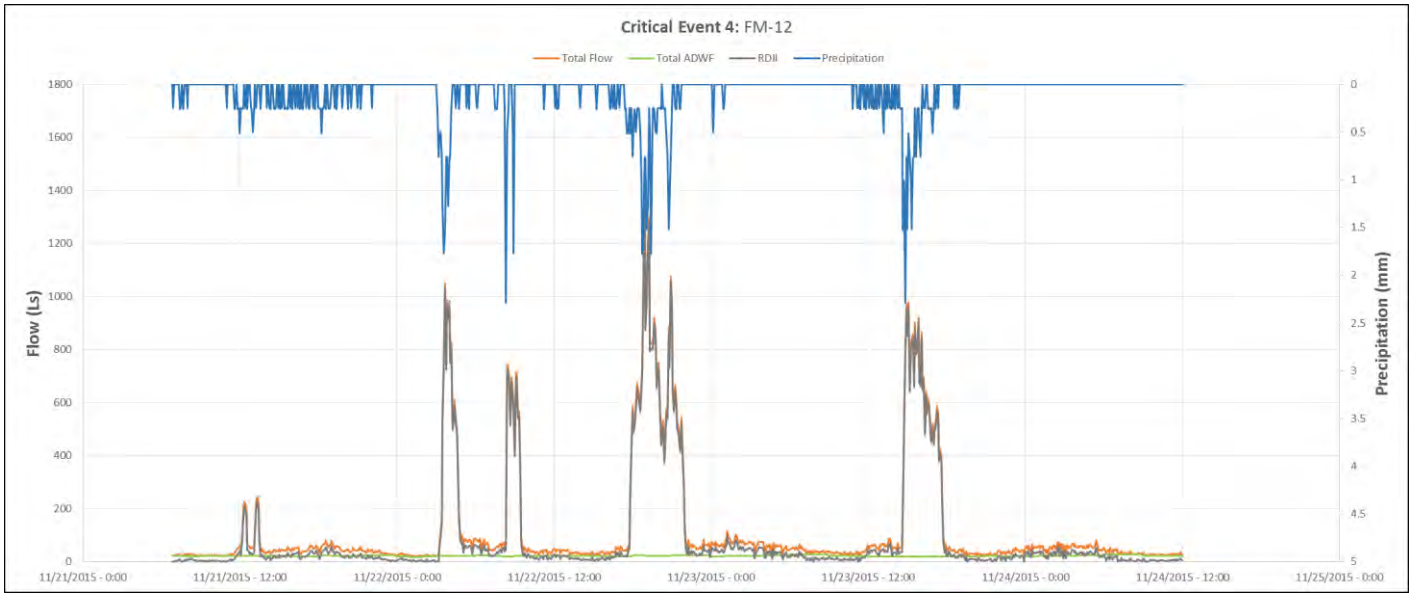
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	69	1701	2170	2484	2884	3176	3467

Wet Weather Flow Graphs



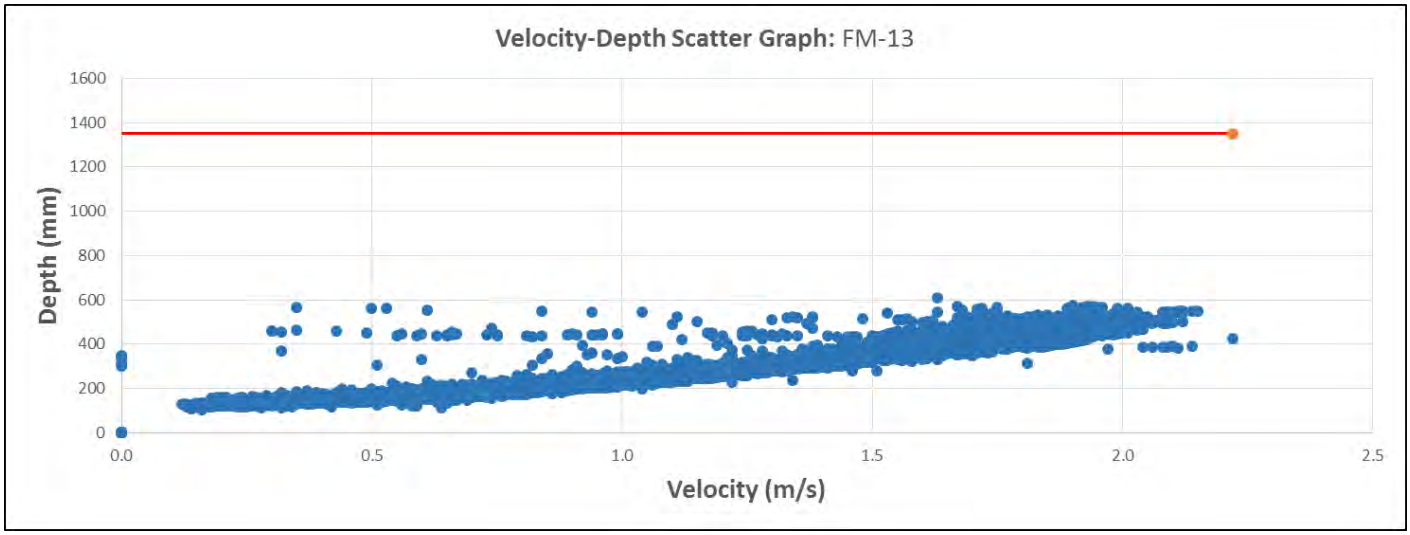



Critical Event 3: FM-12
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
0
200
400
600
800
1000
1200
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

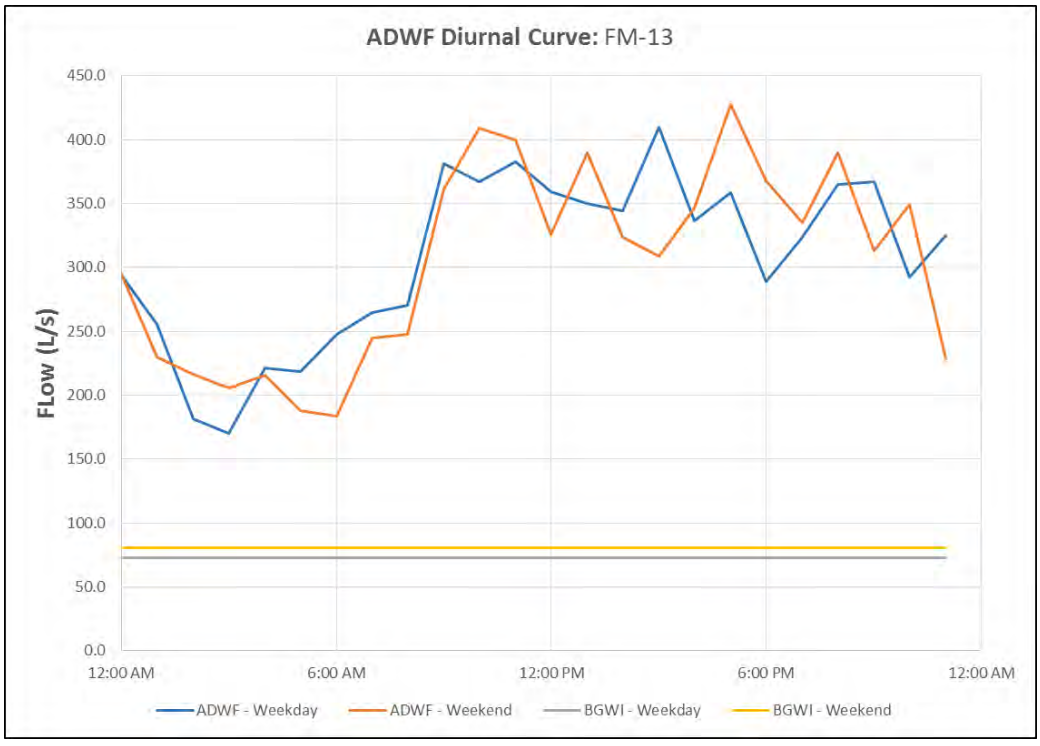

Critical Event 4: FM-12
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
1600
1800
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-13

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.94	0.96
0.78	0.67
0.46	0.61
0.42	0.56
0.63	0.60
0.62	0.48
0.75	0.46
0.82	0.74
0.84	0.75
1.32	1.25
1.25	1.47
1.32	1.43
1.22	1.10
1.18	1.38
1.16	1.09
1.44	1.02
1.12	1.19
1.22	1.55
0.92	1.28
1.07	1.14
1.25	1.38
1.25	1.04
0.94	1.20
1.08	0.66

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	307.3	304.3	L/s
MNF	170.4	183.8	L/s
BGWI	72.5	80.3	L/s
Unit BGWI	0.05	0.06	L/s/ha
Sanitary Flow	234.7	223.9	L/s
Per Capita Sanitary Flow	416.0	396.8	L/cap/d
Peak DWF	409.5	427.2	L/s

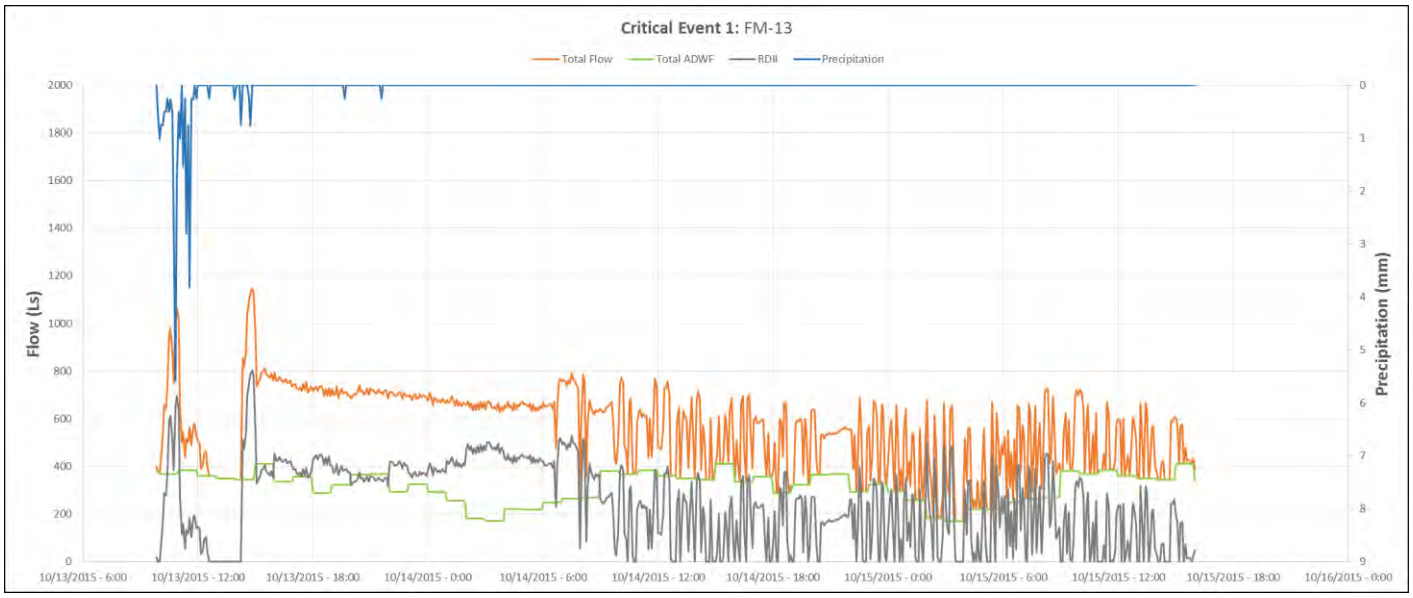
Quantification of RDII

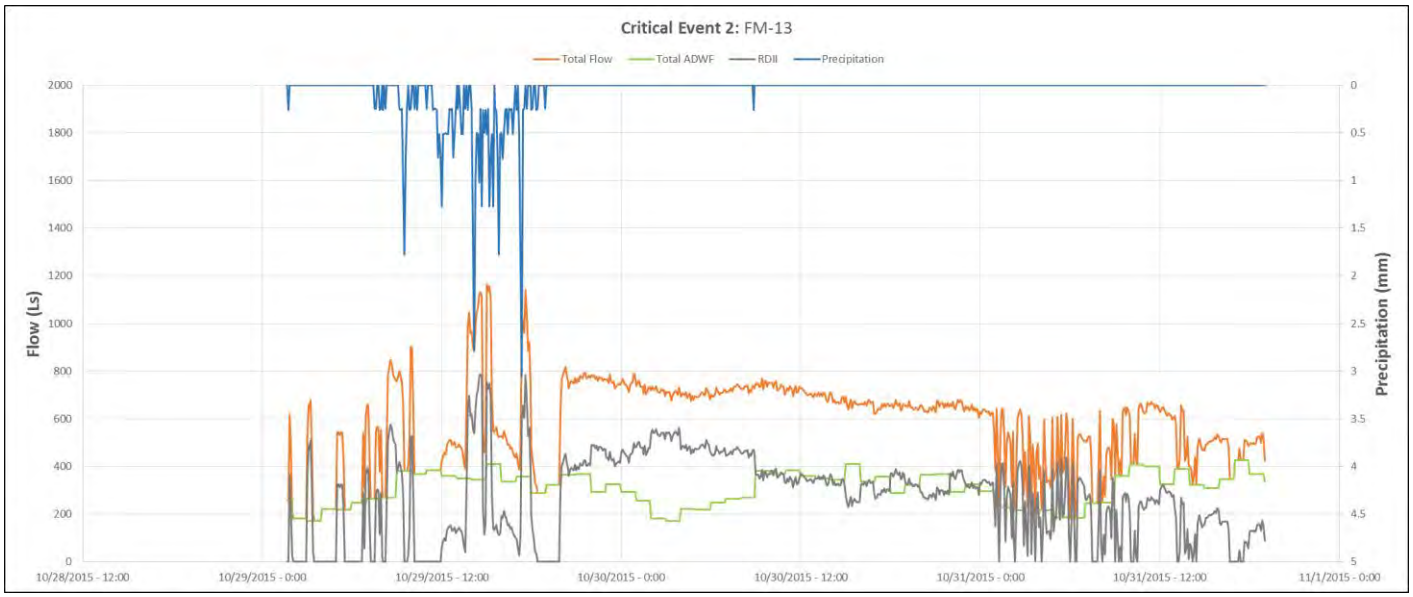
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	805	48.0	12%	0.58
CE2	10/29/2015	10	49	787	64.0	9%	0.57
CE3	11/13/2015	7	29	779	37.0	9%	0.57
CE4	11/21/2015	13	94	769	206.1	16%	0.56

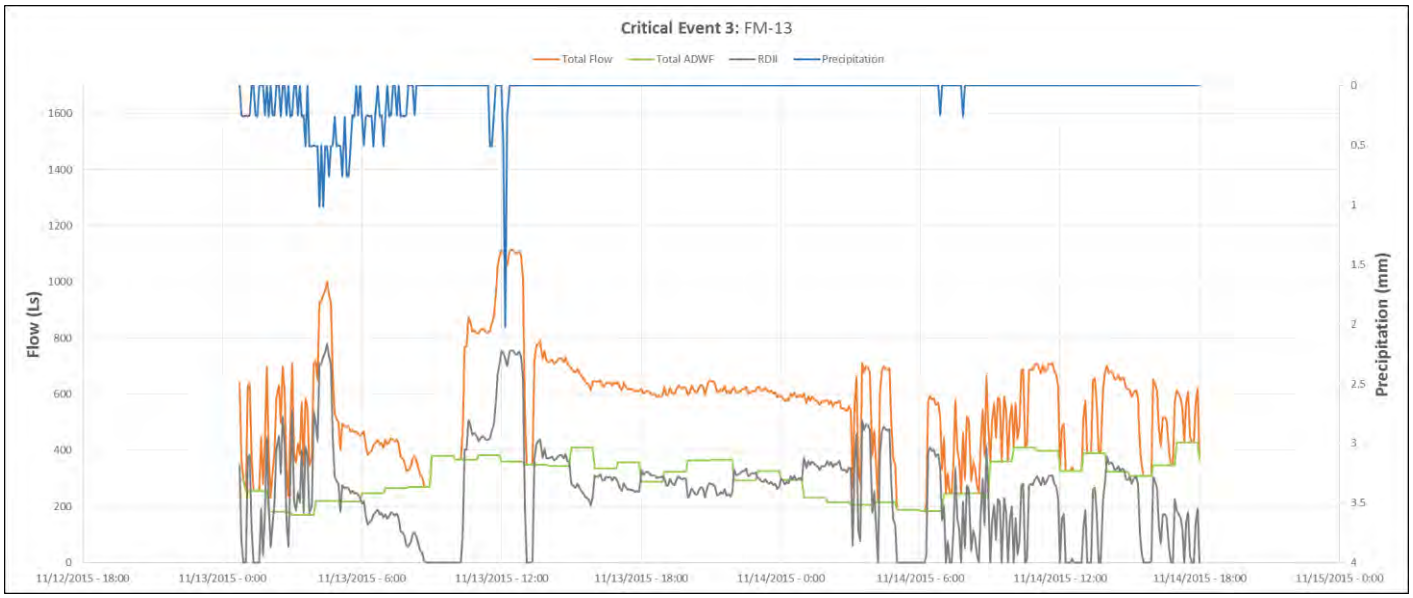
Estimated Peak Wet Weather Design Flows (L/s)

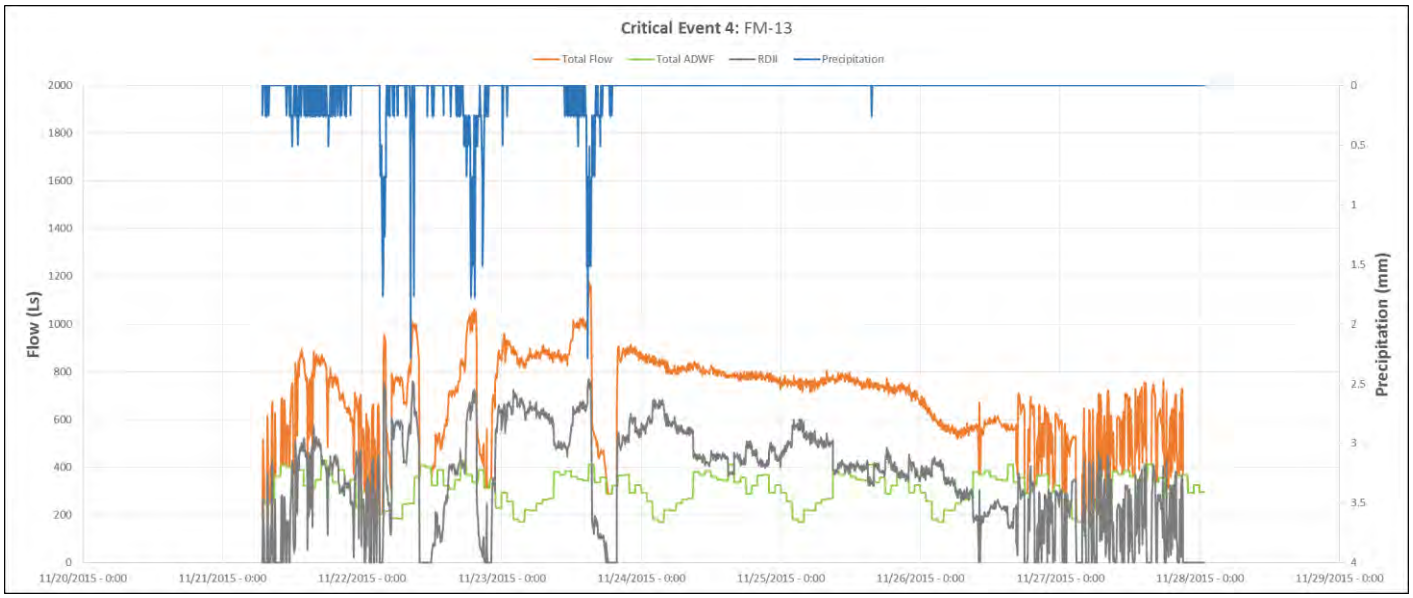
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	1841	1942	2314	2562	2865	3099	3333

Wet Weather Flow Graphs



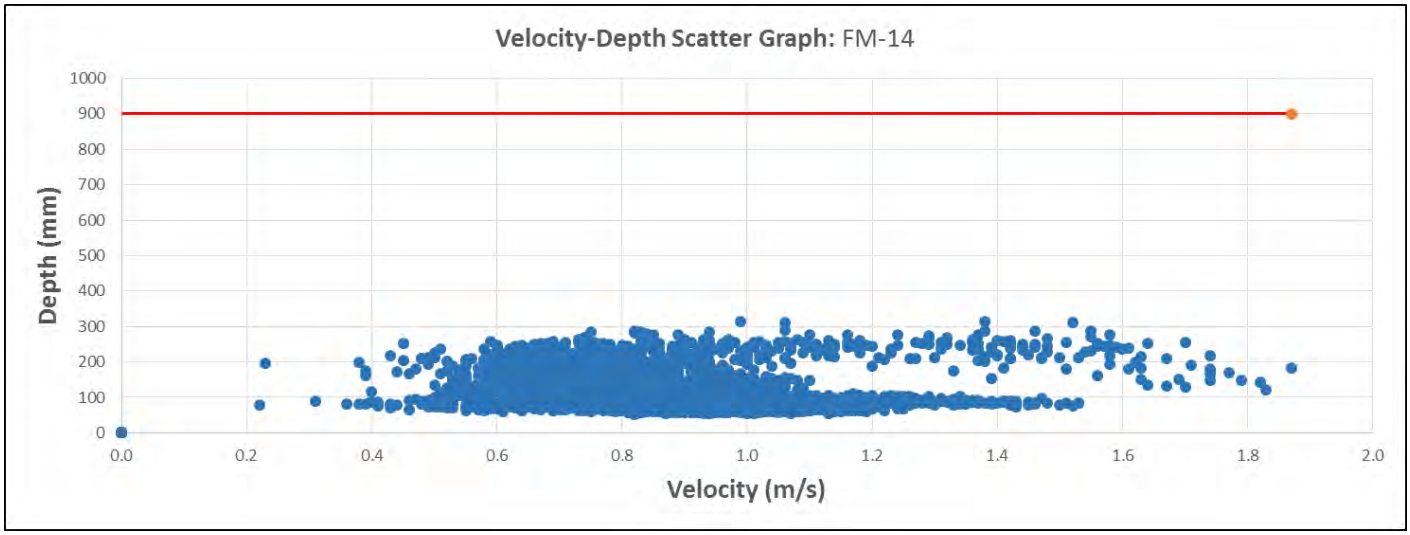



Critical Event 3: FM-13
Total Flow
Total ADWF
RDII
Precipitation
Flow (ls)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
1600
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

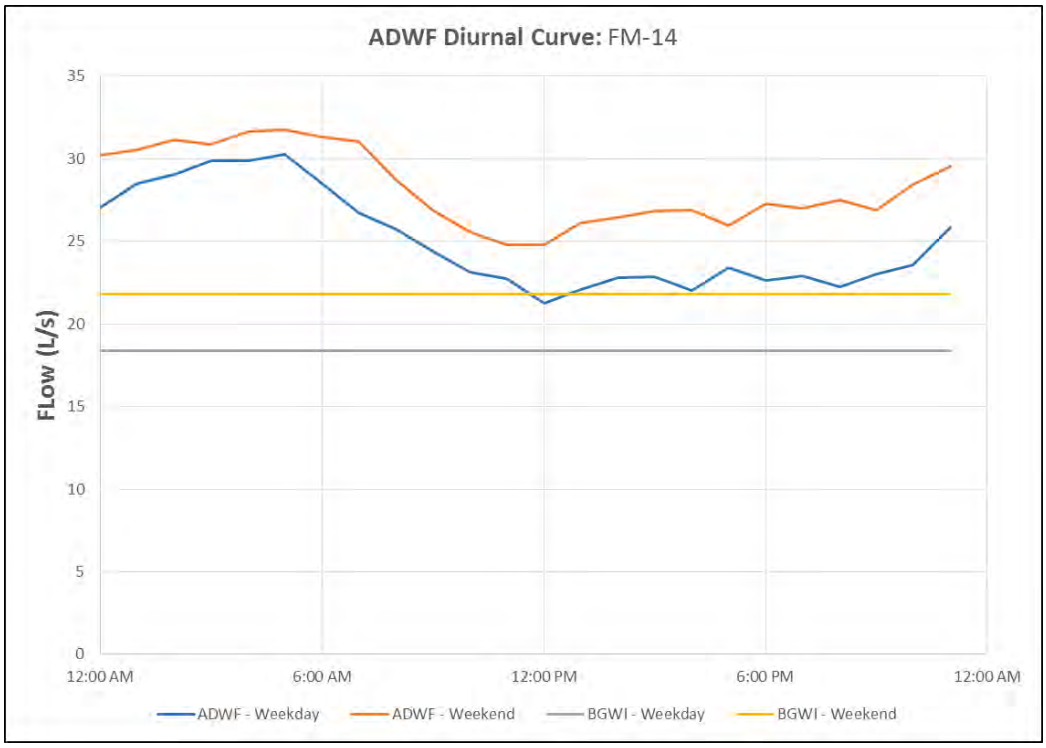

Critical Event 4: FM-13
Total Flow
Total ADWF
RDII
Precipitation
Flow (ls)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
0.5
1
1.5
2
2.5
3
3.5
4
11/20/2015 - 0:00
11/21/2015 - 0:00
11/22/2015 - 0:00
11/23/2015 - 0:00
11/24/2015 - 0:00
11/25/2015 - 0:00
11/26/2015 - 0:00
11/27/2015 - 0:00
11/28/2015 - 0:00
11/29/2015 - 0:00

FM-14

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
1.30	1.30
1.52	1.36
1.61	1.45
1.73	1.40
1.73	1.52
1.80	1.54
1.52	1.48
1.25	1.43
1.11	1.07
0.90	0.79
0.72	0.58
0.65	0.46
0.43	0.47
0.56	0.67
0.67	0.72
0.67	0.78
0.55	0.78
0.76	0.64
0.64	0.85
0.68	0.80
0.58	0.88
0.70	0.79
0.78	1.03
1.12	1.20

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	25.0	28.3	L/s
MNF	21.3	24.8	L/s
BGWI	18.4	21.8	L/s
Unit BGWI	0.25	0.29	L/s/ha
Sanitary Flow	6.6	6.5	L/s
Per Capita Sanitary Flow	137.9	134.6	L/cap/d
Peak DWF	30.3	31.7	L/s

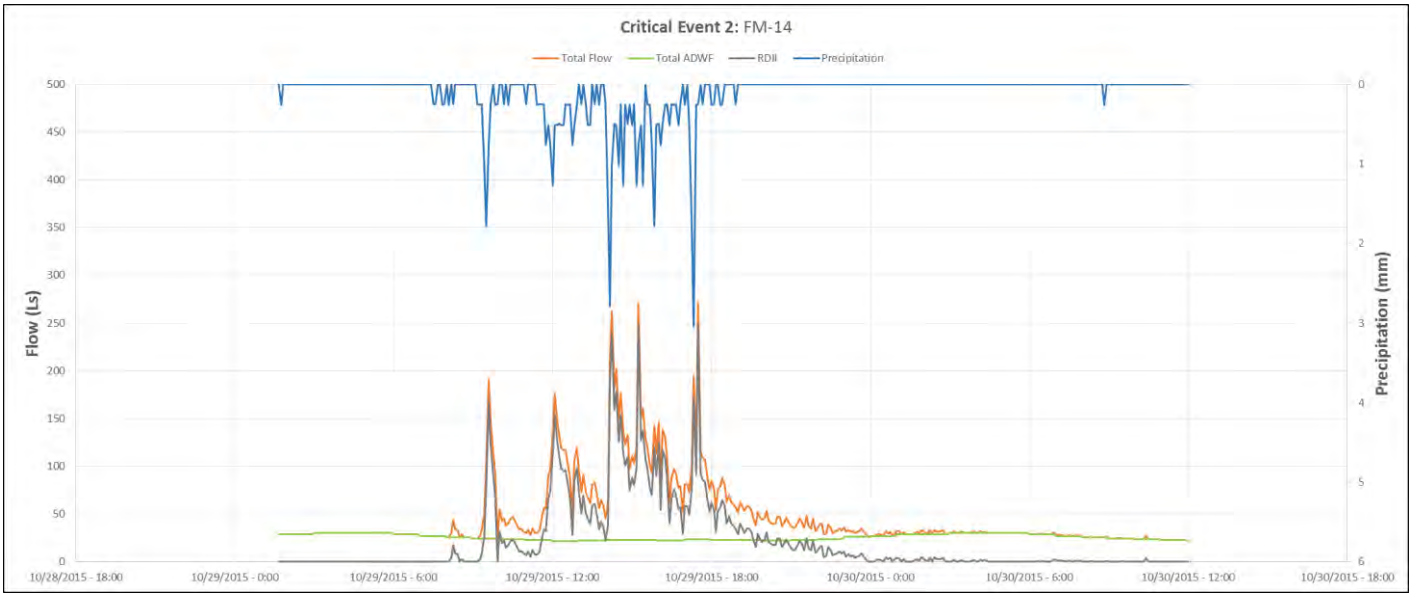
Quantification of RDII

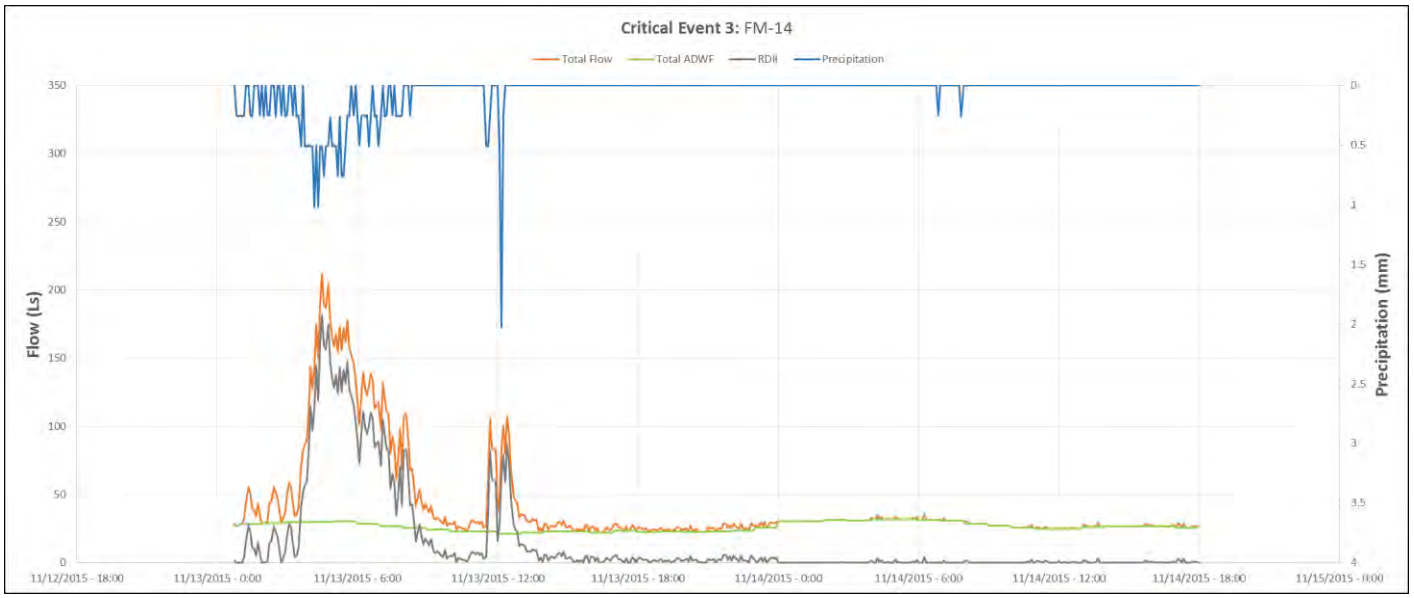
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE2	10/29/2015	10	49	248	2.8	8%	3.31
CE3	11/13/2015	7	29	182	2.3	11%	2.42
CE4	11/21/2015	13	93	271	10.9	16%	3.61

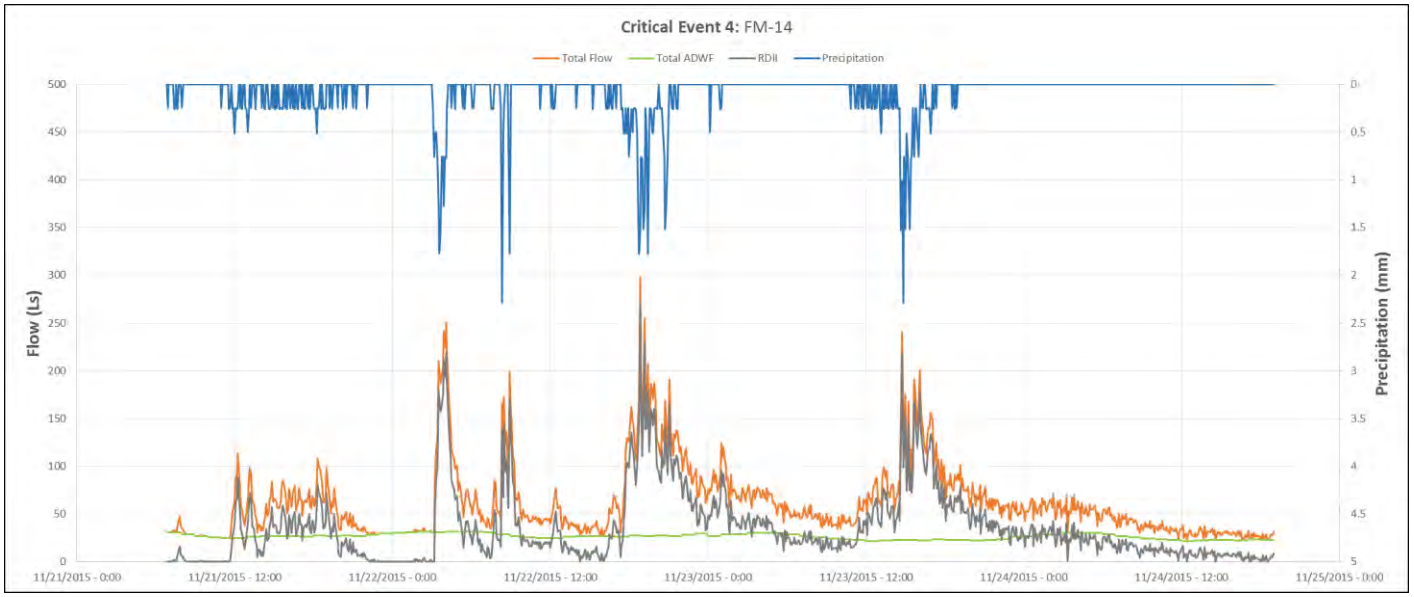
Estimated Peak Wet Weather Design Flows (L/s)

Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	71	527	648	729	831	907	983

Wet Weather Flow Graphs

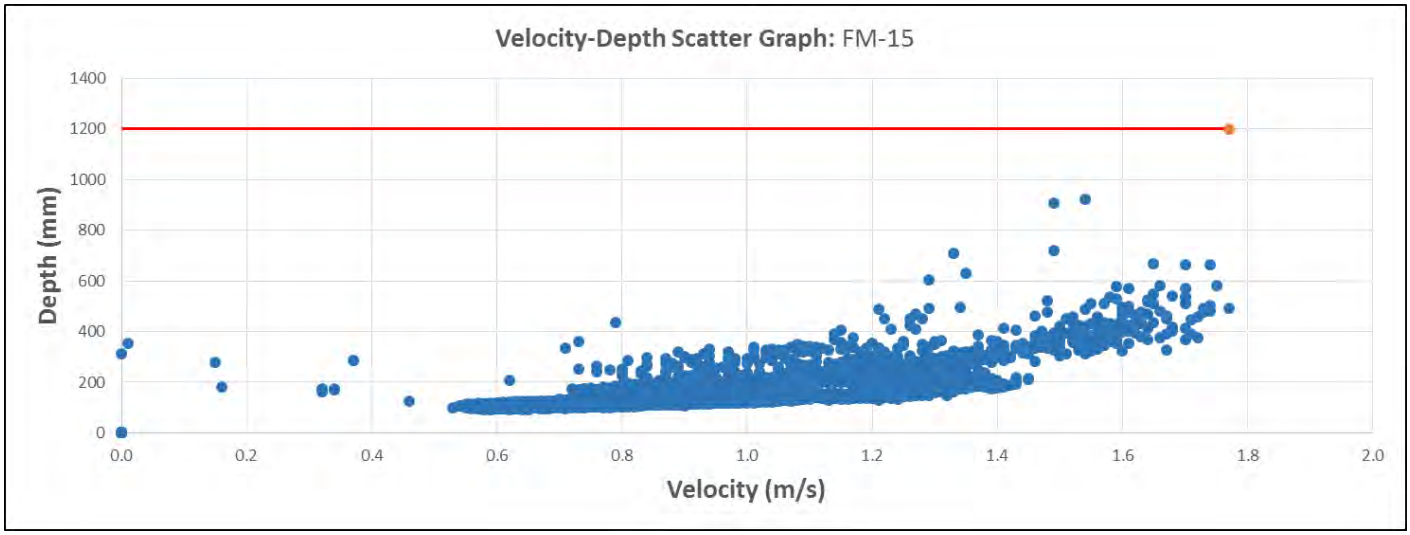



Critical Event 3: FM-14
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
350
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

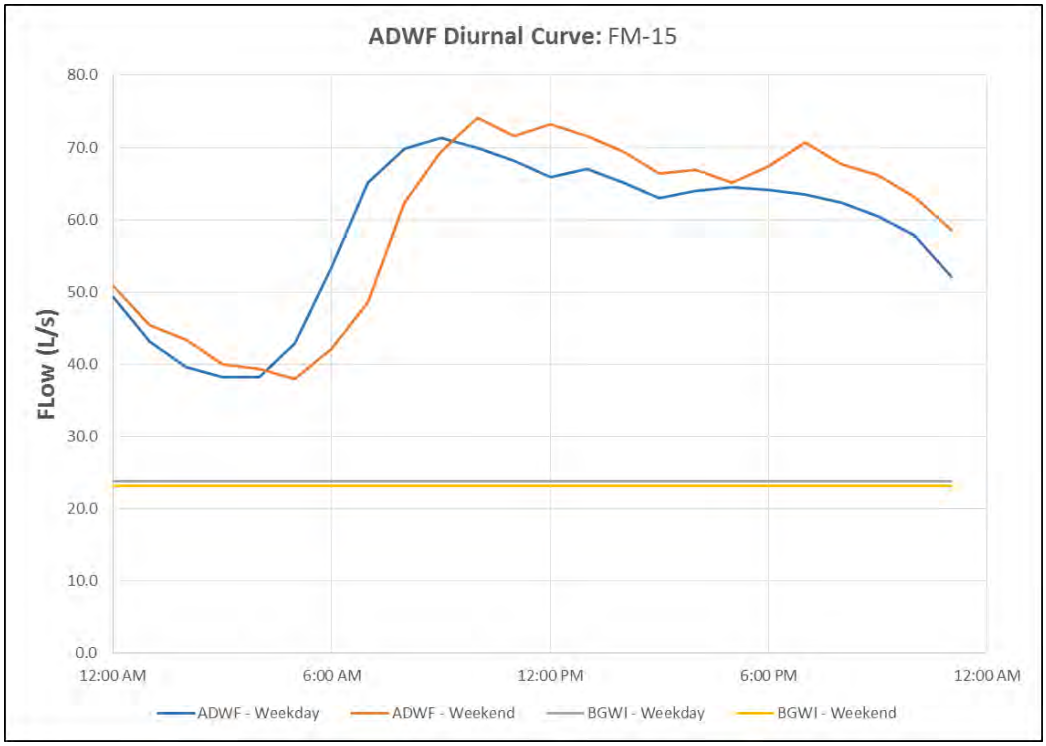

Critical Event 4: FM-14
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
500
450
400
350
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-15

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.74	0.76
0.56	0.61
0.46	0.56
0.42	0.46
0.42	0.44
0.56	0.41
0.86	0.52
1.20	0.70
1.33	1.07
1.38	1.27
1.34	1.40
1.28	1.33
1.22	1.37
1.25	1.33
1.20	1.27
1.14	1.18
1.17	1.20
1.18	1.15
1.17	1.21
1.15	1.30
1.12	1.22
1.06	1.18
0.98	1.10
0.82	0.97

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	58.3	59.6	L/s
MNF	38.2	38.0	L/s
BGWI	23.8	23.1	L/s
Unit BGWI	0.18	0.18	L/s/ha
Sanitary Flow	34.5	36.5	L/s
Per Capita Sanitary Flow	227.3	240.4	L/cap/d
Peak DWF	71.3	74.1	L/s

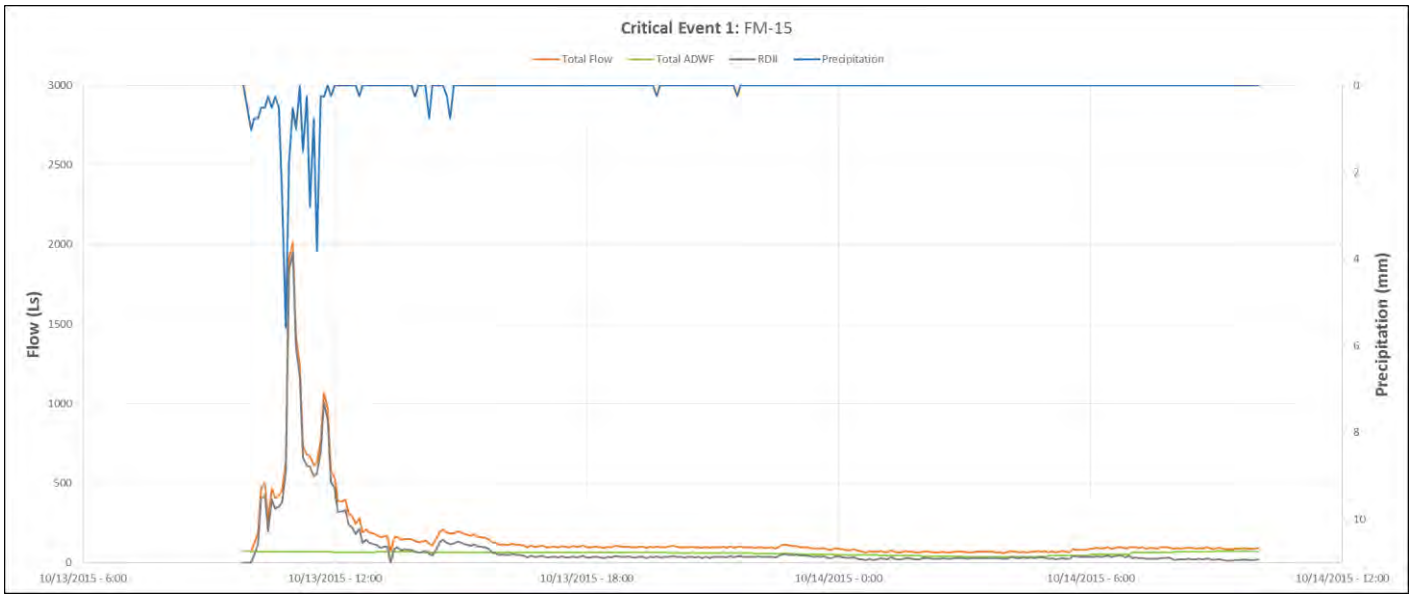
Quantification of RDII

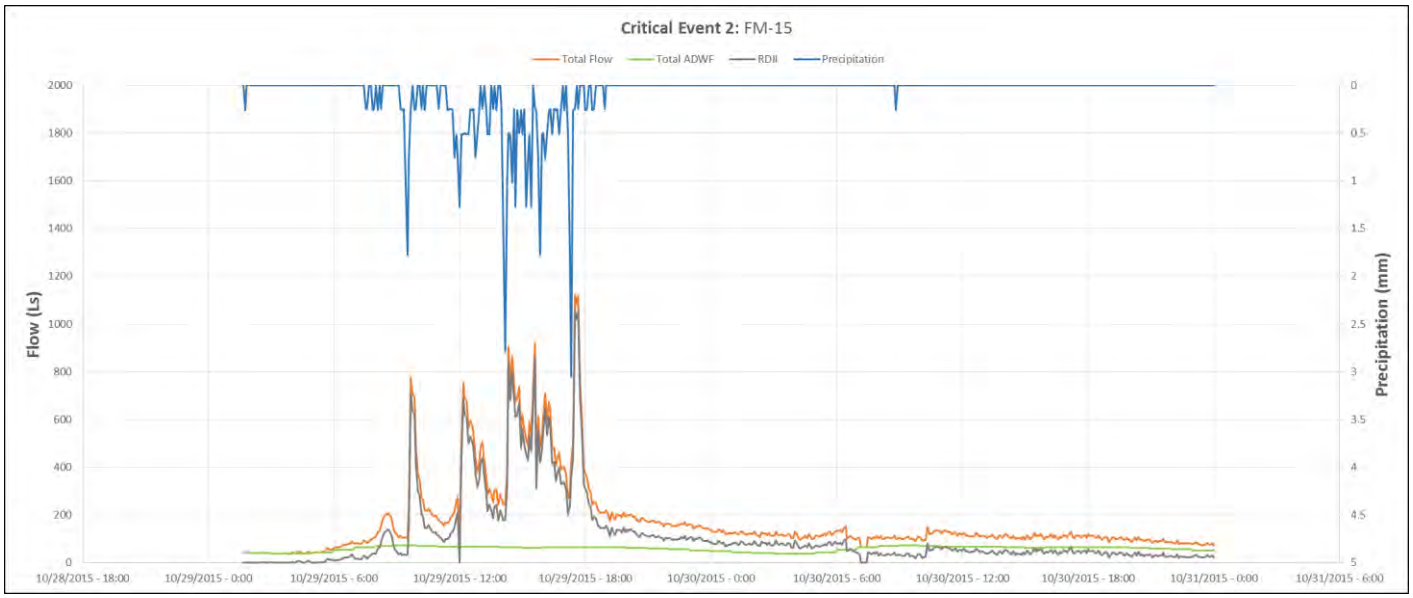
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	1948	8.6	23%	15.13
CE2	10/29/2015	10	49	1057	19.5	31%	8.21
CE3	11/13/2015	7	29	811	11.0	29%	6.29
CE4	11/21/2015	13	93	1414	65.0	54%	10.98

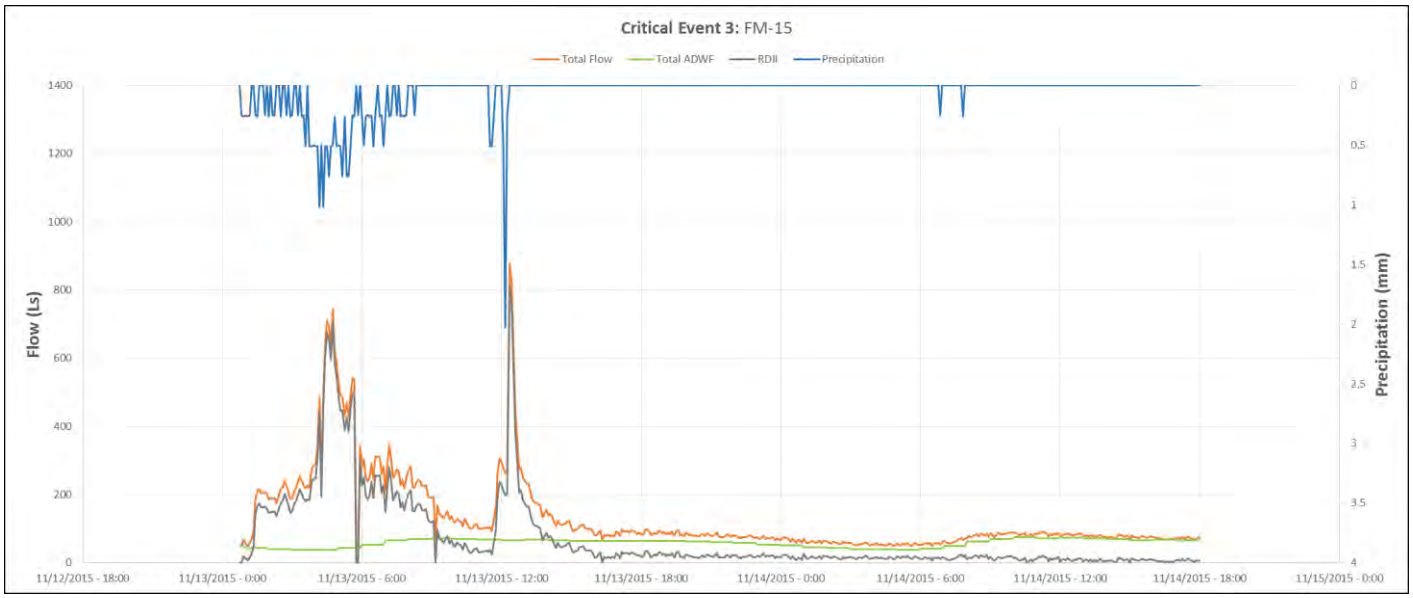
Estimated Peak Wet Weather Design Flows (L/s)

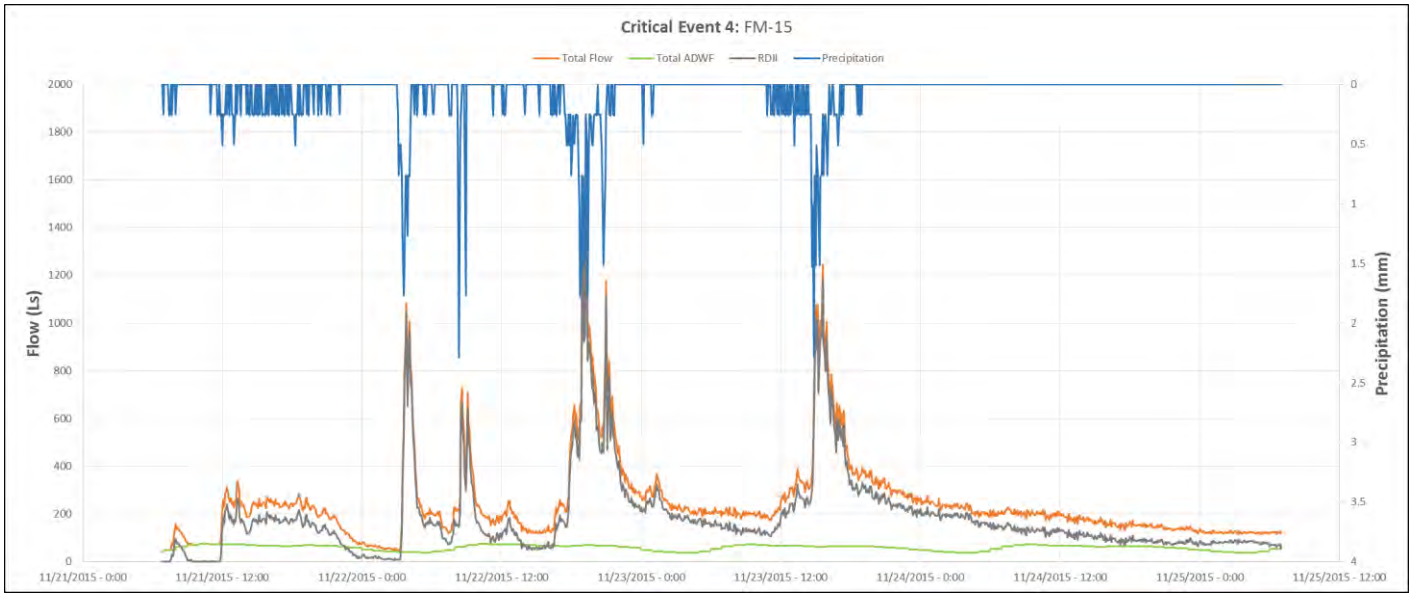
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	298	2018	2492	2809	3208	3505	3803

Wet Weather Flow Graphs



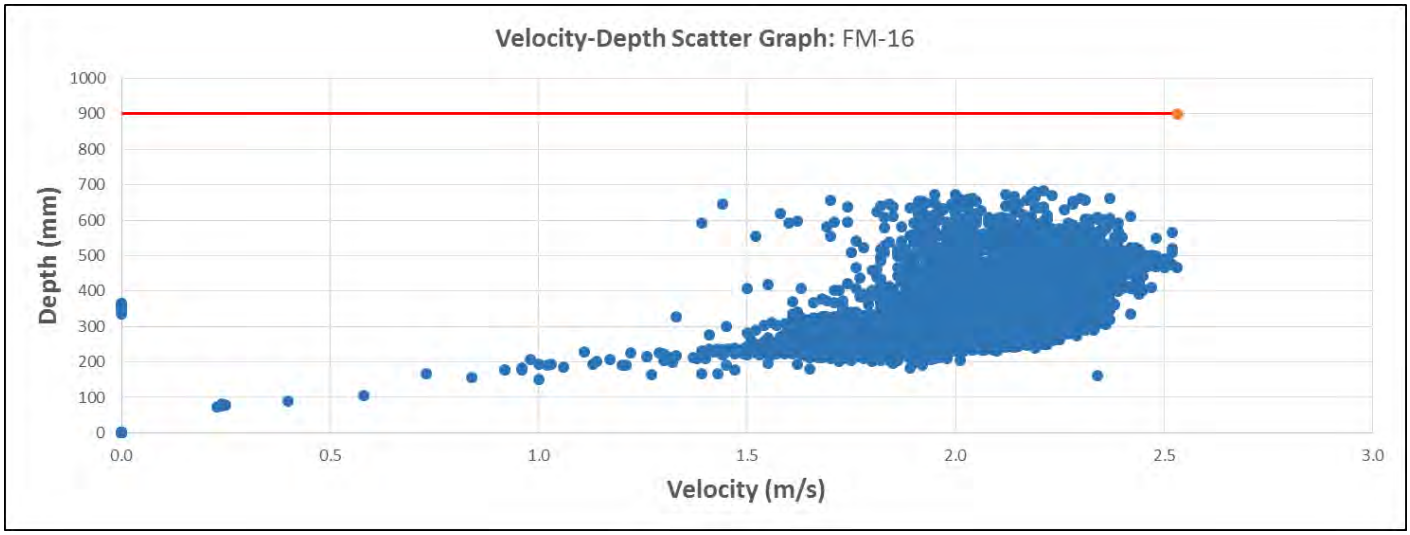



Critical Event 3: FM-15
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

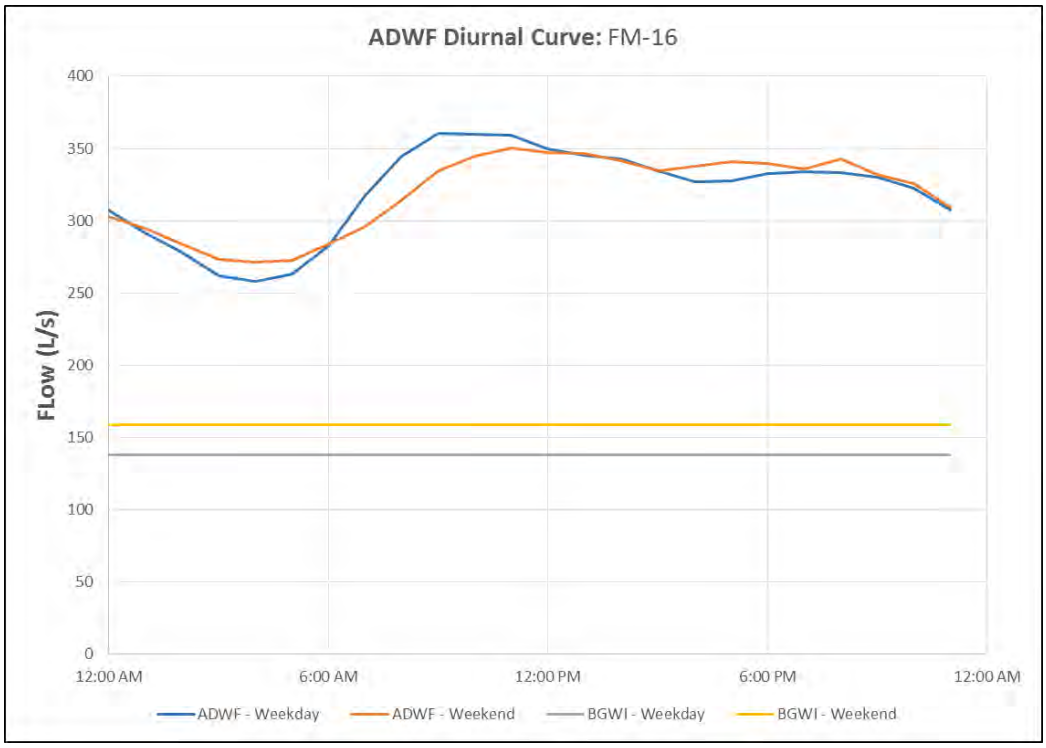

Critical Event 4: FM-15
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
0.5
1
1.5
2
2.5
3
3.5
4
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00

FM-16

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.93	0.90
0.84	0.85
0.77	0.78
0.68	0.71
0.66	0.70
0.69	0.71
0.80	0.78
0.99	0.86
1.14	0.97
1.22	1.10
1.22	1.16
1.22	1.19
1.16	1.18
1.14	1.17
1.13	1.14
1.08	1.10
1.04	1.12
1.04	1.14
1.07	1.13
1.08	1.10
1.08	1.15
1.06	1.08
1.02	1.04
0.93	0.94

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	319.6	319.0	L/s
MNF	257.9	271.7	L/s
BGWI	138.2	158.6	L/s
Unit BGWI	0.15	0.18	L/s/ha
Sanitary Flow	181.3	160.4	L/s
Per Capita Sanitary Flow	194.0	171.7	L/cap/d
Peak DWF	360.1	350.2	L/s

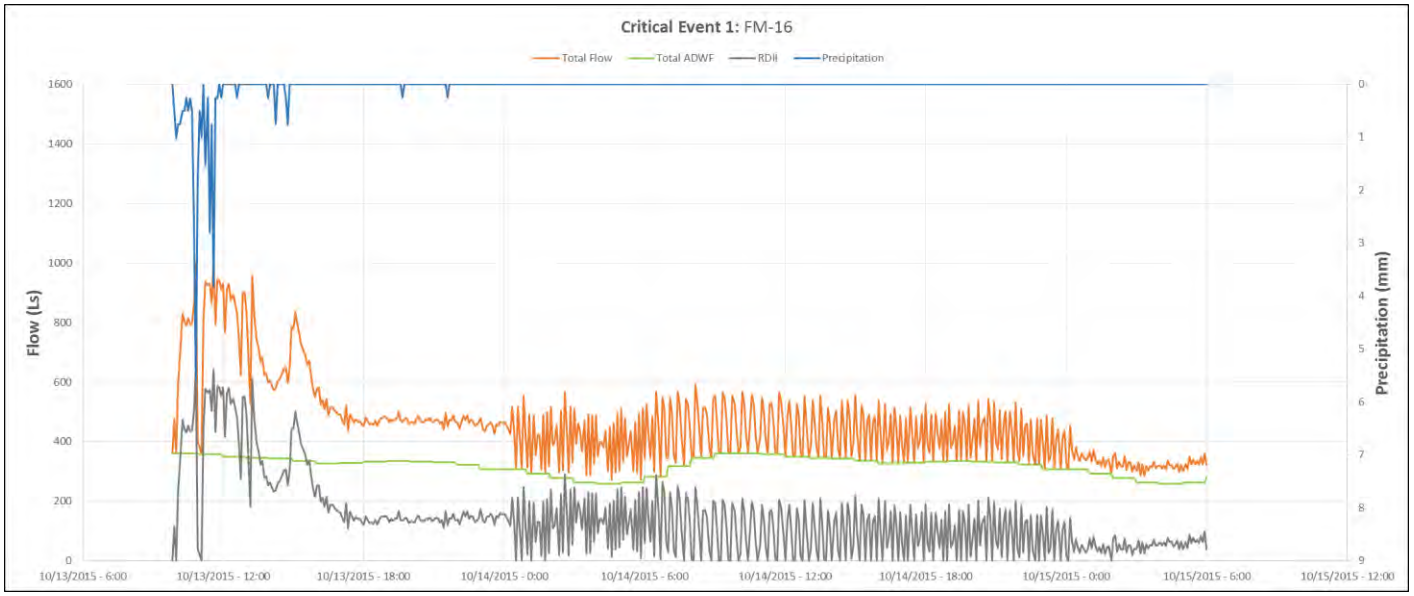
Quantification of RDII

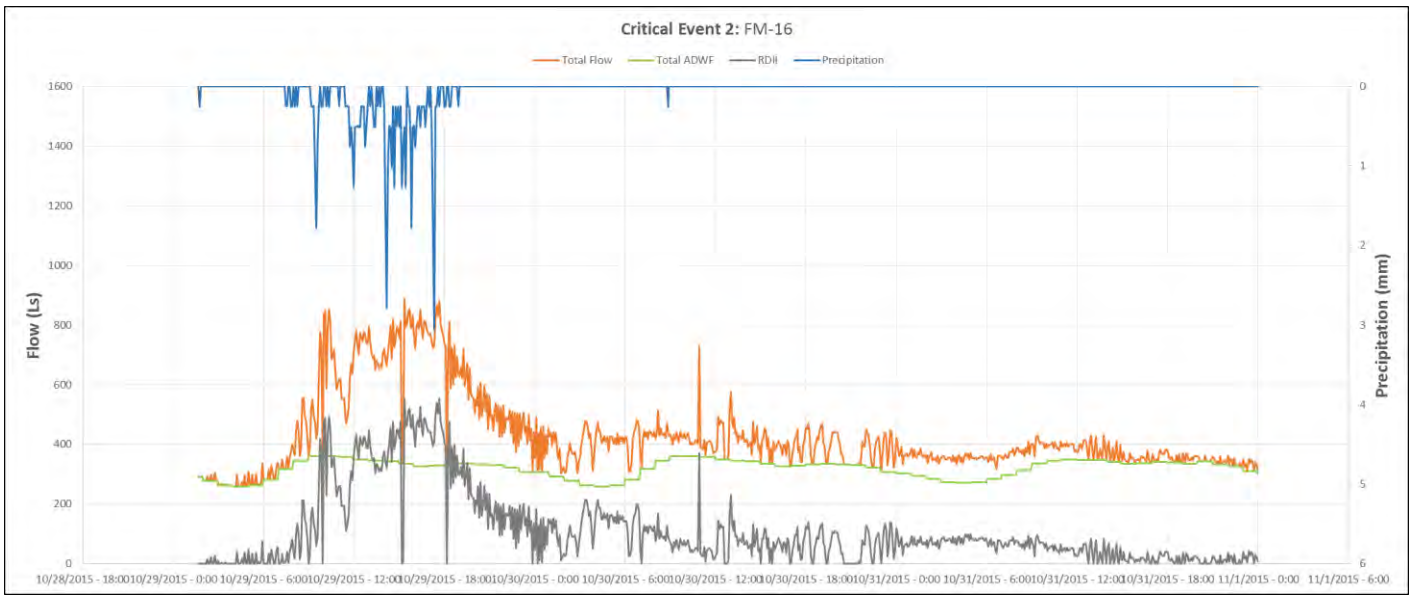
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	644	23.0	9%	0.72
CE2	10/29/2015	10	49	553	27.8	6%	0.62
CE3	11/13/2015	7	29	838	32.7	12%	0.93
CE4	11/21/2015	13	94	859	197.5	23%	0.96

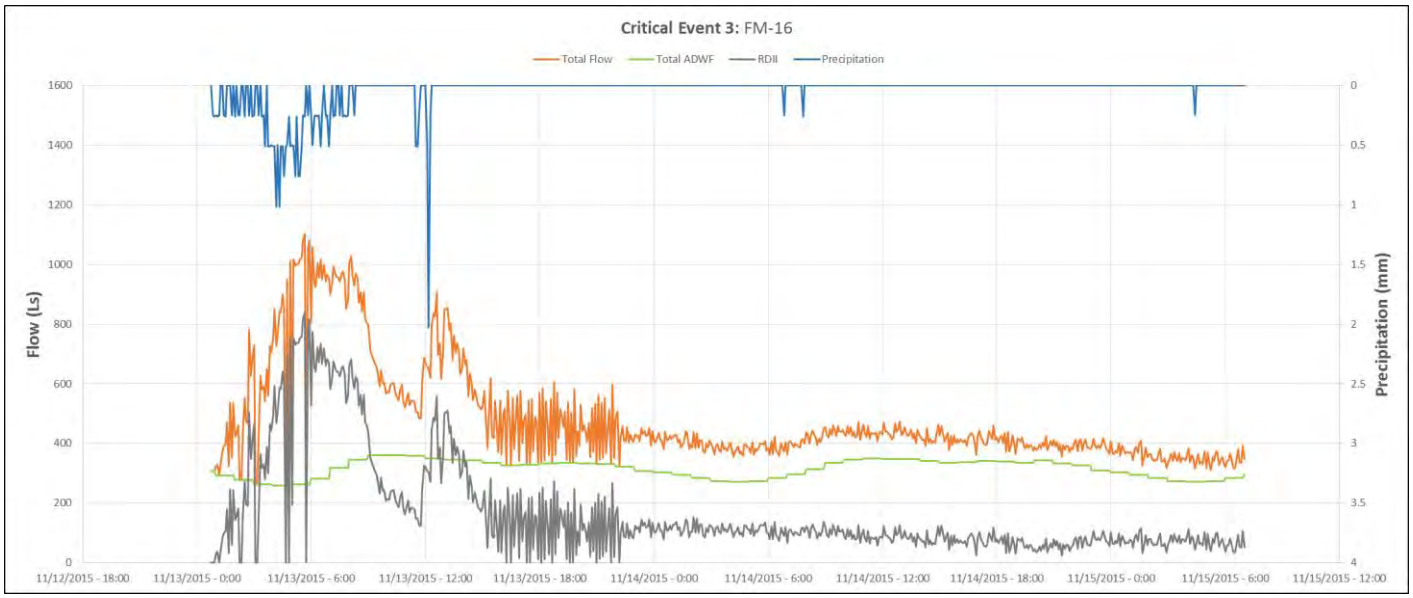
Estimated Peak Wet Weather Design Flows (L/s)

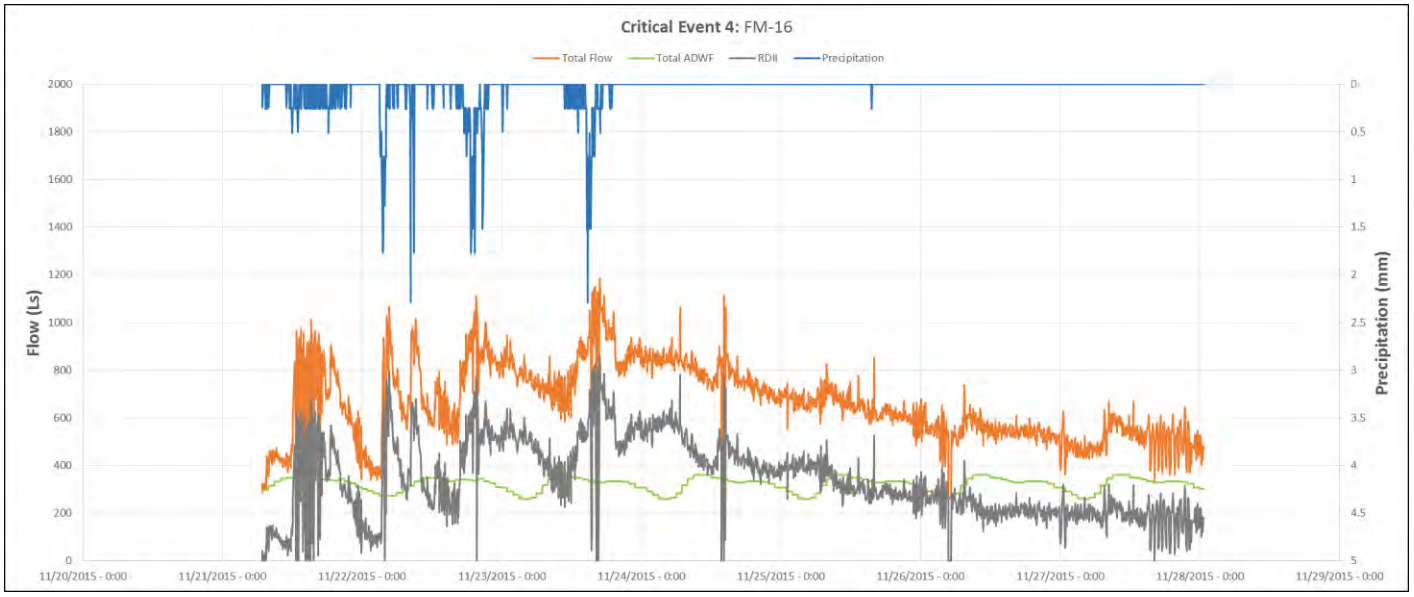
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	1518	1715	2064	2316	2639	2872	3105

