Class Environmental Assessment for Foundation Drain Collector (FDC) Pumping Systems

Lisgar District Environmental Study Report (ESR)
City of Mississauga
Project # TPB188016

Prepared for:

City of Mississauga
201 City Centre Drive, Mississauga, Ontario L5B 3C1

Sept 6-18

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6-Sep-18

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Dear Sir:

Re: Class Environmental Assessment for Foundation Drain Collector (FDC) Pumping Systems, Lisgar District Environmental Study Report (ESR) (Final Draft), City of Mississauga

Wood is pleased to provide you with the Final Draft of the Environmental Study Report (ESR) for the Lisgar District FDC Pumping Systems Class Environmental Assessment (Class EA). In addition to this report and its appendices, there are also a number of other documents which will be compiled to form the Project File, including:

- Public Summary Report, March, 2015
- 2015, 2016, 2017 Monitoring Reports
- Various Reports to Council

We appreciate the input and support provided by City staff over the course of this undertaking and look forward to receiving your comments, in order that the document can be finalized and then filed for Public review. Should you have any questions, please feel free to contact the undersigned.

Yours very truly,

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Per: Ron Scheckenberger, M.Eng., P.Eng.
Principal Consultant

Per: Matthew Senior, M.A.Sc., P.Eng.
Project Engineer

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1.0 Introduction

1.1 Study Area

The Lisgar District is situated in the northwest corner of the City of Mississauga and is bounded by the Canadian Pacific Railway tracks to the north, Britannia Road West to the south, Ninth Line to the west and Tenth Line to the east. It is located within the Sixteen Mile Creek watershed and drains to a tributary of the East Branch of Sixteen Mile Creek (Figure 1.1).

The Lisgar District is mainly made up of single family homes which were largely built over a 25-year period starting in the early 1980s (Figure 1.2).

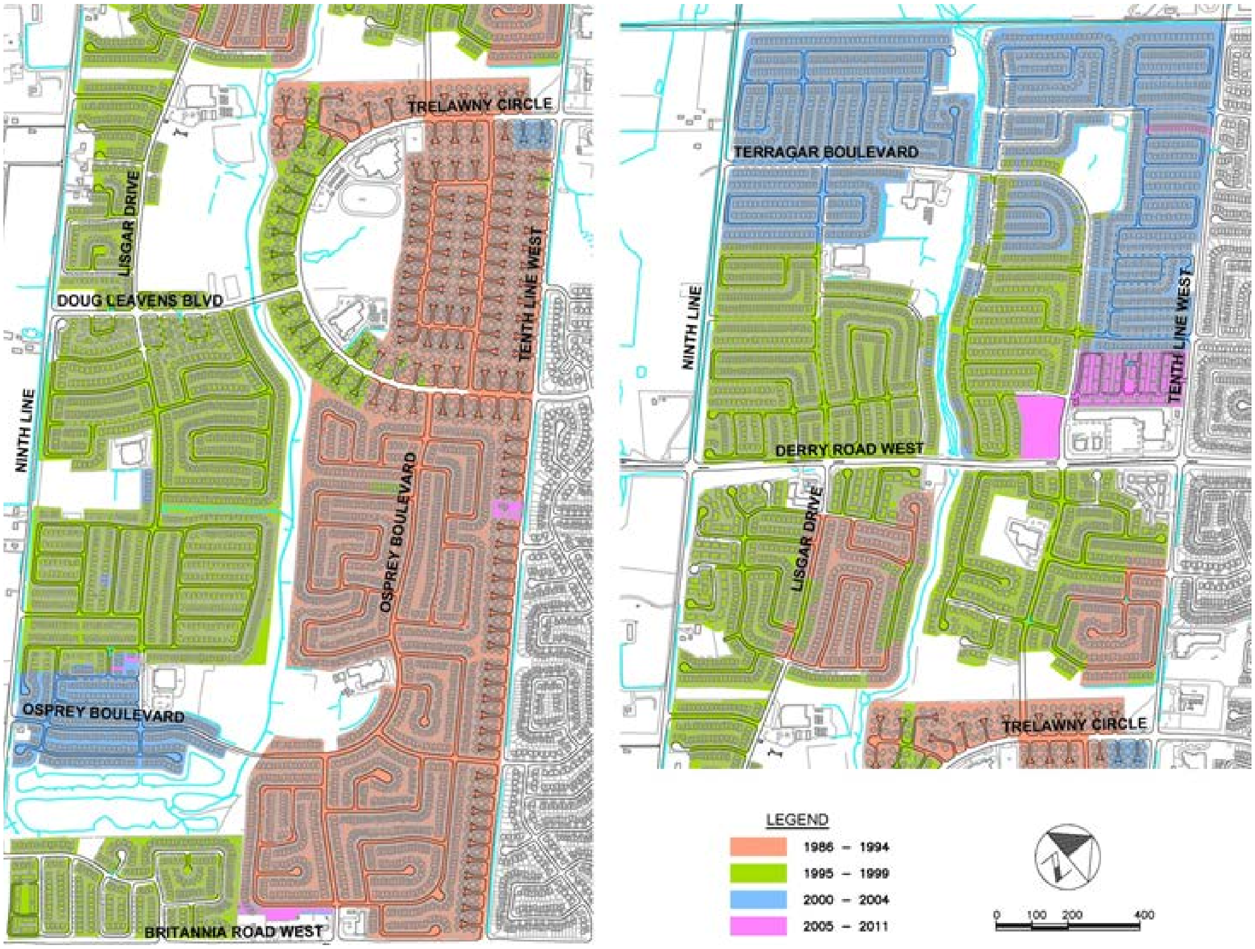
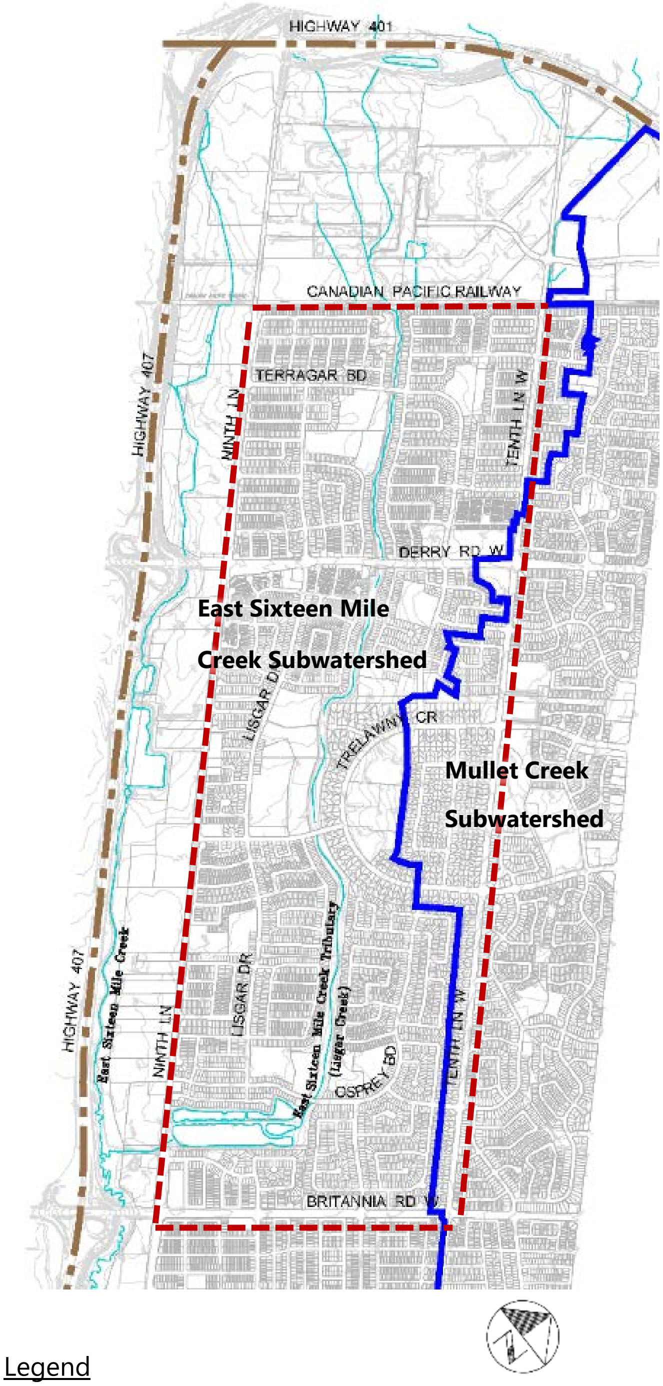


Figure 1.2 Historic Development of Lisgar



Legend

- - Study Area

— East Sixteen Mile Creek Subwatershed Boundary

Figure 1.1 Subwatershed Map

1.2 Process Summary & Overview

Commencing in 2008, a number of homes in the Lisgar District have experienced water seeping into their basements following certain rainfall events. Almost 200 homes are known to have been affected to date (2018); Figure 1.3 generally depicts the areas affected.

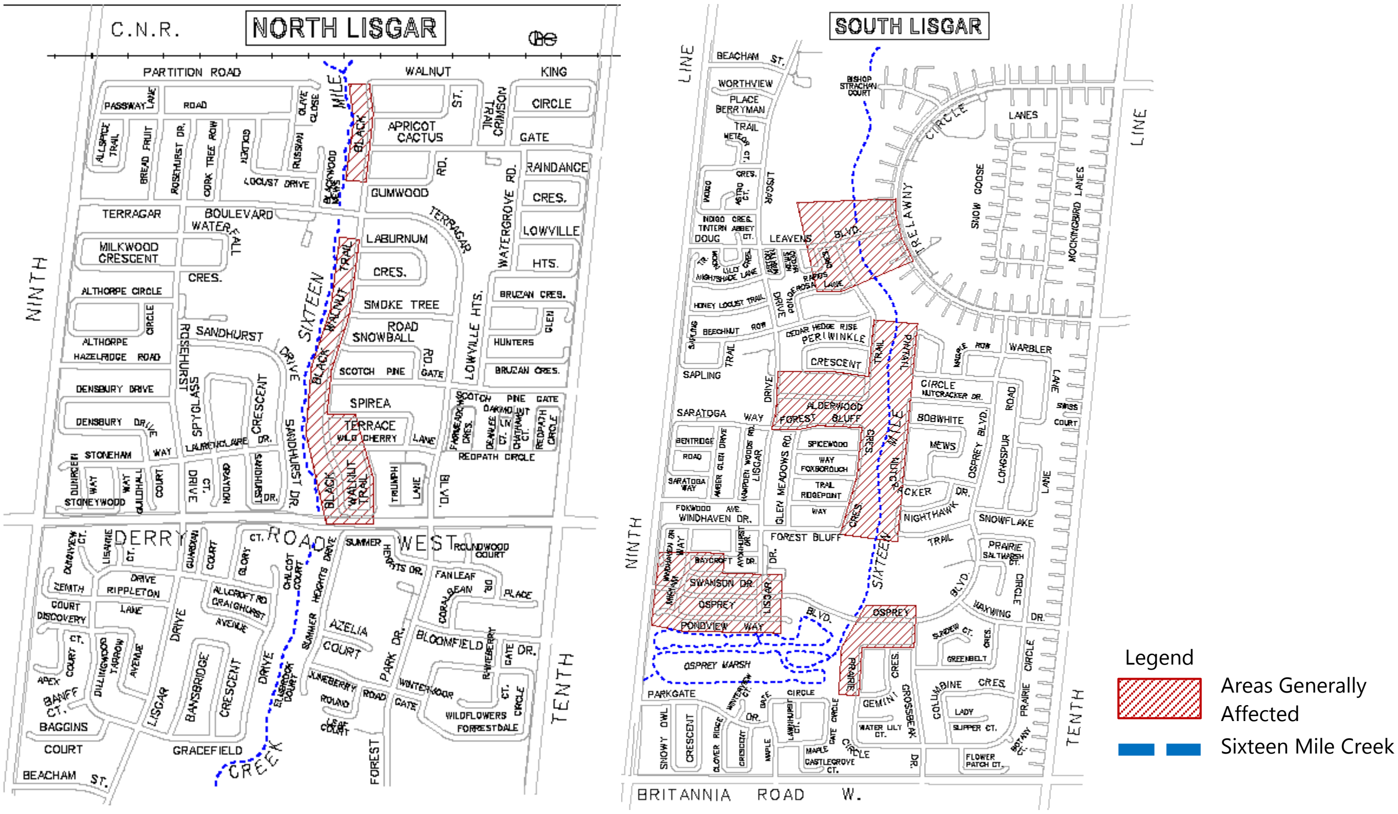


Figure 1.3 Areas Affected by Basement Water Infiltration

After becoming aware of the scale of this issue, the City undertook a number of actions, including:

- Video inspection and cleaning of the foundation drain collector (FDC) system;
- Removal of vegetation along Sixteen Mile Creek;
- Clean-out of bridge crossings and storm outfalls to Sixteen Mile Creek;
- Sealing selected FDC manholes and pipe joints;
- Adjustment to the Osprey Marsh Stormwater Pond outlet; and
- Putting in place a High Water Protocol (deploying pumps during major storms).

The High Water Protocol consists of City staff continuously monitoring weather forecasts and other weather-related information such as High Water Bulletins from local Conservation Authorities. When unfavorable weather conditions are predicted, City staff and/or its contractors are deployed to three locations within the Lisgar District with portable pumps on standby to pump water from the FDC system if required.

Furthermore, the City retained a consultant to conduct an investigation of the problem. Specifically, in October 2011, AMEC Environment & Infrastructure (now known as Wood Environment & Infrastructure

Solutions (Wood)) was retained to undertake an engineering study to determine the cause(s) of basement water infiltration and recommend corrective measures.

After comprehensive monitoring and analysis, the engineering study determined the problem to be primarily related to the build-up of water in the bedding material of the utility trenches that contain the storm, sanitary and FDC sewer systems.

In March 2015 the results of the study were presented to the Public which outlined a Mitigation Plan. The Plan recommended the following measures as the highest priorities for the City to deal with the basement water infiltration issue:

- Strategic lining of priority storm sewers to minimize leakage;
- Construction of a utility trench dewatering system;
- Build permanent FDC pumping stations for high flows; and
- Replace hydraulically deficient FDC pipe lengths when they reach the end of their engineered lifespan.

Following the release of the March 2015 Public Summary Report (Appendix A), Wood was subsequently retained by the City of Mississauga to support the implementation (design, approvals, and construction) of the remediation works, with the highest priority items being storm sewer lining (to reduce leakage) and the design of a utility trench dewatering system (to reduce the build-up of water in the utility trench). In addition, Wood continued to undertake monitoring of the drainage systems within the Lisgar District area to provide ongoing verification of the effectiveness of remedial measures, as they were constructed, and to also allow for further data collection in the event of FDC surcharging or basement water infiltration events, should they occur.

As part of the implementation of the Prioritized Action Plan, storm sewer lining works were completed for the highest priority area (Phase 1 - Black Walnut Trail) between December 2016 and March 2017 (ref Figure 1.4.)

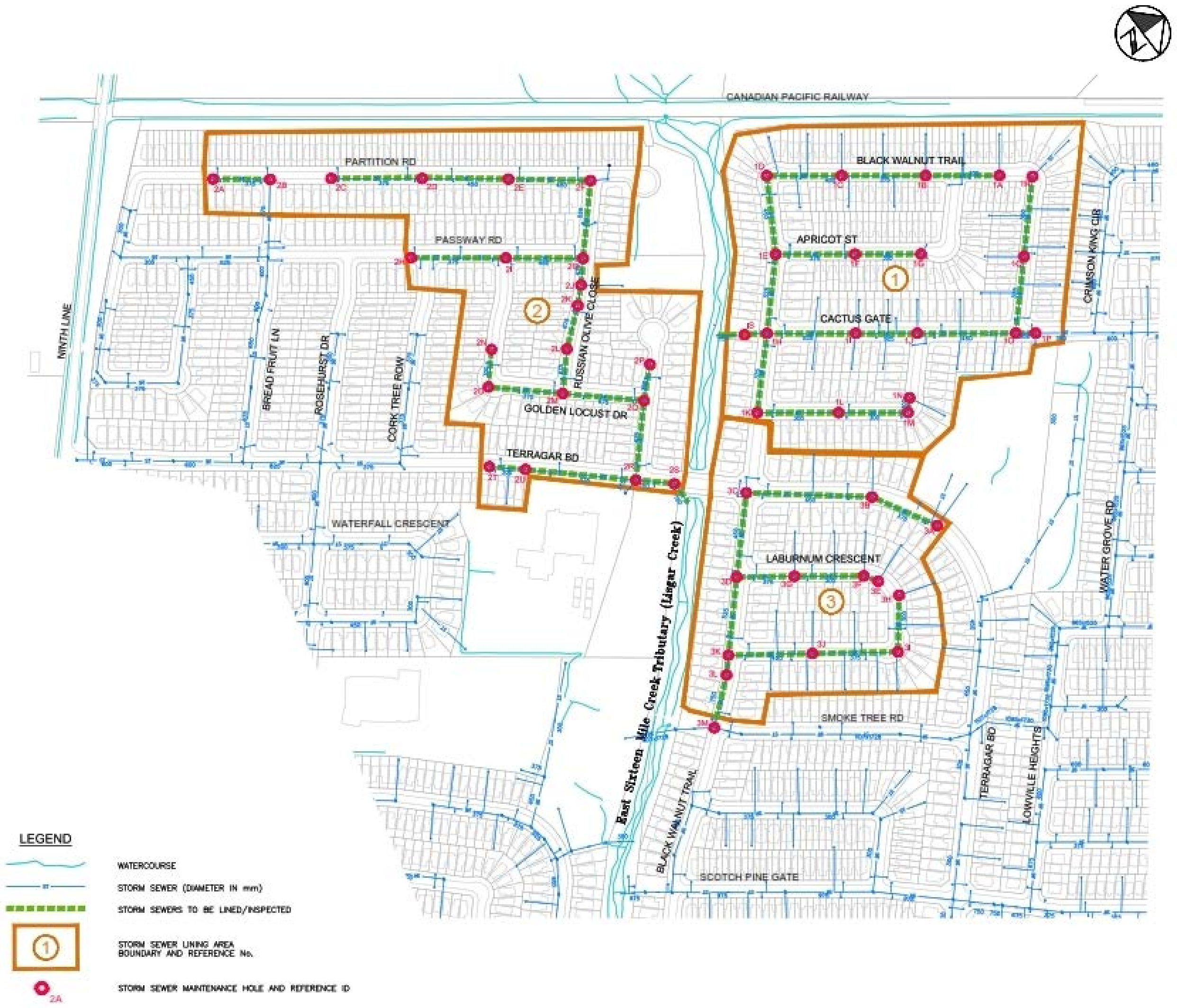


Figure 1.4 Phase 1 Storm Sewer Lining Areas

A second phase of storm sewer lining was planned for the next highest priority area (Doug Leavens Boulevard, Alderwood Trail, and Osprey Boulevard) for later in 2017. However, post-lining storm sewer leakage tests completed in April 2017 indicated a similar rate of leakage under post-lining conditions as under pre-lining, which was unexpected. The City of Mississauga and Wood investigated further, conducting additional testing into the leakage mechanisms, and determined a high potential for leakage from the subdrains in the catchbasins. On this basis, City staff ultimately proceeded with the installation of catchbasin sub-drain plugs along Black Walnut Trail in October and November of 2017, with a second phase of plugs (Doug Leavens Boulevard to Osprey Boulevard) installed in January of 2018. The effectiveness of these plugs will continue to be evaluated over the course of 2018 and beyond.

On July 13-14, 2017, between approximately 11:50 PM and 12:30 AM, a local convective (thunderstorm type) system affected the Black Walnut Trail area of the Lisgar District area. The storm event was not forecasted; City staff had enacted the High Water Protocol earlier in the day but discontinued it based on the forecast. The storm event resulted in reported basement water infiltration for 35 (+/-) residences, the majority (34) located along Black Walnut Trail (1 along Golden Locust Drive). Based on post-event questionnaires completed by affected residents, the infiltrated water was generally characterized as clear, and sourced from around the perimeter of the home.

A public meeting was held on October 18, 2017 to provide the Public with an update on the ongoing works being completed for the Lisgar District Basement Water Infiltration Study, as well as to provide a characterization and analysis of the July 13-14, 2017 storm event. As part of the public meeting, an Updated Action Plan was presented. In addition to previously proposed activities (addressing roadway sub-drain leakage, utility trench dewatering system), an FDC pumping station (similar to that proposed in the March 2015 Public Report) was advanced as a higher priority mitigation measure to be assessed, planned, designed and constructed in 2018/2019.

This Class EA has specifically been undertaken to determine the preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration. The focus is on both a utility trench dewatering system and a high flow FDC pumping station.

1.3 Class Environmental Assessment Process

Overview

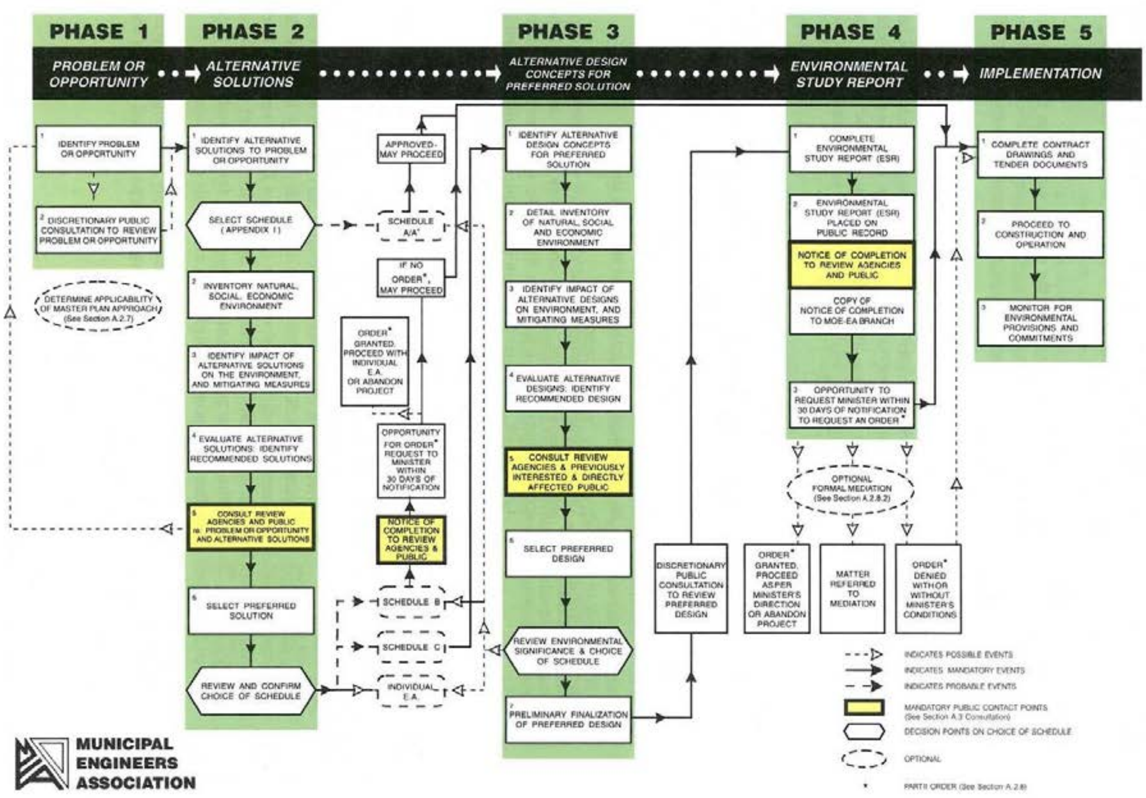
This study has followed the process outlined in the Municipal Engineers Association (MEA), Municipal Class Environmental Assessment (EA), October 2000 (as amended in 2007, 2011, and 2015). The Municipal Class EA process defines mandatory principles, details of project consultation and technical requirements. A Municipal Class EA is considered a legal document which outlines municipal project recommendations and next steps, based on technical assessments, public input and consultation with technical practitioners, agencies and Indigenous Communities.

Municipal Class EA Process

Each Municipal Class EA undertaking, depending on the scope of work and the range of predicted environmental impacts, is classified using Schedules. The Schedule to apply, typically depends on the scope and estimated capital cost of the recommended works. Based on a review of similar forms of infrastructure (in the absence of any precedents with foundation drainage pumping stations), Wood and the City selected Schedule B as being appropriate on the basis of the required level of study and consultation for similar works (ref. Figure 1.5). The various Phases of the Class EA process have been conducted by this study based on the Schedule (i.e., Schedule B: Phases 1 and 2), while Phase 5 will be conducted based on the recommendations herein being continued through to detail design and subsequently construction and monitoring.

As part of the Class EA process the following key principles are considered:

- Establish a Problem and Opportunity Statement;
- Consult with affected parties early in, and throughout the process, such that the planning process is a cooperative venture;
- Consider a reasonable range of alternatives, both functionally different “alternatives” and “alternative methods” of implementing the solution;
- Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects; and,
- Provision of clear and complete documentation of the planning process followed, to allow “traceability” of decision-making with respect to the project.



The copyright for the above flow chart is owned by the Municipal Engineers Association (MEA). No reproduction or redistribution except for municipal purposes is permitted without the express written consent of the MEA.

Figure 1.5: **Municipal Engineers Association (MEA), Municipal Class Environmental Assessment, October 2000 (as amended in 2007, 2011, and 2015)**

This Municipal Class EA is being undertaken to determine the preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration. Through this study, multiple Pumping Station Alternatives have been developed and evaluated by the Project Team and refined through stakeholder and public consultation. The Project Team will ultimately select a Preferred Alternative and develop a preliminary design for the Pumping Station(s). At the end of the study, a Project File documenting the entire study process will be available for public review (ref. Figure 1.6).

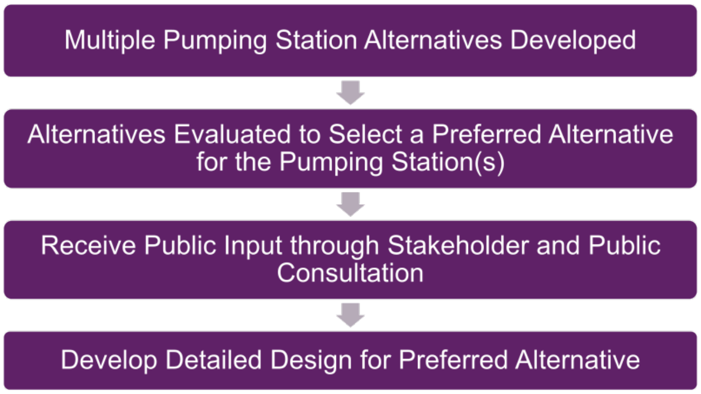


Figure 1.6 Municipal Class EA Process for Lisgar District Pumping Stations

Public, Indigenous and Agency Consultation

In accordance with the Class EA process, consultation has been undertaken with the Public, relevant Indigenous Communities and Regulatory Agencies. A Public Information Centre (PIC) was held on June 14, 2018; notification for the PIC was sent to stakeholders, local residents and agencies by mail. Conservation Halton (CH) provided comments regarding areas of interest or concern on the project, which was followed by correspondence between CH and the Project Team in order to address these concerns. The City received direction from the Provincial Crown regarding Indigenous Communities that may have an interest in the project. Accordingly, letters of notice and project summaries were provided to the Mississaugas of the New Credit First Nations (MNCFN), Six Nations of the Grand River (SNGR) and the Haudenosaunee Confederacy Chiefs Council (HCCC). A detailed summary of the consultation process along with all pertinent documentation can be found in Appendix D.

1.4 Drainage Systems Overview

When agricultural or open space lands are converted to urban uses, such as residential or employment, municipal services including watermains, sanitary sewers and storm sewers are typically constructed within road allowances or public easements to support these developments. The City of Mississauga is responsible for managing all aspects of stormwater within its jurisdiction, whereas the Region of Peel is responsible for stormwater on Regional roads, as well as drinking water, wastewater and solid waste management.

Storm sewers are designed to capture surface runoff from rainfall or snowmelt and then convey this water safely to a waterbody such as a creek, river or lake. In areas with stormwater management facilities (commonly referred to as ponds), which are routinely designed to provide water quality and/or flood control, this water would first outlet into these ponds for treatment before being released to a waterbody. Where the waterbody is comparatively deep in relation to the surrounding lands, the storm sewers can be built sufficiently deep below the ground surface to concurrently capture and convey water draining from the weeping tiles around the basement foundations of homes (Figure 1.7). Alternatively, where the receiving waterbody is high (or shallow) compared to the surrounding lands and basement foundations, the weeping tiles around the homes would not be able to drain through gravity into the storm sewers. In these circumstances, one of two systems would be required to drain the foundation around the homes:

- Sump Pumps; or
- Dedicated Foundation Drain Collector.

A sump pump is a mechanical system used to remove water captured by the weeping tiles around the basement foundations of homes that has been collected in a sump pit (basin) in the residential basement.

Water from the sump pit would either be pumped to the ground surface where it would drain across the yard to the storm sewer or underground into a shallow storm sewer (Figure 1.8).

A Foundation Drain Collector (FDC), typically located in the same utility trench as other municipal services, is a sewer system dedicated to only collect and drain water from weeping tiles of homes to an outlet by gravity flow (Figure 1.9). The FDC system is often referred to as part of a 3-pipe system, the other two being the storm and sanitary systems. At the time of its construction in the Lisgar District, the FDC system was considered to be a preferred solution for many new areas. In fact, the text book *Modern Sewer Design (Canadian Edition, 1980)* states: "*This system virtually eliminates the probability of back-ups into foundation drains, which have caused considerable flooding, and damage to basements*". Figure 1.10 depicts the limits of the Lisgar District within Mississauga served by an FDC system.

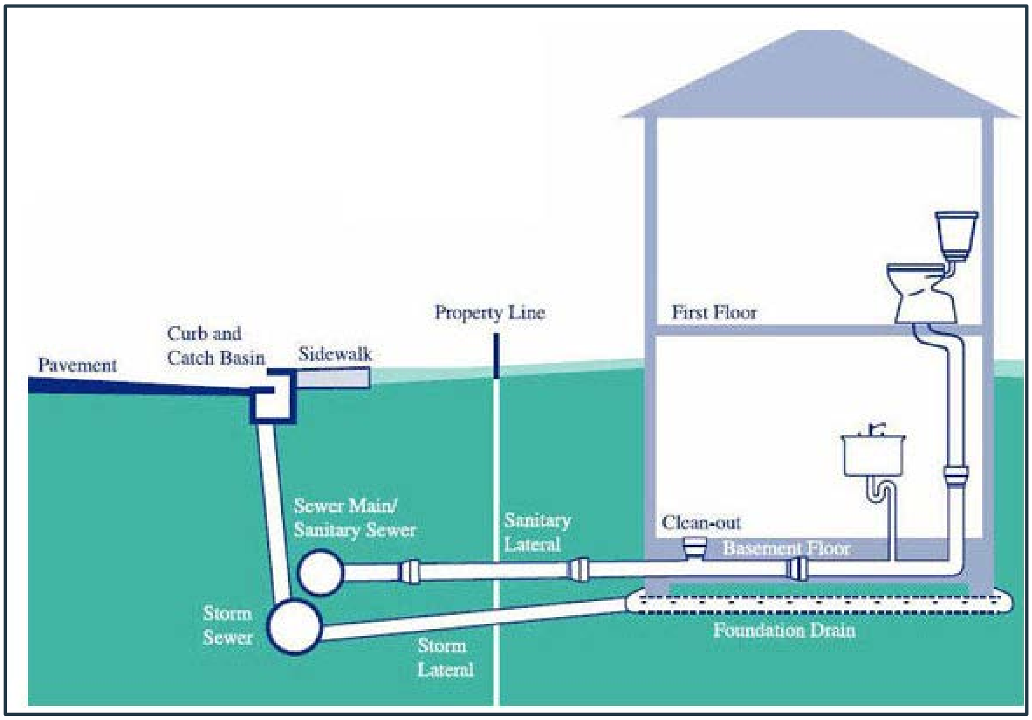


Figure 1.7: Conventional Foundation Drain connected to Storm Sewer

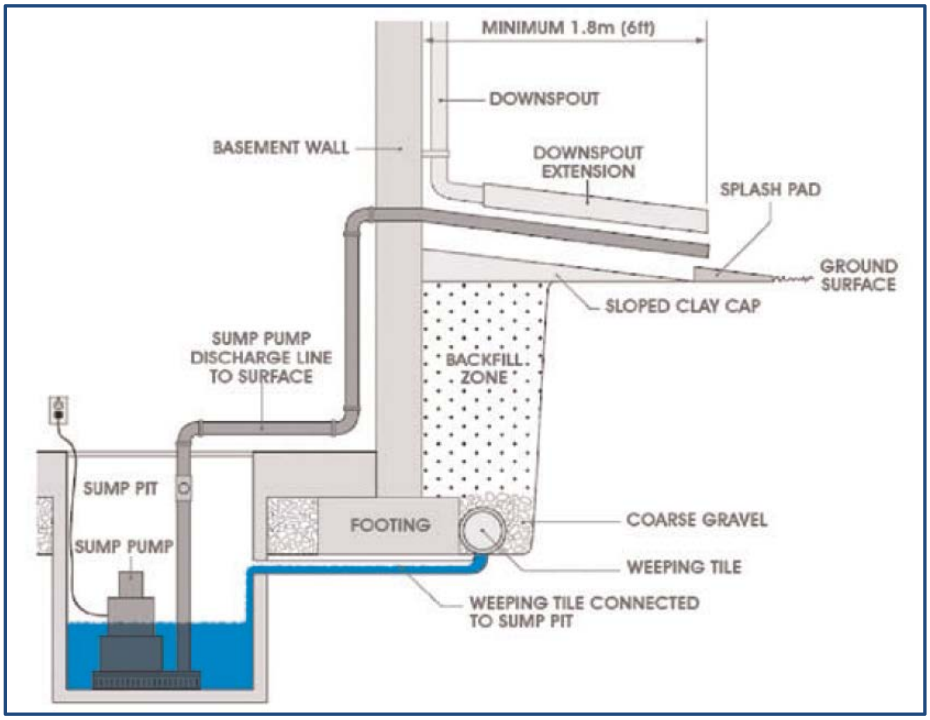


Figure 1.8: Sump Pump to Front/Rear Yards or Storm Sewer

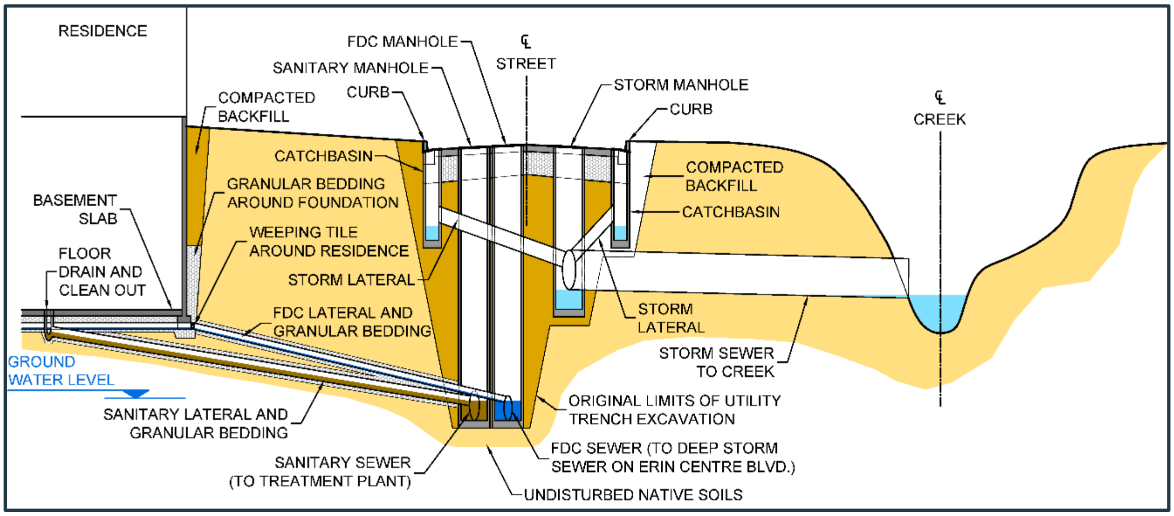
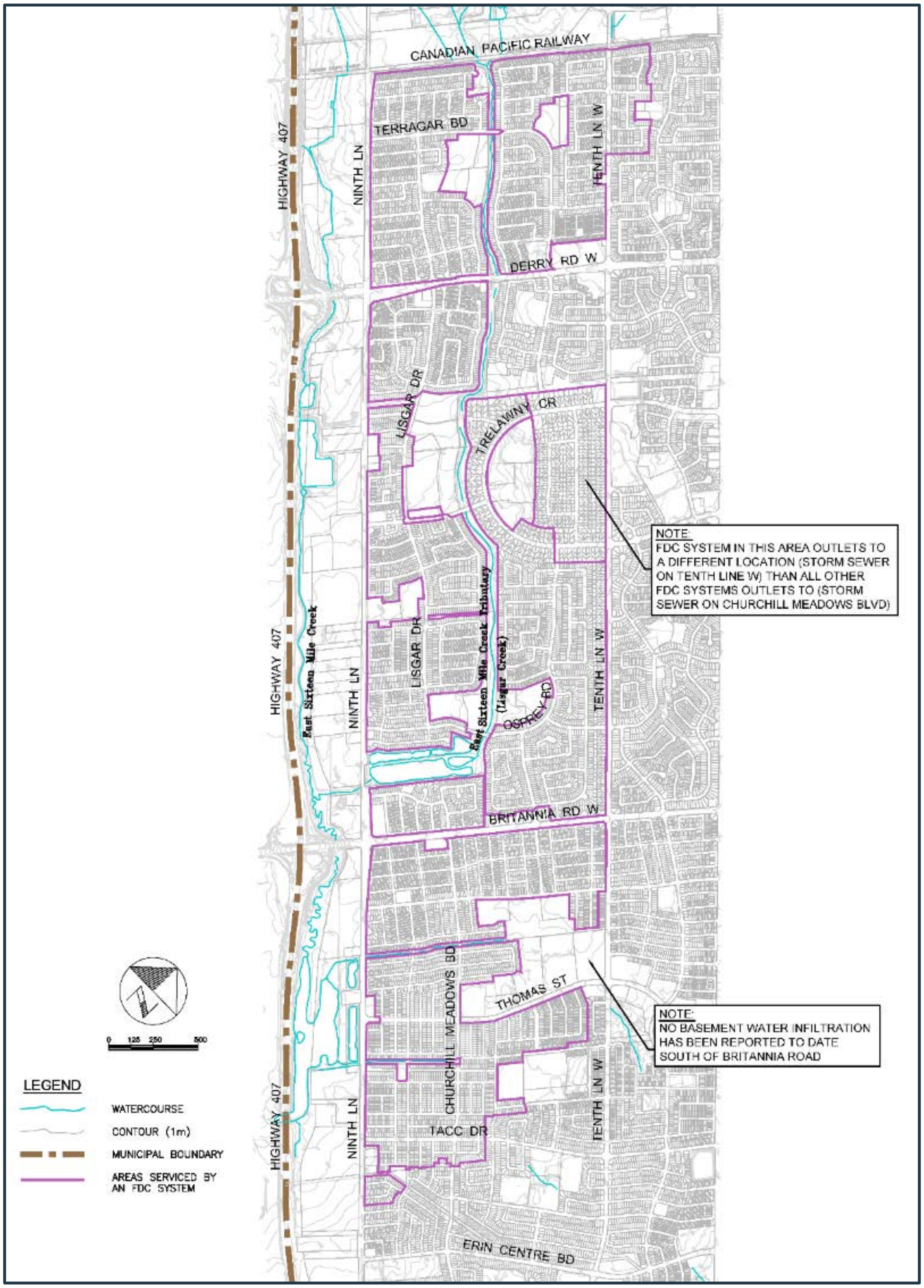


Figure 1.9: Foundation Drain Collector as Found in the Lisgar District



NOTE:
FDC SYSTEM IN THIS AREA OUTLETS TO A DIFFERENT LOCATION (STORM SEWER ON TENTH LINE W) THAN ALL OTHER FDC SYSTEMS OUTLETS TO (STORM SEWER ON CHURCHILL MEADOWS BLVD)

NOTE:
NO BASEMENT WATER INFILTRATION HAS BEEN REPORTED TO DATE SOUTH OF BRITANNIA ROAD

Figure 1.10 Servicing Limits of FDC System in Mississauga

Table 1.1 provides a brief summary of the advantages and disadvantages of these three distinct foundation drainage systems.

Table 1.1 Advantages and Disadvantages of Three Distinct Foundation Drainage Systems

Type	Advantages	Disadvantage
Gravity to Storm Sewer	• No additional infrastructure • Comparatively low cost • No reliance on mechanical system or power	• May back up if storm sewer is overwhelmed • Some additional cost to upsize storm sewers
Sump Pump	• Disconnected from municipal system	• Requires homeowner to operate and maintain the system • Mechanical system needs to operate to function • Relies on power
Foundation Drain Collector	• Dedicated, providing drainage for foundation only • No reliance on mechanical system or power • "Virtually eliminates the probability of back-ups into foundation drains" • Allows for smaller sized storm sewers • Successfully installed in numerous other municipalities without incident (Brampton, Vaughan, Barrie)	• Comparatively high cost to install additional deep and long pipe systems

It should be noted that the technical term 'surcharge' is often used in this report when referring to the flow conditions of sewers. This term refers to a gravity sewer that is overloaded beyond its pipe full flow capacity such that the flow is under pressure.

1.5 Problem Statement

Commencing in 2008 a number of homes in the Lisgar District have experienced water seeping into their basements following certain rainfall events. To address the basement water infiltration issue, the City developed a comprehensive Action Plan in 2015. Following Public and Agency consultation, as well as additional monitoring and investigations, an Updated Action Plan was developed in 2017 to address additional information on system performance through monitoring the July 13-14, 2017 storm and various testing activities. The FDC Pumping Systems must consider several constraints and opportunities related to the drainage area served, property suitability, and the number of houses in proximity that reported basement water infiltration. The Preferred Alternative must consider the Problem while balancing study area constraints and opportunities, in order to best address the basement water infiltration and the interests of local residents. Two forms of mechanical pumping were recommended in 2015 and 2017 to reduce water levels in the utility trench and FDC respectively.

2.0 Studies and Investigations

In response to the initial reports of basement water infiltration, several works and activities were initiated; these generally can be categorized as:

i. Works led by City forces directly

ii. System monitoring to collect data on drainage system performance

iii. Analyses of the data to determine extent, scale and source of problem.

2.1 City-Led

When the City of Mississauga first became aware of basement water infiltration, the causes of this unexpected problem were not known. In response, the City proactively undertook a number of precautionary, investigative and maintenance actions on the storm and FDC sewer systems, the tributary of the East Branch of Sixteen Mile Creek, and the Osprey Marsh Stormwater Management Pond. The following summarizes the work completed by the City in the Lisgar District prior to March 2015. These activities are further described in the Summary Report (March 2015) for the Lisgar District Basement Water Infiltration Investigation (Appendix A).

Table 2.1	City-Led Activities Completed Prior to March 2015
FDC and Storm Sewers	Video inspection and Flushing of FDC and Storm Sewer Systems
	Identifying Sewer Cross-connections
	Sealing FDC Maintenance Access Lids and Cracks
	Cleaning Storm Sewer Outfalls to Creek
	Improvements to Overland Flow Routes
	High Water Protocol
East Sixteen Mile Creek Tributary and Osprey Marsh Stormwater Management Pond	Creek Vegetation Trimming and Debris Removal
	Sediment and Vegetation Removal from Bridge Crossings and Storm Outfalls
	Creek Inspection Protocol
	Reconfiguration of Osprey Marsh Stormwater Management Pond Outlet

2.2 Studies and Investigations Completed Prior to the March 2015 Public Summary Report

Monitoring Work

Wood initiated field monitoring activities in support of the Lisgar District Basement Water Infiltration study in late 2011 and early 2012. These monitoring activities were intended to collect data in order to better inform the understanding of the operational mechanisms of the drainage systems in the Lisgar District, and help identify the source(s) of the basement water infiltration occurrences in this neighbourhood.

Monitoring was conducted for the Foundation Drain Collector (FDC) sewer system, the storm sewer system, surface water (Lisgar Creek), as well as the groundwater system. A comprehensive monitoring program was undertaken over multiple years, and continues to be ongoing, to collect field data needed to help understand the cause(s) of basement water infiltration and to provide guidance in finding the appropriate mitigation measures and also offer feedback on the efficacy of mitigation solutions. The monitoring work has been invaluable in allowing the Team to better understand the drainage systems' response to storm events, and help lead the Team towards identifying the cause(s) of basement water infiltration. Table 2.2 provides a summary of the monitoring work completed between 2011 and 2015.

Table 2.2 Monitoring Work Completed Between 2011 and March 2015

Stormwater System Component	Findings
Groundwater: • Monitoring wells were installed at four main sites. • Both water level and water temperature were monitored continuously at these sites.	• Groundwater temperatures in the native soils do not vary greatly and are not affected by precipitation events. • The shallow groundwater levels in the native soils do not increase rapidly enough during precipitation events which proves that basement water infiltration is not caused by flow through the native soils.
FDC and Storm Sewer System: • Twenty (20) water level monitoring gauges were installed within the FDC and storm sewer systems. • Both water level and water temperature were monitored continuously at these sites.	• The FDC system has been observed to surcharge rapidly in response to rainfall events. • Surcharging is most common along Black Walnut Trail and in the vicinity of Osprey Boulevard, which is generally consistent with locations of reported basement water infiltration. • The short period of time in which the water level in the FDC system has been observed to surcharge and then quickly drop back down strongly suggests that the water is coming in from surface water sources rather than groundwater. • The water temperature data from the observed surcharge events also suggest that the water is coming from surface water sources. • Water levels in the storm sewer along Erin Centre Boulevard, which takes drainage from the FDC system, show that it is not the cause of FDC surcharging.
Tributary and Stormwater Management Pond: • Water level monitoring gauges were installed and monitored at five different locations along the creek, and one directly within the pond. • A temporary rainfall gauge was installed for two of the monitoring years.	• There is nominal creek flow from the GO Station channel, and no apparent connection between these flows and FDC surcharging. • There is no apparent connection between creek flows and FDC surcharging. • There is no apparent connection between water levels within the Osprey Marsh Stormwater Management Pond and FDC surcharging.

Testing Work

To better understand the interactions between the various water sources and components of the drainage system in the Lisgar District, testing work was also undertaken through water sampling and 'in-ground' pilot projects to validate some of the theories. The testing work undertaken between 2011 and 2015 is further described in the Summary Report (March 2015) for the Lisgar District Basement Water Infiltration Investigation (Appendix A and detailed herein in Table 2.3).

Table 2.3 Testing Work Completed Between 2011 and March 2015

Stormwater System Component	Findings
Water Quality Characterization: • A characterization program was completed to assess the chemical properties of the water found in: - Native soils (i.e. the groundwater); - Utility trench (i.e. where the municipal services are); - Creek; - Osprey Marsh Stormwater Management Pond; and - FDC system. • The testing was able to identify commonalities among the various different water sources, and in particular the source of the water in the FDC.	• Under expected operating conditions the quality of the water in the FDC system should show some similarities with the shallow groundwater. However, water in the FDC system water was found to be salt rich, similar to the utility trench, the tributary and the pond. This suggests that the water in the FDC system is very similar to surface water (and dissimilar to groundwater).
Storm Sewer Leakage Testing: • Storm sewer leakage testing was undertaken at three sites where basement water infiltration occurred. • The tests were comprised of: - Blocking the storm sewers and filling them with water to replicate surcharge conditions (under pressure); - Addition of a green fluorescent dye to the storm sewer; and - Monitoring of the dye concentrations and water levels in the utility trench, groundwater and FDC system.	• At all three sites, the storm sewers leaked and at two sites (Wild Cherry Lane and Scotch Pine Gate), the dye was detected in the FDC after two hours. • Tests have proven that there is a flow path from the storm sewer to the FDC through the utility trench with a response time consistent with that observed between major storm events and instances of basement water infiltration.
Storm Sewer Outfall Collar Testing: • Impermeable concrete collars were installed in the utility trench near the outfall of the storm sewers at two locations: - Sixteen Mile Creek (Scotch Pine Gate); and - Osprey Marsh SWM Pond (Pondview Way). • These collars were installed with backflow valves that allow water from the utility trench to drain to the tributary and pond, but not in the other direction.	• Monitoring continued to be underway at both of these sites to assess the effectiveness of the collar in preventing elevated water levels in the utility trench which may be due to inflow from the creek or pond during larger storm events (2016 monitoring findings in Table 5).

The findings from the monitoring, testing and analyses work completed between 2011 and March 2015 resulted in the identification of the primary cause of infiltration (detailed in Section 3.0) and a Prioritized Action plan (detailed in Section 4.0). This information was presented in the Public Report and presentation in March 2015 (Appendix A), subsequent to which, the City's focus shifted towards implementation of remediation activities, in order to work towards mitigating the identified cause(s) of the observed basement water infiltration. Field monitoring activities have continued in parallel, in order to support these activities by assessing the effectiveness of mitigation works after implementation and observed changes in drainage system performance over time.

Analysis Work

Wood has used the data collected over the monitoring periods, as well as additional information provided by the City on the FDC system and area services, to conduct a series of technical analyses as follows:

Table 2.4 Analyses Work Completed in 2015

Monitoring Component	Findings
Groundwater Analysis • Testing work and analyses were undertaken for native soils and granular materials	• Permeability in the utility trench is up to 10 million times greater than the native soils. This has further confirmed that the utility trench is the primary linkage for surface water to reach the FDC system.
Design Check of the FDC Sewer System • Larger number of residences are currently connected to the FDC system than what was intended in the original design; This was known by the City and area developers and computer modelling demonstrated that the system could accept the higher number of connected residences. • Comparison of original design sizes and slopes of the FDC sewers with as-constructed characteristics demonstrated that some sections of the FDC trunk sewer were constructed flatter than intended, which is expected to decrease the available flow capacity.	• Deficiencies in the as-constructed design of the FDC trunk sewer system may contribute marginally to FDC surcharge, however, given the results of the FDC monitoring, these deficiencies are not considered to be a material contributor to FDC surcharging or a cause of the basement infiltration issue. • Observed FDC surcharging has also been noted in areas which are a considerable distance away from FDC sewer deficiencies, which further suggests that these deficiencies are not a material contributor to the FDC surcharging or a cause of the basement infiltration issue.
Computer Modelling of the FDC System • Computer modelling was completed for the FDC sewer system.	• Findings located in the March 2015 Summary Report (Appendix X).

2.3 Studies and Investigations Completed Following the March 2015 Public Summary Report

Table 2.5 and Table 2.6 summarize the findings of monitoring and testing with respect to surface water (FDC, storm sewer, and open watercourses) and groundwater monitoring which occurred in 2015 and 2016 (Appendix B). The analyses of findings from monitoring and testing completed during 2017 and 2018 are ongoing and continue to be used by the City to validate its design and implementation process related to the effectiveness of the subject remediation works. The findings from the monitoring and testing completed in 2017 are summarized at a high level in Table 2.7 (a separate summary report is pending); 2018 monitoring work is ongoing and will also support the FDC pumping system work.

Table 2.5 Monitoring Work Completed in 2015 (March onwards)

Monitoring Component	Findings
Surface Water: • Surface water monitoring gauges were maintained or re-installed in key locations throughout the study area to monitor changes in both water levels, as well as water temperature. • A total of twenty-six (26) water level and water temperature gauges were active in 2015: - Eighteen (18) gauges in the FDC sewer system (one (1) of which was new in 2015); - Six (6) gauges in the storm sewer system (three (3) of which were new in 2015); and - Two (2) gauges were re-installed in surface water features.	• 2015 was considered to be drier than average. • Observed FDC surcharging is primarily restricted to the area north of Derry Road. • FDC surcharge was identified primarily for the storm events of July 7, August 20, and September 19, 2015 at those locations north of Derry Road. • The storm events' surcharge was rapid in nature, suggesting a direct surface water connection. Water temperature data for surcharging sewers indicate a clear rise, again suggesting surface water sources. • It may be possible that there is a localized source of direct runoff in some locations.
Groundwater: • Groundwater monitoring of both water level and temperature data undertaken at seventeen (17) piezometers. • Detailed consideration of: - Water levels in the utility trench and surrounding undisturbed material during two main surcharging events in 2015; and - The performance of the storm sewer collars installed at Pondview Way and Scotch Pine Gate towards the end of 2014.	• The data collected in 2015 indicate that FDC surcharging on August 20, 2015 and September 19, 2015 has originated from build-up of water in the sewer trenches in the Cactus Gate area (Area 1). • The observed surcharging in this area may be due to some combination of potential causes, however there is greater evidence to suggest the role of elevated water levels in sewer trenches as the primary contributing factor. • No discernable difference between water levels at Scotch Pine Gate Collar even during the surcharge events, therefore leakage from the storm sewer is a more significant contributor to water quantities in the sewer trench than flow up the sewer trench itself directly from Sixteen Mile creek. • The Pondview Way collar has had some beneficial effects that locally cause lower water levels in the FDC sewer trench. However, this is not caused by the prevention of flow up the sewer trench from the Osprey Marsh SWMP, but rather by passive dewatering of the FDC sewer trench due to an enhanced connection with Osprey Marsh SWMF.

Table 2.6 Monitoring Work Completed in 2016

Monitoring Component	Findings
Storm Sewer Lining: • Storm sewer lining was completed in the Phase 1 (Black Walnut Trail) area between December2016 and March 2017; including verification of flexural strength and thickness, and water tightness	• Twenty-four (24) samples were tested for flexural strength and thickness, all samples passed design requirements (including seven (7) which required a design reconciliation process) • Nine (9) liner samples were analyzed for water tightness; all submitted samples passed the water tightness testing.
Surface Water Monitoring: • Surface water monitoring gauges were again maintained or installed in key locations throughout the study area to monitor changes in both water levels, as well as water temperature. • A total of twenty-six (26) water level and water temperature gauges were maintained or re-installed: - Eighteen (18) gauges in the FDC sewer system; - Four (4) gauges in the storm sewer system; and - Four (4) gauges in surface water features (including one (1) new location at Cactus Gate)	• 2016 was considered to be drier than average. • Observed FDC surcharging is primarily restricted to the area north of Derry Road, and particularly along the FDC trunk sewer on Black Walnut Trail and in the vicinity of the trunk FDC sewer along Lisgar Creek. • FDC surcharge was identified primarily for events on August 13, 2016 and December 26, 2016. • The August 13, 2016 event indicated a rapid surcharge response (and recession) within the area north of Derry Road to a summer thunderstorm type event, while the December 26 event was characterized by a more prolonged response to a low-intensity event coupled with snowmelt. • The storm events' surcharge was rapid in nature, suggesting a direct surface water connection. Water temperature data for surcharging sewers also indicates a surface water source (rise in temperature for summer event, drop in temperature for winter event) • It may also be possible that there is a localized source of direct runoff in some locations
Groundwater Monitoring: • A total of thirty-two (32) piezometers were monitored during 2016, including nine (9) new sewer trench piezometers which were installed in the Osprey Boulevard area in anticipation of planned storm sewer leakage tests	• The observed water level data from available sewer trench piezometers does not indicate overly high levels during either of the observed FDC surcharge events in 2016. Further elevated levels were noted at other periods during 2016 which did not result in FDC system surcharging.

Table 2.7 Monitoring Work Completed in 2017

Monitoring Component	Findings
Storm Sewer Lining and Leakage Testing: • A post lining storm sewer leakage test for the Phase 1 area (Golden Locust Drive) on April 24-25, 2017 • A second phase of storm sewer lining was originally proposed for the area around Doug Leavens Boulevard and Osprey Boulevard, including Alderwood Trail (issued for tender May 2017), however the contract for the work was ultimately not awarded based on the results of post-lining storm sewer leakage testing. Planned pre-lining storm sewer leakage tests for this area were also not undertaken. • A repeated storm sewer leakage test was completed for the Golden Locust Drive area on July 25-26, 2017, using a modified testing methodology to better assess/isolate components of the storm drainage system	• The results of the April 24-25 storm sewer leakage test generally indicated that leakage was continuing to occur (i.e. outflow from the storm sewer system to the utility trench) despite the storm sewer lining, suggesting another component of the system (other than the lined storm sewers) were continuing to leak • The modified July 25-26 storm sewer leakage test focused on the influence of catchbasin and roadway sub-drain connections. This additional testing indicated that the largest relative rate of leakage appeared to be sourced from catchbasins and connected perforated roadway sub-drains • Based on the findings of these leakage tests, Wood and City staff reviewed remediation options, including backflow preventers. Ultimately, City staff proceeded with the installation of plugs on catchbasin subdrains along Black Walnut Trail in November 2017 (a second phase of installations along Alderwood Trail, Osprey Boulevard and the surrounding area was completed thereafter)
Surface Water Monitoring: • Surface water monitoring gauges were again maintained or installed in key locations throughout the study area to monitor changes in both water levels, as well as water temperature. • A total of thirty-four (34) water level and water temperature gauges were maintained or re-installed: - Twenty (20) gauges in the FDC sewer system (two (2) new gauges installed in support of originally planned Phase 2 Storm Sewer Lining); - Eight (8) gauges in the storm sewer system (including one (1) new gauge along Osprey Boulevard to support originally planned Phase 2 Storm Sewer Lining); and - Six (6) gauges in surface water features, including installations at Alderwood Trail and Osprey Boulevard (not monitored since 2013)	• 2016 was considered to be drier than average. • Similar to previous years, observed FDC surcharging is primarily restricted to the area north of Derry Road, and particularly along the FDC trunk sewer on Black Walnut Trail and in the vicinity of the trunk FDC sewer along Lisgar Creek. • FDC surcharge was identified primarily for events on June 23, 2017 (which did not result in any reported basement water infiltration), and July 13-14, 2017 (which resulted in reported basement water infiltration along the Black Walnut Trail area) • More minor surcharge was noted for events on July 27 and August 4, 2017 • An analysis of the July 13-14, 2017 storm event was completed, noting the pre-wetting conditions and high rainfall total/intensity as primary factors • The nature of the identified surcharge is generally consistent with previously reported observations
Groundwater Monitoring: • A total of thirty-two (32) piezometers were monitored during 2017	• The observed water level data generally indicates consistent findings with previous monitoring years.

3.0 Summary of Potential Causes

As noted earlier, based on the comprehensive monitoring, testing and analysis work completed prior to March 2015, Wood concluded that the primary cause of the basement water infiltration relates to stormwater entering the utility trench.

As storm sewers are not built to be watertight, and due to cracks and leaks expected through aging, stormwater is able to leak out during storm events and migrate into the utility trench, where the bedding material, made of gravel and other granular soils can allow water to move very quickly. Over time, water builds up in the utility trench from storm sewer leakage, as well as through other sources (other utilities, groundwater, etcetera), and is unable to drain away quickly due to the relatively impermeable nature of the native soils surrounding the trench.

It is this situation, in combination with certain storm conditions and local lot drainage where issues may arise. For instance, where the ground and utility trench are already wet, possibly from an earlier storm event, and rainfall subsequently occurs, this may create a condition where there is enough leakage from the storm sewer system during the rainfall event to fill an already wet utility trench and push water up the bedding material around the FDC laterals servicing the homes and into the foundation weeping tiles. This water then drains directly into the FDC pipes through the weeping tiles, which may result in excess flow in the FDC system (surcharge). However, this condition by itself may not lead to basement water seepage. It is this condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage that may lead to water around the weeping tiles being unable to drain and potentially seeping into the basements of homes. This process is illustrated in Figures 3A to 3F.

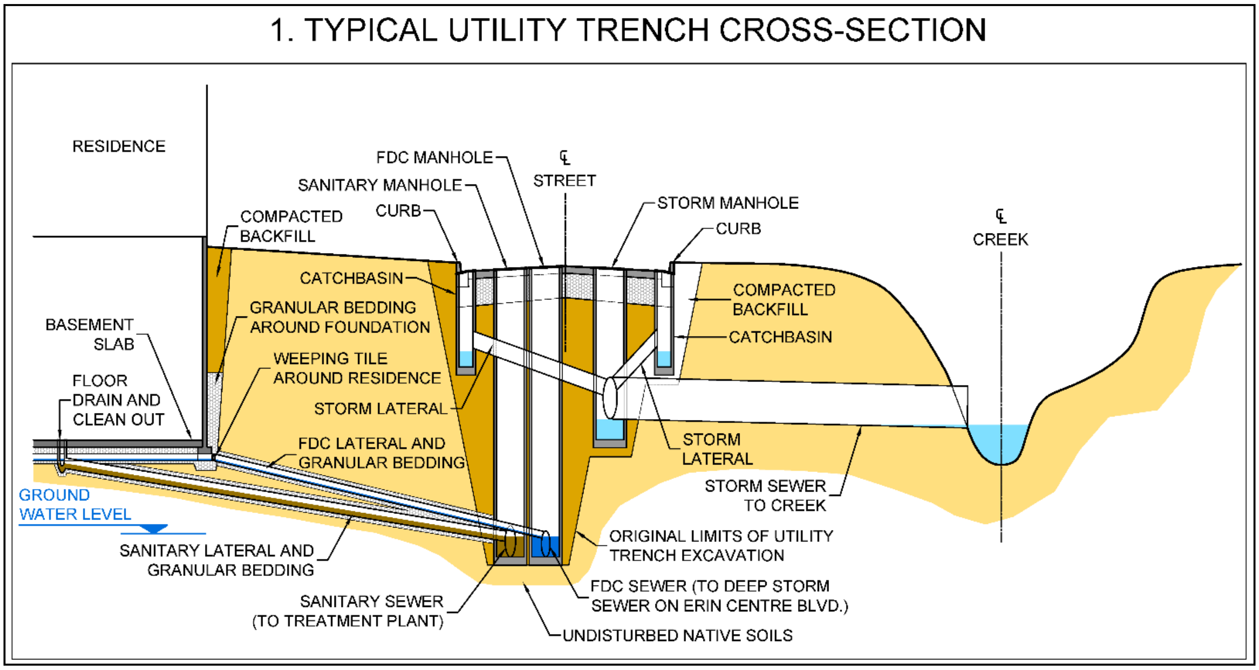


Figure 3A: Basement Infiltration due to water within the Utility Trench

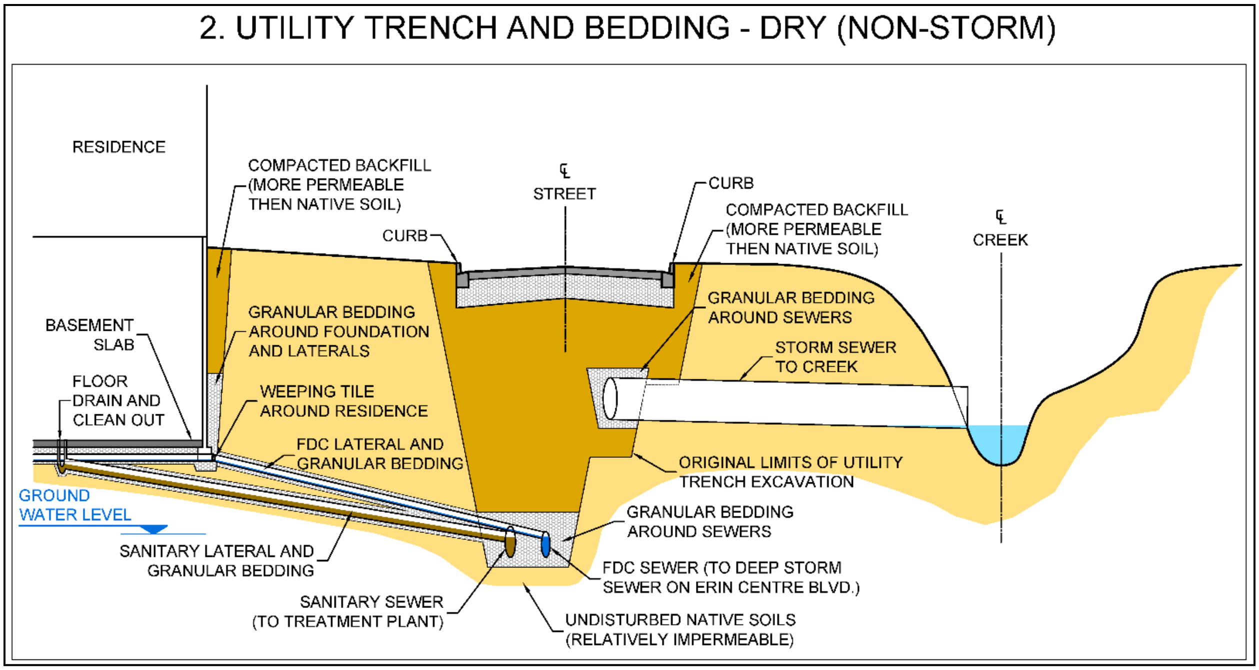


Figure 3B: Basement Infiltration due to water within the Utility Trench

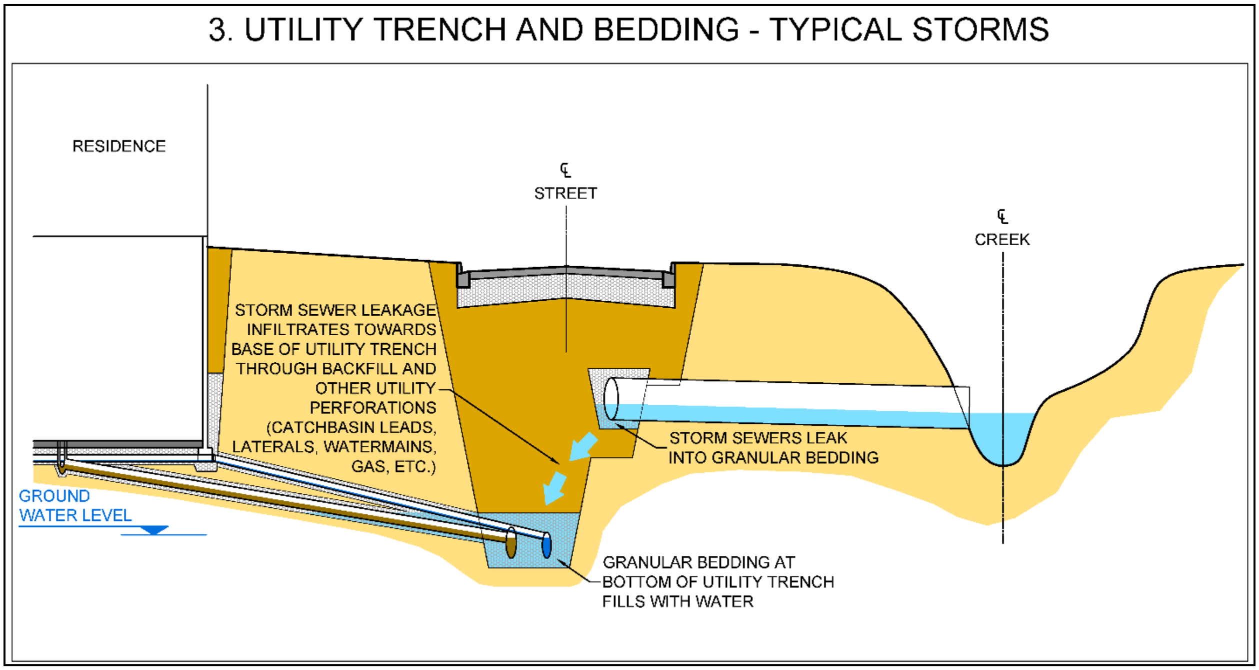


Figure 3C: Basement Infiltration due to water within the Utility Trench

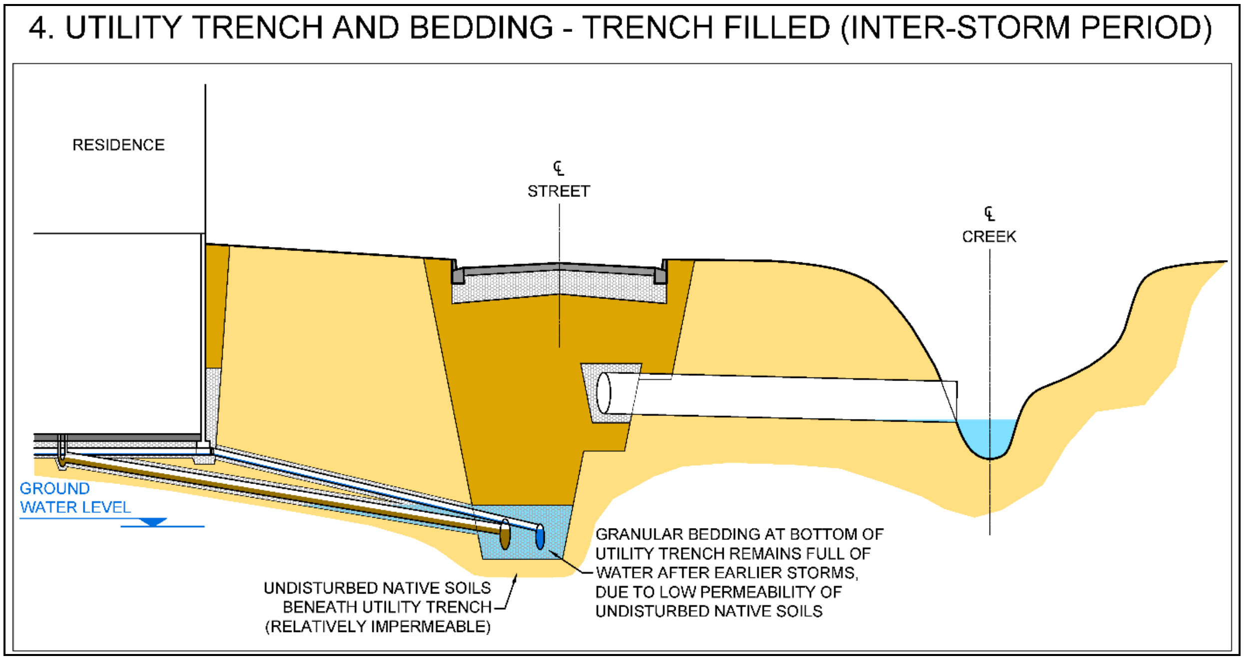


Figure 3D: Basement Infiltration due to water within the Utility Trench

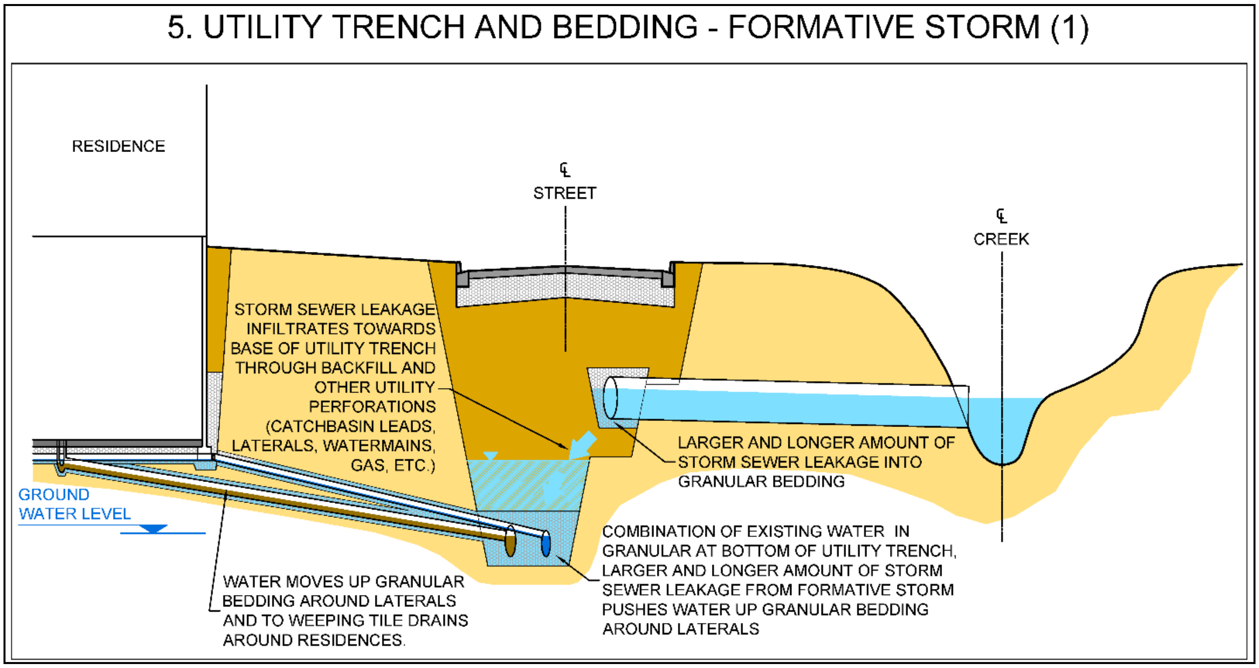


Figure 3E: Basement Infiltration due to water within the Utility Trench

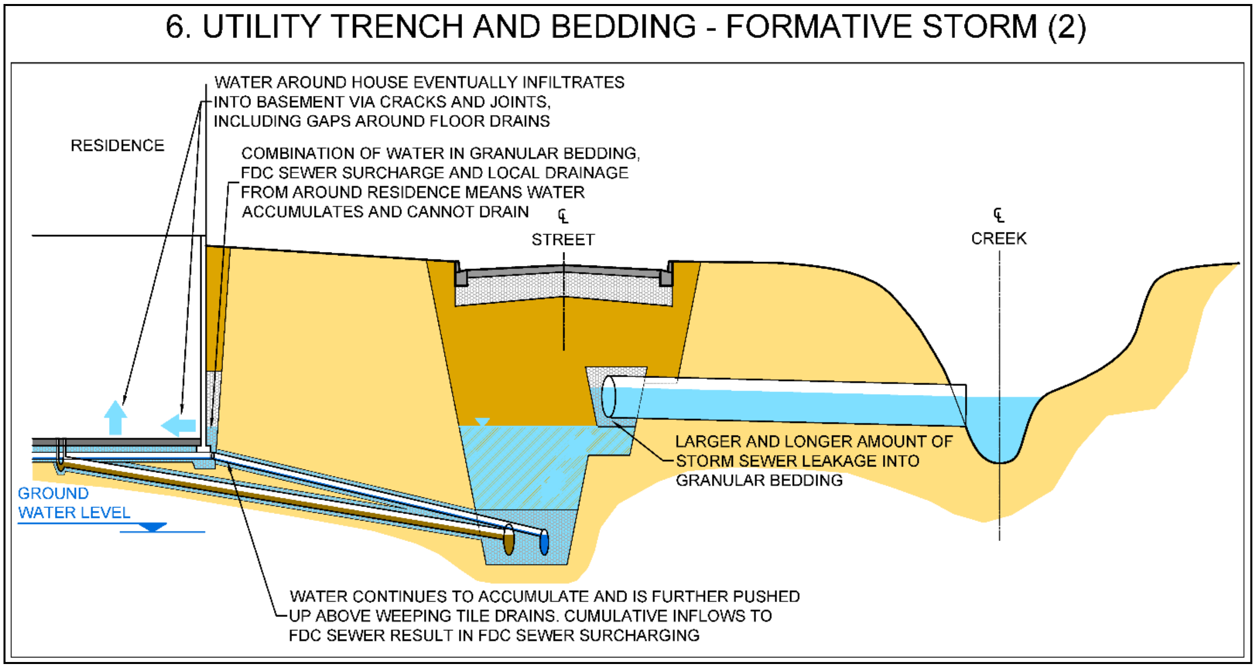


Figure 3F: Basement Infiltration due to water within the Utility Trench

The exact reasons why homes in the Lisgar District have not had basement water seepage before 2008 are not known. It is however considered that the increasing leakage of water from the storm sewers through normal aging has gradually increased the volume of water collected in the trenches over time, ultimately contributing to the problems first experienced in 2008.

The risk of basement water infiltration is also connected to the relative depths of the FDC system and basements of homes in the different areas of the Lisgar District. Under the condition where water has moved up the bedding material surrounding the FDC laterals to the homes, the homes placed at greatest risk of basement water infiltration would be those where the FDC system (and thus the utility trench) is the shallowest. In other words, the less vertical separation between the FDC pipe/utility trench and the basements, the more susceptible basements will be to water seepage.

A number of other factors have been identified which may be also impacting the overall operation of the FDC system, however, none of them, either alone or in combination, would cause water to seep in to basements to the extent reported. Table 3.1 provides a summary of Wood's conclusions with respect to the potential contributing factors in the basement water infiltration investigation. A more extensive description of the potential factors in basement water infiltration is provided in the Summary Report (March 2015) for the Lisgar District Basement Water Infiltration Investigation (Appendix A).

Table 3.1 Summary of Assessment of Potential Factors in Basement Water Infiltration

Potential Factor	**Level of Influence**
Stormwater to Utility Trench	Primary Cause
FDC and Utility Trench Depths	May increase risk of basement water infiltration at specific locations
Groundwater	May contribute additional/excess flows to the FDC and utility trench (Not sufficient to cause problem)
Creek Backwater	
Osprey Marsh Pond (SWM) Backwater	
Basement Walkouts	
Inflow/Infiltration to FDC	
FDC Hydraulics	May impair conveyance capacity of FDC system (Not sufficient to cause problem)
FDC Design	
FDC Tailwater	
FDC Maintenance	
FDC Construction	
Cross-Connections	Not Applicable
Creek Maintenance	
GO Station	
Sanitary System	
Lot Grading	Insufficient information
Basement Construction / Changes	

4.0 Mitigation Plan

The basement water infiltration investigation and the foregoing conclusions led to a prioritized action plan in 2015, which identified potential mitigation measures intended to reduce the risk of future basement water infiltration. The action plan was subsequently updated in 2017 following further investigations.

4.1 Prioritized Action Plan 2015

To address the basement water infiltration issue, eleven (11) alternative actions were developed and evaluated for potential implementation and documented for Public Review in March of 2015. These eleven (11) actions were analyzed by the City and Wood for effectiveness (ability of proposed actions to reduce basement water infiltration) and feasibility (ease of implementation). Through this process, five (5) actions were carried forward to form a Prioritized Action Plan to reduce the risk of basement water infiltration while six (6) actions were screened out. A detailed matrix summarizing each of the eleven alternative actions is provided in Appendix A. The following five actions were recommended to be carried forward as mitigation actions based on their effectiveness and feasibility.

Table 4.1 Prioritized Action Plan 2015

Item #	Action	Description
1	Strategic Lining of Storm Sewers	Sealing the inside surface of storm sewers in strategic locations with an impermeable liner to reduce/eliminate leakage into bedding (and ultimately into FDC system).
2	Construction of a Utility Trench Dewatering System	Dewater bedding material around the FDC system to limit the accumulation of water in the utility trench and provide additional storage volume during storm events.
3	Construction of FDC Pumping Stations	Install pumping stations at key locations of the FDC system which will activate when the system either approaches or reaches surcharge conditions and pump water to the ground surface.
4	FDC Sewer Upgrades	Upsizing selected FDC sewers to increase their conveyance capacity and reduce surcharge.
5	Sump Pumps	Home-owner installs a new basement sump pump system to help to drain the weeping tile system around the home; sump pump would discharge to ground surface.

4.2 Updated Action Plan 2017

A storm event on July 13-14, 2017 resulted in reported instances of basement water infiltration in the Lisgar District. A total of thirty-five (35) residences within the Lisgar District reported basement water infiltration from the July 13-14, 2017 storm event. All of the affected properties were located along the west side of Black Walnut Trail (i.e. backing onto Lisgar Creek), with the exception of one property located along Golden Locust Trail. This is consistent with the location of previously reported instances of basement water infiltration in this area. To date, no instances of basement water infiltration have been reported from other areas in the Lisgar District which have previously reported occurrences; this primarily involves residences in the vicinity of Alderwood Trail and Osprey Boulevard. The July 13-14, 2017 event is notable in that it was the first reported instance of basement water infiltration in this area (Black Walnut Trail) for which field monitoring data are available. Monitoring gauges were in place for the January 13, 2013 event (for which seven (7) residences reported basement water infiltration), however all of these residences were in the vicinity of Osprey Boulevard.

Wood summarized and interpreted available monitoring data for the storm event, as well as suggested additional analyses and next steps. A public meeting was subsequently held on October 18, 2017 to provide an update on the ongoing works being completed for the Lisgar District Basement Water Infiltration Study. As part of the public meeting, an Updated Action Plan was presented (ref. Table 4.2).

Table 4.2 Updated Action Plan 2017

Item #	City Actions	Schedule
1	**Address Roadway Sub-Drain Leakage**	
	• Pursue prototype of roadway sub-drain plugs	Complete
	• Installation of plugs along Black Walnut Trail and other areas	Complete
	• Expansion to other areas within Lisgar District	Pending Monitoring Results
2	**Construction of an Utility Trench Dewatering System**	
	• Carry Out Municipal Class EA Study	Underway (this study)
	• Complete detailed design work	Ongoing
	• Construction	Planned for 2019
3	**Construction of a FDC Pumping Station**	
	• Carry out Municipal Class EA Study	Underway (this study)
	• Conduct Hydraulic Modelling Analysis	Complete
	• Complete detailed design work	Ongoing
	• Construction	Planned for 2018 / 2019
4	**Amend Sump Pump Subsidy Program**	
	• Increased Program Subsidy	Complete
5	**Continue with High Water Protocol**	
	• Continue to monitor and initiate pumping protocol as required	Ongoing
6	**Monitoring**	
	• Implement additional monitoring gauges in key study areas	Complete
	• Monitoring to verify effectiveness of implemented measures	Ongoing

5.0 Pumping Station Alternatives Assessment

A number of Pumping Station alternatives have been developed consisting of low flow and high flow systems. These alternatives are assessed in this Section, based on a number of factors and considerations including: the amount of drainage area served, property suitability and the number of houses in proximity to the proposed location that reported basement water infiltration.

5.1 Low Flow and High Flow Systems

Utility Trench Dewatering Pumping System (Low Flow)

A Utility Trench Dewatering Pumping Station is a system that operates to dewater the utility trench (granular stone bedding) by removing small amounts of water on a continuous basis, much like a residential sump pump. The intent of the utility trench dewatering system for the Lisgar District is to dewater bedding material within the sewer utility trench to limit the accumulation of water, and thus provide additional storage volume during storm events.

By way of background, the preliminary pilot utility trench dewatering design was first reviewed at a meeting with City staff in February 2016. At that time, two (2) potential concepts were presented for consideration for a system at Cactus Gate. Both options were similar, and involved an impermeable collar around the utility trench along Black Walnut Trail, with a diversion of accumulated water into a pumping manhole within the adjacent parkette (and then to the existing storm sewer system). The two (2) options differed on the location of the collar. Option A placed the collar at the south limits of the parkette, while Option B placed the collar further upstream at the north limits of the parkette. City staff ultimately indicated a preference for Option A (February 26, 2016) which was then advanced to a preliminary design stage.

Both options also included an impermeable collar along Lisgar Creek, given concern regarding the potential for surface water movement upstream through connected utility trench bedding material. This was a particular concern in this location, as in addition to the storm sewer outfall, there is also a stub FDC sewer connection, and an active sanitary sewer pipe which crosses the creek (to service the lands north of the CNR). This secondary feature was ultimately included in the preliminary design drawings, however subsequent direction from City staff (February 2017) has indicated that this component of the design should be deferred until a later date.

A preliminary design drawing has been included in Appendix E for reference. As noted previously, the preliminary design incorporates both a primary collar along Black Walnut Trail, and a secondary collar along Lisgar Creek (which as noted, will likely not form part of the subsequent detailed design). The focus of the design is for the system along Black Walnut Trail. As evident, the preliminary design would construct a concrete collar along the lowest portion of the utility trench system (FDC and sanitary sewers) to block the movement of infiltrated water from travelling further downstream. Additional clearstone would be placed to hydraulically connect exfiltration from higher utilities with the lowest portion of the utility trench. This area would then be drained by a series of perforated pipes which would direct drainage to a new maintenance hole. The collected flow would either be pumped directly from this location, or directed to a secondary pumping location, and ultimately pumped out to Lisgar Creek (ref. Appendix E).

FDC Pumping System (High Flow)

An FDC Pumping Station differs from a utility trench dewatering system in that it operates to remove water from the FDC pipe network during periods of high flow. This pump would be larger but operate less frequently and only during certain storm or snowmelt events.

In general, this system would require a new diversion sewer to be connected to the FDC pipe system. The diversion pipe would be set somewhat above the elevation of the existing pipe, such that it would not activate until FDC water levels exceed the capacity of the existing pipe. The diversion pipe would need to be sufficiently sized to ensure conveyance of FDC surcharge flows to a dedicated pumping system, notionally a large diameter maintenance hole or underground tank with a wet well to capture excess flow. Pumps within this system would then re-direct the diverted water to Lisgar Creek, similar to the low flow system described earlier. Unlike the low flow system however, much larger capacity pumps would be required to ensure that pumping rates are sufficient to re-direct FDC surcharge at approximately the rate of inflow.

5.2 Alternative Location Evaluation

Long-List of Alternative Locations

A long-list of potential alternative locations for the proposed FDC pumping systems (both low flow and high flow) has been developed. Based on the predominance of reported instances of basement water infiltration in the area north of Derry Road (Black Walnut Trail), it has been considered that the preferred initial location should be within this priority area. Thus the long-list of alternative locations has been restricted to this general area. Further, it has been generally assumed that for synergy in construction activities, it would be preferred to construct both the low and high flow systems in the same location. Based on a review of the identified area, the following long-list of alternative locations has been generated (refer to Figure 5.1):

Alternative 1. Black Walnut Trail at Cactus Gate Parkette

Alternative 2. Russian Olive Close at Buttonbush Park

Alternative 3. Terragar Boulevard at Lisgar Creek (within the roadway right-of-way)

Alternative 4. Black Walnut Trail at Smoke Tree Road Parkette

Alternative 5. Black Walnut Trail at Scotch Pine Gate Parkette

Alternative 6. Black Walnut Trail at Wild Cherry Lane Easement

Figure 5.1 Potential Pumping Station Locations

Evaluation Criteria

The principal Evaluation Criteria have been identified as follows:

- *Drainage Area Served:* The amount of nearby land that will be serviced by the Pumping Stations.
- *Property Suitability*: The suitability of the property based on public land ownership and local property constraints, such as the amount of public space available (parkette versus City owned easement).
- *Number of Houses in Proximity that Reported Basement Water Infiltration:* The Pumping Station should be located in proximity to the greatest number of houses that reported basement water infiltration in order to best address the issue.

Given the locations of reported basement water infiltration for the July 13-14, 2017 storm event, an FDC pumping station located along Black Walnut Trail has been identified as a priority. As noted, public (City) land ownership is considered a high priority, given the limited capacity of storm sewers within the Lisgar District (originally designed to a 2-year return period standard, given shallow grades and lack of ground cover), and therefore it is considered preferable that any FDC pumping station have a “free” outlet, likely to a surface drainage feature with a direct connection to Lisgar Creek. This would restrict potential FDC pumping stations to locations with immediate access to the creek, given that private property acquisition is considered cost-prohibitive and unlikely to be supported by area property owners. Based on the preceding, a total of 6 locations have been identified in the Long-List of Alternatives (ref. Figure 5.1).

Alternative 1. Black Walnut Trail at Cactus Gate Parkette

This location refers to the City-owned parkette area on the west side of Black Walnut Trail at the intersection with Cactus Gate. An FDC pumping system in this location would serve an area of approximately 9.8 ha.

The parkette is publicly owned (City of Mississauga), which is clearly advantageous. This location would also avoid having operating components of the system within the roadway right-of-way, which would be a long-term operations and maintenance concern. Disruptions to local traffic would be expected during construction, as the intersection of Black Walnut Trail and Cactus Gate would require closure during the work. It is noted however that MiWay Route 32 (to the Lisgar GO Station) does travel along this section of roadway, and would require diversion during construction.

Four (4) of the thirty-five (35) properties which reported basement water infiltration for the July 13-14, 2017 storm event would be located upstream of this location. In addition, based on previously completed surface water monitoring work, FDC pipe surcharging is most frequently observed in the area proximal to this location.

Alternative 2. Russian Olive Close at Buttonbush Park

This location refers to the portion of Buttonbush Park (primarily the existing parking lot area) along the east side of Russian Olive Close, immediately south of Passway Road. An FDC pumping system in this location would serve an area of approximately 7.7 ha.

The parkette is publicly owned (City of Mississauga) which is clearly advantageous. This location would also avoid having operating components of the system within the roadway right-of-way, which would be a long-term operations and maintenance concern. Notwithstanding, features would likely be located beneath an existing parking lot, which could pose long-term operational challenges.

No properties upstream of this location have reported basement water infiltration for previous storm events. As such, this location would not directly benefit upstream properties, but would more likely benefit properties further downstream by removing excess FDC water before it could impact those properties. Based on monitoring work in this area, FDC surcharging has been observed in this location (July 13-14, 2017 storm event among others), although not as frequently as areas along Black Walnut Trail directly.

Alternative 3. Terragar Boulevard at Lisgar Creek (Roadway Right-of Way)

This location refers to the roadway right-of-way along Terragar Boulevard in the vicinity of Lisgar Creek (west of Black Walnut Trail). An FDC pumping system in this location would serve an area of approximately 15.1 ha.

While the roadway would be publicly owned (City of Mississauga), works would be constrained to the roadway right-of-way, which would limit available space and depths of excavation. Further, working in the vicinity of Lisgar Creek and the associated bridge crossing could be challenging. Terragar Boulevard is an arterial roadway, and the only available crossing of Lisgar Creek north of Derry Road. There would therefore be a significant potential impact to transportation and area residents.

Only one (1) property upstream of this location (Golden Locust Trail) reported basement water infiltration for previous storm events. Similar to Alternative 2, the majority of the residences which have reported basement water infiltration for previous storm events would be located downstream of this location, thus the benefit would be in removing excess FDC water before it could impact those properties. Similarly, some FDC surcharging has been noted at the monitoring gauge in his area, but not as frequently as areas further downstream and along Black Walnut Trail.

Alternative 4. Black Walnut Trail at Smoke Tree Road Parkette

This location refers to the parkette on the west side of Black Walnut Trail, directly adjacent to Smoke Tree Road. An FDC pumping system in this location would serve an area of approximately 38.6 ha.

The parkette is publicly owned (City of Mississauga), which is clearly advantageous. This location would also avoid having operating components of the system within the roadway right-of-way, which would be a long-term operations and maintenance concern. Local traffic would be impacted during the construction work, however there are no MiWay transit routes which use this section of Black Walnut Trail. Traffic would need to be re-directed to the north or south to access Terragar Boulevard.

This location would be downstream from 14 of the 35 residences which reported basement water infiltration for the July 13-14, 2017 storm event, or generally at the mid-point of the previously affected area. FDC pipe surcharging is most frequently observed in the area proximal to this location (along Black Walnut Trail).

Alternative 5. Black Walnut Trail at Scotch Pine Gate Parkette

This location refers to the parkette on the west side of Black Walnut Trail, directly adjacent to Scotch Pine Gate. An FDC pumping system in this location would serve an area of approximately 86.1 ha. The area served by a system in this location is considerably higher than upstream locations (Alternatives 1 to 4), due to the large drainage area served by the FDC system along Scotch Pine Gate (approximately 44.6 ha).

The parkette is publicly owned (City of Mississauga), which is clearly advantageous. This location would also avoid having operating components of the system within the roadway right-of-way, which would be a long-term operations and maintenance concern. Local traffic would be impacted during the construction work, however there are no MiWay transit routes which use this section of Black Walnut Trail. Traffic would need to be re-directed to the north or south to access Terragar Boulevard.

This location would be downstream from 22 of the 35 residences which reported basement water infiltration for the July 13-14, 2017 storm event, thus would be expected to have a lesser overall benefit as compared to locations further upstream.

Alternative 6. Black Walnut Trail at Wild Cherry Lane Easement

This location refers to a 7.5 m wide easement held by the City of Mississauga between the west side of Black Walnut Trail and Lisgar Creek, where the storm, sanitary, and FDC sewer services are conveyed. The area served by an FDC pumping system in this location would be approximately 96.0 ha, the largest of any of the considered alternatives due to its downstream location.

This location would be constrained for construction given the relatively narrow width (7.5 m), and also due to the fact that the City of Mississauga does not directly own the property, but simply holds an easement. Further, it is evident that the adjacent homeowners in this area have encroached on the easement area with private development, which would further complicate construction logistics in this location. Local traffic would also be impacted during the construction work, however there are no MiWay transit routes which use this section of Black Walnut Trail. Traffic could be routed around the intersection during construction.

This location would be downstream of all of the residences which reported basement water infiltration for the July 13-14, 2017 storm event (as well as previous basement water infiltration events), given its location at the outlet of the FDC system from the Black Walnut Trail area. This location would be expected to have the least overall benefit as compared to locations further upstream accordingly.

Evaluation of Long-List of Alternatives

The six (6) long-listed alternatives have been assessed relative to the three (3) evaluation criteria previously noted. The scoring has been assessed as either positive, neutral, or negative. The results are presented in Table 5.1.

Table 5.1 Long-list of Alternatives

Potential Pumping Station Locations	Evaluation Criteria			Evaluation
	Drainage Area Served	Property Suitability	# of Reported Cases	Screened/ Short-listed

1. Black Walnut Trail at Cactus Gate Parkette	🟢	🟢	🟢	Short-listed
2. Russian Olive Close at Buttonbush Park	🟡	🟢	🟡	Screened out
3. Terragar Boulevard at Lisgar Creek	🟡	🔴	🟢	Screened out
4. Black Walnut Trail at Smoke Tree Road Parkette	🟢	🟢	🟡	Short-listed
5. Black Walnut Trail at Scotch Pine Gate Parkette	🟢	🟢	🔴	Screened out
6. Black Walnut Trail at Wild Cherry Lane Easement	🟢	🔴	🔴	Screened out

🟢 Positive 🟡 Neutral 🔴 Negative

Based on the preceding screening, the short-listed locations for an FDC pumping system are considered to be:

- Black Walnut Trail at Cactus Gate Parkette
- Black Walnut Trail at Smoke Tree Road Parkette

The two (2) short-listed locations have been assessed further for their technical effectiveness (individually and in combination) using hydraulic modelling; this is summarized in Section 5.3.

5.3 Technical Evaluation of Short-Listed Alternatives

Overview and Methodology

In order to support an informed design process for an FDC pumping station under high flow conditions, an analytical tool was required to assess expected rates of flow within the FDC system during storm events, and the associated effectiveness of potential pumping strategies (locations, numbers, and pump station sizing/capacities). Note: Due to the nature of the Low Flow System (utility trench dewatering), there is no valid technical analysis technique to evaluate the district performance of one site versus another site. As such, for the technical evaluation, only the high flow system has been assessed, with the inherent understanding that the low flow system (utility trench dewatering) would share the same location. Notionally, by capturing infiltrated water from the utility trench system on an ongoing basis, it is expected to improve the overall performance of the combined system.

A hydraulic model of the FDC sewer system was previously developed (PCSWMM modelling software) as part of the assessment work in support of the March 2015 Public Summary Report. This model was used for a number of different assessments, including forensic modelling of an actual storm event (September 2, 2014) based on available FDC monitoring data. In order to verify the effectiveness and feasibility of FDC pumping station(s) at the short-listed locations, the previously developed hydraulic modelling has been used as a basis.

A detailed technical summary of the completed hydraulic modelling has been included in Appendix C; the following provides a summary of the work completed and the associated findings.

In general, the developed hydraulic model has been used to approximate the observed water level responses at monitoring gauges within the Black Walnut Trail area for several historic formative FDC surcharging events. These events include:

- June 12, 2014
- September 10, 2014
- June 23, 2017
- July 13-14, 2017

The model uses an approximate unitary flow response for each of the storm events, and then applies different weighting factors based on identified hydraulic zones, until a reasonable match to the observed water levels is obtained. The resulting flows are then applied to assess the relative benefits of FDC diversions and high flow pumping. The short-listed FDC pumping system alternatives, identified in the preceding section, have been assessed using this technical methodology; the results of these analyses have been summarized briefly herein.

Scenario 1: Diversion at Cactus Gate Parkette Only

Under this scenario, the existing FDC maintenance hole at Cactus Gate and Black Walnut Trail would be used for an FDC diversion, whereby a new diversion sewer would be constructed from the west section of the manhole (MH) towards a new pumping station MH within the parkette.

A number of sub-scenarios have been assessed under this scenario, including varying the diameter/size of the diversion sewer pipe, and consideration of an orifice restrictor on the primary (existing) FDC sewer on Black Walnut Trail to further restrict discharge to the FDC sewer and maximize the flow to the proposed diversion pipe and associated FDC high flow pumping system.

The results generally indicate a relative insensitivity to the size of the diversion pipe, as well as the orifice restrictor. The modelling results indicate a notable reduction in water levels downstream of the proposed FDC pumping system for the four (4) storm events assessed, however the diversion/pumping would not be sufficient to completely eliminate simulated FDC surcharging downstream.

The results suggest that a high flow pump with a capacity of between 46 and 66 L/s would be required to manage diverted flows, although further detailed modelling would be required (at the detailed design stage) to more definitively confirm pump sizing (and wet well geometry).

Scenario 2: Diversion at Smoke Tree Road Parkette Only

Under this scenario, the existing FDC maintenance hole at Smoke Tree Road and Black Walnut Trail would be used for the FDC diversion, whereby a new diversion sewer would be constructed from the west section of the MH towards a new pumping station MH within the parkette.

A number of sub-scenarios have been similarly assessed under this scenario, including varying the diameter/size of the diversion sewer pipe, and consideration of an orifice restrictor on the primary (existing) FDC sewer on Black Walnut Trail to further restrict discharge to the FDC sewer and maximize the flow to the proposed diversion pipe and associated FDC high flow pumping system.

The results again generally indicate a relative insensitivity to the size of the diversion pipe, as well as the orifice restrictor. The modelling results indicate a notable reduction in water levels downstream of the proposed FDC pumping system for the four (4) storm events assessed, however as per Scenario 1, the diversion/pumping would not be sufficient to completely eliminate simulated FDC surcharging downstream.

Given its location further downstream, a high flow pump with a capacity of between 51 and 118 L/s would be required to addressed the diverted flow, although further detailed modelling would be required (at the detailed design stage) to more definitively confirm pump sizing (and wet well geometry).

Summary of Scenario Findings

The hydraulic modelling results indicate that in general, an FDC pumping system at Smoke Tree Road (Scenario 2) would be more effective at reducing FDC water levels in downstream areas than one located further upstream at Cactus Gate (Scenario 1). However, an FDC pumping system at Cactus Gate would be more effective at reducing FDC water levels in the upstream area, as would be expected. Further, the relative difference in the FDC water level reduction further downstream between the two potential mitigation measures is not overly significant. As such, it is considered that the greatest overall benefit in FDC water level reduction is gained through the construction of and FDC pumping system at the Cactus Gate Parkette.

Given the preceding, and the availability of geotechnical data at the Cactus Gate Parkette, it is considered that the Cactus Gate Parkette location is the preferred location for the construction of a combined FDC pumping system (low and high flow components).

6.0 Preferred Solution and Implementation Plan

The alternative assessment (ref. Section 5) has determined the Preferred Solution to involve the construction of a combined FDC pumping system (low and high flow components) at the Cactus Gate Parkette, given the highest scoring on the evaluation criteria, and the associated efficiencies around construction and design, as well as long-term operation and maintenance. The following provides further details on this solution, as well as considerations for implementation

6.1 Low Flow (Utility Trench Dewatering)

As discussed in Section 5, it has been generally assumed that for synergy in construction activities, it would be preferred to construct both the low and high flow systems in the same location. Based on the technical evaluation and screening in the previous section, the Cactus Gate Parkette has been identified as the preferred location, which is also consistent with the previously preferred location of the utility trench dewatering system based on feasibility work in 2016.

As noted, the low flow system operates to dewater the utility trench (granular stone bedding) by removing small amounts of water on a continuous basis, much like a residential sump pump. The intent of the utility trench dewatering system is to dewater bedding material within the sewer utility trench to limit the accumulation of water, and thus provide additional storage volume during storm events.

Given that this operation (small flows being removed on a continuous basis) differs from that of the high flow system (large flows being removed on an infrequent basis) initial concepts have been developed on the basis of separate systems. Notwithstanding, separate systems would necessitate additional infrastructure (additional diversion maintenance holes and pumping wet wells) and duplication of pumping and electrical systems. This would consume a greater amount of the limited available space in the preferred location (Cactus Gate Parkette), while also adding to the construction disruption, and overall project construction costs. Further, mitigation measures can be focused upon the single system, for which any potential impacts would be expected to be more notable for the larger pumping systems associated with the high flow capacity requirements. A combined system is also considered to be advantageous from an operational perspective. The pumps associated with the FDC pumping system need to be operated periodically to ensure function; this is a particular concern for the infrequent requirement for high flow pumping systems. By diverting the low flow component to this system, these pumps would be required to operate to remove this smaller flow, which would in turn reduce manual maintenance and operation requirements.

Based on the preceding review, a combined low flow and high flow FDC pumping system is considered to be the preferred solution. Proposed system details, and a review of potential issues and mitigation measures, is presented in the following section.

6.2 High Flow (FDC Pumping System)

As noted previously, the Cactus Gate Parkette has been identified as the preferred location for the FDC pumping system, based on a review of a long-list of alternative locations, and a subsequent focused technical analysis of pumping effectiveness. As per Section 6.1, it has been determined that a combined high flow – low flow pumping system is the preferred approach, given the associated efficiencies around construction and design, and also long-term operation and maintenance.

The FDC pumping system will require a single larger diameter (3 m +\-) maintenance hole to be used as a wet well to house the pumping systems. While the majority of the system would be underground, a portion of the wet well structure will be located above ground given access requirements for long term operations and maintenance. Supporting features would be expected to include an above-ground electrical panel, accesses for a below-ground control valve chamber, and a new pipe outfall to the existing swale/ditch within the Cactus Gate Parkette (ultimately draining to Lisgar Creek, a tributary of Sixteen Mile Creek). In addition, a standby generator has been considered, to ensure that the FDC pumping system will remain operational in the event of an electrical power outage, which could potentially occur as part of a thunderstorm event (which could cause FDC surcharging).

Table 6.1 Mitigation Considerations

Subject	Impact / Issue	Mitigation / Action
Construction	• Traffic • Noise • Dust • Vibration	• Management plan required to meet City standards • Contract will ensure City requirements are met • Pre-construction condition surveys of adjacent residences are proposed • Active vibration monitoring during construction
Operation	• Noise • Odour • Maintenance	• Pumps will be deep below ground and operate infrequently; noise would be expected to be minimal • Backup generator would operate infrequently; an enclosed model should be considered, and a noise assessment undertaken if required as part of environmental approvals process • Discharges would be stormwater flows (not sanitary) filtered through aggregate material - no odour is anticipated • Proposed maintenance access will be through a dedicated access on the wet well structure; parkette pathway can also be adjusted to allow for direct vehicle access
Aesthetics	• Pumps • Other features • Parkette • Buildings	• Pumps would be well below ground and not visible from the parkette. • Wet well structure would need to extend slightly above the ground surface but generally minor. • Electrical panel and backup generator should be located along the edge of the parkette to the extent possible. • Landscape plan will be created for restoration, and should review opportunities to camouflage features where possible • No permanent buildings are proposed as part of the current concept design.
Creek Discharge	• Outlet	• Located adjacent to creek; Conservation Halton permit may be required if works within regulated area or if local channel requires widening/reinforcement to accept additional discharges from system
Climate Change	• Resiliency	• Pumping station and utility dewatering trench will add capacity to overall system, providing resiliency to changing climate

A preliminary concept design for the FDC pumping system has been developed based on the preceding considerations (ref. Appendix F). This concept plan will necessarily be further refined through the detailed design process. Based on the current concept design, potential impacts and issues have been addressed, along with a proposed mitigation strategy. These considerations are presented in Table 6.1.

The preceding potential impacts and mitigation measures should be implemented into the subsequent detailed design phase for the FDC pumping system.

The performance of the combined Utility Trench Dewatering System and FDC Pumping Station should continue to be monitored after implementation. This ongoing monitoring will verify technical effectiveness (reduction in utility trench water levels and diversion of FDC flows during surcharge events) and any opportunities for improvement/modification to the system and overall design approach. Additional future Pumping Stations may be considered for other areas (including South Lisgar), based on the results of ongoing monitoring. Opportunities for design improvements and modifications based on the findings of the monitoring and review of the initial FDC pumping system, should also be applied to subsequent installations, if planned.

7.0 Summary

7.1 Study Background

Commencing in 2008, approximately 200 homes in the Lisgar District experienced water seeping into their basements following certain rainfall events. In response, the City undertook a number of actions, such as video inspection and cleaning of the foundation drain collector (FDC) system and putting in place a High Water Protocol (deploying pumps during major storms).

In October 2011, Wood was retained to undertake an engineering study to determine the cause(s) of basement water infiltration and recommend corrective measures.

After comprehensive monitoring and analysis, the engineering study determined the problem to be primarily related to the build-up of water in the bedding material of the utility trenches that contain the storm, sanitary and FDC sewer systems.

In March 2015 the results of the study were presented to the Public which outlined a Mitigation Plan. The Plan recommended prioritized mitigation measures for the City to address the basement water infiltration issue, with the highest priority mitigation measure being the strategic lining of priority storm sewers to minimize leakage.

As part of the implementation of the Prioritized Action Plan, storm sewer lining works were completed for the highest priority area (Phase 1 - Black Walnut Trail) between December 2016 and March 2017. Following a large storm event in July 2017 that resulted in reported basement water infiltration, the Prioritized Action Plan was updated in 2017, which advanced an FDC Pumping Station as a higher priority mitigation measure to be assessed, planned, designed and constructed. This Class EA planning study has specifically been undertaken to determine the preferred locations and form of Pumping Station(s) system within the Lisgar District to reduce the potential for basement water infiltration.

7.2 Alternative Assessment

A number of Pumping Station alternatives were developed consisting of low flow and high flow systems.

A Utility Trench Dewatering Pumping Station (low flow system) is a system that operates to dewater the utility trench (granular stone bedding) by removing small amounts of water on a continuous basis, much like a residential sump pump. The intent of the utility trench dewatering system for the Lisgar District is to dewater the bedding material within the sewer utility trench to limit the accumulation of water, and thus provide additional storage volume during storm events. A FDC Pumping Station differs from a utility trench dewatering system in that it operates to remove water from the FDC pipe network during periods of high flow. This pumping system would be larger but operate less frequently and only during certain storm or snowmelt events.

Long-List of Alternatives

A long-list of potential alternative locations for the proposed FDC pumping systems (both low flow and high flow) was developed. Based on the predominance of reported instances of basement water infiltration in the area north of Derry Road (Black Walnut Trail), it was considered that the preferred location should be within this priority area. Thus the long-list of alternative locations was restricted to this general area. Further, it was recommended that for synergy in construction activities, it would be preferred to construct both the low and high flow systems in the same location. Based on a review of the identified area, the following long-list of alternative locations was generated:

Alternative 1. Black Walnut Trail at Cactus Gate Parkette

Alternative 2. Russian Olive Close at Buttonbush Park

Alternative 3. Terragar Boulevard at Lisgar Creek (within the roadway right-of-way)

Alternative 4. Black Walnut Trail at Smoke Tree Road Parkette

Alternative 5. Black Walnut Trail at Scotch Pine Gate Parkette

Alternative 6. Black Walnut Trail at Wild Cherry Lane Easement

Evaluation Criteria

The principal Evaluation Criteria used in the assessment were:

- *Drainage Area Served:* The amount of nearby land that will be serviced by the Pumping Stations.
- *Property Suitability*: The suitability of the property based on public land ownership and local property constraints, such as the amount of public space available (parkette versus City owned easement).
- *Number of Houses in Proximity that Reported Basement Water Infiltration:* The Pumping Station should be located in proximity to the greatest number of houses that reported basement water infiltration in order to best address the issue.

Alternative Assessment

Long-list of Alternatives Assessment				
Potential Pumping Station Locations	**Evaluation Criteria**			**Evaluation**
	Drainage Area Served	**Property Suitability**	**# of Reported Cases**	**Screened/ Short-listed**
1. Black Walnut Trail at Cactus Gate Parkette	🟢	🟢	🟢	Short-listed
2. Russian Olive Close at Buttonbush Park	🟡	🟢	🟡	Screened out
3. Terragar Boulevard at Lisgar Creek	🟡	🔴	🟢	Screened out
4. Black Walnut Trail at Smoke Tree Road Parkette	🟢	🟢	🟡	Short-listed
5. Black Walnut Trail at Scotch Pine Gate Parkette	🟢	🟢	🔴	Screened out
6. Black Walnut Trail at Wild Cherry Lane Easement	🟢	🔴	🔴	Screened out

🟢 Positive 🟡 Neutral 🔴 Negative

Short-list of alternatives

Based on the preceding screening, the short-listed locations for an FDC pumping system were:

- Black Walnut Trail at Cactus Gate Parkette
- Black Walnut Trail at Smoke Tree Road Parkette

The two (2) short-listed locations were subsequently assessed further for their technical effectiveness (individually and in combination) using hydraulic modelling.

7.3 Technical Evaluation of Short-Listed Alternatives

In order to support an informed design process for an FDC pumping station under high flow conditions, a hydraulic model of the FDC sewer system (PCSWMM modelling software) was used for a number of different assessments, including forensic modelling of an actual storm event based on available FDC monitoring data. The hydraulic model was used to model four events ranging between 2014 and 2017, and used an approximate unitary flow response for each of the storm events, and then applies different weighting factors based on identified hydraulic zones, until a reasonable match to the observed water levels is obtained. The resulting flows are then applied to assess the relative benefits of FDC diversions and high flow pumping.

Short-listed Location 1: Diversion at Cactus Gate Parkette Only results generally indicated a relative insensitivity to the size of the diversion pipe, as well as the orifice restrictor. The modelling results indicated a notable reduction in water levels downstream of the proposed FDC pumping system for the four (4) storm events assessed, however the diversion/pumping would not be sufficient to completely eliminate simulated FDC surcharging downstream.

Short-listed Location 2: The Diversion at Smoke Tree Road Parkette Only results again generally indicated a relative insensitivity to the size of the diversion pipe, as well as the orifice restrictor. The modelling results indicated a notable reduction in water levels downstream of the proposed FDC pumping system for the four (4) storm events assessed, however as per Short-listed Location 1, the diversion/pumping would not be sufficient to completely eliminate simulated FDC surcharging downstream.

The hydraulic modelling results indicated that in general, an FDC pumping system at Smoke Tree Road (Short-listed Location 2) would be more effective at reducing FDC water levels in downstream areas than one located further upstream at Cactus Gate (Short-listed Location 1). However, an FDC pumping system at Cactus Gate would be more effective at reducing FDC water levels in the upstream area, as would be expected. Further, the relative difference in the FDC water level reduction further downstream between the two potential mitigation measures is not overly significant. As such, the greatest overall benefit in FDC water level reduction would be realized through the construction of an FDC pumping system at the Cactus Gate Parkette.

Given the preceding, the Cactus Gate Parkette location is the preferred location for the construction of a combined FDC pumping system (low and high flow components).

7.4 Preferred Solution and Implementation Plan

Through the Class EA process documented herein, along with feedback from City staff and the Public, it has been determined that a combined high flow – low flow pumping system is the preferred approach, given the associated efficiencies around construction and design, and also long-term operation and maintenance.

Mitigation measures have been considered to address potential impacts during construction, along with operations and maintenance, specifically to address aesthetics, creek discharge and climate change (ref. Table 6.1). These, along with other specific municipal and Provincial guidance directives, should be considered during final planning and design, construction and implementation, including operation and maintenance.

Appendix A
March 2015 Public Report and Presentation

LISGAR DISTRICT
BASEMENT WATER INFILTRATION INVESTIGATION

SUMMARY REPORT

Submitted to:

City of Mississauga
Mississauga, Ontario

Submitted by:

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March 2015

TP111119B

EXECUTIVE SUMMARY

Lisgar District Basement Water Infiltration Assessment

Commencing in 2008 a number of homes in the Lisgar District experienced water seeping into their basements following certain rainfall events, with the largest number of homes impacted during a rainfall event in late 2011. A total of 187 homes are known to have been affected to date.

After becoming aware of the scale of this issue, the City undertook a number of actions, including:

- Video inspection and cleaning of the foundation drain collector (FDC) system;
- Removal of vegetation along Sixteen Mile Creek;
- Clean-out of bridge crossings and storm outfalls to Sixteen Mile Creek;
- Putting in place a High Water Protocol (deploy pumps during major storms);
- Sealing selected FDC manholes and pipe joints; and
- Adjustment to the Osprey Marsh Stormwater Pond outlet.

In October 2011, the engineering consulting firm of AMEC Environment & Infrastructure (now known as Amec Foster Wheeler Environment & Infrastructure) was retained to undertake an engineering study to determine the cause(s) of basement water infiltration and recommend corrective measures.

After a lengthy and comprehensive monitoring period and analysis, the study findings have determined the problem to be primarily related to the build-up of water in the bedding material of the utility trenches that contain the storm, sanitary and FDC sewer systems.

Leakage from the storm sewer, which is a normal occurrence, combined with the presence of slow draining native soils around the utility trenches has been found to result in water build-up within these trenches. If the build-up of water is significant enough it can travel up the bedding material around the FDC laterals servicing the homes and into the foundation weeping tiles. This water then drains directly into the FDC pipes through the weeping tiles which may result in excess flow in the FDC system (surcharge). However, this condition by itself may not lead to basement water seepage. It is this condition in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage that may lead to water around the weeping tiles being unable to drain and potentially seeping into the basements of homes.

The exact reasons why homes in the Lisgar District have not had basement water seepage before 2008 are not known. It is considered that the increasing leakage of water from the storm sewers through normal aging gradually increased the volume of water collected in the trenches over time, ultimately contributing to the problems first experienced in 2008.

During the course of the investigations a number of other factors have been identified which may be impacting the overall operation of the FDC system; however, based on the information available, none of them, either alone or in combination would cause water to seep into the basements to the extent reported.

These factors include:

- The depth of the FDC system and utility trench relative to residential weeping tile systems in some areas;
- Capacity issues related to pipe sizes and slopes in some sections of the FDC system;
- Potential inflows to the utility trench from groundwater and surface water sources; and
- Rain water and runoff from the lot or roof entering drains in basement walkout areas that are connected to the FDC system

Based on the findings presented in this study, the following two measures are recommended as the highest priorities for the City to deal with the basement water infiltration issue:

- Strategic lining of priority storm sewers to minimize leakage; and
- Construction of a utility trench dewatering system.

Other actions that may be implemented after the highest priority measures are completed include:

- Build permanent FDC pumping stations for high flows; and
- Replace deficient FDC pipe lengths when they reach the end of their engineered lifespan.

It is also suggested that residents who qualify for the City’s Lisgar District Sump Pump Subsidy Program take advantage of the program.

The findings of the engineering study represent a significant step in understanding the cause of a complex basement water infiltration issue in the Lisgar District. Implementation of the two highest priority measures to improve the drainage system’s performance and minimize the risk of future basement water infiltration is recommended to be initiated as soon as funding and approvals are secured.

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1.0 INTRODUCTION

The Lisgar District is situated in the northwest corner of the City of Mississauga and is bounded by the Canadian Pacific Railway tracks to the north, Britannia Road West to the south, Ninth Line to the west and Tenth Line to the east. It is located within the Sixteen Mile Creek watershed and drains to a small tributary of the east branch of Sixteen Mile Creek (Figure 1).

The Lisgar District is mainly made up of single family homes which were largely built over a 25-year period starting in the early 1980s as shown in Figure 2.

Commencing in 2008, a number of homes in the Lisgar District have experienced water seeping into their basements following certain rainfall events. A total of 187 homes are known to have been affected to date.

In response to these events, the engineering consulting firm of AMEC Environment & Infrastructure (now known as Amec Foster Wheeler Environmental & Infrastructure) was retained in late 2011 to undertake an engineering study to determine the cause(s) of basement water infiltration and recommend corrective measures.

This Summary Report provides a high-level discussion on the following matters based on three years of comprehensive field monitoring (2012-2014) and engineering analysis:

- Description of the drainage system servicing the Lisgar District;
- Summary of City-led actions to proactively address concerns;
- Summary of potential causes of the basement water infiltration;
- Detailed description of study activities including field work, testing, monitoring and analysis; and
- Outline of the proposed mitigation approach comprised of priority-based actions for 2015 and beyond.

Figure 1: Subwatershed Map

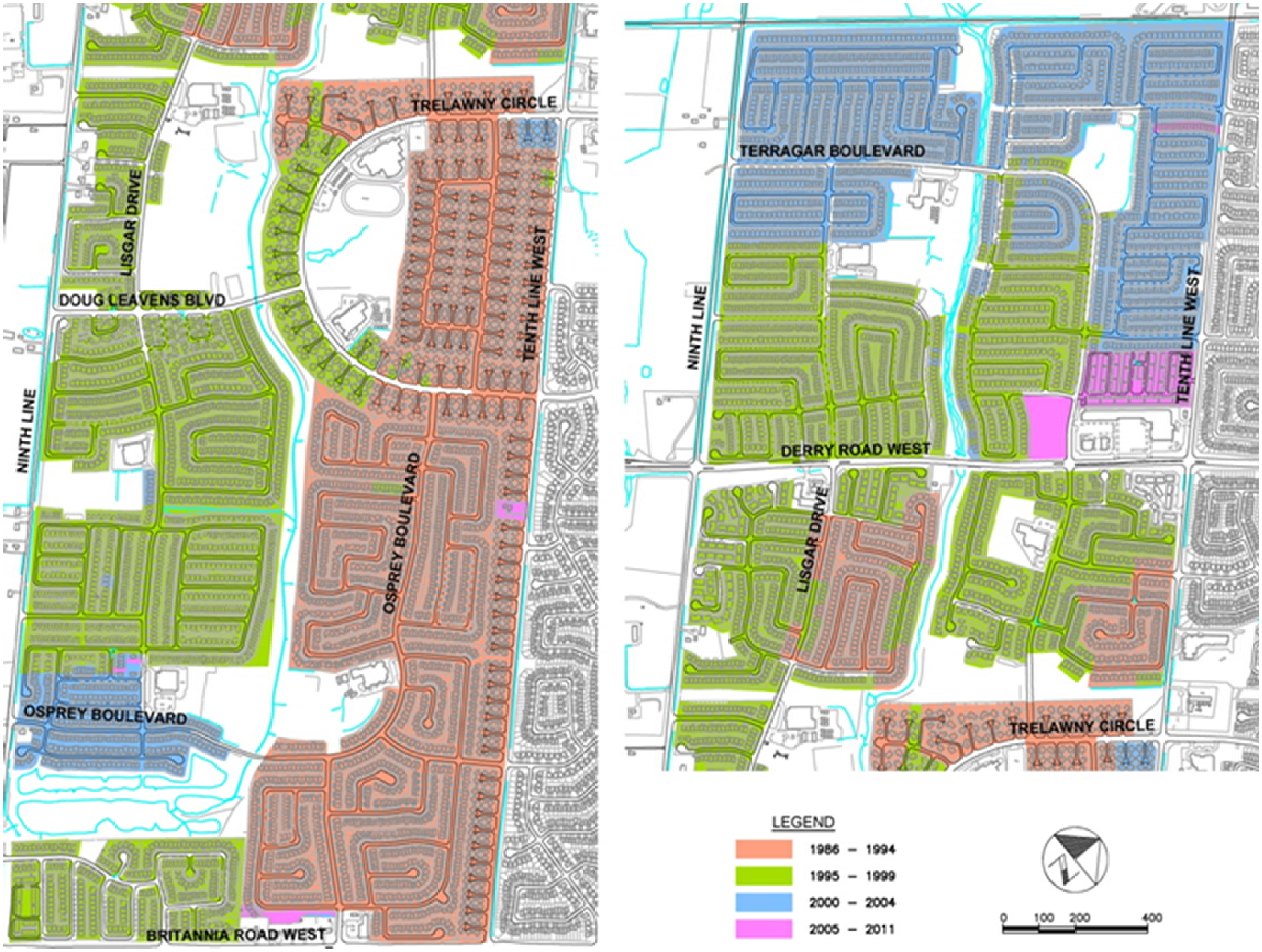


Figure 2: Historic Development of Lisgar District

2.0 OVERVIEW OF DRAINAGE SYSTEMS

When agricultural or open space lands are converted to urban uses, such as residential or employment, municipal services including watermains, sanitary sewers and storm sewers are typically constructed within road allowances or public easements to support these developments. The City of Mississauga is responsible for managing all aspects of stormwater within its jurisdiction, whereas the Region of Peel is responsible for stormwater on Regional roads, as well as drinking water, wastewater and solid waste management.

Storm sewers are designed to capture surface runoff from rainfall or snowmelt and then convey this water safely to a waterbody such as a creek, river or lake. In areas with stormwater management facilities (commonly referred to as ponds), designed to provide water quality and/or flood control, this water would first outlet into these ponds for treatment before being released to a waterbody. Where the waterbody is low in relation to the surrounding lands, the storm sewers can be built sufficiently deep below the ground surface to also capture and convey water draining from the weeping tiles around the basement foundations of homes (Figure 3). Alternatively, where the receiving waterbody is high compared to the surrounding lands and basement foundations, the weeping tiles around the homes would not be able to drain through gravity into the storm sewers. In these circumstances, one of two systems would be required to drain the foundation around the homes:

- Sump Pumps; or
- A Foundation Drain Collector.

A sump pump is a mechanical pump used to remove water captured by the weeping tiles around the basement foundations of homes that has been collected in a sump pit (basin) in the basement. Water from the sump pit would either be pumped to the ground surface or underground into a shallow storm sewer (Figure 4).

A Foundation Drain Collector (FDC), typically located in the same utility trench as other municipal services, is a sewer system dedicated to only collect and drain water from weeping tiles of homes to an outlet by gravity flow (Figure 5). The FDC system is often referred to as part of a 3-pipe system, the other two being the storm and sanitary systems. At the time of its construction, the FDC system was considered to be a preferred solution for many new areas. In fact, the text book *Modern Sewer Design (Canadian Edition, 1980)* states: "*This system virtually eliminates the probability of back-ups into foundation drains, which have caused considerable flooding, and damage to basements*".

The Lisgar District is one area that is serviced by a 3-pipe system. Figure 6 depicts the limits of the area within Mississauga served by an FDC system.

The following images graphically represent the three alternative systems designed to capture and drain water away from the foundations of homes.

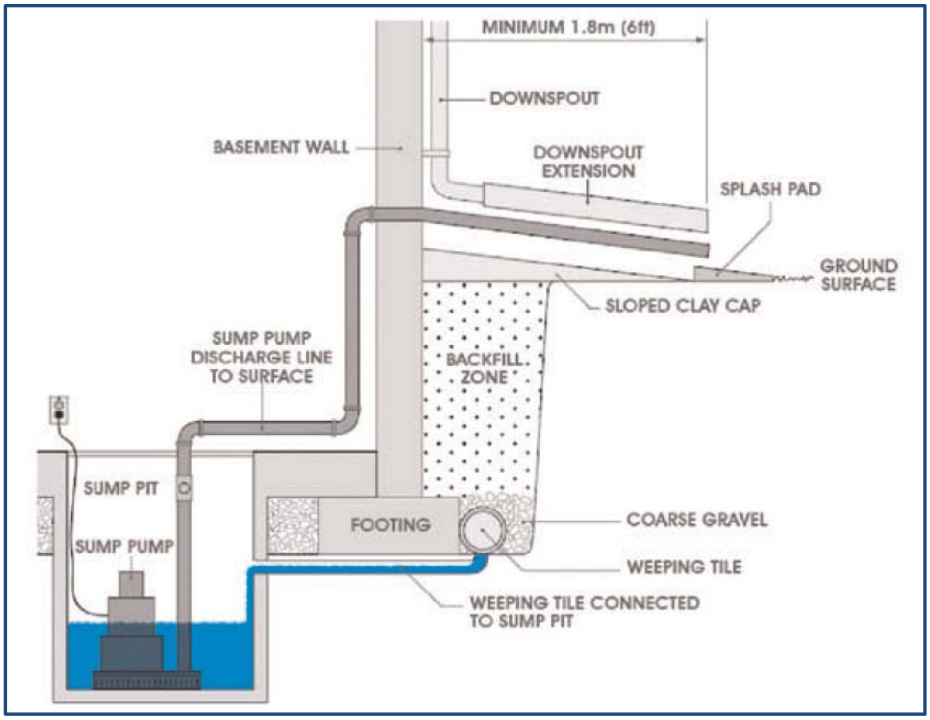


Figure 3: Conventional Foundation Drain connected to Storm Sewer

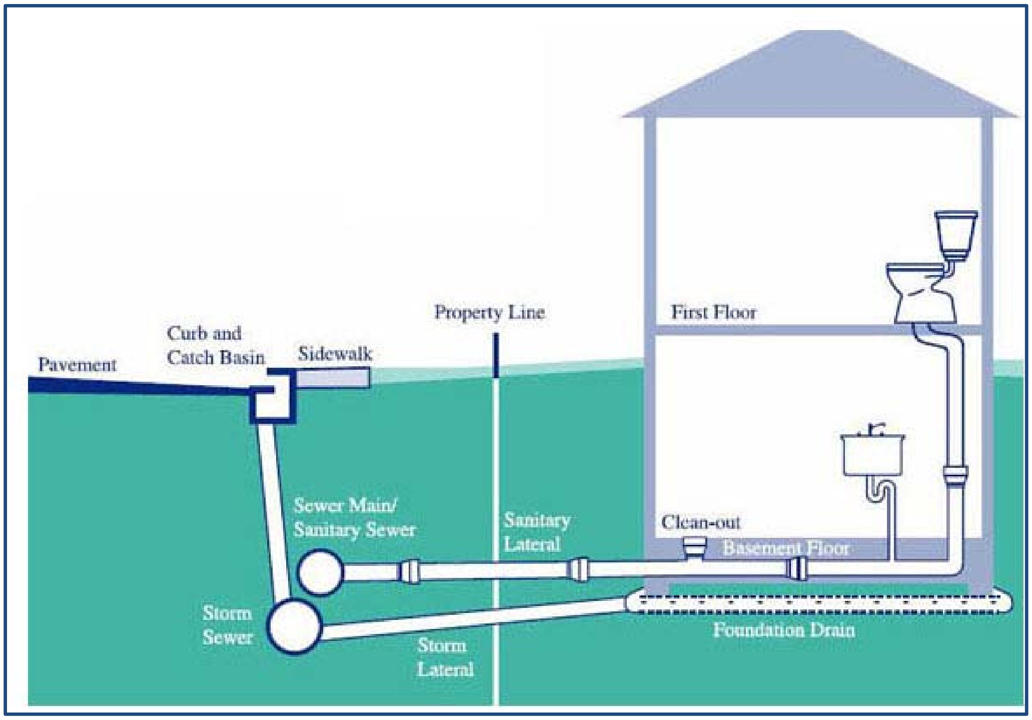


Figure 4: Sump Pump to Front/Rear Yards or Storm Sewer

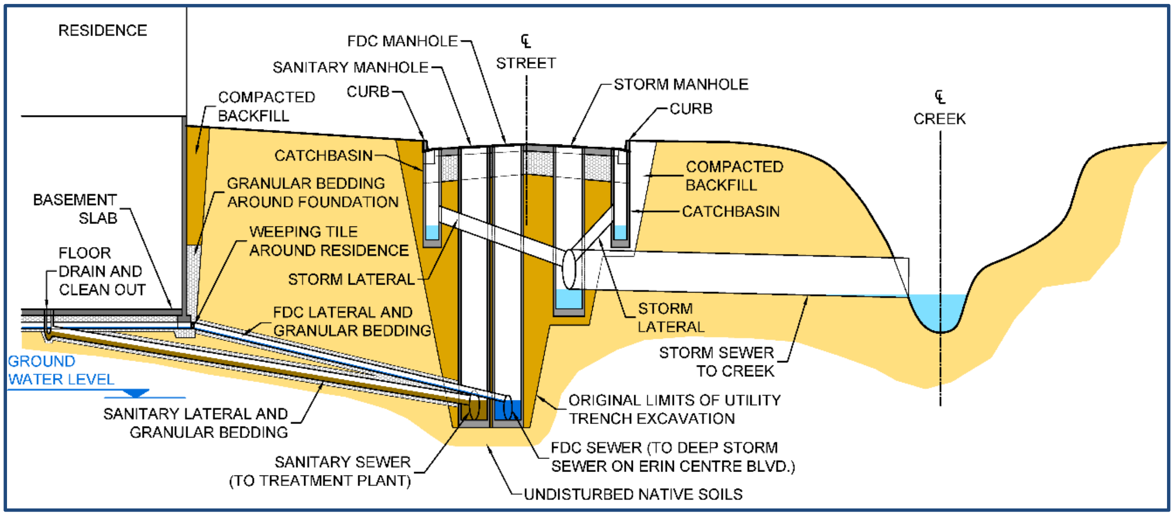
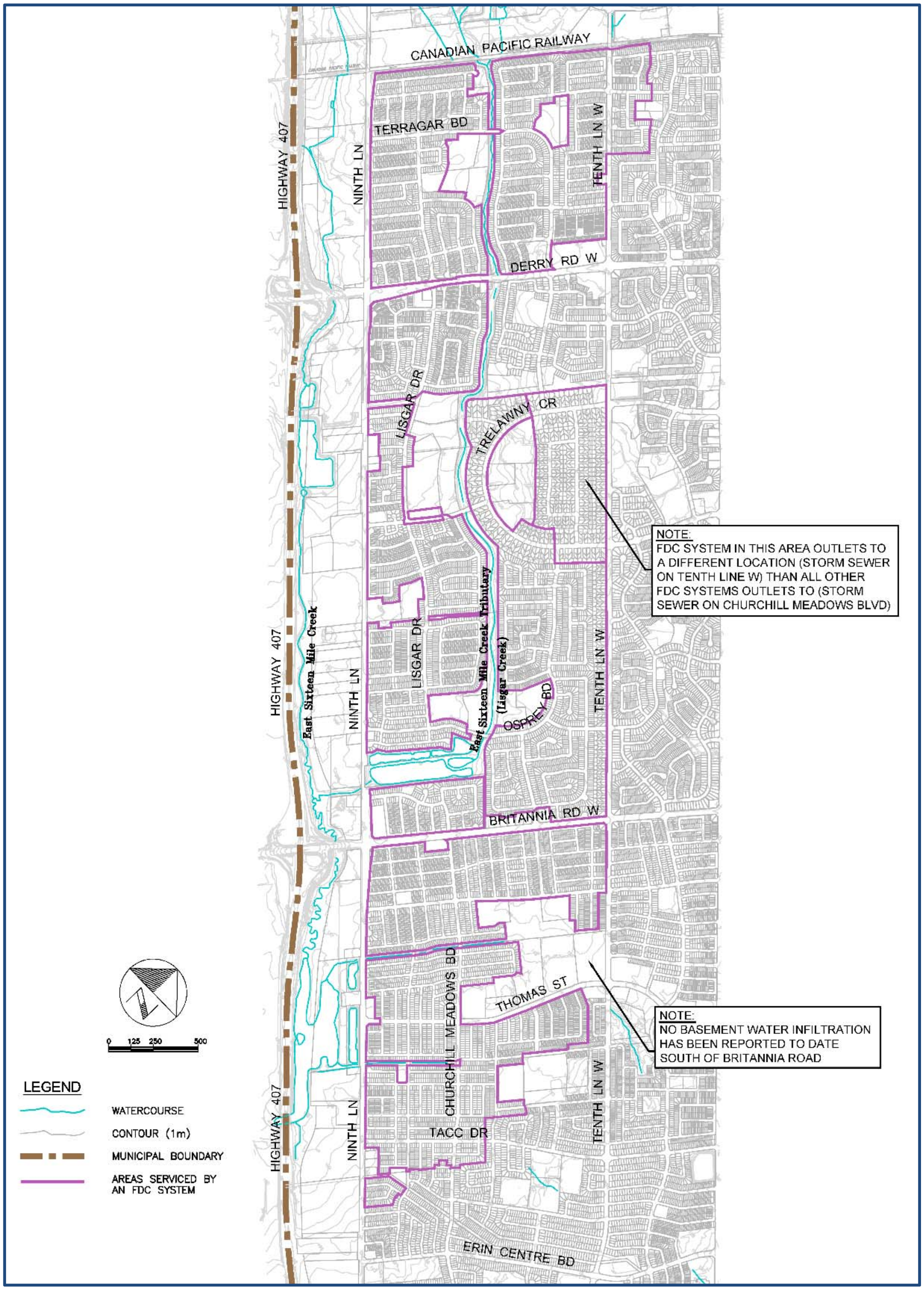


Figure 5: Foundation Drain Collector as Found in the Lisgar District

The following table provides a brief summary of the advantages and disadvantages of these three distinct foundation drainage systems.

Type	Advantages	Disadvantage
Gravity to Storm Sewer	• no additional infrastructure • comparatively low cost • no reliance on mechanical system or power	• may back up if storm sewer is overwhelmed • some additional cost to upsize storm sewers
Sump Pump	• disconnected from municipal system	• requires homeowner to operate and maintain the system • mechanical system needs to operate to function • relies on power
Foundation Drain Collector	• dedicated, providing drainage for foundation only • no reliance on mechanical system or power • “virtually eliminates the probability of back-ups into foundation drains” • allows for smaller sized storm sewers • successfully installed in numerous other municipalities without incident (Brampton, Vaughan, Barrie)	• comparatively high cost to install additional deep and long pipe systems

It should be noted that the technical term ‘surcharge’ is often used in this report when referring to the flow conditions of sewers. This term refers to a gravity sewer that is overloaded beyond its pipe full flow capacity such that the flow is under pressure.



NOTE:
FDC SYSTEM IN THIS AREA OUTLETS TO A DIFFERENT LOCATION (STORM SEWER ON TENTH LINE W) THAN ALL OTHER FDC SYSTEMS OUTLETS TO (STORM SEWER ON CHURCHILL MEADOWS BLVD)

NOTE:
NO BASEMENT WATER INFILTRATION HAS BEEN REPORTED TO DATE SOUTH OF BRITANNIA ROAD

Figure 6: Servicing Limits of FDC System in Mississauga

3.0 CITY-LED ACTIVITIES

When the City of Mississauga first became aware of basement water seepage, the causes of this unexpected problem were not known. However, the City proactively undertook a number of precautionary, investigative and maintenance actions on the storm and FDC sewer systems, the tributary of the East Branch of Sixteen Mile Creek, and the Osprey Marsh Stormwater Management Pond. The following summarizes the work completed by the City in the Lisgar District.

FDC and Storm Sewers

Video Inspection and Flushing of FDC and Storm Sewer Systems

Video inspections of the FDC system and a large portion of the storm sewer system were carried out to identify any potential cracks and leaks (FDC system), as well as debris or obstructions (both systems). Only a few cracks and leaks were detected. Most of them have subsequently been repaired by the City. No significant blockages or debris were observed in either system.

Despite the lack of any significant debris or blockages in the storm and FDC systems, as a further precautionary measure, the FDC system and a portion of the storm sewer system were flushed to clean-out any minor debris accumulations.

Identifying Sewer Cross-connections

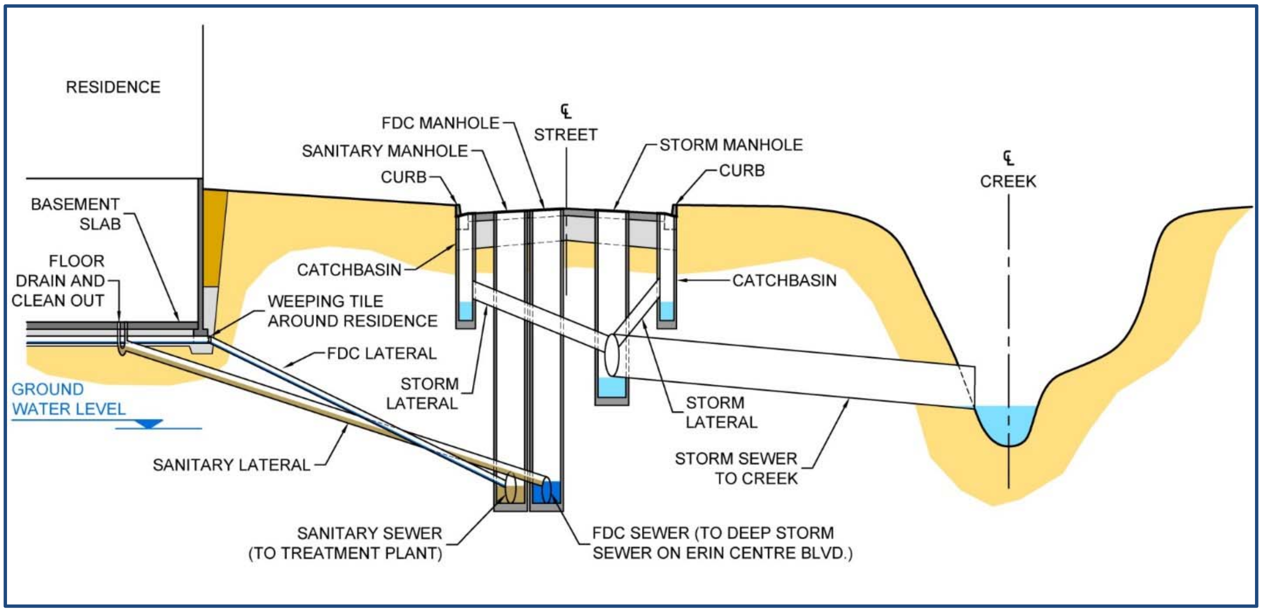


Figure 7: Schematic of Sewer Cross-Connection

The City used investigative techniques (video inspections and dye and smoke tests) to identify homes where cross-connections were suspected; specifically where a residential foundation drain is connected to the sanitary sewer system and the residential sanitary lead is connected to the FDC. Such an occurrence would be expected to increase flows to the FDC sewer system.

The investigation identified two cross-connections. Both have since been repaired.

Sealing FDC Maintenance Access Lids and Cracks

The lids of maintenance access chambers (commonly called “manholes”) to the FDC system were identified as being a potential source of surface water inflow to the FDC system. The City installed maintenance access lid seals to prevent this surface water from entering the FDC system in vulnerable locations; primarily where the FDC sewer is situated adjacent to the tributary of the east branch of Sixteen Mile Creek, and at low points along the roadway where water would be expected to pond during large storm events.

Cracks and leaks in the FDC system, as identified through the video inspection, have also been repaired as noted previously.

Cleaning Storm Sewer Outfalls to Creek

City staff conducted an inspection of the storm sewer outlets to the tributary of the east branch of Sixteen Mile Creek, and identified those where removal of accumulated sediment would benefit the proper operation of the storm sewer system. A total of ten storm sewer outfalls along the tributary between Doug Leavens Boulevard and Osprey Boulevard were subsequently cleaned-out.

Where conditions warranted, the outfalls were also lined with large stones to reduce erosion and ease future clean-out efforts.

Improvements to Overland Flow Routes

In response to reported roadway flooding during the large storm events in 2010 and 2011, grading improvements were undertaken at three locations along Black Walnut Trail (Cactus Gate, Smoke Tree Road, and Scotch Pine Gate) to better define the pathway for surface water to flow to the creek and reduce the potential depth of roadway ponding in these areas.

High Water Protocol

Since late 2011, the City has implemented a High Water Protocol for the Lisgar District. Under this protocol, weather forecasts and other weather-related information such as High Water Bulletins from local Conservation Authorities are continuously monitored by City staff. When unfavorable weather conditions are predicted, City staff and/or its contractors are deployed to three locations within the Lisgar District with portable pumps on standby to pump water from the FDC system if required.

Since this protocol was put into effect, City staff and/or its contractors have operated the pumps on several occasions, including April 10-12, 2013, June 11-12, 2014, and September 10, 2014. No basement water infiltration problems were reported during any of these events.

East Sixteen Mile Creek Tributary and Osprey Marsh Stormwater Management Pond

Creek Vegetation Trimming and Debris Removal

In response to concerns raised by residents, considerable effort and expense was spent by the City to trim the vegetation along the creek corridor between the Canadian Pacific Railway tracks and Doug Leavens Boulevard over the course of 2012. It should be noted that this is not a typical practice for the maintenance and stewardship of a naturalized creek corridor system. The trimmed vegetation re-grew very quickly and has subsequently re-established itself. Further trimming was not undertaken given the findings of this study.

Sediment and Vegetation Removal from Bridge Crossings and Storm Outfalls

Inspections of the bridge crossings and storm outfalls along the tributary of the east branch of Sixteen Mile Creek identified certain areas of sediment and vegetation accumulation. Although the potential impact of this in relation to the basement water infiltration issue was unclear at the time, accumulated sediment, vegetation and other debris were removed from several storm outfalls and beneath the bridges at Osprey Boulevard, Alderwood Trail, and Doug Leavens Boulevards in 2013.

Creek Inspection Protocol

A protocol for a more frequent regular inspection of the tributary of the east branch of Sixteen Mile Creek and bridge crossings was developed to proactively monitor and identify issues such as excessive sediment or debris in the creek which may impede its ability to safely convey water.

Reconfiguration of Osprey Marsh Stormwater Management Pond Outlet

Prior to this study, the City had an approved capital project planned to remove and reconfigure the outlet structures of the Osprey Marsh Stormwater Management Pond. These structures were not allowing the water in the pond to draw down in a timely manner resulting in a higher than normal pond water elevation for an extended period of time. In light of the basement water infiltration concerns, the City proactively cleaned out the accumulated sediment and vegetation around two of the pond outlet structures in late 2011/early 2012 to improve the drainage function of the pond. This was done in advance of the capital project undertaken in 2012 to reconstruct the entire outlet configuration of the pond.

4.0 SUMMARY OF POTENTIAL CAUSES

A main objective of this study was to identify and assess the potential causes of basement water infiltration in the Lisgar District in light of the fact that homes in this area have not had any known issues prior to 2008; more than 20 years since development of the area began. This section discusses a number of these possible causes with more detailed analyses and discussions to follow in subsequent sections.

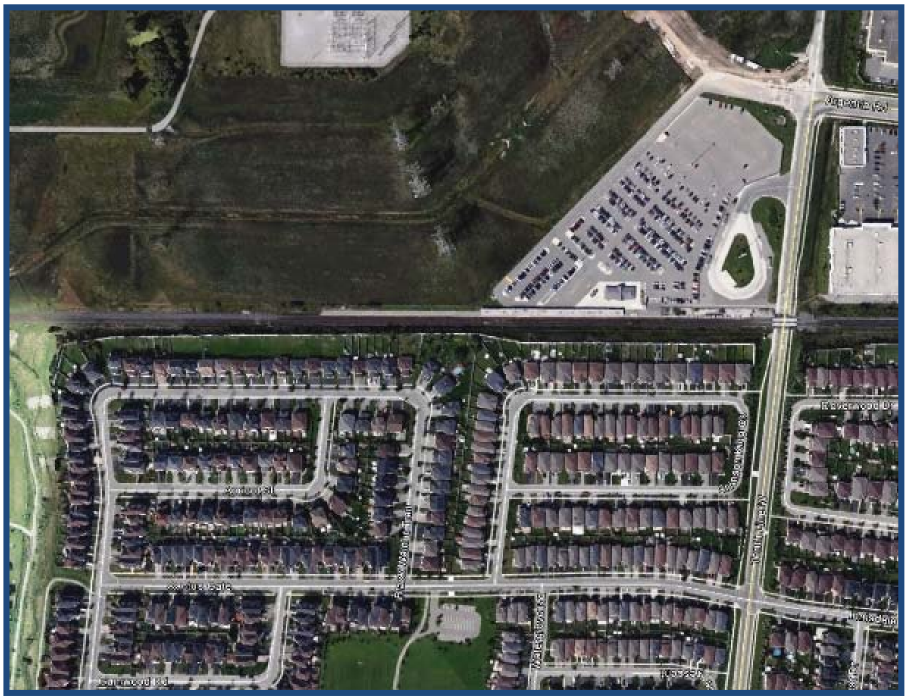
Changes Since Development

One of the initial steps undertaken in this study was to determine what changes could have possibly taken place since the development of the Lisgar District and how these changes may have contributed to basement water infiltration. A list was compiled in consultation with City staff and each possible change was screened based on engineering judgment for further consideration. The possible changes are discussed as follows:

Climate

Most experts agree that weather patterns are changing and extreme weather events are becoming more frequent and more intense. However, rainstorms more severe than those experienced during the basement water infiltration events have occurred over the Lisgar District without any known occurrences of water seepage in basements. While rainfall plays a role with respect to the infiltration events, it is not the more frequent and intense storms that seem to be causing the problem, as will be discussed later in this report. As such, intense storms due to a changing climate were ruled out as a contributing factor to the basement water infiltration issue.

Development



The Lisgar District has been more or less fully developed since the mid-2000s, with a small number of in-fill developments occurring over the past few years. The only significant development in the area was the Lisgar GO Station which was constructed to the north of the Lisgar District around 2007. Further investigation was undertaken to determine if the development of the Lisgar GO Station contributed to the basement water infiltration issue and is discussed later in this report.