Wet Weather Flow Graphs



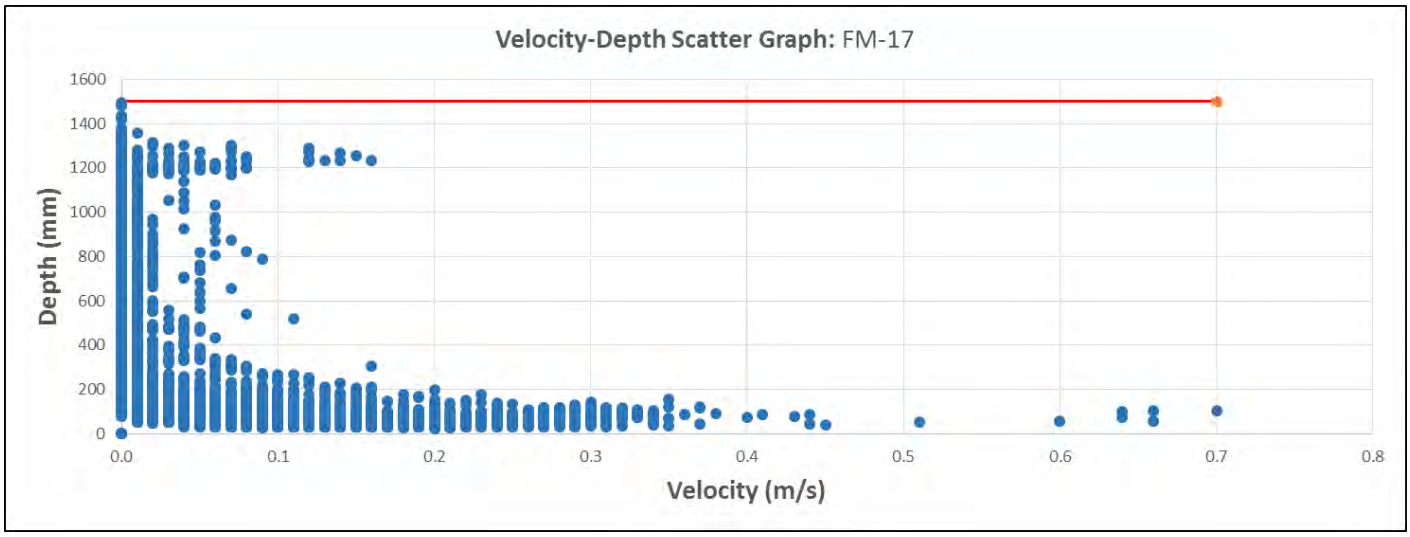



Critical Event 3: FM-16
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00
11/15/2015 - 12:00

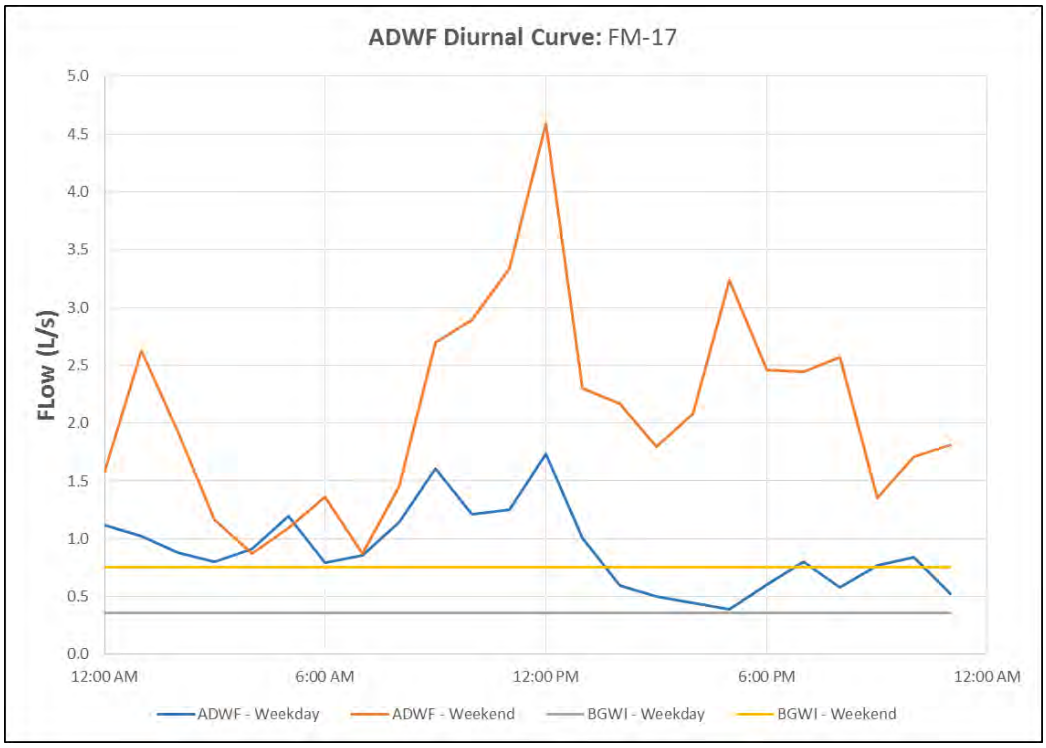

Critical Event 4: FM-16
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/20/2015 - 0:00
11/21/2015 - 0:00
11/22/2015 - 0:00
11/23/2015 - 0:00
11/24/2015 - 0:00
11/25/2015 - 0:00
11/26/2015 - 0:00
11/27/2015 - 0:00
11/28/2015 - 0:00
11/29/2015 - 0:00

FM-17

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
1.40	0.62
1.23	1.39
0.97	0.87
0.82	0.30
1.03	0.09
1.56	0.25
0.80	0.45
0.92	0.08
1.45	0.52
2.32	1.45
1.57	1.59
1.65	1.92
2.54	2.85
1.20	1.15
0.43	1.05
0.26	0.77
0.16	0.99
0.05	1.84
0.45	1.27
0.82	1.26
0.41	1.35
0.75	0.44
0.89	0.71
0.30	0.78

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	0.9	2.1	L/s
MNF	0.4	0.9	L/s
BGWI	0.4	0.8	L/s
Unit BGWI	0.02	0.03	L/s/ha
Sanitary Flow	0.5	1.3	L/s
Per Capita Sanitary Flow	141.1	351.8	L/cap/d
Peak DWF	1.7	4.6	L/s

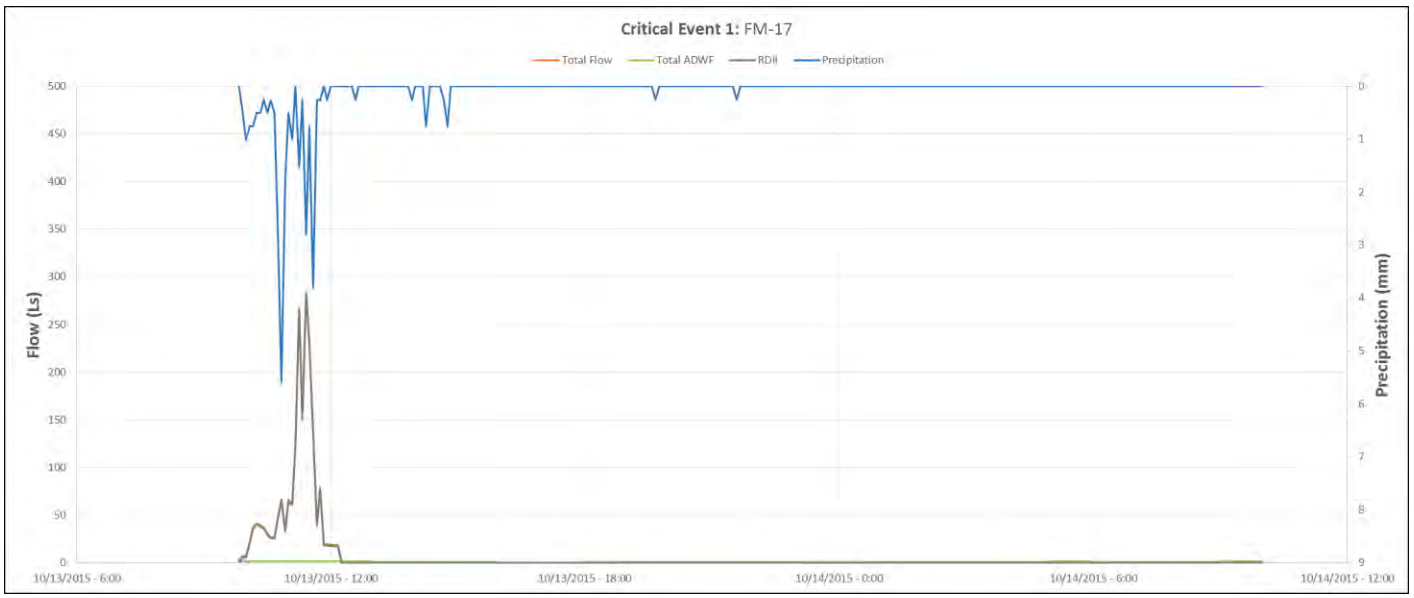
Quantification of RDII

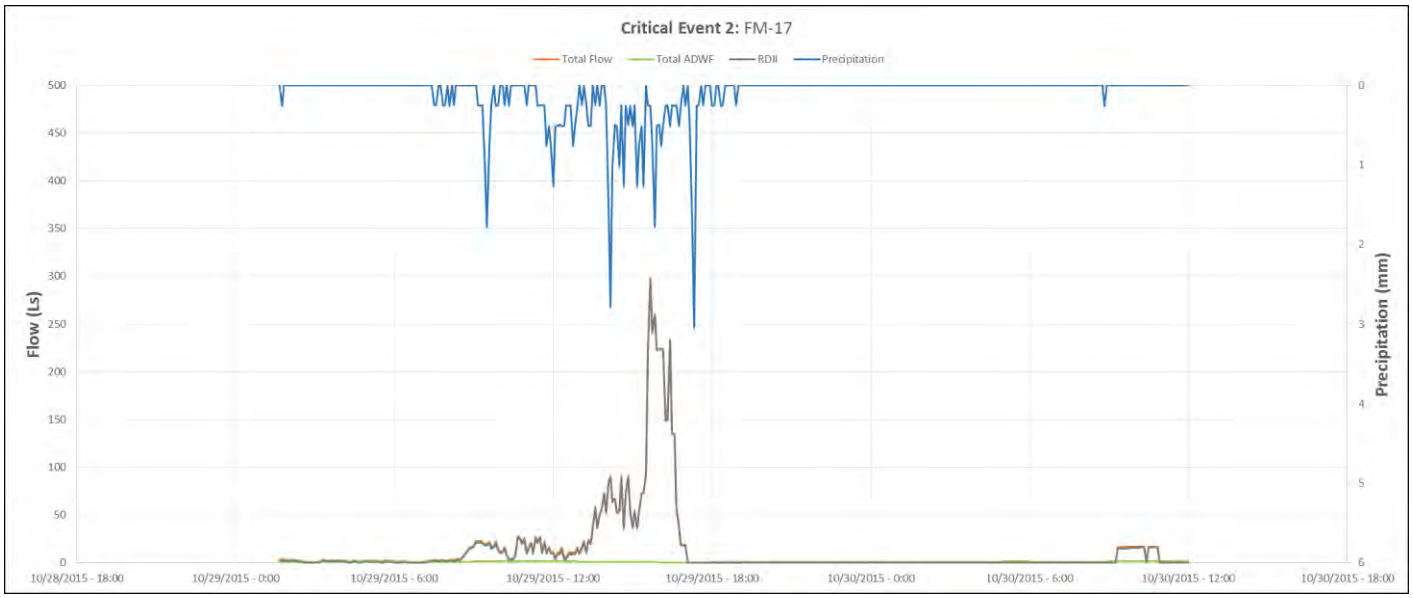
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	283	0.6	9%	12.87
CE2	10/29/2015	10	49	297	1.7	15%	13.51
CE3	11/13/2015	7	29	143	1.3	21%	6.51
CE4	11/21/2015	13	93	129	0.7	3%	5.87

Estimated Peak Wet Weather Design Flows (L/s)

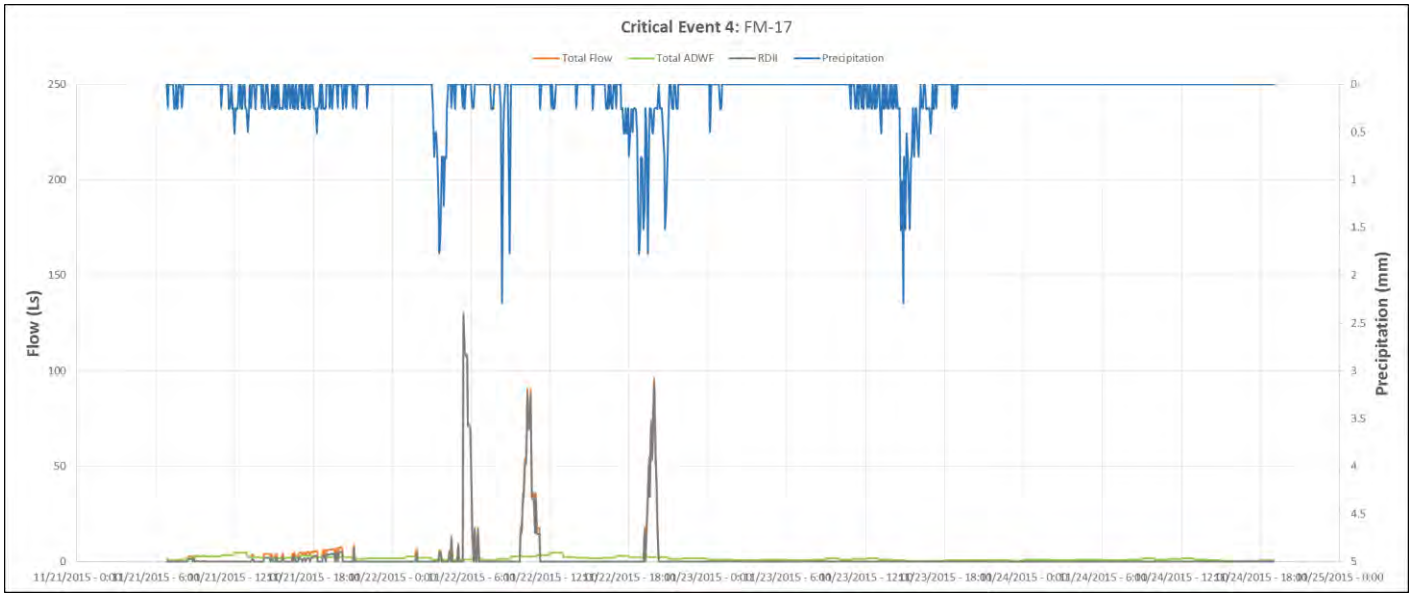
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	11	217	277	317	368	405	442

Wet Weather Flow Graphs



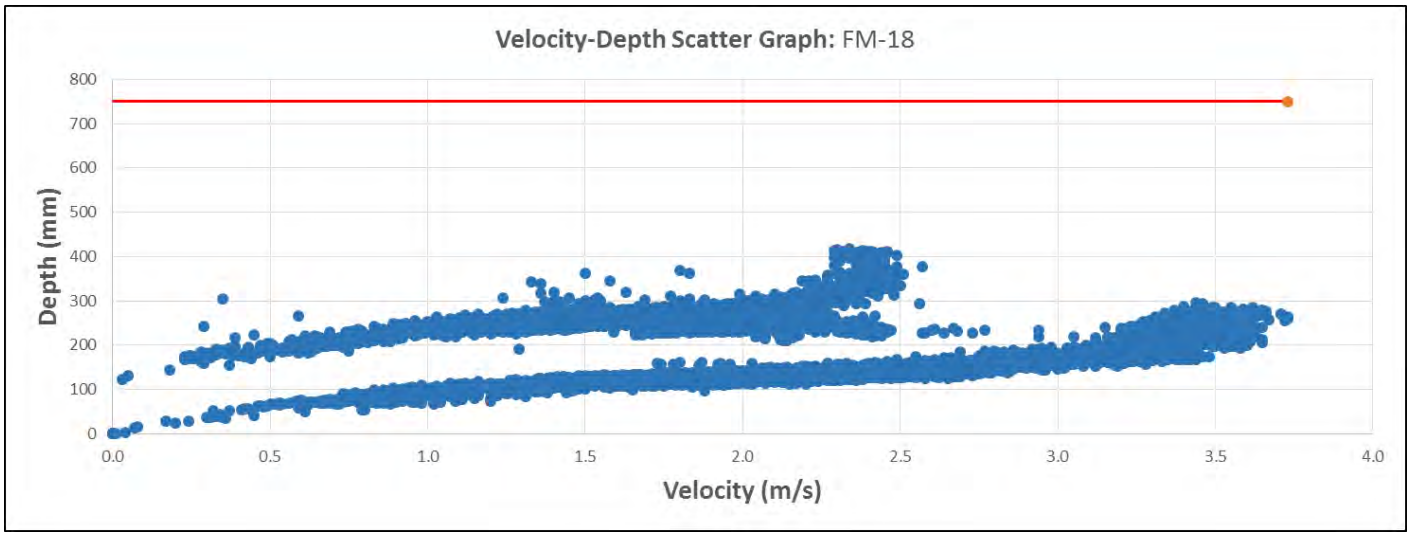



Critical Event 3: FM-17
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

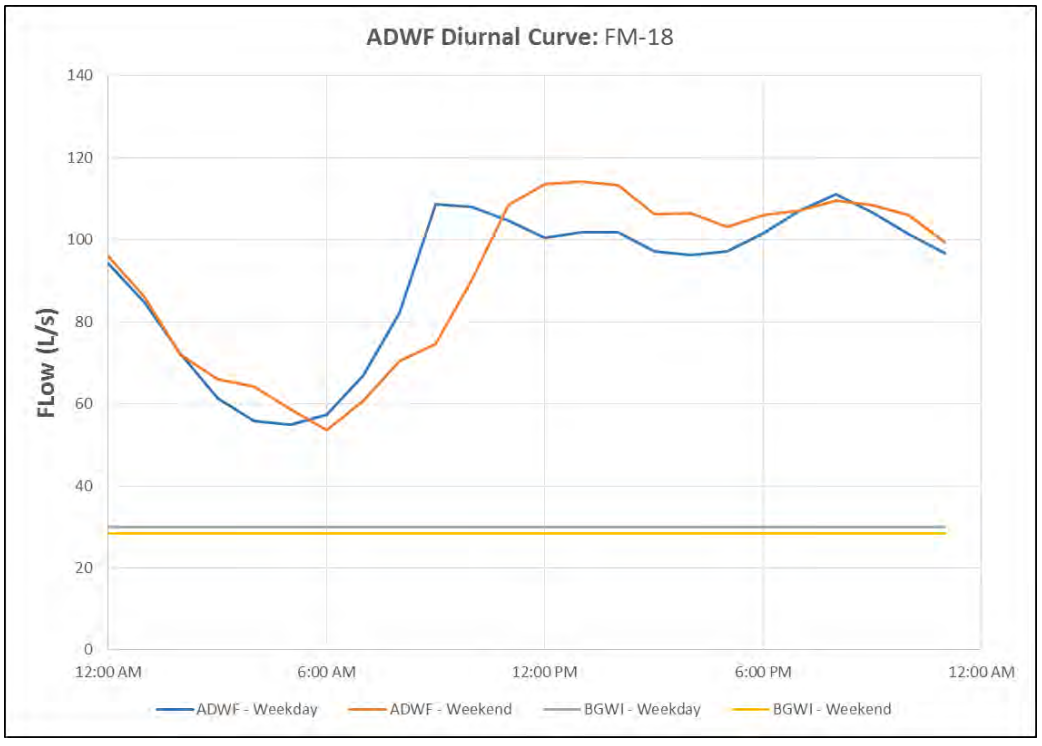

Critical Event 4: FM-17
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 6:00
11/21/2015 - 12:00
11/21/2015 - 18:00
11/22/2015 - 0:00
11/22/2015 - 6:00
11/22/2015 - 12:00
11/22/2015 - 18:00
11/23/2015 - 0:00
11/23/2015 - 6:00
11/23/2015 - 12:00
11/23/2015 - 18:00
11/24/2015 - 0:00
11/24/2015 - 6:00
11/24/2015 - 12:00
11/24/2015 - 18:00
11/25/2015 - 0:00

FM-18

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
1.06	1.07
0.91	0.92
0.70	0.69
0.52	0.60
0.43	0.57
0.42	0.48
0.45	0.40
0.61	0.51
0.86	0.66
1.30	0.73
1.29	0.98
1.23	1.27
1.16	1.35
1.19	1.36
1.19	1.35
1.11	1.24
1.10	1.24
1.11	1.19
1.19	1.23
1.28	1.25
1.34	1.29
1.27	1.27
1.18	1.23
1.10	1.13

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	90.4	91.5	L/s
MNF	55.0	53.7	L/s
BGWI	29.8	28.5	L/s
Unit BGWI	0.07	0.07	L/s/ha
Sanitary Flow	60.6	63.0	L/s
Per Capita Sanitary Flow	248.6	258.5	L/cap/d
Peak DWF	111.2	114.3	L/s

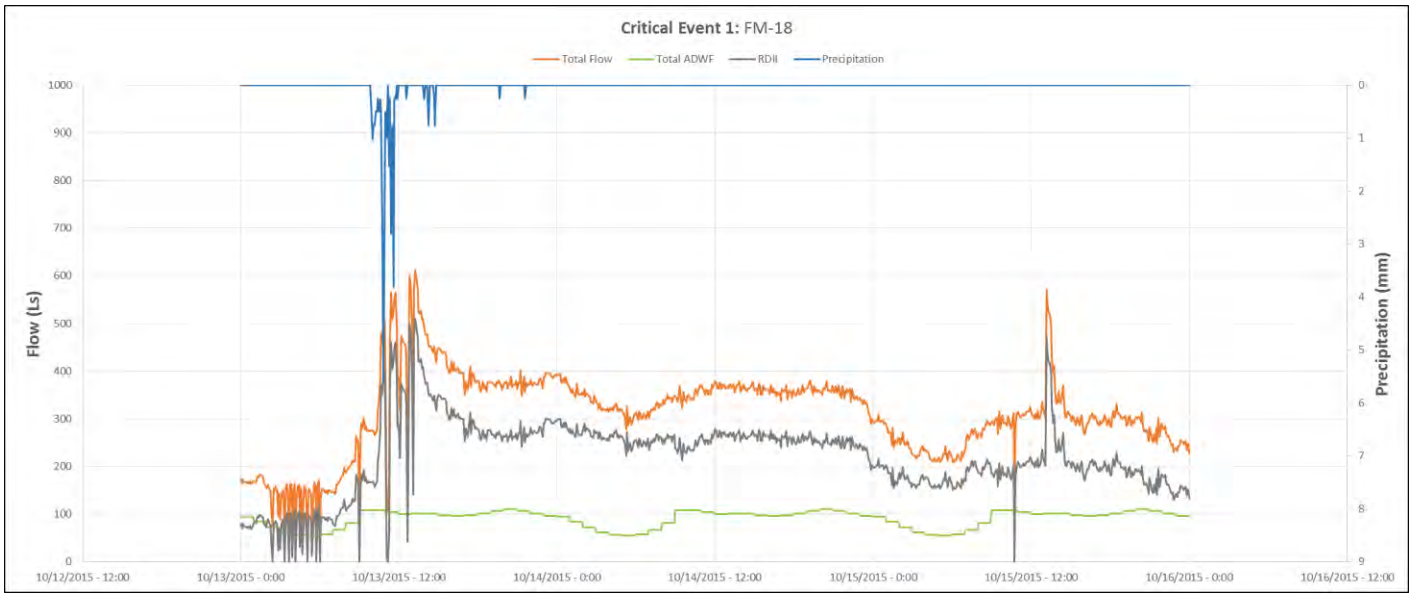
Quantification of RDII

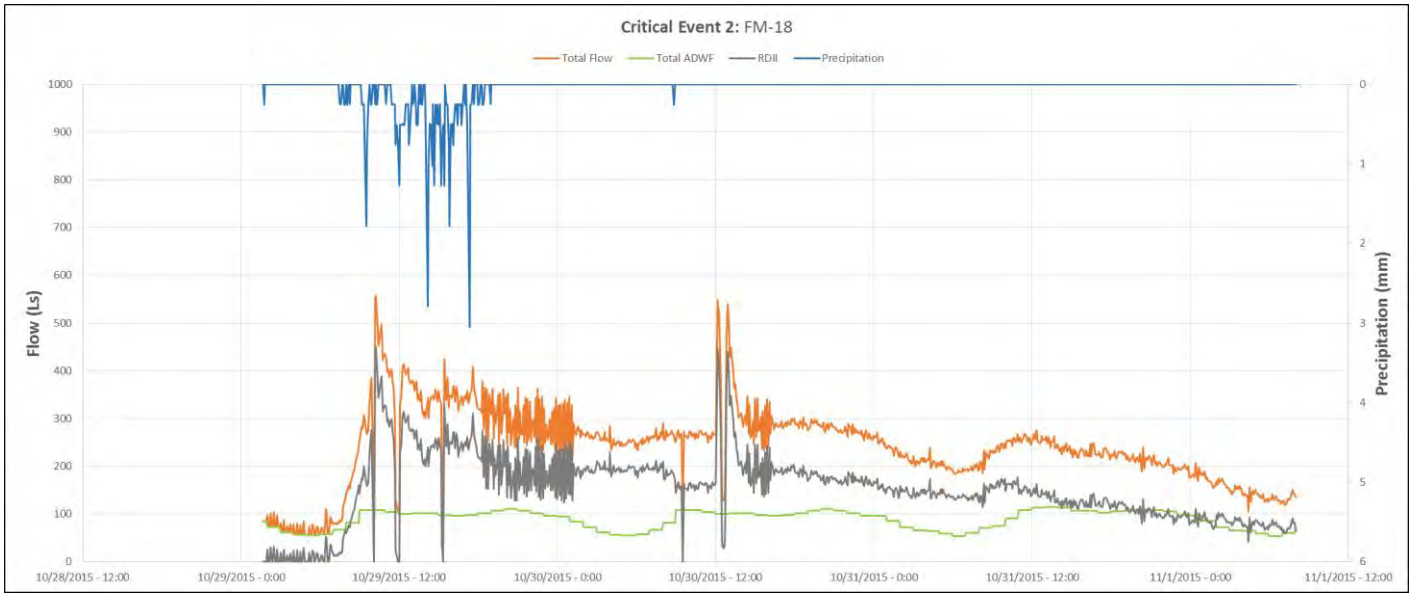
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	510	57.2	48%	1.27
CE2	10/29/2015	10	49	449	42.8	22%	1.12
CE3	11/13/2015	7	29	482	23.6	20%	1.20
CE4	11/21/2015	13	93	459	89.8	24%	1.14

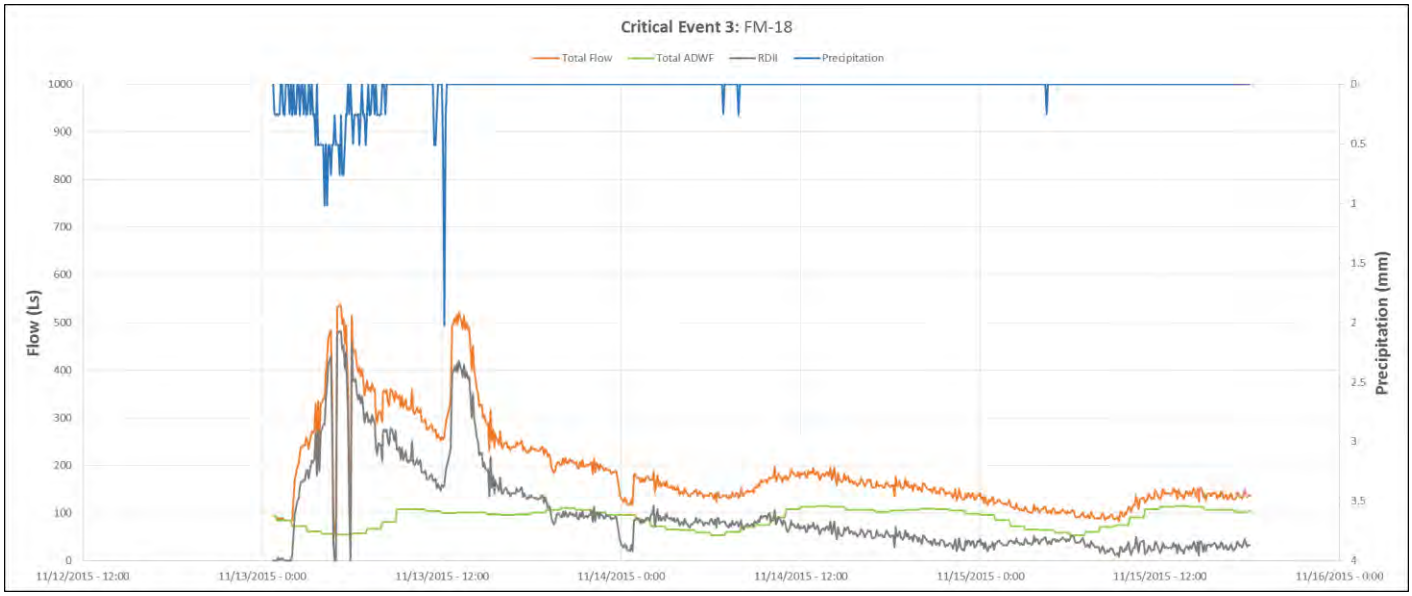
Estimated Peak Wet Weather Design Flows (L/s)

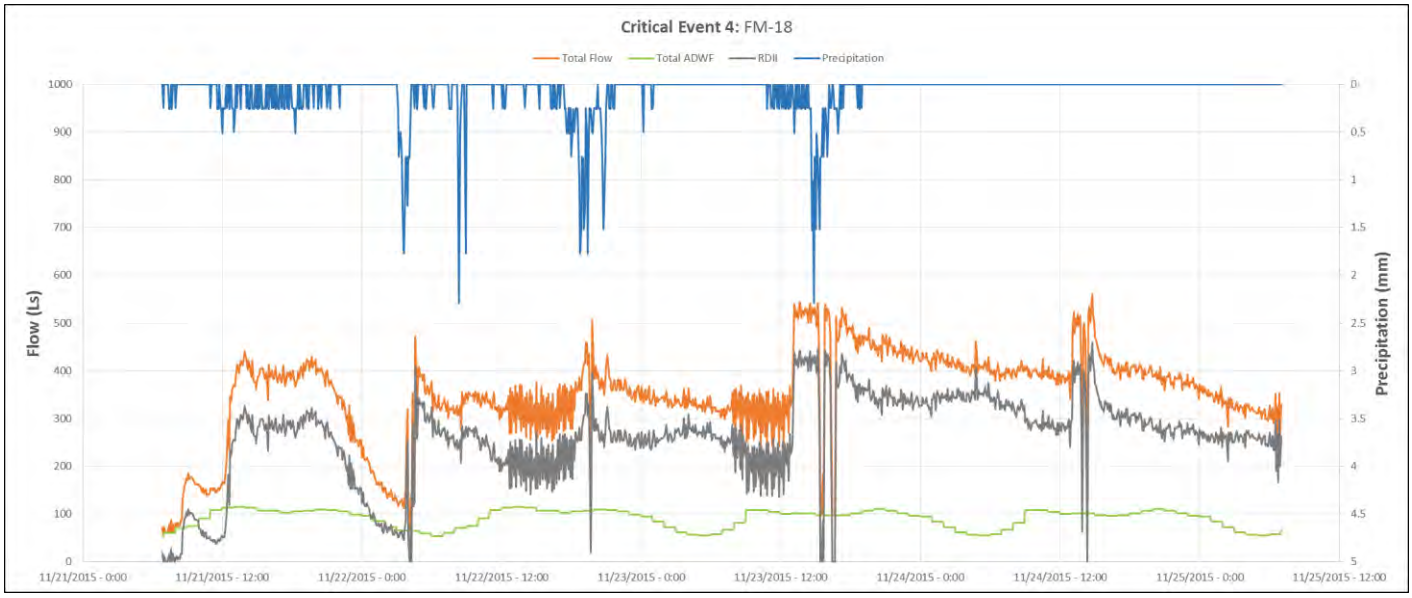
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	375	842	1019	1139	1288	1401	1517

Wet Weather Flow Graphs



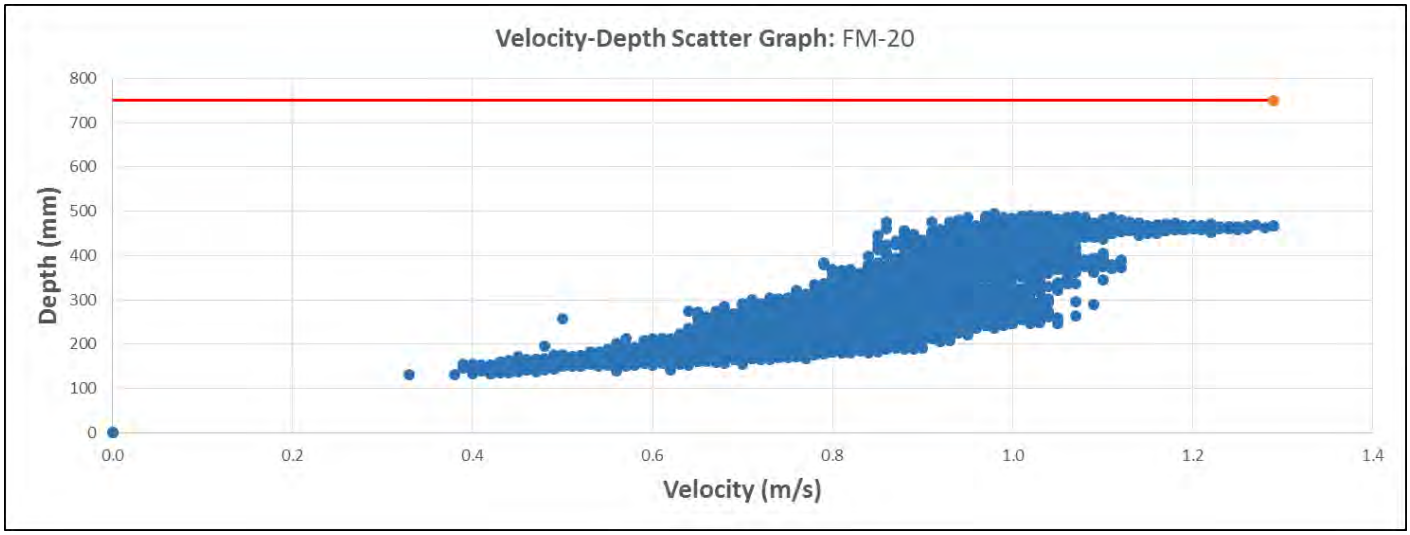



Critical Event 3: FM-18
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
11/12/2015 - 12:00
11/13/2015 - 0:00
11/13/2015 - 12:00
11/14/2015 - 0:00
11/14/2015 - 12:00
11/15/2015 - 0:00
11/15/2015 - 12:00
11/16/2015 - 0:00

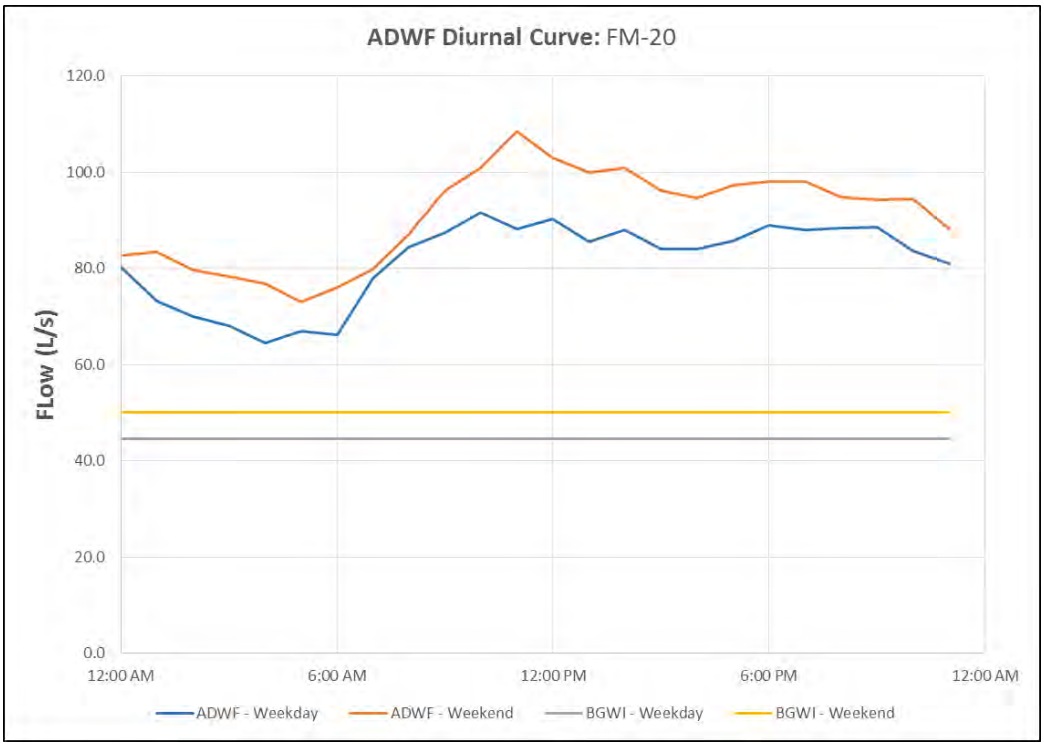

Critical Event 4: FM-18
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00

FM-20

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.97	0.80
0.78	0.82
0.69	0.72
0.64	0.69
0.54	0.66
0.61	0.56
0.59	0.63
0.90	0.73
1.08	0.91
1.16	1.13
1.28	1.25
1.18	1.43
1.24	1.29
1.11	1.22
1.18	1.25
1.07	1.13
1.07	1.09
1.12	1.15
1.20	1.17
1.18	1.18
1.19	1.09
1.19	1.08
1.06	1.09
0.99	0.93

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	81.5	90.9	L/s
MNF	64.6	73.1	L/s
BGWI	44.5	50.1	L/s
Unit BGWI	0.13	0.14	L/s/ha
Sanitary Flow	36.9	40.8	L/s
Per Capita Sanitary Flow	240.0	265.1	L/cap/d
Peak DWF	91.7	108.6	L/s

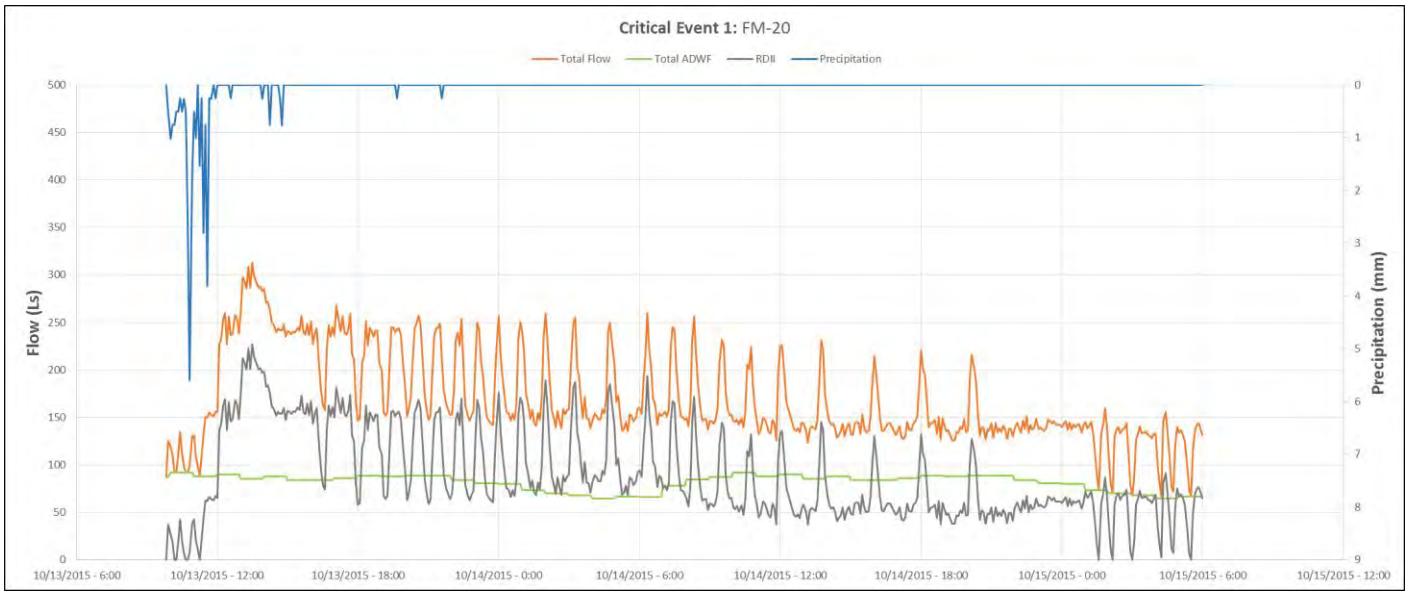
Quantification of RDII

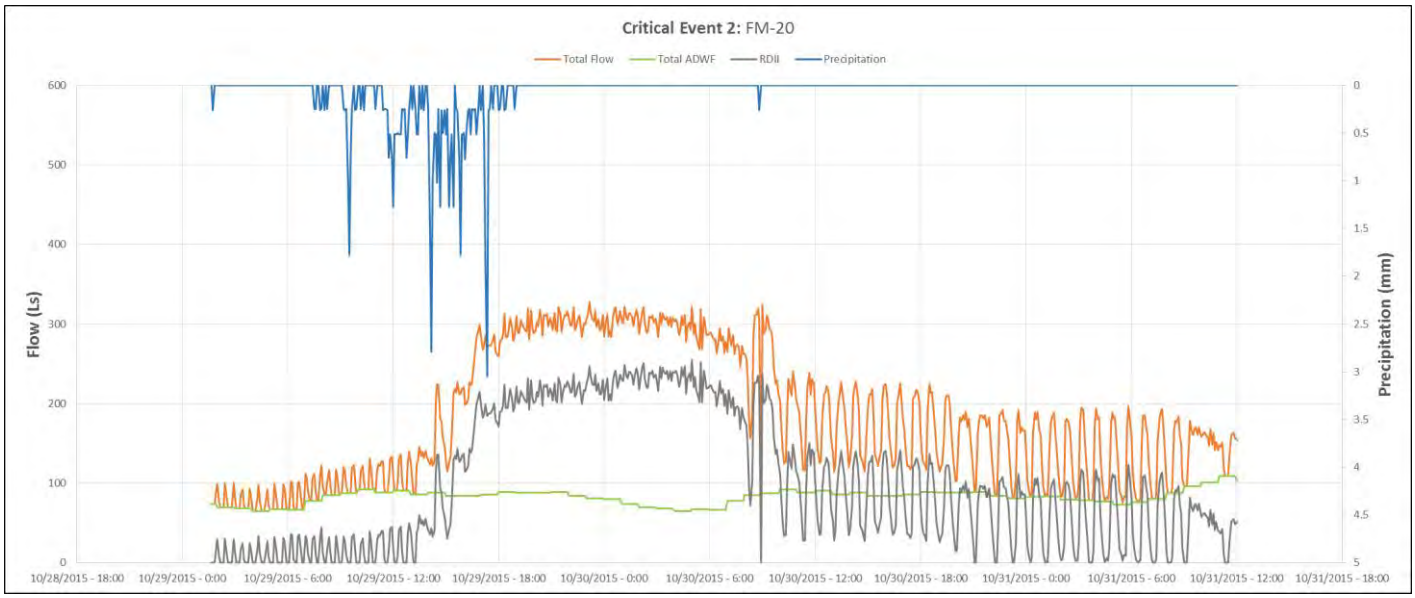
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	227	14.1	14%	0.66
CE2	10/29/2015	10	49	255	21.0	12%	0.74
CE3	11/13/2015	7	29	140	8.8	9%	0.41
CE4	11/21/2015	13	94	307	62.7	19%	0.89

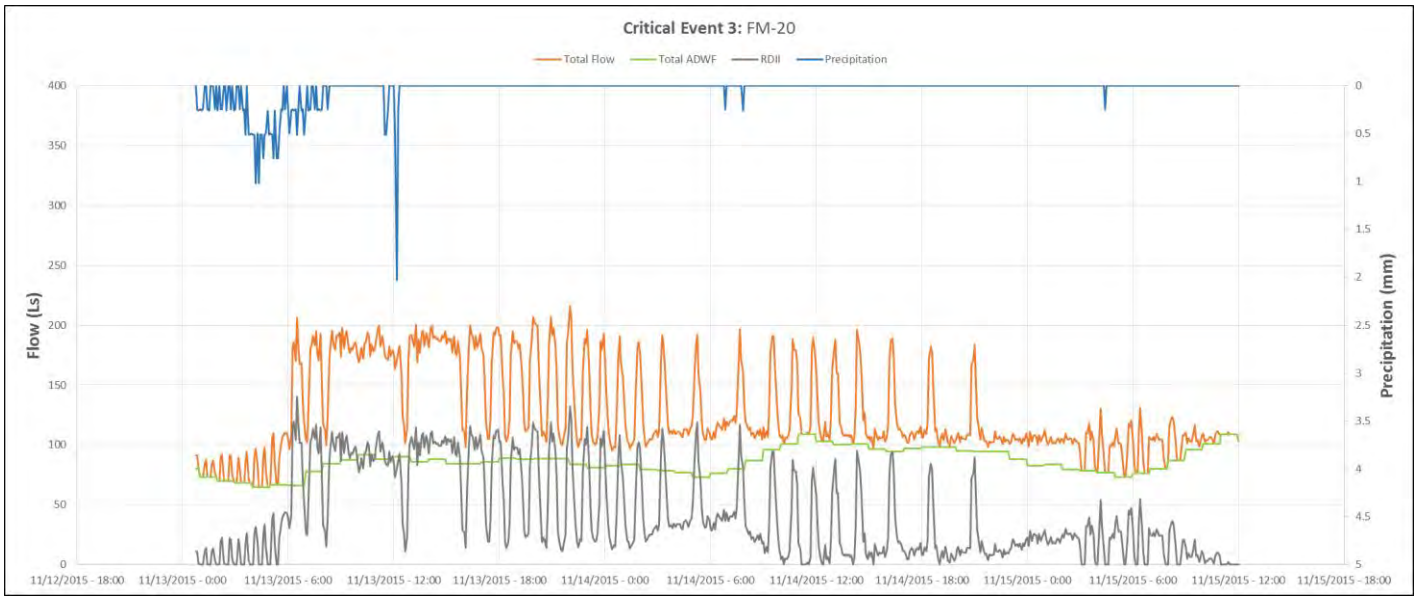
Estimated Peak Wet Weather Design Flows (L/s)

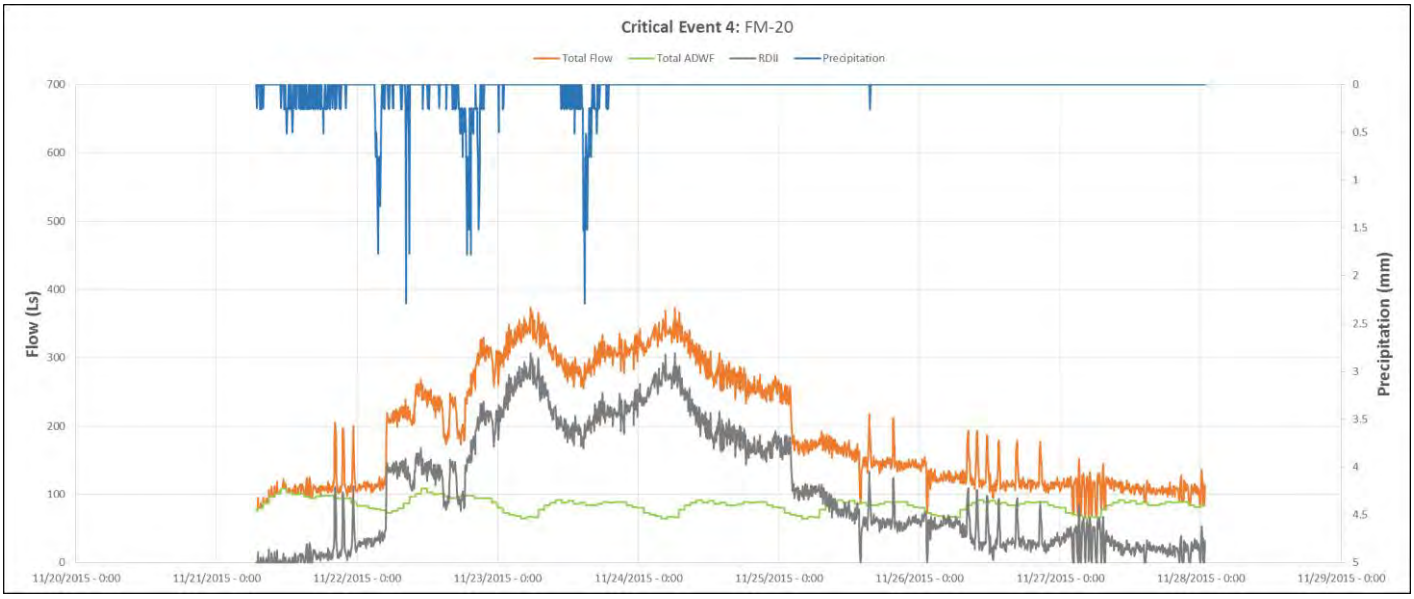
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	275	493	596	666	752	825	894

Wet Weather Flow Graphs



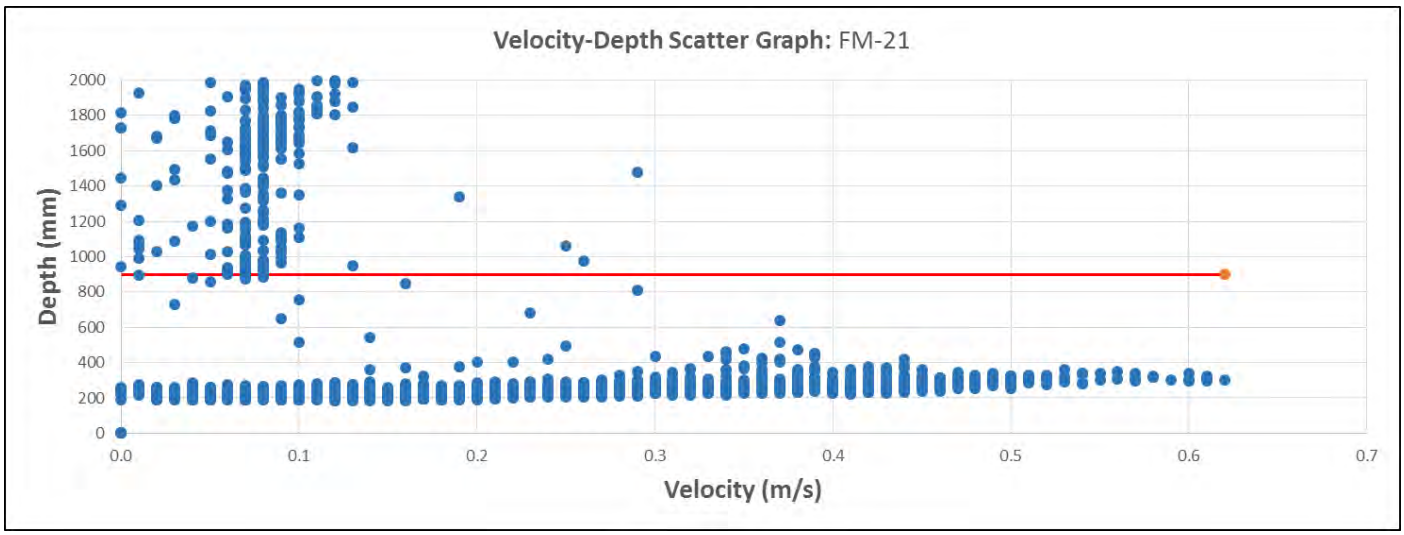



Critical Event 3: FM-20
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
50
100
150
200
250
300
350
400
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00
11/15/2015 - 12:00
11/15/2015 - 18:00

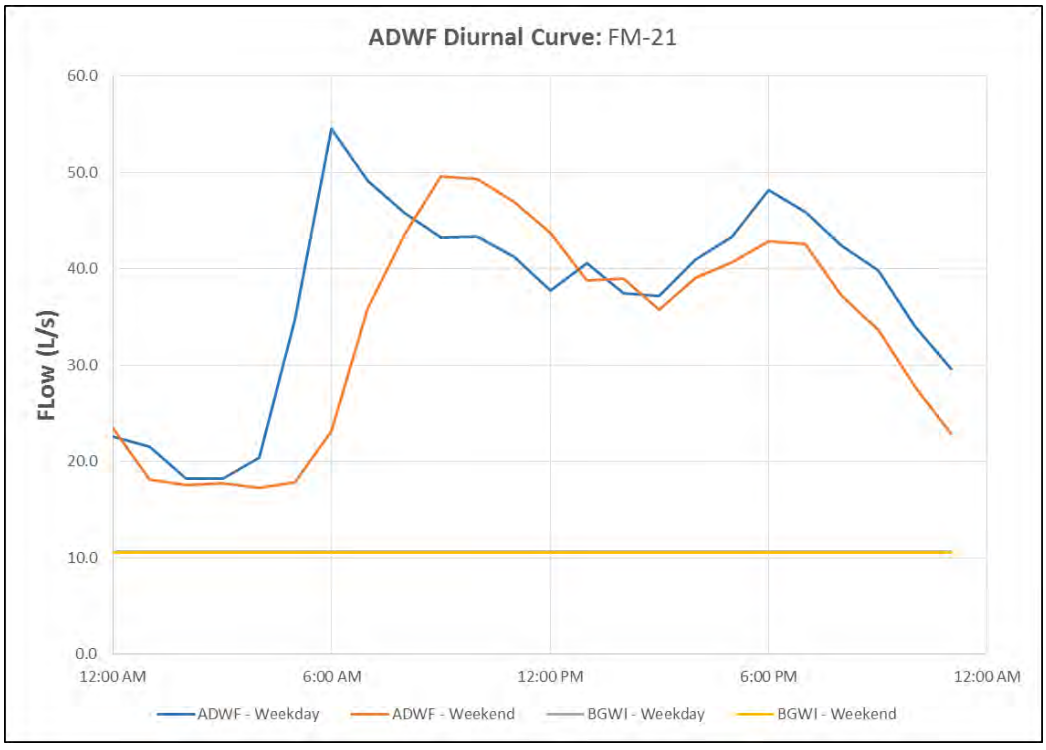

Critical Event 4: FM-20
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
100
200
300
400
500
600
700
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/20/2015 - 0:00
11/21/2015 - 0:00
11/22/2015 - 0:00
11/23/2015 - 0:00
11/24/2015 - 0:00
11/25/2015 - 0:00
11/26/2015 - 0:00
11/27/2015 - 0:00
11/28/2015 - 0:00
11/29/2015 - 0:00

FM-21

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.45	0.56
0.41	0.33
0.28	0.31
0.29	0.31
0.37	0.29
0.91	0.32
1.66	0.55
1.46	1.10
1.33	1.44
1.23	1.70
1.24	1.69
1.16	1.58
1.02	1.44
1.13	1.23
1.01	1.24
1.00	1.10
1.15	1.24
1.24	1.31
1.42	1.41
1.33	1.40
1.20	1.16
1.10	1.01
0.88	0.75
0.72	0.54

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	37.1	33.5	L/s
MNF	18.2	17.3	L/s
BGWI	10.7	10.6	L/s
Unit BGWI	0.02	0.02	L/s/ha
Sanitary Flow	26.4	22.9	L/s
Per Capita Sanitary Flow	129.6	112.6	L/cap/d
Peak DWF	54.5	49.6	L/s

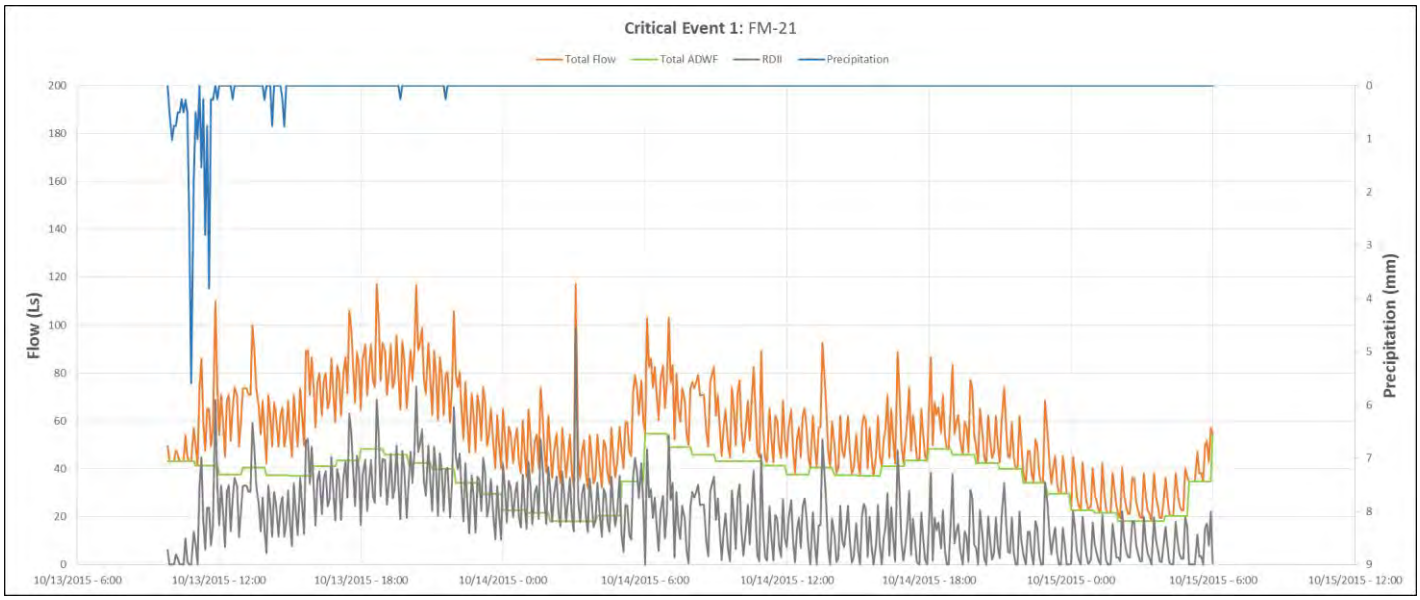
Quantification of RDII

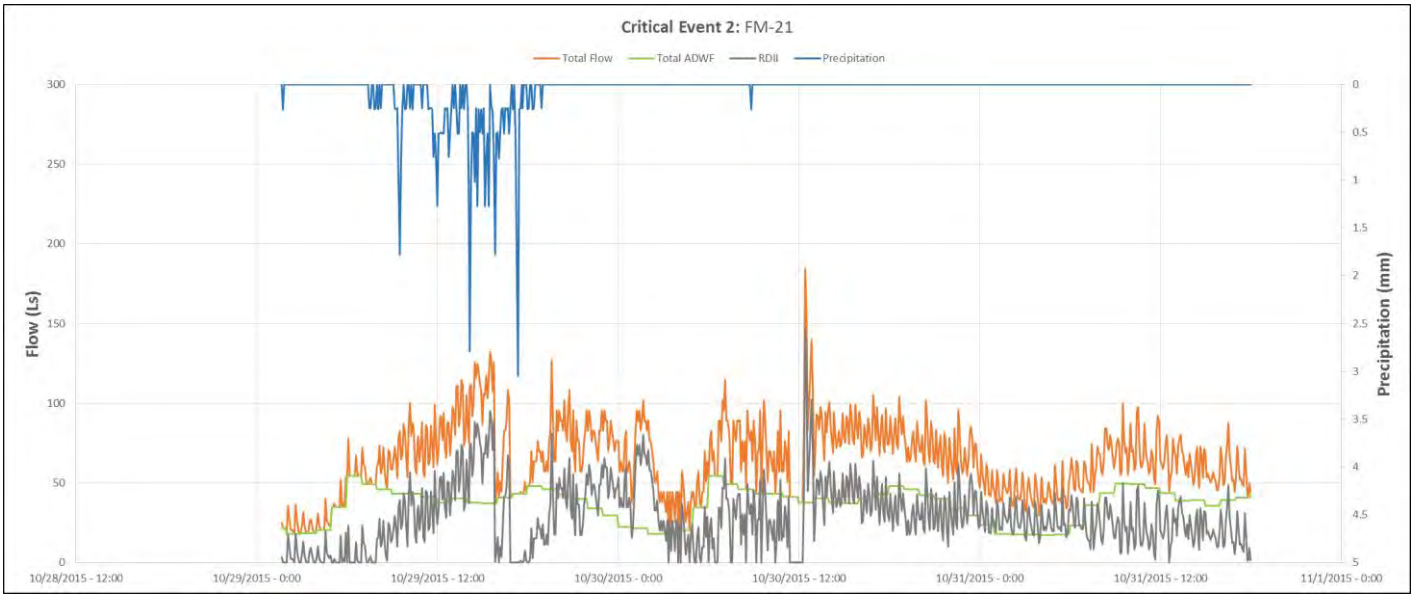
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	99	3.2	2%	0.15
CE2	10/29/2015	10	49	147	6.6	2%	0.22

Estimated Peak Wet Weather Design Flows (L/s)

Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	408	55	55	55	55	55	55

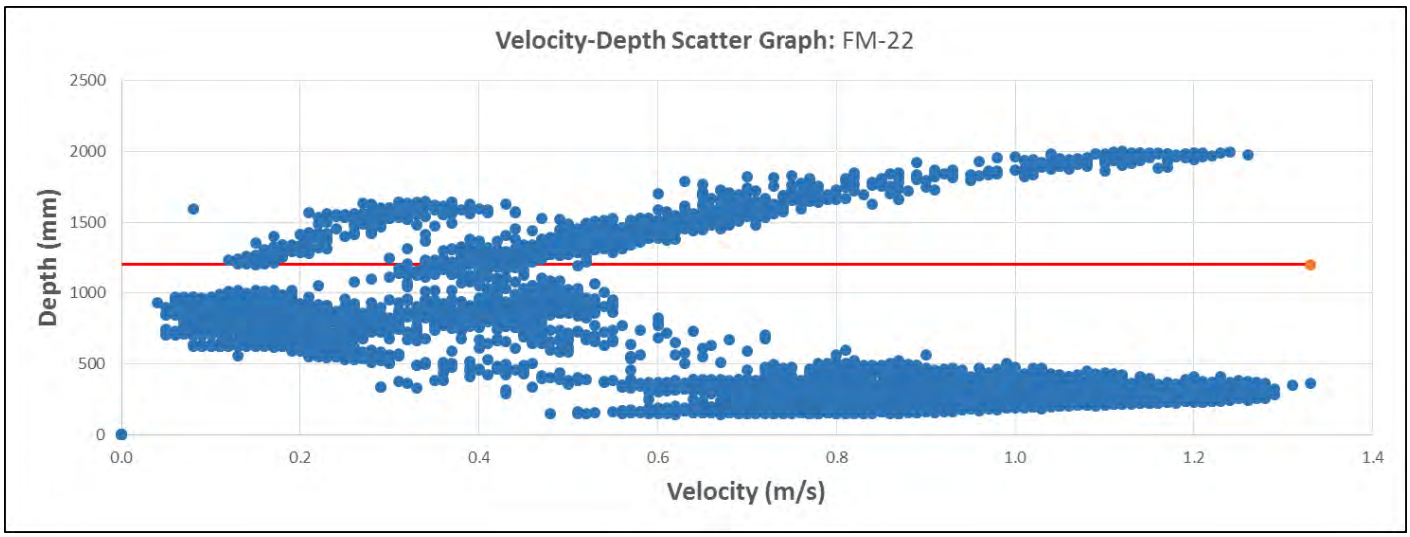
Wet Weather Flow Graphs



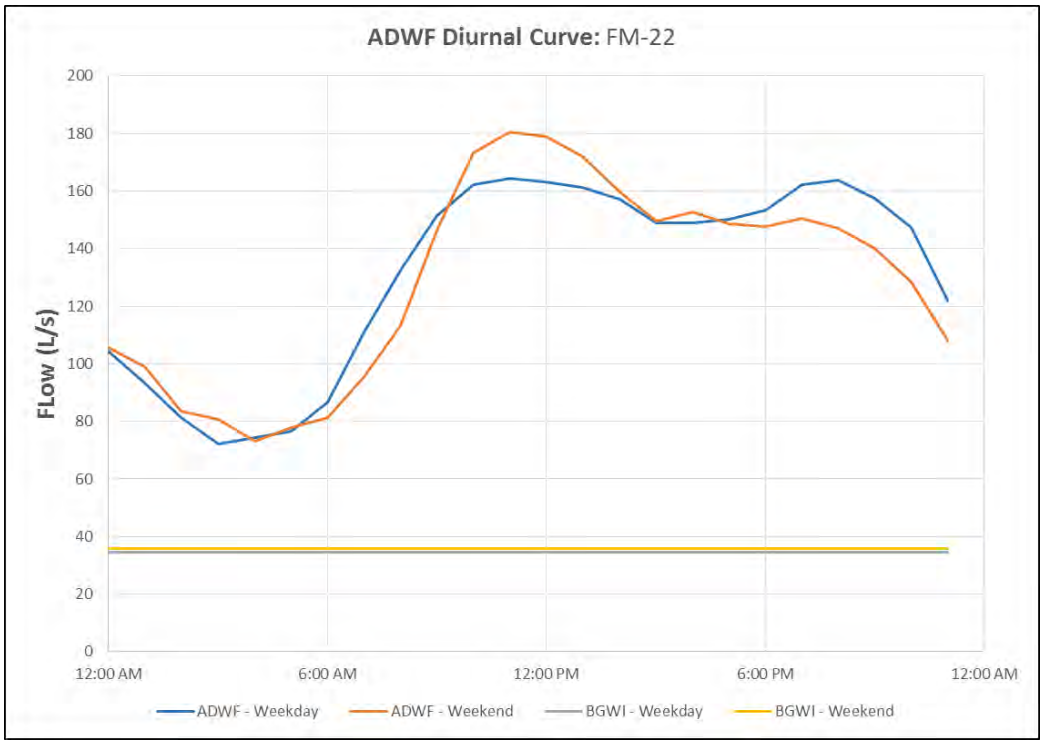


FM-22

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.72	0.75
0.61	0.68
0.48	0.51
0.39	0.48
0.41	0.40
0.44	0.45
0.54	0.49
0.79	0.64
1.01	0.83
1.21	1.19
1.32	1.48
1.35	1.55
1.33	1.54
1.31	1.46
1.27	1.33
1.19	1.22
1.18	1.25
1.20	1.21
1.23	1.20
1.32	1.23
1.34	1.20
1.27	1.12
1.17	0.99
0.91	0.78

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	131.1	128.9	L/s
MNF	72.2	73.3	L/s
BGWI	34.6	35.7	L/s
Unit BGWI	0.02	0.02	L/s/ha
Sanitary Flow	96.5	93.1	L/s
Per Capita Sanitary Flow	333.4	321.9	L/cap/d
Peak DWF	164.4	180.4	L/s

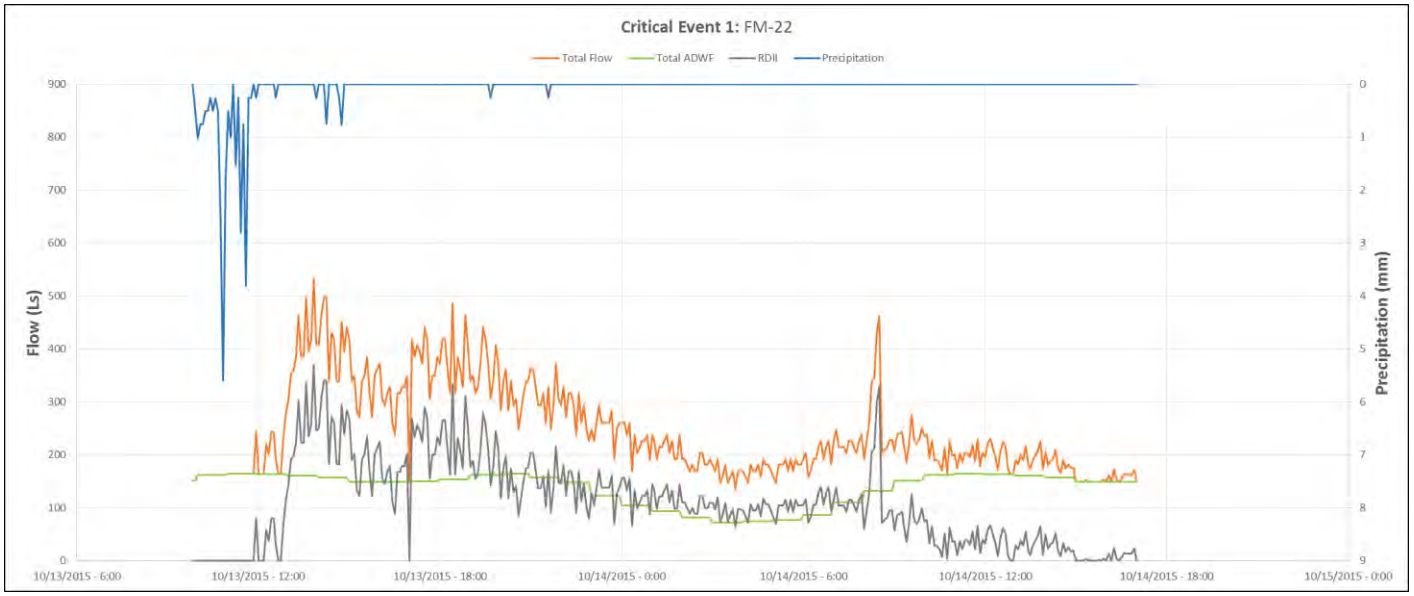
Quantification of RDII

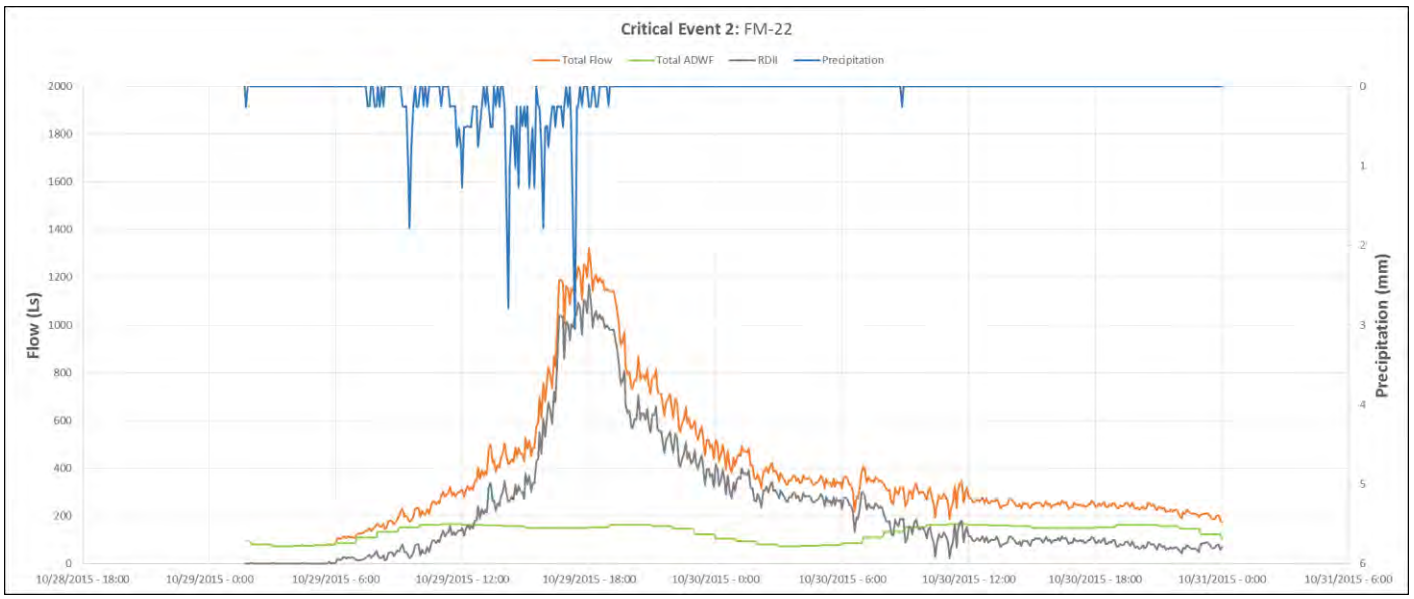
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	370	12.2	2%	0.18
CE2	10/29/2015	10	49	1170	40.0	4%	0.58
CE3	11/13/2015	7	29	276	16.7	3%	0.14
CE4	11/21/2015	13	94	1275	155.9	8%	0.63