__Creek block maturing with vegetation__

As the vegetation along the tributary of the east branch of Sixteen Mile Creek has matured over time, the carrying capacity of this channel, which local storm sewers drain into, has reduced somewhat. This vegetation also traps sediment causing a further loss in capacity, and thereby reduces the efficiency of the tributary to move water. However, the FDC system that conveys water from the foundations of basements does not outlet into this tributary. Nevertheless, investigations were carried out to determine if there are other ways that the tributary may potentially contribute to the basement water infiltration issue.

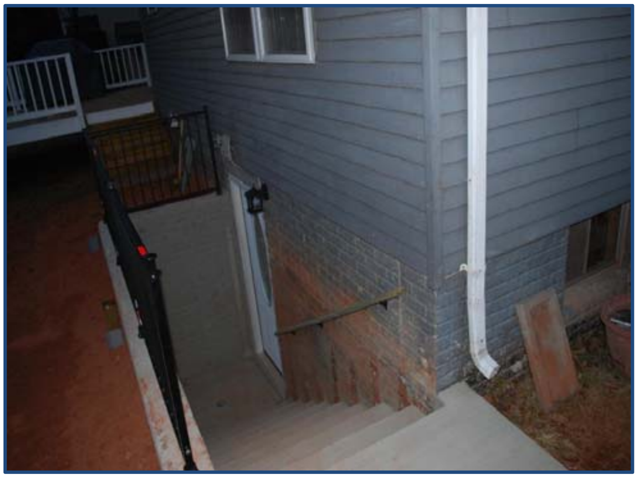
Osprey Marsh Stormwater Management Pond

The Osprey Marsh Stormwater Management Pond has been seen by some residents as a barrier to water conveyance from the tributary of the east branch of Sixteen Mile Creek. However, the pond serves the dual purpose of providing water quality treatment and quantity control for the upstream development lands.

As previously mentioned, the City had a planned and approved capital project to remove and reconfigure the outlet structures of the Osprey Marsh Stormwater Management Pond, prior to the City becoming aware of the scale of water seepage in basements of homes. As a proactive measure, two outlet structures in the pond, which had accumulated sediment and vegetation resulting in a higher than normal water level (1 m +/-), were cleaned out to improve drainage from the pond. The City has since completed the capital project to reconfigure the outlet of the pond, further reducing the drawdown time of the pond following large rainfall events.

It should be noted that the FDC system that conveys water from the foundations of basements does not outlet into this pond. However, further investigation was carried out to determine if other connections exist between the pond and the basement water infiltration issue.

Changes to homes/properties (lot grades, basement walkouts)



Over time, lot grades may change due to the settlement of soils or through physical alterations by homeowners. Depending on this change, the grades on a property may allow water runoff to flow back towards the house, instead of away, thereby increasing the amount of water which may drain to the foundation. However, there is insufficient information to predict with any certainty the level of influence altered grades may have on the basement water infiltration issue.

There are also a significant number of homes in the Lisgar District in which basement walkouts have been built. Rain water and runoff from the lot or roof which flows into a basement walkout can contribute directly to the FDC system since this water may be collected by a drain connected to the home's weeping tiles. While the lack of available information has made it difficult to determine if basement walkouts have contributed to basement water infiltration, further analysis was undertaken based on assumptions regarding the level of influence basement walkouts may be having on the operation of the FDC system.

Aging basement walls and foundations

Concrete foundations are not resistant to cracks. Cracks in a foundation wall can be caused by a number of factors such as concrete shrinkage, aging, settlement into the soil or poor drainage around the house. These cracks provide the opportunity for water to seep into the basement from the exterior. While cracks in foundations are not uncommon, it is challenging to obtain data to determine the level of influence this may have on basement water infiltration given that foundations are located on private property. As such, this possible cause was not analyzed further.

Aging Infrastructure

Like all infrastructure, stormwater related infrastructure gradually ages over time and its concrete components, such as pipes and manholes, typically have a service life of approximately 100 years. While the municipal services in the Lisgar District are comparatively young (less than 35 years), leakage from the storm sewer, which is a normal occurrence, can occur due to:

- cracks in manholes
- displaced/settled sewers
- seals and sewer joints breaking down

As storm sewers are not built to remain watertight, leakage from the system is considered normal. However, in locations where a 3-pipe system is used, opportunities may arise where water, which has leaked from storm sewers, may enter into the FDC system. Additional investigative work was carried out with respect to the issue of storm sewer leakage.

Other Potential Causes

In addition to examining changes that may have taken place since the development of the Lisgar District, other potential causes were also considered, as follows:

Groundwater

Groundwater can be a potential cause of water seepage into basements; however a review of groundwater levels in the area and the properties of the native soils suggest that water moves very slowly in this mainly clay/silt-based soil. This information formed the basis for a number of subsequent tests and analyses on the causes of basement water infiltration which are discussed later.

Foundation Drain Collector

As set out earlier in this report, the FDC system is a sewer system dedicated to only collect and drain water from weeping tiles of homes to an outlet by gravity flow. Issues related to the proper construction and operation of this system may affect the way water around the foundations of homes is conveyed away from the house. Significant efforts were dedicated to the review and analysis of this system. The information below highlights how design and construction issues may affect the proper operation of this system.

a. Maintenance

Since the FDC system is essentially a closed system connected only to foundation weeping tiles, it would be expected only to collect clean filtered foundation drainage and that maintenance needs would be nominal.

b. Design

Design criteria for FDC systems are not as well defined as for other infrastructure such as storm or sanitary sewers; hence values from designers are more difficult to verify based on conventional engineering principles. It should be noted, however, that the design of the Lisgar FDC system was based on the best engineering knowledge at the time.

c. Hydraulics

The capacity of the FDC pipe to carry flow is based on, among other factors, the proper size (diameter) and slope of the pipe for gravity drainage. If the FDC pipe is found to have capacity issues, it may surcharge (exceed capacity and flow under pressure), thereby placing those locations served by that FDC pipe at risk.

d. Outlet

The FDC sewer system ultimately outlets into a downstream storm sewer system at Erin Centre Boulevard. If the capacity of this storm sewer system was to be exceeded under large storm events, this could potentially affect the operation of the FDC system.

e. Depths

Locations with shallower FDC depths in relation to adjacent residential weeping tile systems may be at higher risk of basement water infiltration.

f. Inflow/Infiltration

Some FDC joints at manholes and other locations (cracks) have been shown, based on video camera inspections, to allow water to get into the FDC system. They were comparatively minor and most of them have subsequently been repaired by the City.

g. Construction

Similar to FDC hydraulics, if sections of the FDC system were not constructed in accordance with the specified design, this would be expected to have an impact on FDC conveyance capacity. The potential also exists for the FDC pipes and the utility trench, in which the sewers reside, to have been poorly constructed in a manner which would allow water to directly enter the FDC system. Unfortunately, this is difficult to determine without wide-scale, disruptive excavation. However, video camera inspections suggest that the occurrence of this is low.

Sanitary System

The water that seeped into the affected basements was found to be essentially clear, largely odourless and unlikely to contain sanitary sewage. These findings have been supported based on data collected by the Region of Peel which showed that the sanitary system did not experience any capacity issues. As such, it was determined early on in the study that the sanitary system did not contribute to the basement water infiltration problem.

Private Side of Weeper System (cross-connections and Weeping Tile System condition)

As discussed earlier, extensive testing identified only two cross-connections between the FDC and sanitary sewer systems, which have since been repaired. As there were so few cross-connections discovered, this potential cause has been ruled out as having any influence on the basement water infiltration problem.

The condition of the private side weeping tile system has also been considered as a potential source of the problem as some granular material was found in the FDC sewer through video inspection suggesting some possible localized failures. However, this is very difficult to validate without wide-scale and disruptive excavation around private homes.

Stormwater Leakage to Utility Trench

Storm sewer systems, which capture and convey surface water, are not designed to be water-tight. It is not uncommon or unexpected for storm sewers to leak. However, leakage of stormwater can be substantial and relatively continuous which can potentially fill the lower utility trench with water where the FDC and laterals reside. Investigation into this issue in relation to basement water infiltration was undertaken as part of this study.

5.0 STUDY ACTIVITIES

Amec Foster Wheeler has conducted an extensive program of activities in support of the Lisgar District Basement Water Infiltration Investigation. These activities, which included extensive field monitoring, testing, and analysis, have been undertaken to better understand the existing performance of the various drainage systems and their inter-relationships. These activities have also been conducted to either validate or rule out the possible causes of the observed basement water infiltration as discussed in the previous sections.

Field monitoring is heavily dependent on weather conditions and rainfall. Without the reoccurrence of weather conditions experienced during the basement infiltration events, it is difficult to fully assess how the drainage system responded during those events, and understand the likely primary causes of basement water infiltration. Accordingly, monitoring work has extended over multiple years in order to collect enough representative field data.

In addition, it should be recognized that the interactions between the various components of the drainage system in the Lisgar District have proven to be extremely complex and varied. In order to undertake a complete and thorough investigation, a review of all potential causes of basement water infiltration was required. As field monitoring data were collected and analyzed through the course of the study, Amec Foster Wheeler was able to eliminate some potential causes, and focus on others. As the potential causes were narrowed, additional field work, testing and analysis activities were carried out to clearly prove or disprove theories. This iterative process was lengthy and required a significant amount of time, necessitating multiple years of activities. This process has ensured that a complete and thorough investigation has been undertaken and that appropriate mitigation measures are recommended to reduce the risk of future instances of basement water infiltration.

The study activities completed by Amec Foster Wheeler are summarized as follows:

Monitoring Work

During the course of the study, a comprehensive monitoring program was undertaken over multiple years to collect field data needed to help understand the cause(s) of basement water infiltration and to provide guidance in finding the appropriate mitigation measures. The monitoring work undertaken is described as follows.

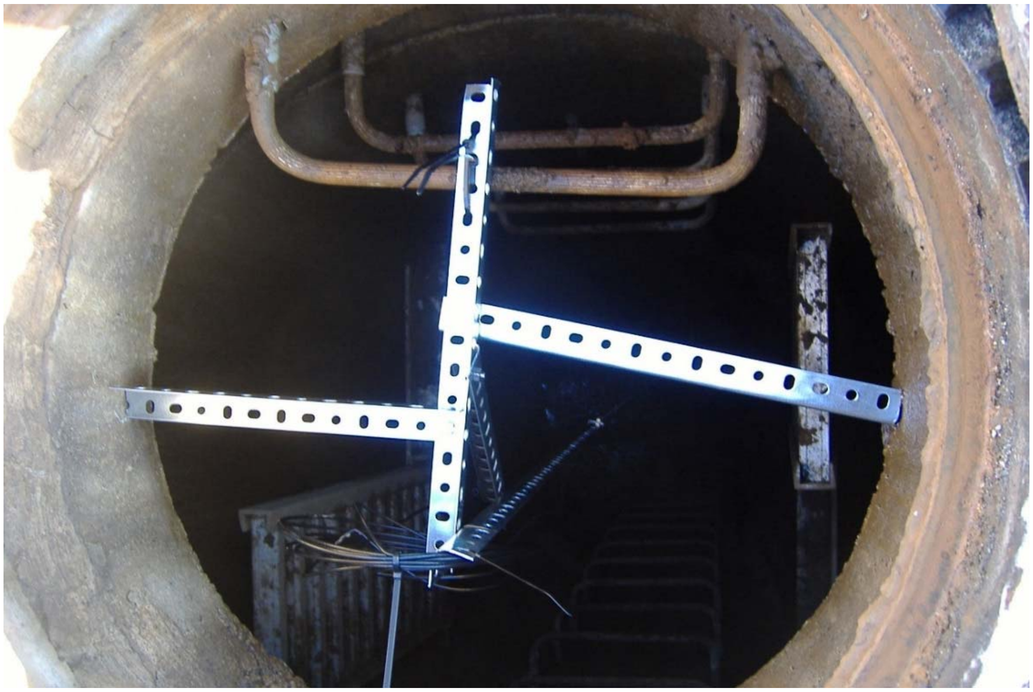
A. Groundwater

- Monitoring wells were installed at four main sites:
    - Black Walnut Trail at Scotch Pine Gate (late 2011);
    - Osprey Boulevard (late 2011);
    - Alderwood Trail (2013); and
    - Pondview Way (2014).
- Two primary types of monitoring wells were installed:
    - In the native (undisturbed) soils; and
    - In the gravel material found in the utility trench.
- Both water level and water temperature were monitored continuously at these sites.

Findings

1. Groundwater temperatures in the native soils do not vary greatly and are not affected by precipitation events.
2. The shallow groundwater levels in the native soils do not increase rapidly enough during precipitation events which proves that basement water infiltration is not caused by flow through the native soils from the Tributary to the East Branch of Sixteen Mile Creek or the Osprey Marsh Stormwater Management Pond.

B. FDC and Storm Sewer System



- Water level monitoring gauges were installed within the FDC and storm sewer systems in order to observe how water levels in these systems respond to storm events;
- The gauges also recorded water temperature, which is a useful parameter as it can distinguish between sources of water; and
- The number and locations of gauges were adjusted over the course of the study to the most suitable sites through interpretation of the collected data:
    - A total of 17 water level monitoring gauges were installed within the FDC sewer system; extending from the Canadian Pacific Railway tracks to Erin Centre Boulevard; and
    - Three additional water level monitoring gauges were installed over the course of the study within the storm sewer system.

Findings

Recorded data from these gauges have shown that:

1. The FDC system has been observed to surcharge rapidly in response to rainfall events (water levels exceed the top of the pipes meaning that the system is flowing under pressure); this surcharging occurs in different locations and in different amounts depending on the storm event.

2. Surcharging is most common along Black Walnut Trail and in the vicinity of Osprey Boulevard, which is generally consistent with locations of reported basement water infiltration.

3. The short period of time in which the water level in the FDC system has been observed to surcharge and then quickly drop back down strongly suggests that the water is coming in from surface water sources rather than groundwater, which moves much more slowly due to the properties of the native soils.

4. The water temperature data from the observed surcharge events also suggest that the water is coming from surface water sources (rise in water temperature over the summer months - warm surfaces, or a drop in water temperature over the early spring/fall/winter months – cold surfaces).

5. Water levels in the storm sewer along Erin Centre Boulevard, which takes drainage from the FDC system, show that it is not the cause of FDC surcharging.

C. Tributary and Stormwater Management Pond

- Water level monitoring gauges were installed and monitored at key locations along the tributary of the east branch of Sixteen Mile Creek and within the Osprey Marsh Stormwater Management Pond during non-winter periods (April to November);

- The number and locations of gauges were adjusted over the course of the study to the most suitable sites through interpretation of the collected data:
  - Gauges were installed at five different locations along the creek, as well as a gauge directly within the pond; and
  - A temporary rainfall gauge was installed for two of the monitoring years.

Findings

Recorded data from these gauges have shown that:

1. There is nominal creek flow from the GO Station channel, and no apparent connection between these flows and FDC surcharging.

2. There is no apparent connection between creek flows and FDC surcharging.

3. There is no apparent connection between water levels within the Osprey Marsh Stormwater Management Pond and FDC surcharging.

Testing Work

To better understand the interactions between the various water sources and components of the drainage system in the Lisgar District, testing work was undertaken through water sampling and 'in-ground' pilot projects to validate some of the theories. The testing work undertaken is described in the following:

A. Water Quality Characterization

- A characterization program was completed to assess the chemical properties of the water found in:
  - native soils (i.e. the groundwater);
  - utility trench (i.e. where the municipal services are);
  - creek;
  - Osprey Marsh Stormwater Management Pond; and
  - FDC system.
- The testing was able to identify commonalities among the various different water sources, and in particular the source of the water in the FDC.

Findings

1. Under expected operating conditions the quality of the water in the FDC system should show some similarities with the shallow groundwater. However, water in the FDC system water was found to be salt rich, similar to the utility trench, the tributary and the pond. This suggests that the water in the FDC system is very similar to surface water (and dissimilar to groundwater). This similarity is particularly evident in winter conditions when surface water was found to contain elevated salt concentrations from the application of road salt.

B. Storm Sewer Leakage Testing

- Storm sewer leakage testing was undertaken in 2013 at three sites where basement water infiltration occurred (Alderwood Trail and Black Walnut Trail at both Wild Cherry Lane and Scotch Pine Gate). The photos above illustrate some of the steps in the leakage testing process;
- The intent of the tests was to confirm whether or not, under high flows, the storm sewer system would be expected to leak and contribute water to the utility trench where the FDC system resides; and
- The tests were comprised of:
  - Blocking the storm sewers and filling them with water to replicate surcharge conditions (under pressure);
  - Addition of a green fluorescent dye to the storm sewer; and
  - Monitoring of the dye concentrations and water levels in the utility trench, groundwater and FDC system.

Findings

1. At all three sites, the storm sewers leaked and at two sites (Wild Cherry Lane and Scotch Pine Gate), the dye was detected in the FDC after two hours.
2. Tests have proven that there is a flow path from the storm sewer to the FDC through the utility trench with a response time consistent with that observed between major storm events and instances of basement water infiltration.

C. Storm Sewer Outfall Collar Testing

- Over the course of the study, it was speculated that water from the tributary of the east branch of Sixteen Mile Creek or the Osprey Marsh Stormwater Management Pond could possibly move upstream through the storm sewer bedding and contribute excess water to the utility trench;

- In order to verify if water in the utility trench was coming from the tributary or the Osprey Marsh SWM pond, a test was conducted at the end of 2014;

- Impermeable concrete collars were installed in the utility trench near the outfall of the storm sewers at two locations:
  - Sixteen Mile Creek (Scotch Pine Gate); and
  - Osprey Marsh SWM Pond (Pondview Way).

- These collars were installed with backflow valves that allow water from the utility trench to drain to the tributary and pond, but not in the other direction; and

- Monitoring is currently underway at both of these sites to assess the effectiveness of the collar in preventing elevated water levels in the utility trench which may be due to inflow from the creek or pond during larger storm events.

Analysis Work

Using the data collected over the monitoring periods, as well as additional information provided by the City on the FDC system and area services, Amec Foster Wheeler conducted a series of technical analyses as follows:

A. Groundwater analysis

Testing work and analyses were undertaken for both the native soils and granular materials (utility trench) at the groundwater monitoring sites.

Findings

1. Tests have shown that the permeability of the granular materials in the utility trench is up to 10 million times greater than the native soils. This has further confirmed that the utility trench is the primary linkage for surface water to reach the FDC system.

B. Design check of the FDC system

A review of the original design of the main FDC sewer system was undertaken. This analysis is described in greater detail as follows:

a. Comparison of the original number of intended residences to be served by the main FDC sewer system:

    - This analysis has shown that a larger number of residences are currently connected to the FDC system than what was intended in the original design; and
    - This was known by both the area developers and the City as the area was developed; a developer's consultant undertook a numerical analysis of the main FDC sewer using computer modelling to demonstrate that the system could accept the higher number of connected residences.

b. Comparison of original design sizes and slopes of the FDC sewers (which affect capacity – higher slopes provide more flow capacity, lower slopes less capacity) with as-constructed (current) characteristics:

    - This review has shown that some sections of the FDC trunk sewer were constructed flatter than intended, which is expected to decrease the available flow capacity.

c. Verification of the design of the FDC trunk sewer, to determine if there is sufficient available capacity to handle expected flow rates, using the original design approach, and current information on the FDC system (sizes and slopes) including the current number of residences serviced by this system:

    - The results of this analysis have shown that there are several sections of the FDC trunk sewer where the expected flow rates exceed the design capacity and would be expected to surcharge the FDC system in localized areas.

Findings

1. The results of these analyses have since identified deficiencies in the as-constructed design of the FDC trunk sewer system, which may contribute to FDC surcharge within localized areas of the overall system. However, given the results of the FDC monitoring,

these deficiencies are not considered to be a material contributor to FDC surcharging or a cause of the basement infiltration issue.

2. Observed FDC surcharging has also been noted in areas which are a considerable distance away from where FDC sewer deficiencies have been identified, which further suggests that these deficiencies, in and of themselves, are not a material contributor to the FDC surcharging or a cause of the basement infiltration issue.

C. Computer modelling of the FDC system

Computer modelling of the FDC system was undertaken in an effort to answer a number of questions related to its performance, and the impact of some of the potential causes. The performance questions and modelling results are provided in the following table.

Questions	**Modelling Results**
How much impact will high water levels at the downstream end of the FDC system (outlet) have on the Lisgar District?	Results show that high water levels downstream would have little impact on the FDC system performance within the Lisgar District, which further confirms that this is not a primary cause of FDC surcharging, although it may be a very limited contributing factor.
How much potential impact would water draining into basement walkouts be expected to have on the FDC system?	Results show that based on the number of basement walkouts identified by City staff (and the estimated flows from those walkouts to the foundation drain), basement walkouts are not the primary cause of FDC surcharging, although they may be a contributing factor at specific locations.
How much potential impact would storm sewer leakage have on the FDC system?	Results show that based on an average storm sewer leakage rate (calculated from the findings of the storm sewer leakage tests conducted in 2013), storm sewer leakage is the primary cause of FDC surcharging during storm events.
Are there certain areas within the Lisgar District which contribute higher flows to the FDC system?	Based on the modelling results for an observed surcharge event in the FDC system along Black Walnut Trail, north of Derry Road, several areas have been identified as having higher relative flow contributions to the FDC system. These identified areas are therefore considered a priority for the implementation of mitigation measures (ref. Section 6).
What measures would be most effective in reducing observed FDC surcharge?	Based on the modelling results for an observed surcharge event, two potential mitigation measures have been modelled and shown to be most effective at reducing FDC surcharge: • FDC sewer upgrades - increasing the sizes of the deficient pipes to better carry higher flows and reduce surcharge; and • FDC pumping - actively pumping out the FDC during surcharge events to limit the amount of surcharging. Both of these measures have been considered as part of the longer term mitigation action plan (Section 6).

Summary and Conclusions

Based on all of the comprehensive monitoring, testing and analysis work, Amec Foster Wheeler has concluded that the primary cause of the basement water infiltration relates to stormwater entering the utility trench.

As storm sewers are not built to be watertight, and due to cracks and leaks expected through aging, stormwater is able to leak out during storm events and migrate into the utility trench, where the bedding material, made of gravel and other granular soils can allow water to move very quickly. Over time, water builds up in the utility trench from storm sewer leakage, as well as through other sources (other utilities, groundwater, et cetera), and is unable to drain away quickly due to the relatively impermeable nature of the native soils surrounding the trench.

It is this situation, in combination with certain storm conditions and local lot drainage where issues may arise. For instance, where the ground and utility trench are already wet, possibly from an earlier storm event, and rainfall subsequently occurs, this may create a condition where there is enough leakage from the storm sewer system during the rainfall event to fill an already wet utility trench and push water up the bedding material around the FDC laterals servicing the homes and into the foundation weeping tiles. This water then drains directly into the FDC pipes through the weeping tiles, which may result in excess flow in the FDC system (surcharge). However, this condition by itself may not lead to basement water seepage. It is this condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage that may lead to water around the weeping tiles being unable to drain and potentially seeping into the basements of homes. This process is illustrated in Figures 8A to 8F.

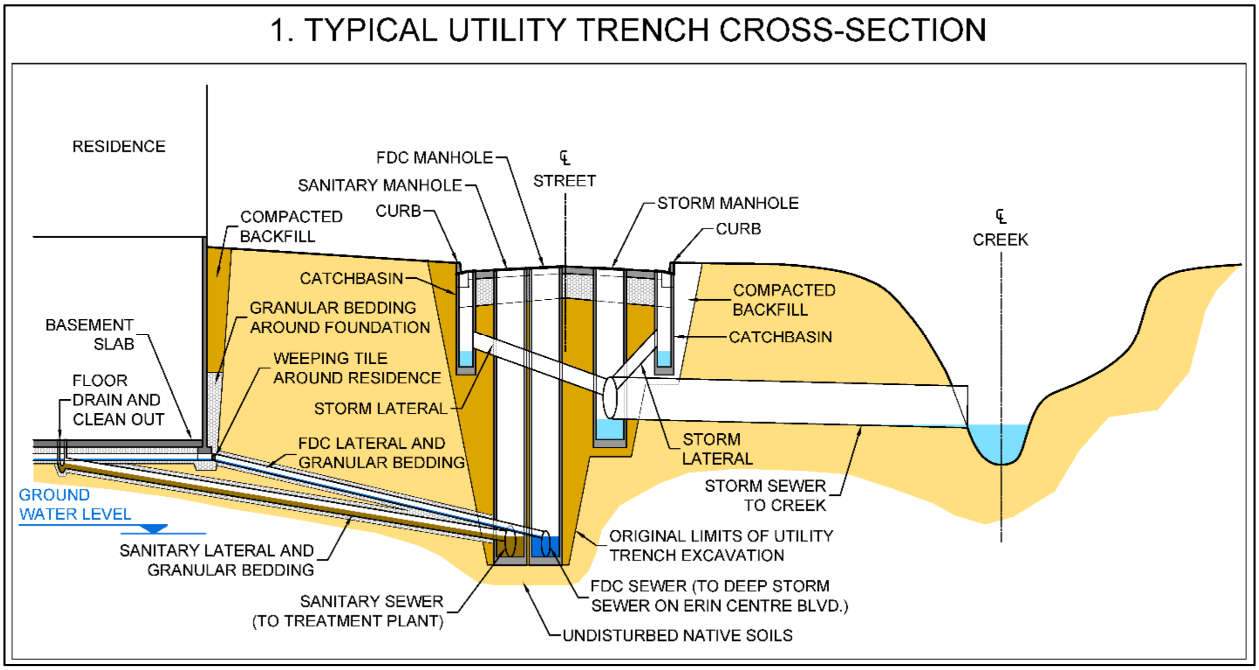


Figure 8A: Basement Infiltration due to water within the Utility Trench

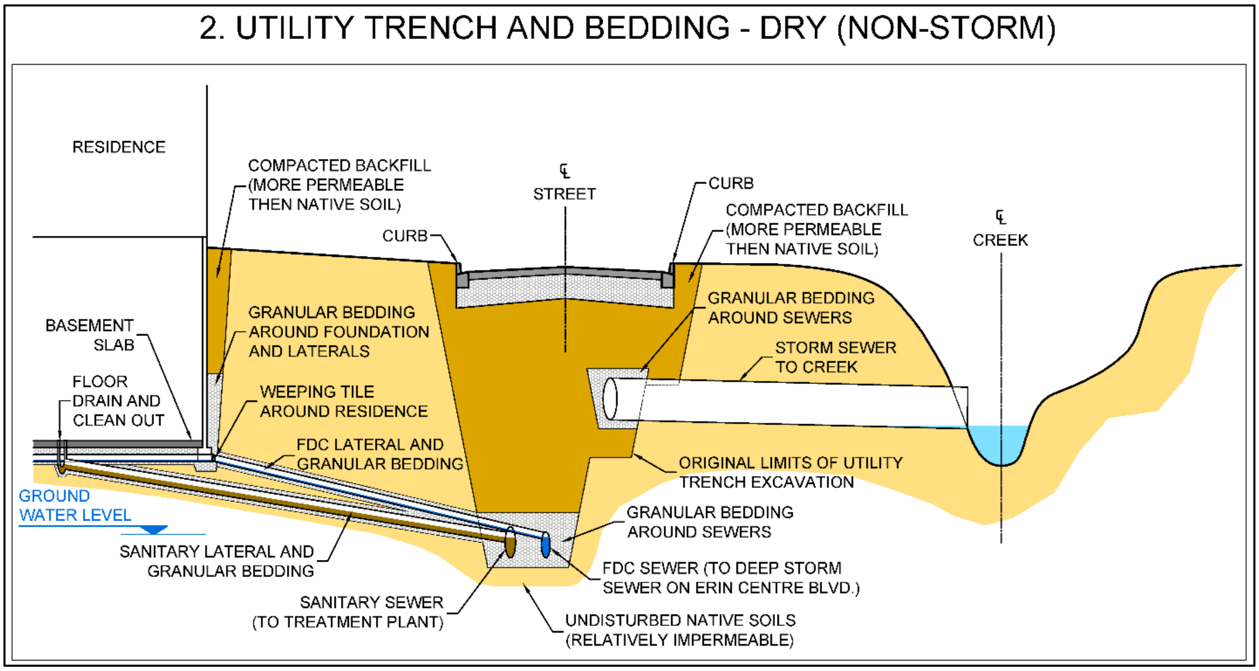


Figure 8B: Basement Infiltration due to water within the Utility Trench

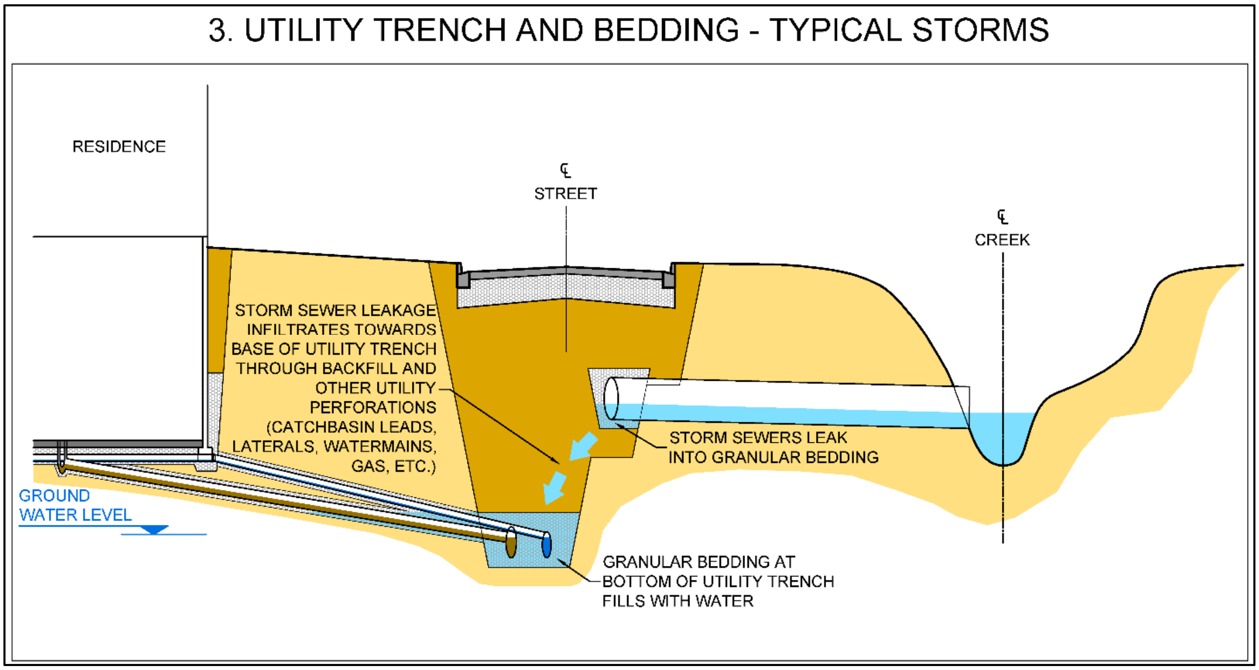


Figure 8C: Basement Infiltration due to water within the Utility Trench

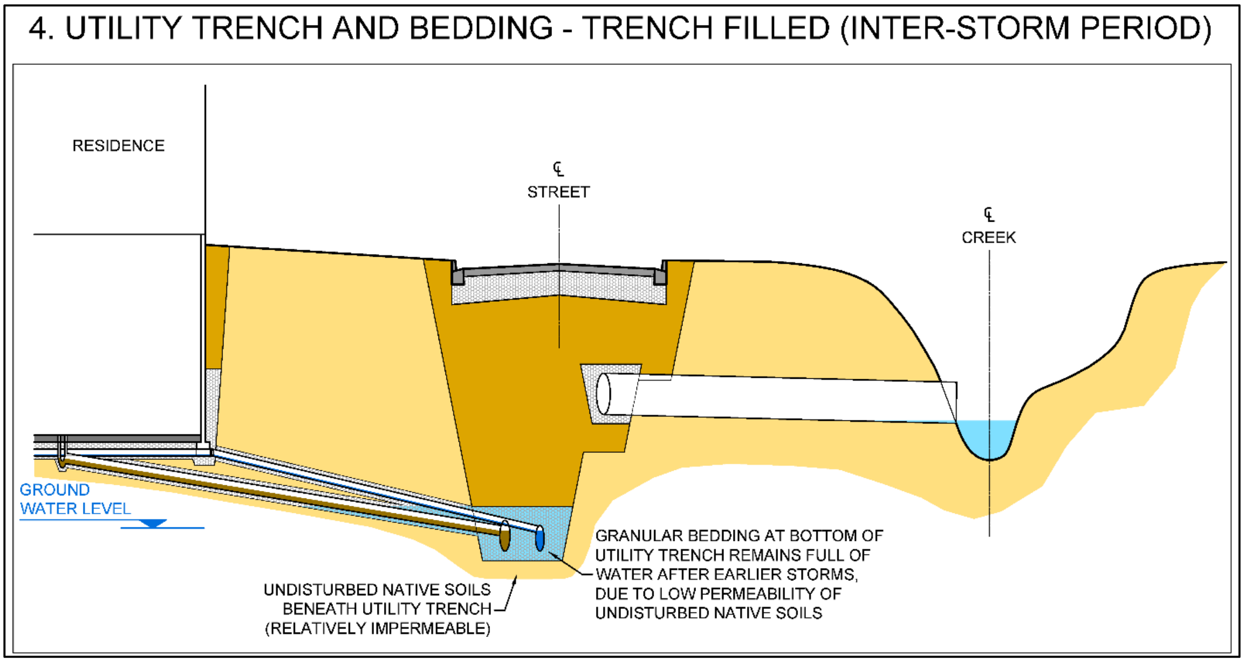


Figure 8D: Basement Infiltration due to water within the Utility Trench

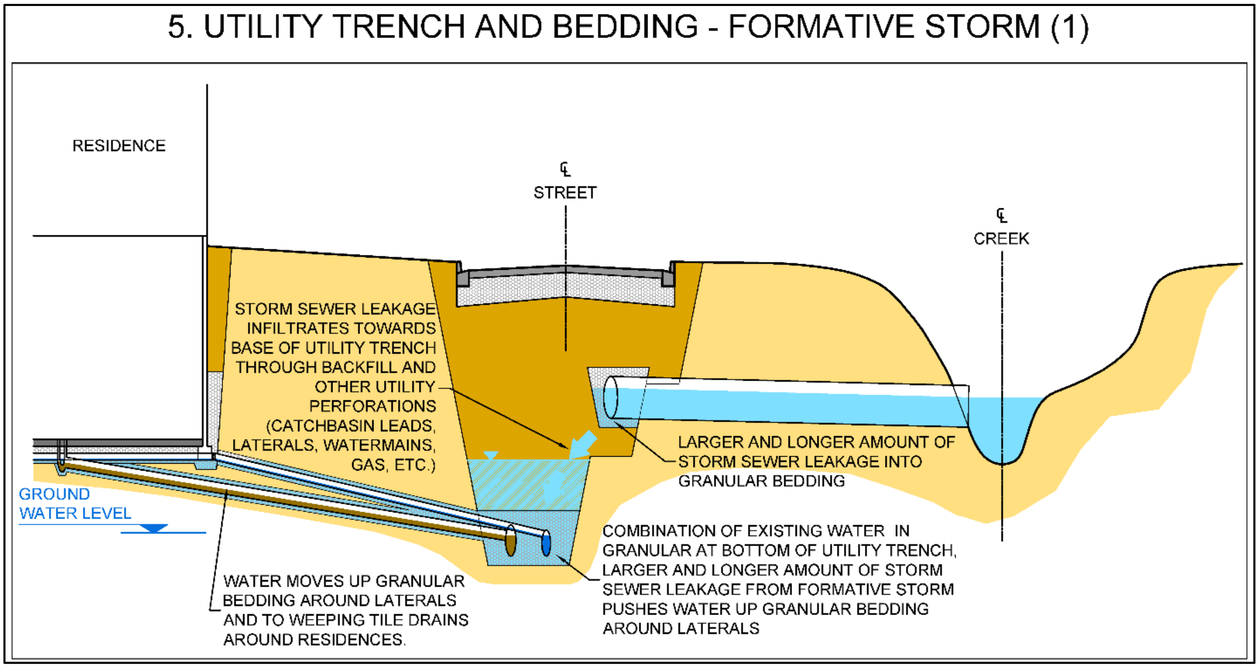


Figure 8E: Basement Infiltration due to water within the Utility Trench

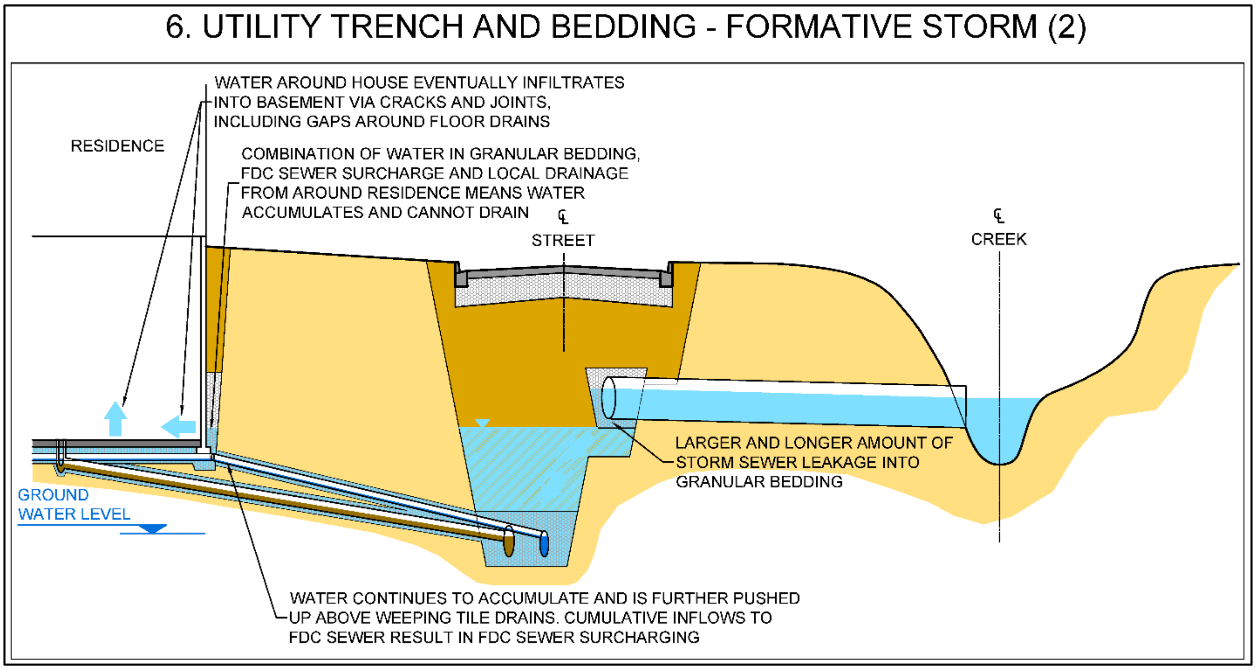


Figure 8F: Basement Infiltration due to water within the Utility Trench

The exact reasons why homes in the Lisgar District have not had basement water seepage before 2008 are not known. It is considered that the increasing leakage of water from the storm sewers through normal aging has gradually increased the volume of water collected in the trenches over time, ultimately contributing to the problems first experienced in 2008.

The risk of basement water infiltration is also connected to the relative depths of the FDC system and basements of homes in the different areas of the Lisgar District. Under the condition where water has moved up the bedding material surrounding the FDC laterals to the homes, the homes placed at greatest risk of basement water infiltration would be those where the FDC system (and thus the utility trench) is the shallowest. In other words, the less vertical separation between the FDC pipe/utility trench and the basements, the more susceptible basements will be to water seepage.

A number of other factors have been identified which may be impacting on the overall operation of the FDC system, however, none of them, either alone or in combination, would cause water to seep in to basements to the extent reported. The following table provides a summary of Amec Foster Wheeler's conclusions with respect to the potential contributing factors in the basement water infiltration investigation. A more extensive version of this table is provided as Appendix 'A'.

Summary of Assessment of Potential Factors in Basement Water Infiltration

Potential Factor	Level of Influence
Stormwater to Utility Trench	Primary Cause
FDC and Utility Trench Depths	May increase risk of basement water infiltration at specific locations
Groundwater	May contribute additional/excess flows to the FDC and utility trench (Not sufficient to cause problem)
Creek Backwater	
Osprey Marsh Pond (SWM) Backwater	
Basement Walkouts	
Inflow/Infiltration to FDC	
FDC Hydraulics	May impair conveyance capacity of FDC system (Not sufficient to cause problem)
FDC Design	
FDC Tailwater	
FDC Maintenance	
FDC Construction	
Cross-Connections	Not Applicable
Creek Maintenance	
GO Station	
Sanitary System	
Lot Grading	Insufficient information
Basement Construction / Changes	

Based on the foregoing conclusions, Section 6 of this report describes potential mitigation measures which are intended to reduce the risk of future basement water infiltration.

6.0 MITIGATION PLAN

To address the basement water infiltration issue, eleven alternative actions were developed and evaluated for potential implementation. They are briefly described as follows:

1. *Strategic Lining of Storm Sewers* – line and seal the inside of selected storm sewers to minimize water leakage into the utility trench.

2. *Construction of a Utility Trench Dewatering System* - drain water from the utility trench at key locations to provide additional storage during storm events and reduce FDC surcharging.

3. *Construction of FDC Pumping Stations* – actively pump from the FDC sewer system to minimize surcharging of the FDC system.

4. *FDC Sewer Upgrades* – Strategically upgrade selected FDC sewers to increase capacity and reduce surcharging occurrences.

5. *Sump Pumps* - install new basement sump pumps to help in draining weeping tiles during storm events. The City should continue with its Lisgar District Sump Pump Subsidy Program for homes with reported basement water infiltration to assist homeowners with the cost of installing new sump pumps.

6. *FDC Backflow Preventers* – install a backflow preventer and clay barrier on residential FDC lateral pipes to prevent FDC surcharge from impacting weeping tiles.

7. *Storage* – construct a storage system (likely an underground tank) to temporarily store excess FDC flow during surcharge events and then release it in a controlled manner.

8. *Storm Sewer Outfall Collars* – construct concrete barriers at storm sewer outfalls (to creek or pond) to limit the ability of water to move back up through the utility trench.

9. *Basement Walkout Covers* – construct roofs/covers over residential basement walkout entrances, to limit stormwater from draining to the FDC.

10. *New FDC Outlet* – re-direct the FDC trunk sewer at the downstream limit away from the existing storm sewer and to a free flowing outfall (such as a creek).

11. *Creek Remediation* – trim or manage vegetation along creek corridor to improve capacity and reduce water levels during major storms.

These eleven actions were analyzed by the City and Amec Foster Wheeler for effectiveness (ability of proposed actions to reduce basement water infiltration) and feasibility (ease of implementation). Through this process, Actions #1 to #5 were carried forward to form a Prioritized Action Plan to reduce the risk of basement water infiltration while Actions #6 to #11 were screened out. A detailed matrix summarizing each of the eleven alternative actions is provided as Appendix ‘B’.

6.1 Prioritized Action Plan

The following five actions are recommended to be carried forward as mitigation actions based on their effectiveness and feasibility.

Item #	Action	Description
1	Strategic Lining of Storm Sewers	Sealing the inside surface of storm sewers in strategic locations with an impermeable liner to reduce/eliminate leakage into bedding (and ultimately into FDC system).
2	Construction of a Utility Trench Dewatering System	Dewater bedding material around the FDC system to limit the accumulation of water in the utility trench and provide additional storage volume during storm events.
3	Construction of FDC Pumping Stations	Install pumping stations at key locations of the FDC system which will activate when the system either approaches or reaches surcharge conditions and pump water to the ground surface.
4	FDC Sewer Upgrades	Upsizing selected FDC sewers to increase their conveyance capacity and reduce surcharge.
5	Sump Pumps	Home-owner installs a new basement sump pump system to help to drain the weeping tile system around the home; sump pump would discharge to ground surface.

Additional details related to the above Prioritized Action Plan are provided as Appendix ‘C’.

It should be noted that the basement water infiltration issue is extremely complex, and the selection of measures to appropriately address the problem remains an iterative process. Actions in the Prioritized Action Plan should be implemented in stages where constructed projects are monitored to assess their effectiveness and to assist staff in making informed decisions on subsequent Actions.

7.0 RECOMMENDED NEXT STEPS

Based on the Prioritized Action Plan, it is recommended that the two highest priority actions, Actions 1 and 2, be planned in order of implementation as soon as funding and approvals are secured to deal with the basement water infiltration issue. It is suggested that the following steps be undertaken:

a) Undertake the design, construction and monitoring related to the storm sewer lining (Action 1) of the Black Walnut Trail area (refer to Figure 9 for locations).

b) Conduct background work to refine key details of the utility trench dewatering system (Action 2) followed by detailed design, approvals, and construction.

c) Undertake additional monitoring to assess effectiveness of steps (a) and (b).

d) The balance of the recommended Actions (Actions 3 and 4) would be staged over time conditional on the results of steps (a), (b), and (c).

It is also recommended that residents who qualify for the City's Lisgar District Sump Pump Subsidy Program take advantage of this program (Action 5).

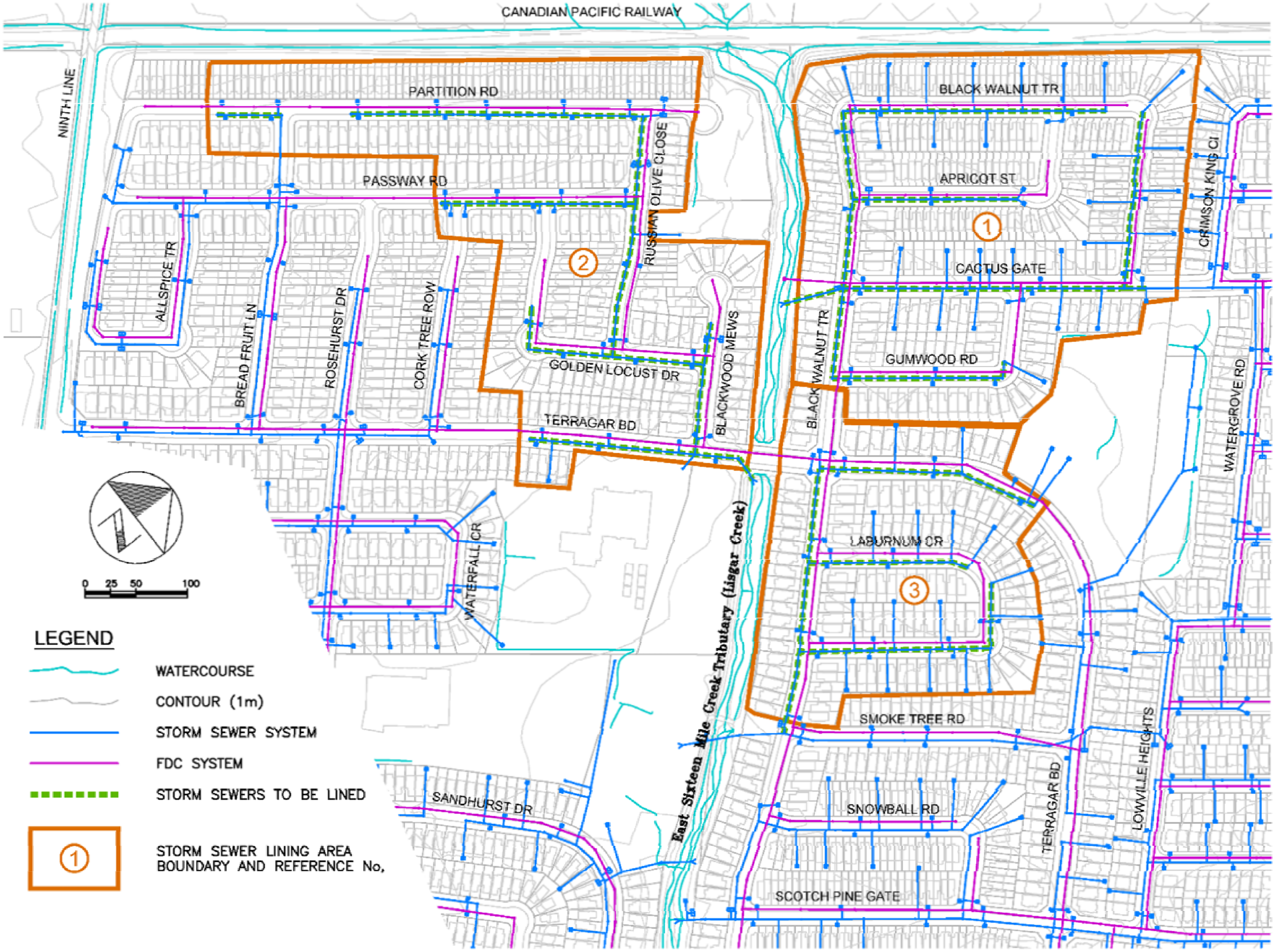


Figure 9: Locations of Proposed Storm Sewer Lining – Black Walnut Trail Area

APPENDIX ‘A’
Summary of Potential Factors of Basement Water Infiltration

APPENDIX 'A' - SUMMARY OF ASSESSMENT OF POTENTIAL FACTORS OF BASEMENT WATER INFILTRATION (MARCH 2015)

Potential Factor	Level of Influence	Notes
Stormwater to Utility Trench	Primary Cause	Validated by 2013 storm sewer leakage tests. 2014 impermeable collar test excavations confirmed significant amount of water in bedding material.
FDC and Utility Trench Depths	May increase risk of basement water infiltration at specific locations	Not a cause of basement water infiltration, but locations with shallower FDC depths (and thus utility trench depths) in relation to adjacent weeping tile systems would be expected to increase the risk of basement water infiltration.
Groundwater	May contribute additional/excess flows to the FDC and utility trench (Not sufficient to cause problem)	Groundwater in part contributes to water accumulation within utility trench bedding material but not viewed as a cause of the basement water infiltration experienced since 2008.
Creek Backwater		May contribute water to utility trench within bedding material, increased residence time within storm sewers but not viewed as a cause of the basement water infiltration experienced since 2008.
Osprey Marsh Pond (SWM) Backwater		Osprey Marsh Pond not a direct cause of surcharging or basement water infiltration, but may contribute to water within utility trench bedding material, increased residence time within storm sewers, however not viewed as a cause of the basement water infiltration experienced since 2008.
Basement Walkouts		Current hydraulic modelling efforts indicate an insufficient number to generate observed FDC flows and volumes under surcharge events; may still be a potential contributor to surcharging or basement water infiltration at specific locations however not viewed as a cause of the basement water infiltration experienced since 2008.
Inflow/Infiltration to FDC		Some contribution to FDC pipe flow due to amount of water within surrounding bedding material through cracks in pipes/MHs, but insufficient to be a cause of the basement water infiltration experienced since 2008.
FDC Hydraulics	May impair conveyance capacity of FDC system (Not sufficient to cause problem)	Sections of the FDC sewer system have been identified as undersized or poorly graded (flat) which exacerbates FDC surcharging, but not viewed as a cause of the basement water infiltration experienced since 2008
FDC Design		Analysis work indicates a number of deficiencies in FDC system using original design criteria, which may exacerbate FDC surcharging at specific locations. FDC system was however designed according to the approved criteria of that time. The deficiencies, while impairing the overall efficiency of the system, are not viewed as a cause of the basement water infiltration experienced since 2008.
FDC Tailwater		Receiving storm sewer has not surcharged during monitoring period; water levels have been above FDC outlet invert but for only brief periods and does not appear to directly correlate with observed FDC surcharge (and does not explain surcharge at upstream limits of system), thus not considered to be the cause of basement water infiltration experienced since 2008.
FDC Maintenance		FDC system flushed since study start-up; FDC systems are closed, hence would typically only require nominal maintenance. CCTV showed some issues with respect to debris accumulation, but generally minimal and not sufficient to cause persistent/widespread surcharge or the basement water infiltration experienced since 2008.
FDC Construction		Detailed information not available for all of the FDC system. Sections of trunk FDC along Ninth Line may have been constructed flatter than design, larger number of residences ultimately connected to FDC system than originally designed, however these discrepancies are not considered to be the primary cause of FDC surcharging or the cause of basement water infiltration experienced since 2008.
Cross-Connections	Not Applicable	Known cross-connections repaired; very few found
Creek Maintenance		Monitoring data do not indicate any correlation to FDC surcharge. Lands regulated by Conservation Halton; work needs to balance ecological impacts. City forces have cleared creek (sediment / vegetation) since study start-up with rapid re-growth noted.
GO Station		Monitoring data do not currently indicate any correlation between GO Station water infiltration and instances of observed FDC surcharge
Sanitary System		Region of Peel monitoring data indicated no sanitary system surcharging or correlation with identified FDC surcharging events
Lot Grading	Insufficient information	Insufficient information available to assess level of influence
Basement Construction / Changes		Insufficient information available to assess level of influence

APPENDIX ‘B’
Summary of Potential Mitigation Measures

APPENDIX ‘B’ - SUMMARY OF POTENTIAL MITIGATION MEASURES (MARCH 2015)

Items	Action	Description	Analytical Support / Theory	Technical Considerations	Policy and Implementation Considerations	Effectiveness	Feasibility	Priority	Potential Further Investigation related to uncertainties and information gaps
1	**Strategic Lining of Storm Sewers**	Sealing the inside surface of storm sewers in strategic locations with an impermeable liner to reduce/eliminate leakage into bedding (and ultimately into FDC)	• Storm sewer leakage tests (2013) confirmed that storm sewers leak into the FDC system • Impermeable collar tests (2014) confirmed a significant amount of water in bedding material; water quality typing suggests surface water as source • Rapid FDC surcharge and temperature signal data strongly suggest a stormwater input; storm sewers largest likely contributor • Preventing storm sewer leakage would directly limit FDC surcharge potential	• Several key preliminary locations based on historic basement infiltration and computer modelling: • Black Walnut Trail (BWT) north of Smoke Tree (32.9 ha – 3.6 km of storm sewer) – Highest priority area • Doug Leavens Boulevard (4.3 ha – 0.5 km of storm sewer) • Alderwood Trail (9.2 ha – 1.0 km of storm sewer) • Osprey Boulevard (16.4 ha – 1.8 km of storm sewer)	• Work would all be done within public right-of-way, minimal disruption • Some loss in storm sewer capacity due to lining, generally nominal (5% +\-) • Preferred methodology to seal MHs and CBs • Need to seal catchbasin leads as well. • Lining of rear-yard catchbasin leads is a potential future work item; private property access may be required	Moderate to High	High	High *(Recommended)*	• Further potential refinement to locations of lining; test effectiveness in select locations before doing widespread lining (additional monitoring) • Need to further explore alternative technologies to determine the optimal lining material
2	**Construction of Utility Trench Dewatering System**	Dewater bedding material around the FDC to limit accumulation of water and provide additional storage volume during storm events	• Impermeable collar tests (2014) confirmed a significant amount of water in bedding material • Would limit excess water accumulation in bedding material and restore storage capacity	• Given depth of FDC sewer bedding relative to surface water, a pumping system would be required • Given that pumping would be quasi-continuous (i.e. during non-storm and storm periods) back-up pumps and power less necessary • Consider several preliminary locations based on historic basement infiltration and forensic modelling: • BWT at Cactus Gate • BWT at Scotch Pine Gate • Along trunk between Derry and Osprey • Osprey Boulevard	• Work would all be done within public right-of-way, minimal disruption • Uncertainty related to available public land to construct; lands would need to be in close proximity to problem areas • Approach to discharge pumped water will need to consider impacts to receivers (storm sewer or creek)	Moderate to High	Moderate to High	High *(Recommended)*	• Variable cost of pumping systems; would need to confirm locations and determine sizing and feasibility before proceeding further. Requires a pre-engineering study • Test effectiveness of a single installation before proceeding with others (additional monitoring); number and location of potential pumping systems to be confirmed based on effectiveness of highest priority pumping system and land ownership.

APPENDIX ‘B’ - SUMMARY OF POTENTIAL MITIGATION MEASURES (MARCH 2015)

Items	Action	Description	Analytical Support / Theory	Technical Considerations	Policy and Implementation Considerations	Effectiveness	Feasibility	Priority	Potential Further Investigation related to uncertainties and information gaps
3	**Construction of FDC Pumping Stations**	Provide pumping stations at key locations for the FDC system; activated once the system either approaches or reaches surcharge conditions; flows to be pumped to surface	• Computer modelling of a monitored surcharge event showed that pumping would be largely successful in reducing surcharge (depth and duration) for upper limits of the FDC system	• A larger pumping system would be required than for utility trench drains given amount and rate of water to be pumped during a storm • Given the need for the system to operate during storm events, back-up power and back-up pumps would be required which would increase costs • Potentially located at same preliminary locations as applied for utility trench drains to reduce costs	• Similar to utility trench drains	Moderate	Moderate to High	Moderate to High ***(Recommended)***	• Additional modelling should be completed to better confirm feasibility and preferred locations of FDC pumping

4	**FDC Sewer Upgrades**	Upsizing selected FDC sewers to increase their conveyance capacity and reduce surcharge	• FDC monitoring data indicate that the FDC system surcharges frequently, particularly in certain locations
			• Computer modelling of a monitored surcharge event showed that a FDC upgrade along a portion of BWT would eliminate surcharge in this location
				• Strategic upsizing by one standard pipe size in two key preliminary locations:
				  ◦ BWT (CNR to Scotch Pine Gate) – 1 km +\-
				  ◦ Along creek (Doug Leavens Blvd. to Ninth Line) – 2 km +\-
				• Focus on trunk FDC pipes; other smaller branches may also be required for upsizing
				• Would need to consider overall cost benefits and likely initiate the work once area infrastructure reaches its engineered lifetime
					• Works along BWT would be disruptive to residents (road reconstruction)
					• Potential synergy with other measures since excavation would be required regardless
					• Works along the FDC system within creek block would be much less disruptive
						Moderate	Moderate	Moderate ***(Recommended)***	• Further modelling assessment required to confirm benefit of FDC sewer upgrade along creek and required extents as well as Ninth Line, if shown to be effective
									• Would need to assess if upgrades negatively impact downstream areas
									• Assess whether additional costs likely given depth of excavation required in some locations (5 m +\-), particularly along BWT

5	**Sump Pumps**	Homeowner installs a new basement sump pump system to help to drain the weeping tile system around the home; sump pump would discharge to surface	• A sump pump should provide added relief for accumulated water within the residential weeping tile system, which should reduce the duration that water is around the home, and thus reduce the potential for basement water infiltration	• 187 homes (to-date) have reported basement water infiltration • Homeowner should confirm that a sump pump can be effectively installed in their basement; in particular that a clear outlet to the surface can be achieved (at least 2 m away from the foundation)	• Homeowner-led approach • City subsidy program in place for homes that have experienced basement water seepage to assist homeowners with cost of installation (up to 50% of invoiced total, up to a maximum of $3,000) • Applications must be reviewed and approved by City staff	Moderate	Moderate	Moderate ***(Recommended)***	• N/A

APPENDIX ‘B’ - SUMMARY OF POTENTIAL MITIGATION MEASURES (MARCH 2015)

Items	Action	Description	Analytical Support / Theory	Technical Considerations	Policy and Implementation Considerations	Effectiveness	Feasibility	Priority	Potential Further Investigation related to uncertainties and information gaps
6	**FDC Backflow Preventers**	Provide an impermeable collar around FDC lateral to prevent migration of bedding water, combined with a backflow valve on FDC lateral itself to eliminate surcharge impact to home	• Storm sewer leakage tests (2013) and impermeable collar tests (2014) confirm significant amount of water within bedding material and the potential for this material to transport water • Monitoring results show a correlation between FDC surcharge and reported instances of basement infiltration (ref. storm event of January 13, 2013) • Assumption that eliminating potential for FDC surcharge and duration to impact basement foundations (via either lateral or bedding material) would therefore eliminate primary cause of basement water infiltration	• Need to confirm least invasive method to install – would open cut excavation be the only solution?	• Likely that collars and backflow valves could be placed within City property (roadway limits) to maintain control • Inspection and maintenance needs may be challenging depending on access and location	Low to Moderate	Low to Moderate	Low to Moderate ***(Screened)***	• Further investigation would be required to identify priority areas • Potential impact to foundations given that no drainage outlet would be available during FDC surcharge events (backflow valve) – would this increase potential for basement water infiltration for certain weather/seasonal conditions? Magnitude of inflow/infiltration though likely significantly less.
7	**Storage**	Incorporate offline storage features (likely underground storage tanks) to detain excess FDC flows and reduce the resulting FDC surcharge	• Monitoring data suggest FDC surcharge continues to occur in several locations; storing some or all of the FDC surcharge would be expected to reduce potential for basement water infiltration • Forensic hydrologic/hydraulic modelling will assist in confirming observed flows and associated volumes within the FDC system	• Would depths of FDC permit gravity drainage or would pumping be required?	• Underground storage systems require significant land at depths to be effective, potentially necessitating the acquisition of private property • Significant additional costs if pumping is required	Moderate	Low to Moderate	Low to Moderate ***(Screened)***	• Additional modelling would be required to confirm observed and required storage volumes for more formative events • Where are preferred locations of storage based on FDC surcharge and available land? • Where would pumping be required?

APPENDIX 'B' - SUMMARY OF POTENTIAL MITIGATION MEASURES (MARCH 2015)

Items	Action	Description	Analytical Support / Theory	Technical Considerations	Policy and Implementation Considerations	Effectiveness	Feasibility	Priority	Potential Further Investigation related to uncertainties and information gaps
8	**Storm Sewer Outfall Collars**	Construct an impermeable barrier around storm sewer outfalls (including all other utilities) to prevent the movement of water from the receiving system back along the bedding material and potentially into the FDC or utility trench	• Storm sewer leakage tests (2013) indicated that storm sewers leak, and that bedding material is likely pathway • Subsequent analyses considered the potential that FDC inflows and elevated water in bedding (and duration) could be the result of storm flows backing up in the bedding material from receiving watercourses, which would have elevated levels during storm events • Two impermeable collars were designed and constructed in 2014 (Scotch Pine Gate and Pondview Way) along with additional monitoring devices • Limited monitoring data to date given construction timing, however initial results suggest that bedding water is primarily coming from upstream rather than downstream	• 42 identified storm sewer outfalls, 2 completed to-date = 40 remaining outfalls. Would it be necessary to install collars for all 40 storm sewer outfalls?	• Would all be within public property, along creeks and Osprey Marsh – minimal disruption to the public	Unknown	Moderate	Low to Moderate ***(Screened)***	• Further monitoring data required to confirm effectiveness at 2 test locations • If considering this alternative, need to strategically target specific locations; more field investigations may be required accordingly
9	**Basement Walkout Covers**	Construct covers over all identified basement walkouts so that rainfall does not contribute to walkout sumps (and potentially directly into the FDC system)	• City reconnaissance work (air photos) indicates a significant number of potential basement walkouts in FDC service area (377 total) which may contribute stormwater flows to FDC • Modelling work to date however indicates that for the area north of Derry Road, there are an insufficient number to be a significant cause of observed FDC surcharge; may be a potential contributor however	• What type of design would be required? Would need to ensure that water drains sufficiently far away from walkout structure (> 2 m?)	• Given that this work would be wholly on private property the only way this action would be difficult to implement. Work would need to be led by the homeowner given that home and walkout configuration would be unique	Low to Moderate	Low	Low ***(Screened)***	• Additional modelling work would be required to confirm potential impact of basement walkouts in other areas (between Derry Road and Britannia Road in particular) • Field confirmation would be required to confirm how many "potential" walkouts are actually present, but difficult to confirm if these features have a direct connection to FDC system or bedding material. Field confirmations would likely reduce numbers and potential contribution; private homeowner cooperation would be required • Are there potentially other walkouts which could not be identified on aerial mapping?

APPENDIX 'B' - SUMMARY OF POTENTIAL MITIGATION MEASURES (MARCH 2015)

Items	Action	Description	Analytical Support / Theory	Technical Considerations	Policy and Implementation Considerations	Effectiveness	Feasibility	Priority	Potential Further Investigation related to uncertainties and information gaps
10	**New FDC Outlet**	Re-direct FDC trunk sewer along Ninth Line to a free outfall (i.e. open channel rather than closed storm sewer)	• Monitoring data indicate water levels in receiving storm sewer do rise to level of invert of FDC outlet; however this is generally brief (10-15 minutes) and at lower depth (only a portion of FDC pipe) • Computer modelling indicates that tailwater conditions have a limited impact on performance of upstream FDC • FDC analysis spreadsheet indicates that trunk along Ninth Line is over-capacity using different design approaches, including the section along Erin Centre Boulevard which would be eliminated under this option	• Sewer cannot be re-directed to Sixteen Mile Creek due to significant depth of sewer (11 m +\- below grade at Ninth Line and Erin Centre Boulevard) • Based on a review of City's topographic mapping, the only likely feasible outlet is watercourse at Ninth Line just east of Hwy 407 EB on-ramp from Hwy 403 (Joshua's Creek watershed – Conservation Halton jurisdiction) • Would need to confirm this channel would have limited backwater influence (free-flowing) and has sufficient capacity • Assume re-direction would begin at Ninth Line and Erin Centre Boulevard • Would require 1.3 km of new FDC sewer; would offer a 0.1% (+\-) grade	• Outlet would appear to still be within the City of Mississauga boundary, but would likely include MTO lands given proximity to Highway 407 and 403; would require consultation and approval with MTO • Would require disruption to traffic along Ninth Line which is a major arterial for the City	Low	Low	Low ***(Screened)***	• Would need to further confirm benefit of re-direction, but monitoring data suggest this would be limited – outlet does not appear to be the source of observed FDC surcharge, although it may be a minor contributor • Further analyses would be required to confirm feasibility of grading, potential utility conflicts, and capacity of receiving watercourse to accept additional flows
11	**Creek Remediation**	Clearing of vegetation growth within Lisgar Creek (Sixteen Mile Creek tributary) to improve conveyance capacity of the channel and lower peak water levels	• Monitoring data to date generally indicate little to no correlation between elevated water levels in watercourses and FDC surcharging; watercourse levels typically peak later than FDC • Speculation has been that elevated water levels within watercourses may contribute to inflows to bedding material via storm sewer outfalls; or may prevent drainage of both bedding material and storm sewers, which increases residence time and accumulation (i.e. exfiltration from storm sewers) • Data collection from impermeable collars (2014) may further assist in assessing impact, and potential benefit of impermeable collars.	• Need to review to determine if a product or approach could limit vegetation re-growth, while still maintaining a natural aesthetic and obtaining approval from Conservation Halton	• Previous clean-out was time consuming and labour intensive • Vegetation grew back rapidly, negating the effort • Work would run counter to Conservation Halton objectives, would require on-going permit applications	Low	Low	Low ***(Screened)***	• Further monitoring data collection from impermeable collars may assist in assessing impact of elevated creek water levels on potential for stormwater movement through bedding material; however this is currently speculated to be of minimal benefit • How much could peak water levels be reduced through vegetation clearing? Additional hydraulic analyses would be required; need to factor in rapid re-growth of vegetation as noted

APPENDIX ‘C’
Details of Prioritized Action Plan

The following provides additional details related to the recommended potential actions:

1. Storm Sewer Lining

What's involved?

Re-line and seal the inside of storm sewers in priority areas.

Why will it help?

By preventing water from leaking out of the storm sewer system, the potential for leakage into the utility trench below should be significantly reduced, which should also reduce FDC surcharging frequency and extent.

How is it done?

There are several different methods available: one method involves inserting and attaching a liner; another method involves spraying sealant around the inside of the sewer

Where would it be done?

A number of priority areas have been identified based on:

- Locations of reported basement water infiltration;
- Locations where field monitoring data show the most frequent FDC surcharge; and
- Locations identified by computer modelling analysis.

The current list of locations includes the areas around:

- Black Walnut Trail (north of Smoke Tree Road);
- Doug Leavens Boulevard (west of the creek);
- Alderwood Trail; and
- Osprey Boulevard (east of the creek).

Based on an initial screening process, Black Walnut Trail (north of Smoke Tree Road) is considered to be a priority location.

2. Utility Trench Dewatering

What's involved?

Continuously drain water that has been accumulating in the utility trench at key locations.

Why will it help?

By draining the water from the utility trench as it accumulates, storage volume is restored which can be available during storm events if required, which should further reduce FDC surcharging.

How is it done?

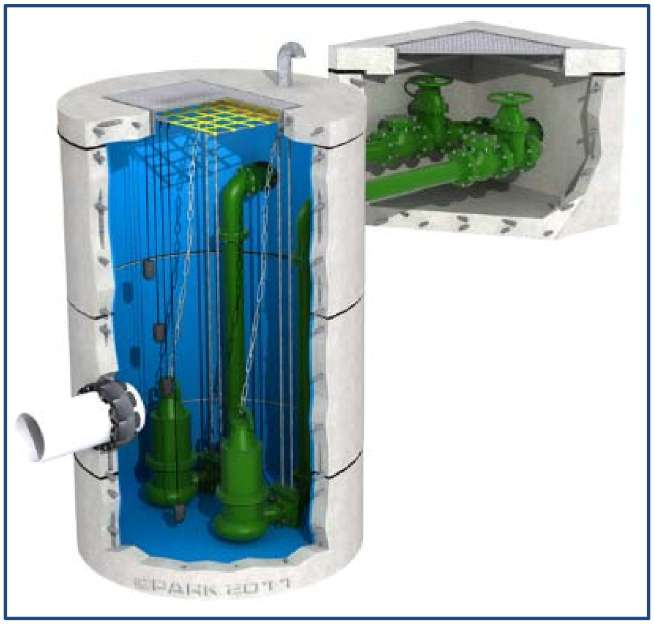
Because of the depth of the FDC system (in most locations), drainage by gravity is not possible. The water will therefore need to be pumped (using a system similar to a residential sump pump) to the surface, and then likely outlet to the creek.

Where would it be done?

A total of four different installations are currently considered; however, the precise number of installations required will need further study. The preliminary locations include:

- Black Walnut Trail (two different locations);
- Along the creek/trunk FDC between Derry Road and Osprey Boulevard; and
- Osprey Boulevard.

3. FDC Pumping Stations



What's involved?

Actively pump excess flow from the FDC sewer system during surcharge events.

Why will it help?

Pumping away the excess flow within the FDC system should reduce flows and therefore reduce the amount of FDC surcharge.

How is it done?

A permanent pumping station would need to be established which would be connected to the FDC system, likely by a new pipe at an existing FDC maintenance hole. The pumping station would involve an underground storage chamber with a "wet well" (to provide some depth of water to pump from) and one or more large pumps. These pumps would be triggered once water levels rise to a pre-set elevation, and would then turn on and pump the diverted water out of the FDC (likely to the surface and/or to the creek). The pumps would then shut off again once water levels drop enough

Where would it be done?

Further study and investigations would be required to confirm the precise number and locations of these pumping stations. Compared to dewatering of the utility trench, it should be noted that the FDC pumping costs will be significantly greater due to the requirements for larger pumps, backup units, backup power systems, more space and land.

4. FDC Sewer Upgrades

What's involved?

Increase the size and/or slope of existing FDC sewers.

Why will it help?

Larger and/or steeper sloped sewers can carry more water – by making the FDC sewers larger the amount of surcharging should be reduced.

How is it done?

The ground, including the roadway in most areas, is dug up to expose the existing FDC sewer pipe. The pipe is then removed piece by piece. A new larger pipe is installed including new larger maintenance holes, if required, and the ground and roadway are then restored.

Where would it be done?

No definite locations have been identified as of yet; further study and assessment would be required. Also, due to the disruption to the roadway, and the relative age of the FDC, storm and sanitary sewers, FDC upgrades should be coordinated with planned road works and/or when the sewer are approaching the end of their service life.

5. Sump Pumps

What's involved?

Homeowners in the Lisgar District with reported basement water infiltration installing a new sump pump system in their basement.

Why will it help?

Sump pumps would help to drain water from the weeping tile system around a home during a storm event, which should limit or reduce the potential for basement infiltration.

How is it done?

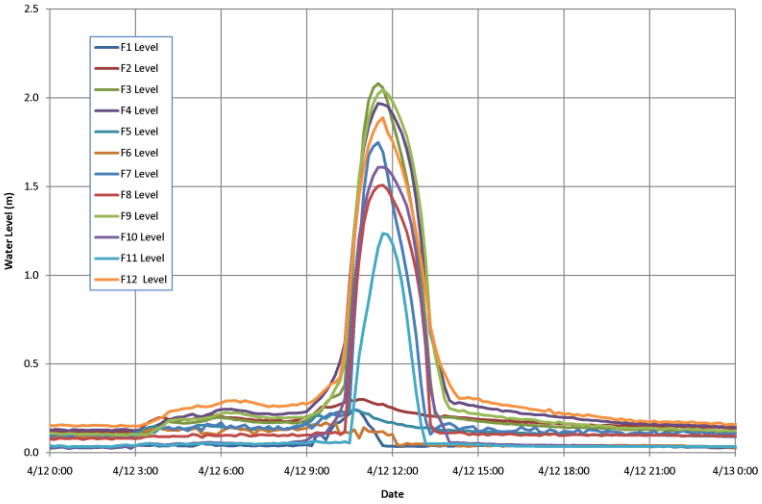
Part of the basement floor in a home would need to be cut and a sump pit created and connected in to the weeping tile system around the home. A sump pump is then installed, which begins pumping once water levels in the sump reach a pre-set water level. The water is then pumped out to the ground surface at a distance typically of at least 2 metres from the home.

Where would it be done?

The City of Mississauga is continuing to offer the Lisgar District Sump Pump Subsidy Program to homeowners in the Lisgar District with reported basement water infiltration. A financial subsidy is available to eligible homeowners of up to 50% of the sump pump installation cost, to a maximum of $3,000 per household.

Lisgar District Basement Water Infiltration Investigation
Presentation of Final Report
City of Mississauga

March 26, 2015



Agenda

1. Purpose of Presentation
2. Summary of Findings
3. Study Area
4. Overview of Drainage Systems
5. City Activities
6. Summary of Potential Causes
7. Study Activities
   - *Monitoring*
   - *Testing*
   - *Analysis*
   - *Summary and Conclusions*
8. Mitigation Plan
9. Recommended Next Steps
10. Summary Report

1. Purpose of Presentation

1. Purpose of Presentation

To present the findings of the consultant's assessment regarding the Lisgar District Basement Water Infiltration study, including:

- A summary of the field work and associated analysis
- The resulting conclusions regarding the main cause of the basement water infiltration, and other secondary factors
- The proposed Mitigation Plan

2. Summary of Findings

2. Summary of Findings

History of the Problem:

- Beginning in 2008, some homes experienced water seeping into their basements following certain rainfall events
- A total of 187 homes are known to have been affected to date.
- The City undertook a number of proactive measures
- In October 2011, the engineering consulting firm Amec Foster Wheeler Environmental & Infrastructure was retained to undertake an engineering study to determine the possible causes of this problem

2. Summary of Findings

Summary of the Primary Cause:

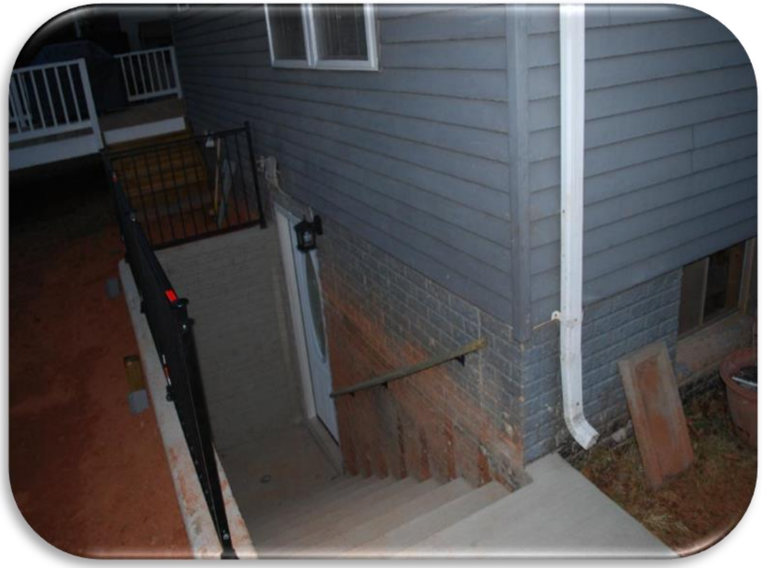
- Leakage from the storm sewer system (which is a normal and expected occurrence), combined with the presence of slow draining native soils (around the utility trench) results in water build-up
- If the build-up of water is significant, it travels up the bedding material around the Foundation Drain Collector (FDC) laterals servicing the homes and into the foundation weeping tiles
- Water then drains directly into the FDC pipes through the weeping tiles which can surcharge (overload) the system
- This condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage may lead to water around the home’s weeping tiles being unable to drain and potentially seeping into the basements of homes.

2. Summary of Findings

Potential Secondary Factors:

Some other identified issues and risk factors include:

- The depth of the FDC system and utility trench relative to weeping tiles in some locations (i.e. more susceptible);
- Pipe capacity in some sections of the FDC system;
- Potential inflows from groundwater and surface water sources (creek/pond via storm sewer outfall);
- Rain water and runoff from the lot or roof entering drains serving basement walkout areas that are connected to the FDC system.



2. Summary of Findings

Prioritized Action Plan:

Following measures are recommended as the highest priorities for the City:

a) *Strategic lining of priority storm sewers to minimize leakage (capital cost estimated to be $8M - $9M)*
b) *Construction of a utility trench dewatering system.(capital cost estimated to be $3M - $4M)*
c) *Additional monitoring to assess effectiveness of a) and b) (approximately $100,000)*

Other recommended actions may be staged over time, conditional on the results of the above, including:

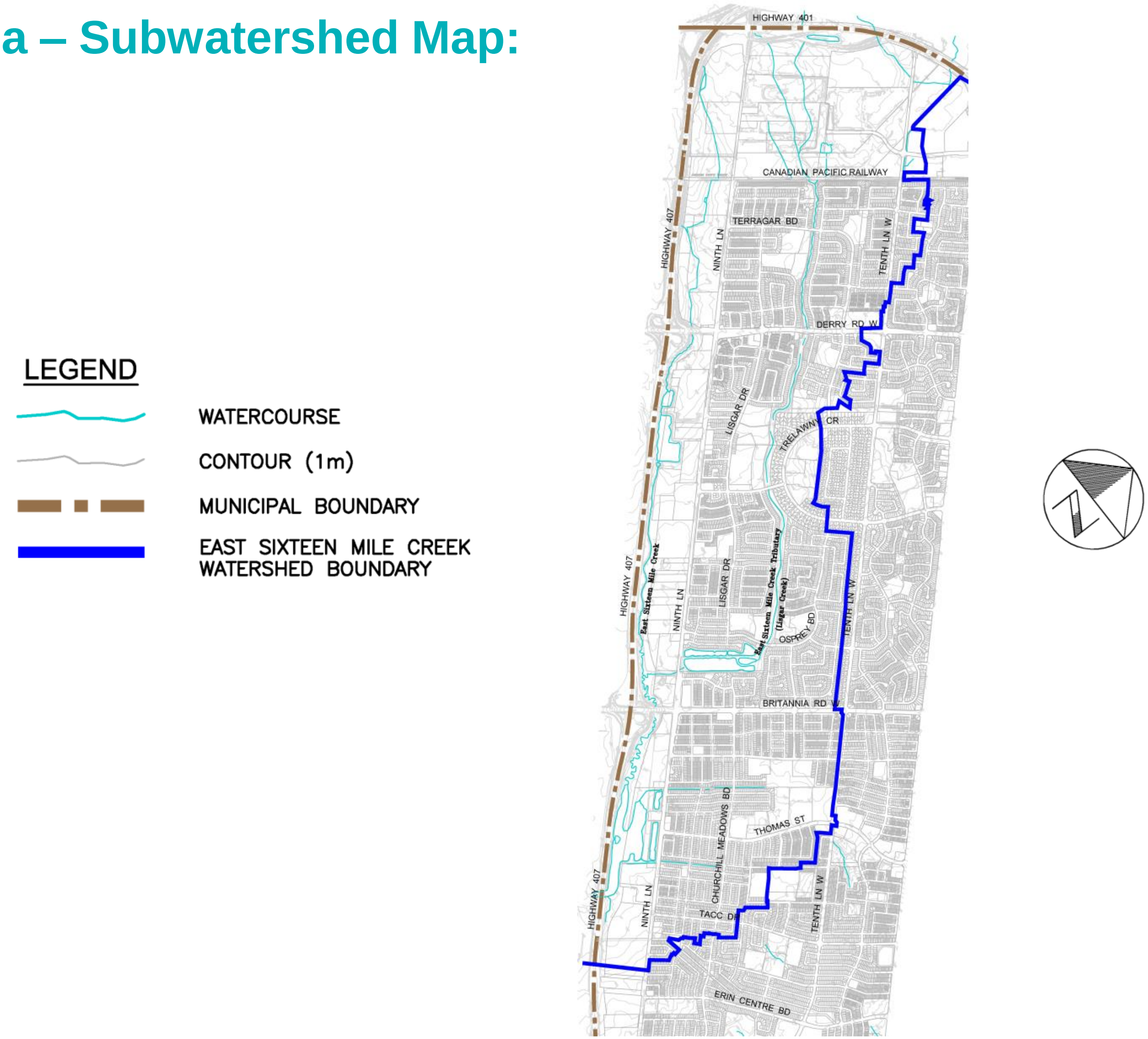
a) *Building permanent FDC pumping stations for high flows (capital cost estimated to be $6M - $7M)*
b) *Replace deficient FDC pipe lengths when they reach the end of their engineered lifespan (capital cost estimated to be $2M - $3M)*

It is also suggested that residents who qualify for the City's Lisgar District Sump Pump Subsidy Program take advantage of this program.

3. Study Area

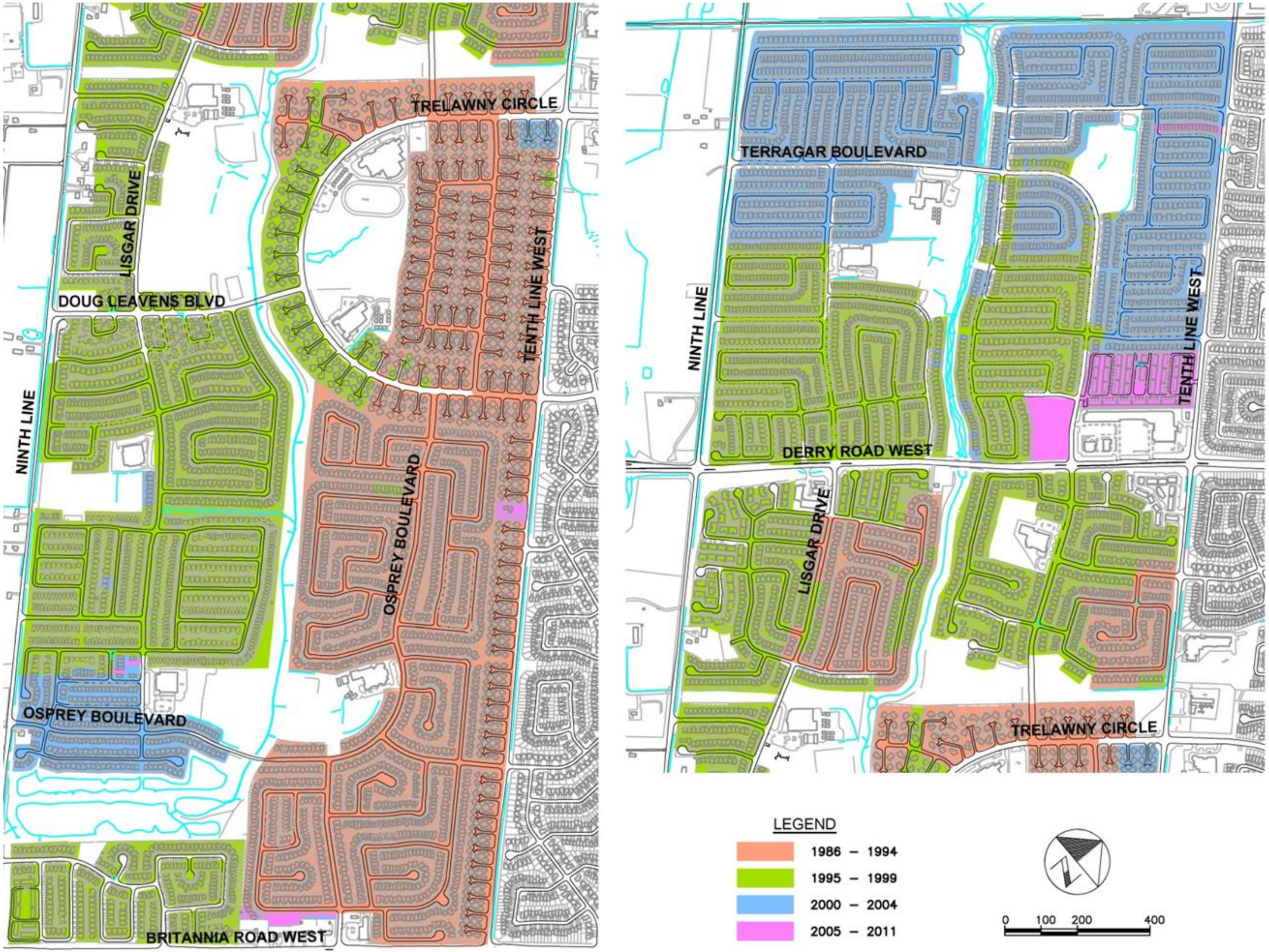
3. Study Area

Study Area – Subwatershed Map:



3. Study Area

Study Area – Eras of Development:



4. Overview of Drainage System

4. Overview of Drainage System

Typical Foundation Drainage Systems:

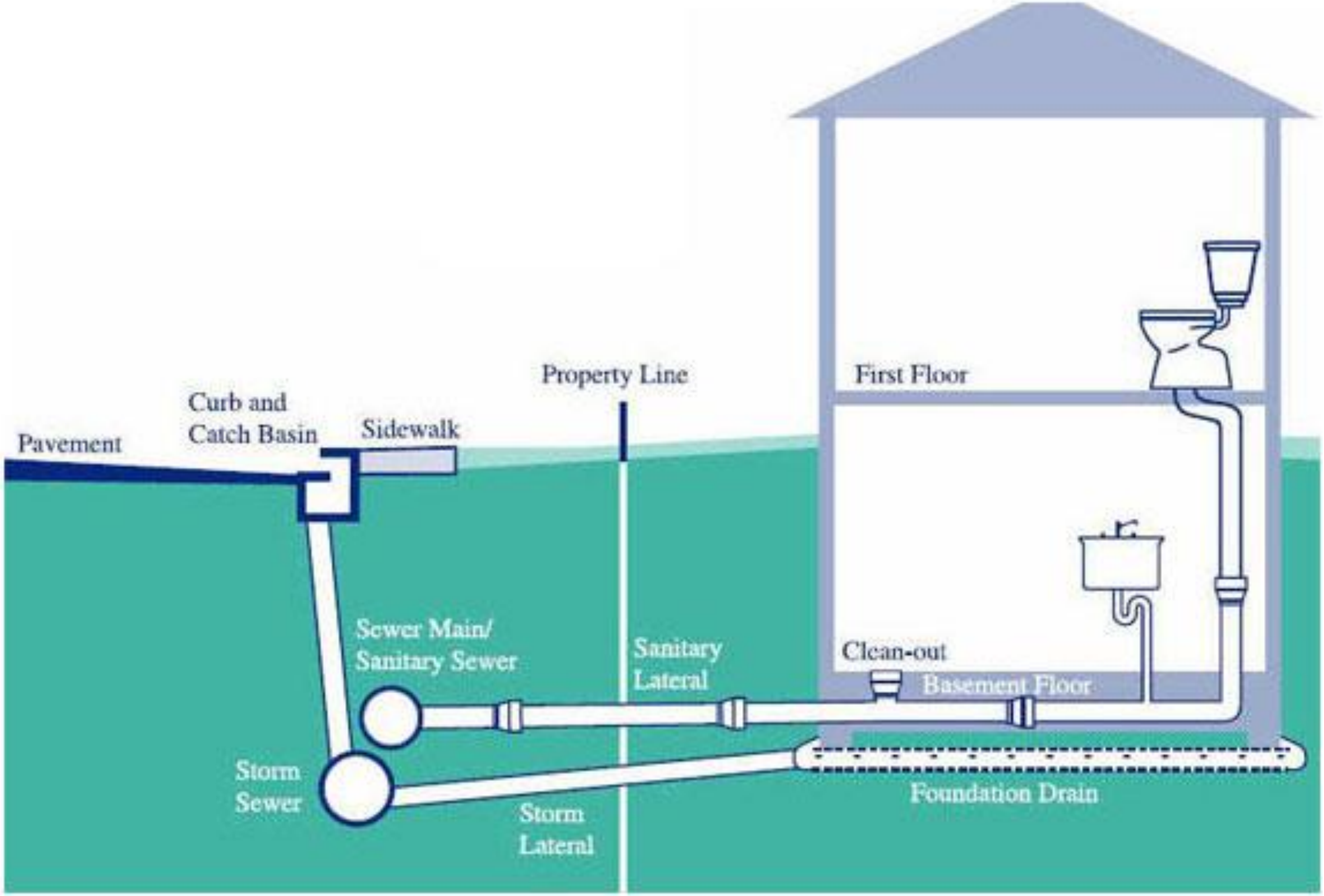
Typical Foundation Drainage Systems to address water build up around residential foundations:

1. Gravity Drainage to Storm Sewer
2. Sump Pump to Front/Rear Yards or Storm Sewer
3. 3-Pipe System – Foundation Drain Collector (FDC)

4. Overview of Drainage System

Typical Foundation Drainage Systems:

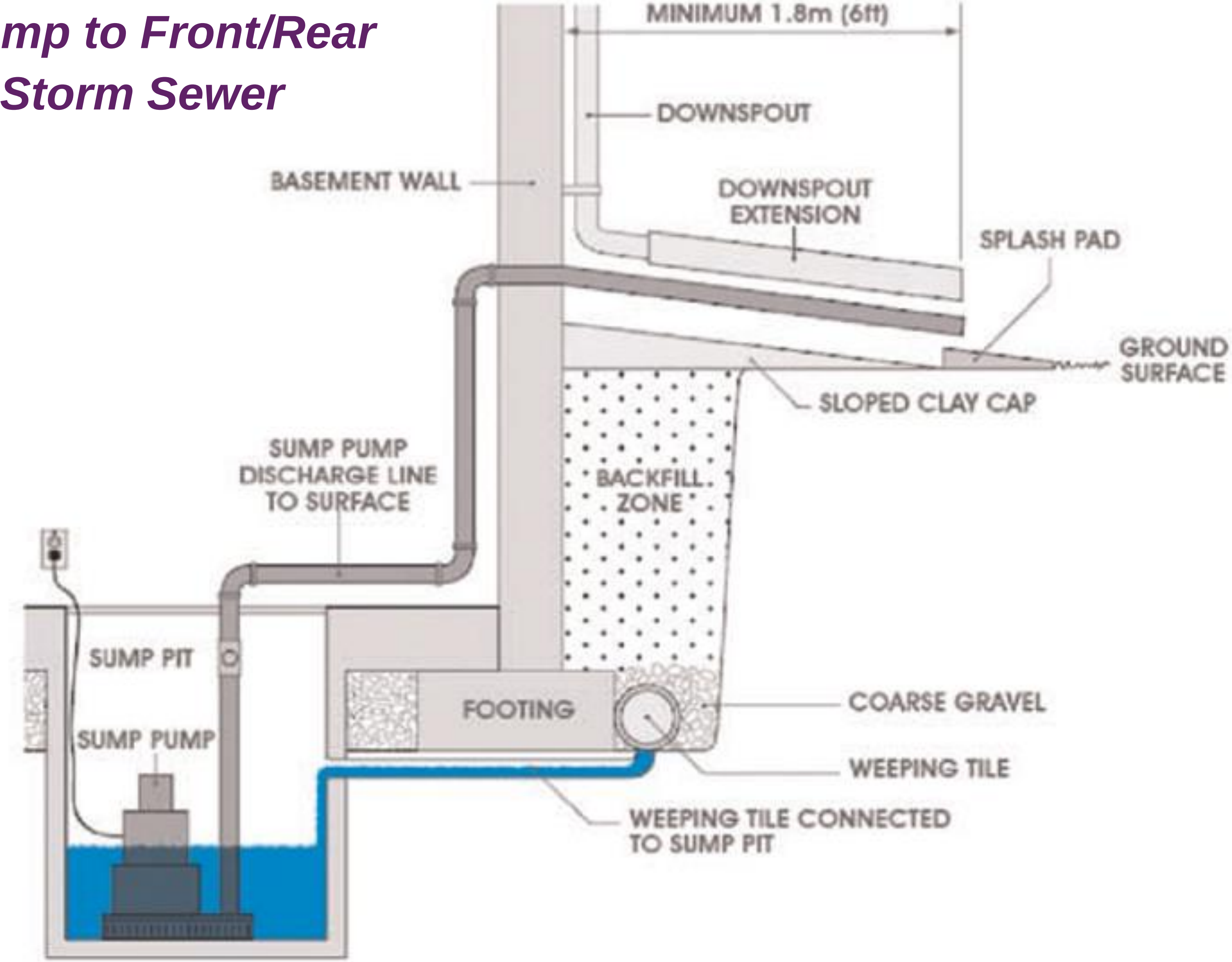
i. Gravity Drainage to Storm Sewer



4. Overview of Drainage System

Typical Foundation Drainage Systems:

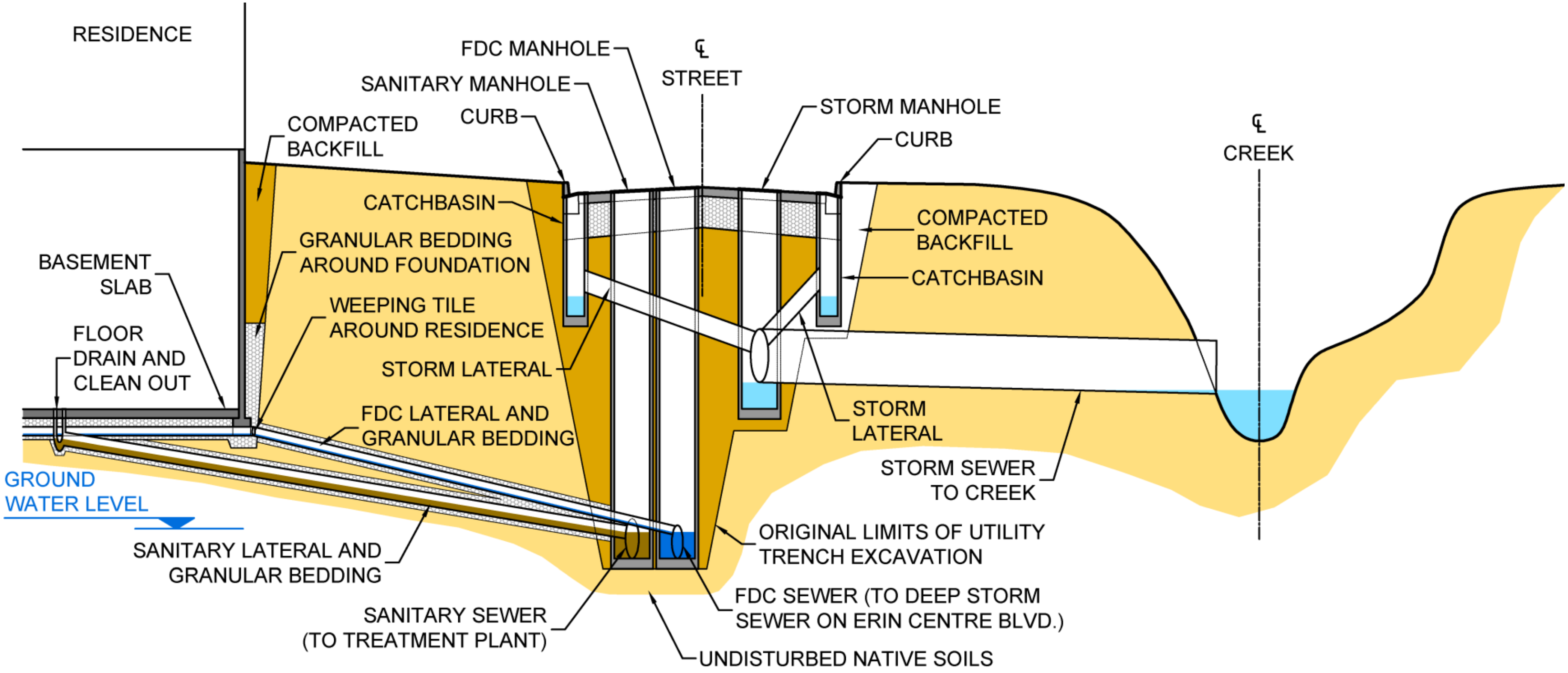
ii. Sump Pump to Front/Rear Yards to Storm Sewer



4. Overview of Drainage System

Typical Foundation Drainage Systems:

iii. 3-Pipe System - Foundation Drain Collector (FDC)



- "*This system virtually eliminates the probability of back-ups into foundation drains, which have caused considerable flooding, and damage to basements*" (Modern Sewer Design, 1980)

4. Overview of Drainage System

Type	Advantages	Disadvantage
Gravity to Storm Sewer	• no additional infrastructure • comparatively low cost • no reliance on mechanical system or power	• may back up if storm sewer is overwhelmed • some additional cost to upsize storm sewers
Sump Pump	• disconnected from municipal system	• requires homeowner to operate and maintain the system • mechanical system needs to operate to function • relies on power
Foundation Drain Collector	• dedicated, providing drainage for foundation only • no reliance on mechanical system or power • “virtually eliminates the probability of back-ups into foundation drains” • allows for smaller sized storm sewers • Successfully installed in numerous other municipalities without incident (Brampton, Vaughan, Barrie)	• comparatively high cost to install additional deep and long pipe systems

4. Overview of Drainage System

Why was the 3-Pipe System (FDC) used in Lisgar?

- Gravity drainage to the Sixteen Mile Creek Tributary not possible since creek is too shallow
- Alternatively, millions of cubic metres of material would have needed to be brought into area to elevate the land on average 1.5 m +\- (not practical/feasible)
- Sump pumps must always be maintained in good operating condition and also require a continuous supply of electricity; at the time (1980/1990's) sump pump system reliability not as robust
- 3 Pipe-System has been successfully used in other municipalities across Ontario and elsewhere

5. City Activities

5. City Activities

FDC and Storm Sewer:

- Video Inspection and Flushing of FDC and Storm Sewer Systems
- Identifying Sewer Cross-connections
- Sealing FDC Maintenance Access Lids and Cracks
- Cleaning Storm Sewer Outfalls to Creek
- Improvements to Overland Flow Routes
- High Water Protocol

5. City Activities

East Sixteen Mile Creek Tributary (“Creek”)and Osprey Marsh Stormwater Management Facility (“Pond”):

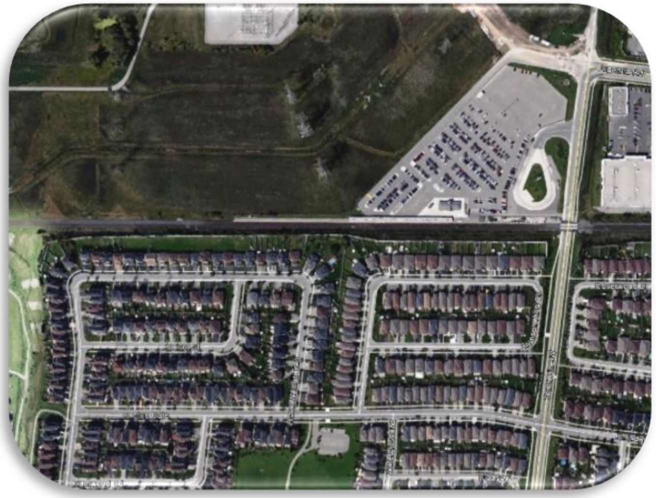
- Creek Vegetation Trimming and Debris Removal
- Sediment and Vegetation Removal from Bridge Crossings and Storm Outfalls
- Creek Inspection Protocol
- Reconfiguration of Osprey Marsh Stormwater Management Pond Outlet

6. Summary of Potential Causes

6. Summary of Potential Causes

Changes Since Development of Lisgar District:

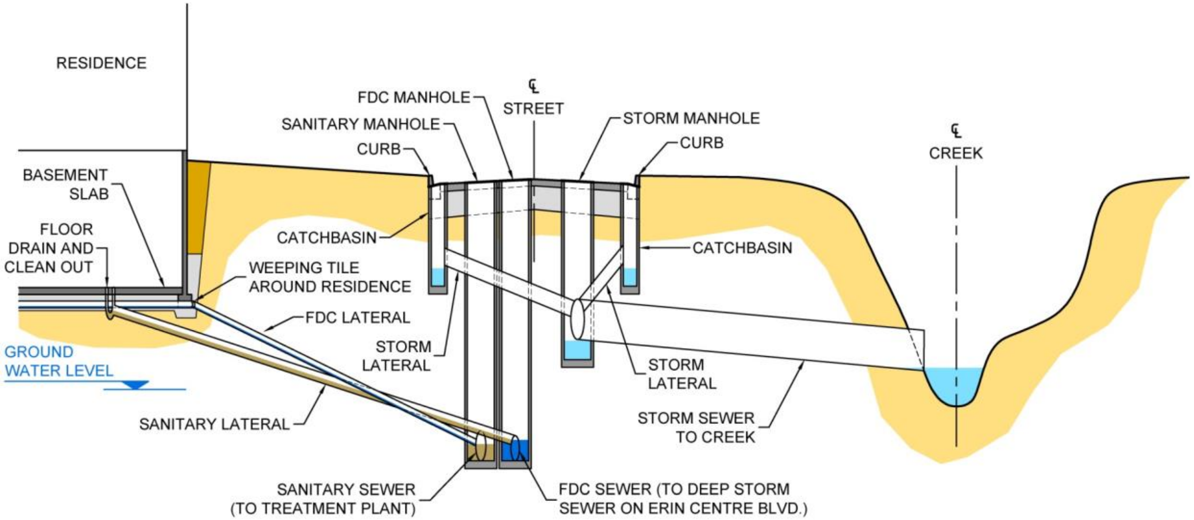
- Climate
- Development
- Creek Block Maturing with Vegetation
- Osprey Marsh Stormwater Management Pond
- Changes to Homes/Properties (lot grades, basement walkouts)
- Aging Basement Walls and Foundations
- Aging Infrastructure



6. Summary of Potential Causes

Other Potential Causes:

- Groundwater levels
- Sanitary Sewer system
- Private Weeper System (cross-connections and weeping tile system condition)
- Stormwater Leakage to Utility Trench



Cross-connection

6. Summary of Potential Causes

Other Potential Causes:

- Foundation Drain Collector
    - a. *Maintenance*
    - b. *Design*
    - c. *Hydraulics*
    - d. *Outlet*
    - e. *Depths*
    - f. *Inflow/Infiltration*
    - g. *Construction*

7. Study Activities

- *Monitoring*
- *Testing*
- *Analysis*
- *Summary and Conclusions*

7. Study Activities

Monitoring Work:

Groundwater – *Activities*

- Monitoring wells were installed at four main sites:
    - Black Walnut Trail at Scotch Pine Gate (late 2011);
    - Osprey Boulevard (late 2011);
    - Alderwood Trail (2013); and
    - Pondview Way (2014).

- Two primary types of monitoring wells were installed:
    - In the native (undisturbed) soils; and
    - In the gravel material, found in the utility trench

- Both water level and water temperature were monitored continuously at these sites.

7. Study Activities

Monitoring Work:

Groundwater - *Findings*

- Groundwater temperatures in the native soils do not vary greatly and are not affected by precipitation events.

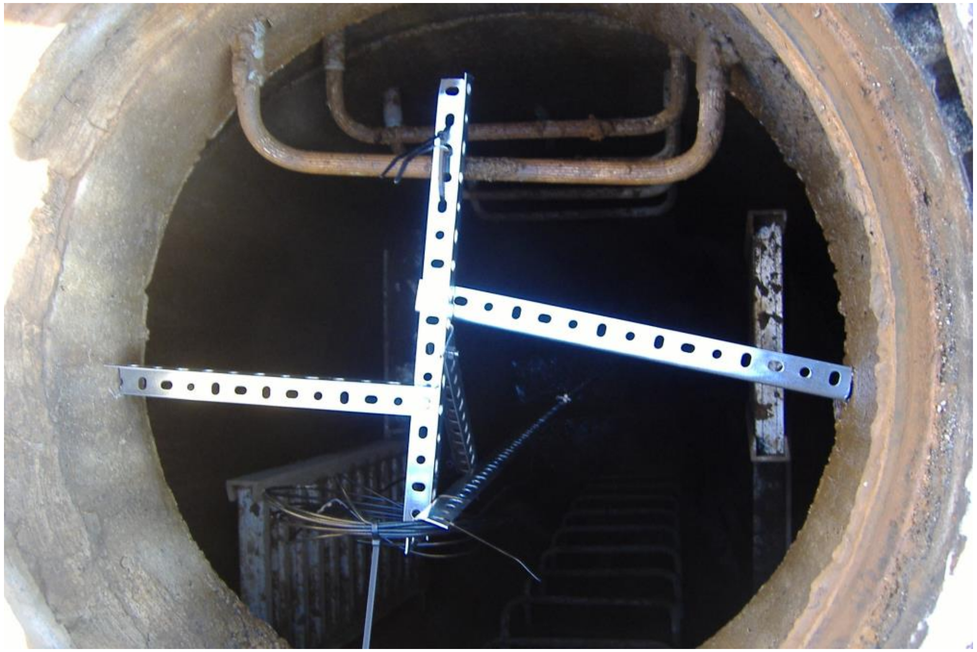
- The shallow groundwater levels in the native soils do not increase rapidly during precipitation events

- The permeability (ability to move water) of the granular materials in the utility trench is up to 10 million times greater than the native soil (confirmed and discussed further in the Analysis section)

7. Study Activities

Monitoring Work:

FDC and Storm Sewer System - *Activities*



- Water level monitoring gauges were installed to observe how water levels in these systems respond to storm events – also recorded temperature

- A total of 17 water level monitoring gauges were installed within the FDC sewer system across the study area

- Three (3) water level monitoring gauges were installed within the storm sewer system.

7. Study Activities

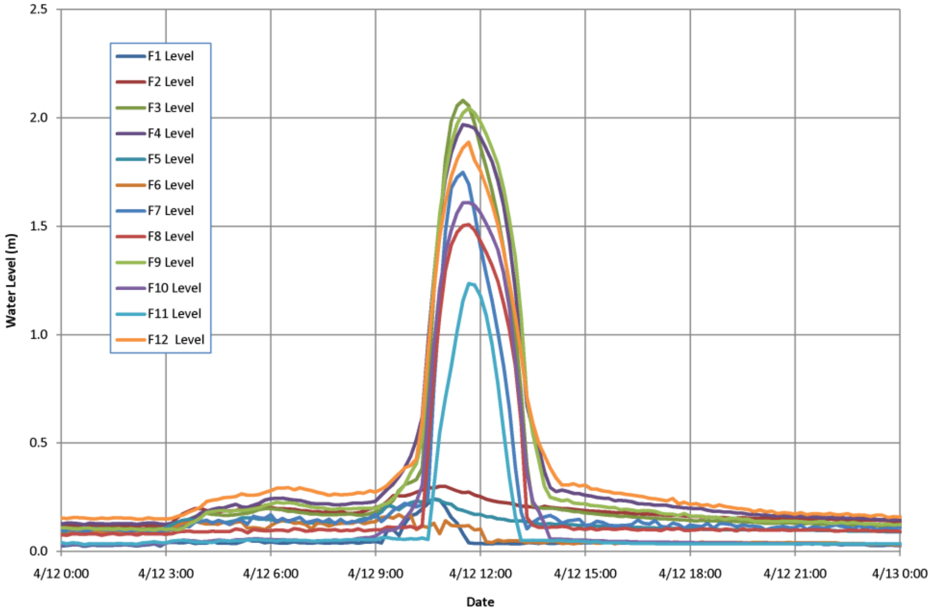
Monitoring Work:

FDC and Storm Sewer System - *Findings*

- The FDC system surcharges rapidly in response to rainfall events - occurs in different locations and amounts depending on the storm event

- Most prevalent along Black Walnut Trail and in the vicinity of Osprey Boulevard

- Strong indication that the excess water is coming from surface water sources rather than groundwater, based on:
  - Speed that FDC water level rises and falls
  - Water temperature signals



7. Study Activities

Monitoring Work:

Creek Tributary and Stormwater Management Pond – *Activities*

- Water level monitoring gauges were installed and monitored along the tributary of the east branch of Sixteen Mile Creek and within the Osprey Marsh Stormwater Management Pond

- Gauges were installed at five (5) different locations along the creek, as well directly within the pond

- A temporary rainfall gauge was also installed in the study area

7. Study Activities

Monitoring Work:

Creek Tributary and Stormwater Management Pond - *Findings*

- There is nominal creek flow from the GO Station channel, and no apparent connection between these flows and FDC surcharging

- There is no apparent connection between creek flows and FDC surcharging

- There is no apparent connection between water levels within the Osprey Marsh Stormwater Management Pond and FDC surcharging

GO Station

7. Study Activities

Testing Work:

Water Quality - *Activities*

- A sampling program was conducted to assess the chemical properties of the water found in the:
    - native soils (i.e. the groundwater);
    - utility trench (i.e. where the municipal services are);
    - creek;
    - Osprey Marsh Stormwater Management Pond; and
    - FDC system.

- Objective to identify any commonalities among the various different water sources

7. Study Activities

Testing Work:

Water Quality - *Findings*

- The water in the FDC system was found to be salt rich, similar to the utility trench, the tributary and the pond

- The water in the FDC system is therefore similar to surface water, and dissimilar to groundwater

- This similarity is particularly evident in winter conditions (road salt)

7. Study Activities

Testing Work:

Storm Sewer Leakage Testing – *Activities*

- Undertaken in 2013 at three sites where basement water infiltration occurred in the past

- Intent to confirm whether or not, under high flows, the storm sewer system would be expected to leak and contribute water to the utility trench

- Tests were comprised of:
  - *Blocking the storm sewers and filling them with water to replicate surcharge conditions*
  - *Addition of a safe green fluorescent dye to the storm sewer*
  - *Monitoring of the dye concentrations and water levels in the utility trench, groundwater and FDC system*

7. Study Activities

Testing Work:

Storm Sewer Leakage Testing - *Findings*

- At all three sites, the storm sewers leaked and at two sites the dye was detected in the FDC after only two hours

- Tests have proven that there is a flow path from the storm sewer to the FDC through the utility trench, with a response time consistent with that observed between ‘ideal’ storm events and instances of reported basement water infiltration

7. Study Activities

Testing Work:

Storm Sewer Outfall Collar Testing – *Activities*

- It was speculated that water from the creek or the Osprey Marsh Stormwater Management Pond could possibly move upstream through the storm sewer bedding at outfalls

- As a test, impermeable concrete collars were installed in the utility trench near the outfall of the storm sewers at two locations

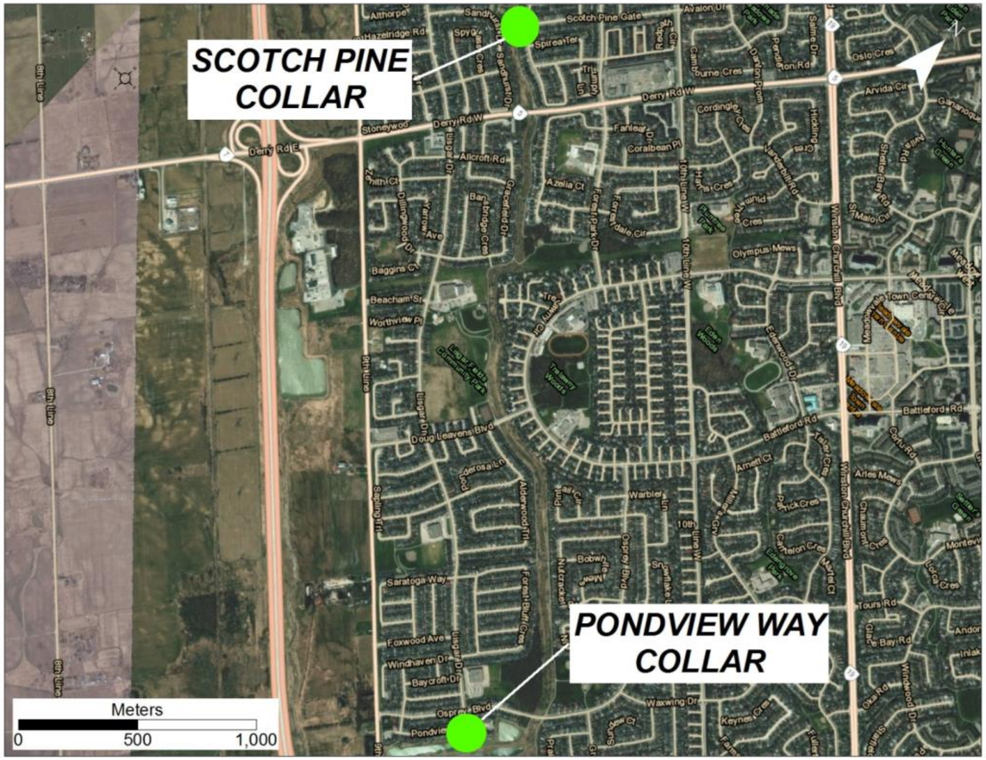
- These collars were installed with backflow valves that allow water from the utility trench to drain to the creek and pond, but not in the other direction

7. Study Activities

Testing Work:

Storm Sewer Outfall Collar Testing – *Findings*

- Monitoring is currently underway at both sites to assess the effectiveness of the collar in preventing elevated water levels in the utility trench



7. Study Activities

Analysis Work:

Groundwater - *Activities*

- Properties of native soils and granular materials measured at the groundwater monitoring sites (estimated using “slug” testing where a volume of water is either quickly added or removed to test response, as well as dye tracer tests and other analyses)

Groundwater - *Findings*

- As noted earlier, the permeability (ability to move water) of the granular materials in the utility trench is up to 10 million times greater than the native soils providing a ‘perfect’ pathway for water

7. Study Activities

Analysis Work:
Design Check of the FDC System – *Activities*

Three (3) Checks:

i. Comparison of the original number of intended residences to be served by the main FDC sewer system

ii. Comparison of original design sizes and slopes of the FDC sewers with as-constructed characteristics

iii. Verification of the design of the FDC trunk sewer (using original design approach), to determine if there is sufficient available capacity to handle expected flow rates

7. Study Activities

Analysis Work:
Design Check of the FDC System – *Findings*

- Some deficiencies have been identified in the as-constructed design of the FDC trunk sewer system which could impair the conveyance capacity of the FDC system; however none are considered to be the cause of basement water infiltration

- Observed FDC surcharging has been noted in areas which are a considerable distance from areas of identified FDC sewer deficiencies, which further confirms this finding

7. Study Activities

Analysis Work:

Computer Modelling of the FDC System – *Activities and Findings*

Q1: How much impact will high water levels at the downstream end of the FDC system (outlet) have on the Lisgar District?

A1: *Results show that high water levels downstream would have little impact on the FDC system performance within the Lisgar District, which further confirms that this is not a primary cause of FDC surcharging, although it may be a very limited contributing factor.*

Q2: How much potential impact would water draining into basement walkouts be expected to have on the FDC system?

A2: *Results show that based on the number of basement walkouts identified by City staff (and the estimated flows from those walkouts to the foundation drain), walkouts are not the primary cause of FDC surcharging, although they may be a contributing factor at specific locations.*

7. Study Activities

Analysis Work:

Computer Modelling of the FDC System – *Activities and Findings*

Q3: How much potential impact would storm sewer leakage have on the FDC system?

A3: *Results show that based on an average storm sewer leakage rate (calculated from the findings of the storm sewer leakage tests conducted in 2013), storm sewer leakage is the primary cause of FDC surcharging during storm events.*

Q4: Are there certain areas within the Lisgar District which contribute higher flows to the FDC system?

A4: *Based on the modelling results for an observed surcharge event in the FDC system along Black Walnut Trail, several areas have been identified as having much higher relative flow contributions to the FDC system. These identified areas are therefore considered a priority for the implementation of mitigation measures*

7. Study Activities

Analysis Work:

Computer Modelling of the FDC System – *Activities and Findings*

Q5: What measures would be most effective in reducing observed FDC surcharge?

A5: *Based on the modelling results for an observed surcharge event, two potential mitigation measures (which have been assessed using the model) have been shown to be effective at reducing FDC surcharge:*

FDC sewer upgrades - increasing the sizes of the deficient pipes to better carry higher flows and reduce surcharge; and
FDC pumping - actively pumping out the FDC during surcharge events to limit the amount of surcharging.

7. Study Activities

Summary and Conclusions:

Primary Cause – Stormwater to the Utility Trench

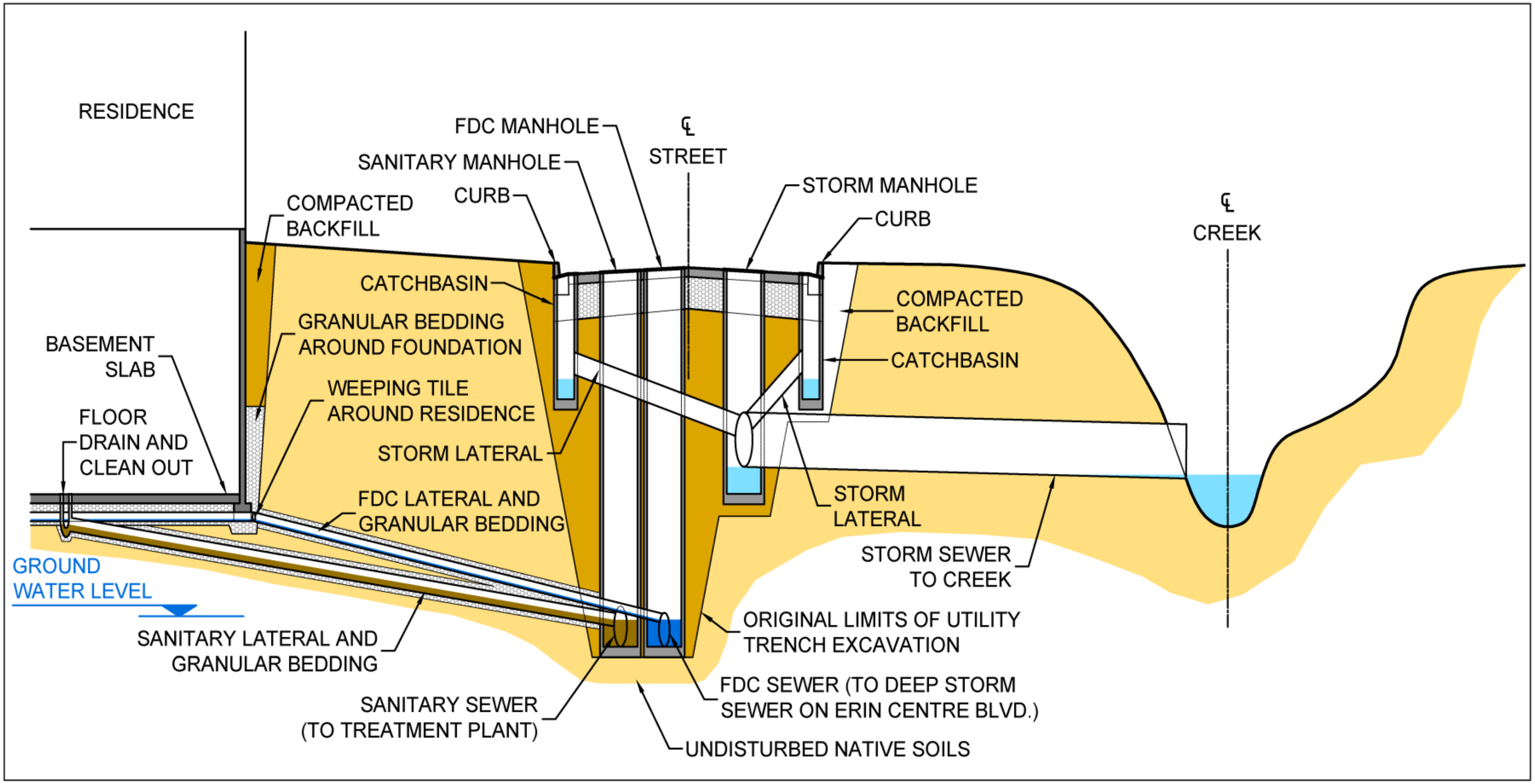
- Leakage from the storm sewer system (which is a normal and expected occurrence), combined with the presence of slow draining native soils (around the utility trench) results in water build-up
- If the build-up of water is significant, it travels up the bedding material around the Foundation Drain Collector (FDC) laterals servicing the homes and into the foundation weeping tiles
- Water then drains directly into the FDC pipes through the weeping tiles which can surcharge (overload) the system
- This condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage may lead to water around the home’s weeping tiles being unable to drain and potentially seeping into the basements of homes.

7. Study Activities

Summary and Conclusions:

Primary Cause – Stormwater to the Utility Trench

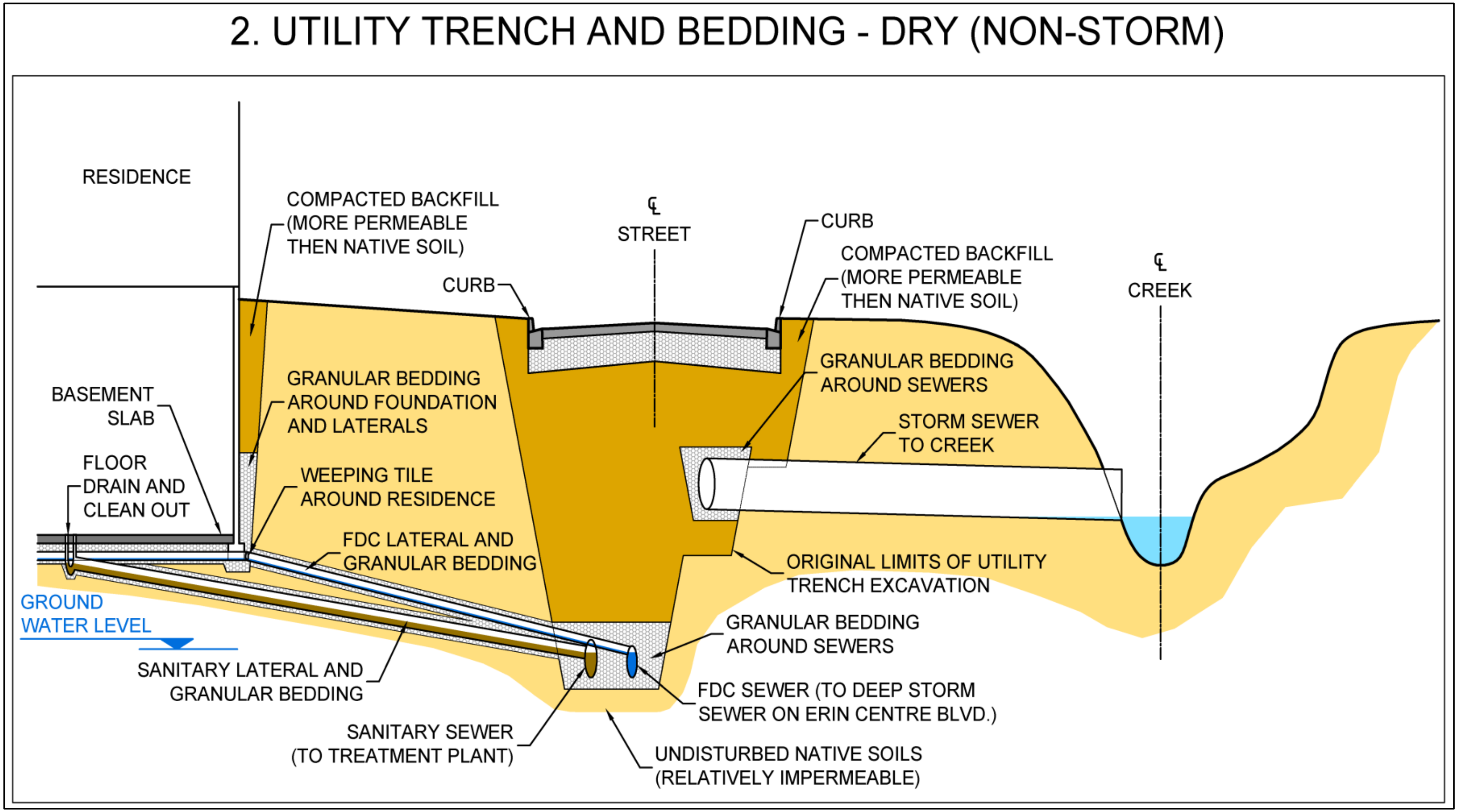
1. TYPICAL UTILITY TRENCH CROSS-SECTION



7. Study Activities

Summary and Conclusions:

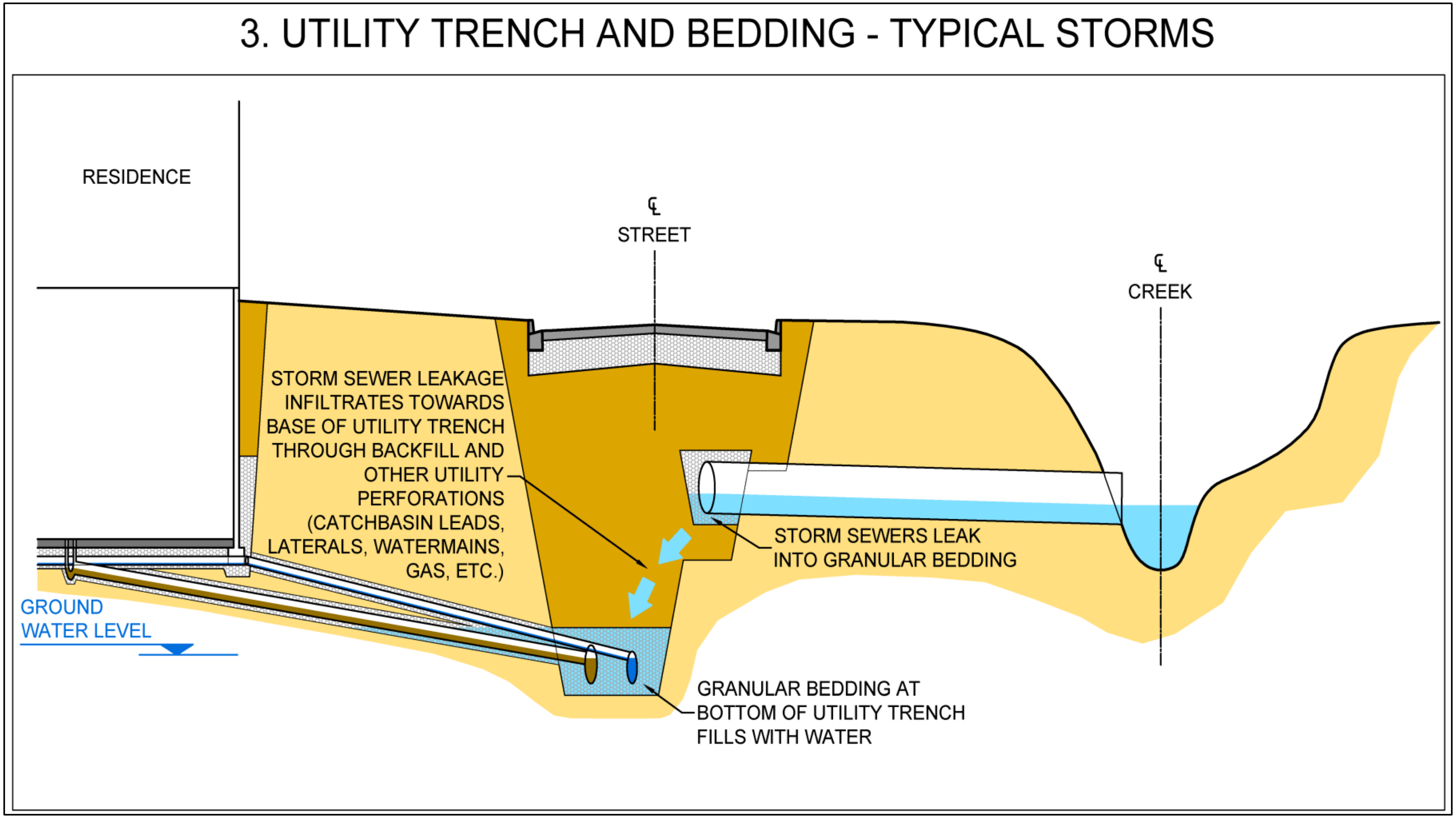
Primary Cause – Stormwater to the Utility Trench



7. Study Activities

Summary and Conclusions:

Primary Cause – Stormwater to the Utility Trench

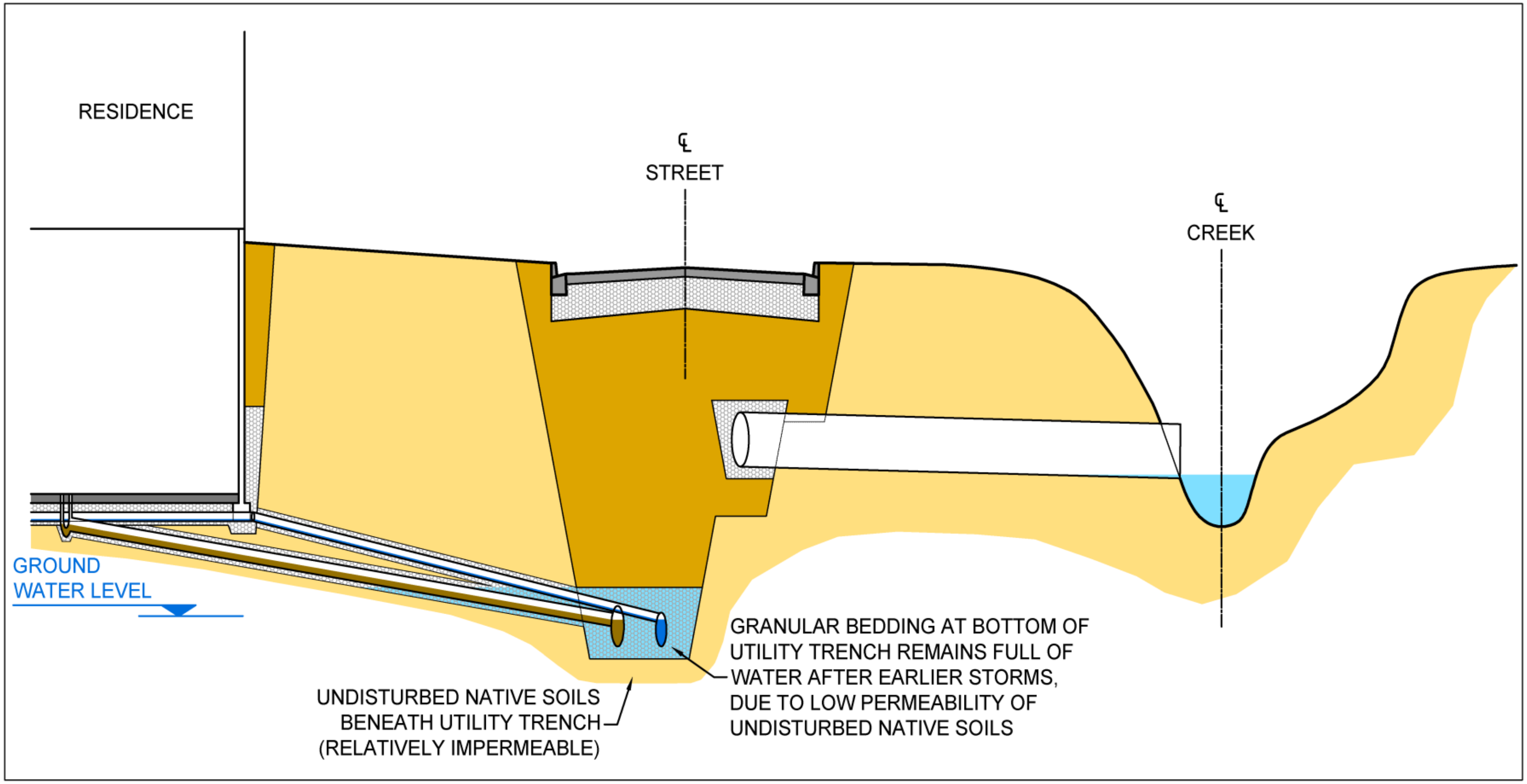


7. Study Activities

Summary and Conclusions:

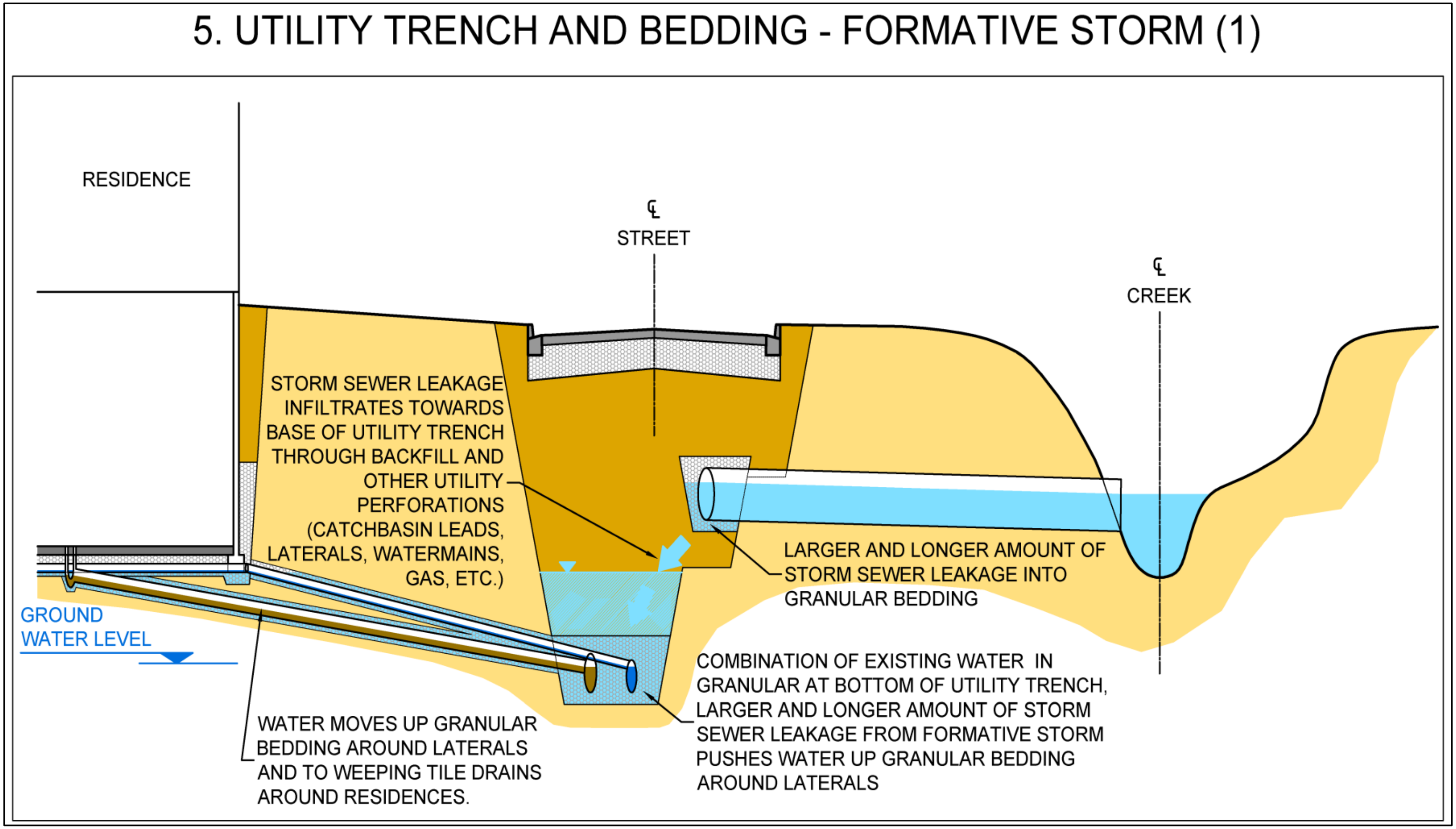
Primary Cause – Stormwater to the Utility Trench

4. UTILITY TRENCH AND BEDDING - TRENCH FILLED (INTER-STORM PERIOD)



7. Study Activities

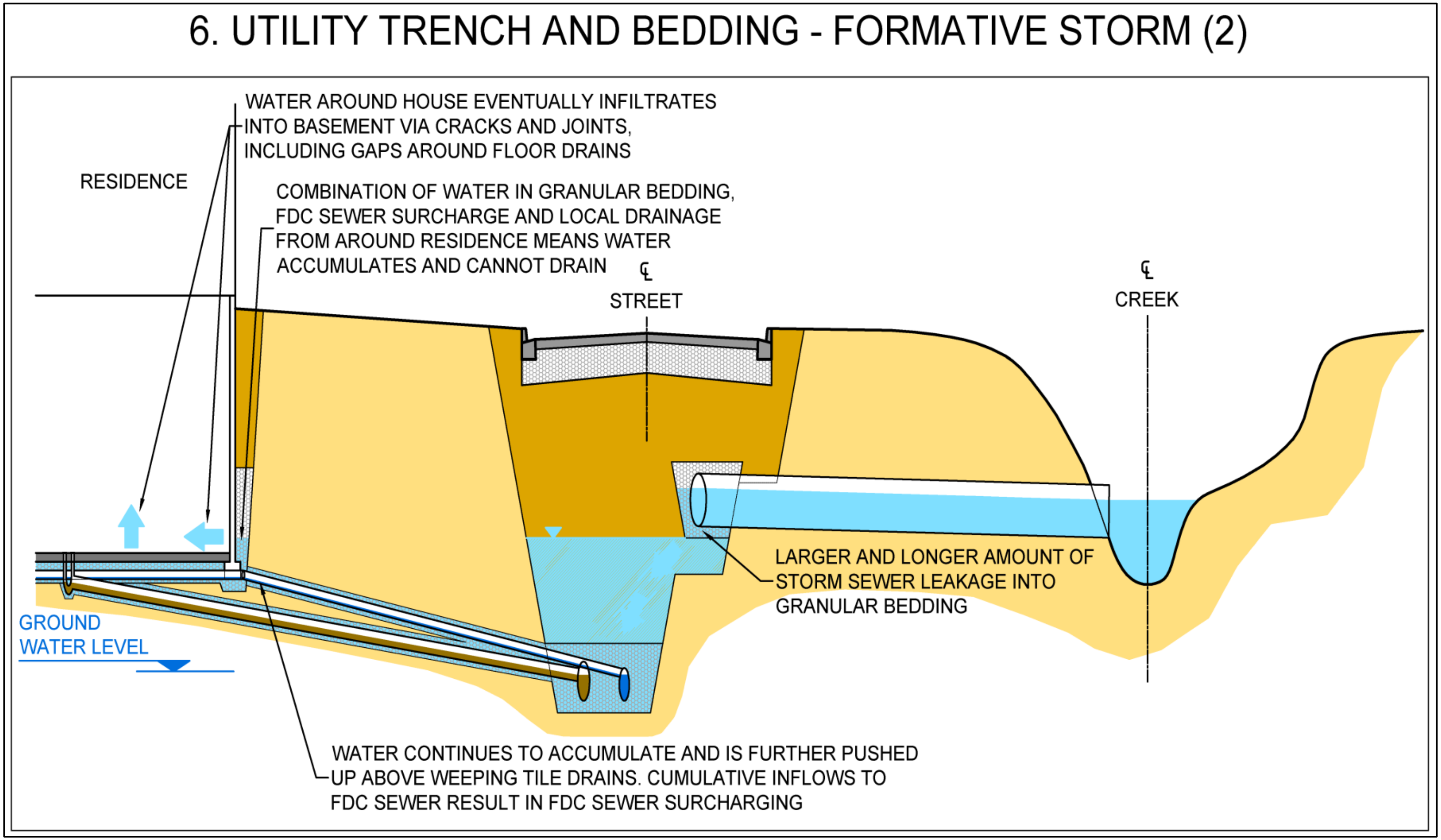
Summary and Conclusions:
Primary Cause – Stormwater to the Utility Trench



7. Study Activities

Summary and Conclusions:

Primary Cause – Stormwater to the Utility Trench



7. Study Activities

Summary and Conclusion: Assessment of Potential Factors

Potential Factor	Level of Influence
Stormwater to Utility Trench	Primary Cause
FDC and Utility Trench Depths	May increase risk of basement water infiltration at specific locations
Groundwater	May contribute additional flows to the FDC and utility trench (Not sufficient to cause problem)
Creek Backwater	
Osprey Marsh Pond (SWM) Backwater	
Basement Walkouts	
Inflow/Infiltration to FDC	
FDC Hydraulics	May affect conveyance capacity of FDC system (Not sufficient to cause problem)
FDC Design	
FDC Tailwater	
FDC Maintenance	
FDC Construction	
Cross-Connections	Not Applicable
Creek Maintenance	
GO Station	
Sanitary System	
Lot Grading	Insufficient information
Basement Construction / Changes	

8. Mitigation Plan

8. Mitigation Plan

Long List of Potential Alternatives:

Mitigation measures carried forward for further consideration:

1. *Strategic Lining of Storm Sewers*
2. *Construction of a Utility Trench Dewatering System*
3. *Construction of FDC Pumping Stations*
4. *FDC Sewer Upgrades*
5. *Sump Pumps*

Mitigation measures screened from any further consideration:

6. *FDC Backflow Preventers*
7. *Storage System*
8. *Storm Sewer Outfall Collars (pending results of monitoring)*
9. *Basement Walkout Covers*
10. *New FDC Outlet*
11. *Creek Remediation*

8. Mitigation Plan

Prioritized Action Plan:

These measures are recommended as the highest priorities for the City:

a) *Strategic lining of priority storm sewers to minimize leakage (capital cost estimated to be $8M - $9M)*

b) *Construction of a utility trench dewatering system.(capital cost estimated to be $3M - $4M)*

c) *Undertake additional monitoring to assess effectiveness of a) and b) (approximately $100,000)*

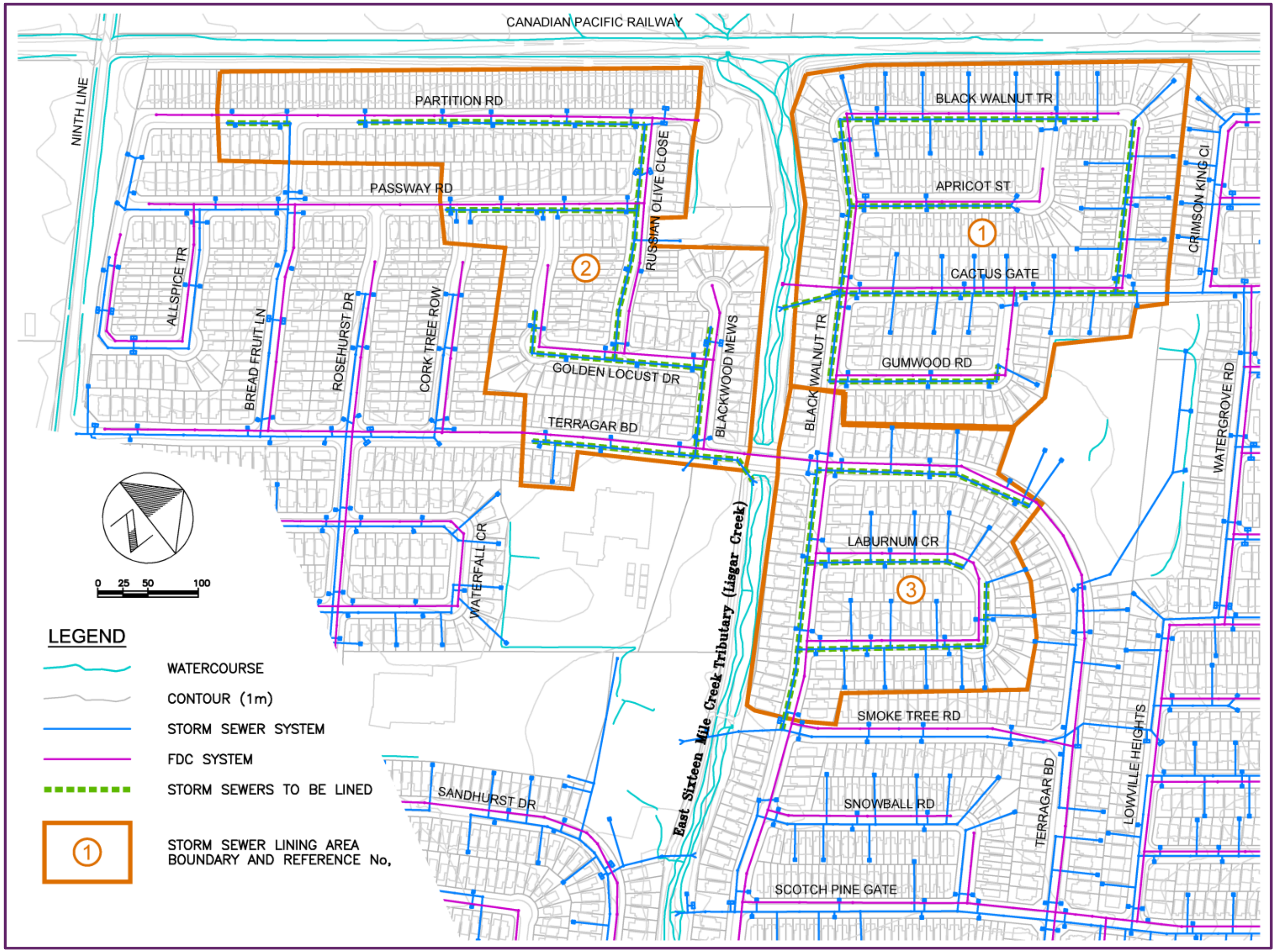
Other recommended actions may be staged over time, conditional on the results of the above, including:

a) *Building permanent FDC pumping stations for high flows (capital cost estimated to be $6M - $7M)*

b) *Replace deficient FDC pipe lengths when they reach the end of their engineered lifespan (capital cost estimated to be $2M - $3M)*

8. Mitigation Plan

Black Walnut Trail area – *Highest Priority*



8. Mitigation Plan

Prioritized Action Plan:

- It is also suggested that residents who qualify for the City's Lisgar District Sump Pump Subsidy Program take advantage of this program.
- To date, only 3 residents have applied to the program.
- The City will subsidize homeowners who install a sump pump up to 50% of the cost of the installation, to a maximum of $3,000
- Program details are available at: *http://www.mississauga.ca/portal/residents/lisgarsubsidy/*
- *Applications forms are available here tonight*

9. Recommended Next Steps

9. Recommended Next Steps

- A Corporate Report will be taken to General Committee on April 8th 2015 with recommendations planned for 2015 for General Committee's consideration

- Other potential mitigation measures may be considered as part of the 2016-2018 Business Planning process

10. Summary Report

10. Summary Report

- A copy of the Summary Report and tonight's presentation will be available tomorrow on the City's Lisgar Basement Water Infiltration Investigation webpage at: http://www.mississauga.ca/portal/residents/lisgarinvestigation/

Appendix B

Monitoring Reports (2015, 2016)

Lisgar District Basement Water Infiltration Study

2015 Monitoring Report

City of Hamilton

Prepared for:

City of Mississauga

Prepared by:

Amec Foster Wheeler
Environment & Infrastructure
3215 North Service Road
Burlington, ON L7N 3G2
(905) 335-2353

November 2016

Project No. TP115060

LISGAR DISTRICT BASEMENT WATER INFILTRATION STUDY
2015 MONITORING REPORT

CITY OF MISSISSAUGA

Submitted to:

City of Mississauga

Submitted by:

Amec Foster Wheeler Environment & Infrastructure
3215 North Service Road
Burlington, ON L7N 3G2

Tel: 905-335-2353
Fax: 905-335-1414

November 2016

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1. INTRODUCTION AND SCOPE

Amec Foster Wheeler initiated field monitoring activities in support of the Lisgar District Basement Water Infiltration study in late 2011 and early 2012. These monitoring activities were intended to collect data in order to better inform the understanding of the operational mechanisms of the drainage systems in the Lisgar District, and help identify the source(s) of the basement water infiltration occurrences in this neighbourhood.

Monitoring was conducted for the Foundation Drain Collector (FDC) sewer system, the storm sewer system, surface water (Lisgar Creek), as well as the groundwater system. A limited number of gauges were installed during this initial period. Based on discussions with City staff, a larger number of gauges were installed to supplement the initial gauge installations in mid-2012. Preliminary results from the initial 2012 monitoring were presented in memoranda to City staff on April 12, 2012, and September 26, 2012. The latter memorandum noted the first major monitored surcharge event on September 8, 2012. These results were also later presented to City staff and other team members at a presentation on February 22, 2013.

Monitoring works continued into 2013 and 2014, with additional gauges being installed based on the findings identified at that time, as well as direction from City staff. The findings of the 2013 monitoring year were presented to City staff in a memorandum (January 8, 2014). The monitoring work was invaluable in allowing the Team to better understand the drainage systems' response to storm events, and help lead the Team towards identifying the cause(s) of basement water infiltration. This work culminated in a public report and presentation (March 25, 2015) which summarized the findings of the multi-year monitoring effort and the resulting conclusions that were drawn from these data.

Subsequent to the Public Report and presentation in March 2015, the study's focus shifted towards remediation activities, in order to work towards mitigating the identified cause(s) of the observed basement water infiltration. Field monitoring activities have continued in parallel, in order to support these activities by assessing the effectiveness of mitigation works after implementation, and observed changes in drainage system performance over time.

This report has been prepared to summarize and document the findings of the 2015 monitoring year, both with respect to surface water (FDC, storm sewer, and open watercourses) and groundwater monitoring. Note that a separate memorandum was previously generated to summarize the results of the 2015 storm sewer leakage testing (January 29, 2016); a copy of this memorandum has been included in Appendix E for reference.

2. SURFACE WATER

2.1. Overview

Surface water monitoring gauges have been installed in key locations throughout the study area to monitor changes in both water levels, as well as water temperature. The number of surface water monitoring gauges has varied each monitoring year, as changes and adjustments have been made to the program, based on the findings of the previous year and the planned testing and remediation works. For 2015, a total of twenty-six (26) water level and water temperature gauges (Solinst^{TM} Leveloggers) were installed throughout the study area, including:

- Eighteen (18) gauges in the FDC sewer system
- Six (6) gauges in the storm sewer system
- Two (2) gauges in surface water features

Summary figures showing all of the above-noted surface water monitoring gauges are included in Appendix A, along with Table A1, which includes details of all of the gauges installed since the beginning of the monitoring program in 2011.

A total of four (4) new gauges were installed for the 2015 monitoring year, in order to support the proposed storm sewer lining works within the three (3) different lining areas in Black Walnut Trail (refer to Appendix A for a reference figure). The new gauges for 2015 include:

- F24 (FDC at Golden Locust Dr/Russian Olive Cl)
- S6 (Storm Sewer at Golden Locust Dr/Russian Olive Cl)
- S7 (Storm Sewer at Cactus Gate/Black Walnut Tr)
- S8 (Storm Sewer at Laburnum Cr/Black Walnut Tr)

Gauge F24 was added to the monitoring program to support the assessment of storm sewer lining in Area 2, as no previous monitoring of the FDC system had occurred in this area. Data from this gauge were also used to support storm sewer leakage testing (as documented in a separate memorandum; refer to Appendix E).

Storm Sewer gauges S6 to S8 were also added to assist with the storm sewer leakage testing process, as well as to attempt to quantify “pre-lining” storm sewer flow conditions (i.e. baseline), with the intent to compare these flows to “post-lining” conditions in the future.

All surface water monitoring gauges have typically employed a 5-minute logging time step, in order to ensure that any rapidly peaking storm events are adequately captured.

2.2. Results

Overall, the 2015 year was considered to be drier than average; observed monthly precipitation totals from nearby City and Environment Canada gauges are presented in Table 2.1, along with the associated 1981-2010 climate normals.

Table 2.1. 2015 Observed Climate Data

Month	1981-2010 Climate Normal for Pearson Airport (mm)	Observed Precipitation for 2015 (mm)		
		Environment Canada (Pearson Airport)	City Gauge 11 (Ninth Line/CNR)	City Gauge 7 (Britannia/Erin Mills)
January	51.8	31.4	19.4	19.6
February	47.7	31.2	7.4	13.2
March	49.8	14.3	7.2	8.6
April	68.5	78.8	64.0	45.2
May	74.3	62.8	65.6	36.6
June	71.5	160.2	112.8	111.8
July	75.7	24.4	52.6	29.2
August	78.1	61.6	45.6	55.2
September	74.5	62.0	54.2	59.4
October	61.1	67.6	74.6	66.4
November	75.1	35.4	33.0	24.6
December	57.9	45.6	38.6	32.2
TOTAL	**785.9**	**675.3**	**575.0**	**502.0**

Annual precipitation totals were below average by some 14% to 36% depending on the gauge location. Monthly precipitation totals were consistently near or below average for all months with the exception of June (which well exceeded the monthly average at all gauge locations), and October (which slightly exceeded the monthly average).

These observed precipitation trends are reflected in the surface water monitoring data for the Lisgar District, which indicate minimal surcharging of the FDC system during 2015, with the exception of a few notable events.

As in previous years, observed FDC surcharging is primarily restricted to the area north of Derry Road (Black Walnut Trail), and in particular tends to be restricted to gauges F5 and F1, which lie directly along the FDC trunk sewer on Black Walnut Trail (refer to Appendix A for a location plan).

In general, F1 tends to indicate an elevated static water level throughout. During measurements on July 2, 2015, upstream gauge F5 had a measured depth of 0.03 m, and downstream gauge F6 had a measured depth of 0.02 m. However the measured depth in F1 was approximately 0.10 m. Although the locations have differing pipe diameters and slopes, a reasonably consistent depth of water would be expected. The reason for the difference is currently unclear, but could be related to the more frequent occurrences of observed surcharge at this location. All three (3) locations (F5, F1, and F6) were also noted to have plastic and debris on the gauges, which is unexpected given that the FDC system is essentially a closed system meant to receive drainage solely from residential weeping tiles.

FDC surcharge was identified primarily for the storm events of July 7, August 20, and September 19, 2015 at those locations north of Derry Road; a more detailed discussion of these events follows. A minor surcharge was noted for gauge F1 only, for the events of May 10 and May 30, 2015, however given the isolated nature of those events, they have not been discussed further herein. Rainfall data for the primary three (3) events are presented in Table 2.2. Water level and water temperature response graphs are included in Appendix A.

Table 2.2. Rainfall Data for Key Surcharge Events

Storm Date	Rainfall Source	5-Day Antecedent Rainfall (mm)	Duration of Event (hours)	Depth of Event (mm)	Peak 5-Minute Intensity (mm/hr)
July 7, 2015	City Gauge 11 (Ninth Line/CNR)	12.8	1.6	15.2	52.8
	City Gauge 7 (Britannia/Erin Mills)	0.2	1.6	11.4	38.4
August 20, 2015	City Gauge 11 (Ninth Line/CNR)	4.6	0.3	0.6	2.4
	City Gauge 7 (Britannia/Erin Mills)	7.8	1.1	7.6	50.4
September 19, 2015	City Gauge 11 (Ninth Line/CNR)	0	0.9	16.4	57.6
	City Gauge 7 (Britannia/Erin Mills)	0	0.7	10.0	50.4

July 7, 2015

A minor surcharge was observed on July 7, 2015, at approximately 16:40 (daylight savings time). Based on the rainfall data presented in Table 2.2, this event was not typical of a thunderstorm type event, with a depth of approximately 15 mm over 1.6 hours. Surcharge was noted at locations F5 and F1; the surcharge appears to have abated by the time flows reach the next downstream gauge (F6). The magnitude of surcharge was not particularly large; 0.40 m at F5 (0.25 m sewer pipe) and 0.57 m at F1 (0.375 m pipe). The surcharge was rapid in nature, and rising and falling in less than an hour, suggesting a direct surface water connection. Water temperature data indicate a clear rise, clearly suggesting surface water sources, as established in previous investigations.

For locations downstream of Derry Road, although FDC water levels peak in response to the storm event, there was no surcharge indicated.

August 20, 2015

The FDC system surcharge observed on August 20, 2015 occurred at approximately 10:00 (daylight savings time). Based on the rainfall data presented in Table 2.2, this event was again not particularly significant, with a depth of approximately 8 mm over 1.1 hours (the closer gauge 11 recorded only a negligible amount of rainfall). Surcharge was noted at locations F5 and F1; and the surcharge appeared to have abated by the time flows reached the next downstream gauge (F6). The magnitude of observed surcharge was approximately the same at both F5 and F1 (1.13 m), which is significant given the pipe sizes (0.25 m and 0.375 m respectively). A surcharge was also indicated for gauge F14 of 0.55 m, as compared to the 0.20 m pipe size. The surcharge was again rapid in nature, rising and falling in less than an hour, suggesting a direct surface water connection. Water temperature data for surcharging sewers indicate a clear rise, again suggesting surface water sources.

For locations downstream of Derry Road, although FDC water levels peaked in response to the storm event, there was no surcharge indicated.

September 19, 2015

The FDC system surcharge observed on September 19, 2015 occurred at approximately 15:00 (daylight savings time). Based on the rainfall data presented in Table 2.2, this event was a typical thunderstorm type event, with a depth of approximately 16 mm over less than an hour. Surcharge was noted at locations F5 and F1; and the surcharge appeared to have abated by the time flows reached the next downstream gauge (F6). The magnitude of observed surcharge was slightly higher at F1 than F5 (1.16 m as compared to 1.04 m) which is significant given the pipe sizes (0.25 m and 0.375 m respectively). A minor surcharge was also indicated for gauge F14 of 0.37 m, as compared to the 0.20 m pipe size. The surcharge was rapid in nature, rising and falling in less than an hour, suggesting a direct surface water connection. Water temperature data for surcharging sewers indicated a clear rise, again suggesting surface water sources.

For locations downstream of Derry Road, gauge F3 (immediately downstream of Doug Leavens Boulevard) did indicate surcharging for this event, to a maximum depth of 0.73 m (pipe diameter of 0.525 m). This surcharge was eliminated however at the next downstream gauge (F4). Periodic surcharging of this location (F3) has been noted in previous years; it is again somewhat counterintuitive given that the surcharge observed at gauges north of Derry Road had abated based on the upstream gauge (F2). This suggests another input of surface water in between these two locations, or some type of blockage or obstruction. Phase 2 of the storm sewer lining works (Doug Leavens Boulevard, Alderwood Trail, and Osprey Boulevard) could potentially address these issues; further monitoring in 2017 will be required to confirm this condition.

2.3. Conclusions and Recommendations

Continuously elevated static water levels were noted at gauge F1; this location (along with gauges F5 and F6) were also noted to have repeated surcharge in 2015, consistent with observations from previous years. Plastic and debris were also noted on these gauges during field observations in 2015.

The continued surcharge and elevated levels in this specific area (Black Walnut Trail north of Derry Road) continues to be a concern. The responses observed in 2015 are extremely rapid, consistent with previous observations years, and continue to suggest a direct surface water connection. Peak rainfall intensity appears to be the primary driver for surcharge in these locations, unlike some surcharge events in previous years which were observed to be as a result of longer lasting, higher depth events. Sewer trench water levels may have also been a factor, as discussed in further detail in Section 3 of this report.

The pending storm sewer lining and utility trench dewatering work for this area may result in a change in characteristics in 2017; this will be monitored as remediation activities progress. It may also be possible that there is a localized source of direct runoff in this location – such as rooftop downspouts connected directly into the residential weeping tile, which would cause the rapid localized response, as evident from the monitored results.

City staff may therefore consider conducting a field inspection of residences in this area (Black Walnut Trail) to confirm whether or not any such direct connections can be observed and remediated. In addition, a repeat CCTV inspection of this section of the FDC sewer should be considered, in order to identify any changes in dry weather inflow points, debris, or other potential issues.

FDC surcharge was also observed for the F3 monitoring location (south of Doug Leavens Boulevard) for the September 19, 2015 storm event. Similar to other locations, this surcharge was rapid and is consistent with observations from previous years. Pending storm sewer lining in 2017 for the Phase 2 area may address this issue; further monitoring will confirm this matter. Given its location on the trunk FDC and the contributing drainage areas, a field assessment for direct connections of potential stormwater runoff would likely be too complex to complete. A repeat CCTV inspection could however be considered by City staff for this section to re-confirm that there are no obvious blockages or extraneous sources of water inflow evident.

3. GROUNDWATER

3.1. Overview

Groundwater monitoring has been undertaken on a continuous basis through 2015 for seventeen (17) piezometers. Monitoring has comprised both water level and temperature data, and a 10 minute recording interval has been used similar to monitoring undertaken in 2012, 2013 and 2014. The main groundwater monitoring sites that had data recorded are:

- Cactus Gate (Area 1)
- Golden Locust Drive (Area 2)
- Smoke Tree Road / Laburnum Crescent (Area 3)
- Scotch Pine Gate
- Osprey Boulevard
- Alderwood Trail
- Pondview Way

The details of all piezometer installations can be found in Table B1 (Appendix B). Figure B1 shows the locations of all the groundwater monitoring sites. Detailed location maps for each site are shown in Appendix C and six month hydrographs (January 2015 – June 2015; July 2015 – December 2015) for the monitoring sites at Cactus Gate, Golden Locust Drive, Smoke Tree Road, Scotch Pine Gate, Alderwood Trail, Osprey Boulevard and Pondview Way are shown in Appendix D.

The monitoring undertaken for Area 1 [Apricot 1 (A1), Cactus Gate 2 (CG2) and Cactus Gate 3 (CG3)], Area 2 [Golden Locust 1 (GL1), and Golden Locust 2 (GL2)] and Area 3 [Laburnum 1 (L1), Smoke Tree 1 (ST1) and Smoke Tree 2 (ST2)], as defined in the Summary Report (March 2015) has previously been discussed in the memorandum describing the results of the storm sewer leakage tests (dated January 29, 2015 – refer to Appendix E for a copy), however, these have been considered further in light of the FDC surcharging events recorded on August 20, 2015 and September 19, 2015 (as discussed in Section 2 of this report, and discussed further in Section 3.2 with respect to groundwater impacts).

Overall groundwater levels and sewer trench water levels in 2015 have been consistent with monitoring undertaken during the preceding three years. For the groundwater level monitoring this summary considers in more detail:

- Water levels during the two main surcharging events in 2015 (August 20, 2015 and September 19, 2015);
- The performance of the storm sewer collars that were installed at Pondview Way and Scotch Pine Gate towards the end of 2014.

The one (1) year of data post collar installation is considered enough to allow a good assessment the performance of the collars at both these sites.

3.2. Groundwater Levels during Surcharging Events

The FDC surcharging on August 20, 2015 and September 19, 2015 was mostly recorded in the FDCs to the north of Derry Road, as described in Section 2 of this report. The hydrographs shown in Appendix D have both the August and September, 2015 FDC surcharging events indicated. With the exception of the Cactus Gate site, it is noteworthy that none of sewer trench piezometers show excessively elevated water levels during the surcharging events. For example, higher water levels were recorded in most sewer trench piezometers for the large rainfall event on the October 27-28, 2015.

Figure B2 shows a detailed hydrograph of the Cactus Gate sewer trench piezometers with both surcharge events and rainfall from the City of Mississauga Britannia Gauge (Gauge 7). The maximum water levels attained in the sewer trench piezometers after rainfall are reasonably consistent, regardless of when surcharging has occurred. The main difference is in the antecedent water levels; surcharging has tended to occur when antecedent water levels have been above 200 meters above sea level (masl) at Cactus Gate from preceding precipitation events.

Since the installation of the sewer trench piezometers at Cactus Gate (Area 1), Golden Locust Drive (Area 2) and Smoke Tree Road / Laburnum Crescent (Area 3), there is now a far greater coverage of water levels in the sewer trenches across the Lisgar District. It is hence possible to identify with more confidence where the build-up in the sewer trench water levels is contributing to the surcharging. The data collected in 2015 indicate that FDC surcharging on August 20, 2015 and September 19, 2015 has originated from build-up of water in the sewer trenches in the Cactus Gate area (Area 1).

These findings are noteworthy given the results presented in Section 2, which did not indicate much antecedent rainfall, and that rainfall intensity appears to have been the primary driver as compared to previous events which were based more on higher depths and antecedent rainfall amounts. Ultimately, the observed surcharging in this area may be due to some combination of these potential causes, however there is greater evidence to suggest the role of elevated water levels in sewer trenches as the primary contributing factor.

3.3. Monitored Performance of Impermeable Collars

3.3.1. Methodology

Groundwater level, temperature and conductivity data and water quality data have provided information that creek water (or water from the Osprey Marsh SWMF) could flow up the sewer trench during larger precipitation events. This is a source of water to the sewer trench system in addition to the storm sewer leakage that could ultimately contribute to surcharging in the FDC system. Impermeable collars were therefore installed at the Scotch Pine Gate and Pondview Way sites in the fall of 2014 with the purpose of assessing their effectiveness in preventing flow up the sewer trench from Sixteen Mile Creek and the Osprey Marsh storm water management facility (SWMF). Copies of the design drawings have been included in Appendix B for reference.

3.3.2. Overview of Collar Construction

During Phase 3 of the investigation, ‘impermeable’ collars were installed during the period October 29 and November 13, 2014 at the Scotch Pine Gate and Pondview Way sites. The following installations were completed at the two sites:

- Sewer trench piezometers up and downstream of the proposed collar prior to collar installation to collect background groundwater level data prior to installation at the Pondview Way site. Appropriately located sewer trench piezometers had already been installed in 2011 / 2012 at the Scotch Pine Gate site;
- A concrete collar around the sewer which is deeper and wider than the sewer trench and therefore forms an effective barrier for flow up the sewer trench. Concrete has a hydraulic conductivity that is likely lower than 1E-10 m/s and therefore considerably lower than the hydraulic conductivity of the surrounding Halton Till. For the purposes of the present investigation the collar can therefore be regarded as impermeable;
- Backflow valves in the concrete collar that allow flow towards the creek when water levels in the sewer trench are higher than creek water levels. The backflow valves close when water levels in the creek are higher than the water levels in the sewer trench; and
- Installation of collar piezometers in the clear stone bedding of the inflows (i.e. upstream) and outflows (i.e. downstream creek side) of the backflow valves to provide a means of measuring the performance of the backflow valves.

Detailed design drawings used for construction are included in Appendix B.

3.3.3. Scotch Pine Gate Collar

Construction at Scotch Pine Gate entailed the excavation of earth around the single 975 mm diameter concrete storm sewer, placing wood forms around the sewer, installation of backflow values through the forms, placement of concrete in the forms, stripping the forms from the concrete, backfill of gravel, then compacted silty clay material to finished grade.

The constructed concrete collar at Scotch Pine Gate is approximately 2 m in height (approximately 0.5 m below and above the concrete storm sewer), 1.1 m thick and 2.8 m wide. Three backflow valves were installed: two deep backflow valves with one on each side situated at the base elevation of the storm sewer to allow normal flow towards the creek, and one additional shallow backflow valve which was situated at the mid-point elevation of the storm sewer to allow additional flow towards the creek under high water conditions. Figure B3 shows the completion of the collar. The upstream and downstream sewer trench piezometers are Scotch Pine 2 (SP2) and Scotch Pine 5 (SP5) respectively and the upstream downstream collar piezometers are Scotch Pine 7 (SP7) and Scotch Pine 8 (SP8) respectively. The 2015 water levels for all four (4) piezometers are shown in Appendix D, which show that the water levels are almost identical for these piezometers. Figure B4 shows a more detailed hydrograph with observed rainfall data (City of Mississauga Gauge 7) for the summer of 2015, when surcharging occurred in the FDC north of Derry Road. Again there is no discernable difference between any of the water levels even during the surcharge events. Noticeably higher water levels on the downstream side of the collar would be expected if flow to the sewer trench from the Sixteen Mile Creek was significant, particularly during the two surcharge events. However, it is likely that leakage on either side of the collar equalizes water levels across this feature. Presently it would appear that leakage from the storm sewer is a more significant contributor to water quantities in the sewer trench than flow up the sewer trench itself directly from Sixteen Mile creek. Nevertheless, sealing of the storm sewer at Scotch Pine Gate might indicate that the collar has a positive function in reducing water levels in the sewer trench. Lining of the storm sewers in this area (Scotch Pine Gate) is not immediately planned, however should potentially be considered in the future. Monitoring of the impermeable collar should continue should this lining work ultimately proceed.

3.3.4. Pondview Way Collar

Construction at Pondview Way was similar to Scotch Pine Gate, however, Pondview Way has three sewers: a 1200 mm × 1500 mm elliptical concrete storm sewer; a 300 mm PVC sanitary sewer and a 375 mm FDC sewer. The sanitary and FDC sewers are quite deep (3.5 m +\-) as compared to the shallower storm sewer (2.3 m +/-); the resulting spacing created a much larger excavation than at Scotch Pine Gate. The constructed concrete collar at Pondview Way is approximately 3.5 m high (approximately 0.5 m below the FDC and 0.5 m above the concrete storm sewer), 1 m thick and 10 m wide. Six backflow valves were installed; three deep backflow valves at the base elevation of the FDC sewer, one at the base elevation of the sanitary sewer, one at the base elevation of the storm sewer to allow normal flow towards Osprey Marsh SWM Facility and one additional shallow backflow valve which was situated near the top of the storm sewer to allow additional flow towards the facility under high water conditions. Figure B3 shows the completion of the collar.

Figure B5 shows the water levels measured in the sewer trench piezometers before and after the installation of the impermeable collar. The upstream piezometer (Pondview 1 (PV1)) located in the FDC sewer trench has not shown any notable change since the installation of the collar. The downstream piezometer (Pondview 4 (PV4)) has shown a permanent drop in water level of approximately 15 to 20 cm following completion of the collar.

Figure B6 shows a long-section of the Pondview Way collar with a post-completion water level profile for all the piezometers. This shows water level drawdown in the FDC sewer trench towards the collar both on the upstream and downstream side. As the water level at Osprey SWMF is lower than that in the FDC sewer trench, it is indicating depressurization of the FDC bedding and upward flow to the storm sewer trench from where it flows to the Osprey SWMF. This strongly suggests that the silty clay fill in the storm sewer trench is of low enough hydraulic conductivity to confine the water in the FDC sewer trench. The cross-connection between the FDC and storm sewer trench occurs via the clear stone that has been placed either side of the collar to ensure that all the backflow valves are hydraulically connected to optimize flow through the collar when water levels in the sewer trench are higher than at Osprey SWMF.

The installation has caused a permanent, passive dewatering of the sewer trench. However, the construction has also cross-connected the storm sewer with the FDC sewer trench on the downstream pond side; a connection that did not exist prior to the installation of the collar. Under high water level conditions in the pond, it is now possible for water to flow from the pond to the FDC sewer bedding on the downstream side. However, the collar itself would prevent any potential migration of this water further upstream.

The water levels for all four piezometers are shown in Appendix D, which show that the passive dewatering of the FDC sewer trench that occurred after the installation of the collar has been maintained throughout 2015. The water levels are shown in more detail on Figure B7 during the summer of 2015 when surcharging occurred in the FDC north of Derry Road. Again under these conditions, dewatering of the FDC sewer trench is maintained during the surcharging events, which is not surprising as no surcharging was observed around Pondview Way in the FDC.

The full record for the Pondview Way piezometers (Appendix D) shows that the water levels on the downstream side on occasion do equal those on the upstream side. This occurs when the water levels in the Osprey SWMF are high. The present monitoring does not indicate that this is an adverse effect, particularly as upstream and downstream pre-collar water levels in the FDC sewer trench were the almost the same.

Overall, it can be concluded that the Pondview Way collar has had some beneficial effects that locally cause lower water levels in the FDC sewer trench. However, this is not caused by the prevention of flow up the sewer trench from the Osprey Marsh SWMP, but rather by passive dewatering of the FDC sewer trench due to an enhanced connection with Osprey Marsh SWMF.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

The following conclusions are made based on the results from the 2015 monitoring with respect to observed surcharge events:

i. FDC surcharging was observed in the area north of Derry Road in 2015 (Black Walnut Trail); in particular the area around gauges F1 and F5. Surcharging was most notable for storm events on August 20, 2015 and September 19, 2015. Surcharging at this location is consistent with observations from previous years.
ii. FDC surcharging was also noted further downstream (Doug Leavens Boulevard) at gauge F3 for the September 19, 2015 storm event only. This is consistent with observations from previous years.
iii. Observed FDC surcharging was rapid and peaked in response to short, higher intensity storm events (with depths of approximately 15 mm) with minimal antecedent rainfall. Although this rapid response is consistent with previous annual monitoring observations, the lack of antecedent rainfall and response to more intense rainfall as compared to higher depth, longer duration events is noteworthy. The results again suggest a rapid, direct connection to the FDC system from surface water sources.
iv. With the installation of the eight (8) new sewer trench piezometers in 2015 there is now a much greater coverage of sewer trench water levels across the Lisgar District. The data collected indicate that FDC surcharging on August 20, 2015 and September 19, 2015 has originated from the build-up of water in the sewer trenches in the Cactus Gate area (Area 1).

The following conclusions are made based on the results from the 2015 monitoring with respect to the performance of the constructed impermeable collars:

a. The Scotch Pine Gate collar does not presently provide any benefit in reducing water levels in the sewer trenches. It is possible that lining of the storm sewer at the Scotch Pine Gate collar may show that the collar may act to reduce water levels in the sewer trench during higher rainfall periods;
b. The Pondview Way collar provides some benefit in reducing water levels in the FDC sewer trench. However, the mechanism is by passive dewatering of the pre-installation confined FDC sewer trench, by connecting it with the storm sewer trench and the Osprey SWMF through the clear stone placed as part of the collar installation. No noticeable benefits in reducing water levels upstream of the collar have been observed during larger precipitation events by preventing flow up the sewer trench from Osprey Marsh SWMF;

4.2. Recommendations

The following recommendations are made based on the 2015 monitoring:

i. Present surface water and groundwater level monitoring should be continued throughout the period of planned remediation works in 2016 and 2017 (storm sewer lining and utility trench dewatering), in order to assess the effects on reducing water levels in the sewer trench.

ii. The City should consider undertaking a field assessment of the area of observed surcharge (Black Walnut Trail), in order to further assess the potential for any direct connection from impervious areas to the FDC system (such as directly connected downspouts or basement walkouts), given the repeated surcharging in this area. Although elevated trench water levels have been demonstrated to be a primary cause, potential additional direct connections should also be further reviewed.

iii. The City should consider undertaking a repeat CCTV inspection of the FDC sewer in this area of Black Walnut Trail as well as the localized area around Doug Leavens Boulevard. This could potentially be deferred until the completion of storm sewer lining works along Black Walnut Trail (scheduled for completion by the end of 2016), in order to also assess any differences resulting from storm sewer lining works.

iv. The City should consider lining the storm sewer in the immediate vicinity of the Scotch Pine Gate collar to provide a final assessment of the utility of this structure in reducing water levels in the sewer trench. This could also benefit observed instances of FDC surcharging in this area, and would be logical given the number of observed instances of basement water infiltration in this area. Storm sewer lining in this location could include a larger area along Black Walnut Trail and related side streets downstream of the limits of the current (2016) storm sewer lining (Smoke Tree Road).

4.3. Closure

We trust the foregoing to be satisfactory. Please do not hesitate to contact our office should you wish to discuss further.

Yours truly,

Amec Foster Wheeler Environment & Infrastructure
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Appendix A

Surface Water Monitoring Data

TABLE A1 - SUMMARY OF SURFACE WATER MONITORING GAUGES

Phase/Year	Drainage System	Gauge ID	UTM X	UTM Y	Initial Install Date	Uninstall Date	Notes
1 (2012)	Barologger	Barologger	598476	4825803	11-Jan-12	ongoing	For barometric data correction - installed at F2 location
	FDC	F1	597990	4826331	11-Jan-12	ongoing	Black Walnut Trail between Smoke Tree and Laburnum
		F2	598476	4825803	11-Jan-12	ongoing	Along creek just south of Derry
		F3	599310	4824853	11-Jan-12	ongoing	Along creek just south of Doug Leavens
		F4	600203	4823931	11-Jan-12	ongoing	Along berm of Osprey Marsh
		F5	597775	4826540	07-Jun-12	ongoing	Black Walnut Trail at Gumwood Road
		F6	598220	4826060	07-Jun-12	ongoing	Black Walnut Trail between Spirea and Wild Cherry
		F7	599191	4824895	07-Jun-12	18-Jun-13	Along creek just north of Doug Leavens. Relocated as part of Phase 2 works (F19)
		F8	599702	4824567	07-Jun-12	ongoing	Between Alderwood Trail and Creek, along trailway
		F9	600162	4824161	07-Jun-12	18-Jun-13	Along creek just north of Osprey. Relocated as part of Phase 2 works (F20)
		F10	600003	4823833	07-Jun-12	ongoing	Lisgar Drive at Pondview Way
		F11	599820	4823522	07-Jun-12	14-Jun-13	Along Ninth Line at edge of Osprey Marsh. Relocated as part of Phase 2 works (F21)
		F12	600019	4823259	05-Jul-12	ongoing	Along Ninth Line just north of Britannia
		F13	597765	4826668	18-Oct-12	12-Dec-12	Cactus Gate just east of Black Walnut Trail - temporary gauge to monitor local surcharge, re-installed in late 2013
		F14	597651	4826662	18-Oct-12	12-Dec-12	Black Walnut Trail at Apricot - temporary gauge to monitor local surcharge, re-installed in late 2013
		F15	598198	4826230	18-Oct-12	12-Dec-12	Scotch Pine just east of Black Walnut Trail - temporary gauge to monitor local surcharge
	Storm Sewer	S1	598115	4826109	07-Jun-12	ongoing	Last MH before outfall to creek off of Scotch Pine
	Surface Water	GO Channel	597435	4826700	09-Aug-12	12-Dec-12	Within tributary GO Channel just usptream of main branch
		Rail	597551	4826643	12-Jul-12	12-Dec-12	Within main branch just south of CNR
		Scotch Pine	598088	4826087	12-Jul-12	12-Dec-12	Within main branch just upstream of storm sewer outfall
		Osprey	600156	4824156	23-Jul-12	12-Dec-12	Within main branch just upstream of Opsrey Boulevard
	Rain Gauge	Lisgar Middle School	598714	4825132	23-Jul-12	12-Dec-12	On roof of Lisgar Middle School
2 (2013)	FDC	F13	597765	4826668	29-Oct-13	ongoing	Cactus Gate just east of Black Walnut Trail - previously used location, used to monitor local surcharge
		F14	597651	4826662	29-Oct-13	ongoing	Black Walnut Trail at Apricot - previously used location, used to monitor local surcharge
		F16	601061	4823685	05-Jun-13	ongoing	McDowell Drive by public school - intended as background data for "normal" FDC outside of Lisgar area
		F17	601087	4822271	20-Jun-13	ongoing	Along Trunk FDC (Ninth Line) by Deepwood Heights
		F18	602075	4821872	20-Jun-13	ongoing	Trunk FDC along Erin Centre just upstream of confluence with trunk storm sewer
		F19	598584	4825216	18-Jun-13	ongoing	Re-located F7 - Gracefield Drive just east of Lisgar Drive
		F20	600223	4824113	18-Jun-13	ongoing	Re-located F9 - along Osprey Boulevard just upstream of trunk FDC
		F21	599485	4824307	14-Jun-13	ongoing	Lisgar Drive between Alderwood and Forest Bluff - FDC splitter MH
		F22	598229	4825996	08-Oct-13	11-Oct-13	Short-term gauge for October 2013 sewer leakage test - along creek at Black Walnut\Wild Cherry
		F23	599261	4824995	29-Oct-13	05-Dec-14	Trelawny Circle at Doug Leavens Boulevard - added to address surcharge issues. Removed due to gauge malfunction
	Storm Sewer	S2	599655	4824555	05-Jun-13	30-Apr-14	Storm sewer along walkway off corner of Alderwood Trail - removed in 2014 due to malfunctions
		S3	602162	4821894	20-Jun-13	ongoing	Trunk Storm Sewer along Churchill Meadows just south of Erin Centre
		S4	598258	4826026	08-Oct-13	11-Oct-13	Short-term gauge for October 2013 sewer leakage test - along creek at Black Walnut\Wild Cherry
	Surface Water	Rail	597551	4826643	15-May-13	05-Dec-13	As per Phase 1 location, re-installed in 2013
		Scotch Pine	598088	4826087	09-Apr-13	05-Dec-13	As per Phase 1 location, re-installed in 2013
		Alderwood	599742	4824578	04-Jun-13	29-Oct-13	Installed to provide creek data coincidental with storm, FDC, and GW monitoring at Alderwood
		Osprey (Creek)	600156	4824156	09-Apr-13	05-Dec-13	As per Phase 1 location, re-installed in 2013
		Osprey Marsh SWM	599906	4823462	09-Apr-13	05-Dec-13	Within Osprey Marsh SWM pond near outlet
		16MC Trib	599848	4823256	09-Apr-13	05-Dec-13	Within channel (16 MC Trib) downstream of Osprey Marsh SWM
	Rain Gauge	Lisgar Middle School	598714	4825132	17-Apr-13	22-Nov-13	Gauge actually pulled in December, but no useable data past Nov 22nd (snow)
3 (2014)	Storm Sewer	S5	600036	4823797	10-Oct-14	ongoing	New gauge installed at Pondview Way to support impermeable collar monitoring work
	Surface Water	Scotch Pine	598088	4826087	10-Oct-14	05-Dec-14	Same as previous locations, re-installed late in 2014 to support impermeable collar monitoring work
		Osprey Marsh SWM	599906	4823462	02-Apr-14	05-Dec-14	Same as previous locations, re-installed in 2014 to support impermeable collar monitoring work
4 (2015)	FDC	F24	597687	4826452	02-Jul-15	ongoing	Installed to support storm sewer lining and pre-lining leakage tests - area 2 (Golden Locust Dr at Russian Olive Close)
	Storm Sewer	S6	597626	4826377	09-Jul-15	24-Nov-15	Installed to support storm sewer lining and pre-lining leakage tests - area 2 (Golden Locust Dr at Russian Olive Close)
		S7	597706	4826583	09-Jul-15	18-Aug-16	Installed to support storm sewer lining and pre-lining leakage tests- area 1 (Cactus Gate at Black Walnut Trail)
		S8	597687	4826452	20-Jul-15	24-Nov-15	Installed to support storm sewer lining and pre-lining leakage tests - area 3 (Laburnum Cr at Black Walnut Trail)
	Surface Water	Scotch Pine	598088	4826087	27-May-15	25-Nov-15	Same as previous locations, re-installed late in 2015
		Osprey Marsh SWM	599906	4823462	27-May-15	25-Nov-15	Same as previous locations, re-installed late in 2015

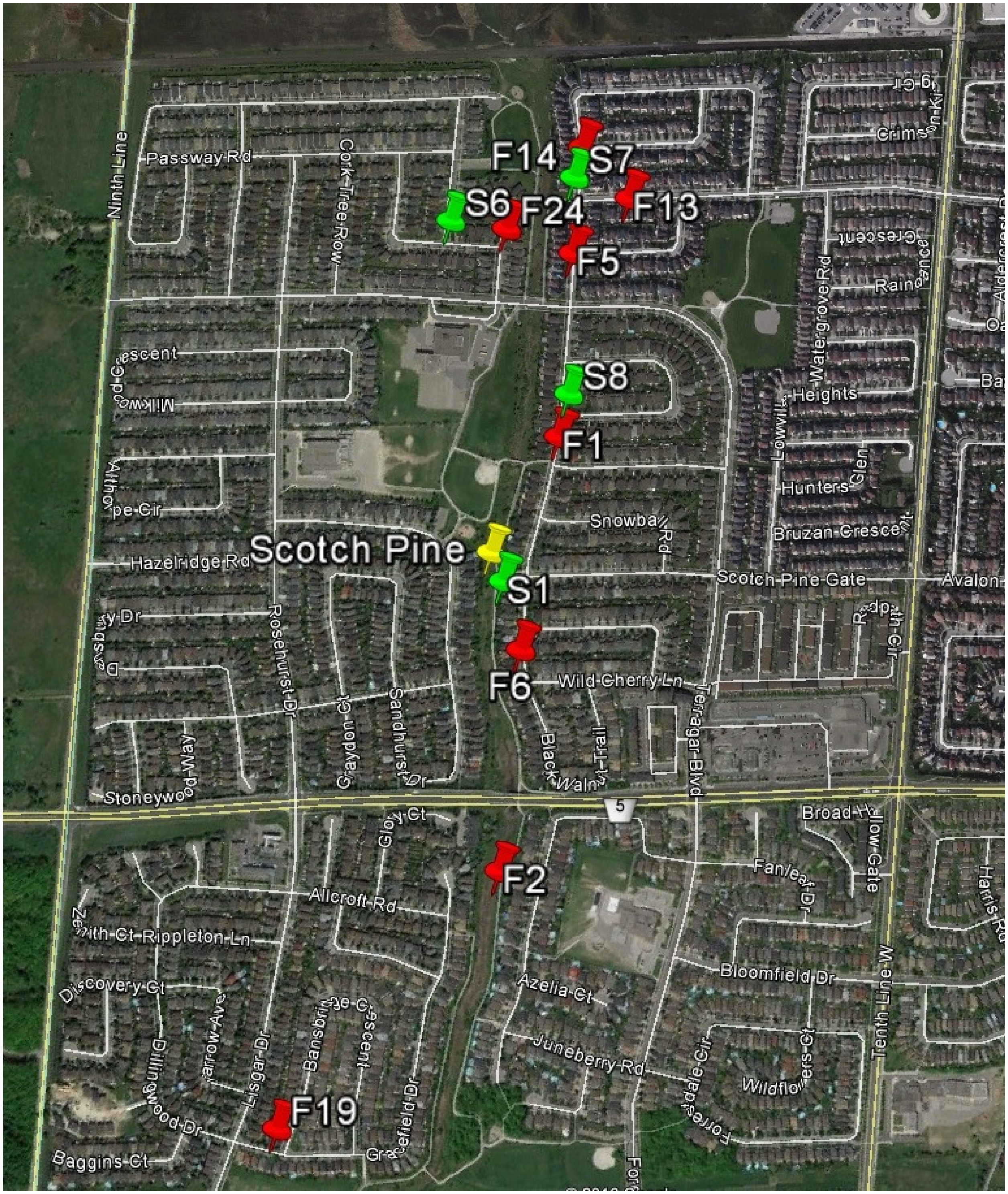


Figure A1: Surface Water Monitoring Gauges near Derry Road and CNR

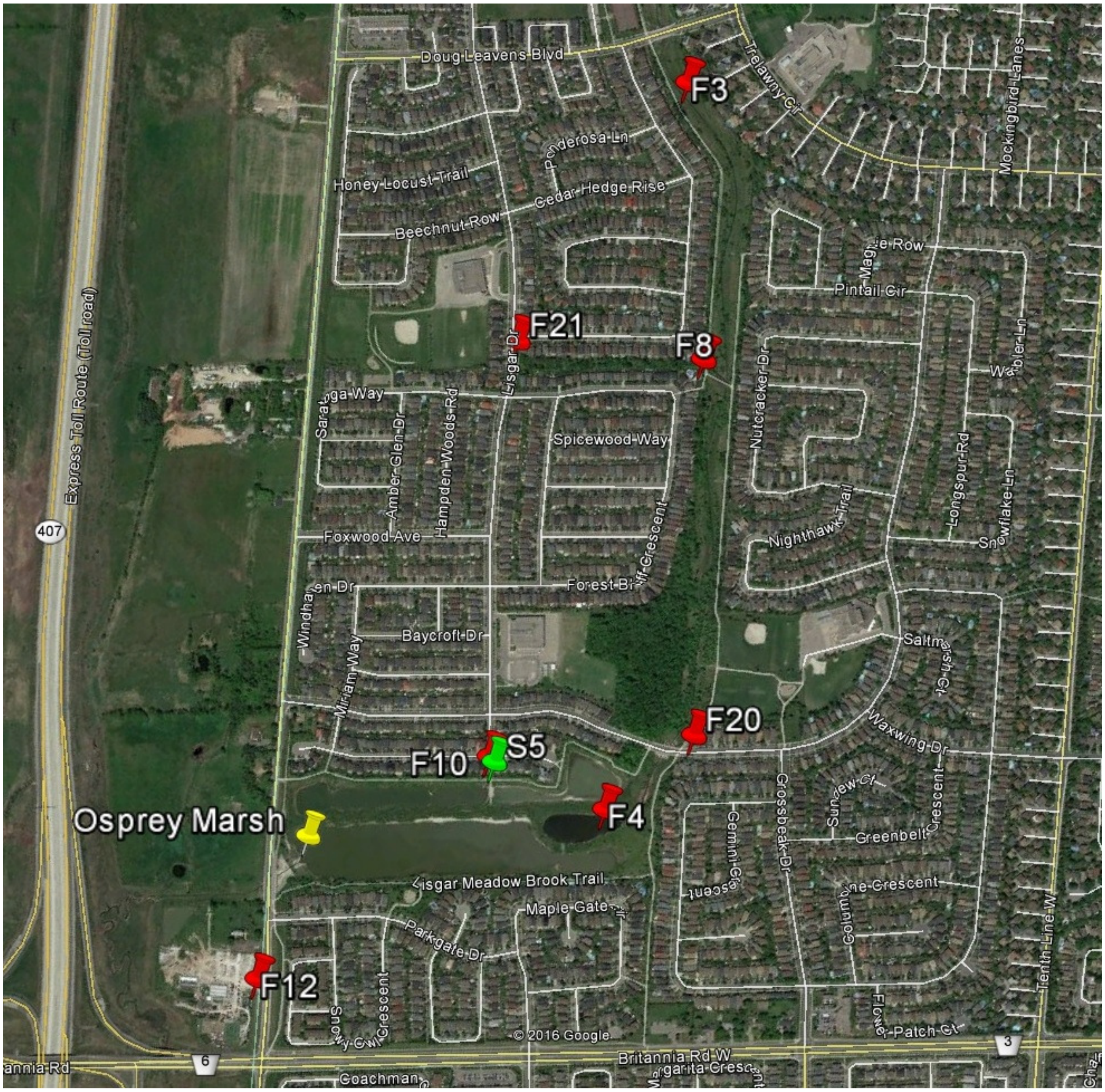


Figure A2: Surface Water Monitoring Gauges between Derry Road and Britannia Road

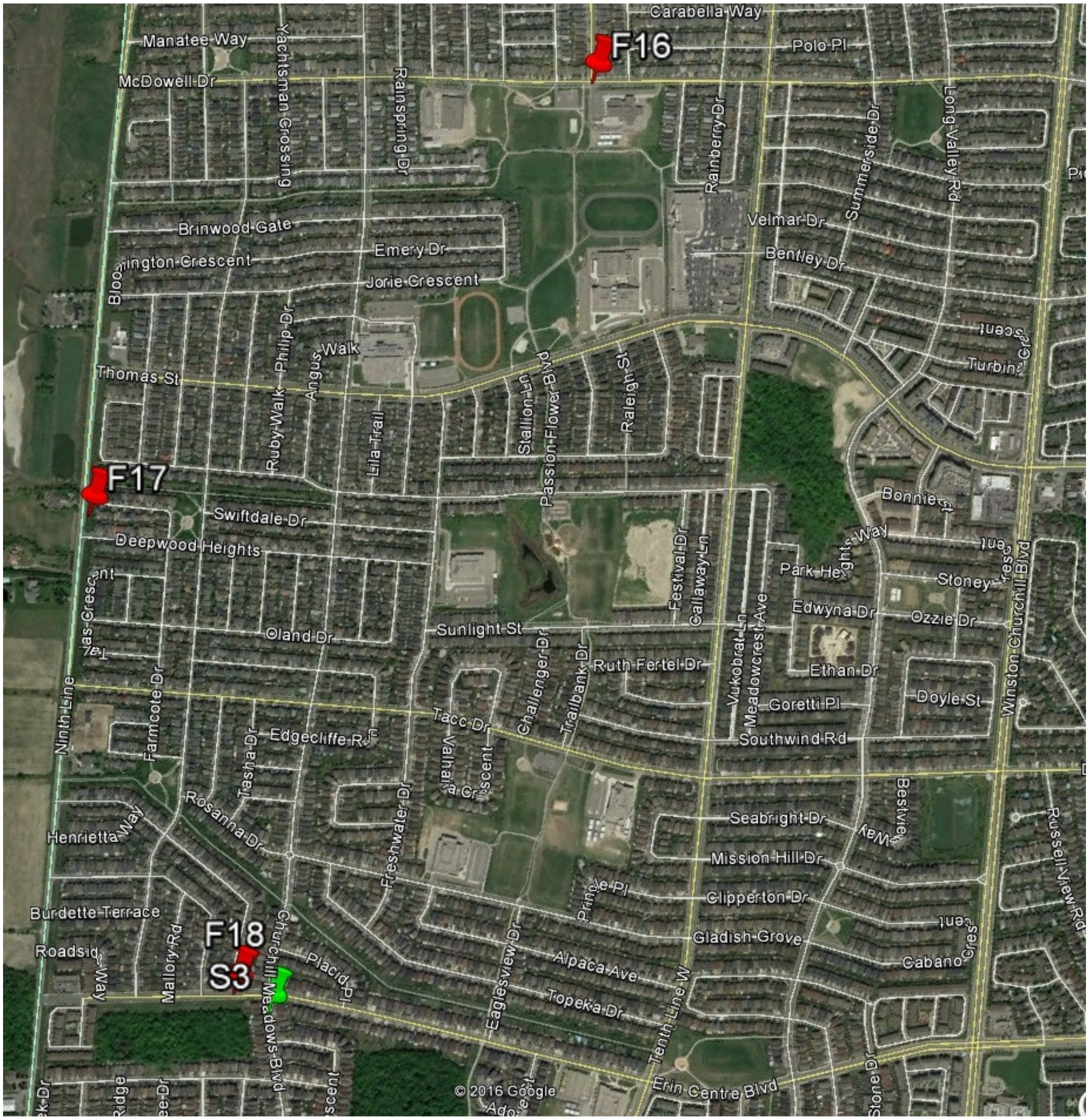
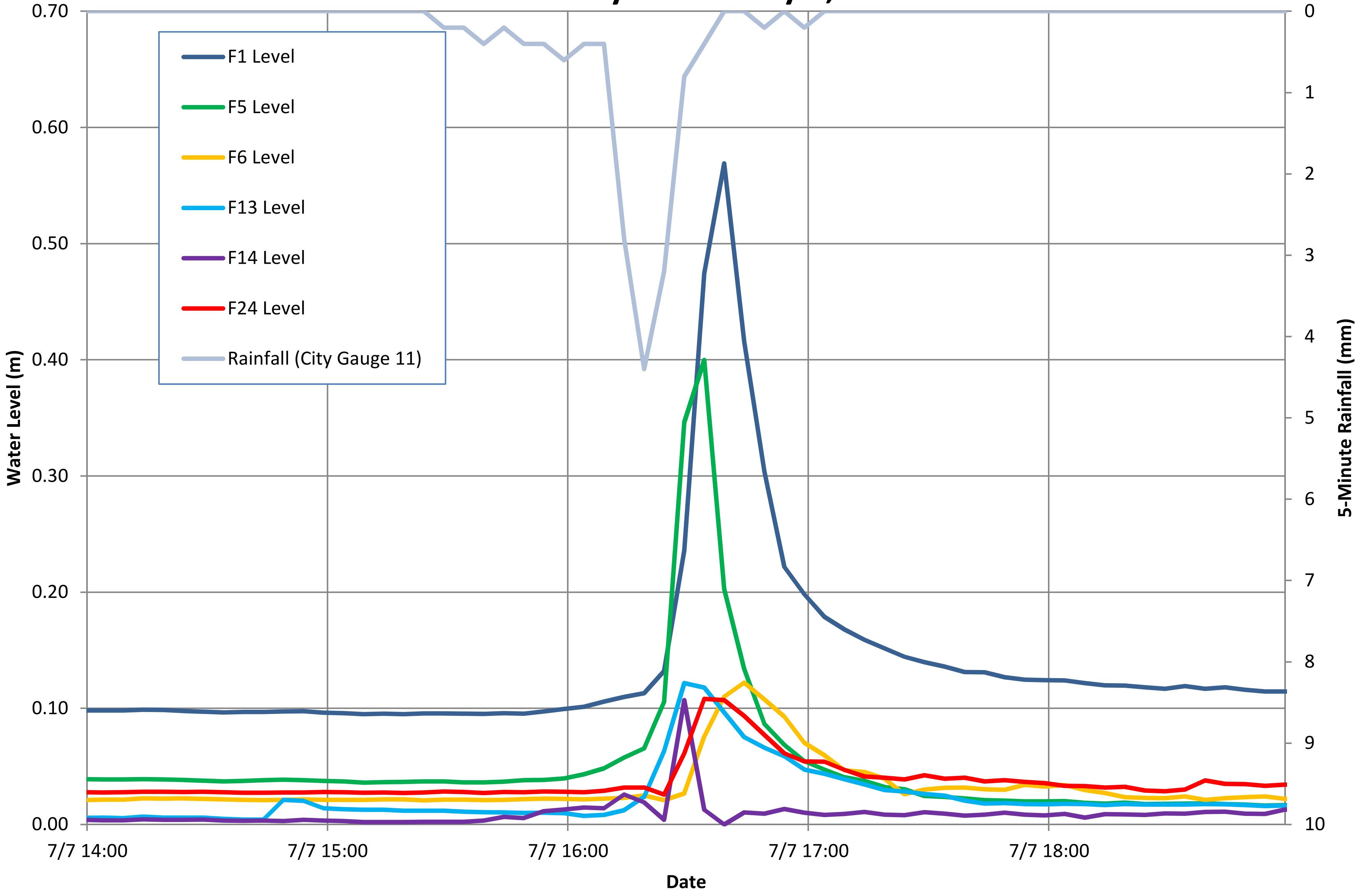


Figure A3: Surface Water Monitoring Gauges south of Britannia Road

Figure A4: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - July 7, 2015



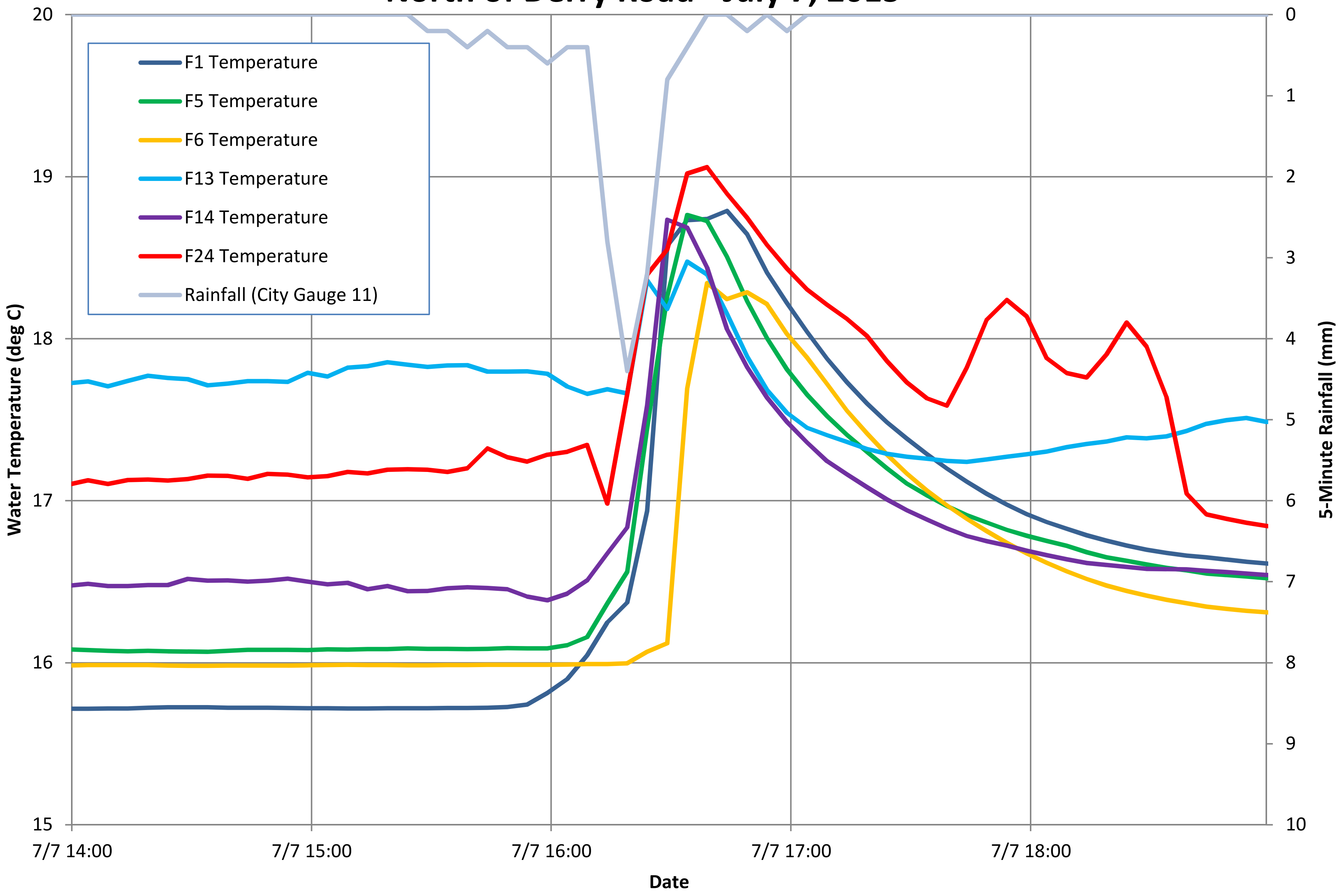


Figure A5: Observed Water Temperature at FDC Monitoring Sites
North of Derry Road - July 7, 2015

Figure A6: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - August 20, 2015

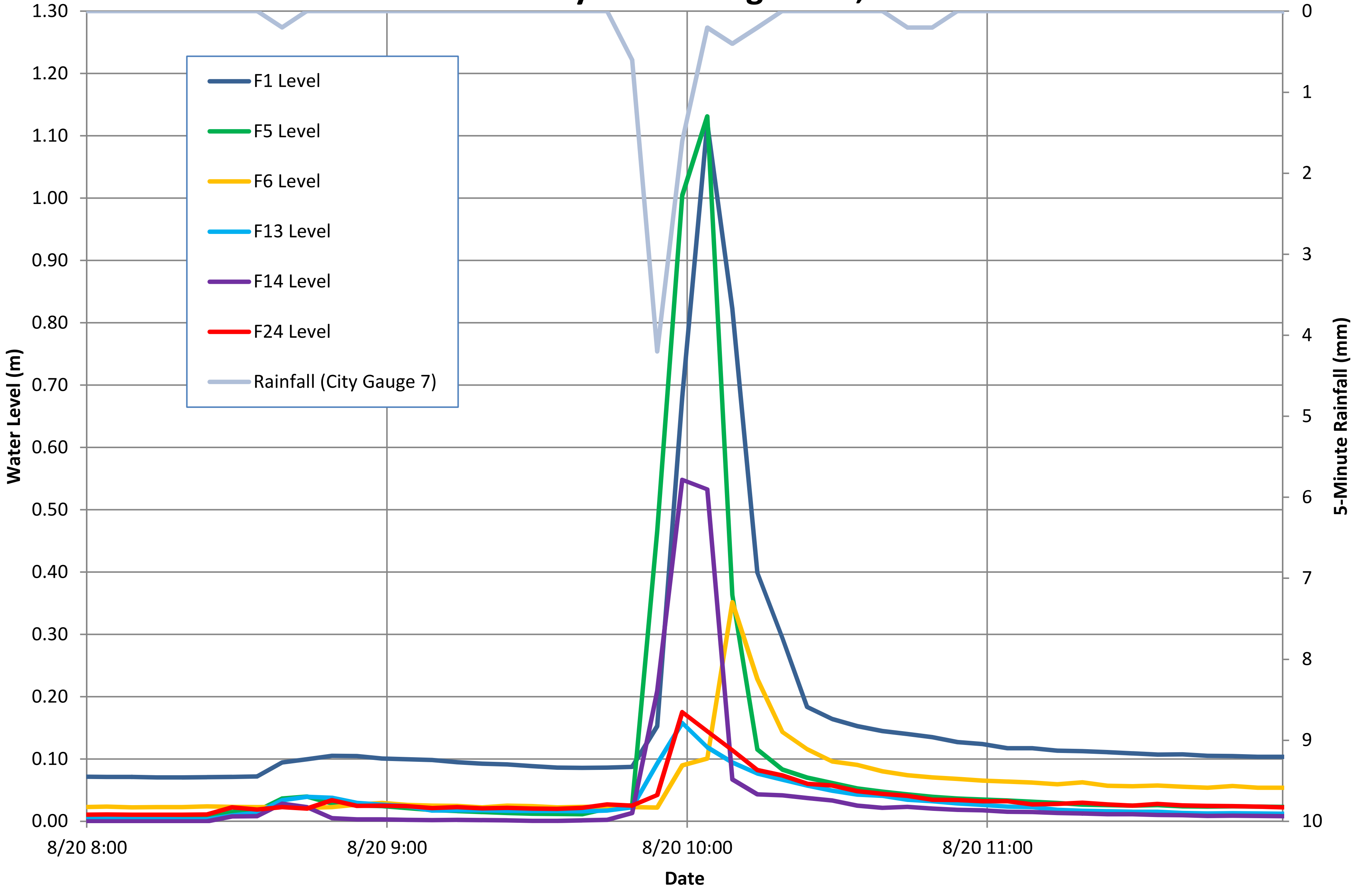


Figure A7: Observed Water Temperature at FDC Monitoring Sites North of Derry Road - August 20, 2015

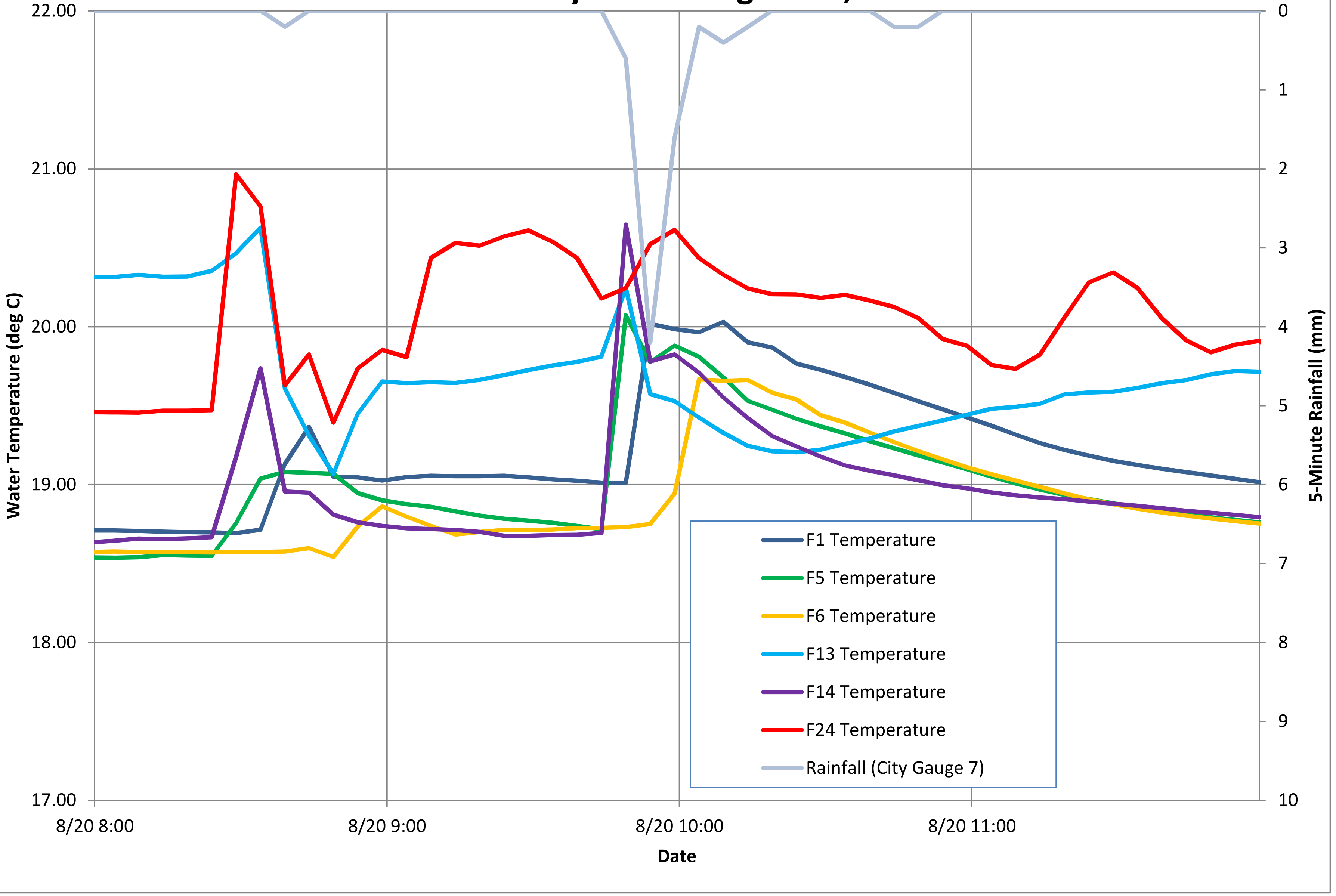
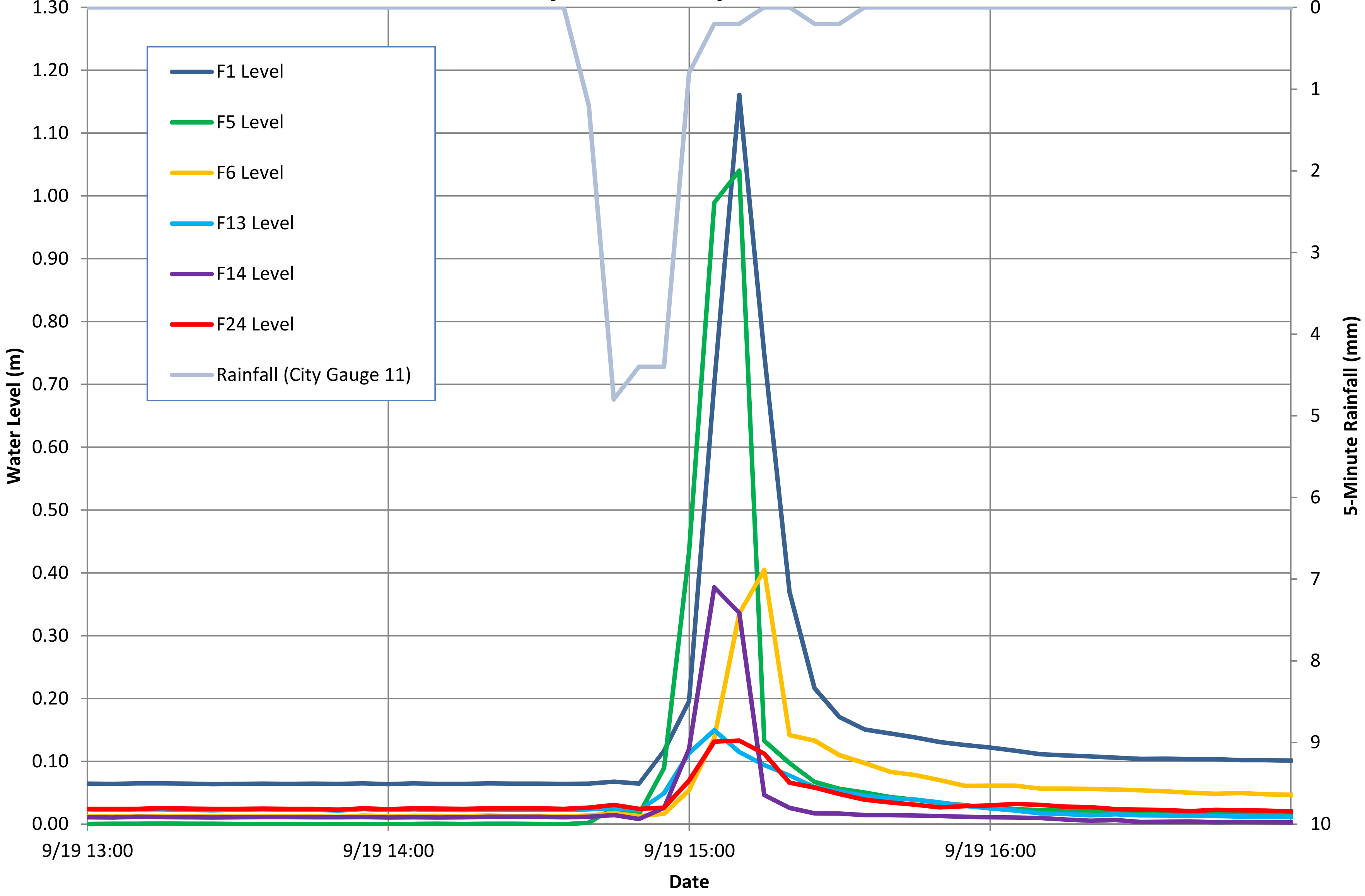


Figure A8: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - September 19, 2015



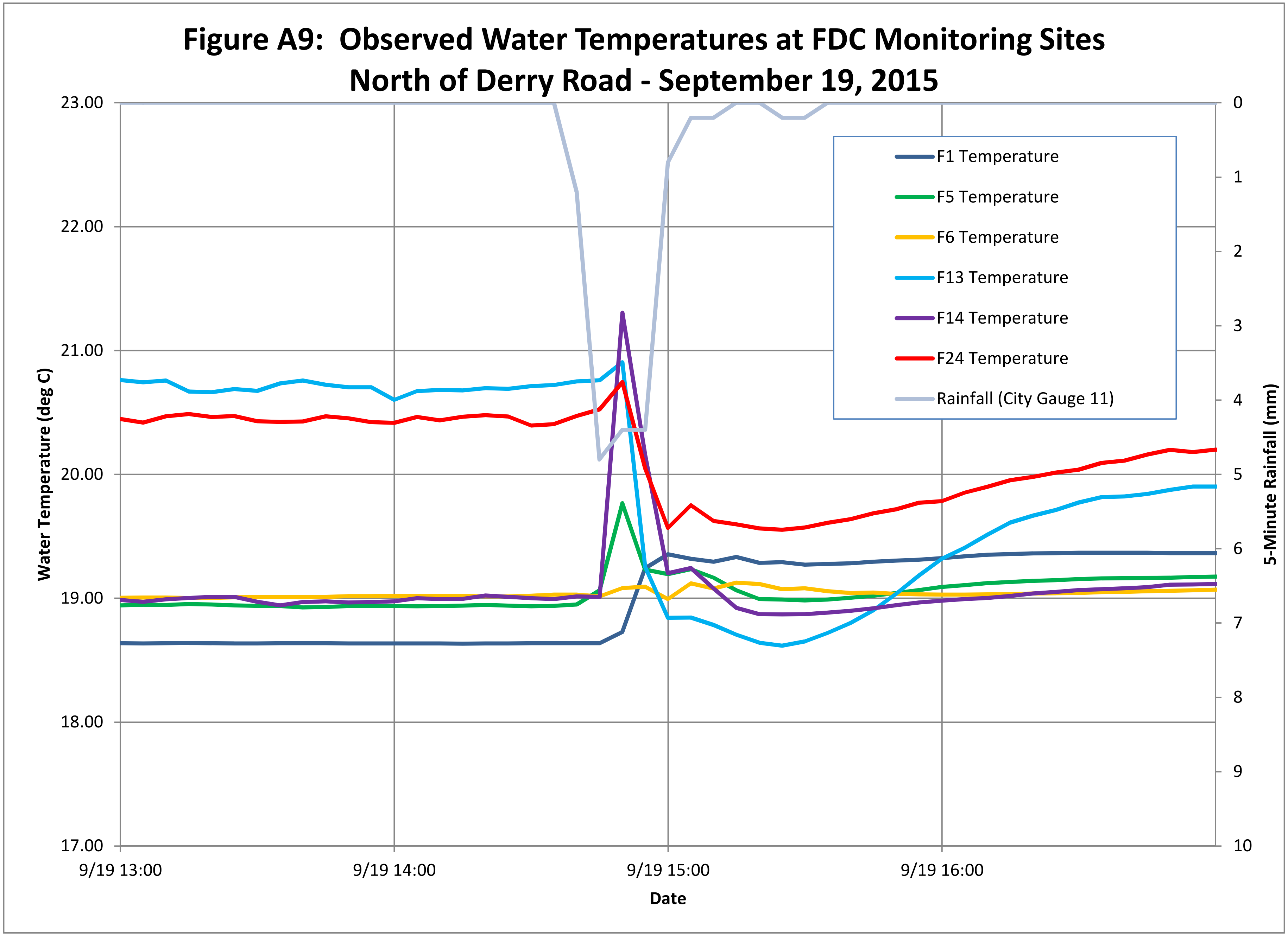
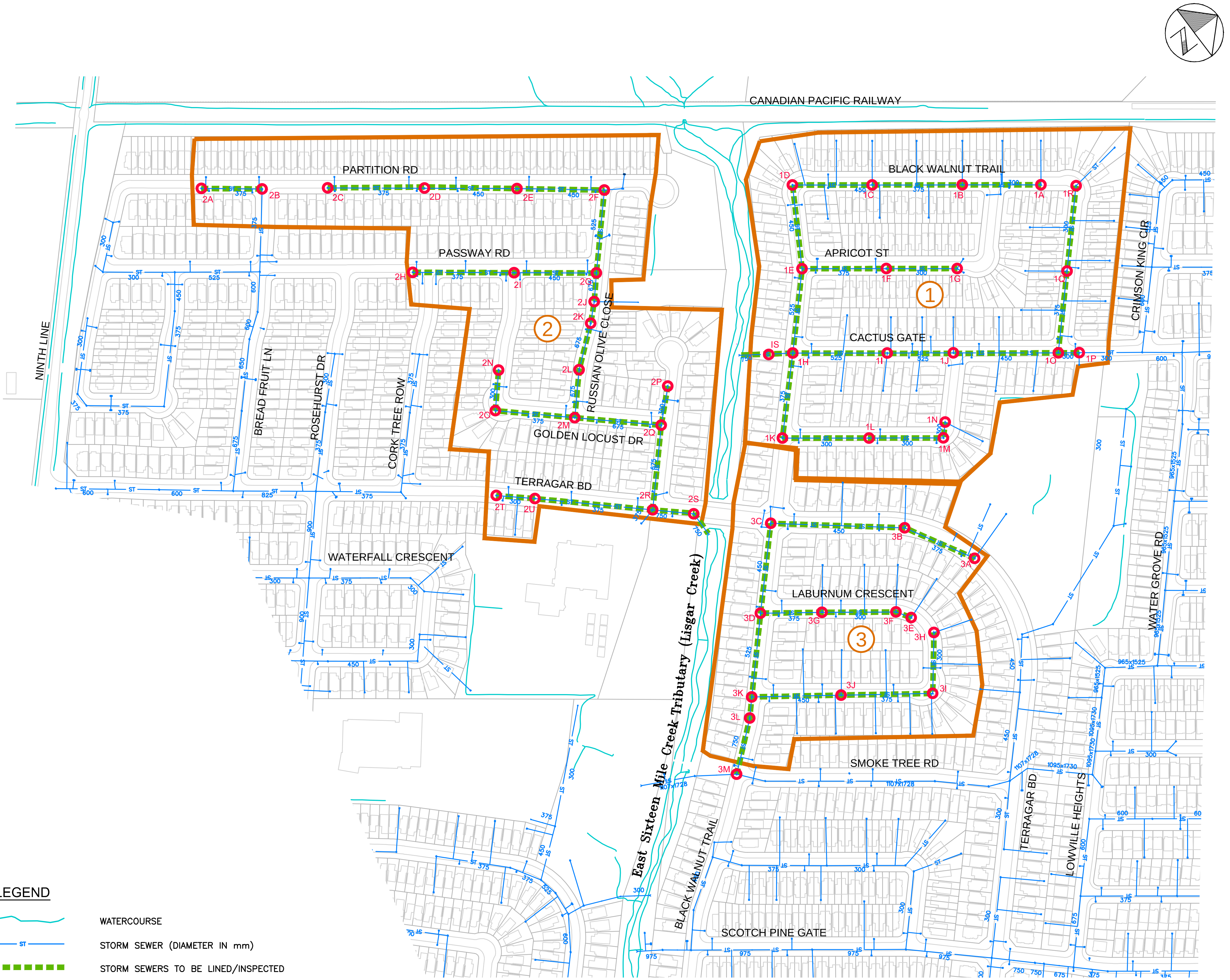


Figure A9: Observed Water Temperatures at FDC Monitoring Sites
North of Derry Road - September 19, 2015
Water Temperature (deg C)
23.00
22.00
21.00
20.00
19.00
18.00
17.00
5-Minute Rainfall (mm)
0
1
2
3
4
5
6
7
8
9
10
9/19 13:00
9/19 14:00
9/19 15:00
9/19 16:00
Date
F1 Temperature
F5 Temperature
F6 Temperature
F13 Temperature
F14 Temperature
F24 Temperature
Rainfall (City Gauge 11)

REVISIONS		
DATE	DETAILS	INIT.



LEGEND

- 〰 WATERCOURSE
- —ST— STORM SEWER (DIAMETER IN mm)
- ▬ ▬ ▬ STORM SEWERS TO BE LINED/INSPECTED
- ① STORM SEWER LINING AREA BOUNDARY AND REFERENCE No.
- ○ 2A STORM SEWER MAINTENANCE HOLE AND REFERENCE ID

LISGAR DISTRICT
STORM SEWER LINING
(FA. 49453-16)

amec foster wheeler

MISSISSAUGA

PRODUCED FOR - T&W, ENGINEERING AND WORKS

STORM SEWER LINING OVERVIEW

SCALE AS NOTED	AREA	PROJECT No. TP115060
C.A.D.D. BY J.S.	CHECKED BY M.S.	PLAN No.
DATE JUNE 2016	SHEET 1 OF 11	Figure 1

Appendix B

Groundwater Monitoring Figures

Table B1 Summary of Piezometers Lisgar District

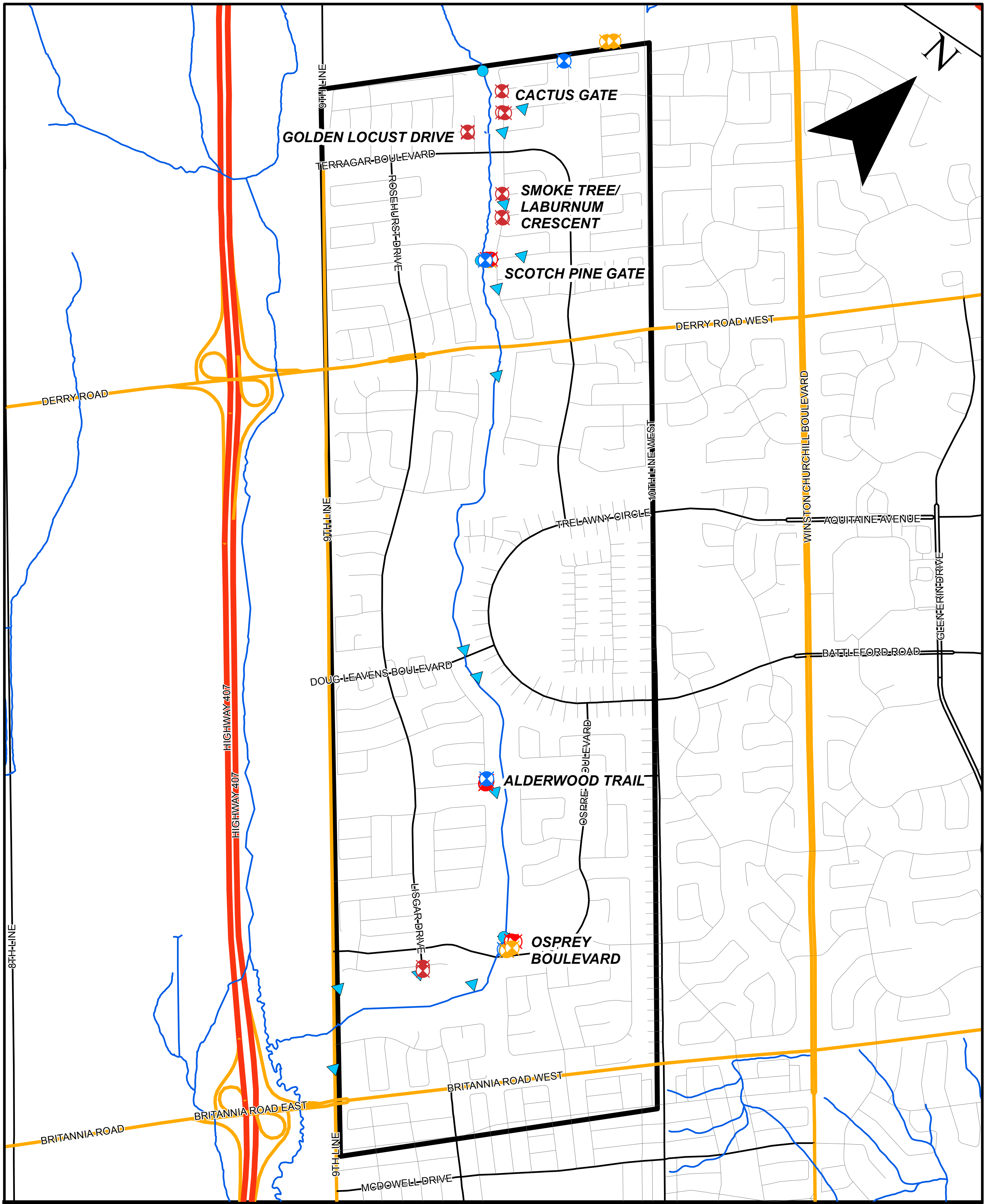
Site	Piezometer Name	Piezometer Type[1]	Surface Elevation (masl)	Screen Interval (mbgs)	Material Monitored	K[2],[3] (m/s)	Period Monitored	Decommission Date	Notes
Lisgar GO Station	GO1	SDP	207.10	1.6-1.8	Silty clay (fill)	-	6/15/12 - 5/14/13	5/23/13	GO sanitary sewer trench
	GO2	SDP	206.20	1.6-1.8	Silty clay (fill)	-	6/15/12 - 5/14/13	5/23/13	GO storm sewer trench
Black Walnut Trail	BW1	Standard	205.39	3.9 - 5.4	Silty clay	-	12/23/11 - 5/22/13	5/23/13	Background, near GO Station
Cactus Gate	CG1	Standard	202.19	3.9 - 5.4	Silty sand	-	12/23/11 - 5/22/13	5/23/13	Background near 16 Mile Creek
Scotch Pine Gate	SP1	Standard	199.43	2.5 - 3.9	Silt & clayey silt	*8.4E-09*	12/23/11 - 5/22/13	5/23/13	Close to 16 Mile Creek
	SP2	Sewer Trench	199.33	0.6 - 2.1	Silty clay (fill)	1.1E-06	12/23/11 - present	-	Storm sewer trench
	SP3	Standard	199.99	2.7 - 4.2	Silty to coarse sand	6.5E-07	12/23/11 - present	-	Close to 7244 Black Walnut Trail
	SP4	SDP	200.00	1.8 - 2.0	Clayey silt	*1.2E-08*	3/02/12 - 11/21/13	-	Close to 7244 Black Walnut Trail - dry
	SP5	Sewer Trench	199.57	0.8 - 2.0	Silty clay (fill)	3.5E-05	5/31/12 - present	-	Storm sewer - dry at record start
	SP6	SDP	200.02	1.5 - 1.7	Fill	-	8/16/12 - 5/22/13	5/23/13	Close to 7254 Black Walnut Trail - dry
	SP7	Collar	199.56	2.9 - 3.1	Gravel sewer bedding	-	11/11/14 - present	-	Storm sewer trench
	SP8	Collar	199.61	2.9 -3.1	Gravel sewer bedding	-	11/11/14 - present	-	Storm sewer trench
Osprey Boulevard	OSP1	Standard	189.63	3.7 - 5.2	Silty clay	-	12/23/11 - 5/22/13	5/23/13	Close to 16 Mile Creek
	OSP2	Standard	190.00	3.7 - 5.2	Silty clay	-	12/23/11 - present	-	Close to 6088 Osprey Blvd
	OSP3	SDP	190.20	2 - 2.2	Silty clay	-	3/02/12 - present	-	SDP close to 6088 Osprey Blvd
	OSP4	Sewer Trench	190.37	0.6 - 2.1	Silty clay (fill)	2.1E-07	5/31/12 - 5/28/14	-	Storm sewer trench - mostly dry
	OSP5	Sewer Trench	190.36	0.8 - 2.0	Silty clay (fill)	2.2E-07	5/31/12 - present	-	Storm sewer trench - frequently dry
	OSP6	SDP	190.90	2.3-2.5	Fill	-	8/1/12 - 5/28/14	-	SDP between 6088 and 6092 Osprey Blvd
Alderwood Trail	AT1	Sewer Trench	192.08	1.7 - 2.4	Silty clay / Gravel (fill)	-	5/29/13 - 5/22/14	-	Storm sewer trench
	AT2	Sewer Trench	192.00	2.0 - 2.7	Silty clay / Gravel (fill)	-	5/29/13 - 9/30/13	-	FDC branch sewer trench
	AT3	Sewer Trench	192.06	2.1 - 2.9	Silty clay / Gravel (fill)	-	5/29/13 - present	-	FDC sewer lateral trench
	AT4	Standard[4]	192.14	2.0 - 3.5	Silty clay	-	5/29/13 - present	-	Background
Pondview Way	PV1	Sewer Trench	190.57	2.5- 4.0	Silty clay / Gravel (fill)	1.2E-06	5/28/14 - present	-	FDC branch sewer trench
	PV2	Collar	190.12	3.7 - 3.9	Gravel sewer bedding	-	11/21/14 - present	-	FDC branch sewer trench
	PV3	Collar	190.08	3.7 - 3.9	Gravel sewer bedding	-	11/21/14 - present	-	FDC branch sewer trench
	PV4	Sewer Trench	189.66	1.8 - 3.3	Silty clay / Gravel (fill)	1.3E-04	5/28/14 - present	-	FDC branch sewer trench
Cactus Gate	A1	Sewer Trench	202.86	1.2 - 2.1	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	CG2	Sewer Trench	202.52	1.6 - 2.5	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	CG3	Sewer Trench	202.69	3.1 - 4.6	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
Golden Locust	GL1	Sewer Trench	203.56	1.7 - 2.6	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	GL2	Sewer Trench	203.59	2.2 - 3.7	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
Smoke Tree	LB1	Sewer Trench	201.36	1.1 - 2.0	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	ST1	Sewer Trench	200.94	1.2 - 2.7	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	ST2	Sewer Trench	200.98	2.8 - 4.3	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench

1 SDP = shallow drive point

2 Hydraulic conductivity derived from slug testing - italicized are those piezometers with limited response

3 Arithmetic mean is given for those piezometers with more than one test (SP2, PV1, PV4)

4 AT4 was installed with hydrovac due to proximity of underground services



LEGEND

▭ Study Area

⊕ Standard Piezometer

⊕ Shallow Drive Point

⊕ Sewer Trench Piezometer

Surface Water Monitoring Location

● Creek Gauge

■ Storm Sewer Gauge

▲ FDC Gauge

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION
CITY OF MISSISSAUGA

LOCATION PLAN

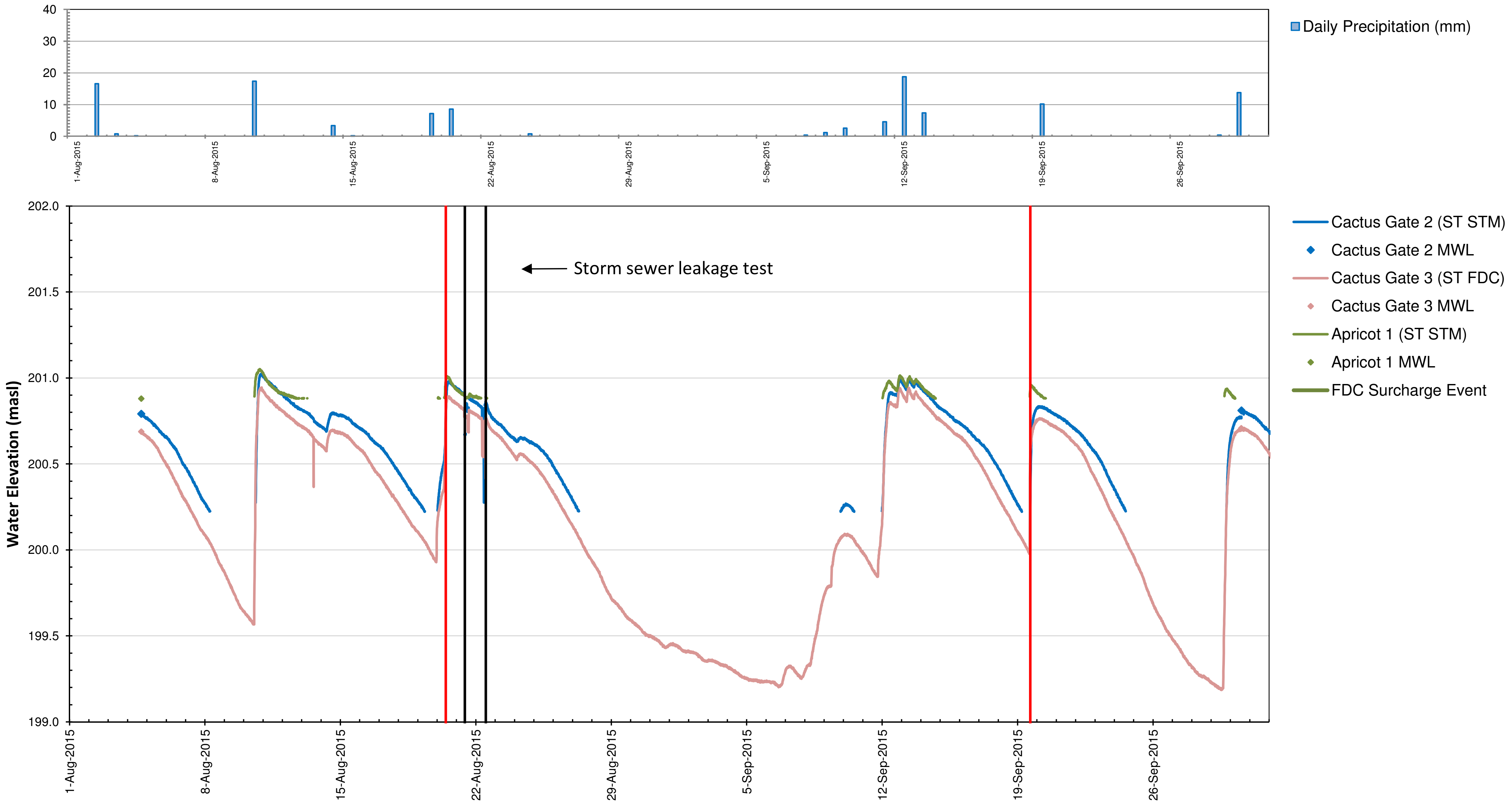
amec
foster
wheeler

Scale 1:20000
0 75 150 300

Consultant File No.
TP115060.2000

Figure No.
B1

Figure B2 - Hydrograph of Water Levels Area 1 (Cactus Gate)



Amec Foster Wheeler
Environment Infrastructure
TP115060

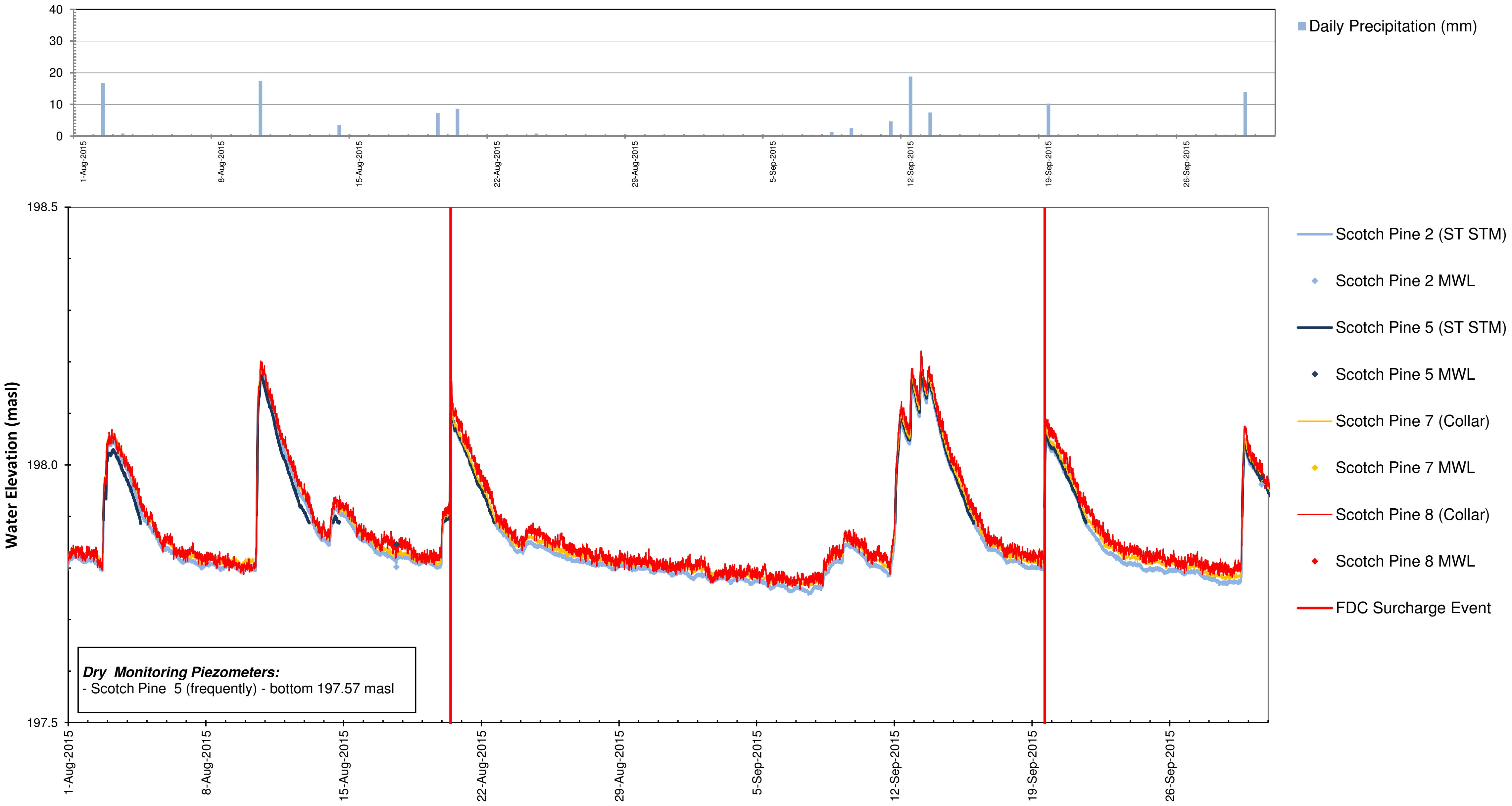
P:\01-PROJECTS\TP - Burlington\2015\TP115060 - Mississauga BF Remediation\05 - Data & Field Work\Phase 4 Water Level\GWL - 2015 (Jul - Dec) (2016-01-04)

SCOTCH PINE GATE

PONDVIEW WAY

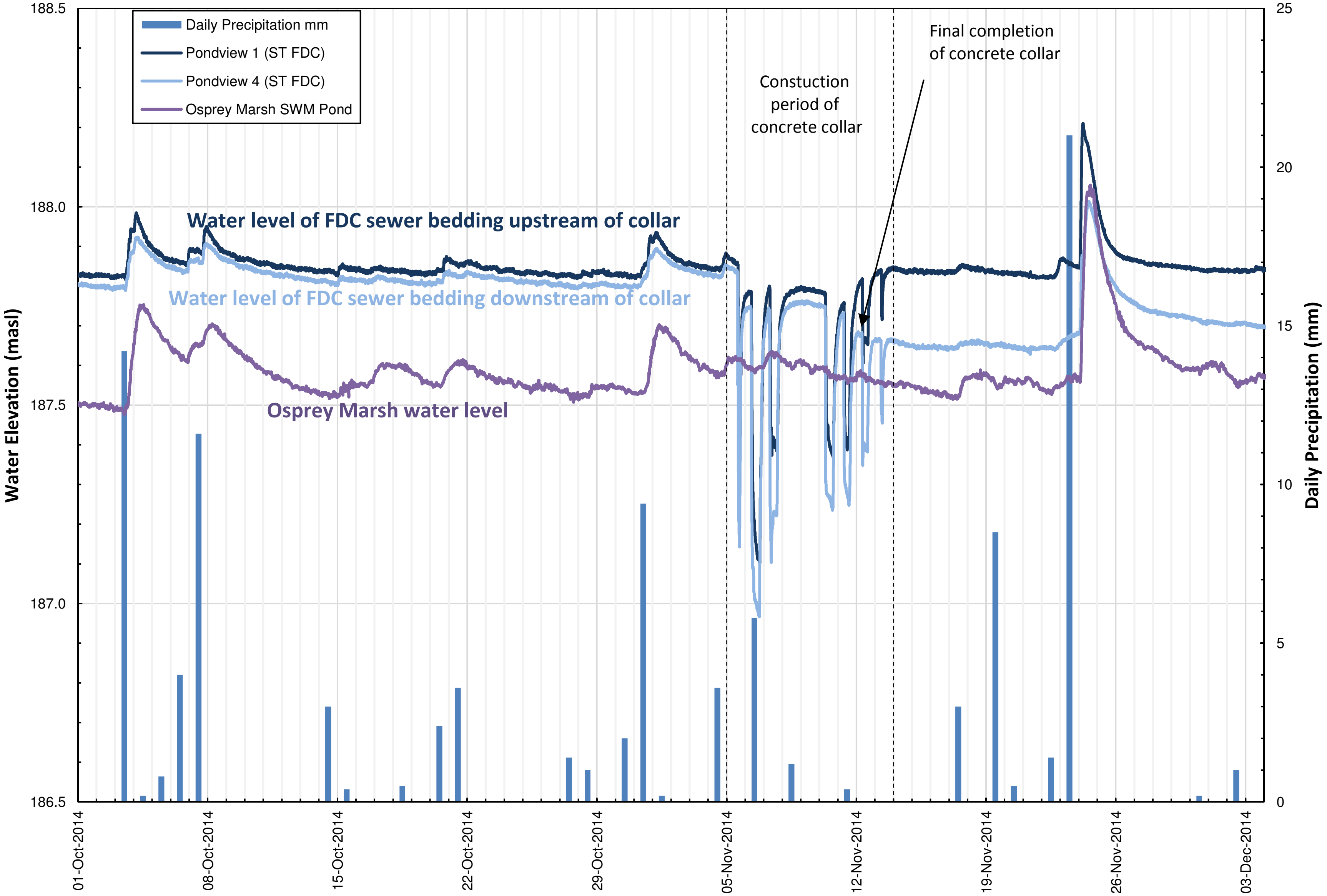
LISGAR DISTRICT BASEMENT INFILTRATION INVESTIGATION CITY OF MISSISSAUGA	IMPERMEABLE COLLAR CONSTRUCTION AT SCOTCH PINE GATE AND PONDVIEW WAY	amec foster wheeler	Scale NA Consultant File No. TP111119B Figure No. B3

Figure B4 - Hydrograph of Water Levels - Scotch Pine Gate



Dry Monitoring Piezometers:
- Scotch Pine 5 (frequently) - bottom 197.57 masl

Figure B5 - Pondview Water Levels during Collar Construction



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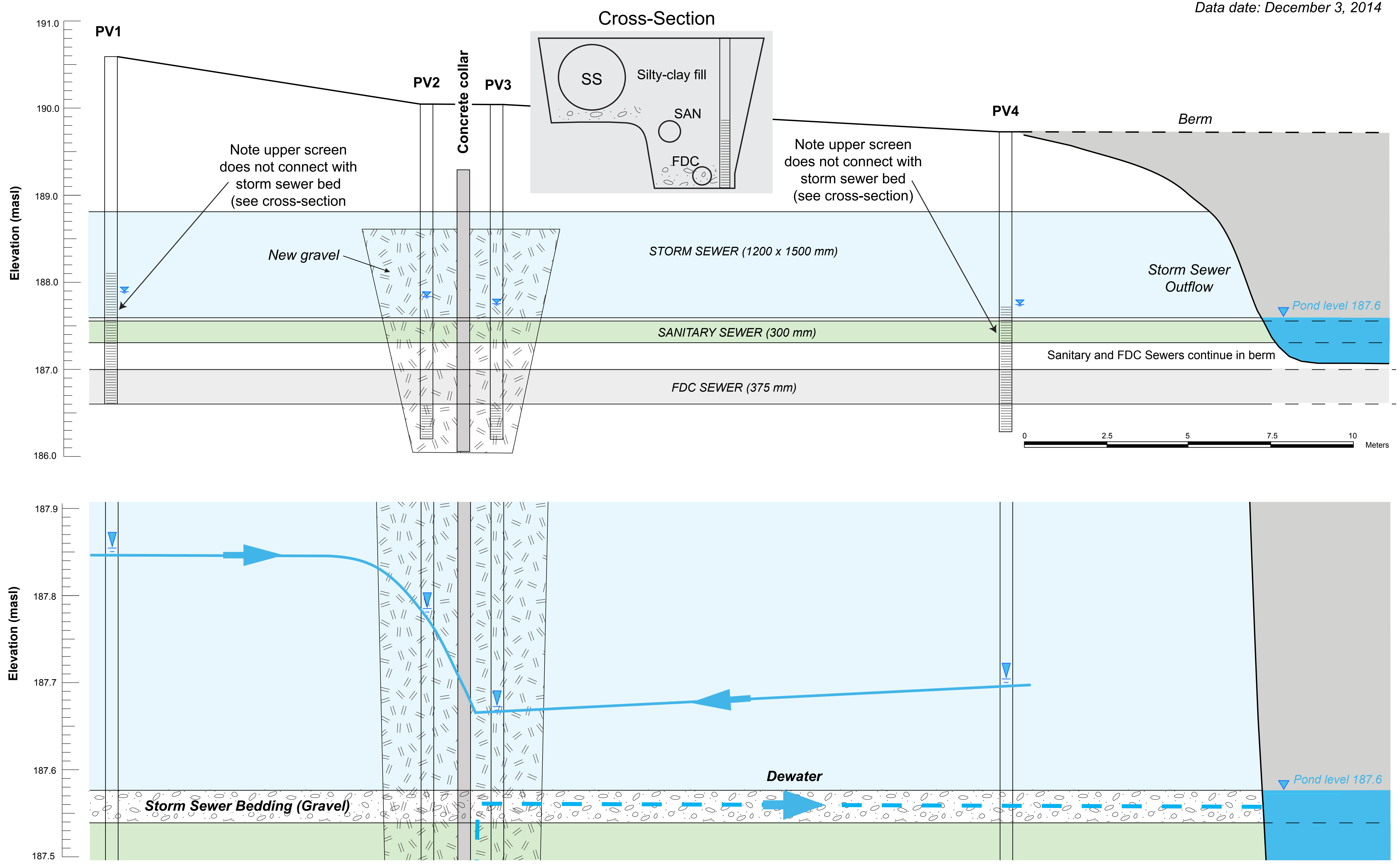


LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

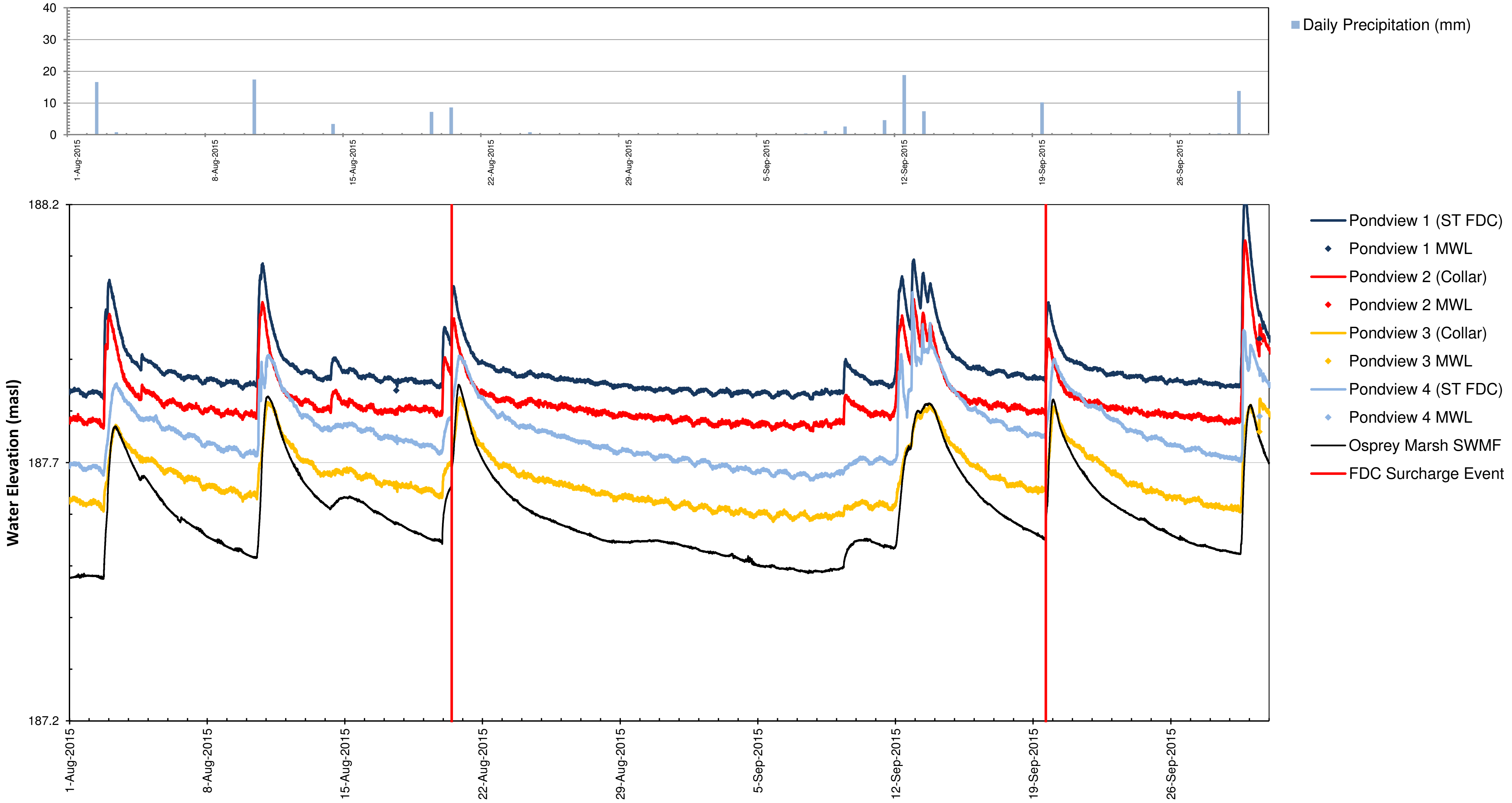
CITY OF MISSISSAUGA

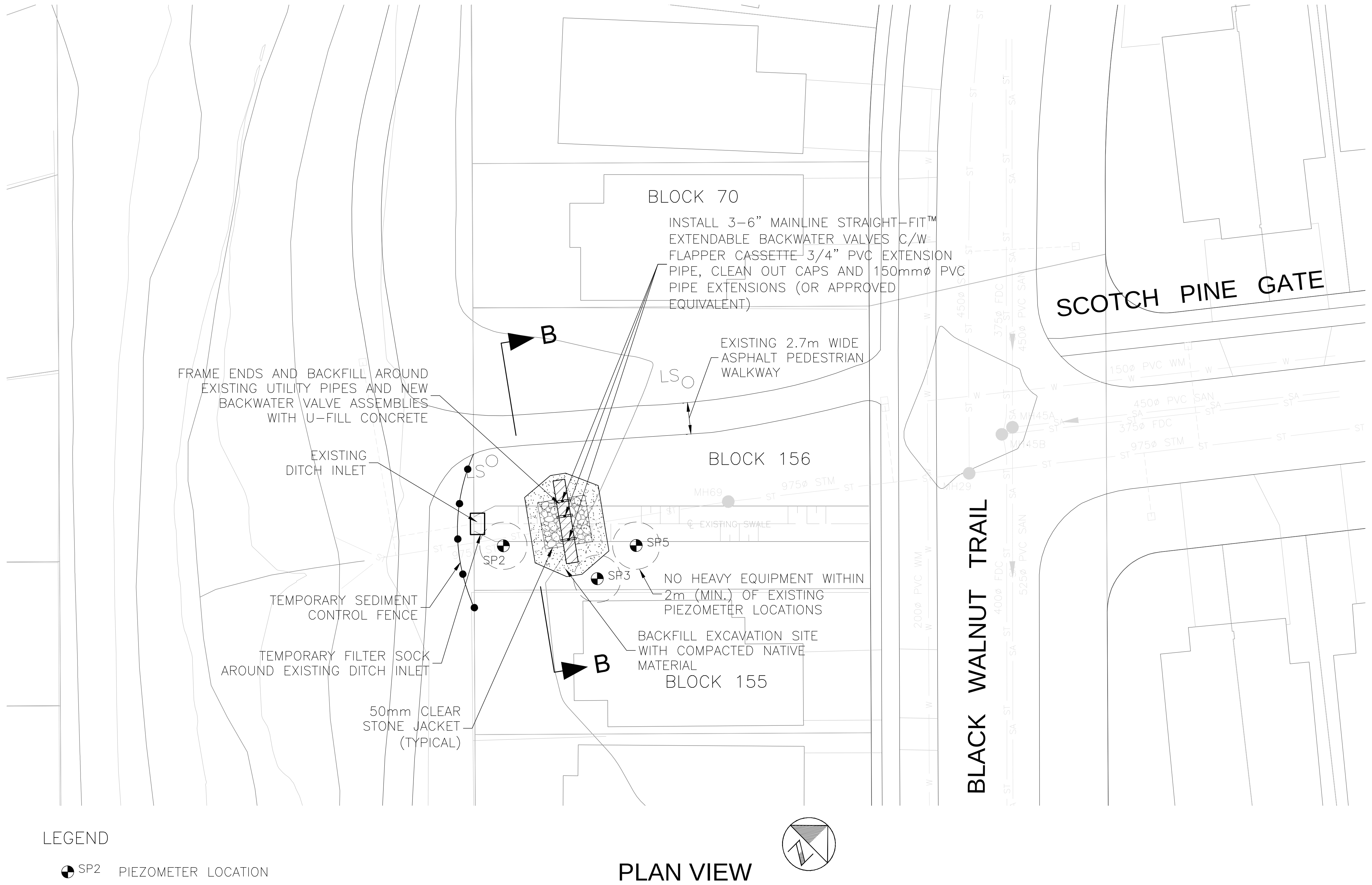
LONG-SECTION AT PONDVIEW WAY
IMPERMEABLE COLLAR

Scale	NA
Consultant File No.	TP111119B
Figure No.	B6

Last Saved: 2015-02-20 Last Saved By: devin.funovitz Plotted: 2014-12-11

Figure B7 - Hydrograph of Water Levels - Pondview Lane

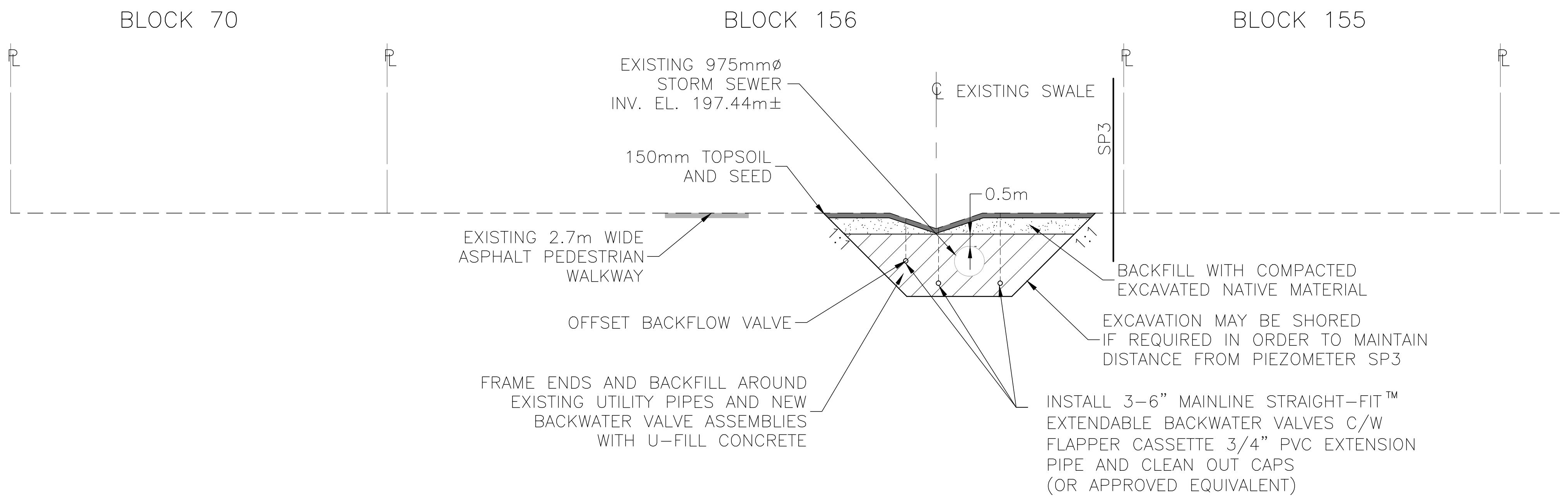




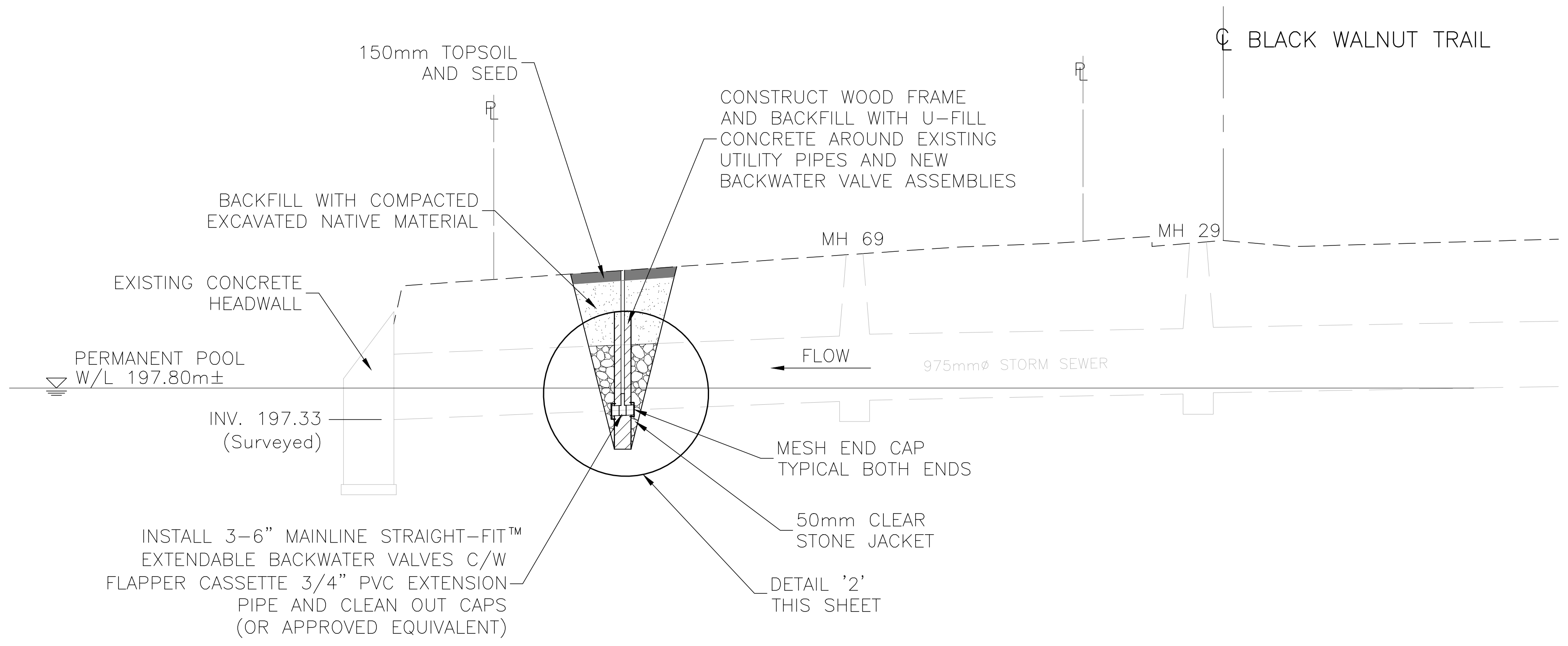
LEGEND

● SP2 PIEZOMETER LOCATION

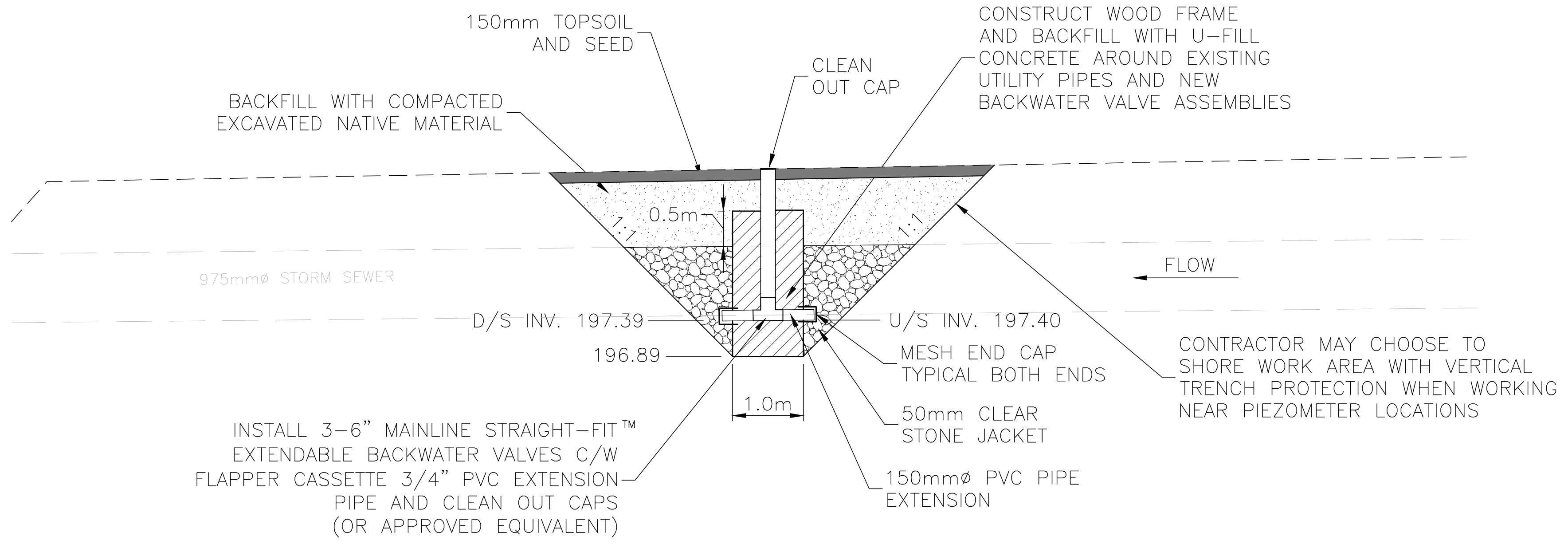
PLAN VIEW
SCALE 1:300



SECTION B-B
SCALE 1:150



PROFILE VIEW
SCALE H = 1:300 V = 1:75



NOTE:
BACKWATER VALVE ASSEMBLY AND PCV EXTENSION PIPES TO BE PLACED BELOW THE LOWEST UTILITY PIPE IN TRENCH FOR THOSE VALVES SHOWN.

DETAIL '2'
SCALE 1:75

SCALE VALID ONLY FOR 24"x36" VERSION

No	Date	Drawn	Appr'd	Revisions
3	OCT 27	JS	MJS	ADDITIONAL BACKWATER VALVES AND CLEAR STONE
2	SEPT 15	MBK	MJS	RAISE COLLAR ABOVE STM MORE CLEAR STONE, SHORING
1	AUG 27	MBK	RS	INITIAL SUBMISSION FOR CITY REVIEW

APPROVALS

Design	MS	Checked	RBS
Drawn	MBK	Checked	MS

Scale 1:300 (0 5 10 20)

Date AUGUST 2014

LISGAR DISTRICT BASEMENT
INFILTRATION ASSESSMENT

CITY OF MISSISSAUGA

BLACK WALNUT TRAIL
UTILITY TRENCH
IMPERMEABLE COLLAR

amec

Contract No.

Consultant File No.
TP111119B

Drawing No.
SHEET 2 OF 2

Plotted: 2014–10–27 Plotted By: josh.seraj
Last Saved: 2014–10–27 Last Saved By: josh.seraj

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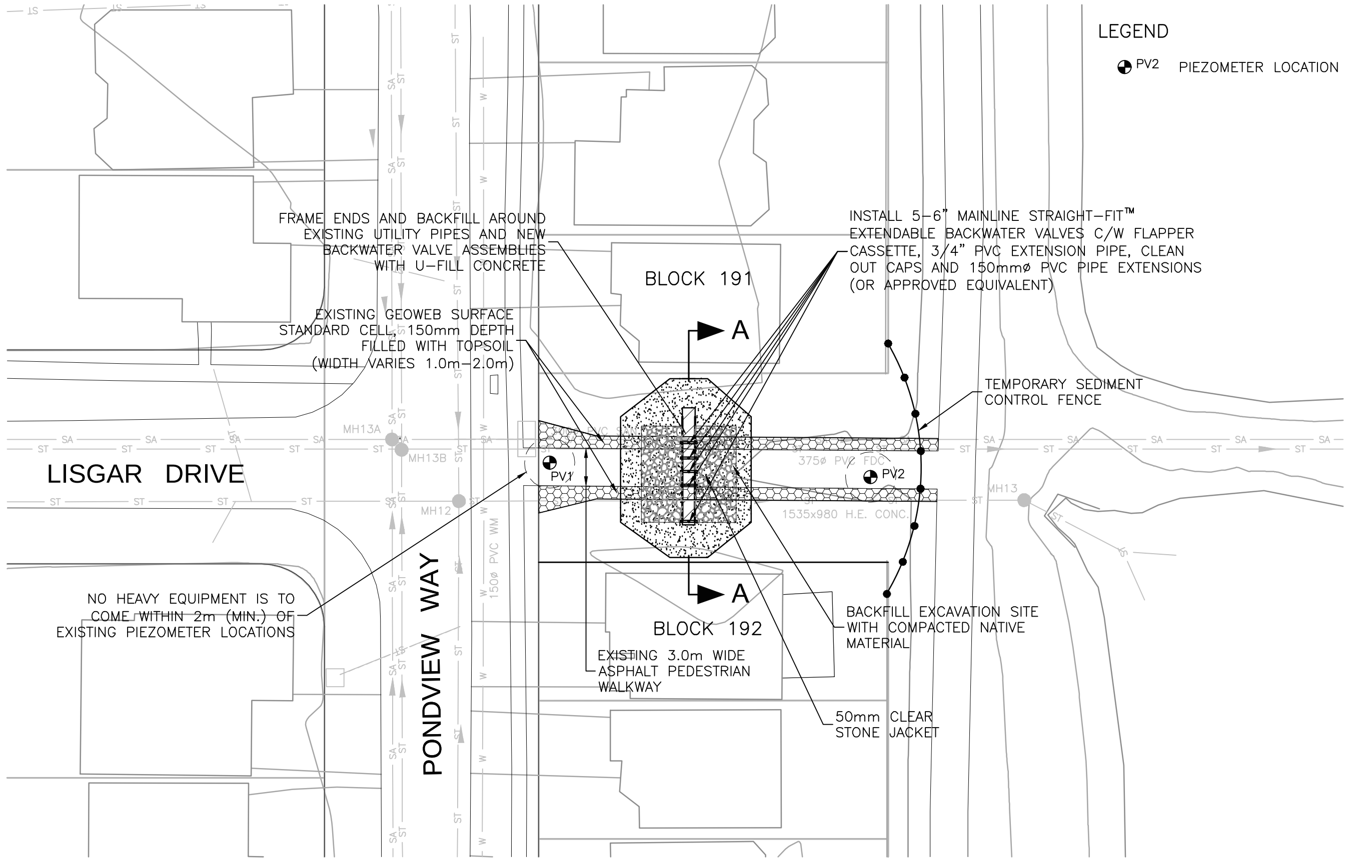
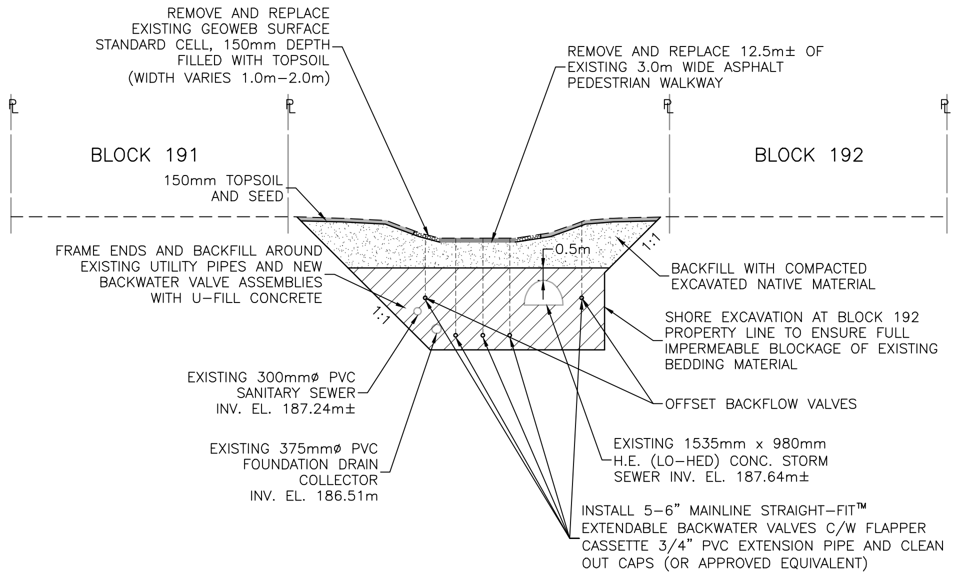


PLAN VIEW

SCALE 1:300



SECTION A-A

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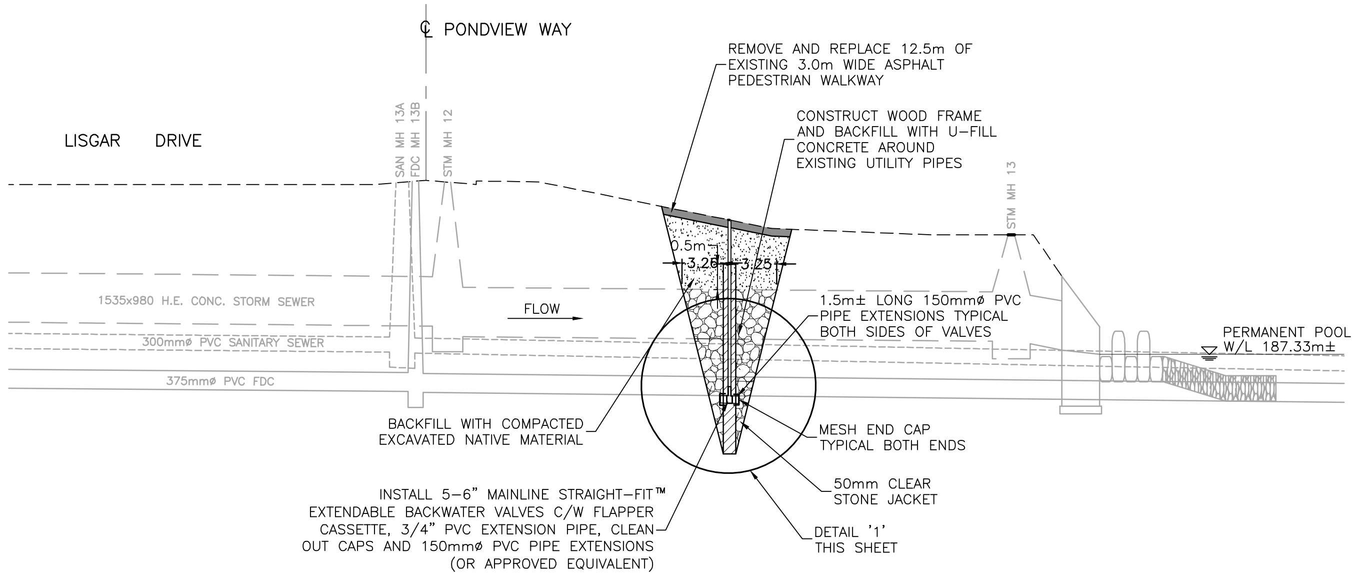
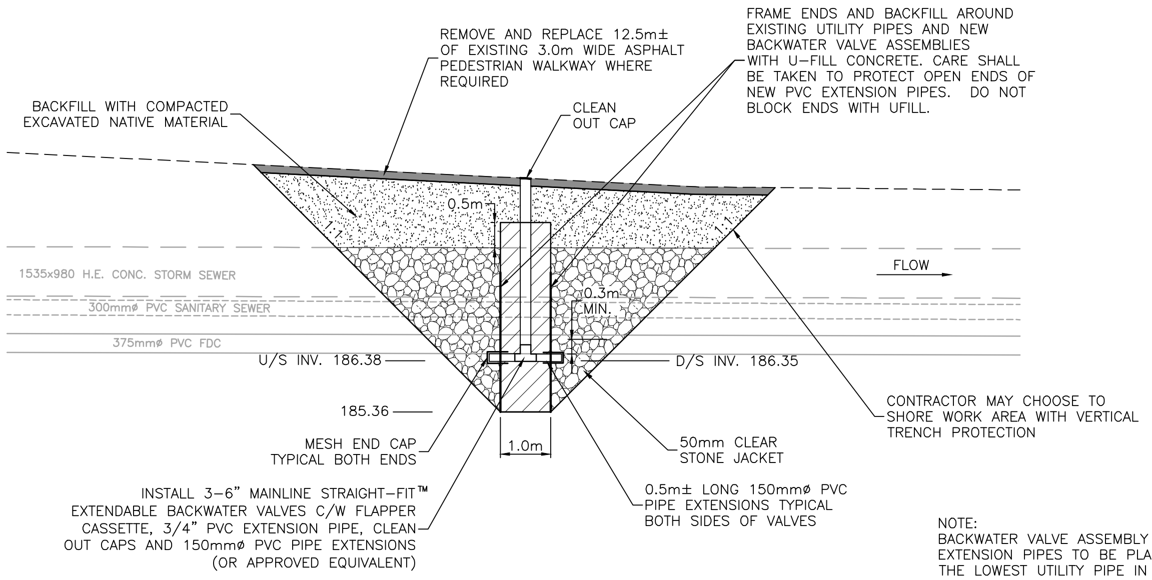


PROFILE VIEW

SCALE H = 1:300 V=1:75



DETAIL '1'

SCALE 1:75

NOTE:
BACKWATER VALVE ASSEMBLY AND PCV EXTENSION PIPES TO BE PLACED BELOW THE LOWEST UTILITY PIPE IN TRENCH FOR THOSE VALVES SHOWN.

SCALE VALID ONLY FOR 24"x36" VERSION

No	Date	Drawn	Appr'd	Revisions
3	OCT 27	JS	MJS	ADDITIONAL BACKWATER VALVES AND CLEAR STONE
2	SEPT 15	MBK	MJS	RAISE COLLAR ABOVE STM MORE CLEAR STONE, SHORING
1	AUG 27	MBK	RS	INITIAL SUBMISSION FOR CITY REVIEW

APPROVALS

Design	MS	Checked	RBS
Drawn	MBK	Checked	MS

Scale 1:300

0 5 10 20

Date AUGUST 2014

LISGAR DISTRICT BASEMENT
INFILTRATION ASSESSMENT
CITY OF MISSISSAUGA

LISGAR DRIVE
UTILITY TRENCH
IMPERMEABLE COLLAR

amec

Contract No.