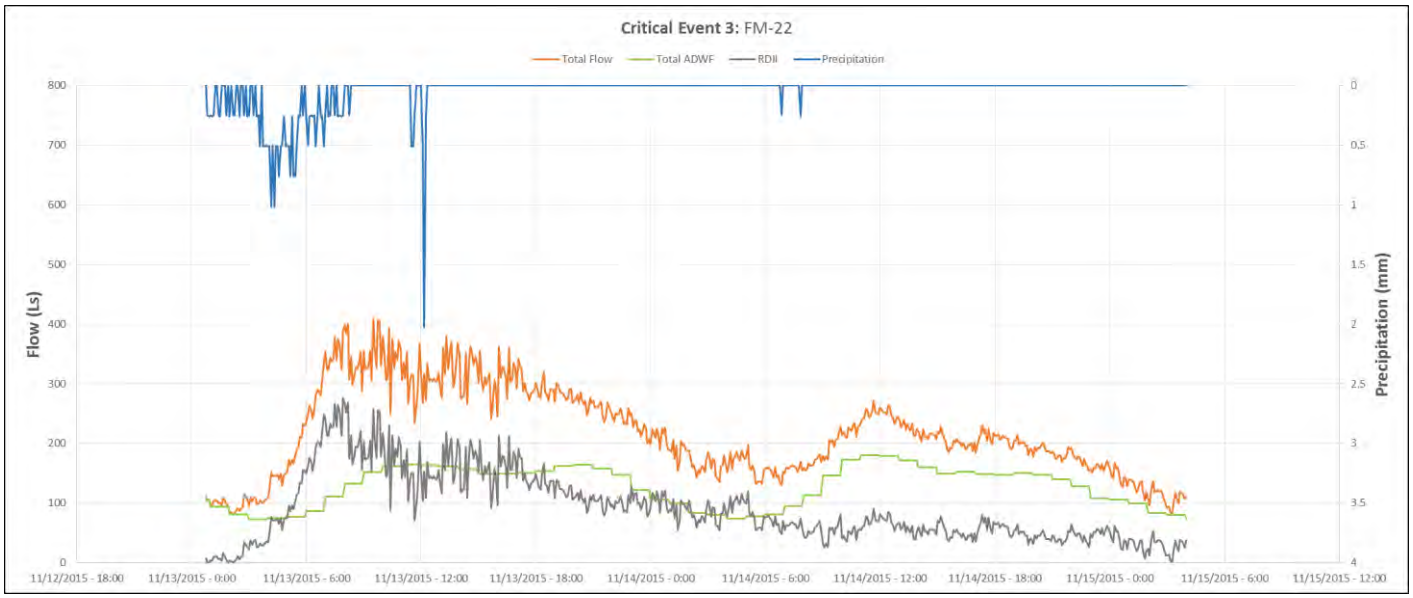
Estimated Peak Wet Weather Design Flows (L/s)

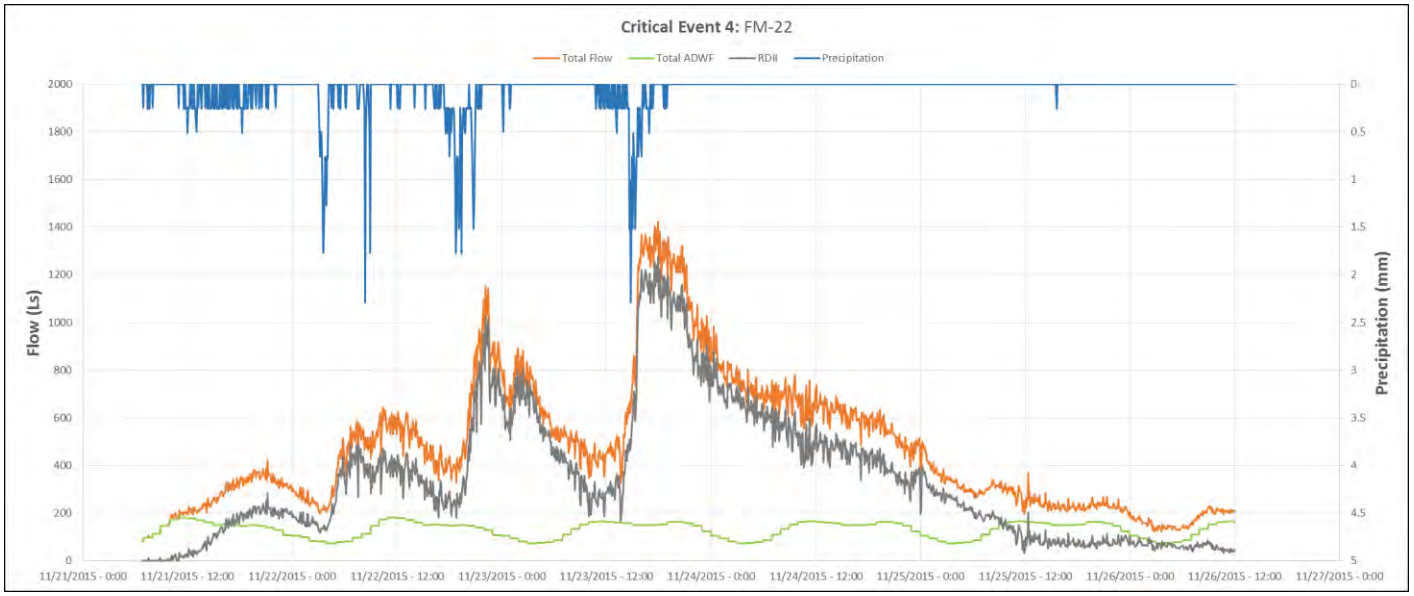
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	860	1633	2037	2299	2642	2885	3127

Wet Weather Flow Graphs



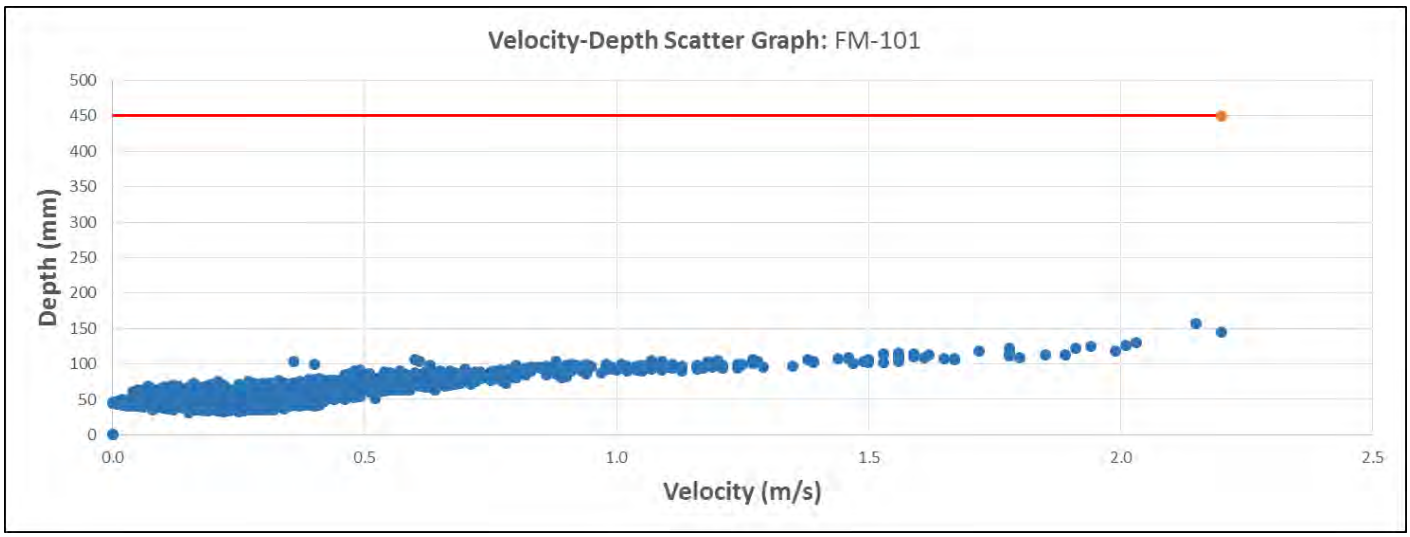



Critical Event 3: FM-22
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
100
200
300
400
500
600
700
800
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00
11/15/2015 - 12:00

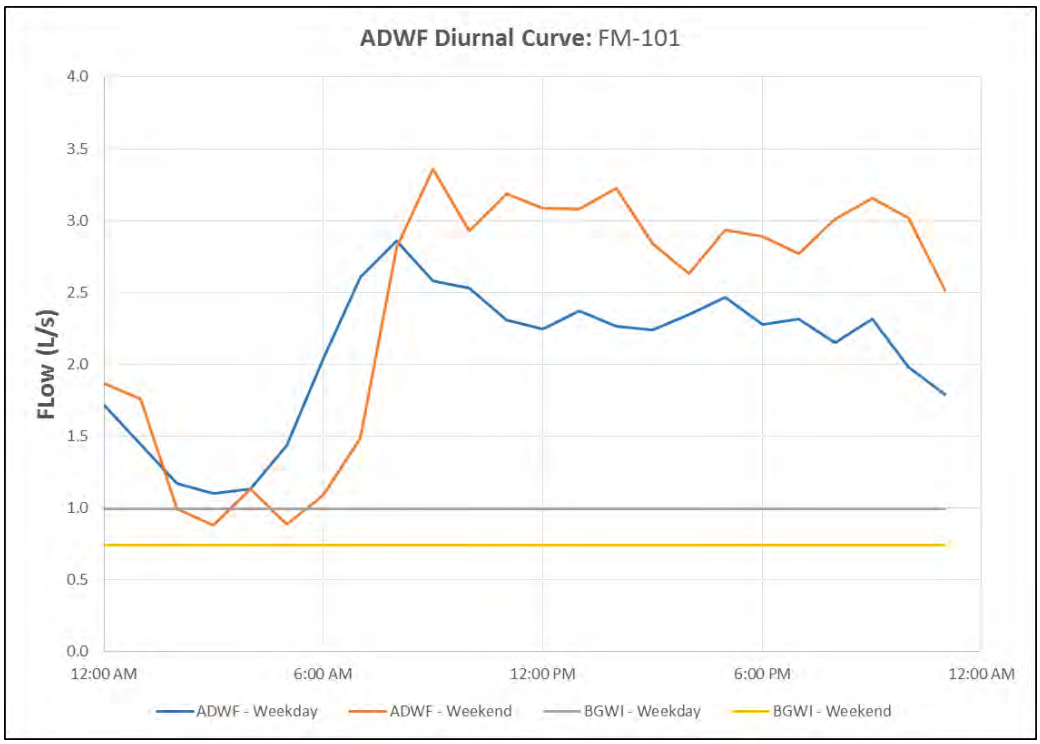

Critical Event 4: FM-22
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00
11/26/2015 - 0:00
11/26/2015 - 12:00
11/27/2015 - 0:00

FM-101

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.67	0.68
0.42	0.62
0.16	0.15
0.10	0.08
0.13	0.23
0.41	0.08
0.97	0.21
1.50	0.45
1.73	1.25
1.48	1.58
1.43	1.32
1.22	1.48
1.16	1.42
1.28	1.41
1.18	1.50
1.16	1.27
1.26	1.14
1.37	1.32
1.19	1.30
1.23	1.22
1.08	1.37
1.23	1.46
0.92	1.38
0.74	1.07

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	2.1	2.4	L/s
MNF	1.1	0.9	L/s
BGWI	1.0	0.7	L/s
Unit BGWI	0.13	0.10	L/s/ha
Sanitary Flow	1.1	1.7	L/s
Per Capita Sanitary Flow	211.7	325.3	L/cap/d
Peak DWF	2.9	3.4	L/s

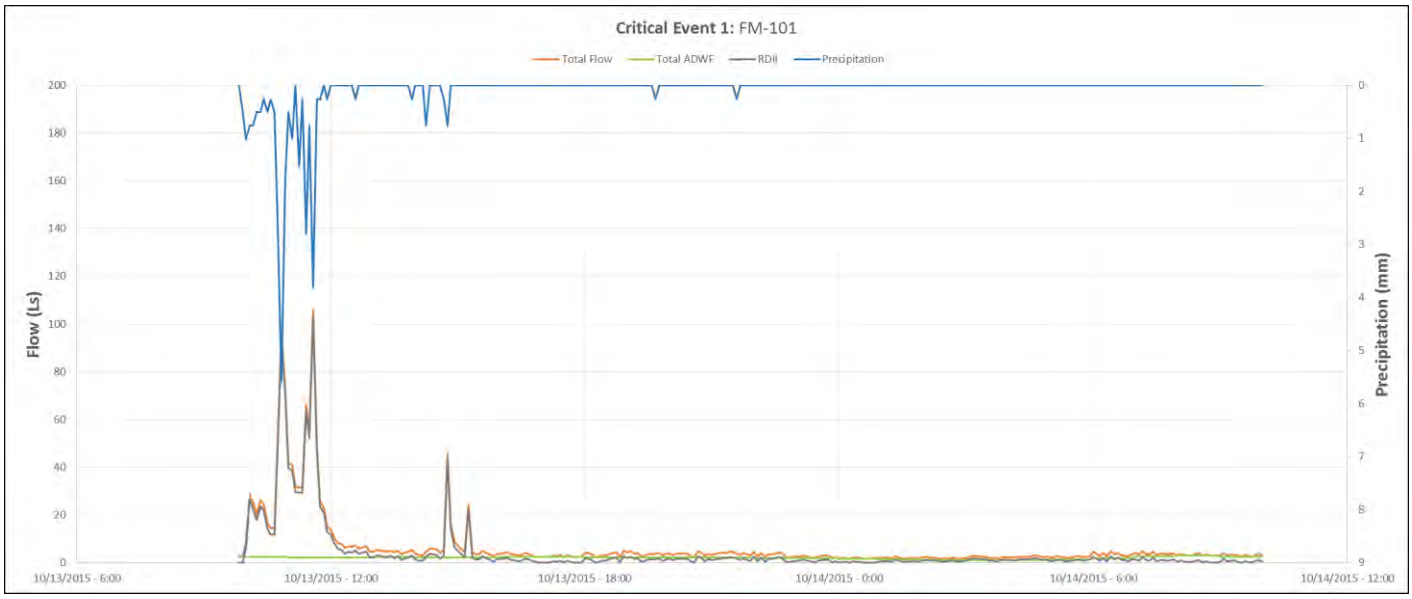
Quantification of RDII

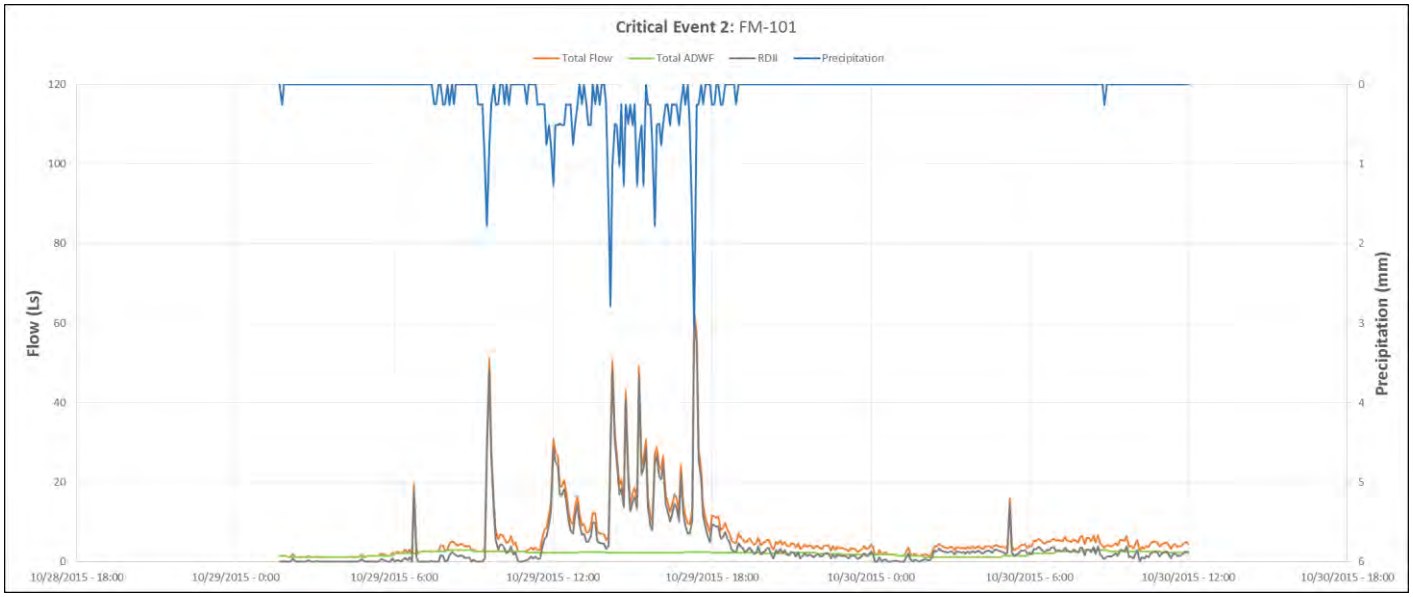
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	104	0.4	17%	13.64
CE2	10/29/2015	10	49	60	0.6	15%	7.90
CE3	11/13/2015	7	29	38	0.4	16%	5.05
CE4	11/21/2015	13	93	74	1.6	22%	9.78

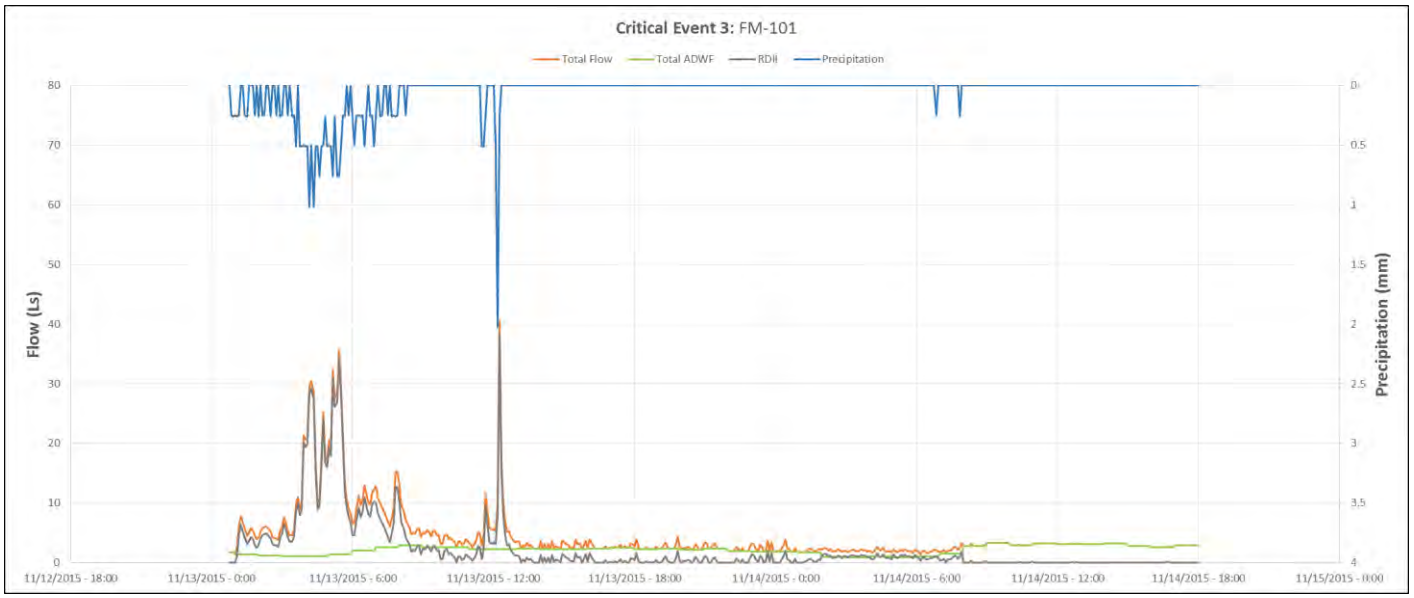
Estimated Peak Wet Weather Design Flows (L/s)

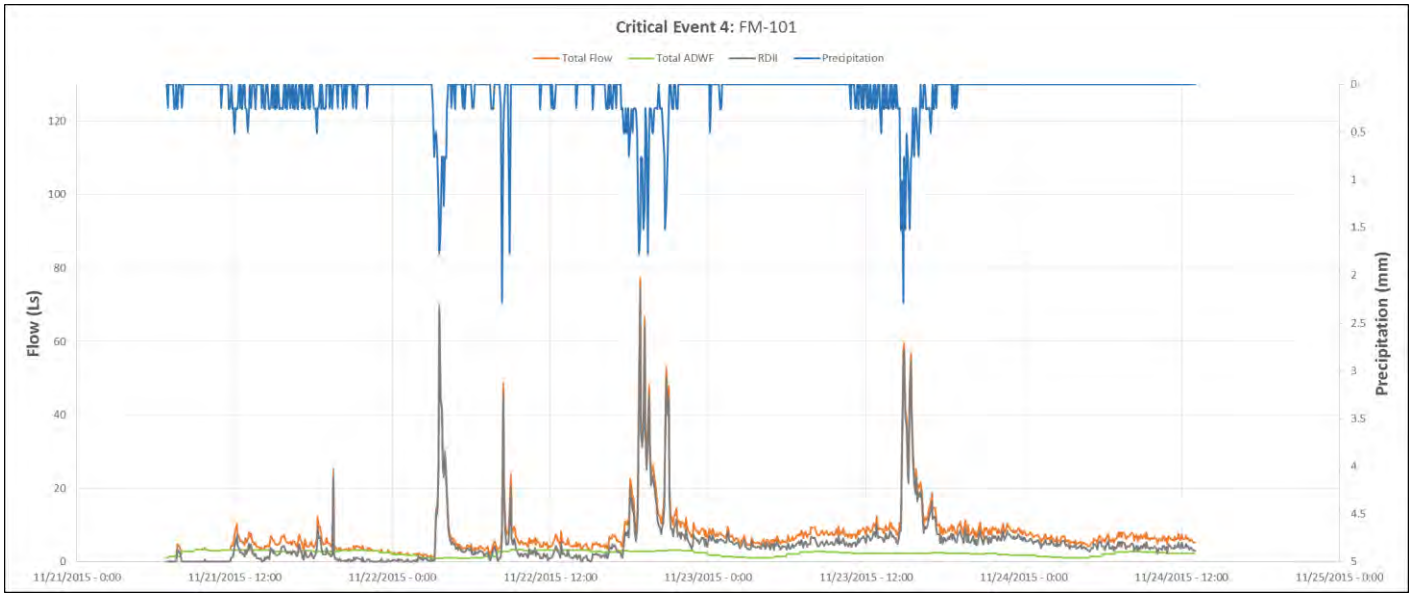
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	13	100	124	140	160	175	189

Wet Weather Flow Graphs



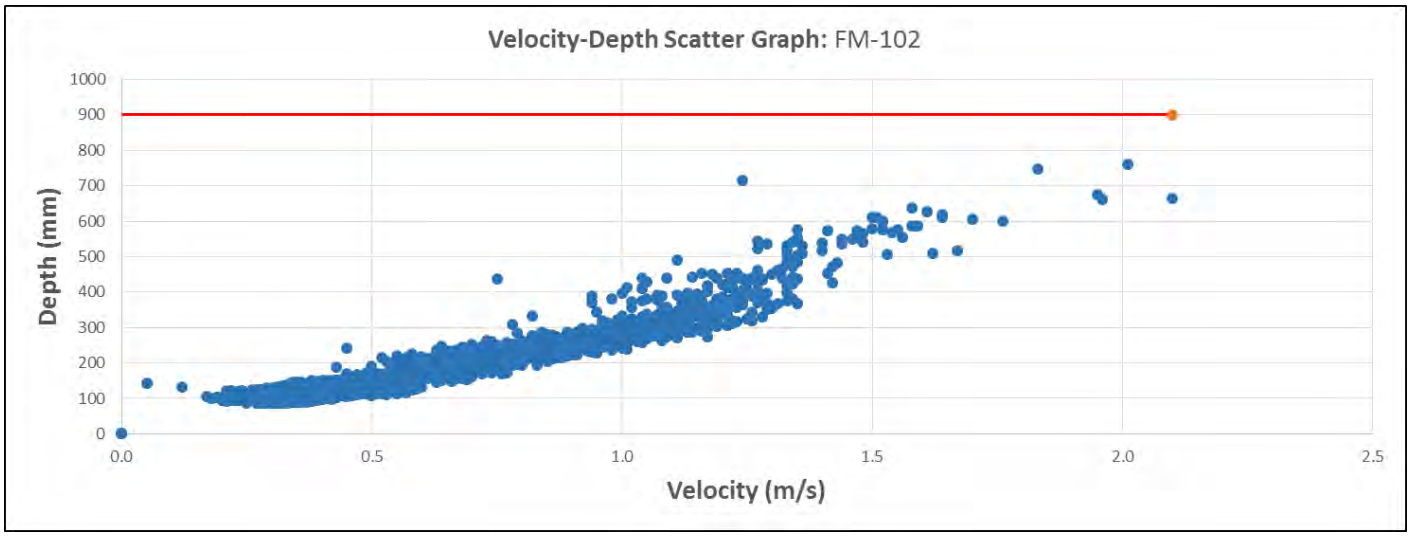



Critical Event 3: FM-101
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

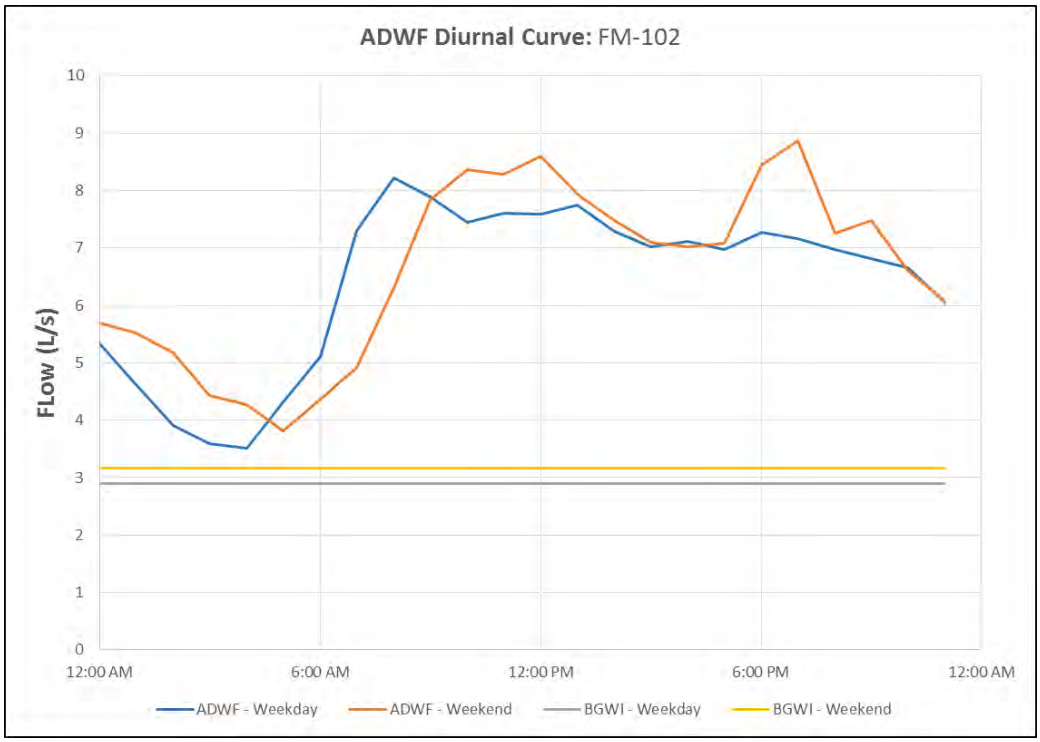

Critical Event 4: FM-101
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-102

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.70	0.73
0.49	0.68
0.29	0.58
0.20	0.37
0.18	0.32
0.41	0.19
0.63	0.35
1.26	0.51
1.52	0.91
1.43	1.35
1.30	1.50
1.34	1.48
1.34	1.57
1.39	1.38
1.25	1.25
1.18	1.14
1.20	1.12
1.16	1.14
1.25	1.53
1.22	1.65
1.17	1.18
1.12	1.25
1.08	0.99
0.90	0.84

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	6.4	6.6	L/s
MNF	3.5	3.8	L/s
BGWI	2.9	3.2	L/s
Unit BGWI	0.05	0.06	L/s/ha
Sanitary Flow	3.5	3.5	L/s
Per Capita Sanitary Flow	106.9	105.5	L/cap/d
Peak DWF	8.2	8.9	L/s

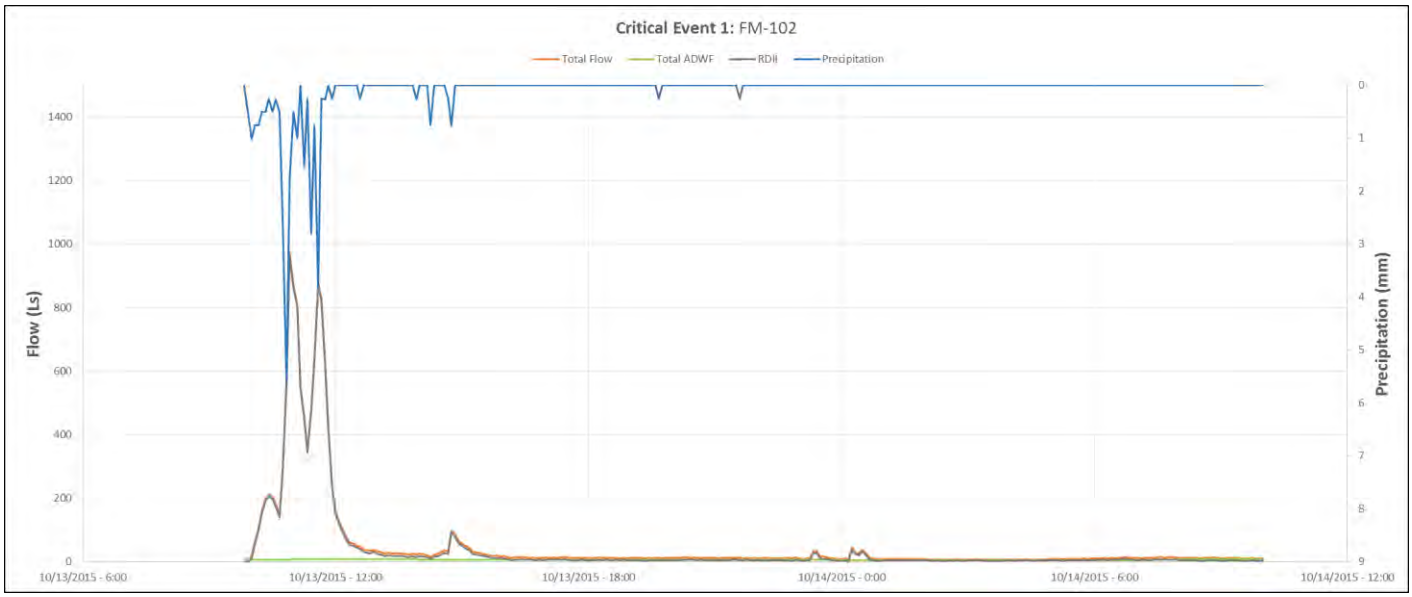
Quantification of RDII

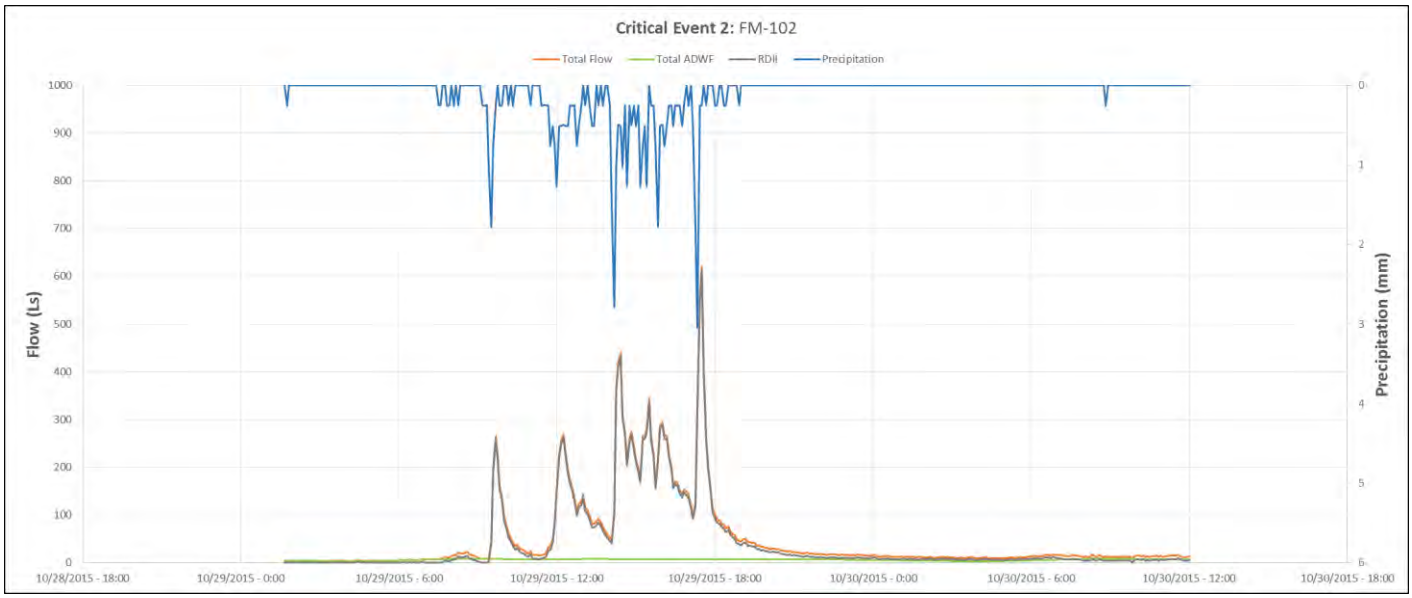
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	964	3.9	25%	18.20
CE2	10/29/2015	10	49	613	5.6	22%	11.57
CE3	11/13/2015	7	28	271	3.0	20%	5.12
CE4	11/21/2015	13	93	619	16.2	33%	11.68

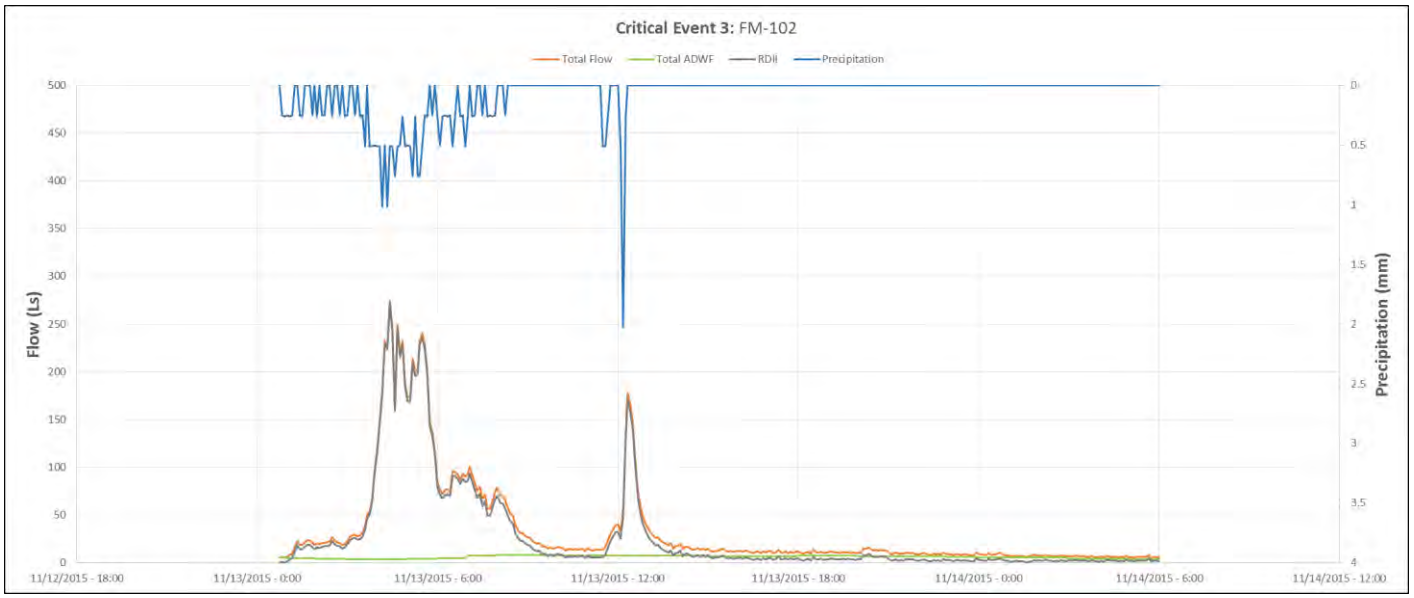
Estimated Peak Wet Weather Design Flows (L/s)

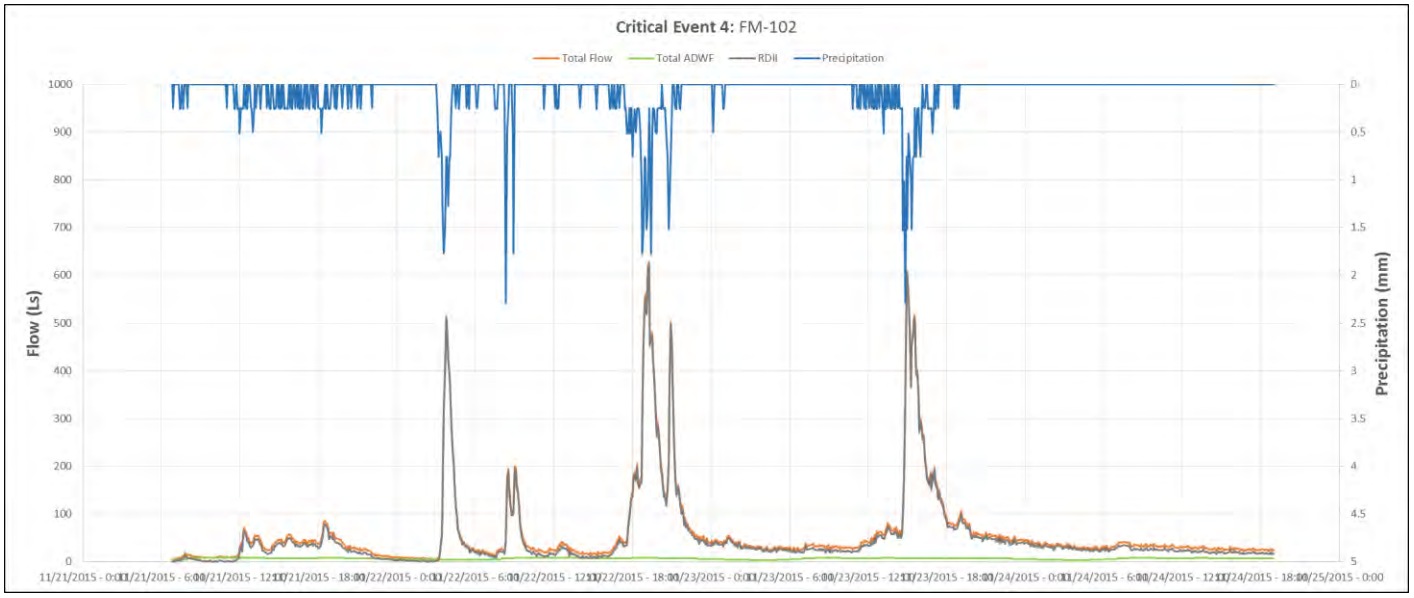
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	29	864	1103	1263	1467	1616	1765

Wet Weather Flow Graphs



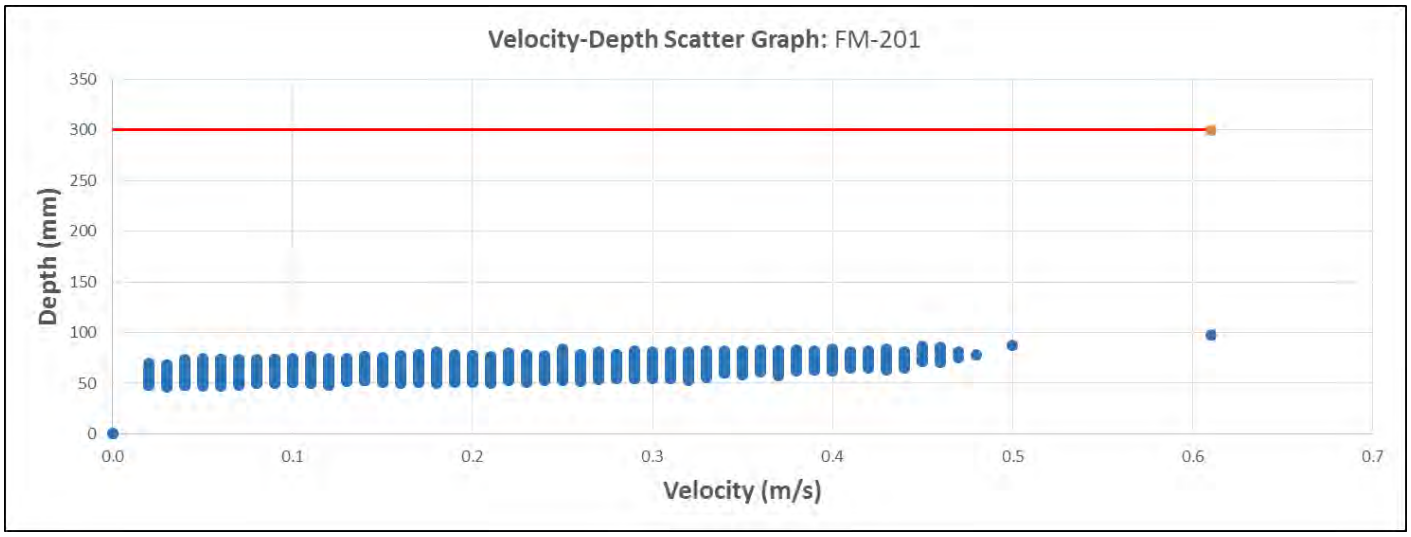



Critical Event 3: FM-102
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

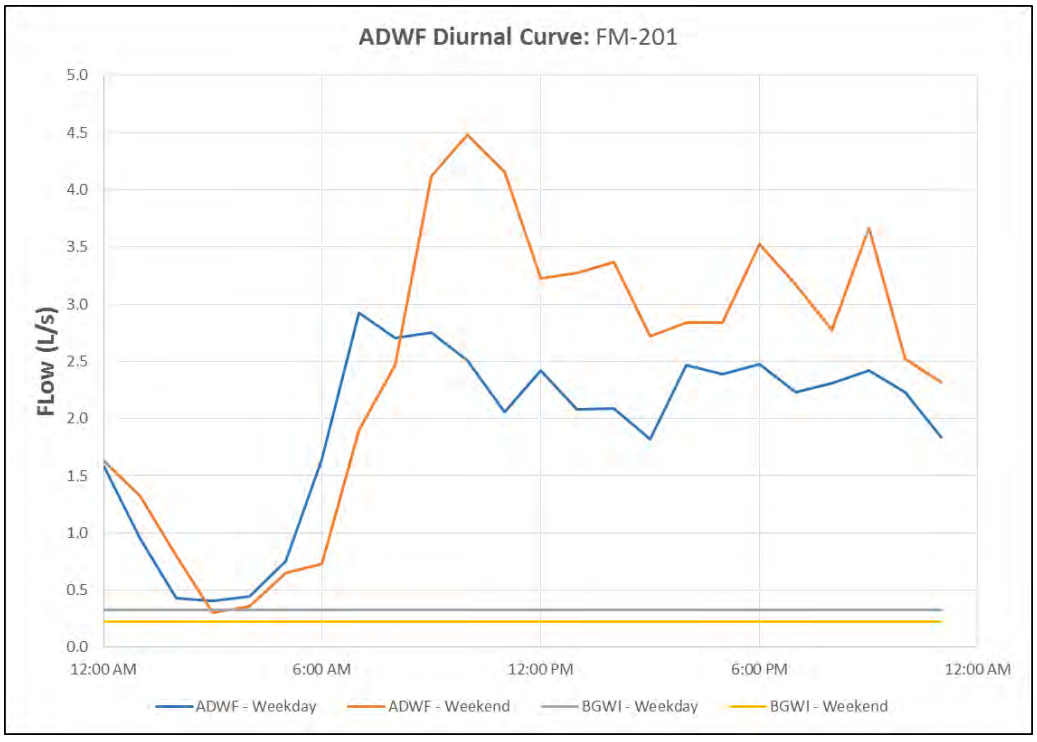

Critical Event 4: FM-102
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)

FM-201

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.79	0.63
0.39	0.49
0.06	0.26
0.05	0.04
0.07	0.06
0.27	0.19
0.83	0.23
1.64	0.75
1.50	1.00
1.53	1.74
1.37	1.90
1.09	1.75
1.32	1.34
1.11	1.36
1.11	1.40
0.94	1.11
1.35	1.17
1.30	1.17
1.36	1.47
1.20	1.31
1.25	1.14
1.32	1.54
1.20	1.03
0.95	0.93

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	1.9	2.5	L/s
MNF	0.4	0.3	L/s
BGWI	0.3	0.2	L/s
Unit BGWI	0.05	0.03	L/s/ha
Sanitary Flow	1.6	2.2	L/s
Per Capita Sanitary Flow	120.8	170.7	L/cap/d
Peak DWF	2.9	4.5	L/s

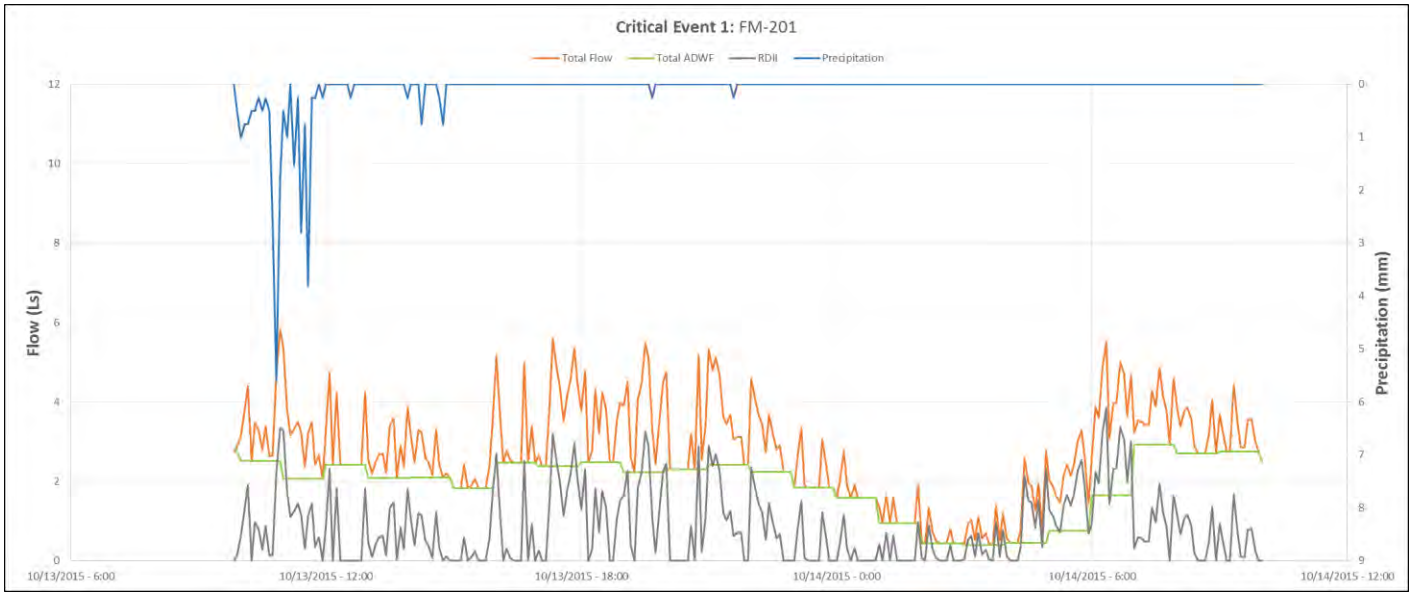
Quantification of RDII

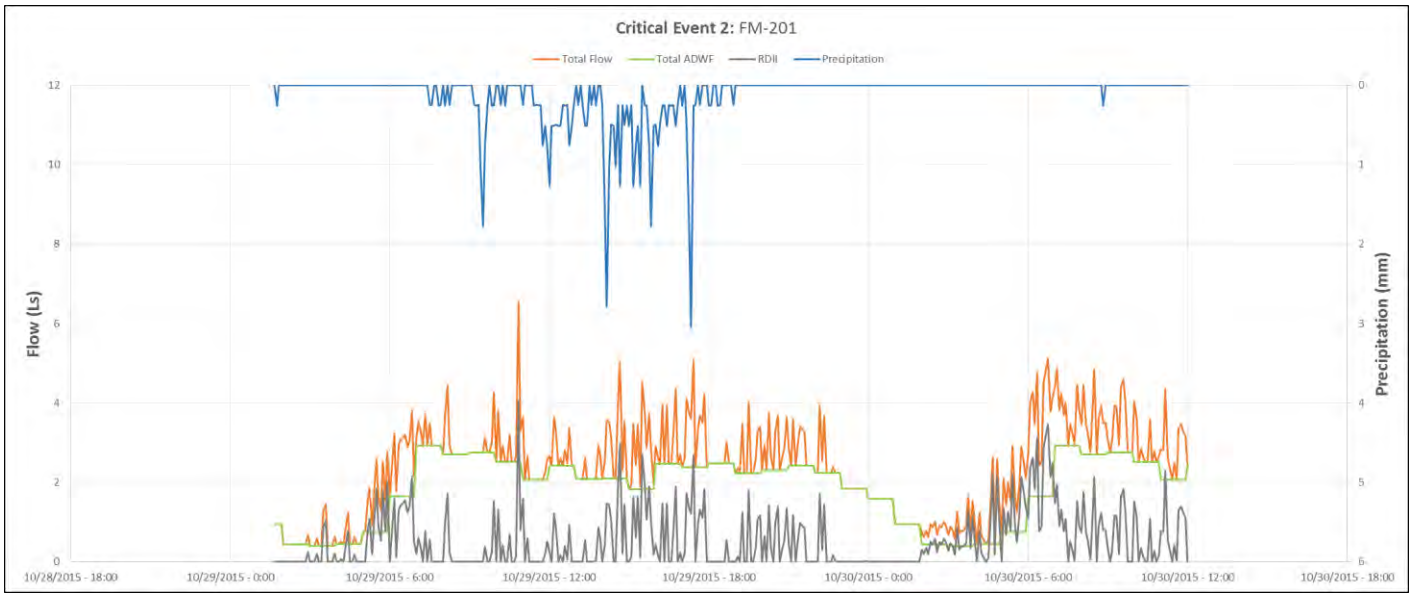
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	4	0.1	4%	0.58
CE2	10/29/2015	10	49	4	0.1	2%	0.60
CE3	11/13/2015	7	29	2	0.0	2%	0.31
CE4	11/21/2015	13	93	5	0.3	5%	0.80

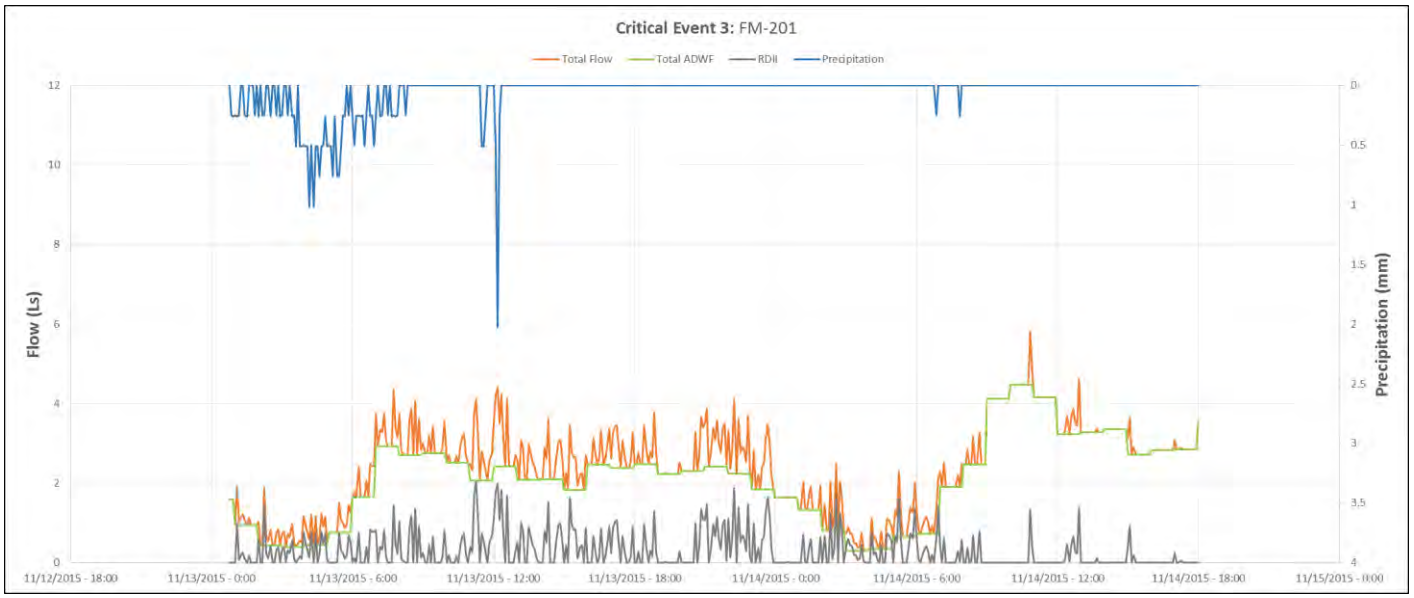
Estimated Peak Wet Weather Design Flows (L/s)

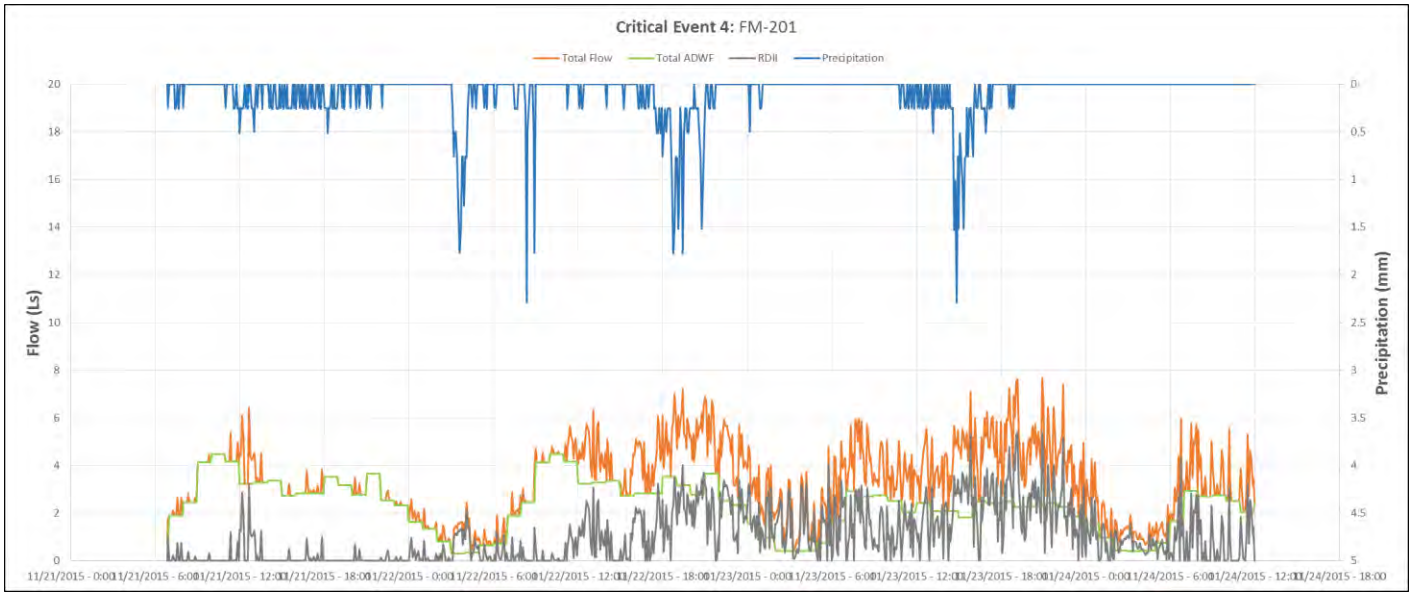
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	22	12	14	16	17	19	20

Wet Weather Flow Graphs



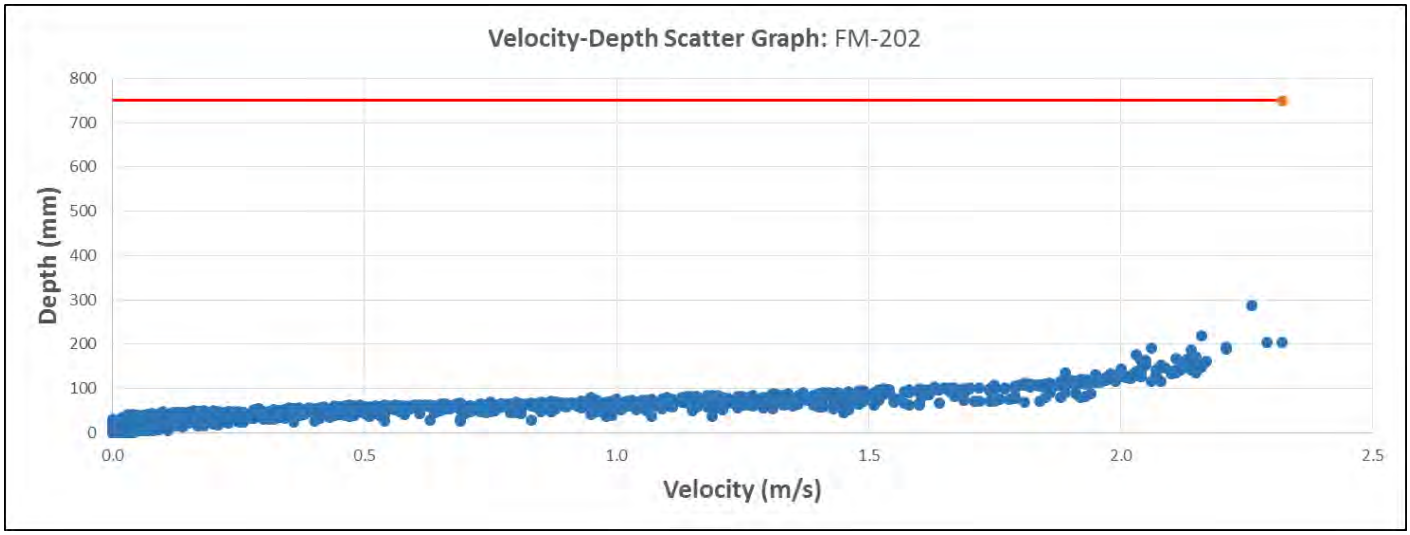



Critical Event 3: FM-201
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00


Critical Event 4: FM-201
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)

FM-202

Velocity-Depth Scatter Graph



DWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors

*Stormwater Sewer System

Dry Weather Flow Analysis

*Stormwater Sewer System

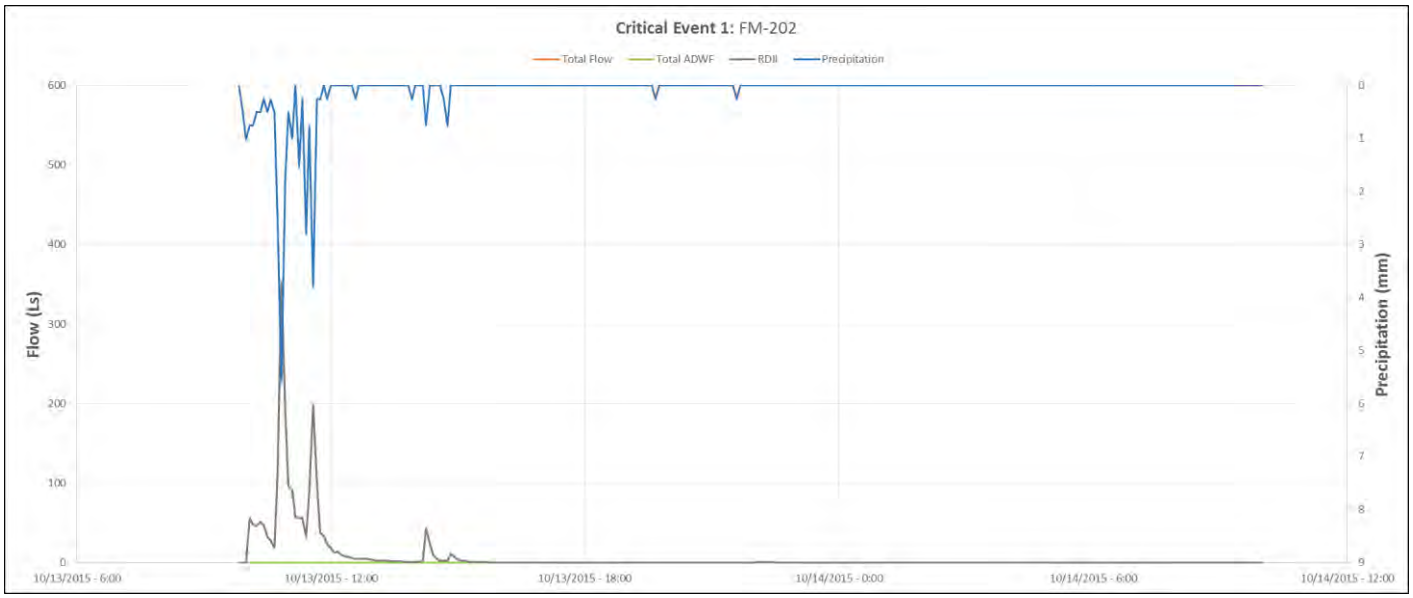
Quantification of RDII

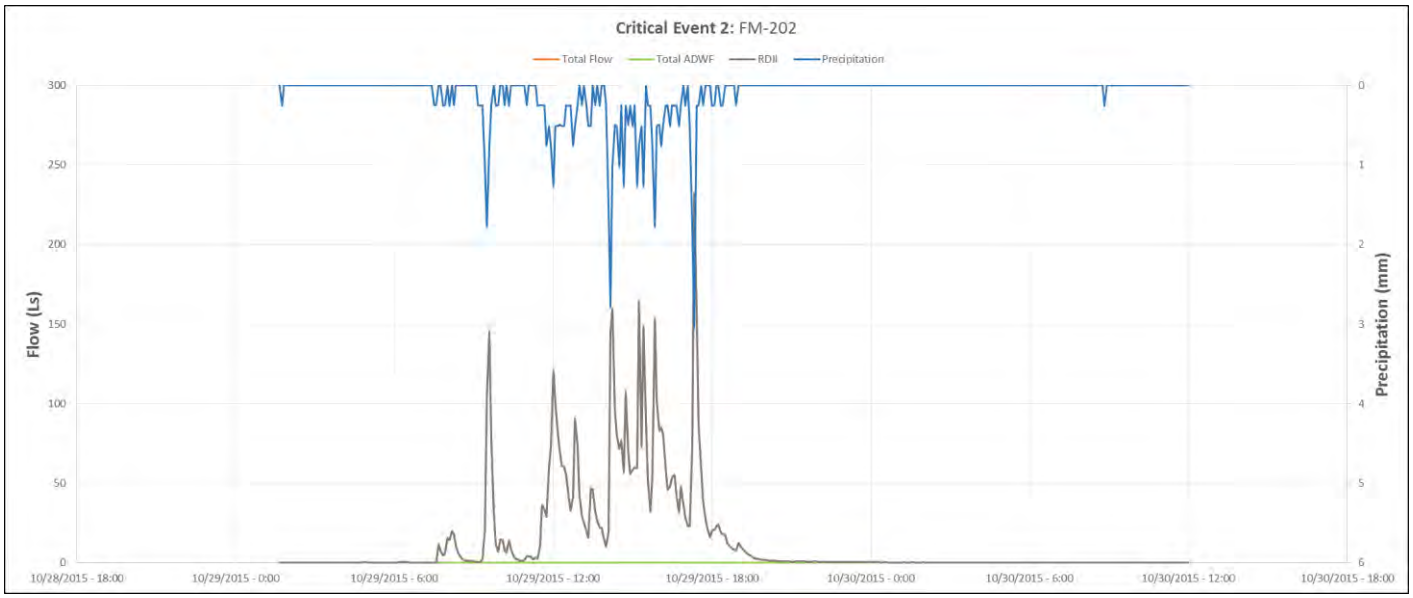
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	352	0.6	32%	52.50
CE2	10/29/2015	10	49	233	1.7	53%	34.70
CE3	11/13/2015	7	29	186	1.2	60%	27.69
CE4	11/21/2015	13	93	227	3.6	57%	33.84

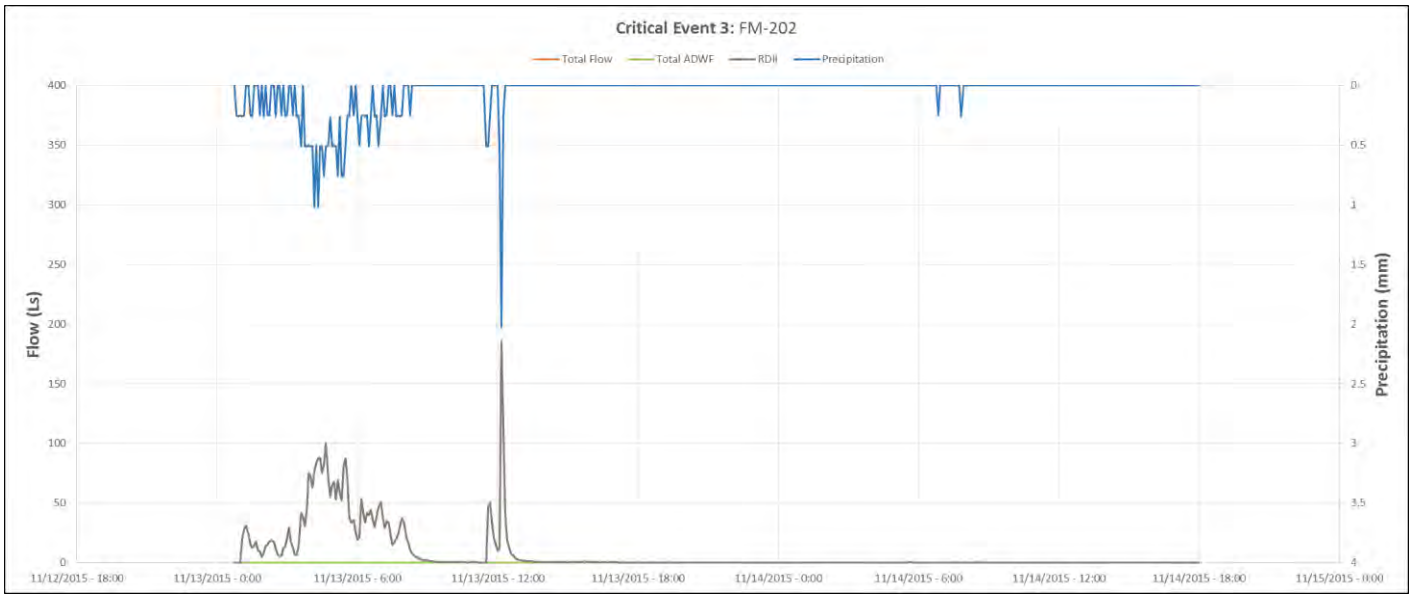
Estimated Peak Wet Weather Design Flows (L/s)