Consultant File No. TP111119B

Drawing No. SHEET 1 OF 2

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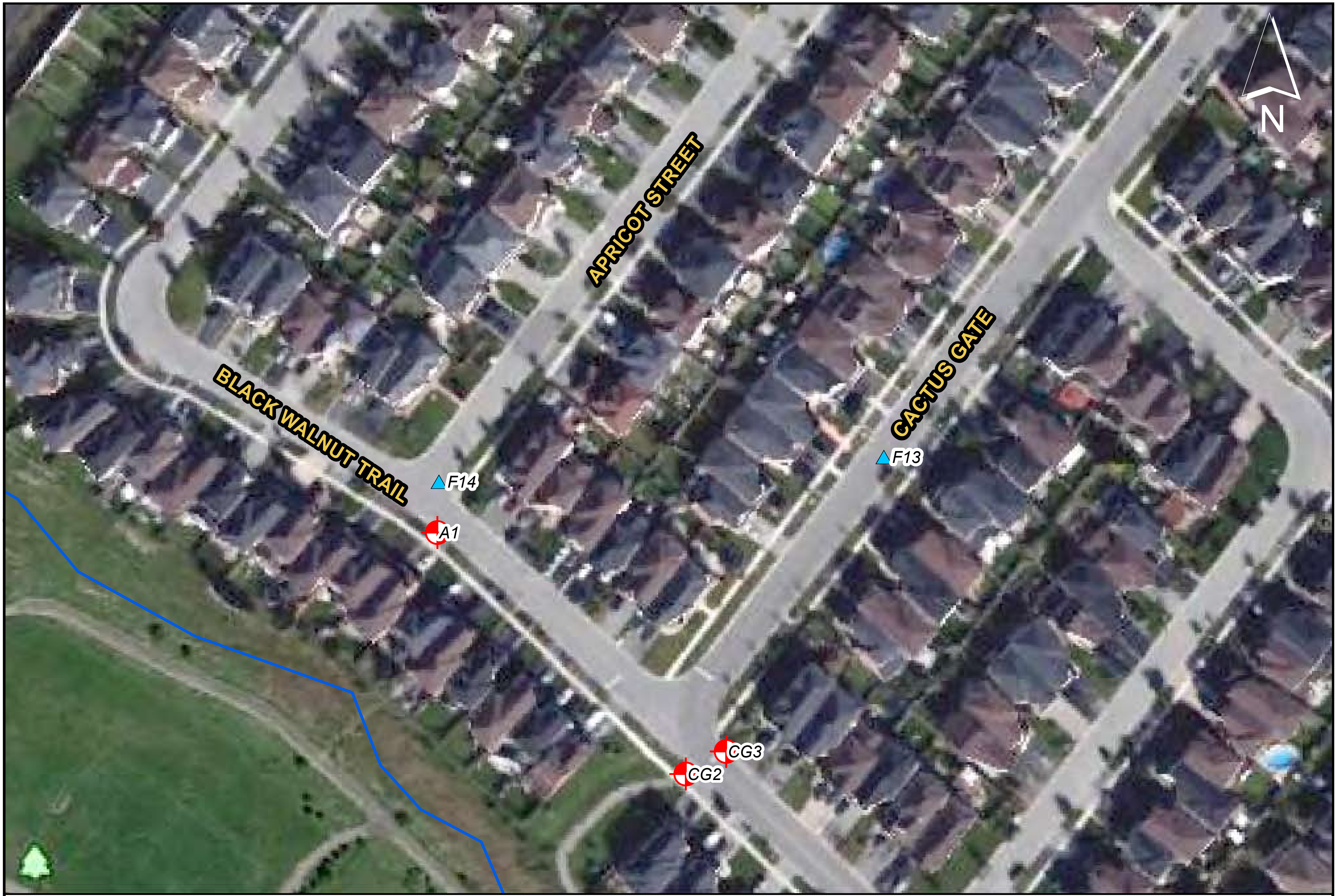
Plotted By: josh.seraj
Last Saved By: josh.seraj

Plotted: 2014-10-27
Last Saved: 2014-10-27

Appendix C

Groundwater Piezometer Maps



LEGEND

- ⊕ Standard Piezometer
- ⊕ Shallow Drive Point
- ⊕ Sewer Trench Piezometer

Surface Water Monitoring Location

- ● Creek Gauge
- ■ Storm Sewer Gauge
- ▲ FDC Gauge
- — Watercourse

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PIEZOMETERS -
CACTUS GATE

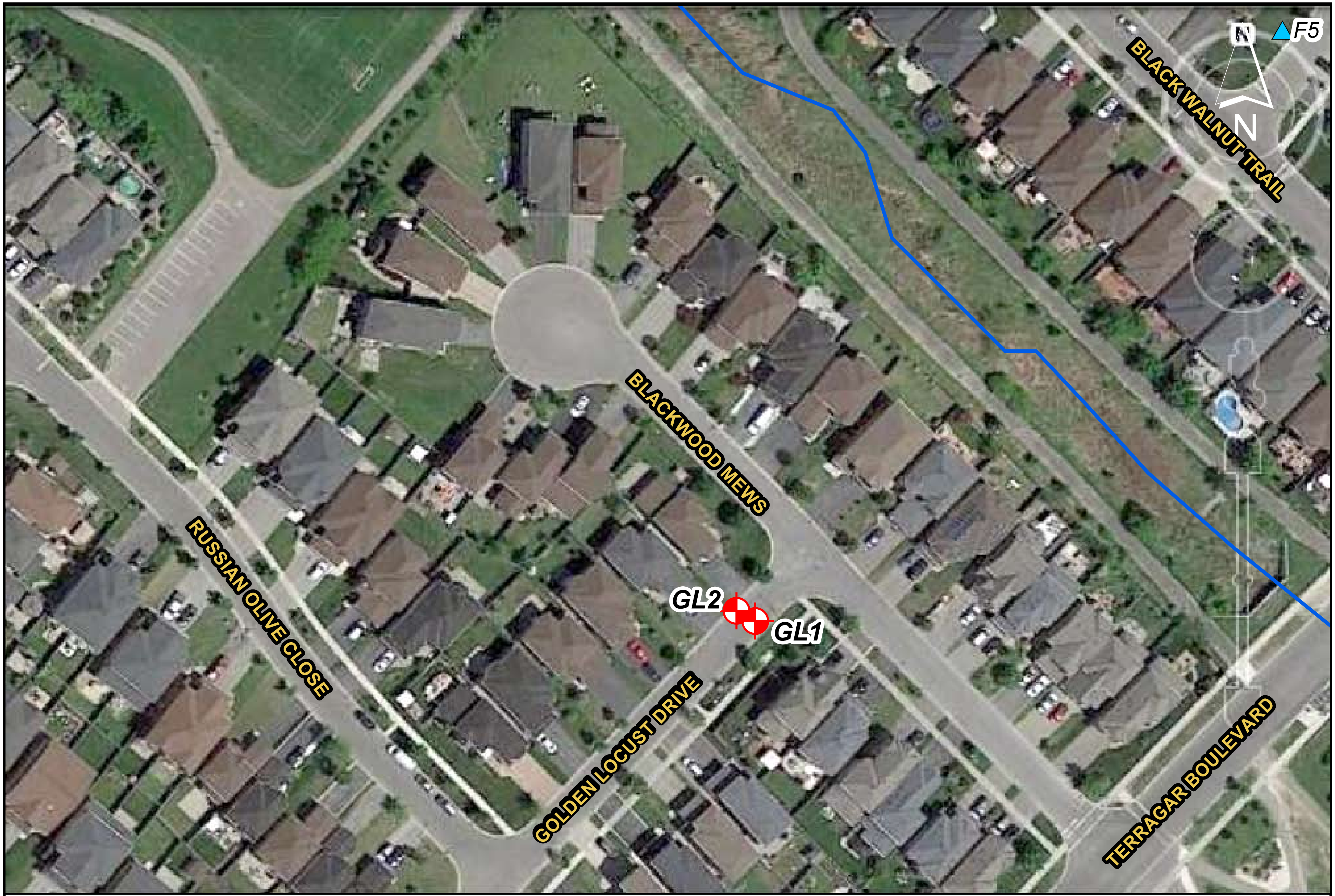
amec
foster
wheeler

Scale 1:1,326

6 3 0 6 Meters

Consultant File No.
TP115060.2000

Figure No.
C1



LEGEND

⊕ Sewer Trench Piezometer

— Watercourse

Surface Water Monitoring Location

● Creek Gauge

■ Storm Sewer Gauge

▲ FDC Gauge

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

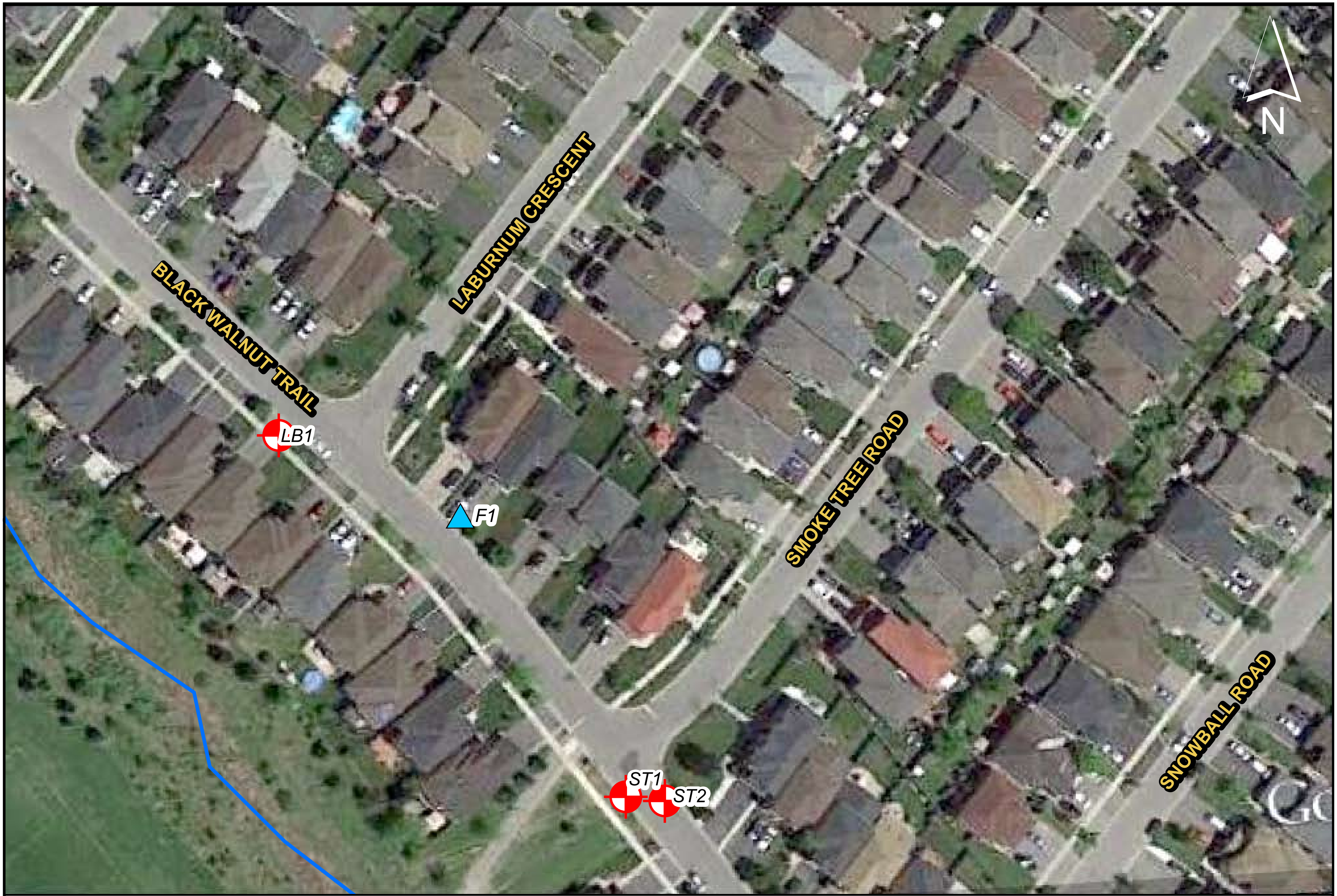
CITY OF MISSISSAUGA

PIEZOMETERS-
GOLDEN LOCUST DRIVE

Scale 1:1,000
0 1 2 4 6 8 Meters

Consultant File No.
TP115060.2000

Figure No.
C2



LEGEND

⊕ Sewer Trench Piezometer

— Watercourse

Surface Water Monitoring Location

● Creek Gauge

■ Storm Sewer Gauge

▲ FDC Gauge

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PIEZOMETERS-
SMOKE TREE/
LABURNUM CRESCENT

amec
foster
wheeler

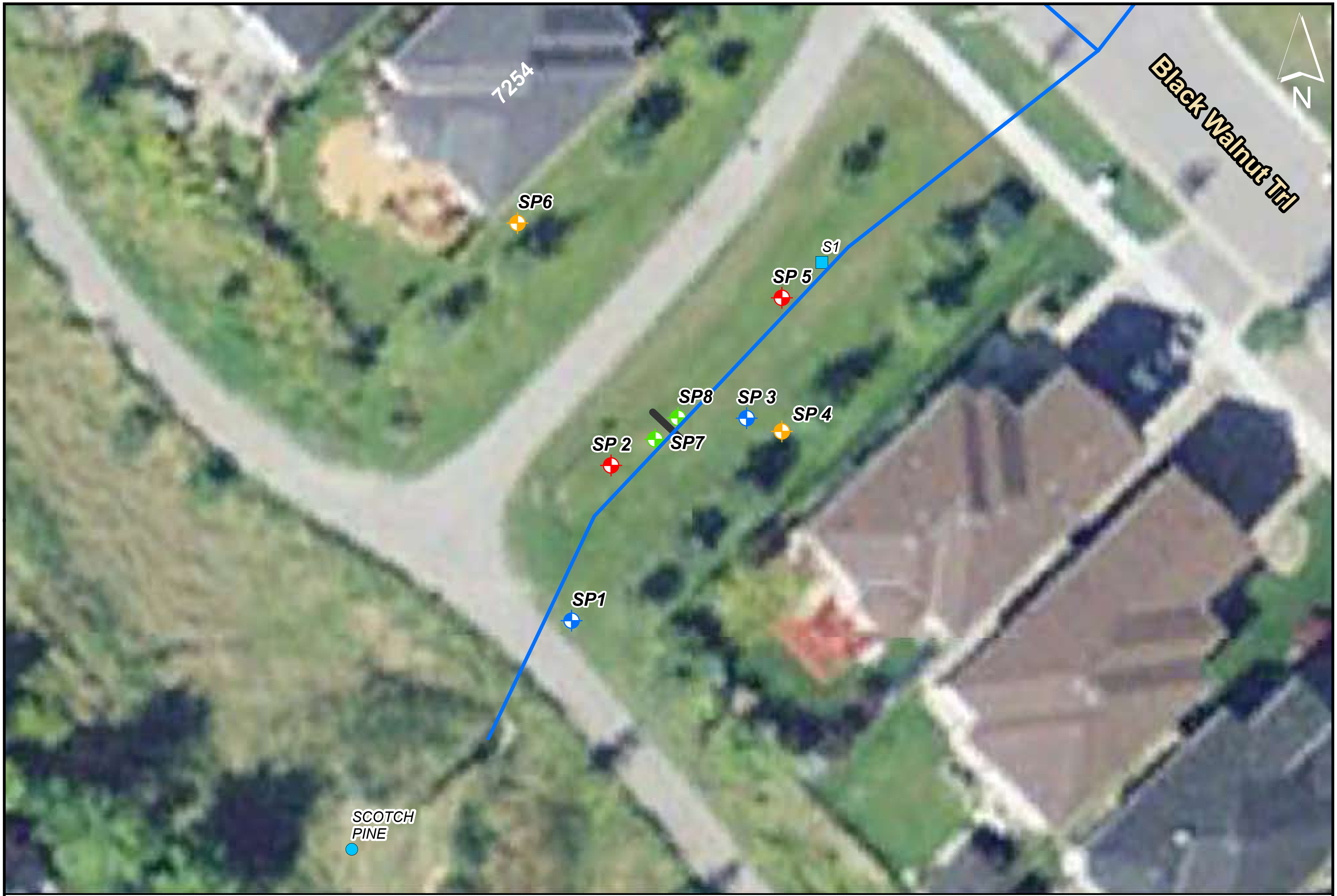
SCALE VALID ONLY FOR
8.5"x11" VERSION

Scale 1:1000
5.5 2.75 0 5.5 Meters

Consultant File No.
TP115060.2000

Figure No.
C3

Last Saved: 2015-02-20 Last Saved By: devin.funovitz Plotted: 2014-12-15



LEGEND

⊕	Standard Piezometer	▬	Concrete Collar
⊕	Shallow Drive Point	—	Storm Sewer
⊕	Sewer Trench Piezometer		**Surface Water Monitoring Location**
⊕	Collar Piezometer	●	Creek Gauge
		■	Storm Sewer Gauge
		▲	FDC Gauge

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

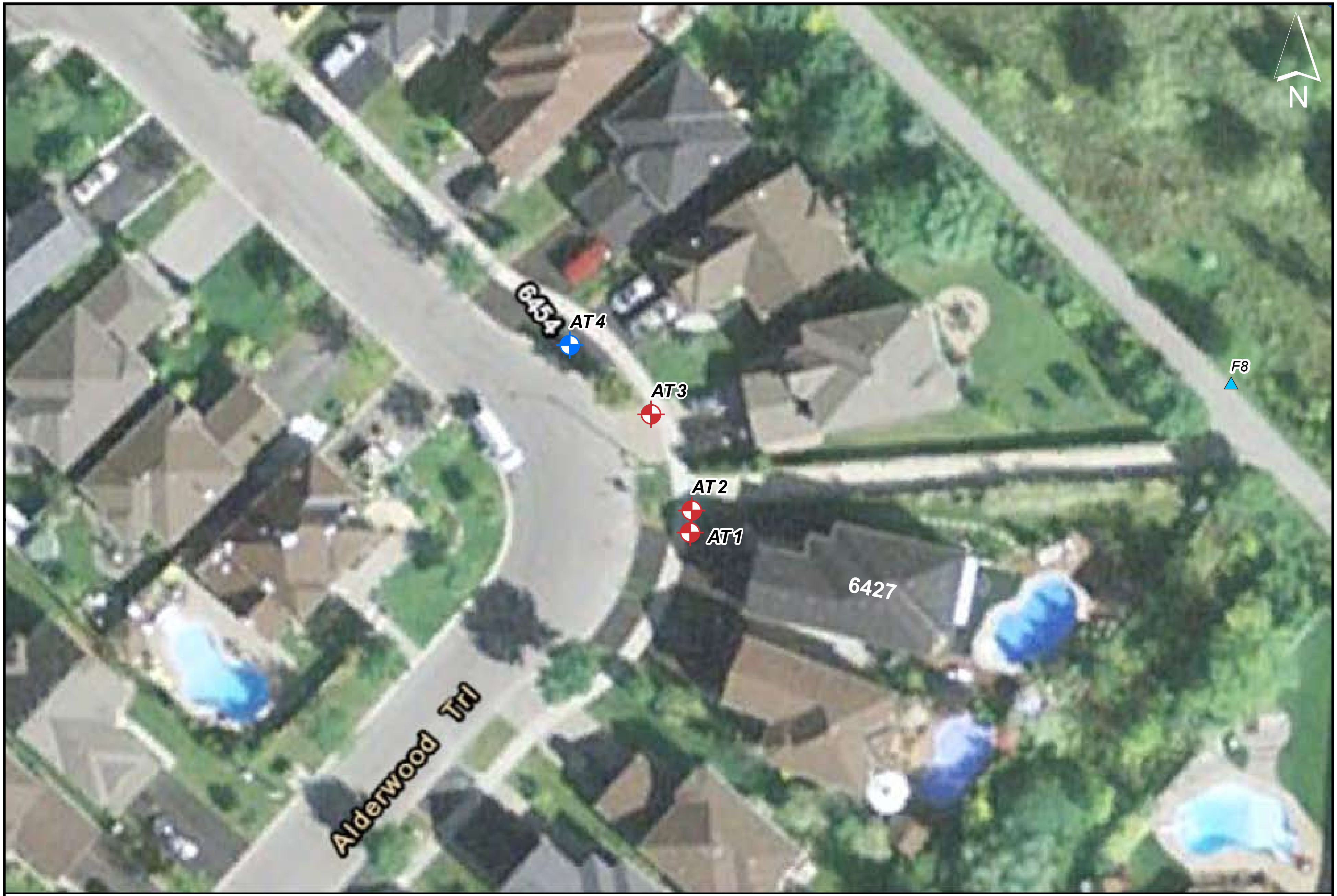
PIEZOMETERS -
SCOTCH PINE GATE

amec foster wheeler

Scale 1:300
0 1.5 3 6

Consultant File No.
TP115060.2000

Figure No.
C4



LEGEND

⊕ Standard Piezometer

⊕ Sewer Trench Piezometer

Surface Water Monitoring Location

- ● Creek Gauge
- ■ Storm Sewer Gauge
- ▲ FDC Gauge

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PIEZOMETERS -
ALDERWOOD TRAIL

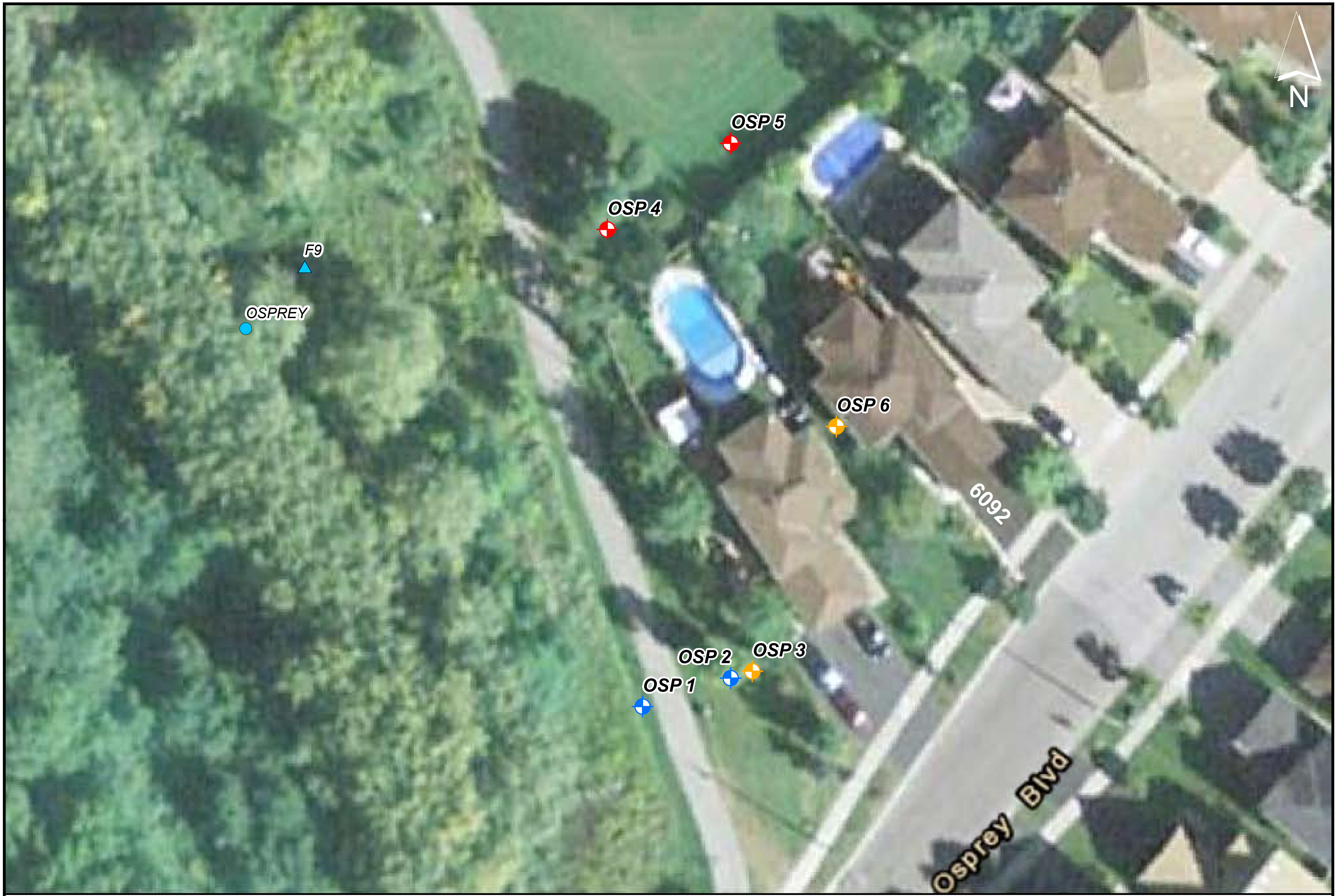
amec
foster
wheeler

Scale 1:500
0 2.5 5 10

Consultant File No.
TP115060.2000

Figure No.
C5

Last Saved: 2015-02-11 Last Saved By: devin.funovitz Plotted: 2014-12-12



LEGEND

⊕ Standard Piezometer
⊕ Shallow Drive Point
⊕ Sewer Trench Piezometer

Surface Water Monitoring Location

● Creek Gauge
■ Storm Sewer Gauge
▲ FDC Gauge

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PIEZOMETERS -
OSPREY BOULEVARD

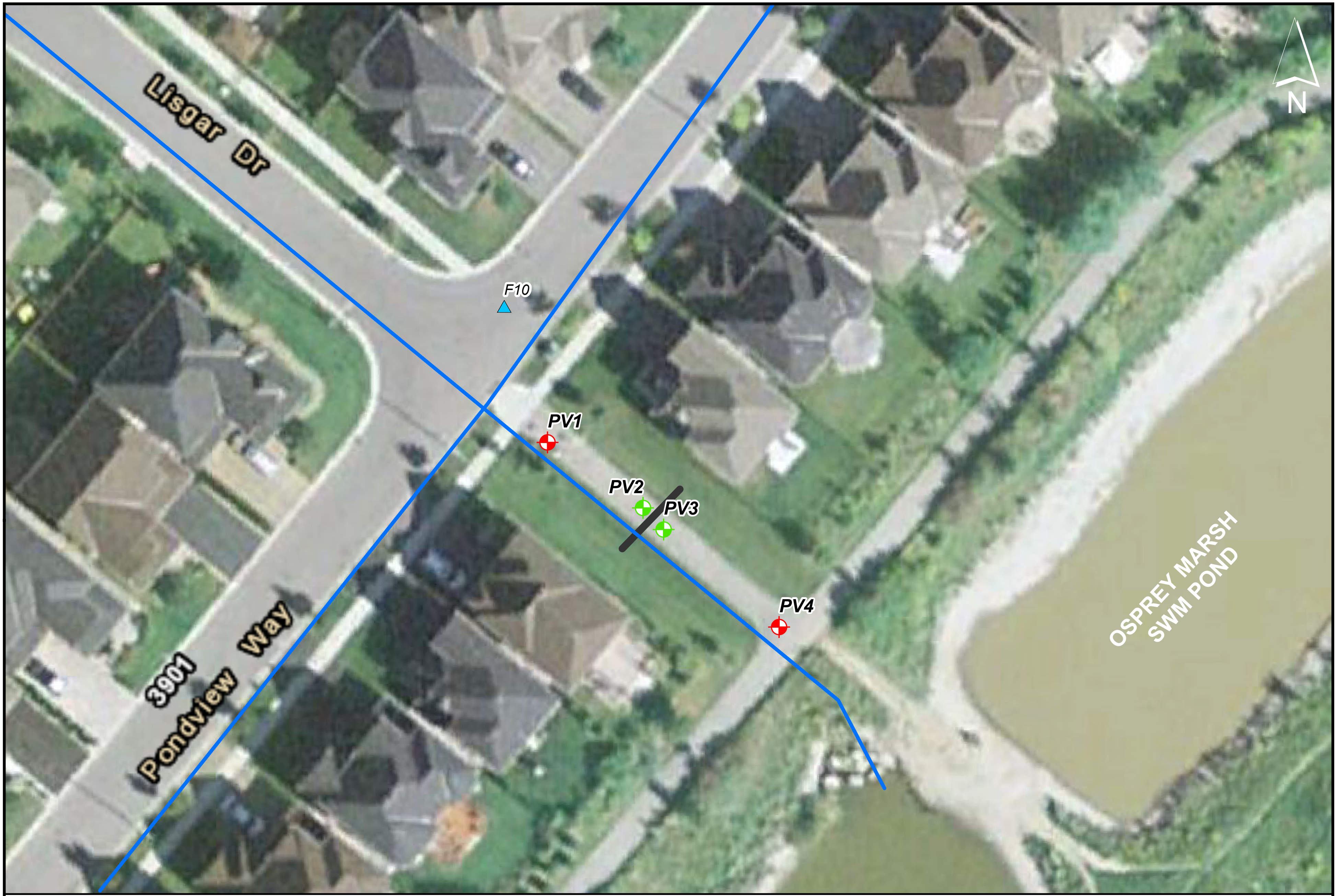
amec
foster
wheeler

Scale 1:500
0 2.5 5 10

Consultant File No.
TP115060.2000

Figure No.
C6

Last Saved: 2015-02-11 Last Saved By: devin.funovitz Plotted: 2014-12-12



LEGEND

- ⌖ Sewer Trench Piezometer
- ⌖ Collar Piezometer
- ▬ Concrete Collar
- ― Storm Sewer

Surface Water Monitoring Location

- ● Creek Gauge
- ■ Storm Sewer Gauge
- ▲ FDC Gauge

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PIEZOMETERS -
PONDVIEW WAY

amec
foster
wheeler

Scale 1:500
0 2.5 5 10

Consultant File No.
TP115060.2000

Figure No.
C7

Last Saved: 2015-02-11 Last Saved By: devin.funovitz Plotted: 2014-12-12

Appendix D

Groundwater Monitoring Data

Figure D1a - Hydrograph of Water Levels Area 1 (Cactus Gate)

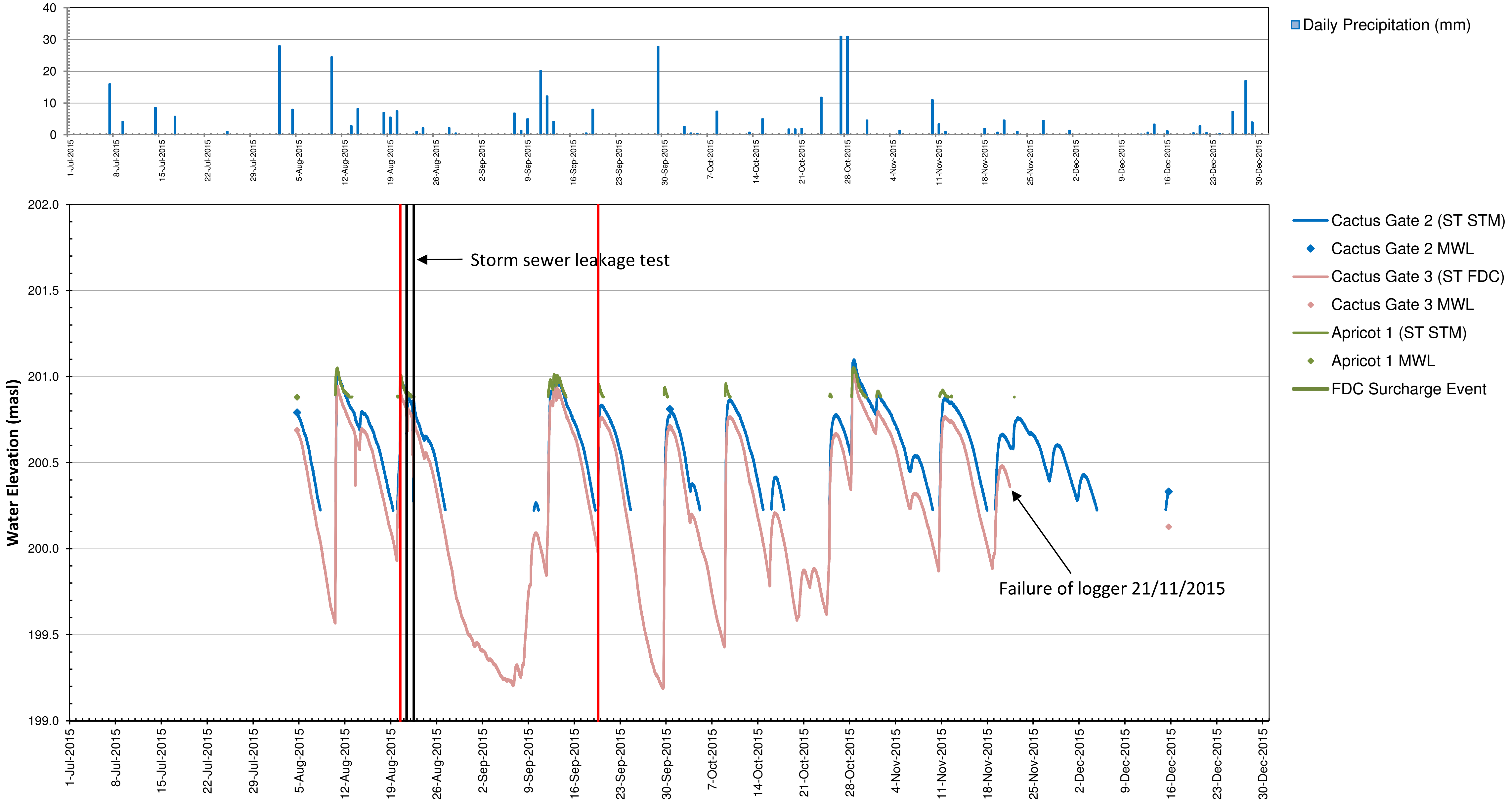
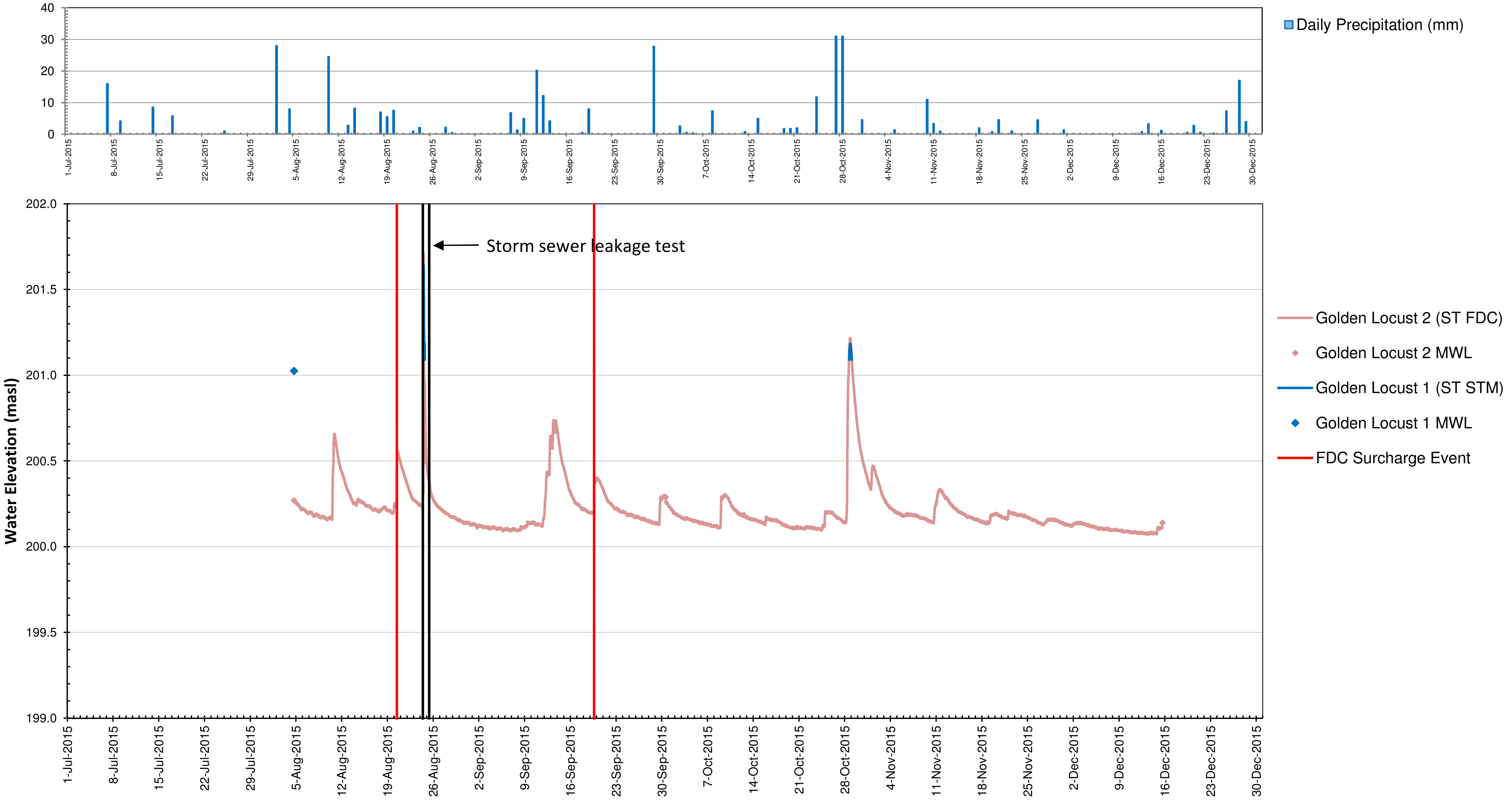


Figure D2a - Hydrograph of Water Levels Area 2 (Golden Locust)



Amec Foster Wheeler
Environment Infrastructure
TP115060

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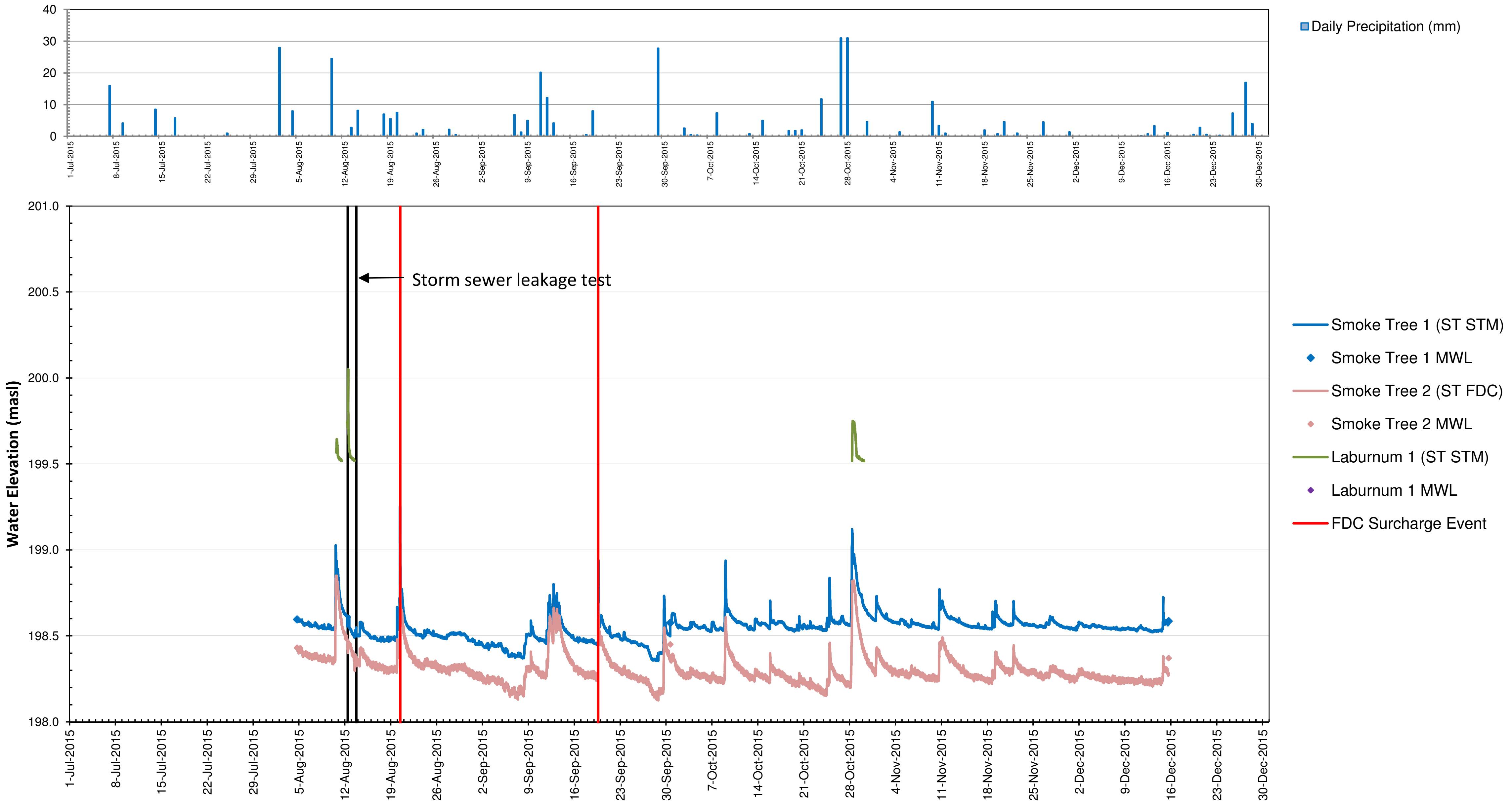
Figure D3a - Hydrograph of Water Levels Area 3 (Smoke Tree Road / Laburnum Crescent)



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Environment Infrastructure
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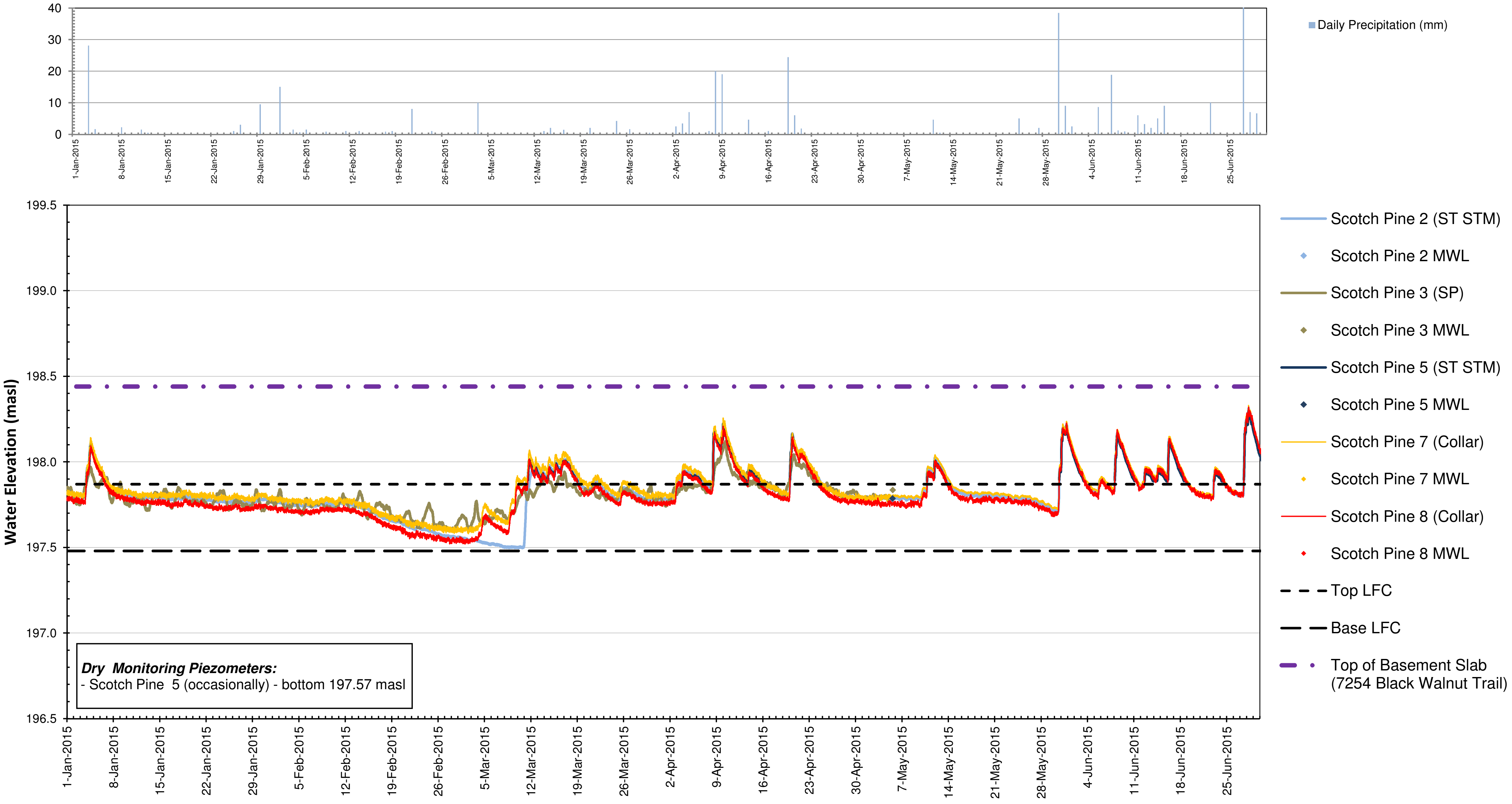
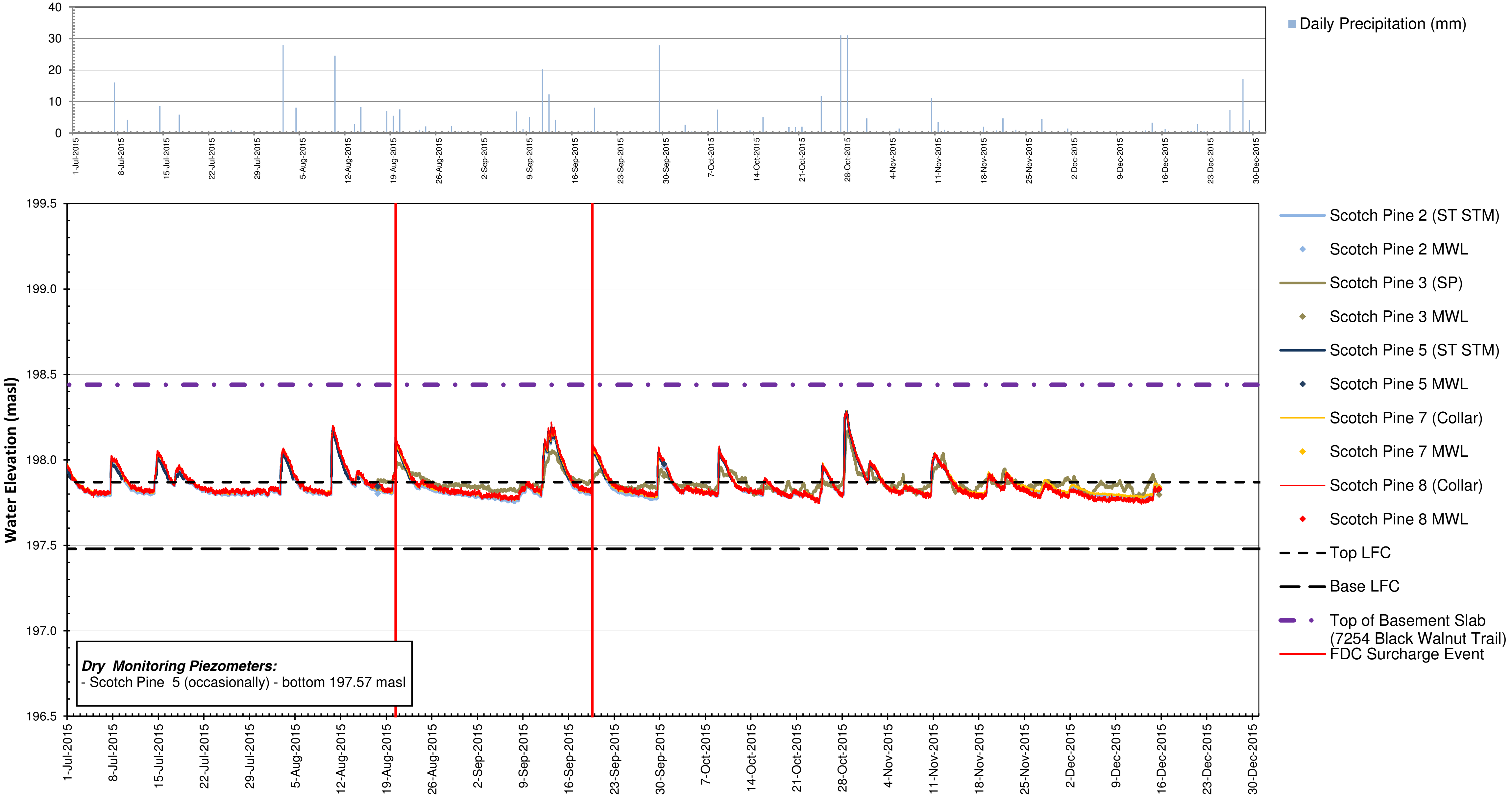
Figure D4a - Hydrograph of Water Levels - Scotch Pine Gate



Amec Foster Wheeler
Environment & Infrastructure
TP115060

amec foster wheeler

Figure D4a - Hydrograph of Water Levels - Scotch Pine Gate



Amec Foster Wheeler
Environment Infrastructure
TP115060

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Figure D5a - Hydrograph of Water Levels - Alderwood Trail

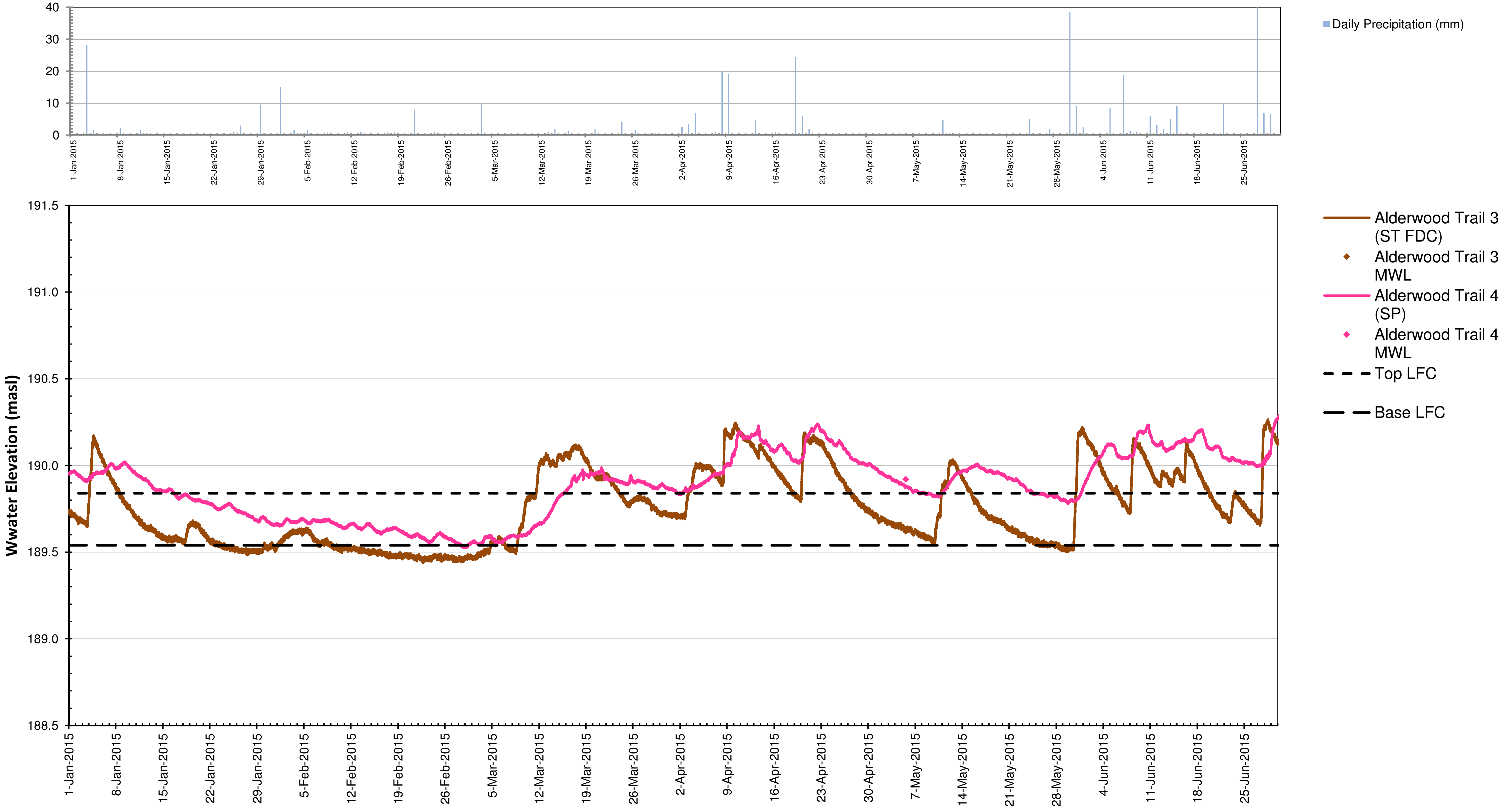


Figure D5b - Hydrograph Water Levels - Alderwood Trail

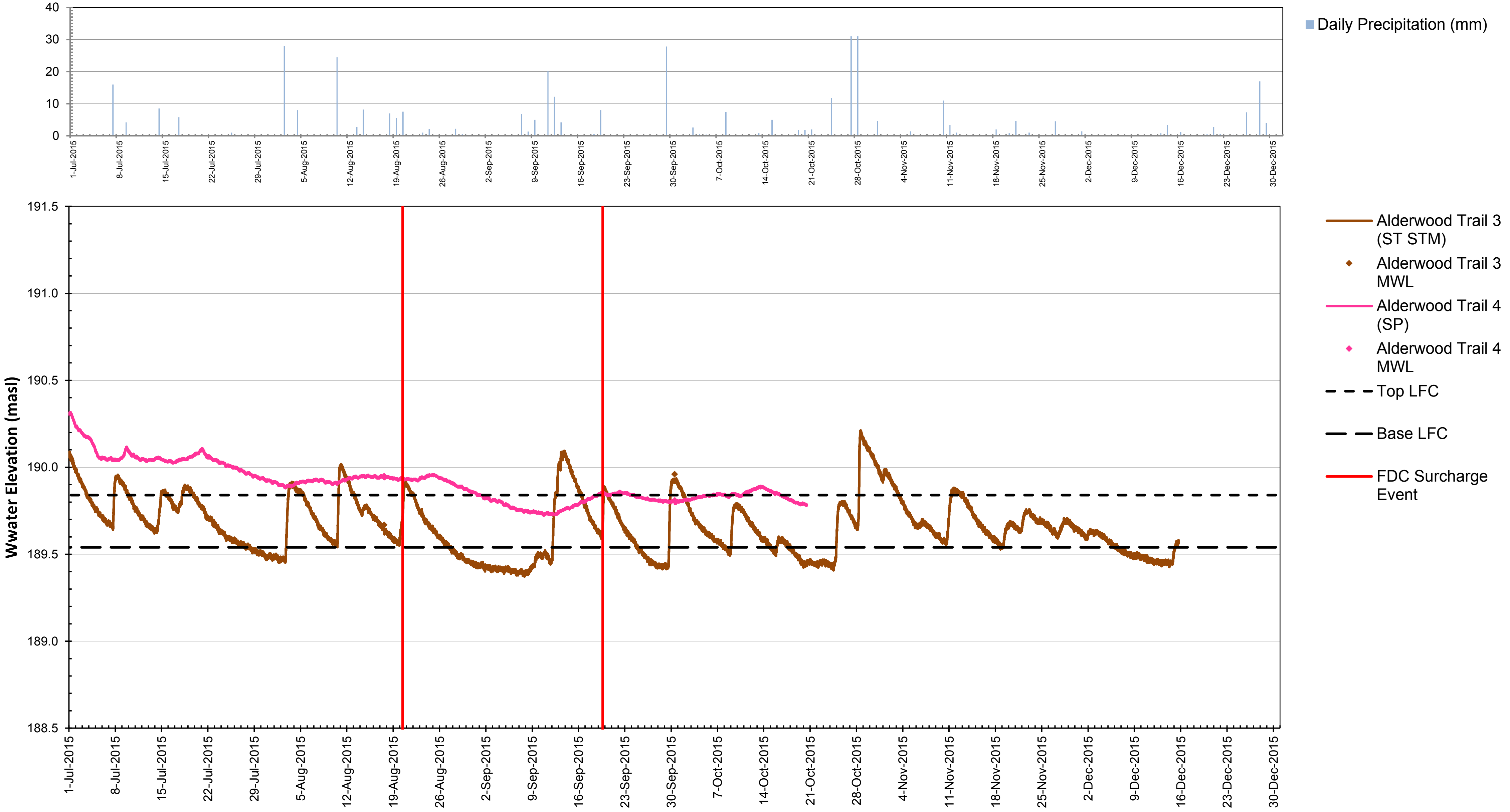
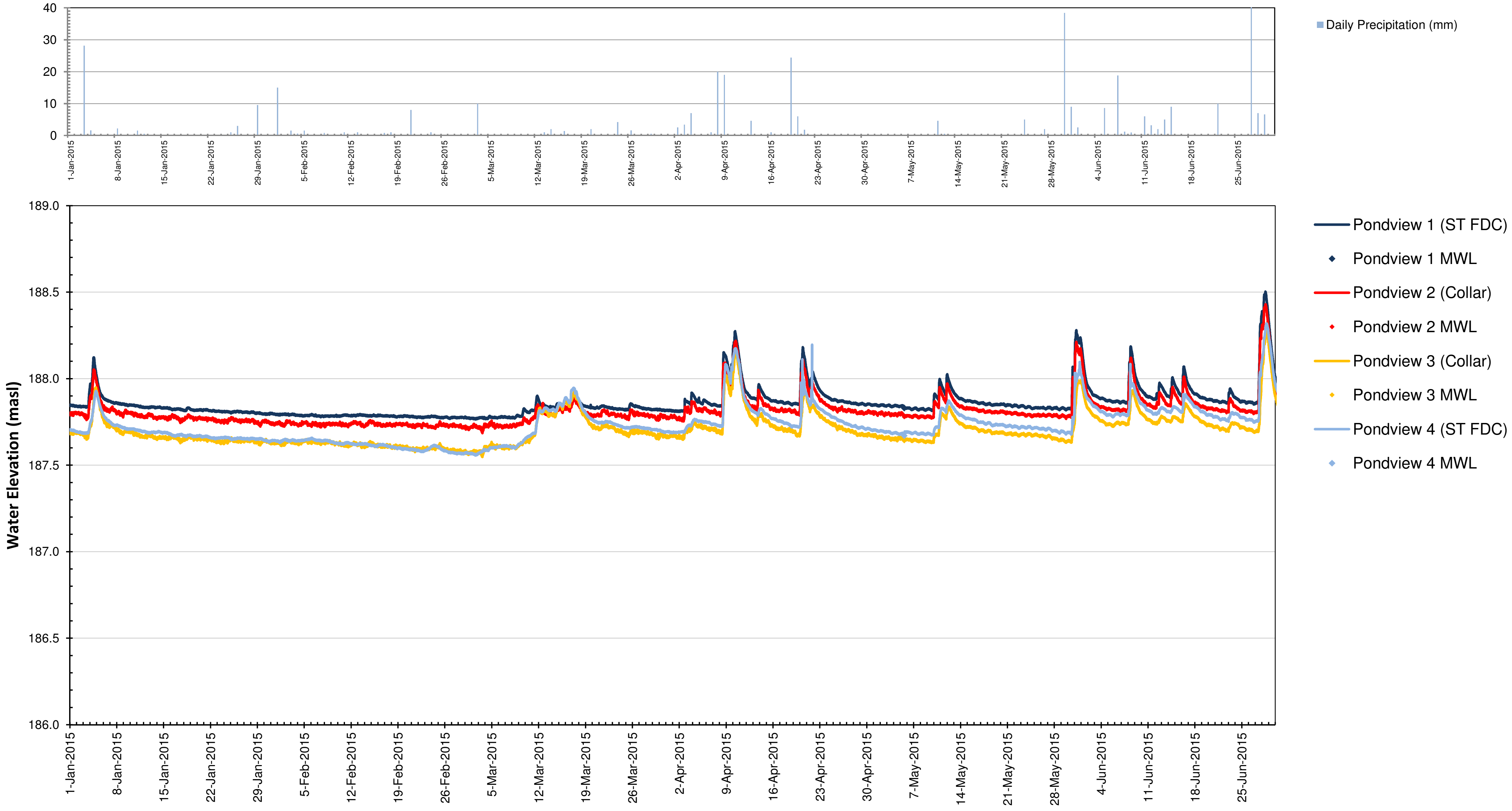


Figure D6a - Hydrograph of Water Levels - Pondview Lane



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TP115060

Figure D6a - Hydrograph of Water Levels - Pondview Lane

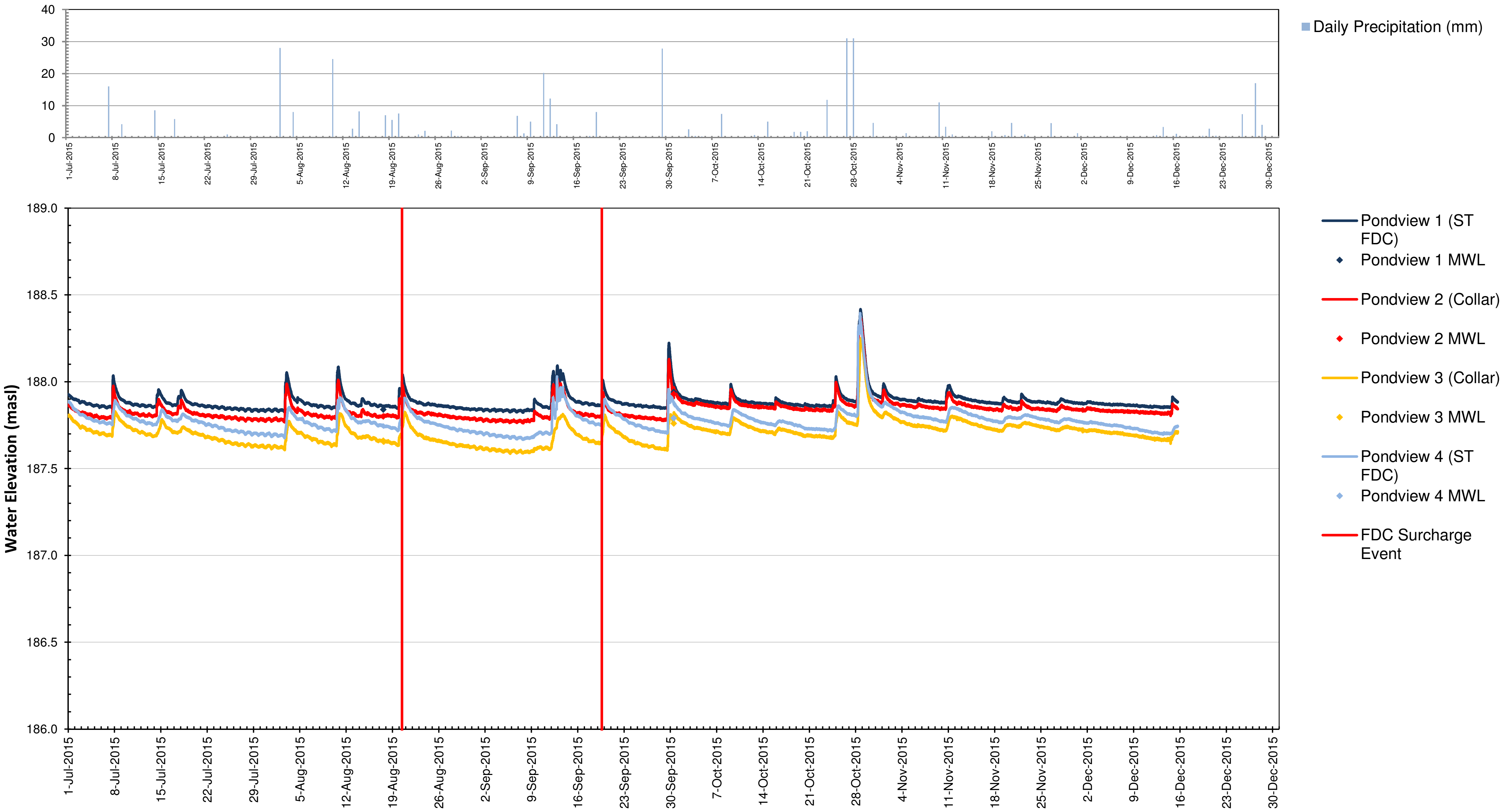

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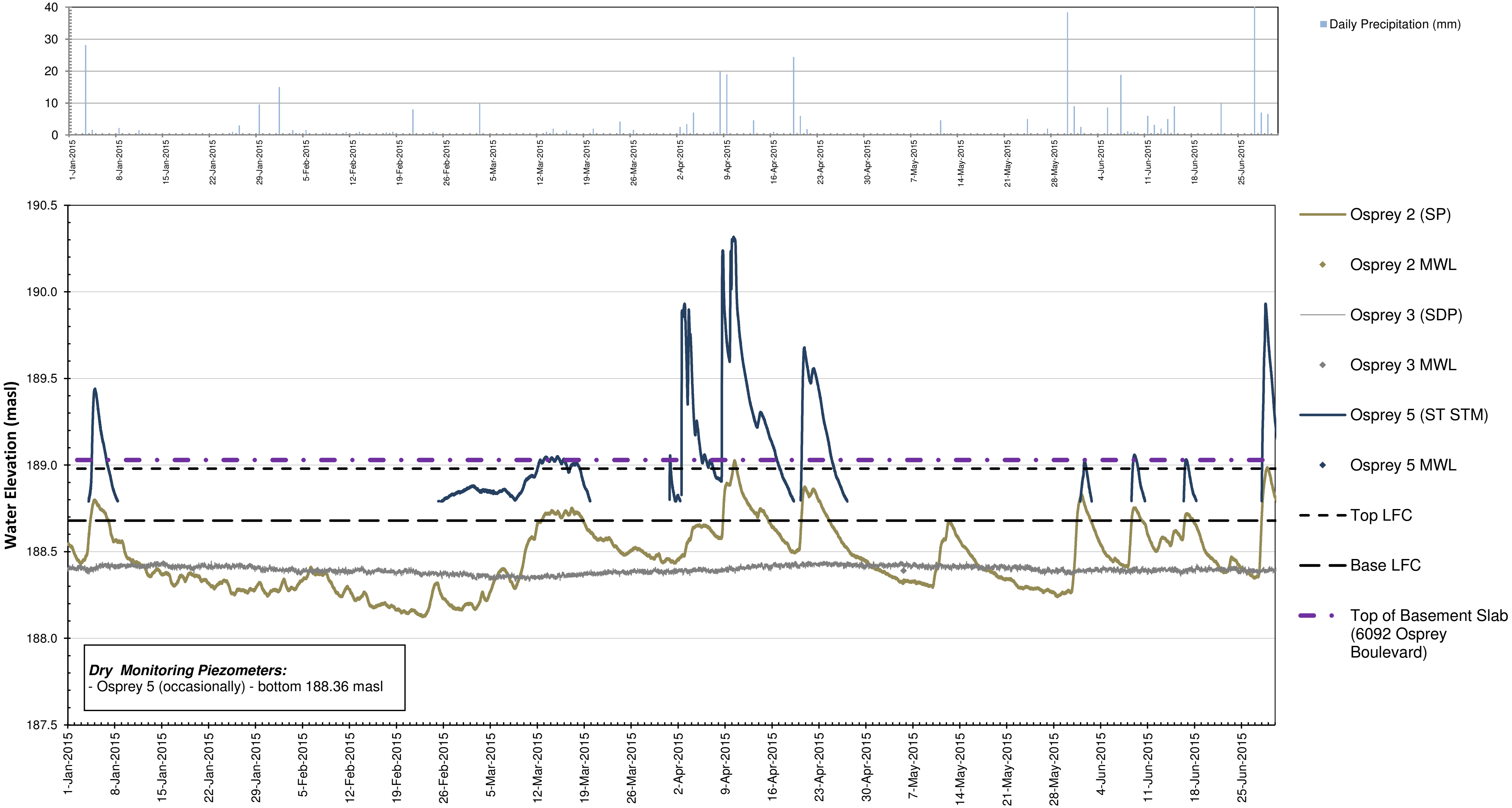
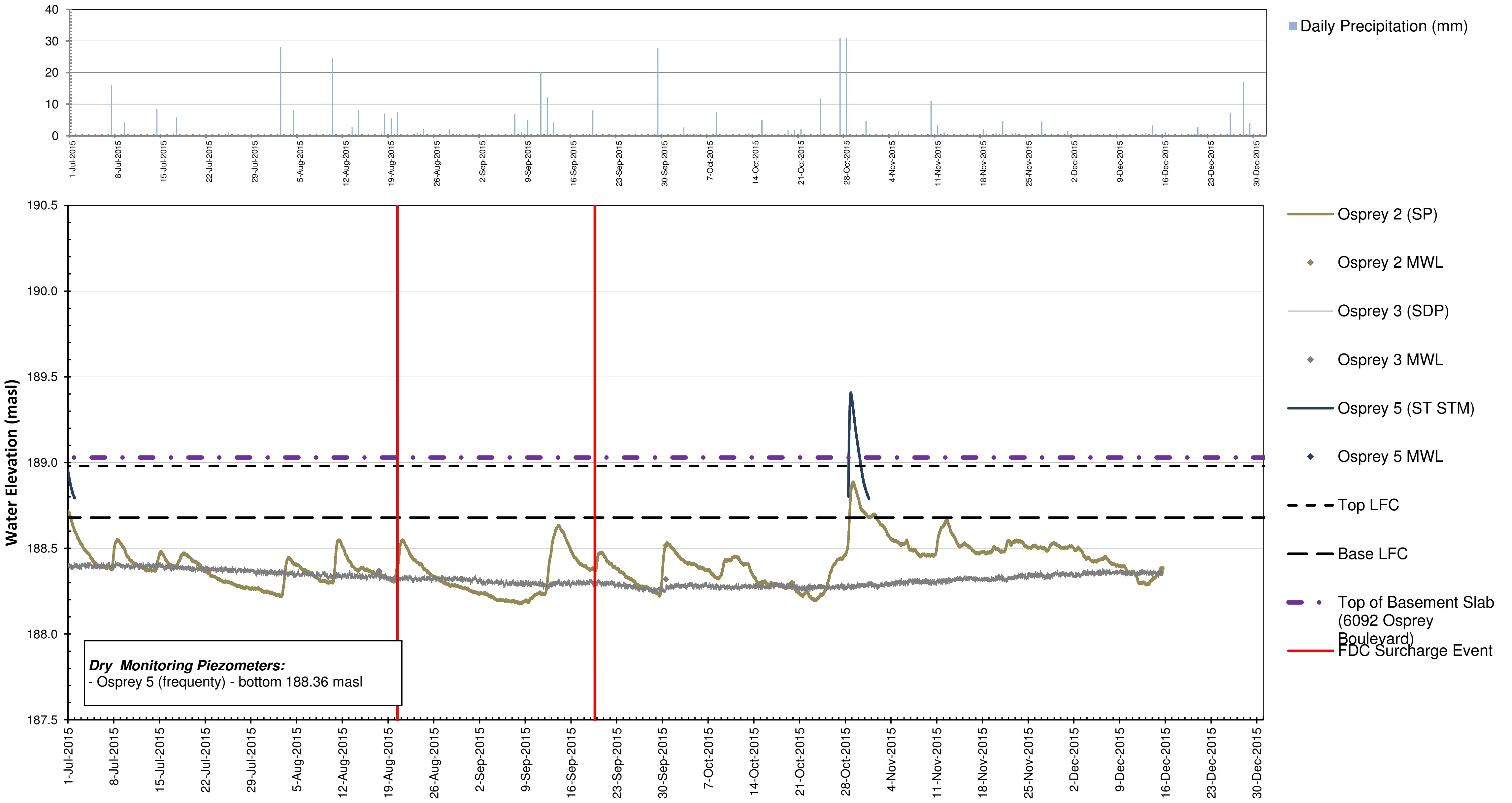
Figure D7a - Hydrograph of Water Levels - Osprey Boulevard



Dry Monitoring Piezometers:
- Osprey 5 (occasionally) - bottom 188.36 masl

Figure D7b - Hydrograph of Water Levels - Osprey Boulevard



Amec Foster Wheeler
Environment Infrastructure
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Appendix E

2015 Storm Sewer Leakage Testing Memorandum
(January 29, 2016)

Memo

To: Anthony DiGiandomenico, City of Mississauga

From: Martin Shepley
Nick Schmidt

cc: Matt Senior
Ron Scheckenberger
Jeremy Blair,

Date: January 29, 2016

Re. Lisgar District Basement Water Infiltration Investigation, Remediation Work Phase Summary of Pre-lining 2015 Groundwater Monitoring Installations and Leakage Tests

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This memorandum summarizes the installation and monitoring of sewer trench piezometers and storm sewer leakage tests undertaken during 2015 prior to the proposed lining of selected areas of storm sewers as part of the Remediation Work Phase for the Lisgar District Basement Water Infiltration Investigation.

Three areas (Figure 1) were identified as pilot areas for storm sewer lining (Amec Foster Wheeler, 2015):

- Area 1, located around Cactus Gate;
- Area 2, located around Golden Locust Drive; and
- Area 3, located around Smoke Tree Road.

To assess baseline conditions within these areas prior to lining, the following field investigations were completed in 2015:

- Installation and monitoring of eight (8) sewer trench piezometers in the pilot areas; and
- The completion of three 24 hour storm sewer leakage tests in each of the pilot areas.

This memorandum provides documents the field work undertaken during 2015. It also provides some preliminary conclusions on the data collected and recommendations for further work.

1. 2015 Piezometer Installations

Storm sewer piezometers were installed in the three (3) pilot areas to obtain baseline water level monitoring data in storm sewer trenches and foundation drainage collector (FDC) sewer trenches prior to lining.

Sewer trench piezometers were installed as follows (Figure 1):

- Area 1 – one upstream and one downstream piezometer in the storm sewer trench (Apricot 1 and Cactus Gate 2) and one downstream piezometer in the FDC sewer trench (Cactus Gate 3);
- Area 2 – one downstream piezometer in the storm sewer trench (Golden Locust 1) and one in the FDC sewer trench (Golden Locust 2): and
- Area 3 – one upstream and one downstream piezometer in the storm sewer trench (Laburnum 1 and Smoke Tree 1) and one downstream piezometer in the FDC sewer trench (Smoke Tree 2).

The details of each piezometer installation can be found in Table 1.

As noted, the new sewer trench piezometers were located along the sections of sewer trench where storm leakage testing was planned. As most piezometers had to be located within the roadway, they were sited at the most practical locations for each respective pilot area, given consideration for local traffic conditions. The FDC sewer trench piezometers were installed approximately adjacent to the downstream storm sewer trench piezometer.

Continuous data collection started on August 4, 2015 for all eight (8) new sewer trench piezometers. The water levels for the new sewer trench piezometers are shown in Figure 2a (Area 1), Figure 2b (Area 2) and Figure 2c (Area 3) with all data collected for 2015. All sewer trench piezometers installed in 2015 show a rapid response to precipitation events, similar to sewer trench piezometers being monitored at the existing sites (Scotch Pine Gate, Osprey Boulevard, Alderwood Trail and Pondview Lane) and remain consistent with the present understanding of widespread storm sewer leakage within the Lisgar District. The following observations are of note:

- The upstream sewer trench piezometers (Area 1, Apricot 1; Area 3, Laburnum 1) are mostly dry; they only wet during the storm sewer leakage tests or larger precipitation events (e.g. October 27-28, 2015);
- The water levels in the storm sewer trench are higher than in the FDC sewer trench indicating leakage from the storm sewer trench to the FDC sewer trench; and
- There was one logger failure (Cactus Gate 3), which will be replaced;
- The water level records for the sewer trench piezometers in Area 1 (Cactus Gate) are very different from those of Area 2 and 3 and other sewer trench piezometers installed across the Lisgar District. Cactus Gate 2 and Cactus Gate 3 show a water level rise that is more pronounced in response to precipitation pronounced with relatively slow recessions during dry periods. The sustained higher water levels may indicate a greater potential for inducing flow to the FDC through the sewer trench system at Area 1.

The groundwater level record for Cactus Gate 1 (a standard well completed to native till, now decommissioned) showed a similar rise and recession behavior to the sewer trench piezometers in Area 1, which further suggests that the groundwater conditions in Area 1 are different from the rest of the Lisgar District.

2. 2015 Storm Sewer Leakage Testing

Storm sewer leakage tests were undertaken to assess the existence of a flow path from the storm sewer through the sewer bedding to the FDC within the three pilot areas. These tests were similar in execution to previous storm sewer leakage tests undertaken during the investigation phases of the Lisgar District Basement Infiltration Investigation (Amec Foster Wheeler, 2015), comprising:

- A pre-test planning stage for selection of blocking locations, filling points, sampling points and fill targets (water volume and level);
- Blocking of a section of the storm sewer using an inflatable packer for a period of approximately 24 hours;
- Controlled filling of the storm sewer by providing water from nearby fire hydrants, the quantity and flow rate of water was measured with a flow meter attached to the fire hydrant. The storm sewers were filled to levels expected during a storm event, generally around the level of the obvert of the storm sewer for the locations tested;
- Addition of a controlled amount of sodium fluorescein dye (industrial name is Uranine, but further referred to as fluorescein in this report) to the blocked storm sewer during filling. The target concentration of fluorescein in the storm sewer was approximately 100 to 150 µg/L. These are concentrations at which the fluorescein is only weakly visible in water;
- Continuous measurement of water levels during the test in the storm sewer, FDC and sewer trench piezometers;
- Regular sampling of FDC water using an autosampler for the purpose of measuring fluorescein concentrations; and
- Occasional sampling of water from the sewer trench piezometers also for measuring fluorescein concentrations.

The detection of the fluorescein dye in the FDC during the test is the key indicator to prove the flow path from storm sewer to FDC. Fluorescein fluoresces yellow-green and is at higher concentrations visible to the naked eye; it is detectable at very low concentrations with a fluorometer (<< 1 ug/L).

Storm sewer leakage tests were undertaken at the following locations (Figure 1) and on the following dates:

- Laburnum Crescent, August 12-13, 2015 (Area 3);
- Cactus Gate, August 21-22, 2015 (Area 1); and
- Golden Locust Drive, August 24-25, 2015 (Area 2).

All three tests were undertaken during dry weather with no precipitation (note the precipitation record used on Figure 2 is the Environment Canada Station for Oakville Town (ID 6155750) and does not necessarily reflect the exact precipitation during the tests). The duration of each test is shown on Figure 2 indicating the sewer trench water level conditions prior to and after each test:

- At Laburnum Crescent and Golden Drive the tests were undertaken at the end of a recession and water levels were relatively low in the sewer trench;
- At Cactus Gate water levels in the sewer trench were comparatively high, occurring at the start of a recession from antecedent precipitation. As noted in Section 1, the Area 1 sewer trench water levels appear to be more sustained than other sewer trenches monitored across the Lisgar District and this condition directly affects the results of this particular test.

A factual description of each test is given in the following three subsections below with a brief discussion of the results.

2.1 Laburnum Crescent, August 12-13, 2015 (Area 3)

The extent of the Laburnum Crescent test is shown in Figure 3, showing the blocking and filling locations, test-specific manhole numbering for identifying sampling points and the location of the sewer trench piezometers. The test comprised the blocking of the storm sewer at one manhole

(BWTSS8) on Black Walnut Trail between Smoke Tree Road and Laburnum Crescent as indicated on Figure 3.

A total water volume of 116 m^3 was added to the storm sewer on August 12, 2015 (10:46 am – 12:15 pm) from two fire hydrants. During this period fluoroscein dye was continuously added at both inflow points; the final concentration in the storm sewer was estimated at 100 μg/L based on water volume and quantity of dye added.

On August 13, 2015 at 11:45 am an additional 24 m^3 of water was added, but without dye, with the purpose of establishing a constant head and potentially to measure a secondary pulse of dye in the receiving FDC. At 5:30 pm on August 13, 2015 the water release valve of the packer was opened followed by deflation and removal of the packer.

Results

Water levels and the measured fluorescein concentrations of the test are shown in Figure 4; Figure 3 shows the locations of the sampling points. The main results are summarized as follows:

- The water level in the storm sewer quickly decreased (leaked) when it was pushed into surcharge conditions;
- Positive breakthrough occurred (i.e. measurement of tracer) in the FDC sewer (BWTFDC9) with a peak concentration within 2 hours of 7.4 μg/L (~14× dilution);
- Positive breakthrough occurred in the storm sewer trench at Laburnum 1 (LB1) with a peak concentration within 4 hours of 14.9 μg/L (~7× dilution);
- Positive breakthrough occurred in the storm sewer trench at Smoke Tree 1 (ST1) with a peak concentration within 6 hours of 8.7 μg/L (~11× dilution); and
- Positive breakthrough occurred in the FDC sewer trench at Smoke Tree 2 (ST2) with a peak concentration within 6 hours of 5.0 μg/L (~20× dilution).

Discussion

The rapid breakthrough of the dye in the FDC is consistent with the results of the 2013 storm sewer leakage tests on Black Walnut Trail (Scotch Gate Pine and Wild Cherry Lane). The downstream sewer trench piezometers (Smoke Tree 1 and 2) show a later breakthrough consistent with their location immediately downstream of the immediate footprint of the test to the south of the large elliptical storm sewer (1220×1990 mm) on Smoke Tree Lane. Neither of the two Smoke Tree piezometers show a water level rise, suggesting that the sewer trench of the Smoke Tree elliptical storm sewer is a significant water conduit (strong flow in this storm sewer is noted during dryer periods). The water level in the blocked storm sewer rose outside of the inflow periods. Uncontrolled inflow to the test was later traced by City staff to an upstream leaking lawn sprinkler system. A satisfactory constant head test could not be undertaken due to these uncontrolled inflows to the blocked storm sewer.

2.2 Cactus Gate, August 21-22, 2015 (Area 1)

The extent of the Cactus Gate test is shown in Figure 5, showing the blocking and filling locations, test-specific manhole numbering for identifying sampling points and the location of the sewer trench piezometers. The test comprised the blocking of the storm sewer outfall to the west of Black Walnut Trail and Cactus Gate as indicated on Figure 5.

A total water volume of 75 m^3 was added to the storm sewer on August 21, 2015 (10:15 am – 11:05 am) from two nearby fire hydrants. During this period fluoroscein dye was continuously added at both inflow points; the final concentration in the storm sewer was estimated at 210 µg/L based on water volume and quantity of dye added.

The water level was topped up on August 22, 2015 (9:13 am - 10:05 am) by adding an additional 52 m^3 to induce a second pulse of dye moving through the system. During the second filling the water levels in the storm sewer rose 28 cm above the maximum level the day before. At 12:15 pm on August 22, 2015 the water release valve of the packer was opened followed by deflation and removal of the packer.

Results

Water levels and the measured fluorescein concentrations of the test are shown in Figure 6; Figure 5 shows the locations of the sampling points. The main results are summarized as follows:

- Water levels in the storm sewer did not decrease quickly even when pushed well above surcharge conditions on August 22, 2015;
- There was a very subdued response to filling of the storm sewer in the sewer trench piezometers;
- No positive breakthrough occurred in the closest FDC sewer monitored (BWTFDC3);
- No positive breakthrough occurred in the storm sewer trench at Apricot 1 (A1).
- No positive breakthrough occurred in the storm sewer trench at Cactus Gate 2 (CG2).
- A breakthrough occurred in the FDC sewer trench at Cactus Gate 3 (CG3) with a peak concentration within 0.5 hours of 3.1 µg/L (~67× dilution), followed by a drop and then slow increase in dye concentration with a second peak at 24 hours of 3.5 µg/L (~60× dilution).
- A late and diffuse positive breakthrough in the FDC sewer downstream at Smoke Tree (BWTFDC9) of about 1 µg/L (~200× dilution).

Discussion

This test was conducted under relatively high water level conditions in comparison to the other two tests reported in this memorandum and the three tests undertaken in 2013 in the Lisgar District. These water levels were due to antecedent rainfall that occurred from August 18 to August 20. Leakage out of the storm sewer appears to have been relatively limited at this location. This could be due to either:

- the storm sewer being relatively tight along the test section with few leaks; and / or
- the relatively high water levels in the sewer trench restricting leakage out of the filled storm sewer.

Either explanation is consistent with the lack of a positive breakthrough for this test at the closest FDC sewer monitored (BWTFDC3). It is notable that the dilution factors of the dye breakthroughs are considerably higher than the other two tests, which is consistent with the larger quantities of water in the sewer trench at this location during the test. It is expected that leakage into the FDC occurs immediately downstream of the test, as indicated by the dye breakthroughs in both Cactus Gate 3 (CG3) and at BWTFDC9.

2.3 Golden Locust Drive, August 24-25, 2015 (Area 2)

The extent of the Golden Locust Drive test is shown in Figure 7, showing the blocking and filling locations, test-specific manhole numbering for identifying sampling points and the location of the sewer trench piezometers. The test comprised the blocking of the storm sewer at a manhole (GLDSS4) which is on Blackwood Mews at the intersection of Golden Locust Drive as indicated on Figure 7.

A total water volume of 193 m^3 was added to the storm sewer on August 24, 2015 (10:30 am – 12:15 pm) from two nearby fire hydrants into the storm sewer. During this period fluoroscein dye was continuously added at both inflow points; the final concentration in the storm sewer was estimated at 67 µg/L based on water volume and quantity of dye added.

The water level was topped up in the afternoon of August 24, 2015 (3:30 pm – 4:25 pm) by adding an additional 21 m^3 to induce a second pulse of dye moving through the system from the storm sewer. The rate of water flow into the storm sewer was reduced and a constant head test was undertaken (4:25 pm – 5:10 pm) by approximately maintaining a constant water level in the storm sewer. A constant head was achieved (4:50 pm – 5:10 pm) allowing the determination of an average leakage rate for the conditions in the storm sewer. At 9:00 am on August 25, 2015 the water release valve of the packer was opened followed by deflation and removal of the packer and return of the sewer to normal operating conditions.

Results

Water levels and the measured fluorescein concentrations of the test are shown in Figure 8; Figure 7 shows the locations of the sampling points. The main results are summarized as follows:

- Water levels in storm sewer quickly decreased (leaked) when it was pushed into surcharge conditions;
- The FDC was dry at the start of the test; a flow was measured in the FDC during filling of the storm sewer;
- Positive breakthrough (i.e. measurement of tracer) in the FDC sewer (GLFDC4) with a peak concentration within 1.5 hours of 27.7 µg/L (~2.5× dilution);
- Positive breakthrough in the bedding of the storm sewer at GL1 with a peak concentration within 1.5 hours of 50.7 µg/L (~1.3× dilution);
- Positive breakthrough in the bedding of the FDC sewer at GL2 with a peak concentration within 2-3 hours of 23.1 µg/L (~2.9× dilution);
- Leakage is estimated at approximately 2 L/s (~170 m^3/d) for surcharged conditions based on the constant head test.

Discussion

The pathway from storm sewer via the storm sewer trench to the FDC was proven in this test not only by dye breakthrough in the FDC, but also by the generation of flow in the FDC itself. The test is also noteworthy as it is in an area that is at higher topographic elevation than other tests. This is the only test from the three baseline tests where conditions allowed for a reliable constant head test to be undertaken for determining leakage from the storm sewer.

3. Conclusions

The following conclusions are made based on the results from the 2015 storm sewer leakage tests undertaken to assess baseline conditions prior to lining of storm sewers in Area 1, 2, and 3:

- All three storm sewer leakage tests (Area 1, Area 2 and Area 3) show clear evidence of leakage from the storm sewer to the storm sewer trench and FDC sewer trench, both from water level responses and dye breakthroughs in the sewer trench piezometers. Of the three areas, Area 1 showed the weakest evidence for this flow pathway; however, this may be attributable to other factors;
- All three storm sewer leakage tests (Area 1, Area 2 and Area 3) had dye breakthrough in the FDC, which verifies the conclusions of the forensic hydraulic and hydrologic modelling undertaken in by Amec Foster Wheeler (2015);
- Monitoring in Area 1, before and after the Cactus Gate test, has highlighted more sustained high water level conditions with slower water level recessions in the storm sewer trench in comparison to the other areas and also other previously monitored sites within the Lisgar District; and
- The Golden Locust Drive test (Area 2) is noteworthy as it is proves the storm sewer to FDC connection in a geographically ‘elevated’ part of the Lisgar District. This area has the potential to be a significant contributor to the head conditions that generate the surcharging in the FDC.

4. Recommendations

The following recommendations are made based on the conclusions from the 2015 baseline storm sewer leakage tests and monitoring in Area 1, Area 2 and Area 3:

- Area 2 and Area 3 should undergo storm sewer lining based on the testing undertaken in these two areas;
- The intersection of Cactus Gate and Black Walnut Trail should be considered for installing a sewer trench dewatering system as this is a location of marked water build-up in the sewer trench in comparison to other areas tested and monitored; and
- The sewer trench piezometers in Area 1, Area 2 and Area 3 should be continued to be monitored to provide a full time-series of water level baseline conditions up to lining of the storm sewers and water level conditions after lining.

5. References

Amec Foster Wheeler, 2015. Lisgar District Basement Water Infiltration Investigation, Summary Report. Report for City of Mississauga.

Table 1 Summary of Piezometers Lisgar District

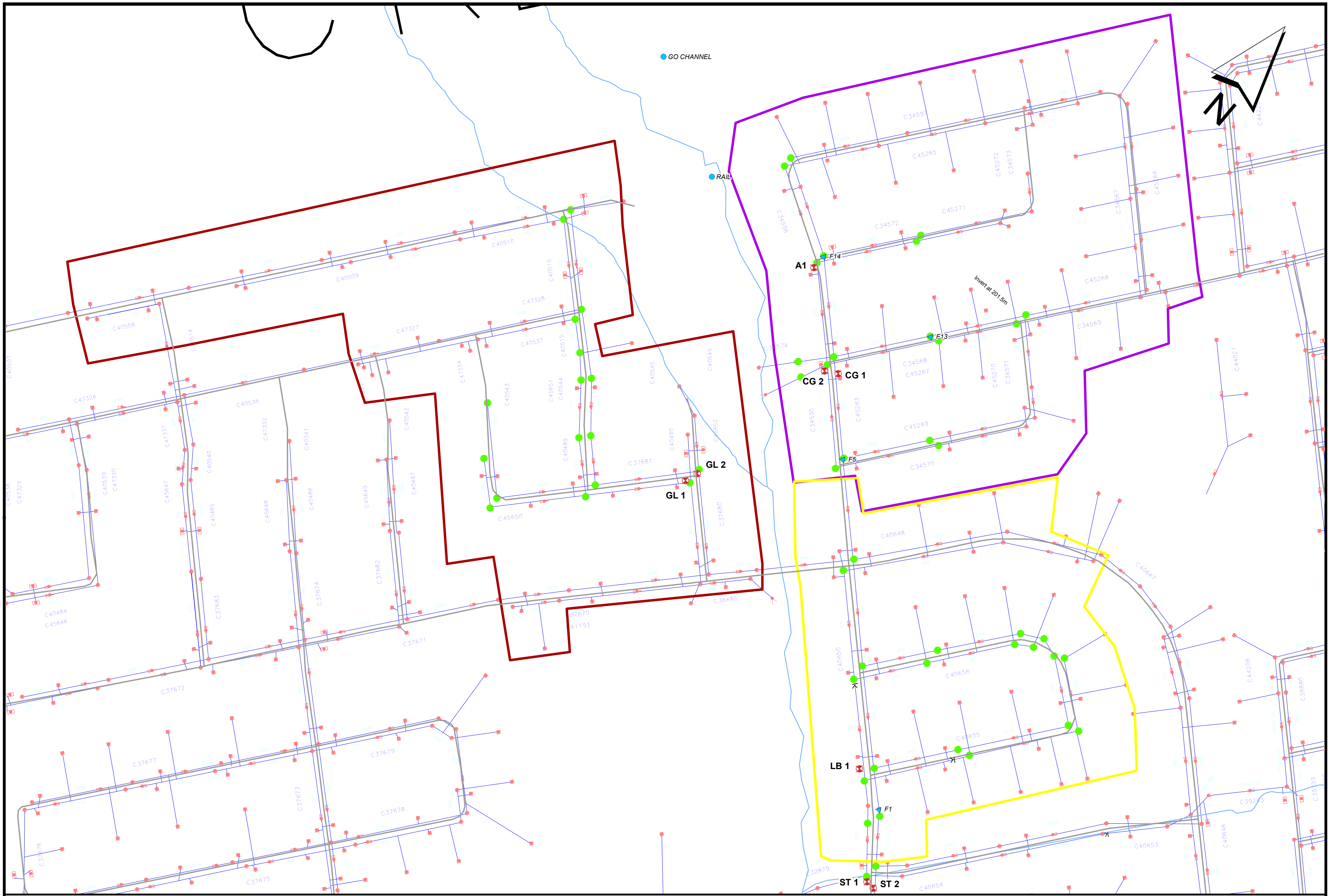
Site	Piezometer Name	Piezometer Type(1)	Surface Elevation (masl)	Screen Interval (mbgs)	Material Monitored	K(2),(3) (m/s)	Period Monitored	Decommission Date	Notes
Lisgar GO Station	GO1	SDP	207.10	1.6-1.8	Silty clay (fill)	-	6/15/12 - 5/14/13	5/23/13	GO sanitary sewer trench
	GO2	SDP	206.20	1.6-1.8	Silty clay (fill)	-	6/15/12 - 5/14/13	5/23/13	GO storm sewer trench
Black Walnut Trail	BW1	Standard	205.39	3.9 - 5.4	Silty clay	-	12/23/11 - 5/22/13	5/23/13	Background, near GO Station
Cactus Gate	CG1	Standard	202.19	3.9 - 5.4	Silty sand	-	12/23/11 - 5/22/13	5/23/13	Background near 16 Mile Creek
Scotch Pine Gate	SP1	Standard	199.43	2.5 - 3.9	Silt & clayey silt	*8.4E-09*	12/23/11 - 5/22/13	5/23/13	Close to 16 Mile Creek
	SP2	Sewer Trench	199.33	0.6 - 2.1	Silty clay (fill)	1.1E-06	12/23/11 - present	-	Storm sewer trench
	SP3	Standard	199.99	2.7 - 4.2	Silty to coarse sand	6.5E-07	12/23/11 - present	-	Close to 7244 Black Walnut Trail
	SP4	SDP	200.00	1.8 - 2.0	Clayey silt	*1.2E-08*	3/02/12 - 11/21/13	-	Close to 7244 Black Walnut Trail - dry
	SP5	Sewer Trench	199.57	0.8 - 2.0	Silty clay (fill)	3.5E-05	5/31/12 - present	-	Storm sewer - dry at record start
	SP6	SDP	200.02	1.5 - 1.7	Fill	-	8/16/12 - 5/22/13	5/23/13	Close to 7254 Black Walnut Trail - dry
	SP7	Collar	199.56	2.9 - 3.1	Gravel sewer bedding	-	11/11/14 - present	-	Storm sewer trench
	SP8	Collar	199.61	2.9 -3.1	Gravel sewer bedding	-	11/11/14 - present	-	Storm sewer trench
Osprey Boulevard	OSP1	Standard	189.63	3.7 - 5.2	Silty clay	-	12/23/11 - 5/22/13	5/23/13	Close to 16 Mile Creek
	OSP2	Standard	190.00	3.7 - 5.2	Silty clay	-	12/23/11 - present	-	Close to 6088 Osprey Blvd
	OSP3	SDP	190.20	2 - 2.2	Silty clay	-	3/02/12 - present	-	SDP close to 6088 Osprey Blvd
	OSP4	Sewer Trench	190.37	0.6 - 2.1	Silty clay (fill)	2.1E-07	5/31/12 - 5/28/14	-	Storm sewer trench - mostly dry
	OSP5	Sewer Trench	190.36	0.8 - 2.0	Silty clay (fill)	2.2E-07	5/31/12 - present	-	Storm sewer trench - frequently dry
	OSP6	SDP	190.90	2.3-2.5	Fill	-	8/1/12 - 5/28/14	-	SDP between 6088 and 6092 Osprey Blvd
Alderwood Trail	AT1	Sewer Trench	192.08	1.7 - 2.4	Silty clay / Gravel (fill)	-	5/29/13 - 5/22/14	-	Storm sewer trench
	AT2	Sewer Trench	192.00	2.0 - 2.7	Silty clay / Gravel (fill)	-	5/29/13 - 9/30/13	-	FDC branch sewer trench
	AT3	Sewer Trench	192.06	2.1 - 2.9	Silty clay / Gravel (fill)	-	5/29/13 - present	-	FDC sewer lateral trench
	AT4	Standard(4)	192.14	2.0 - 3.5	Silty clay	-	5/29/13 - present	-	Background
Pondview Way	PV1	Sewer Trench	190.57	2.5- 4.0	Silty clay / Gravel (fill)	1.2E-06	5/28/14 - present	-	FDC branch sewer trench
	PV2	Collar	190.12	3.7 - 3.9	Gravel sewer bedding	-	11/21/14 - present	-	FDC branch sewer trench
	PV3	Collar	190.08	3.7 - 3.9	Gravel sewer bedding	-	11/21/14 - present	-	FDC branch sewer trench
	PV4	Sewer Trench	189.66	1.8 - 3.3	Silty clay / Gravel (fill)	1.3E-04	5/28/14 - present	-	FDC branch sewer trench
Cactus Gate	A1	Sewer Trench	202.86	1.2 - 2.1	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	CG2	Sewer Trench	202.52	1.6 - 2.5	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	CG3	Sewer Trench	202.69	3.1 - 4.6	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
Golden Locust	GL1	Sewer Trench	203.56	1.7 - 2.6	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	GL2	Sewer Trench	203.59	2.2 - 3.7	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
Smoke Tree	LB1	Sewer Trench	201.36	1.1 - 2.0	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	ST1	Sewer Trench	200.94	1.2 - 2.7	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	ST2	Sewer Trench	200.98	2.8 - 4.3	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench

1 SDP = shallow drive point

2 Hydraulic conductivity derived from slug testing - italicized are those piezometers with limited response

3 Arithmetic mean is given for those piezometers with more than one test (SP2, PV1, PV4)

4 AT4 was installed with hydrovac due to proximity of underground services



LEGEND

● Creek Gauge

▲ FDC Gauge

⊕ Sewer Trench Piezometer

● Manholes

🟪 Area 1

🟥 Area 2

🟨 Area 3

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

LOCATION PLAN

amec foster wheeler

Scale 1:4400
0 20 40 80

Consultant File No.
TP115060.2000

Figure No.
1

Figure 2a - Hydrograph of Water Levels Area 1 (Cactus Gate)

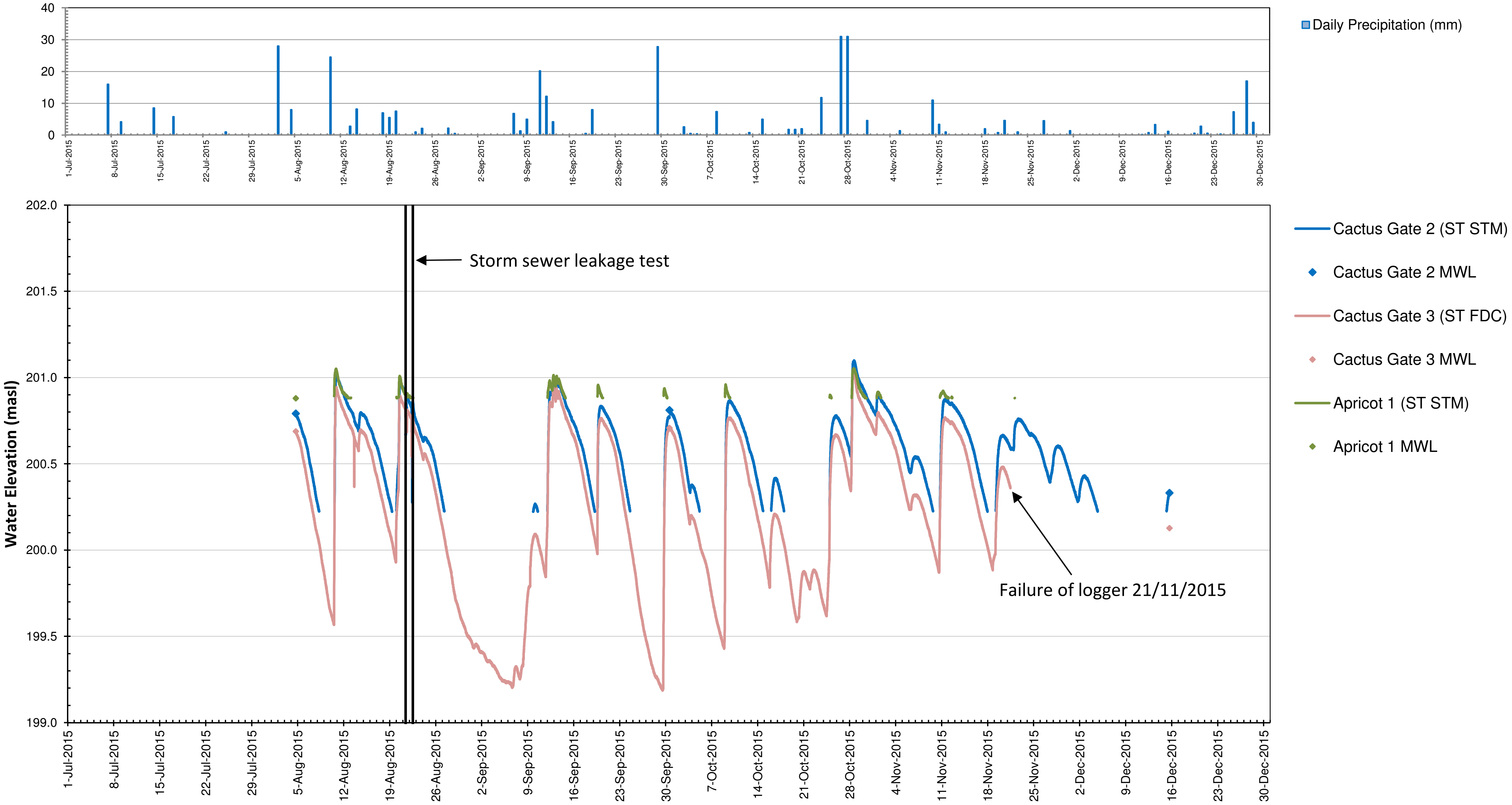
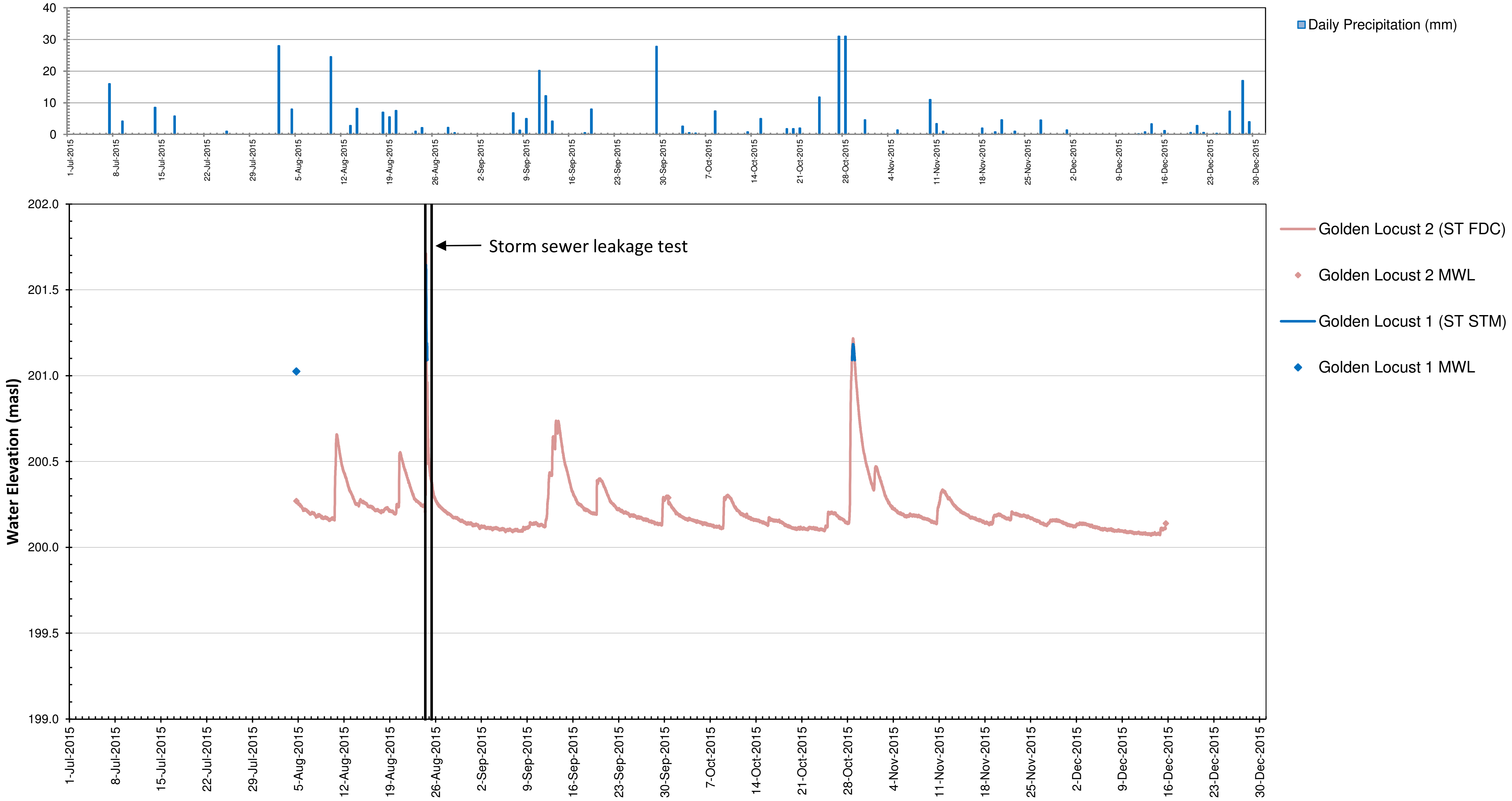
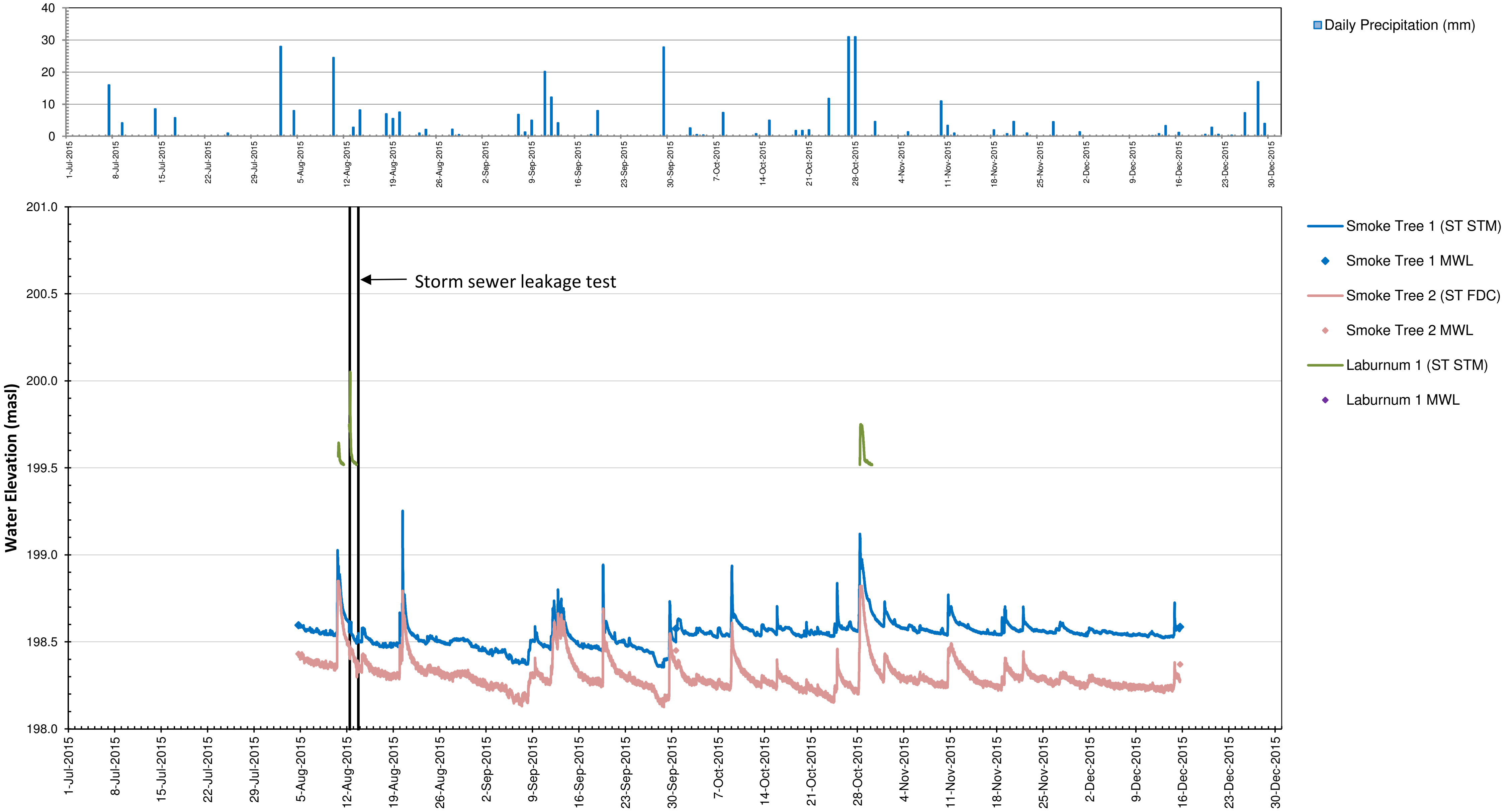


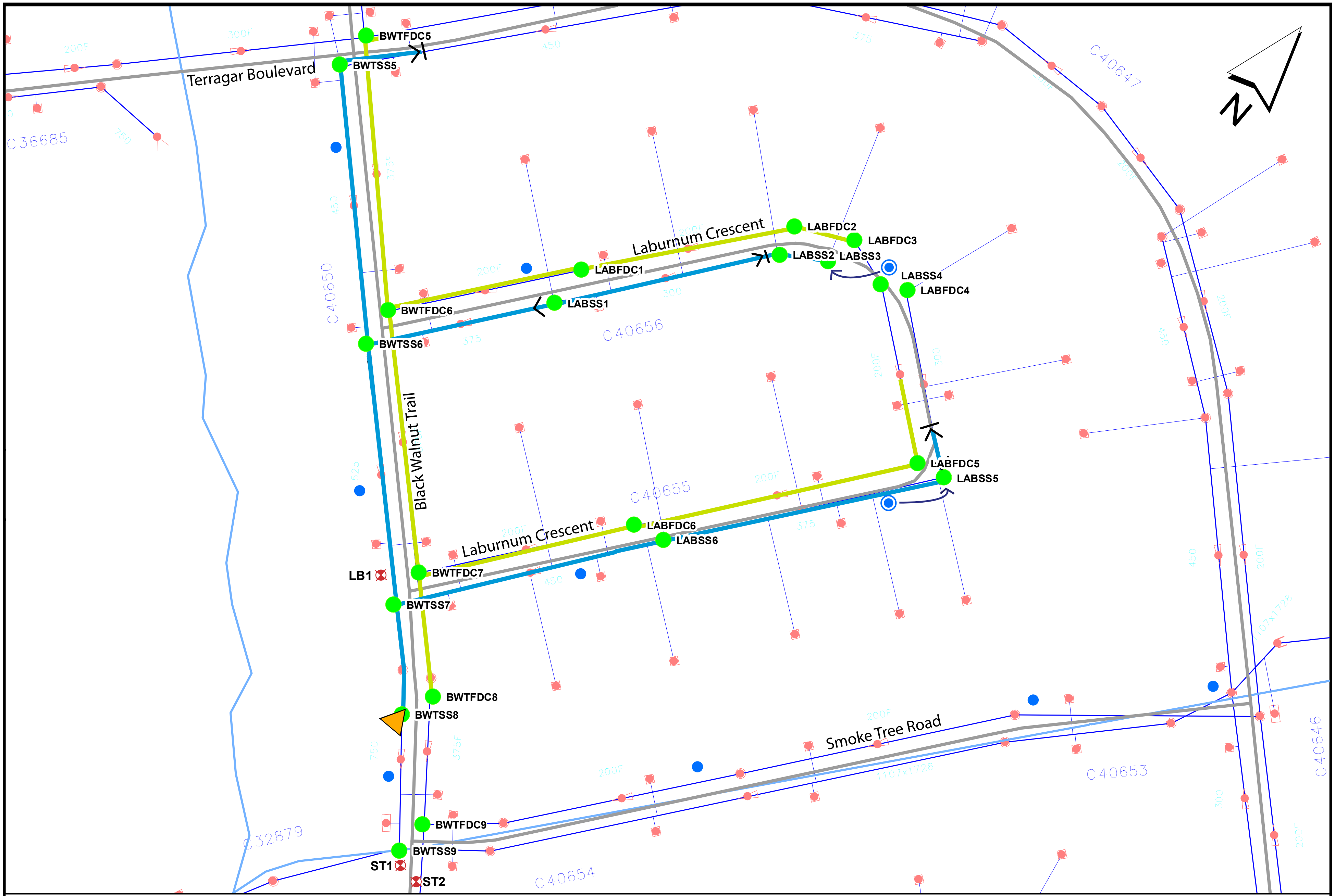
Figure 2b - Hydrograph of Water Levels Area 2 (Golden Locust)



TP115060

Figure 2c - Hydrograph of Water Levels Area 3 (Laburnum Crescent)





LEGEND

- ◉ Fire Hydrant Selected
- ⊕ Sewer Trench Piezometer
- ● Fire Hydrant
- ▲ Block Storm Sewer
- ● Manholes (labelled with ID)
- ━ Storm Sewer Tested
- ━ FDC Tested
- < Obvert
- K Invert

NOTE:
Fill to 201 masl

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PLAN - LABURNUM CRESCENT

STORM SEWER LEAKAGE
TEST AREA 3

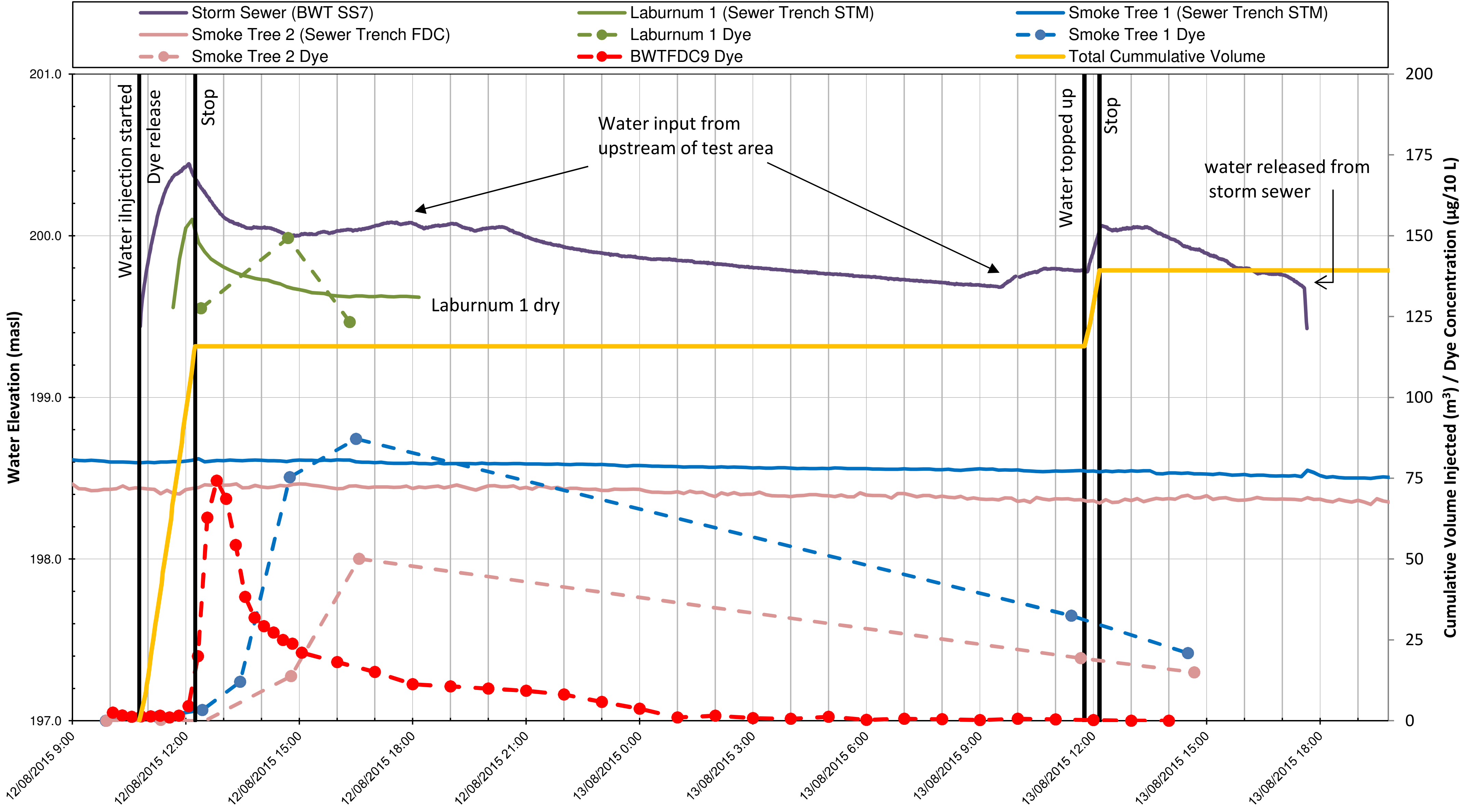
amec foster wheeler

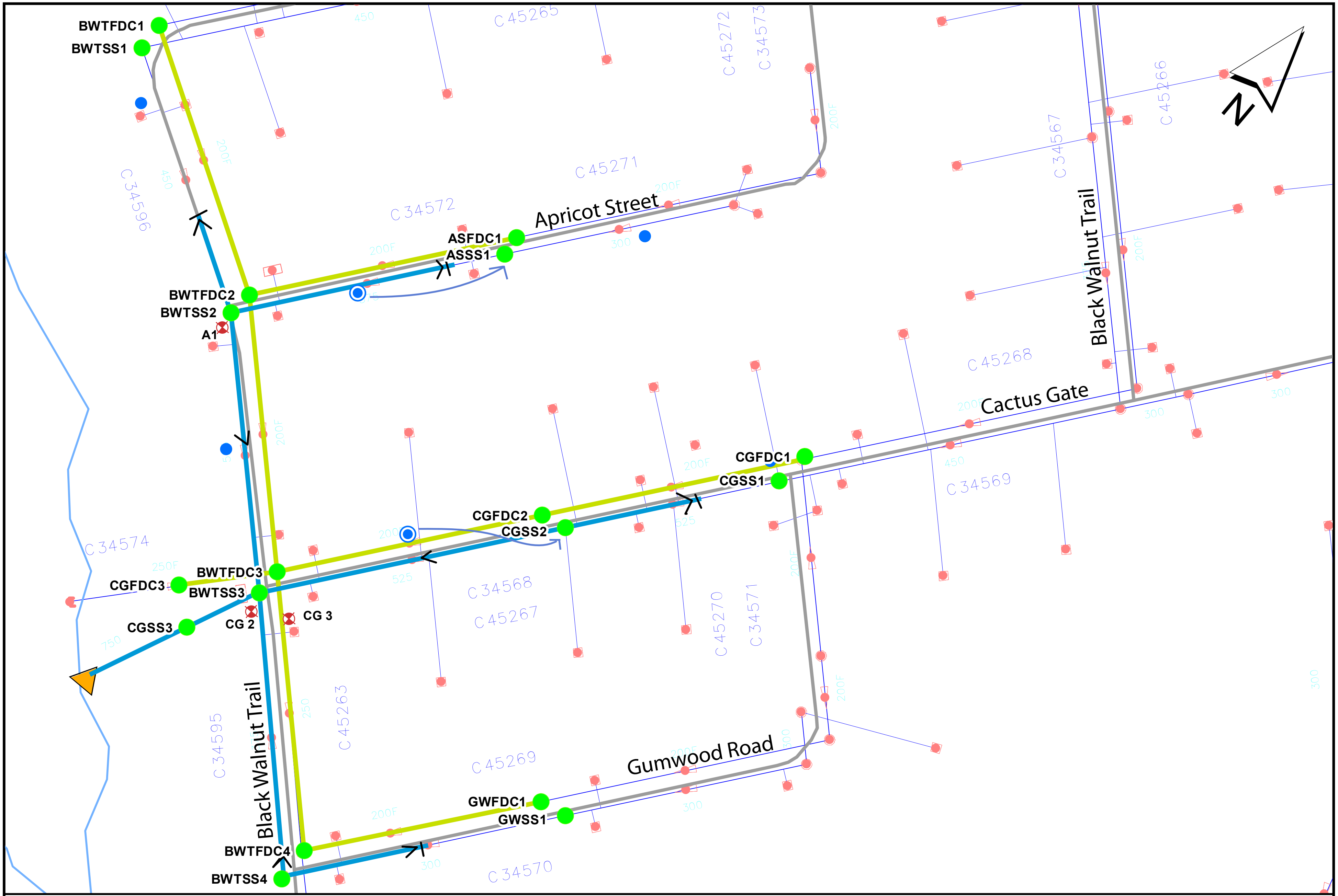
Scale 1:1720
0 5 10 20

Consultant File No.
TP115060

Figure No.
3

Figure 4 Results - Storm Sewer Leakage Test Area 3 (Laburnum Crescent)





LEGEND

- ◉ Fire Hydrant Selected
- ⌖ Sewer Trench Piezometer
- ● Fire Hydrant
- ● Manholes (labelled with ID)
- ▬ Storm Sewer Tested
- ▬ FDC Tested
- ▲ Block Storm Sewer
- < Obvert
- |< Invert
- ― Permanent Watercourse
- ― Intermittent Watercourse

NOTE:
Fill to 201.5 masl

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PLAN - CACTUS GATE

STORM SEWER LEAKAGE
TEST AREA 1

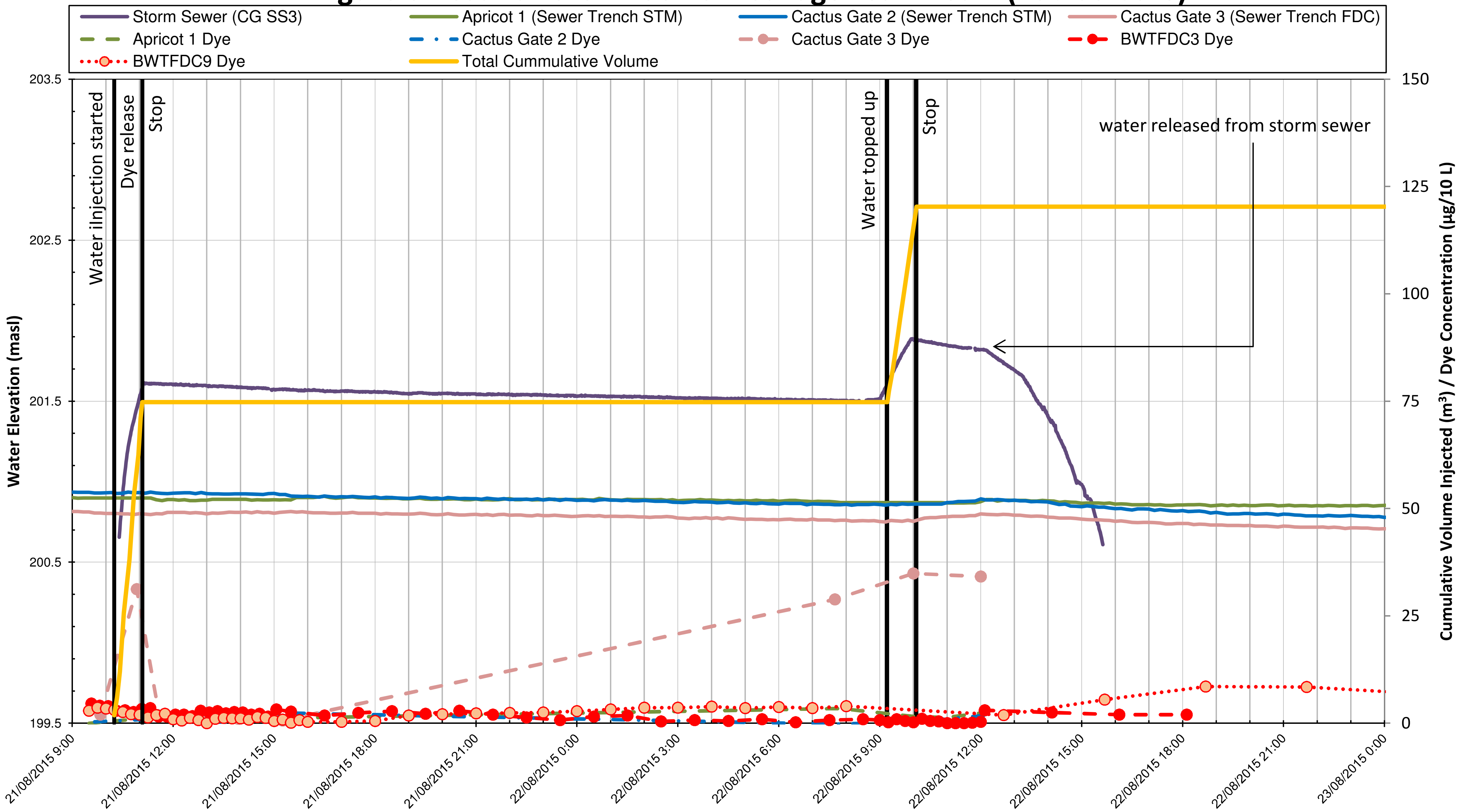
amec
foster
wheeler

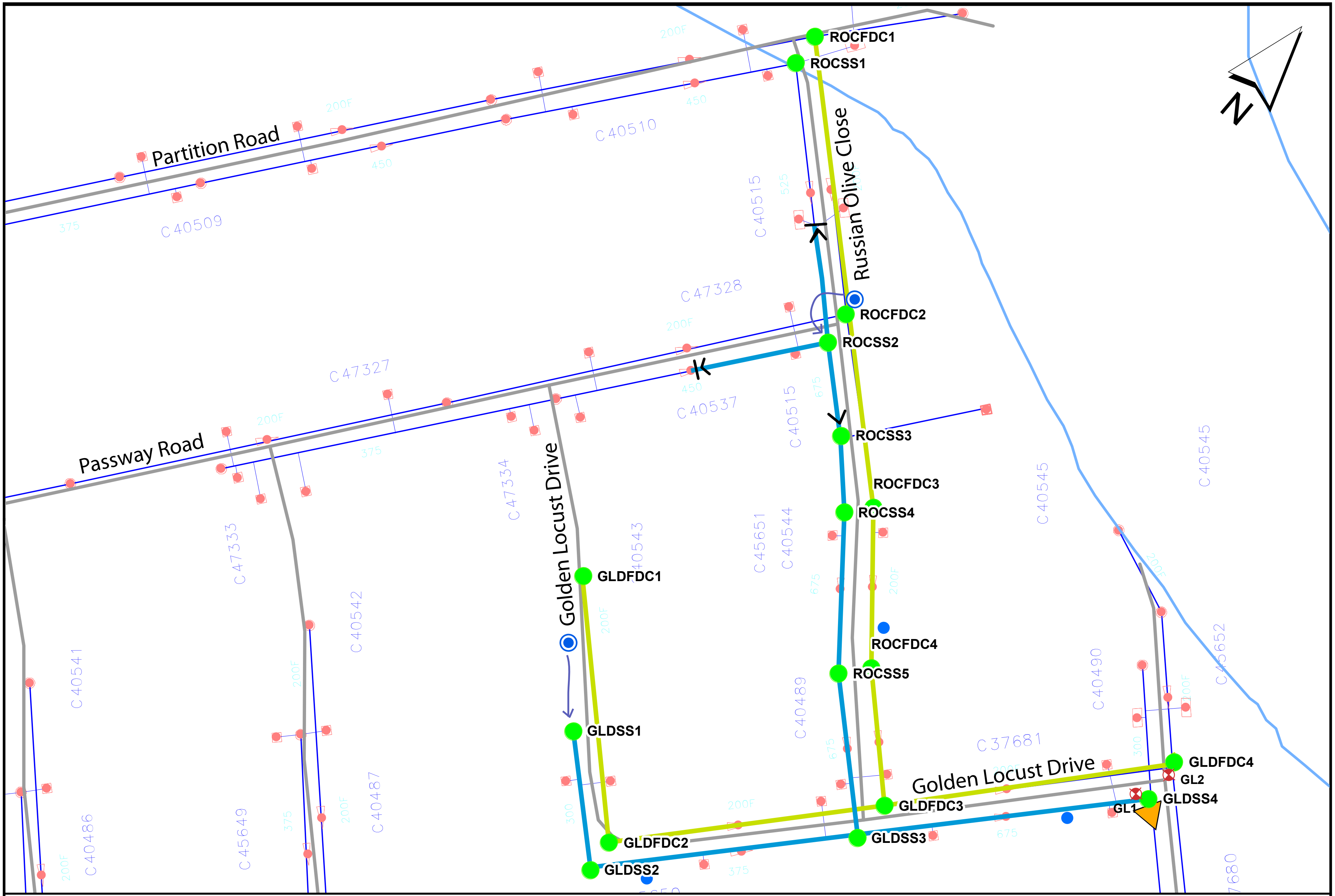
Scale 1:1610
0 5 10 20

Consultant File No.
TP115060

Figure No.
5

Figure 6 Results - Storm Sewer Leakage Test Area 1 (Cactus Gate)





LEGEND

◉ Fire Hydrant Selected
⊕ Sewer Trench Piezometer
● Fire Hydrant
● Manholes (labelled with ID)
— Storm Sewer Tested
— FDC Tested
▲ Block Storm Sewer
< Obvert
K Invert
— Permanent Watercourse
— Intermittent Watercourse

NOTE:
Fill to 203.5 masl

SCALE VALID ONLY FOR
8.5"x11" VERSION

LISGAR DISTRICT BASEMENT
INFILTRATION INVESTIGATION

CITY OF MISSISSAUGA

PLAN - GOLDEN LOCUST DRIVE

STORM SEWER LEAKAGE
TEST AREA 2

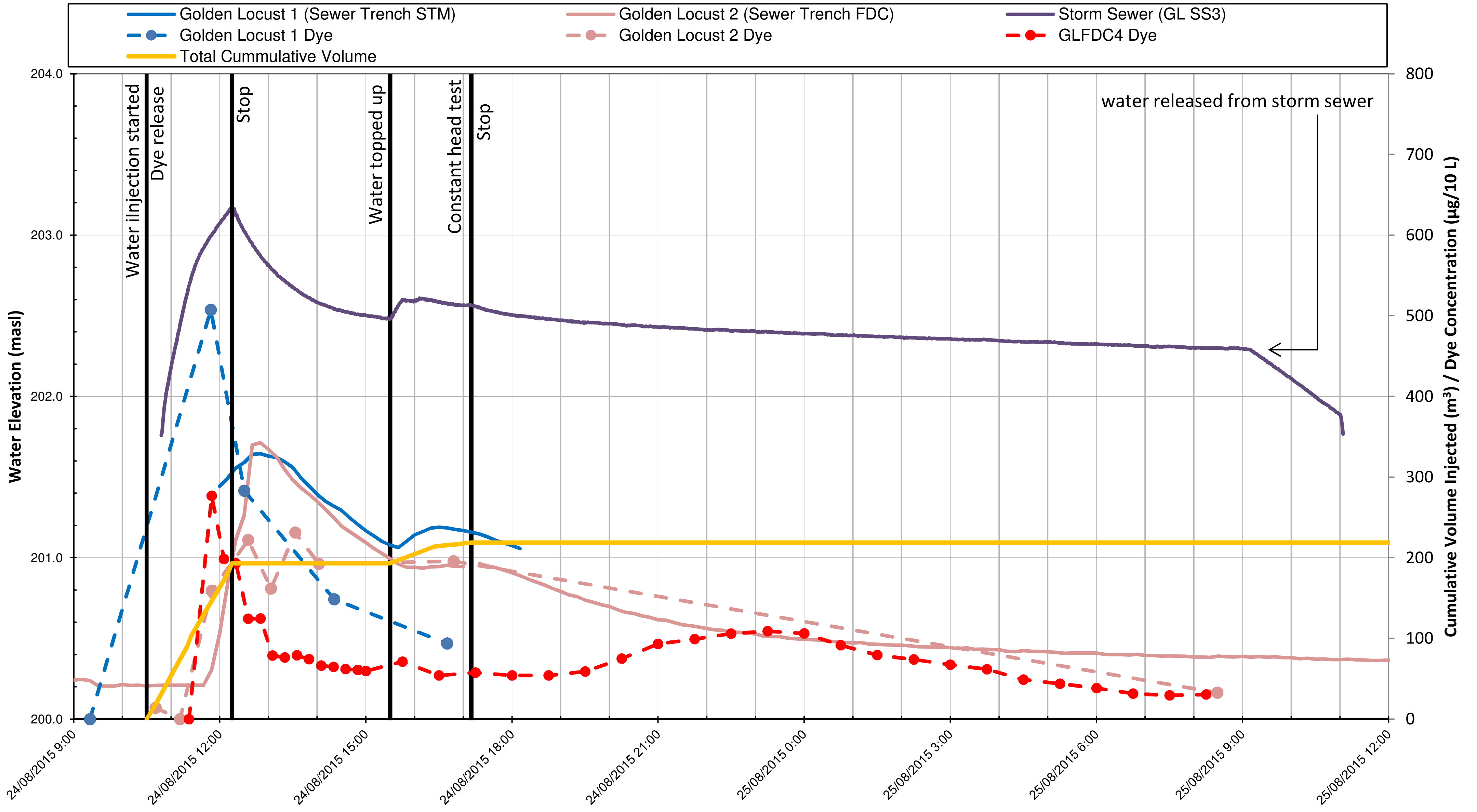
amec
foster
wheeler

Scale 1:1582
0 5 10 20

Consultant File No.
TP115060

Figure No.
7

Figure 8 Results - Storm Sewer Leakage Test Area 2 (Golden LocustDrive)



Lisgar District Basement Water Infiltration Study

2016 Monitoring Report (Revised)

Prepared for:

City of Mississauga

Prepared by:

Amec Foster Wheeler
Environment & Infrastructure
3450 Harvester Road, Suite 100
Burlington, ON L7N 3W5
(905) 335-2353

July 2017 (Revised)

Project No. TP115060

LISGAR DISTRICT BASEMENT WATER INFILTRATION STUDY
2016 MONITORING REPORT (REVISED)

CITY OF MISSISSAUGA

Submitted to:

City of Mississauga

Submitted by:

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Suite 100
Burlington, ON L7N 3W5
Tel: 905-335-2353
Fax: 905-335-1414

July 2017 (Revised)

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1.0 INTRODUCTION / BACKGROUND

Amec Foster Wheeler initiated field monitoring activities in support of the Lisgar District Basement Water Infiltration study in late 2011 and early 2012. These monitoring activities were intended to better understand the drainage systems in the Lisgar District as shown in Figure 1, and help identify the source(s) of the basement water infiltration occurrences in this neighbourhood.

Monitoring was conducted for the Foundation Drain Collector (FDC) sewer system, the storm sewer system, surface water (Lisgar Creek), as well as the groundwater system through the installation of piezometers. A limited number of gauges were installed during this initial period. Based on discussions with City staff, a larger number of gauges were installed to supplement the initial gauges in mid-2012. Preliminary results from the initial 2012 monitoring were presented in memoranda to City staff on April 12, 2012, and September 26, 2012. The latter memorandum noted the first major monitored surcharge event of September 8, 2012. These results were also later presented to City staff and other team members at a presentation on February 22, 2013.

Monitoring works continued into 2013 and 2014, with additional gauges being installed based on the findings identified at that time, as well as direction from City staff. The findings of the 2013 monitoring year were presented to City staff in a memorandum (January 8, 2014). The monitoring work was invaluable in allowing the team to better understand the drainage systems' response to storm events, and help lead the team towards identifying the cause(s) of basement water infiltration. This work culminated in a Public Report and presentation (March 25, 2015) which summarized the findings of the multi-year monitoring effort and the resulting conclusions that were drawn from these data.

Subsequent to the Public Report and presentation in March 2015, the study's focus shifted towards remediation activities, in order to attempt to mitigate the identified cause(s) of the observed basement water infiltration. The highest priority items from the City's Priority Action Plan, storm sewer lining, and a pilot utility trench dewatering system, have either been partially implemented or have advanced through the design stages in 2016 and 2017. Field monitoring activities have continued in parallel, in order to continue to support these activities by assessing their effectiveness after implementation, and observed changes in drainage system performance over time. The locations of the current monitoring areas are shown on Figure 2.

Consistent with the previously prepared report for the 2015 Monitoring year, this report has been prepared to summarize both the remediation works completed over the course of 2016, as well as the associated ongoing field monitoring and resulting findings. Given the timing of this report and ongoing activities, this report also includes some works completed in early 2017.

2.0 STORM SEWER LINING

2.1 Overview

Amec Foster Wheeler, in conjunction with the City of Mississauga, previously completed an extensive investigation into the causes of reported instances of basement water infiltration within the Lisgar District of the City. The findings of this investigation were summarized in "Lisgar District Basement Water Infiltration Investigation – Summary Report" (Amec Foster Wheeler, March 2015), which was presented and released to the public. This report identified stormwater infiltration to the utility trench, largely from leaking storm sewers, as the primary cause of basement water infiltration. Storm sewer leakage was conclusively demonstrated through a series of leakage tests in various areas. Storm sewer lining was ultimately proposed as a high priority measure (as part of the City's overall Priority Action Plan) to assist in addressing this cause. By minimizing/eliminating storm sewer leakage (through the sealing of cracks, gaps and leaks) into the utility trench bedding, instances of basement water infiltration should be further minimized/eliminated. Based on the field work and analyses completed for the study, as well as reported instances of basement water infiltration, an area at the upstream limits of the Lisgar District (referred to as Phase 1) was identified as the highest priority location for storm sewer lining activities. Appendix D provides an overview of the Phase 1 storm sewer lining area.

Prior to retaining a contractor to undertake storm sewer lining, the City undertook a request for prequalification (RFPQ) process (City of Mississauga Procurement FA.49.559-15) which closed in January 2016. Given the number of different approaches and technologies for storm sewer lining, the City sought to pre-qualify the most appropriate technology through this process. Potential bidders were required to meet specified mandatory criteria to ensure its suitability (i.e. that the technology was "no dig", that it could be applied to the study area particulars, that the technology has been successfully applied elsewhere, and that there were no significant adverse environmental impacts of the technology). Bidders were then required to provide answers to a series of questions developed by the City of Mississauga and Amec Foster Wheeler, related to Life Cycle, Performance, Method of Implementation, and Environmental and Safety. These questions related to both technologies for storm sewer lining and maintenance hole lining. Bidder responses were assessed against a scoring matrix developed prior to the receipt of submissions, which included evaluation criteria and scores for each question, as well as overall weighting factors.

Bidders also provided budgetary pricing for both the primary intended scope of work (lining of storm sewer mains and maintenance holes), as well as an ancillary scope of work (lining of catchbasin leads (rear-yard and mainline) and lining of catchbasins (rear-yard and mainline)). These costs were used for reference and budgeting purposes only.

A combined team of City and Amec Foster Wheeler staff was responsible for reviewing and scoring the RFPQ submissions in order to determine a preferred technology. Based on this process, the final evaluation (March 2016) determined that ultraviolet light cured in place pipe

(UV-CIPP) was the preferred technology for storm sewer lining, based on its performance and in particular its environmental and safety characteristics.

Prior to the finalization of the RFPQ process, City staff indicated that the City's preference was to proceed with the lining of mainline storm sewers first, given that those were considered to be of the highest priority. Lining of maintenance holes was deferred until a later date, to be assessed pending the monitored of the effectiveness of the storm sewer lining work. No specific technology was pre-qualified for maintenance hole lining, although scoring was also completed for the various technologies submitted. In general, a greater variety of options was noted with respect to maintenance hole lining.

2.2 Phase 1 Lining

Following the RFPQ process, a Request For Tender (RFT) was issued by the City of Mississauga (Procurement FA.49.453-16) for the Phase 1 storm sewer lining using UV-CIPP, which closed in August 2016. An overview of the works is provided in Appendix D. The tender was ultimately awarded to Pipeflo Contracting Corp (Pipeflo). A startup meeting occurred in September 2016, however due to time delays associated with ordering of the CIPP liners, storm sewer lining works did not commence until December 2016 (although pre-lining preparatory activities did occur prior to this date).

Pipe liner designs were submitted by Ian Doherty, P. Eng. of Trenchless Design on October 6, 2016 in conformance with ASTM F1216. As part of this design process, some changes were suggested to the design parameters specified in the contract documents. Specifically, it was suggested by Trenchless Design that a long term retention factor of 65% was more appropriate for the reinforced-fibreglass liner technology employed by Pipeflo, rather than the 50% value specified in the contract documents (which was considered more suitable for other technologies such as felt). In addition, Trenchless Design suggested that the ovality could be reduced from 4% in the contract documents to 3% for concrete pipe (4% would continue to be used for PVC pipe), and that a soil modulus of 6.9 MPa could be considered in place of the value of 4.8 MPa specified in the contract documents. Given that the values specified in the contract documents are consistent with those used by the Region of Peel for sanitary sewer rehabilitation work, and in order to ensure that the procurement process remained open and transparent (i.e. by not revising liner parameter and thicknesses after contract award), the CIPP design parameters in the specification were employed for all designs without modification.

Storm sewer lining was completed between December 13, 2016 and March 17, 2017. Lining dates for each segment are provided in Table D1 in Appendix D. The majority of the lining work (43/51 segments lined in total) was completed between January 9 and February 27, 2017.

Although no in-water works were to be completed as part of the Phase 1 lining scope, the downstream limits of two (2) sections of the storm sewers being lined, involved storm sewer outfalls to Lisgar Creek. As such, a permit was required from Conservation Halton (CH). A permit application was submitted by Amec Foster Wheeler on behalf of the City of Mississauga, which included erosion and sediment control plans for both outfalls (Cactus Gate and Terragar Boulevard). The permit application also included a separate permit application directly from the City of Mississauga to undertake a clean-out of the outfall at Cactus Gate. The combined permit (Permit No. 5453) was ultimately issued by CH on December 20, 2016. No in-water works were completed until this permit was approved; some limited mainline storm sewer lining (i.e. outside of the regulated area) was however completed beginning on December 13, 2016.

As part of the quality assurance/quality control process for the storm sewer lining, samples of the cured CIPP liner at the downstream end of storm sewer runs were collected where feasible by Pipeflo. Given that samples are collected from downstream maintenance holes (with a typical clear opening diameter of 578 mm as per OPSD 401.010), larger diameter liner samples cannot be collected in these locations. Larger diameter liner samples can however be collected at storm sewer outfalls. As per the tender documents, the City's original intent was to complete 100% sampling (i.e. one sampler from each segment of liner installed). However, as per Table D1 (Appendix D), only approximately half (24/51) of the liners installed included a liner sample. These samples were transferred to a qualified testing laboratory, Paragon Systems, for analysis. All submitted samples were analyzed for flexural strength and modulus of elasticity (ASTM D790), and average and minimum liner thickness (ASTM D5813), to ensure conformity with the design parameters specified in the tender documents. Of the 24 samples analyzed, 17 indicated initial conformance with the design values (strength, modulus and thickness). The remaining 7 samples underwent a "design reconciliation process" as per ASTM F1216, whereby the equation for minimum liner thickness is re-calculated using the tested values of flexural strength and modulus of elasticity. In all cases, the resulting measured thickness was in excess of the minimum required, which confirms that these 7 liner samples are not deficient.

In addition to structural testing of liner samples, approximately 1/3 of the liner samples were also analyzed for watertightness using an industry accepted test methodology from Europe (APS); no ASTM standard is available for this testing. All of the submitted samples (9 in total) passed the watertightness testing.

2.3 Phase 2 Lining

A second phase of storm sewer lining was proposed for the next highest priority area based on the earlier monitoring results and analyses, and historic reported instances of basement water infiltration. A map of the proposed Phase 2 lining area extents is provided in Appendix D; it generally includes the area along Osprey Boulevard to the east of Lisgar Creek, as well as the area around Alderwood Trail. The Phase 2 lining work is currently planned for later in 2017, however has not yet been definitively confirmed.

Both pre-lining and post-lining leakage testing have been proposed for the Phase 2 lining areas (3 testing areas: Alderwood Trail, Osprey Boulevard and Waxwing Trail). The pre-lining leakage testing should be completed prior to the commencement of lining construction, and should incorporate any modifications in testing methodology developed as part of Amec Foster Wheeler's experience with previous storm sewer leakage testing.

3.0 PILOT UTILITY TRENCH DEWATERING SYSTEM

3.1 Overview

The intent of the utility trench dewatering system is to dewater bedding material within the sewer utility trench to limit the accumulation of water, and thus provide additional storage volume during storm events. The utility trench dewatering system is a pilot test to assess if a dewatering system can be a viable proactive measure in preventing future basement water infiltration. The utility trench dewatering system is currently in the detailed design stage, with construction currently slated to occur in late 2017.

Based on the results of the Amec Foster Wheeler's ongoing field monitoring and analyses, the pilot utility trench dewatering system has been recommended for construction within the parkette at Black Walnut Trail and Cactus Gate. Cactus Gate is notable amongst the monitoring sites for having large water level variations in the utility trench with relatively slow recessions, indicating that storage may be significant at his site. Given this characteristic, the availability of public land (parkette), and the frequency of FDC surcharging and number of reported instances of basement water infiltration in this area, the Cactus Gate was considered the preferred location

3.2 Design

The initial pilot utility trench dewatering design was initially reviewed at a meeting with City staff in February 2016. At that time, two (2) potential concepts were presented for consideration for a system at Cactus Gate, both of which have been included in Appendix D for reference. Both options were similar, and involved an impermeable collar around the utility trench along Black Walnut Trail, with a diversion of accumulated water into a pumping manhole within the parkette (and then to the existing storm sewer system). The two (2) options differed on the location of the collar. Option A placed the collar at the south limits of the parkette, while Option B placed the collar further upstream at the north limits of the parkette. City staff ultimately indicated a preference for Option A (February 26, 2016) which was then advanced to a preliminary design stage.

Both options also included an impermeable collar along Lisgar Creek, given concern regarding the potential for surface water movement upstream through connected utility trench bedding material. This was a particular concern in this location, as in addition to the storm sewer outfall, there is also a stub FDC sewer connection, and an active sanitary sewer pipe which crosses the creek (to service the lands north of the CNR). This secondary feature was ultimately included in the preliminary design drawings, however subsequent direction from City staff (February 2017) has indicated that this component of the design should be deferred until a later date.

Preliminary design drawings have been included in Appendix D for reference. As noted previously, the preliminary design incorporates both a primary collar along Black Walnut Trail, and a secondary collar along Lisgar Creek (which as noted, will likely not form part of the subsequent detailed design). The focus of the design is for the system along Black Walnut Trail.

As evident, the preliminary design would construct a concrete collar along the lowest portion of the utility trench system (FDC and sanitary sewers) to block the movement of infiltrated water from travelling further downstream. Additional clearstone would be placed to hydraulically connect exfiltration from higher utilities with the lowest portion of the utility trench. This area would then be drained by a series of perforated pipes which would direct drainage to a new maintenance hole. The maintenance hole would include a low capacity pumping system to pump accumulated flows back into the storm sewer system, and ultimately out to Lisgar Creek. An overflow system would also be incorporated.

Some consideration has also been given to potentially allow for a diversion of FDC surcharge flow from the upstream maintenance hole, through the inclusion of a new overflow pipe and shutoff valve. This would potentially assist in mitigating the FDC surcharge, repeatedly noted in this location (refer to Section 4, as well as the 2015 Monitoring Report and previous documentation). This would need to be further considered as part of detailed design.

The design remains in the preliminary design stage, pending the receipt of further comments from City staff and potentially other agencies (including the Region of Peel, given that the proposed system would be conducted around Regional infrastructure).

Pending resolution of further comments, the preliminary design would be advanced to the detail stage and constructed in late 2017, in order to allow for sufficient time to complete a long-term (1 month +\-) pumping test for the unit. As per the approved work plan, this test would be completed in order to more definitively ascertain the required pumping capacity prior to obtaining and installing a permanent pumping system and other related appurtenances (electrical systems, SCADA, etcetera). Consideration would be required for operation of the utility trench system under all stages, i.e. the initial pumping test phase, the subsequent phase between the removal of temporary pumps and the installation of permanent pumps, and the final long-term operation with permanent pumps in place.

Some supporting design elements have also been commenced, pending resolution of further comments. A preliminary landscaping plan has been completed by Dougan & Associates. Moon-Matz has been retained to undertake the electrical design for the system. Based on recent discussions with Moon-Matz staff, it is considered likely that electrical servicing would need to be deferred until a pump size is determined, given the associated uncertainty related to electrical requirements. An on-site electrical converter may ultimately be required depending on the pump type and capacity selected. OZA Inspections Limited (OZA) has also been retained to provide pre-condition inspection of adjacent residences prior to construction commencement (as well as follow up inspections following construction completion). OZA would also undertake on-site and remote vibration monitoring during the construction period.

3.3 Geotechnical Investigation

A Geotechnical Investigation for the utility trench dewatering system was undertaken in fall of 2016 to determine geotechnical parameters and provide geotechnical recommendations for the final design of the dewatering system. The results of this investigation are summarized in the Amec Foster Wheeler Report entitled “Geotechnical Investigation – Lisgar District Basement Water Infiltration Study: Pilot Utility Trench Dewatering System, Black Walnut Trail at Cactus Gate” (October 2016).

One of the notable findings from the report is the presence of a layer of more permeable silty sand in the study area at depths of between 4.2 and 5.6 m +\- below grade. This material is more permeable than the typical clayey silt/silty clay Halton Till material. This material tended to be saturated, and would be able to move water more readily than the relatively impermeable till material. As such, the design of the utility trench dewatering system would need to account for this through the placement of impermeable liners and membranes and the risk for subsidence during construction and operation would need to be assessed.

3.4 Permit To Take Water

A Permit to Take Water (PTTW) application for construction dewatering and a pumping test was submitted to the Ministry of the Environment and Climate Change (MOECC) in the Spring of 2017. This application was made to permit temporary dewatering which is expected to be required during construction, and to permit a pumping test to confirm required pumping capacity of a utility trench dewatering system. To support this application, a Hydrogeological Report was prepared entitled “Hydrogeological Report – Cactus Gate Proposed Utility Trench Dewatering System, Mississauga, Ontario” (April 2017) which detailed the hydrogeological conditions and expected dewatering rates for the construction and pumping test and risk of subsidence. Subsequent to the permit submission, initial comments were received from MOECC staff on May 18, 2017. A response was discussed with City staff and issued to the MOECC on June 9, 2017. This included submission of a settlement monitoring plan and a discharge plan. A finalized PTTW (5165-ANALKJ) was received July 5, 2017, and is valid until June 30, 2018. The utility trench dewatering system may require a PTTW if the City decide to use this system operationally beyond the conditions of the present permit.

4.0 SURFACE WATER MONITORING

4.1 Overview

Surface water monitoring gauges have been installed in key locations throughout the study area to monitor changes in both water levels, as well as water temperature. The number of surface water monitoring gauges has varied each year, as changes and adjustments are made to the program based on the findings of the previous year and the planned testing and remediation works. For 2016, a total of twenty-six (26) water level and water temperature gauges (Solinst Leveloggers) were installed throughout the study area, this includes:

- Eighteen (18) gauges in the FDC sewer system
- Four (4) gauges in the storm sewer system
- Four (4) gauges in surface water features

Summary figures showing all of the above-noted surface water monitoring gauges are included in Appendix A, along with Table A1, which includes details of all of the gauges since the beginning of the monitoring program.

Only one (1) new monitoring gauge was installed over the course of 2016, a new surface water (creek) monitoring gauge at Cactus Gate. This gauge was installed to collect additional data around the Cactus Gate area, given planned activities in this area (both storm sewer lining and utility trench dewatering system). Additional surface water gauges (installed in previous years) were also re-installed in 2016, namely the Rail and Scotch Pine sites north of Derry Road, and the gauge located within the Osprey Marsh SWM Facility.

Storm Sewer Gauges S6 to S8, which were installed in 2015 to support the planned Phase 1 storm sewer lining and associated leakage testing, were not re-installed in 2016 due to the expected construction timing. Gauge S7 was re-installed for a brief period in 2016 (June 22 to August 18), in order to collect additional data around Cactus Gate, given planned activities noted previously. The gauge was removed prior to the expected storm sewer lining startup.

All surface water monitoring gauges typically employ a 5-minute logging time step, in order to ensure that any rapidly peaking storm events are adequately captured.

4.2 Results

Overall, the 2016 year was considered to be drier than average; observed monthly precipitation totals from nearby City and Environment Canada gauges are presented in Table 4.1, along with the associated 1981-2010 climate normals.

Table 4.1. 2016 Observed Climate Data

Month	1981-2010 Climate Normal for Pearson Airport (mm)	Observed Precipitation for 2016 (mm)		
		Environment Canada (Pearson Airport)	City Gauge 11 (Ninth Line/CNR)	City Gauge 7 (Britannia/Erin Mills)
January	51.8	38.4	15.4[1]	87.2
February	47.7	45.6	46.2	63.0
March	49.8	80.0	81.0	118.4
April	68.5	59.8	36.0	93.6
May	74.3	34.2	49.6	46.2
June	71.5	26.4	44.8	24.6
July	75.7	39.8	42.2	47.6
August	78.1	66.8	56.0	48.8
September	74.5	66.4	75.0	60.8
October	61.1	40.6	40.8	33.0
November	75.1	55.2	15.4[1]	47.0
December	57.9	77.4	0.0[1]	49.4
TOTAL	**785.9**	**630.6**	**502.4[1]**	**719.6**

1. Data appears questionable; further screening may be required.

Annual precipitation totals were below average by some 20% for the Pearson Airport gauge; monthly totals at this location were also consistently lower with the exception of March and December. The May-July period was particularly dry (55% below the climate normal).

With respect to the City precipitation gauges, data from Gauge 11 (Ninth Line/CNR – closest in proximity to the Lisgar District) indicated questionable data for January, November and December. Notwithstanding, the data for the February-October period indicated similar trends to the data from the Pearson Airport gauge (May-July period 41% below the climate normal). Data from Gauge 7 (Britannia/Erin Mills) is further removed from the Lisgar District. This gauge however indicated somewhat higher annual precipitation totals, particularly for the winter/early spring period (January-April). For the balance of the year (May-December), Gauge 7 indicated slightly drier conditions than the Pearson Airport Gauge (357.4 mm at Gauge 7, as compared to 406.8 mm at Pearson Airport – climate normal is 568.2 mm).

The overall season trend is therefore drier than average conditions. These observed precipitation trends are reflected in the surface water monitoring data for the Lisgar District, which indicate minimal surcharging of the FDC system during 2016, with the exception of a few notable events.

A limited amount of FDC surcharging was observed in 2016. As in previous years, observed FDC surcharging is primarily restricted to the area north of Derry Road (Black Walnut Trail), and in particular tends to be restricted to gauges F5 and F1, which lie directly along the FDC trunk sewer on Black Walnut Trail. FDC surcharging also tends to occur in the vicinity of the trunk FDC sewer along Lisgar Creek, in the area around Doug Leavens Boulevard (gauge F3 in particular). Refer to Appendix A for specific gauge locations.

FDC surcharge was identified primarily for events on August 13, 2016 and December 26, 2016. Elevated water levels were also noted for an event on January 12, 2017, however this event did not result in any observed FDC surcharging. Likewise, elevated water levels were noted for an event on April 6, 2017, however this event did also not result in any observed FDC surcharging. The April 6, 2017 is noteworthy since City staff reported that the High Water Protocol (HWP) was activated for this event, and pumping of the FDC occurred at one location (Osprey Boulevard) between approximately 5:00 and 7:00 PM that day due to observed increased in flow in the FDC sewer system.

Rainfall data for the primary two (2) FDC surcharging events are presented in Table 4.2. Water level and water temperature response graphs are included in Appendix A.

Table 4.2. Rainfall Data for Key Surcharge Events (2016)

Storm Date	Rainfall Source	5-Day Antecedent Rainfall (mm)	Duration of Event (hours)	Depth of Event (mm)	Peak 5-Minute Intensity (mm/hr)
August 13, 2016	EC Pearson Airport	0.2	NA	28.0[1]	NA
	City Gauge 11 (Ninth Line/CNR)	1.4	0.9	17.8	55.2
	City Gauge 7 (Britannia/Erin Mills)	3.4	0.9	11.4	62.4
December 26, 2016	EC Pearson Airport	6.8	NA	19.8[1]	NA
	City Gauge 11 (Ninth Line/CNR)	NA	NA	NA	NA
	City Gauge 7 (Britannia/Erin Mills)	11.8	1.9 (14.9)[2]	6.2 (13.2)[2]	9.6

1. Based on daily data only
2. First value is for primary portion of storm event, bracketed value is for overall storm event.

August 13, 2016

The FDC system surcharge observed on August 13, 2016 occurred at approximately 14:00 (Daylight Savings Time). Based on the rainfall data presented in Table 4.2, the storm event was not particularly large, but was consistent with a thunderstorm type event (spatially variable, high intensity for a short duration). The observed peak 5-minute intensity would still be well below a 2-year storm event (104.5 mm/hr) based on the City of Mississauga's current intensity-duration-frequency (IDF) curves. Likewise, the observed rainfall total (which occurred in approximately 1 hour) would also be less than a 2-year storm event (23.6 mm or 23.6 mm/hr), using the same comparative.

The observed FDC surcharging was localized to the area north of Derry Road, as has been reported for numerous past historic storm events. As evident from Figure A4, surcharging is primarily indicated at gauges F5 (Black Walnut Trail at Gumwood Road) and F1 (Black Walnut Trail at Smoke Tree Road). Surcharge levels are similar at these two locations, with an observed depth relative to the invert of 0.64 m at F5 (0.25 m diameter FDC sewer) and 0.62 m at F1 (0.375 m diameter FDC sewer). Further downstream, at gauge F6 (Black Walnut Trail at Spirea Terrace), the peak water level (0.39 m relative to the invert) is below the diameter of the FDC sewer (0.45 m). The observed peak continues to decrease further downstream, including gauge F2 (immediately downstream of Derry Road).