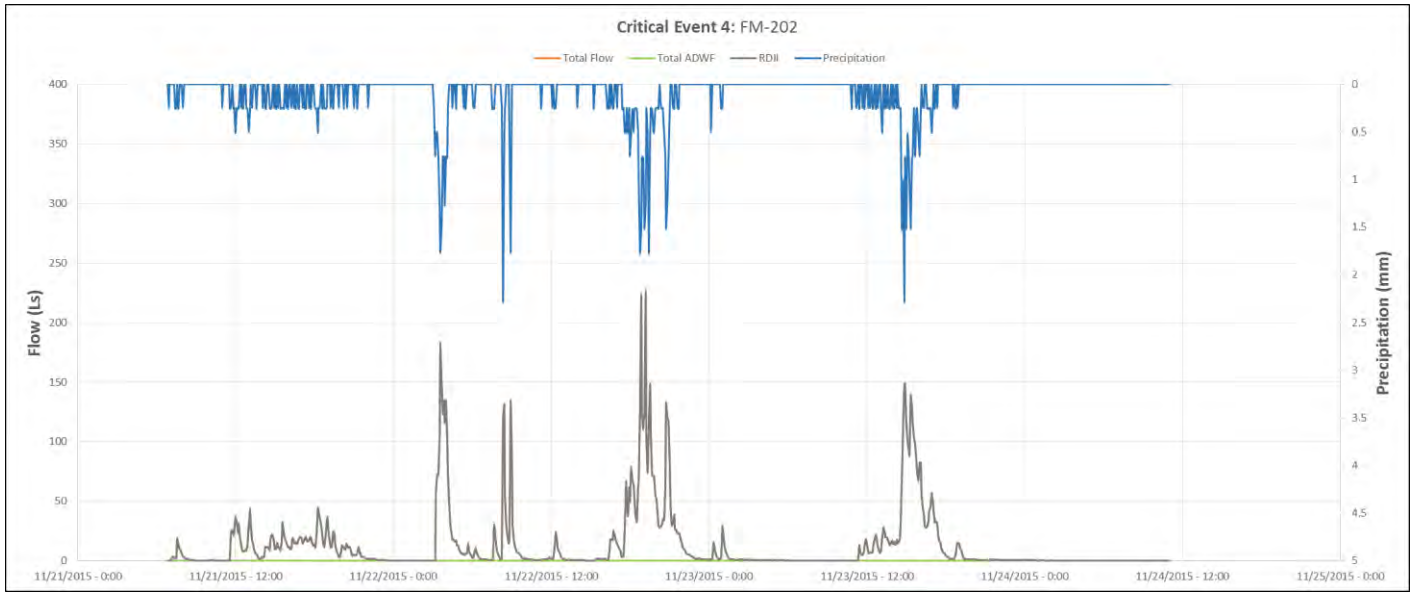
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	NA	289	369	422	489	539	588

Wet Weather Flow Graphs



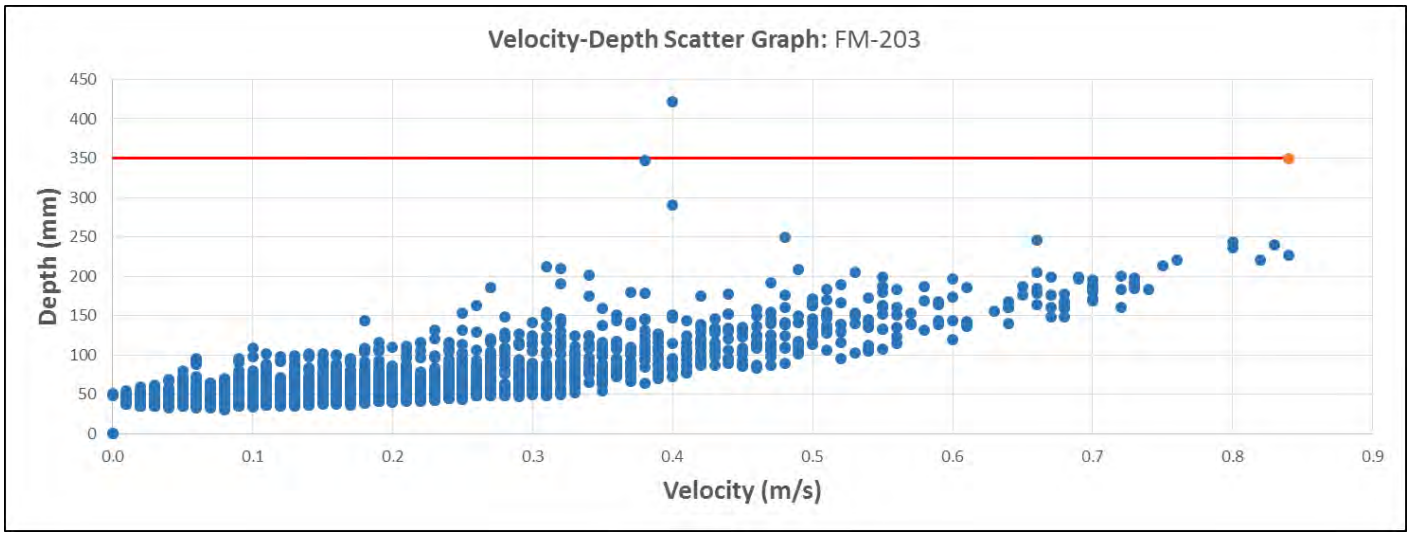



Critical Event 3: FM-202
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
400
350
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

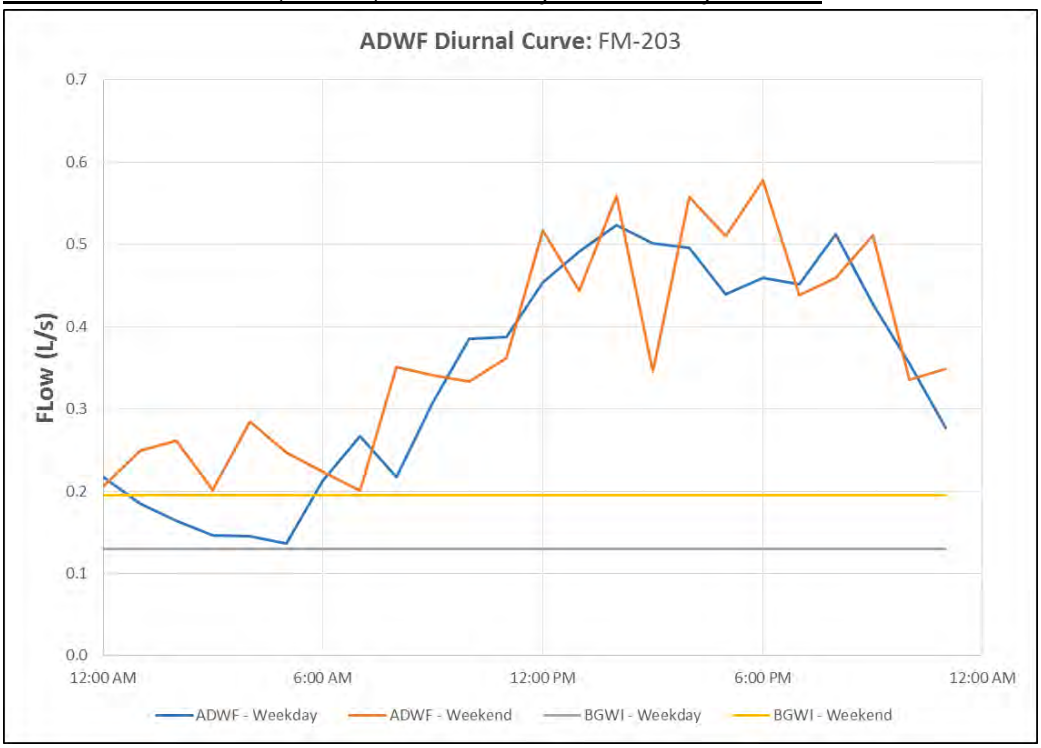

Critical Event 4: FM-202
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
400
350
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-203

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.41	0.06
0.26	0.31
0.16	0.38
0.08	0.04
0.07	0.52
0.03	0.30
0.39	0.16
0.65	0.04
0.41	0.89
0.85	0.84
1.22	0.79
1.23	0.96
1.54	1.84
1.72	1.42
1.88	2.09
1.77	0.86
1.74	2.08
1.47	1.81
1.57	2.19
1.53	1.39
1.82	1.51
1.41	1.81
1.07	0.81
0.70	0.88

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	0.3	0.4	L/s
MNF	0.1	0.2	L/s
BGWI	0.1	0.2	L/s
Unit BGWI	0.06	0.09	L/s/ha
Sanitary Flow	0.2	0.2	L/s
Per Capita Sanitary Flow	210.8	175.5	L/cap/d
Peak DWF	0.5	0.6	L/s

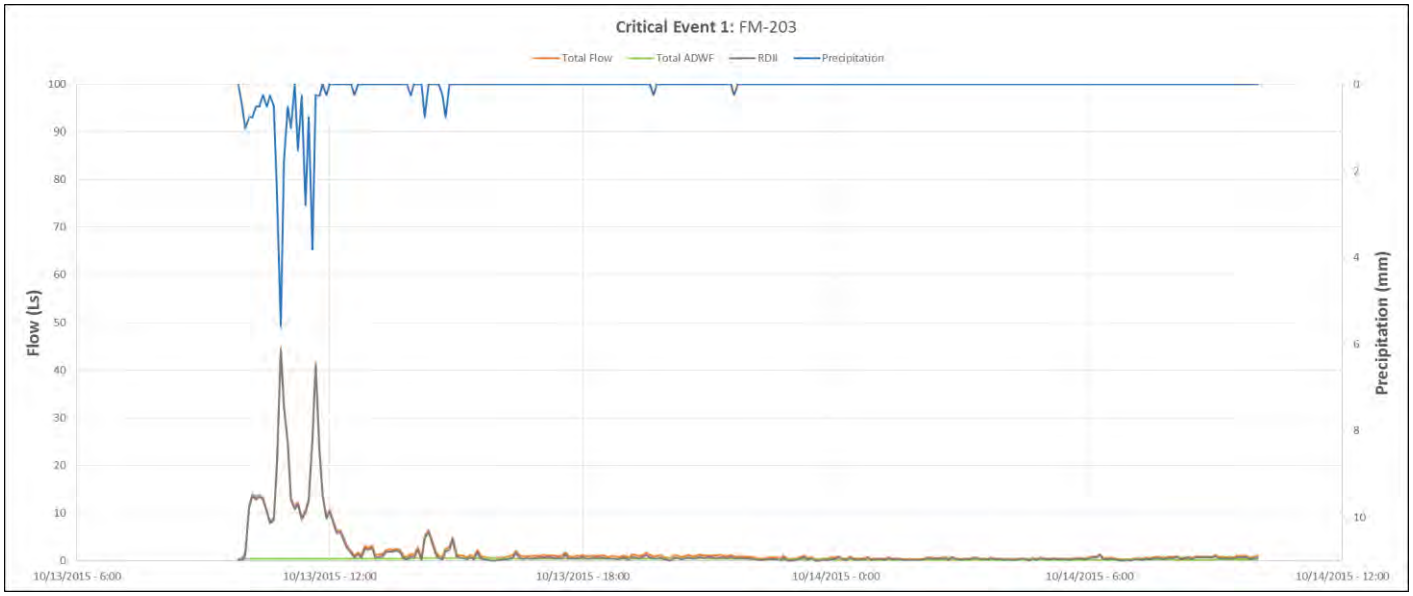
Quantification of RDII

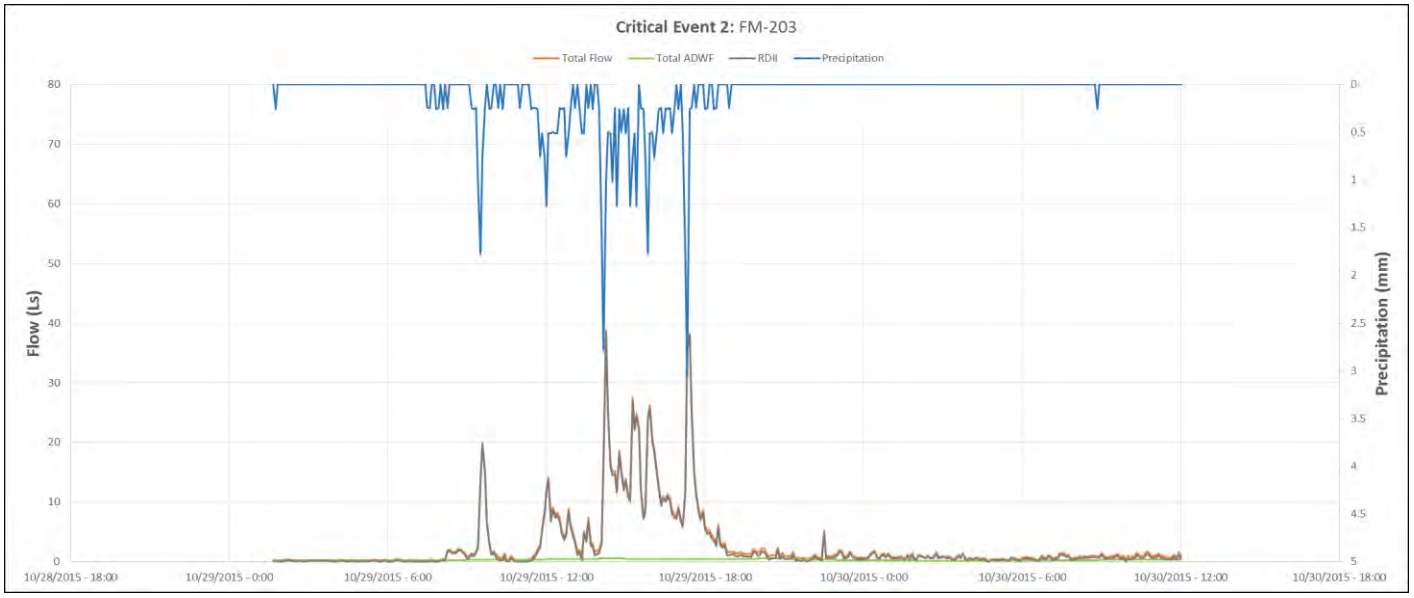
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	44	0.2	28%	21.14
CE2	10/29/2015	10	49	38	0.3	33%	18.27
CE3	11/13/2015	7	28	21	0.2	35%	10.10
CE4	11/21/2015	13	93	40	0.6	32%	19.20

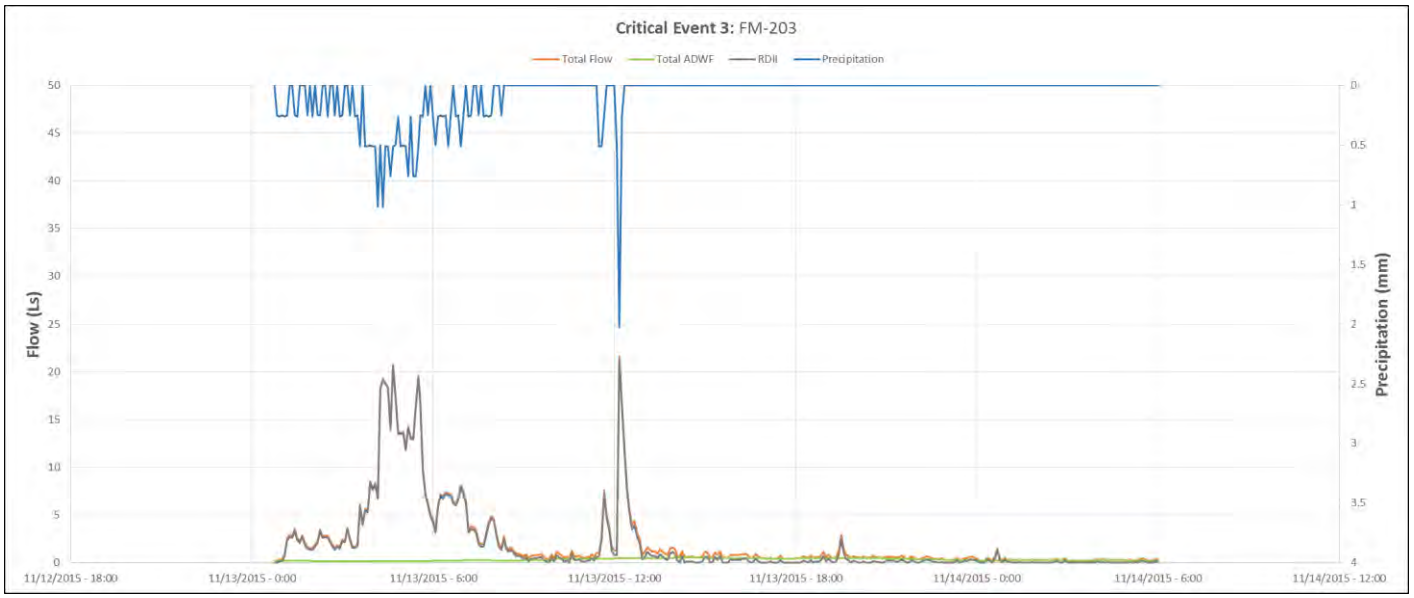
Estimated Peak Wet Weather Design Flows (L/s)

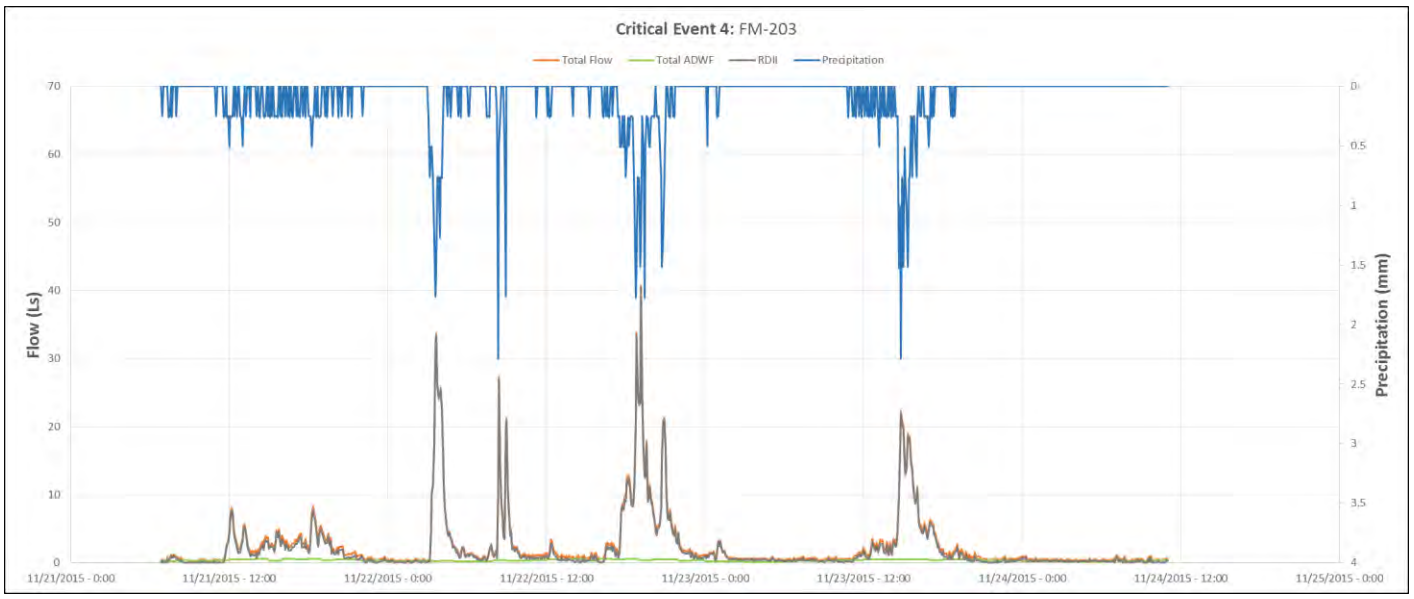
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	2	55	68	77	88	96	104

Wet Weather Flow Graphs



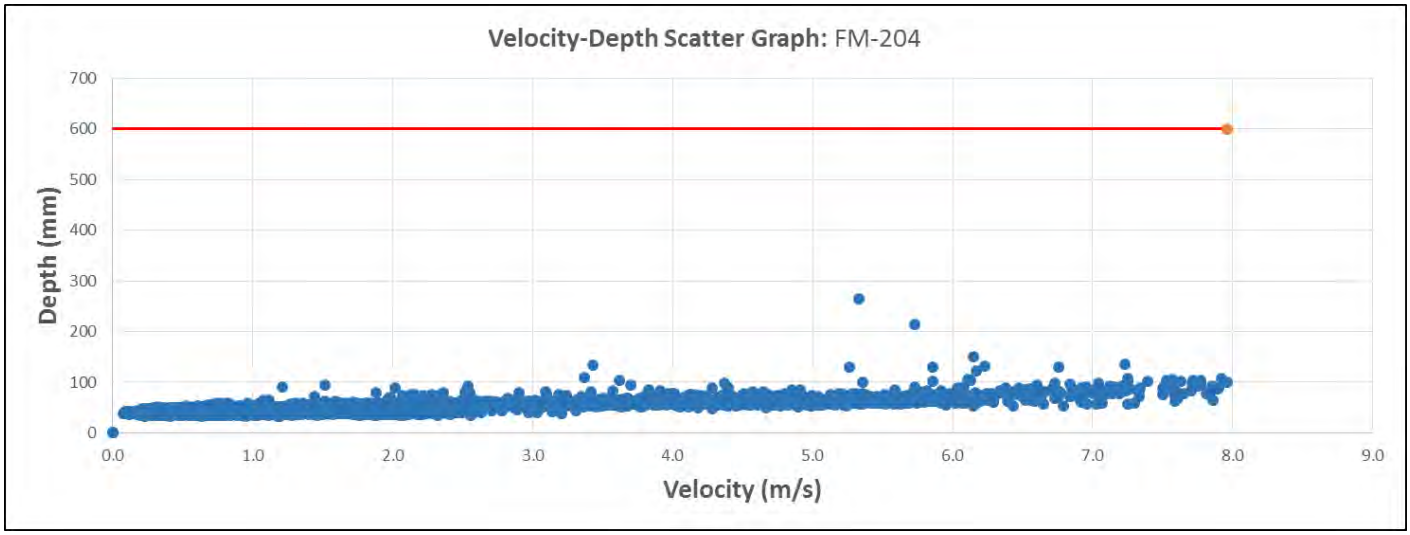



Critical Event 3: FM-203
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

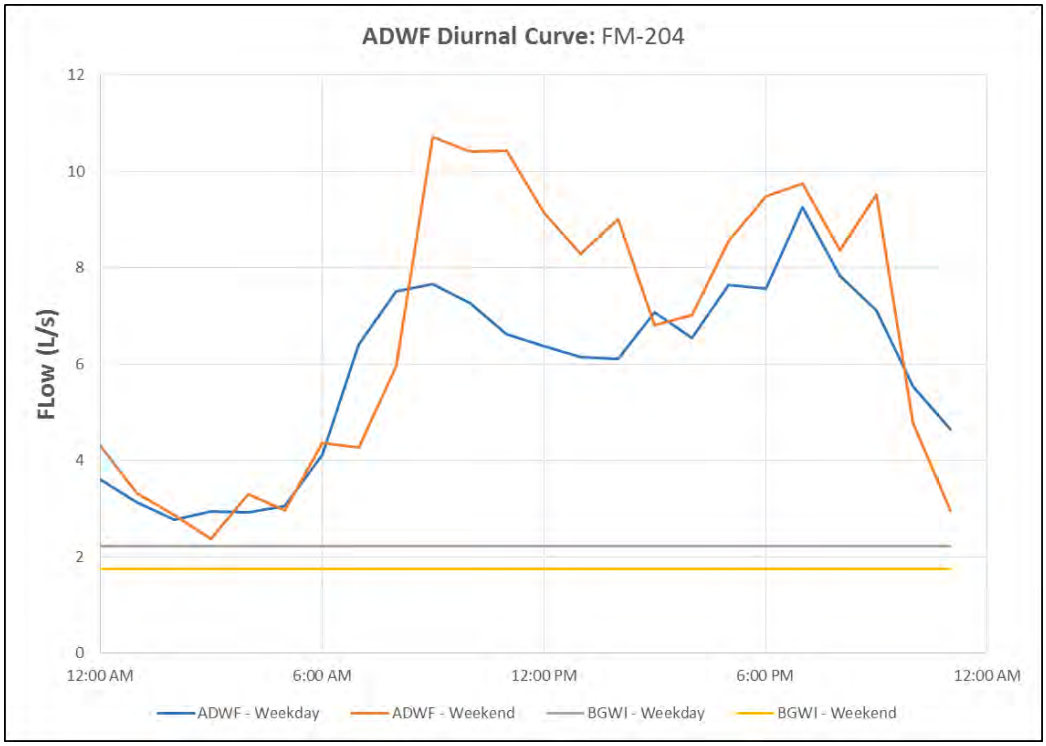

Critical Event 4: FM-203
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-204

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.38	0.53
0.25	0.32
0.15	0.23
0.20	0.13
0.19	0.32
0.23	0.25
0.52	0.54
1.16	0.52
1.47	0.86
1.51	1.84
1.40	1.78
1.22	1.78
1.15	1.52
1.09	1.34
1.08	1.49
1.35	1.04
1.20	1.08
1.51	1.40
1.48	1.59
1.95	1.64
1.55	1.36
1.36	1.59
0.92	0.62
0.67	0.25

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	5.8	6.6	L/s
MNF	2.8	2.4	L/s
BGWI	2.2	1.7	L/s
Unit BGWI	0.21	0.16	L/s/ha
Sanitary Flow	3.6	4.9	L/s
Per Capita Sanitary Flow	358.3	485.4	L/cap/d
Peak DWF	9.3	10.7	L/s

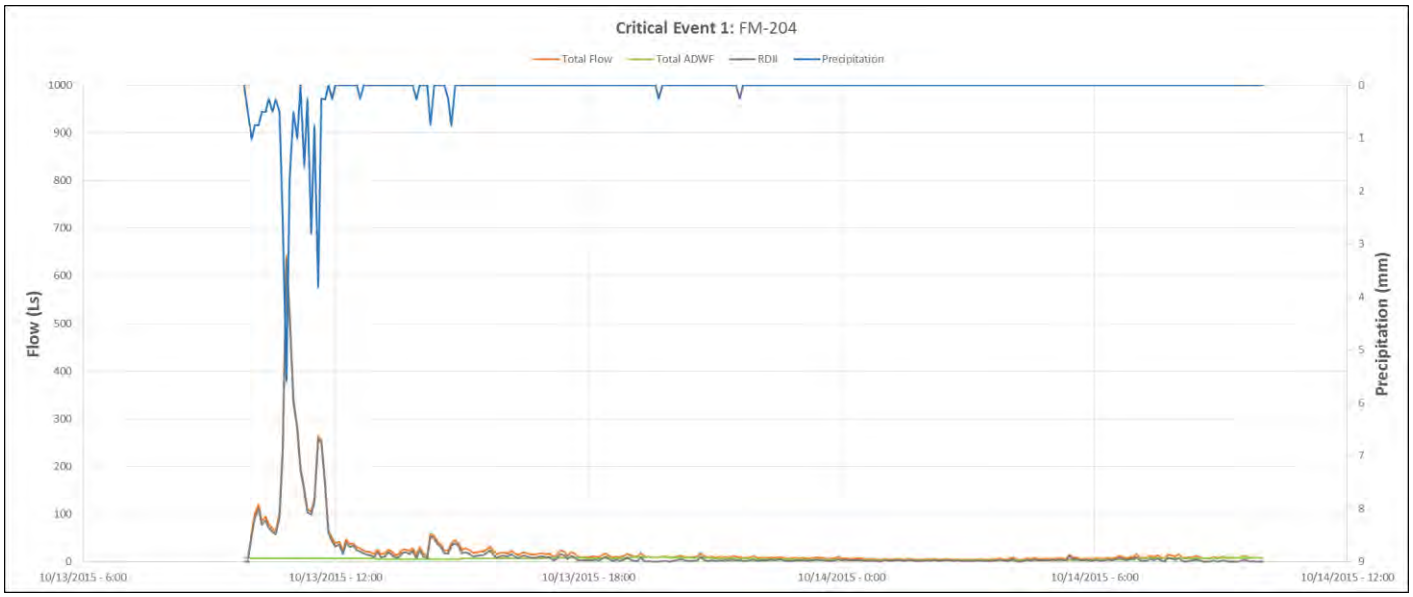
Quantification of RDII

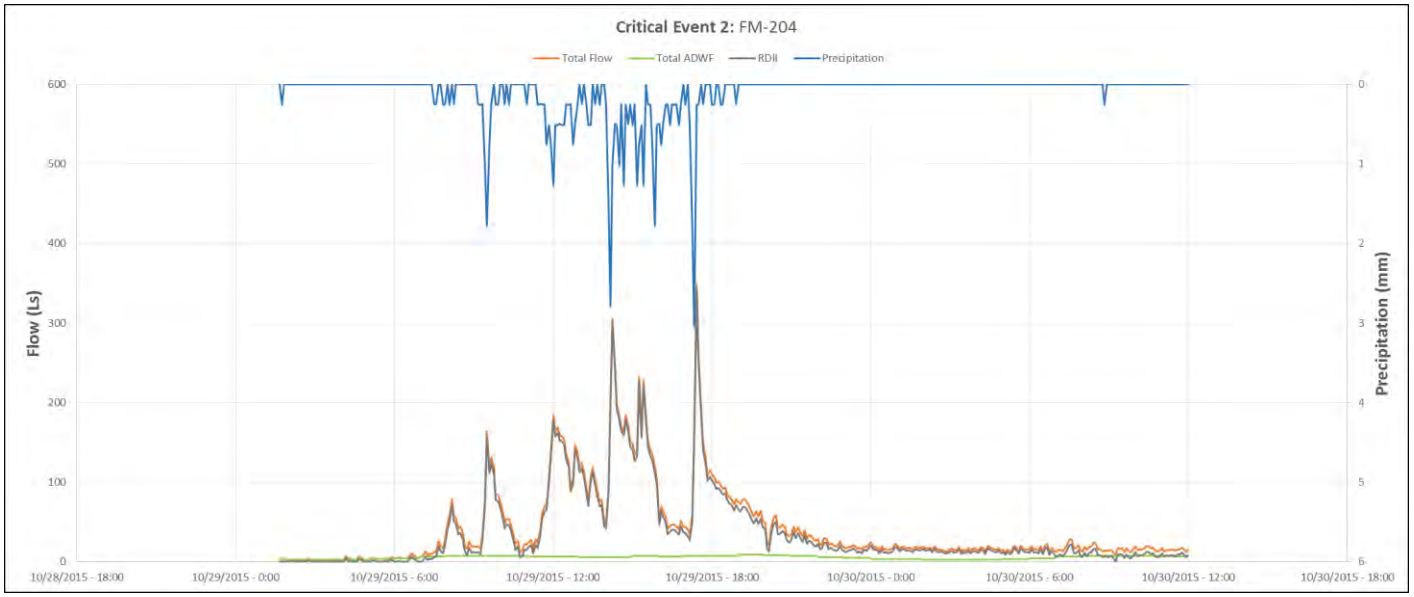
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	634	1.8	56%	58.74
CE2	10/29/2015	10	49	341	4.6	87%	31.59
CE3	11/13/2015	7	28	205	4.0	132%	18.95
CE4	11/21/2015	13	93	265	14.6	144%	24.51

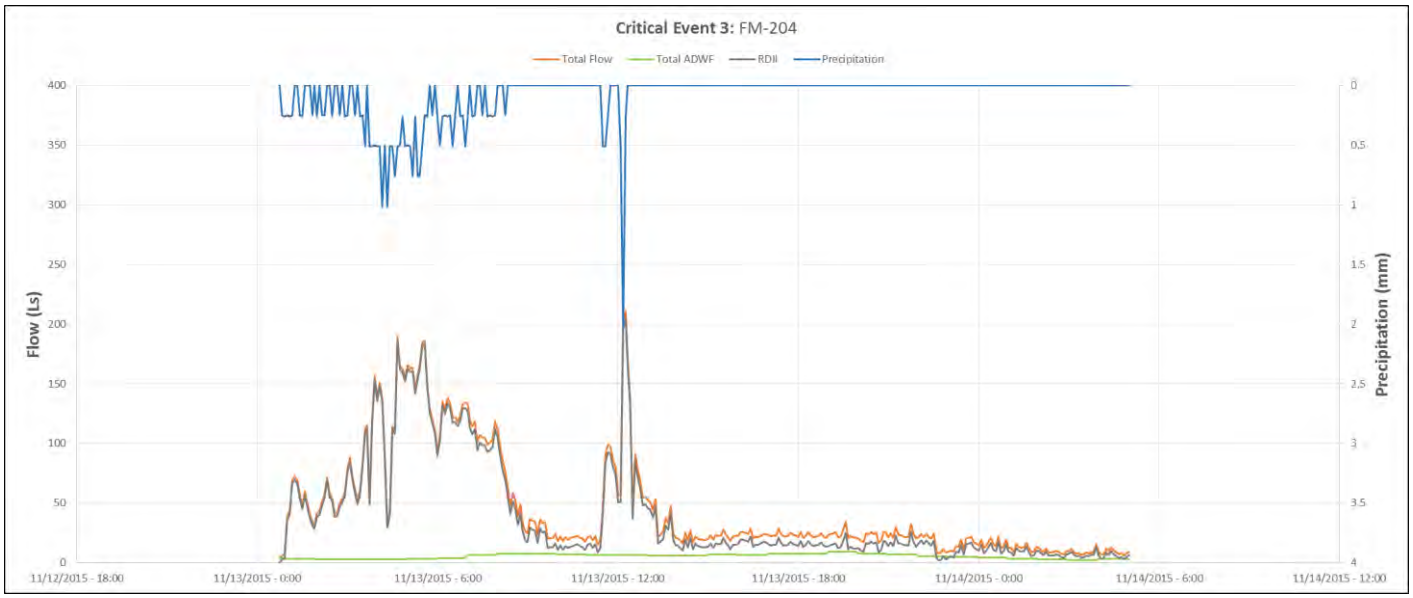
Estimated Peak Wet Weather Design Flows (L/s)

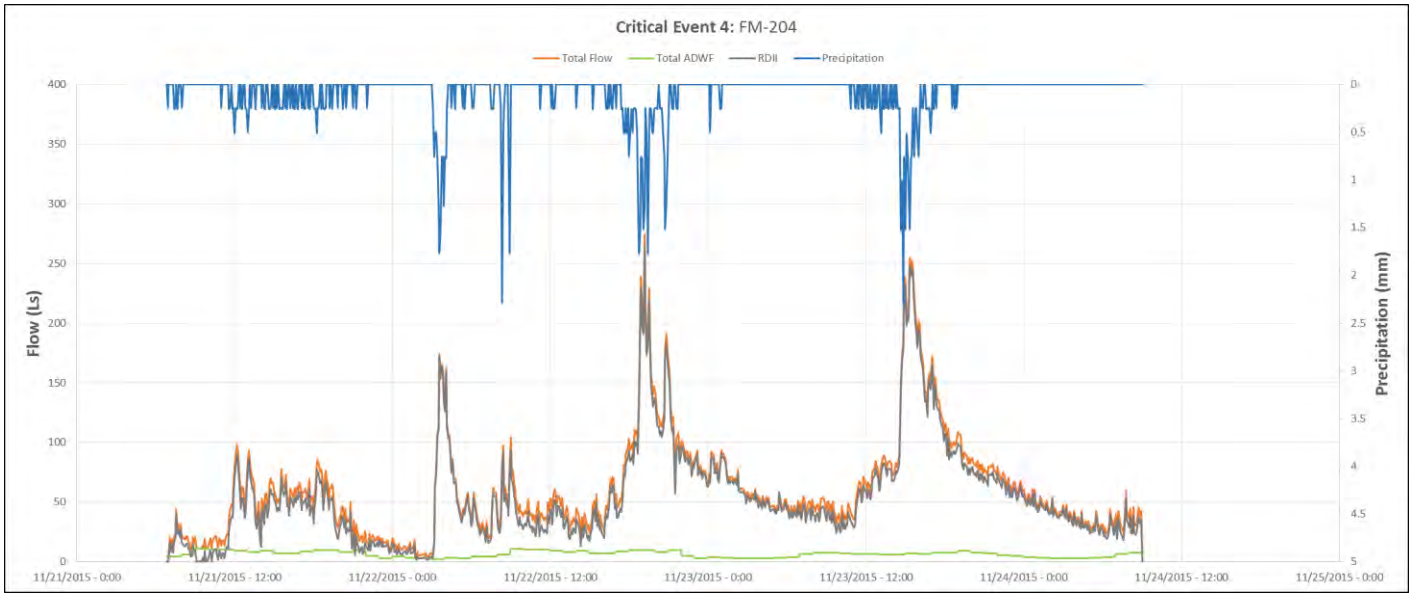
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	39	464	574	648	741	810	880

Wet Weather Flow Graphs



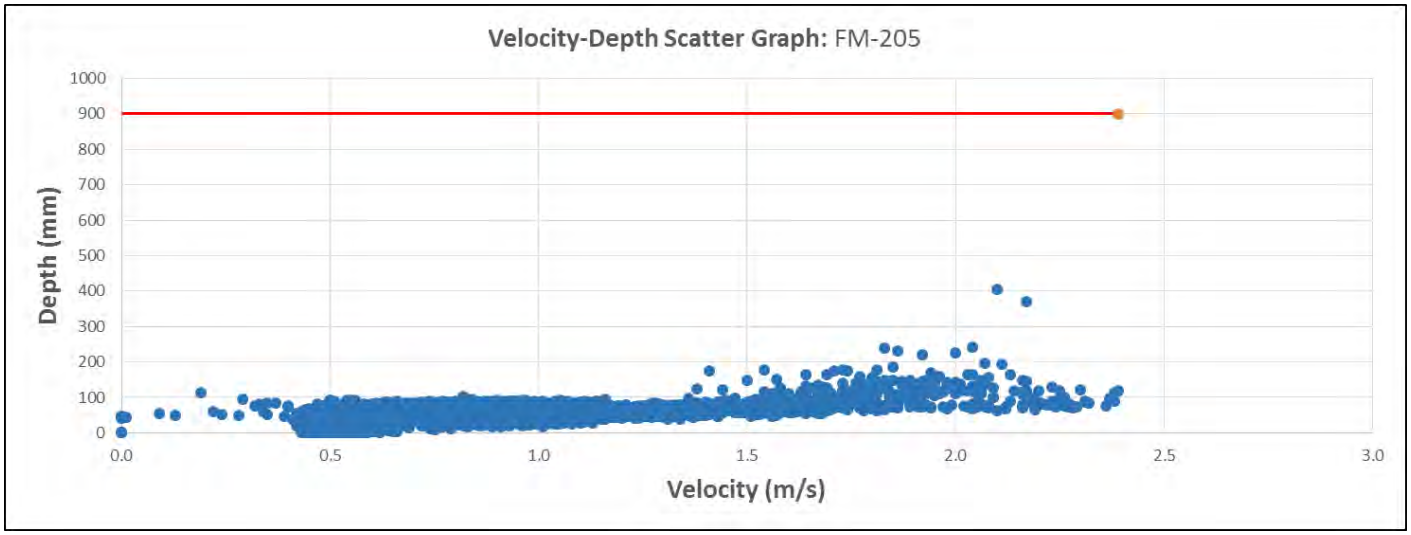



Critical Event 3: FM-204
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
400
350
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

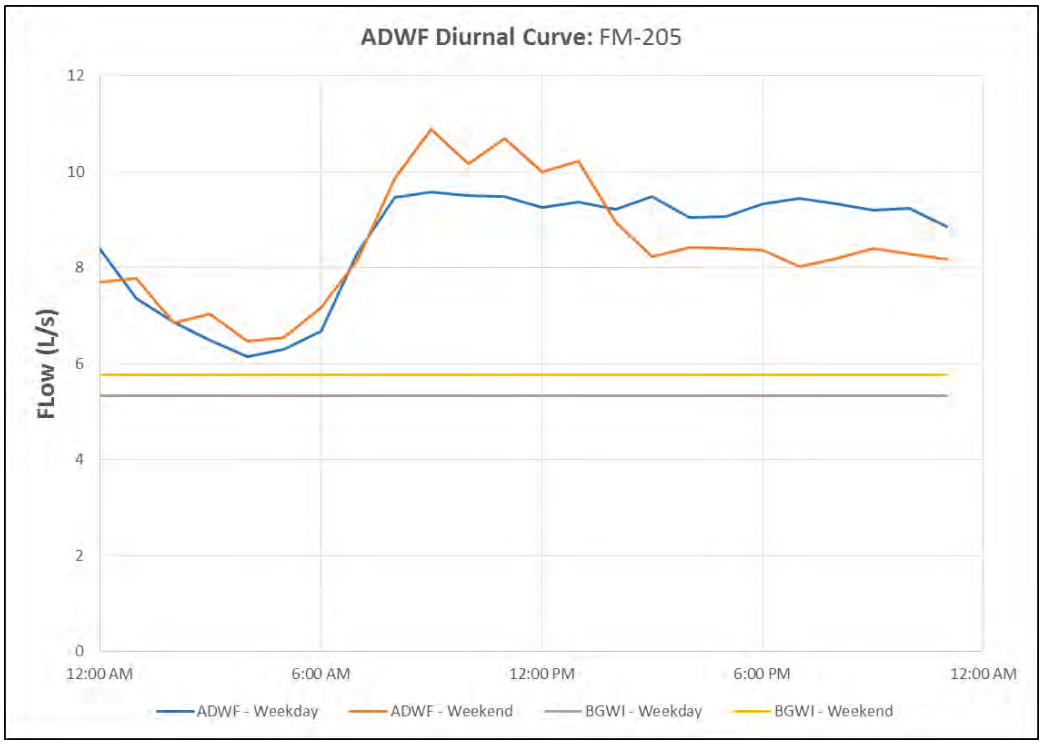

Critical Event 4: FM-204
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
400
350
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-205

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.94	0.72
0.63	0.75
0.47	0.40
0.36	0.47
0.25	0.26
0.30	0.29
0.42	0.52
0.92	0.89
1.28	1.52
1.32	1.90
1.29	1.63
1.29	1.84
1.22	1.57
1.25	1.66
1.21	1.19
1.29	0.91
1.15	0.99
1.16	0.98
1.24	0.96
1.27	0.84
1.24	0.90
1.20	0.98
1.21	0.93
1.10	0.89

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	8.6	8.5	L/s
MNF	6.1	6.5	L/s
BGWI	5.3	5.8	L/s
Unit BGWI	0.21	0.22	L/s/ha
Sanitary Flow	3.2	2.7	L/s
Per Capita Sanitary Flow	182.3	151.9	L/cap/d
Peak DWF	9.6	10.9	L/s

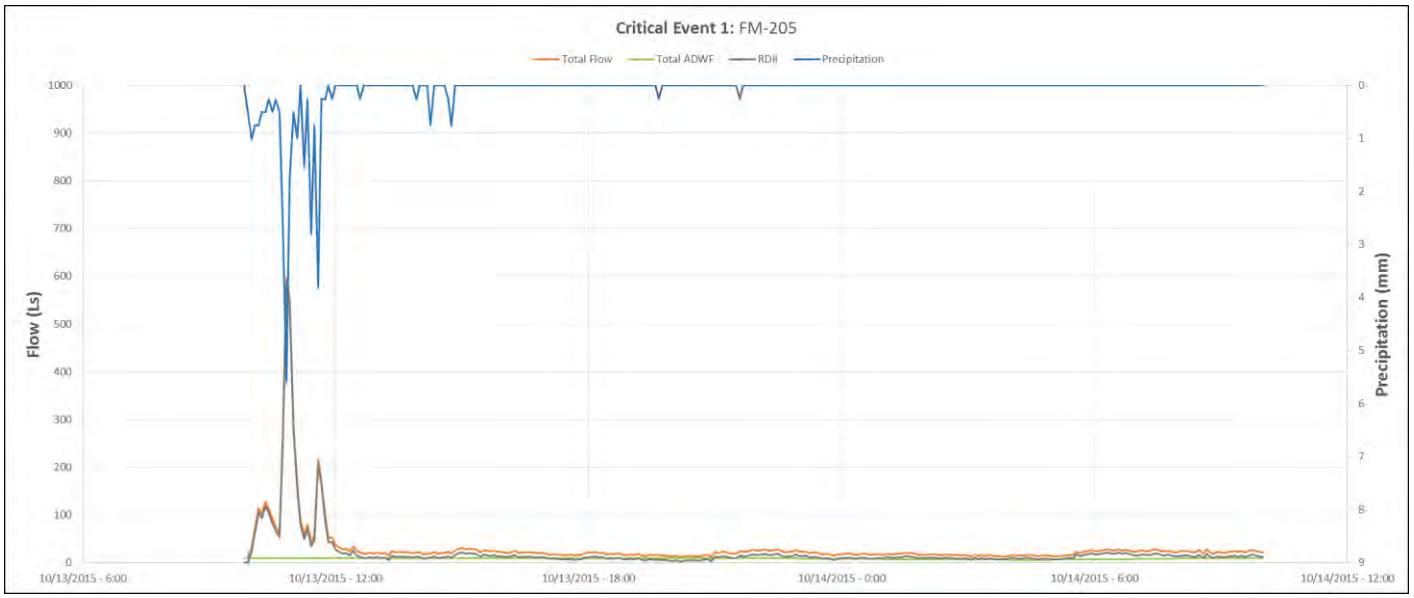
Quantification of RDII

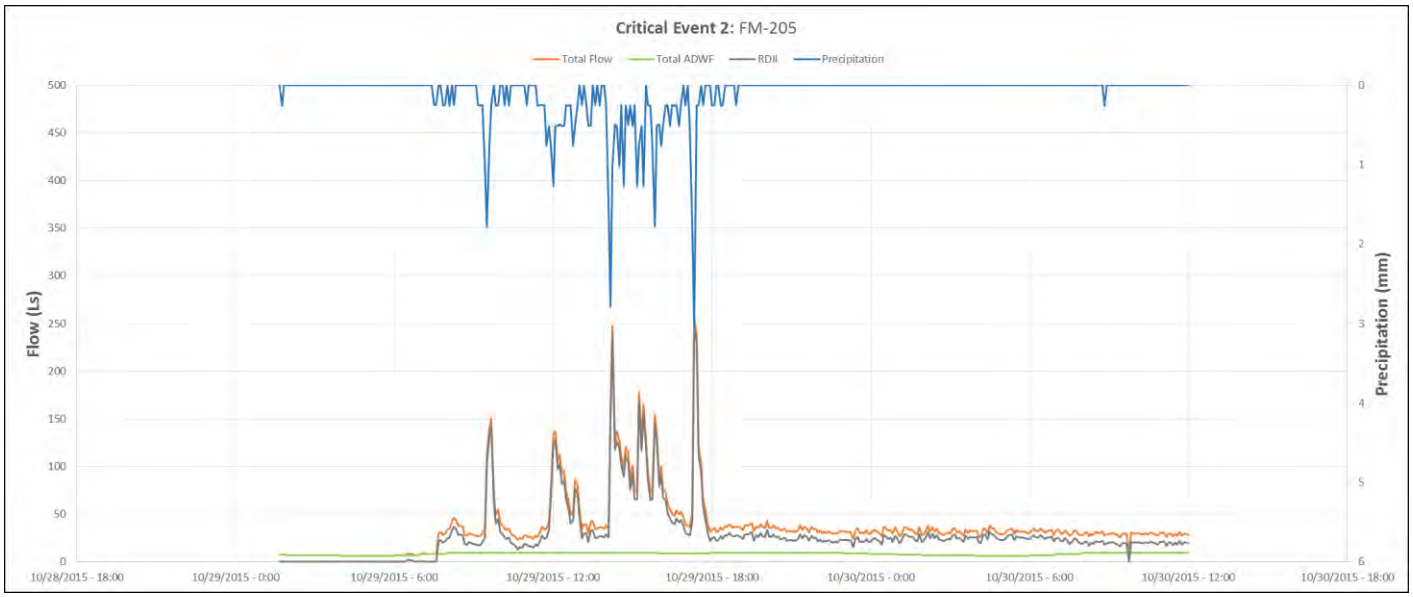
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	589	2.0	25%	22.74
CE2	10/29/2015	10	49	246	3.7	29%	9.51
CE3	11/13/2015	7	28	141	2.5	35%	5.43
CE4	11/21/2015	13	93	210	7.8	32%	8.11

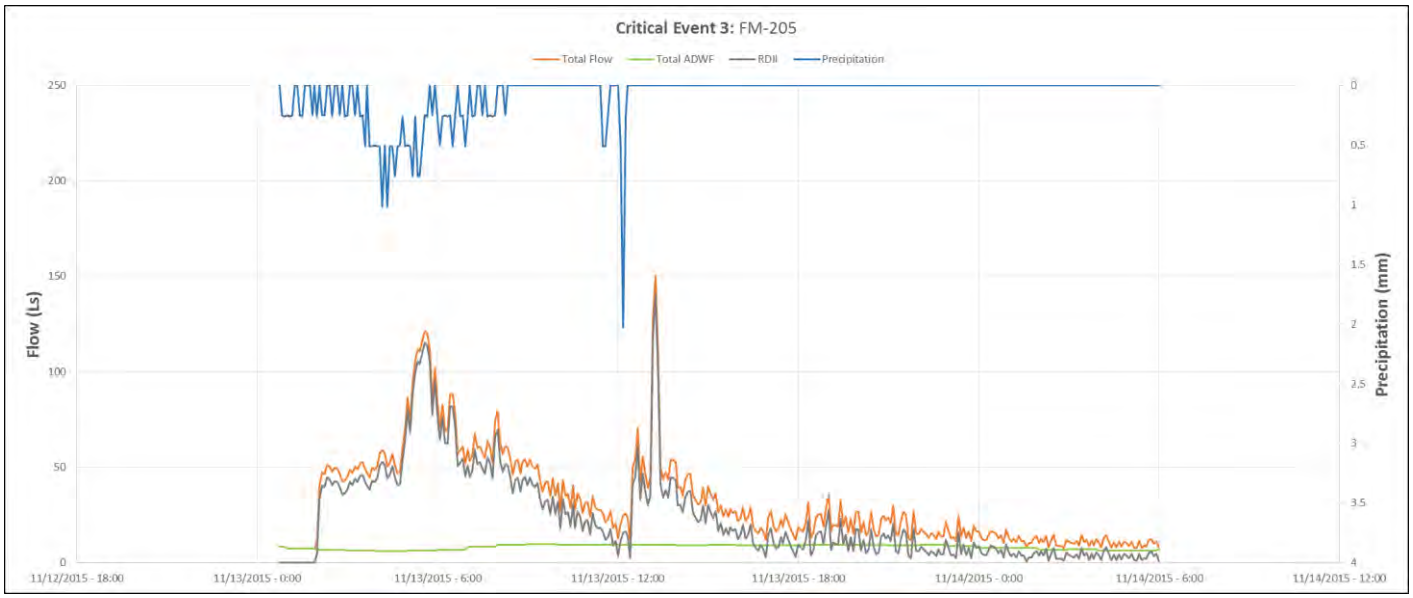
Estimated Peak Wet Weather Design Flows (L/s)

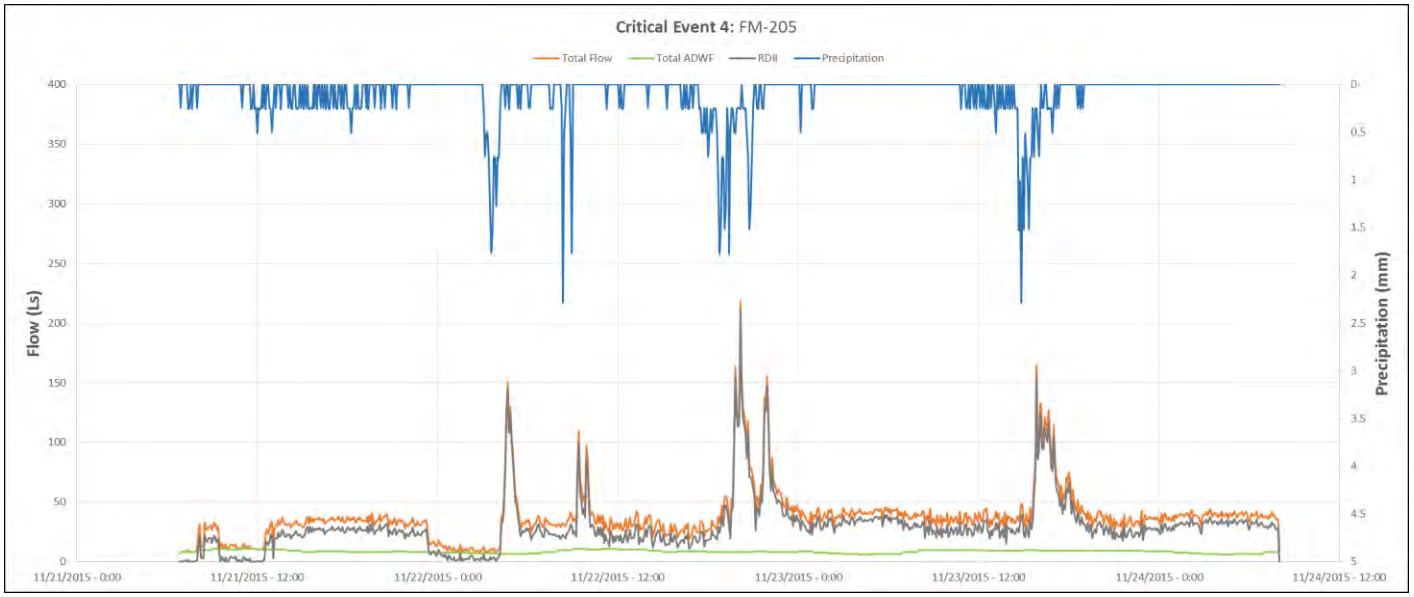
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	30	372	474	542	628	691	754

Wet Weather Flow Graphs



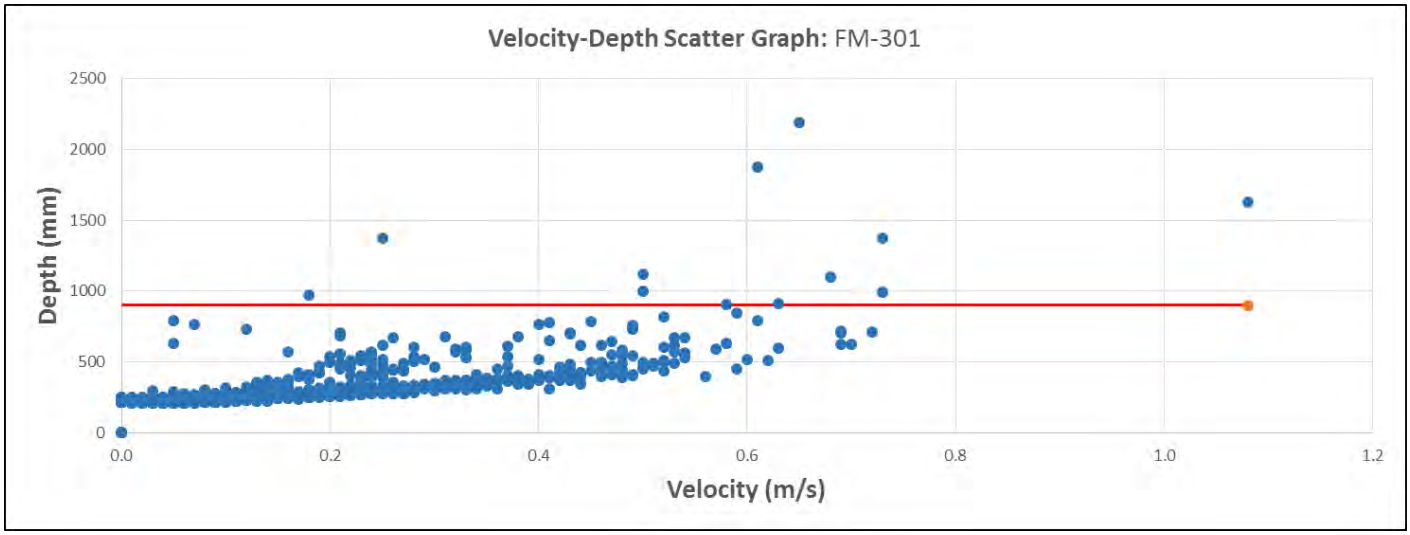



Critical Event 3: FM-205
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

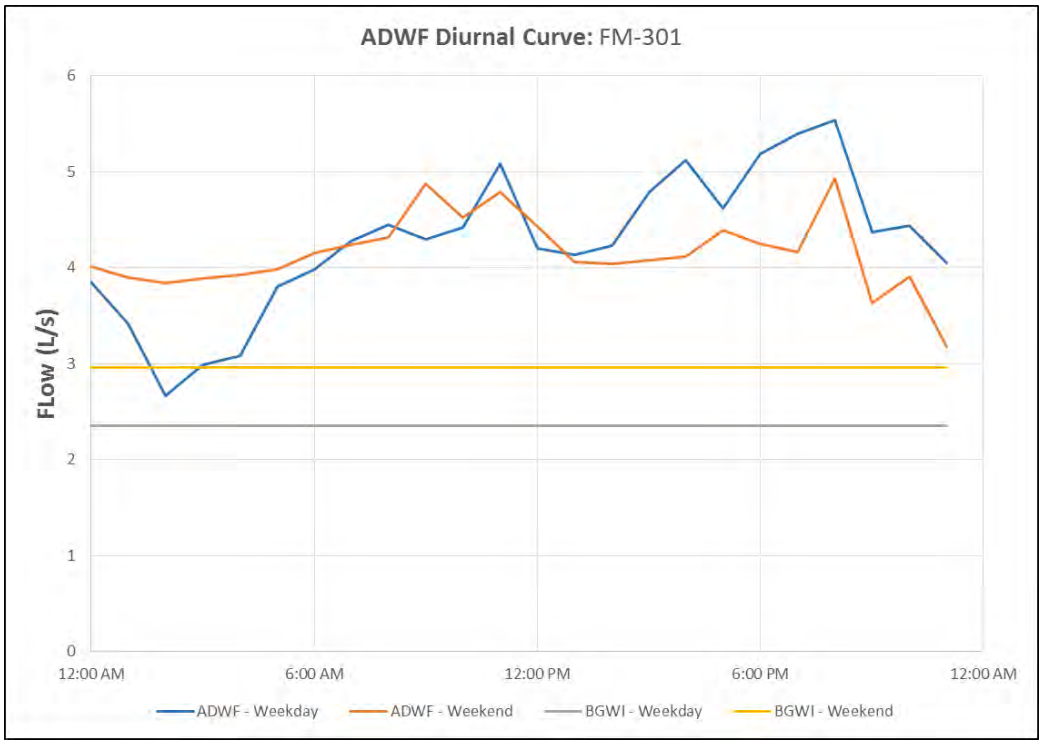

Critical Event 4: FM-205
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
400
350
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00

FM-301

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.78	0.88
0.56	0.79
0.16	0.74
0.33	0.78
0.38	0.81
0.76	0.86
0.85	1.00
1.01	1.07
1.09	1.14
1.01	1.61
1.08	1.31
1.43	1.53
0.97	1.23
0.93	0.92
0.98	0.91
1.27	0.94
1.45	0.97
1.18	1.20
1.48	1.08
1.59	1.01
1.67	1.65
1.05	0.57
1.09	0.79
0.89	0.19

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	4.3	4.2	L/s
MNF	2.7	3.2	L/s
BGWI	2.4	3.0	L/s
Unit BGWI	0.06	0.08	L/s/ha
Sanitary Flow	1.9	1.2	L/s
Per Capita Sanitary Flow	351.2	219.8	L/cap/d
Peak DWF	5.5	4.9	L/s

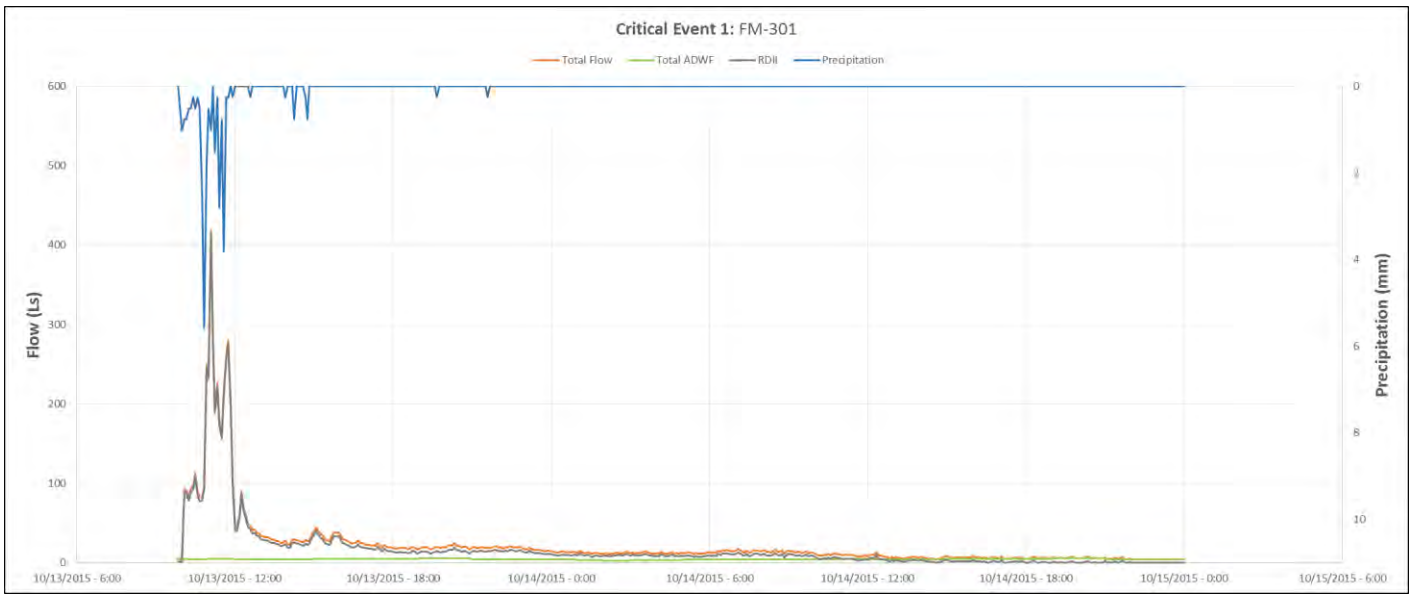
Quantification of RDII

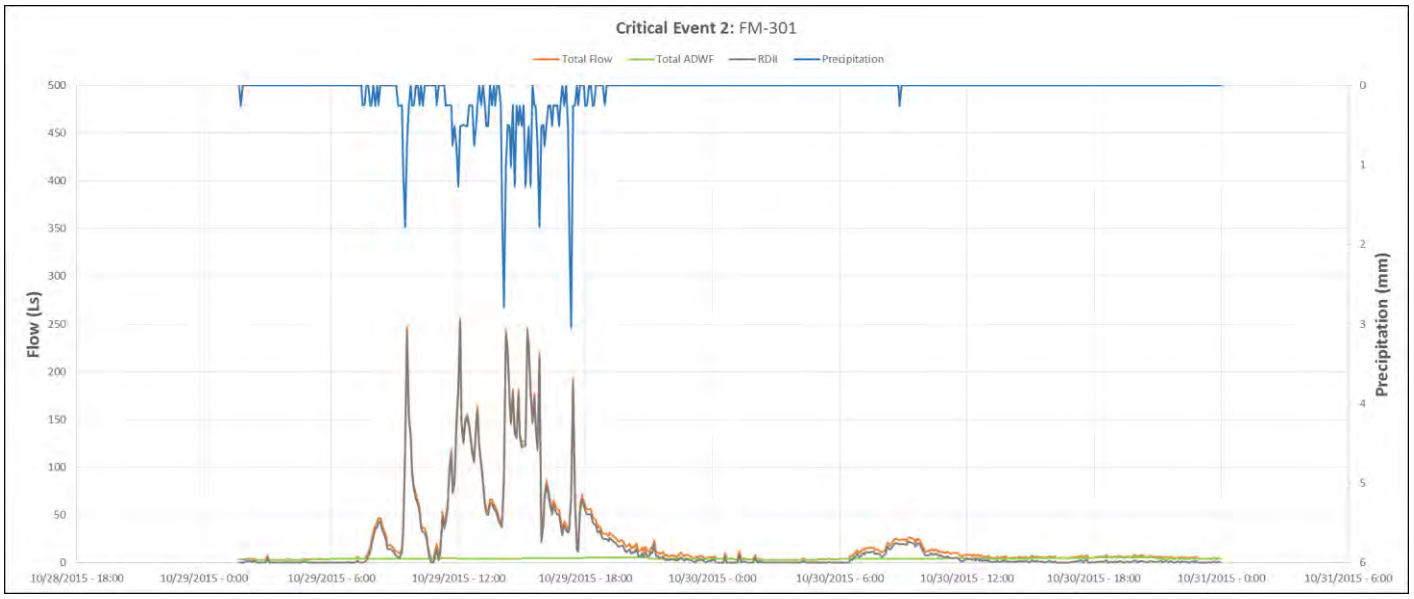
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	414	2.5	22%	10.69
CE2	10/29/2015	10	49	252	3.5	18%	6.50

Estimated Peak Wet Weather Design Flows (L/s)

Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	17	489	607	686	785	859	933

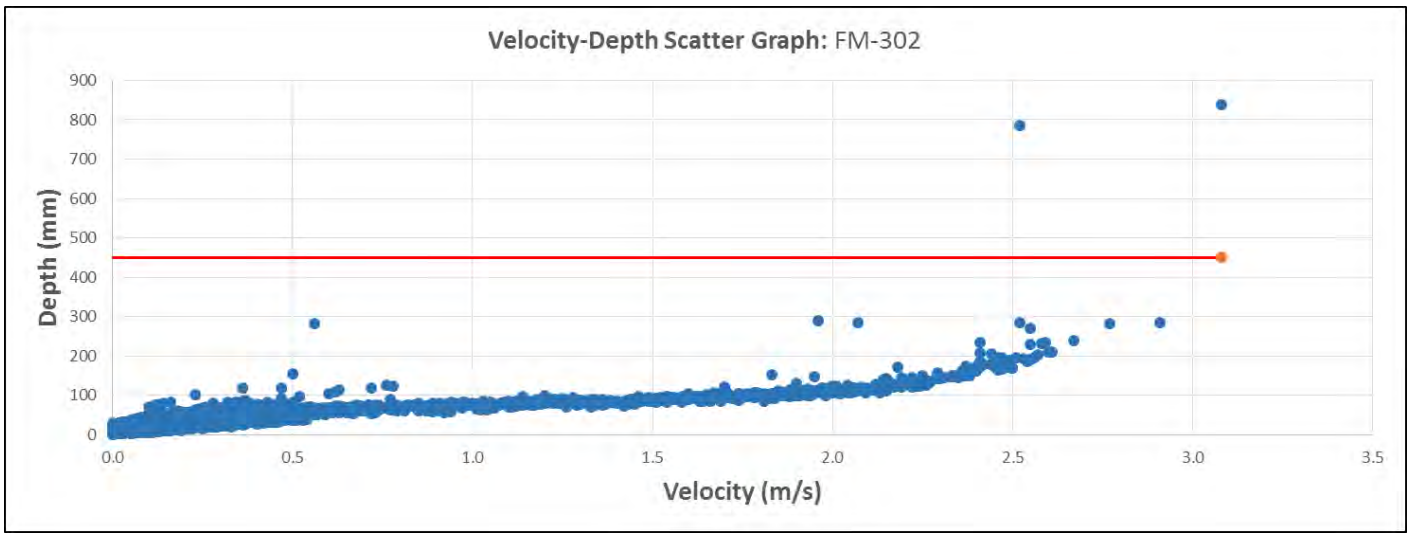
Wet Weather Flow Graphs





FM-302

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors

*Stormwater Sewer System

Dry Weather Flow Analysis

*Stormwater Sewer System

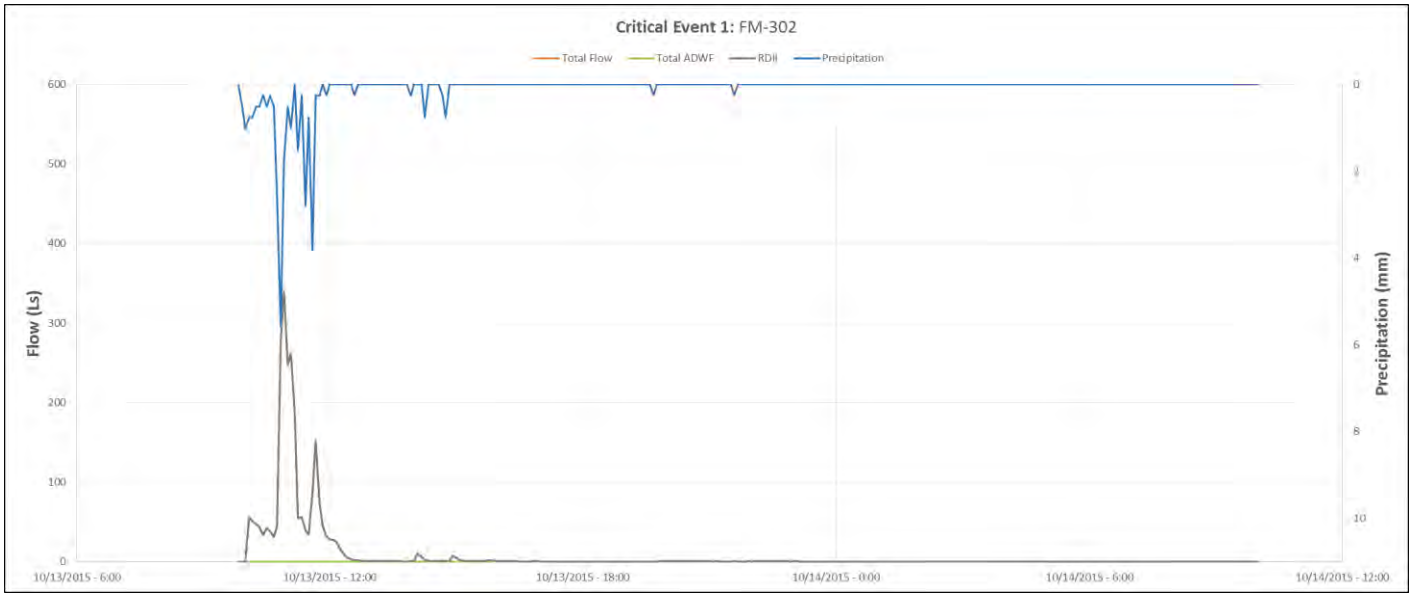
Quantification of RDII

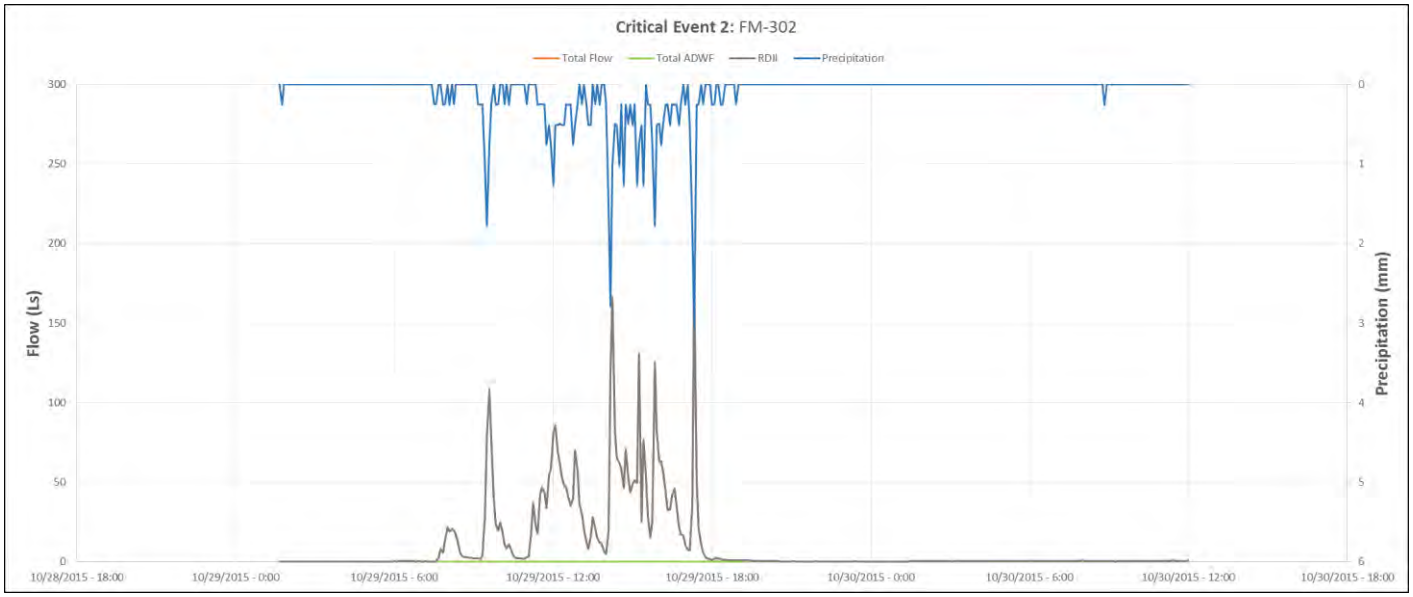
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	340	0.8	11%	14.29
CE2	10/29/2015	10	49	175	1.3	11%	7.37
CE3	11/13/2015	7	28	83	0.9	13%	3.49
CE4	11/21/2015	13	93	198	3.2	14%	8.33

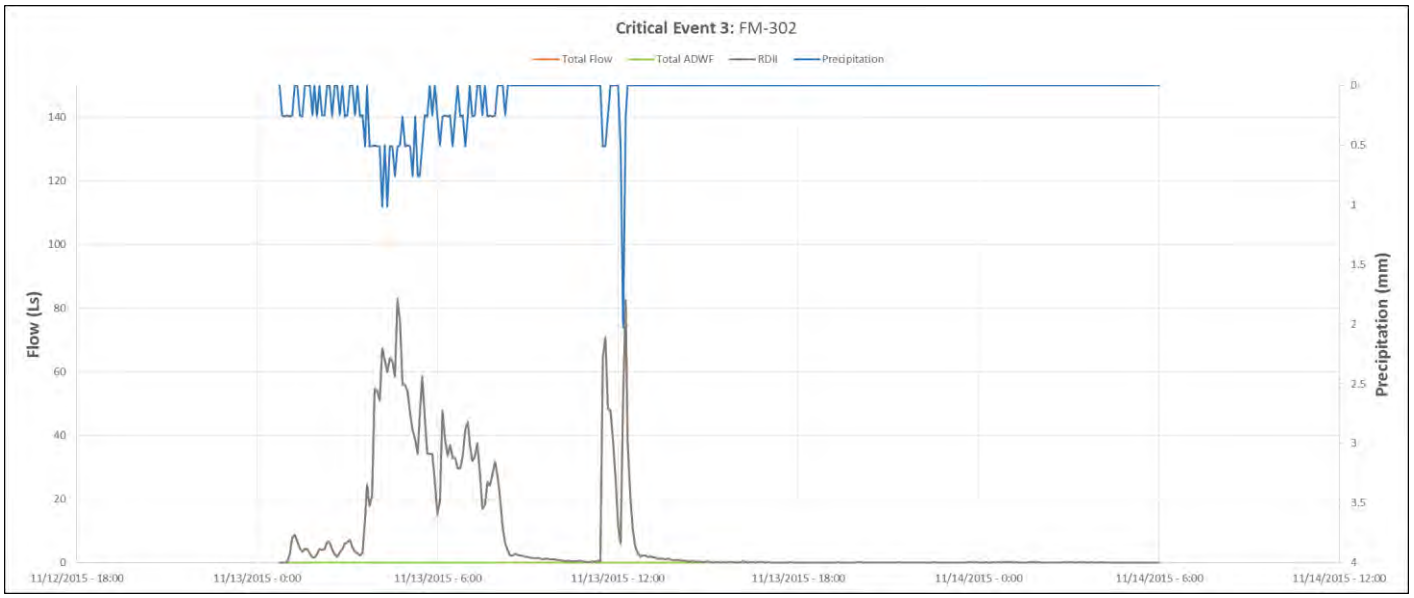
Estimated Peak Wet Weather Design Flows (L/s)

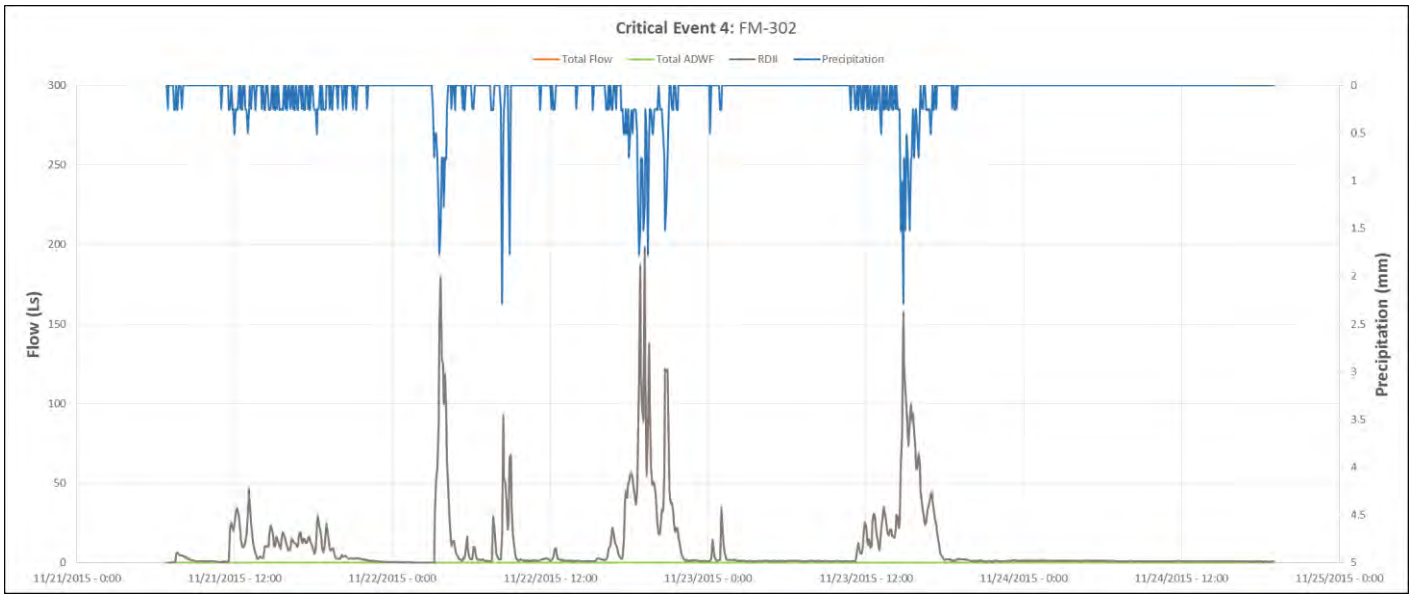
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	NA	238	304	349	406	447	488

Wet Weather Flow Graphs



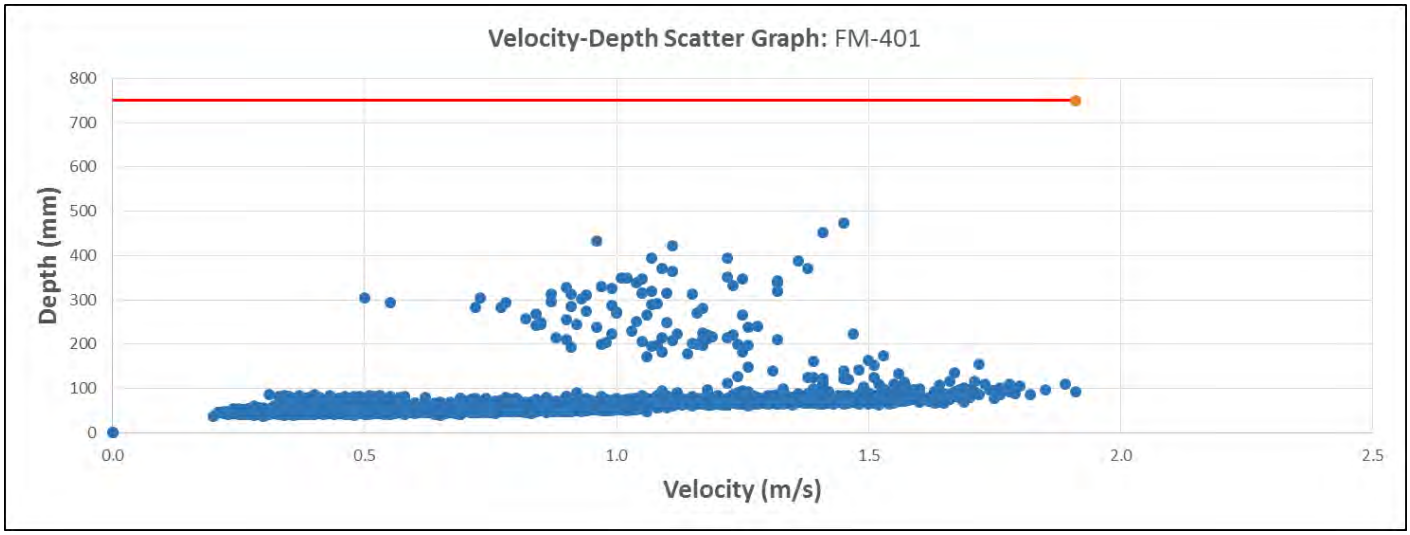



Critical Event 3: FM-302
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
20
40
60
80
100
120
140
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

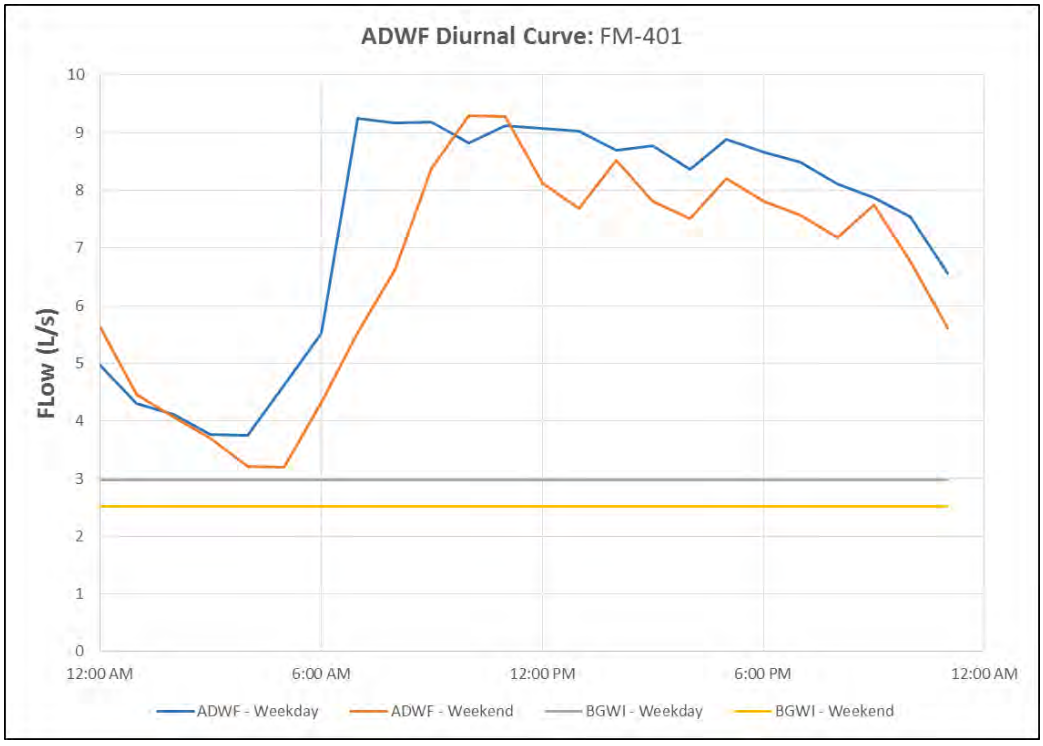

Critical Event 4: FM-302
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
0
50
100
150
200
250
300
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-401

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.46	0.76
0.30	0.48
0.26	0.38
0.18	0.29
0.18	0.17
0.38	0.16
0.58	0.44
1.43	0.74
1.41	1.01
1.41	1.44
1.33	1.67
1.40	1.66
1.39	1.38
1.38	1.27
1.30	1.47
1.32	1.30
1.23	1.22
1.35	1.40
1.30	1.30
1.26	1.24
1.17	1.14
1.12	1.28
1.04	1.04
0.82	0.76

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	7.4	6.6	L/s
MNF	3.8	3.2	L/s
BGWI	3.0	2.5	L/s
Unit BGWI	0.23	0.19	L/s/ha
Sanitary Flow	4.4	4.1	L/s
Per Capita Sanitary Flow	424.2	393.3	L/cap/d
Peak DWF	9.3	9.3	L/s

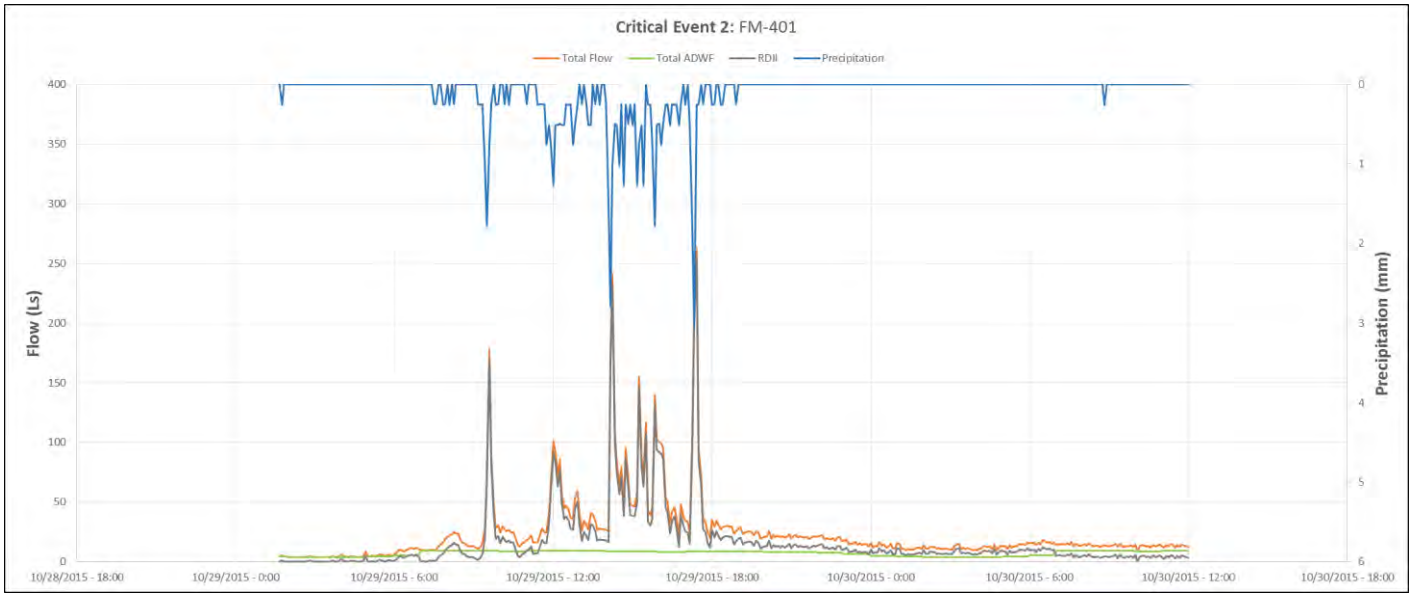
Quantification of RDII

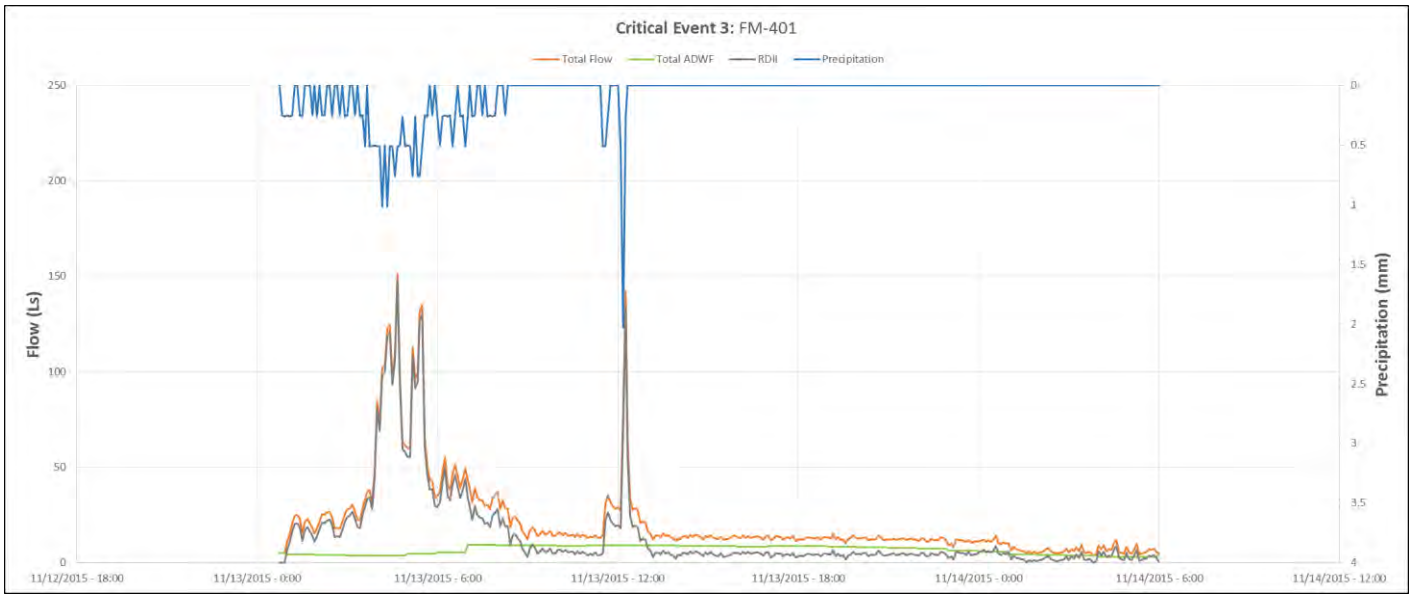
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE2	10/29/2015	10	49	254	2.1	33%	19.52
CE3	11/13/2015	7	28	148	1.6	42%	11.37
CE4	11/21/2015	13	94	339	7.0	57%	26.11

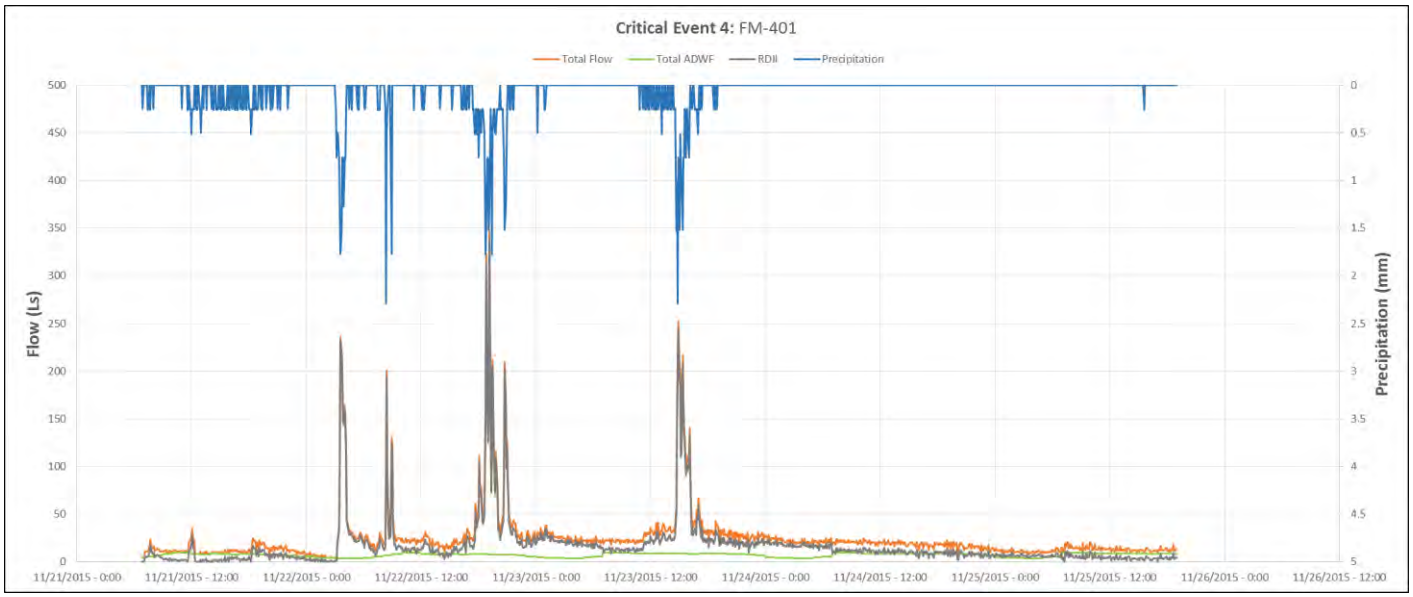
Estimated Peak Wet Weather Design Flows (L/s)

Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	36	361	459	526	610	671	732

Wet Weather Flow Graphs

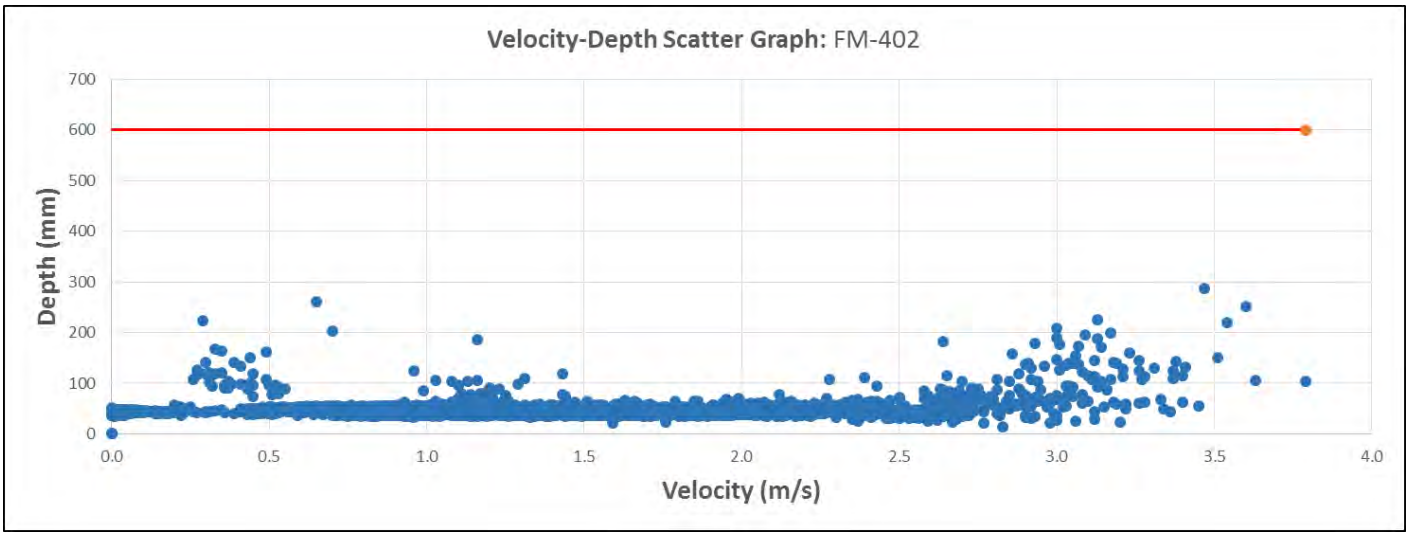



Critical Event 3: FM-401
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

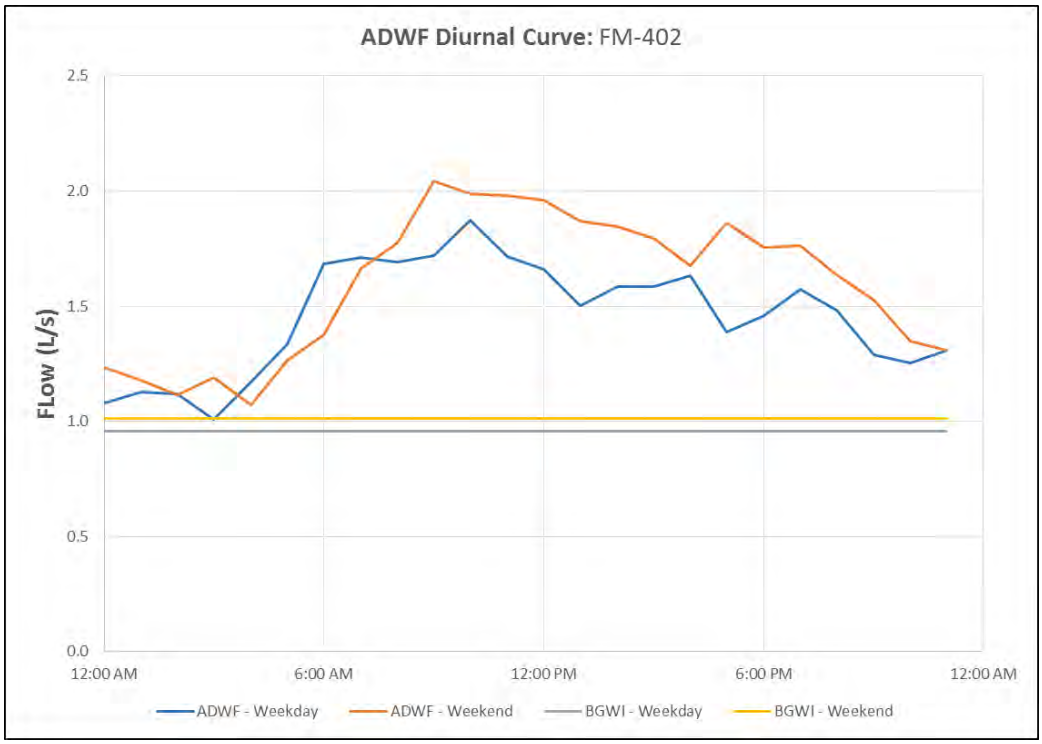

Critical Event 4: FM-401
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
500
450
400
350
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00
11/25/2015 - 12:00
11/26/2015 - 0:00
11/26/2015 - 12:00

FM-402

Velocity-Depth Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.24	0.38
0.34	0.28
0.33	0.18
0.10	0.31
0.42	0.10
0.76	0.44
1.46	0.63
1.51	1.12
1.48	1.32
1.53	1.78
1.84	1.68
1.52	1.67
1.41	1.63
1.09	1.48
1.26	1.43
1.26	1.34
1.36	1.14
0.86	1.47
1.00	1.28
1.24	1.29
1.05	1.08
0.67	0.89
0.59	0.58
0.70	0.51

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	1.5	1.6	L/s
MNF	1.0	1.1	L/s
BGWI	1.0	1.0	L/s
Unit BGWI	0.07	0.08	L/s/ha
Sanitary Flow	0.5	0.6	L/s
Per Capita Sanitary Flow	106.7	124.4	L/cap/d
Peak DWF	1.9	2.0	L/s

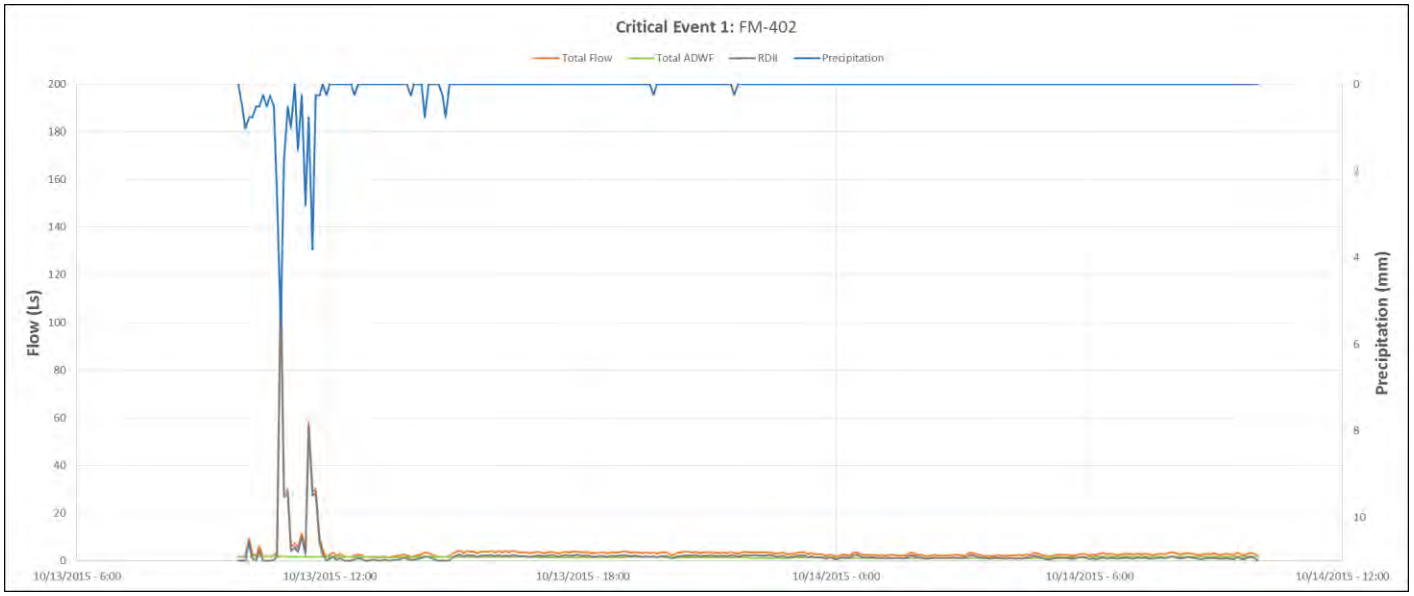
Quantification of RDII

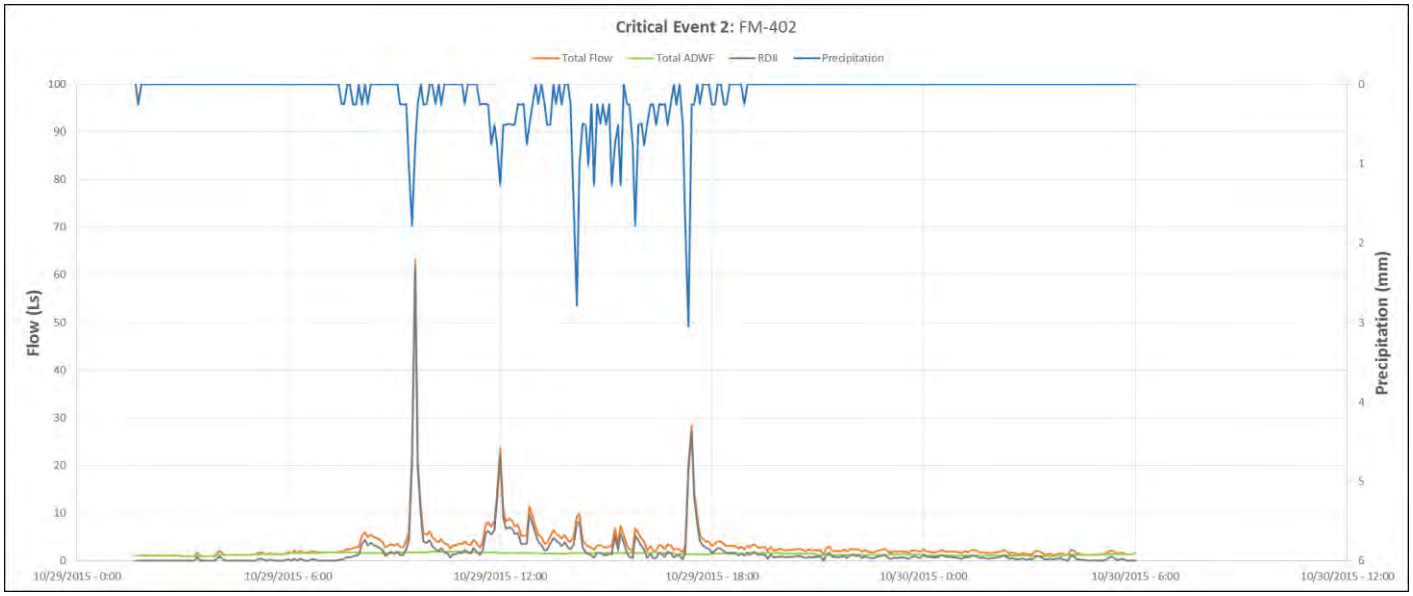
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	116	0.2	5%	8.73
CE2	10/29/2015	10	49	61	0.2	3%	4.62
CE3	11/13/2015	7	29	66	0.1	4%	4.94
CE4	11/21/2015	13	93	178	0.8	6%	13.38

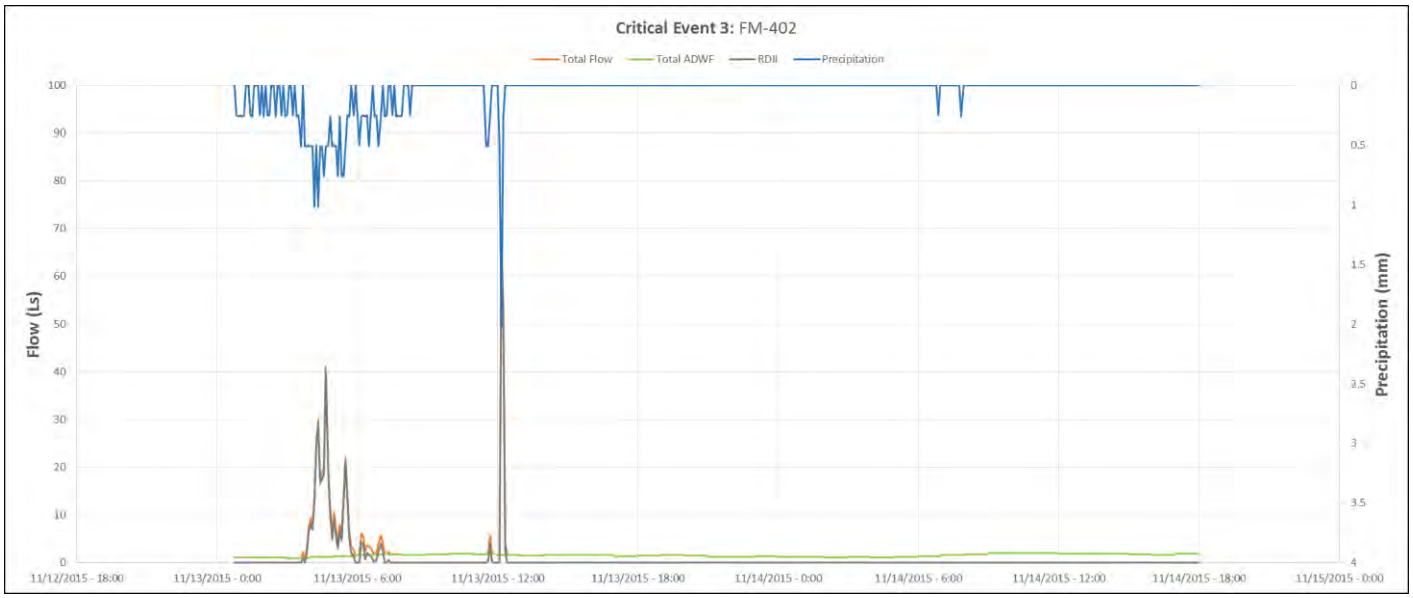
Estimated Peak Wet Weather Design Flows (L/s)

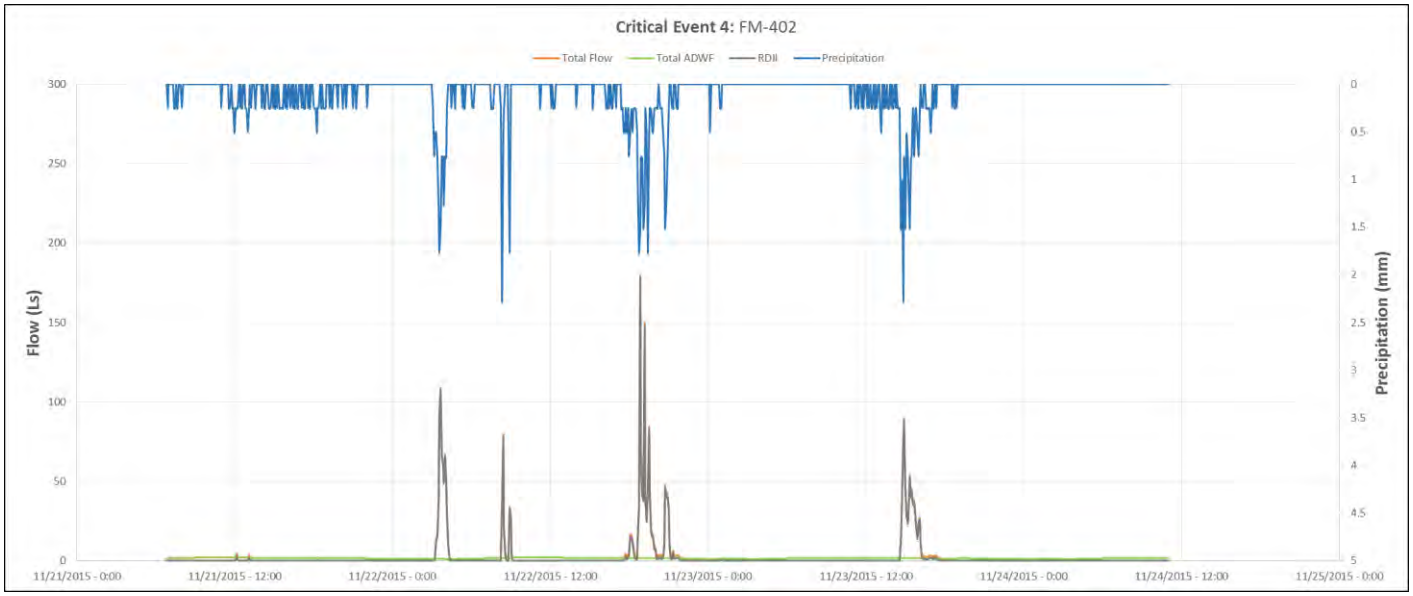
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	5	74	91	103	118	129	140

Wet Weather Flow Graphs



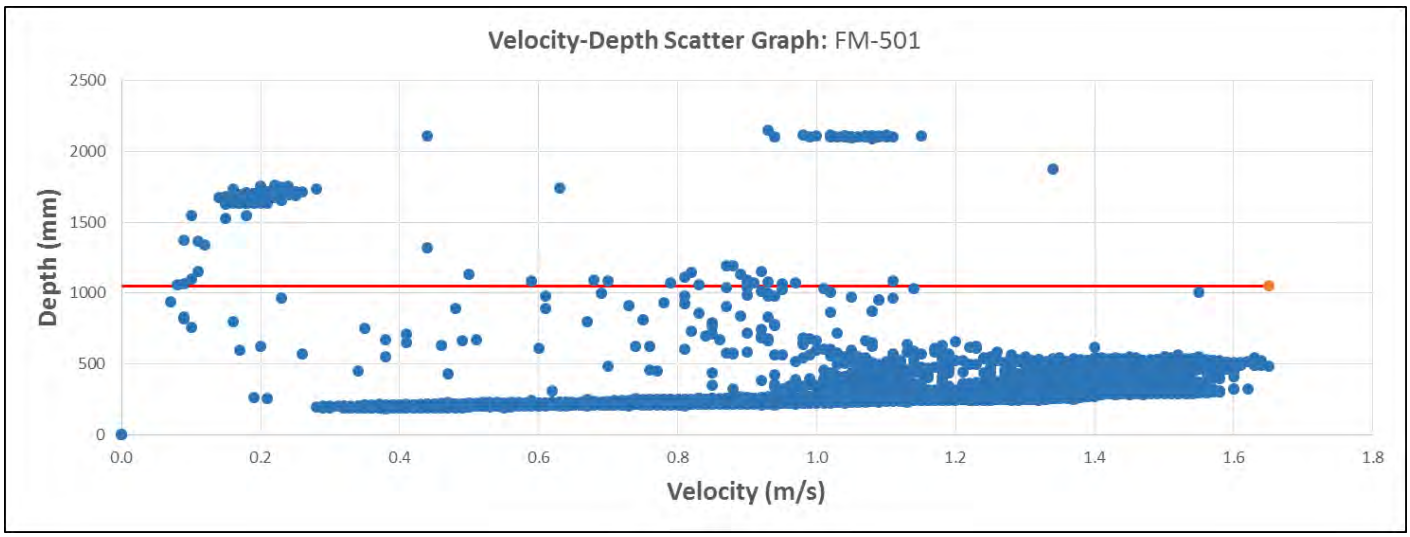



Critical Event 3: FM-402
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00

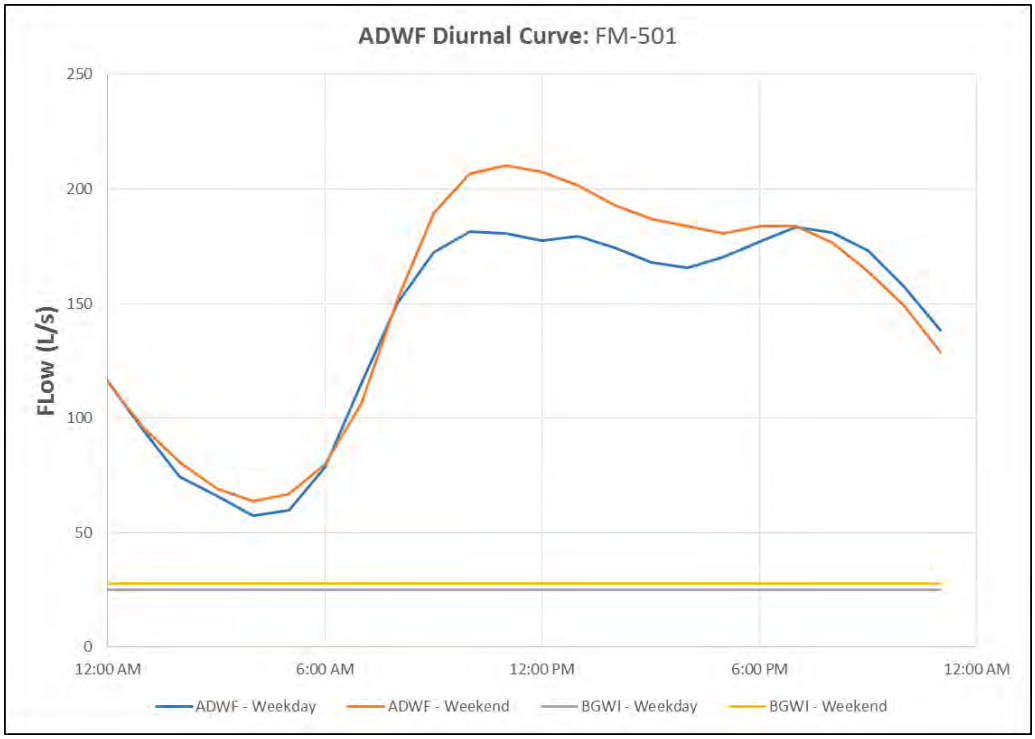

Critical Event 4: FM-402
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-501

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.78	0.72
0.60	0.56
0.43	0.44
0.35	0.34
0.28	0.30
0.30	0.32
0.46	0.43
0.78	0.65
1.08	1.02
1.27	1.33
1.34	1.48
1.34	1.51
1.31	1.48
1.33	1.43
1.28	1.36
1.23	1.31
1.21	1.29
1.25	1.26
1.31	1.29
1.36	1.29
1.34	1.23
1.27	1.12
1.14	1.00
0.98	0.83

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	141.4	149.0	L/s
MNF	57.5	63.9	L/s
BGWI	24.9	27.8	L/s
Unit BGWI	0.01	0.02	L/s/ha
Sanitary Flow	116.4	121.2	L/s
Per Capita Sanitary Flow	532.9	554.7	L/cap/d
Peak DWF	183.2	210.3	L/s

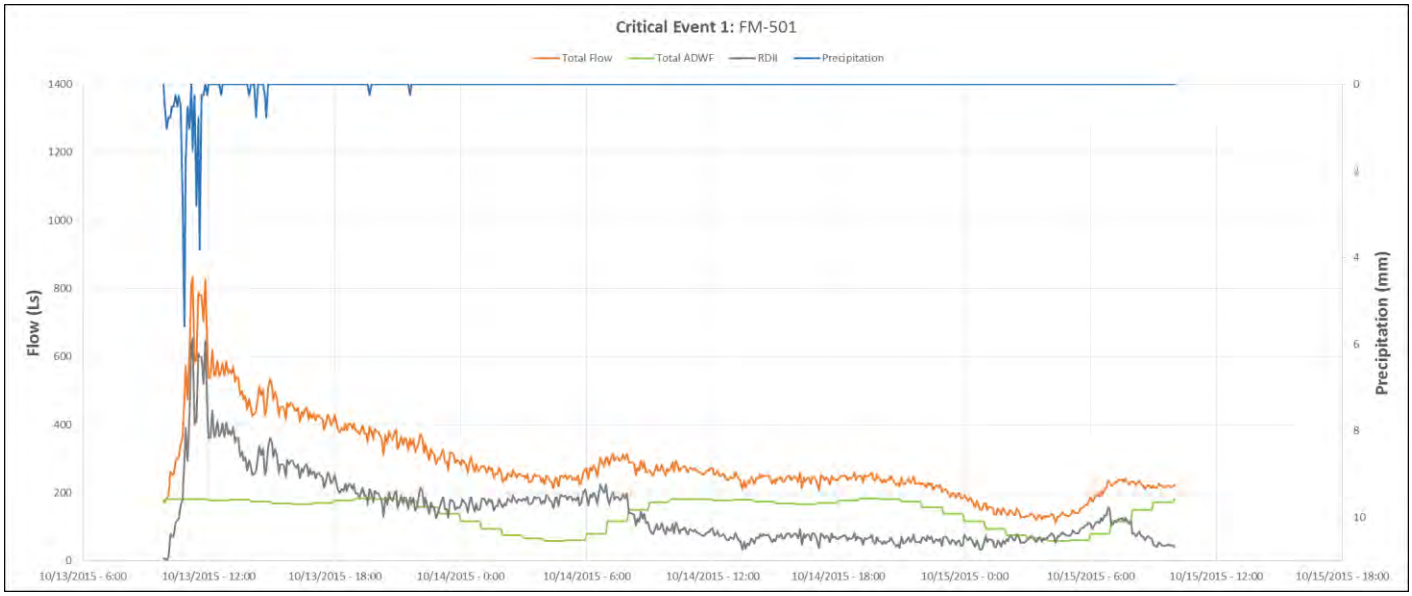
Quantification of RDII

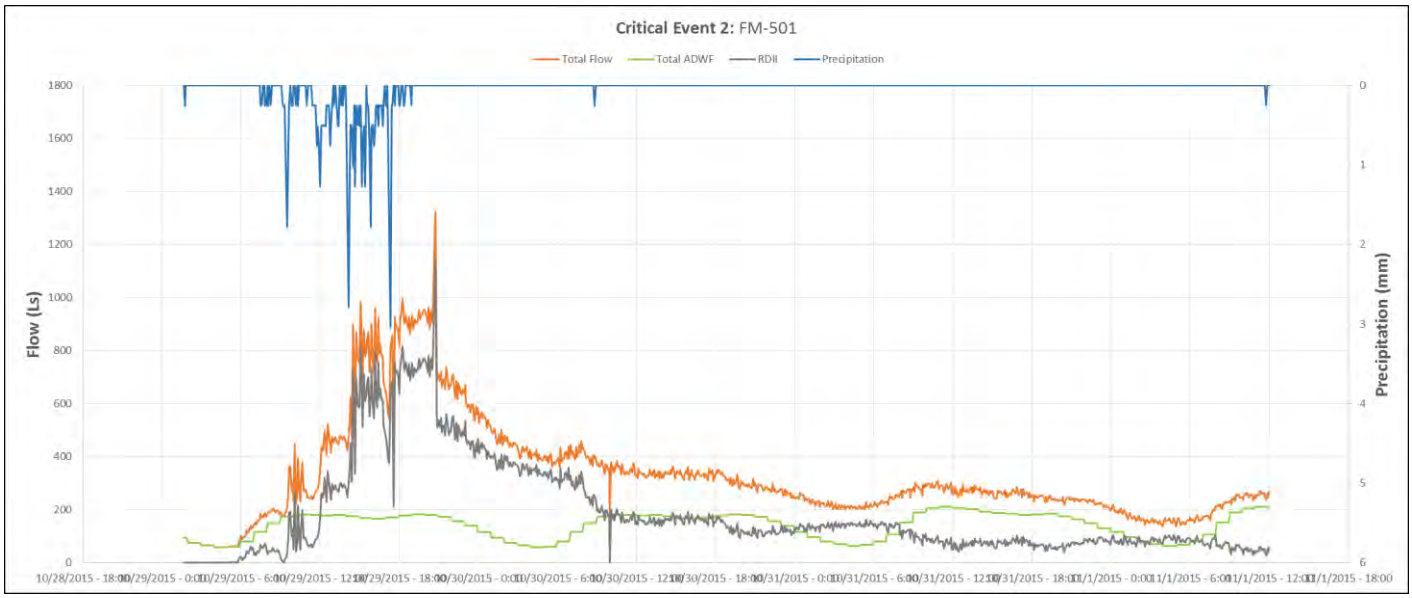
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	652	25.0	5%	0.36
CE2	10/29/2015	10	50	1143	55.7	6%	0.63
CE3	11/13/2015	7	29	447	24.7	5%	0.25
CE4	11/21/2015	13	94	628	151.1	9%	0.35

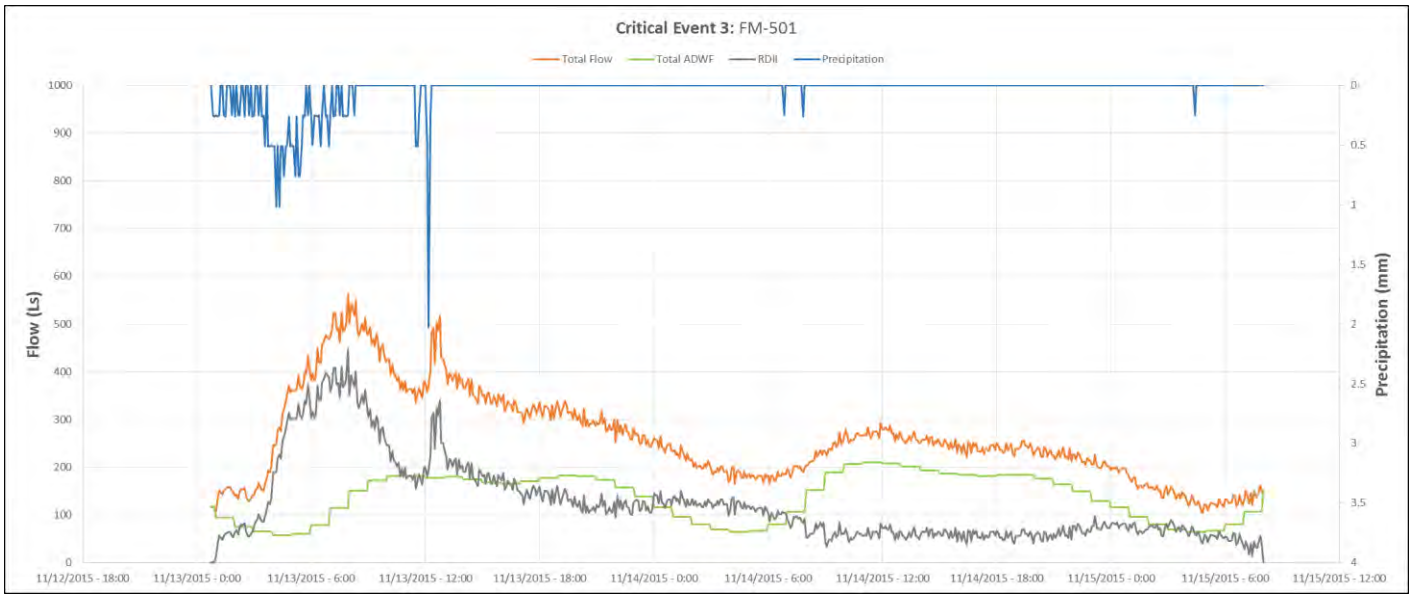
Estimated Peak Wet Weather Design Flows (L/s)

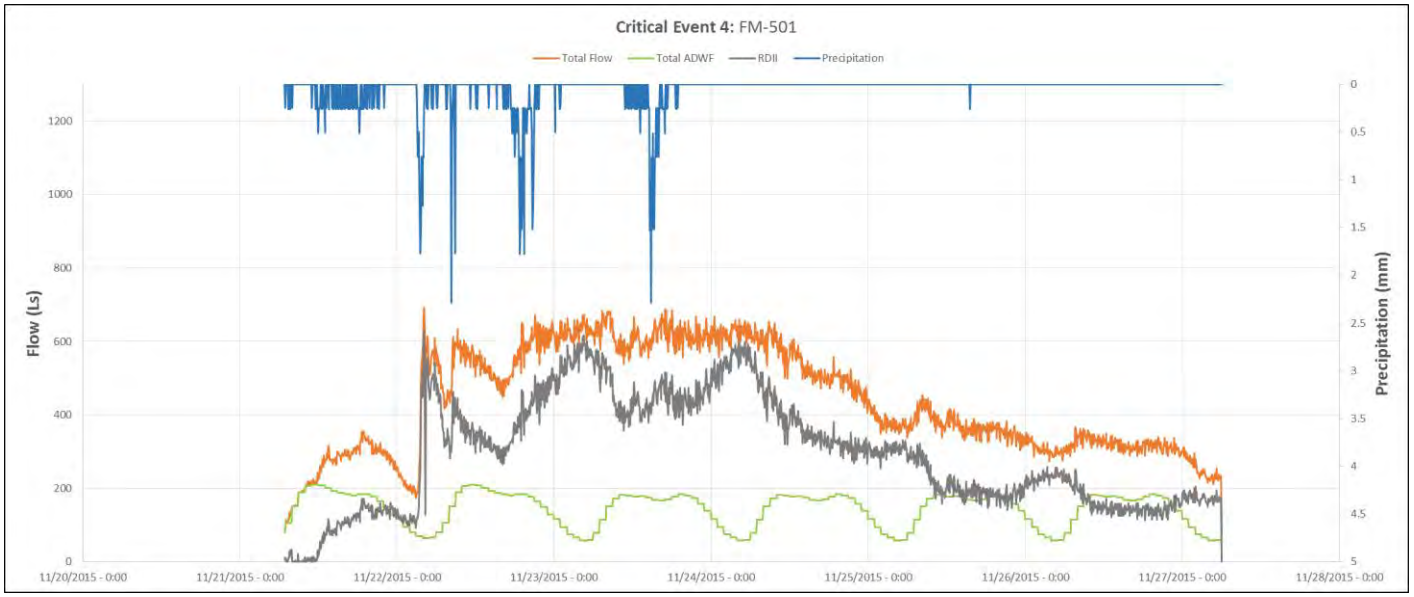
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	739	1423	1749	1966	2237	2437	2636

Wet Weather Flow Graphs



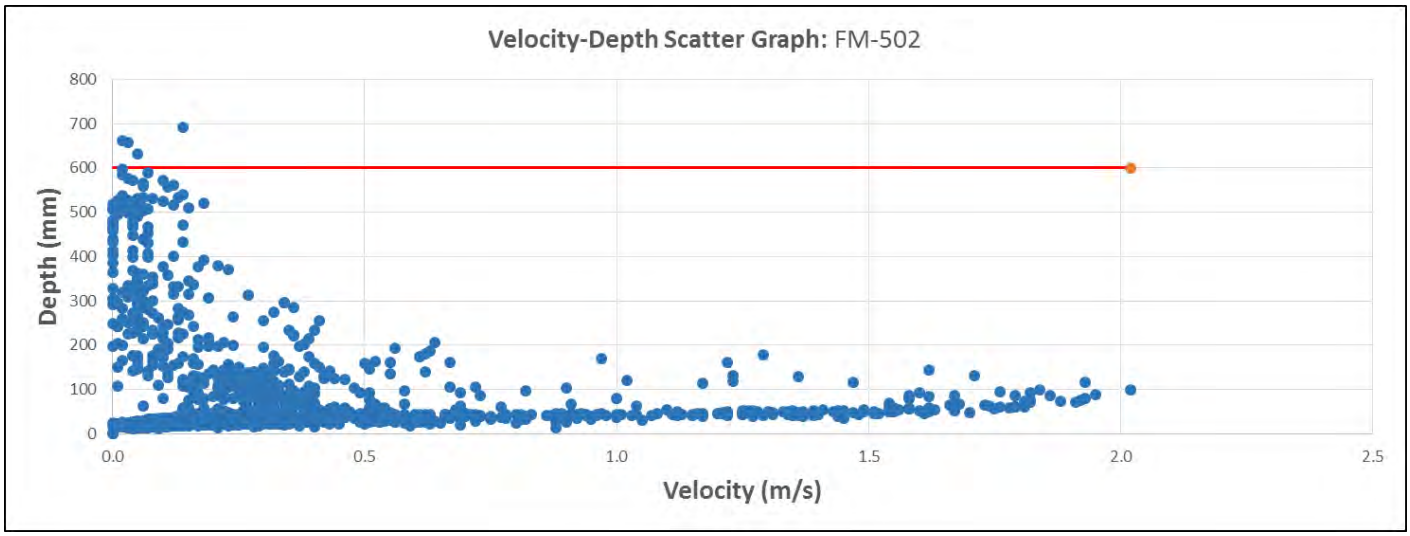



Critical Event 3: FM-501
Total Flow
Total ADWF
RDII
Precipitation
Flow (ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00
11/15/2015 - 12:00

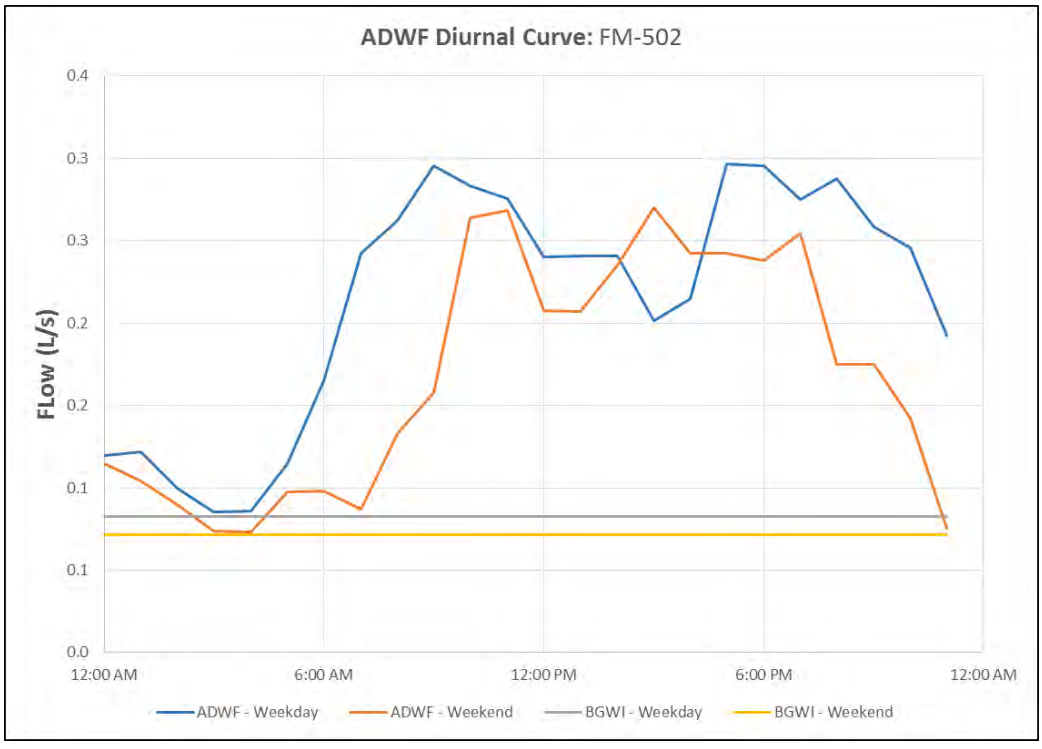

Critical Event 4: FM-501
Total Flow
Total ADWF
RDII
Precipitation
Flow (ls)
Precipitation (mm)
11/20/2015 - 0:00
11/21/2015 - 0:00
11/22/2015 - 0:00
11/23/2015 - 0:00
11/24/2015 - 0:00
11/25/2015 - 0:00
11/26/2015 - 0:00
11/27/2015 - 0:00
11/28/2015 - 0:00

FM-502

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.28	0.45
0.30	0.34
0.13	0.19
0.02	0.02
0.03	0.02
0.24	0.27
0.62	0.28
1.22	0.16
1.37	0.64
1.62	0.90
1.53	2.00
1.47	2.05
1.20	1.41
1.20	1.41
1.20	1.70
0.90	2.06
1.00	1.78
1.63	1.78
1.62	1.73
1.46	1.90
1.56	1.07
1.34	1.07
1.24	0.74
0.83	0.04

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	0.2	0.2	L/s
MNF	0.1	0.1	L/s
BGWI	0.1	0.1	L/s
Unit BGWI	0.02	0.01	L/s/ha
Sanitary Flow	0.1	0.1	L/s
Per Capita Sanitary Flow	129.1	94.5	L/cap/d
Peak DWF	0.3	0.3	L/s

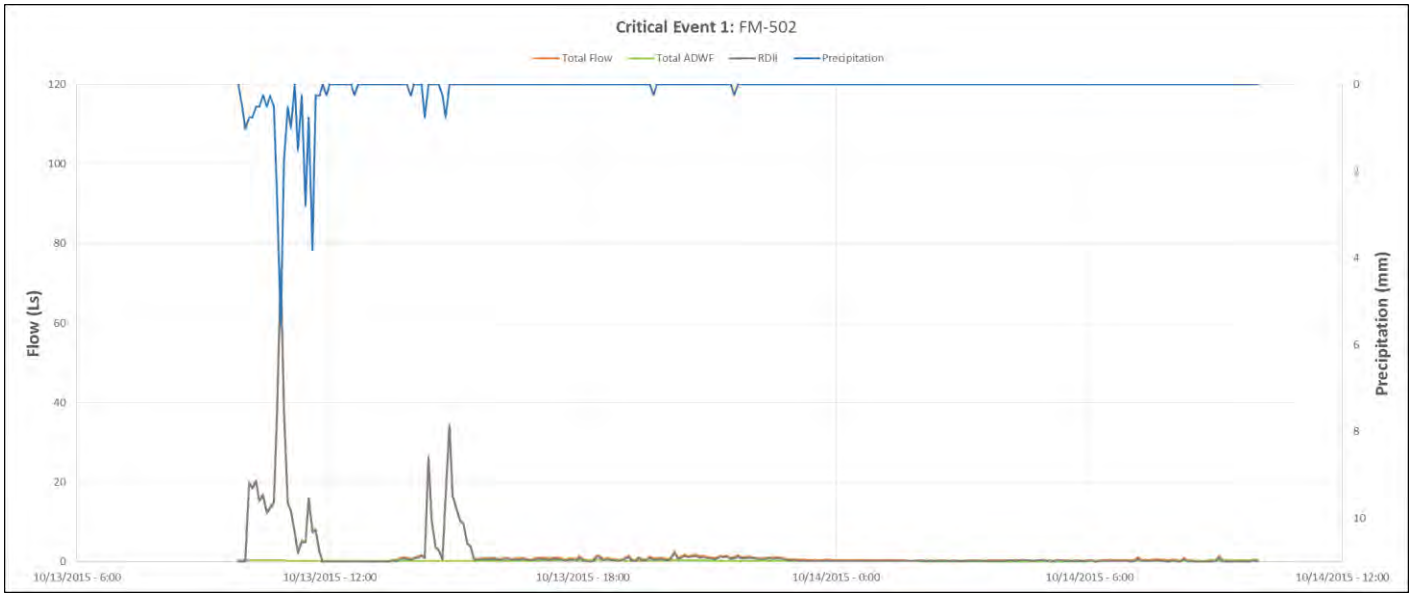
Quantification of RDII

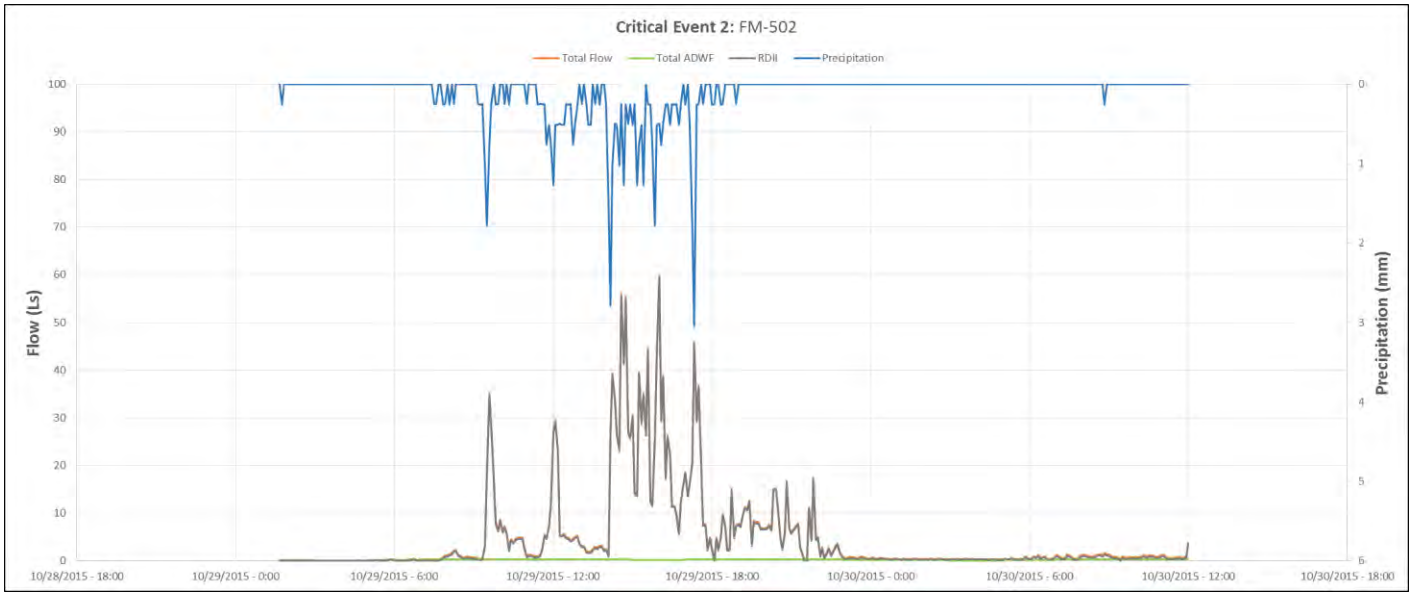
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	73	0.2	11%	13.58
CE2	10/29/2015	10	49	60	0.6	22%	11.06
CE3	11/13/2015	7	28	28	0.2	14%	5.26
CE4	11/21/2015	13	93	90	1.9	38%	16.73

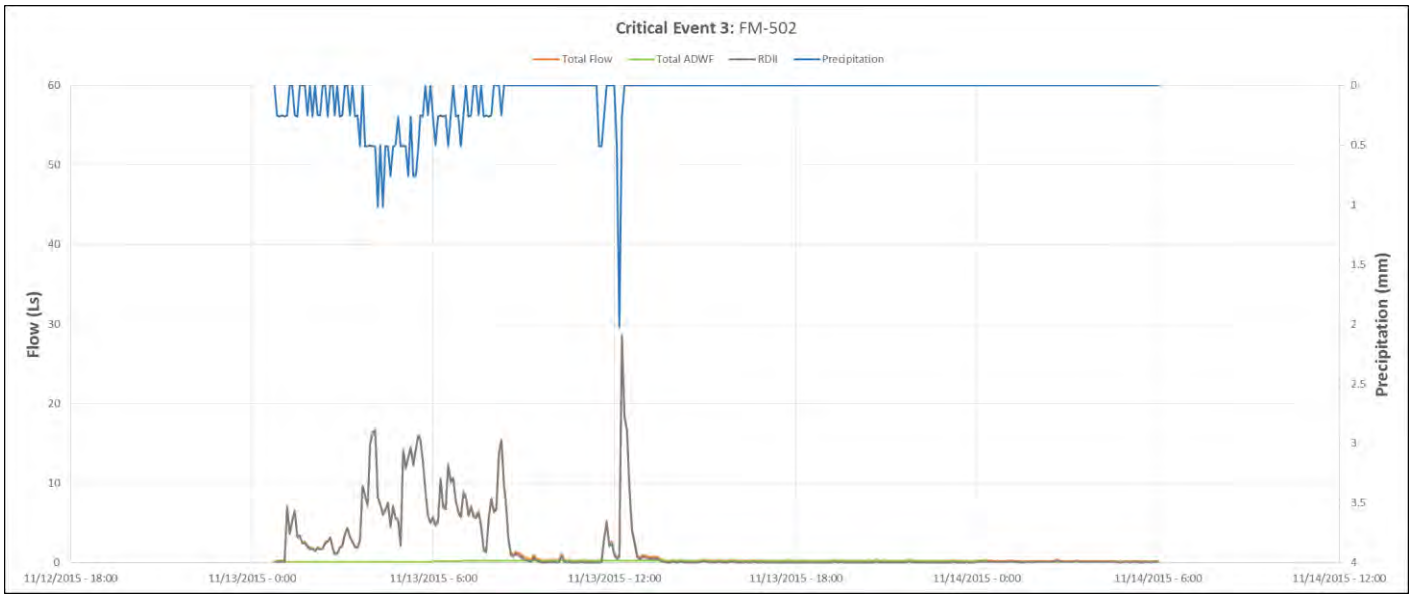
Estimated Peak Wet Weather Design Flows (L/s)

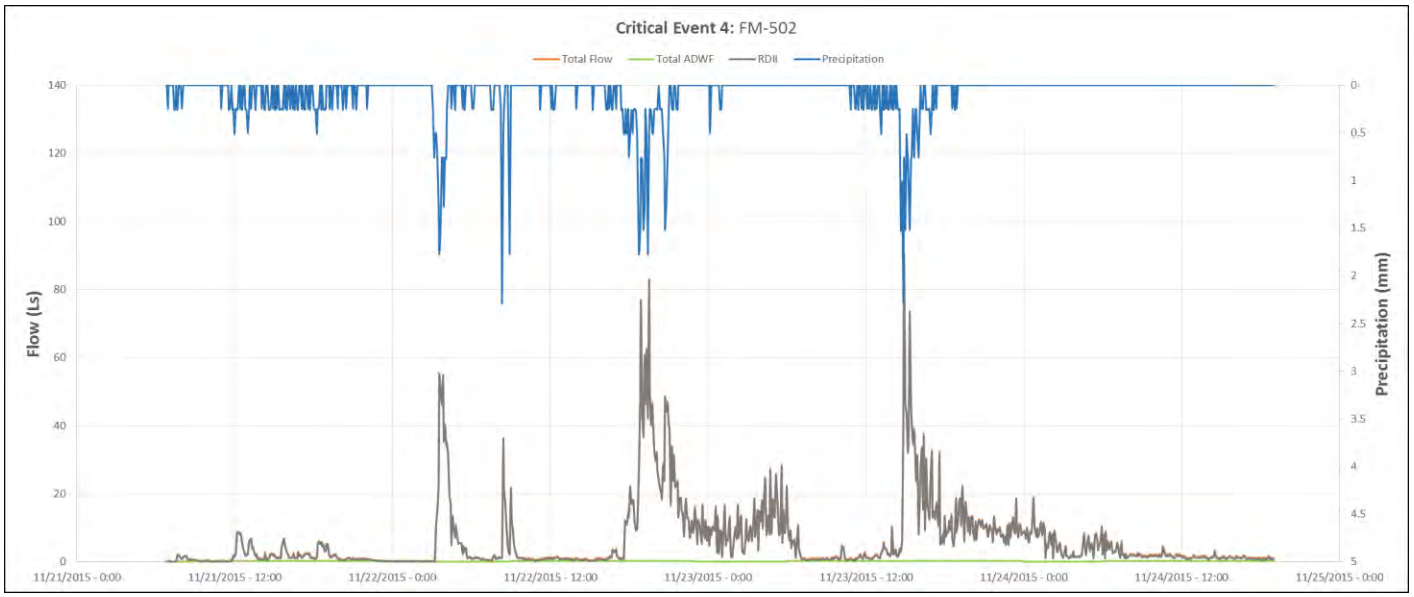
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	1	95	121	139	161	178	194

Wet Weather Flow Graphs



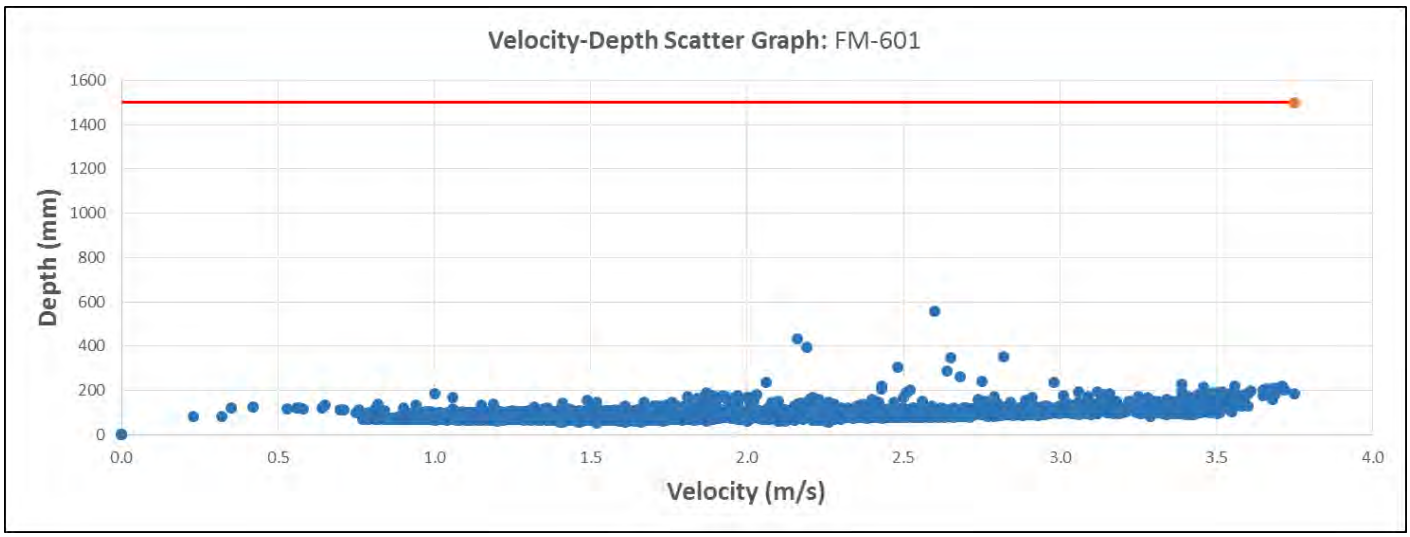



Critical Event 3: FM-502
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
0
10
20
30
40
50
60
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00

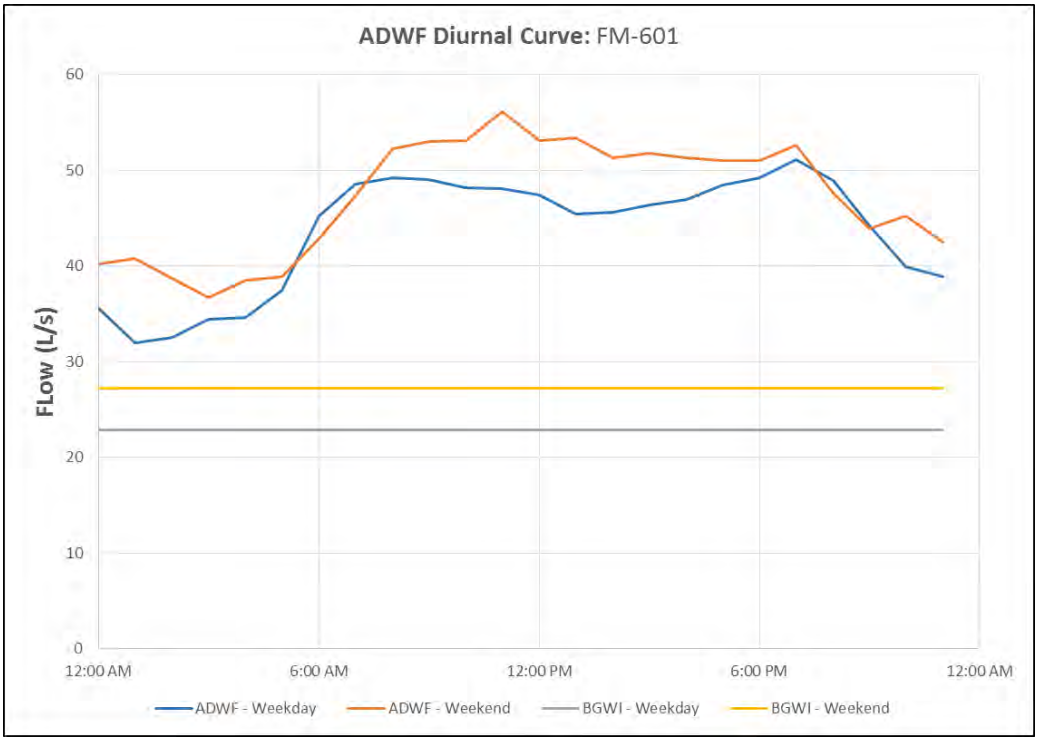

Critical Event 4: FM-502
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
0
20
40
60
80
100
120
140
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-601

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.61	0.65
0.44	0.68
0.47	0.58
0.56	0.48
0.56	0.56
0.70	0.59
1.08	0.78
1.23	1.00
1.27	1.25
1.26	1.29
1.22	1.29
1.22	1.44
1.18	1.30
1.09	1.31
1.10	1.20
1.13	1.23
1.16	1.21
1.23	1.19
1.27	1.19
1.36	1.27
1.25	1.02
1.02	0.84
0.82	0.90
0.77	0.76

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	43.7	47.2	L/s
MNF	32.0	36.7	L/s
BGWI	22.9	27.2	L/s
Unit BGWI	0.22	0.27	L/s/ha
Sanitary Flow	20.8	20.0	L/s
Per Capita Sanitary Flow	197.8	190.4	L/cap/d
Peak DWF	51.2	56.1	L/s

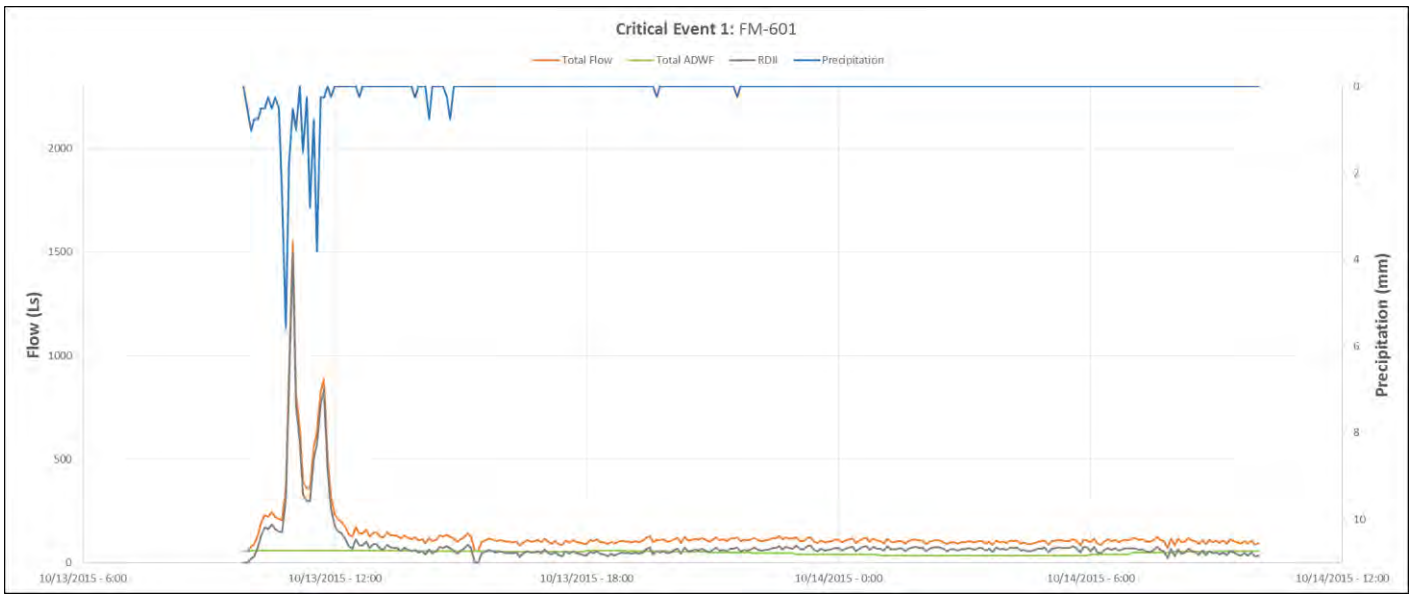
Quantification of RDII

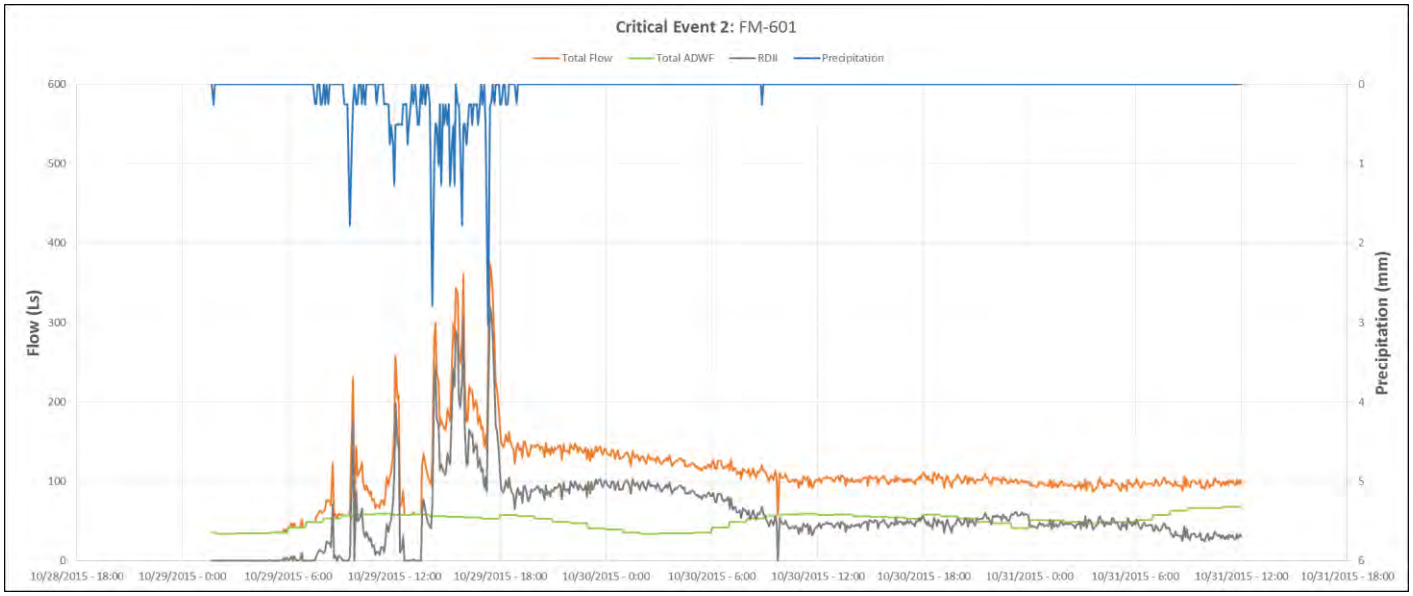
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	1495	7.8	26%	14.76
CE2	10/29/2015	10	49	321	12.1	24%	3.19
CE3	11/13/2015	7	29	196	9.9	33%	1.92
CE4	11/21/2015	13	93	534	34.7	36%	5.32

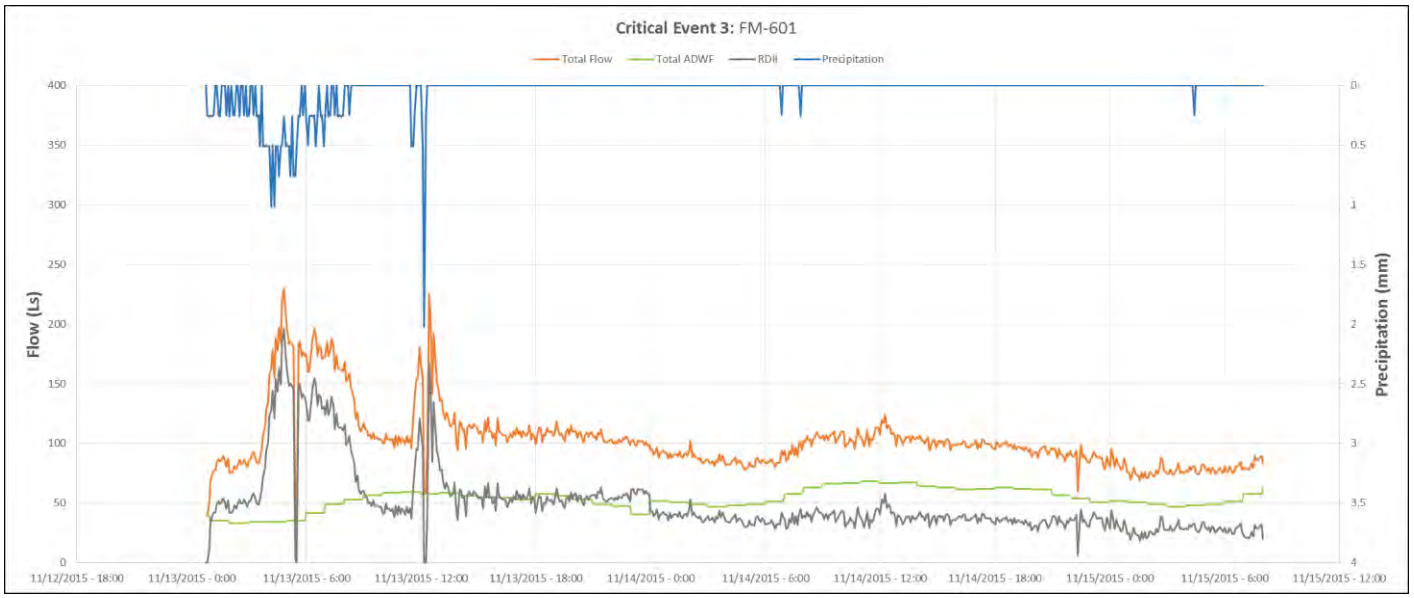
Estimated Peak Wet Weather Design Flows (L/s)

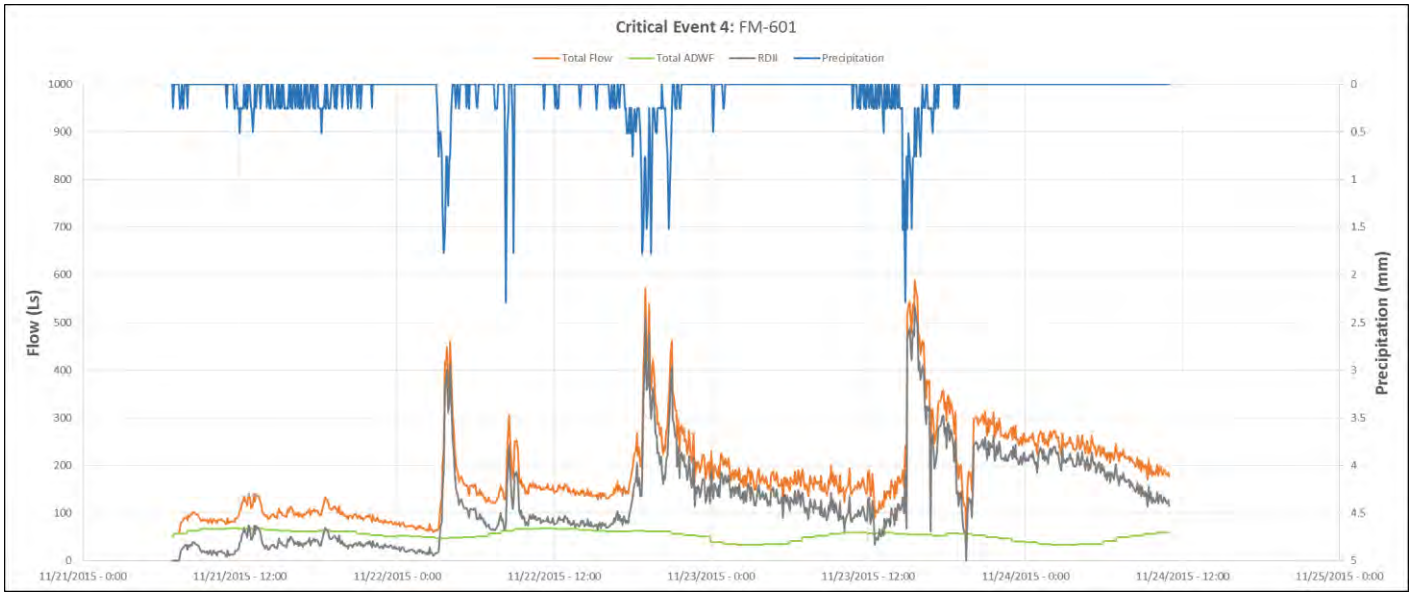
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	183	878	1079	1213	1382	1508	1634

Wet Weather Flow Graphs



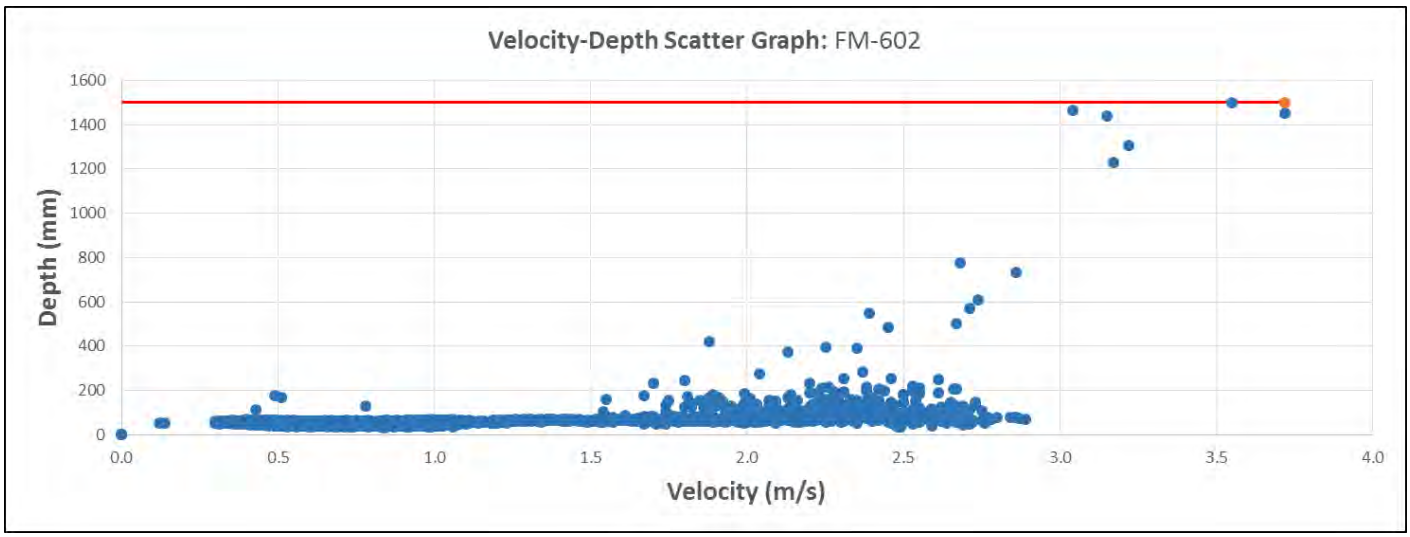



Critical Event 3: FM-601
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
0
50
100
150
200
250
300
350
400
0
0.5
1
1.5
2
2.5
3
3.5
4
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00
11/14/2015 - 18:00
11/15/2015 - 0:00
11/15/2015 - 6:00
11/15/2015 - 12:00

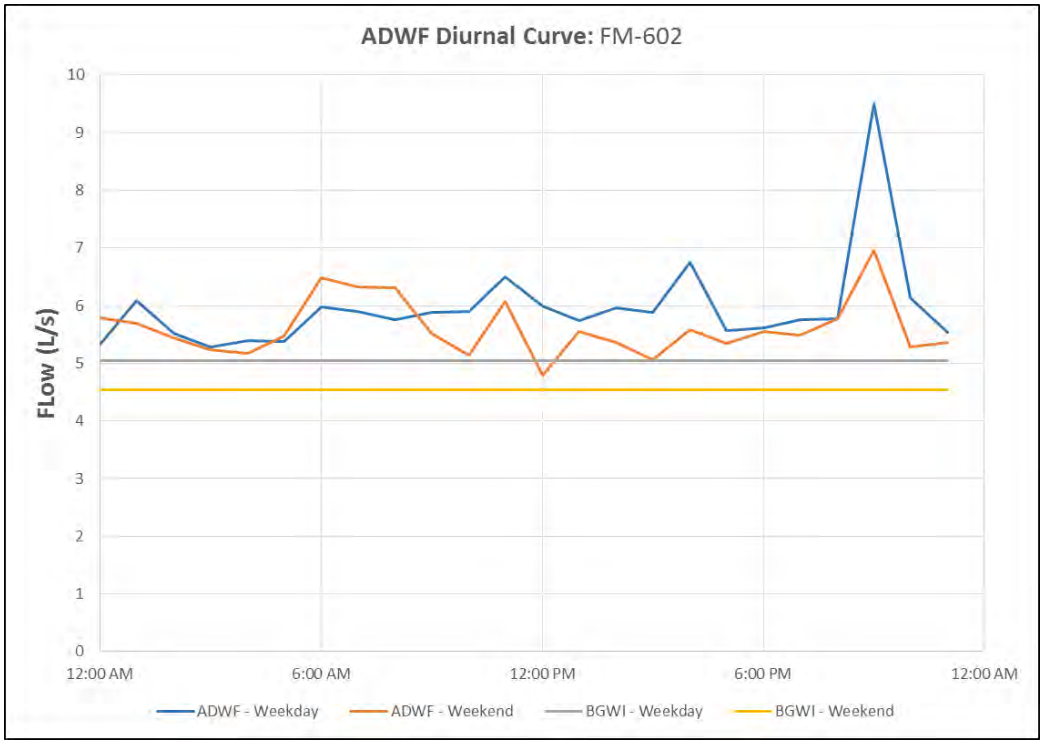

Critical Event 4: FM-601
Total Flow
Total ADWF
RDII
Precipitation
Flow (l/s)
Precipitation (mm)
0
100
200
300
400
500
600
700
800
900
1000
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

FM-602

Velocity-Depth Scatter Graph



ADWF Diurnal Curve, BGWI, and Sanitary Flow Hourly Factors



Weekday (factor)	Weekend (factor)
0.30	1.16
1.14	1.08
0.51	0.83
0.25	0.64
0.37	0.59
0.36	0.86
1.02	1.82
0.93	1.67
0.78	1.64
0.90	0.92
0.92	0.56
1.58	1.43
1.04	0.23
0.75	0.94
0.99	0.76
0.92	0.48
1.87	0.96
0.56	0.75
0.62	0.94
0.78	0.88
0.79	1.14
4.88	2.26
1.20	0.69
0.53	0.76

Dry Weather Flow Analysis

Variable	Weekday	Weekend	Units
ADWF	6.0	5.6	L/s
MNF	5.3	4.8	L/s
BGWI	5.1	4.5	L/s
Unit BGWI	0.48	0.43	L/s/ha
Sanitary Flow	0.9	1.1	L/s
Per Capita Sanitary Flow	84.3	98.8	L/cap/d
Peak DWF	9.5	7.0	L/s

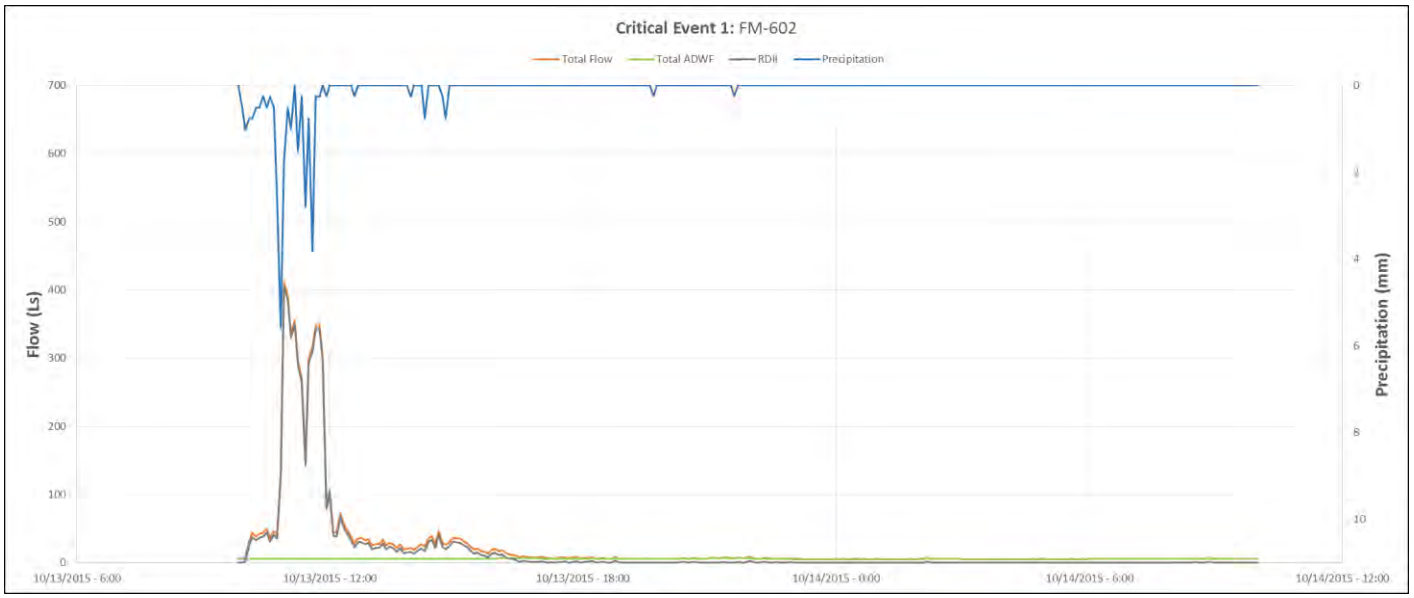
Quantification of RDII

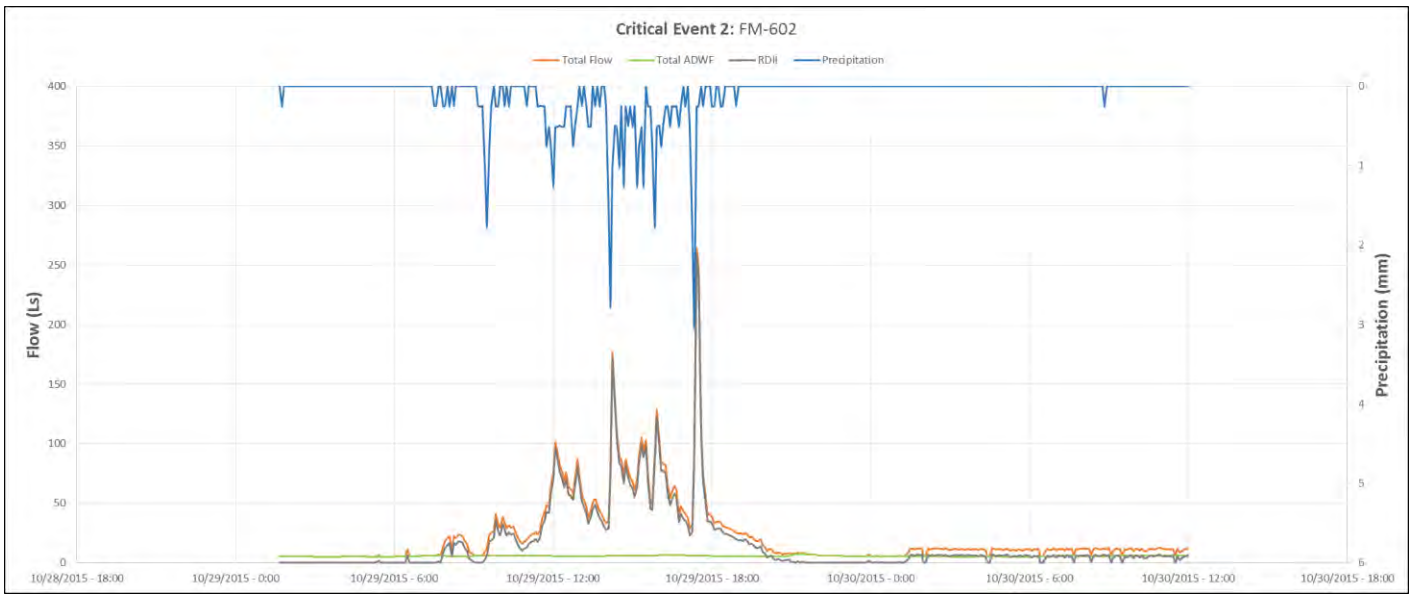
Critical Event	Date	Peak 1-hr (mm/hr)	Total Depth (mm)	Peak RDII (L/s)	Total RDII (ML)	Event Cv (%)	Unit Peak RDII (L/s/ha)
CE1	10/13/2015	21	30	405	1.7	54%	38.57
CE2	10/29/2015	10	49	258	2.1	41%	24.61
CE3	11/13/2015	7	28	87	1.3	43%	8.22
CE4	11/21/2015	13	93	289	5.7	58%	27.56

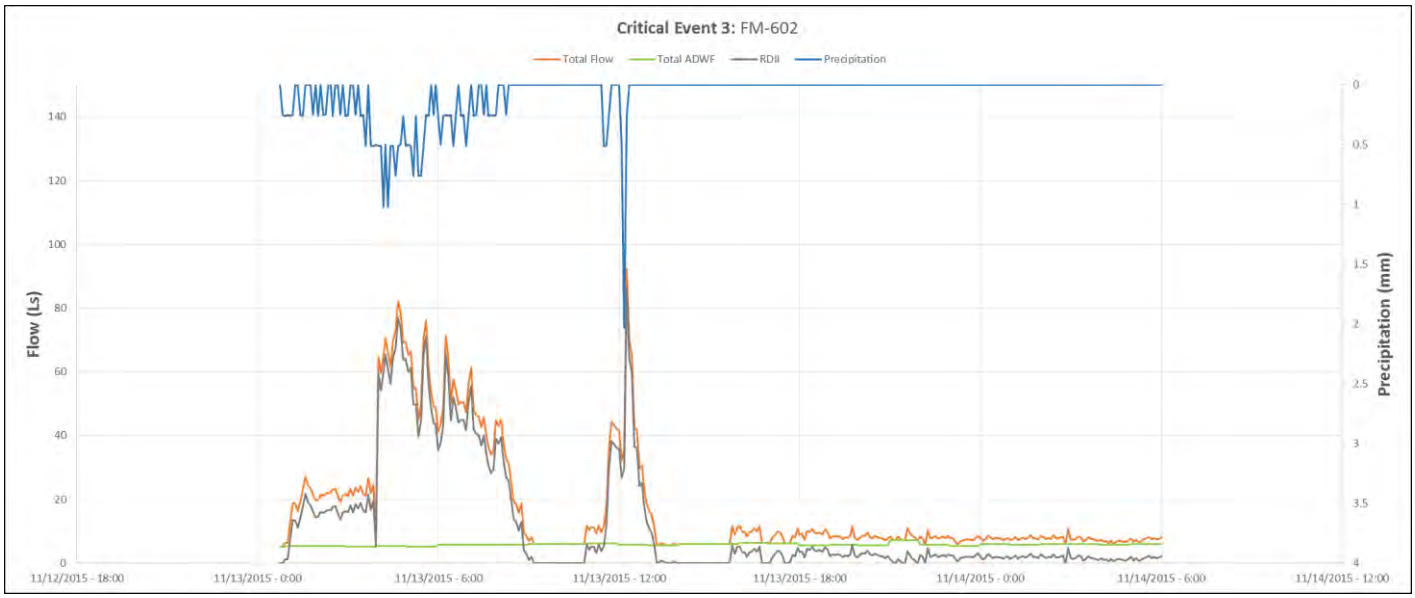
Estimated Peak Wet Weather Design Flows (L/s)

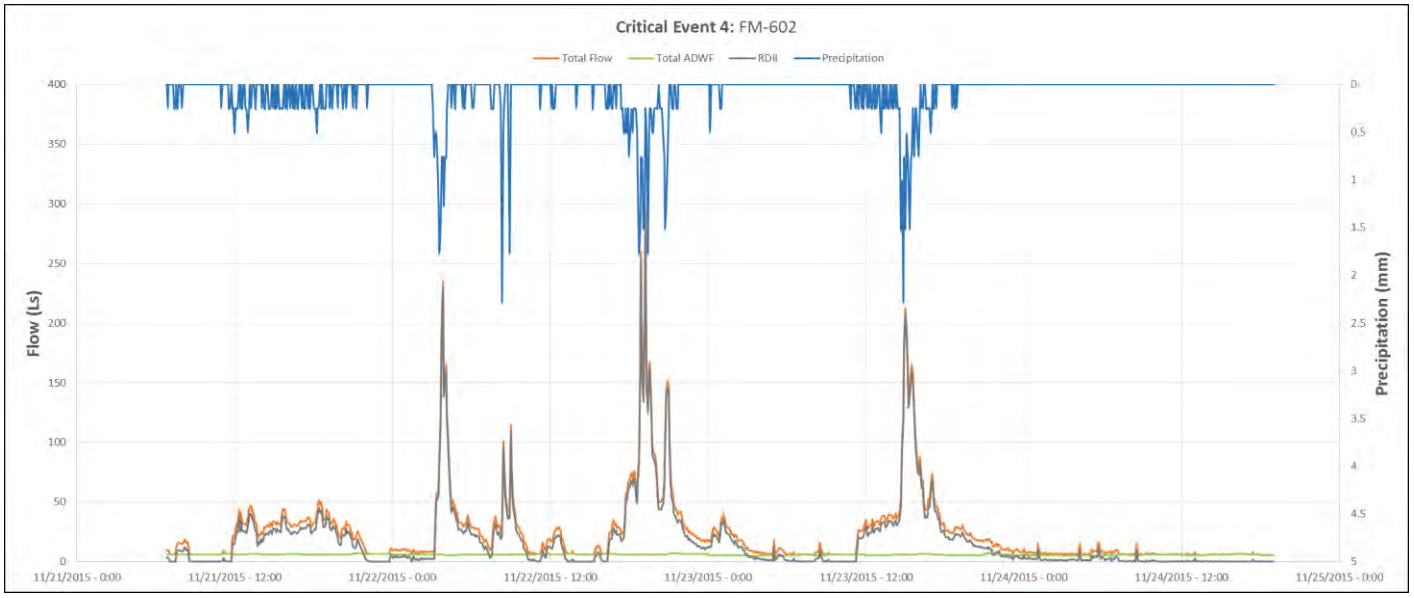
Full Pipe Capacity	Design Criteria	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
NA	13	335	426	488	565	622	679

Wet Weather Flow Graphs






Critical Event 3: FM-602
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/12/2015 - 18:00
11/13/2015 - 0:00
11/13/2015 - 6:00
11/13/2015 - 12:00
11/13/2015 - 18:00
11/14/2015 - 0:00
11/14/2015 - 6:00
11/14/2015 - 12:00


Critical Event 4: FM-602
Total Flow
Total ADWF
RDII
Precipitation
Flow (Ls)
Precipitation (mm)
11/21/2015 - 0:00
11/21/2015 - 12:00
11/22/2015 - 0:00
11/22/2015 - 12:00
11/23/2015 - 0:00
11/23/2015 - 12:00
11/24/2015 - 0:00
11/24/2015 - 12:00
11/25/2015 - 0:00

Appendix C Low Impact Development (LID) Best Practice Review

Low Impact Development – Background Review

The significance of proper onsite management of stormwater runoff, both quantitative and qualitative, is rising due to the increases in impervious areas and intensity of precipitation events. As infill development occurs, the hard surfaces limits natural groundwater infiltration thereby increasing stormwater runoff.

Traditional stormwater management systems consist of the onsite collection and direct conveyance of stormwater to either a basin, water body, or sewer system. Separate sewer systems collect stormwater and convey the flow to a body of water with little treatment, resulting in higher concentrations of runoff pollutants. Combined sewer systems, such as the case for the majority of the Halifax Peninsula, convey a mixture of stormwater runoff and wastewater from end users; the combined sewer systems are susceptible to overflows of raw sewage. In either case, this type of stormwater management could potentially lead to a variety of negative environmental, economic, and social consequences. The most common issues associated with these practices include:

- Bank erosion and increased turbidity
- Destruction of wildlife and habitats
- Contaminated water bodies and beach closures
- Downstream flooding
- Infrastructure damage
- Unnecessary conveyance and treatment costs
- Disruption of groundwater table and natural cycle.

There are many interpretations of the term *Low Impact Development* (LID), but in general it refers to a land development or re-development approach that utilizes site specific methods and techniques to manage both the quantity and quality of stormwater runoff, at the source. Different onsite wet weather flow management strategies can be implemented to reduce the conveyance of stormwater, which could help resolve existing capacity deficiencies while providing additional environmental and social benefits. It can be a cost-effective approach by minimizing the potential capital costs associated with new hard or grey infrastructure. It is a sustainable stormwater practice that can be applied to high density urban areas as well as low density neighbourhoods.

Common principles associated with the LID approach include:

- Decentralized controls to infiltrate, evaporate, or store onsite runoff
- Pollution prevention
- Conserve natural areas
- Minimize impacts on hydrology
- Maintain runoff rate and duration from site.

As previously mentioned, traditional stormwater management systems collect and convey runoff from the site into sewers, and then either to storage facilities, large retention ponds, or direct discharge into water bodies. These controls do not allow for the recharge of groundwater or pollution control. The need for conveyance and retention of stormwater can be minimized through the LID approach resulting in less stress on existing separate or combined sewer system infrastructure. Portland Oregon's active LID program was put in place to satisfy environmental commitments that include CSO discharges; the case studies below provide more details regarding some aspects of their program. Minimizing the conveyance of stormwater runoff can help reduce capacity issues within a combined sewer system, and reduce the discharge of stormwater runoff pollutants that are associated with separate storm sewer systems. Although sewer separation may help reduce CSO discharge, the tradeoff is an increase in the discharge of runoff pollutants. The LID approach focuses on reducing the quantity of stormwater runoff and therefore any associated

pollutants. This stormwater management approach focuses on the problem, being development patterns and imperviousness, rather than the symptoms, which are large stormwater volumes.

Capacity issues, which are resulting in flooding and/or discharge of runoff pollutants and CSOs, are not only a result of growth and increased imperviousness but also changes in precipitation patterns. Precipitation events are expected to increase in frequency and severity and for this reason, limiting the source may be more adaptable for the future than increasing the amount of grey infrastructure. Planning for and maintaining waste and stormwater infrastructure should be done with a changing climate in mind. The expected intensity, duration, and frequency of events should be considered over the lifetime of the infrastructure and therefore other best practices other than conveyance should be considered.

Many cities throughout the United States are employing green infrastructure solutions, as presented in the case studies below. They consider green infrastructure to be a smart investment of public funds that provide the triple bottom line of benefits (social, economic, environmental) and extend the life of existing grey infrastructure. Other stormwater management principles similar to the LID approach have been established internationally. The United Kingdom has established an approach originally called the *Sustainable Urban Drainage System* (SuDS), now commonly referred to as the *Sustainable Drainage System* (SDS) to accommodate rural sustainable water management practices. In Australia, the common approach to sustainable stormwater management is the *Water-Sensitive Urban Design* (WSUD). Similar to LID, SDS and WSUD integrate stormwater, groundwater, and wastewater management into the land planning and engineering design stage. This type of practice helps govern stormwater runoff thereby minimizing the impacts on the environment and existing infrastructure.

B1. Green Infrastructure

Green Infrastructure can be used as a means of meeting LID targets and encompasses a variety of techniques that utilize nature as a driver for onsite management of stormwater. These techniques provide great flexibility with a variety of benefits in support of the LID principles. Green infrastructure utilizes vegetation, soils, and natural processes to improve infiltration rates and/or capture and reuse stormwater to reduce the quantity and improve the quality of stormwater runoff. These techniques aim at minimizing onsite production of stormwater flows thereby minimizing the required capacity of combined sewers. This reduction in stormwater conveyance has many advantages:

- Increased capacity within the existing sewers
- Decrease in CSO frequency, volume, and peak flow
- Less treatment required at facilities.

Many municipalities are finding that for their unique system, they can effectively manage stormwater runoff in a more cost-effective and overall beneficial way in comparison to the traditional collect and convey approach. Green infrastructure can be implemented at any scale from a single to lot to entire citywide plan. Green infrastructure can refer to a “system”, similar to wastewater, water, and stormwater systems. With respect to combined sewer systems, municipalities do not have to rely solely on conventional storage or sewer separation techniques. The individual techniques that make up the green infrastructure systems are dependent on many aspects of the area or community in which it is to be implemented. The appropriate type of green infrastructure will depend on the type of development, topography, weather, and other area specific characteristics.

The most common types of green infrastructure are presented below and each has its own advantages, disadvantages, costs, and benefits.



Rainwater Harvesting



Green Roof



Vegetated Bioswale



Pervious Surface



Tree Box



Rain Garden

These techniques aim at minimizing onsite production of stormwater flows thereby minimizing the required capacity of combined sewers. This reduction in stormwater conveyance has three primary advantages:

- Increased capacity within the existing sewers
- Decrease in CSO frequency, volume, and peak flow (combined sewer systems)
- Decrease in the discharge of stormwater runoff pollutants (separate sewer systems)
- Less treatment required at facilities

B2. Public versus Private (ownership)

Green infrastructure can be implemented at the site level or community/neighborhood level. Green infrastructure is often thought of as development related, however it can be either publically or privately owned and the implementation, feasibility, costs, and benefits can differ. It is much more difficult to implement green infrastructure privately as it requires significant buy-in and commitment by the developers and community. It typically requires rebates or fee-based incentives to encourage its implementation. It is also very difficult to ensure that they are properly maintained so that it remains effective as part of a system wide stormwater management strategy. For this reason, privately owned green infrastructure is typically better served for localized benefits. Green infrastructure that is owned by the municipality or region may be easier to implement and the benefits can be realized at the system wide level.

B3. Localized and System Wide Benefits

Green infrastructure systems can provide many environmental, social, and economic benefits to the localized are as well as the larger community. The benefits are summarized into three categories:

Environmental

- Sources of vegetation can improve air quality reducing greenhouse gases
- Groundwater recharge ensures the water table remains as was before development
- Provides protection and/or creation of wildlife and insect habitats
- Water conservation
- Minimizes pollution associated with stormwater discharge into water bodies or overflows (improved water quality)
- Minimize sewer overflow events
- Drinking water source protection

Social

- Minimizes heat island effect by providing shade and protection against sun
- Improved aesthetics and communal benefits such as recreational opportunities
- Efficient land use
- Establish urban greenways and attractive streetscapes
- Flood mitigation
- Enhanced livability with respect to green roofs
- Educate the public about stormwater management

Economic

- Reduced life-cycle costs
- Increased property values and communal marketability
- Minimize need for grey infrastructure (reduction in construction and maintenance costs)
- Minimizes treatment costs
- The implementation of green infrastructure techniques and subsequent reduction stormwater runoff can slow down the trend toward increased stormwater utility fees and taxes that are inevitable with traditional stormwater management systems
- Encourage economic development
- Reduce energy consumption

Although the social and environmental benefits are evident, many municipalities undervalue the contribution of green infrastructure simply because it is difficult to quantify the potential benefits i.e. reduction in flows entering the sewer systems. It is difficult to determine, with a high level of accuracy, the capacity of the green infrastructure system, in addition to the lack of confidence that it will remain at that level over time. More research including the monetization of benefits and detailed financial analyses would be required to gain more insight to better value these systems against traditional grey infrastructure.

Although the benefits of green infrastructure is difficult to quantify, there is evidence from many case studies, including those below, that demonstrate the potential. If properly planned and there is sufficient commitment from all stakeholders, the implementation of an LID approach can provide reduced infrastructure costs as the need for large-scale storage and end-of-pipe systems are minimized. Land used for detention ponds can be put towards an alternative use that is beneficial to the public and environment such as recreational or reforestation. An LID approach also enhances the livability or property value by improving the aesthetics and hydrologic conditions of the site. Should be noted that all of this is dependent on many factors and opportunities with the area, such as soil conditions, land use, etc.

B4. Implementation

The flexibility of green infrastructure techniques means that the systems can be implemented at all scales for any type of development depending on land limitations and surroundings, whether it be urban, high-density urban, or rural. However, the implementation of green infrastructure requires strategic planning, commitment from multiple stakeholders, and interaction with the public, primarily local residents. Since the majority of the impervious surfaces are privately owned, these stakeholders are essential to the magnitude of benefits resulting from the implementation of a green infrastructure system. Communal involvement is required for a municipality to reach desired stormwater runoff reductions and therefore public policies and initiatives are required.

B5. Policies, Initiatives, and Goals

Policies and initiatives are required to initialize the implementation of green infrastructure and LID strategies and it will take time. Once the long-term benefits are realized, future implementation of green infrastructure will be encouraged and more easily justifiable. Policies can emphasize the reduction of impervious surfaces, preservation of vegetation, and/or water quality improvements.

It is essential to have short-term site specific and long-term system specific goals. Progress must be monitored and measured in the early stages of implementing policies and initiatives to continuously improve the program. This iterative process has helped Portland, Oregon, establish one of the most mature and functional hybrid stormwater systems in the United States; more details are provided below. Feasible locations should be selected that will generate the greatest outcomes, such as those that are prone to flooding, good soil for infiltration, and large flat rooftops.

Case studies should be reviewed and pilots need to be implemented to provide public awareness and education. Many case studies have found that to implement successful stormwater management, municipalities must implement multiple policies and initiatives, including stormwater ordinance and new regulations to govern new development, funding systems for capital projects, and financial incentives to encourage redevelopment and retrofit. Policies can be categorized as either public or private sector policies, where public programs can be set up internally by government agencies and private sector programs apply to private development and property owners including both residential and commercial. Common policies and initiatives that are applicable to most municipalities, and can be implemented in combination, are as follows:

Public Sector

- Education and Outreach – any kind of awareness regarding existing green infrastructure projects or the general importance and impact of reducing stormwater runoff on the surrounding environment and levels of service.
- Demonstration projects – can serve for testing new programs or be evidence of the feasibility and functionality.
- Transportation and Capital Projects – e.g. street retrofits, public buildings, parks, etc.
    - A lot of potential as these projects can reduce runoff from large impervious areas. Only requires small percentage of total project funding to go towards green infrastructure portion.
- Local Code Review and Revision – to remove barriers on new stormwater regulations and standards

Private Sector

- Stormwater Regulations (not just minimizing peak flow rate)
    - The enforcement of on-site stormwater runoff management using a specified threshold. It is common to implement a requirement that addresses pre- and post-development runoff flows. It can be a volume-based, process-based, or menu based approach.
    - Impervious surface ratio requirements

- A mandatory green roof policy

- Incentives for Implementing Green Infrastructure
  - Stormwater fees – generate a dedicated revenue stream that directs the costs for stormwater management towards the properties producing the runoff. Typical method is to calculate user fee based on total lot size and percentage of imperviousness. ****This was noted by the EPA as one of the most critical elements that will ensure the successful implementation of other green infrastructure policies and programs.*
  - Stormwater fee discounts – encourage retrofits of existing properties and implementation of green infrastructure
    - Philadelphia, Portland, and Seattle provide property owners the ability to reduce the amount they pay by decreasing impervious surfaces
    - Less burden on public infrastructure
    - Discount support fee-for-service system.
    - See the following table for an example of stormwater fee discount programs from the "Municipal Policies for Managing Stormwater with Green Infrastructure by US EPA"

Goal of Discount	Mechanism for Fee Reduction	Process for Implementation
Reduce Imperviousness	- % fee reduction - Per-square-foot credit	- % reduction in imperviousness - Square feet of pervious surfaces
On-site Management	- % fee reduction - Quantity/Quality credits	- List of practices with associated credits - Total area (square feet) managed
	- % fee reduction - Quantity credit	- % reduction in imperviousness - Performance-based - Total area managed (square feet) - Practices based on pre-assigned performance values
Use of Specific Practices	- % fee reduction - Onetime credit	- List of practice associated credits

To help deal with the many implementation barriers, the EPA report recommended the following 3-step policy implementation to support the local green infrastructure initiatives and programs.

1. Stormwater Regulation and Code Review – encourages and mandates green infrastructure.
2. Demonstrations/Pilot Studies, Education/Outreach, and Incentives – can set the stage for instituting a stormwater utility.
3. Capital and Transportation Projects, Stormwater Fees, and Fee Discounts – the most difficult as it requires more political and support and takes the most time to complete the process.

B6. Implementation Barriers

There are many barriers to implementing green infrastructure that can add time and effort and in some cases prevent the advancement of its implementation.

- Quantifying the benefits or reduction of stormwater runoff before implementation i.e. justifying green infrastructure.
- Implementing the framework and policies.
    - Funding/cost concerns
    - Lack of political support/leadership
    - Resistance to change
    - Coordination of multiple stakeholders
- Land use and/or soil conditions
- Maintaining its effectiveness.

In areas where land is mostly developed, there may not be a significant amount of space to implement sufficient LID to meet criteria such as limiting CSO discharges or preventing basement flooding. Due to dense urbanism, widespread retrofitting with green infrastructure may be disruptive, costly, and take a long time to complete, in comparison to implementing LID with new development.

Traditionally, there is a lack of funding, political support/leadership, resistance to change, coordination of multiple stakeholders and partners, legislative action, conflicting regulations, need for technical information and training, misunderstanding about land use issues, and cost benefit analyses. Since the implementation of LID is a new concept for many municipalities, the learning curve tends to be slower in the beginning and therefore it is important to identify partners and begin with small projects that can then evolve into official policies and initiatives.

A single initiative or policy will most likely not be enough to gain momentum therefore multiple programs and policies are recommended. Where there is a lack of LID opportunities, given a unique system or circumstance, green infrastructure may not be productive on its own. If this is the case, a hybrid of green and grey infrastructure can be used to ensure that the criteria and level of service are met and the benefits of LID are still gained.

A document developed by North Carolina State University “Low Impact Development a Guidebook for North Carolina”, contains almost every aspect of LID, for both on-site LIDs and municipal programs, including local government maintenance and enforcement after construction. One way of providing regulatory inspections (to meet legal, ordinance, and permit requirements) is to have a qualified professional do an assessment, usually paid for by the entity responsible for the maintenance or funded by the financial-performance guarantee. The executed and recorded operation and maintenance agreement obligates the owner to ensure the LID is inspected by a professional engineer every 5 years. The O&M agreement obligates the owner to maintain LIDs to city standards. If the municipality is responsible for the functionality of the green infrastructure, any performance bonds or guarantees can be called upon and used to recoup cost of maintenance, inspections, or repairs.

With respect to the maintenance and enforcement of LID practices, the document discusses the transition from construction (when the developer or contractor is responsible for its functionality) to post-construction (when another entity, such as Halifax Water, is responsible). The document recommends enforcing inspections and maintenance requirements to preserve the long-term functionality and benefits of the LID systems. Different options include:

- Site LID Operating Permits: the permit would specify maintenance requirements and provisions and would typically require renewal after a certain period (typically 5 years)

- Maintenance Plans: make maintenance plans legally enforceable by passing an ordinance that references them and specifies provisions for enforcement.

Financial Performance Guarantees: requires developer and landowner to provide various future costs related to LID functionality such as maintenance, repair, replacement, and inspections that another party would take care of. Can be in the form of performance bonds, liens, letter of credit, etc.

B7. Costs of Green Infrastructure

The costs incurred with the implementation of green infrastructure, whether it be by a developer, consumer, or municipality, can be recovered however it is difficult to quantify. Due to the difficulty in quantifying the effectiveness of green infrastructure, it is difficult to estimate the return on investment. Municipalities may experience a direct correlation with the management of their systems, property owners may see in increase property or home value, commercial areas may experience better economic benefits, however it is difficult to quantify these financial benefits and estimate the cost recovery.

A LID strategy can be more cost effective than other solutions, however it is very dependent on the opportunities unique to the land and municipality's situation. Look into the credit valley information. An analysis conducted by the city of Vancouver indicated that retrofitting with green infrastructure will cost marginally more than rehabilitating the conventional system, however the additional benefits of aesthetic city space and reduction of water pollution justify this additional cost. The study also noted that green infrastructure being implemented with new development will cost less than traditional stormwater controls. Although the focus is traditionally on retrofitting with green infrastructure, implementing these techniques in the early stages of community development can provide the most benefits at the least cost. In many cases, green infrastructure is less costly than conventional controls when it is part of large-scale retrofit projects rather than individual small-scale properties.

Low Impact Development – Case Studies

Toronto's Green Roof Bylaw

Toronto's Wet Weather Plan includes four principles:

- Recognize rainwater and snowmelt as valuable resource
- Manage wet weather flows on watershed basis
- Implement hierarchy of wet weather practices
  - Source
  - Conveyance
  - End-of pipe
- Educating communities and involving the public

Toronto is recognized as having one of the most advanced green roof initiative. An Environment Canada study estimated that greening 6% of Toronto's roofs would cost $36 million over 10 years however would retain 1 billion gallons of stormwater annually. In 2009, Toronto became the first city in North America to implement a bylaw that requires new development (residential, commercial, or institutional), with a gross floor area of at least 2,000 m^2, to include a green roof as part of the structure; residential building with less than 6 stories are exempt. The required percent coverage of green roof increases with gross floor area from 20% to 60%. The city has created guidelines and an official plan that is continuously updated and improved to help with the designing and planning of the green roof. Toronto's green Roof Strategy also helps meet the goals of the City's Climate Change Action Plan.

From February 1, 2010 – March 1, 2015, 260 green roofs have been constructed totaling 196,000 m^2 of additional green space. It is estimated that this green space has resulted in a reduction of 435,000 ft^3 of stormwater each year in addition to 1.5 million KWH of energy savings for building owners.

At Ryerson University, a study evaluated municipal level benefits of wide-scale implementation of green roofs throughout Toronto. The assumptions included all buildings with roof area greater than 3,750 square feet and were covered by at least 75%; this represents 8% of total city land area. The results were $100 million of stormwater capital cost savings, $40 million in CSO capital cost savings, and $650,000 in CSO annual cost savings.

*Recent green roof projects in Canada have averaged between $6 and $7 per square foot.

Toronto also has also implemented a mandatory downspout disconnection program. For new homes, municipal code prohibits connection of downspouts to sanitary, combined, or storm sewer systems. For existing homes, a citywide voluntary downspout disconnection program was put in place in 1998. Toronto offered to disconnect at no cost to property owners. In 2003, Toronto's Wet Weather Flow Management Master Plan identified downspout disconnection as one of the most effective and available source control options to reduce system demands. By 2006, an average of 2,300 disconnections were being completed per year with 1.5 million annual funding. Starting in 2011, it became mandatory to disconnect unless home owners secured an exemption.

Portland Oregon's Green Stormwater Management

Portland Oregon is recognized nationally for its green stormwater management strategy. The strategy encompasses many comprehensive programs that have been implemented and updated over many years. The success is a result of a city wide program that was viewed as necessary for the city of Portland due to its large combined sewer system. Instead of solely implementing new gray infrastructure, the city has invested in green infrastructure that has led to an estimated savings to ratepayers of $224 M in otherwise CSO costs. About half of Portland's land are is impervious, of which 25% streets and 40% rooftops.

Portland's policies target the on-site management of both private and public development. With respect to the private developments, incentives for homeowners and developers are used to encourage the implementation of LID.

- Portland's Downspout Disconnection Program targets homes and small businesses in combined sewer areas (the program includes public education about stormwater and CSOs).
  - Portland's downspout disconnections (about 56,000 properties) prevent an estimated 1 billion gallons of stormwater from entering the system each year.
- Portland's Clean River Rewards provides discounts on stormwater user fees; up to 100% of on-site stormwater management services and up to 35% of the total stormwater bill depending on the extent and effectiveness of practices to limit flow rate, pollution, and disposal.
  - 35,000 participants (residential and commercial) have received $5.5 M in retroactive credits for having properties that meet LID criteria. Participation is expected to reach 110,000 of 176,000 ratepayers.
- Portland has a Stormwater Management Code and Manual, which all new development or redevelopment, over 500 square feet of impervious surface, must follow.
- A Floor Area Bonus for Roof Gardens and Eco-roofs. This bonus increases a building's allowable area in exchange for adding a green Roof.
  - There are over 120 buildings throughout the city with a green Roof.
  - New city-owned buildings are required to have green roof covering 70%.
- A pilot stormwater trading program allows developers who are unable to satisfy on-site stormwater management requirement to privately finance or buy credits for stormwater mitigation elsewhere in the city.

The city has been accumulating significant data on the effectiveness of decentralized stormwater management technologies. A vegetated curve extension was proven to reduce the peak flow from a 25-year storm (two inches in six hours) by 88%, and prevented 85% of the initial 2,000 gallons from entering the combined sewer system; cost was approximately $15,000. Over two years of monitoring a 10-story building with over 5,000 square feet of green roof (4-5 inches thick), found that it retained 58% rainfall. Infiltration planters for a 36,000 square foot parking lot can retain entire volume of a 2-year storm; cost was approximately $75,500.

Philadelphia Water Department – Grant Funding for Green Infrastructure

Philadelphia's sewer collection system is 60% combined sewers and 40% separate sewers. To improve stormwater management, the Philadelphia Water Department (PWD) began to implement policies and initiatives to create a new stormwater standard. This standard is made up of the following four requirements:

- Channel protection (control one year storm)
  - Redevelopment may be exempt
- Flood protection (post-development conditions must be equal to pre-development)
  - Redevelopment may be exempt
- Water quality (infiltrate/manage first inch of rainfall on site from all connected impervious surfaces)
- Site design requirements to reduce imperviousness

Philadelphia has an impervious-based billing system where 80% of the city's new stormwater fee is based on impervious area and the remainder is on property's gross area. This ensures that vacant lots, parking lots, etc. are accounted for appropriately. They offer a fee discount up to 100% of the impervious area charge. The development community is now building green infrastructure projects which help achieve the city's goals.

A competitive grand program in July 2014 called the greened Acre Retrofit Program (GARP). This program was aimed at encouraging contractors, design firms, and consulting firms to implement green infrastructure projects by competing for public grant funding set aside for the green infrastructure market. Some benefits recognized by the PWD included the following:

- *"The local sewer or stormwater utility obtains installed (and privately maintained) stormwater infrastructure at a fraction of the cost of public right-of-way projects with similar environmental benefit;*
- *Local green infrastructure contractors benefit from a program that rewards project aggregation and provides long-term green infrastructure maintenance opportunities; and*
- *Property owners benefit from aggregators identifying cost-effective green infrastructure opportunities that can result in reduced stormwater fees and improved property value."*

Chicago, Illinois

The city of Chicago uses pilot projects to demonstrate the effectiveness and implementation of green infrastructure practices to the public and development community. As the public and development community become more familiar with the concepts, the adoption of financial incentives, new policies, and changes in stormwater regulations become more feasible. The pilot projects have also led to increased cost-competitiveness within the green infrastructure market.

The city's green roof program began with a 20,300 square foot roof on its own city hall. The green roof retains 75% of the volume from a one-inch storm, preventing it from reaching the combined sewer system. This pilot project led to a pilot program which included the implementation of 80 green roofs that totaled over 1 million square feet. The Chicago Department of Environment found that runoff from green roofs was generally 50% less than regular roof tops, and even greater for smaller storms. The city now sponsors installations and demonstration sites by providing incentives. A density bonus is offered to developers who cover at least 50% of their roof with a green roof, or 2,000 square feet, whichever is greater. By 2010, over 4 million square feet of green roofs have been installed on 300 buildings.

Public outreach programs have been implemented to engage homeowners to purchase rain barrels and install rain gardens. Over 440 residents have purchased 55-gallon rain barrels for 15$ and the program cost to the city has been $40,000, excluding labour. It is estimated that this pilot project will divert 760,000 gallons annually from combined sewer systems. This is a small number relative to the entire system however the program targeted localized areas with a high frequency of basement flooding. The city of Chicago has also began two studies to assess the effectiveness of green infrastructure technologies. They have monitored green roofs and completed a stormwater reduction practices feasibility study using hydraulic modelling. Two primary results were:

- In a 1,370 acre area, 80% residential, disconnecting all homes reduced the peak flow by 30% for a one-year storm. This corresponded to an estimated 20% reduction in CSO outfall and a drop in water levels in the sewer system by 8 inches.
- Six inch deep rain gardens at each home could further reduce total runoff by 7% for a one-year storm event.

Milwaukee, Wisconsin

Milwaukee Wisconsin has developed a strategy to limit CSO discharge by implementing green infrastructure within combined sewer areas. Their green roof program began with a pilot study that involved the installation of a 20,000 square foot green roof on a 114-unit midrise building at a cost of $380,000. This green roof retains 80% of a two-inch storm and the remaining 20% is directed to rain gardens. Further monitoring and modelling of other green infrastructure techniques showed that a downspout disconnection, rain barrel, and rain garden programs, in residential areas, could reduce contribution to annual CSO

volumes by 14-38%, flows to treatment plants by 31-37%, and stormwater peak flow rates by 5-36% depending on the size of the event.

Kitchener and Waterloo, Region of Waterloo

The cities of Kitchener and Waterloo have implemented a stormwater funding system that requires property owners to retain increased volumes of stormwater and reduce water demands to be rewarded with tax credits. They replaced their tax-based funding with a user pay system so that users pay for stormwater management services that reflect their use of the service. The first step was to determine how much each property contributed to run-off; this was based on the impervious area of the property. The financial research led to the development of 13 funding tiers that range from 47$ to $23,000 annually. After switching to the user based system, the residential portion of funding decreased from 75% to 55%, whereas the industrial, commercial, and institutional properties saw an increase. These changes were viewed as appropriate since they were based on the footprint and base amount of runoff entering the sewer system.

After the implementation of the user based system, the cities implemented a stormwater credit program for properties who wish to install onsite stormwater controls. This program saw contributions from both the residential and non-residential property owners and less than a year later, Waterloo received 750 applications and Kitchener 4,500. The public is also now inquiring about different stormwater retention techniques that they can implement, which is providing the cities with an opportunity to educate the communities on the importance of good stormwater management principles.

Leadership in Energy and Environmental Design (LEED)

The LEED initiative was established by the U.S. green Building Council (USGBC) and is centered on sustainable planning and design as this is a growing focal point of many municipalities. The USGBC credits projects that meet a number of criteria, which demonstrates its contribution to improving the triple bottom line, the environment, society, and the economy.