Observed water temperature data (Figure A5) indicate a general rise during the surcharge event, suggesting warmer surface water sources as compared to the cooler sub-surface water during summer conditions. Observed temperatures at F13 and F24 indicate slightly more variable results, with F24 in particular indicating more of a decrease in temperature during the storm event. The reason for this counter-intuitive result is currently unknown; it is unknown if the gauge's location (the only gauge located on the west side of Lisgar Creek on Golden Locust Drive) is a factor in this case.

No surcharge conditions were observed downstream of Derry Road, consistent with reported conditions for short duration high intensity storms in summer conditions in previous monitoring years.

December 26, 2016

The observed surcharge event of December 26, 2016 differed notably from the August 13, 2016 event. Whereas the August 13, 2016 event indicated a rapid surcharge response (and recession) within the area north of Derry Road to a summer thunderstorm type event, the December 26 event was characterized by a more prolonged response to a low-intensity event coupled with snowmelt. The surcharging for the December 26, 2016 event was also observed further downstream (Doug Leavens Boulevard and downstream along Ninth Line); no surcharging was observed north of Derry Road.

Based on climate data from Environment Canada's Pearson Airport station, this event was also impacted by snowmelt conditions. On December 22, 2016, a total of 19 cm was recorded on the ground, with 8 cm on the day prior to the event (December 25, 2016). Only 1 cm of snow was recorded on the day following the event (December 27, 2016). The actual observed rainfall total on December 26 was relatively minor; 13.2 mm at the City's Gauge 7 (6.2 mm for the main portion of the storm which resulted in surcharge). This further suggests a rain-on-snow and snowmelt type event.

As noted, although FDC water levels rose in the area north of Derry Road in response to the melt/rainfall event (Figure A6), no surcharging occurred in this area. FDC system surcharging for this event occurs first in the vicinity of Doug Leavens Boulevard (gauge F3 – maximum observed water level of 0.90 m; pipe diameter of 0.525 m). Figure A8 indicates the observed water levels in this area. A similar magnitude of observed surcharge is indicated further downstream at gauge F4, along the FDC trunk within the Osprey Marsh (0.81 m; pipe diameter of 0.6 m). More minor surcharge is indicated along local FDC collectors immediately upstream of the trunk FDC, including F8 (Alderwood Trail, 0.46 m water level, 0.2 m FDC pipe diameter) and F10 (Pondview Way, 0.41 m water level, 0.375 m FDC pipe diameter). The peak water levels in these locations generally coincide with the peak within the FDC trunk, suggesting a backwater effect, with primary surcharge along the trunk between Doug Leavens Boulevard and the Osprey Marsh SWM facility.

Further surcharging is indicated along the trunk FDC sewer along Ninth Line (Figure A10). A peak water level of 0.78 m is indicated at gauge F12 (Ninth Line at Britannia; 0.75 m pipe diameter) indicating a slight surcharge, while an increased peak water level of 1.02 m is indicated at gauge F17 (Ninth Line at Deepwood Heights; 0.75 mm pipe diameter) indicating a more substantial surcharge. The observed surcharge is however abated at the downstream limits of the FDC trunk at gauge F18 (Erin Centre Boulevard at Churchill Meadows, 0.52 m observed water level; 0.75 m pipe diameter). The elevated surcharge at gauge F17 may reflect the relatively flat slope of the sewer in this location (as low as 0.02% +\-), relative to the steeper location at F18 which is also in close proximity to the drop outlet to the storm sewer system along Churchill Meadows. The maximum observed water level in the downstream storm sewer system (gauge S3; 0.46 m) was below the elevation drop between the FDC sewer and the storm sewer (0.97 m) thus would not be expected to have had no impact on backwater conditions.

Observed water temperature data (Figures A7, A9 and A11 for the three areas respectively) again indicate a surface water source. A clear decrease in water temperature is observed during the surcharge event (18:00 to 0:00 in particular), indicative of cold water from snowmelt and surface sources, as compared to more temperature-moderated sub-surface water sources. Figure A9 indicates temperature drops and oscillations occurring earlier than this period at gauge F8 (Alderwood Trail). The reason for this is currently unclear, however it may indicate a more substantive surface water contribution from this area. The oscillations in temperature appear to approximately coincide with the inputs of rainfall, which would support this theory.

4.3 Discussion

The two (2) observed FDC surcharge events of 2016 are consistent with previous observations of FDC system behavior. The August 13, 2016 storm event was similar to the most common type of previously observed surcharging, specifically rapid surcharging in response to a summer-type thunderstorm event, occurring specifically in the area of Black Walnut Trail north of Derry Road. The December 26, 2016 storm event indicated a more gradual yet still rapid response to a low intensity event with saturated ground conditions (snowmelt and rain-on-snow), where response occurs at the south limits of the study area, particularly in the vicinity of Doug Leavens Boulevard. Water temperature data continue to suggest a surface water connection in both cases, as has been suggested previously. This is also confirmed by the rapid nature of the surcharging in both cases, which is not considered feasible from groundwater movement.

Although surface water inputs appear to be the primary source of FDC surcharging, sewer trench water levels are also considered to be a factor, albeit one that is less clear for the surcharging events monitored in 2016 (as discussed in further detail in subsequent sections of this report).

Storm sewer lining for the Phase 1 area (north of Derry Road) was largely completed over the course of early 2017, as noted previously, thus any potential benefits from this work will not be evident in the 2016 monitoring data. The 2017 monitoring data will be reviewed to assess any potential changes in drainage system performance. The proposed utility trench dewatering system at Cactus Gate is also intended to reduce the accumulation of water within the FDC utility trench bedding material, with the aim of further minimizing the frequency of FDC surcharge. The drainage system performance will continue to be monitored and assessed to evaluate the benefit of these measures.

As suggested in the 2015 monitoring report, it may also be possible that there is a localized source of direct runoff in some locations, specifically the area north of Derry Road, but also for areas in the immediate vicinity of Doug Leavens Boulevard. Direct connections could include features such as rooftop downspouts connected directly into the residential weeping tile, which would provide a rapid localized response as is seen from the monitored results. It was suggested that City staff further investigate this matter accordingly. City staff then undertook preliminary verification of residences with potentially connected downspouts in the Phase 1 Lining area using Google Earth Streeview. A copy of this mapping was provided to Amec Foster Wheeler on December 13, 2016 (a copy is included in Appendix A). Highlighted properties were estimated to be approximately 20% of the total properties in the two zones assessed (Zones 1 and 3). Based on this information, Amec Foster Wheeler was initially requested to undertake a further analysis of these areas. However, physical testing of these areas was ultimately considered not feasible, given the extent of the private property access required.

Notwithstanding the preceding, a direct surface water connection in this area, as well as other areas of the FDC sewershed, is possible. While these sources may not be the primary cause of FDC surcharging, they may be contributing factors.

5.0 GROUNDWATER MONITORING

5.1 Overview

Groundwater monitoring has been undertaken on a continuous basis in a total of thirty-two (32) piezometers during 2016. Monitoring has comprised both water level and temperature data, and a 10-minute recording interval has been used common with monitoring undertaken in 2012, 2013, 2014 and 2015.

5.2 Piezometer Installations - 2016

Ten (10) piezometers were installed in 2016 in preparation for undertaking storm sewer leakage tests for the Phase 2 lining areas (ref. Section 2.3) and during the Geotechnical Investigation for the Pilot Utility Trench Dewatering System (ref. Section 3.3).

Further, nine (9) sewer trench piezometers were installed in the Phase 2 lining areas in November 2016 in preparation for undertaking storm sewer leakage tests.

Area 4: No piezometers were installed as there is no leakage test planned for this area.

Area 5: the following piezometers were installed.

- Two (2) sewer trench piezometers on Alderwood Trail (AT prefix for piezometers) in November 2016 in the FDC sewer trench (AT5, and AT6). (Figure B5)

Area 6: the following piezometers were installed.

- Two (2) sewer trench piezometers on Osprey Boulevard (OSP prefix for piezometers) in November 2016 with one in the storm sewer trench (OSP7) and one in the FDC sewer trench (OSP8). (Figure B8)
- Three (3) sewer trench piezometers on Prairie Circle (PC prefix for piezometers) in November 2016 in the FDC sewer trench (PC1, PC 2, and PC3). (Figure B8)
- Two (2) sewer trench piezometers on Waxwing Drive (WW prefix for piezometers) in November 2016 with one in the storm sewer trench (WW1) and one in the FDC sewer trench (WW2). (Figure B8)

One (1) standard piezometer was installed in the Cactus Gate Parkette (CG4) in August 2016 (Figure B1) during the Geotechnical Investigation. The piezometer was installed into the native sandy silt / silty sand soils to determine geotechnical information for construction of the Pilot Utility Trench Dewatering System.

Continuous data collection started in November and December 2016 for the foregoing piezometer installations. To limit the total number of transducers required, three transducers were relocated and thus monitoring was discontinued in AT1, LB1, GL1, all of which were storm sewer utility trench piezometers which were predominately dry.

5.3 Groundwater Monitoring

The groundwater monitoring areas are:

- Cactus Gate (Area 1) – Figure B1
- Golden Locust Drive (Area 2) – Figure B2
- Smoke Tree Road / Laburnum Crescent (Area 3) – Figure B3
- Scotch Pine Gate– Figure B4
- Alderwood Trail (Area 5) – Figure B5
- Pondview Way– Figure B6
- Osprey Boulevard – Figure B7
- Osprey Boulevard, Prairie Circle, & Waxwing Drive (Area 6) – Figure B8

The detailed maps of all the groundwater monitoring areas can be found in Appendix B. Six month hydrographs (January 2016 – June 2016 and July 2016 – December 2016) of all the monitoring areas are shown in Appendix B. The details of all piezometer installations can be found in Appendix C.

Overall groundwater levels and sewer trench water levels in 2016 have been consistent with monitoring undertaken during the preceding years. The new monitoring sites at Prairie Circle, Waxwing and Osprey Boulevard are noteworthy in that the majority of piezometers have quite large water-level variations, consistently of the order of one to two meters. These hydrographs show some similarity with those at Cactus Gate, which previously had been considered untypical of water level responses in the utility trench to storm sewer leakage. At all these locations, it appears groundwater storage effects are more prevalent, possibly due to their location being relatively distal from a discharge location of the utility trench (e.g. to a downstream FDC weeper or the creek).

For the groundwater monitoring, this summary considers in more detail:

- Water levels during the two surcharging events in 2016 (August 13, 2016 and December 26, 2016);
- The Phase 1 storm sewer lining that was installed in Areas 1, 2, and 3 towards the end of 2016 and early 2017.

5.4 Groundwater Levels during Surcharging Events

The FDC surcharging event on August 13, 2016 indicated surcharging in the northern portion of the study area (north of Derry Road) along Black Walnut Trail. The observed surcharge dissipated beyond Derry Road, as described in Section 4.2 of this report. The FDC surcharging event on December 26, 2016 indicated surcharging in the southern portion of the site (south of Derry Road) in the Doug Leavens and Osprey Boulevard area and further south along the trunk FDC on Ninth Line as described in Section 2 of this report.

The hydrographs shown in Appendix B include the FDC surcharging events indicated, for each area where surcharging was identified. Monitoring areas north of Derry Road (except for the Golden Locust Drive area) indicate the August 13, 2016 event, and the monitoring areas south of Derry indicate the December 26, 2016 event.

For the August, 2016 event, the recorded water levels in the sewer trench piezometers for the northern portion of the study area (i.e. Black Walnut Trail) are not considered to be overly elevated as compared to other time periods. Groundwater levels on numerous other occasions are of equal or greater magnitude, including the December, 2016 event (for which FDC system surcharging was not identified in the northern portion of the site). The recorded water levels in the sewer trench piezometers, for the southern portion of the study area, indicate only moderate water levels. It is noteworthy that the observed water levels within the utility trench at Cactus Gate were very low prior to the August, 2016 surcharge event, which is in contrast to the surcharge event in August and September of 2015 when the antecedent water levels were 0.6 to 0.7 m higher at this location (refer to the 2015 Monitoring Report for further details).

For the December, 2016 event, sewer trench piezometers throughout the study area indicate elevated groundwater levels. This includes the area north of Derry Road, for which FDC system surcharging was not identified. It is noteworthy however that on other occasions during 2016, groundwater levels are further elevated (as compared to levels for the December 2016 event) at many locations and FDC system surcharging has not resulted.

5.5 Groundwater Levels Following Lining

The dates of the commencement of storm sewer lining for area 1 (Cactus Gate), area 2 (Golden Locust Drive) and area 3 (Smoke Tree Road / Laburnum Crescent) in December 2016 are indicated on the hydrographs for each location in Appendix B. A complete listing of completion dates is provided in Appendix D. Given that lining works extended into March of 2017 (as per Appendix D), there is limited data in 2016 to assess groundwater levels. Further monitoring over the course of 2017 is required to confirm the monitored impact of the storm sewer lining.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions are made based on the results from the 2016 monitoring with respect to observed surcharge events:

- FDC surcharging was again observed in the area north of Derry Road on August 13, 2016 (Black Walnut Trail); in particular the area around gauges F1 and F5. Surcharging at this location is consistent with observations from previous years. This surcharging is characterized by short, intense thunderstorm type events during warm weather conditions.
- FDC surcharging was also noted further downstream (Doug Leavens Boulevard, Osprey Marsh, and Ninth Line) at gauges F3, F4 (and F8 and F10, and F12 and F17 for the December 26, 2016 event only. This event differed from the majority of recent surcharging events (2015 and 2016) in that it was a lower intensity, longer lasting event with saturated ground conditions (rain on snow and snowmelt in this case). This event still resulted in a relatively rapid surcharge response however.
- Observed FDC surcharging was rapid and peaked, generally 3 hours or less. The results of both observed water levels and water temperatures again suggest a rapid, direct connection to the FDC system from surface water sources.
- With the installation of the nine new sewer trench piezometers in 2016 there is now a greater coverage of sewer trench water levels across in the southern portion of the Lisgar District.
- The observed water level data from available sewer trench piezometers does not indicate overly high levels during either of the observed FDC surcharge events in 2016. Further elevated levels were noted at other periods during 2016 which did not result in FDC system surcharging.

6.2 Recommendations

The following recommendations are made based on the 2016 monitoring:

- Present surface water and groundwater level monitoring should be continued throughout planned remediation works in 2017 and 2018 (storm sewer lining and utility trench dewatering system) in order to assess the effects on reducing water levels in the sewer trench.
- Post-lining storm sewer leakage testing is to be completed at Golden Locust Drive to assess the effectiveness of the Phase 1 storm sewer lining work.
- Depending on the results of the repeated post-lining leakage test at Golden Locust Drive, the City may wish to consider conducting an additional post-lining leakage test (with the revised methodology) within the Phase 1 area where pre-lining leakage testing was conducted (i.e. either Area 1 – Black Walnut Trail and Cactus Gate or Area 3 – Black Walnut Trail and Laburnum Crescent).
- Pre-lining leakage tests for the Phase 2 lining areas should be completed prior to proceeding with the additional storm sewer lining.

6.3 Closure

We trust the foregoing to be satisfactory. Please do not hesitate to contact our office should you wish to discuss further.

Yours truly,

Amec Foster Wheeler Environment & Infrastructure
a division of Amec Foster Wheeler Americas Limited

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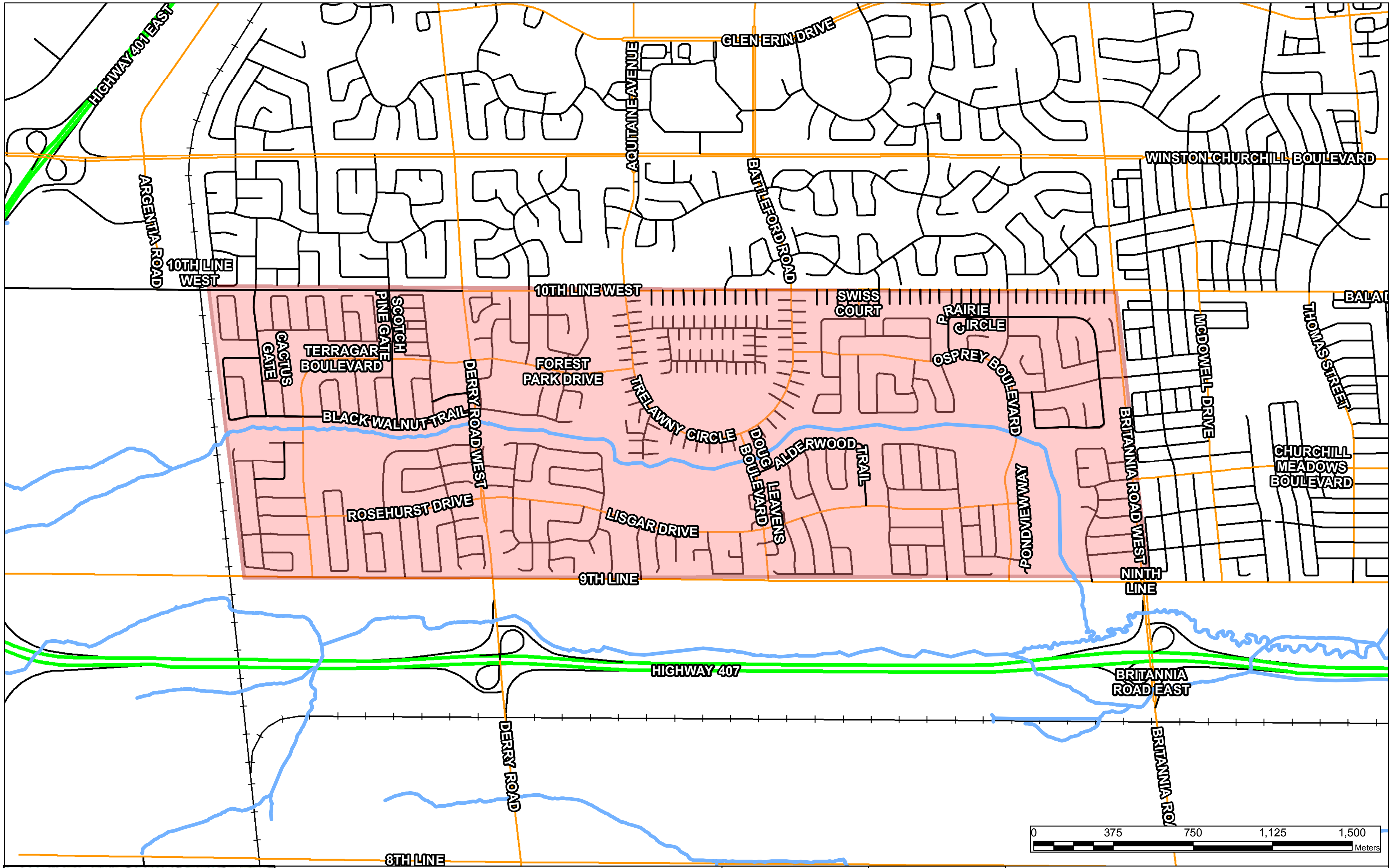
Per: Nick Schmidt, P.Geo.
Project Hydrogeologist

Per: Martin Shepley, D.Phil, M.Sc, P.Geo.
Associate Hydrogeologist

MGS/MJS/cc



LEGEND

- Permanent Watercourse
- 🟥 Site Location

NOTES:
This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open ORN, 2012; OHN, 2012

CLIENT:
MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N
SCALE: 1:25,000	

N E S W

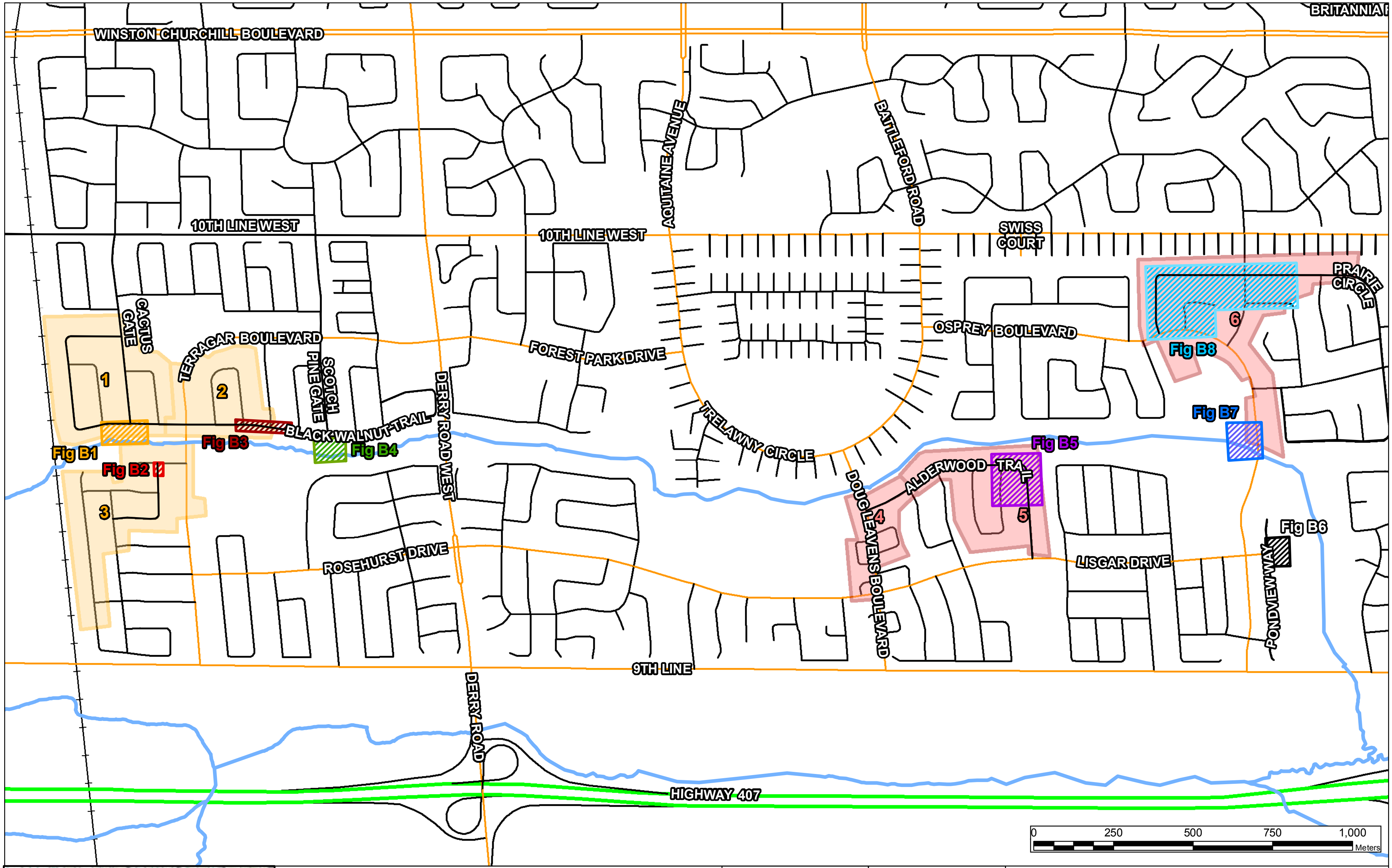
LISGAR BASEMENT WATER INFILTRATION INVESTIGATION
Mississauga, Ontario

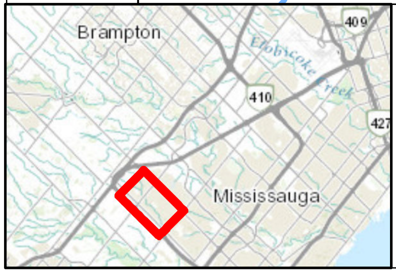
Site Location

PROJECT N°: TP115060		**FIGURE:** **1**
DATE: July 2017		

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

amec foster wheeler





LEGEND

- 🟦 Osprey Boulevard- Figure B7
- 🟩 Scotch Pine Gate- Figure B4
- 🟪 Alderwood Trail- Figure B5
- 🟧 Cactus Gate- Figure B1
- 🟥 Golden Locust- Figure B2
- ⬛ Pondview Way- Figure B6
- 🟦 Prairie Circle, Waxwing Drive, Osprey Boulevard- Figure 8
- 🟥 Smoke Tree Road and Laburnum Crescent- Figure B3
- — Permanent Watercourse
- 🟧 Phase 1 Lining Areas
- 🟥 Phase 2 Lining Areas

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT: MISSISSAUGA

Drawn By: LJM
Checked By: MS
Revision: A
Projection: UTM Zone 17N
SCALE: 1:16,646

N E S W

LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Phase 1 and 2 Lining Areas

PROJECT N°: TP115060
DATE: July 2017
FIGURE: 2

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Appendix A

Surface Water Monitoring Data

TABLE A1 - SUMMARY OF SURFACE WATER MONITORING GAUGES (2016)

Phase/Year	Drainage System	Gauge ID	UTM X	UTM Y	Initial Install Date	Uninstall Date	Notes
1 (2012)	Barologger	Barologger	598476	4825803	11-Jan-12	ongoing	For barometric data correction - installed at F2 location
	FDC	F1	597990	4826331	11-Jan-12	ongoing	Black Walnut Trail between Smoke Tree and Laburnum
		F2	598476	4825803	11-Jan-12	ongoing	Along creek just south of Derry
		F3	599310	4824853	11-Jan-12	ongoing	Along creek just south of Doug Leavens
		F4	600203	4823931	11-Jan-12	ongoing	Along berm of Osprey Marsh
		F5	597775	4826540	07-Jun-12	ongoing	Black Walnut Trail at Gumwood Road
		F6	598220	4826060	07-Jun-12	ongoing	Black Walnut Trail between Spirea and Wild Cherry
		F7	599191	4824895	07-Jun-12	18-Jun-13	Along creek just north of Doug Leavens. Relocated as part of Phase 2 works (F19)
		F8	599702	4824567	07-Jun-12	ongoing	Between Alderwood Trail and Creek, along trailway
		F9	600162	4824161	07-Jun-12	18-Jun-13	Along creek just north of Osprey. Relocated as part of Phase 2 works (F20)
		F10	600003	4823833	07-Jun-12	ongoing	Lisgar Drive at Pondview Way
		F11	599820	4823522	07-Jun-12	14-Jun-13	Along Ninth Line at edge of Osprey Marsh. Relocated as part of Phase 2 works (F21)
		F12	600019	4823259	05-Jul-12	ongoing	Along Ninth Line just north of Britannia
		F13	597765	4826668	18-Oct-12	12-Dec-12	Cactus Gate just east of Black Walnut Trail - temporary gauge to monitor local surcharge, re-installed in late 2013
		F14	597651	4826662	18-Oct-12	12-Dec-12	Black Walnut Trail at Apricot - temporary gauge to monitor local surcharge, re-installed in late 2013
		F15	598198	4826230	18-Oct-12	12-Dec-12	Scotch Pine just east of Black Walnut Trail - temporary gauge to monitor local surcharge
	Storm Sewer	S1	598115	4826109	07-Jun-12	ongoing	Last MH before outfall to creek off of Scotch Pine
	Surface Water	GO Channel	597435	4826700	09-Aug-12	12-Dec-12	Within tributary GO Channel just usptream of main branch
		Rail	597551	4826643	12-Jul-12	12-Dec-12	Within main branch just south of CNR
		Scotch Pine	598088	4826087	12-Jul-12	12-Dec-12	Within main branch just upstream of storm sewer outfall
		Osprey	600156	4824156	23-Jul-12	12-Dec-12	Within main branch just upstream of Opsrey Boulevard
	Rain Gauge	Lisgar Middle School	598714	4825132	23-Jul-12	12-Dec-12	On roof of Lisgar Middle School
2 (2013)	FDC	F13	597765	4826668	29-Oct-13	ongoing	Cactus Gate just east of Black Walnut Trail - previously used location, used to monitor local surcharge
		F14	597651	4826662	29-Oct-13	ongoing	Black Walnut Trail at Apricot - previously used location, used to monitor local surcharge
		F16	601061	4823685	05-Jun-13	ongoing	McDowell Drive by public school - intended as background data for "normal" FDC outside of Lisgar area
		F17	601087	4822271	20-Jun-13	ongoing	Along Trunk FDC (Ninth Line) by Deepwood Heights
		F18	602075	4821872	20-Jun-13	ongoing	Trunk FDC along Erin Centre just upstream of confluence with trunk storm sewer
		F19	598584	4825216	18-Jun-13	ongoing	Re-located F7 - Gracefield Drive just east of Lisgar Drive
		F20	600223	4824113	18-Jun-13	ongoing	Re-located F9 - along Osprey Boulevard just upstream of trunk FDC
		F21	599485	4824307	14-Jun-13	ongoing	Lisgar Drive between Alderwood and Forest Bluff - FDC splitter MH
		F22	598229	4825996	08-Oct-13	11-Oct-13	Short-term gauge for October 2013 sewer leakage test - along creek at Black Walnut\Wild Cherry
		F23	599261	4824995	29-Oct-13	05-Dec-14	Trelawny Circle at Doug Leavens Boulevard - added to address surcharge issues. Removed due to gauge malfunction
	Storm Sewer	S2	599655	4824555	05-Jun-13	30-Apr-14	Storm sewer along walkway off corner of Alderwood Trail - removed in 2014 due to malfunctions
		S3	602162	4821894	20-Jun-13	ongoing	Trunk Storm Sewer along Churchill Meadows just south of Erin Centre
		S4	598258	4826026	08-Oct-13	11-Oct-13	Short-term gauge for October 2013 sewer leakage test - along creek at Black Walnut\Wild Cherry
	Surface Water	Rail	597551	4826643	15-May-13	05-Dec-13	As per Phase 1 location, re-installed in 2013
		Scotch Pine	598088	4826087	09-Apr-13	05-Dec-13	As per Phase 1 location, re-installed in 2013
		Alderwood	599742	4824578	04-Jun-13	29-Oct-13	Installed to provide creek data coincidental with storm, FDC, and GW monitoring at Alderwood
		Osprey (Creek)	600156	4824156	09-Apr-13	05-Dec-13	As per Phase 1 location, re-installed in 2013
		Osprey Marsh SWM	599906	4823462	09-Apr-13	05-Dec-13	Within Osprey Marsh SWM pond near outlet
		16MC Trib	599848	4823256	09-Apr-13	05-Dec-13	Within channel (16 MC Trib) downstream of Osprey Marsh SWM
	Rain Gauge	Lisgar Middle School	598714	4825132	17-Apr-13	22-Nov-13	Gauge actually pulled in December, but no useable data past Nov 22nd (snow)
3 (2014)	Storm Sewer	S5	600036	4823797	10-Oct-14	ongoing	New gauge installed at Pondview Way to support impermeable collar monitoring work
	Surface Water	Scotch Pine	598088	4826087	10-Oct-14	05-Dec-14	Same as previous locations, re-installed late in 2014 to support impermeable collar monitoring work
		Osprey Marsh SWM	599906	4823462	02-Apr-14	05-Dec-14	Same as previous locations, re-installed in 2014 to support impermeable collar monitoring work
4 (2015)	FDC	F24	597687	4826452	02-Jul-15	ongoing	Installed to support storm sewer lining and pre-lining leakage tests - area 2 (Golden Locust Dr at Russian Olive Close)
	Storm Sewer	S6	597626	4826377	09-Jul-15	24-Nov-15	Installed to support storm sewer lining and pre-lining leakage tests - area 2 (Golden Locust Dr at Russian Olive Close)
		S7	597706	4826583	09-Jul-15	18-Aug-16	Installed to support storm sewer lining and pre-lining leakage tests- area 1 (Cactus Gate at Black Walnut Trail)
		S8	597687	4826452	20-Jul-15	24-Nov-15	Installed to support storm sewer lining and pre-lining leakage tests - area 3 (Laburnum Cr at Black Walnut Trail)
	Surface Water	Scotch Pine	598088	4826087	27-May-15	25-Nov-15	Same as previous locations, re-installed late in 2015
		Osprey Marsh SWM	599906	4823462	27-May-15	25-Nov-15	Same as previous locations, re-installed late in 2015
5 (2016)	Storm Sewer	S7	597706	4826583	22-Jun-16	18-Aug-16	Storm sewer gauge at Cactus Gate re-installed to support data collection for lining and trench dewatering
	Surface Water	Rail	597551	4826643	25-May-16	06-Dec-16	Same as previous location, re-installed in 2016
		Cactus Gate	597673	4826550	25-May-16	06-Dec-16	New location for 2016 - support assessment of trench dewatering system, sewer lining
		Scotch Pine	598088	4826087	25-May-16	06-Dec-16	Same as previous location, re-installed in 2016
		Osprey Marsh SWM	599906	4823462	25-May-16	06-Dec-16	Same as previous location, re-installed in 2016

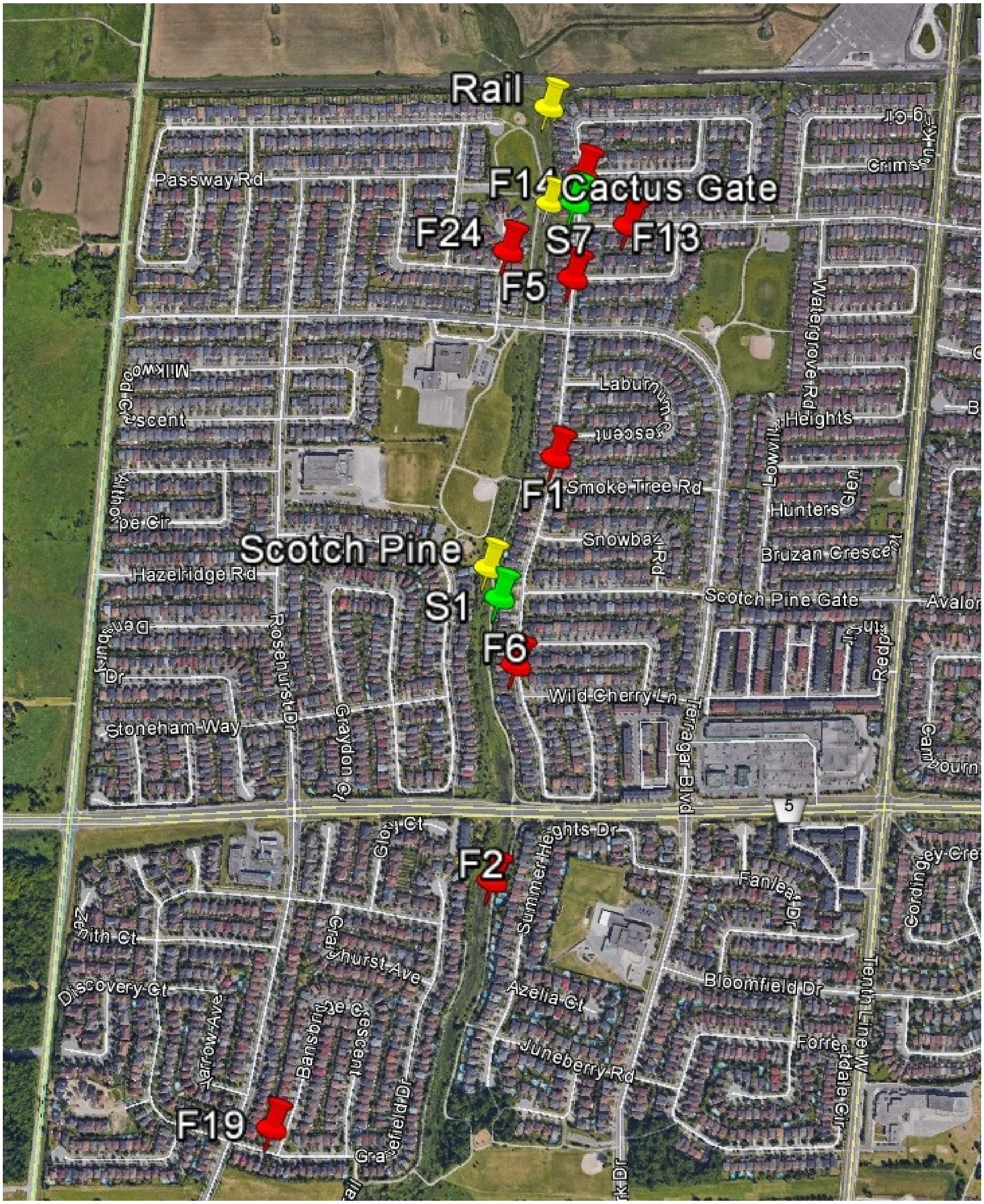


Figure A1: Surface Water Monitoring Gauges near Derry Road and CNR

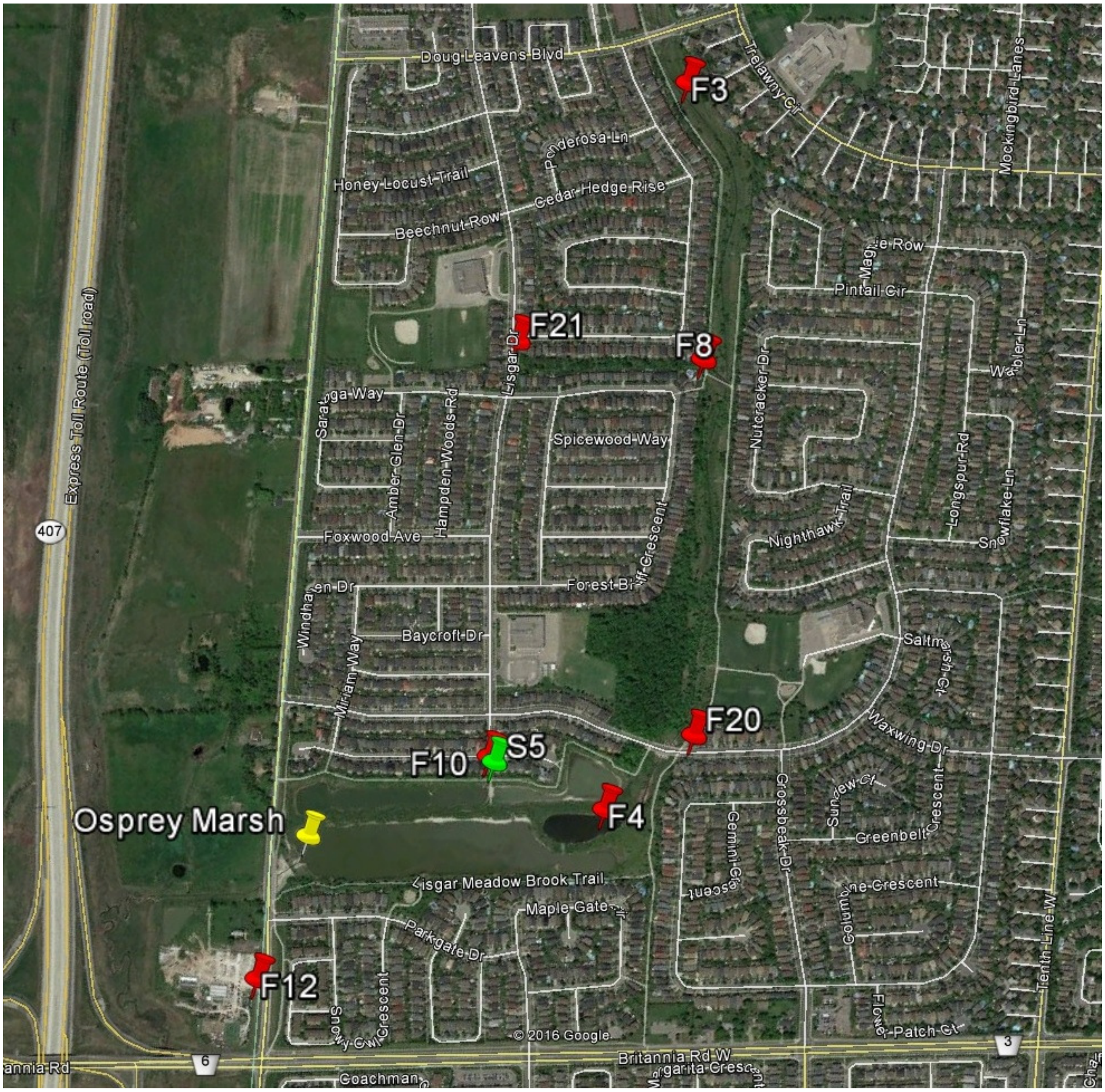


Figure A2: Surface Water Monitoring Gauges between Derry Road and Britannia Road

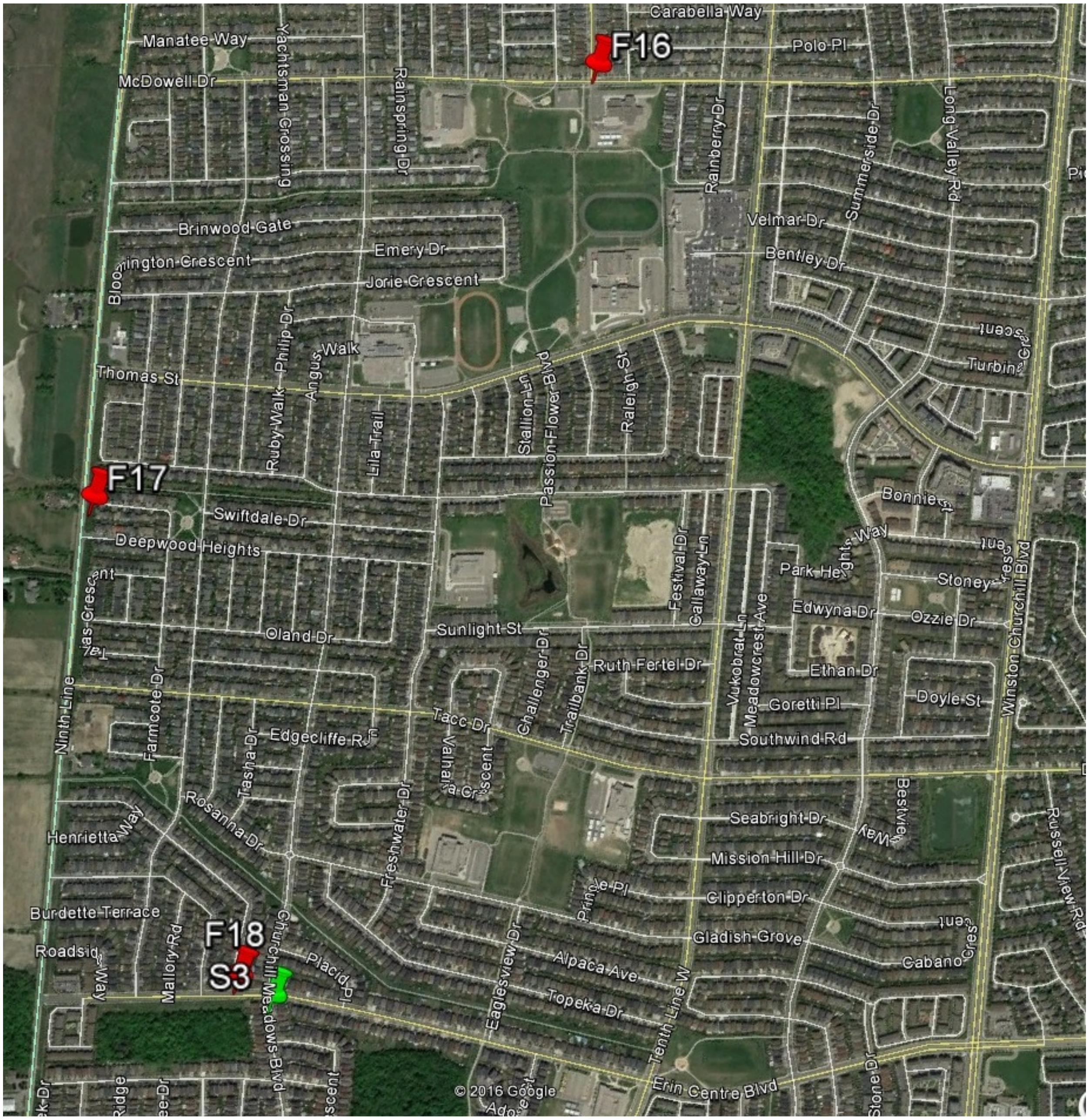
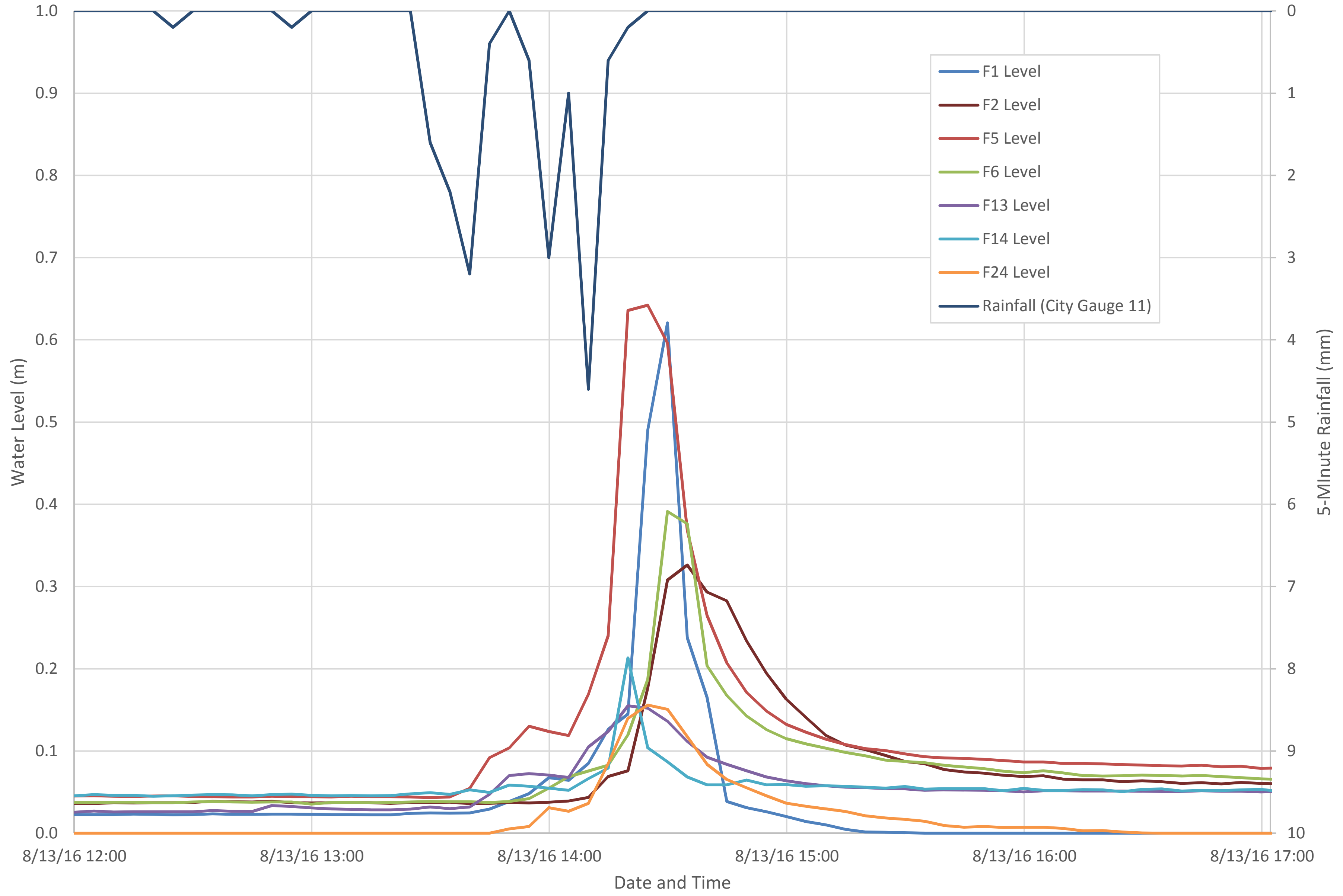


Figure A3: Surface Water Monitoring Gauges south of Britannia Road

Figure A4: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - August 13, 2016



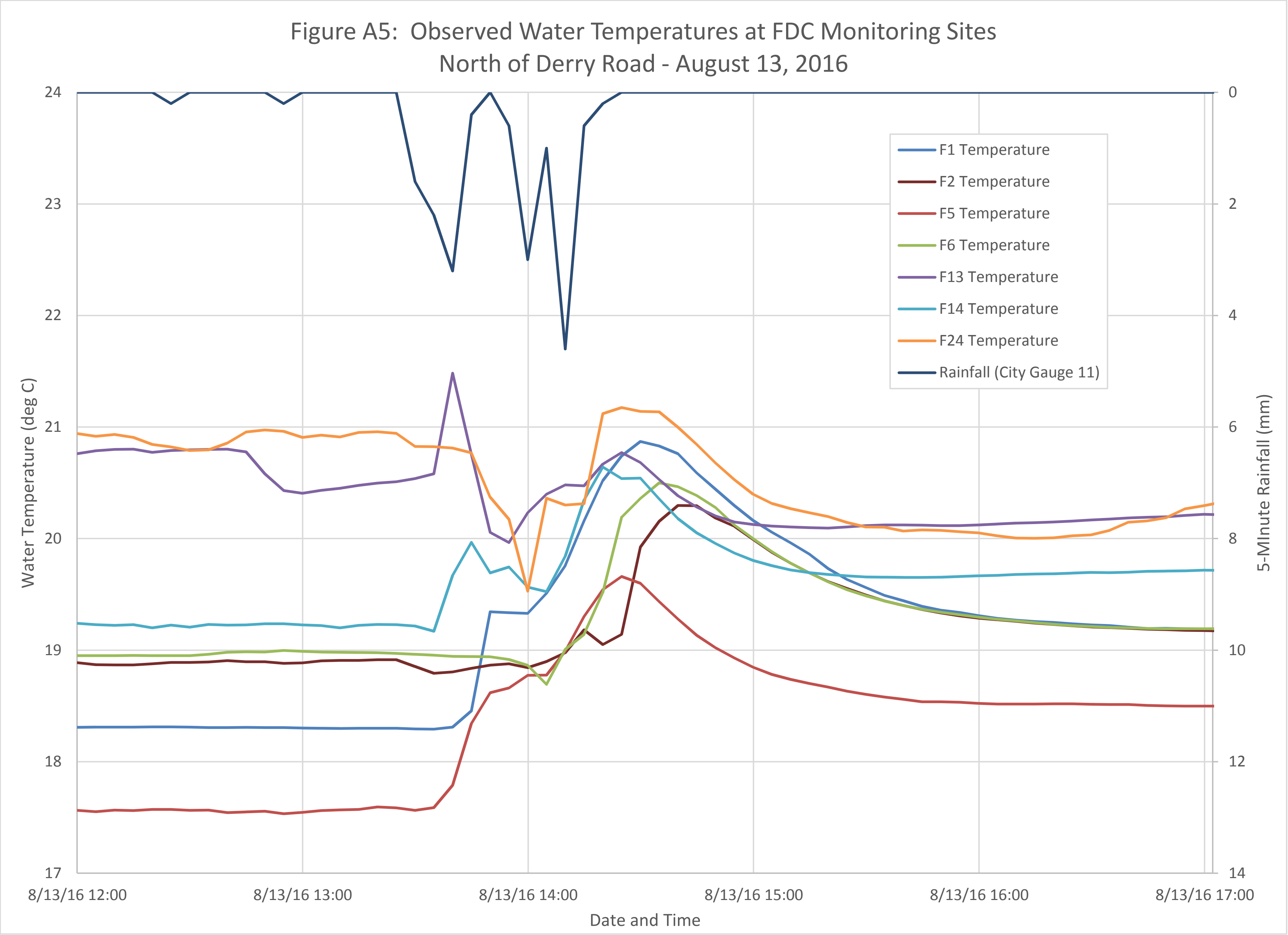
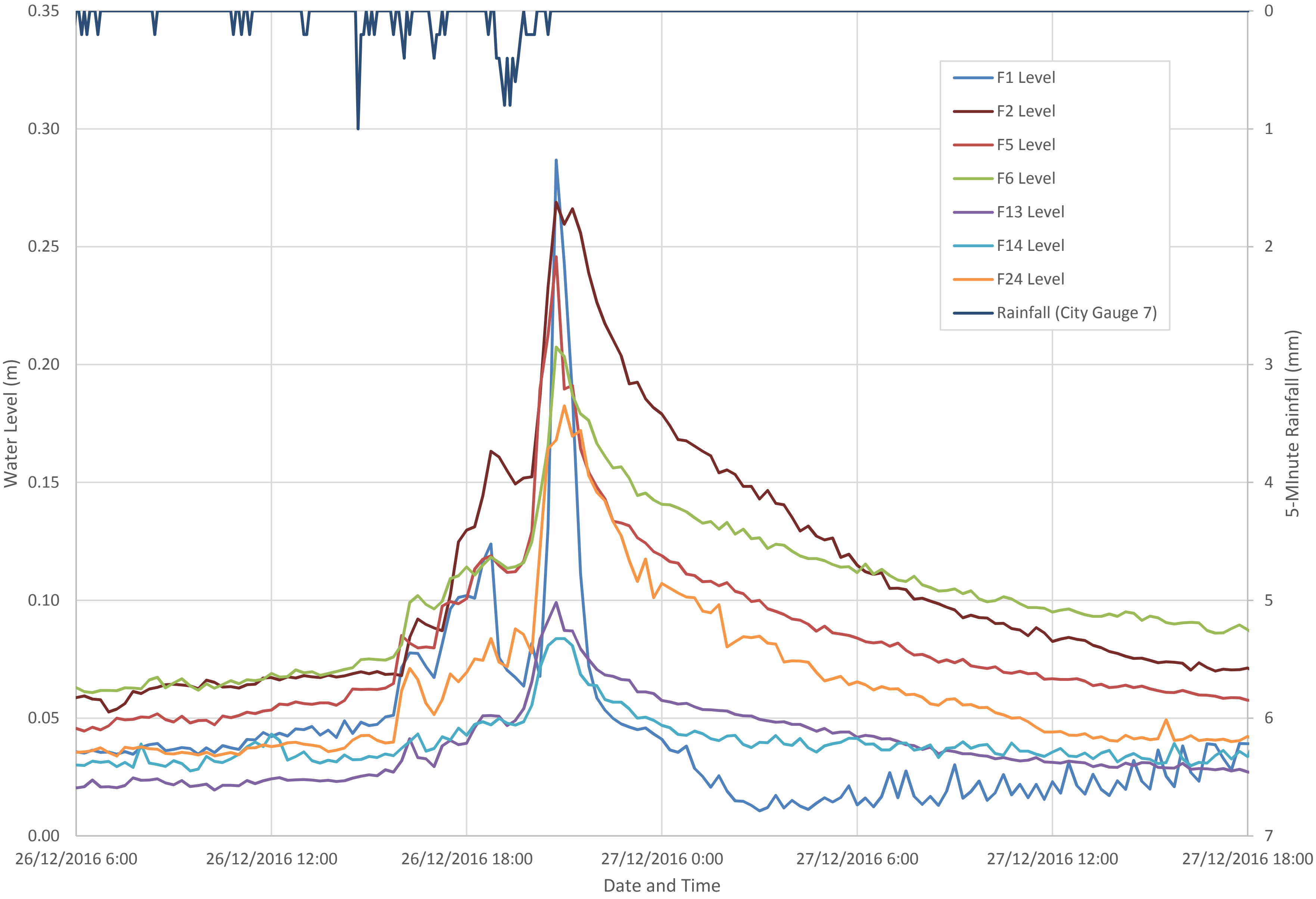


Figure A5: Observed Water Temperatures at FDC Monitoring Sites
North of Derry Road - August 13, 2016
24
23
22
21
20
19
18
17
Water Temperature (deg C)
0
2
4
6
8
10
12
14
5-MInute Rainfall (mm)
8/13/16 12:00
8/13/16 13:00
8/13/16 14:00
8/13/16 15:00
8/13/16 16:00
8/13/16 17:00
Date and Time
F1 Temperature
F2 Temperature
F5 Temperature
F6 Temperature
F13 Temperature
F14 Temperature
F24 Temperature
Rainfall (City Gauge 11)

Figure A6: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - December 26, 2016



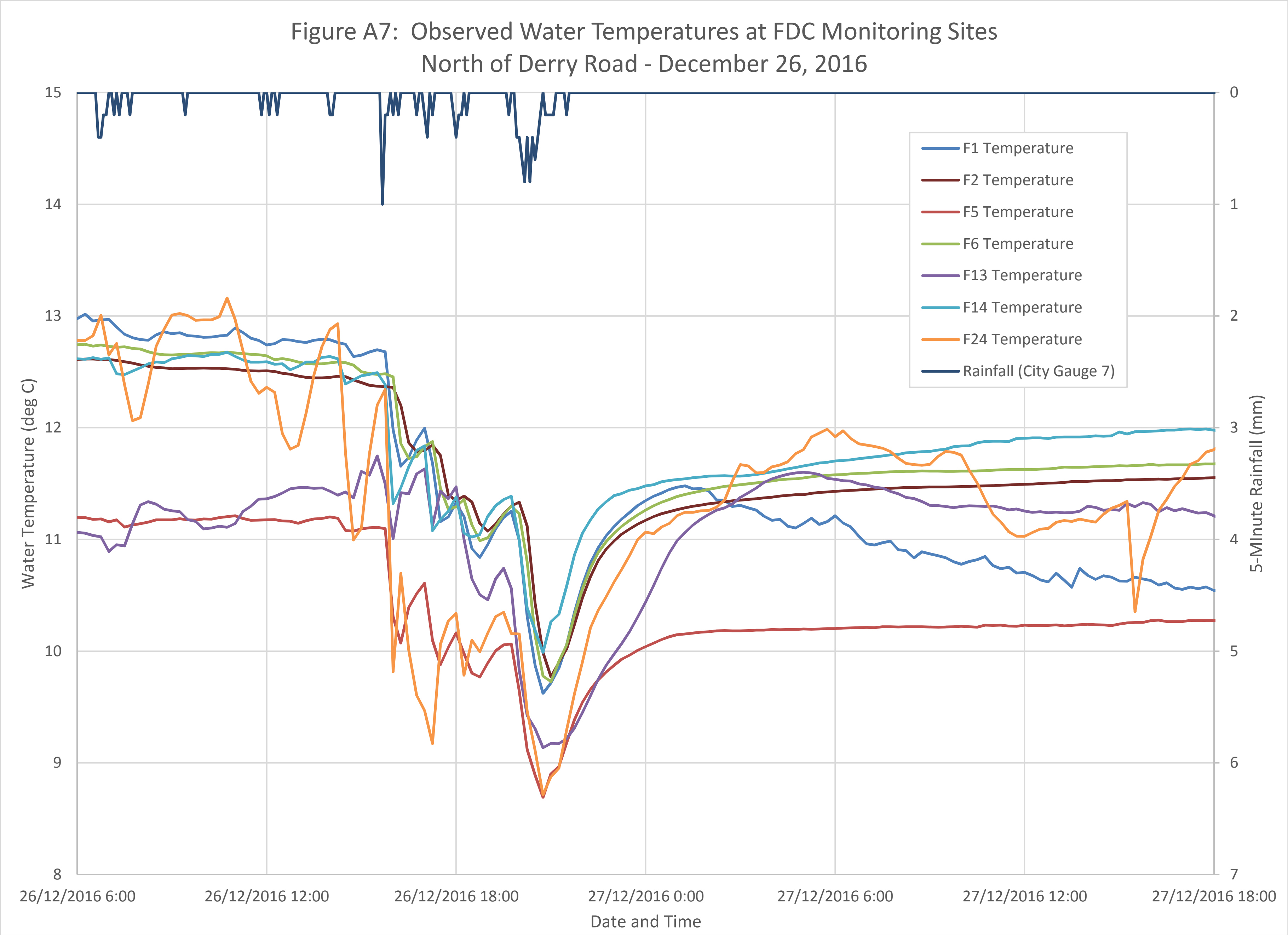


Figure A7: Observed Water Temperatures at FDC Monitoring Sites
North of Derry Road - December 26, 2016
Water Temperature (deg C)
15
14
13
12
11
10
9
8
5-MInute Rainfall (mm)
0
1
2
3
4
5
6
7
26/12/2016 6:00
26/12/2016 12:00
26/12/2016 18:00
27/12/2016 0:00
27/12/2016 6:00
27/12/2016 12:00
27/12/2016 18:00
Date and Time
F1 Temperature
F2 Temperature
F5 Temperature
F6 Temperature
F13 Temperature
F14 Temperature
F24 Temperature
Rainfall (City Gauge 7)

Figure A8: Observed Water Levels (Corrected) at FDC Monitoring Sites between Derry Road and Britannia Road - December 26, 2016

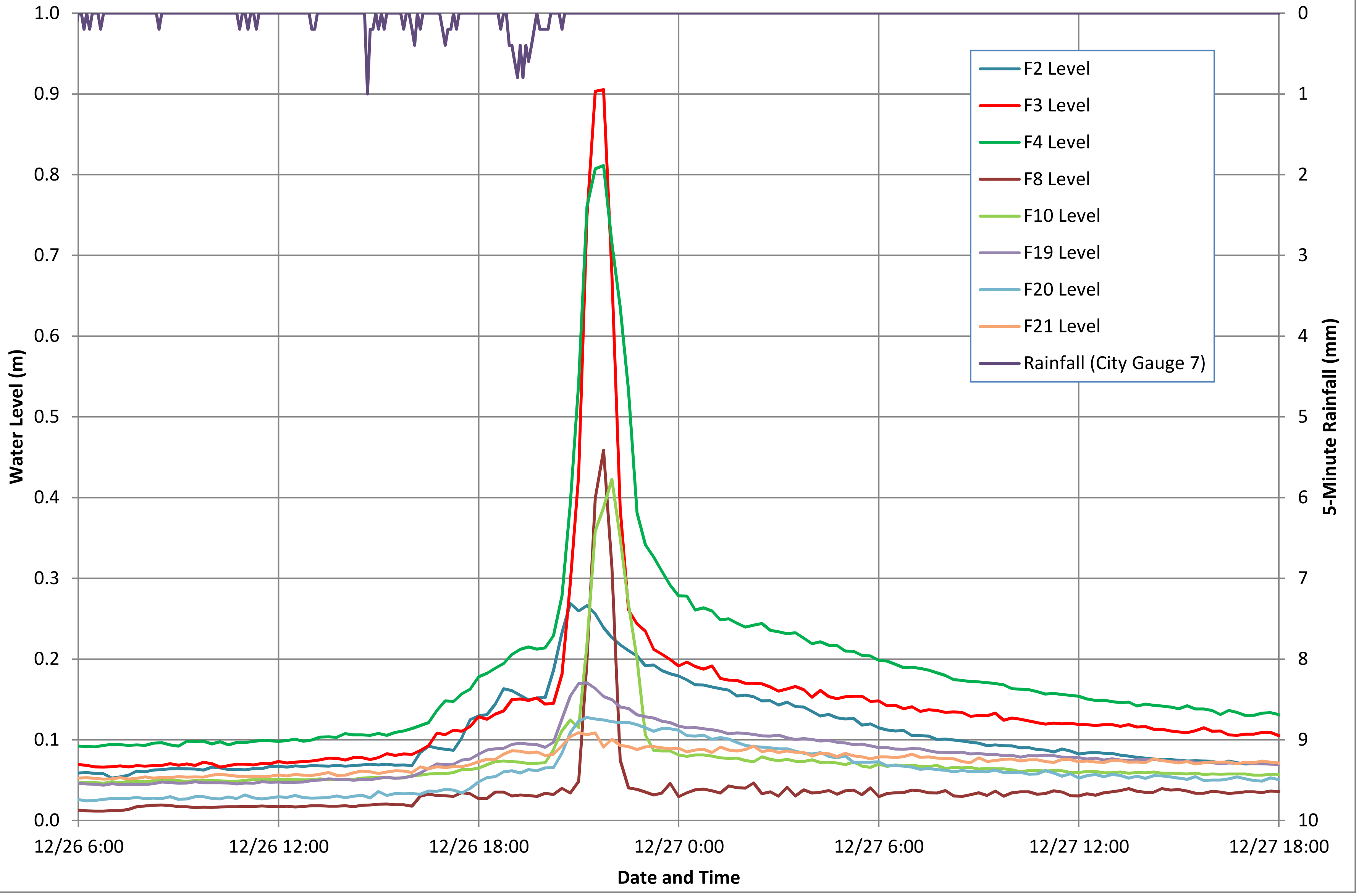


Figure A9: Observed Water Temperatures at FDC Monitoring Sites between Derry Road and Britannia Road - December 26, 2016

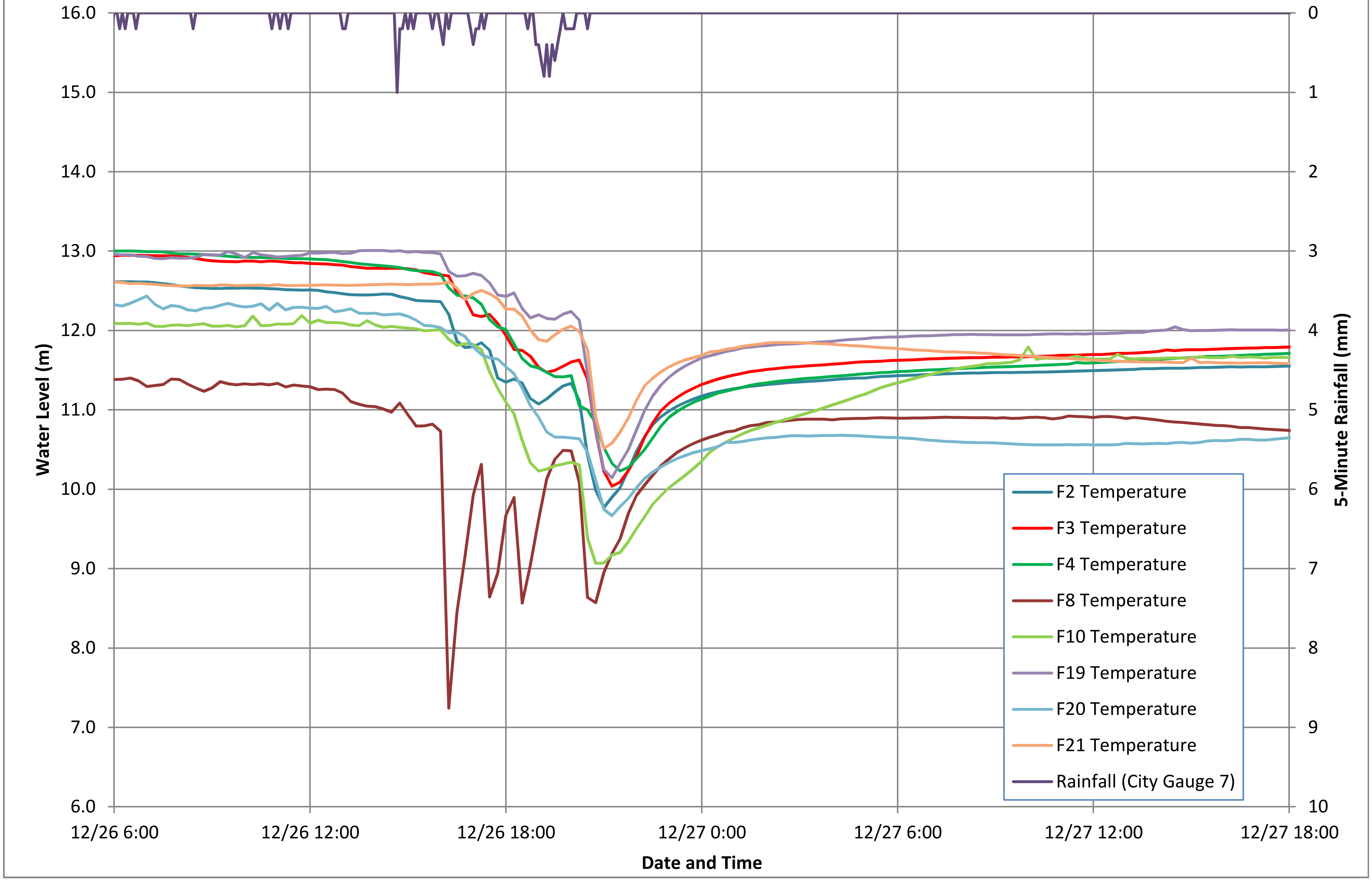


Figure A10: Observed Water Levels (Corrected) at FDC Monitoring Sites between Britannia Road and Erin Centre Boulevard - December 26, 2016

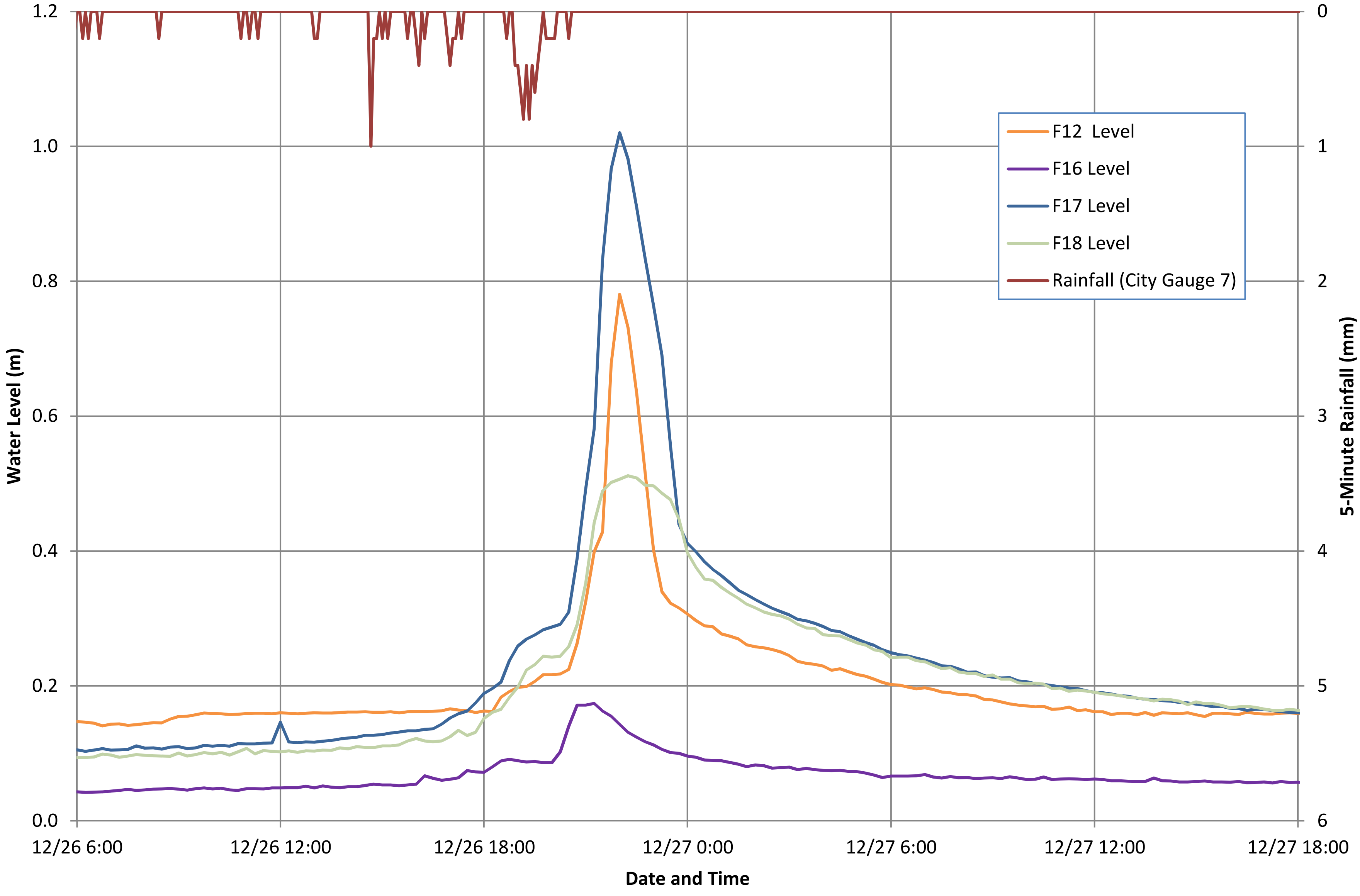
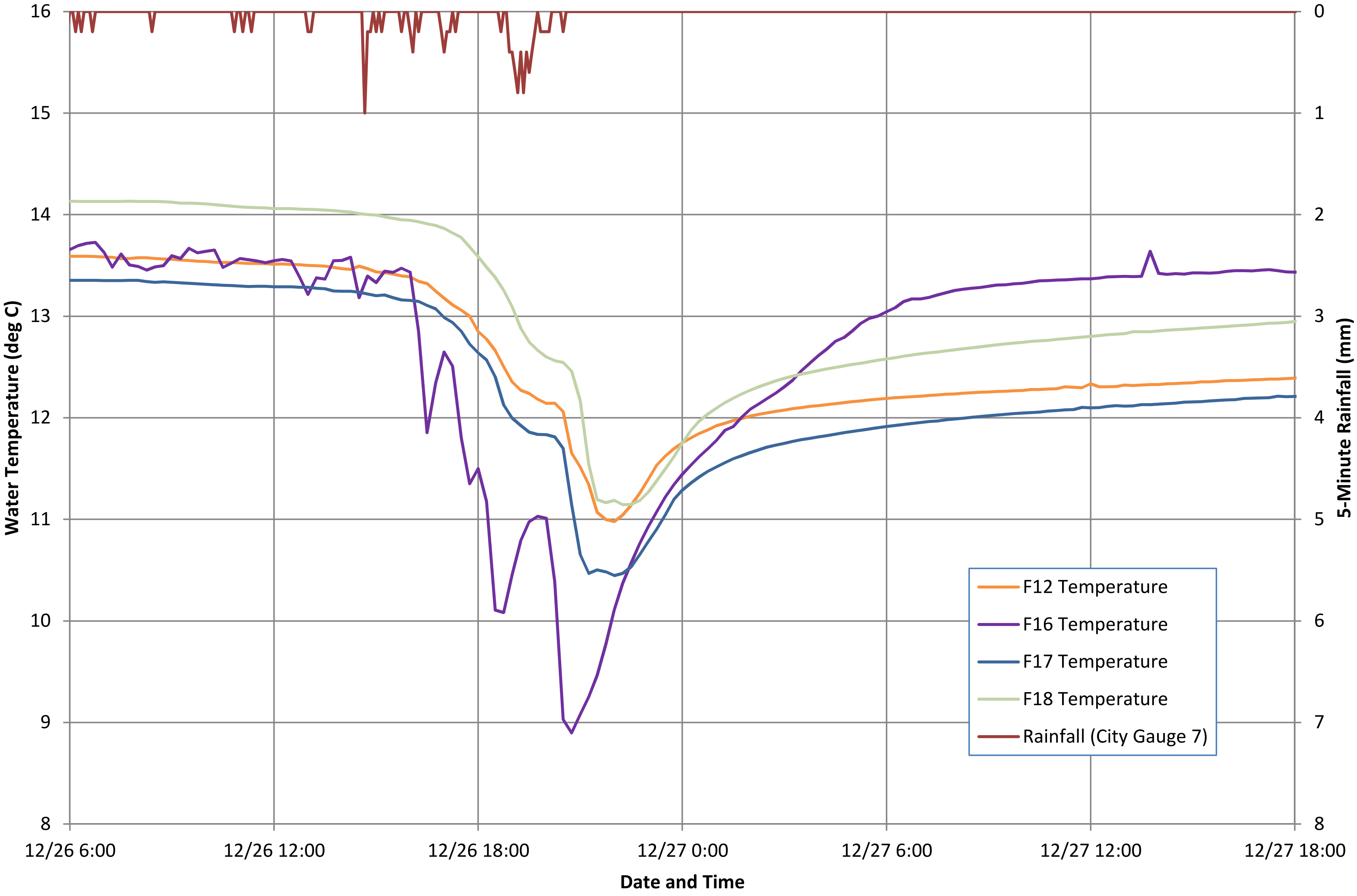
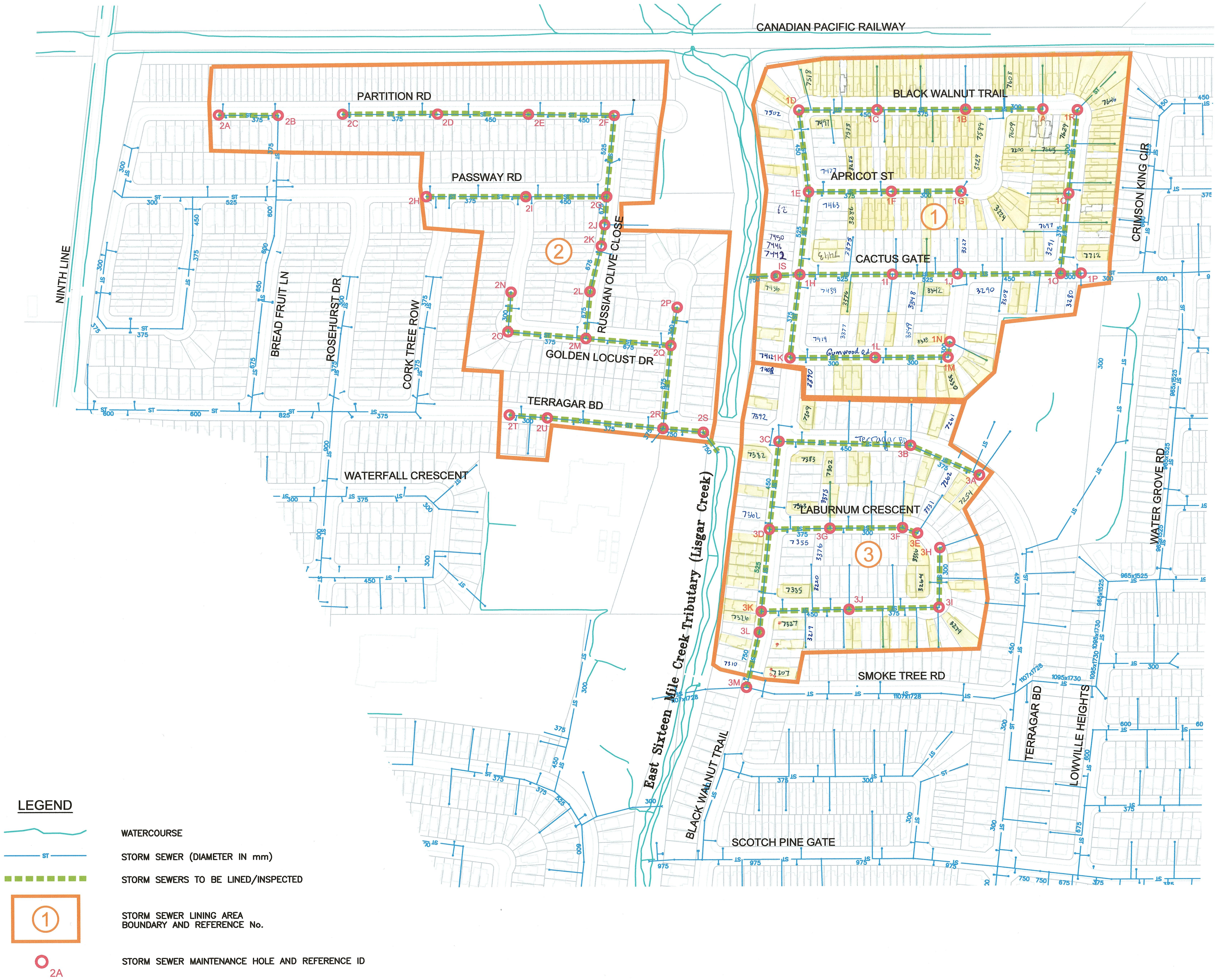


Figure A11: Observed Water Temperatures at FDC Monitoring Sites between Britannia Road and Erin Centre Boulevard - December 26, 2016



REVISIONS		
DATE	DETAILS	INT.



LEGEND

WATERCOURSE

STORM SEWER (DIAMETER IN mm)

STORM SEWERS TO BE LINED/INSPECTED

① STORM SEWER LINING AREA BOUNDARY AND REFERENCE No.

2A STORM SEWER MAINTENANCE HOLE AND REFERENCE ID

LISGAR DISTRICT
STORM SEWER LINING
(FA. 49453-16)

amec foster wheeler

MISSISSAUGA

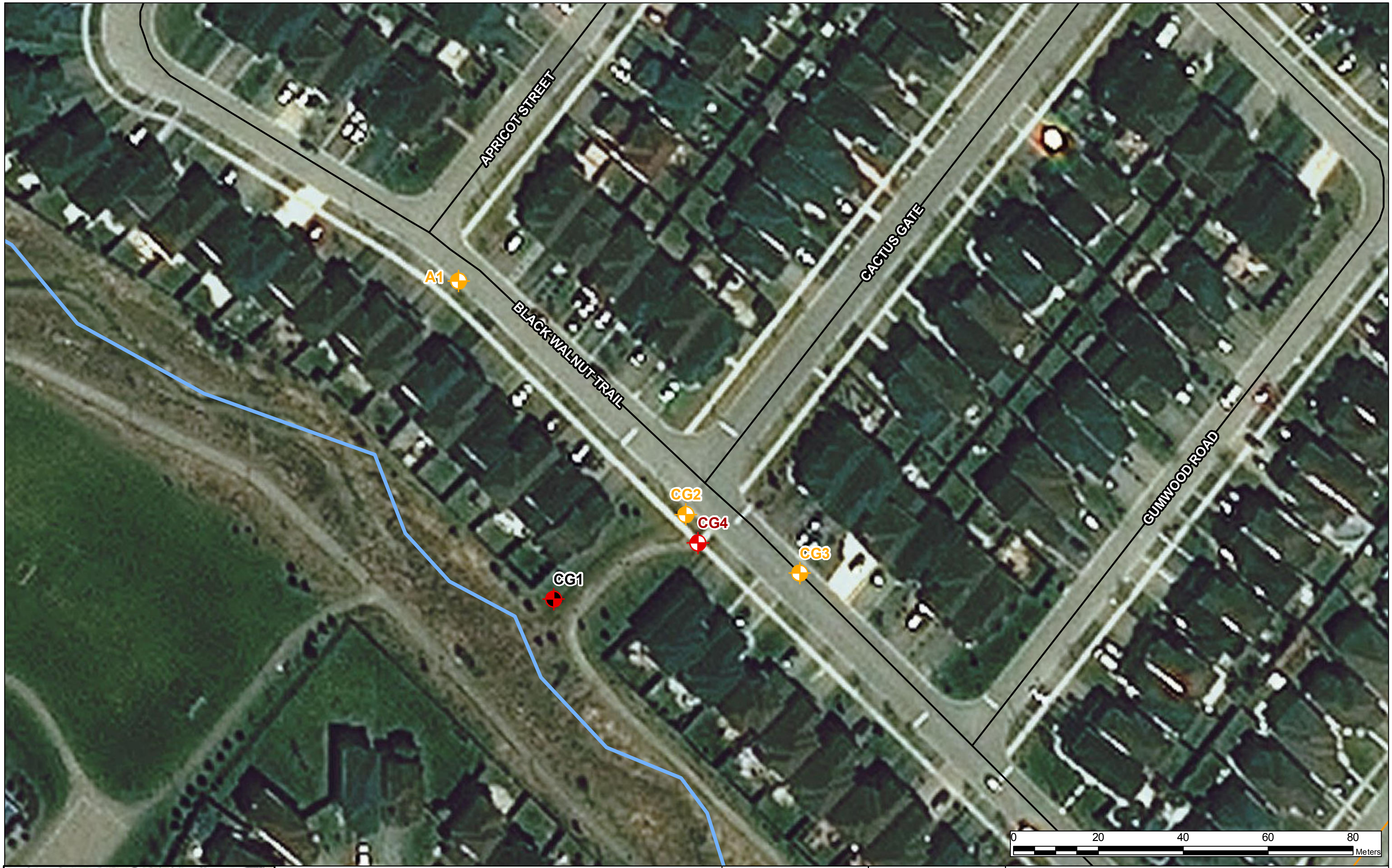
PRODUCED FOR - T&W, ENGINEERING AND WORKS

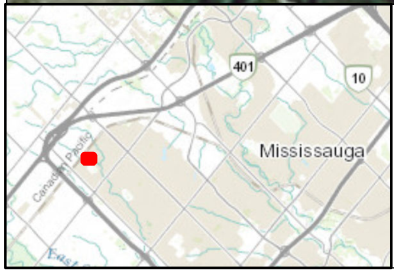
STORM SEWER LINING OVERVIEW

SCALE	AS NOTED	AREA		PROJECT No.	TP115060
C.A.D.D. BY	J.S.	CHECKED BY	M.S.	PLAN No.	Figure 1
DATE	JUNE 2016	SHEET 1 OF 11			

Appendix B

Groundwater Monitoring Locations and Data





LEGEND

⊕ Sewer Trench Piezometer

⊕ Standard Piezometer

⊕ Standard Piezometer-Decomissioned

— Permanent Watercourse

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT:

MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N
SCALE: 1:1,250	

N E S W

LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Cactus Gate- Grounwater Monitoring Locations

PROJECT N°: TP115060

DATE: July 2017

FIGURE: B1

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

amec foster wheeler

Figure B1a - Hydrograph of Water Levels - Cactus Gate (Area 1)

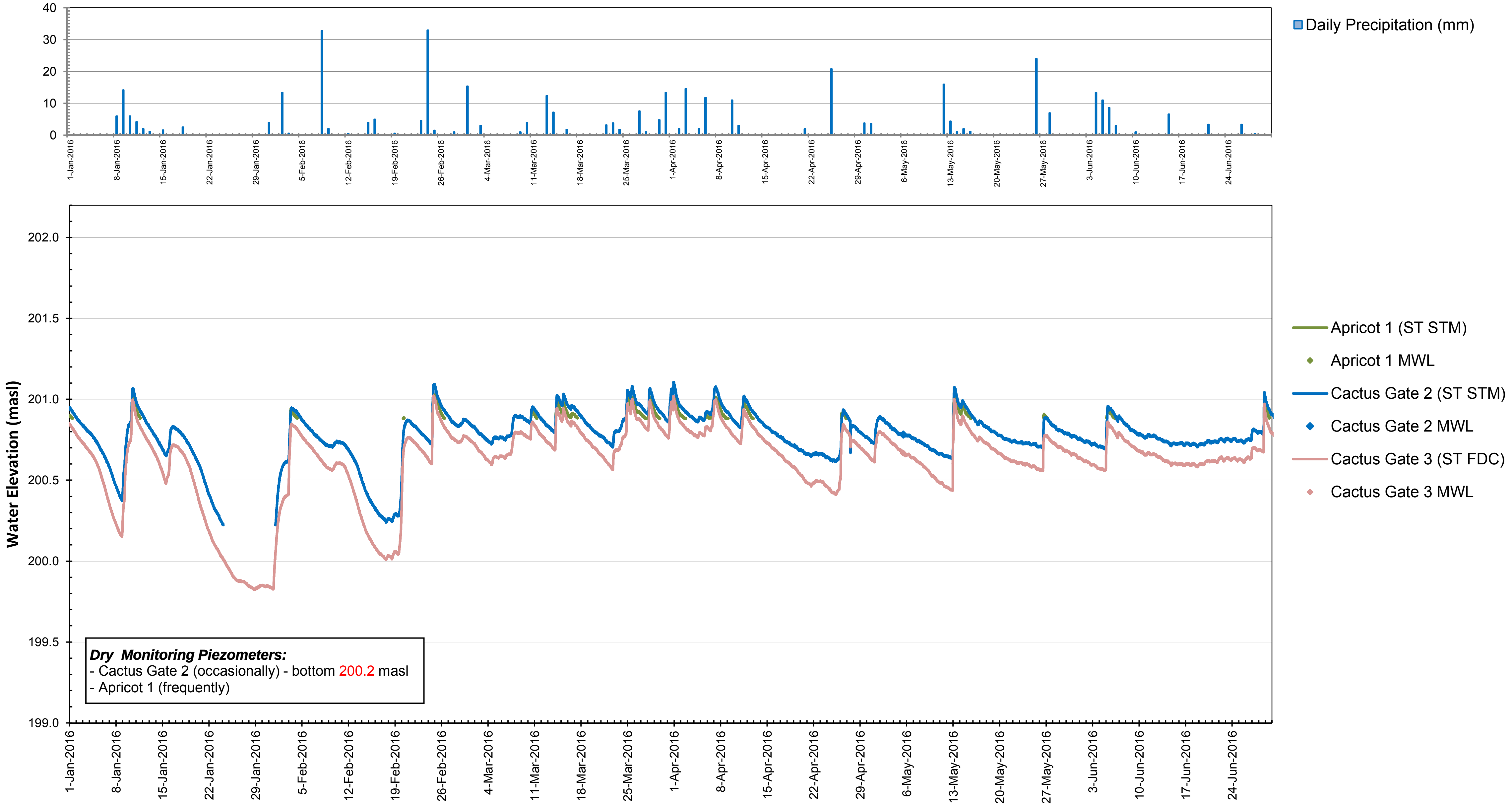
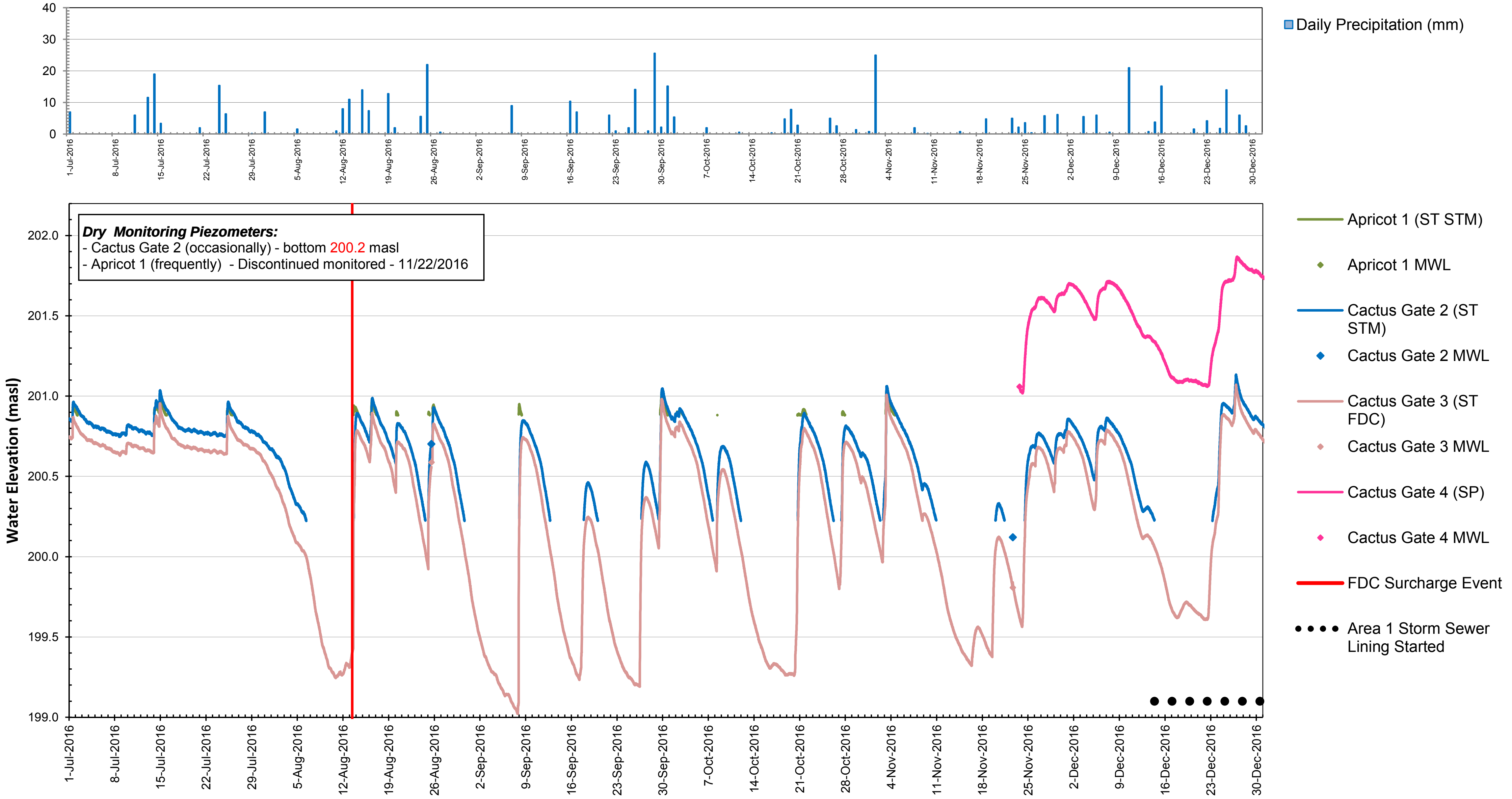


Figure B1b - Hydrograph of Water Levels - Cactus Gate (Area 1)



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Environment Infrastructure
TP115060

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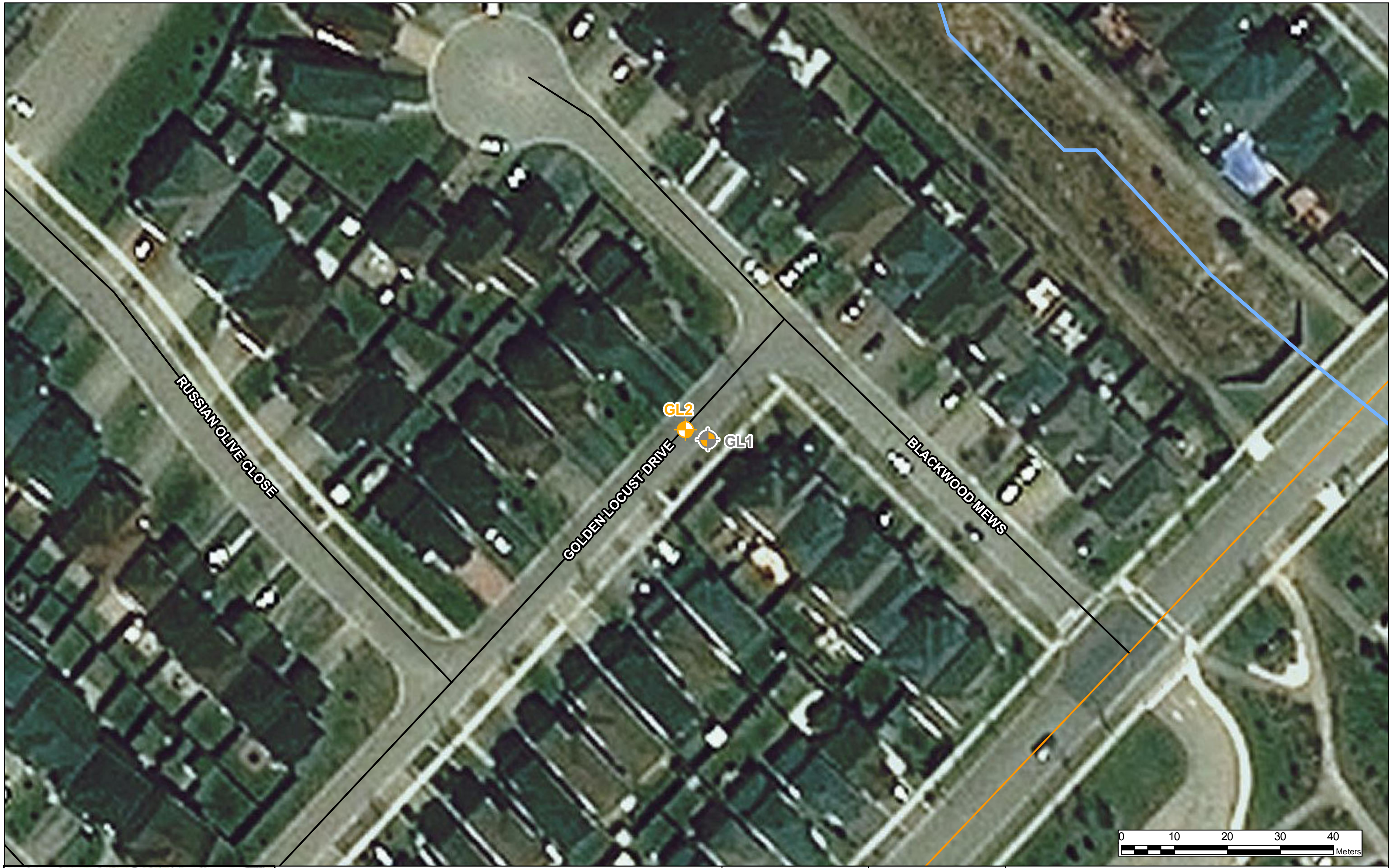

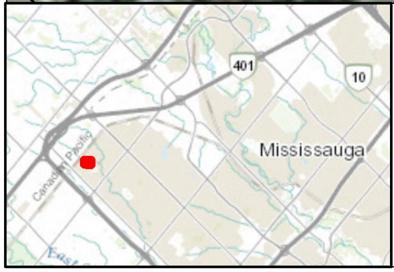

LEGEND

- ⊕ Sewer Trench Piezometer
- ⊕ Sewer Trench Piezometer- no longer being monitored
- ▬ Permanent Watercourse

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT: MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N

SCALE: 1:1,000

LISGAR BASEMENT WATER INFILTRTION INVESTIGATION

Mississauga, Ontario

Golden Locust- Grounwater Monitoring Locations

PROJECT N°: TP115060

DATE: July 2017

FIGURE: **B2**

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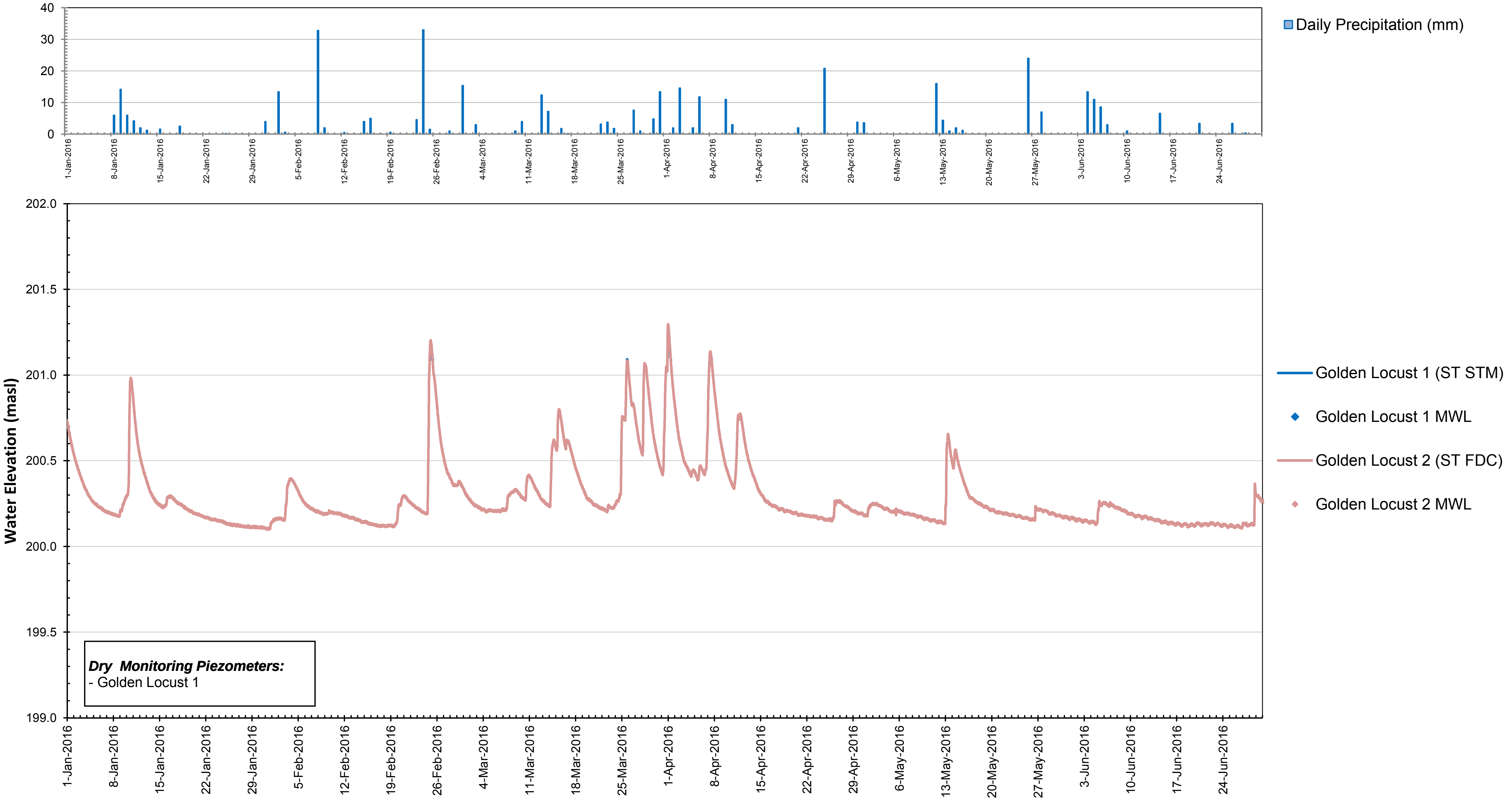
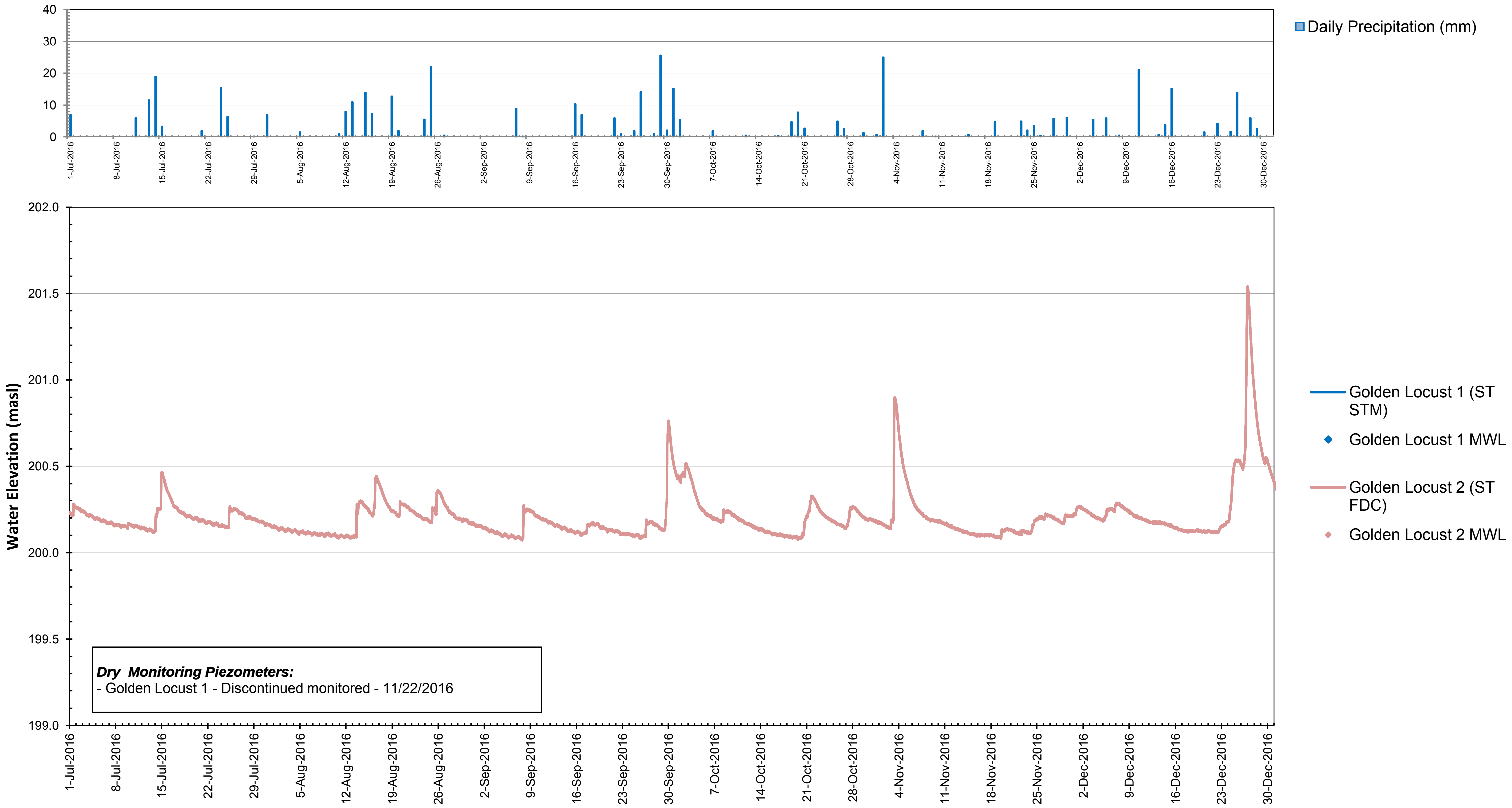
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

Figure B2a - Hydrograph of Water Levels - Golden Locust (Area 2)

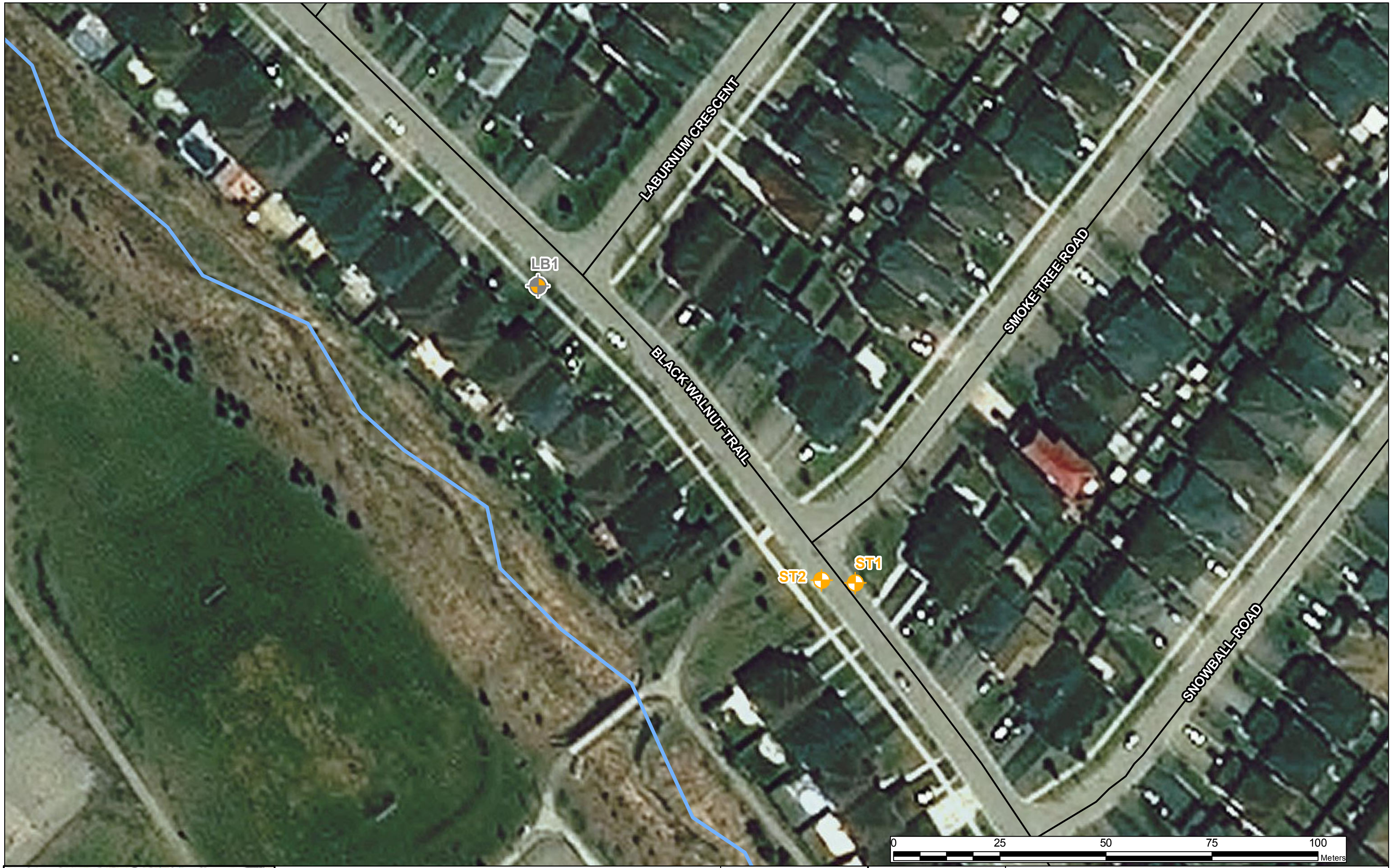


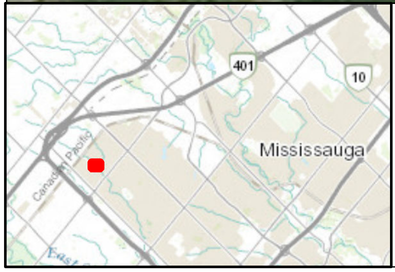
Dry Monitoring Piezometers:
- Golden Locust 1

Figure B2b - Hydrograph of Water Levels - Golden Locust (Area 2)



Dry Monitoring Piezometers:
- Golden Locust 1 - Discontinued monitored - 11/22/2016





LEGEND

- ⊕ Sewer Trench Piezometer
- ⊕ Sewer Trench Piezometer- no longer being monitored
- — Permanent Watercourse

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

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Checked By: MS

Revision: A

Projection: UTM Zone 17N

SCALE: 1:1,250

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LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Smoke Tree Road and Laburnum Crescent-
Grounwater Monitoring Locations

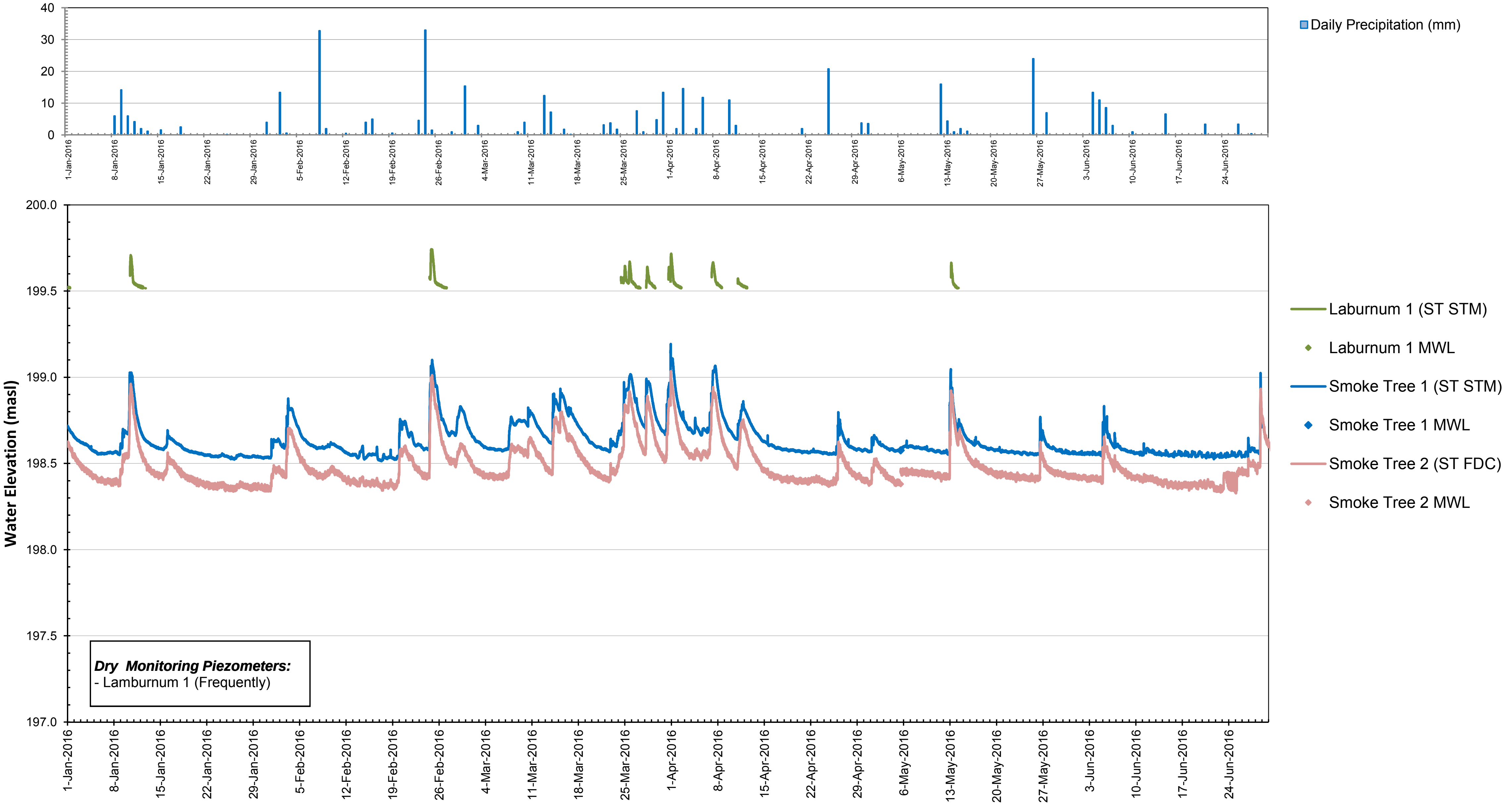
PROJECT N°: TP115060

DATE: July 2017

FIGURE: **B3**

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

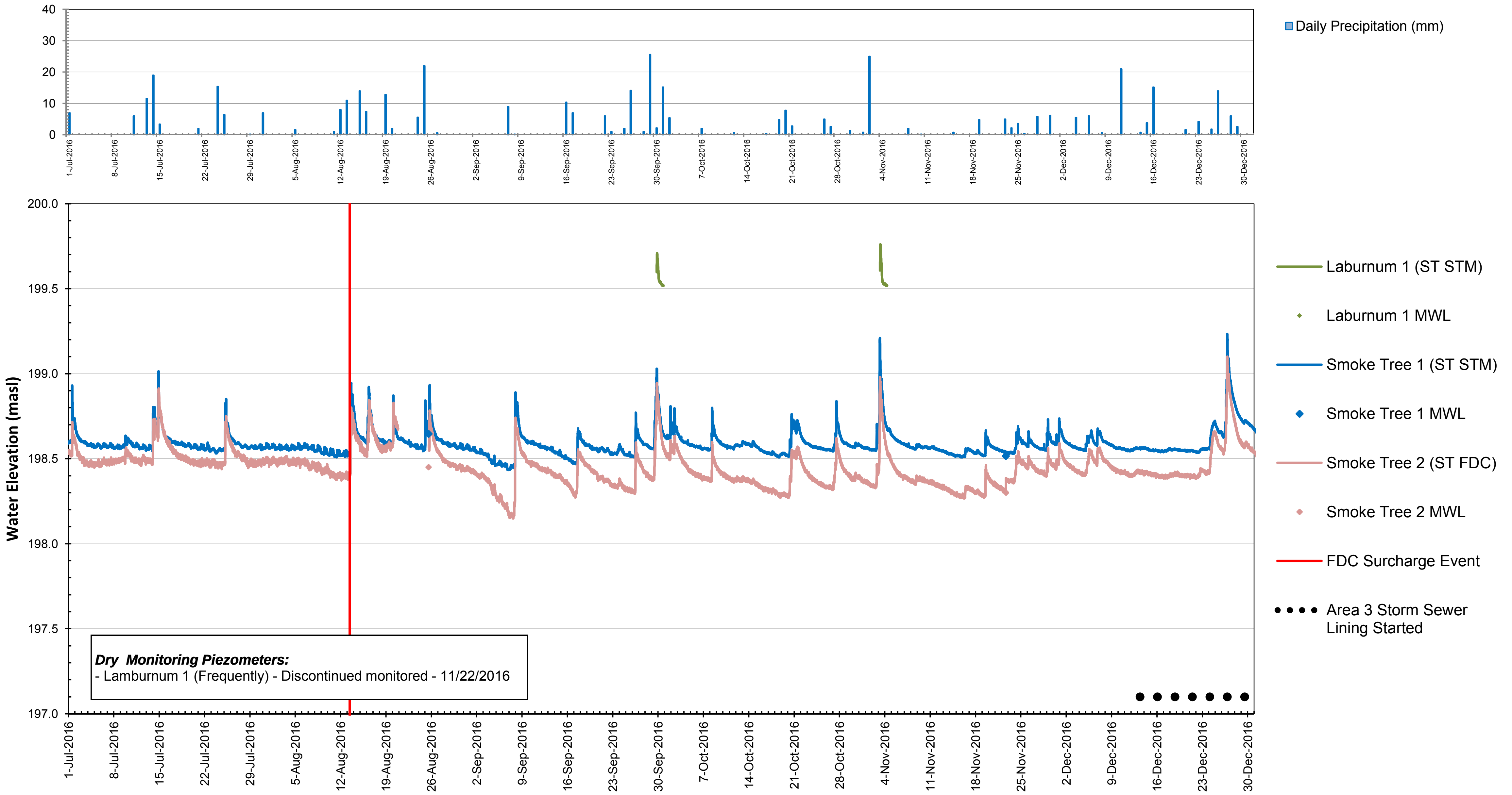
Figure B3a - Hydrograph of Water Levels - Smoke Tree Road / Laburnum Crescent (Area 3)



Dry Monitoring Piezometers:
- Lamburnum 1 (Frequently)

Amec Foster Wheeler
Environment Infrastructure
TP115060

Figure B3b - Hydrograph of Water Levels - Smoke Tree Road / Laburnum Crescent (Area 3)



Dry Monitoring Piezometers:
- Lamburnum 1 (Frequently) - Discontinued monitored - 11/22/2016

Amec Foster Wheeler
Environment Infrastructure
TP115060

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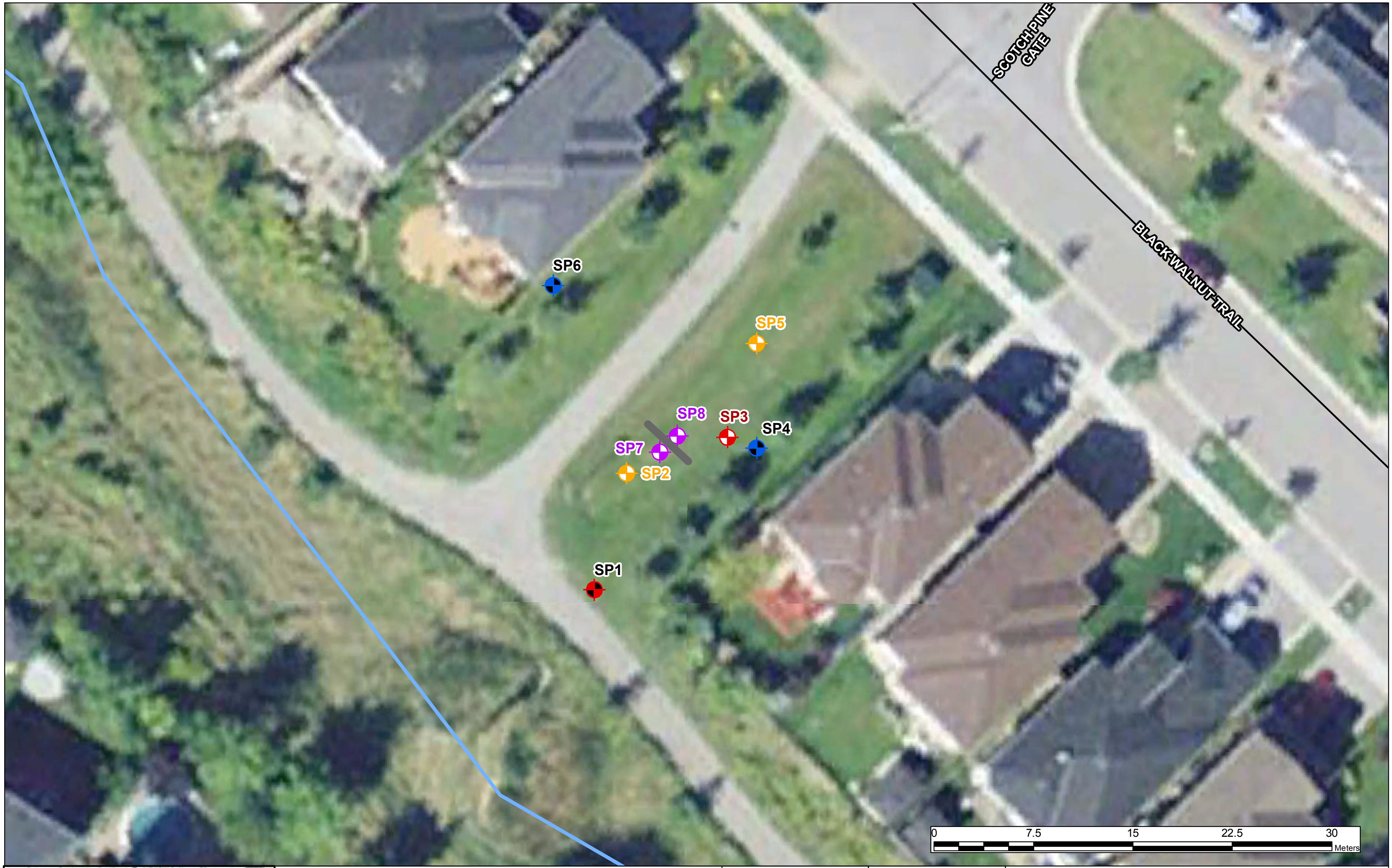

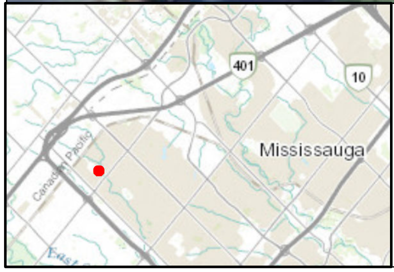

LEGEND

- ⊕ Collar Piezometer
- ⊕ Sewer Trench Piezometer
- ⊕ Shallow Drive Point- Decomissioned
- ⊕ Standard Piezometer
- ⊕ Standard Piezometer- Decomissioned
- ▬ Concrete Collar
- ▬ Permanent Watercourse

NOTES:
This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT:
MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N
SCALE: 1:400	

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LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Scotch Pine Gate- Grounwater Monitoring Locations

PROJECT N°: TP115060
DATE: July 2017
FIGURE: B4

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
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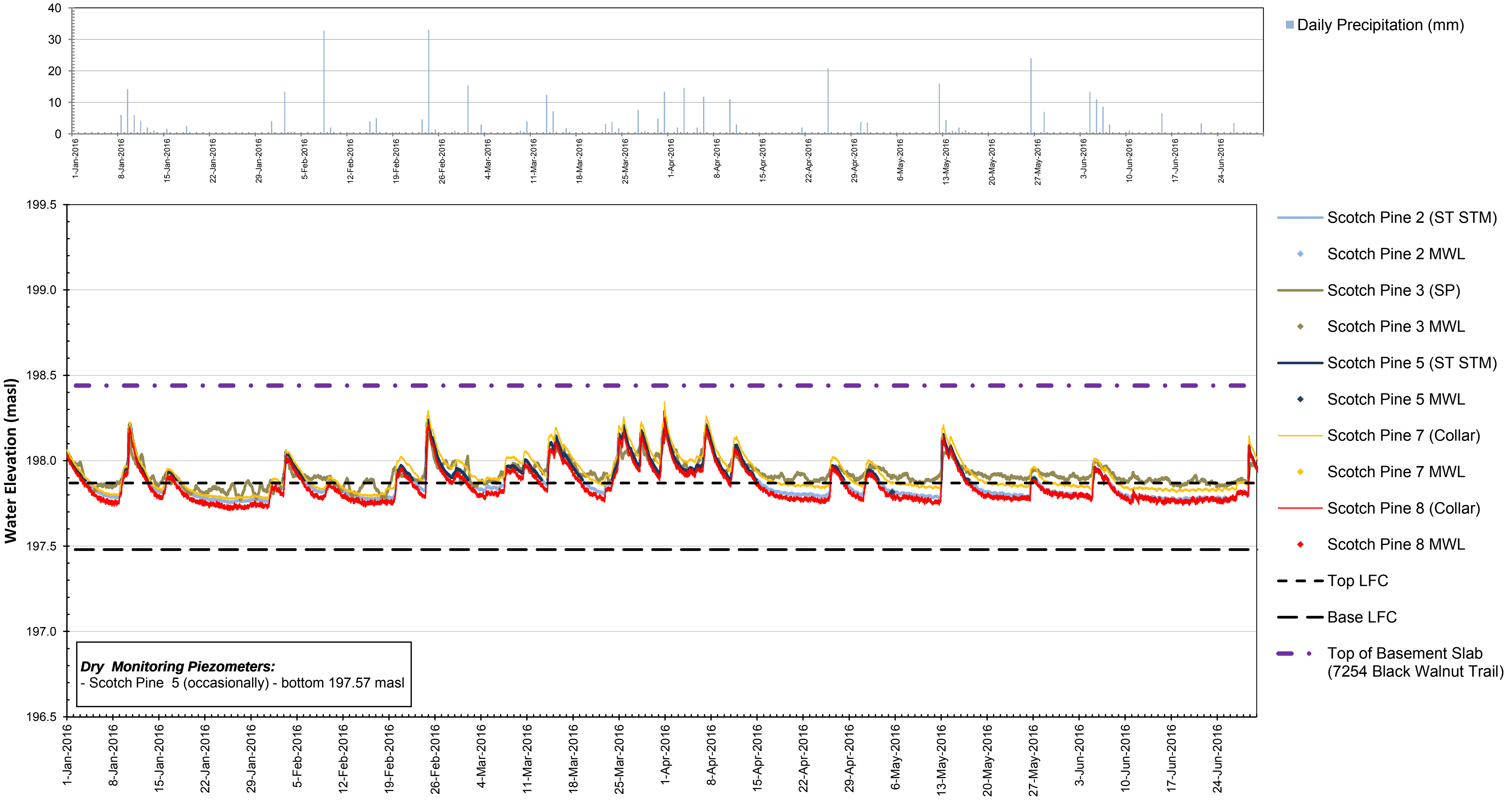
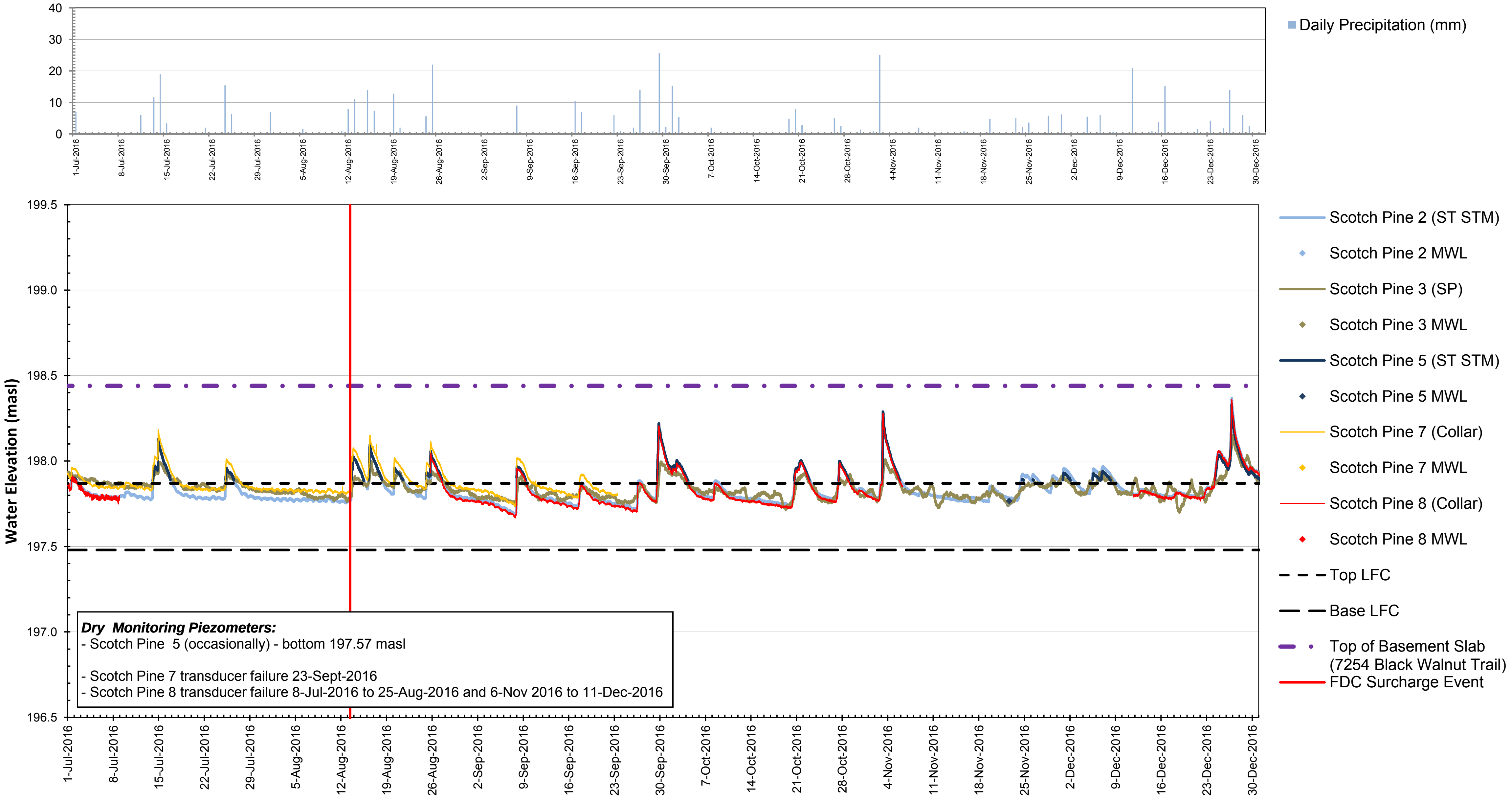
Figure B4a - Hydrograph of Water Levels - Scotch Pine Gate



Dry Monitoring Piezometers:
- Scotch Pine 5 (occasionally) - bottom 197.57 masl

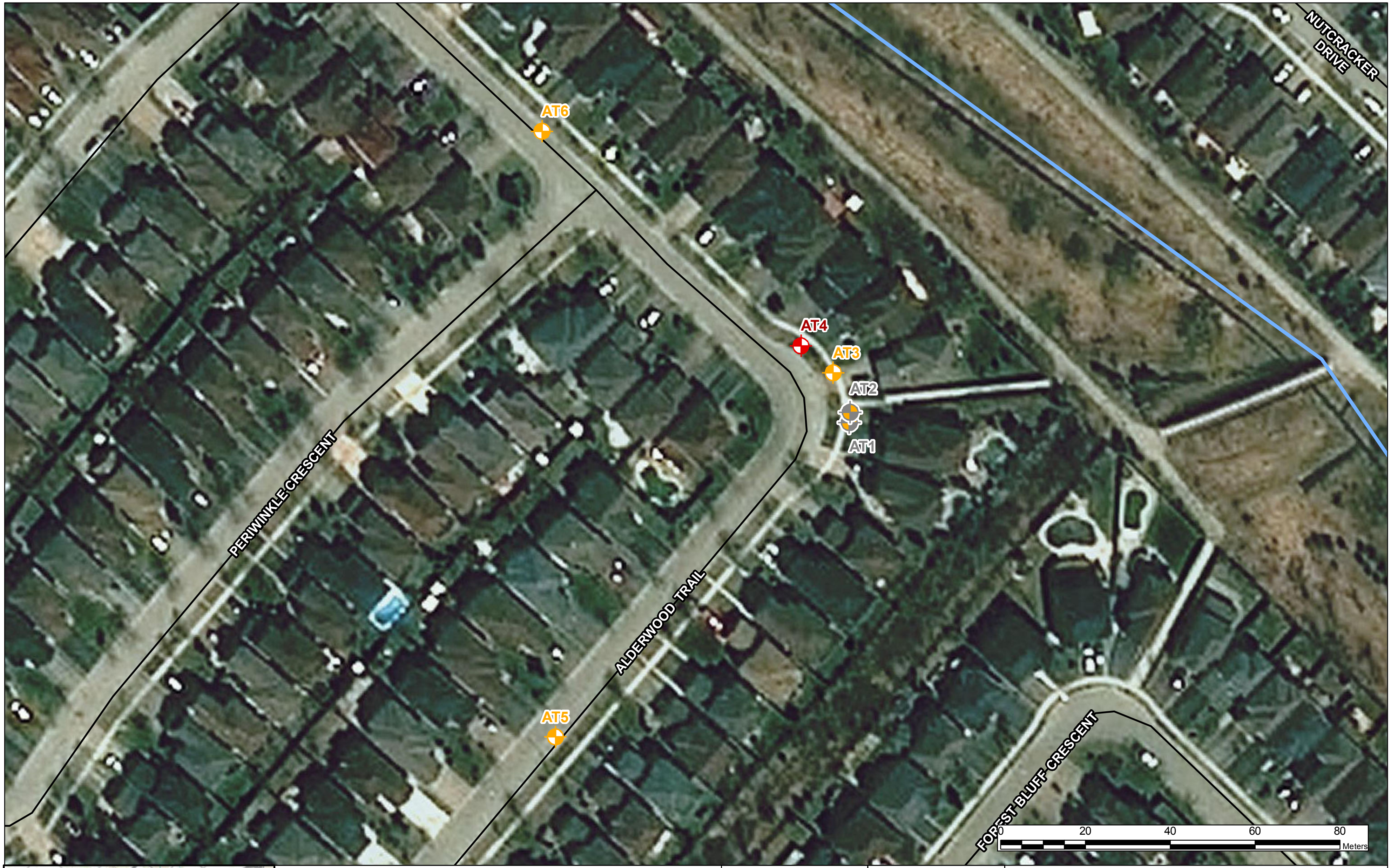
Figure B4b - Hydrograph of Water Levels - Scotch Pine Gate

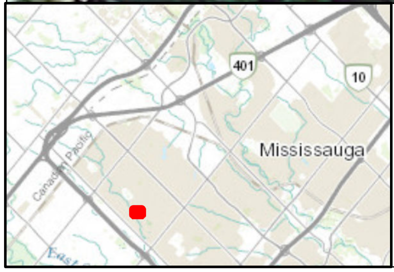


Dry Monitoring Piezometers:

- Scotch Pine 5 (occasionally) - bottom 197.57 masl

- Scotch Pine 7 transducer failure 23-Sept-2016
- Scotch Pine 8 transducer failure 8-Jul-2016 to 25-Aug-2016 and 6-Nov 2016 to 11-Dec-2016





LEGEND

- Sewer Trench Piezometer
- Sewer Trench Piezometer- no longer being monitored
- Standard Piezometer
- Permanent Watercourse

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; .OHN, 2012

CLIENT:
MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N
SCALE: 1:1,250	

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LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Alderwood Trail- Grounwater Monitoring Locations

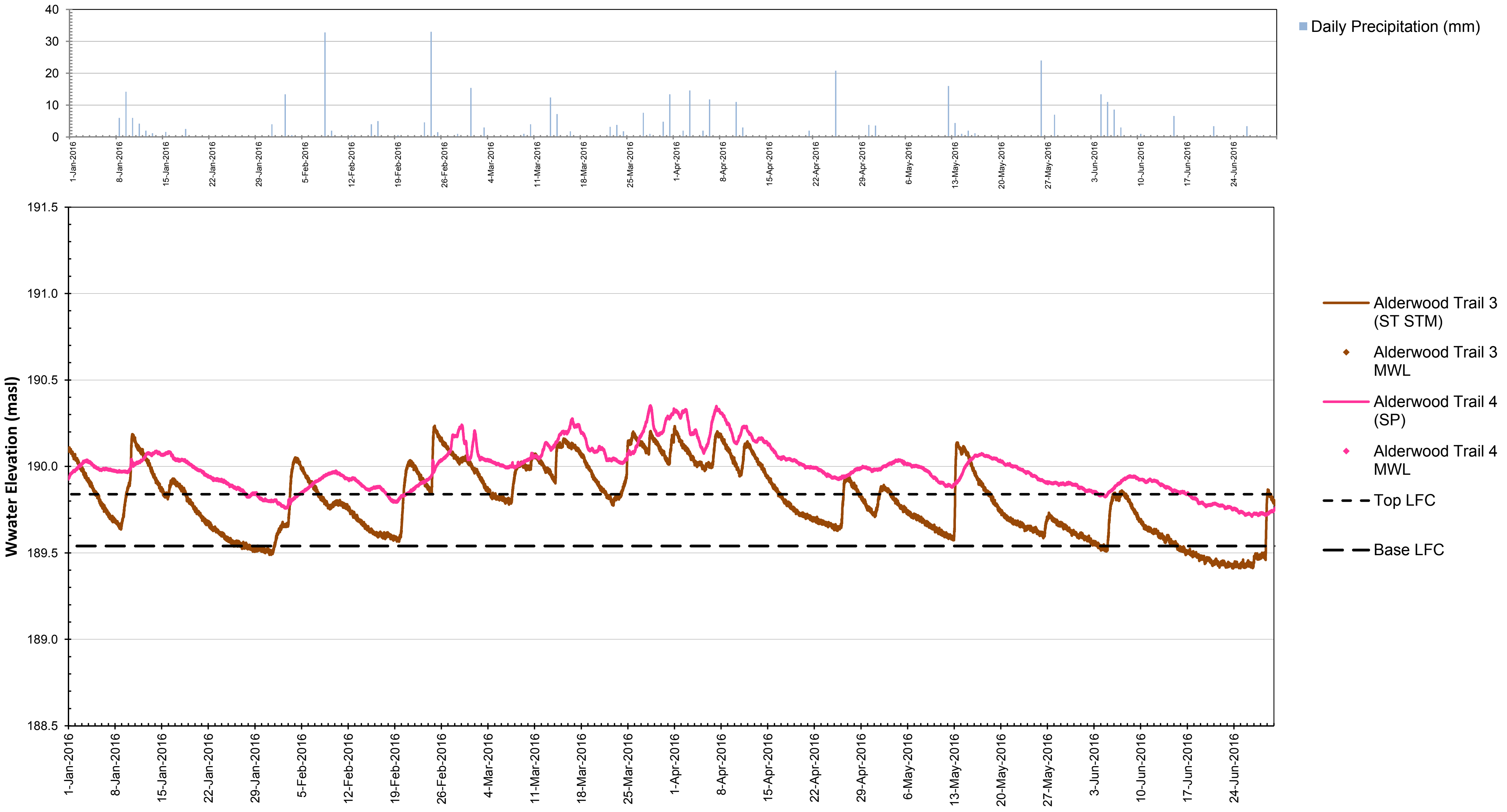
PROJECT N°: TP115060

DATE: July 2017

FIGURE: **B5**

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

Figure B5a - Hydrograph of Water Levels - Alderwood Trail



Amec Foster Wheeler
Environment Infrastructure
TP115060

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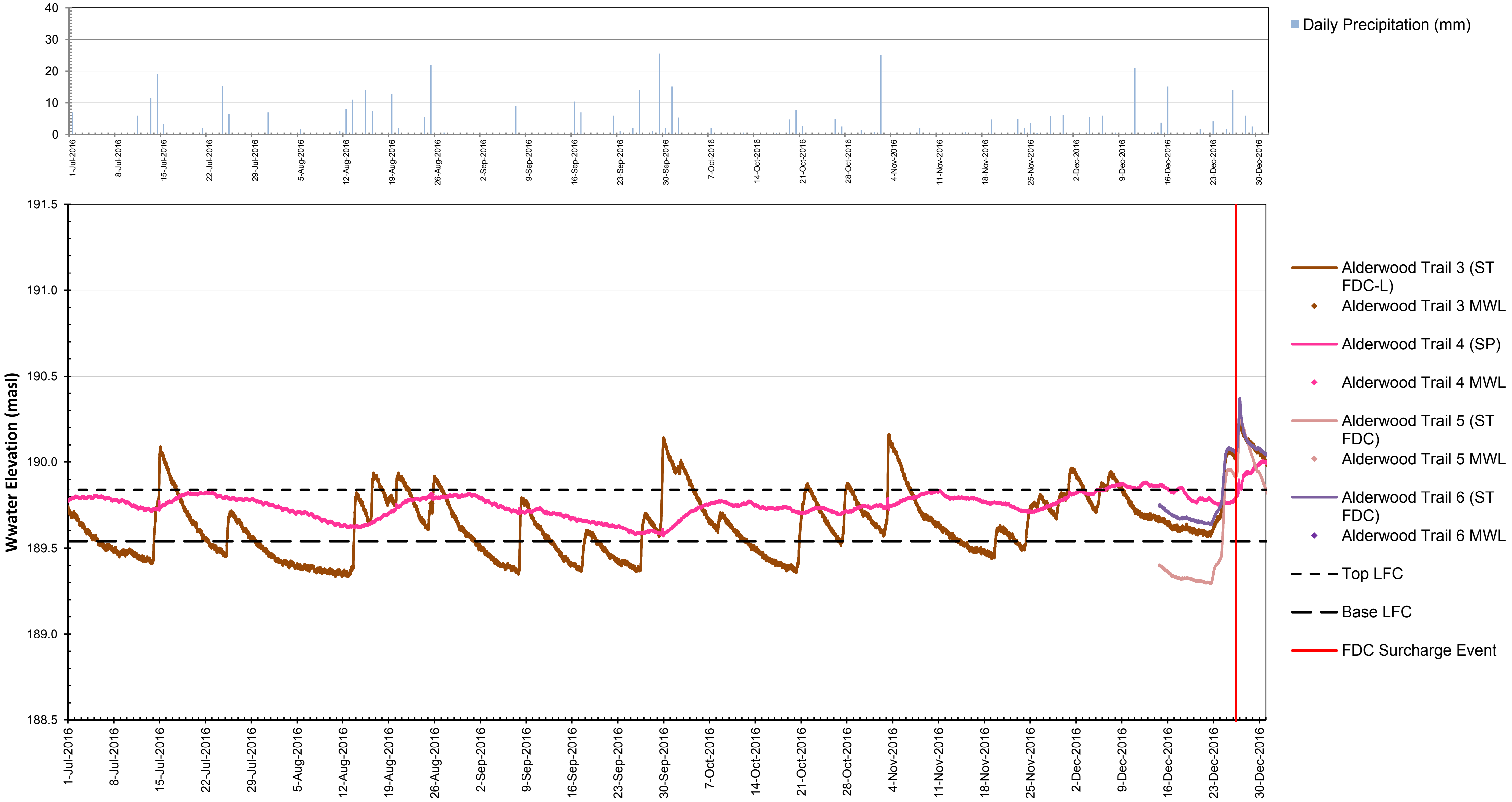
Figure B5b - Hydrograph of Water Levels - Alderwood Trail



Amec Foster Wheeler
Environment Infrastructure
TP115060

P:\01-PROJECTS\TP - Burlington\2015\TP115060 - Mississauga BF Remed-Ph1\05 - Data & Field Work\Phase 1 Water Level\GWL - 2016 (Jul - Dec) (2017-06-20)

LEGEND

Monitoring Wells

⊕ Collar Piezometer

⊕ Sewer Trench Piezometer

▬ Concrete Collar

NOTES:
This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT:
MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N
SCALE: 1:500	

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LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Pondview Way- Groundwater Monitoring Locations

PROJECT N°:	TP115060	FIGURE: B6
DATE:	July 2017	

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

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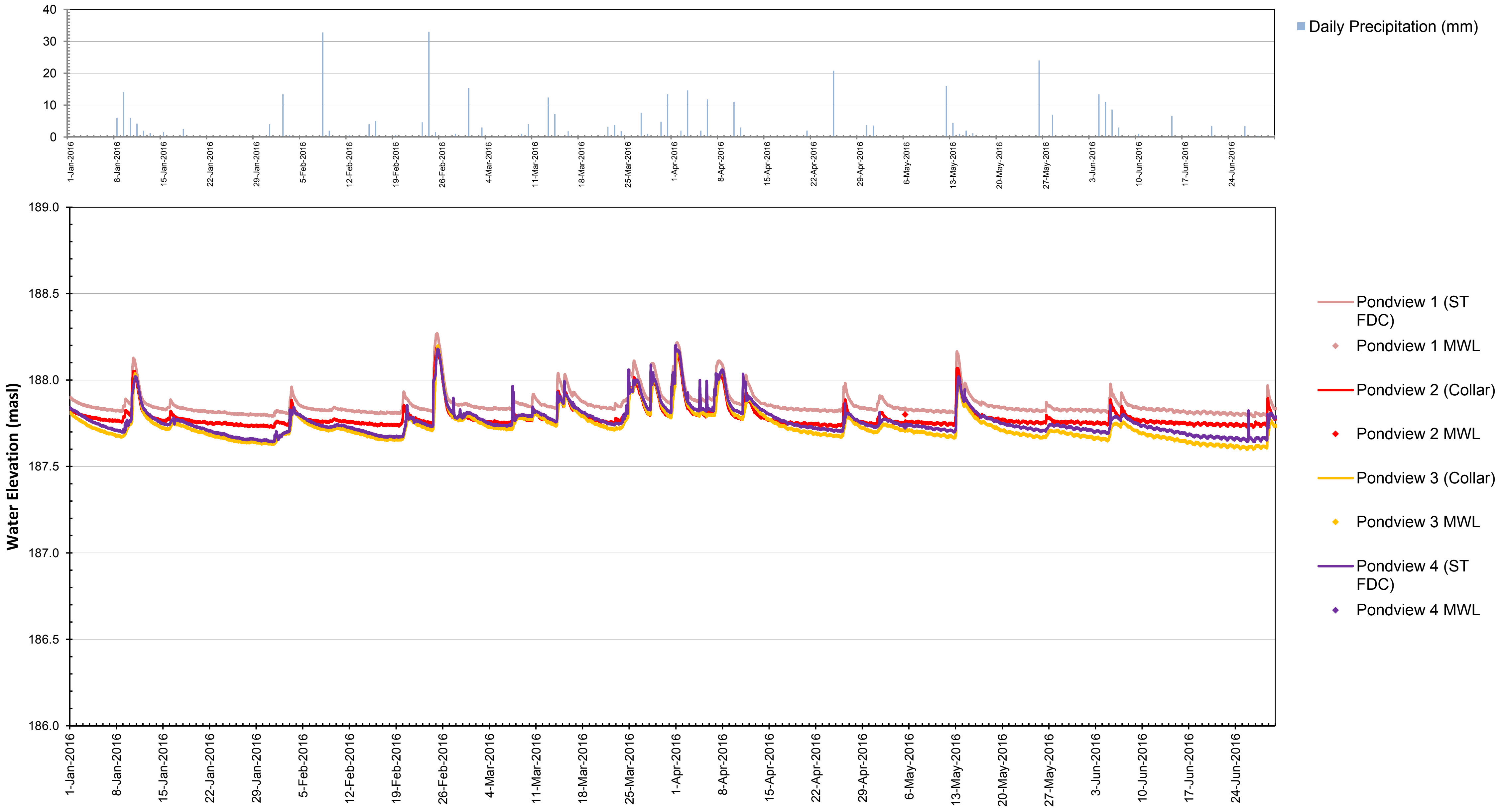
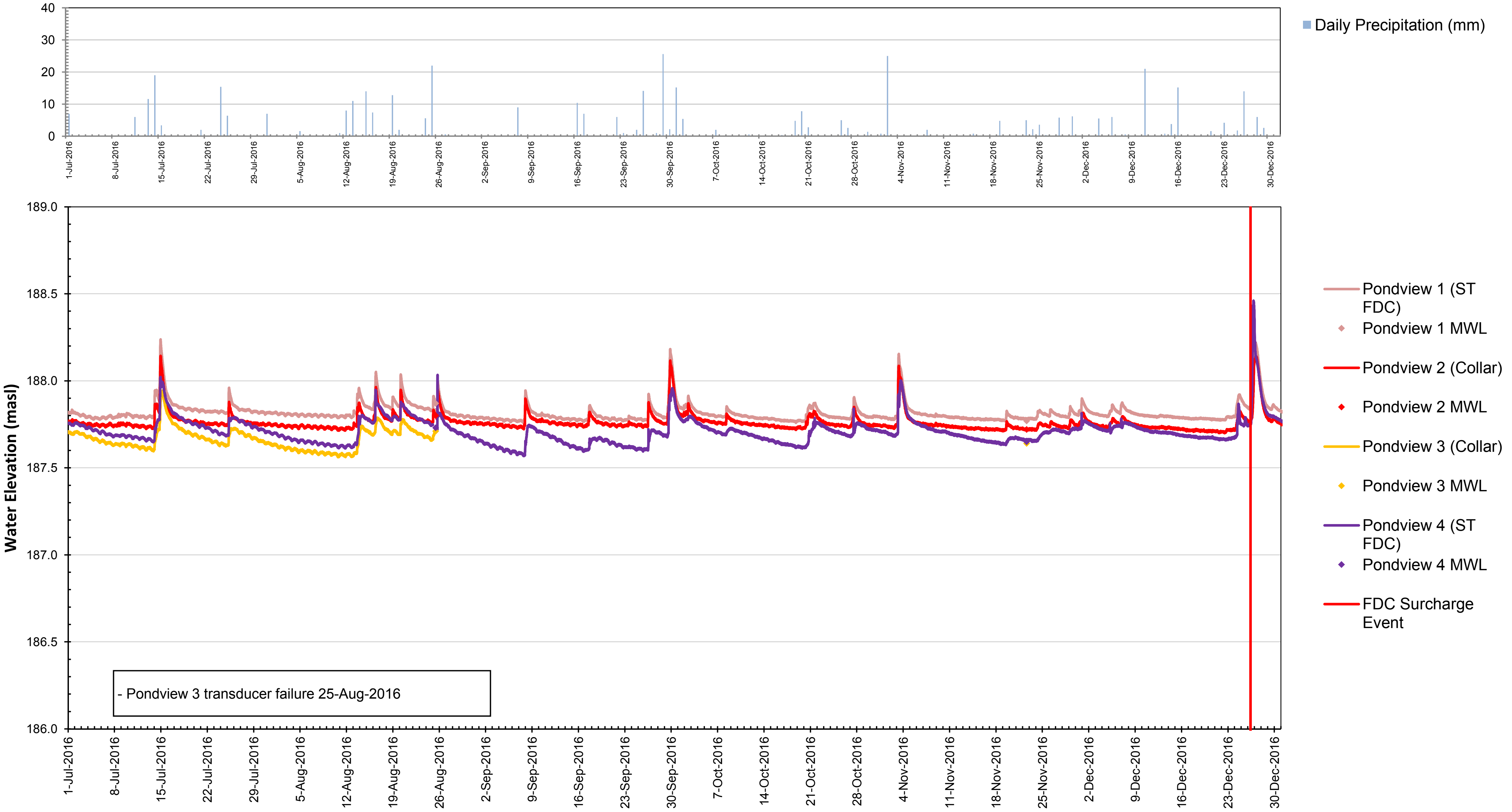
Figure B6a - Hydrograph of Water Levels - Pondview Lane



Amec Foster Wheeler
Environment Infrastructure
TP115060

P:\01-PROJECTS\TP - Burlington\2015\TP115060 - Mississauga BF Remed-Ph1\05 - Data & Field Work\Phase 1 Water Level\GWL - 2016 (Jan - Jun) (2017-06-20)

Figure B6b - Hydrograph of Water Levels - Pondview Lane



- Pondview 3 transducer failure 25-Aug-2016

Amec Foster Wheeler
Environment Infrastructure
TP115060

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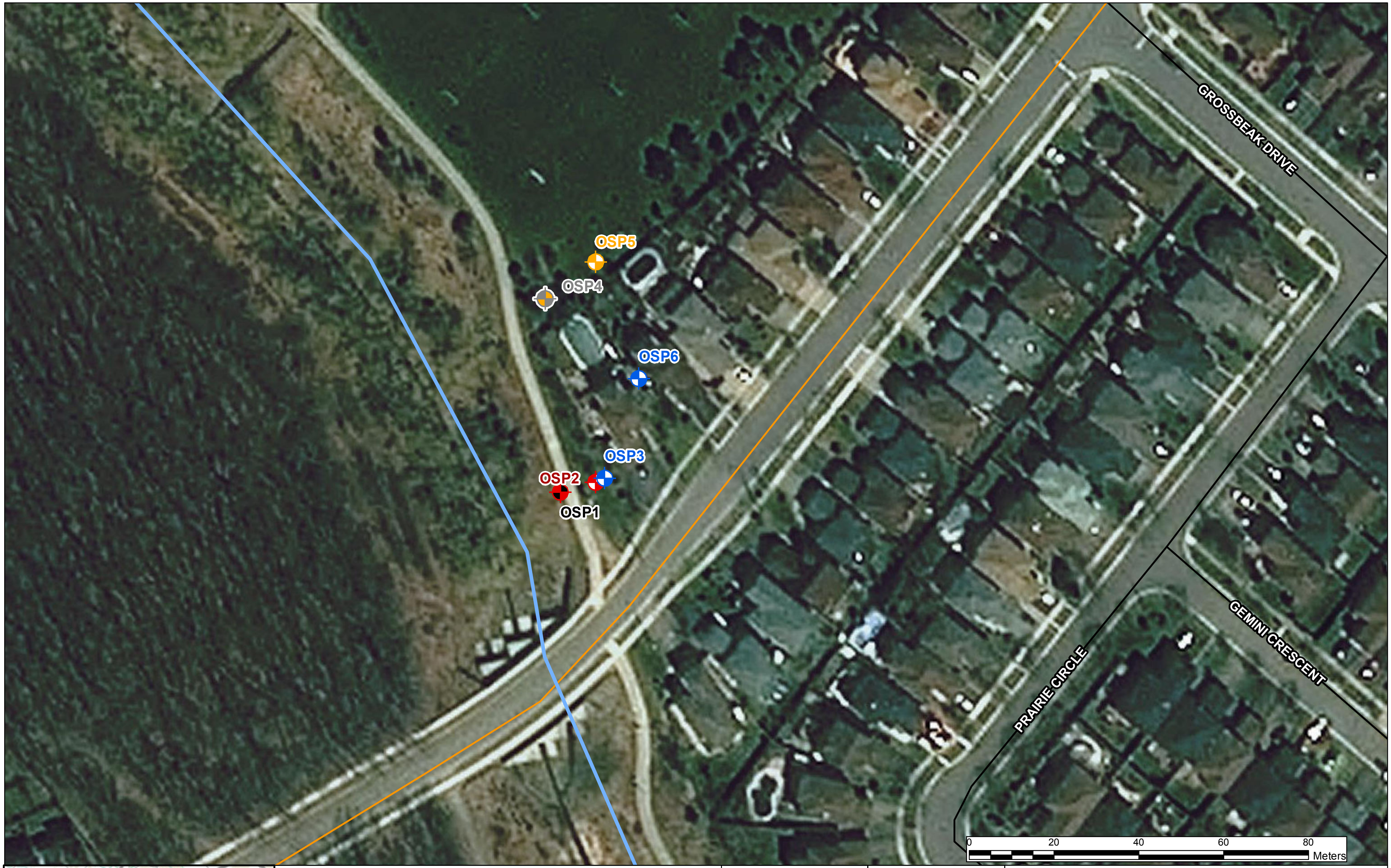
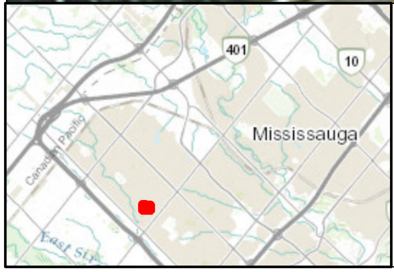




LEGEND

Monitoring Wells

- ⊕ Sewer Trench Piezometer
- ⊕ Sewer Trench Piezometer- no longer being monitored
- ⊕ Shallow Drive Point
- ⊕ Standard Piezometer
- ⊕ Standard Piezometer- Decomissioned
- — Permanent Watercourse

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT: MISSISSAUGA

Drawn By: LJM
Checked By: MS
Revision: A
Projection: UTM Zone 17N
SCALE: 1:1,250

LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

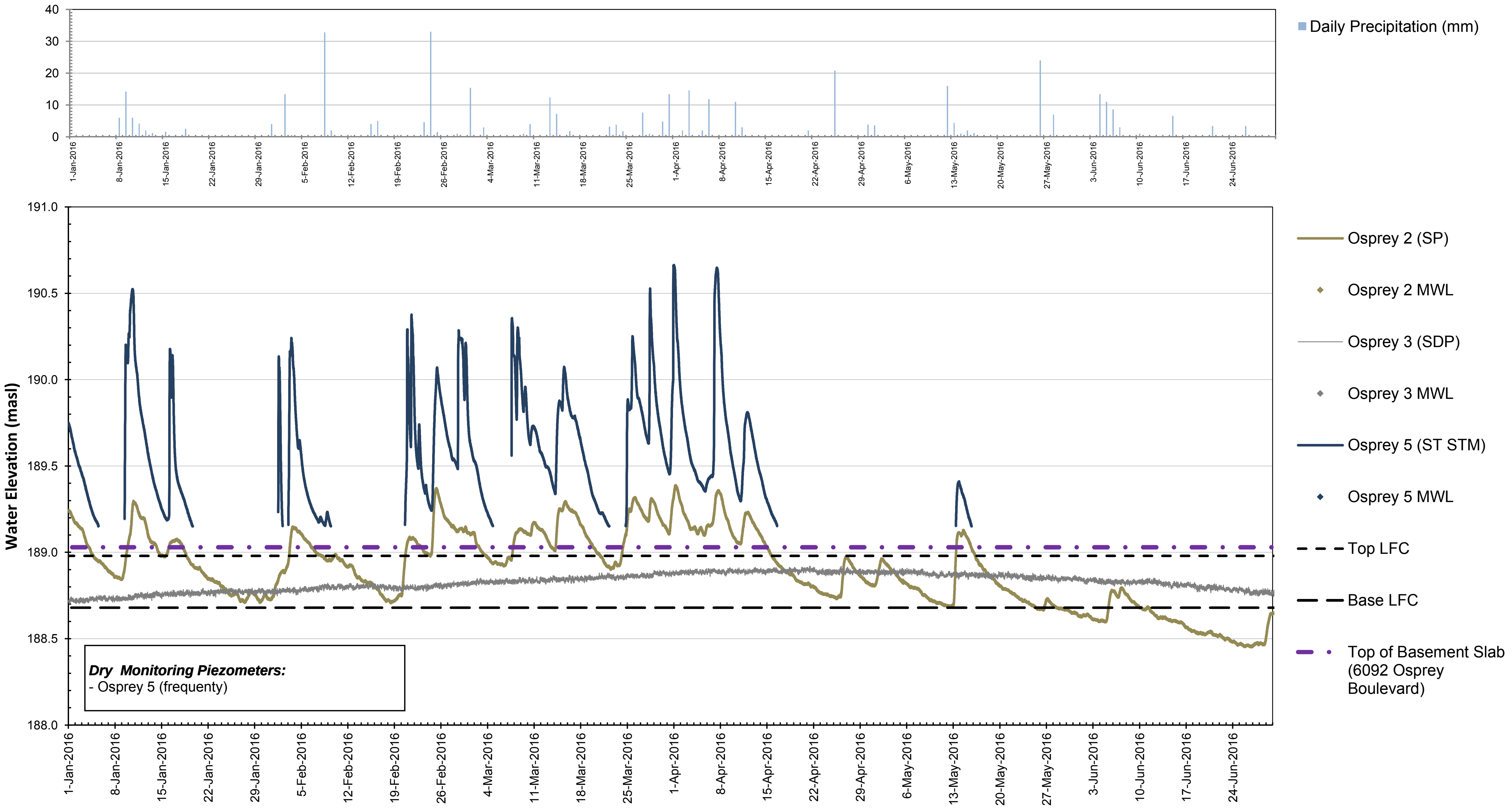
Mississauga, Ontairo

Osprey Boulevard- Monitoring Well Location

PROJECT N°: TP115060
DATE: July, 2017
FIGURE: B7

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

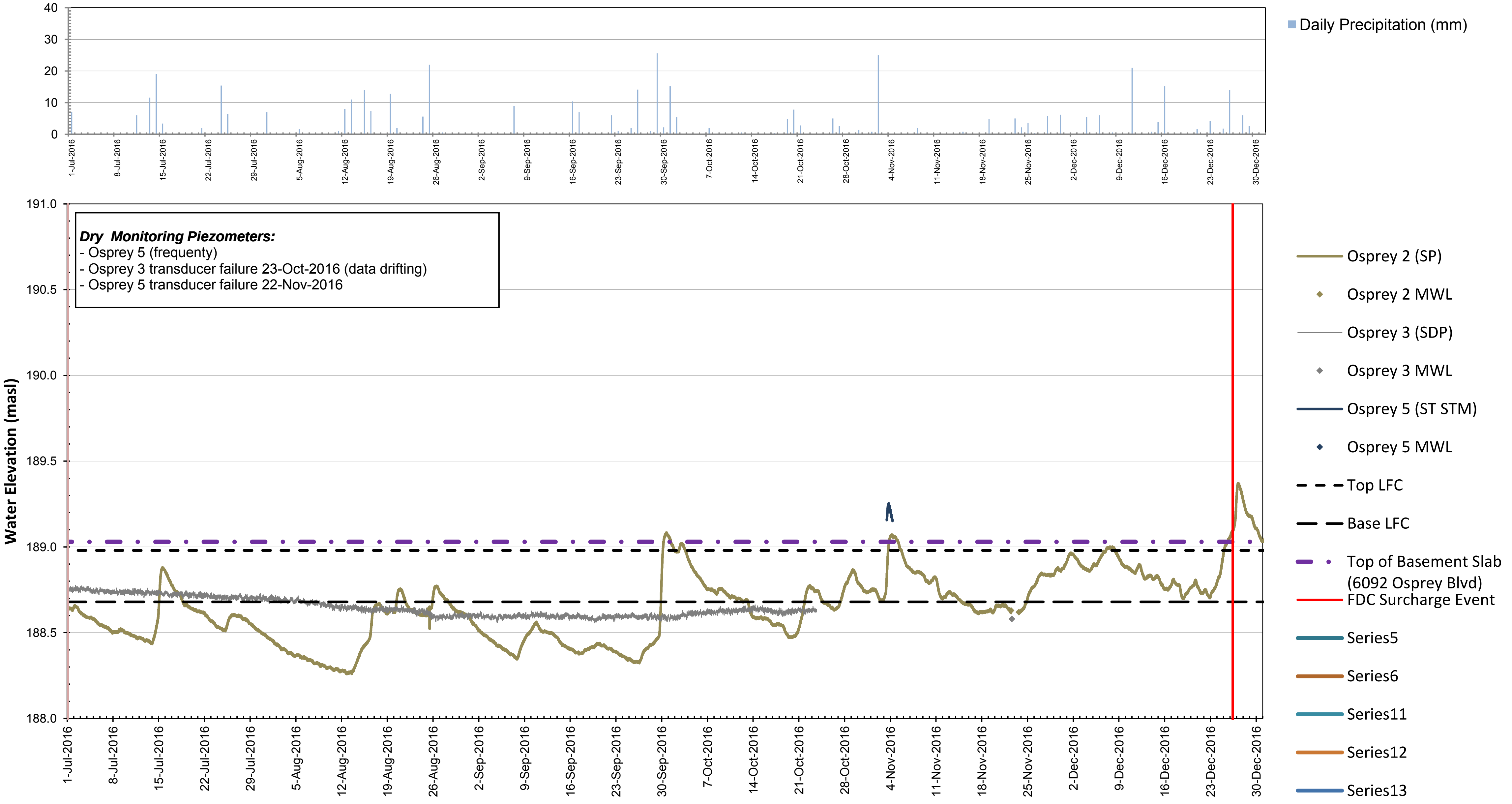
Figure B7a - Hydrograph of Water Levels - Osprey Boulevard



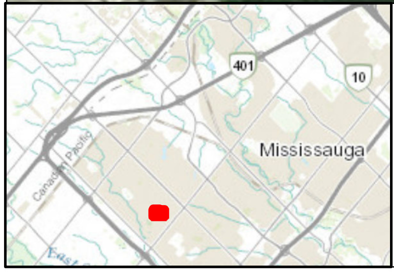
Dry Monitoring Piezometers:
- Osprey 5 (frequenty)

Amec Foster Wheeler
Environment Infrastructure
TP115060

Figure B7b - Hydrograph of Water Levels - Osprey Boulevard



Dry Monitoring Piezometers:
- Osprey 5 (frequenty)
- Osprey 3 transducer failure 23-Oct-2016 (data drifting)
- Osprey 5 transducer failure 22-Nov-2016



LEGEND

Monitoring Wells

⊕ Sewer Trench Piezometer

NOTES:

This drawing should be read in conjunction with the AMEC Foster Wheeler Environment & Infrastructure Report No.TP115060

Conditions encountered in the field may be different from the interpreted information presented on this figure.