Leadership in Energy and Environmental Design (LEED) is a recognized standard in North America that promotes sustainable development. A development, redevelopment, or restoration of an existing building can earn a LEED status by demonstrating its commitment to sustainability and improving social and environmental impacts. There are five (5) categories of which can earn points including:

- Water conservation
- Energy efficiency
- Material selection
- Sustainable site design
- Indoor environmental quality.

The LID principles in section 2.1 are recognized throughout the LEED standard in the water conservation and sustainable site design categories. There are credits for implementing a green roof, having a certain ratio of pervious land, minimizing parking, and stormwater reuse to name a few. Each of these categories contribute to the LID approach by using GI techniques. Grants for LEED credited development or substitutes for similar types of projects could encourage developers, consulting firms, and design firms to consider a LID approach for the long-term benefits of a sustainable, environmentally friendly, socially and financially beneficial development. Implementing a program to encourage a standard such as LEED could be beneficial to the developer, public, and municipality in both the short-term and more importantly the long-term.

Sustainable Site Design Stormwater design – quantity control: if existing imperviousness <50% post-development peak runoff rate and quantity not more than pre-development rate, if >50% than at least 25% less (can use any form of GI)

Sustainable Site Design Stormwater design – quality control: capture and treat runoff from 90% average annual rainfall

Green roof can be used to earn multiple credits including:

- Reduce Heat island effect (i.e. reduce imperviousness)
- Stormwater design quantity control (increase infiltration)
- Maximize open space (if roof used for occupants)
- Optimize energy performance (control internal temperatures).

Appendix D Population Allocation Technical Memo

Date:	4/7/2016	File:	715009
To:	Meghan Woszczynski, David Blades, Heather Miller		
From:	James Jorgensen		
Project:	715009 Halifax LoWSCA		
Subject:	LoWSCA and WRWIP Model Population Allocation		

TECHNICAL MEMO

Introduction

There were two methods adopted for allocation of population for the Halifax Model and Dartmouth Model. Although the WRWIP and the LoWSCA projects were mutually exclusive, they cover with the same geographical area and share similar growth data and information. To be able to provide a growth model with comparable growth allocation for both the projects the following population allocation method was adopted.

The basic approach was to apply the LoWSCA growth to the six study areas (4 Halifax peninsula and 2 Dartmouth) and then amend the growth projections for the existing growth polygons used for the RWWFP so that the total growth population allocated in the hydraulic models is equal to the new Traffic Survey Zone (TSZ) populations provided by HRM.

Population Equivalent

The Traffic Survey Zones (TSZ) projected growth have both Population and Employment numbers for every 5year period, as a first step to carry out the allocation these two values were added to provide a Population Equivalent (PE) number. This PE value was used for both the allocation methods. For modelling purposes the residential and employment will share the same per capita flow allocation so this approach is justified. TSZs which had populations year 2011 less than year 2046 was considered to have growth. The TSZs with negative growth were ignored during the allocation process.

Population Allocation Methods

Two methods were followed to carry out Population allocation:

1. LoWSCA Allocation method
2. WRWIP Allocation method

The following text provides a step by step explanation of the approaches, followed by summary tables of the population numbers used. The key findings and results are summarized as follows:

Considering the growth projections for the LoWSCA results in a redistribution of the projected growth taking growth away from suburban growth areas and allocating it to downtown Halifax and Dartmouth growth zones – the LoWSCA ‘pockets’. This complements the intention to focus growth on intensification areas.

Allocation Method- LoWSCA

1. As a first step to carry out the allocation, the LoWSCA growth identified within each TSZ was summarized. It was noted that some of the LowSCA growth overlapped more than one TSZ. Figure 1 shows the overlay of TSZ and the LoWSCA development.

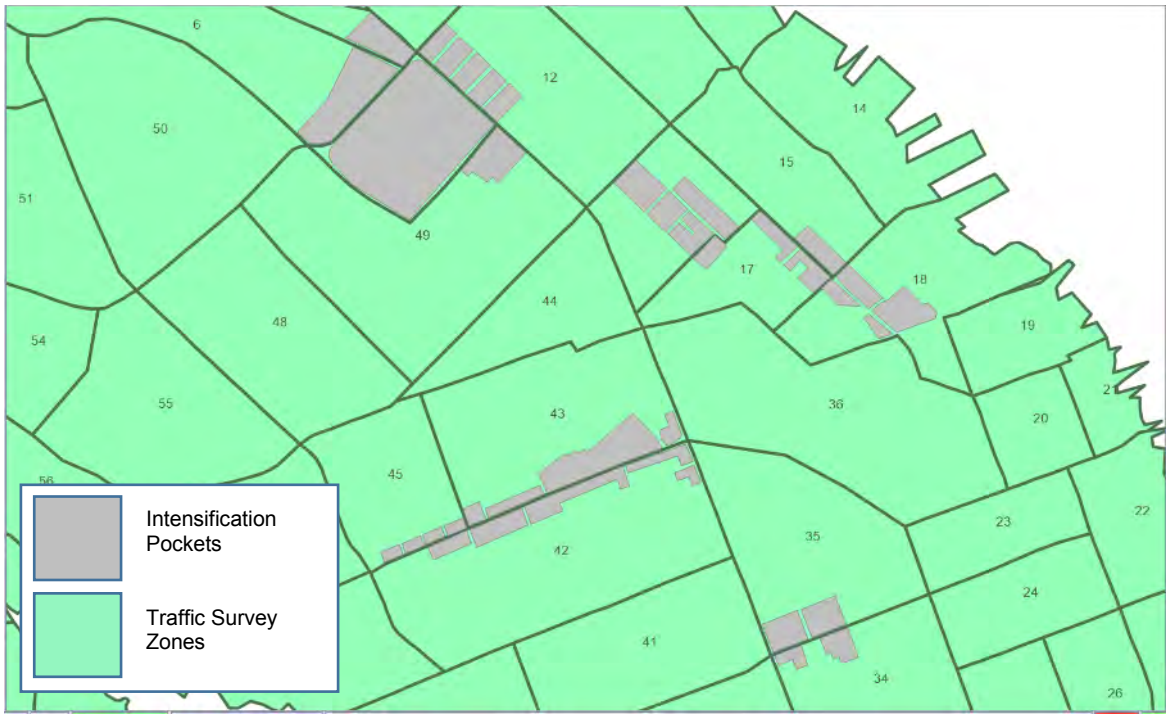


Figure 1: LoWSCA Area and TSZ

2. As the LoWSCA growth was well defined, allocation of the LoWSCA growth and its respective flows to new manholes was carried out first.
3. Then two conditions were checked, one if the allocated LoWSCA growth within each TSZ was less than TSZ PE (i.e., LoWSCA< TSZ), and the other being if the allocated LoWSCA growth within each TSZ was more than the TSZ PE (LoWSCA>TSZ).
4. It was noted that the all the TSZ containing the LoWSCA fell under the second condition.
5. Then the WRWIP growth identified for the peninsula was compared with what had already been allocation as LoWSCA growth.
6. It was noted that the WRWIP TSZ Growth Identified within the Halifax Peninsula was in excess of the LoWSCA by 10,435 PE. I.e. population from suburban areas would need to be reallocated to the peninsula to maintain the total TSZ growth numbers.
7. This 10,435 PE didn't have specific geographic location identified within the peninsula.
8. To spatially allocate the 10,435 TSZ's within the peninsula where there was growth identified but not associated to the LoWSCA intensification areas was selected.
9. A sum of the PE identified through the previous step came to 23,865 PE.
10. In order to keep the distribution of additional WRWIP growth (noted in Step 6) in line with the TSZ growth distribution. Each TSZ growth was reduced by a factor of 0.44 to achieve 10,435 required (1 – (10,435/23,865)).

11. This approach results in the allocation of population in the model equal to the sum of all the TSZ where growth was identified
12. Flows were calculated for the WRWIP modelled growth, equal to the TSZ distribution, and respective flows were allocated to manholes in the model.
13. This method was done for Halifax Peninsula.

WRWIP Allocation method

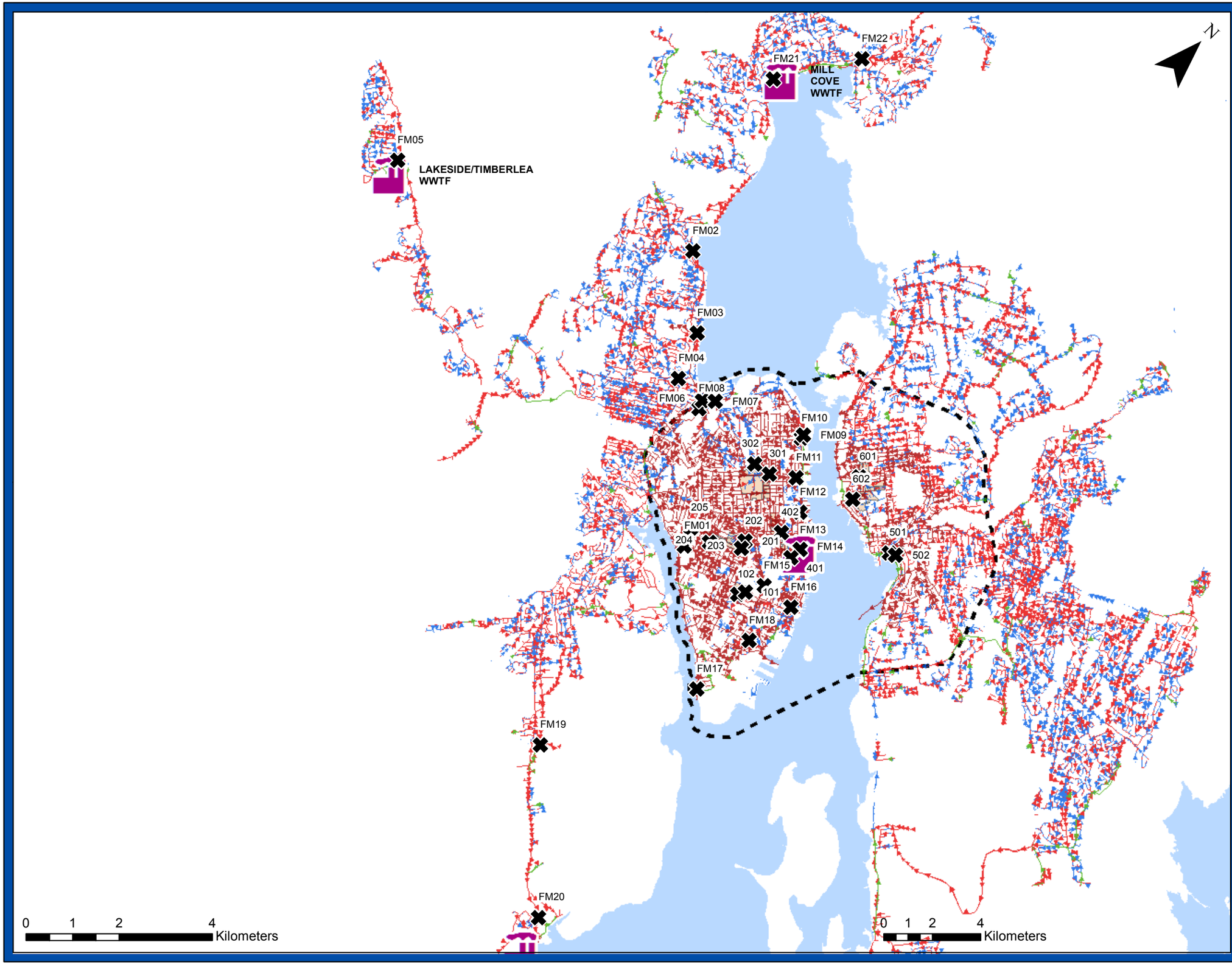
1. As a first step to carry out the allocation, the existing growth polygons, used for the RWWFP, were summarized based on the TSZ that were within or overlapped. It was noted that some of the RWWFP polygon growth areas overlapped more than one TSZ.
2. Then two conditions were checked:
    a. Is the allocated RWWFP growth within each TSZ less than TSZ PE (i.e., RWWFP< TSZ),
    b. Is the allocated RWWFP growth within each TSZ more than the TSZ PE (RWWFP>TSZ).
3. It was noted that the all the TSZ containing the RWWFP growth fell under the second condition (b). I.e. population needs to be redistributed from suburban growth areas to the downtown areas.
4. In order to keep the distribution of additional WRWIP/TSZ growth (as in the LoWSCA allocation Step 6) in line with the TSZ growth distribution. Each TSZ growth was reduced by a factor of 0.2 to achieve this.
5. This approach results in the allocation of population in the model equal to the total TSZ growth. The reallocation of growth means that the suburban WRWIP identified growth to be 47,465, which is 10,435 (Increase in Peninsula growth) less than the original RWWFP allocation of 59,803.
6. Flows were calculated for the WRWIP modelled growth, equal to the TSZ distribution, and respective flows were allocated to manholes in the model.
7. This method was done for Halifax Non Peninsula and Mill Cove and Dartmouth Non LoWSCA areas.

Population Allocation Summary Table

Area	Total TSZ Growth	LoWSCA allocation of TSZ
Halifax Peninsula Growth	36,639	26,184
Halifax Non-Peninsula	59,820	0
Halifax Total Growth	96,459	0

Area	Total TSZ Growth	LoWSCA allocation of TSZ
Dartmouth Peninsula Growth-LoWSCA	3043	11,512
Dartmouth Non-Peninsula	40,172	0
Dartmouth Total Growth	43,215	0

Appendix E Model Calibration Graphs



Halifax Water
LoWSCA and WRWIP
Flow Monitor Locations

Legend

- LoWSCA_Study_Areas
- Regional Centre Boundary

Existing Wastewater Infrastructure

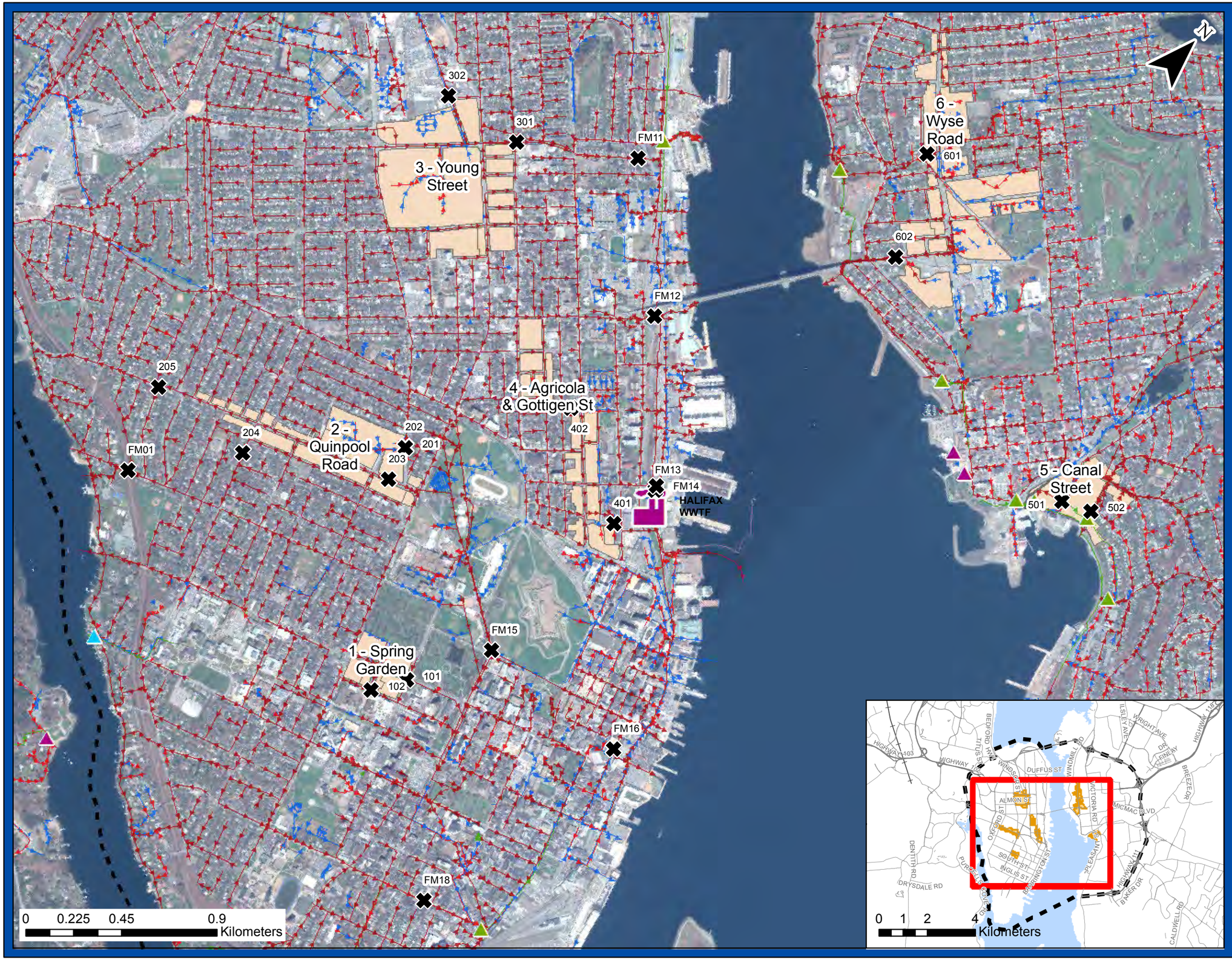
- Sanitary Pumping Station
- Storm Pumping Station
- Combined Pumping Station
- Wastewater Treatment Facility

Sewer Pipe

- Force Main
- Combined Sanitary Main
- Combined Sanitary Trunk
- Stormwater Main
- Sanitary Main
- Sanitary Trunk
- Flow Monitor Locations

BluePlan ENGINEERING

715009-WW
July 2016
Data Source: Halifax Water
Scale: 1:150,000 | ATS 1977 MTM 5 Nova Scotia



Halifax Water

Halifax Water
LoWSCA and WRWIP
Flow Monitor Locations

Legend

- LoWSCA_Study_Areas
- Regional Centre Boundary

Existing Wastewater Infrastructure

- Sanitary Pumping Station
- Storm Pumping Station
- Combined Pumping Station
- Wastewater Treatment Facility

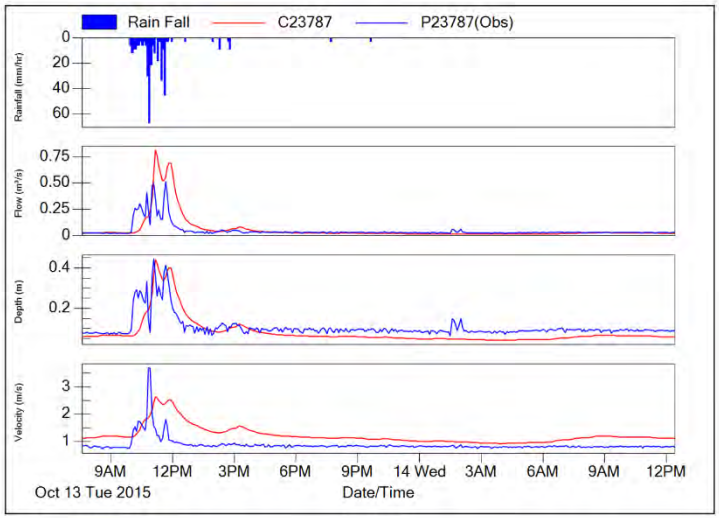
Sewer Pipe

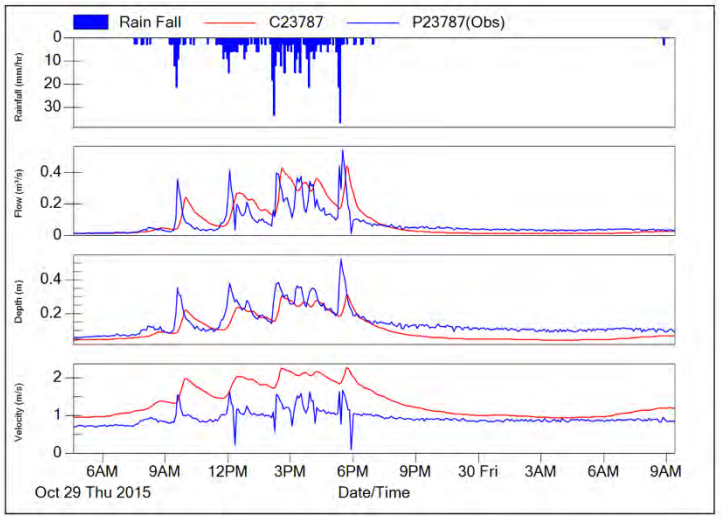
- Force Main
- Combined Sanitary Main
- Combined Sanitary Trunk
- Stormwater Main
- Sanitary Main
- Sanitary Trunk
- Flow Monitor Locations

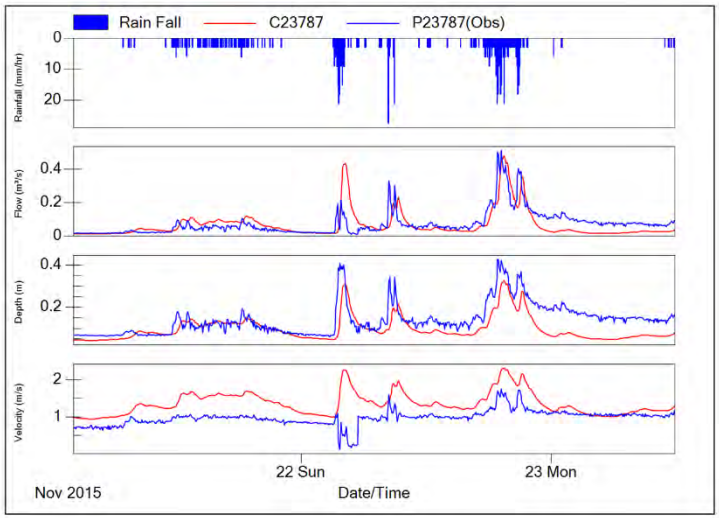
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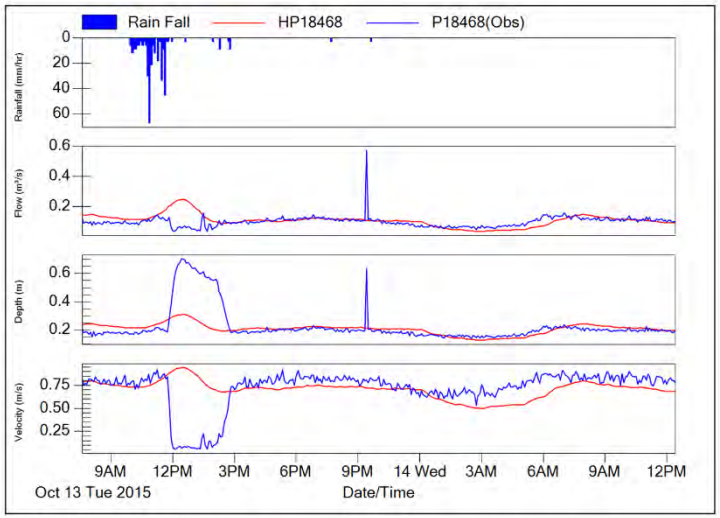
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_1

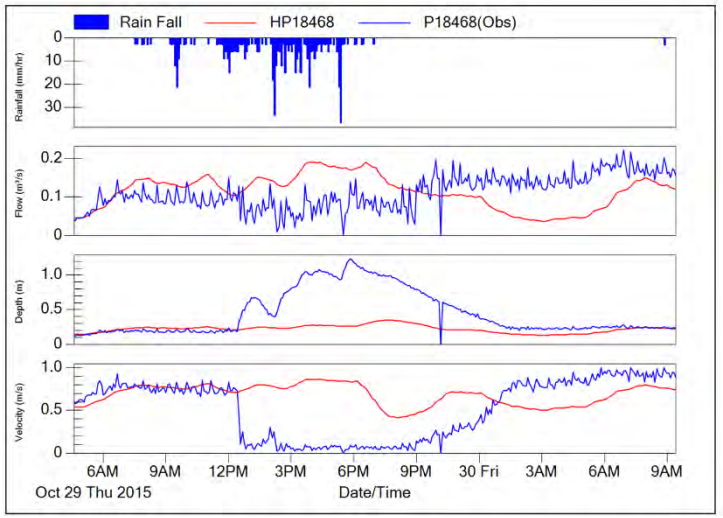


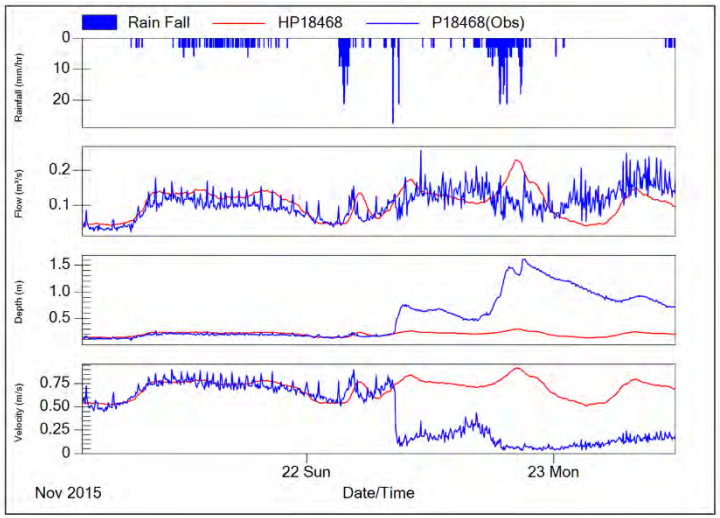




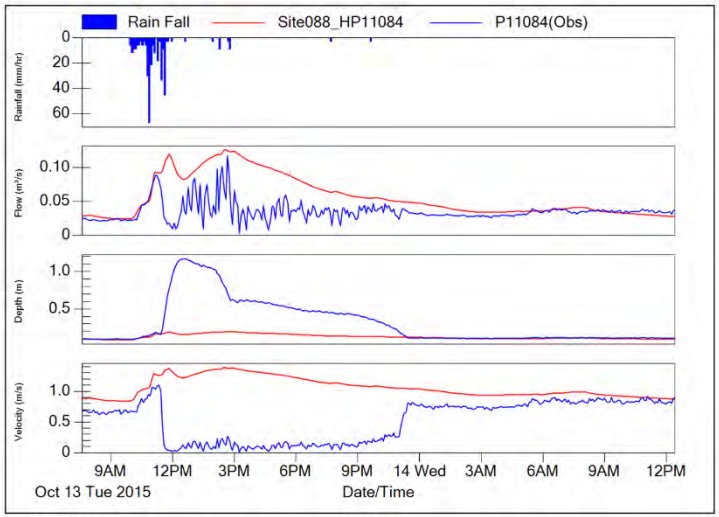
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_2

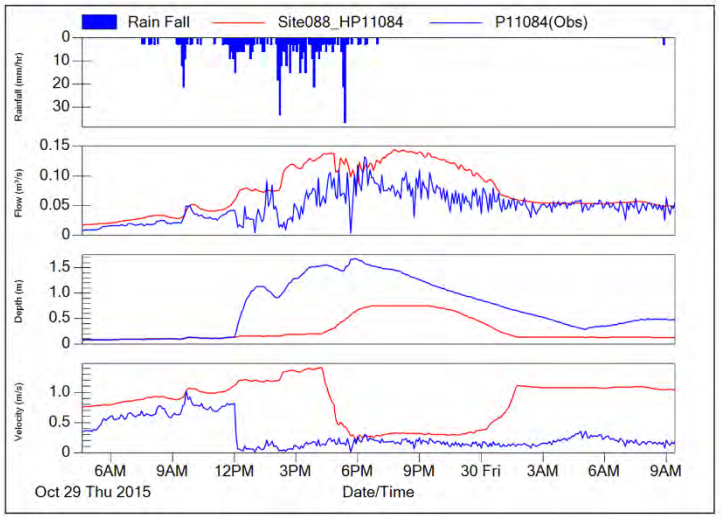


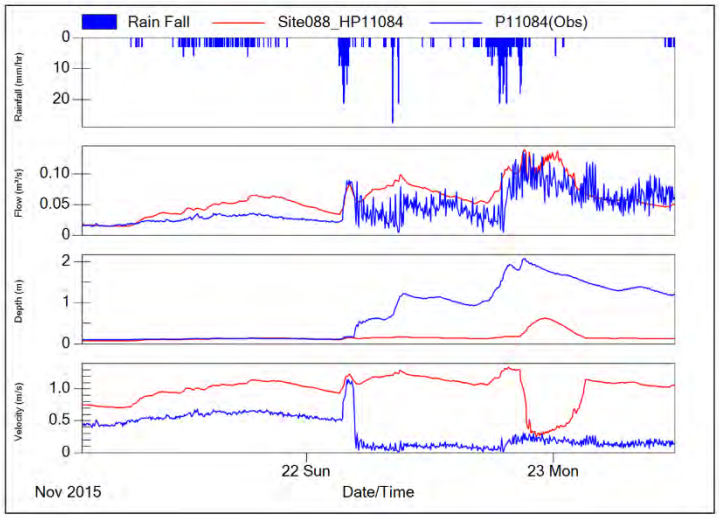




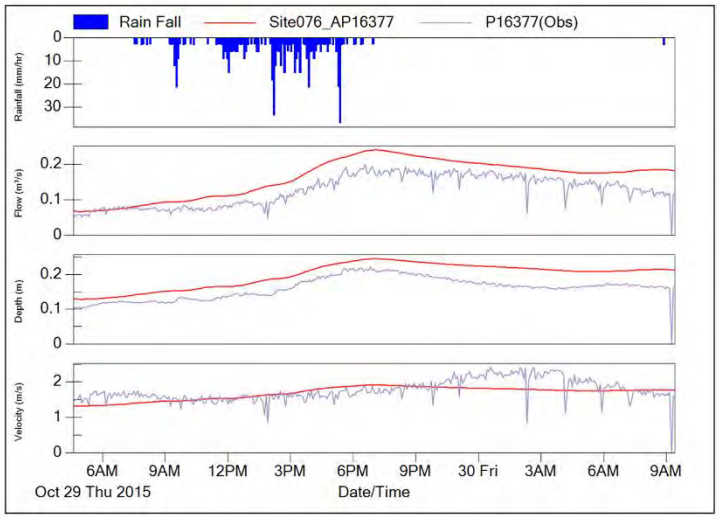
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_3

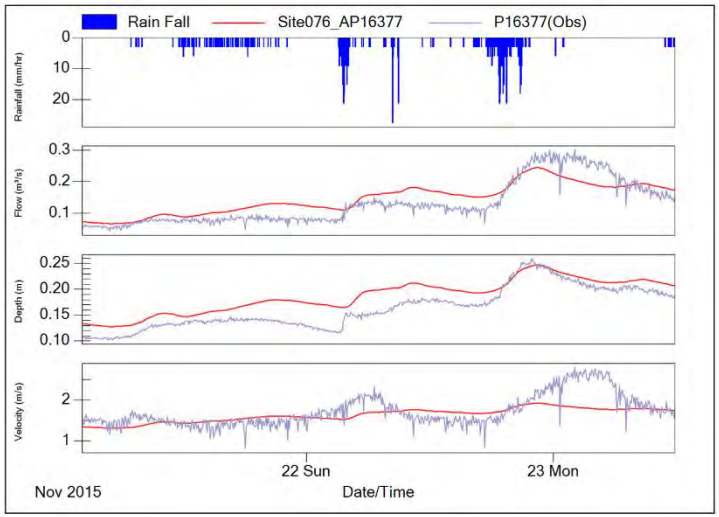




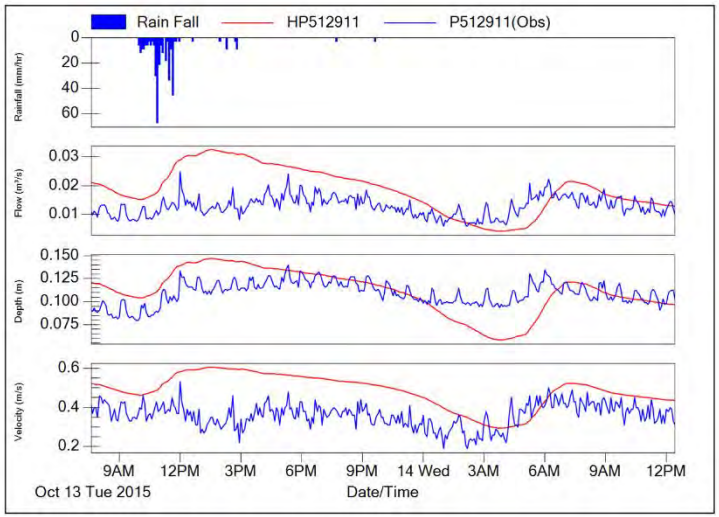


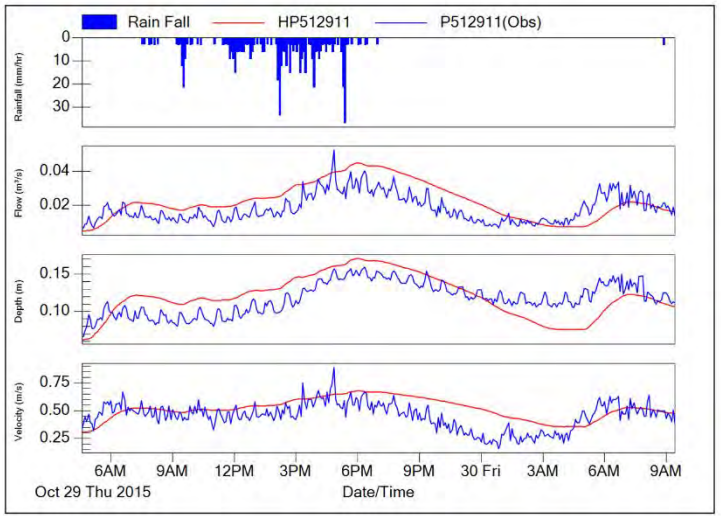
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_4

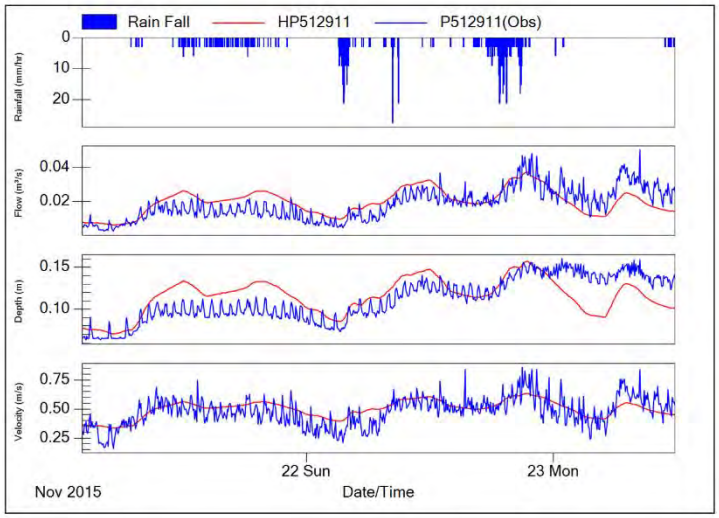




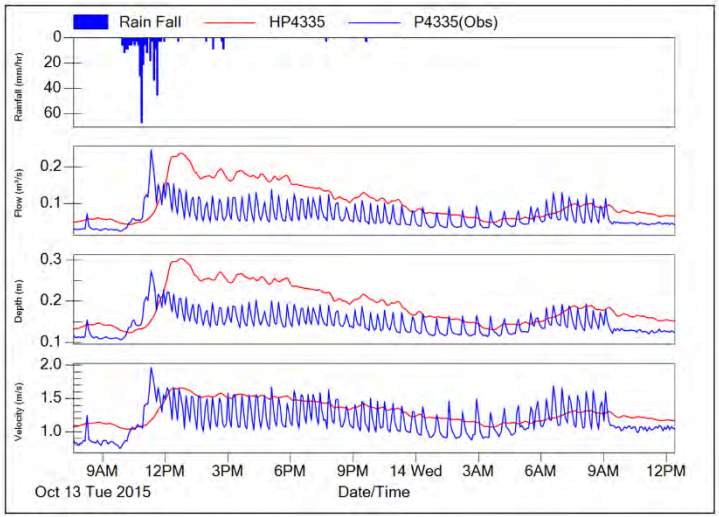
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_5

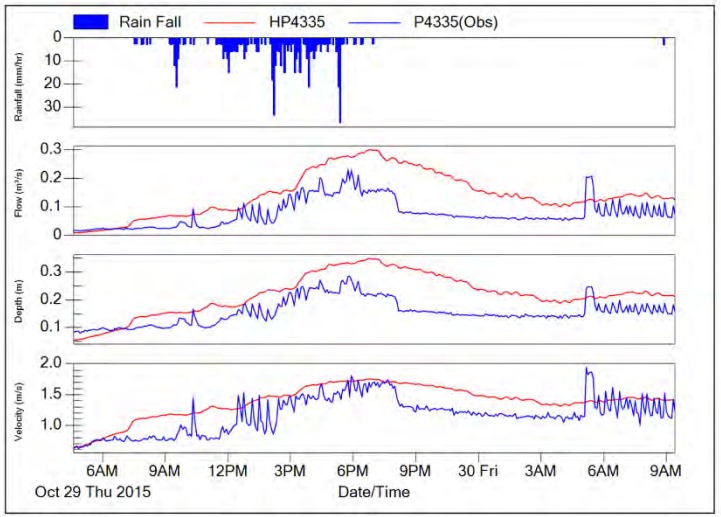


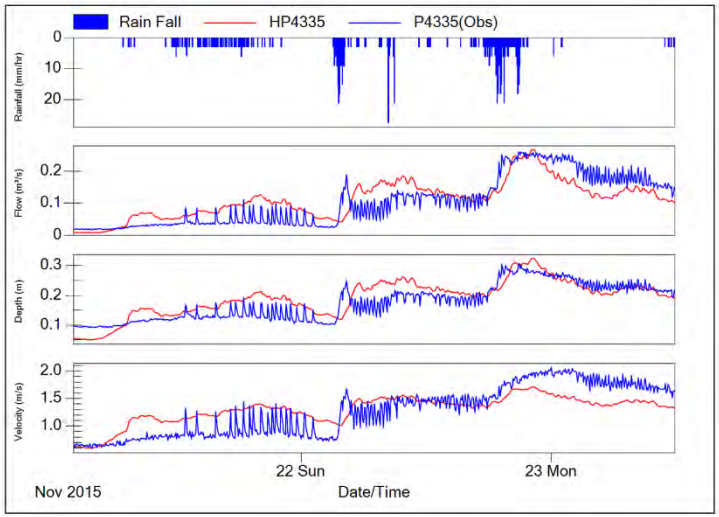




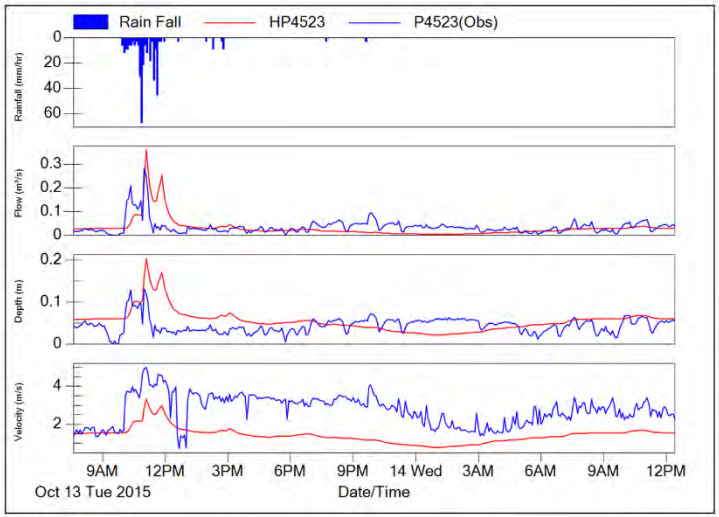
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_6

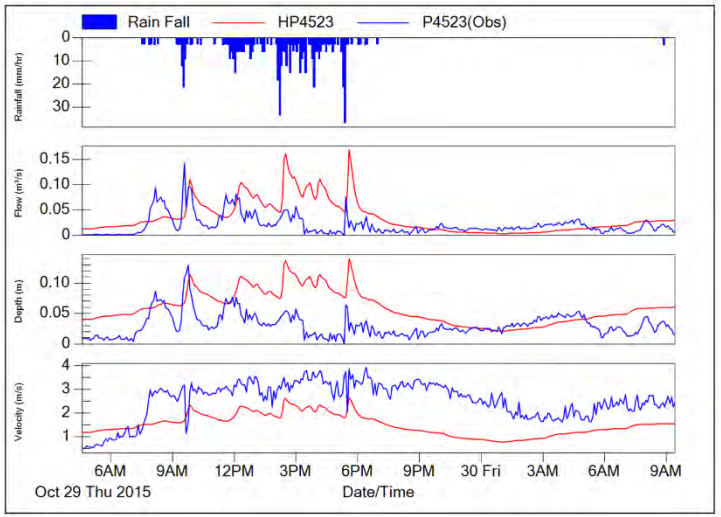


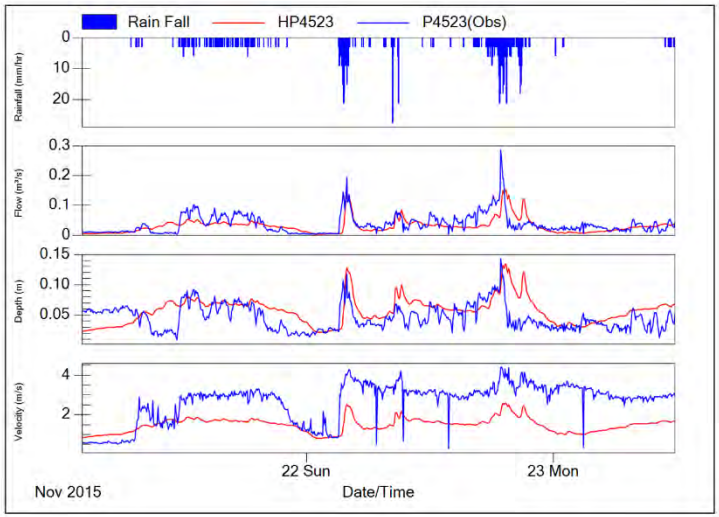




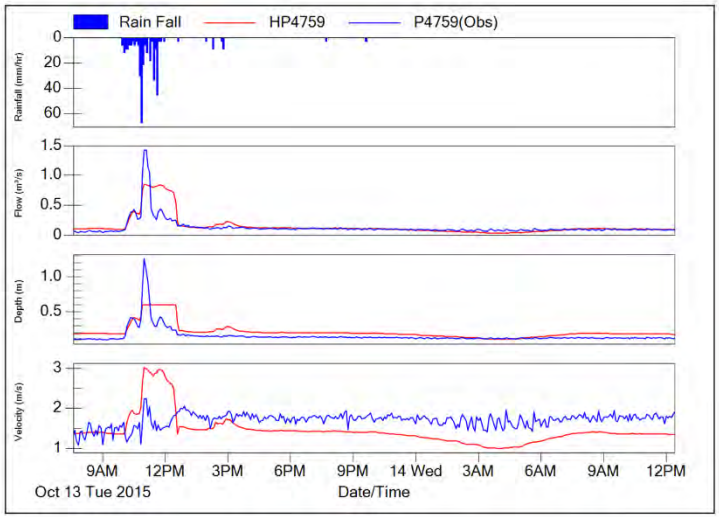
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_7

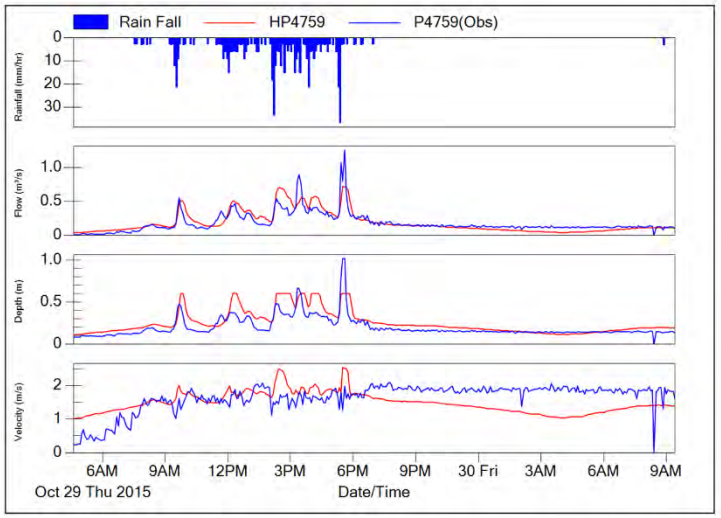


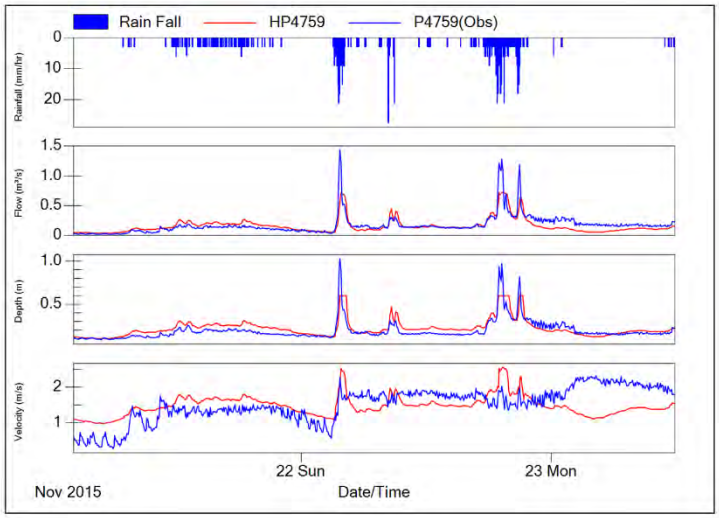




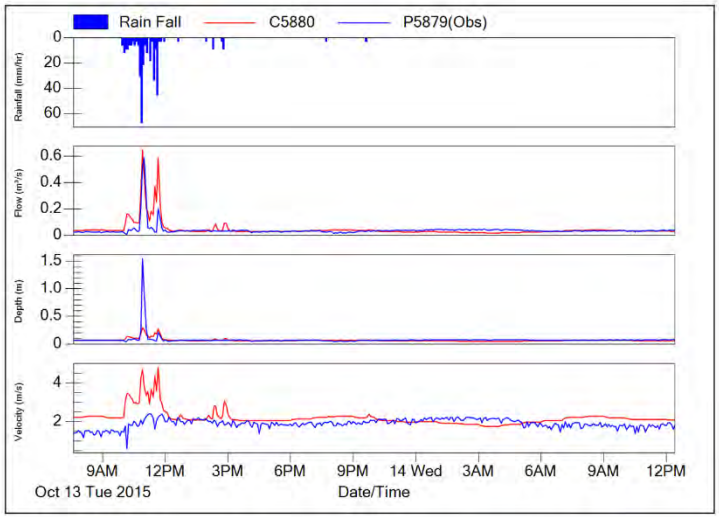
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_8

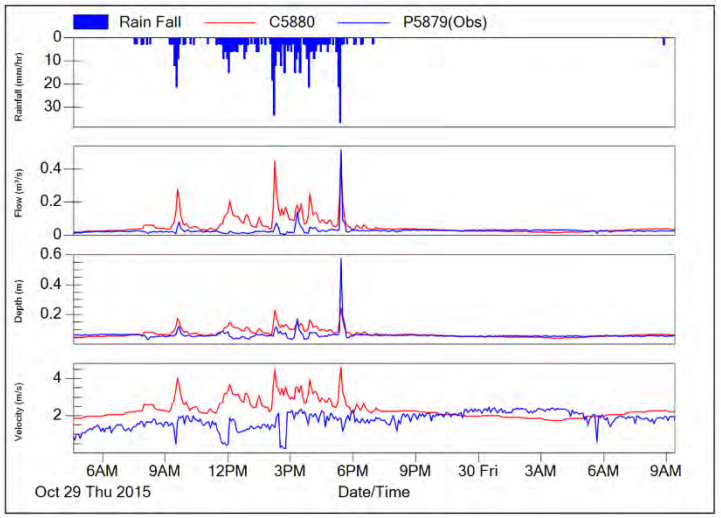


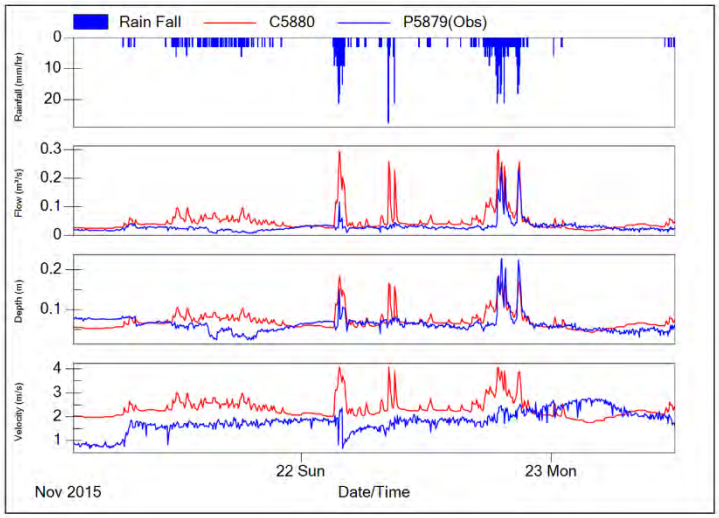




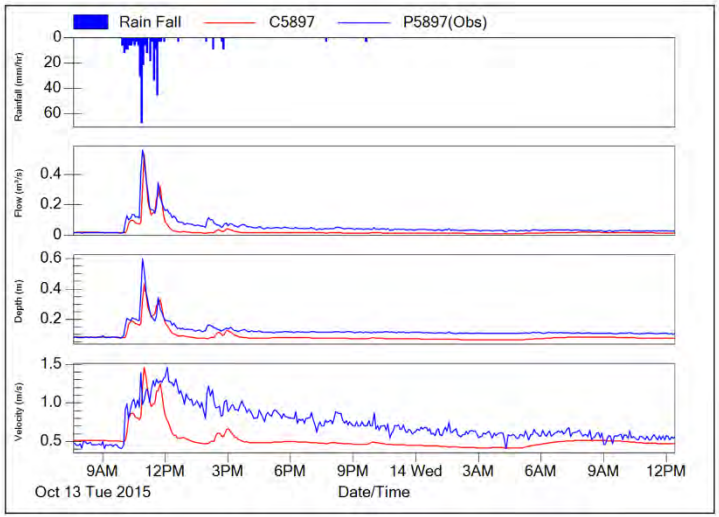
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_9

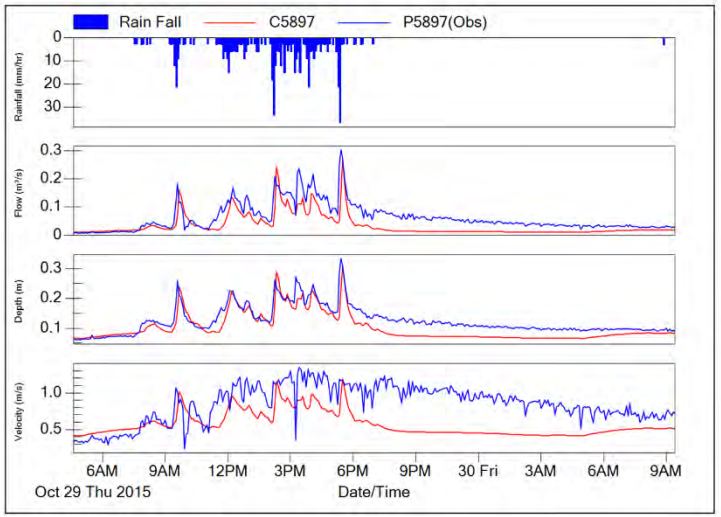


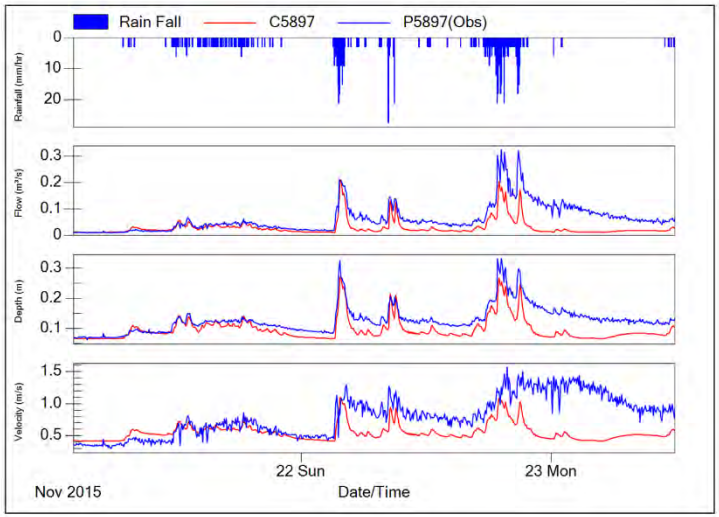




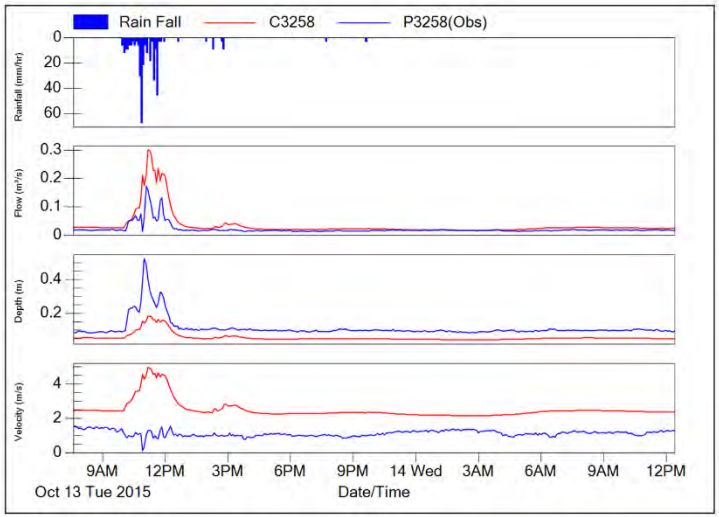
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_10

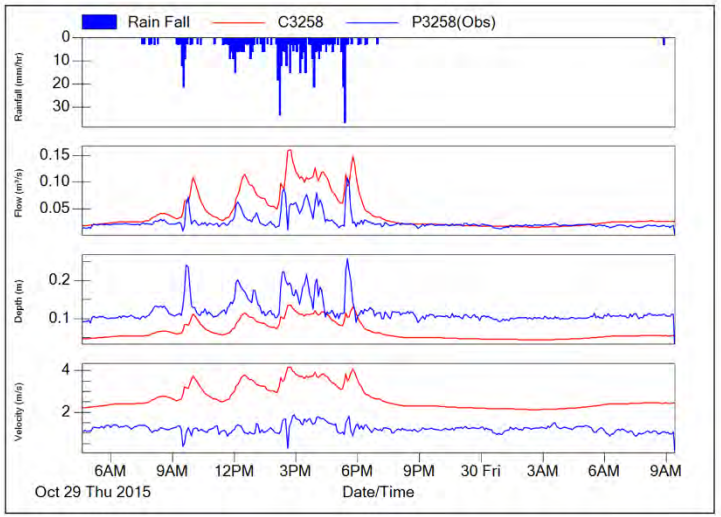


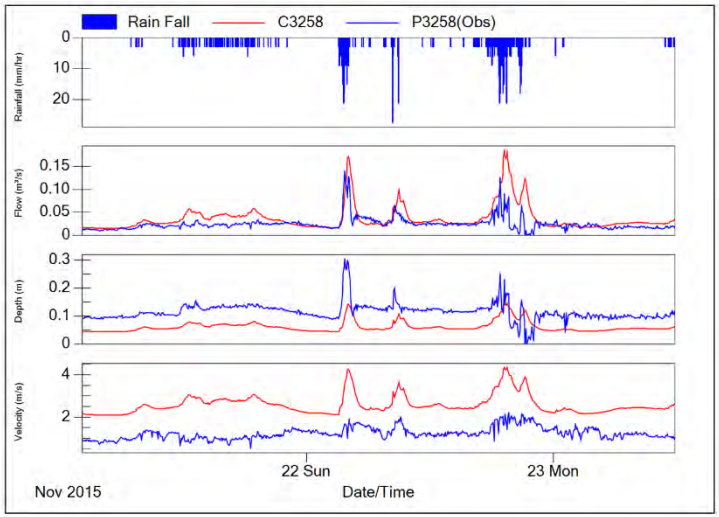




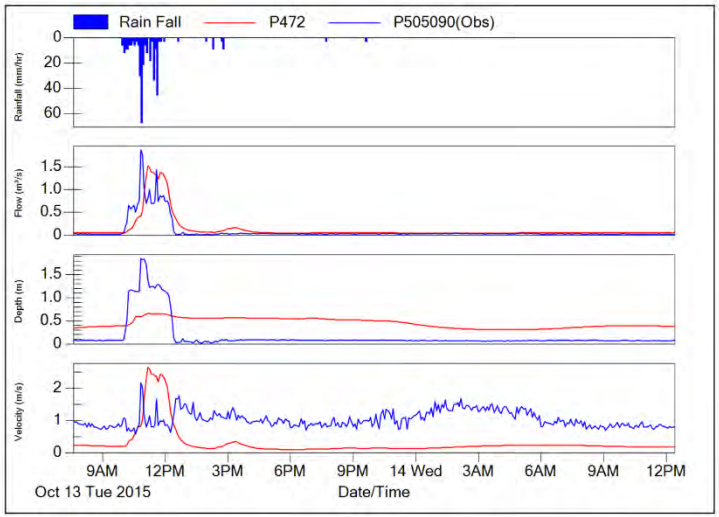
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_11

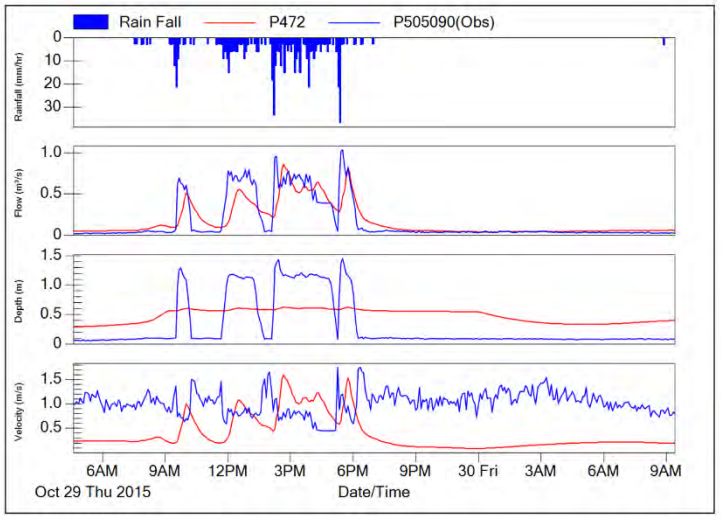


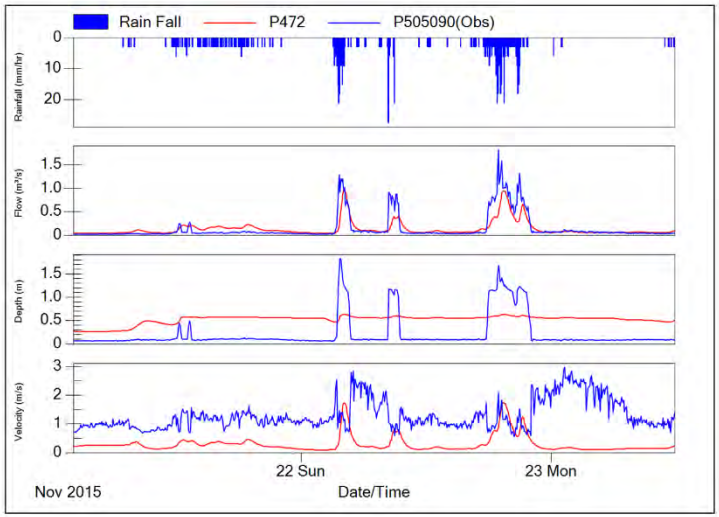




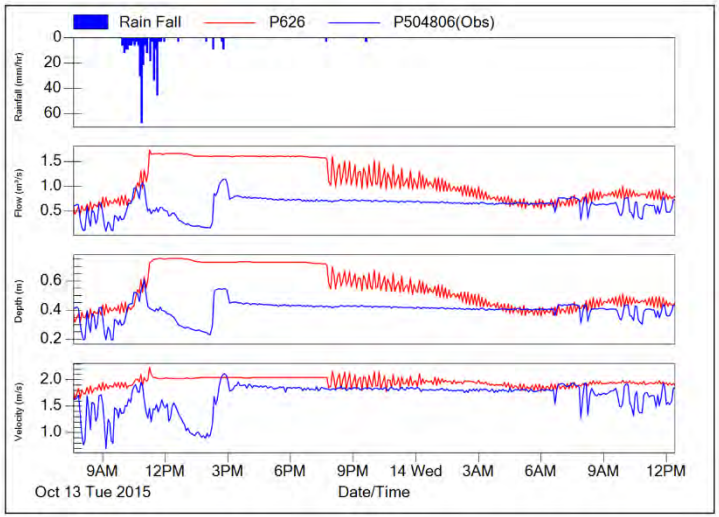
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_12

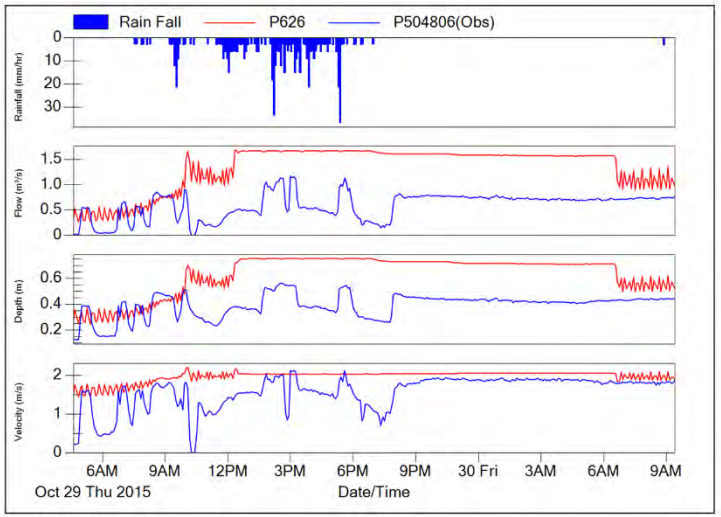


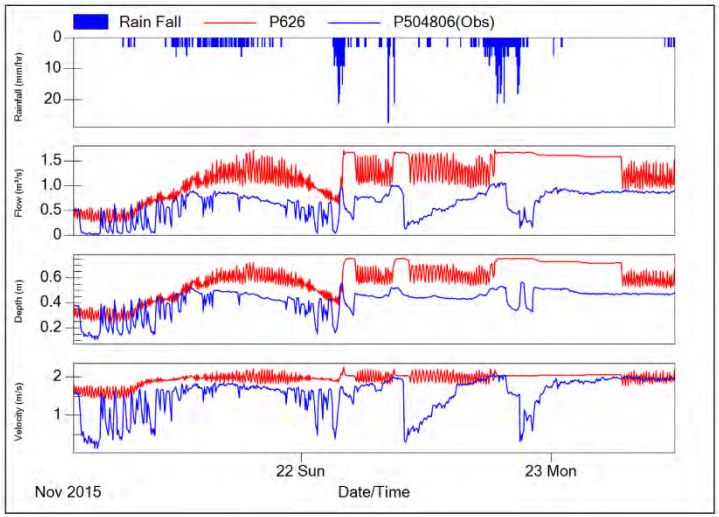




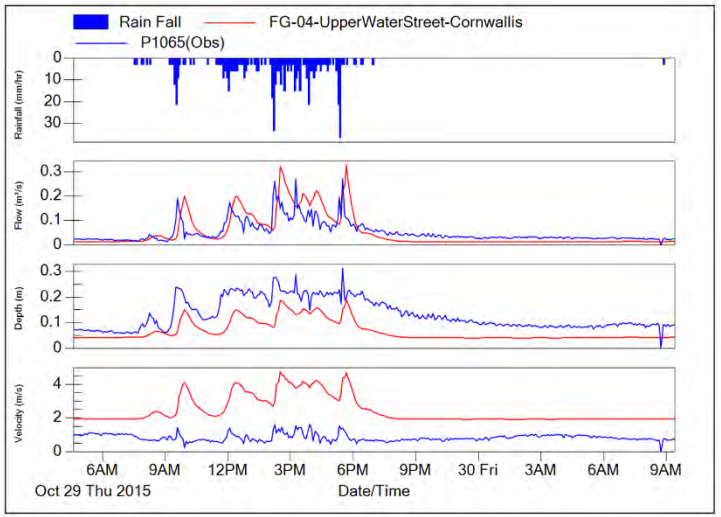
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_13

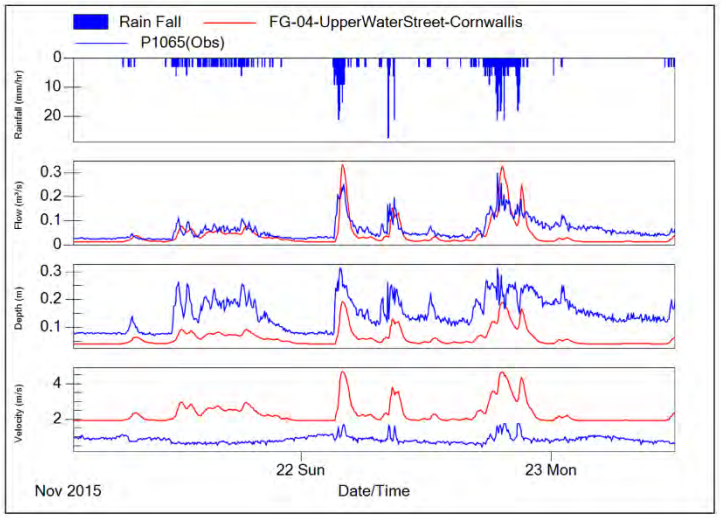




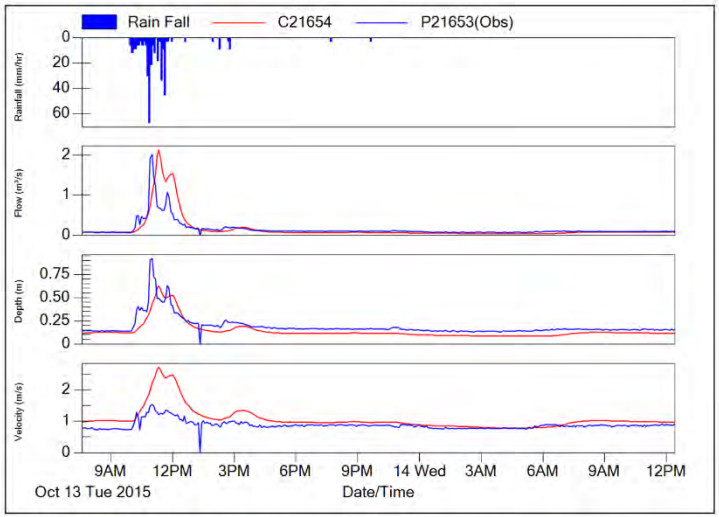


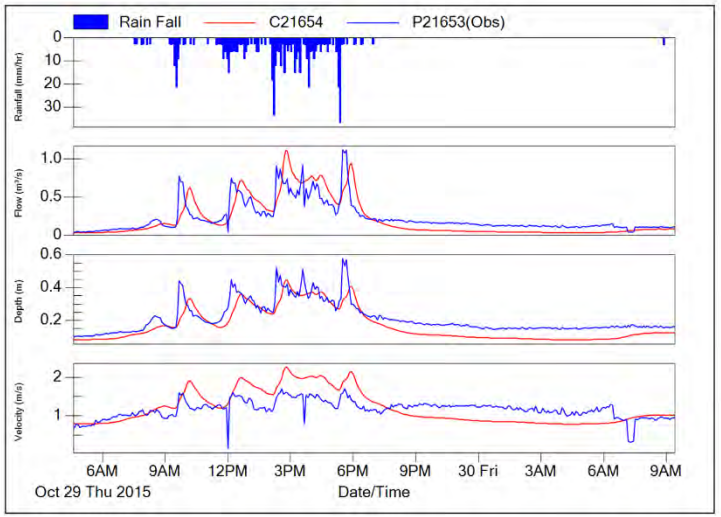
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_14