SOURCE: Some data presented in this figure is from the Ontario open dataset: ORN, 2012; OHN, 2012

CLIENT:

MISSISSAUGA

Drawn By: LJM	Checked By: MS
Revision: A	Projection: UTM Zone 17N
SCALE: 1:1,783	

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LISGAR BASEMENT WATER INFILTRATION INVESTIGATION

Mississauga, Ontario

Osprey Boulevard, Praire Circle and Waxwing Drive-
Groundwater Monitoring Locations

PROJECT N°: TP115060

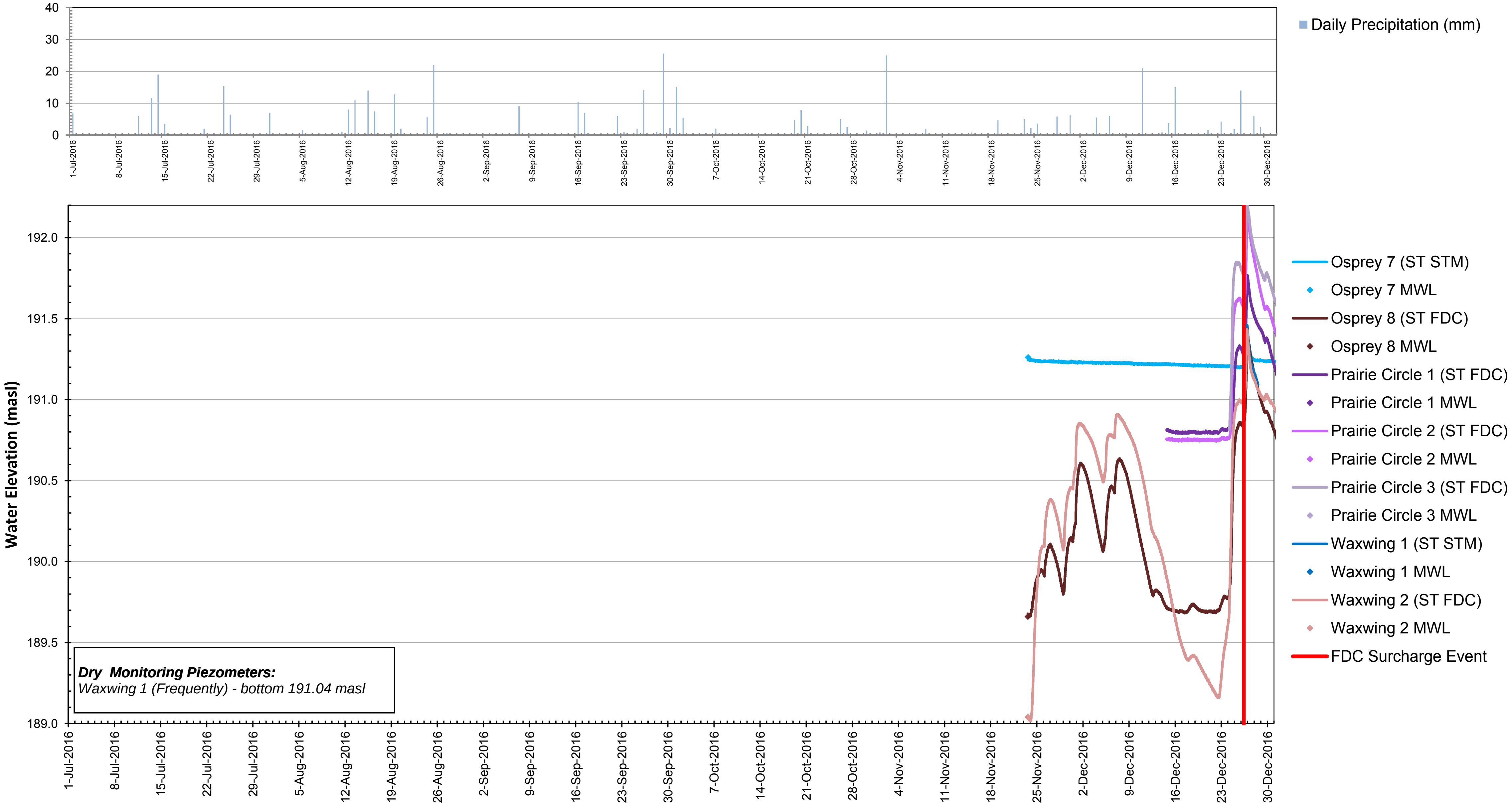
DATE: July 2017

FIGURE: **B8**

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100, Burlington, Ontario, L7N 3W5
tel: 905 335 2353 www.amecfw.com

amec foster wheeler

Figure B8a - Hydrograph of Water Levels - Osprey Boulevard, Prairie Circle & Waxwing Drive



Dry Monitoring Piezometers:
Waxwing 1 (Frequently) - bottom 191.04 masl

Amec Foster Wheeler
Environment Infrastructure
TP115060

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Appendix C

Groundwater Monitoring Piezometer Details

Table 1 Summary of Piezometers Lisgar District

Site	Piezometer Name	Piezometer Type(1)	Surface Elevation (masl)	Screen Interval (mbgs)	Material Monitored	K(2),(3) (m/s)	Period Monitored	Decommission Date	Notes
Lisgar GO Station	GO1	SDP	207.10	1.6-1.8	Silty clay (fill)	-	6/15/12 - 5/14/13	5/23/13	GO sanitary sewer trench
	GO2	SDP	206.20	1.6-1.8	Silty clay (fill)	-	6/15/12 - 5/14/13	5/23/13	GO storm sewer trench
Black Walnut Trail	BW1	Standard	205.39	3.9 - 5.4	Silty clay	-	12/23/11 - 5/22/13	5/23/13	Background, near GO Station
Cactus Gate	CG1	Standard	202.19	3.9 - 5.4	Silty sand	-	12/23/11 - 5/22/13	5/23/13	Background near 16 Mile Creek
Scotch Pine Gate	SP1	Standard	199.43	2.5 - 3.9	Silt & clayey silt	*8.4E-09*	12/23/11 - 5/22/13	5/23/13	Close to 16 Mile Creek
	SP2	Sewer Trench	199.33	0.6 - 2.1	Silty clay (fill)	1.1E-06	12/23/11 - present	-	Storm sewer trench
	SP3	Standard	199.99	2.7 - 4.2	Silty to coarse sand	6.5E-07	12/23/11 - present	-	Close to 7244 Black Walnut Trail
	SP4	SDP	200.00	1.8 - 2.0	Clayey silt	*1.2E-08*	3/02/12 - 11/21/13	-	Close to 7244 Black Walnut Trail - dry
	SP5	Sewer Trench	199.57	0.8 - 2.0	Silty clay (fill)	3.5E-05	5/31/12 - present	-	Storm sewer - dry at record start
	SP6	SDP	200.02	1.5 - 1.7	Fill	-	8/16/12 - 5/22/13	5/23/13	Close to 7254 Black Walnut Trail - dry
	SP7	Collar	199.56	2.9 - 3.1	Gravel sewer bedding	-	11/11/14 - present	-	Storm sewer trench
	SP8	Collar	199.61	2.9 -3.1	Gravel sewer bedding	-	11/11/14 - present	-	Storm sewer trench
Osprey Boulevard	OSP1	Standard	189.63	3.7 - 5.2	Silty clay	-	12/23/11 - 5/22/13	5/23/13	Close to 16 Mile Creek
	OSP2	Standard	190.00	3.7 - 5.2	Silty clay	-	12/23/11 - present	-	Close to 6088 Osprey Blvd
	OSP3	SDP	190.20	2 - 2.2	Silty clay	-	3/02/12 - present	-	SDP close to 6088 Osprey Blvd
	OSP4	Sewer Trench	190.37	0.6 - 2.1	Silty clay (fill)	2.1E-07	5/31/12 - 5/28/14	-	Storm sewer trench - mostly dry
	OSP5	Sewer Trench	190.36	0.8 - 2.0	Silty clay (fill)	2.2E-07	5/31/12 - present	-	Storm sewer trench - frequently dry
	OSP6	SDP	190.90	2.3-2.5	Fill	-	8/1/12 - 5/28/14	-	SDP between 6088 and 6092 Osprey Blvd
	OSP7	Sewer Trench	193.16	1.2 - 2.1	Silty clay / Gravel (fill)	-	11/23/16 - present	-	Storm sewer trench
	OSP8	Sewer Trench	193.15	2.6 - 3.5	Silty clay / Gravel (fill)	-	11/23/16 - present	-	FDC sewer trench
Alderwood Trail	AT1	Sewer Trench	192.08	1.7 - 2.4	Silty clay / Gravel (fill)	-	5/29/13 - 5/22/14	-	Storm sewer trench
	AT2	Sewer Trench	192.00	2.0 - 2.7	Silty clay / Gravel (fill)	-	5/29/13 - 9/30/13	-	FDC sewer trench
	AT3	Sewer Trench	192.06	2.1 - 2.9	Silty clay / Gravel (fill)	-	5/29/13 - present	-	FDC sewer lateral trench
	AT4	Standard(4)	192.14	2.0 - 3.5	Silty clay	-	5/29/13 - present	-	Background
	AT5	Sewer Trench	192.38	1.4 - 2.9	Silty clay / Gravel (fill)	-	12/14/16 - present	-	FDC sewer trench
	AT6	Sewer Trench	192.36	1.7 - 3.2	Silty clay / Gravel (fill)	-	12/14/16 - present	-	FDC sewer trench
Pondview Way	PV1	Sewer Trench	190.57	2.5- 4.0	Silty clay / Gravel (fill)	1.2E-06	5/28/14 - present	-	FDC sewer trench
	PV2	Collar	190.12	3.7 - 3.9	Gravel sewer bedding	-	11/21/14 - present	-	FDC sewer trench
	PV3	Collar	190.08	3.7 - 3.9	Gravel sewer bedding	-	11/21/14 - present	-	FDC sewer trench
	PV4	Sewer Trench	189.66	1.8 - 3.3	Silty clay / Gravel (fill)	1.3E-04	5/28/14 - present	-	FDC sewer trench
Cactus Gate	A1	Sewer Trench	202.86	1.2 - 2.1	Silty clay / Gravel sewer bedding	-	8/4/15 - 11/22/16	-	Storm sewer trench
	CG2	Sewer Trench	202.52	1.6 - 2.5	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	CG3	Sewer Trench	202.69	3.1 - 4.6	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
	CG4	Standard	202.86	3.9 - 6.9	Sandy Silt / Silty Sand	5.0E-07	11/23/16 - present	-	FDC sewer trench
Golden Locust	GL1	Sewer Trench	203.56	1.7 - 2.6	Silty clay / Gravel sewer bedding	-	8/4/15 - 11/22/16	-	Storm sewer trench
	GL2	Sewer Trench	203.59	2.2 - 3.7	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
Smoke Tree	LB1	Sewer Trench	201.36	1.1 - 2.0	Silty clay / Gravel sewer bedding	-	8/4/15 - 11/22/16	-	Storm sewer trench
	ST1	Sewer Trench	200.94	1.2 - 2.7	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	Storm sewer trench
	ST2	Sewer Trench	200.98	2.8 - 4.3	Silty clay / Gravel sewer bedding	-	8/4/15 - present	-	FDC sewer trench
Prairie Circle	PC1	Sewer Trench	193.59	1.7 - 3.2	Silty clay / Gravel sewer bedding	-	12/14/16 - present	-	FDC sewer trench
	PC2	Sewer Trench	194.00	1.9 - 3.4	Silty clay / Gravel sewer bedding	-	12/14/16 - present	-	FDC sewer trench
	PC3	Sewer Trench	194.01	1.9 - 3.4	Silty clay / Gravel sewer bedding	-	12/14/16 - present	-	FDC sewer trench
Waxwing	WW1	Sewer Trench	193.33	1.4 - 2.3	Silty clay / Gravel sewer bedding	-	11/23/16 - present	-	Storm sewer trench
	WW2	Sewer Trench	193.29	2.9 - 4.4	Silty clay / Gravel sewer bedding	-	11/23/16 - present	-	FDC sewer trench

Notes:
1 SDP = shallow drive point
2 Hydraulic conductivity derived from slug testing - italicized are those piezometers with limited response
3 Arithmetic mean is given for those piezometers with more than one test (SP2, PV1, PV4)
4 AT4 was installed with hydrovac due to proximity of underground services

RECORD OF BOREHOLE No Black Walnut 1

1 OF 1

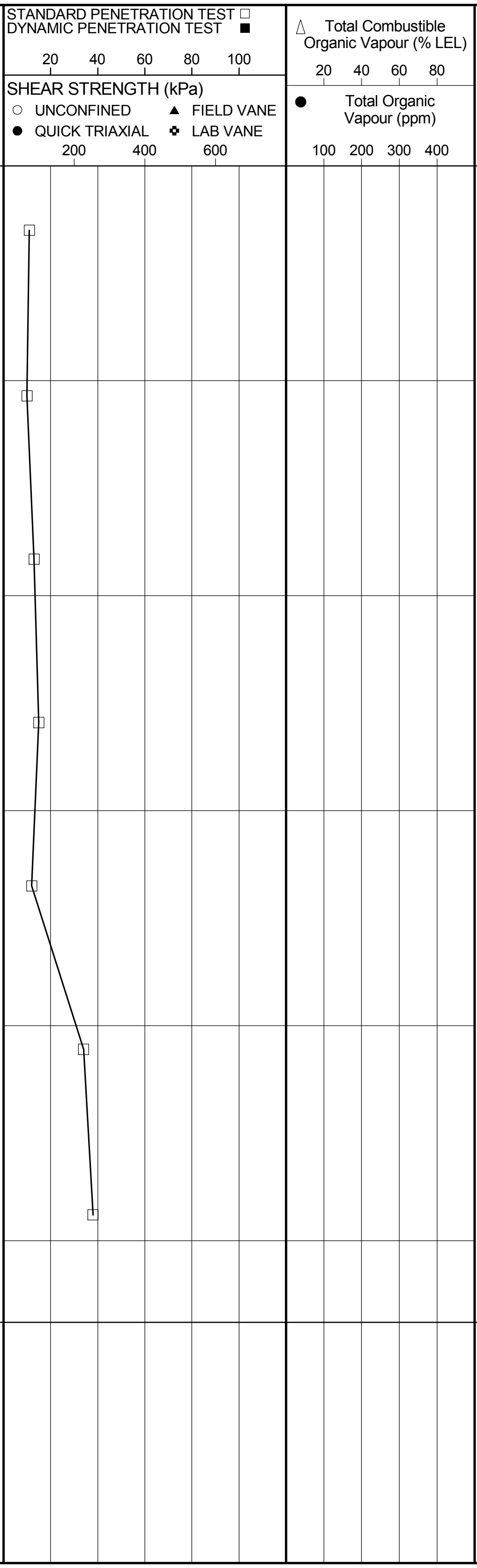
PROJECT Black Walnut Trail Subdivision
CLIENT City of Mississauga
JOB NO. TP111119 DATE 12/22/2012
LOCATION UTM 17T 597745 m E, 4826930 m N
Mississauga, Ontario
EQUIPMENT CME 55, 0.2 m OD Hollow Stem Augers
ORIGINATED BY NS
COMPILED BY NS
CHECKED BY MS

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
205.4 0.0	Asphalt
205.3 0.1	Granular road base.
205.1 0.3	Coarse Sand **Fill** with gravel. Moist.
204.8 0.6	Brown Silty Clay **Fill,** trace sand and gravel. Slightly drier than plastic limit.
203.6 1.8	Small pieces of asphalt.
202.4 3.0	Brown **Silty Clay,** trace sand and gravel. About plastic limit to slightly wetter than plastic limit.
200.7 4.7	Becoming slightly drier than plastic limit.
200.0 5.4	Borehole terminated. No water in borehole upon start of well installation.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	11
2	SS	10
3	SS	13
4	SS	15
5	SS	12
6	SS	34
7	SS	38



OBSERVATIONS & REMARKS

Well Details:
50 mm ID Sch. 40 PVC above 1.52 m long 10-slot screen (3.86-5.38 m). Bentonite plug (0.46-3.56 m) above No. 2 Sand (3.56-5.38 m). Flush mounted casing, top of well casing 0.05 m below ground surface.

Water level in well measured on 1/11/2012.

amec

RECORD OF BOREHOLE No Cactus Gate 1

1 OF 1

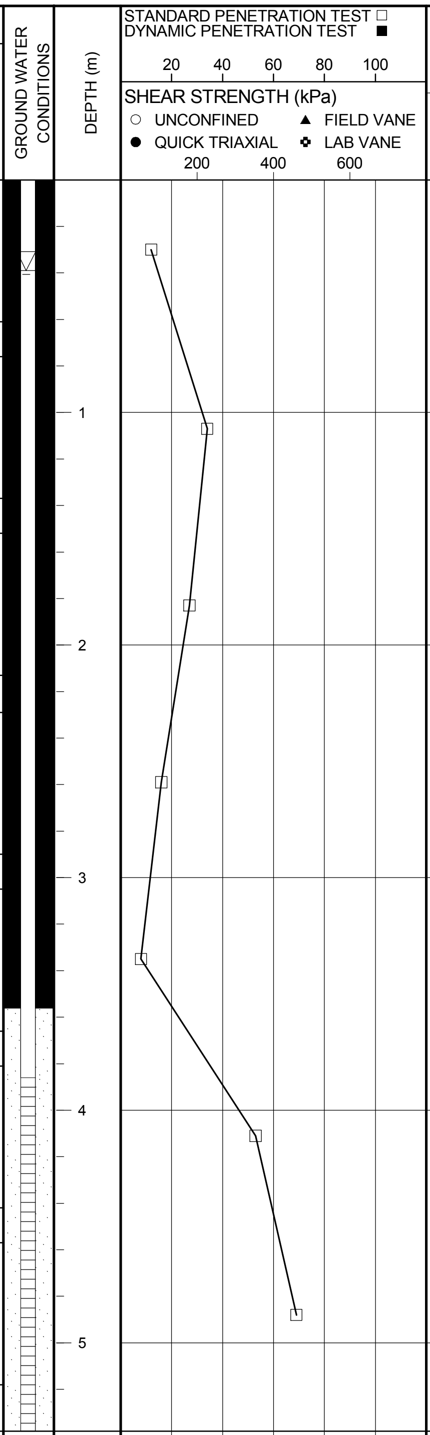
PROJECT Black Walnut Trail Subdivision
LOCATION UTM 17T 591674 m E, 4826570 m N
Mississauga, Ontario
ORIGINATED BY NS
CLIENT City of Mississauga
COMPILED BY NS
JOB NO. TP111119
DATE 12/22/2011
EQUIPMENT CME 55, 0.2 m OD Hollow Stem Augers
CHECKED BY MS

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
202.2 0.0	Dark Brown Clayey Silt **Topsoil,** trace sand, rootlets. Slightly wetter than plasic limit.
202.1 0.1	Brown **Clayey Silt,** trace sand and gravel. Flaky and moist, numerous cracks in sample.
200.7 1.5	Trace cobbles, yellow silt in cracks.
199.2 3.0	Brown **Silty Clay,** trace sand and gravel. Wetter than plastic limit.
198.5 3.7	Brown **Silty Sand,** trace gravel and cobbles. Moist.
196.8 5.4	Borehole terminated. 0.03 m of water in borehole opon start of well installation.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	12
2	SS	34
3	SS	27
4	SS	16
5	SS	8
6	SS	53
7	SS	69



△ Total Combustible Organic Vapour (% LEL) 20 40 60 80

● Total Organic Vapour (ppm) 100 200 300 400

OBSERVATIONS & REMARKS

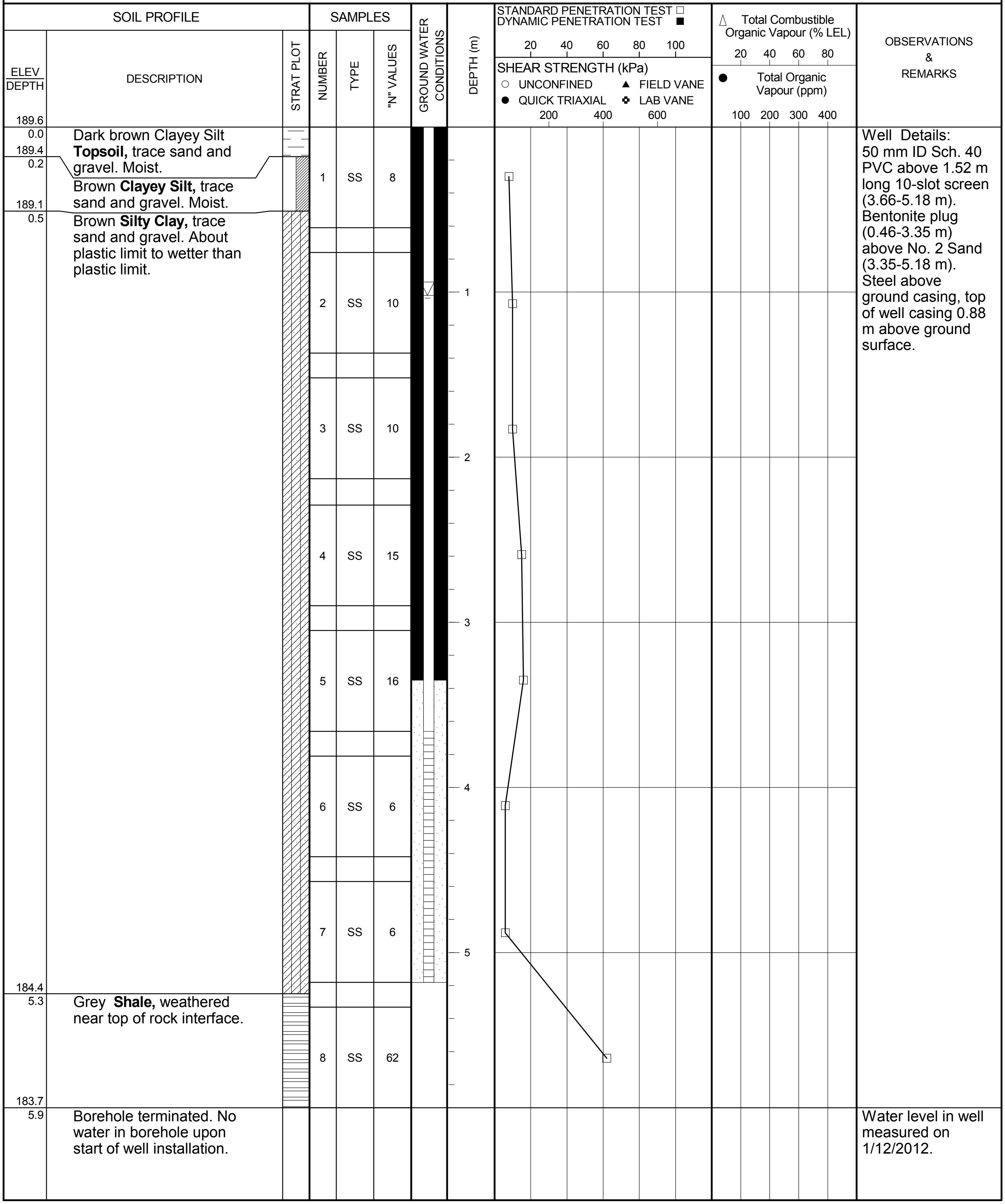
Well Details:
50 mm ID Sch. 40 PVC above 1.52 m long 10-slot screen (3.86-5.38 m). Bentonite plug (0.46-3.56 m) above No. 2 Sand (3.56-5.38 m). Steel above ground casing, top of well casing 0.99 m above ground surface.

Water level in well measured on 1/11/2012.

RECORD OF BOREHOLE No Osprey 1

1 OF 1

PROJECT Black Walnut Trail Subdivision
CLIENT City of Mississauga
JOB NO. TP111119 DATE 12/21/2011
LOCATION UTM 17T 600197 m E, 4824116 m N
Mississauga, Ontario
EQUIPMENT CME 55, 0.2 m OD Hollow Stem Augers
ORIGINATED BY JB
COMPILED BY NS
CHECKED BY MS



ELEV DEPTH	DESCRIPTION
189.6	
0.0	Dark brown Clayey Silt **Topsoil,** trace sand and gravel. Moist.
189.4 0.2	Brown **Clayey Silt,** trace sand and gravel. Moist.
189.1 0.5	Brown **Silty Clay,** trace sand and gravel. About plastic limit to wetter than plastic limit.
184.4 5.3	Grey **Shale,** weathered near top of rock interface.
183.7 5.9	Borehole terminated. No water in borehole upon start of well installation.

NUMBER	TYPE	"N" VALUES
1	SS	8
2	SS	10
3	SS	10
4	SS	15
5	SS	16
6	SS	6
7	SS	6
8	SS	62

OBSERVATIONS & REMARKS

Well Details: 50 mm ID Sch. 40 PVC above 1.52 m long 10-slot screen (3.66-5.18 m). Bentonite plug (0.46-3.35 m) above No. 2 Sand (3.35-5.18 m). Steel above ground casing, top of well casing 0.88 m above ground surface.

Water level in well measured on 1/12/2012.

RECORD OF BOREHOLE No Osprey 2

1 OF 1

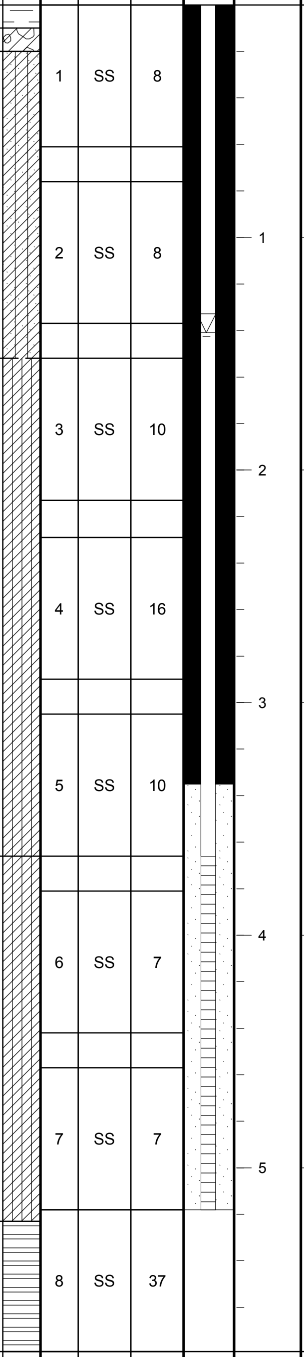
PROJECT Black Walnut Trail Subdivision
CLIENT City of Mississauga
JOB NO. TP111119 DATE 12/21/2011
LOCATION UTM 17T 600204 m E, 4824121 m N
Mississauga, Ontario
EQUIPMENT CME 55, 0.2 m OD Hollow Stem Augers
ORIGINATED BY JB
COMPILED BY NS
CHECKED BY MS

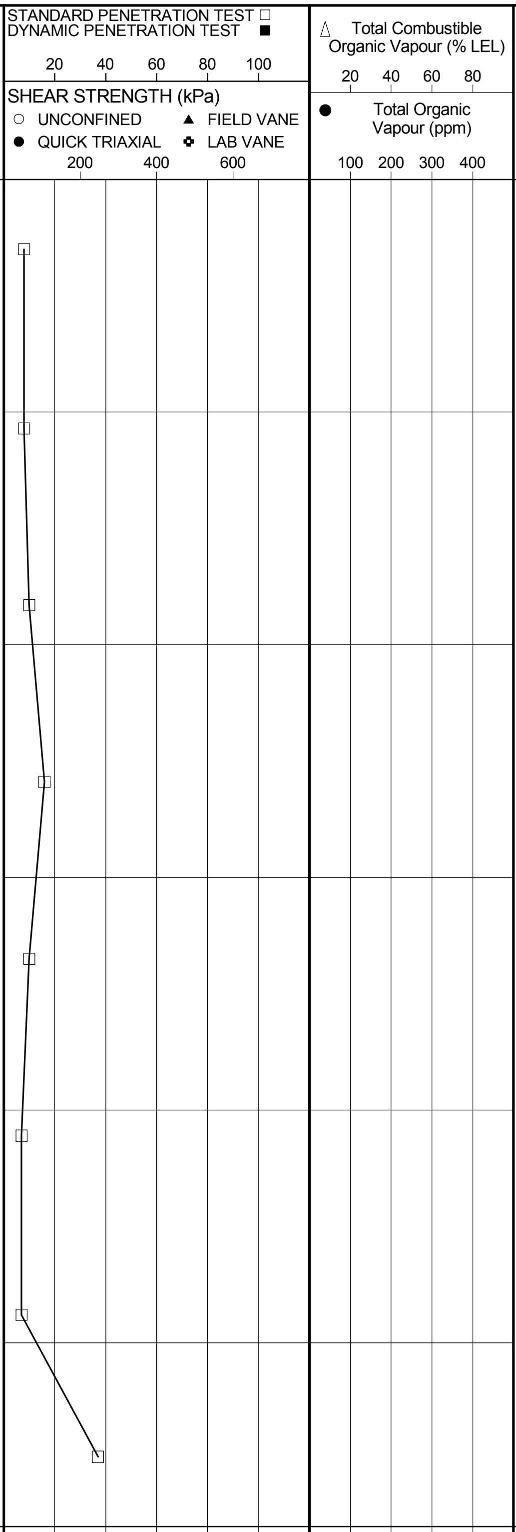
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
190.0	
189.9 0.1	Dark brown Clayey Silt **Topsoil,** trace sand and gravel. Moist.
189.8 0.2	Brown **Clayey Gravel** some sand. Moist.
	Brown **Silty Clay,** trace sand. About plastic limit.
188.5 1.5	Becoming grey and wetter than plastic limit.
186.3 3.7	Grey **Silty Clay,** trace sand and gravel. Wetter than plastic limit.
184.8 5.2	Grey **Shale,** weathered near top of rock interface.
184.2 5.8	Borehole terminated. No water in borehole upon start of well installation.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	8
2	SS	8
3	SS	10
4	SS	16
5	SS	10
6	SS	7
7	SS	7
8	SS	37





OBSERVATIONS & REMARKS

Well Details: 50 mm ID Sch. 40 PVC above 1.52 m long 10-slot screen (3.66-5.18 m). Bentonite plug (0.46-3.35 m) above No. 2 Sand (3.35-5.18 m). Steel above ground casing, top of well casing 0.77 m above ground surface.

Water level in well measured on 1/12/2012.

RECORD OF BOREHOLE No Scotch Pine 1

1 OF 1

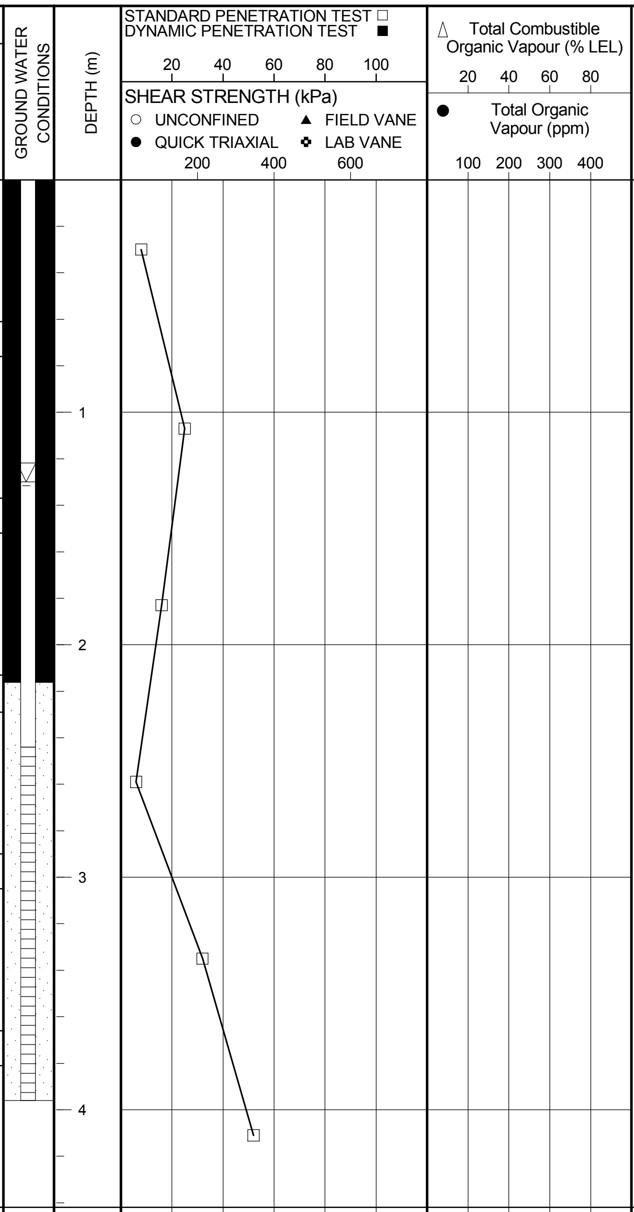
PROJECT Black Walnut Trail Subdivision
CLIENT City of Mississauga
JOB NO. TP111119 DATE 12/20/2011
LOCATION UTM 17T 598107 m E, 4826097 m N
Mississauga, Ontario
EQUIPMENT CME 55, 0.2 m OD Hollow Stem Augers
ORIGINATED BY NS
COMPILED BY NS
CHECKED BY MS

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
199.4	
199.3 0.1	Dark Brown Clayey Silt **Topsoil,** trace sand. About plastic limit.
	Brown Clayey Silt **Fill,** trace sand and gravel. Small pieces of foreign material. Slightly drier than plastic limit to about plastic limit.
198.7 0.7	Brown **Clayey Silt,** trace sand and gravel, cobble present at 1.25 m. Iron staining, drier than plastic limit.
197.9 1.5	Brown **Silty Clay,** trace sand and gravel. Vertical fracture with iron staining present throughout sample. Drier than plastic limit.
197.2 2.2	Grey Brown **Clayey Silt,** some sand, trace gravel. Wetter than plastic limit.
196.4 3.1	Brown **Silt,** some sand, trace gravel. Liminar and moist.
195.7 3.8	Brown **Silty Clay,** trace sand and gravel. Drier than plastic limit.
195.1	
195.0 4.4	Grey **Shale,** weathered near top of rock interface.
	Borehole terminated. No water in borehole upon start of well installation.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	8
2	SS	25
3	SS	16
4	SS	6
5	SS	32
6	SS	52



OBSERVATIONS & REMARKS

Well Details:
50 mm ID Sch. 40 PVC above 1.52 m long 10-slot screen (2.44-3.96 m). Bentonite plug (0.46-2.16 m) above No. 2 Sand (2.16-3.96 m). Steel above ground casing, top of well casing 1.00 m above ground surface.

Water level in well measured on 1/12/2012.

RECORD OF BOREHOLE No Scotch Pine 3

1 OF 1

PROJECT Black Walnut Trail Subdivision

CLIENT City of Mississauga

JOB NO. TP111119 DATE 12/20/2011

LOCATION UTM 17T 598117 m E, 4826103 m N
Mississauga, Ontario

EQUIPMENT CME 55, 0.2 m OD Hollow Stem Augers

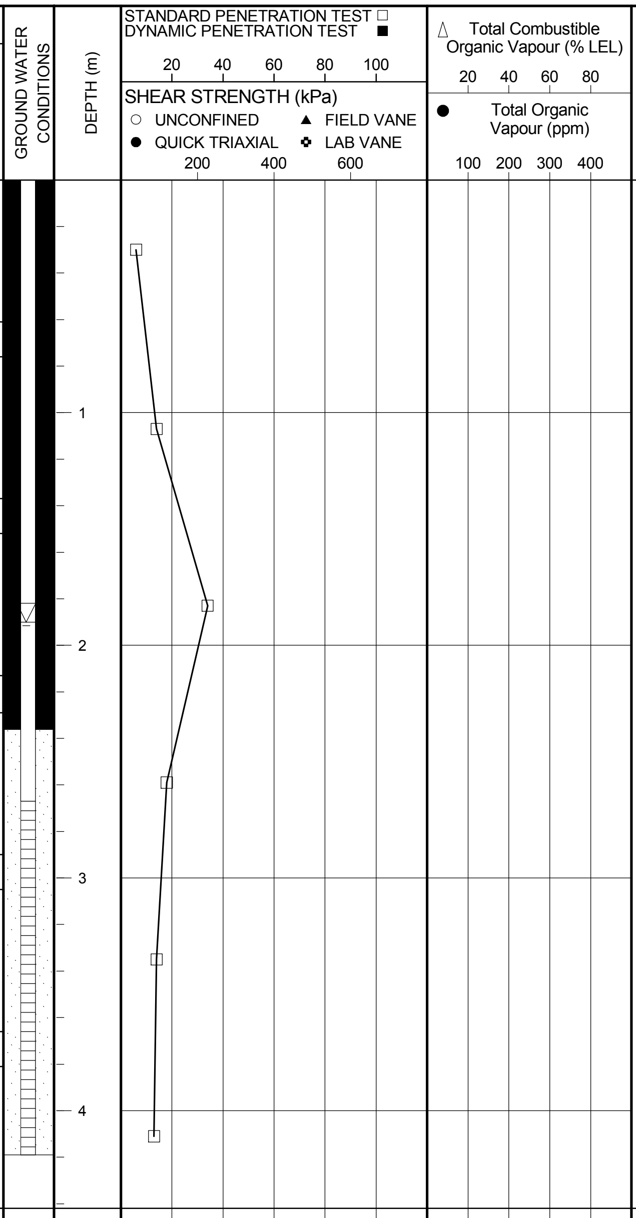
ORIGINATED BY NS
COMPILED BY NS
CHECKED BY MS

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
200.0	
199.9 0.0	Dark Brown Clayey Silt **Topsoil,** trace sand. About plastic limit.
0.1	Brown Clayey Silt**Fill,** trace sand and gravel. About plastic limit over slightly drier than plastic limit.
199.3 0.7	Reddish brown silt lense with iron staining.
198.5 1.5	Brown **Clayey Silt,** trace sand and gravel. Mottled, iron staining. Drier than plastic limit.
197.8 2.2	Grey Brown **Silty Sand,** trace gravel. Moist.
196.9 3.1	Becoming Coarse Sand
196.6 3.4	Becoming Fine Sand
196.3 3.7	Brown **Sandy Silt,** trace gravel. Moist.
195.7 4.3	Grey **Shale,** weathered near top of rock interface.
195.6 4.4	Borehole terminated. No water in borehole upon start of well installation.

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	6
2	SS	14
3	SS	34
4	SS	18
5	SS	14
6	SS	13



OBSERVATIONS & REMARKS

Well Details:
50 mm ID Sch. 40 PVC above 1.52 m long 10-slot screen (2.67-4.19 m). Bentonite plug (0.46-2.36 m) above No. 2 Sand (2.36-4.19 m). Steel above ground casing, top of well casing 0.97 m above ground surface.

Water level in well measured on 1/12/2012.

RECORD OF BOREHOLE No. CG4 (1)

Project Number:	**TP115060.9600**	Drilling Location:	**4826682N; 597714E**	Logged by:	**TR**
Project Client:	**City of Mississauga**	Drilling Method:	**200 mm Hollow Stem Augering**	Compiled by:	**TR**
Project Name:	**Lisgar, 2016 Pilot Utility Trench Dewatering System**	Drilling Machine:	**Truck Mounted Drill**	Reviewed by:	**KG**
Project Location:	**Black Walnut Trail and Cactus Gate**	Date Started:	**18 Aug 16** Date Completed: **18 Aug 16**	Revision No.:	**0, 14/10/16**

LITHOLOGY PROFILE

Geodetic Ground Surface Elevation: 202.9 m

DESCRIPTION	Elevation (m)	Depth (m)
180 mm **Topsoil**	202.8	0.2
Brown Clayey Silt/Silty Clay **FILL** trace gravel and rootlets very stiff DTPL	202.5	0.4
Brown **Clayey Sandy Silt** trace gravel and organics firm DTPL	200.0	3.0
Brown to grey **Sandy Silt** some clay, trace gravel compact moist	197.3	5.6
Greyish brown **Silty Sand** trace clay and gravel very dense moist to wet	195.5	7.5
BOREHOLE TERMINATED		

SOIL SAMPLING / FIELD TESTING / LAB TESTING

FIELD TESTING: PenetrationTesting ○ SPT ☐ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: ★ Rinse pH Values 2 4 6 8 10 12; △ Soil Vapour Reading parts per million (ppm) 100 200 300 400; ▲ Lower Explosive Limit (LEL); W_P W W_L Plastic Liquid 20 40 60 80

Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	W	GR	SA	SI	CL
SS	1	100	19	9				
SS	2	92	22	15				
SS	3	100	23	13				
SS	4	100	30	11				
SS	5	100	24	11				
SS	6	100	18	8	8	29	48	15
SS	7	100	28	9				
SS	8	100	100/28	7				
SS	9	67	51	13				

100
28

DEPTH (m): 1, 2, 3, 4, 5, 6, 7

ELEVATION (m): 202, 201, 200, 199, 198, 197, 196

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%)

AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited
1-505 Woodward Avenue
Hamilton, Ontario
Canada L8H 6N6
Tel (905) 312-0700
Fax (905) 312-0771
www.amec.com

▽ Groundwater depth encountered on completion of drilling: 2.9 m.

▼ Groundwater depth observed on 25/08/2016 at a depth of: 1.3 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 42

Appendix D

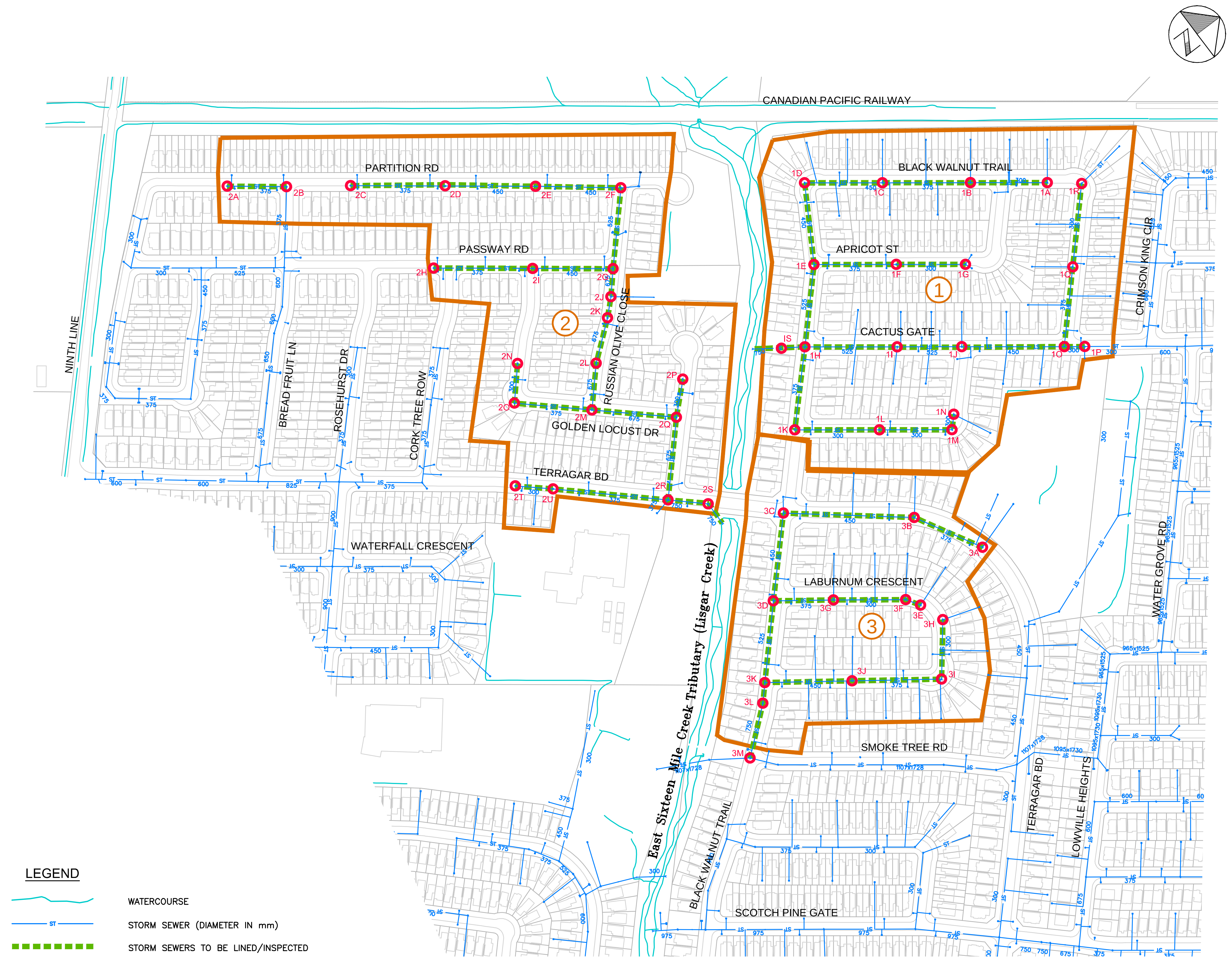
Storm Sewer Lining and Utility Trench Dewatering System Materials

TABLE D1 - LISGAR STORM SEWER LINING PHASE 1 (BLACK WALNUT TRAIL AREA)

LINING AREA	START MH	FINISH MH	STREET	CB Leads (250)	CB Leads (300)	MATERIAL	DIAMETER (mm)	ACTUAL LENGTH (m)	DEPTH U/S (m)	DEPTH D/S (m)	DATE LINING COMPLETED	STRENGTH AND MODULUS TESTING	RECONCILIATION REQUIRED?	WATERTIGHT TESTING
1	MH1A	MH1B	BLACKWALNUT TRAIL	3		PVC	300	82.8	1.5	1.5	09-Jan-17	Y	Y	Y
1	MH1B	MH1C	BLACK WALNUT TRAIL	3		CONC	375	85	1.6	1.7	14-Dec-16	Y	N	
1	MH1C	MH1D	BLACK WALNUT TRAIL	5		CONC	450	94.2	1.7	1.8	16-Feb-17			
1	MH1D	MH1E	BLACK WALNUT TRAIL	2		CONC	450	88.2	1.8	1.8	15-Feb-17			
1	MH1E	MH1H	BLACK WALNUT TRAIL	2		CONC	525	90	1.8	1.9	27-Feb-17			
1	MH1F	MH1E	APRICOT ST	3	1	CONC	375	92.3	1.6	1.8	17-Jan-17			
1	MH1G	MH1F	APRICOT ST	0		PVC	300	71.4	1.7	1.6	11-Jan-17	Y	Y	
1	MH1H	MH1S	PARKETTE @ BLACK WALNUT TR.	0	1	CONC	750	18.3	2.6	2.6	09-Feb-17			
1	MH1I	MH1H	CACTUS GATE	4		CONC	525	86.6	2.0	2.0	13-Feb-17			
1	MH1J	MH1I	CACTUS GATE	6		CONC	525	82.6	2.0	2.0	13-Jan-17			
1	MH1K	MH1H	BLACK WALNUT TRAIL	1		CONC	375	88.8	1.9	2.0	21-Feb-17			
1	MH1L	MH1K	GUMWOOD RD	2		PVC	300	84.5	1.7	1.7	15-Dec-16	Y	Y	
1	MH1M	MH1L	GUMWOOD RD	3		PVC	300	84.5	1.5	1.7	15-Dec-16	Y	Y	
1	MH1N	MH1M	GUMWOOD RD	0		PVC	300	14.3	1.4	1.5	13-Jan-17			
1	MH1O	MH1J	CACTUS GATE	6		CONC	450	108.9	2.0	2.0	01-Feb-17	Y	N	Y
1	MH1P	MH10	CACTUS GATE	1		PVC	300	16.1	1.8	2.1	13-Jan-17	Y	N	
1	MH1Q	MH1O	BLACK WALNUT TRAIL	4		CONC	375	91.7	1.4	1.8	16-Jan-17			Y
1	MH1R	MH1Q	BLACKWALNUT TRAIL	4		PVC	300	86.7	1.6	1.4	24-Feb-17	Y	N	
1	MH1S	OUTFALL	PARKETTE @ BLACK WALNUT TR.	0		CONC	750	31.2	2.6	0.0	09-Feb-17			
2	MH2A	MH2B	PARTITION RD	4		PVC	375	62.1	2.0	2.1	13-Jan-17			
2	MH2C	MH2D	PARTITION RD	4		PVC	375	101.5	2.0	2.2	18-Jan-17	Y	N	
2	MH2D	MH2E	PARTITION RD	2		PVC	450	97.7	2.2	2.2	08-Feb-17			
2	MH2E	MH2F	PARTITION RD	4		PVC	450	95.9	2.2	2.4	06-Feb-17	Y	N	
2	MH2F	MH2G	RUSSIAN OLIVE CLOSE	0	2	CONC	525	86.5	2.4	2.5	14-Feb-17			
2	MH2G	MH2J	RUSSIAN OLIVE CLOSE	0		CONC	675	21.1	2.5	2.5	19-Jan-17			
2	MH2H	MH2I	PASSWAY RD	7		PVC	375	99.8	2.2	2.4	22-Feb-17	Y	N	Y
2	MH2I	MH2G	PASSWAY RD	4		PVC	450	90.6	2.4	2.5	30-Jan-17	Y	N	
2	MH2J	MH2K	RUSSIAN OLIVE CLOSE	0		CONC	675	22.5	2.5	2.6	19-Jan-17			
2	MH2K	MH2L	RUSSIAN OLIVE CLOSE	2		CONC	675	59.8	2.6	2.6	20-Jan-17			
2	MH2L	MH2M	RUSSIAN OLIVE CLOSE	2		CONC	675	50.4	2.6	2.8	20-Jan-17			
2	MH2M	MH2Q	GOLDEN LOCUST DR	3		CONC	675	92.6	2.8	2.5	21-Feb-17			
2	MH2N	MH2O	GOLDEN LOCUST DR	2		PVC	300	29.5	1.6	1.8	17-Jan-17	Y	N	Y
2	MH2O	MH2M	GOLDEN LOCUST DR	2		PVC	375	82.2	1.8	1.8	24-Feb-17			
2	MH2P	MH2Q	BLACKWOOD MEWS	0	2	PVC	300	39.2	2.1	2.6	01-Feb-17	Y	N	Y
2	MH2Q	MH2R	BLACKWOOD MEWS	2		CONC	675	88.9	2.6	2.8	16-Mar-17			
2	MH2R	MH2S	TERRAGAR BLVD	1		CONC	750	36.8	2.8	2.8	13-Mar-17			
2	MH2S	OUTFALL	TERRAGAR BLVD	0		CONC	750	20.5	2.8	0.0	17-Mar-17	Y	N	
2	MH2T	MH2U	TERRAGAR BLVD	2		PVC	300	40.5	2.6	2.8	17-Feb-17	Y	N	
2	MH2U	MH2R	TERRAGAR BLVD	3		PVC	375	128.5	2.8	2.8	25-Feb-17			
3	MH3A	MH3B	TERRAGAR BLVD	2		CONC	375	55.5	1.8	1.8	23-Feb-17	Y	N	Y
3	MH3B	MH3C	TERRAGAR BLVD	5		CONC	450	122.5	1.8	2.2	31-Jan-17	Y	N	
3	MH3C	MH3D	BLACK WALNUT TRAIL	3		CONC	450	93.2	1.6	1.8	18-Jan-17	Y	Y	
3	MH3D	MH3K	BLACK WALNUT TRAIL	2		CONC	525	88.5	1.8	2.1	09-Jan-17	Y	N	Y
3	MH3E	MH3F	LABURNUM CRES	0		PVC	300	18.3	1.4	1.4	13-Dec-16	Y	Y	
3	MH3F	MH3G	LABURNUM CRES	3		PVC	300	79.5	1.4	1.5	13-Dec-16	Y	Y	Y
3	MH3G	MH3D	LABURNUM CRES	2		CONC	375	56.7	1.5	1.8	22-Feb-17			
3	MH3H	MH3I	LABURNUM CRES	3		PVC	300	61	1.5	1.8	10-Feb-17			
3	MH3I	MH3J	LABURNUM CRES	6		CONC	375	84.3	1.8	1.8	31-Jan-17	Y	N	
3	MH3J	MH3K	LABURNUM CRES	7		CONC	450	100	1.8	2.1	11-Jan-17	Y	N	
3	MH3K	MH3L	BLACK WALNUT TRAIL	0		CONC	750	33.5	2.1	2.1	02-Feb-17			
3	MH3L	MH3M	BLACK WALNUT TRAIL	1	1	CONC	750	52.5	2.1	2.4	03-Feb-17			

REVISIONS

DATE	DETAILS	INIT.



LEGEND

〰	WATERCOURSE
—ST—	STORM SEWER (DIAMETER IN mm)
🟩	STORM SEWERS TO BE LINED/INSPECTED
①	STORM SEWER LINING AREA BOUNDARY AND REFERENCE No.
○ 2A	STORM SEWER MAINTENANCE HOLE AND REFERENCE ID

LISGAR DISTRICT
STORM SEWER LINING
(FA. 49453-16)

amec foster wheeler

MISSISSAUGA

PRODUCED FOR - T&W, ENGINEERING AND WORKS

STORM SEWER LINING OVERVIEW

SCALE AS NOTED	AREA	PROJECT No. TP115060
C.A.D.D. BY J.S.	CHECKED BY M.S.	PLAN No.
DATE JUNE 2016	SHEET 1 OF 11	Figure 1

DATE	DETAILS	INIT.

REVISIONS

LEGEND

- WATERCOURSE
- ST — STORM SEWER SYSTEM
- STORM SEWERS TO BE LINED
- ① STORM SEWER LINING AREA BOUNDARY AND REFERENCE No.
- ○ 6U STORM SEWER MAINTENANCE HOLE AND REFERENCE ID

SCALE VALID ONLY FOR 24"x36" VERSION

LISGAR DISTRICT
STORM SEWER LINING
(PRC000198)

amec foster wheeler

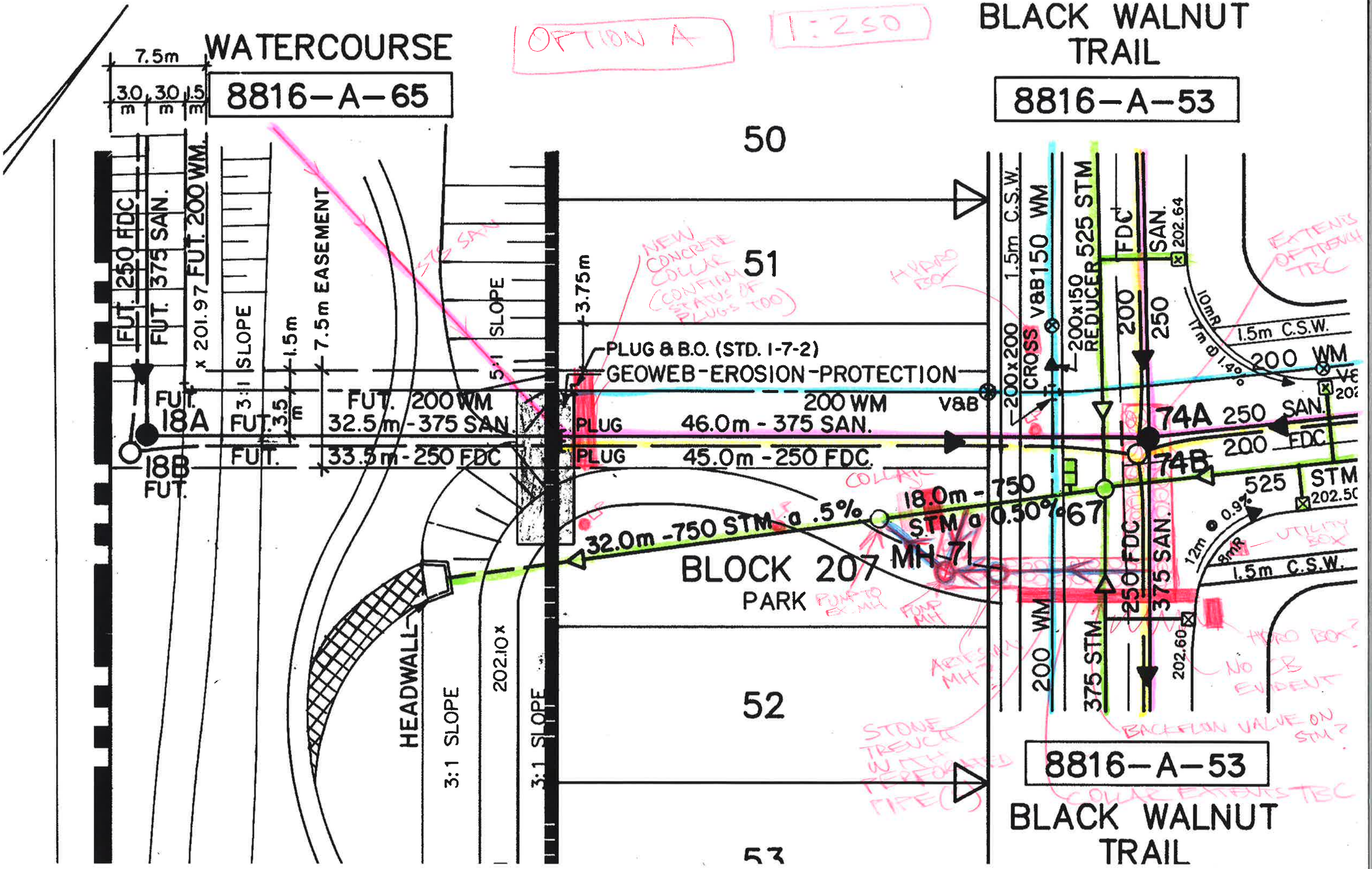
MISSISSAUGA

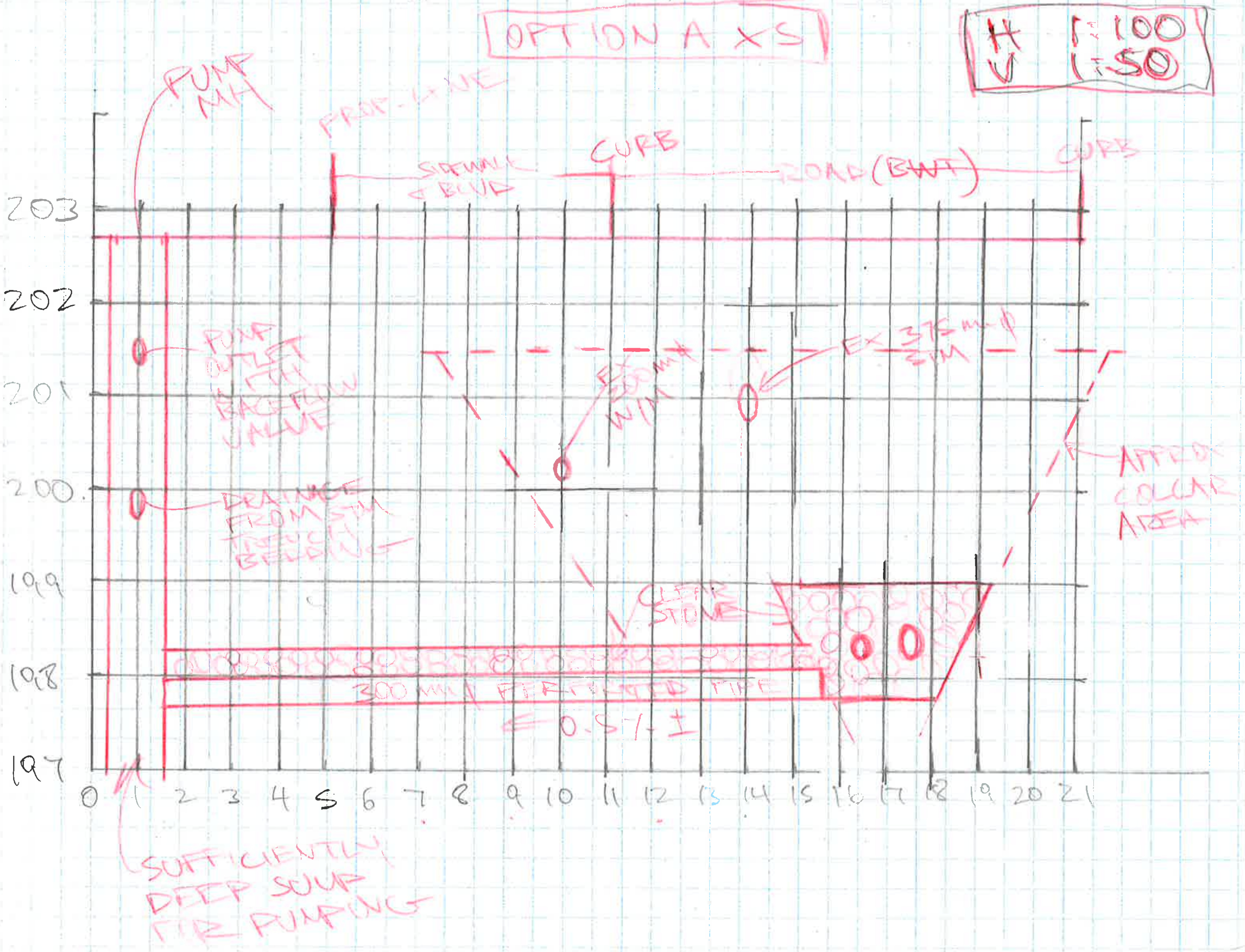
PRODUCED FOR - T&W, ENGINEERING AND WORKS

STORM SEWER LINING OVERVIEW

SCALE 1:2500	AREA	PROJECT No. TPB178055
C.A.D.D. BY R.M.B.	CHECKED BY M.S.	PLAN No. Figure 1
DATE MAY 2017	SHEET 1 OF 9	

Last Saved: 2017-05-10 Last Saved By: richard.bartolo Plotted: 2017-05-11 Plotted By: richard.bartolo Path: P:\2017\Projects\TPB178055 – Lisgar Improvements\06_DES-ENG\01_CAD\02_DWGS\05_WR\01_PROJ\17-04 (2017SS Lining)\Fig1 Overview(2017).dwg


OPTION A
1:250
WATERCOURSE
8816-A-65
7.5m
3.0 m
3.0 m
1.5 m
BLACK WALNUT TRAIL
8816-A-53
50
51
52
53
FUT. 250 FDC
FUT. 375 SAN.
FUT. 200 WM.
x 201.97
3:1 SLOPE
1.5m
7.5m EASEMENT
5:1 SLOPE
3.75m
375 SAN
NEW CONCRETE COLLAR (CONFIRM STATUS OF PLUGS TOO)
HYDRO BOX
PLUG & B.O. (STD. 1-7-2)
GEOWEB-EROSION-PROTECTION
FUT. 18A
18B FUT.
FUT. 3.5 m
FUT. 200 WM
32.5m - 375 SAN.
FUT.
33.5m - 250 FDC
PLUG
PLUG
200 WM
46.0m - 375 SAN.
45.0m - 250 FDC.
V&B
COLLAR
18.0m - 750 STM @ 0.50%
32.0m - 750 STM @ .5%
MH 71
67
BLOCK 207
PARK
PUMP TO EX. MH
PUMP MH
ARTESIAN MH
HEADWALL
3:1 SLOPE
202.10x
3:1 SLOPE
1.5m C.S.W.
V&B 150 WM
200x200 CROSS
200x150 REDUCER
525 STM
FDC
200
250
SAN.
202.64
EXTENDS OF TRENCH TBC
10mR
17m @ 1.4%
1.5m C.S.W.
200 WM
V&
202
74A
250 SAN.
74B
200 FDC
525
STM
202.50
12m @ 0.9%
8mR
UTILITY BOX
1.5m C.S.W.
200 WM
375 STM
250 FDC
375 SAN.
202.60
HYDRO BOX?
NO CB EVIDENT
BACKFLOW VALVE ON STM?
STONE TRENCH WITH PERFORATED PIPE(?)
COLLAR EXTENTS TBC


OPTION A XS
H 1:100
V 1:50
PUMP MH
PROP. LINE
SIDEWALK & BLVD
CURB
ROAD (BWT)
CURB
203
202
201
200
199
198
197
PUMP OUTLET C/W BACKFLOW VALVE
EX 375mm Ø STM
EX 200mm WM
APPROX COLLAR AREA
DRAINAGE FROM STM TRENCH BEDDING
CLEAR STONE
300 mm PERFORATED PIPE
← 0.5% ±
0
1
2
3
4
5
6
7
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16
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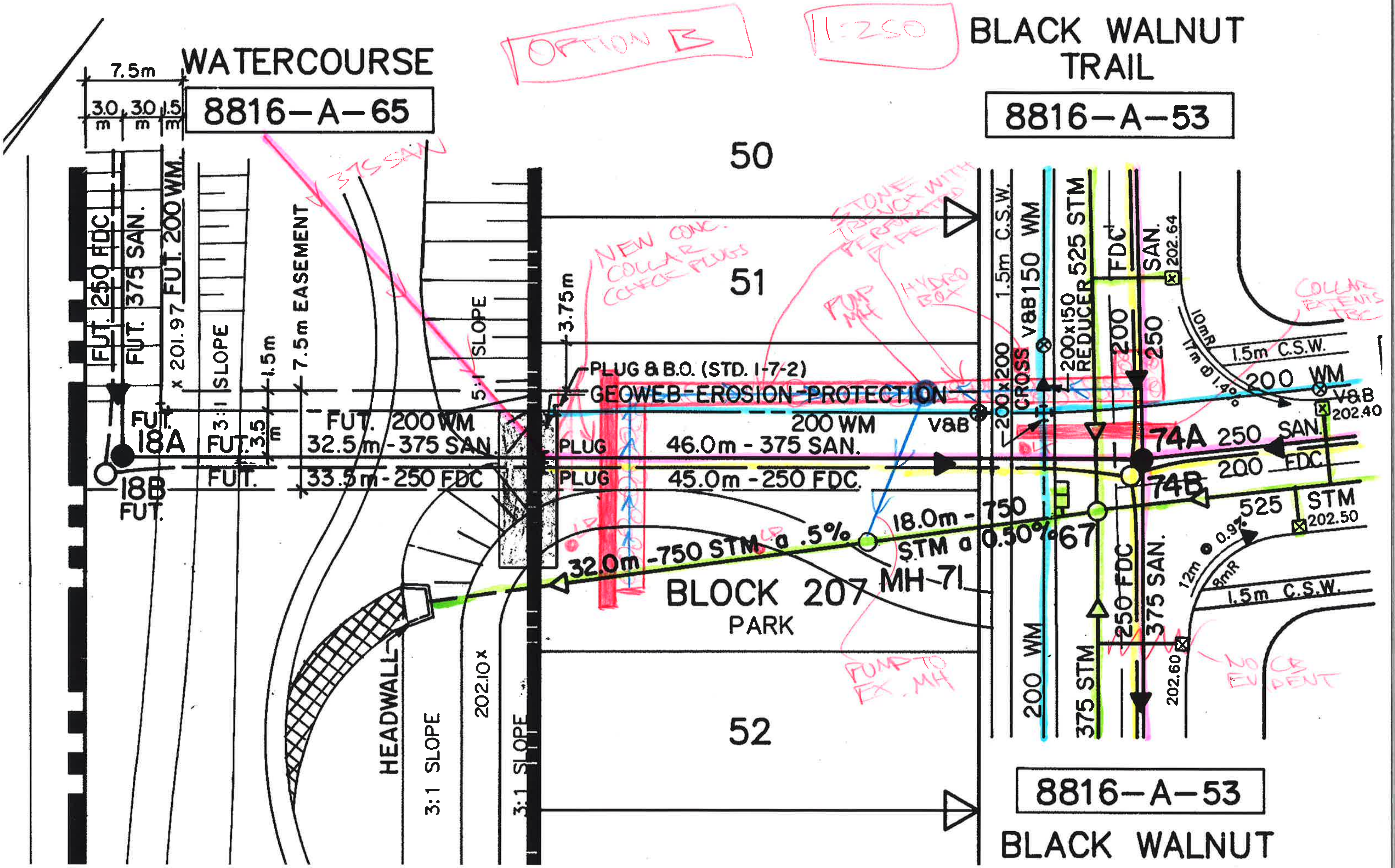
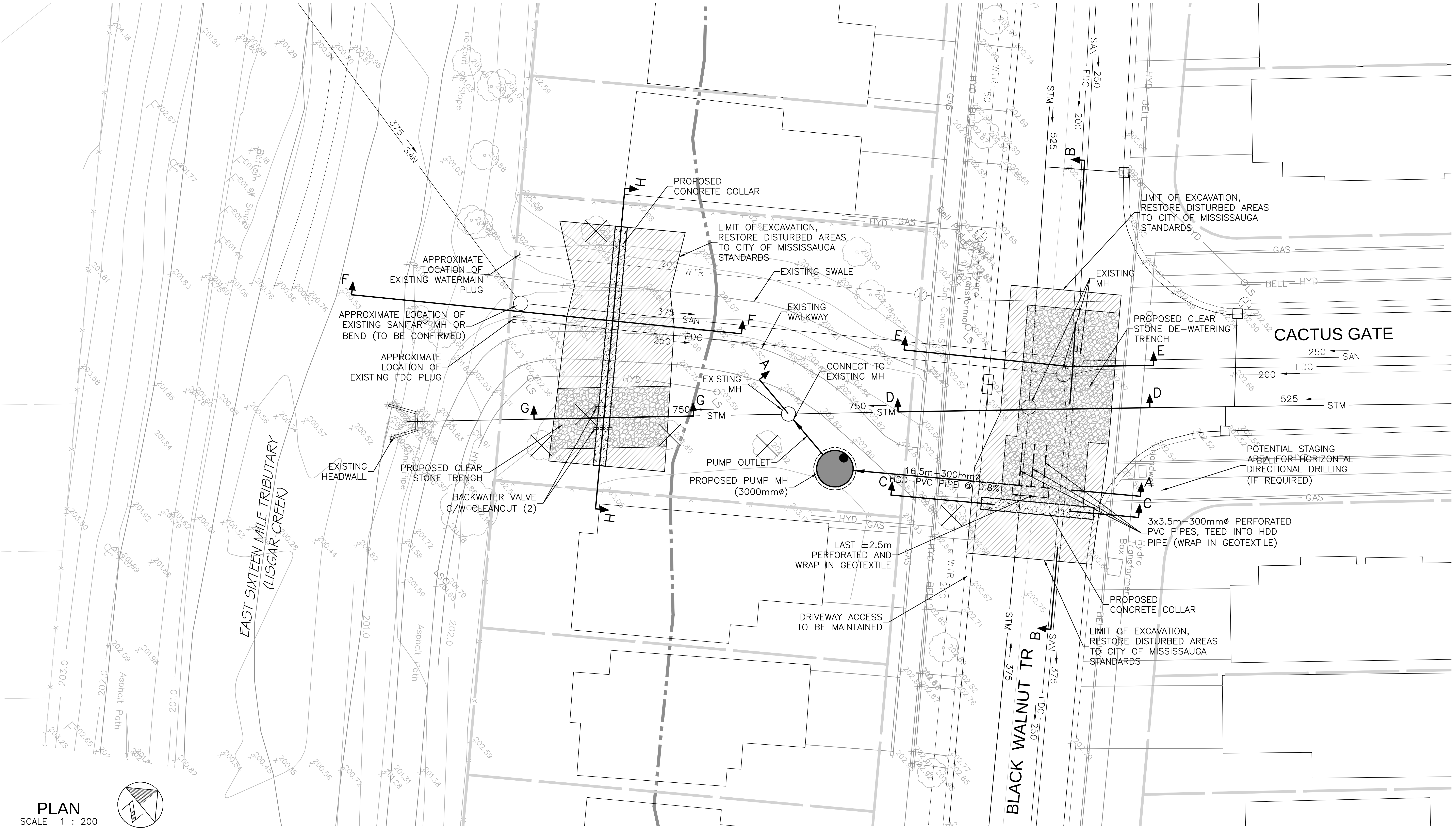
18
19
20
21
SUFFICIENTLY DEEP SUMP FOR PUMPING

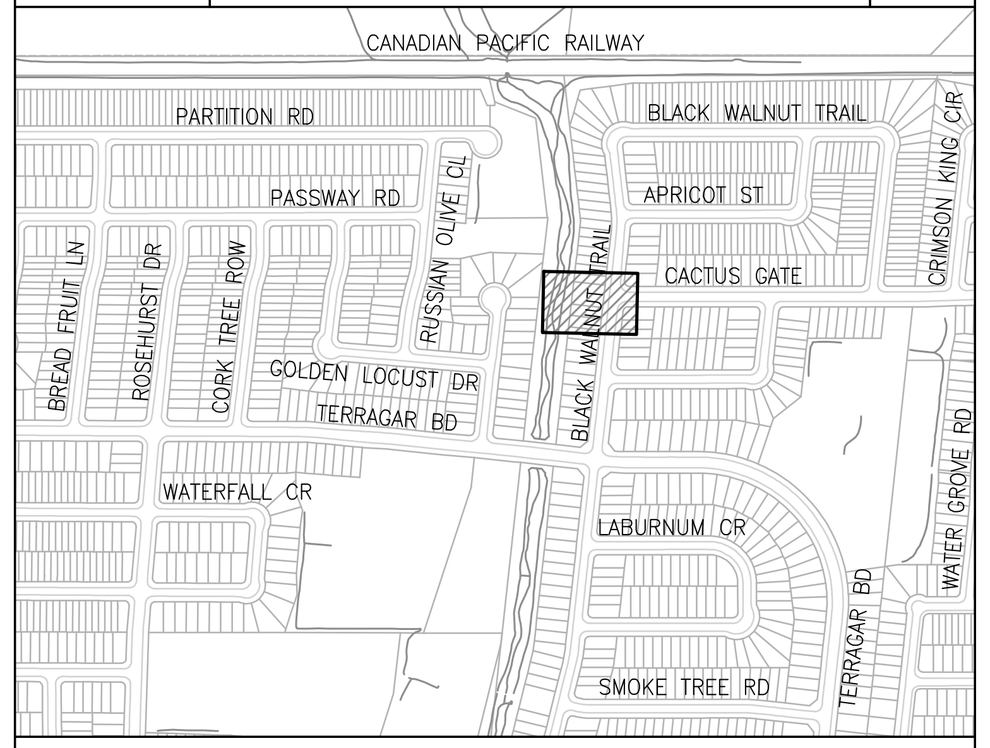

OPTION B
1:250
WATERCOURSE
8816-A-65
7.5m
3.0 m
3.0 m
1.5 m
BLACK WALNUT TRAIL
8816-A-53
50
51
52
375 SAN
FUT. 250 FDC
FUT. 375 SAN.
FUT. 200 WM.
x 201.97
3:1 SLOPE
1.5m
7.5m EASEMENT
5:1 SLOPE
3.75m
3.5 m
FUT. 18A
18B FUT.
FUT.
FUT. 200 WM
32.5m - 375 SAN.
33.5m - 250 FDC
PLUG & B.O. (STD. 1-7-2)
GEOWEB-EROSION-PROTECTION
NEW CONC. COLLAR CONCRETE PLUGS
STONE TRENCH WITH PERFORATED PIPE
PUMP MH
HYDRO BOX
PLUG
PLUG
200 WM
46.0m - 375 SAN.
45.0m - 250 FDC.
V&B
200x200 CROSS
1.5m C.S.W.
V&B 150 WM
200x150 REDUCER
525 STM
FDC
200
250
SAN. 202.64
10mR
17m @ 1.4%
1.5m C.S.W.
200 WM
V&B 202.40
COLLAR EXTENDS TBC
74A
250 SAN.
200 FDC
74B
525 STM 202.50
18.0m - 750 STM @ 0.50%
67
32.0m - 750 STM @ .5%
MH-71
BLOCK 207 PARK
12m @ 0.9%
9mR
1.5m C.S.W.
200 WM
375 STM
250 FDC
375 SAN.
202.60
NO CB EVIDENT
PUMP TO EX. MH
HEADWALL
3:1 SLOPE
202.10 x
3:1 SLOPE
8816-A-53
BLACK WALNUT



PLAN
SCALE 1 : 200

REVISIONS

DATE	DETAILS	INIT.
JAN. 2017	INITIAL CITY REVIEW	M.S.



KEY PLAN

LEGEND

～	WATERCOURSE
—	CONTOUR (0.5m)
x200.44	EXISTING SURVEYED ELEVATION CITY OF MISSISSAUGA (DEC 2011)
— —	PROPERTY LINE
— · · —	CONSERVATION HALTON APPROXIMATE REGULATION LIMIT
—HYD—	HYDRO
—BELL—	BELL
—GAS—	GAS
—WTR—	WATERMAIN SYSTEM
—STM—	STORM SEWER SYSTEM
—FDC—	FDC SYSTEM
—SAN—	SANITARY SEWER SYSTEM
⊗	EXISTING TREE TO BE REMOVED
▨	COMPACTED NATIVE SILTY CLAY BACKFILL
▒	50mmø CLEAR STONE

LISGAR DISTRICT
UTILITY TRENCH
DE-WATERING SYSTEM

amec foster wheeler

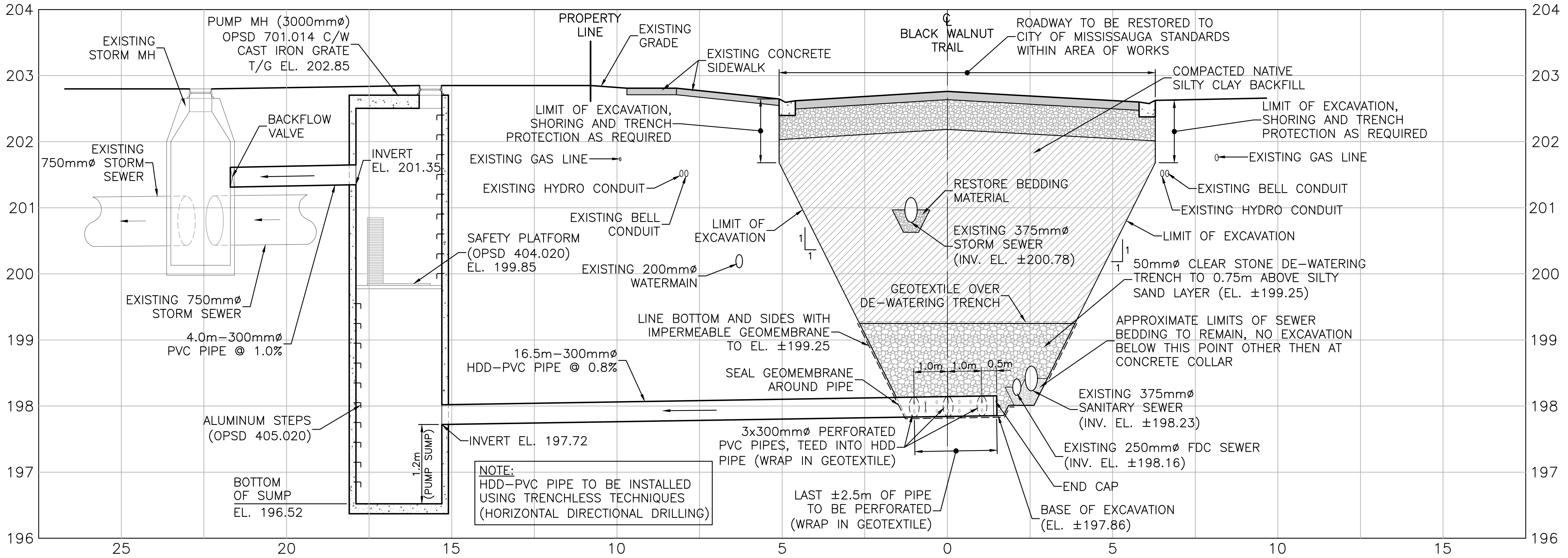
MISSISSAUGA

PRODUCED FOR - T&W, ENGINEERING AND WORKS

PLAN AND DETAILS

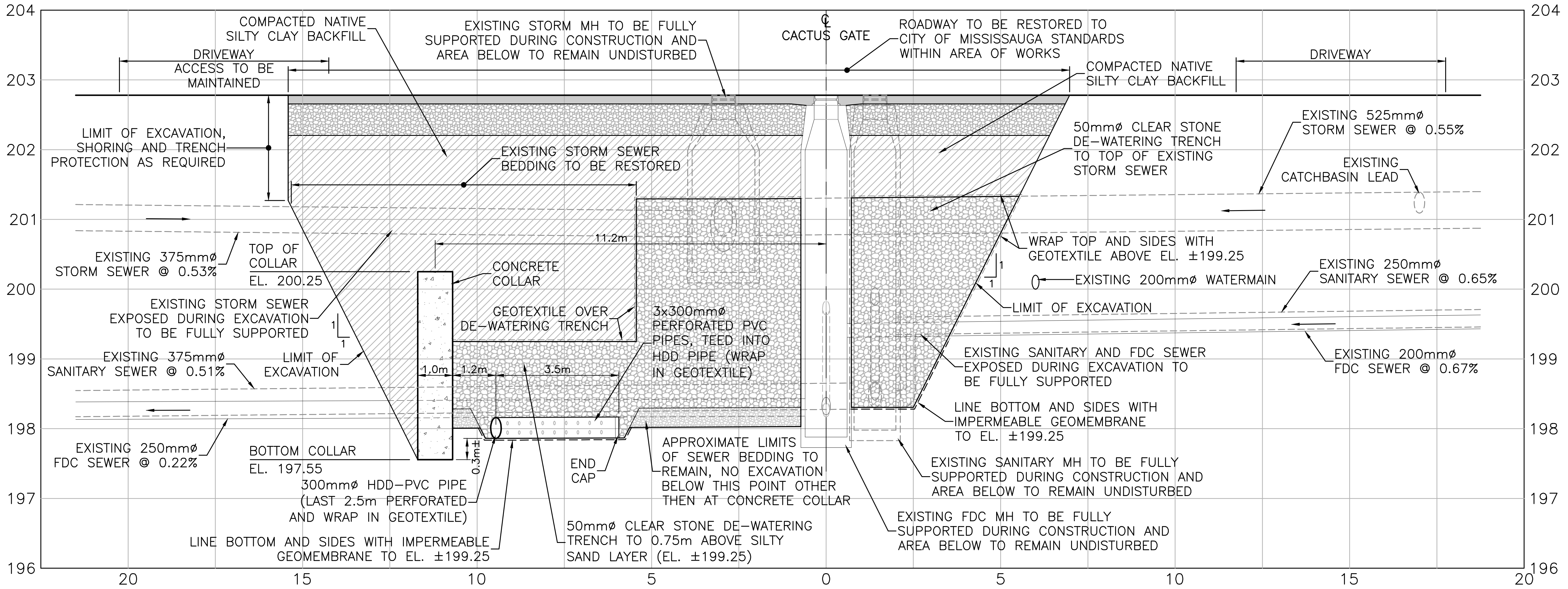
SCALE AS NOTED	AREA	PROJECT No. TP115060
C.A.D.D. BY R.M.B.	CHECKED BY M.S.	PLAN No. Figure TD1
DATE JAN. 2017	SHEET 1 OF 3	

Last Saved: 2017-01-13 Last Saved By: richard.bartolo Plotted: 2017-01-16 Plotted By: richard.bartolo Path: P:\Work\TP115060\water\dwg\16-12 (TrenchDewater)\FigTD1-3 CactusGate.dwg



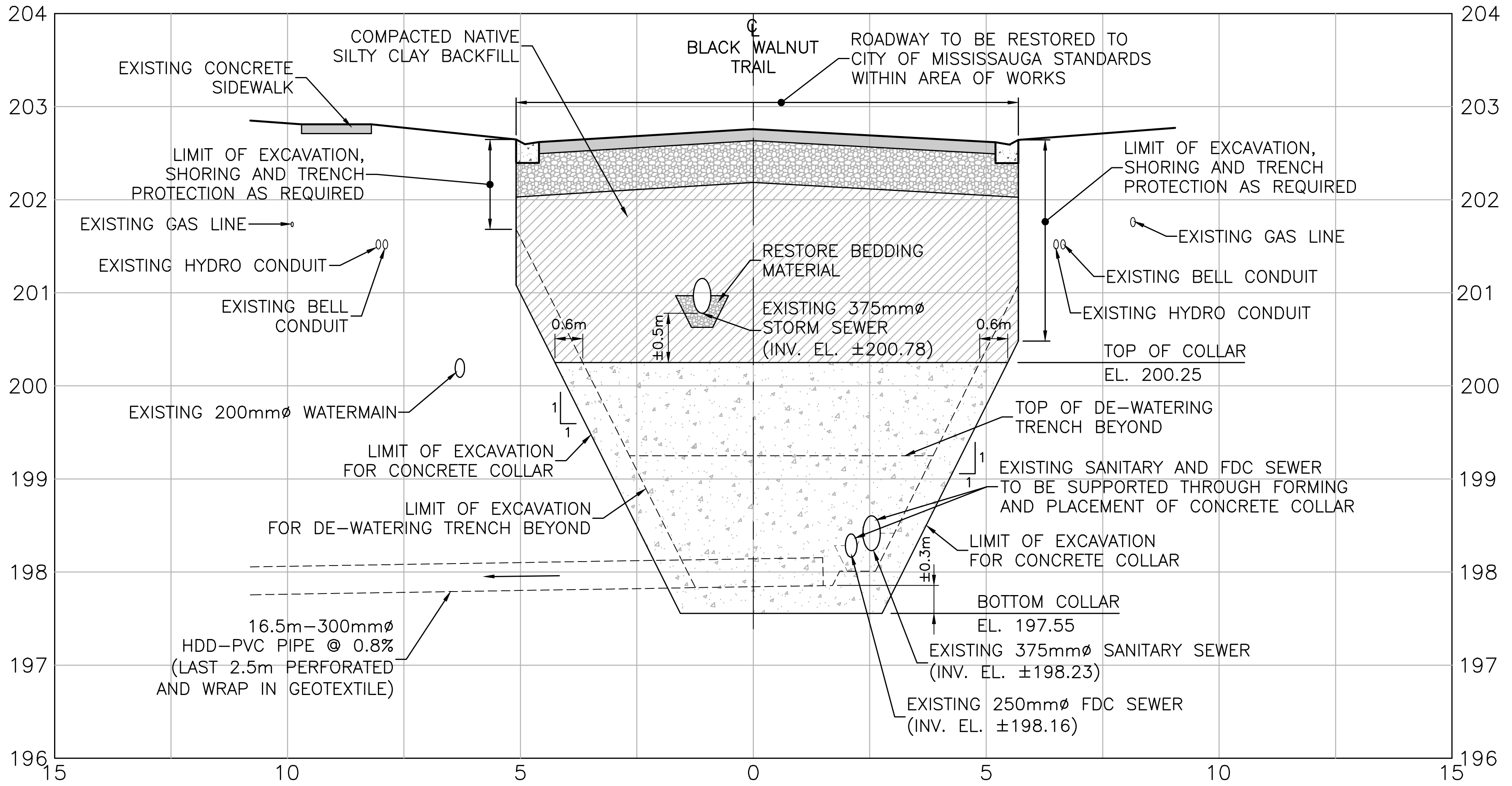
SECTION A-A

SCALE
HORIZONTAL 1:100 VERTICAL 1:50



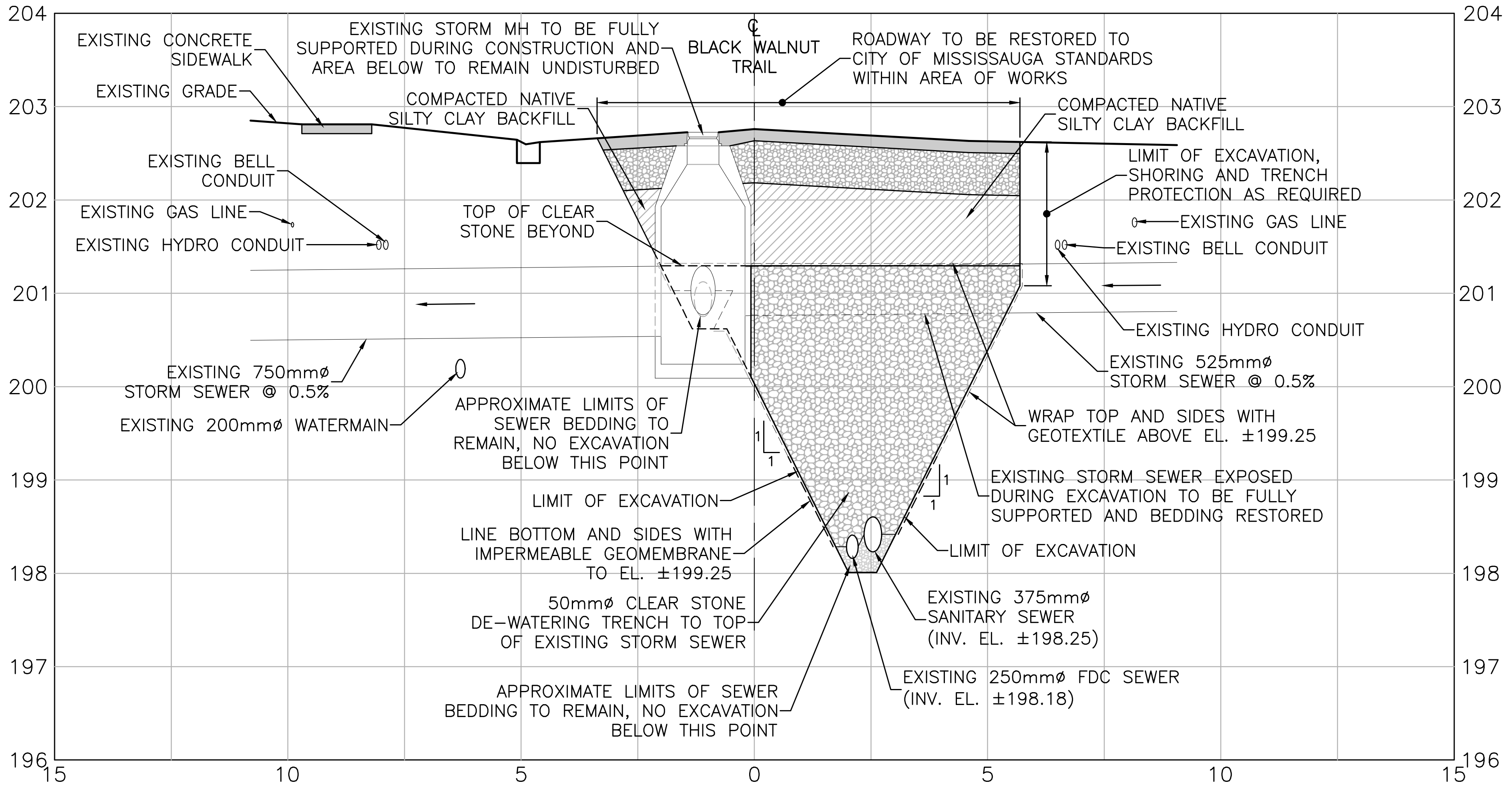
SECTION B-B

SCALE
HORIZONTAL 1:100 VERTICAL 1:50



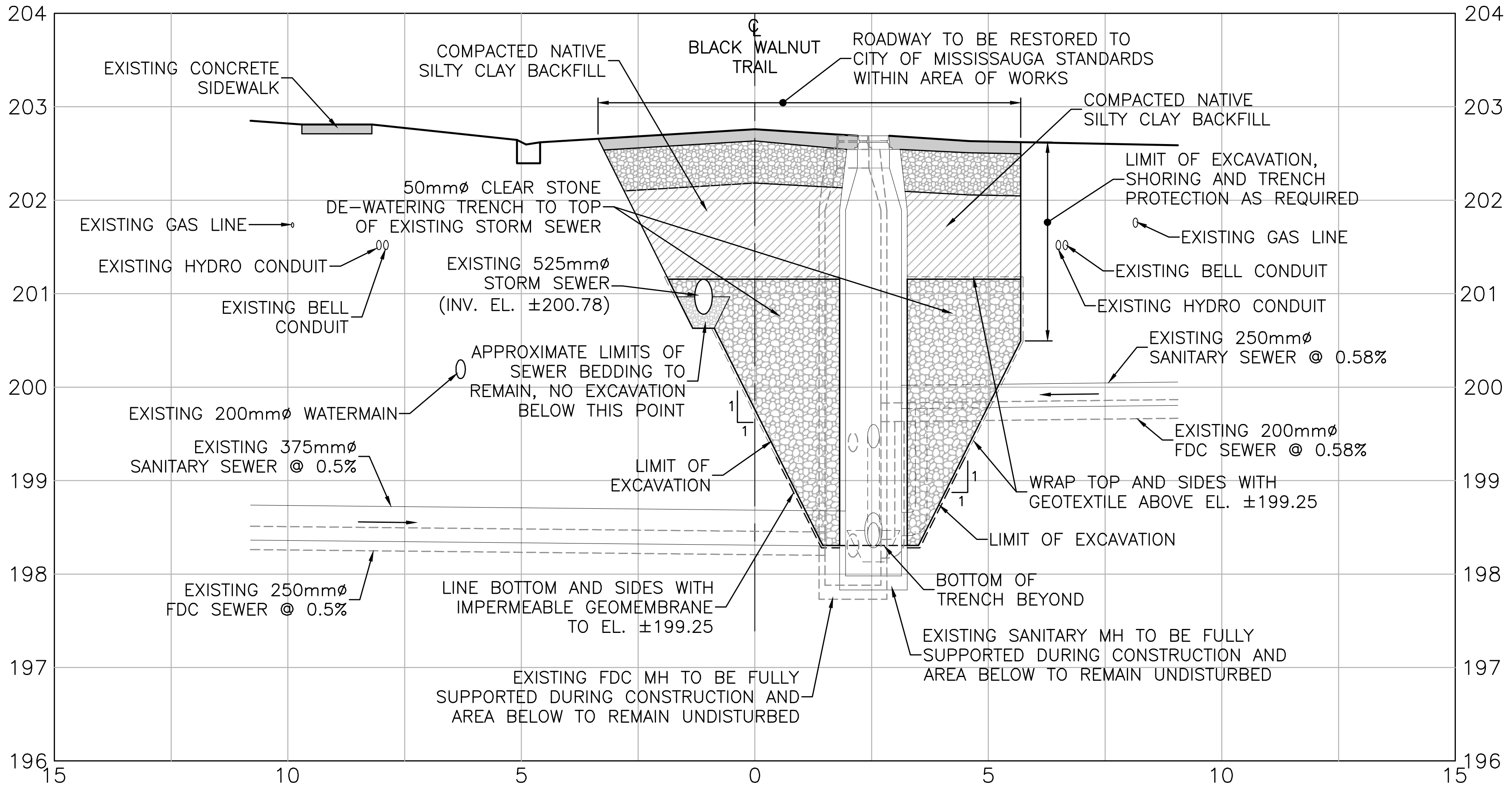
SECTION C-C

SCALE
HORIZONTAL 1:100 VERTICAL 1:50



SECTION D-D

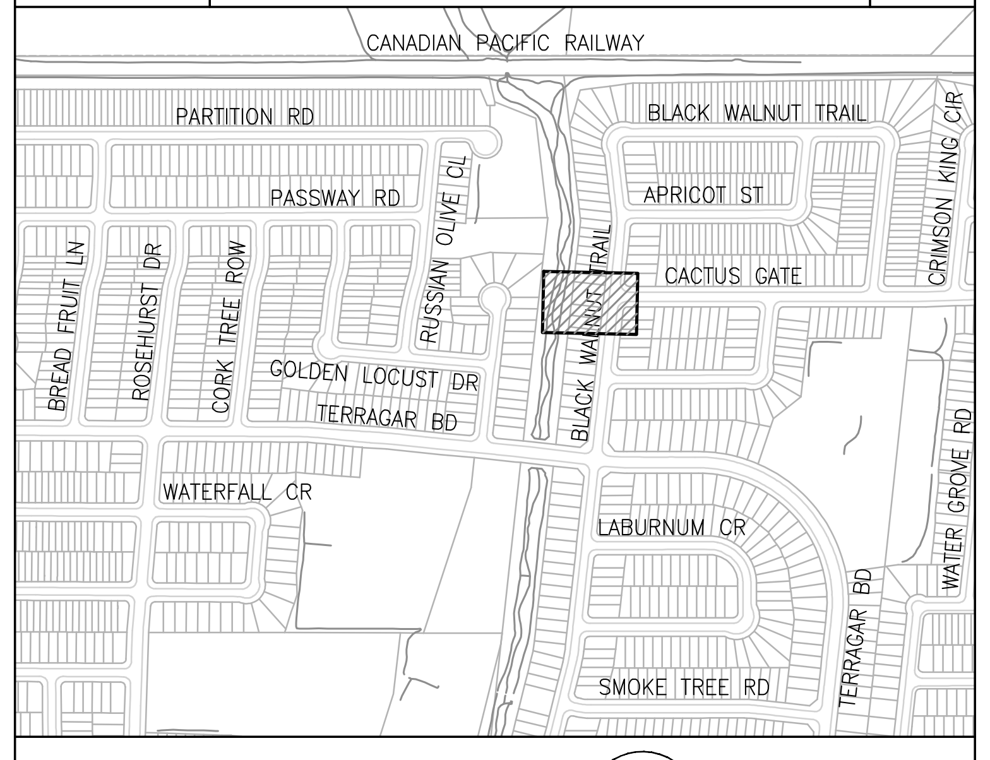
SCALE
HORIZONTAL 1:100 VERTICAL 1:50



SECTION E-E

SCALE
HORIZONTAL 1:100 VERTICAL 1:50

REVISIONS		
DATE	DETAILS	INIT.
JAN. 2017	INITIAL CITY REVIEW	M.S.



KEY PLAN

LISGAR DISTRICT
UTILITY TRENCH
DE-WATERING SYSTEM

amec foster wheeler

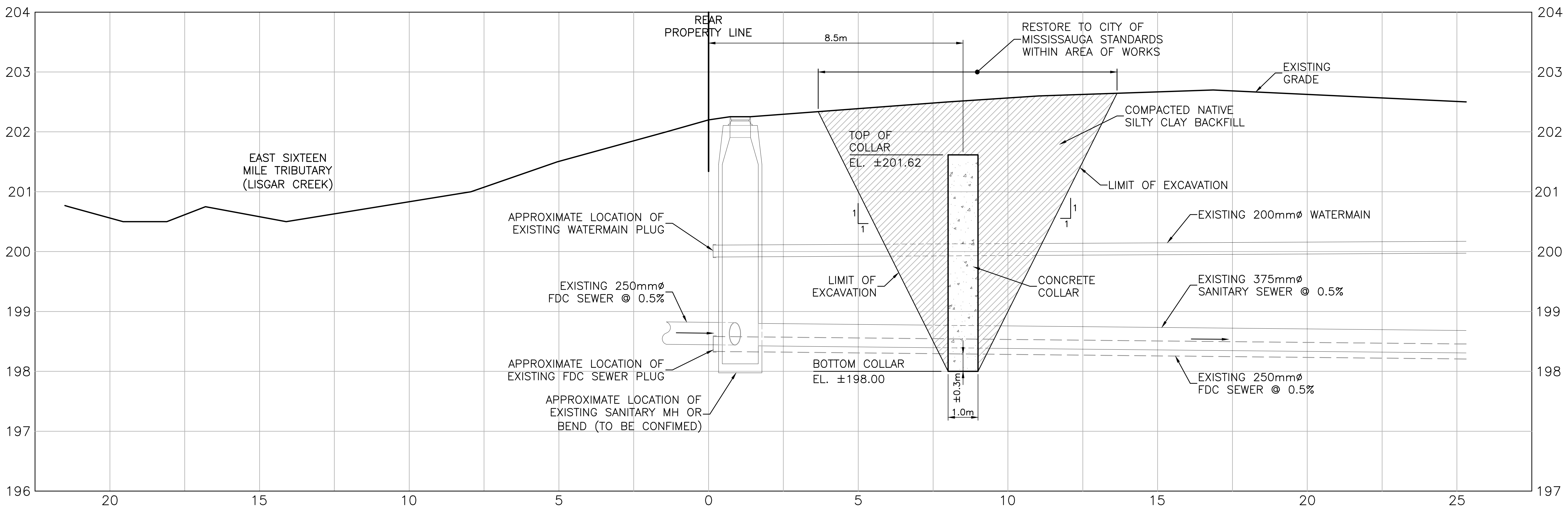
MISSISSAUGA

PRODUCED FOR - T&W, ENGINEERING AND WORKS

SECTIONS

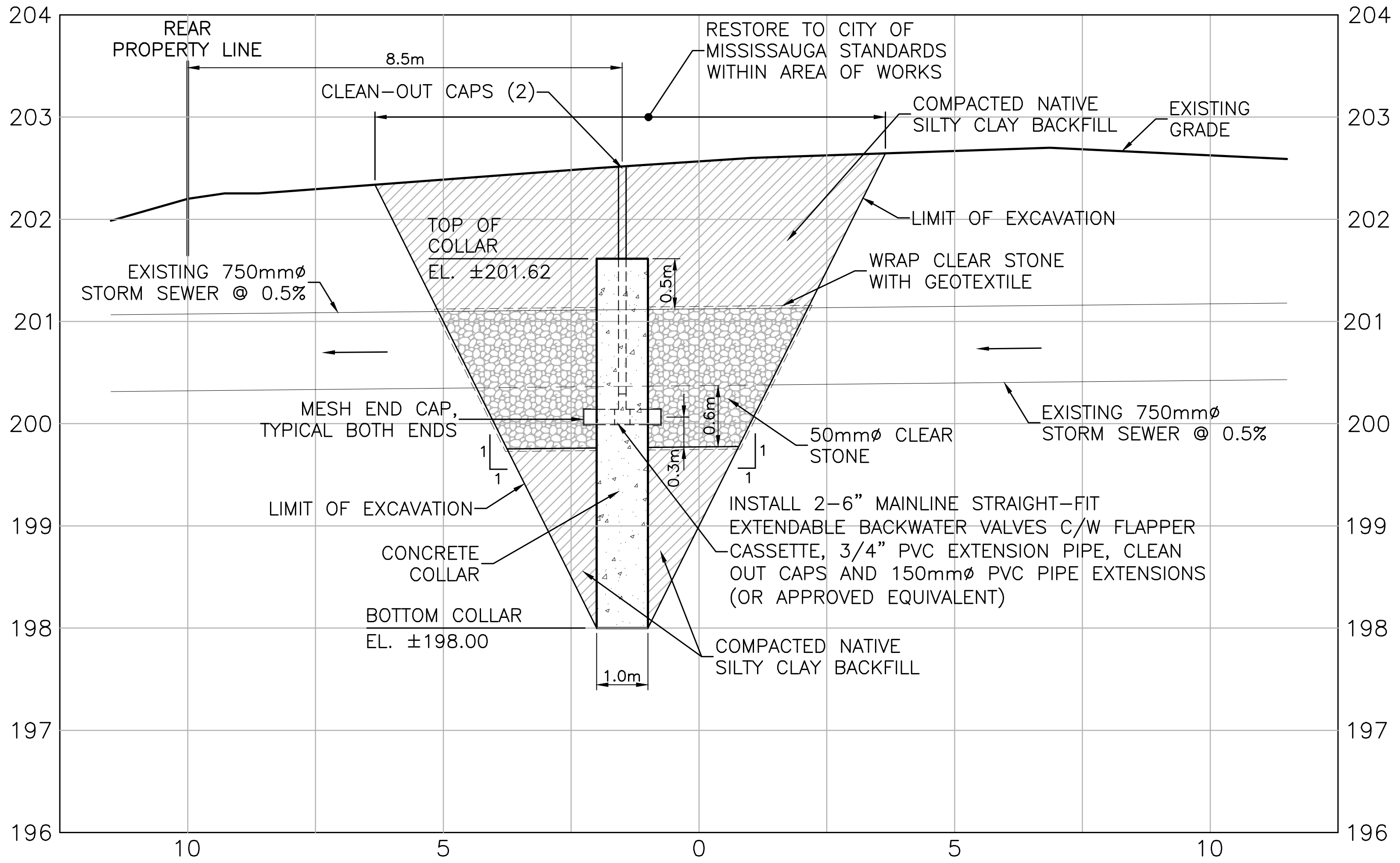
SCALE AS NOTED	AREA	PROJECT No. TP115060
C.A.D.D. BY R.M.B.	CHECKED BY M.S.	PLAN No. Figure TD2
DATE JAN. 2017	SHEET 2 OF 3	

Last Saved: 2017-01-13 Last Saved By: richard.bartolo Plotted: 2017-01-16 Plotted By: richard.bartolo Path: P:\Work\TP115060\water\dwg\16-12 (TrenchDewater)\FigTD1-3 CactusGate.dwg



SECTION F-F

SCALE
HORIZONTAL 1:100 VERTICAL 1:50



SECTION G-G

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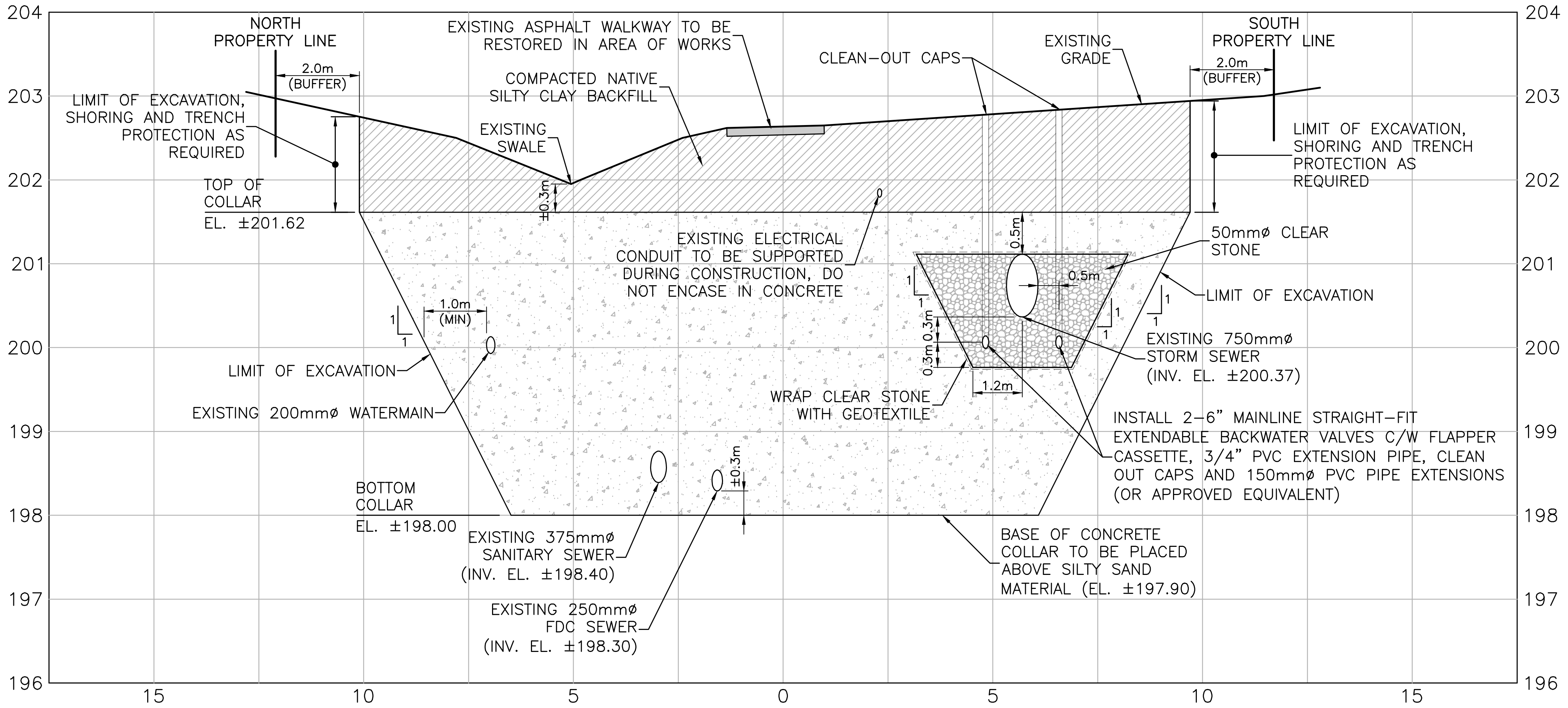
HORIZONTAL 1:100 VERTICAL 1:50

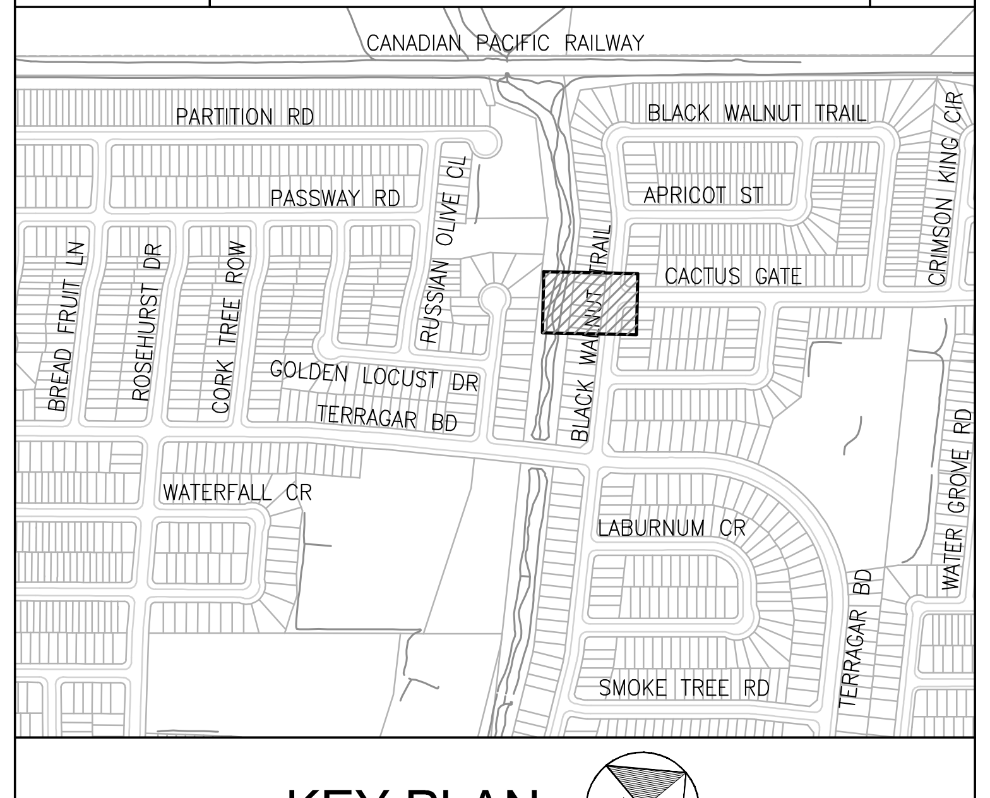


SECTION H-H

SCALE
HORIZONTAL 1:100 VERTICAL 1:50

REVISIONS

DATE	DETAILS	INIT.
JAN. 2017	INITIAL CITY REVIEW	M.S.



KEY PLAN

LISGAR DISTRICT
UTILITY TRENCH
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SECTIONS

SCALE AS NOTED	AREA	PROJECT No. TP115060
C.A.D.D. BY R.M.B.	CHECKED BY M.S.	PLAN No.
DATE JAN. 2017	SHEET 3 OF 3	Figure TD3

Appendix C
Technical Memoranda

Memo

To: Jeff Smylie and Louie Jakupi, City of Mississauga

From: Matthew Senior and Ron Scheckenberger

Date: March 12, 2018

File: TPB188016

Re: **FDC Pumping Station – Hydraulic Modelling and Location Analysis**
Lisgar District Basement Water Infiltration Assessment – Remediation Phase

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1. Introduction, Background and Purpose

Further to our approved scope of November 13, 2017, we hereby provide you with a summary of the analyses completed to date with respect to the proposed foundation drain collector (FDC) pumping station for the Lisgar District within the City of Mississauga.

As you are aware, Amec Foster Wheeler has supported the City since late 2011 with regards to the ongoing issues related to basement water infiltration in the Lisgar District. From 2011 to 2015, efforts were largely focused around data collection (monitoring) and analysis efforts. The findings of this period were ultimately documented in a March 2015 Public Summary Report, which concluded the problem was primarily related to the build-up of water in the bedding material of utility trenches that contain the storm, sanitary, and FDC sewer systems and presenting the effective conveyance of foundation drains around area homes. As part of the March 2015 report, a Priority Action Plan was developed, with the highest priority items including lining of priority storm sewer to minimize leakage, and the construction of a utility trench dewatering system. Subsequent priority measures (depending on the success of the highest priority items) included construction of a permanent FDC pumping station for high flows, and the replacement of deficient sections of the FDC sewer system.

Amec Foster Wheeler was subsequently retained by the City of Mississauga to support the remediation works phase of the study, with the highest priority items being storm sewer lining (to reduce leakage) and the design of a utility trench dewatering system (to reduce the build-up of water in the utility trench). In addition, Amec Foster Wheeler continued to undertake monitoring of the drainage systems within the Lisgar District to provide ongoing verification of the effectiveness of remedial measures as they were constructed, and to also allow for data collection in the event of FDC surcharging or basement water infiltration events, should they occur.

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Storm sewer lining works for the highest priority area (Phase 1 - Black Walnut Trail) were completed between December 2016 and March 2017. A second phase of storm sewer lining was planned for the next highest priority area (Doug Leavens Boulevard, Alderwood Trail, and Osprey Boulevard) for later in 2017. However, post-lining storm sewer leakage tests completed in April 2017 indicated an approximately similar rate of leakage under post-lining conditions as under pre-lining, which was unexpected. A repeated post-lining leakage test was completed in July 2017 using a revised testing procedure. The results of this additional testing (as documented in the August 28, 2017 revised draft memorandum) indicated that the highest relative rate of storm sewer leakage is sourced from catchbasins, and specificially from the roadway sub-drains which connect into these catchbasins. Notwithstanding, the revised testing indicated that other components of the storm sewer system (maintenance holes and catchbasin leads) also continued to leak with the catchbasin blockers in place, albeit at a lesser rate than the catchbasins and sub-drains. The City of Mississauga and Amec Foster Wheeler subsequently pursued a number of potential mitigation measures to this end. City staff ultimately proceeded with the installation of catchbasin sub-drain plugs along Black Walnut Trail in October and November of 2017, with a second phase of plugs (Doug Leavens Boulevard to Osprey Boulevard) installed in January of 2018. The effectiveness of these plugs will continue to be evaluated over the course of 2018 and beyond.

As you are also aware, a storm event on July 13-14, 2017 resulted in reported instances of basement water infiltration in the Lisgar area. A total of thirty-five (35) residences within the Lisgar District reported basement water infiltration from the July 13-14 storm event (ref. e-mail Blair-Senior, July 25, 2017). All of the affected properties are located along the west side of Black Walnut Trail (i.e. backing onto Lisgar Creek), with the exception of one property located along Golden Locust Trail. This is consistent with the location of previously reported instances of basement water infiltration in this area. To date, no instances of basement water infiltration have been reported from other areas in the Lisgar District which have previously reported occurrences; this primarily involves residences in the vicinity of Alderwood Trail and Osprey Boulevard. The July 13-14, 2017 event is notable in that is the first reported instance of basement water infiltration in this area (Black Walnut Trail) for which field monitoring data are available. Monitoring gauges were in place for the January 13, 2013 event (for which seven (7) residences reported basement water infiltration), however all of these residences were in the vicinity of Osprey Boulevard.

A memorandum was generated by Amec Foster Wheeler (August 1, 2017) to summarize and interpret available monitoring data for the storm event, as well as suggested additional analyses and next steps. A public meeting was subsequently held on October 18, 2017 to provide an update on the ongoing works being completed for the Lisgar District Basement Water Infiltration Study. As part of the public meeting, an updated action plan was presented. In addition to previously proposed activities (addressing roadway sub-drain leakage, utility trench dewatering system), an FDC pumping station (similar to that proposed in the March 2015 public report) was advanced as a higher priority mitigation measure to be designed and constructed in 2018.

Amec Foster Wheeler has proceeded with the initial analysis in support of the FDC pumping station; specifically Tasks 1 and 2 of the November 13, 2017 work plan. This memorandum is intended to summarize these efforts, related to hydraulic modelling of the FDC system, analysis of pumping station feasibility and required capacity, and recommendations for location(s) and sizing.

2. Hydraulic Modelling and Analysis of Recorded Storm Events

2.1. Model Development and Methodology

In order to support an informed design process for an FDC pumping station, an analytical tool is considered to be required. Such a tool is intended to be used to assess expected rates of flow within the FDC system during storm events, and the associated effectiveness of potential pumping strategies (locations, numbers, and pump station sizing/capacities).

A hydraulic model of the FDC sewer system was previously developed (PCSWMM) as part of the assessment work in support of the March 2015 Public Summary Report. Although this work was not formally documented, details were provided in the internal presentation of December 16, 2014. That model was used for a number of different assessments, including forensic modelling of an actual storm event (September 2, 2014) based on available FDC monitoring data. A similar approach to that work has been employed for the current assessment.

The previously developed PCSWMM model is not an “all pipes” model, but rather a model of the trunk FDC system, from Black Walnut Trail to the systems’ ultimate outlet to the storm sewer system at Erin Centre Boulevard and Churchill Meadows (some 8 km +\- downstream). For the purposes of the current assessment, and as was done for the previously noted forensic assessment (September 2, 2014 event), the model has been truncated 250 m +\- downstream of gauge F2 (which is located 120 m +\- downstream of Derry Road), given the focus on FDC surcharging and basement water infiltration within the Black Walnut Trail area of the Lisgar District.

The previously developed PCSWMM model has been updated for the current assessment to include a higher level of discretization. The primary area of additional model resolution is in the Golden Locust Drive\Russian Olive Close area, to the west of Lisgar Creek (north of Terragar Boulevard). The previous (December 2014) modelling did not include any FDC sewers in this area, given the lack of available monitoring data in this area at that time. However, an FDC monitoring gauge (F24) was subsequently installed in this area in July of 2015, and has been operational since that time (including data for the 2017 monitoring year). As such, additional model resolution in this area will be required in order to allow for a comparison to monitoring data. The current modelling has added eight (8) sections of FDC sewer in this area, based on available plan and profile drawings. In addition to the preceding, the first section of FDC sewer from side streets to the trunk along Black Walnut Trail has also been added to the modelling (using available plan and profile drawing data), which results in an additional nine (9) sections of FDC sewer within the modelling. Figure A1 (attached) presents the limits of the FDC sewer system included in the modelling, along with relevant FDC monitoring locations.

In addition to the hydraulic component of the FDC model, flow inputs are required. The FDC sewer system was originally designed using an approach similar to that employed for sanitary sewers, with a set flow rate applied per unit (0.075 L/s/residence), based on recommendations from the previous development engineer of record (Paul Theil and Associates). However, given the known issues with FDC surcharging in response to storm events, this approach is clearly inappropriate for the current assessment; a more dynamic approach is required.

Consistent with the approach for the previous (December 2014) modelling assessment, flow inputs as part of the modelling are applied based on a “typical” unitary response (i.e. an FDC flow hydrograph per unit area), and then scaled (multiplied) based on the appropriate contributing FDC drainage area to each point of interest. These FDC flow inputs are then routed by the FDC sewer pipe hydraulic model, which permits a comparison of the resulting calculated water levels to monitored levels for specific storm events.

The monitoring gauges used in the Lisgar District measure water level and temperature only; they do not include a velocity (or flow) component. While theoretical methods (i.e. Manning’s Equation and the orifice equation) can be used to generate a rating curve for the monitoring gauges, this does not differentiate between surcharge due to excess upstream flow, and surcharge due to downstream tailwater conditions. As such, the hydraulic modelling is considered necessary to validate estimated flows and the associated simulated water level response.

Overall FDC drainage areas have been delineated as part of previous assessments (including the December 2014 assessment). These areas have been further refined for the current assessment, particularly for the area west of Lisgar Creek (i.e. area to the F24 monitoring gauge). Resulting FDC drainage areas are presented in Figure A2 (attached). Key FDC drainage area statistics to FDC monitoring gauges are presented in Table 2.1.

Table 2.1. Summary of Estimated Contributing Drainage Areas to FDC Monitoring Gauges

FDC Monitoring Gauge	Number of Modelled FDC Subcatchments	FDC Drainage Area (ha)	Percentage of Total Area (to F2)
F14	2	5.36	5.2%
F13	1	3.28	3.2%
F5	5	11.97	11.7%
F24	4	11.39	11.1%
F1	17	33.93	33.1%
F6	23	89.04	86.9%
F2	26	102.46	100.0%

In order to simulate the FDC system response to surcharge-causing events, a suitable event must first be selected. A review of potential storm events is presented in Section 2.2.

2.2. Potential Storm Events

A review of previous storm events which are known to have resulted in FDC system surcharging was previously presented as part of the assessment of the July 13-14, 2017 storm event (August 1, 2017 memorandum). Key rainfall data (based on the City of Mississauga’s gauge 11 – Gary Morden Fire Training Centre) for these events are presented in Table 2.2.

Table 2.2. Rainfall Event Comparison (City Gauge 11) for FDC Surcharging Events (Black Walnut Trail)

Event Date	5-Day Ante-cedent Rainfall (mm)	Event Length (hours)	Event Depth (mm)	30 Minute Data		1 Hour Data		6 Hour Data	
				Peak Intens (mm/hr)	Approx Return Period (years)	Peak Intens (mm/hr)	Approx Return Period (years)	Peak Intens (mm/hr)	Approx Return Period (years)
Sep 8, 2012	30.0	9.5	36.4	23.6	< 2	14.8	< 2	4.6	< 2
Aug 2, 2013	30.8	4.3	22.0	26.8	< 2	19.6	< 2	3.7	< 2
Aug 27, 2013	5.0	2.2	17.4	24.8	< 2	12.4	< 2	2.9	< 2
Sep 20, 2013	0.2	18.1	45.2	32.4	< 2	16.8	< 2	4.0	< 2
Nov 17, 2013	2.4	1.5	14.0	23.6	< 2	13.6	< 2	2.3	< 2
Jun 12, 2014	7.6	1.3	23.2	26.0	< 2	21.6	< 2	3.9	< 2
Sept 2, 2014	9.2	1.7	17.8	30.4	< 2	16.8	< 2	3.0	< 2
Sept 10, 2014	**26.4**	**6.3**	**40.4**	**42.4**	**2 - 5**	**26.8**	**2 - 5**	**6.6**	**2**
July 7, 2015	12.8	1.6	15.2	24.0	< 2	14.4	< 2	2.5	< 2
Aug 20, 2015	4.6	0.3	0.6[2]	1.2	< 2	0.6	< 2	0.1	< 2
Sep 19, 2015	0	0.9	16.4	31.6	< 2	16.4	< 2	2.7	< 2
Aug 13, 2016	1.4	0.9	17.8	20.0	< 2	17.8	< 2	3.0	< 2
Dec 26, 2016	NA	NA	NA	NA	NA	NA	NA	NA	NA
Jun 23, 2017	84.0[1]	1.5	16.8	18.0	< 2	13.8	< 2	2.8	< 2
Jul 14, 2017	**5.4**	**0.8**	**31.8**	**50.0**	**5**	**29.0**	**2 - 5**	**5.3**	**< 2**

1. To be verified – Pearson Airport gauge recorded only 10.6 mm over same period, City Gauge 12 recorded 14.2 mm for same period.
2. Potentially a resolute thunder storm cell which was not measured at the gauge, given low reported total rainfall.

The data presented in Table 2.2 confirm that the July 14, 2017 storm event was the largest on record (of observed FDC surcharging events since monitoring began in 2012) with respect to the 30 minute and 1 hour peak rainfall intensities. It was also the only recorded storm events with an intensity greater than the City of Mississauga's 2-year return period, with the exception of the September 10, 2014 storm event.

In addition to the preceding, the August 1, 2017 memorandum also presented the peak depth and duration (time of surcharge above estimated basement elevations) at key gauges along Black Walnut Trail: gauges F5, F1, and F6 (refer to Figure A1 for locations). As noted in previous annual monitoring reports, FDC surcharging has been repeatedly observed at gauges F5 and F1 in particular (Black Walnut Trail in the vicinity of Terragar Boulevard). The results of this analysis are presented in Table 2.3.

Table 2.3. Comparison of Observed FDC Surcharging Events along Black Walnut Trail

Event Date	5-Day Ante-cedent Rainfall (mm)	Rain Event Length (hours)	Rain Event Depth (mm)	Gauge F5 (0.25 m)		Gauge F1 (0.375 m)		Gauge F6 (0.45 m)	
				Peak Depth (m)	Time above bsmt[3] (mins)	Peak Depth (m)	Time above bsmt[3] (mins)	Peak Depth (m)	Time above bsmt[3] (mins)
Sep 8, 2012	30.0	9.5	36.4	2.56	NA	2.27	NA	1.84	NA
Aug 2, 2013	30.8	4.3	22.0	0.76	NA	0.41	NA	0.20	NA
Aug 27, 2013	5.0	2.2	17.4	1.02	NA	0.79	NA	0.34	NA
Sep 20, 2013	0.2	18.1	45.2	0.78	NA	0.83	NA	0.20	NA
Nov 17, 2013	2.4	1.5	14.0	0.53	NA	0.45	NA	0.09	NA
Jun 12, 2014	7.6	1.3	23.2	2.41	NA	2.70	NA	2.16	NA
Sept 2, 2014	9.2	1.7	17.8	1.43	NA	1.36	NA	0.45	NA
Sept 10, 2014	26.4	6.3	40.4	2.74	NA	2.68	NA	1.85	NA
July 7, 2015	12.8	1.6	15.2	0.40	NA	0.57	NA	0.12	NA
Aug 20, 2015[2]	4.6	0.3	0.6[2]	1.13	NA	1.12	NA	0.35	NA
Sep 19, 2015	0	0.9	16.4	1.04	NA	1.16	NA	0.41	NA
Aug 13, 2016	1.4	0.9	17.8	0.64	NA	0.62	NA	0.16	NA
Dec 26, 2016	NA	NA	NA	0.25	NA	0.29	NA	0.21	NA
Jun 23, 2017	84.0[1]	1.5	16.8	2.21	NA	2.13	NA	1.57	NA
Jul 14, 2017	5.4	0.8	31.8	3.45	NA	3.27	120	2.71	115

1. To be verified – Pearson Airport gauge recorded only 10.6 mm over same period, City Gauge 12 recorded 14.2 mm for same period.
2. Potentially a resolute thunder storm cell which was not measured at the gauge, given low reported total rainfall.
3. Based on estimated basement elevation at gauge location – estimated as MH lid elevation less 1.8 m to finished floor elevation. To be confirmed through additional survey.

As evident from Table 2.3, the July 14, 2017 storm event resulted in the largest FDC system response in the Black Walnut Trail area of all recorded FDC surcharge events since monitoring began in 2012. The monitored results also indicate that the July 13-14 event was the only one on record which would have been sufficient to reach the estimated basement elevations. This would be consistent with the lack of reports of basement water infiltration for any of the previous surcharging events during the monitoring period.

Notwithstanding the preceding, there are a number of additional formative FDC surcharging responses (surcharge depth of 2 m +\- or greater) which could also be used for model simulation and assessment of mitigation measures. These potential events include:

- September 8, 2012
- June 12, 2014
- September 10, 2014
- June 23, 2017

For the current assessment, the June 23, 2017 storm event has been simulated in addition to the July 13-14, 2017 storm event. This event resulted in a notable system surcharge, and also offers a similar availability of monitoring gauge data to the July 13-14, 2017 storm event (i.e. availability of gauge F24 in particular). The analyses for these two events are described in subsequent sections.

2.3. June 23, 2017 Storm Event

The June 23, 2017 was the second recorded FDC surcharge event of 2017. This event was of a smaller magnitude than the July 13-14, 2017 storm event, as evident from the statistics presented in Section 2.2. Notwithstanding, the storm event did results in a notable surcharge in the FDC system, approximately the 5th highest over the 5-year monitoring period to date. Figure A3 (attached) presents the observed water level response. Consistent with previously observed FDC surcharge event, this event was primarily localized towards the upper end of the Black Walnut Trail system, with surcharge most evident at gauges F5 and F1. Gauge F14 (further upstream along Black Walnut Trail) also exhibits a notable surcharge. The surcharge continues further downstream (gauges F6 and F2), however routing and attenuation effects are evident. The observed FDC surcharge again appears to be sourced from the upper portion of the Black Walnut Trail area, and exhibits a rapid response to rainfall input, with a delay of less than an hour between peak rainfall intensity and the observed peak water level in the FDC system. The recession of the FDC surcharge is equally rapid, with the surcharge event lasting approximately one hour.

As noted earlier, in order to simulate the storm event response, a unitary flow response is required. Based on the locations of observed surcharge, and the contributing drainage area, the gauge response at F13 has been selected. This location is somewhat elevated compared to the other most upstream FDC monitoring gauge (F14), with an invert approximately 1 m +\- higher. Further, the F13 gauge indicates less of a surcharged response than F14, which potentially allows for a more unattenuated unitary response (i.e. less impacted by surcharge/pressure flow and backwater). The observed water level at F13 has been converted to an estimated flow using a combined theoretical rating curve; Manning's Equation for low (unpressurized) flows, transitioning to an orifice equation approach for pressure flows. This is generally consistent with available nomographs for pipe flow (ref. MTO Drainage Management Manual, 1997). The resulting flow hydrograph is then divided by the contributing drainage area (3.28 ha for gauge F13) to develop a unitary flow response ($m^3/s/ha$).

The unitary flow response function is then applied to hydraulic model nodes, based on the contributing FDC drainage areas (as presented in Figure A2). Scaling factors (i.e. multiplier for unitary flow response to be applied at each node) are then determined/estimated iteratively, in order to attempt to replicate the observed water level responses for the storm events.

As documented in the December 2014 presentation, the analyses completed for the November 2, 2014 storm event determined notably higher rates of contributing flow from the upper portions of the FDC sewershed, with a negligible flow contribution for the lower portion of the sewershed (i.e. downstream of gauge F1). The highest estimated rates of inflow for that event were noted to be upstream of gauge F5. These general findings are supported by the observed flow response, with elevated surcharge noted at F14 and F5.

Based on the preceding, contributing FDC drainage areas were divided into “zones” of expected common contributing FDC flow rates. Figure A4 presents these approximate zones; relevant details are also presented in Table 2.4.

Table 2.4. Approximate FDC Drainage Area Zones used for Hydraulic Modelling Assessment

Zone	Description	Incremental Contributing Drainage Area (ha)	Percentage of Total Area (to F2)
1	Black Walnut Trail – north of gauge F5	11.96	11.7%
2	Area west of Lisgar Creek (Golden Locust Drive)	15.12	14.8%
3	Black Walnut Trail between F5 and F1	6.83	6.7%
4	Black Walnut Trail between F1 and F6 (including Scotch Pine Gate area)	55.11	53.8%
5	Areas downstream of F6	13.43	13.1%

As per the results of the previous December 2014 assessment, the majority of contributing flow was noted to be sourced from Zones 1-3, which represents only a third of the total contributing drainage area to the downstream limits at gauge F2. A significant proportion of the contributing drainage area is from the FDC line along Scotch Pine Gate, which serves an area of some 43.8 ha.

Using an iterative approach, scaling factors have been first approximated for the Zone 1 area (i.e. gauges F13 and F14), and subsequently for Zone 2 (gauge F24). Once these scaling factors have provided a reasonable approximation of the observed water levels for these areas, additional scaling factors are developed for Zones 3, 4 and 5. Figures A5-A8 (attached) present the resulting simulated fit to observed water level data; Table 2.5 presents the associated scaling factors applied

Table 2.5. Estimated Scaling Factors for Simulated fit of Observed FDC Response to June 23, 2017 Storm Event

Zone	Description	Scaling Factor[1]
1	Black Walnut Trail – north of gauge F5	0.67
2	Area west of Lisgar Creek (Golden Locust Drive)	0.30
3	Black Walnut Trail between F5 and F1	0.30
4	Black Walnut Trail between F1 and F6 (including Scotch Pine Gate area)	0.20
5	Areas downstream of F6	0.20

1. Inflow at each node within zone is determined by the unitary flow hydrograph multiplied by the incremental drainage area to each node multiplied by the scaling factor.

Figures A5-A8 indicate a good fit to the observed data at the upper end of the system (F13, F14, and F24). The fit at gauge F5 somewhat underestimates the observed peak water level, and also the timing of the rising limb. This is notable considering that the responses at gauges F13 and F14 are well matched, and there is a minimal additional contributing drainage area at this point. This potentially suggests a more direct source of rapid inflow between these locations. One potential source could be the roadway sag point at Black Walnut Trail and Cactus Gate. As demonstrated through the most recently completed storm sewer leakage testing, catchbasin subdrains have been demonstrated to be the primary source of inflow to the FDC system. A higher degree of inflow would be expected at roadway sag points. Further assessment would be required to confirm this more definitively, however this would appear to be a reasonable explanation.

While the peak water level at gauge F1 is well matched, the overall simulated shape is somewhat more peaky than the observed form. This may be attributable to the under-estimation at gauge F5 as noted previously. Conversely, the observed response at the downstream gauge F6 is somewhat overestimated; the simulated effects of routing and attenuation are not as evident as in the observed results. Overall however, the simulated modelling provides a good representation of the observed water level responses, and provides a reasonable approximation for the assessment of the effectiveness of mitigation measures, as discussed further in Section 3.

2.4. July 13-14, 2017 Storm Event

A similar approach to that applied for the June 23, 2017 has been employed for the simulation of the July 13-14, 2017 storm event. Figure A9 presents the observed water level responses for this storm event. Key statistics and parameters are presented in Section 2.2; a more detailed analysis of the specifics of this storm event is also included as part of the previously prepared August 1, 2017 memorandum.

In order to simulate the storm event response, a unitary flow response is again required. Based on the locations of observed surcharge, and the contributing drainage area, the gauge response at F13 has been selected. This location is somewhat elevated compared to the other most upstream FDC monitoring gauge (F14), with an invert approximately 1 m +\- higher. Further, the F13 gauge indicates less of a surcharged response than F14, which potentially allows for a more unattenuated unitary response (i.e. less impacted by surcharge/pressure flow and backwater). Notwithstanding, a notable surcharge is still observed at this gauge, which renders the development of a unitary flow response approximate at best, particularly given the dynamic and variable nature of the July 13-14, 2017 storm event (highly localized/spatially variable thunder storm). The observed water level at F13 has been converted to an estimated flow using a combined theoretical rating curve; Manning's Equation for low (unpressurized) flows, transitioning to an orifice equation approach for pressure flows. The resulting flow hydrograph is then divided by the contributing drainage area (3.28 ha for gauge F13) to develop a unitary flow response ($m^3/s/ha$). The unitary flow response function has then been applied to hydraulic model nodes, based on the contributing FDC drainage areas (as presented in Figure A2). Scaling factors (i.e. multiplier for unitary flow response to be applied at each node) are then determined/estimated iteratively, in order to attempt to replicate the observed water level responses for the storm events.

Using an iterative approach, scaling factors have been first approximated for the Zone 1 area (i.e. gauges F13 and F14), and subsequently for Zone 2 (gauge F24). Once these scaling factors have provided a reasonable approximation of the observed water levels for these areas, additional scaling factors are developed for Zones 3, 4 and 5. Figures A9-A12 (attached) present the resulting simulated fit to observed water level data; Table 2.6 presents the associated scaling factors applied based on the overall iterative process.

Table 2.6. Estimated Scaling Factors for Simulated fit of Observed FDC Response to July 13-14, 2017 Storm Event

Zone	Description	Scaling Factor[1]
1	Black Walnut Trail – north of gauge F5	0.26 to 0.34[2]
2	Area west of Lisgar Creek (Golden Locust Drive)	0.17
3	Black Walnut Trail between F5 and F1	0.03
4	Black Walnut Trail between F1 and F6 (including Scotch Pine Gate area)	0.03
5	Areas downstream of F6	0.03

1. Inflow at each node within zone is determined by the unitary flow hydrograph multiplied by the incremental drainage area to each node multiplied by the scaling factor.
2. Higher factors applied to areas tributary to F13, and area between F13 and F15; lesser factors applied to areas tributary to F14.

The results presented in Figure A10 present the current fit to observed data at gauges F13 and F14. The results indicate that while the overall peak water level is reasonably well represented, the overall timing and shape is not as well represented. The simulated first peak response is delayed compared to the observed data; and the secondary simulated peak is larger than what was observed. The secondary peak represents the impacts of tailwater downstream (additional flow inputs further downstream); which is discussed further in relation to other monitoring sites. As evident in Table 2.6, the highest proportion of relative flow contributions are still estimated to be sourced from this area.

The results presented in Figure A11 (gauge F24 – west side of Lisgar Creek) indicate a reasonably good overall fit to both the simulated peak water level, as well as the timing of the rising limb. However, the simulated results indicate a more pronounced secondary peak than was observed; this peak is considered the result of downstream tailwater/backwater. As per Table 2.6, this area also indicates a relatively elevated rate of estimated flow contribution compared to downstream areas. Notwithstanding, only one (1) property reported basement water infiltration in this area, along Golden Locust Trail. However, the results suggest that this area may be contributing additional flows and impacting downstream areas, while not being directly impacted given the relative depth of the FDC sewer system in this area, and the elevation difference between the system in this area and that along Black Walnut Trail (FDC sewer invert at gauge F24 is some 3 m +\- higher than the FDC sewer node at Black Walnut Trail and Terragar Boulevard).

The results presented in Figure A12 for gauge F5 indicate similar results to that for the June 23, 2017 storm event. While the simulated result reasonably represents the observed conditions, the peak is under-estimated, and the rising limb is also delayed compared to observed conditions. This again suggests an additional source of inflow in this area, potentially from the sag point at Black Walnut Trail and Cactus Gate. Some of the difference in this case could however also be attributable to the representation of observed water levels at upstream gauges F13 and F14; if the rising limbs of these responses were better represented, it is possible the response at gauge F5 would also be better represented.

Lastly, the results presented in Figure A13 indicate that downstream responses at gauges F1 and F6 are both under-estimated. Both the peak observed water level, and shape (rising and falling limbs, and overall duration) are also not as well modelled. This suggests additional flow contributions in this downstream area, or more elevated tailwater/backwater restrictions. Further model iterations have been undertaken which increase scaling factors (relative flow contributions) for areas in zones 3, 4 and 5. However, these iterations determined that further flow contributions result in worsened data fits for upstream areas (gauges F13, F14, and F24) due to tailwater impacts, with the secondary observed water level peak becoming excessively pronounced.

Overall, the current simulated results for the July 13-14, 2017 storm event do not provide as good a fit as those for the June 23, 2017 storm event. This is considered attributable to a number of factors, including:

- The dynamic and spatially variable nature of the storm event (thunder storm event) – thus the unitary flow hydrograph employed for all locations may not be as representative of actual conditions in other locations.
- The fact that the model is not an “all pipes” model – thus full system-wide pipe routing and storage factors may not be fully accounted for, particularly given the longer duration and elevated water levels associated with the July 13-14, 2017 storm event.
- The potential role of the loss of flow and storage from basement water infiltration (which is not accounted for in the modelling).
- Lack of gauging information for the large FDC flow input from Scotch Pine Gate (43.8 ha) to verify the relative contributions from this large area.
- Assumed boundary conditions – additional flow inputs further downstream (of Derry Road) may result in higher tailwater conditions than simulated within the modelling using a normal boundary condition downstream of gauge F2.

Notwithstanding, the generated responses are considered the best feasible fit to the data given the above noted constraints. As noted, further increases in downstream flow contributions to downstream areas (Zones 3, 4, and 5) result in worsened fits for downstream areas. As such, the current simulation results for the July 13-14, 2017 storm event are considered acceptable, and sufficient for the purposes of the current assessment of mitigation alternatives, as discussed further in Section 3.

2.5. Additional Analyses

The preceding analyses have focused on the response of the FDC system to two (2) formative storm events (June 23 and July 13-14, 2017). Notwithstanding, it is considered that there could be potential value in simulating other observed formative storm events as noted in Section 2.2 (specifically September 8, 2012, June 12, 2014, and September 10, 2014). In addition, modelling of the FDC surcharge event of September 2, 2014 has also previously been completed (December 2014 presentation materials). These events may yield additional insights into the FDC response, and could be applied to the simulation of mitigation measures (discussed further in Section 3).

As per the approved work plan (November 13, 2017), these data could also be used to support a further assessment of the hydrologic relationship between estimated peak flows and corresponding surface drainage areas (i.e. contributing FDC catchments) and rainfall intensity using simplified approaches (similar to the Rational Method). These results would then be used to develop a range of expected flows under more formative storm events which would allow for a form of statistical analysis. These relative increases could then be applied to the other model simulations to assess the relative increase in pumping capacity required.

These analyses have not been completed as part of the current assessment, however it is suggested that these measures be considered as part of subsequent analyses in order to confirm the preferred approach as the project advances towards detailed design.

3. Mitigation Analysis

3.1. Review of Potential Locations and Mitigation Strategies

Overview

Based on previous discussion with City staff, the FDC pumping station was notionally proposed for the Cactus Gate Parkette, in order to take advantage of synergies with the proposed utility trench dewatering system, also to be constructed at the Cactus Gate Parkette in 2018. It is expected that these synergies would result in some overall reductions in the level of effort associated with the design and construction services required for the FDC pumping station, in particular during the tendering and construction phase (since these two projects would then be expected to be tendered and constructed as a single project).

Notwithstanding, the Cactus Gate location has not, as of yet, been definitively confirmed as the preferred location for the FDC pumping station. As part of the broader scale assessment, prior to committing to this location, a comprehensive review of potential locations is to be completed. Given the locations of reported basement water infiltration for the July 13-14, 2017 storm event, it is suggested that the pumping station would be located somewhere along Black Walnut Trail, however there are multiple potential locations which could be considered.

A key consideration is public (City) land ownership. Given the limited capacity of storm sewers within the Lisgar District (originally designed to a 2-year return period standard, given shallow grades and lack of ground cover), it is considered preferable that any FDC pumping station have a “free” outlet, likely to a surface drainage feature with a direct connection to Lisgar Creek. This would restrict potential FDC pumping stations to locations with immediate access to the creek, given that property acquisition is considered cost-prohibitive and unlikely to be supported by area property owners. Based on the preceding, potential locations would include:

- Black Walnut Trail at Cactus Gate Parkette
- Russian Olive Close at Buttonbush Park
- Terragar Boulevard at Lisgar Creek (within the roadway right-of-way)
- Black Walnut Trail at Smoke Tree Road Parkette
- Black Walnut Trail at Scotch Pine Gate Parkette
- Black Walnut Trail at Wild Cherry Lane easement

Potential locations are illustrated in Figure A14 (attached). These potential options have been briefly assessed herein for feasibility.

Black Walnut Trail at Cactus Gate Parkette

As noted previously, the Cactus Gate Parkette was notionally considered to be the preferred option for the FDC pumping station, given the potential synergy with the proposed utility trench dewatering system. This would minimize requirements for additional field investigations for any secondary site – utility locates, topography, and geotechnical investigations in particular. It would also likely add efficiency to the design and construction phases, by focusing on a single site rather than two.

As suggested in Amec Foster Wheeler's memorandum of August 1, 2017, the current utility trench dewatering system design could be revised to incorporate a permanent FDC sewer pumping component. Based on a preliminary review, this could include two (2) different layouts. In the first, an FDC overflow pipe would be constructed parallel to Black Walnut Trail (from the upstream maintenance hole at Cactus Gate) with flows from the utility trench dewatering system and the FDC system ultimately directed to a common pumping maintenance hole (two different capacity pumps, low and high capacity units respectively, could be considered accordingly). In the second layout, a separate pumping maintenance hole would be implemented at the north limits of the site, with the FDC overflow pipe being perpendicular to Black Walnut Trail (likely replacing the existing stub FDC line within the Cactus Gate Parkette).

Based on the results of the forensic hydraulic modelling, the highest rate of FDC flow contributions is sourced from this area (Zone 1). This is also consistent with past observations of FDC pipe surcharging from previous annual monitoring reports (and the data presented in Table 2.3). Only four (4) of the thirty-five (35) properties which reported basement water infiltration for the July 13-14, 2017 storm event would be located upstream of this location however. Notwithstanding, it is considered that the value of and FDC pumping station at this location would be to remove the highest estimated relative FDC flow contributions as far upstream as possible, in order to reduce flows downstream and associated FDC surcharging impacts to residences.

Disruptions to local traffic would be expected during construction, as the intersection of Black Walnut Trail and Cactus Gate would require closure during the work. However, this intersection would require closure regardless for the construction of the utility trench dewatering system. It is noted however that MiWay Route 32 (to the Lisgar GO Station) does travel along this section of roadway, and would require diversion during construction.

Based on the preceding, the Cactus Gate parkette is considered to be a viable potential location for an FDC pumping station, and is assessed further as part of the additional hydraulic analyses discussed further in Section 3.2.

Russian Olive Close at Buttonbush Park

The results for the forensic hydraulic modelling of the FDC system indicate that after Zone 1, which has the highest relative contributions, Zone 2 (west of Lisgar Creek – Golden Locust Drive) has the next highest relative rates of FDC flow contributions. The results suggest that this area may be contributing additional flows and impacting downstream areas, while not being directly impacted given the relative depth of the FDC sewer system in this area, and the elevation difference between the system in this area and that along Black Walnut Trail (FDC sewer invert at gauge F24 is some 3 m +\- higher than the FDC sewer node at Black Walnut Trail and Terragar Boulevard). Only one (1) property along Golden Locust Drive reported basement water infiltration for the July 13-14, 2017 storm event.

One potential location for and FDC pumping station would be along Russian Olive Close at Buttonbush Park. This location would divert excess flows from the FDC sewer line easterly through the park, discharging to Lisgar Creek. This would reduce flow impacts to the downstream FDC system, and more vulnerable residences along Black Walnut Trail.

Although an FDC pumping station in this location would likely benefit downstream properties, the relative contributing area (7.8 ha +\-) would be less than that for a location at the Cactus Gate Parkette (9.7 ha +\-), and at a lesser estimated relative rate of FDC flow contribution. Further, as noted only one (1) property has reported basement water infiltration for the July 13-14, 2017 storm event in this area, compared to the higher number of reported properties along Black Walnut Trail.

Based on the preceding, the Russian Olive Close at Buttonbush Park site is not considered to be a high priority location for the initial FDC pumping station installation. Further monitoring of this area is recommended for 2018 to determine whether FDC surcharging would extend to this additional area, and the relative benefit of pumping in this area as opposed to other excess FDC inflow mitigation efforts.

Terragar Boulevard at Lisgar Creek (Roadway Right-of Way)

An FDC pumping station could potentially be considered within the roadway right-of-way on Terragar Boulevard, with an outlet directly to Lisgar Creek. In order to maximize the benefit of such an FDC pumping station, it is suggested that such a station would be located on the north-east side of the culvert crossing, and would divert high flows from Zone 2, but also potentially Zone 1, by incorporating a relief pipe from the FDC trunk at Black Walnut Trail and Terragar Boulevard. This would potentially reduce excess FDC inflows from a larger area (29.3 ha +\-) and thus have a greater benefit to properties downstream. It is noted that the majority of the residences affected by the July 13-14, 2017 storm event are located along Black Walnut Trail south of Terragar Boulevard, and would therefore benefit directly from this additional diversion.

Notwithstanding the preceding benefits, the Terragar Boulevard right-of-way is considered to be a constrained location for construction. Terragar Boulevard is an arterial roadway for the area, and the only available roadway crossing of Lisgar Creek north of Derry Road. Given the expected duration of construction (2 months +\-) the potential impact to area residents would be a concern.

In addition, this location is only some 150 m +\- downstream of the parkette at Cactus Gate, and 250 m +\- upstream of the parkette at Smoke Tree Road, suggesting there is minimal benefit to this specific location when other more available locations are in close proximity.

Based on the preceding, the Terragar Boulevard site is not considered a feasible location for the initial FDC pumping station installation. Locations immediately upstream (Cactus Gate Parkette) or downstream (Smoke Tree Road) are considered to be preferable locations.

Black Walnut Trail at Smoke Tree Road Parkette

Similar to the parkette at Cactus Gate, the City of Mississauga also owns a parkette along the west side of Black Walnut Trail at Smoke Tree Road. This location could similarly be used for the construction of an FDC pumping station, and would reduce works within the right-of-way. Local traffic would be impacted during the construction work, however there are no MiWay transit routes which use this section of Black Walnut Trail. Traffic would need to be re-directed to the north of south to access Terragar Boulevard.

This location would serve a larger drainage area (38.4 ha +\-) than the Cactus Gate location (9.7 ha +\-) however, including Zones 1, 2 and 3. However, this location would be further downstream from residences which reported basement water infiltration for the July 13-14, 2017 storm event (14 of the 35 residences would be upstream of this location). As such, further hydraulic modelling is required to determine how effective an FDC pumping station would be in reducing both upstream and downstream FDC surcharging.

Based on the preceding, the Smoke Tree Road Parkette site is considered a viable potential site for an FDC pumping station. Further hydraulic analyses are required to determine the relative benefit of this site as compared to the Cactus Gate Parkette, or whether a combination of both sites would yield the most efficient reduction in flows.

Black Walnut Trail at Scotch Pine Gate Parkette

The City of Mississauga also owns a parkette 180 m +\- south of the Smoke Tree Parkette, at Scotch Pine Gate. This location has been monitored extensively as part of previous analyses and investigations, including numerous boreholes and piezometers, and the construction of a pilot utility trench collar (along with the other construct collar at Pondview Way).

This location would potentially serve a large drainage area (83.0 ha +\-) due to the large contributing FDC drainage area to the east along Scotch Pine Gate (43.8 ha +\-). Similar to the Smoke Tree Road location however, this location would be even further downstream from residences which reported basement water infiltration for the July 13-14, 2017 storm event (22 of the 35 residences would be upstream of this location). As such, it is expected that an FDC pumping station in this location would be of a lesser benefit. This is also confirmed by the results of the forensic modelling of the two 2017 FDC surcharge events, which noted a much lesser degree of relative FDC inflows for downstream areas. Further data on the Scotch Pine Gate FDC branch should also be collected, to confirm the relative rates of inflow from this sizeable area.

Based on the preceding, the Scotch Pine Gate Parkette is not considered a preferred location for an FDC pumping station. The location upstream at Smoke Tree Road is considered preferable as it would be targeted at the estimated higher rates of excessive FDC inflow from these areas, and would benefit a greater number of downstream properties.

Black Walnut Trail at Wild Cherry Lane Easement

The City of Mississauga holds a 7.5 m easement over the section where the storm, sanitary, and FDC sewer services pass between Black Walnut Trail and the east side of the Lisgar Creek corridor. This location could potentially also be used for and FDC pumping station. However, the same reasons noted for the Scotch Pine Gate parkette would again apply to this location; namely that it is too far downstream to have any direct benefit to affected properties, and would not target the areas identified as having the highest relative rates of excess inflow to the FDC system. The Wild Cherry Lane area would also be further constrained as the City does not directly own the property, but simply holds an easement, over a more limited space than for the upstream parkette areas. Further, it is evident that the adjacent homeowners in this area have encroached on the easement area with development, which would further complicate construction in this location.

Based on the preceding the Wild Cherry Lane area is not considered a preferred location for an FDC pumping station.

Summary

Based on the preceding screening, the preferred locations for an FDC pumping station are considered to be:

- Black Walnut Trail at Cactus Gate Parkette
- Black Walnut Trail at Smoke Tree Road Parkette

These locations will be assessed further for their technical effectiveness (individually and in combination) using the hydraulic modelling developed for the June 23 and July 13-14, 2017 storm events. This is presented in Section 3.2.

As per the preceding discussion, an FDC pumping station at Buttonbush Park may be considered in the future, however further monitoring in this area is considered warranted to assess the degree of FDC surcharging. Follow-up hydraulic modelling could be completed following the collection of additional data for this area.

3.2. Hydraulic Modelling Analysis

Overview and Methodology

In order to verify the effectiveness and feasibility of FDC pumping station(s) at the short-listed locations, the previously developed hydraulic modelling has been applied.

It is considered that any FDC pumping station would be constructed using a flow diversion from the FDC trunk sewer. A new FDC sewer pipe would be constructed which connects to an existing FDC maintenance hole, and directs the flows westerly to a new maintenance hole. This maintenance hole would serve as the pumping station/wet well, with pumped flows to be directed either to the storm sewer system, or preferably directly to surface to avoid tailwater/backwater impacts, and given the expected lower frequency of pump operation in this case as compared to the utility trench dewatering system (i.e. only during more formative storm events which cause FDC surcharge). The diversion pipe would need to be carefully sited (i.e. invert elevation offset as compared to the trunk FDC sewer) and sized (sufficient capacity to convey overflows to the pumping station MH, while fitting within the dimensions of the existing MH along Black Walnut Trail).

Prior to assessing wet well dimensions and pump capacities, the modelling has been applied to determine the required size of a diversion FDC sewer pipe. A “free” boundary condition has been assumed for the outfall of the diversion sewer pipe, based on the assumption of a sufficient capacity pumping system and wet well that tailwater would not be a concern.

In addition to the preceding, consideration could also be given to restricting flows into the existing FDC system at the point of diversion (existing MH) to force a greater proportion of flow towards the FDC pumping station. This would increase the frequency of pump operation, but would also further restrict excess FDC flows to the downstream trunk sewer system.

Several different modelling scenarios have been conducted based on the preceding general approach, and identified preferred locations.

Scenario 1: Diversion at Cactus Gate Parkette Only

Under this scenario, the existing FDC maintenance hole at Cactus Gate and Black Walnut Trail would be used for the FDC diversion. A new FDC diversion sewer would be constructed from the west section of the MH towards a new pumping station MH within the parkette. An entry loss coefficient of 1.0 has been applied to the diversion sewer to reflect the hydraulic inefficiency of the skew (90 degree) angle of the inlet. Consideration will be required to maximum size that can be accommodated within the existing FDC maintenance hole, which as per plan and profile drawings is a 1200 mm diameter circular unit. Based on this dimension, the maximum diameter of any diversion pipe is considered to be 600 mm.

It is noted that there is a stub 250 mm diameter FDC connection through the parkette at this location; this would likely need to be removed to support the installation of the new diversion sewer. There is also a parallel sanitary sewer line which is active (serves development to the north of the CNR) and is in close proximity (both in plan and profile) to the FDC stub. Any FDC diversion sewer would need to carefully consider this feature; and would potentially need to be aligned away from this sewer to accommodate the large pumping station maintenance hole that would ultimately be required.

Two different sub-scenarios have been considered as part of this overall scenario:

- **Scenario 1a** – diversion sewer placed above obvert of existing 250 mm diameter FDC trunk sewer (invert elevation of 198.43 m +\-), existing FDC sewer outlet remains as is
- **Scenario 1b** – restrictor plate placed on existing 250 mm diameter at springline (i.e. 50% of full depth), and FDC diversion sewer placed above the springline (invert elevation of 198.31 m +\-).

Scenario results are presented in Table 3.1. Hydraulic gradeline (HGL) plots are presented in Figures A15 to A20 (attached).

Table 3.1. Hydraulic Modelling Results for Scenario 1 (Diversion at Cactus Gate Parkette Only)

Scenario	Storm Event	Node Inflow (m^3/s)	Diversion Pipe Diameter (mm)	Diverted Flow (m^3/s)	Remaining Flow (m^3/s)	HGL Reduction along Black Walnut Trail (m)
1a	June 23	0.096	250	0.047	0.050	0.44 – 1.47
			600	0.051	0.045	0.48 – 1.62
	July 14	0.094	250	0.046	0.049	0.82 - 2.62
			600	0.051	0.046	0.85 - 2.77
1b	June 23	0.096	250	0.058	0.038	0.67 – 1.38
			600	0.066	0.029	0.71 – 1.49
	July 14	0.094	250	0.057	0.037	0.89 – 2.37
			600	0.066	0.028	0.95 – 2.46

The simulated results indicate that a flow diversion at Cactus Gate would notably reduce the hydraulic gradeline (and associated FDC surcharging) during both simulated events, but would not totally eliminate it. Residual surcharging is indicated particularly for downstream areas for the June 23, 2017 storm event; notably, residual surcharging is minimal for the July 14, 2017 event (which had a notably higher FDC response). This is considered attributable to the higher relative rates of flows for Zones 3, 4, and 5 for the June 23, 2017 storm event. Given the uncertainty with respect to the modelling, and in particular to the estimation of water levels for the downstream area for the July 14, 2017 storm event, these results should be interpreted with caution. Notwithstanding, the results do indicate that a flow diversion would be effective in reducing the HGL for both simulated storm events, from between 0.44 and 2.77 m, depending on the location.

The simulation results indicate that the HGL reduction is relatively insensitive to the size of the diversion pipe, with minimal differences indicated between a 250 mm diameter pipe, and a much larger 600 mm diameter pipe. The simulated results also indicate a minimal benefit from an orifice restrictor on the mainline FDC pipe.

Based on the simulated peak flow rates, a pump with a capacity of between 46 and 66 L/s would be required to address diverted flows without any accumulation within a wet well pumping area; this could be readily addressed by commercially available pump units. This would equate to a pumping capacity of up to 871 USGPM, which is notably less than the maximum capacity of commercially available 6” centrifugal pumps.

Scenario 2: Diversion at Smoke Tree Road Parkette Only

Under this scenario, the existing FDC maintenance hole at Smoke Tree Road and Black Walnut Trail would be used for the FDC diversion. A new FDC diversion sewer would be constructed from the west section of the MH towards a new pumping station MH within the parkette. An entry loss coefficient of 1.0 has been applied to the diversion sewer to reflect the hydraulic inefficiency of the skew (90 degree) angle of the inlet. Consideration will be required to maximum size that can be accommodated within the existing FDC maintenance hole, which as per plan and profile drawings is a 1200 mm diameter circular unit. Based on this dimension, the maximum diameter of any diversion pipe is considered to be 525 mm (given the inlet/outlet pipe dimensions of 375 mm).

Two different sub-scenarios have been considered as part of this overall scenario:

- **Scenario 2a** – diversion sewer placed above obvert of existing 375 mm diameter FDC trunk sewer (invert elevation of 196.94 m +\-), existing FDC sewer outlet remains as is
- **Scenario 2b** – restrictor plate placed on existing 375 mm diameter at springline (i.e. 50% of full depth), and FDC diversion sewer placed above the springline (invert elevation of 196.75 m +\-).

Scenario results are presented in Table 3.2. Hydraulic gradeline (HGL) plots are presented in Figures A21 to A26 (attached).

Table 3.2. Hydraulic Modelling Results for Scenario 2 (Diversion at Smoke Tree Road Parkette Only)

Scenario	Storm Event	Node Inflow (m^3/s)	Diversion Pipe Diameter (mm)	Diverted Flow (m^3/s)	Remaining Flow (m^3/s)	HGL Reduction along Black Walnut Trail (m)
2a	June 23	0.158	250	0.075	0.117	0.14 – 1.18
		0.167	525	0.116	0.118	0.16 – 1.54
	July 14	0.178	250	0.051	0.133	0.47 – 1.41
		0.183	525	0.062	0.132	0.49 – 1.58
2b	June 23	0.155	250	0.079	0.093	0.17 – 1.31
		0.170	525	0.118	0.072	0.19 – 1.73
	July 14	0.179	250	0.065	0.114	0.09 – 1.25
		0.184	525	0.093	0.091	0.33 – 1.52

The results presented in Table 3.2 indicate a slight variability in the simulated node inflow; this is due to the dynamic nature of the PCSWMM modelling, which can result in increased flow capacity due to changes in tailwater/backwater conditions.

Similar to the results for Scenario 1, the simulated results for Scenario 2 indicate that a flow diversion at Smoke Tree Road would notably reduce the hydraulic gradeline (and associated FDC surcharging) during both simulated events, but would not totally eliminate it. area for the July 14, 2017 storm event, these results should be interpreted with caution. The results indicate that a flow diversion at Smoke Tree Road would be effective in reducing the HGL for both simulated storm events, from between 0.09 and 1.73 m, depending on the location.

The simulation results indicate that the HGL reduction is again relatively insensitive to the size of the diversion pipe, with minimal differences indicated between a 250 mm diameter pipe, and a much larger 525 mm diameter pipe. Greater differences are however indicated in this location than were previously indicated for the Cactus Gate location however. The simulated results also indicate a minimal benefit from an orifice restrictor on the mainline FDC pipe. The simulated results for the July 14, 2017 storm event however indicate more variable results with the implementation of an orifice restrictor. While a reduced HGL is indicated downstream of the restrictor (at Smoke Tree Road), a slightly elevated HGL is indicated further upstream than without the restrictor, likely attributable to the elevated HGL within the mainline diversion MH.

Based on the simulated peak flow rates, a larger pump with a capacity of between 51 and 118 L/s would be required to address diverted flows without any accumulation within a wet well pumping area; this could be readily addressed by commercially available pump units. This would equate to a pumping capacity of up to 1,557 USGPM, which is again less than the maximum capacity of commercially available 6" centrifugal pumps.

Summary of Scenario Findings

Figures A27 and A28 (attached) present an HGL comparison of Scenarios 1a and 2a for the June 23 and July 14, 2017 storm events respectively. The results indicate that as would be expected, a diversion to an FDC pump MH at Smoke Tree Road would be more effective at reducing the HGL in downstream areas than one located further upstream at Cactus Gate. However, a diversion to an FDC pump MH at Cactus Gate would clearly be more effective at reducing the HGL in the upstream area, as would be expected. Further, the relative difference in the HGL further downstream between the two potential mitigation measures is not as significant, more so for the July 14, 2017 storm event, which indicates a minimal difference in HGL. This is again considered attributable to the modelling assumptions for this event, which assumed a lesser contribution of flow from Zones 3, 4 and 5.

Given the preceding, and the previously noted advantages and synergies of constructing the FDC pumping station in conjunction with the planned utility trench dewatering system at the same location, it is recommended that the FDC pumping station be constructed at the Cactus Gate Parkette location. Further assessment would be required to determine the incremental benefit of a secondary pumping station further downstream, such as at Smoke Tree Road. However, for the initial pumping station planned for 2018, it is suggested that the Cactus Gate parkette is the logical location.

4. Next Steps

We consider that the next steps in this effort should include:

- City to review current memorandum, with a meeting as required to discuss and confirm the preliminary preferred option with respect to an FDC pumping station (construct at Cactus Gate Parkette) and a preliminary design layout
- Amec Foster Wheeler to continue to advance additional FDC modelling work noted in this memorandum, including:
    - Simulation/re-creation of other previous FDC surcharging events, including one (1) or more of the remaining three (3) largest events (September 8, 2012, June 12, 2014, September 10, 2014)
    - Statistical analysis of relationship between simulated peak flows and drainage area and rainfall intensity, similar to a Rational Method type approach, in order to estimate potential additional flow increases associated with more intense rainfalls

- Amec Foster Wheeler to further review range of commercially available pump options with manufacturers, including related considerations (electrical/power requirements, wet well dimensions, etcetera)
- Following discussions and confirmation with City staff, Amec Foster Wheeler to advance a revised preliminary (30%) design for City review, including previous City comments on the conceptual utility trench dewatering system
- Amec Foster Wheeler to advance detailed design package, including contract materials

We trust that the foregoing meets your current requirements. We look forward to discussing this memorandum in further detail with you at your convenience, and to continue to advance this project to ensure construction is completed in 2018.

MJS\RBS

/Attached Figures A1 to A28

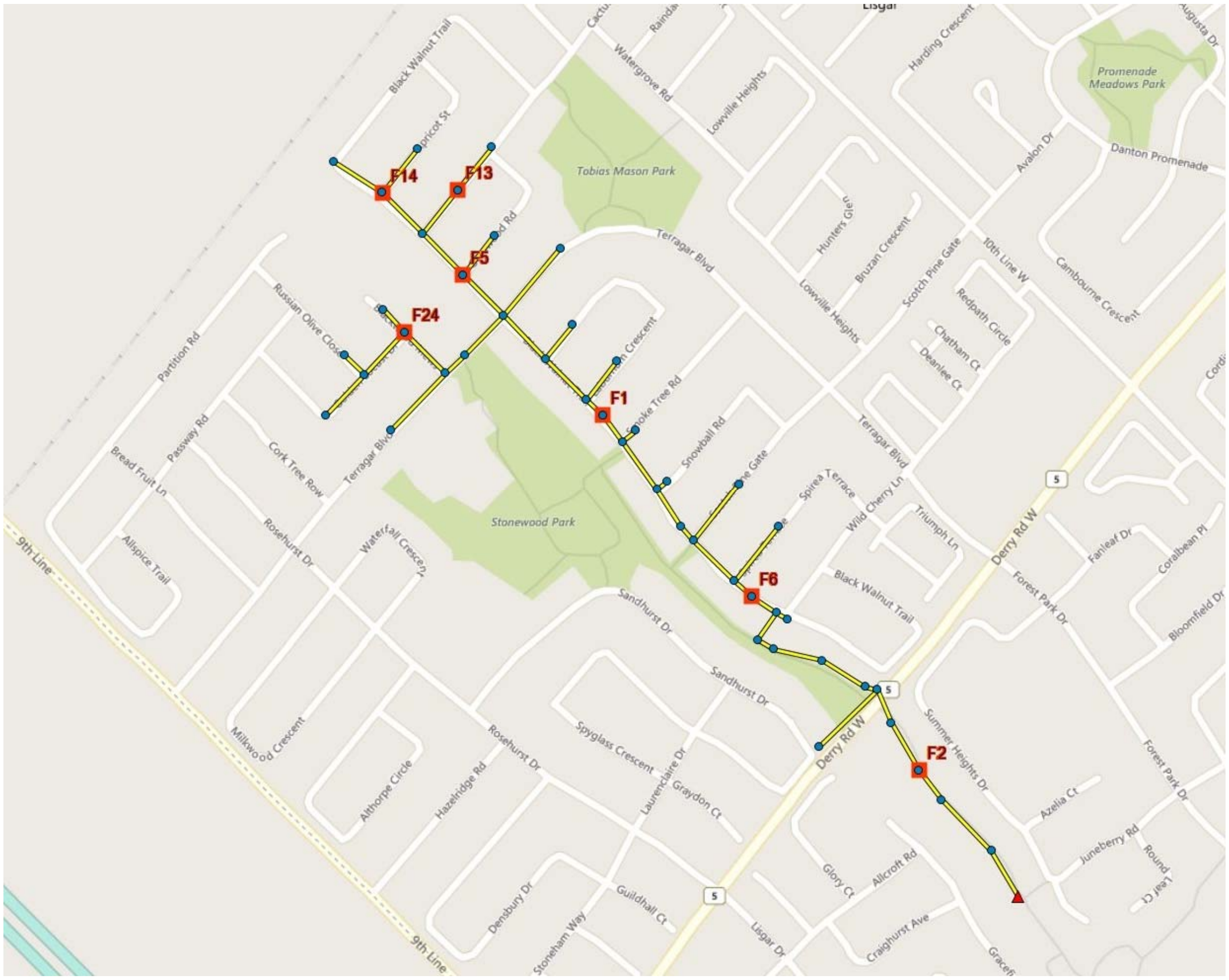


Figure A1: Extents of FDC Sewer System within PCSWMM Model and FDC Monitoring Locations

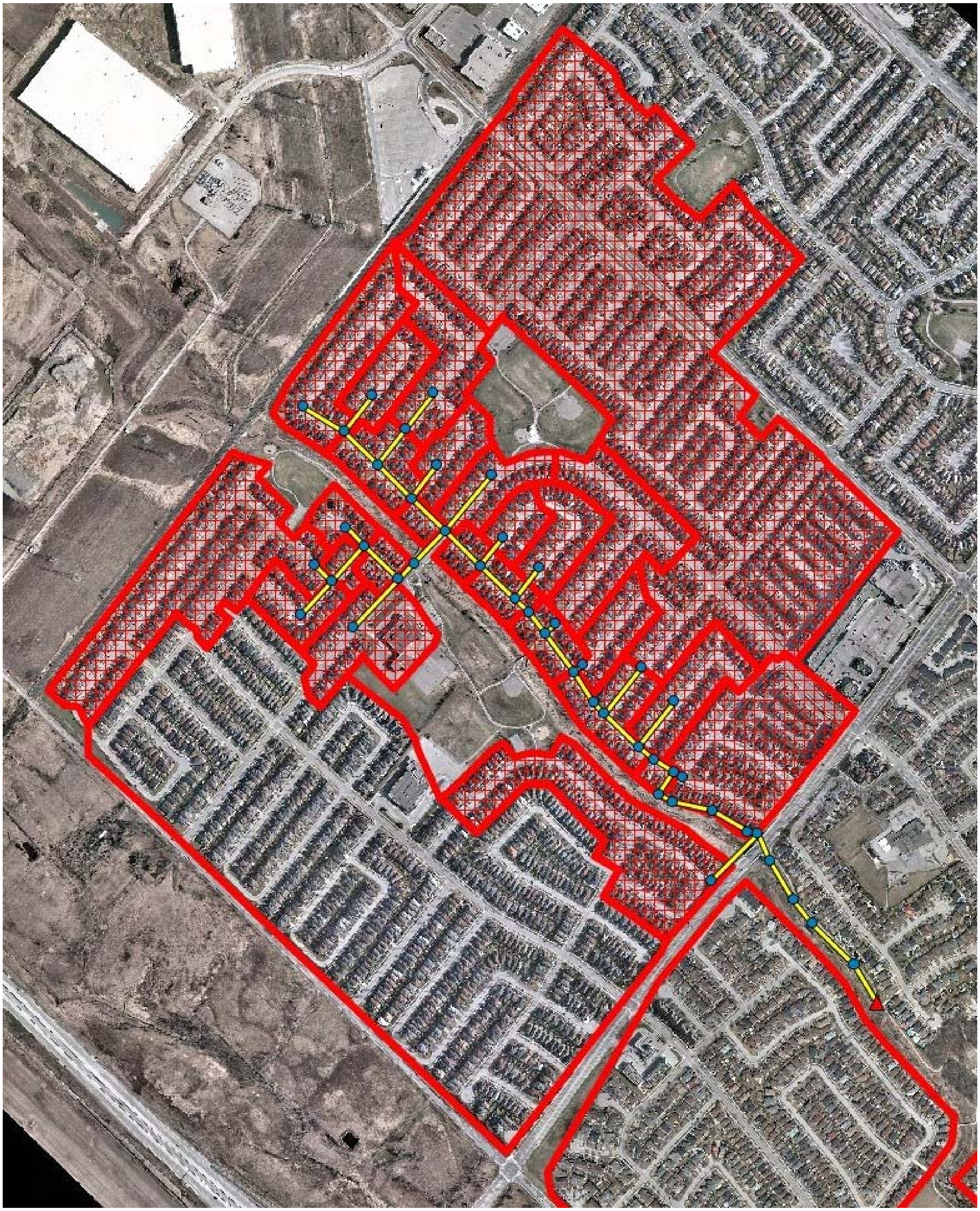


Figure A2: **Estimated FDC Contributing Drainage Areas**

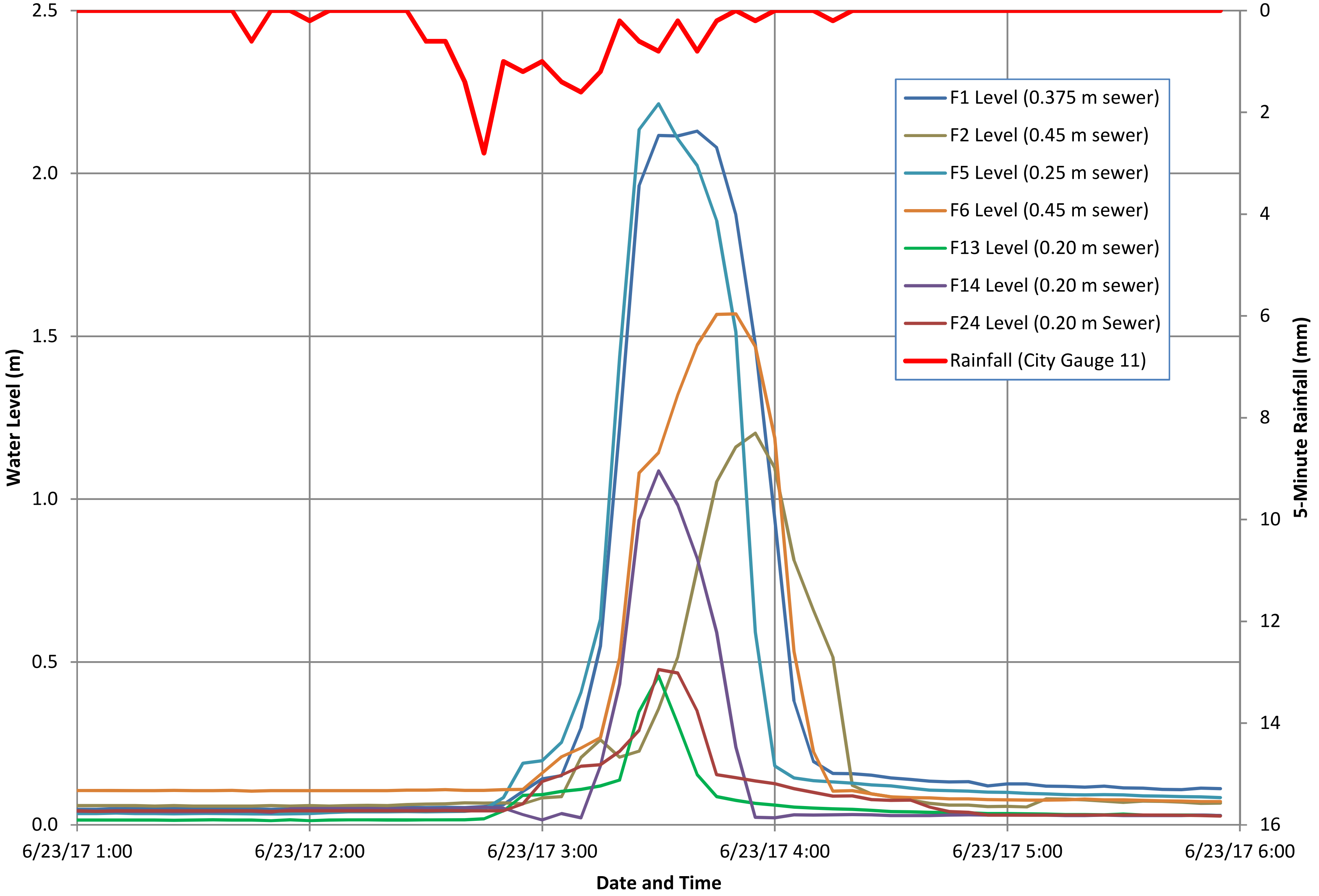


Figure A3: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - June 23, 2017 Event

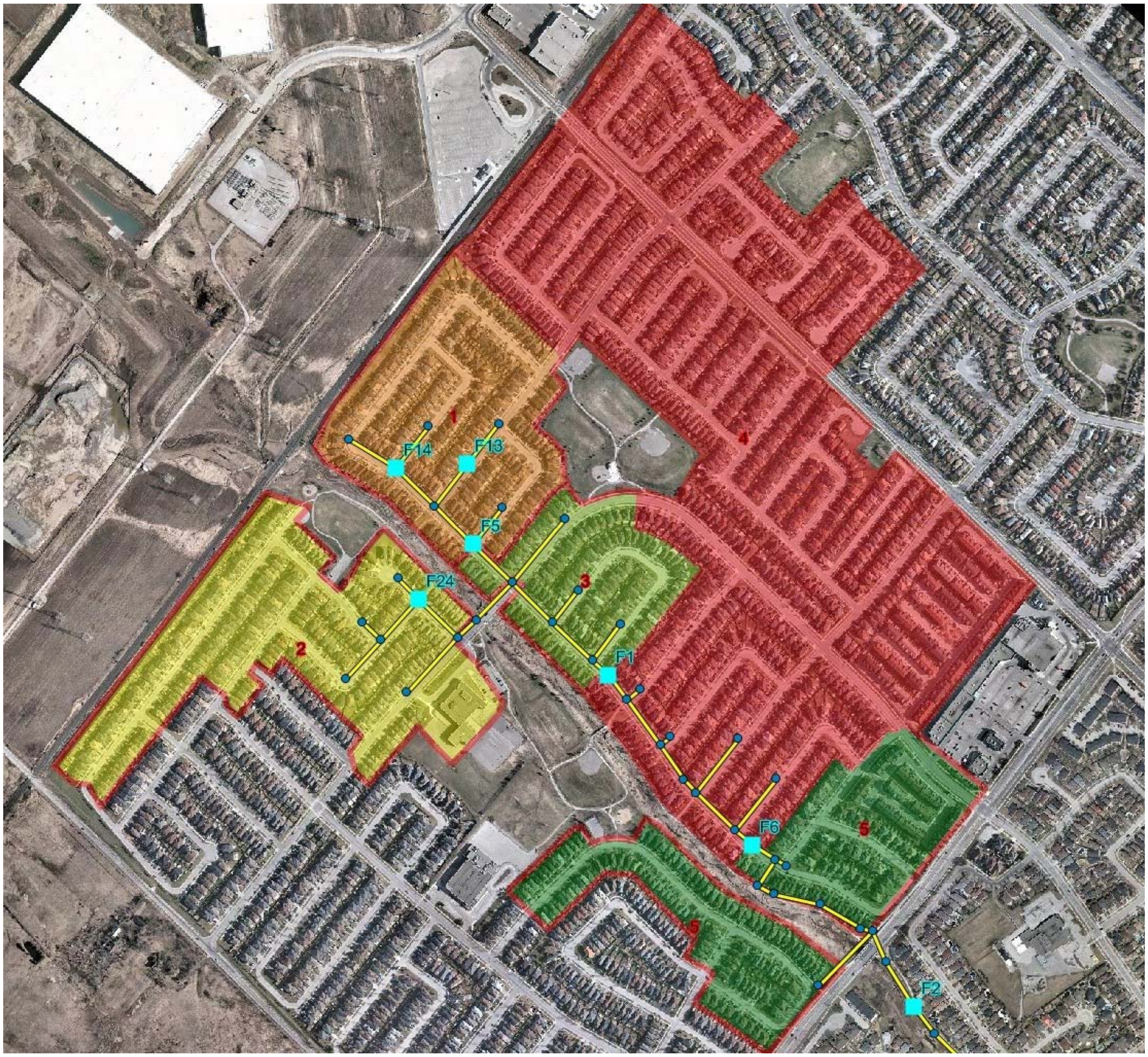


Figure A4: FDC Drainage Area Zones applied for Hydraulic Modelling Assessment

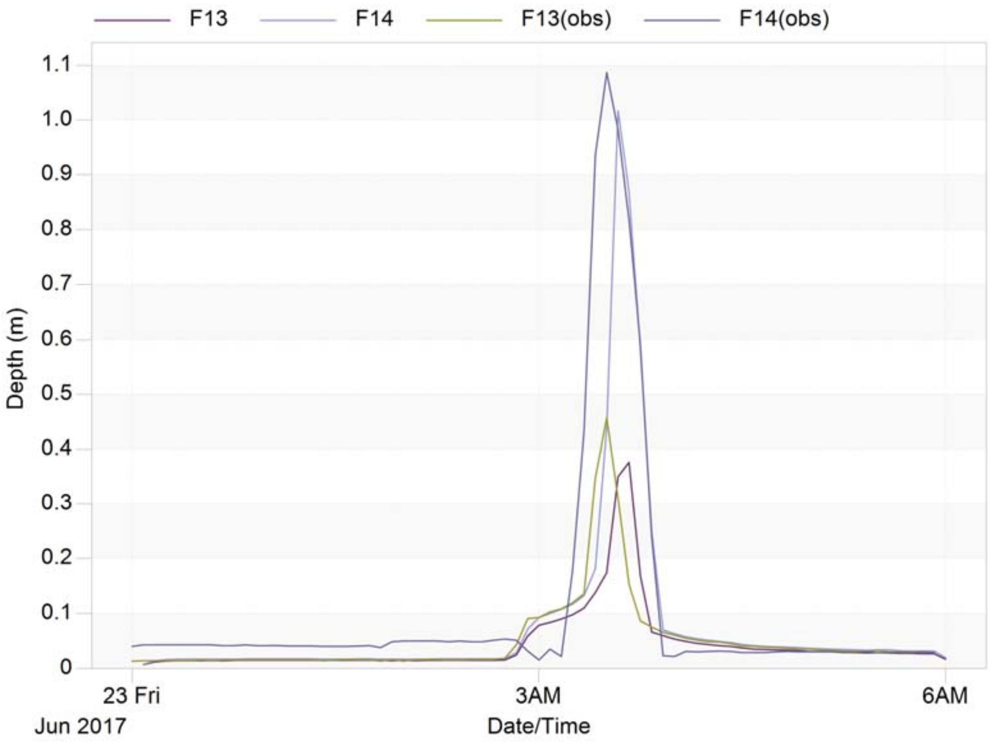


Figure A5: Simulated Fit for June 23, 2017 Storm Event – Gauges F13 and F14

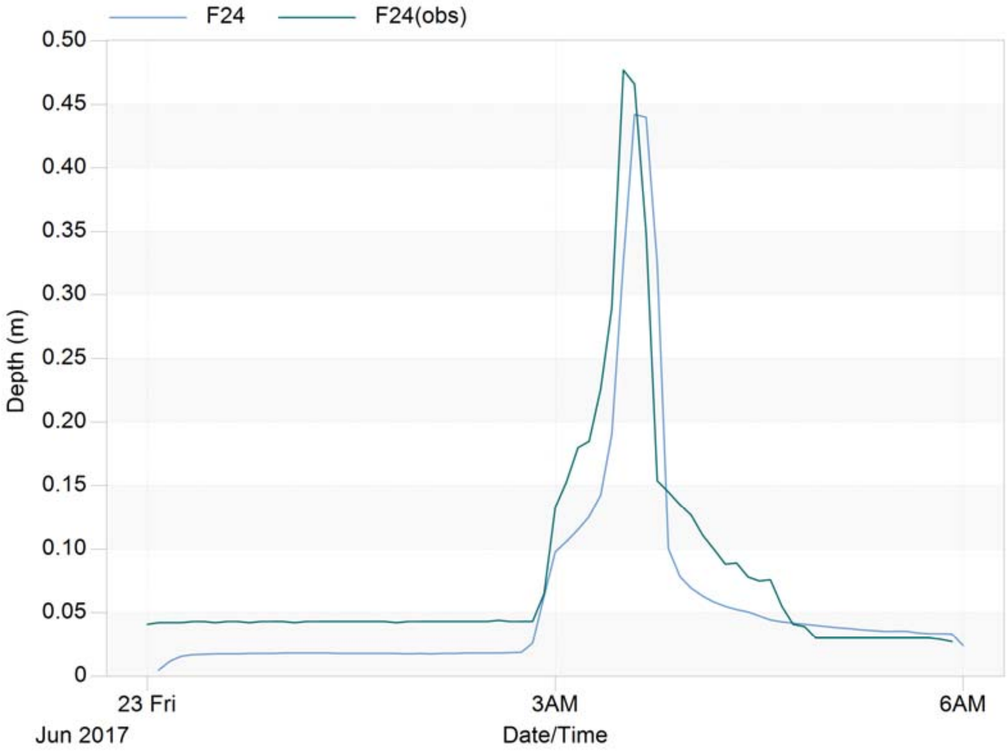


Figure A6: Simulated Fit for June 23, 2017 Storm Event – Gauges F13 and F14

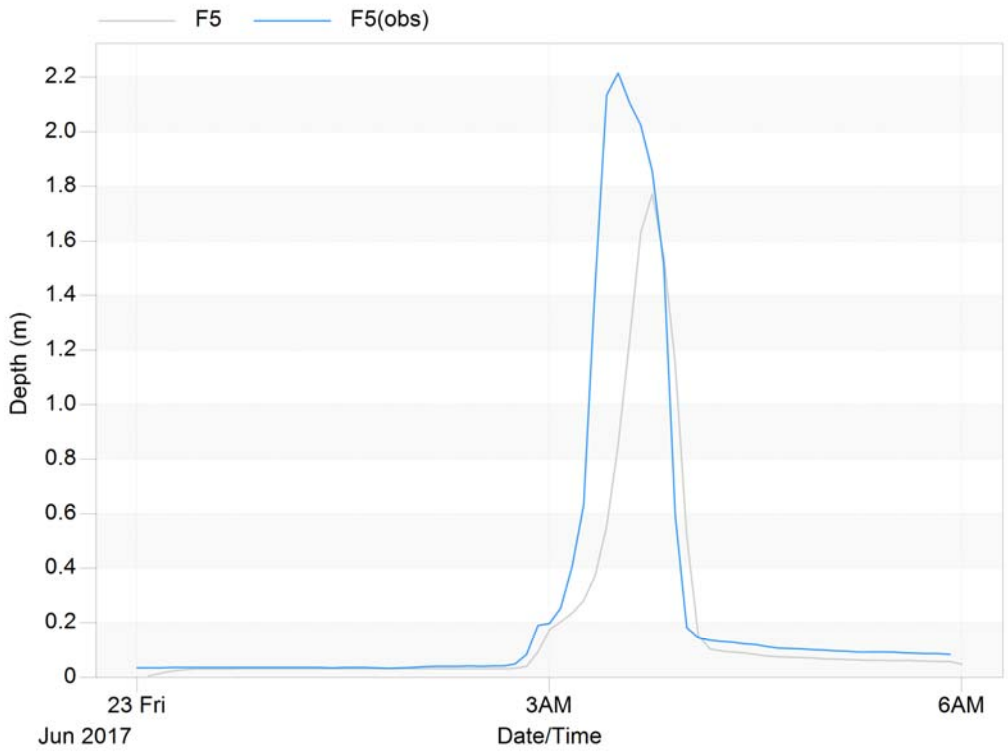


Figure A7: Simulated Fit for June 23, 2017 Storm Event – Gauge F5

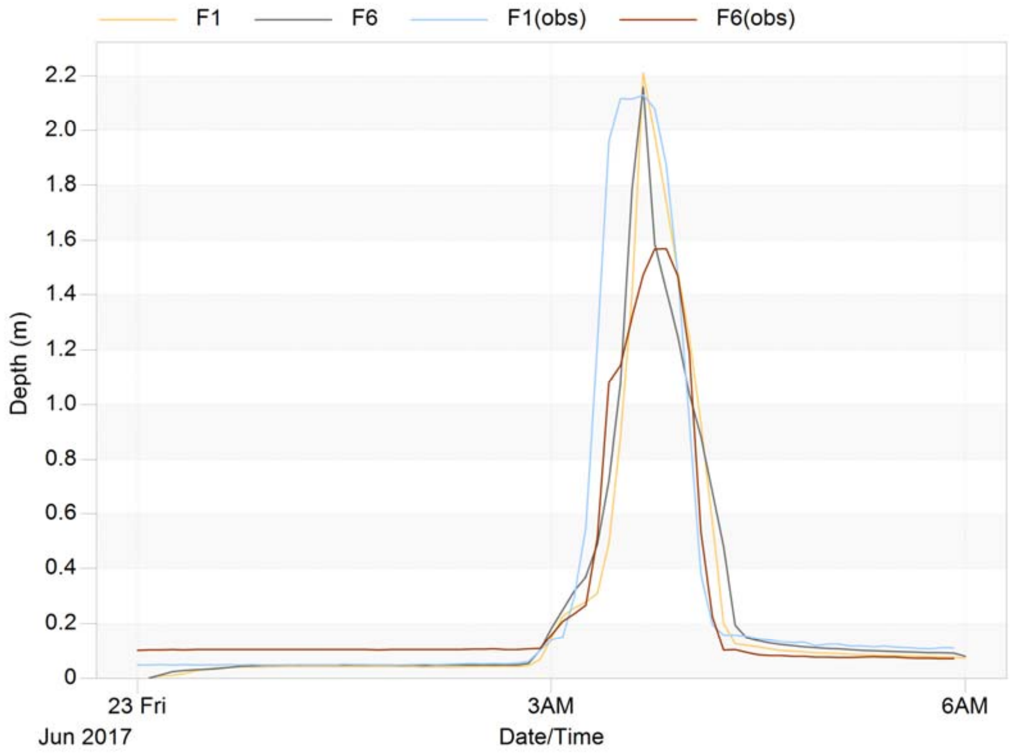
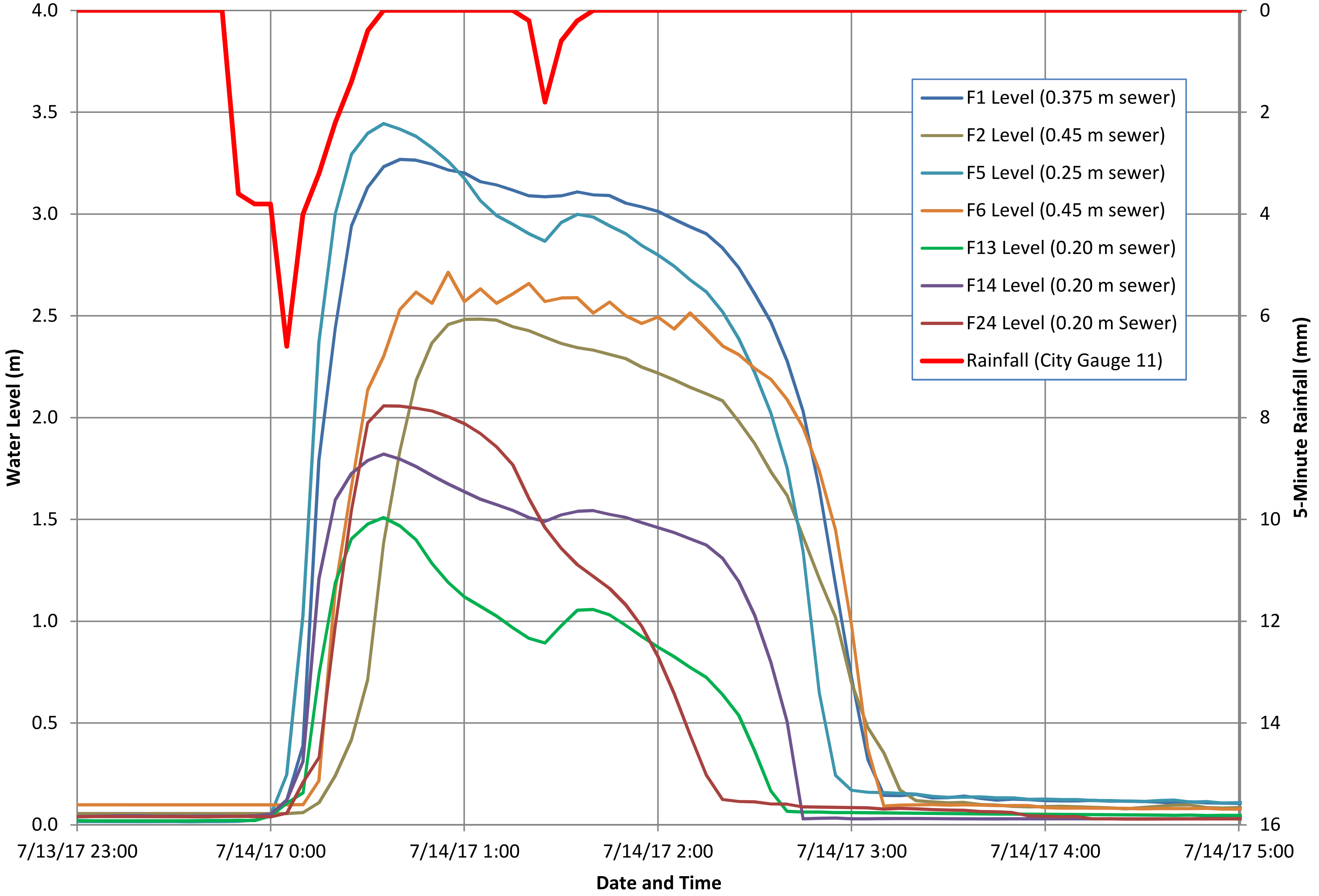


Figure A8: Simulated Fit for June 23, 2017 Storm Event – Gauges F1 and F6

Figure A9: Observed Water Levels at FDC Monitoring Sites
North of Derry Road - July 14, 2017 Event



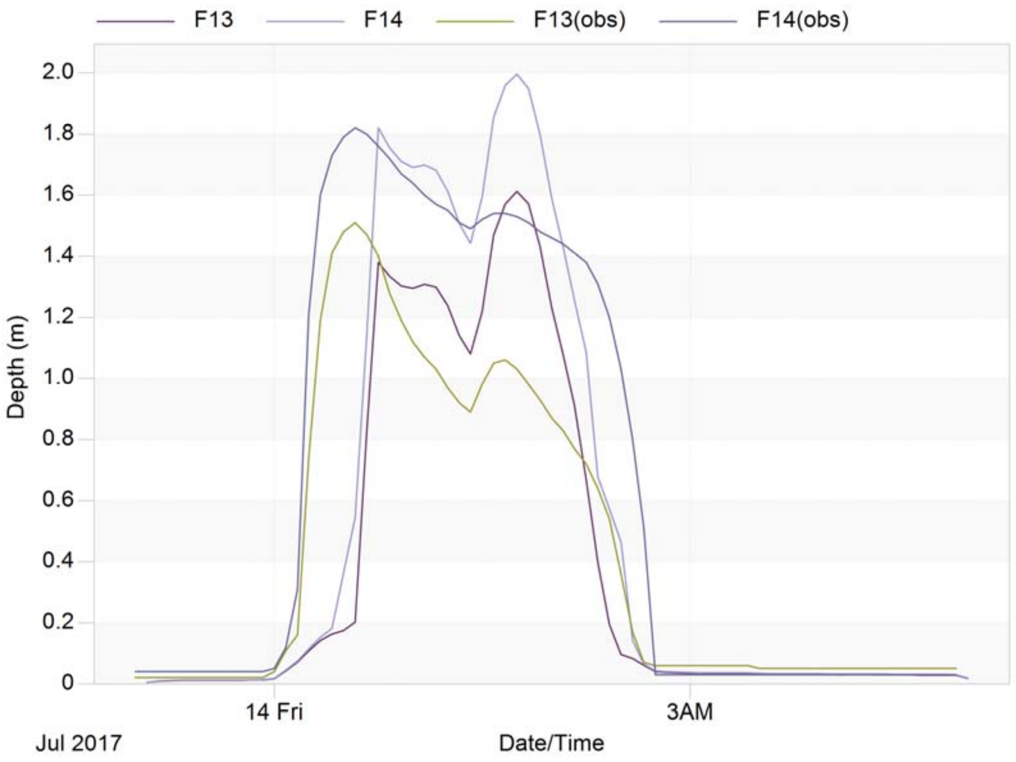


Figure A10: Simulated Fit for July 14, 2017 Storm Event – Gauges F13 and F14

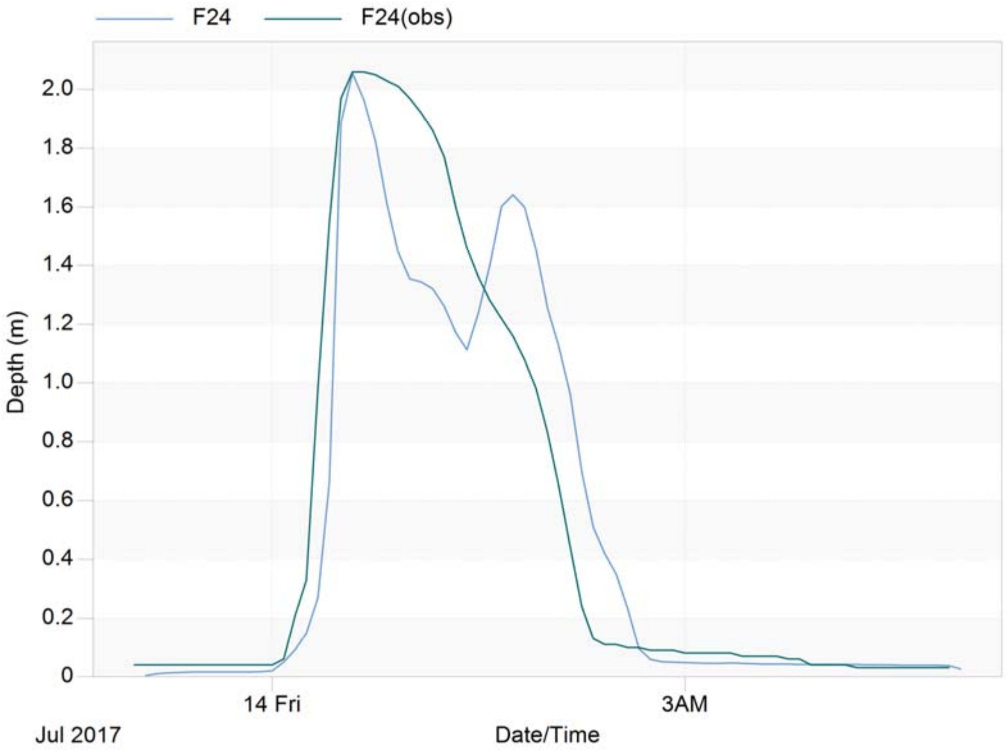


Figure A11: Simulated Fit for July 14, 2017 Storm Event – Gauge F24

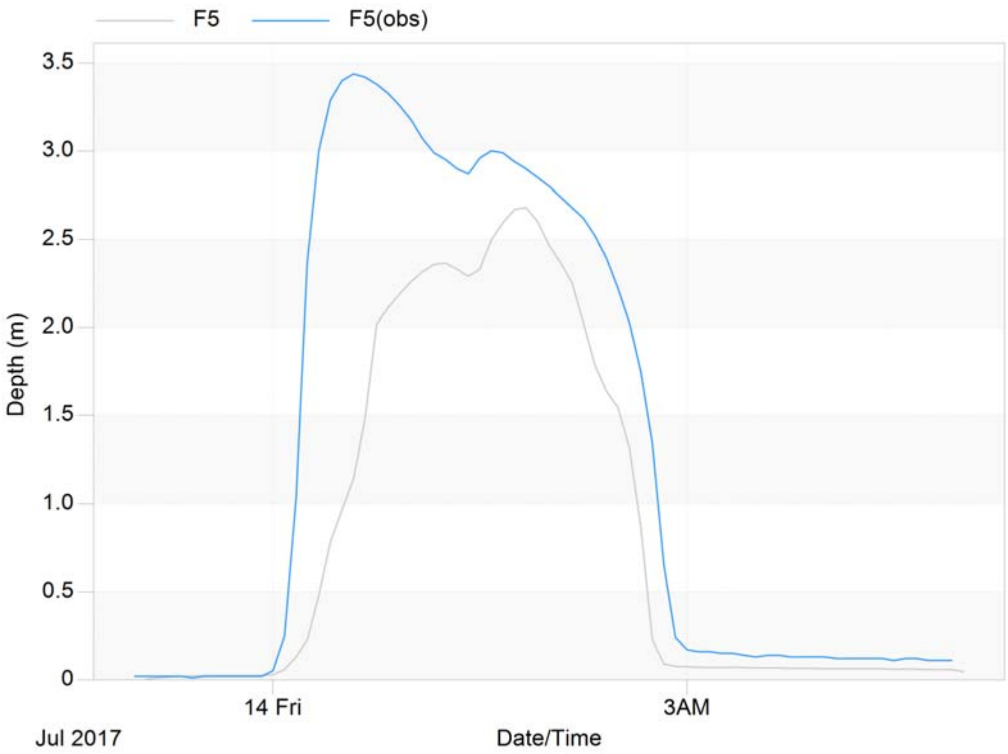


Figure A12: Simulated Fit for July 14, 2017 Storm Event – Gauge F5

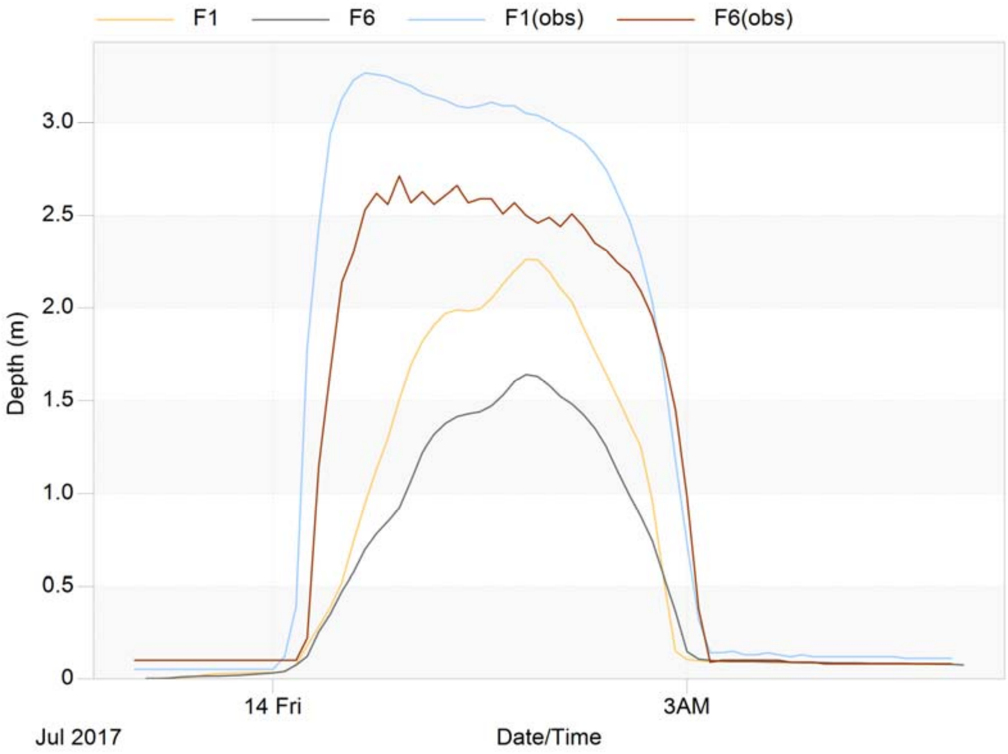


Figure A13: Simulated Fit for July 14, 2017 Storm Event – Gauges F1 and F6

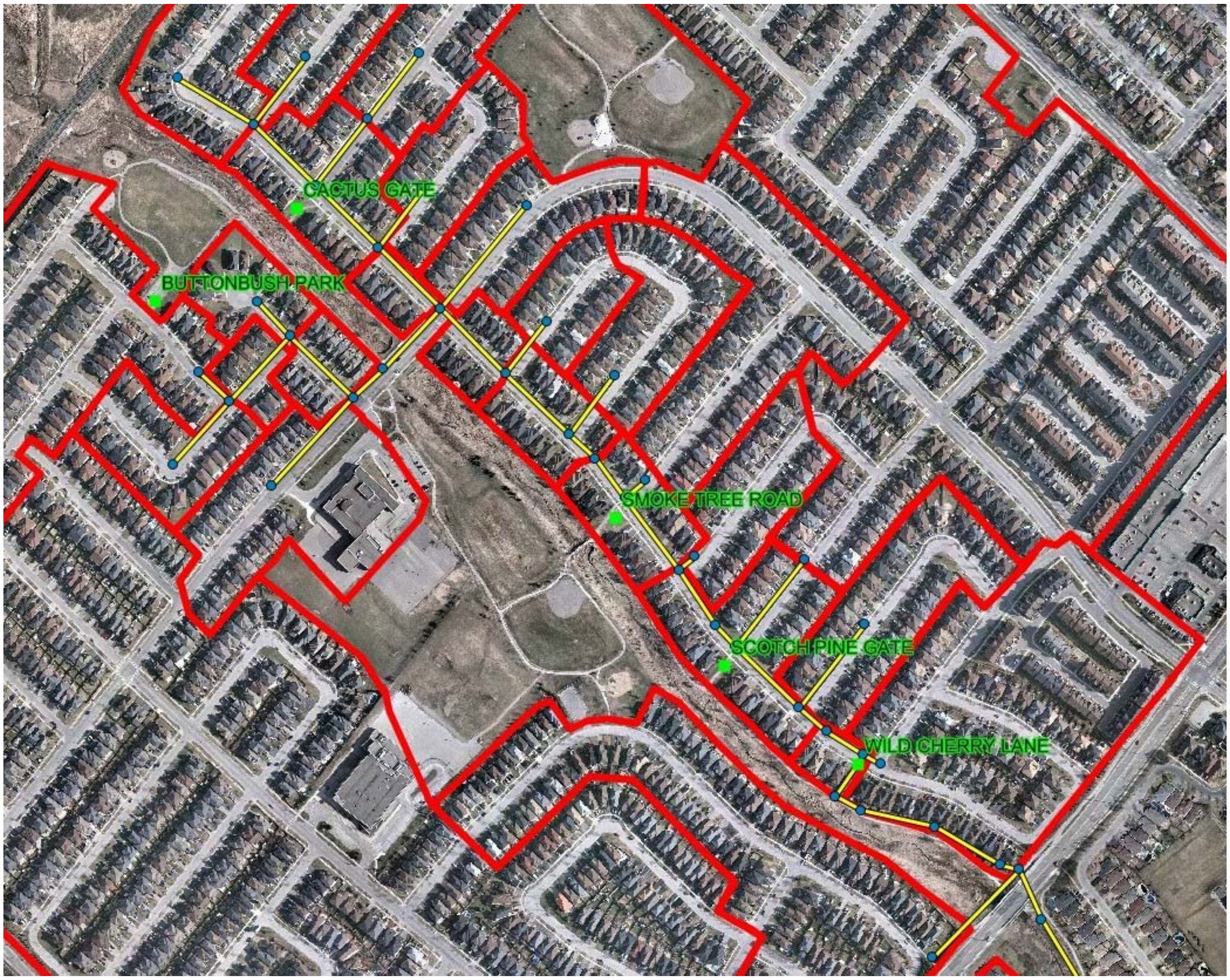


Figure A14: Long-List of Potential FDC Pumping Station Locations

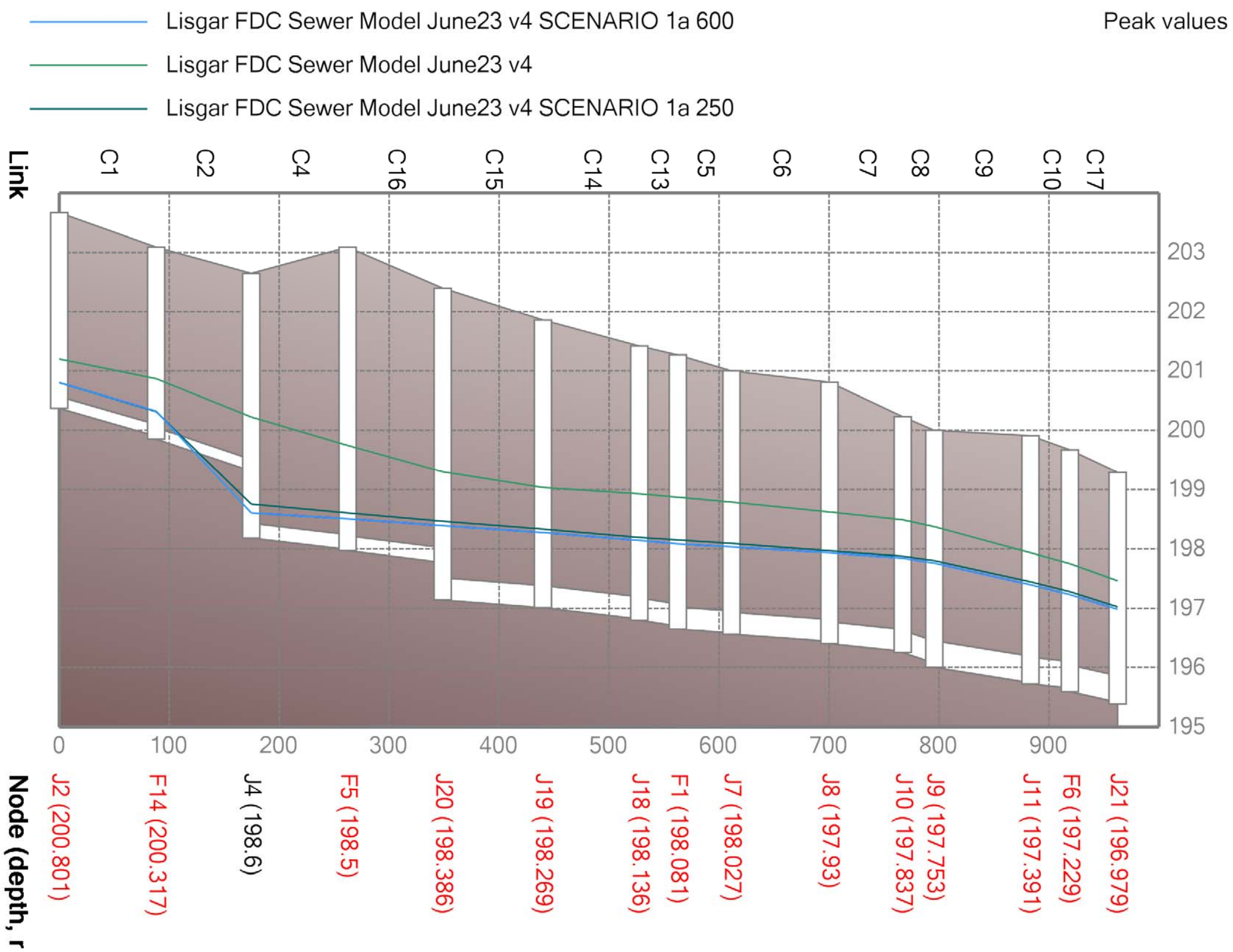


Figure A15: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – Scenario 1a

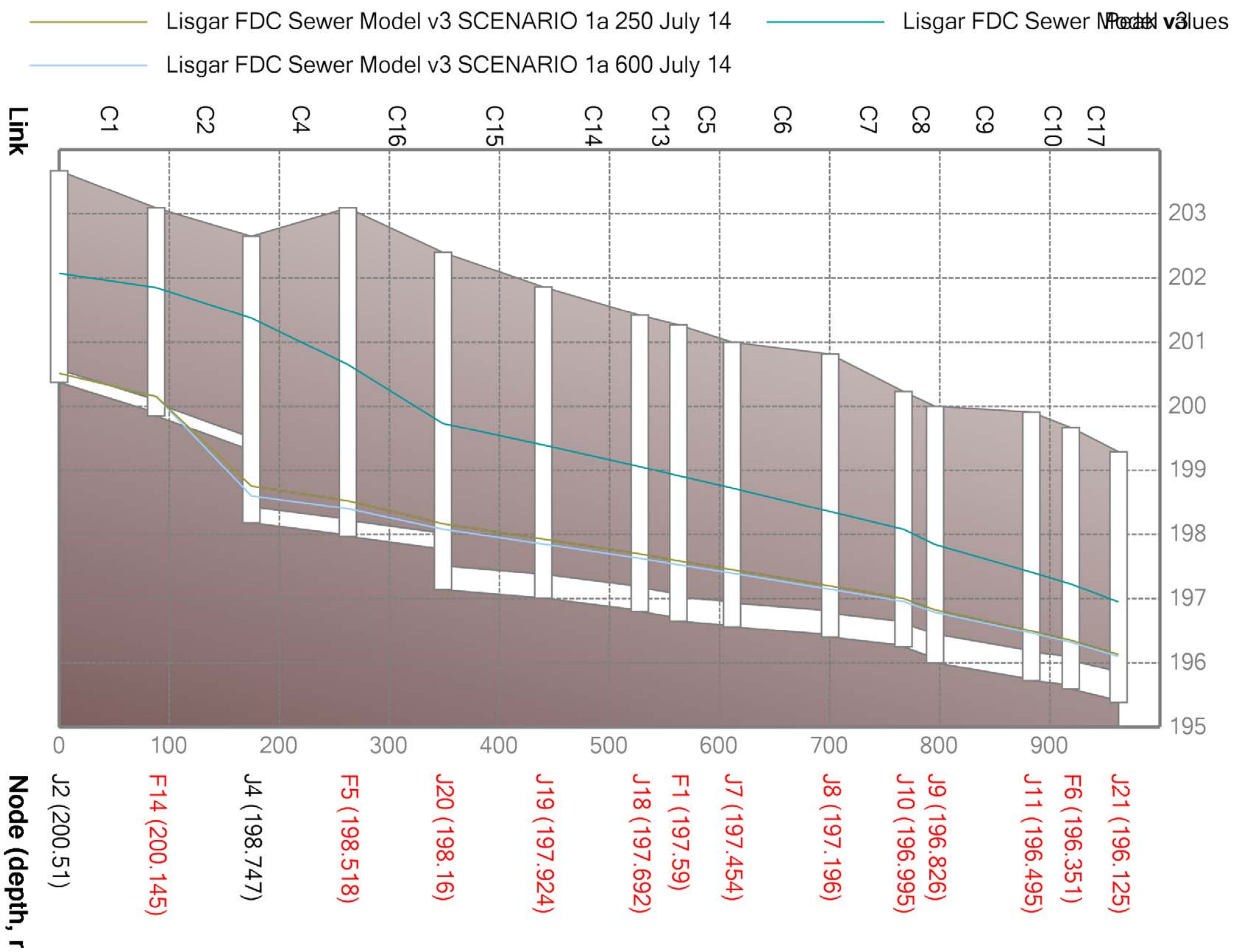


Figure A16: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event – Scenario 1a

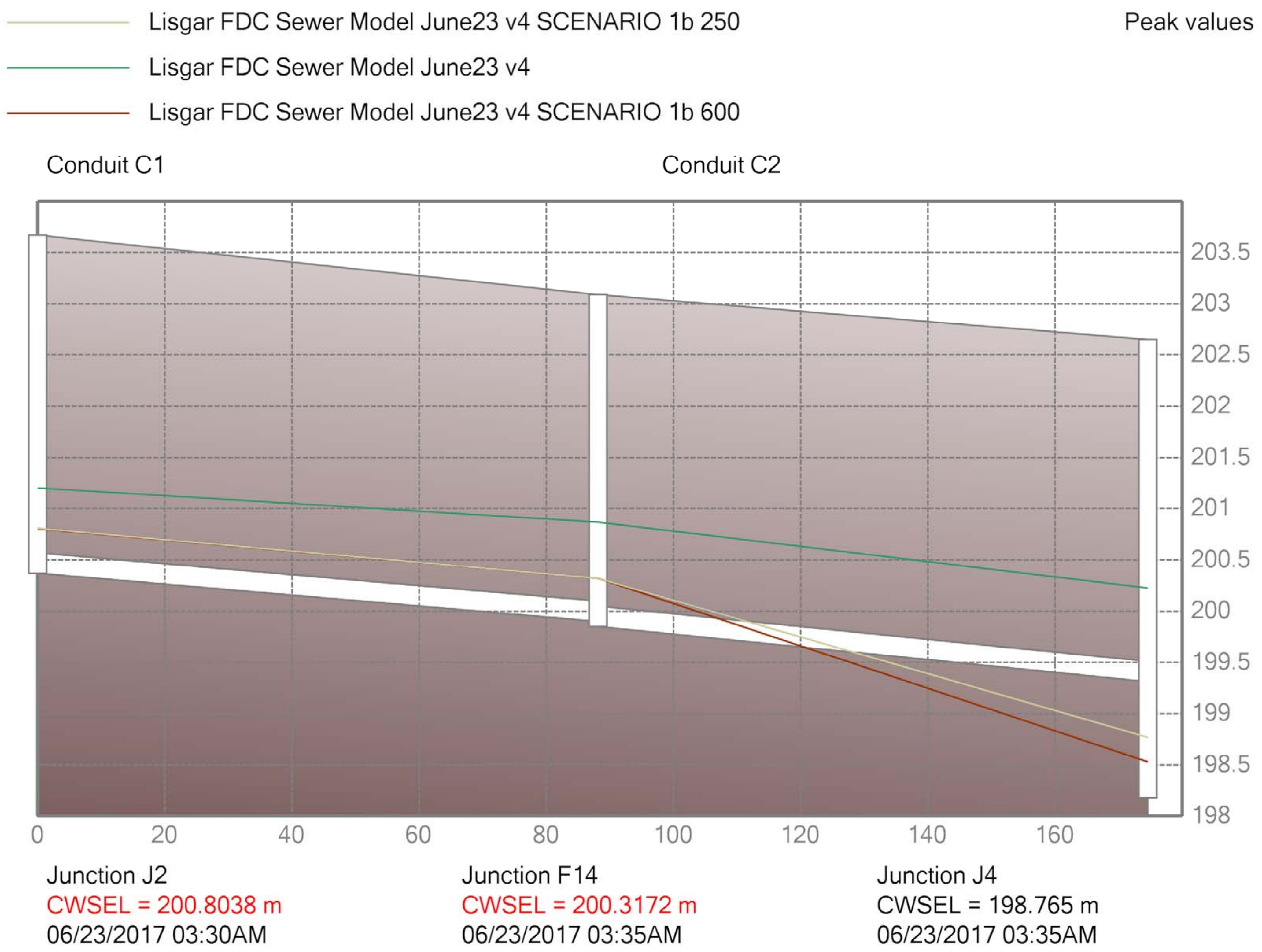


Figure A17: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – (Upstream of Cactus Gate) – Scenario 1b

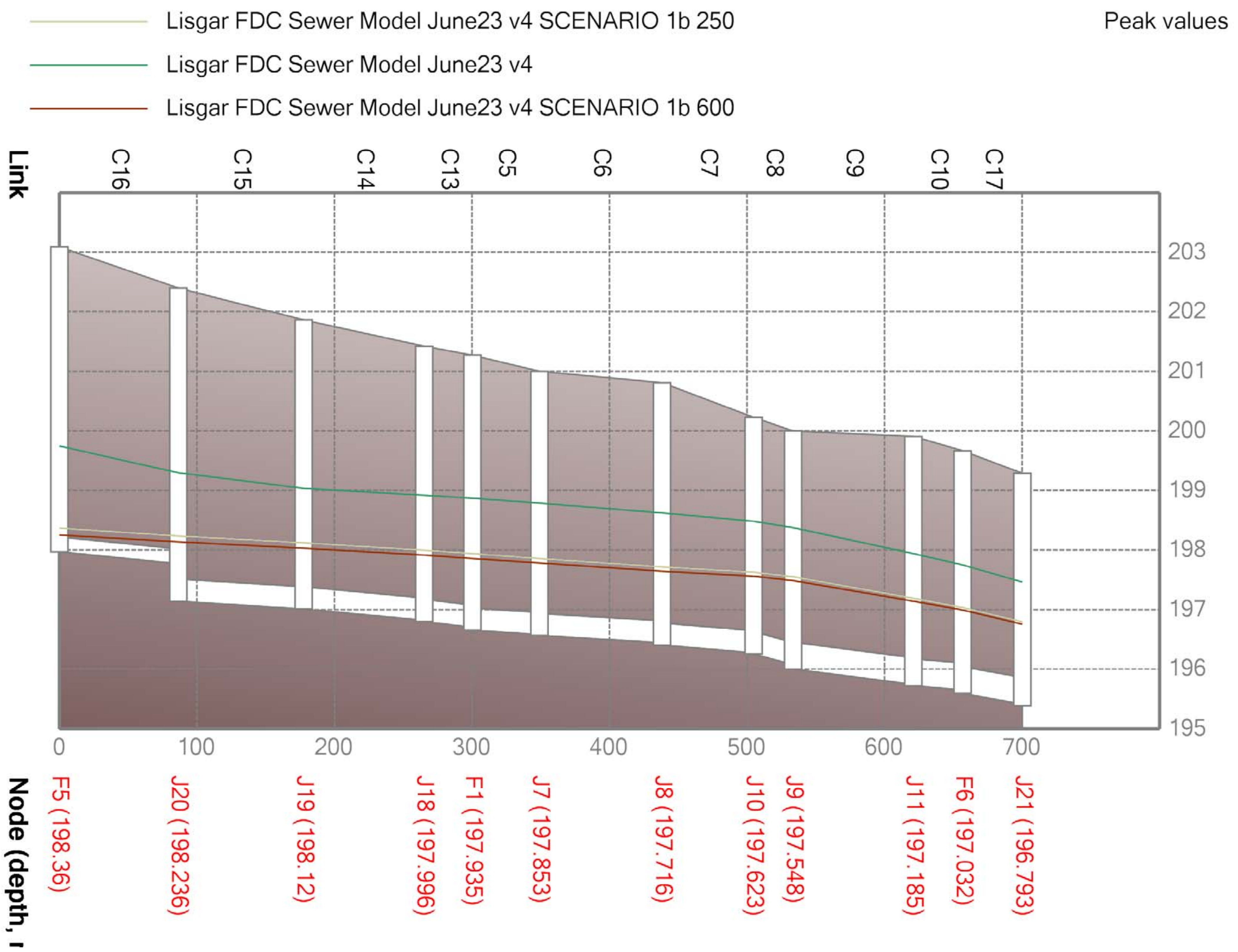


Figure A18: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – (Downstream of Cactus Gate) – Scenario 1b

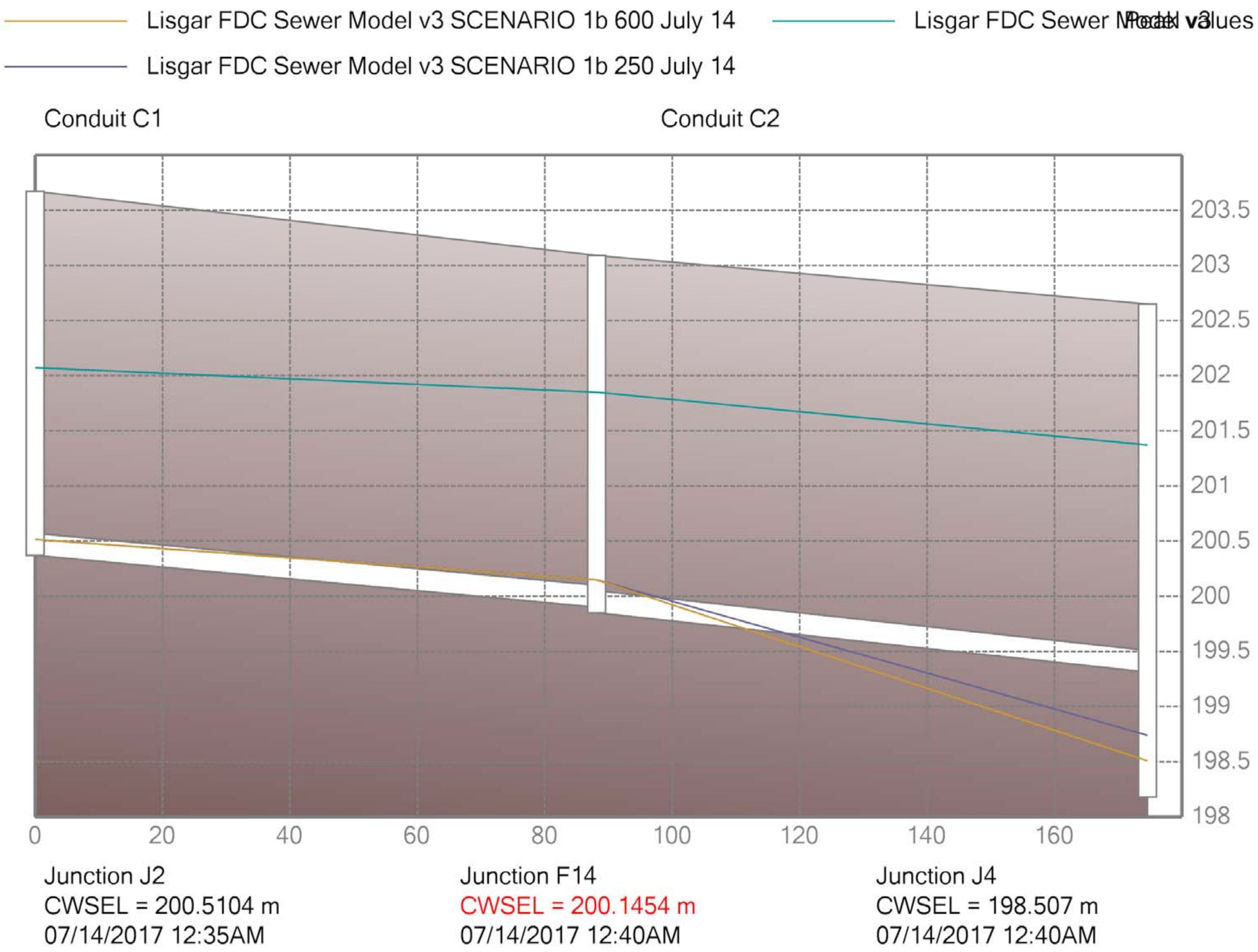


Figure A19: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event (Upstream of Cactus Gate) – Scenario 1b

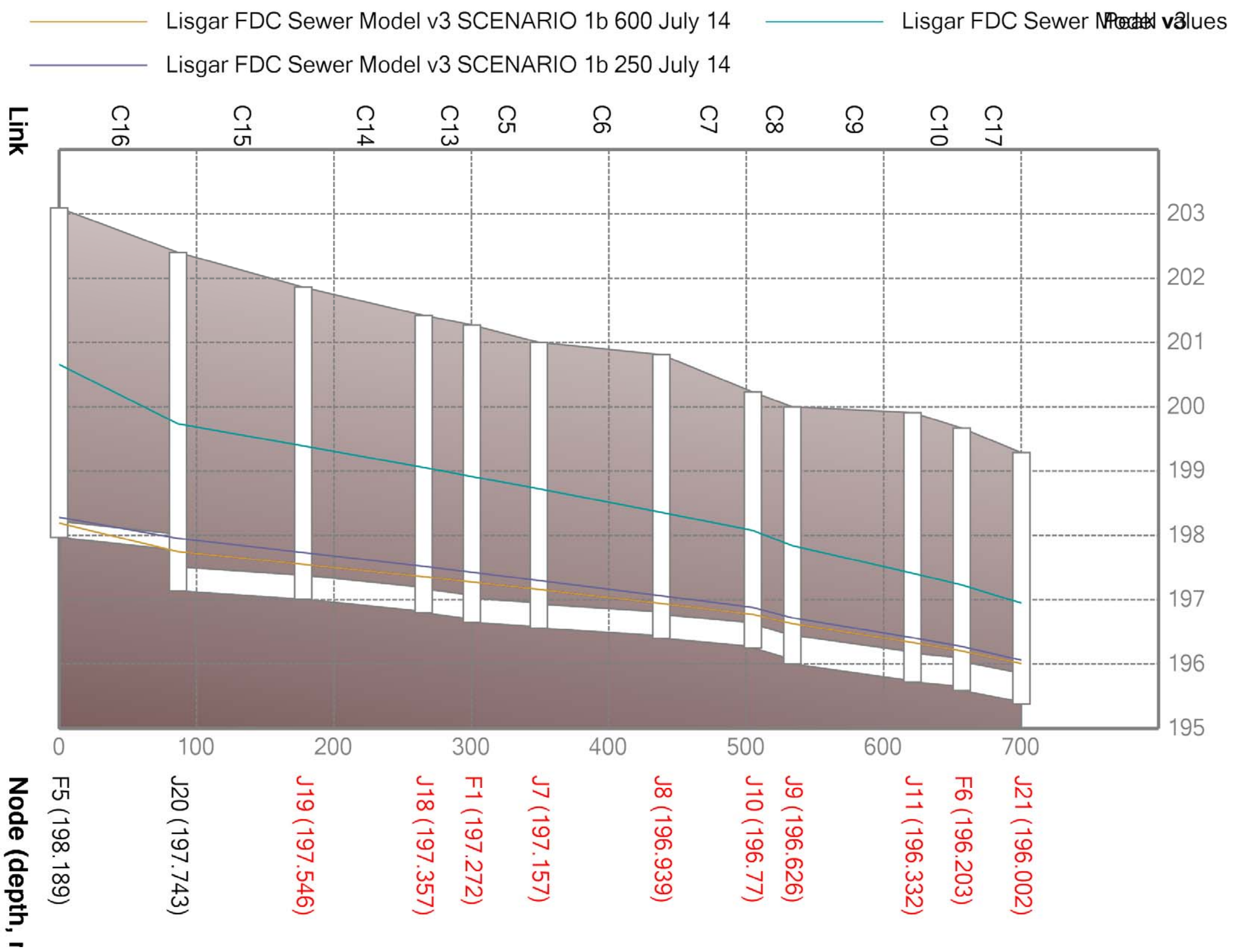


Figure A20: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event (Downstream of Cactus Gate) – Scenario 1b

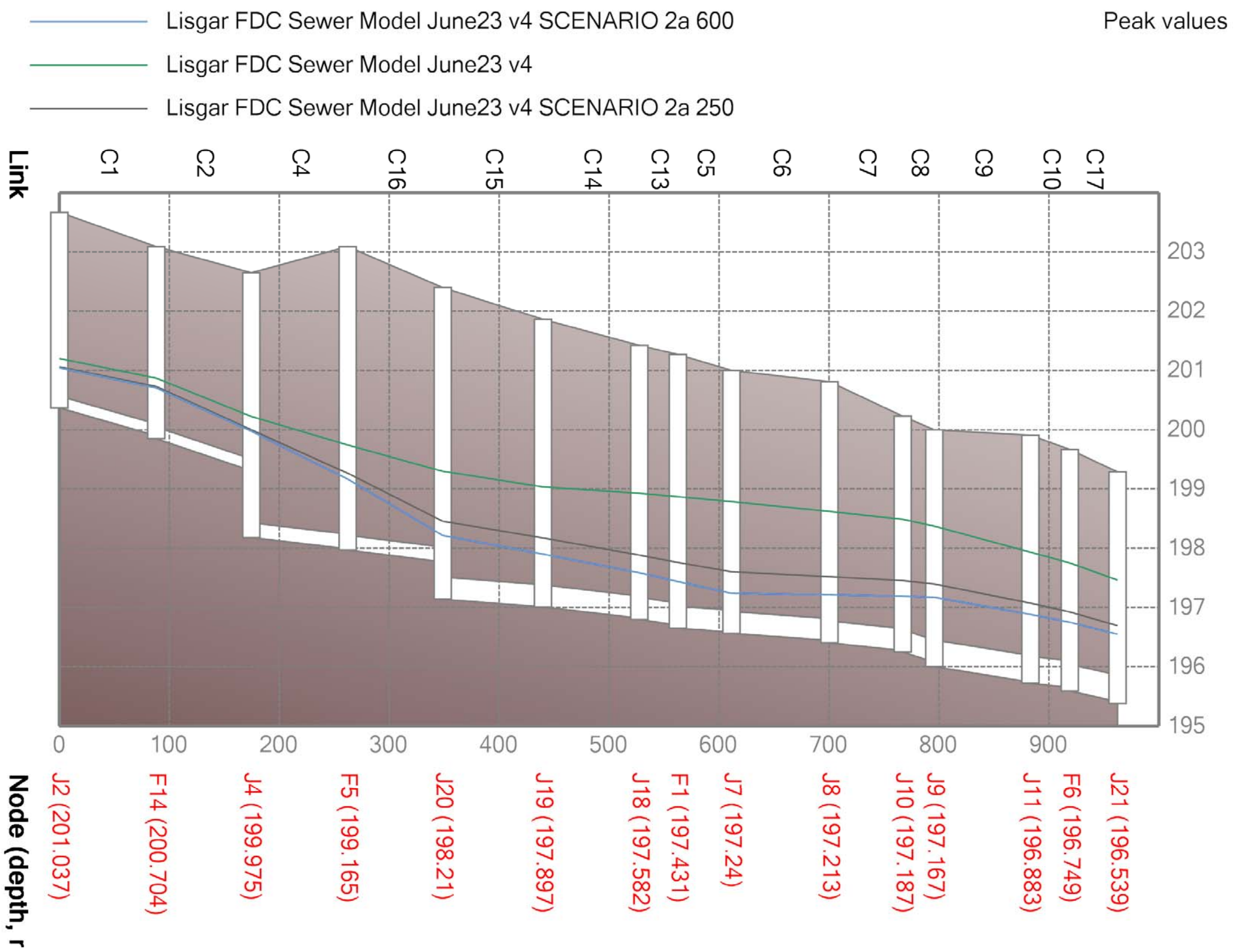


Figure A21: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – Scenario 2a

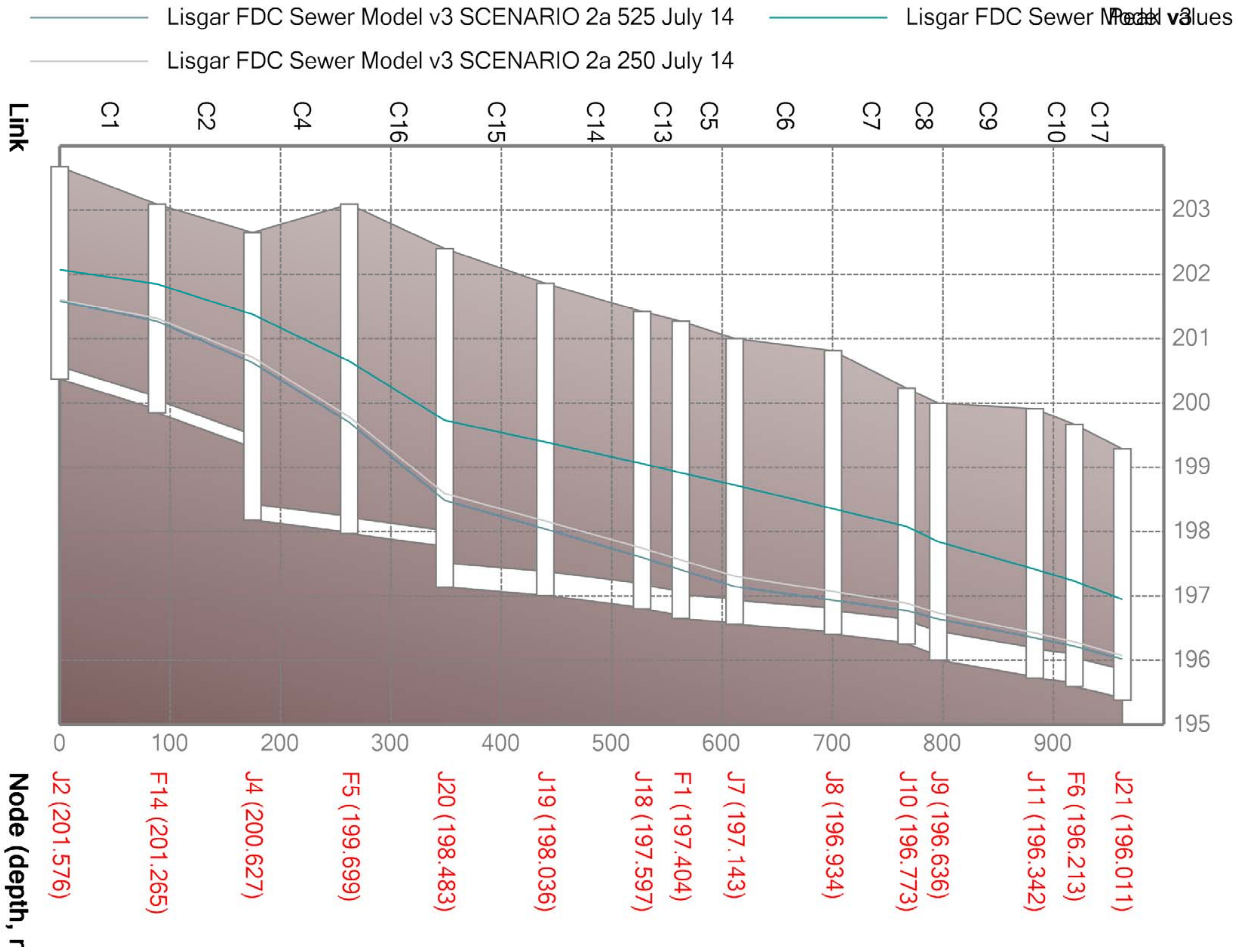


Figure A22: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event – Scenario 2a

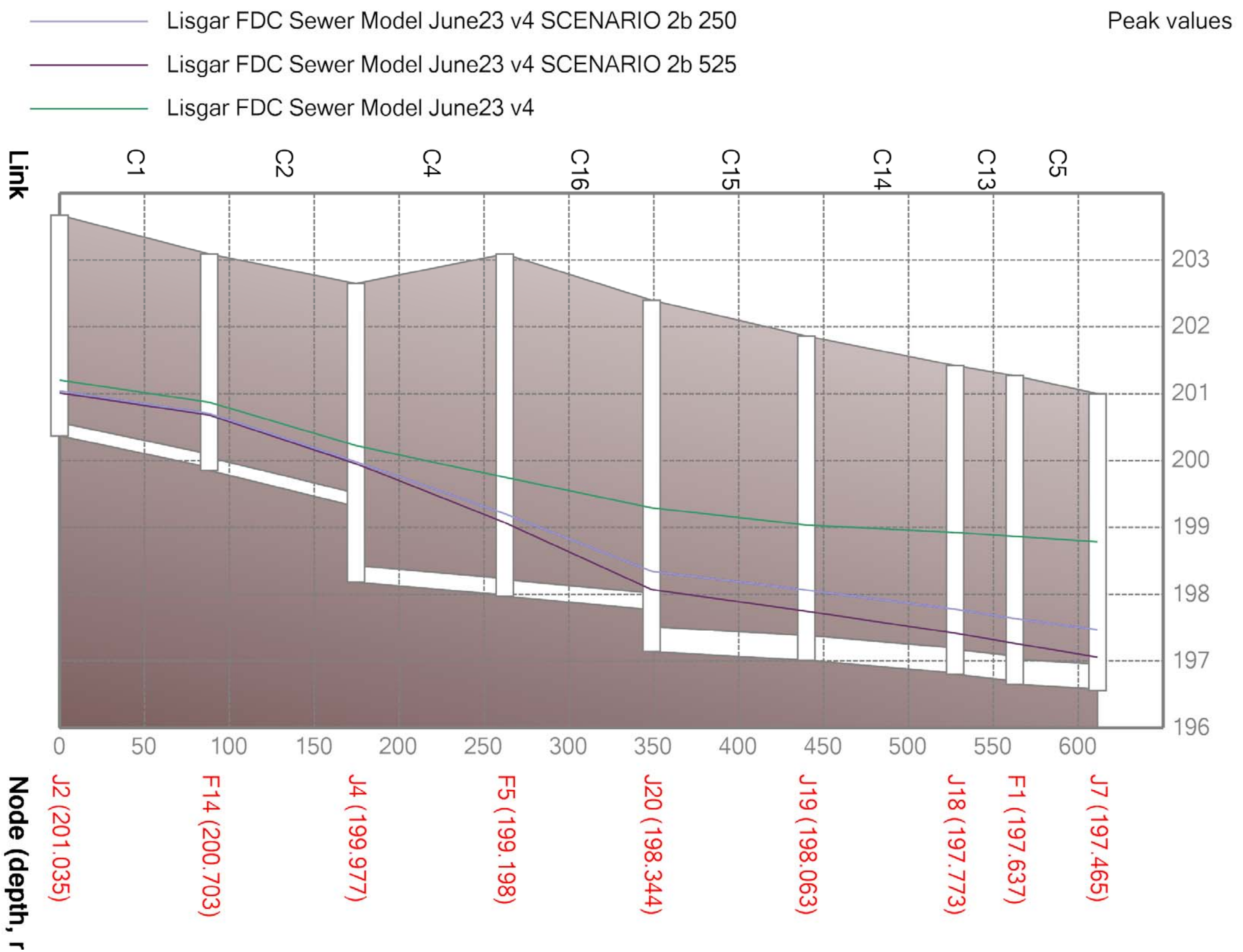


Figure A23: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – (Upstream of Smoke Tree Road) – Scenario 2b

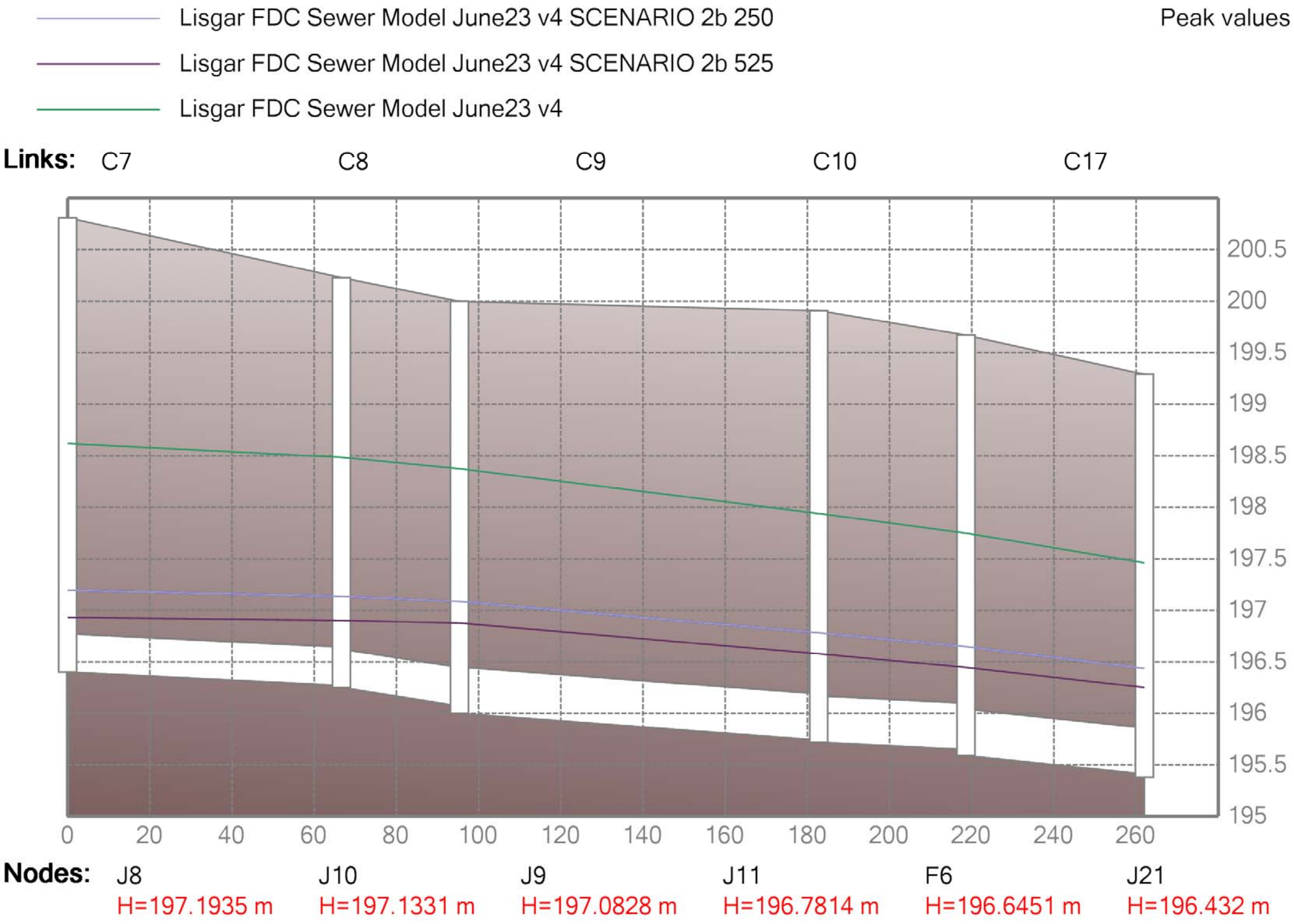


Figure A24: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – (Downstream of Smoke Tree Road) – Scenario 2b

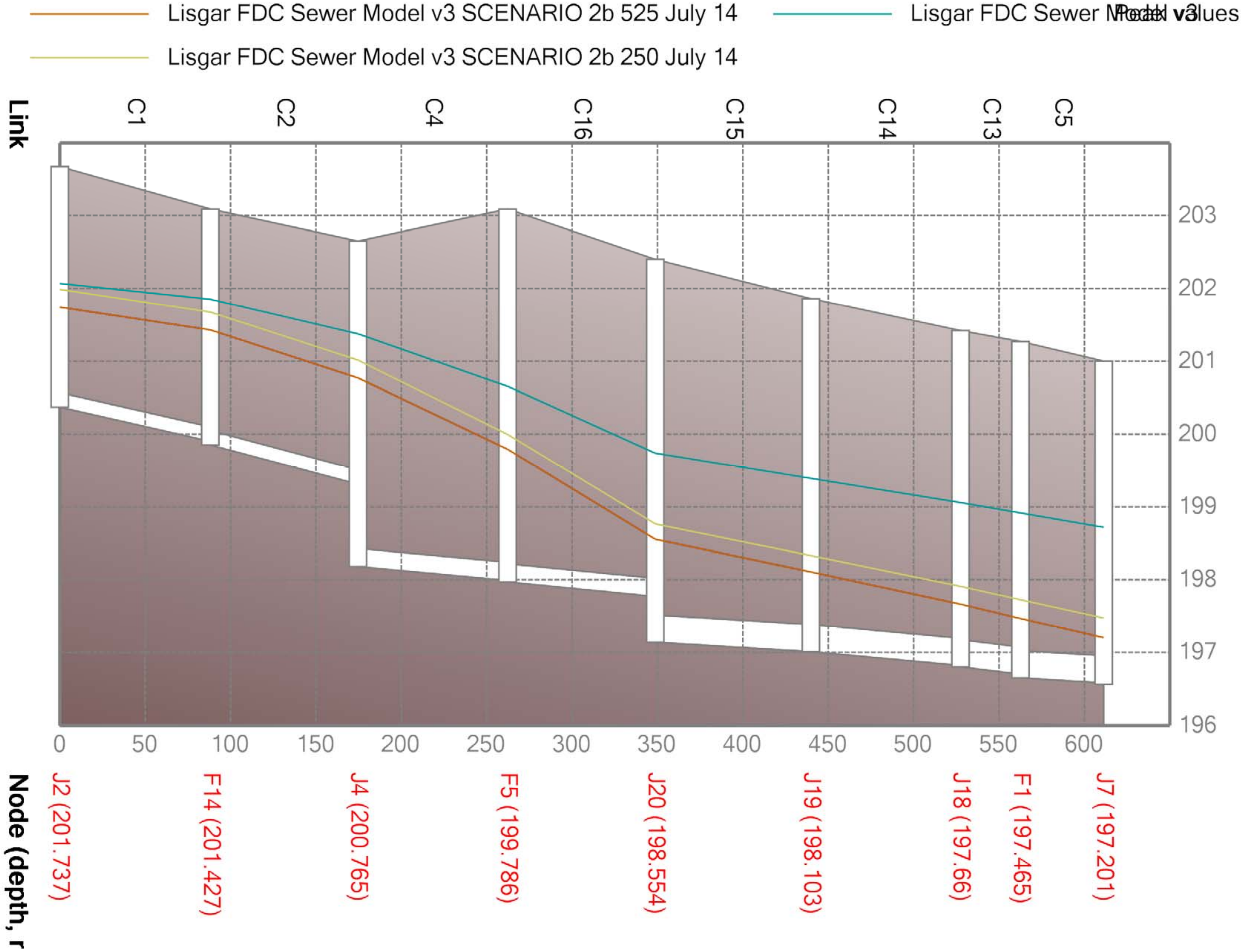


Figure A25: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event (Upstream of Smoke Tree Road) – Scenario 2b

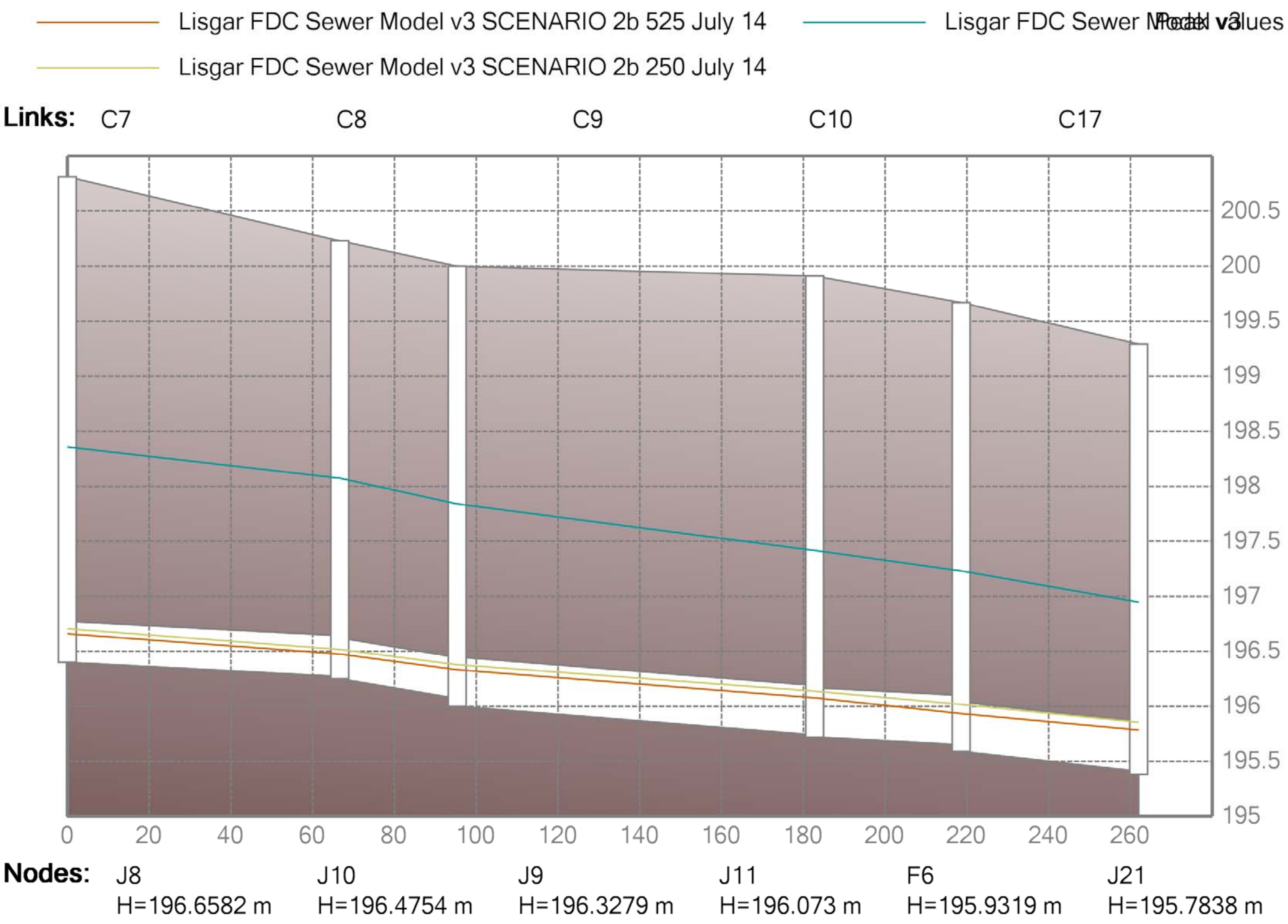


Figure A26: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event (Downstream of Smoke Tree Road) – Scenario 2b

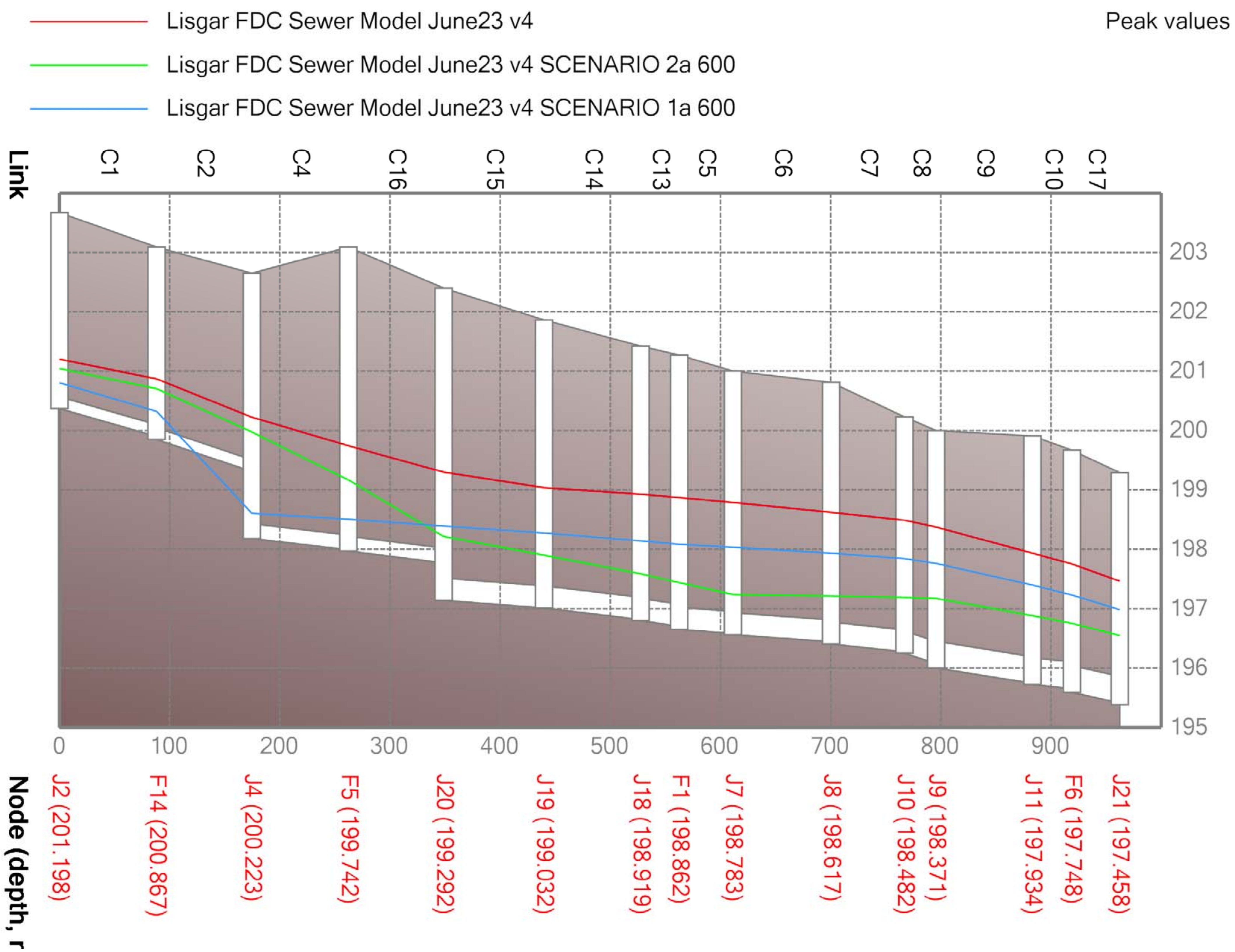


Figure A27: Simulated HGL along Black Walnut Trail for June 23, 2017 Storm Event – Comparison of Scenarios 1a and 2a (600 mm and 525 mm diameter diversion pipes)

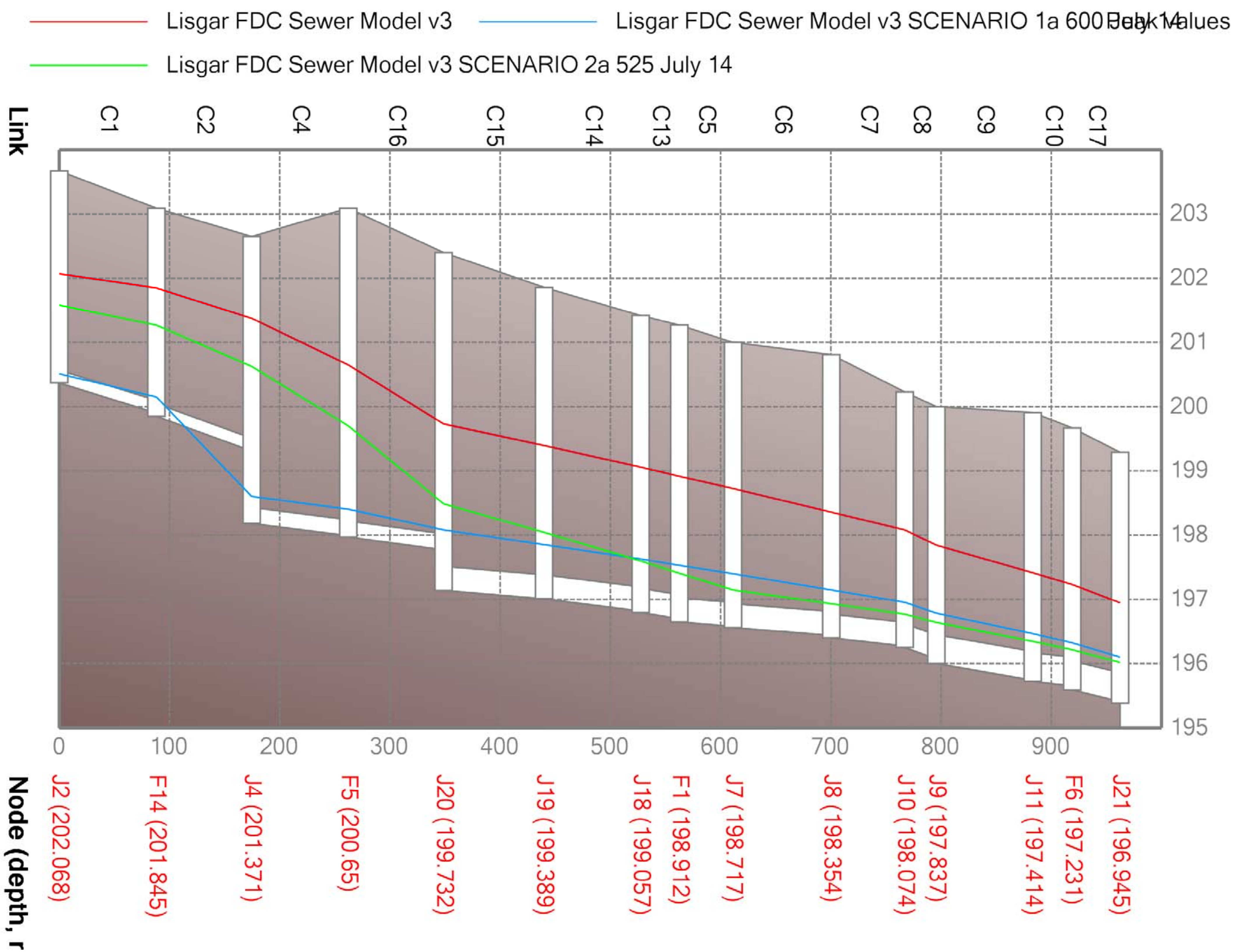


Figure A28: Simulated HGL along Black Walnut Trail for July 14, 2017 Storm Event – Comparison of Scenarios 1a and 2a (600 mm and 525 mm diameter diversion pipes)

Memo

To: Jeff Smylie and Louie Jakupi, City of Mississauga

From: Matthew Senior and Ron Scheckenberger

Date: May 1, 2018

File: TPB188016

Re: **FDC Pumping Station – Additional Hydraulic Modelling and Analysis**
Lisgar District Basement Water Infiltration Assessment – Remediation Phase,
City of Mississauga

1. Introduction, Background, and Purpose

Further to the approved scope of November 13, 2017, the technical memorandum of March 12, 2018 (ref. Senior/Scheckenberger-Smylie/Jakupi) and the direction received at the most recent meeting of April 11, 2018, we hereby provide you with a summary of the additional analyses completed in support of the proposed foundation drain collector (FDC) pumping station for the Lisgar District within the City of Mississauga.

The previously submitted technical memorandum of March 12, 2018 (ref. Senior/Scheckenberger-Smylie/Jakupi) provided a summary of the primary analyses completed in support of the above-noted FDC pumping station. As summarized in that memorandum, the preferred location was identified as being at the Cactus Gate Parkette along Black Walnut Trail, to be constructed in conjunction with the proposed utility trench dewatering system. The analyses concluded that this location was preferred for a number of reasons, including the obvious synergy in tendering and construction, previously completed geotechnical and sub-surface utility investigations, and higher simulated rates of FDC inflow in this area. Subsequent hydraulic modelling analyses confirmed that this location would have the greatest potential reduction in FDC hydraulic gradelines (HGLs) in the upstream area (as compared to an alternate location at Smoke Tree Road), and would have a similar benefit in HGL reduction to downstream areas along Black Walnut Trail. As such, the Cactus Gate Parkette location was considered preferred for the initial (2018) construction (subsequent FDC pumping stations may be considered for other downstream locations, based on the findings of subsequent monitoring work). This location was confirmed by City staff based on subsequent discussions (ref. e-mail Jakupi-Senior, March 27, 2018).

Based on the outcomes from the meeting with City staff (April 11, 2018), it was recommended that additional FDC modelling analyses be completed, specifically the simulation at least one (1) or more additional historic FDC surcharging events (in addition to the June 23, 2017 and July 14, 2017 storm events, which were simulated as part of the previously noted memorandum). In addition, it was recommended that Wood Environment & Infrastructure Solutions (Wood) further consider the proposed statistical analysis of the relationship between simulated peak flows and drainage area and rainfall intensity (similar to a Rational

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a Division of Wood Canada Limited
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Registered in Canada No. 773289-9; GST: 899879050 RT0008; DUNS: 25-362-6642

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Method type approach). This current memorandum summarizes these additional analyses, and further confirms the expected design basis for pumping capacity for the FDC pumping system.

2. Additional Storm Event Simulations

As outlined in the March 12, 2018 memorandum (ref. Senior/Scheckenberger-Smylie/Jakupi), three (3) of the next largest observed FDC surcharging events in the Black Walnut Trail area were noted as potential candidates for additional hydraulic modelling analysis; these include:

- September 8, 2012
- June 12, 2014
- September 10, 2014

Based on a review of the available monitoring data, and for consistency, the two (2) more recent storm events from 2014 have been applied for the current additional simulation. Note that data from gauge F24 (west of Lisgar Creek – Golden Locust Drive) are not available for the 2014 storm event, as this gauge was not installed until July 2015 (refer to Figure A1 for monitoring gauge locations). Thus simulated water level responses have been compared to the other available gauges in this area (F13, F14, F5, F1 and F6).

The simulation methodology for the two (2) storm events is consistent with that applied for previous storm events (ref. March 12, 2018 memorandum). A unitary flow response at the upstream F13 gauge has been determined, based on the observed water level response, a theoretical rating curve (Manning's Equation for low flow and orifice equation for high flows), and the contributing drainage area to the gauge (3.28 ha) to determine the unitary hydrograph (m^3/s per ha). This unitary flow response time series has then been applied to hydraulic model nodes, based on the contributing FDC drainage areas (as per Figure A2), multiplied by a calibrated scaling factor, which is determined iteratively in order to attempt to replicate the observed water level responses for the storm event in question. The drainage area "zones" applied in previous assessments (refer to Figure A3) have been similarly applied for the current assessment, with the same general observation from previous assessments, that a higher relative rate of FDC inflow is expected from the upper reaches of the FDC sewershed (i.e. Zone 1).

2.1. Simulation of June 12, 2014 Storm Event

The June 12, 2014 storm event resulted in between the 2nd and 4th highest FDC system surcharge in the Black Walnut Trail area since monitoring began in 2012. A maximum water level of 2.70 m was observed at Gauge F1 for this storm event, exceeded only by the July 14, 2017 storm event for the six (6) years of available monitoring data [refer to Figure A14 (attached) for the observed storm event response]. The observed FDC surcharge for this event was noted further downstream as well, with observed FDC water levels of 3.07 m and 2.66 m at gauges F3 (Doug Leavens Boulevard) and F4 (Osprey Marsh), and 2.69 m at gauge F17 (Ninth Line), however the surcharge ultimately dissipated at the downstream limits (Erin Centre Boulevard and Churchill Meadows).

Observed rainfall intensities for this storm event were less than a 2-year return period, and antecedent conditions were not considered significant (7.6 mm in preceding 5-day period). The storm itself was approximately 23.2 mm in depth, over a 1.3-hour period. Given the time of year and short duration, this suggests a thunder-storm type event, which could have had isolated portions of more intense rainfall, given the spatial variability associated with such storm events.

Scaling factors have been determined iteratively for the simulation of the June 12, 2014 storm event to attempt to reasonably replicate observed water levels. Table 2.1 presents the resulting estimated scaling factors for the different FDC drainage area zones. Figures A4-A9 (attached) present the resulting simulated fit to observed water level data.

Table 2.1: Estimated Scaling Factors for Simulated Fit of Observed FDC Response to June 12, 2014 Storm Event

FDC Area Zone	Description	Scaling Factor[1]
1	Black Walnut Trail – north of Gauge F5	0.46 to 0.49[3]
2	Area west of Lisgar Creek (Golden Locust Drive)[2]	0.26
3	Black Walnut Trail between F5 and F1	0.26
4	Black Walnut Trail between F1 and F6 (including Scotch Pine Gate area)	0.11
5	Areas downstream of F6	0.11

1. Inflow at each node within zone is determined by the unitary flow hydrograph multiplied by the incremental drainage area to each node multiplied by the scaling factor.
2. Note that there is no observed water level gauge in this area to verify scaling factor (Gauge F24 was not installed for this storm event).
3. Slightly reduced factor of 0.46 applied to area contributing to gauge F13 as compared to rest of Zone 1.

Figures A4-A9 indicate a generally good fit to the observed data both with respect to peak water level and shape, although the simulated water level responses are slightly delayed as compared to the observed responses. The response at Gauge F1 is also somewhat under-estimated, however the response at the downstream Gauge F6 indicates a good match, albeit slightly low on volume.

The scaling factor results are consistent with previous analyses, which indicate the highest relative rate of flow contribution for upstream areas.

Overall, it is considered that the simulated modelling for this storm event provides a good representation of the observed water level responses, and provides a reasonable approximation for the assessment of the effectiveness of diversions/pumping, as described in Section 3.

2.2. Simulation of September 10, 2014 Storm Event

The September 10, 2014 storm event resulted in between the 2nd and 3rd highest FDC system surcharge in the Black Walnut Trail area since monitoring began in 2012. A maximum water level of 2.74 m was observed at Gauge F5 for this storm event, exceeded only by the July 14, 2017 storm event for the six (6) years of available monitoring data [refer to Figure A15 (attached) for the observed storm event response]. The observed FDC surcharge for this storm event extended further downstream to Doug Leavens Boulevard (gauge F3) but dissipated beyond (i.e. Osprey Marsh (gauge F4) and further downstream).

This storm event had a larger observed depth than the June 12, 2014 event (40.4 mm), however this occurred over a longer duration (6.3 hours). Observed rainfall intensities for this storm event were also higher; between a 2 and 5 year event (30 minute and 1 hour data) or approximately equal to a 2 year event (6 hour data). This storm event was also characterized by a higher antecedent rainfall total (26.4 mm in the preceding 5-day period). It is notable that this storm event was the only recorded event with rainfall intensities greater than a 2-year storm event, with the exception of the July 13-14, 2017 storm event over the monitoring period. No reported basement water infiltration was noted as a result of this storm event.

Scaling factors have been determined iteratively for the simulation of the September 10, 2014 storm event to attempt to reasonably replicate observed water levels. Table 2.2 presents the resulting estimated scaling factors for the different FDC drainage area zones. Figures A9-A13 (attached) present the resulting simulated fit to observed water level data.

Table 2.2: Estimated Scaling Factors for Simulated Fit of Observed FDC Response to September 10, 2014 Storm Event

FDC Area Zone	Description	Scaling Factor[1]
1	Black Walnut Trail – north of Gauge F5	0.32
2	Area west of Lisgar Creek (Golden Locust Drive)[2]	0.15
3	Black Walnut Trail between F5 and F1	0.15
4	Black Walnut Trail between F1 and F6 (including Scotch Pine Gate area)	0.07
5	Areas downstream of F6	0.07

1. Inflow at each node within zone is determined by the unitary flow hydrograph multiplied by the incremental drainage area to each node multiplied by the scaling factor.
2. Note that there is no observed water level gauge in this area to verify scaling factor (Gauge F24 was not installed for this storm event).

Figures A9-A13 indicate a generally good fit to the observed data both with respect to peak water level and shape, although the simulated water level responses are slightly delayed as compared to the observed responses. The response at Gauges F5 and F1 is also somewhat under-estimated, however the response at the downstream Gauge F6 indicates a slight over-estimation, which suggests that on average the simulated response is reasonable.

The scaling factor results are consistent with previous analyses, which indicate the highest relative rate of flow contribution for upstream areas.

Overall, it is considered that the simulated modelling for this storm event provides a good representation of the observed water level responses, and provides a reasonable approximation for the assessment of the effectiveness of diversions/pumping, as described in Section 3.

3. Mitigation Analyses

3.1. Analysis of Flow Diversions

As per the approach advanced in the previous March 12, 2018 memorandum, hydraulic modelling of an FDC sewer diversion (to a pumping station) has been completed to assess the expected effectiveness. As per the recommendations cited within the March 12, 2018 memorandum, and direction from City staff (ref. e-mail Jakupi-Senior, March 27, 2018), this diversion would be assumed to be located within the Cactus Gate Parkette. As such, two (2) different sub-scenarios have been considered:

- **Scenario 1a** – diversion sewer placed above obvert of existing 250 mm diameter FDC trunk sewer (invert elevation of 198.43 m), existing FDC sewer outlet remains as is
- **Scenario 1b –** restrictor plate placed on existing 250 mm diameter FDC sewer at springline (i.e. 50% of full depth), and FDC diversion sewer placed above the springline (invert elevation of 198.31 m)

Based on the results documented in the previous March 12, 2018 memorandum, diversion flow rates were noted to be relatively insensitive to the diameter (size) of the diversion pipe (i.e. 250 mm minimum or 600 mm maximum). Based on direction from City staff (April 11, 2018 meeting), it is suggested that the largest feasible pipe size be implemented for the diversion, to maximize the effectiveness of the flow diversion to the FDC pumping station. Both sub-Scenarios 1a and 1b have therefore assumed a 600 mm diameter diversion pipe. Simulated results are presented in Table 3.1; hydraulic gradline (HGL) plots are presented in Figures A16 to A17 (June 12, 2014 storm event) and A18 to A19 (September 10, 2014 storm event).

Table 3.1: Simulated Hydraulic Modelling Results for Diversion at Cactus Gate Parkette

Scenario	Storm Event	Node Inflow (m^3/s)	Diverted Flow to Pumping Station (m^3/s)	Diverted Volume to Pumping Station (m^3)	Remaining Flow in FDC Trunk (m^3/s)	HGL Reduction along Black Walnut Trail compared to baseline (m)
1a	June 12, 2014	0.094	0.056	96	0.046	0.54 – 1.99
	Sept 10, 2014	0.093	0.049	117	0.045	0.72 – 2.19
1b	June 12, 2014	0.094	0.065	137	0.029	0.54 – 2.07
	Sept 10, 2014	0.093	0.064	155	0.029	0.87 – 2.27

The results presented in Table 3.1 indicate that an FDC sewer diversion would be largely effective, with consistently more than half of the simulated peak inflow being diverted to the theoretical pumping station unit. Hydraulic gradeline (HGL) reductions of between 0.5 and 2.3 m would result for the two scenarios. The attached HGL plots indicate that Scenario 1b (with orifice restrictor in place) would result in a lower overall HGL due to the additional flow diverted; an average further HGL reduction along Black Walnut Trail of 0.2 m is indicated with the orifice restrictor, which relates to the increased flow and volume diversion under this scenario. As discussed previously with City staff (April 11, 2018 meeting), additional considerations related to backup power are required to ensure that the implementation of an orifice restrictor does not result in any negative impacts to upstream residents along this reach of the FDC. Notwithstanding, it is considered that the expected benefit to downstream areas outweighs the potential minor risk to upstream properties, subject to the implementation of suitable backup measures and considerations as part of the detailed design phase (such as an overflow relief).