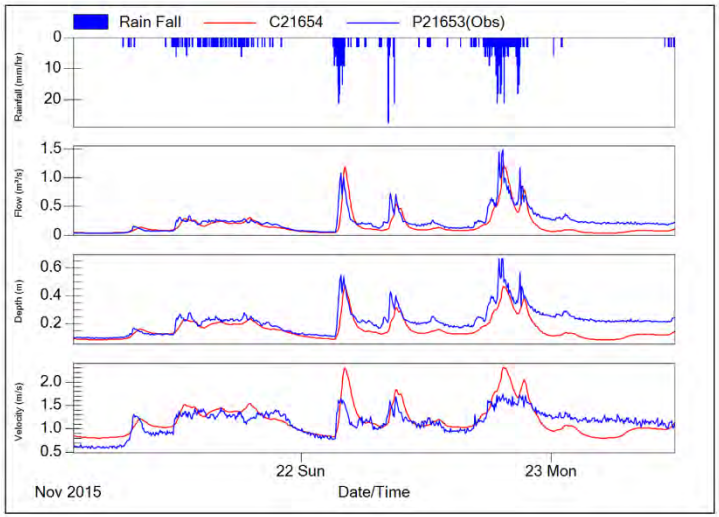




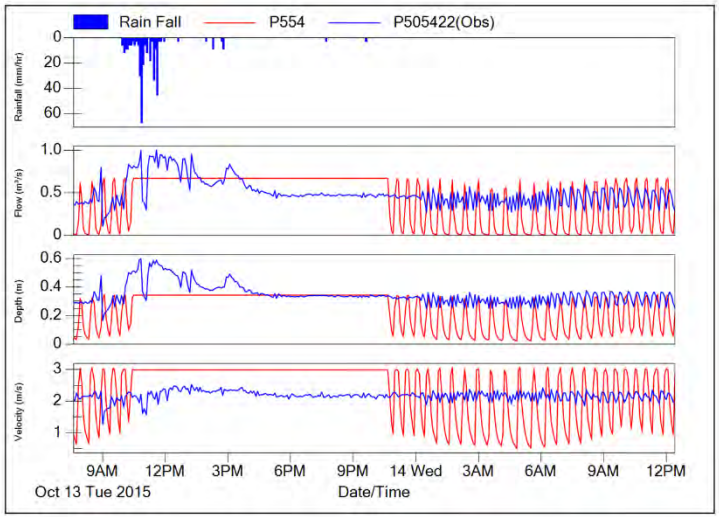
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_15

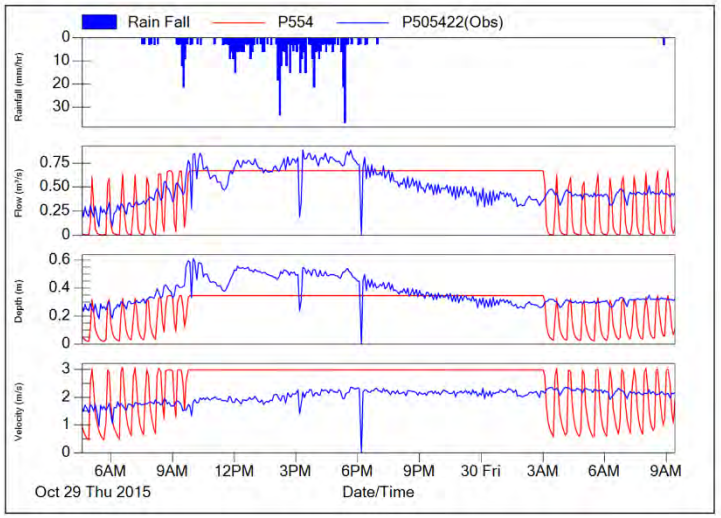


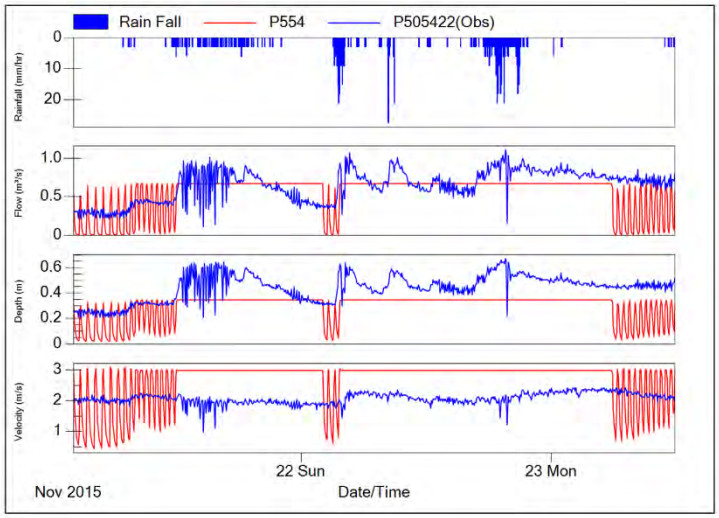




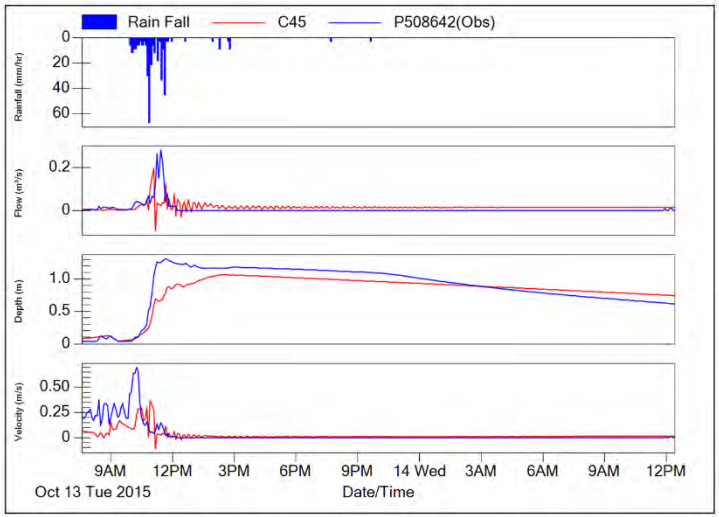
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_16

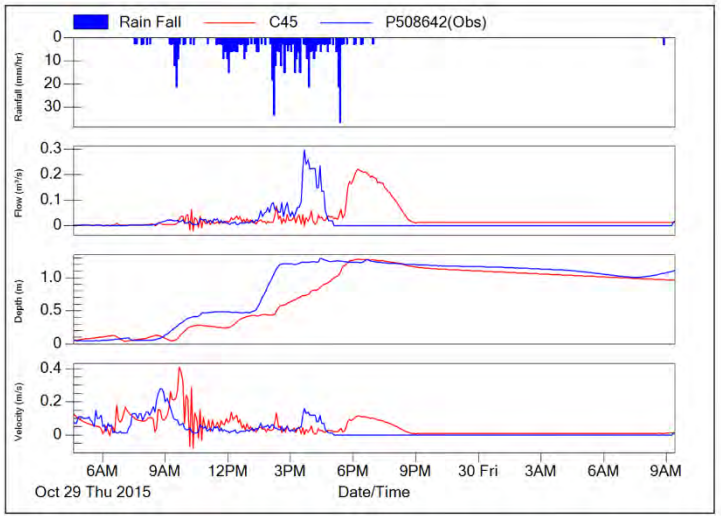


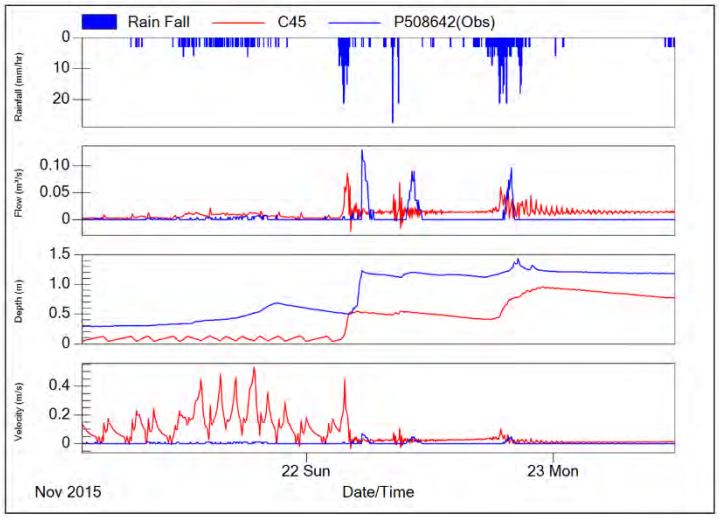




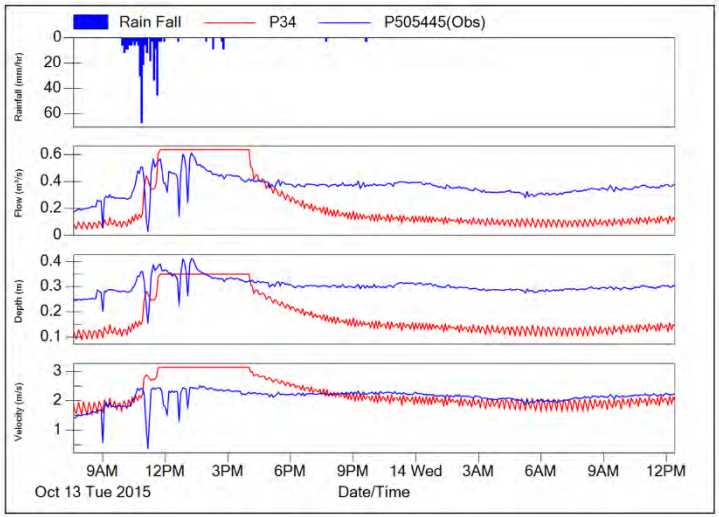
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_17

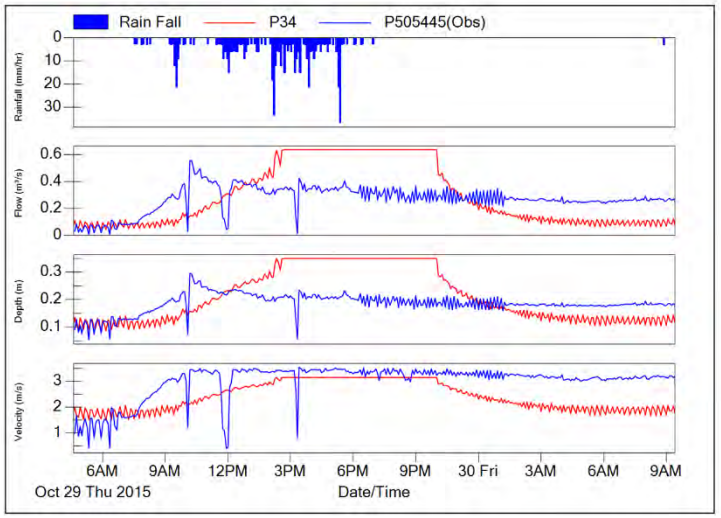


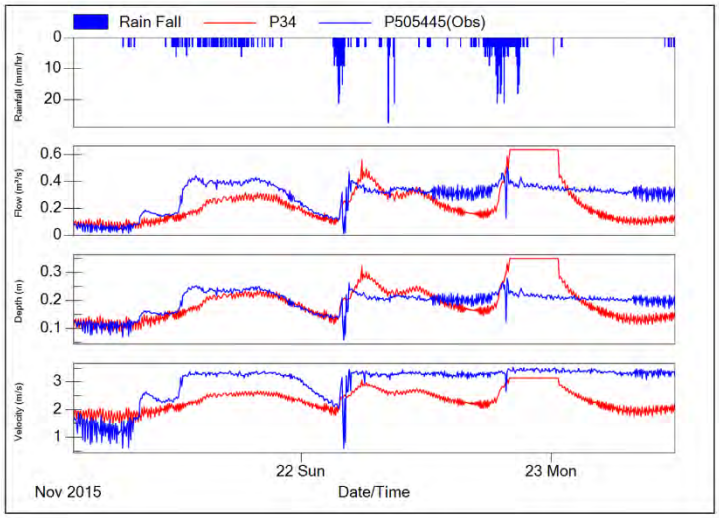


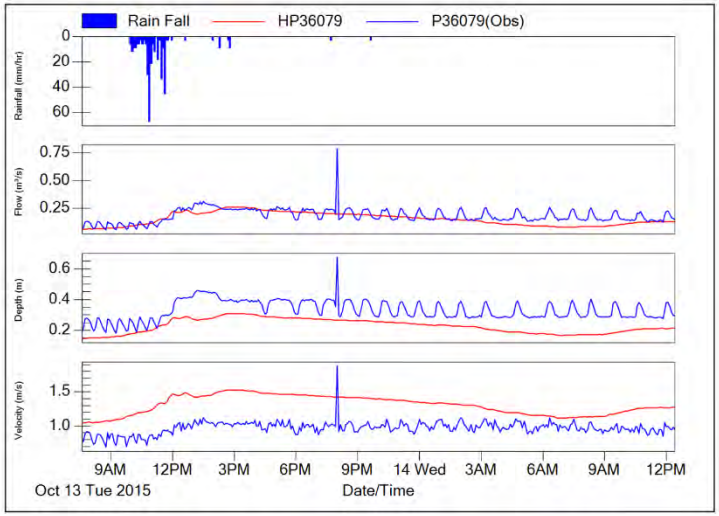


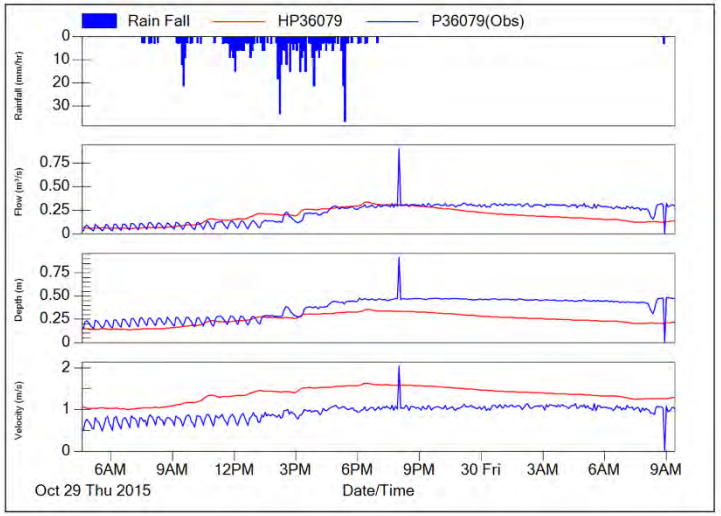
LoWSCA and WRWIP Hydraulic Model Calibration Graphs
FM_18

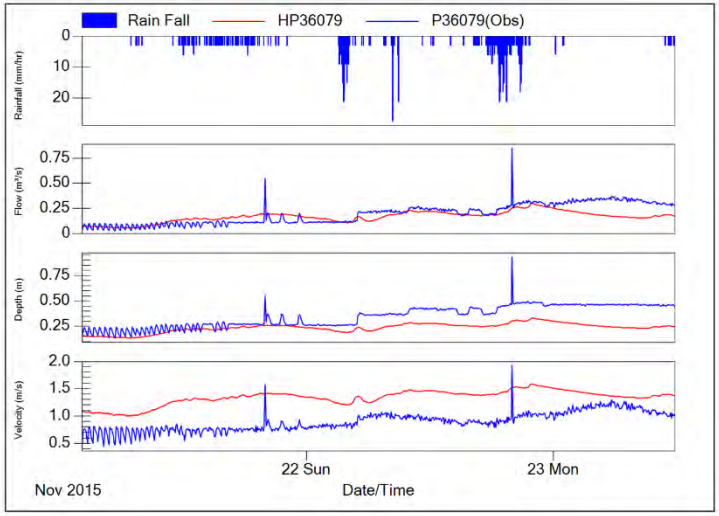


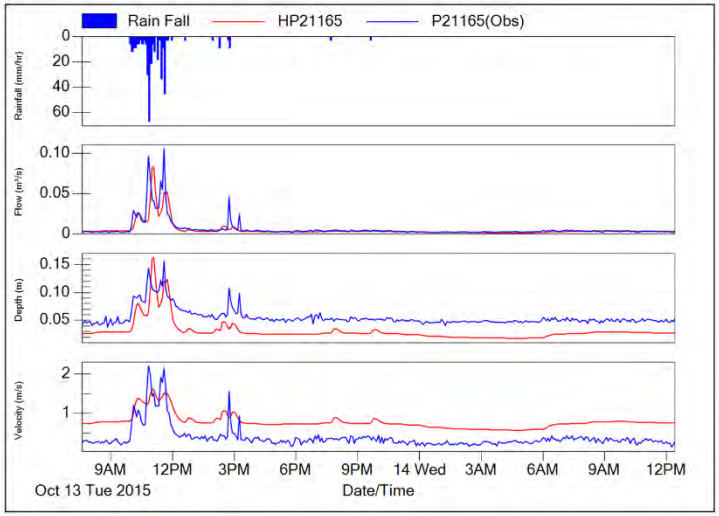


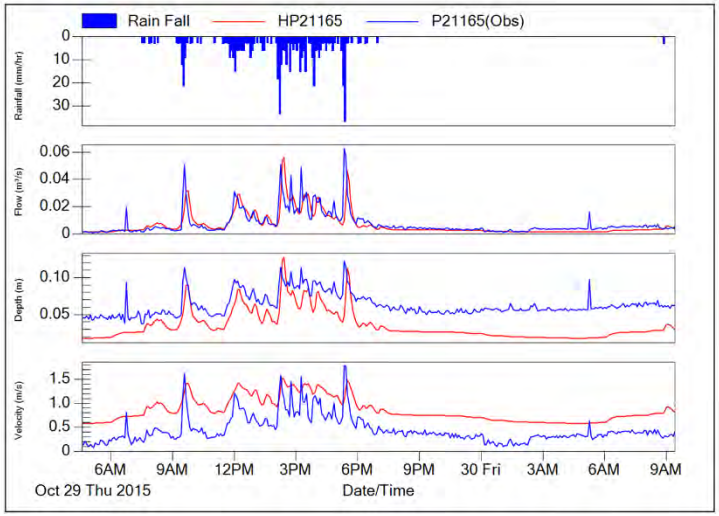


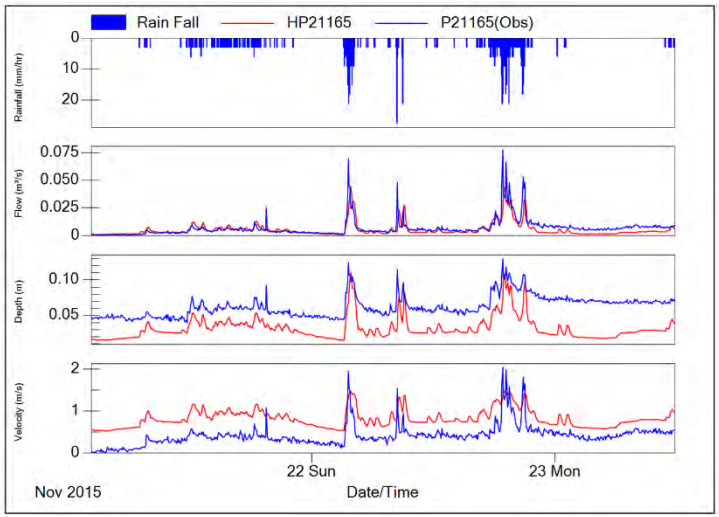

Rain Fall
HP36079
P36079(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.75
0.50
0.25
Depth (m)
0.6
0.4
0.2
Velocity (m/s)
1.5
1.0
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

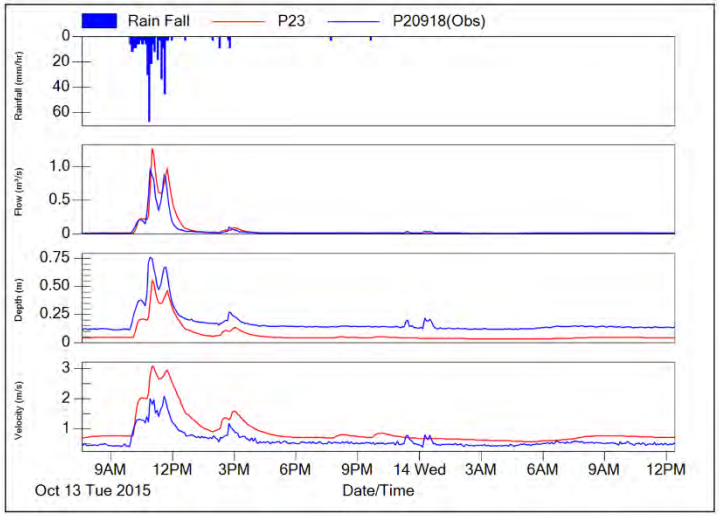

Rain Fall
HP36079
P36079(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.75
0.50
0.25
0
Depth (m)
0.75
0.50
0.25
0
Velocity (m/s)
2
1
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

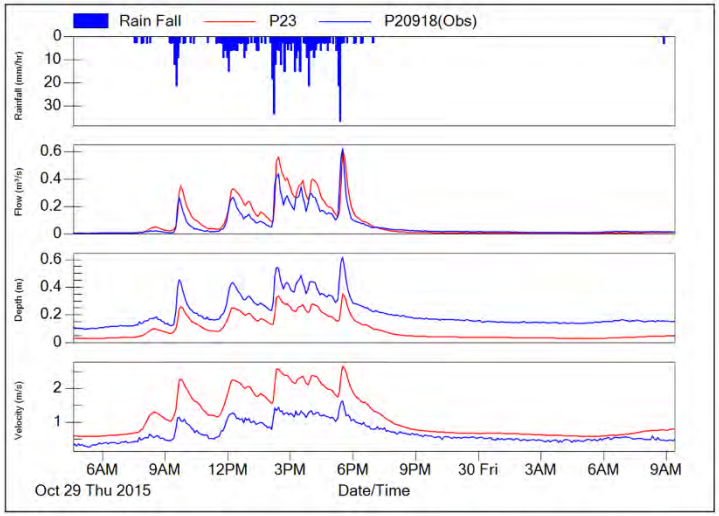

Rain Fall
HP36079
P36079(Obs)
Rainfall (mm/hr)
0
10
20
Flow (m³/s)
0.75
0.50
0.25
0
Depth (m)
0.75
0.50
0.25
Velocity (m/s)
2.0
1.5
1.0
0.5
22 Sun
23 Mon
Nov 2015
Date/Time

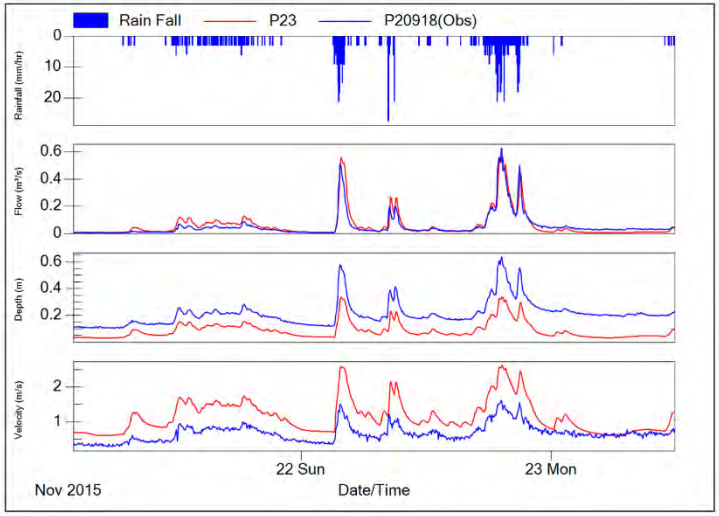

Rain Fall
HP21165
P21165(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.10
0.05
0
Depth (m)
0.15
0.10
0.05
Velocity (m/s)
2
1
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

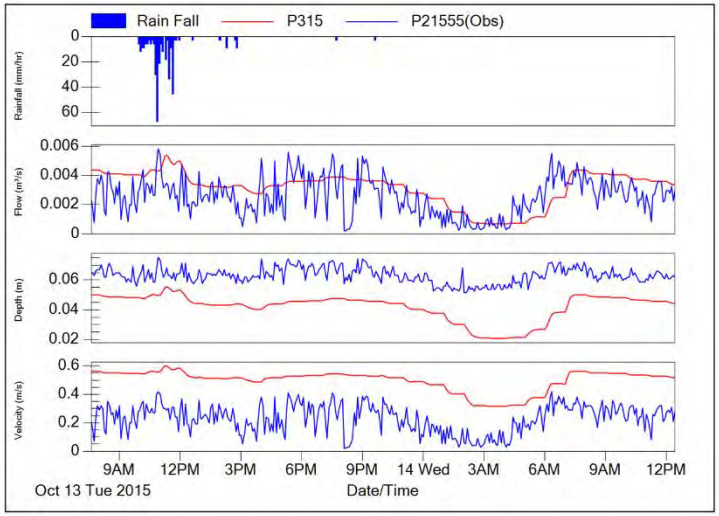

Rain Fall
HP21165
P21165(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.06
0.04
0.02
0
Depth (m)
0.10
0.05
Velocity (m/s)
1.5
1.0
0.5
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

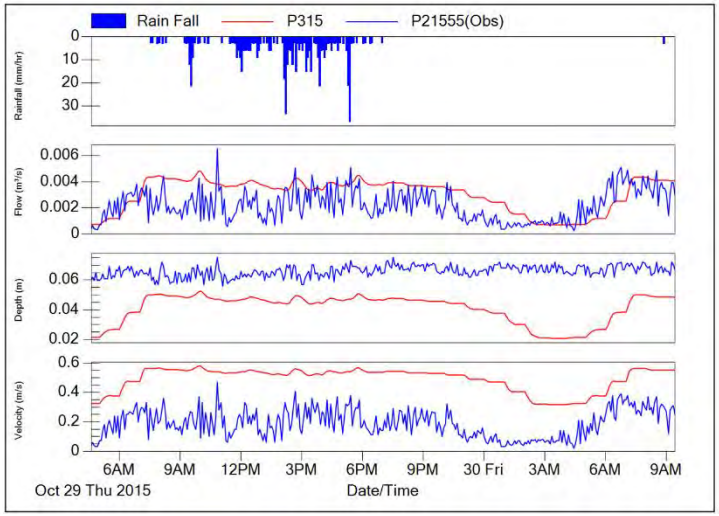

Rain Fall
HP21165
P21165(Obs)
Rainfall (mm/hr)
0
10
20
Flow (m³/s)
0.075
0.050
0.025
0
Depth (m)
0.10
0.05
Velocity (m/s)
2
1
0
22 Sun
23 Mon
Nov 2015
Date/Time

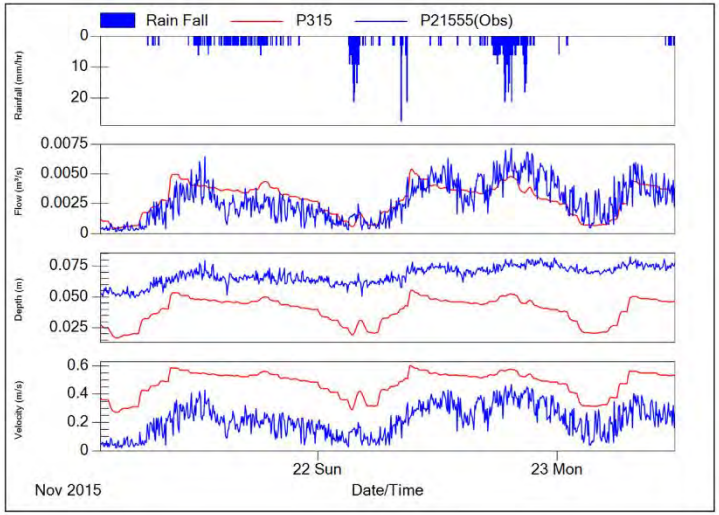

Rain Fall
P23
P20918(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

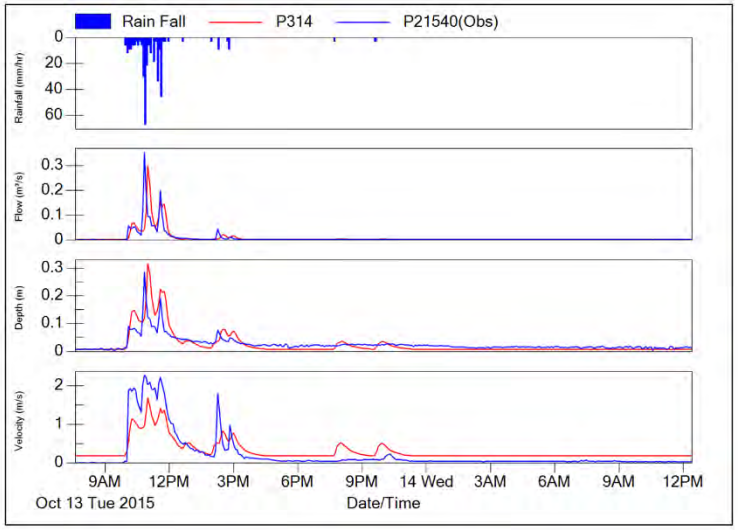

Rain Fall
P23
P20918(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

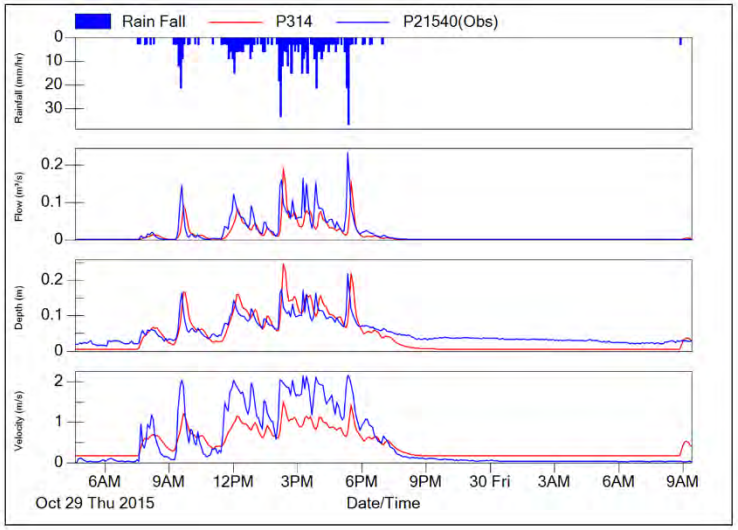

Rain Fall
P23
P20918(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
22 Sun
23 Mon
Nov 2015
Date/Time

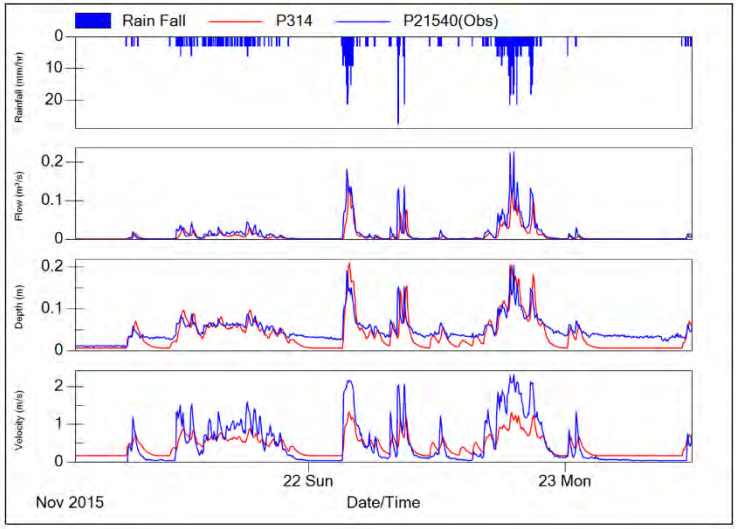

Rain Fall
P315
P21555(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.006
0.004
0.002
0
Depth (m)
0.06
0.04
0.02
Velocity (m/s)
0.6
0.4
0.2
0
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

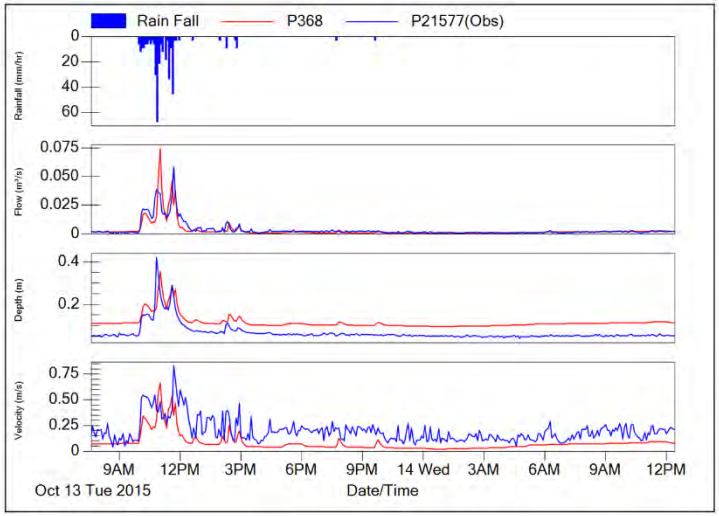

Rain Fall
P315
P21555(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.006
0.004
0.002
0
Depth (m)
0.06
0.04
0.02
Velocity (m/s)
0.6
0.4
0.2
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

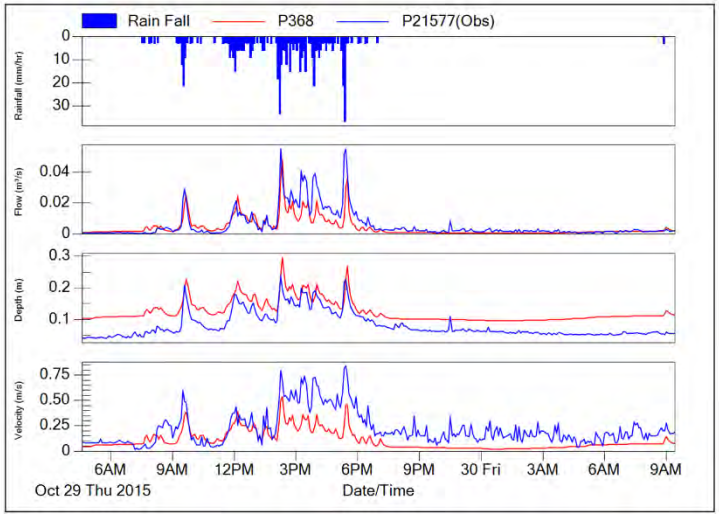

Rain Fall
P315
P21555(Obs)
Rainfall (mm/hr)
0
10
20
Flow (m³/s)
0.0075
0.0050
0.0025
0
Depth (m)
0.075
0.050
0.025
Velocity (m/s)
0.6
0.4
0.2
0
22 Sun
23 Mon
Nov 2015
Date/Time

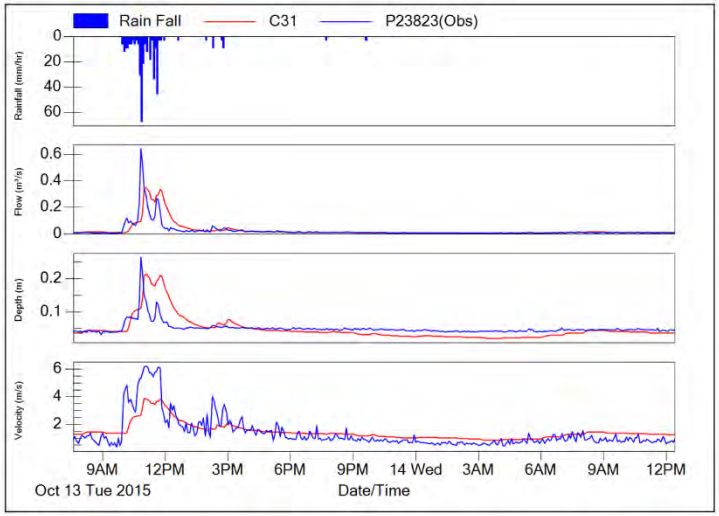

Rain Fall
P314
P21540(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

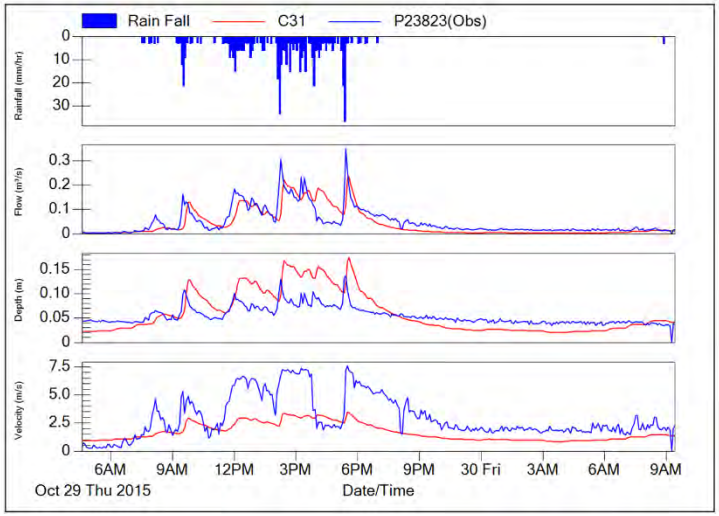

Rain Fall
P314
P21540(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

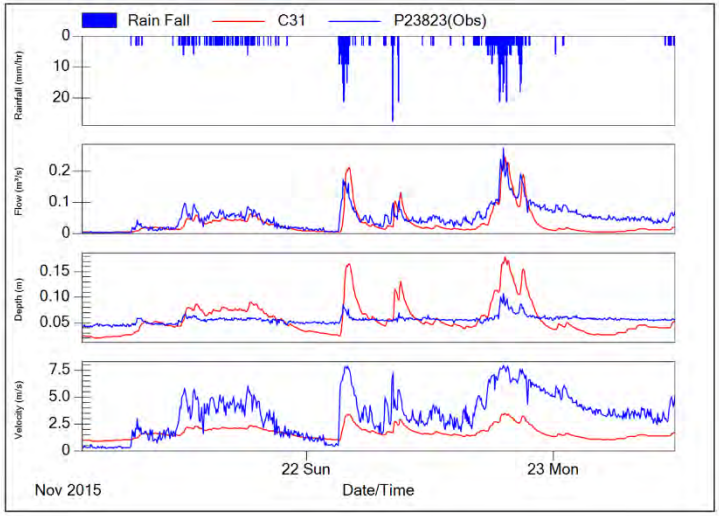

Rain Fall
P314
P21540(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
22 Sun
23 Mon
Nov 2015
Date/Time

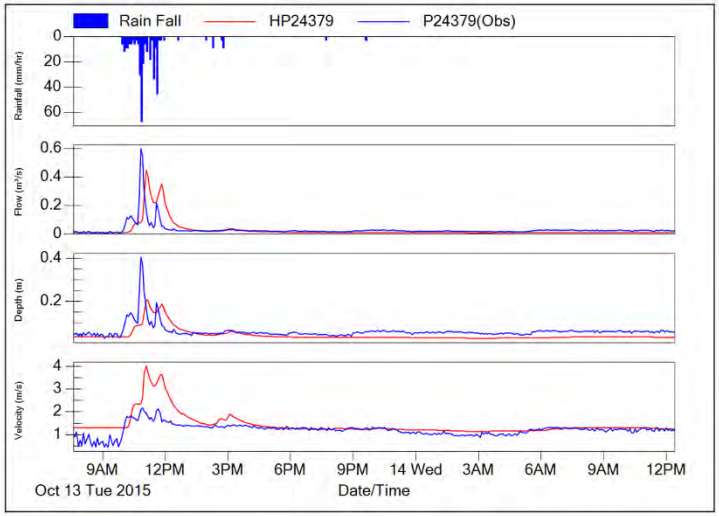

Rain Fall
P368
P21577(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.075
0.050
0.025
0
Depth (m)
0.4
0.2
Velocity (m/s)
0.75
0.50
0.25
0
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

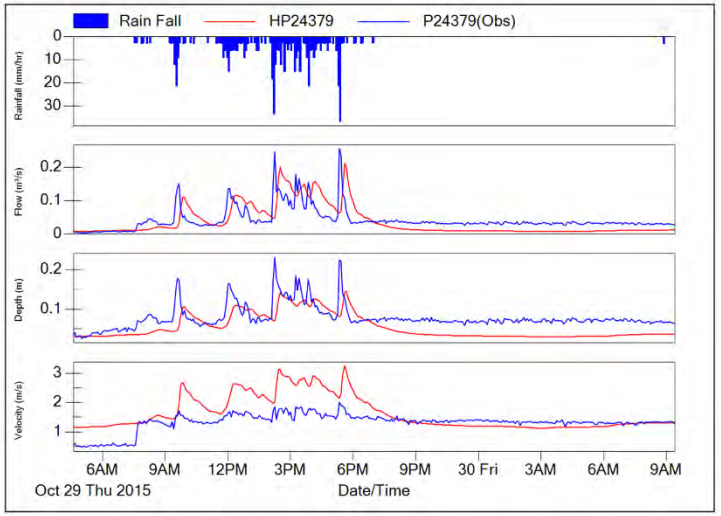

Rain Fall
P368
P21577(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.04
0.02
0
Depth (m)
0.3
0.2
0.1
Velocity (m/s)
0.75
0.50
0.25
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

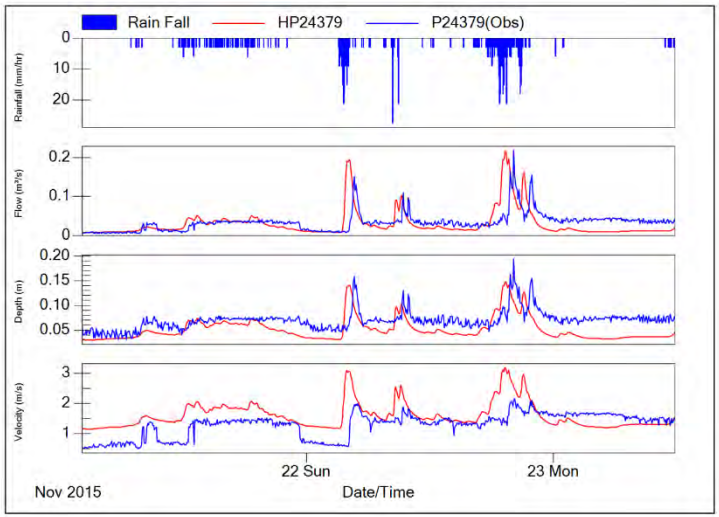

Rain Fall
C31
P23823(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

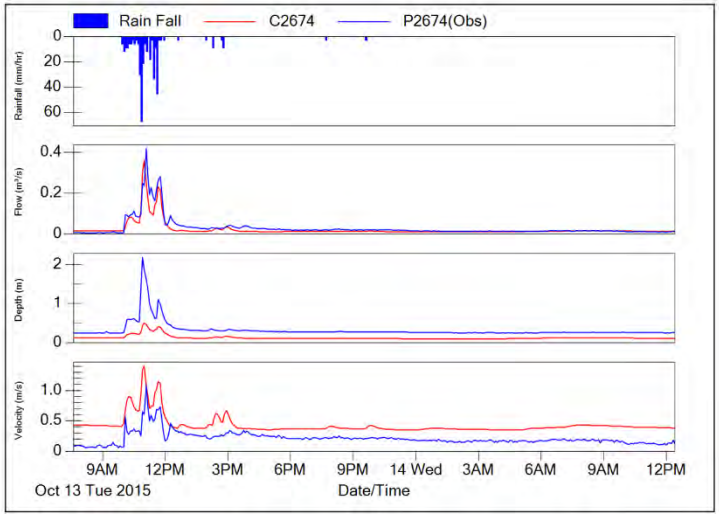

Rain Fall
C31
P23823(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

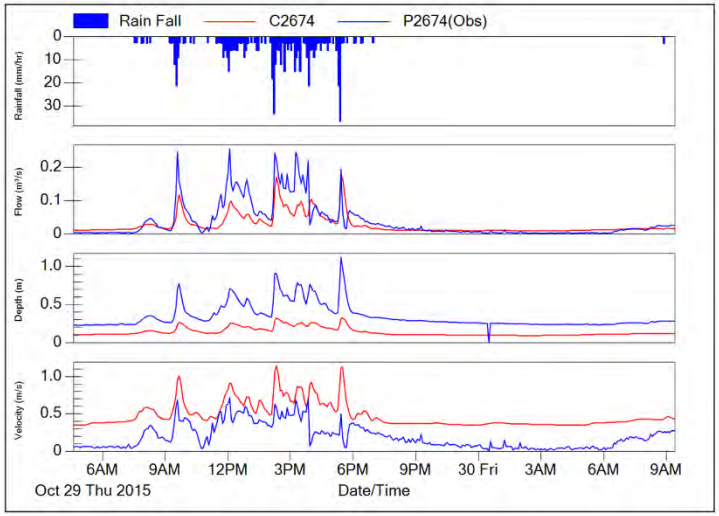

Rain Fall
C31
P23823(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
22 Sun
23 Mon
Nov 2015
Date/Time

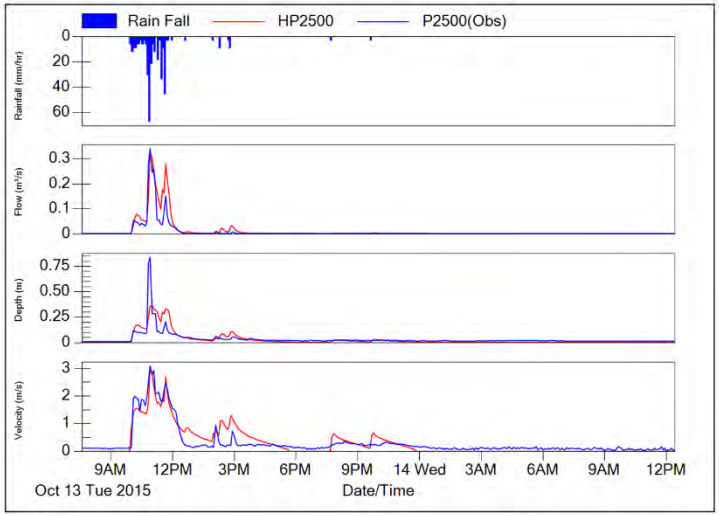

Rain Fall
HP24379
P24379(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

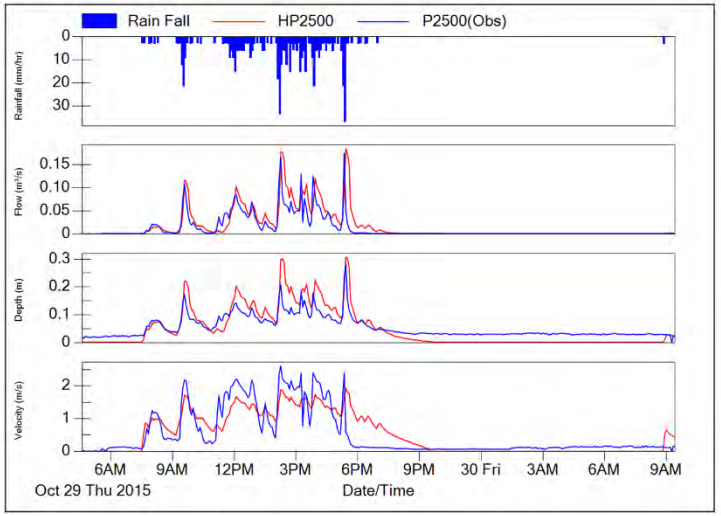

Rain Fall
HP24379
P24379(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

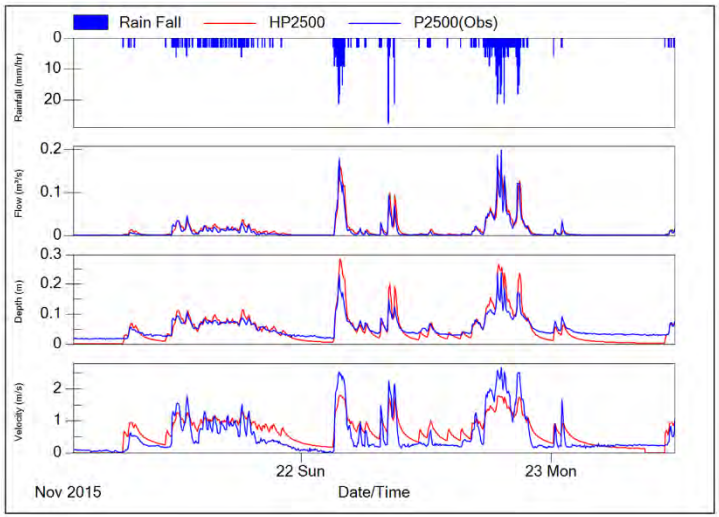

Rain Fall
HP24379
P24379(Obs)
Rainfall (mm/hr)
Flow (m³/s)
Depth (m)
Velocity (m/s)
22 Sun
23 Mon
Nov 2015
Date/Time

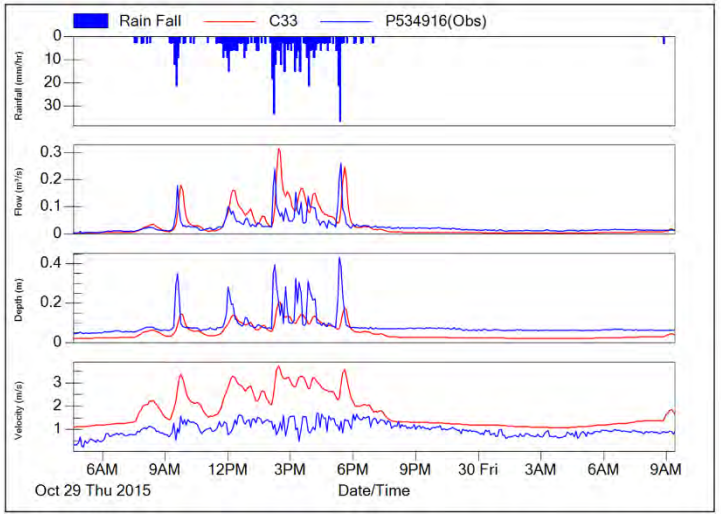

Rain Fall
C2674
P2674(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.4
0.2
0
Depth (m)
2
1
0
Velocity (m/s)
1.0
0.5
0
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

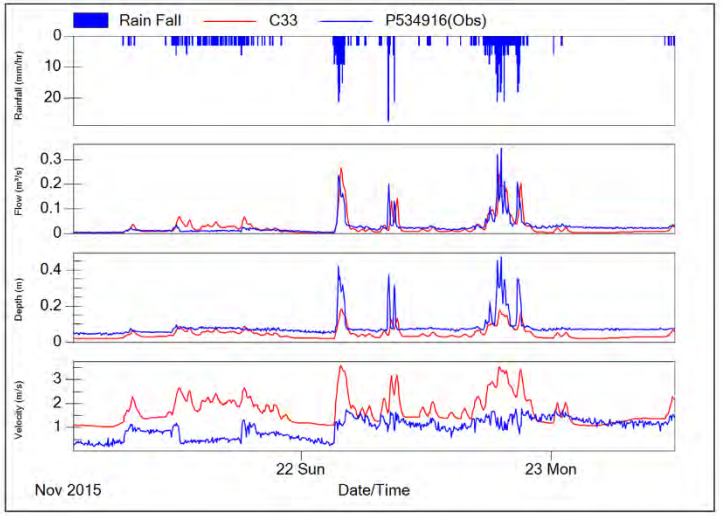

Rain Fall
C2674
P2674(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.2
0.1
0
Depth (m)
1.0
0.5
0
Velocity (m/s)
1.0
0.5
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

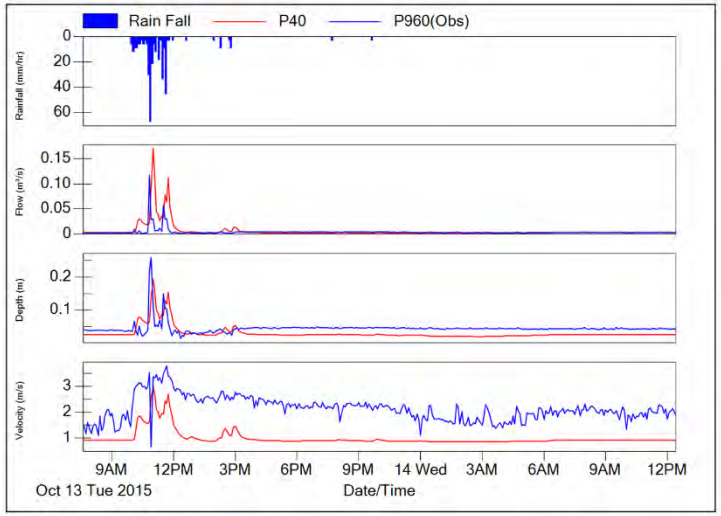

Rain Fall
HP2500
P2500(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.3
0.2
0.1
0
Depth (m)
0.75
0.50
0.25
0
Velocity (m/s)
3
2
1
0
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time

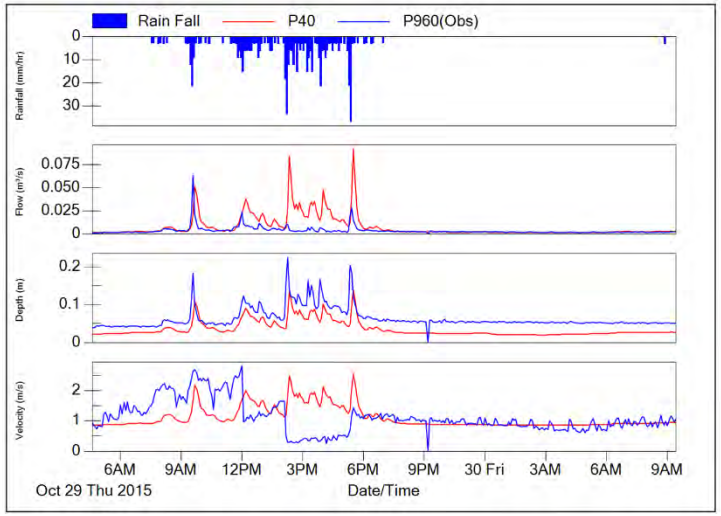

Rain Fall
HP2500
P2500(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.15
0.10
0.05
0
Depth (m)
0.3
0.2
0.1
0
Velocity (m/s)
2
1
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time

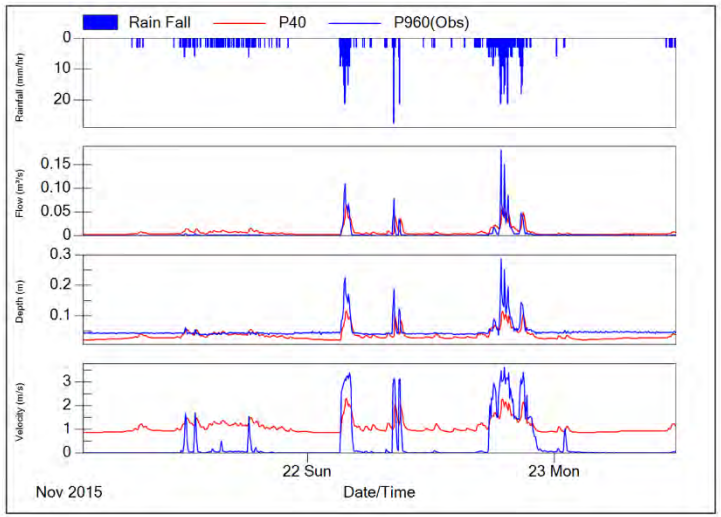

Rain Fall
HP2500
P2500(Obs)
Rainfall (mm/hr)
0
10
20
Flow (m³/s)
0.2
0.1
0
Depth (m)
0.3
0.2
0.1
0
Velocity (m/s)
2
1
0
22 Sun
23 Mon
Nov 2015
Date/Time


Rain Fall
C33
P534916(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.3
0.2
0.1
0
Depth (m)
0.4
0.2
0
Velocity (m/s)
3
2
1
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time


Rain Fall
C33
P534916(Obs)
Rainfall (mm/hr)
0
10
20
Flow (m³/s)
0.3
0.2
0.1
0
Depth (m)
0.4
0.2
0
Velocity (m/s)
3
2
1
22 Sun
23 Mon
Nov 2015
Date/Time


Rain Fall
P40
P960(Obs)
Rainfall (mm/hr)
0
20
40
60
Flow (m³/s)
0.15
0.10
0.05
0
Depth (m)
0.2
0.1
Velocity (m/s)
3
2
1
9AM
12PM
3PM
6PM
9PM
14 Wed
3AM
6AM
9AM
12PM
Oct 13 Tue 2015
Date/Time


Rain Fall
P40
P960(Obs)
Rainfall (mm/hr)
0
10
20
30
Flow (m³/s)
0.075
0.050
0.025
0
Depth (m)
0.2
0.1
0
Velocity (m/s)
2
1
0
6AM
9AM
12PM
3PM
6PM
9PM
30 Fri
3AM
6AM
9AM
Oct 29 Thu 2015
Date/Time


Rain Fall
P40
P960(Obs)
Rainfall (mm/hr)
0
10
20
Flow (m³/s)
0.15
0.10
0.05
0
Depth (m)
0.3
0.2
0.1
Velocity (m/s)
3
2
1
0
22 Sun
23 Mon
Nov 2015
Date/Time

Appendix F Development Capacity Tracking Tool Technical Memo

Development Capacity Tracking Tool

Regional Centre
Local Wastewater Servicing Capacity Analysis

Prepared by
GM BluePlan for:



The Halifax Regional Water Commission

Project No. 715009
July 26, 2016



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1 Introduction

A Development Capacity Tracking Tool (DCTT) was developed as part of the Regional Centre Local Wastewater Servicing Capacity Analysis (LoWSCA) project. The aim of the DCTT is to provide users with the ability to track proposed, approved, and/or built development, and quickly assess the performance of the existing system under different development scenarios. Outputs from the tool may include, but are not limited to:

- Tracking development over time and documenting whether or not it is proposed, approved, built but not included in base flows, or built and included in base flows,
- Identifying where and how much available capacity exists within the system, in terms of population, units, or hectares for greenfield development,
- Identifying trigger points for capital upgrades for different 'what if' scenarios,
- Prioritizing areas with greatest development potential and those with limitations.

Objectives that were used to meet the aim of the tool were:

- Ensure everything is fully dynamic so that inputs, such as people per unit, units per hectare, and per capita rates, can be changed and all results automatically updated,
- Provide considerations for different development types, such as intensification versus greenfield development, and apartments versus detached housing,
- Provide considerations for proposed, approved, and built development; this allows for continuous tracking of development as they move through different phases,
- Use modelling results for existing flow conditions,
- Results from the tool can be mapped as an output,
- Tool can be easily updated by any user.

When assessing capacity, it is important that the tool is used as an initial capacity indicator and not the absolute answer for supporting infrastructure decisions. Modelling and capacity assessment exercises should still be used in the evaluation of proposed developments.

This document provides an outline of the methodology that was used in the development of the DCTT in addition to a set of user guidelines, for general use or future updates. The final section of the memo presents preliminary results for two scenarios, LoWSCA proposed development under a 2-Year and a 5-Year design storm for both the Halifax Peninsula and Dartmouth areas.

2 Methodology

This section outlines the general methodology of the DCTT to provide insight into how the tool works and how it was designed. The approach was developed to ensure that the desired functionality was met and that it was easily updateable. The tool was created for both the Halifax Peninsula and Dartmouth systems.

The general approach allows the user to enter all development information in one tab and the manholes in which they would like to apply the loadings. The tool then distributes all the growth flows from the loading point to the furthest point downstream. The growth flows within each pipe are then added to the existing flows that were exported from the model to attain a required flow that can be compared against capacity; after which the remaining capacity can be identified. It should be noted that the model exports (network and results) are the primary components that will govern the usefulness of the tool and the accuracy of the results.

2.1 Network

A network was created to allow for the distribution of growth flows from the point of application to the furthest point downstream, either the treatment works or an outfall. The network was created using links (Conduits, Weirs, Outlets, Pumps, Orifices) and nodes (Junctions, Storages, Outfalls) exported from the existing hydraulic model; elements are connected based on the link and node IDs, and the upstream and downstream nodes assigned to each link.

The network follows that in the model so that it can make use of the existing flows, which were estimated and calibrated using flow monitoring data. However since the model is not all-pipe, the current network consists of only trunk infrastructure with 'pockets' of local infrastructure, which include the LoWSCA areas.

One special network consideration is made for circular references. Because the DCTT transfers growth flows from one link to the next all the way downstream until it gets to an outfall, locations where links share common nodes or can return flows to an upstream node need to be resolved. There was one such case in the Halifax model at one of the Herring Cove catchment pumping stations; "Drain_Tank2-to-1" and "Drain_Tank3-to-1" weirs were removed.

2.2 Flow Splits

Once the network was created, considerations had to be made for flow splits; flow splits do not change the existing flows, which are based on results, however do impact the distribution of growth flows. When the growth flows reach a point where there is a flow split, the tool identifies which way to send the flow. This process is very flexible and is set up as automatic with the ability for manual override.

The process begins with the identification of the flow splits. For each link, the tool determines how many total links share its upstream node; if it returns a 1, then the link is not part of a flow split. Where flow splits are identified, the tool calculates the minimum inlet elevation of all links involved in that flow split. Each inlet elevation is then compared against the corresponding minimum to determine whether or not the link should be considered. A link that is part of a flow split takes on growth flow if it is within a specified range from the minimum, which is implemented as an input and can be adjusted in the generic inputs tab, it is currently 0.3m. The final step is to identify, for each link, the percentage of the growth flow in the upstream manhole that is to be carried forward.

1. If the link is not part of a flow split then it is receives 100% of the growth flow from the upstream manhole.

2. If the link is part of a flow split but the inlet elevation is not within the specified range, from the minimum inlet elevation, it receives 0% of the growth flow from the upstream manhole.
3. If the link is part of a flow split and its inlet elevation is within the specified range from the minimum inlet elevation, then the percentage of growth flow is a function of how many other links have inlet elevations within the range (i.e. two links at a flow split both with inlet elevations within the specified range receive 50% of the growth flow each).

There is a final option for manual override. If the user wishes to enter their own flow split distribution, such as for a 'what if' scenario, then the value used for the analysis can be overwritten.

2.3 Existing Flows

Existing flows are exported from the hydraulic model for each link; results are included for a 2-Year, 5-Year, 10-Year, and 25-Year design storm. These flows represent the base flows to which the growth flows are added.

2.4 Generic Inputs

All generic inputs, used throughout the DCTT, are located within one tab to provide simplicity and easy updating of all variables. The tab includes inputs such as:

- Design criteria
- Representation of pipe full capacity (currently 80% full represents trigger point)
- Flow split criteria
- People per unit and units per hectare, for different land uses
- Desired design storm to be used in the analysis.

2.5 Development Tracking

The development tracking tab has two tables, one for proposed development and one for approved development. Developments and their specifications can be added to these tables including the manhole that it is to be applied to in the existing network. These tables allow for development tracking overtime in addition to 'what if' scenarios in the proposed development section, which are further discussed in the User Guidelines. There is a drop down in the approved development table so that the user can identify if a) it has been built and b) if the flows have been included in the existing model results; approval and built dates can also be entered for tracking purposes.

It is important to note that proposed developments can be entered but not necessarily included in the capacity assessment; controlled by the "Include" column in the development tracking tab. Similarly, the "Included in Baseline Flow" column controls whether or not a development in the approved development table is to be included in the capacity analysis.

2.6 Growth Analysis

The growth analysis tab utilizes the development tracking tables to assign growth population, and growth I/I contributing areas if specified, to the selected manholes. The defined network and flow split analysis are then used to distribute these flows downstream. The growth analysis calculates the cumulative growth population and cumulative growth I/I contributing area for each link, and does so separately for built, approved, proposed, and total developments.

For each link, the population and area values are then used with the design criteria equation to calculate a growth flow. The growth analysis is done in this way to ensure that an appropriate Harmon Peaking Factor is used as the flows accumulate downstream.

2.7 Capacity Assessment

The baseline flows are established by selecting the desired design storm on the generic inputs tab. For each Conduit, the growth flow is added to the baseline flow and is compared against the pipe full capacity.

The pipe full capacity is calculated for each Conduit based on the specifications that were exported from the model. An equivalent diameter was estimated based on the shape of the sewer and the methods are outlined in the generic inputs tab. The calculated capacity is then multiplied by the pipe full criteria to attain the trigger point capacity, currently 80% but can be adjusted on the generic inputs tab. A pre-post comparison is made to determine the sewers that are triggered by the applied developments.

The final step is to identify the remaining capacity for each Conduit in terms of population, units, or hectares.

2.7.1 Intensification

The remaining capacity, in terms of flow, is calculated and used to estimate the available growth in terms of population. This process uses the design criteria entered in the generic inputs tab. It should be noted that the Harmon's Peaking Factor is assumed to be 3 for this exercise to simplify the calculation process, however it can be changed in the generic inputs tab. The resulting population number is then used to estimate the available number of units using the people per units input.

2.7.2 Greenfield

Similar to the intensification exercise, the remaining capacity in terms of flow is calculated for each Conduit, however this time it is used to estimate the available growth in terms of catchment area. This process uses the design criteria entered in the generic inputs tab in addition to the people per hectare rate, which is dependent on the land use. The calculated catchment area is then multiplied by the people per hectare rate to determine an available population, and in turn, an available number of units depending on the people per unit rate. This process is completed for four types of Greenfield development:

- Detached Homes
- Semi-Detached Homes
- Townhomes
- Apartments

2.8 Outputs and Mapping

The outputs from the capacity assessment are summarized in an "Export for GIS" tab. This tab is used to produce a CSV file that is joined to a Conduit shapefile exported from the hydraulic model. This is then used to create maps to present the available capacities, trigger points, and areas with the greatest opportunity for growth. The mapping process is completed in ArcGIS and utilizes a single map template. The user can load any number of scenarios and group as required.

3 User Guidelines

The User Guidelines provides all the necessary steps for updating the DCTT inputs, tracking development applications, running scenarios, and producing the desired outputs. The guidelines are broken up into four sections depending on the task that the user wishes to complete.

3.1 Updating Network

The network only requires updating if new elements are added to the model. It is recommended that the network only be updated after major changes to the model such as the development of an all-pipe model or the addition of local “pockets”.

If the network requires updating, the user is required to update the DCTT Template:

1. Update the ‘Link Data’ and ‘Node Data’ tabs with the appropriate data; columns A-N. The required data for each element, and the ‘Type’, is outlined as follows:
    a. **Links**: *Conduits, Weirs, Outlets, Pumps, Orifices*
        i. Conduits: must include all columns
        ii. Pumps: must include columns A-D
        iii. Weirs, Outlets, Orifices: must include columns A-E
    b. **Nodes**: *Junctions, Storages, Outfalls*
        i. All nodes: must include both columns
    c. The equivalent diameter and pipe full capacity columns must be dragged down to the last row of data.
2. Any element that creates a circular reference as outlined in the methodology must be removed; if there are any, excel will highlight them in the ‘Growth Analysis’ tab, which is where the error will occur.
3. The ‘Flow Splits’, ‘Growth Analysis’, ‘Capacity Summary’, and ‘Export for GIS’ tabs all need to be updated by highlighting the last row and dragging it so that it captures all the required data (i.e. until it starts returning 0, blanks, or errors).
4. Once completed, the updated tool becomes the new DCTT Template.

In addition to updating the DCTT Template, the user must update the conduits shapefile located in the ‘DCTT Mapping’ folder. This shapefile is a direct export of the conduits in the model and therefore must match the conduits in the excel sheet.

3.2 Updating Existing Design Flows

If either the DCTT network or the baseline hydraulic model results have been updated, the ‘Existing System Model’ tab must be updated. If the existing flow requires updating, the user is required to:

1. Update columns B-F with model exports. For each link, the existing flows for a 2-Year, 5-Year, 10-Year, and 25-Year must be entered.
2. Columns A and G must dragged down to the last row of data.
3. Once completed, the updated tool becomes the new DCTT Template.

3.3 Development Scenarios

To begin a new scenario, make a copy of the DCTT Template and save it as a new scenario in the ‘DCTT Scenarios’ folder. In the tool, update any inputs in the ‘Generic Inputs’ tab as required, including the desired

design storm that is to be used as the baseline flows. The next step is to enter all development related information in the 'Development Tracking' tab; an efficient way of developing scenarios is to build off an existing list of proposed developments and change the scenarios by turning developments on and off. Once satisfied with the inputs, the DCTT is dynamic and will automatically update the results, which will be ready for exporting. These results include the assessment of capacity for all Conduits.

It should be noted that if development information is being copied from another sheet, or from proposed to approved, it should be pasted as values only to preserve the conditioning formatting. It should also be noted that negative values cannot yet be assessed, they can be entered and tracked but must be turned off and not included in the analysis.

3.4 Mapping

If the user would like to create a map for a scenario, the following steps are required:

1. Open the DCTT corresponding to the scenario of interest.
2. Select the 'EXPORT for GIS' tab.
3. Click File – Save As and browse for the 'DCTT Scenarios' folder. Save the file as a CSV (comma delimited).
4. Open the ArcGIS document located in the 'DCTT Mapping' folder and create a new scenario by copying the template scenario.
5. Right click on the scenario and select Join.
6. Browse to the .csv file, click OK.

Any of the Intensification or Greenfield outputs can be mapped, including available population, units, or hectares. It is also recommended to group mapping scenarios under select categories. As long as the CSV files remain in the original location and are not renamed, the Map file will maintain all desired scenarios.

4 Interpreting the Outputs

It is important to be aware of the Conduit specifications when interpreting the results. In certain instances, the pipe slope is negative, 0, or very small, resulting in very limited to no pipe full capacity. This issue may cause skewed results and therefore it is important to interpret the outputs at a block or pocket level and not just pipe by pipe. Scenarios should also be compared against the baseline scenario to confirm whether or not it is a constraint or a function of the pipe specifications.

Another important note to be aware of is the distribution of wet weather flows in the model. In certain parts of the model, the wet weather flows are assigned using subcatchments, which are assigned to a single manhole. In some instances, this results in local pipes upstream that do not experience wet weather flows (usually pipes at the extremities of a local network). Therefore, baseline flows for these pipes in the DCTT only include dry weather flow and may show more capacity then in reality. Similar to the limitations caused by the Conduit slope, outputs should be interpreted at a block or pocket level and not just pipe by pipe.

In conclusion, the user should always keep in mind that the DCTT and its outputs are a function of the model network and the model inputs, and not necessarily an exact representation of reality.

5 Future DCTT Updates

The existing DCTT can be further refined as new data becomes available. Since the tool's defined network mirrors that in the hydraulic model, many local sewers are not represented, as outlined in Section 2.1. With the continuous improvements to the hydraulic model, and future development of an all-pipe, the DCTT can incorporate more manholes, to which developments can be loaded, and more local sewers that can be assessed. Further refining can be accomplished through changes to the assigning of wet weather flows, as outlined in Section 4.