3.2. Rainfall Intensity Analysis

As part of the approved scope of work (November 13, 2017), and subsequent discussions with City staff (April 11, 2018 meeting), it was also considered worthwhile to assess the relationship between estimated FDC peak flows, and contributing drainage area and rainfall intensity. Such an analysis has similarities to the well-known Rational Method for storm sewer design (Q=CiA), which directly correlates storm flows to varying rainfall intensity, drainage area, and a Runoff Coefficient representing the rainfall-runoff characteristics of the subject area. In this regard, expected inflows to the proposed FDC pumping station under less frequent, more formative storm events (i.e. > 5 year storm event, potentially up to and including the 100 year storm event) could be assessed, and an appropriate pumping capacity rate selected accordingly.

Notwithstanding, the results of the completed hydraulic modelling (both as documented in the previous March 12, 2018 memorandum and the current summary) indicate similar peak flow results at the key node of interest (FDC MH at Cactus Gate Parkette) for all of the four (4) storm events simulated to date:

- June 12, 2014: 0.094 m^3/s
- September 10, 2014: 0.093 m^3/s
- June 23, 2017: 0.096 m^3/s
- July 14, 2017: 0.094 m^3/s

The preceding finding from the detailed modelling suggests a relatively constant rate of peak inflow to the FDC system; it is hypothesized that potentially inflows are constrained/limited by the capacity of the FDC sewer system in this area, which is relatively small (200 mm diameter pipe typically). Based on the simulation results, varying observed FDC surcharge depths are therefore likely more influenced by varying rates of FDC peak flows further downstream, which would define tailwater constraints.

Based on the preceding relatively constant rate of simulated FDC peak flow, any attempts at a correlation analysis between peak flow and rainfall intensity would likely not provide reasonable results. Therefore, rather than attempting to determine a FDC peak flow factor to account for future more intense storm events, the FDC pumping station design should consider opportunities to provide additional capacity, such as a backup/redundant FDC pumping system which could be utilized if so required.

4. Summary and Next Steps

To summarize, two (2) additional observed storm events (June 12 and September 10, 2014) have been simulated using the developed hydraulic model of the FDC system. The results are considered to be similar to those generated as part of the previous summary memorandum (March 12, 2018) with respect to simulated peak flows to the proposed FDC pumping station at the Cactus Gate Parkette, as well as the provided effectiveness of the proposed diversion sewer. Based on these additional results, it is recommended that the FDC pumping station proceed as previously proposed at this location (separate system from utility trench dewatering system). It is recommended that the previously proposed flow restrictor on the FDC trunk sewer also be implemented as proposed, in order to maximize the potential diversion of flows to the proposed pumping system and further reduce inflows downstream. Design redundancies, including a system overflow, should be considered accordingly in the design. Given the relative consistency in simulated FDC peak flows, a correlation analysis with rainfall is not considered feasible. Other design measures to account for more intense future storm events will need to be considered as part of the detailed design effort accordingly.

We consider that the next steps in this effort should include:

- City to review current memorandum and provide any additional comments
- Wood to review range of commercially available pump options with manufacturers, including related considerations (electrical/power requirements, wet well dimensions, etcetera)
- Wood to similarly review requirements for adjacent utility trench dewatering system
- Following confirmation with City staff, Wood to advance a revised preliminary (30%) design for City review (including previous City comments on the conceptual utility trench dewatering system), with a target delivery date of 4-5 weeks (early June, 2018)
- Wood to advance detailed design package, including contract materials

We trust the foregoing and attached to be satisfactory. We look forward to discussing this memorandum in further detail with you at your convenience, and to continue to advance this project to ensure construction is completed in 2018.

MJS

/Attached Figures A1 to A3 (Study Area Figures)
Figures A4 to A13 (Simulation/Calibration Hydrographs)
Figures A14 to A15 (Storm Event Water Level Plots)
Figures A16 to A19 (Hydraulic Gradeline Plots)

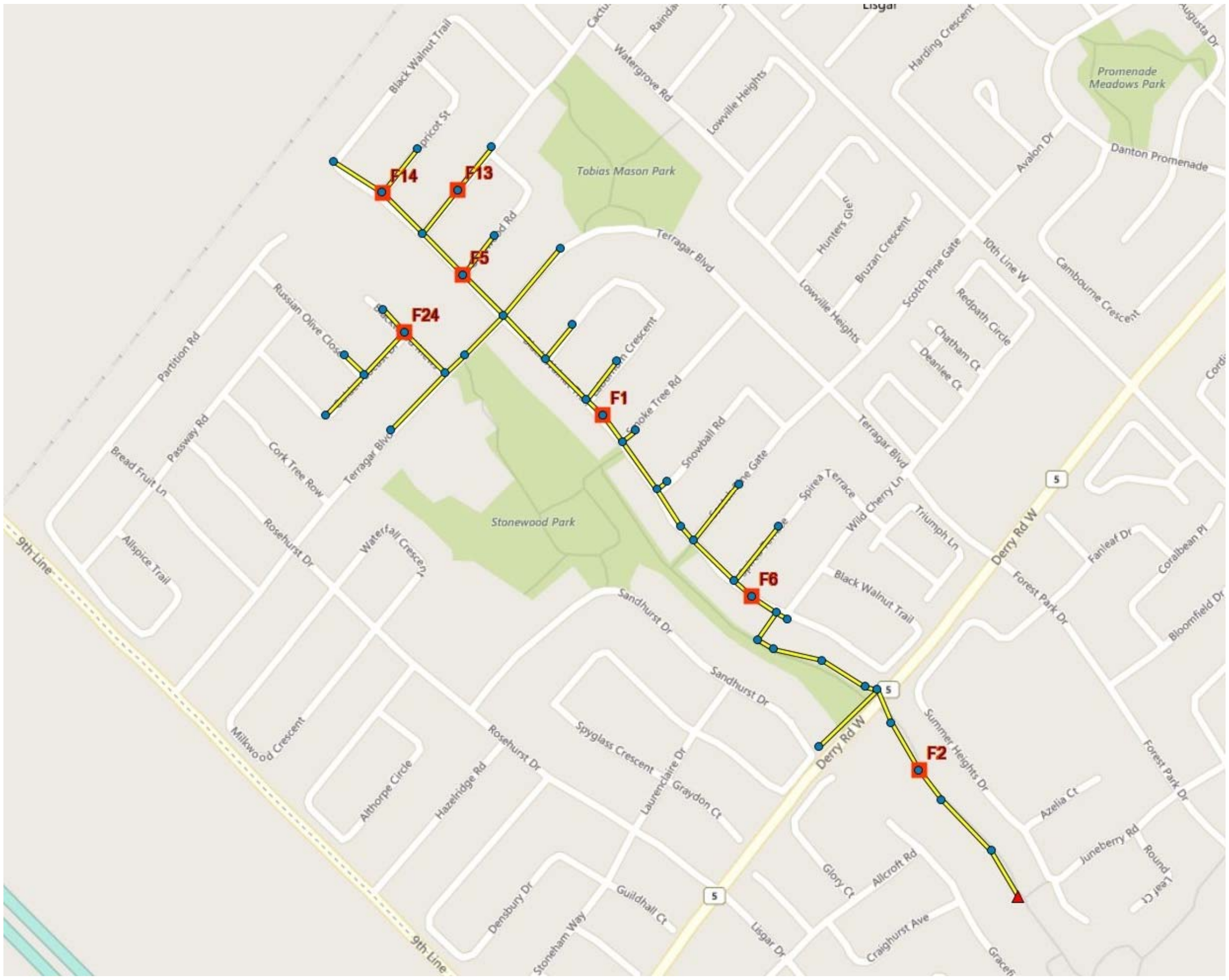


Figure A1: Extents of FDC Sewer System within PCSWMM Model and FDC Monitoring Locations

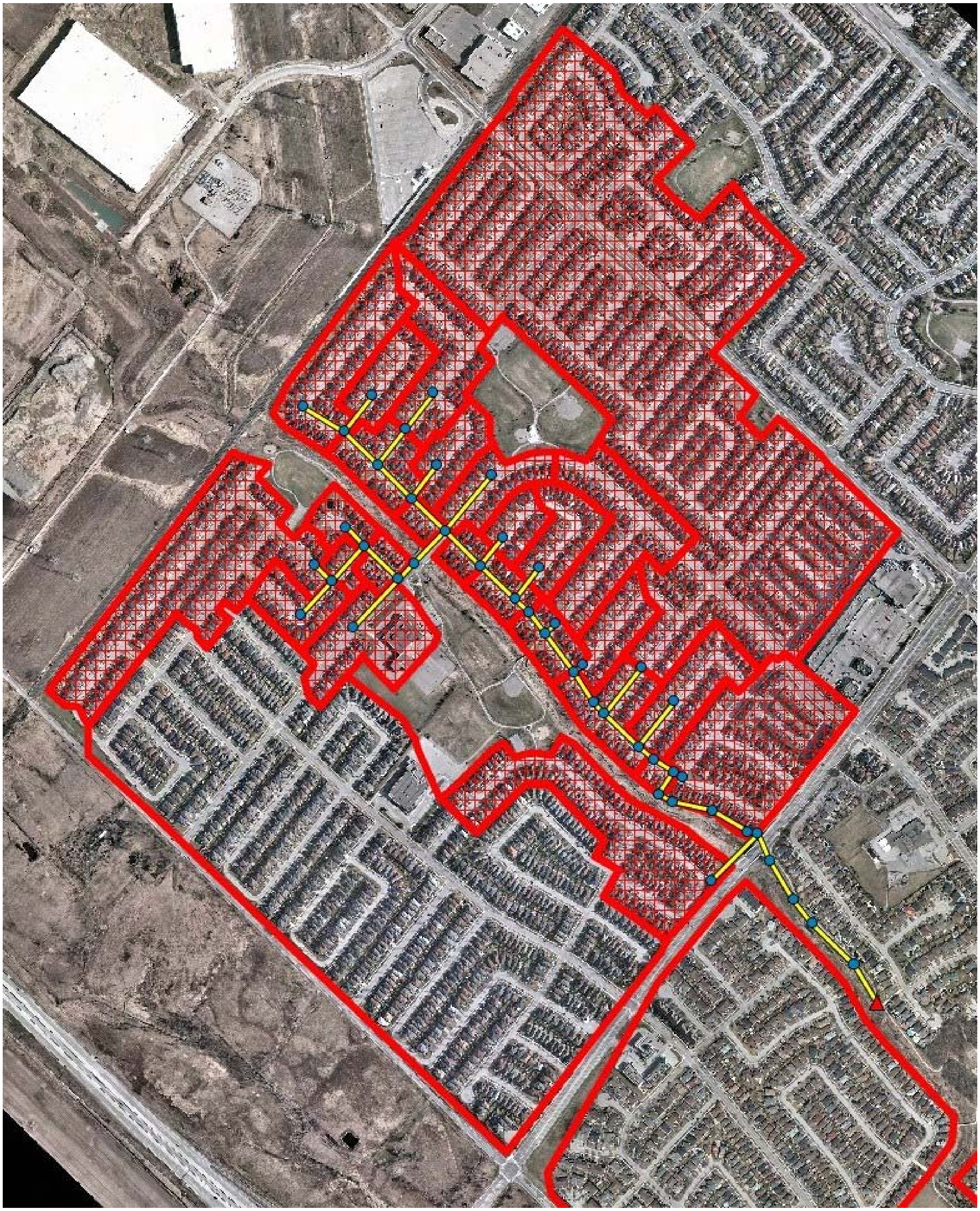


Figure A2: Estimated FDC Contributing Drainage Areas

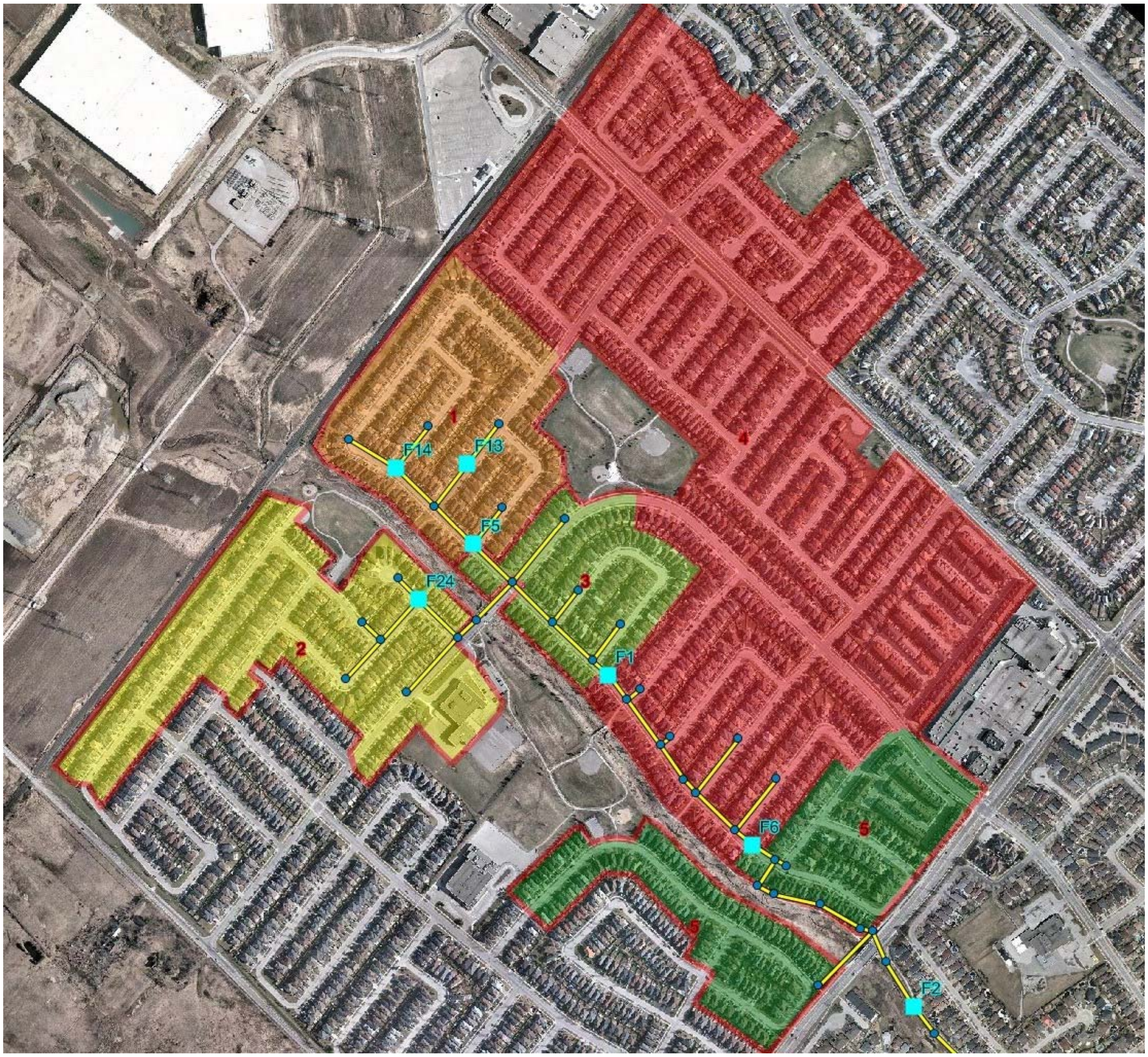


Figure A3: FDC Drainage Area Zones applied for Hydraulic Modelling Assessment

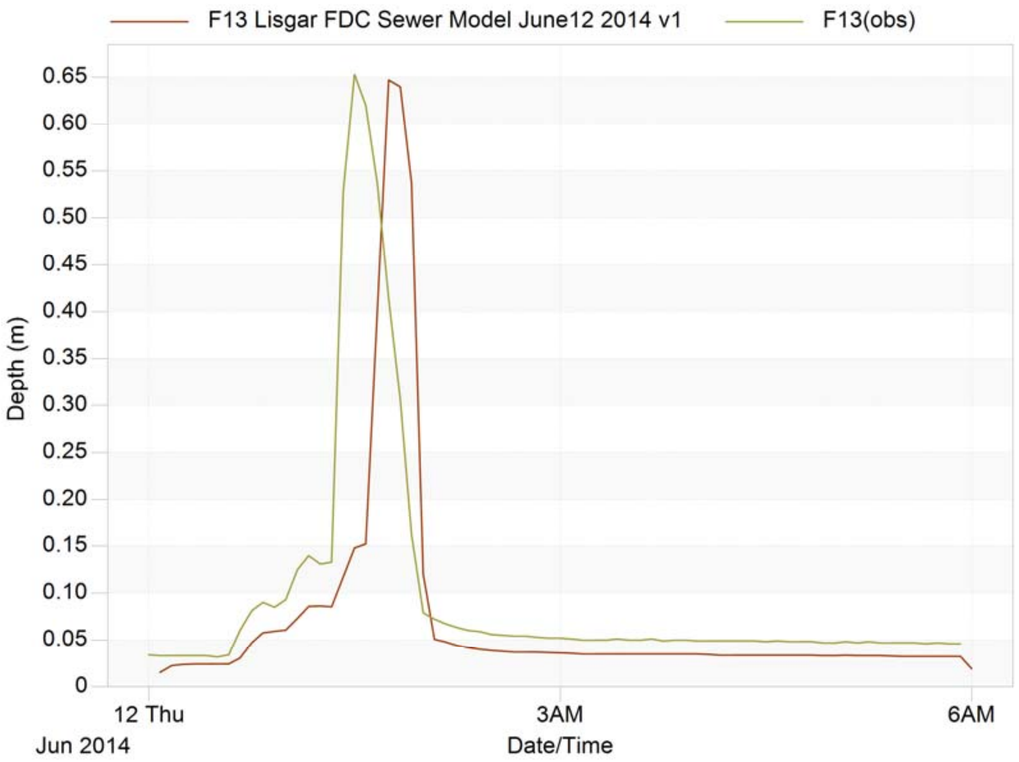


Figure A4: Simulated Fit for June 12, 2014 Storm Event – Gauge F13

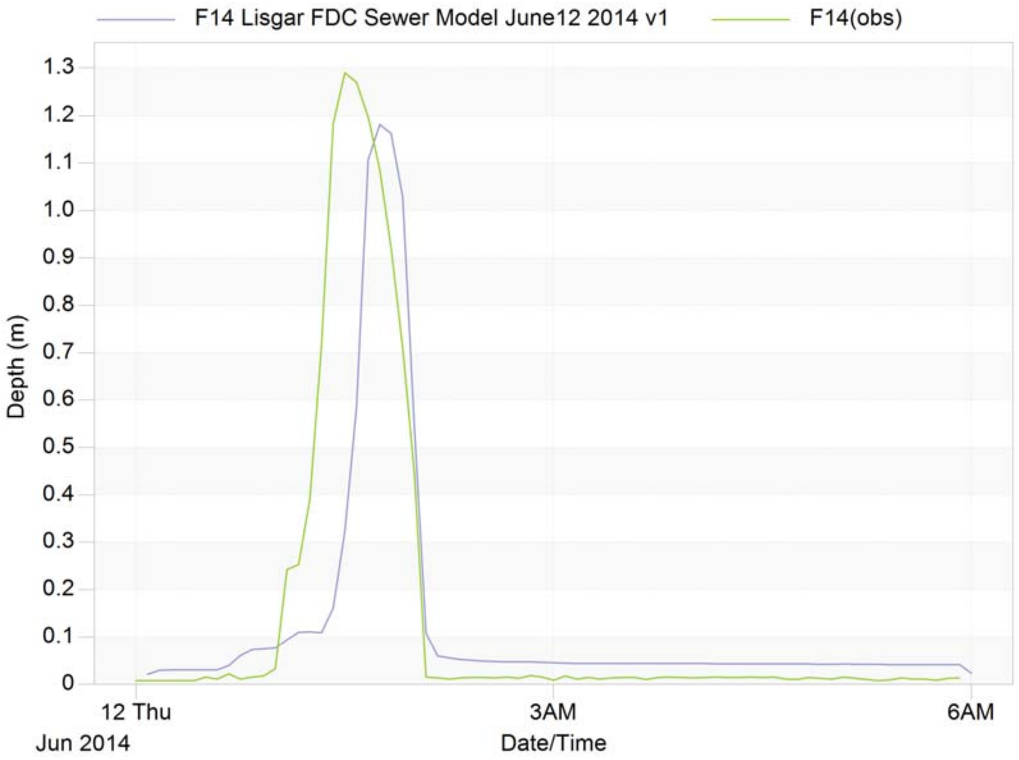


Figure A5: Simulated Fit for June 12, 2014 Storm Event – Gauge F14

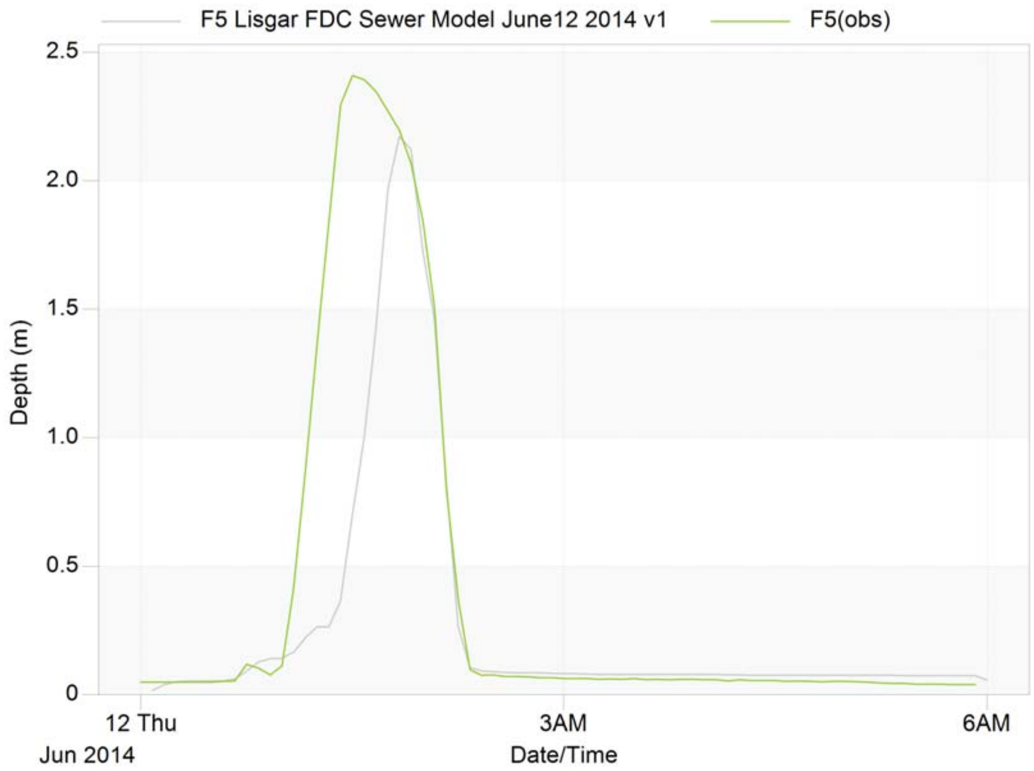


Figure A6: Simulated Fit for June 12, 2014 Storm Event – Gauge F5

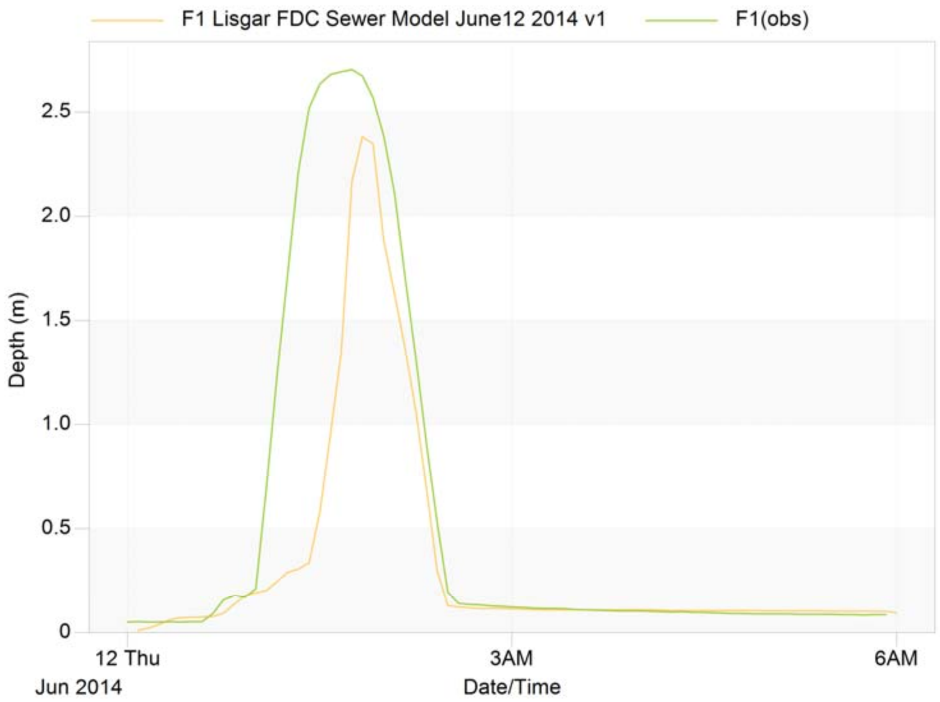


Figure A7: Simulated Fit for June 12, 2014 Storm Event – Gauge F1

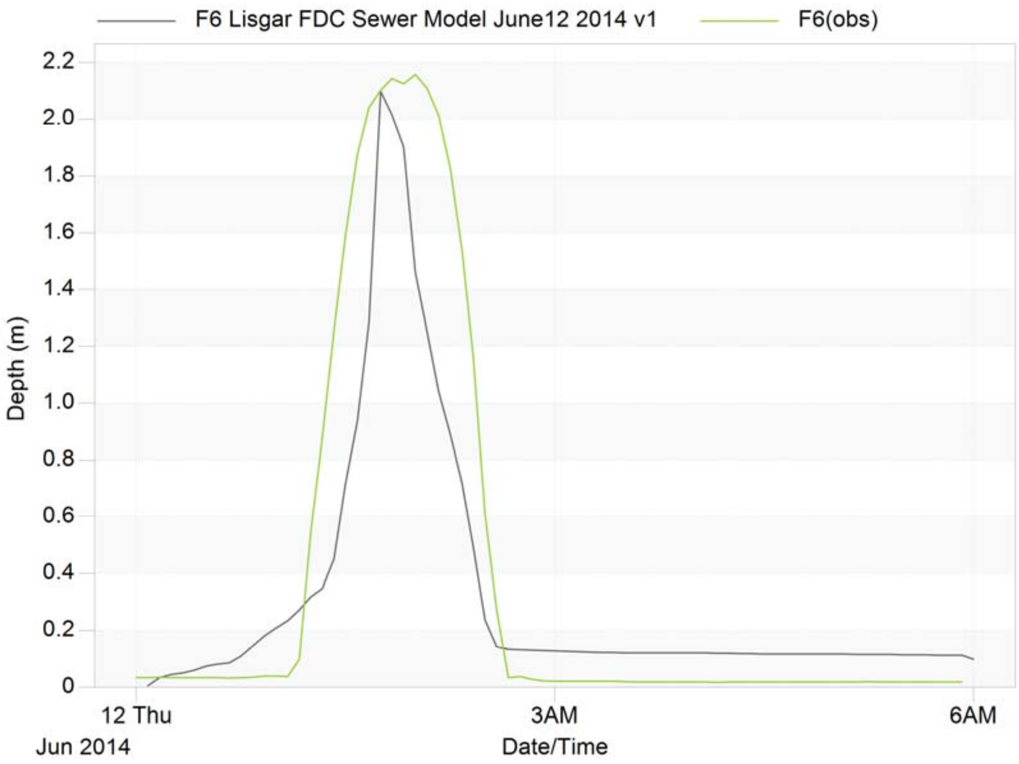


Figure A8: Simulated Fit for June 12, 2014 Storm Event – Gauge F6

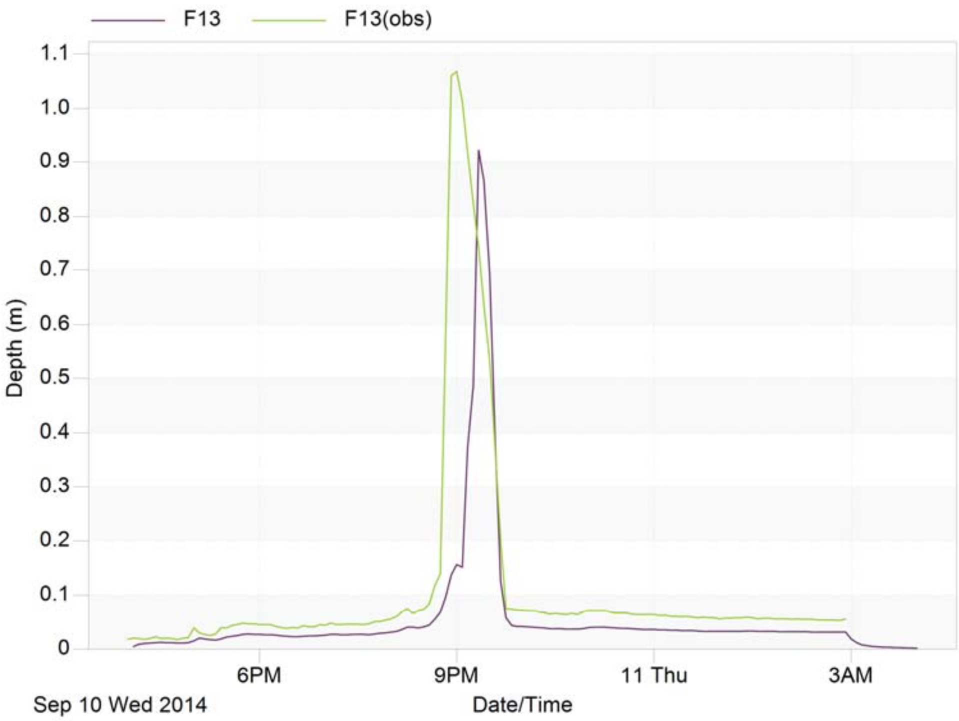


Figure A9: Simulated Fit for September 10, 2014 Storm Event – Gauge F13

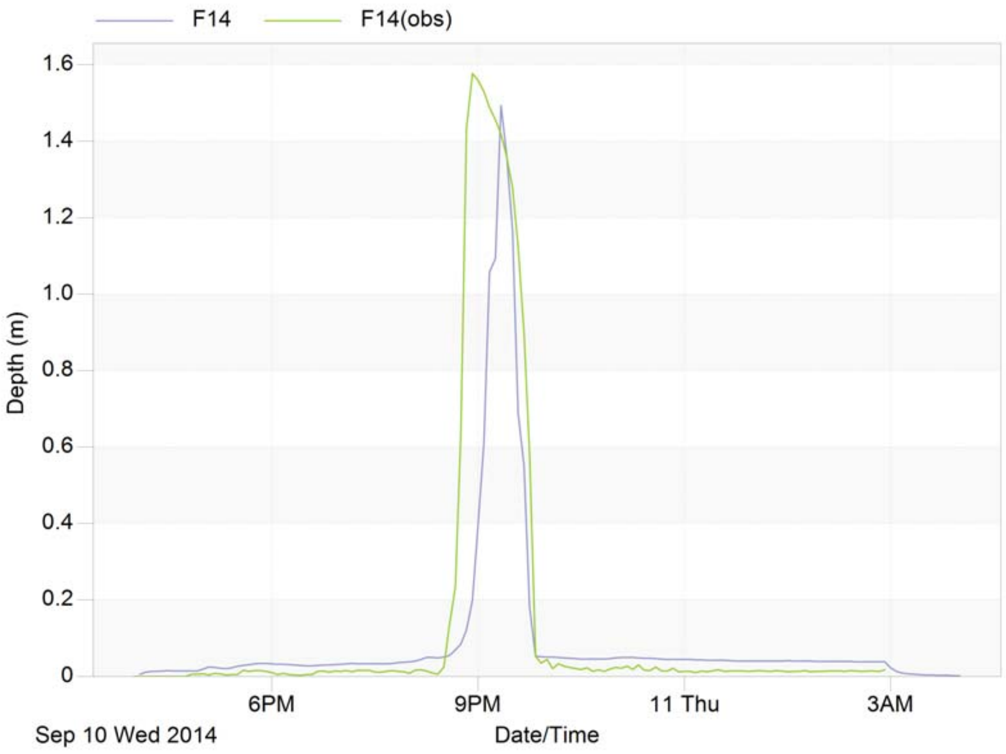


Figure A10: Simulated Fit for September 10, 2014 Storm Event – Gauge F14

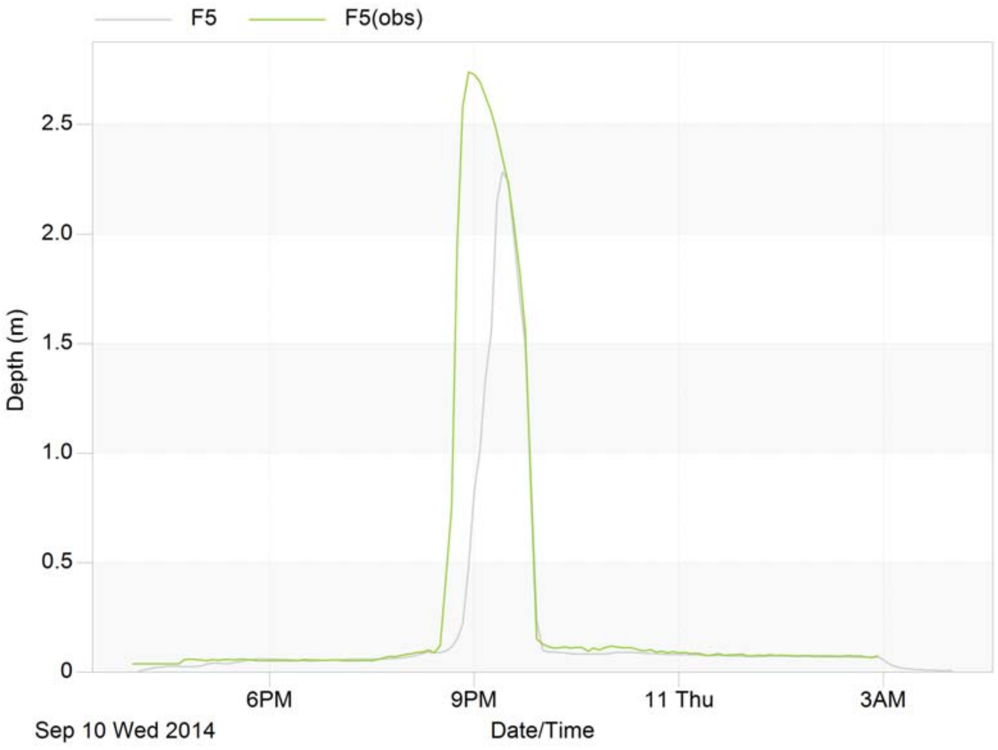


Figure A11: Simulated Fit for September 10, 2014 Storm Event – Gauge F5

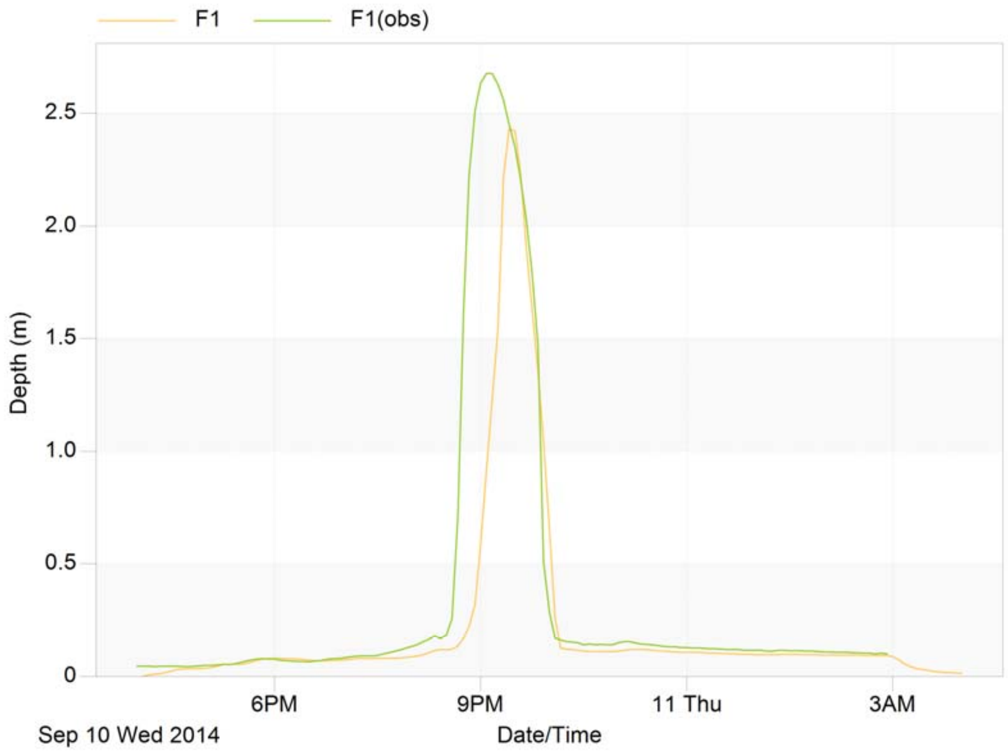


Figure A12: Simulated Fit for September 10, 2014 Storm Event – Gauge F1

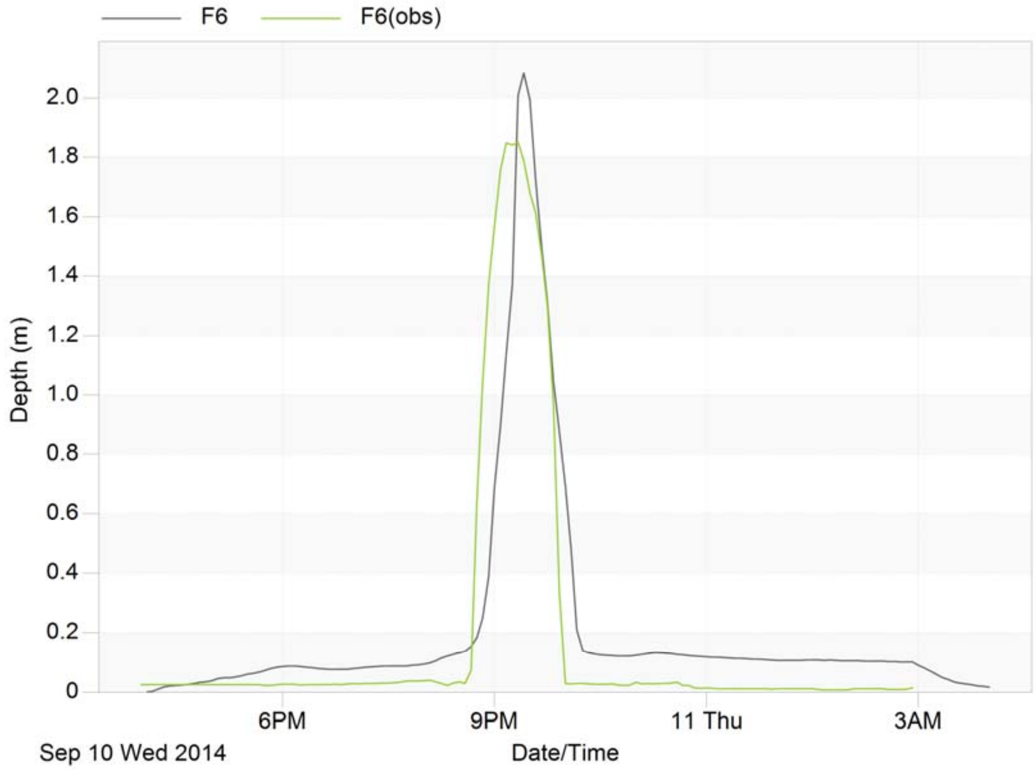


Figure A13: Simulated Fit for September 10, 2014 Storm Event – Gauge F6

Figure A14: Observed Water Levels (Corrected) at FDC Monitoring Sites North of Derry Road for June 12, 2014 event

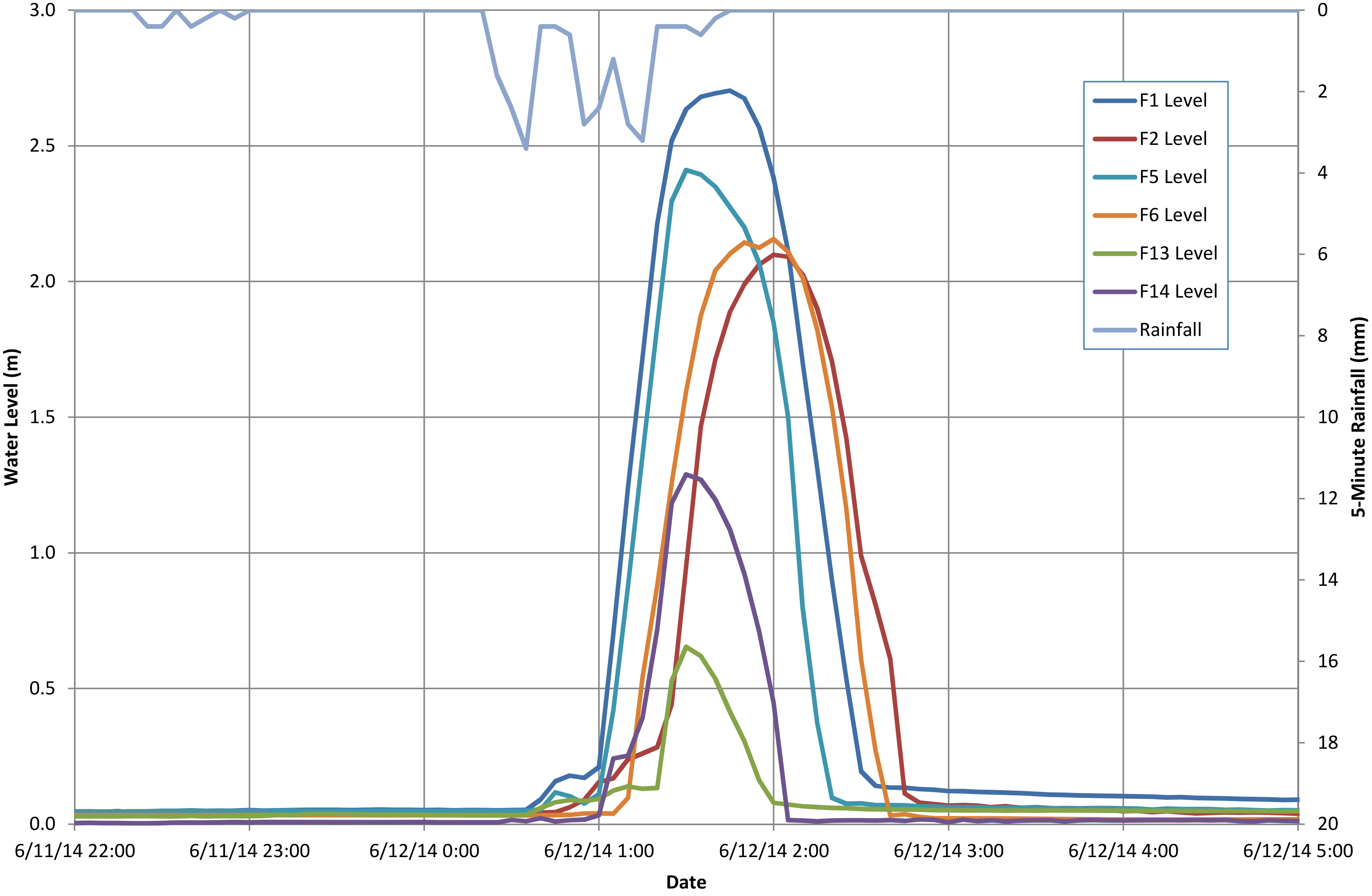
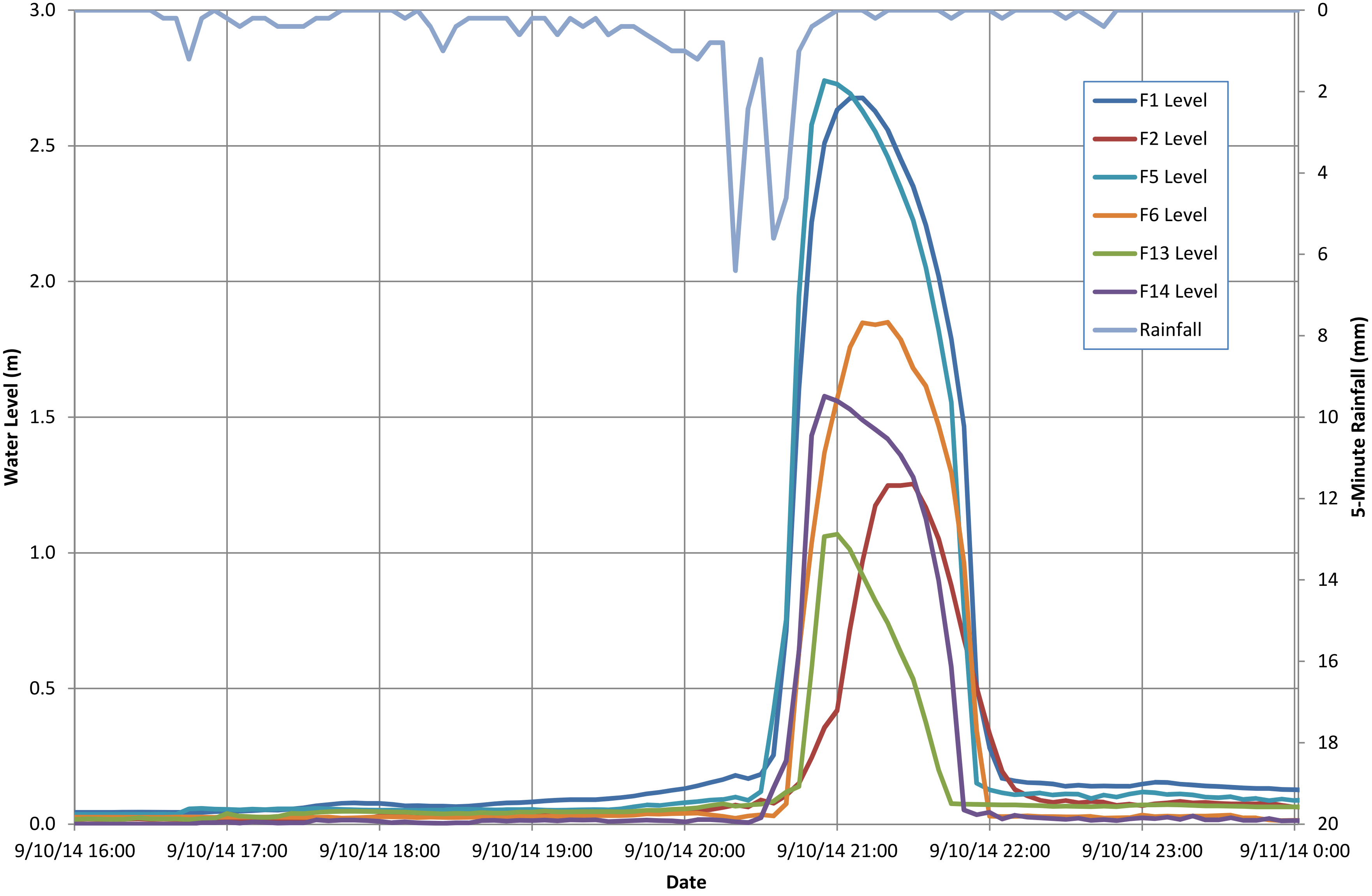


Figure A15: Observed Water Levels (Corrected) at FDC Monitoring Sites North of Derry Road for September 10, 2014 event



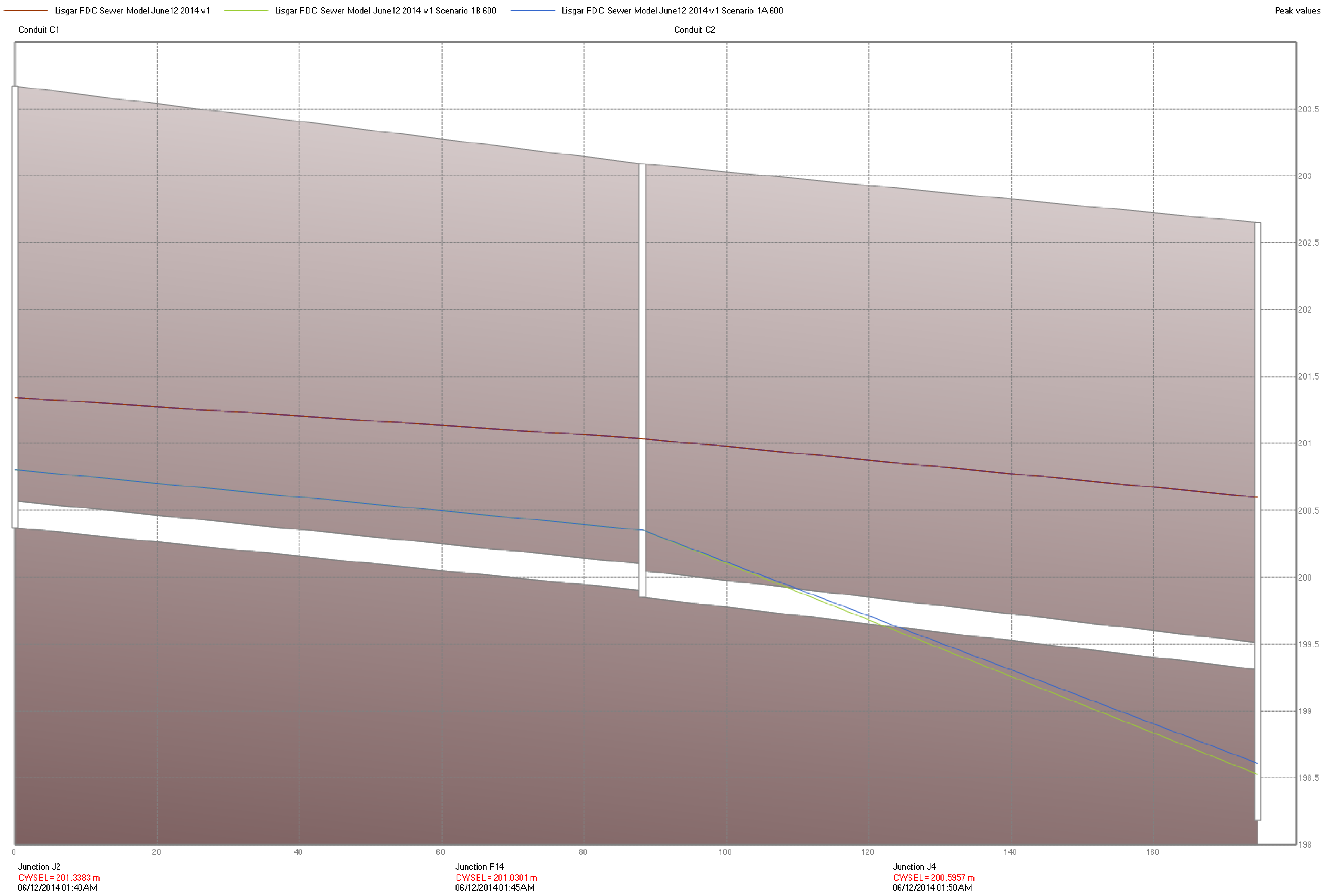


Figure A16: Simulated HGL upstream of Cactus Gate for June 12, 2014 storm event, with and without pumping station (Options 1A and 1B) in place

Appendix D
Consultation Summary

1.0 Introduction

The basement water infiltration issue in the Lisgar District began in 2008, when a number of homes experienced water seeping into their basements following certain rainfall events. In response, the City has undertaken a number of actions, including sealing FDC manholes and pipe joints, storm sewer lining, and implementing a High Water Protocol. Consultation, particularly between the City and Lisgar residents, has been a critical component of this process as it has evolved over the years through various investigations, action plans and public meetings.

This study represents the latest development of the ongoing Lisgar investigation and has followed the process outlined in the Municipal Engineers Association (MEA), Municipal Class Environmental Assessment (EA), October 2000 (as amended in 2007, 2011, and 2015). This Municipal Class EA is classified as a Schedule B undertaking, which defines mandatory principles and details of project consultation. This consultation summary report details the consultation that occurred as part of this process with the public, Indigenous communities and Regulatory Agencies.

2.0 Public Information Centre

A Public Information Centre (PIC) was held on Thursday June 14, 2018 from 6:30 pm to 9:00 pm at the Garry W Morden Centre, located at 7535 Ninth Line, Mississauga Ontario. The PIC was advertised on the City of Mississauga website, and two notices were mailed to approximately 150 local residents. One notice was tailored specifically to the residents located adjacent to the Cactus Gate Parkette, informing them that it had been selected as the Preferred Solution for the Pumping Station location. The second notice was addressed to the remaining residents of the Lisgar District, informing them that an alternative assessment had been completed and the findings along with the Preferred Solution would be presented at the PIC.

The PIC was part of Phase 2 of the Municipal Class EA process, and approximately nine people signed the attendance record. The PIC was an opportunity for the public to review the investigations that had been completed to date, the Pumping Station alternative assessment and the Preferred Solution. The information was presented on 21 display boards for participants to review at their own pace and discuss with the Project Team. Comment forms were provided at the PIC and provided online on the City of Mississauga website.

One public comment was received inquiring about the potential for Low Impact Development to be incorporated into the solution for the Lisgar District basement water infiltration issue.

All materials regarding the PIC and public comment received can be found in Appendix D1.

3.0 Indigenous Consultation

The City received direction from the Provincial Crown to undertake the procedural aspects of the duty to consult with Indigenous communities that may have an interest in the project, which included the Mississaugas of the New Credit First Nations (MNCFN), Six Nations of the Grand River (SNGR) and the Haudenosaunee Confederacy Chiefs Council (HCCC). Plain language introductory letters and project summary were provided to each Indigenous community by email. Follow-up phone calls were placed to community representatives of MNCFN, SNGR and Haudenosaunee Development Institute (HDI) in order to determine potential interest in the project; no responses were received.

All materials regarding Indigenous community consultation can be found in Appendix D2.

4.0 Regulatory Agency Consultation

The City mailed the notices of Commencement and PIC to the applicable Regulatory Agencies, including Conservation Halton (CH), the Ministry of Environment, Conservation and Parks, the Ministry of Natural Resources and Forestry, the Ministry of Tourism, Culture and Sport, the Ministry of Transportation, the Department of Fisheries and Oceans Canada, and Alectra. CH provided comments and an Environmental Assessment checklist on June 29, 2018, identifying project areas of interest, applicable policies and EA study requirements. The City responded on July 13, 2018, addressing the two principle areas of interest to CH: the Foundation Drain Collection Outlet to Sixteen Mile Creek Tributary and the volume and character of flow from the proposed Pumping Stations. The City indicated the impacts to both would be negligible to non-existent due to the clear flow and smaller rates and suggested that additional detailed studies would not be required as they would be sufficiently addressed in the Class EA report.

All materials regarding Regulatory Agency consultation can be found in Appendix D3.

5.0 Conclusion

The City will continue to meet all regulatory requirements as outlined in the Municipal Class EA process as the Project File is posted for public review and will continue to prioritize consultation as it has throughout the Lisgar District basement water infiltration investigation. The City will discuss the project with Indigenous communities and members of the public as necessary to address questions and comments.

D1 Materials

CITY OF MISSISSAUGA
NOTICE OF STUDY COMMENCEMENT AND PUBLIC INFORMATION CENTRE
Lisgar District Pumping Stations Municipal Class Environmental Assessment

WHAT?

- The City of Mississauga is undertaking a Municipal Class Environmental Assessment (EA) to determine preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration

WHY?

- Commencing in 2008 several homes in the Lisgar District experienced water seeping into their basements following certain rain events
- In response, the City undertook a number of actions, including the initiation of the Lisgar District Basement Water Infiltration Investigation, which recommended a set of preferred actions to be strategically undertaken to address the potential for basement water infiltration
- This Municipal Class EA has been undertaken to plan for one of the key recommendations related to building permanent foundation drain collector (FDC) Pumping Station(s)

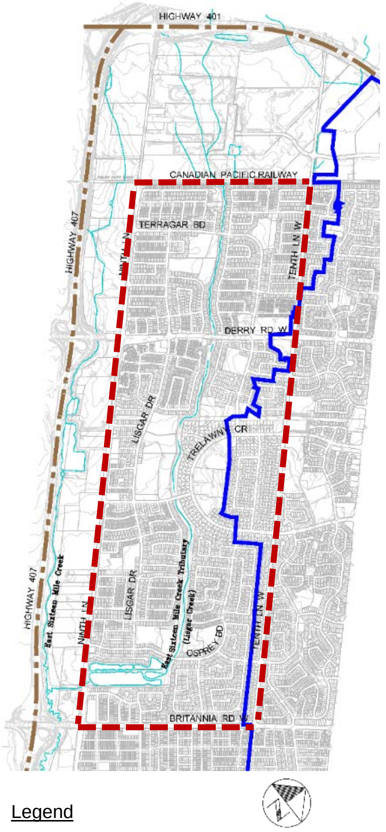
HOW?

- The Study will be completed as a Schedule B undertaking following the Municipal Class Environmental Assessment process
- Multiple Pumping Station Alternatives will be developed and evaluated by the Project Team and refined through stakeholder and public consultation. The Project Team will then select a Preferred Alternative and develop a design for the Pumping Station(s).
- At the end of the study, a Project File documenting the entire study process will be available for public review

PUBLIC CONSULTATION:

- A key component of this process is stakeholder consultation (public, landowners and agencies). A Public Information Centre (PIC) will be held as an opportunity to review the investigation findings and proposed Pumping Station locations
- The PIC will include storyboards and a one-on-one discussion period for individuals to meet with the Project Team, review material and discuss the project

WHERE?



Legend

- - Study Area

— East Sixteen Mile Creek Subwatershed Boundary

Date: June 14, 2018
Time: 6:30 p.m. to 8:30 p.m.
Venue: Gary W Morden Centre (7535 Ninth Line, Mississauga ON)

Web: http://www.mississauga.ca/portal/residents/lisgarinvestigation

- If you have any questions or comments regarding the Study, require additional information, or would like to be placed on the project mailing list to be notified about upcoming public meetings, please contact:

Louie Jakupi, P.Eng.
Project Manager
City of Mississauga
201 City Centre Dr, Suite 800
Mississauga, ON L5B 2T4
(905) 615-3200, ext. 3321
louie.jakupi@mississauga.ca

Ron Scheckenberger, P.Eng., M.Eng.
Consultant Project Manager
Wood, Environment & Infrastructure Solutions
3450 Harvester Rd, Suite 100
Burlington, ON L7N 3W5
(905) 335-2353 ext. 3109
ron.scheckenberger@woodplc.com

With exception of personal information, all comments shall become part of the public records. Questions about this collection should be directed to the Project Manager above.

This notice was first issued on May 23, 2018.

City of Mississauga
Transportation and Works Department
201 City Centre Drive, Suite 800
MISSISSAUGA, ON L5B 2T4
mississauga.ca

Dear Resident,

Re: Lisgar District Pumping Stations Municipal Class Environmental Assessment

The City of Mississauga is undertaking a Municipal Class Environmental Assessment (EA) to determine the preferred locations and form of Pumping Stations within the Lisgar District to reduce the potential for basement water infiltration. The study area is bounded by Canadian Pacific Railway to the north, Ninth Line to the west, Britannia Road W. to the south and Tenth Line W. to the east. However, the area most recently affected by basement water infiltration is located along Black Walnut Trail.

This Municipal Class EA has been undertaken to plan for the construction of permanent Pumping Stations. Multiple Pumping Station(s) Alternatives have been developed and evaluated by the Project Team and a preferred location has been identified.

We are reaching out to you to advise that the recommended location for the first Pumping Station is the Cactus Gate parkette, in proximity to your property.

A Public Information Centre (PIC) will be held as an opportunity for public input. Please refer to the PIC notice on the back of this letter.

If you are unable to attend the Public Information Centre and have any questions regarding the study, or would like to be placed on the project mailing list to be notified about upcoming public meetings, please contact one of the following Project Team members below.

Sincerely,

Louie Jakupi, P.Eng.
Project Manager
City of Mississauga
201 City Centre Dr, Suite 800
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MISSISSAUGA

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ron.scheckenberger@woodplc.com

Welcome

Welcome to the Public Information Centre for:

Lisgar District Basement Water Infiltration Class Environmental Assessment Study for Pumping Stations

The purpose of this Public Information Centre is to:

Provide an overview of the study

Obtain public input on the preliminary proposed solution

Please sign in if you would like to be included on the project mailing list

Information presented this evening will be available on the City of Mississauga's Lisgar Basement Water Infiltration Investigation website:

http://www.mississauga.ca/portal/residents/lisgarinvestigation

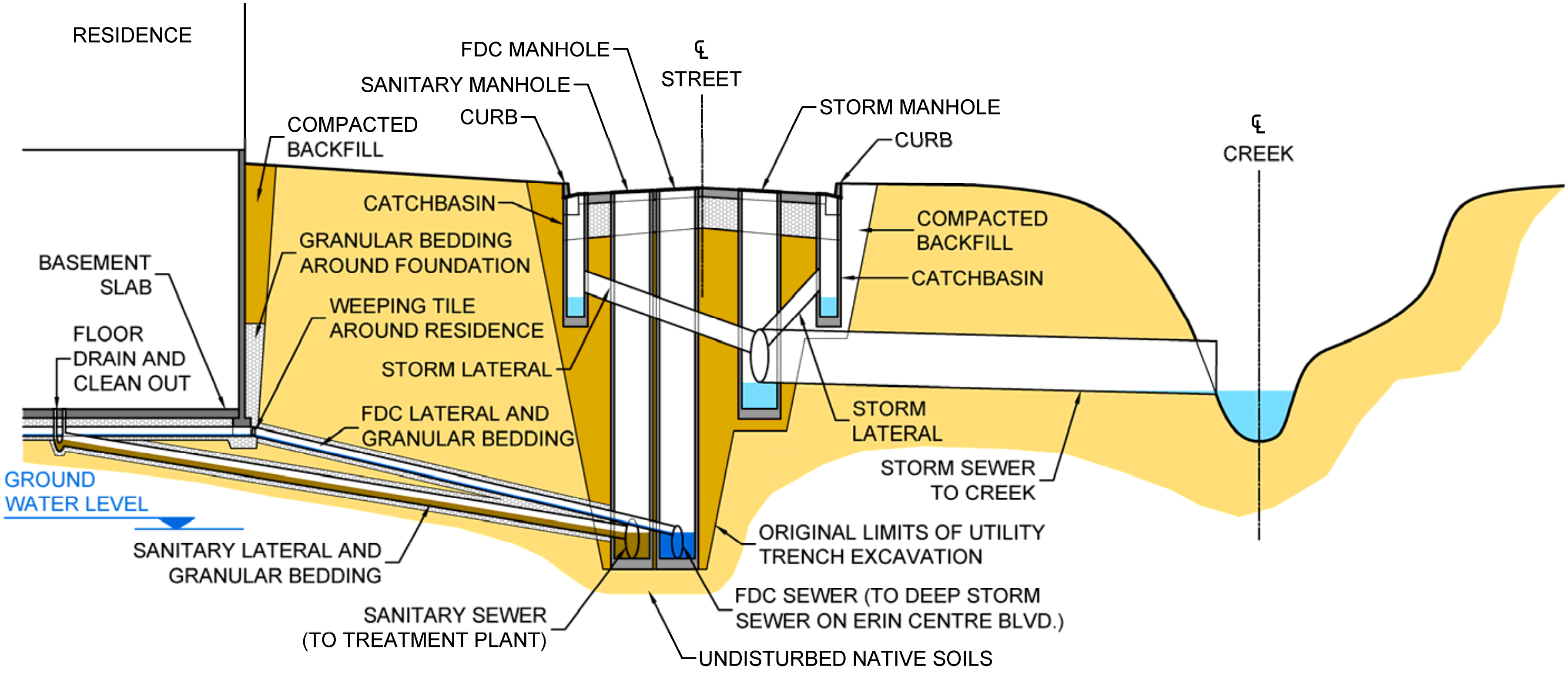
1. Recap and History of Problem

Timeline:

Beginning in 2008	October 2011	March 2015	October 2017
A number of homes experienced water seeping into their basements after certain rainfall events	Wood (formerly AmecFW) retained to undertake an engineering study and multi-year monitoring to determine possible causes and develop a prioritized action plan	Public presentation of findings along with a Prioritized Action Plan to be implemented in stages Action Plan approved by Council on April 15, 2015 Constructed projects to be monitored to assess effectiveness and to assist staff in making informed decisions on subsequent actions	Community update meeting held to review ongoing work, including updated Prioritized Action Plan and response to July 13-14, 2017 storm event Updated Prioritized Action Plan approved by Council on November 22, 2017

2. Overview of Foundation Drainage System

3-Pipe System - Foundation Drain Collector (FDC)



3. Past Study/ Investigations

Initial Broad Study to Identify Causes of Basement Water Infiltration including:

Monitoring Work:

- Groundwater
- FDC and Storm Sewer System
- Creek Tributary and Stormwater Management Pond

Testing:

- Water Quality
- Storm Sewer Leakage Testing
- Storm Sewer Outfall Collar Testing
- Smoke Testing

City-led Mitigation:

- Inspection
- Cleaning
- Sealing
- Monitor Capital Works
- High Water Protocol
- Sump Pump Subsidy

Investigations led to the implementation of priority mitigation measures over a period of time

4. Primary Cause

Excess Stormwater into the Utility Trench

- Leakage from the storm sewer system (which is a normal and expected occurrence), combined with the presence of slow draining native soils (around the utility trench) results in water build-up
- If the build-up of water is significant, it travels up the bedding material around the Foundation Drain Collector (FDC) laterals servicing the homes and into the foundation weeping tiles
- Water then drains directly into the FDC pipes through the weeping tiles which can surcharge (overload) the system
- This condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage may lead to water around the home’s weeping tiles being unable to drain and potentially seeping into the basements of homes.

5. Status of Mitigation Plan

Updated Action Plan:

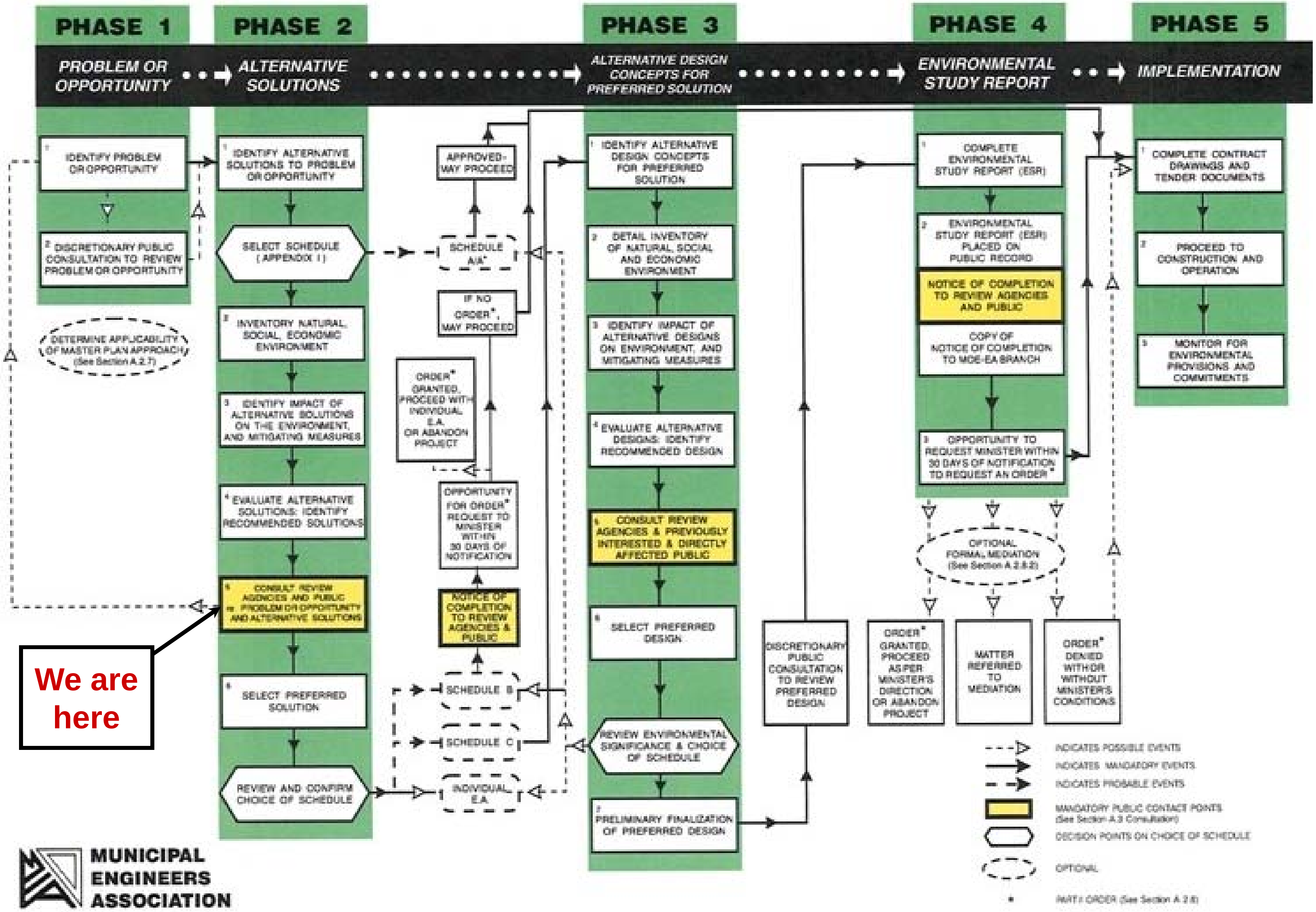
City Actions	Schedule
ADDRESS ROADWAY SUB-DRAIN LEAKAGE	
• *Pursue prototype of roadway sub-drain plugs*	*Complete*
• *Installation of plugs along Black Walnut Trail and other areas*	*Complete*
• *Expansion to other areas within Lisgar District*	*Pending Monitoring Results*
CONSTRUCTION OF AN UTILITY TRENCH DEWATERING SYSTEM	
• *Carry Out Municipal Class EA Study*	*Underway*
• *Complete detailed design work*	*Ongoing*
• *Construction*	*Planned for 2018*
CONSTRUCTION OF A FDC PUMPING STATION	
• *Carry Out Municipal Class EA Study*	*Underway*
• *Conduct Hydraulic Modelling Analysis*	*Complete*
• *Complete detailed design work*	*Ongoing*
• *Construction*	*Planned for 2018*

5. Status of Mitigation Plan

Updated Action Plan:

City Actions	Schedule
AMEND SUMP PUMP SUBSIDY PROGRAM	
• *Increased Program Subsidy*	*Complete*
CONTINUE WITH HIGH WATER PROTOCOL	
• *Continue to monitor and initiate updated pumping protocol as required*	*Ongoing*
MONITORING	
• *Implement additional monitoring gauges in key study areas*	*Complete*
• *Monitoring to verify effectiveness of implemented measures*	*Ongoing*

6. Municipal Class EA Study Process



We are here

6. Municipal Class EA Study Process

Study: This Municipal Class EA Study is being undertaken for the permanent Utility Trench and Foundation Drain Collector (FDC) Pumping Stations.

Schedule: The Design and Construction of the Pumping Stations is a Schedule B undertaking

Multiple Pumping Station Alternatives Developed

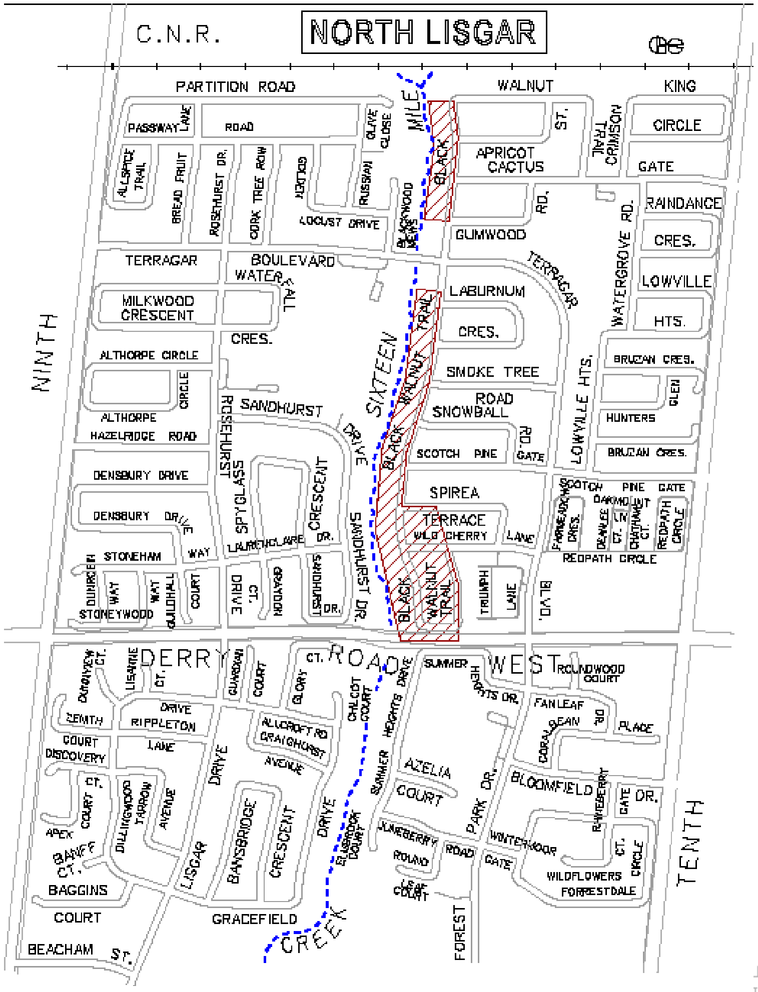
Alternatives Evaluated to Select a Preferred Alternative for the Pumping Station(s)

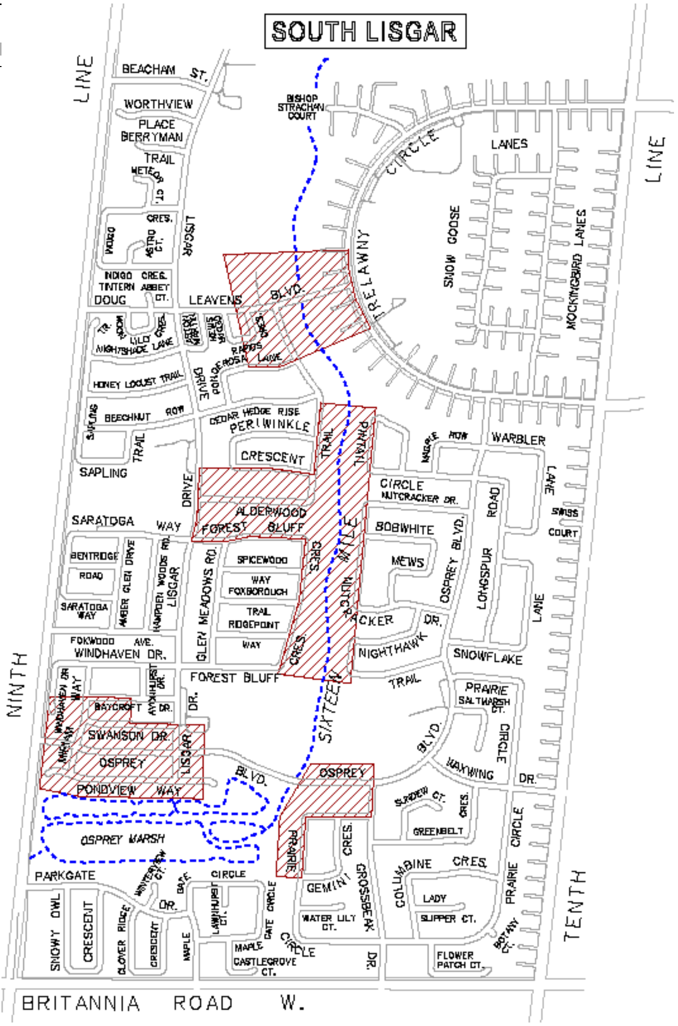
Receive Public Input through Stakeholder and Public Consultation

Develop Detailed Design for Preferred Alternative

7. Pumping Station Assessment

Areas Generally Affected by Basement Water Infiltration





Legend

🟥 Areas Generally Affected

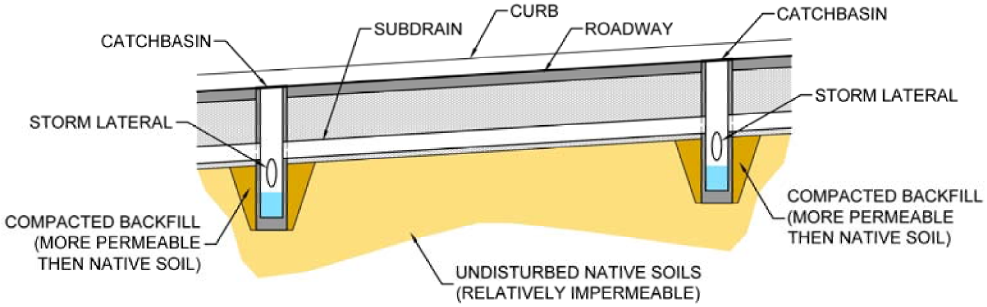
— Sixteen Mile Creek

7. Pumping Station Assessment

Types of Systems:

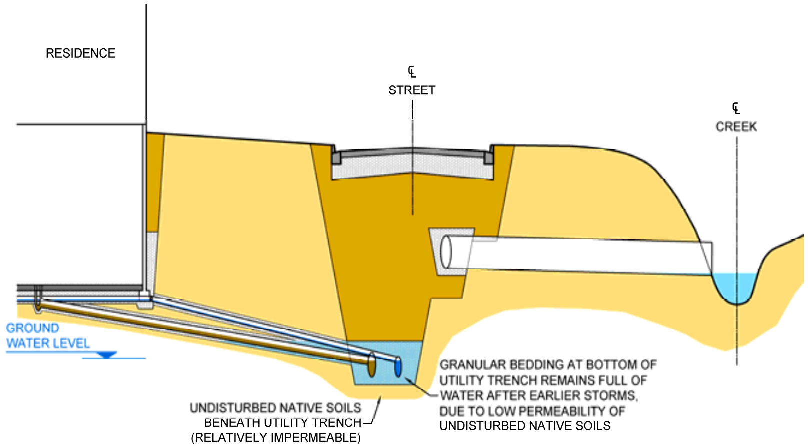
Utility Trench Dewatering Pumping Station (Low Flow):

- System operates to dewater the utility trench (granular stone bedding) by removing small amounts of water on a continuous basis, much like a sump pump.



FDC Pumping Station (High Flow):

- System operates to remove water from the FDC pipe network during periods of high flow. This pump would be larger but operate less frequently and only during certain rain storms



7. Pumping Station Assessment

Potential Pumping Station Locations (Long-list of Alternatives):

Using the following criteria, 6 potential pumping station locations were identified

Criteria for Siting:

- Public Land Ownership
- Drainage Area served
- Proximity to the number of houses with reported incidents of basement water infiltration
- North of Derry Rd. W - identified as a priority area given greater number of reported incidents of basement water infiltration

1. Black Walnut Trail at Cactus Gate Parkette
2. Russian Olive Close at Buttonbush Park
3. Terragar Boulevard at Lisgar Creek
4. Black Walnut Trail at Smoke Tree Road Parkette
5. Black Walnut Trail at Scotch Pine Gate Parkette
6. Black Walnut Trail at Wild Cherry Lane Easement

7. Pumping Station Assessment

Evaluation Criteria

Drainage Area Served: The drainage area served means the amount of nearby land that will be serviced by the Pumping Station, therefore a larger drainage area is a positive factor.

Property Suitability: The suitability of the property is evaluated based on public land ownership and local property constraints, such as the amount of public space available (parkette versus City owned easement).

Number of Houses in Proximity that Reported Basement Water Infiltration: The Pumping Station should be located in proximity to the greatest number of houses that reported basement water infiltration in order to best address the issue.

7. Pumping Station Assessment

Evaluation of Alternatives

Long-list of Alternatives	**Evaluation Criteria**			**Evaluation**
Potential Pumping Station Locations	Drainage Area Served	Property Suitability	# of Reported Cases	Screened / Short-listed
1. Black Walnut Trail at Cactus Gate Parkette	🟢	🟢	🟢	Short-listed
2. Russian Olive Close at Buttonbush Park	🟡	🟢	🟡	Screened out
3. Terragar Boulevard at Lisgar Creek	🟡	🔴	🟢	Screened out
4. Black Walnut Trail at Smoke Tree Road Parkette	🟢	🟢	🟡	Short-listed
5. Black Walnut Trail at Scotch Pine Gate Parkette	🟢	🟢	🔴	Screened out
6. Black Walnut Trail at Wild Cherry Lane Easement	🟢	🔴	🔴	Screened out

🟢 Positive 🟡 Neutral 🔴 Negative

7. Pumping Station Assessment

Based on the evaluation of alternatives, two locations have been short-listed:

1. Black Walnut Trail at Cactus Gate Parkette: Located on City- owned parkette and where monitoring has shown that the FDC in the area was often seen to be overloaded.

4. Black Walnut Trail at Smoke Tree Road Parkette: Located on City-owned parkette and serves a large drainage area, however located further downstream of residences which reported basement water infiltration.

Technical Assessment of Short-Listed Alternatives

The two short-listed alternatives have been further evaluated by:

- Modelling the effectiveness of lowering water levels
- Interpreting the results of the modelling

Leading to the Selection of a Preliminary Preferred Site

7. Pumping Station Assessment

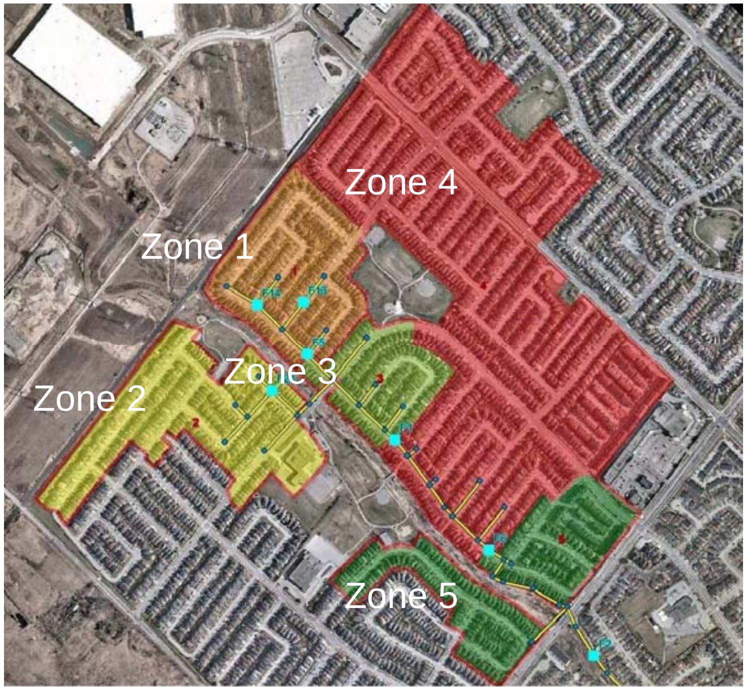
Technical Assessment

A hydraulic model of the FDC sewer system was developed to assess expected rates of flow within the FDC system during storm events in order to evaluate the effectiveness of potential pumping station locations, including the number of pumps required and their size and capacity.

- The model was compared to four large rainfall events between 2012 and 2017 to determine locations where greatest surcharging (overloading) of FDC sewers occurred

- Zone 1 demonstrated the highest rates of FDC flow contributions, followed by Zone 2

- The Highest relative overall benefit was determined to be from pumping systems in these areas (i.e. Zones 1 and 2)



8. Proposed Preliminary Solution

Recommendations:

- **The Parkette at Black Walnut Trail and Cactus Gate is the Preliminary Preferred Location**
- Construct both a Utility Trench Dewatering and FDC Pumping System in the same location to reduce construction impacts and costs.
- Monitor performance of Utility Trench Dewatering and FDC Pumping Stations.
- Additional future Pumping Stations may be considered for other areas (including South Lisgar), based on results of ongoing monitoring

8. Proposed Preliminary Solution

Mitigation Considerations:

Subject	Impact / Issue	Mitigation / Action
Construction	• Traffic • Noise • Dust • Vibration	• Management plan required to meet City standards • Contract will ensure City requirements are met • Pre-construction surveys of adjacent residences are proposed • Active monitoring during construction
Operation	• Noise • Odour • Maintenance	• Pumps will be below ground and operate infrequently • Stormwater flows (not sanitary) - no odour is anticipated • Proposed maintenance access will be through a manhole chamber
Aesthetics	• Pumps • Parkette • Buildings	• Both pumps would be below ground • Landscape plan will be created for restoration • A permanent servicing building may be required
Creek Discharge	• Outlet	• Located adjacent to creek; Conservation Halton permit may be required if works within regulated area
Climate Change	• Resiliency	• Pumping station and utility dewatering trench will add capacity to overall system, providing resiliency to changing climate

9. Next Steps

Next Steps:

Consultation/ EA Process

- Receive input from Public, stakeholders and Indigenous Communities
- File Project File for 30 Day Review

Design

- Initiate Detailed Design of preferred system

Approvals

- Submit for approvals and permitting, including utilities, Ministry of the Environment and Climate Change and possibly Conservation Halton

Tender & Construction

- Issue Tender and proceed to Construction, anticipated for 2018-2019, subject to Class EA Study approval

9. Next Steps

How Can You Get Involved?

- Join our Project Mailing list for timely, relevant updates by adding your name to the sign-in sheet
- Review information shared at this Public Meeting
- Provide input by completing a Comment Form
- Speak with one of the Project Team members:

Louie Jakupi, P.Eng.

City of Mississauga

Phone: (905) 615-3200, ext. 3321

Email: Louie.Jakupi@mississauga.ca

Ron Scheckenberger, M.Eng., P.Eng.

Wood Environment & Infrastructure Solutions

Phone: (905) 335-2353 ext. 3109

Email: Ron.Scheckenberger@woodplc.com

FDC Sump Pump Subsidy Program

Available Next Steps for Residents:

- It is continued to be suggested that residents who qualify for the City's FDC Sump Pump Subsidy Program take advantage of this program.
- The City will subsidize homeowners who install a sump pump up to a maximum of $6,000
- Program details are available at: *http://www.mississauga.ca/portal/stormwater/fdc-sump-pump-subsidy/*

- *Applications forms are available here tonight*

COMMENT FORM

LISGAR DISTRICT PUMPING STATIONS
Municipal Class Environmental Assessment
Public Information Centre

June 14, 2018
6:30 – 8:30 pm

The City of Mississauga welcomes your comments on the Lisgar District Pumping Stations Municipal Class Environmental Assessment. Drop your completed Comment Form in the box provided or mail/fax/e-mail your comments to either of the following individuals by **June 28, 2017**:

Louie Jakupi, P.Eng.
Project Manager
City of Mississauga
201 City Centre Dr, Suite 800
Mississauga, ON L5B 2T4
Tel: (905) 615-3200, ext. 3321
E-mail: louie.jakupi@mississauga.ca
Website :
www.mississauga.ca/portal/residents/lisgarinvestigation

Ron Scheckenberger, M.Eng., P.Eng.
Consultant Project Manager
Wood, Environment & Infrastructure Solutions
3450 Harvester Rd, Suite 100
Burlington ON L7N 3G2
Tel: 905.335.2353 ext. 3109
Toll Free: 1.866.751.2353
Email: ron.scheckenberger@woodplc.com

Comments:

Thank-you for your participation. If you wish to be added to our Project Mailing List to be kept informed about the study please provide your contact information below.

Name:
Address:
City:
Postal Code:
Phone:
E-mail:

Personal information, as defined by the Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) is collected under the authority of the Municipal Act, 2001, and in accordance with the provisions of MFIPPA. Personal information on this Public Open House Comment Sheet will be used for the purpose of informing the Lisgar District Pumping Stations Municipal Class Environmental Assessment.

D2 Materials

From: Stokke, Samantha
To: Stokke, Samantha
Subject: FW: Mississauga - Lisgar District Pumping Stations Class EA - Indigenous Engagement
Date: September-06-18 4:31:57 PM

From: Bell, Trevor (MOECC) <Trevor.Bell@ontario.ca>
Sent: June-25-18 2:13 PM
To: Stokke, Samantha <samantha.stokke@woodplc.com>
Cc: Louie Jakupi <Louie.Jakupi@mississauga.ca>; Jeff Smylie <Jeff.Smylie@mississauga.ca>; Scheckenberger, Ron <ron.scheckenberger@woodplc.com>; Senior, Matt <matt.senior@woodplc.com>; Kelly, Mary K <mary.k.kelly@woodplc.com>; Alikakos, Mary (MOECC) <Mary.Alikakos@ontario.ca>
Subject: RE: Mississauga - Lisgar District Pumping Stations Class EA - Indigenous Engagement

Hi Samantha,

Sorry for the delay. The following communities should be engaged for your project:

Six Nations of the Grand River
Haudenosaunee Confederacy Chiefs Council
Mississaugas of the New Credit First Nation

A formal letter in response to the Notice of Commencement will follow this week.

Best regards,
Trevor

Trevor Bell
Environmental Resource Planner and EA Coordinator
Technical Support Section | Central Region
Ministry of the Environment and Climate Change
5775 Yonge St., 8th Floor
Toronto, ON M2M 4J1
T: 416-326-3577
E: trevor.bell@ontario.ca

From: Kelly, Mary K
To: Hazel Hill (hdi2@bellnet.ca)
Cc: Louie.Jakupi@mississauga.ca; Scheckenberger, Ron; Stokke, Samantha
Subject: Mississauga - Lisgar District Pumping Stations Class EA
Date: July-20-18 1:04:30 PM
Attachments: Lisgar_ClassEA_Project_Summary.pdf
image001.png
Notice of Study Commencement and PIC.PDF
2018-07-20_Lisgar_HDI.PDF

Good afternoon Ms. Hill,

The City of Mississauga is undertaking a Class Environmental Assessment to determine preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration.

Please find attached a letter from the City as well as a summary of the Project and copy of the Notice of Commencement.

I will follow-up with Haudenosaunee Development Institute next week to further discuss. Please do not hesitate to contact us should you have any questions or comments.

Cheers, Mary

Mary Kathryn Kelly, B.Sc.
Senior Human Environment Consultant / Indigenous Business Initiative Lead
Direct/Mobile: 705-493-9393
mary.k.kelly@woodplc.com
www.woodplc.com

MISSISSAUGA

City of Mississauga
Transportation and Works Department
201 City Centre Drive, Suite 800
MISSISSAUGA, ON L5B 2T4
mississauga.ca

July 20, 2018

Attn: Hazel Hill, Executive Director

Haudenosaunee Development Institute
16 Sunrise Court, Suite 407, P.O. Box 714
Ohsweken, ON N0A 1M0
Hdi2@bellnet.ca

Dear Ms. Hill,

RE: Lisgar District Pumping Stations, Municipal Class Environmental Assessment, City of Mississauga

The City of Mississauga is undertaking a Municipal Schedule 'B' Class Environmental Assessment (EA) to determine preferred locations and form of Pumping Station(s) within the Lisgar District in the City of Mississauga (ref. attached map) to reduce the potential for basement water infiltration. Multiple Pumping Station Alternatives will be examined, including the impacts of these alternatives on the social, cultural and natural environment. The City has retained Wood Environment & Infrastructure Solutions (Wood) to undertake this Class EA.

The City has received direction from the Provincial Crown that the Haudenosaunee Confederacy Chiefs Council may have an interest in learning more about the project. The City is committed to involving stakeholders and Indigenous Communities in the project. The Provincial Crown has delegated the procedural aspects of the Duty to Consult to the City. For information, the City has attached a project summary and the Notice of Commencement. Please feel free to share this information within your community as you feel appropriate.

We are interested in understanding any interests or questions that the Haudenosaunee Confederacy Chiefs Council may have about this proposed project and if there is a potential for the project to affect Indigenous and treaty rights. We would also be interested to know if there are any sites of cultural significance to your community. The City would welcome the opportunity to meet with your community to provide more information about the project and discuss any interests or questions you may have.

We will contact you by telephone in the near future to determine your interest in a meeting.

Should you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

Louie Jakupi, P.Eng.
Project Manager
City of Mississauga
Tel: 905.615.3200 ext.3321
Louie.Jakupi@mississauga.ca

Ron Scheckenberger, P.Eng., M.Eng.
Consultant Project Manager
Wood, Environment & Infrastructure Solutions
Tel: 905.335.2353 ext. 3109
Ron.Scheckenberger@woodplc.com

c.c. Mary Kelly, Wood, Environment & Infrastructure Solutions
mary.k.kelly@woodplc.com
Encl: Project Information Sheet
Notice of Commencement

From: Kelly, Mary K
To: Fawn Sault
Cc: Louie.Jakupi@mississauga.ca; Scheckenberger, Ron; Stokke, Samantha
Subject: Mississauga - Lisgar District Pumping Stations Class EA
Date: July-20-18 1:03:33 PM
Attachments: Lisgar_ClassEA_Project_Summary.pdf
image001.png
Notice of Study Commencement and PIC.PDF
2018-07-20_Lisgar_MNCFN.PDF

Good afternoon Fawn,

The City of Mississauga is undertaking a Class Environmental Assessment to determine preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration.

Please find attached a letter from the City as well as a summary of the Project and copy of the Notice of Commencement.

I will follow-up with Mississaugas of the New Credit First Nation next week to further discuss. Please do not hesitate to contact us should you have any questions or comments.

Cheers, Mary

Mary Kathryn Kelly, B.Sc.
Senior Human Environment Consultant / Indigenous Business Initiative Lead
Direct/Mobile: 705-493-9393
mary.k.kelly@woodplc.com
www.woodplc.com

wood.

MISSISSAUGA

City of Mississauga
Transportation and Works Department
201 City Centre Drive, Suite 800
MISSISSAUGA, ON L5B 2T4
mississauga.ca

July 20, 2018

Attn: Ms. Fawn Sault

Mississaugas of the New Credit First Nation
4065 Highway 6
Hagersville, ON N0A 1H0
Fawn.Sault@newcreditfirstnation.com

Dear Ms. Sault,

RE: Lisgar District Pumping Stations, Municipal Class Environmental Assessment, City of Mississauga

The City of Mississauga is undertaking a Municipal Schedule ‘B’ Class Environmental Assessment (EA) to determine preferred locations and form of Pumping Station(s) within the Lisgar District in the City of Mississauga (ref. attached map) to reduce the potential for basement water infiltration. Multiple Pumping Station Alternatives will be examined, including the impacts of these alternatives on the social, cultural and natural environment. The City has retained Wood Environment & Infrastructure Solutions (Wood) to undertake this Class EA.

The City has received direction from the Provincial Crown that the Mississaugas of the New Credit First Nation may have an interest in learning more about the project. The City is committed to involving stakeholders and Indigenous Communities in the project. The Provincial Crown has delegated the procedural aspects of the Duty to Consult to the City. For information, the City has attached a project summary and the Notice of Commencement. Please feel free to share this information within your community as you feel appropriate.

We are interested in understanding any interests or questions that the Mississaugas of the New Credit First Nation may have about this proposed project and if there is a potential for the project to affect Indigenous and treaty rights. We would also be interested to know if there are any sites of cultural significance to your community. The City would welcome the opportunity to meet with your community to provide more information about the project and discuss any interests or questions you may have.

We will contact you by telephone in the near future to determine your interest in a meeting.

Should you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

Louie Jakupi, P.Eng.	Ron Scheckenberger, P.Eng., M.Eng.
Project Manager	Consultant Project Manager
City of Mississauga	Wood, Environment & Infrastructure Solutions
Tel: 905.615.3200 ext.3321	Tel: 905.335.2353 ext. 3109
Louie.Jakupi@mississauga.ca	Ron.Scheckenberger@woodplc.com

c.c. Mary Kelly, Wood, Environment & Infrastructure Solutions
mary.k.kelly@woodplc.com
Encl: Project Information Sheet
Notice of Commencement

From: Kelly, Mary K
To: Ava Hill
Cc: Louie.Jakupi@mississauga.ca; Scheckenberger, Ron; Stokke, Samantha; jthomas@sixnations.ca
Subject: Mississauga - Lisgar District Pumping Stations Class EA
Date: July-20-18 1:04:04 PM
Attachments: Lisgar_ClassEA_Project_Summary.pdf
image001.png
Notice of Study Commencement and PIC.PDF
2018-07-20_Lisgar_SNGR.PDF

Good Afternoon Chief Hill,

The City of Mississauga is undertaking a Class Environmental Assessment to determine preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration.

Please find attached a letter from the City as well as a summary of the Project and copy of the Notice of Commencement.

I will follow-up with Six Nations of the Grand River next week to further discuss. Please do not hesitate to contact us should you have any questions or comments.

Cheers, Mary

Mary Kathryn Kelly, B.Sc.
Senior Human Environment Consultant / Indigenous Business Initiative Lead
Direct/Mobile: 705-493-9393
mary.k.kelly@woodplc.com
www.woodplc.com

City of Mississauga
Transportation and Works Department
201 City Centre Drive, Suite 800
MISSISSAUGA, ON L5B 2T4
mississauga.ca

July 20, 2018

Attn: Ava Hill, Chief

Six Nations of the Grand River
2498 Chiefswood Road, P.O. Box 5000
Ohsweken, ON N0A 1M0
AvaHill@sixnations.ca

Dear Chief Hill,

RE: Lisgar District Pumping Stations, Municipal Class Environmental Assessment, City of Mississauga

The City of Mississauga is undertaking a Municipal Schedule 'B' Class Environmental Assessment (EA) to determine preferred locations and form of Pumping Station(s) within the Lisgar District in the City of Mississauga (ref. attached map) to reduce the potential for basement water infiltration. Multiple Pumping Station Alternatives will be examined, including the impacts of these alternatives on the social, cultural and natural environment. The City has retained Wood Environment & Infrastructure Solutions (Wood) to undertake this Class EA.

The City has received direction from the Provincial Crown that the Six Nations of the Grand River may have an interest in learning more about the project. The City is committed to involving stakeholders and Indigenous Communities in the project. The Provincial Crown has delegated the procedural aspects of the Duty to Consult to the City. For information, the City has attached a project summary and the Notice of Commencement. Please feel free to share this information within your community as you feel appropriate.

We are interested in understanding any interests or questions that the Six Nations of the Grand River may have about this proposed project and if there is a potential for the project to affect Indigenous and treaty rights. We would also be interested to know if there are any sites of cultural significance to your community. The City would welcome the opportunity to meet with your community to provide more information about the project and discuss any interests or questions you may have.

We will contact you by telephone in the near future to determine your interest in a meeting.

Should you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

Louie Jakupi, P.Eng.
Project Manager
City of Mississauga
Tel: 905.615.3200 ext.3321
Louie.Jakupi@mississauga.ca

Ron Scheckenberger, P.Eng., M.Eng.
Consultant Project Manager
Wood, Environment & Infrastructure Solutions
Tel: 905.335.2353 ext. 3109
Ron.Scheckenberger@woodplc.com

c.c. Mary Kelly, Wood, Environment & Infrastructure Solutions
mary.k.kelly@woodplc.com

Encl: Project Information Sheet
Notice of Commencement

Lisgar District Pumping Stations Municipal Class Environmental Assessment, City of Mississauga

Project Description

The City of Mississauga is undertaking a Municipal Class Environmental Assessment (EA) to determine preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration. Wood Environment & Infrastructure Solutions is the consultant retained to complete the Class EA project.

A Class EA is a decision-making and planning process that identifies potential effects of projects, such as infrastructure improvements, so that they can be managed prior to implementation.

Class Environmental Assessment

Beginning in 2008 several homes in the Lisgar District experienced water seeping into their basements following specific rain events. In response, the City undertook several actions, including the Lisgar District Basement Water Infiltration Investigation, which recommended a set of strategic preferred actions to address the potential for basement water infiltration. This Class EA will support planning for one of these actions: building permanent foundation drain collector (FDC) Pumping Station(s).

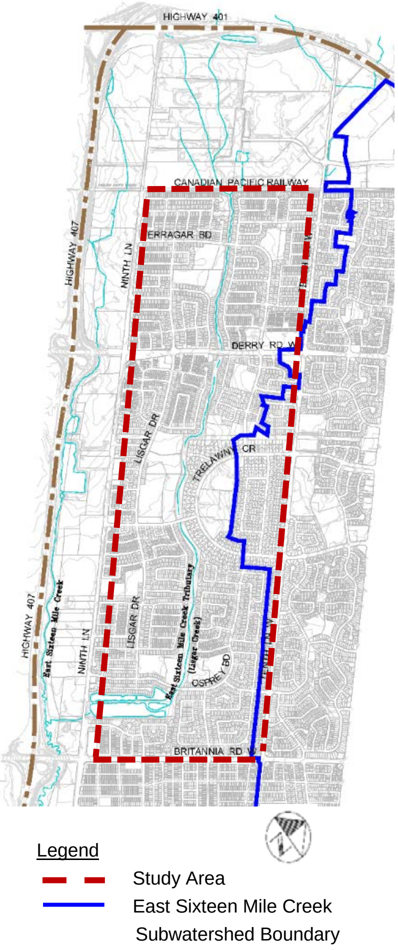
As part of the Class EA, multiple Pumping Station Alternatives will be developed and evaluated by the Project Team and refined through engagement with interested parties. Based on the evaluation and input of interested parties, the Project Team will select a Preferred Alternative and develop a design for the Pumping Station(s).

The Class EA planning process helps identify potential effects of proposed projects. Each proposed alternative is assessed against baseline conditions to determine the potential effects, and where necessary, identify mitigation measures. From these alternatives, a preferred alternative will be identified.

A key component of this study is to consult with regulatory agencies, conservation authorities, stakeholders and Indigenous groups.

Baseline Studies

As part of the overall study, various baseline investigations are being conducted to determine the system constraints and opportunities specific to the movement of water in the study area, including both surface and subsurface. These investigations form the basis for establishing a reasonable set of alternatives and allowing for a fulsome assessment.



Potential Project Related Effects

Potential effects are expected to be minimal as the project works are anticipated to occur within established residential areas. Potential Pumping Station Alternatives that are proposed on previously undisturbed land will be subject to all applicable investigations, including archaeological assessments. Potential effects, such as noise and odour impacts associated with construction, will be monitored and regulated.

Schedule and Next Steps

- Pumping Station Alternative Assessment, on-going
- Public Information Session, occurred June 14, 2018
- Project file documenting the entire study process, tentatively planned for summer 2018

Additional Information

For more information about this project, visit:

http://www.mississauga.ca/portal/residents/lisgarinvestigation

Contact Information

City of Mississauga

Louie Jakupi, P. Eng.
Project Manager
201 City Centre Dr, Suite 800
Mississauga, ON L5B 2T4
Tel: 905.615.3200 ext.3321
Louie.Jakupi@mississauga.ca

Wood, Environment & Infrastructure Solutions

Ron Scheckenberger, P.Eng., M.Eng.
Consultant Project Manager
3450 Harvester Road, Suite 100
Burlington, ON L7N 3W5
Tel: 905.335.2353 ext. 3109
Ron.Scheckenberger@woodplc.com

D3 Materials

From:	Matt Howatt
To:	Louie Jakupi
Subject:	RE: Black Walnut Trail/Cactus Gate Pumping Station - Schedule B Municipal Class EA
Date:	June-18-18 3:44:45 PM
Attachments:	image001.png

Thanks, Louie. We will follow up questions/comments as soon as possible within the next two weeks, as requested.

Matt

From: Louie Jakupi [mailto:Louie.Jakupi@mississauga.ca]
Sent: June 18, 2018 1:28 PM
To: Matt Howatt
Subject: RE: Black Walnut Trail/Cactus Gate Pumping Station - Schedule B Municipal Class EA

Hi Matt,
Thanks for following up. We don't currently have any design details, but we have selected a preferred site for the pumping stations (which is at Black Walnut Trail and Cactus Gate parkette). Please refer to our public information boards from the June 14th meeting, link provided here:

https://www7.mississauga.ca/documents/TW/stormwater/pdf/June-14-2018-PIC-Slides.pdf

I would ask that if you have any comments/questions, to please let me know within the next two weeks.

Thanks
Louie

From: Matt Howatt [mailto:mhowatt@hrca.on.ca]
Sent: Monday, June 18, 2018 1:13 PM
To: Louie Jakupi
Subject: RE: Black Walnut Trail/Cactus Gate Pumping Station - Schedule B Municipal Class EA

Hi Louie,

I hope all is well. We received the Notice of Study Commencement on May 29 and I understand that the PIC took place last week on June 14.

Normally, we provide a letter in response to the Notice of Study Commencement outlining our regulatory interests in the study area and a checklist of issues/criteria that CH staff foresee as being important to consider in the study.

I've read through the information available on the City's website and am wondering if you have any additional information you could share at this time that would provide us with an idea of the level of CH's involvement in the Class EA? (e.g. preliminary drawings, design details, location of pumping station(s), etc.)

In speaking with my colleagues, I understand that we permitted some work that may have been related to this project in 2016 at Cactus Gate/Black Walnut Trail – I'll be looking into this file as well.

Thank you,
Matt

From: Louie Jakupi [mailto:Louie.Jakupi@mississauga.ca]
Sent: May 10, 2018 2:39 PM
To: Matt Howatt
Cc: Ben Davis
Subject: RE: Black Walnut Trail/Cactus Gate Pumping Station - Schedule B Municipal Class EA

Hi Matt,
Thanks for reaching out. I've added your name to our stakeholder list for the EA – someone from (legacy) AmecFW (now Wood PLC) will be reaching out to you with the PIC notice. In the meantime, if you are interested, you can check out the slides from our last community engagement session related to the Lisgar basement water infiltration project here:
http://www7.mississauga.ca/documents/TW/pdfs/Oct-18-2017-Public-Meeting-Slides.pdf

If you have any questions, please don't hesitate to contact me.

Have a good day,

Louie Jakupi P.Eng.
Storm Drainage Engineer, Environmental Services Section
T 905-615-3200 ext.3321
louie.jakupi@mississauga.ca

City of Mississauga | Transportation & Works Department
Transportation & Infrastructure Planning Division

From: Matt Howatt [mailto:mhowatt@hrca.on.ca]
Sent: Thursday, May 10, 2018 2:00 PM
To: Louie Jakupi
Cc: Ben Davis
Subject: Black Walnut Trail/Cactus Gate Pumping Station - Schedule B Municipal Class EA

Hi Louie,

Thanks for the background information you provided on our call regarding the above noted project. If you could please send me the Notice of Study Commencement and any other background information, it would be appreciated.

I will be the Conservation Halton contact for the study and will be working with Ben Davis, our Regulations Officer in Mississauga, to coordinate our review and feedback through the study process.

Regards,
Matt

Matt Howatt
Environmental Planner

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
905.336.1158 ext. 2311 | Fax 905.336.6684 | mhowatt@hrca.on.ca
conservationhalton.ca

Conservation
Halton

905.336.1158
Fax: 905.336.7014
2596 Britannia Road West
Burlington, Ontario L7P 0G3
conservationhalton.ca

Protecting the Natural
Environment from
Lake to Escarpment

June 29, 2018

Louie Jakupi, P.Eng.
Project Manager
City of Mississauga
201 City Centre Drive, Suite 800
Mississauga, ON
L5B 2T4

BY MAIL & EMAIL (louie.jakupi@mississauga.ca)

Dear Mr. Jakupi,

Re: Notice of Study Commencement and Public Information Centre
Lisgar District Pumping Stations Municipal Class Environmental Assessment
CH File: MPR 728

Conservation Halton (CH) staff have reviewed the Notice of Commencement (NOC) received on May 29, 2018 for the above-noted Municipal Class Environmental Assessment (EA). Staff has prepared the attached *'Environmental Assessment Checklist'*, that identifies potential environmental issues that should be considered during this EA.

Purpose of EA

The City of Mississauga is undertaking an EA to determine preferred locations and form of Pumping Station(s) within the Lisgar District to reduce the potential for basement water infiltration.

Overview and General Comments

The attached EA checklist identifies a list of issues and criteria that staff foresees as being important to evaluate during the study. Additional requirements may become evident as the study progresses. These comments are preliminary and more comments will be provided once additional information about the study is made available.

As per CH's Plan Review Fee Schedule 2018, staff requires a Municipal EA – Schedule B review fee of $3,000.00 to be provided prior to commencing technical review and issuing comments.

Recommendation
Staff recommends that study information and any preliminary drawings of the preferred system be circulated to CH to confirm staff's support and any permit requirements for development proposed in the regulated area.

We trust these comments are of assistance. If you have any questions, please contact the undersigned at extension 2311.

Sincerely,

Matt Howatt
Environmental Planner

Encl. 1 – Conservation Halton EA Checklist

ENVIRONMENTAL ASSESSMENT

The following list identifies the areas of interest or concern that Conservation Halton may have with the subject Environmental Assessment (EA). The level of detail recommended will be dependent on the proposed works as well as the natural hazards, natural heritage system, and environmental conditions in the study area. The proponent should contact Conservation Halton staff early in the EA process to discuss the level of study that is suggested and to establish Terms of Reference for specific studies where appropriate.

All technical assessments should be completed by a qualified professional and the input of the various experts should be carefully coordinated to ensure consistency throughout the Environmental Study Report.

PROJECT TITLE: Lisgar District Pumping Stations	DATE: June 29, 2018
LOCATION: City of Mississauga, Lisgar District	FILE: MPR 728
TIMING WINDOW RESTRICTION:	

	Applicable
General Submission Requirements	
Ontario Regulation 162/06	
The study area contains (*Watercourse / Wetland / Lake Ontario Shoreline*). Conservation Halton regulates the *(erosion hazards / flooding hazards and 7.5 m / 15 m allowances associated with the feature). Ontario Regulation 162/06* requires that a Permit be obtained from Conservation Halton prior to development, interference with wetlands or alterations to shorelines and watercourses. *Ontario Regulation 162/06* and Conservation Halton's Board-approved *Policies and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy* ***(hereafter referred to as Conservation Halton's Policies and Guidelines)*** are available at www.conservationhalton.ca. Provide sufficient information to allow Conservation Halton staff to determine whether a Permit could be issued at detailed design in the ESR.	☒
The study area contains a *(provincially significant wetland / locally significant wetland)* that is (greater than or equal to 2 ha / less than 2 ha) in size. As per *Ontario Regulation 162/06*, Conservation Halton regulates 120 metres from the limit of a provincially significant wetland (PSW) or wetland great or equal to 2 ha in size and 30 metres from the limit of a wetland less than 2 ha in size. Obtain permission from Conservation Halton prior to development within the regulated area.	☐
Identify areas where Permits pursuant to *Ontario Regulation 162/06* will be required and include such Permits as future commitments in the environmental study report (ESR). Some details related to future Permits may not be deferred to detailed design. Review the requirements of Policy 3.51 (Public Infrastructure – Utilities, Trails and Transportation) of *Conservation Halton's Policies and Guidelines.*	☒
Survey drainage features watercourses, ditchlines, culverts, valley slopes, and all other relevant topographical features.	☒
Plot all areas regulated by Conservation Halton on drawings. ARL mapping may be utilized if more detailed study is not required at this time, however, please ensure that drawings indicate that limits shown are an approximation of the regulated area. Staff has enclosed Approximate Regulation Limit (ARL) mapping for your information. Digital mapping is available upon request.	☒

A Data Request Form is required for all digital information requests. The form and additional information on data holdings can be found at Conservation Halton's website at the following link http://www.conservationhalton.ca/planning-permits in the "Mapping and Data" section. ☐ Flood Plain Modelling available ☐ Flood Plain Modelling not available	☐
Ensure that 'potential impacts to and risks from natural hazards' *(flooding, erosion, and unstable bedrock/soils)* is one of the evaluation criteria. The proposed alternative must have no negative impacts on natural hazards and must not increase risk to life and property from natural hazards in order for Conservation Halton to issue a future approval under *Ontario Regulation 162/06*. Opportunities to improve any deficiencies with respect to flooding and erosion should also be investigated.	☒
Identify and assess through hydrologic and hydraulic analysis all potential flood plain impacts with consideration of maintaining flood storage, no increased flood levels on adjacent or downstream properties, no increased on-site flood risks, and appropriate flow velocities under the full range of storm conditions.	☒
Conservation Halton endeavours to have all public roadways flood free under Regional Storm conditions. At a minimum, safe access and egress for both pedestrians and vehicles as defined in the *MNRF's Technical Guide on River and Stream Systems: Erosion Hazard Limit (2002)* **(*hereafter referred to as MNRF's Technical Guide*)** should be provided, resulting in a maximum flood depth of 0.3 m, a maximum flood velocity of 1.7 m/s and a maximum depth-velocity product of 0.4 m^2/s. *MNRF's Technical Guide* may not provide sufficient accessibility for emergency vehicles due to the operational practices of each Emergency Response Organization. If a roadway is considered by the Province or local municipality to be an Emergency Route then there should be no overtopping of the road with flood waters.	☐
Consider *MTO's 2008 Highway Drainage Design Standards* and/or the local municipal engineering standards for flooding along/over roads. This document is available through the MTO Online Library Catalogue at http://www.library.mto.gov.on.ca.	☐
Identify and assess through a fluvial geomorphological assessment all potential erosion hazard impacts associated with a watercourse's migration, downcutting and meander belt. *MNRF's Technical Guide* should be followed. http://www.renaud.ca/public/Environmental-Regulations/MNR%20Technical%20Guide%20Flooding%20Hazard%20Limit.pdf	☒
Provide a fluvial geomorphological assessment to verify that the preferred alternative design has adequately allowed for natural channel functions and sediment transport, as well as minimizes the risk to infrastructure.	☒
Ensure habitat connectivity and wildlife movement are incorporated into the planning design and construction practices of all works. The design practices should maintain, and where possible improve or restore, key ecological linkages.	☐
Contact staff to arrange a site visit to stake the *(Physical Top of Bank / Wetland)*. An OLS must also be present during this site visit.	☐
Identify and assess all potential erosion hazard impacts associated with valley slopes through a geotechnical assessment. *MNRF's Technical Guide* should be followed.	☐
Identify any potential areas of unstable bedrock, karst or unstable soils within the study area. If these areas are found, the appropriate geotechnical analysis, karst assessment, hydrogeological evaluation or other study necessary to assess the impacts from and on these natural hazards by each alternative should be undertaken.	☐

A hydrologic evaluation is required to determine if there is an impact to the hydrological functions of the wetland as a result of the proposed works and to evaluate the various alternatives.	☐
A geotechnical and coastal engineering report is required to identify soil properties to determine the long term stable slope allowance associated with the Lake Ontario shoreline.	☐
A topographic survey is required to identify the lands impacted by the flooding hazard associated with *(Lake Ontario / Watercourse).*	☒
Use trenchless technologies for crossings of all wetlands and permanent flowing watercourses, wherever possible.	☐
	Applicable
Natural Heritage	
When undertaking any fieldwork and/or when making recommendations related to natural heritage and/or natural hazards, refer to the *Ministry of Natural Resources and Forestry (MNRF): Natural Heritage Reference Manual for Natural Heritage Policies, 2nd Edition, 2010; Significant Wildlife Habitat Technical Guideline, 2002;* and, *MNRF's Technical Guide. Natural Hazards Technical Guide and Understanding Natural Hazards* *http://www.renaud.ca/public/Environmental-Regulations/MNR%20Technical%20Guide%20Flooding%20Hazard%20Limit.pdf*	☐
The study area may contain or pass between natural features. As per policy 3.51 and 4.6.8 of *Conservation Halton's Policies and Guidelines* and policy 2.1.2 of the *Provincial Policy Statement, 2014* ***(hereafter referred to as PPS, 2014)***, the diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and groundwater features. The use of ecopassages or other measures to facilitate wildlife movement should be evaluated.	☐
The study area contains *a (provincially / locally significant)* wetland. As per policy 4.6.1 of *Conservation Halton's Board Policies and Guidelines* and Policy 2.1.4 of the *PPS, 2014,* development and site alteration shall not be permitted in significant wetlands or significant coastal wetlands.	☐
The study area may contain the habitat of Endangered or Threatened species. As per Policy 2.1.7 of the *PPS, 2014,* development and site alteration shall not be permitted in the habitat of Endangered/Threatened Species. The provincial *Endangered Species Act and/or federal Species at Risk Act* may also apply. Please contact MNRF *Aurora District at* esa.aurora@ontario.ca and *Guelph District at* esa.guelph@ontario.ca for further information on Endangered Species Act requirements.	☒
The study area contains an area of natural and scientific interest (ANSI). As per policy 4.6.7 of *Conservation Halton's Policies and Guidelines* and policy 2.1.5 (e) of the *PPS, 2014*, development and site alteration shall not be permitted in significant areas of natural and scientific interest (ANSI) unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions. Contact MNRF for further information.	☐

The study area may contain a significant wildlife habitat. As per Policy 2.1.5 (d) of the *PPS, 2014,* development and site alteration shall not be permitted in significant wildlife habitat unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions. Refer to the MNRF's *Significant Wildlife Habitat Technical Guidelines, 2002* *http://www.ontario.ca/document/guide-significant-wildlife-habitat.*	☐
The study area contains a significant valleyland of the (……………. Creek). As per policy 3.1 and 3.2 (a) of *Conservation Halton's Policies and Guidelines* and policy 2.1.5 (c) of the *PPS, 2014*, development and site alteration shall not be permitted in significant valleylands unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.	☐
The study area contains significant woodlands. As per policy 4.6.4 of *Conservation Halton's Policies and Guidelines* and policy 2.1.5 (b) of the *PPS, 2014*, development and site alteration shall not be permitted in significant woodlands unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions. Contact the *(Region of Halton / City of Hamilton / Mississauga / County of Wellington)* for further information on significant woodlands.	☐
Development and site alteration shall not be permitted on adjacent lands to the natural heritage features and areas identified in Policies 2.1.3 and 2.1.5 of the *PPS, 2014,* unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions. Please note that the *MNRF's Natural Heritage Reference Manual for Natural Heritage Policies*, Second Edition (2010) http://docs.files.ontario.ca/documents/3270/natural-heritage-reference-manual-for-natural.pdf considers adjacent lands to be within 120 metres.	☐
The study area contains the Environmental Significant Areas (ESA). The Environmental Study Report must address impacts to the ESA. Please contact the *(Region of Halton / City of Hamilton / County of Wellington / City of Mississauga)* for further information on the ESA.	☐
Use Ecological Land Classification to map natural and semi-natural features to vegetation type and identify protection/mitigation measures. ELC data sheets are required with the ESR submission (please include digital species spreadsheets).	☐
Refer to Conservation Halton's *Environmental Impact Study Guidelines* for information on general study requirements, impact assessment and appropriate timing and protocols for surveys. These guidelines can be found at www.conservationhalton.ca. Also, refer to *Conservation Halton's Policies and Guidelines, Section 5.10 – Environmental Impact Assessments (EIA)/Environmental Impact Studies (EIS).*	☐
Conservation Halton's Landscaping and Tree Preservation Guidelines should be consulted at detailed design. These guidelines can be found at http://www.conservationhalton.ca/policies-and-guidelines. Also, refer to *Conservation Halton's Policies and Guidelines, Section 5.11 - Tree Preservation Plans and 512 - Revegetation/Rehabilitation/Landscape Plans.*	☒
	Applicable
Fish Habitat	
Include a detailed description and habitat map of in-stream and bank habitat features including bankfull width, pools, riffles, undercut banks, eroding banks, root wads and large woody debris, thalweg/low flow location, backwater areas, substrate type, etc. as per *MTO Protocol: Environmental Guide for Fish and Fish Habitat, 2009.* Include photo documentation of the study area with a key map indicating photo locations.	☐

Provide thermal regime information for the watercourse within the study area using the Chu et. al. (2009) protocol. This can be obtained at TRCA's website at http://www.trca.on.ca/dotAsset/124131.pdf.	☐
The study area contains fish habitat. As per policy 4.6.3 of *Conservation Halton's Policies and Guidelines* and Policy 2.1.6 of the *PPS, 2014*, development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements.	☐
As per policy 3.6.1 of *Conservation Halton's Policies and Guidelines*, a fisheries setback of *(30 / 15)* metres from the bankfull channel width for (coldwater / warmwater) watercourse should be applied.	☐
The *Fisheries Act* requires that projects avoid causing serious harm to fish unless authorized by the Minister of Fisheries and Oceans Canada. Work conducted in or near water bodies that support fish that are part of or that support a commercial, recreational or Aboriginal fishery require compliance with the *Fisheries Act* to ensure no serious harm to fish. Refer to the DFO's website for additional information (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html) or call 1-855-852-8320 or email fisheriesprotection@dfo-mpo.gc.ca.	☐
	Applicable
Groundwater	
A hydrogeological study in support of an Environment Assessment must establish that the proposed activities will not cause unacceptable groundwater quantity and/or quality impacts which may affect the natural environment, and if impacts are expected, they can be mitigated in a sustainable way. Please refer to the following document *'Requirements for Completion of Hydrogeological Studies to Facilitate Conservation Halton's Reviews' that can be obtained from Conservation Halton's* website www.conservationhalton.ca.To scope a study to a specific proposal contact Conservation Halton's hydrogeologist.	☐
As per policy 4.6.9 of *Conservation Halton's Policies and Guidelines*, please ensure that all proposed works should consider Policies 2.2.1 and 2.2.2 of the *PPS, 2014,* regarding water.	☐
	Applicable
Stormwater Management/Drainage	
Demonstrate quality/quantity/erosion controls within the Stormwater Management section of the Environmental Study Report. Also examine the potential to combine SWM with adjacent development. The use of low impact development and at source controls should be explored as part of the stormwater management strategy for the proposal. Ensure mitigation of thermal impacts and at minimum 80% TSS removal will be required; note that additional requirements may apply based on the recommendations in the Subwatershed Study and the sensitivity of the receiving water body.	☒
As per... The quality requirements are... The quantity requirements are... The erosion control requirements are..	☐

Identify existing vs. proposed drainage areas and maintain existing drainage divides. Proposed diversions must be clearly identified and the potential impacts fully assessed as part of the project's evaluation.	☐
	Applicable
Other Requirements	
Recommendations and requirements from the following *(Watershed / Subwatershed)* studies should be followed: •	☐
Conservation Halton owns land within the study area. Identify any potential impacts to Conservation Halton land (direct – adjacent to, and indirect – road closures, detours etc.). Questions regarding Conservation Halton landholdings should be directed to Conservation Halton's Manager, Risk & Land Holdings Services directly at *(905) 336 1154 ext. 2256).*	☐
If infrastructure is proposed within existing easements/r-o-w or if there are additional property requirements, assess the impacts of utility relocation (i.e., telephone poles, union gas, etc.) on natural heritage features, natural hazard areas and fish habitat. This should not be left to detailed design as the relocation can have a significant impact on natural heritage features.	☐
Conservation Halton does not screen on behalf of MNRF for *Lakes and Rivers Improvement Act* implications. Contact the MNRF to determine if this Act applies to the proposed works.	☐
The Province and Crown Corporations do not require permits from Conservation Halton under *Ontario Regulation 162/06*. Efforts to comply with the requirements of *Ontario Regulation 162/06* and address areas of provincial interest are appreciated.	☐
A review timeline of 4 weeks to be incorporated into the project schedule. Staff also request *( )* hard copies of the ESR for review.	☐
Provide a figure with proposed works and/or alternatives overlaid on an airphoto.	☐
Other:	☐

Prepared by: Matt Howatt
Signature:

Date: June 29 2018

MISSISSAUGA

City of Mississauga
Transportation and Works
201 City Centre Drive, Suite 800
MISSISSAUGA ON L5B 2T4
mississauga.ca

July 13, 2018
TPB188016

Matt Howatt
Environmental Planning Technician
Conservation Halton
2596 Britannia Road West
Burlington, ON L7P 0G3

Dear Sir:

RE: Response to Conservation Halton Correspondence (reference June 29, 2018 Howatt-Jakupi) Regarding Lisgar District Pumping Stations Municipal Class Environmental Assessment (ref. CH File: MPR728)

Thank you for your correspondence of June 29, 2018 regarding Conservation Halton (CH)'s requirements with respect to the subject Municipal Class Environmental Assessment. As you are aware, the City of Mississauga has been actively working on the basement water infiltration issues in Lisgar District for several years and has periodically engaged CH in matters requiring regulation and areas of joint interest. To this end, a Public Report was presented to Council in early 2015 which summarized the City's activities over the preceding three (3) to four (4) years, as well as advancing a set of recommendations and actions.

For the past two (2) years plus, the City has been actively implementing these recommendations, working towards the current project which constitutes the Class Environmental Assessment for one of the core recommendations associated with pumping stations, to remove excess water from the foundation drain collection system.

Based upon the City's review and advice from its consultant, Wood Environment & Infrastructure Solutions (Wood), there is a limited potential influence on matters of direct interest with respect to CH associated with the subject works (i.e. pumping station systems). In specific terms, those matters are considered as follows:

i. Foundation Drain Collection Outlet to Sixteen Mile Creek Tributary

As CH staff is likely aware, one of the recommendations from the preceding and ongoing studies relates to dewatering the bedding (utility trench) of the Foundation Drain Collector on an ongoing basis to reduce the accumulation of water in this zone. Furthermore, it is recommended, in a dual pumping station setting, to also remove water directly from the foundation drain collection sewer.

In light of the foregoing, the new outfall to the Sixteen Mile Creek Tributary is anticipated to be located within the regulated area and will be designed such that it would not obstruct flows in the Sixteen Mile Creek Tributary, similar to a storm sewer outlet, however flow from it would be much cleaner, less frequent and much smaller rates.

ii. Volume and Character of Flow from Proposed Pumping Stations

The second matter of interest to CH relates directly to the volume and character of flow, which is proposed to be discharged from the pumps (low flow and high flow) to the Sixteen Mile Creek Tributary. As cited above, this is anticipated to be clear flow, free from sediment, as it would be largely filtered through the residential media and backfill trench. In terms of its quantity, it would also be considered to be several orders of magnitude less than that would be anticipated to flow through the Sixteen Mile Creek Tributary during similar flood events, hence any potential influence on flooding and / or stream morphology is anticipated to be negligible or non-existent, particularly taking into account timing effects.

As such, based on the City and Wood's interpretation of areas of CH interest, namely construction of the outfall in a regulated area, and discharge of clear flow to the Sixteen Mile Creek Tributary, it is respectfully suggested that the requirement for detailed study and documentation, defining no impacts to floodplains (through updated hydraulics) or fluvial stability (through detailed fluvial geomorphological studies) are not required. Future submissions, including the final Class Environmental Assessment (Class EA) report, will depict the limits of the regulation per CH, in order to define those lands potentially affected. In addition, given that the works are outside of the area of any endangered or threatened species (as the lands constitute an existing City parkette), it is also not considered required to provide any further details on SAR.

We trust the foregoing is clear and look forward to working with CH to bring this project to completion. Should you have any questions, please contact the undersigned.

Yours very truly,

City of Mississauga

Per: Louie Jakupi, P.Eng.
Storm Drainage Engineer

RBS/cc

c.c. Ron Scheckenberger, Wood

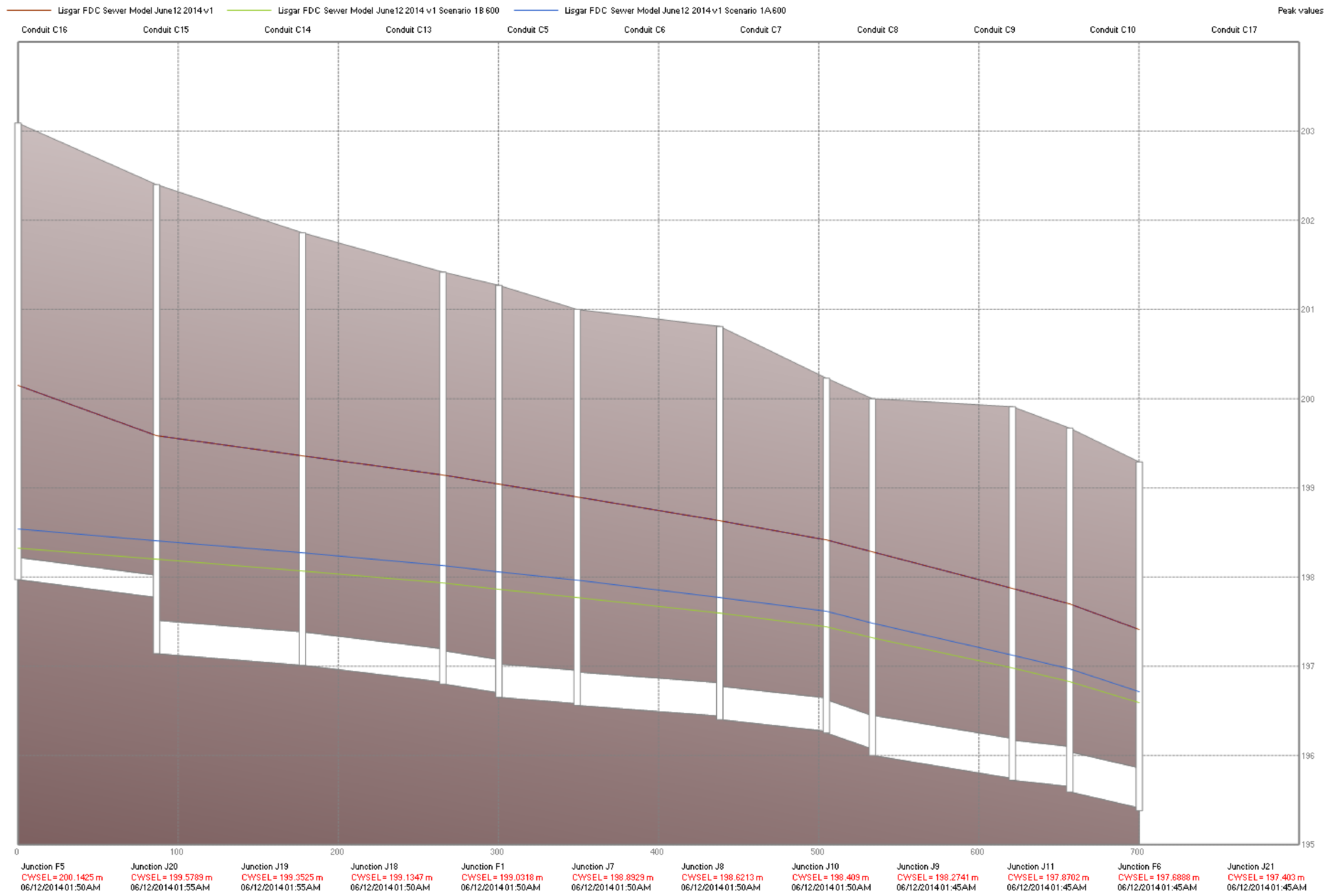


Figure A17: Simulated HGL downstream of Cactus Gate for June 12, 2014 storm event, with and without pumping station (Options 1A and 1B) in place

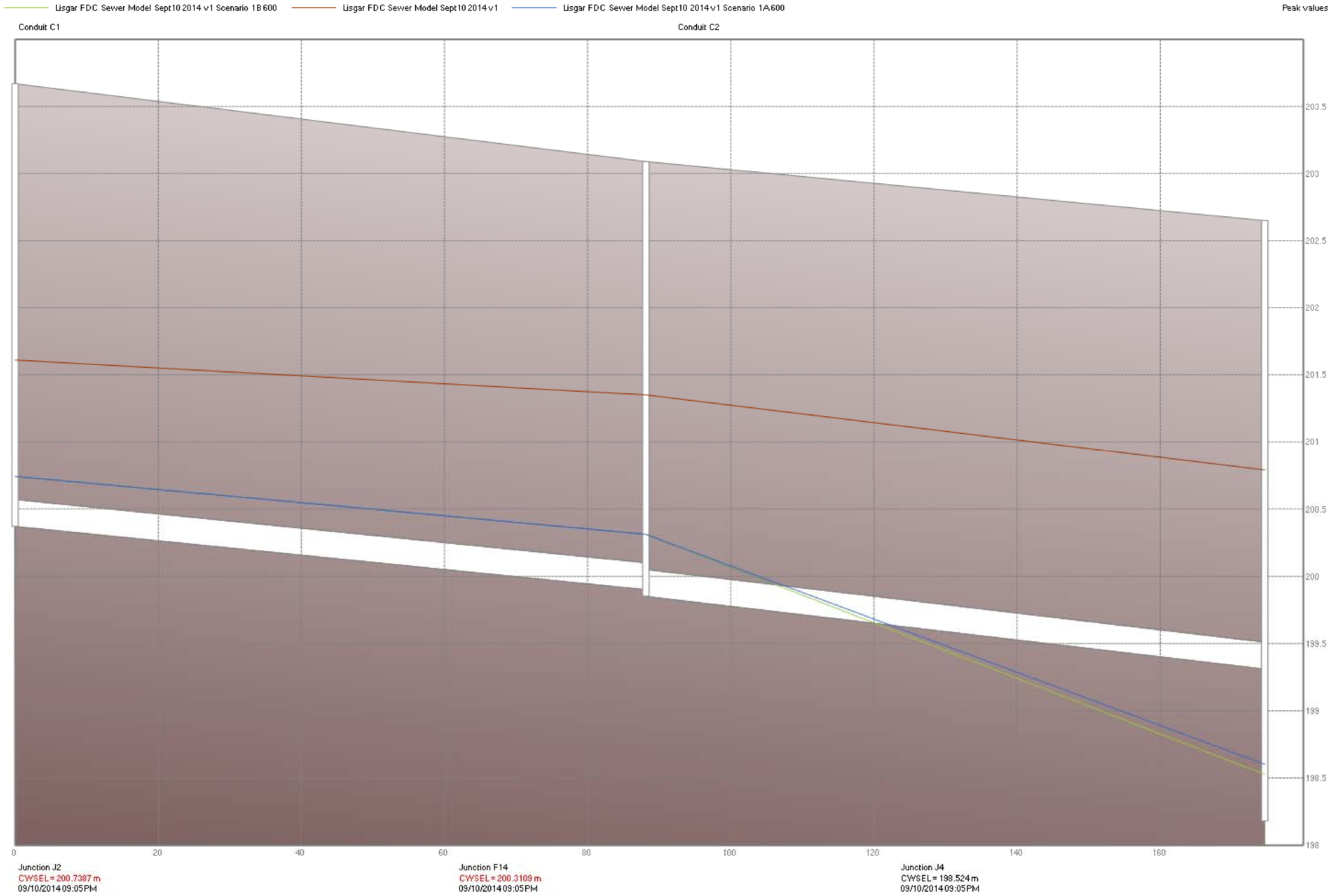


Figure A18: Simulated HGL upstream of Cactus Gate for September 10, 2014 storm event, with and without pumping station (Options 1A and 1B) in place

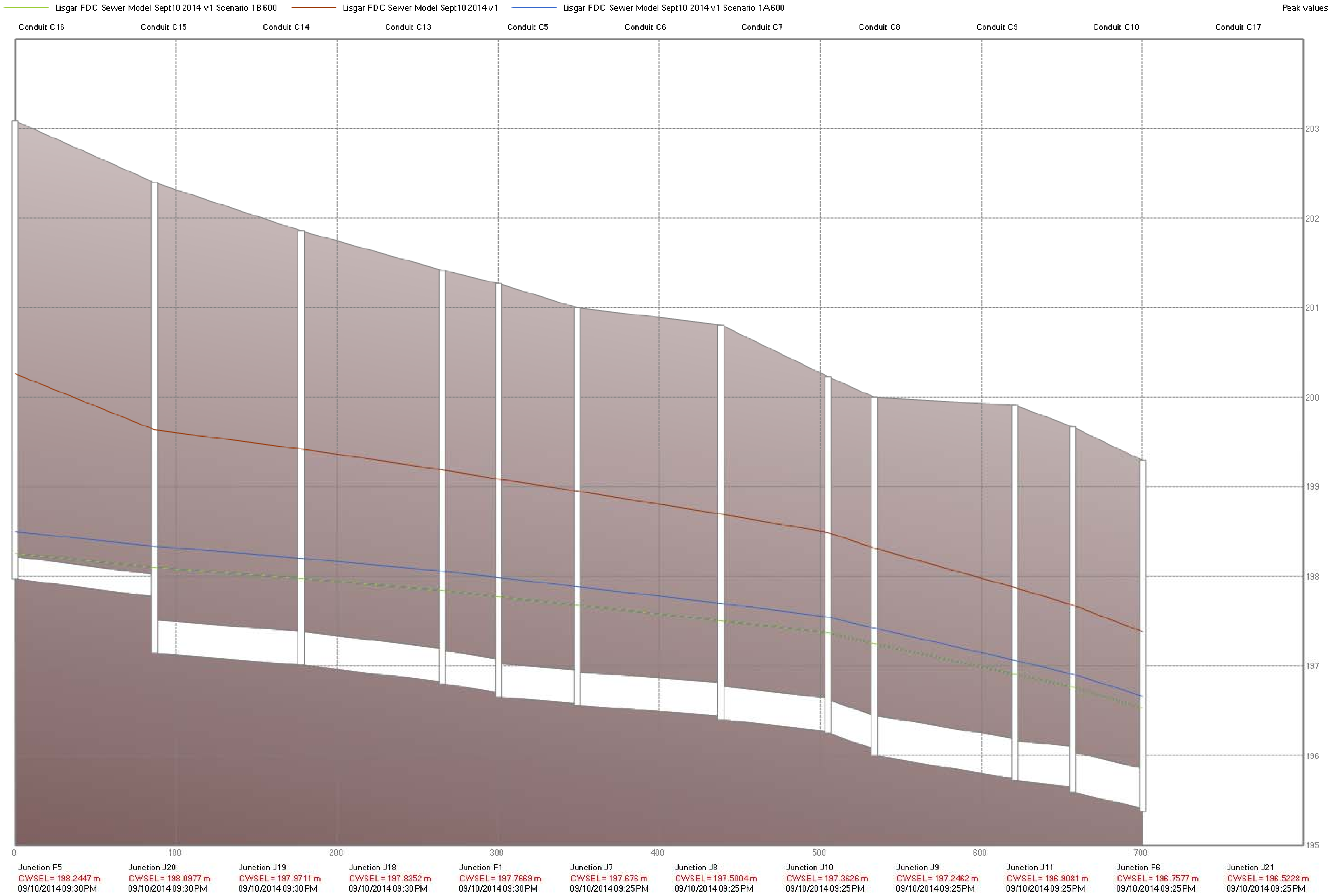
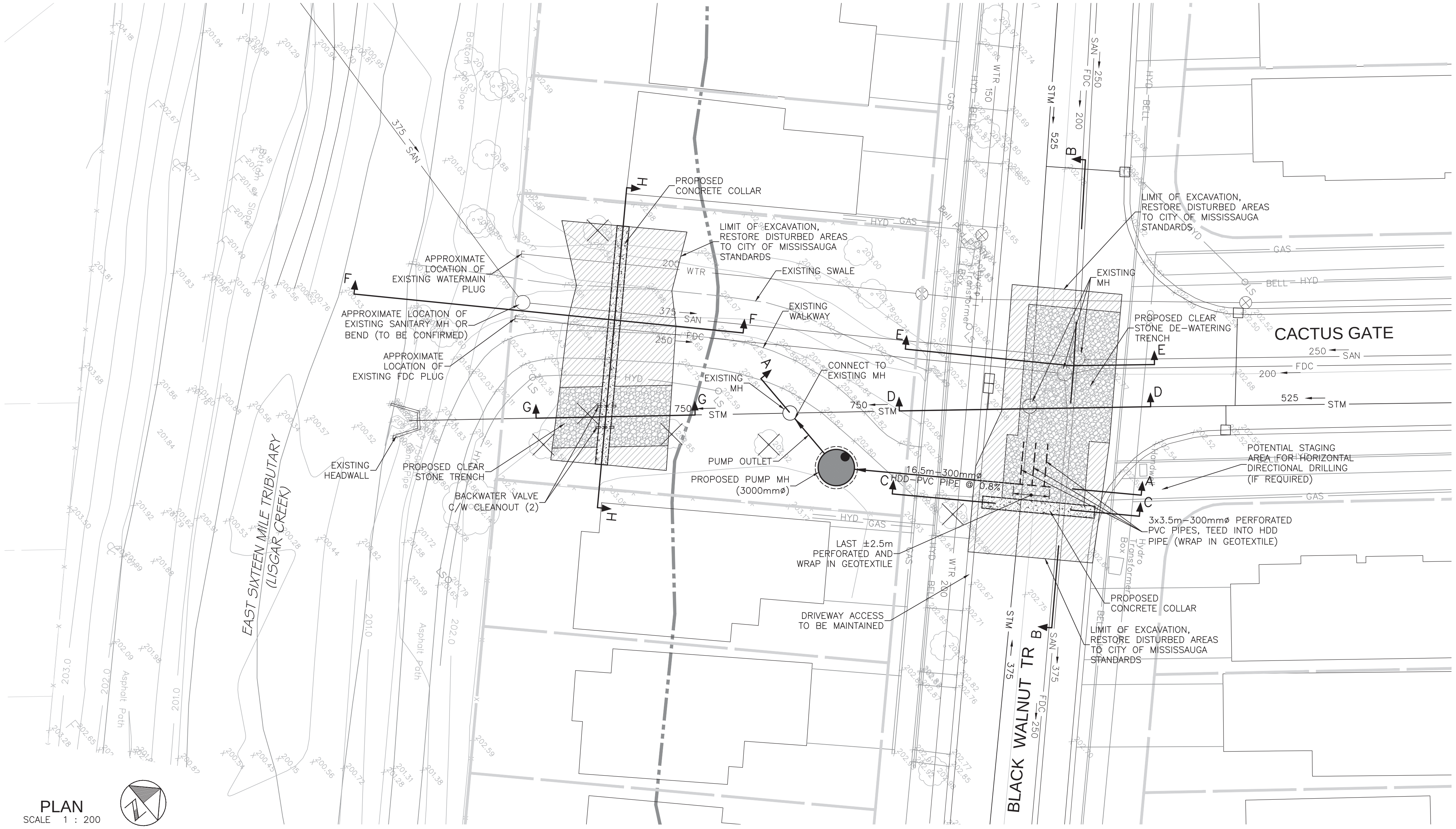


Figure A19: Simulated HGL downstream of Cactus Gate for September 10, 2014 storm event, with and without pumping station (Options 1A and 1B) in place

Appendix E

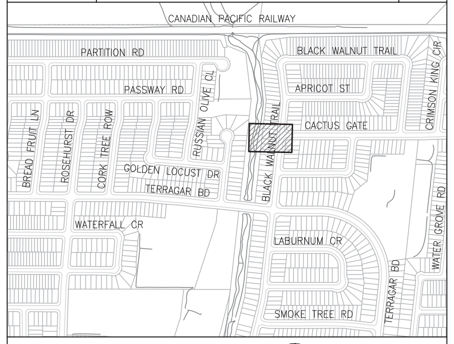
Preliminary Pumping Station (Low Flow) Plan and Details

Path: P:\Work\TP115060\water\dwg\16-12 (TrenchDewater)\FigTD1-3 CactusGate.dwg Plotted By: richard.bartolo Plotted: 2017-01-16 Last Saved By: richard.bartolo Last Saved: 2017-01-13



PLAN
SCALE 1 : 200

REVISIONS		
DATE	DETAILS	INIT.
JAN. 2017	INITIAL CITY REVIEW	M.S.



KEY PLAN

LEGEND

	WATERCOURSE
	CONTOUR (0.5m)
200.44	EXISTING SURVEYED ELEVATION CITY OF MISSISSAUGA (DEC 2011)
	PROPERTY LINE
	CONSERVATION HALTON APPROXIMATE REGULATION LIMIT
HYD	HYDRO
BELL	BELL
GAS	GAS
WTR	WATERMAIN SYSTEM
STM	STORM SEWER SYSTEM
FDC	FDC SYSTEM
SAN	SANITARY SEWER SYSTEM
⊗	EXISTING TREE TO BE REMOVED
▨	COMPACTED NATIVE SILTY CLAY BACKFILL
▩	50mmø CLEAR STONE

LISGAR DISTRICT
UTILITY TRENCH
DE-WATERING SYSTEM

amec foster wheeler

MISSISSAUGA

PRODUCED FOR - T&W, ENGINEERING AND WORKS

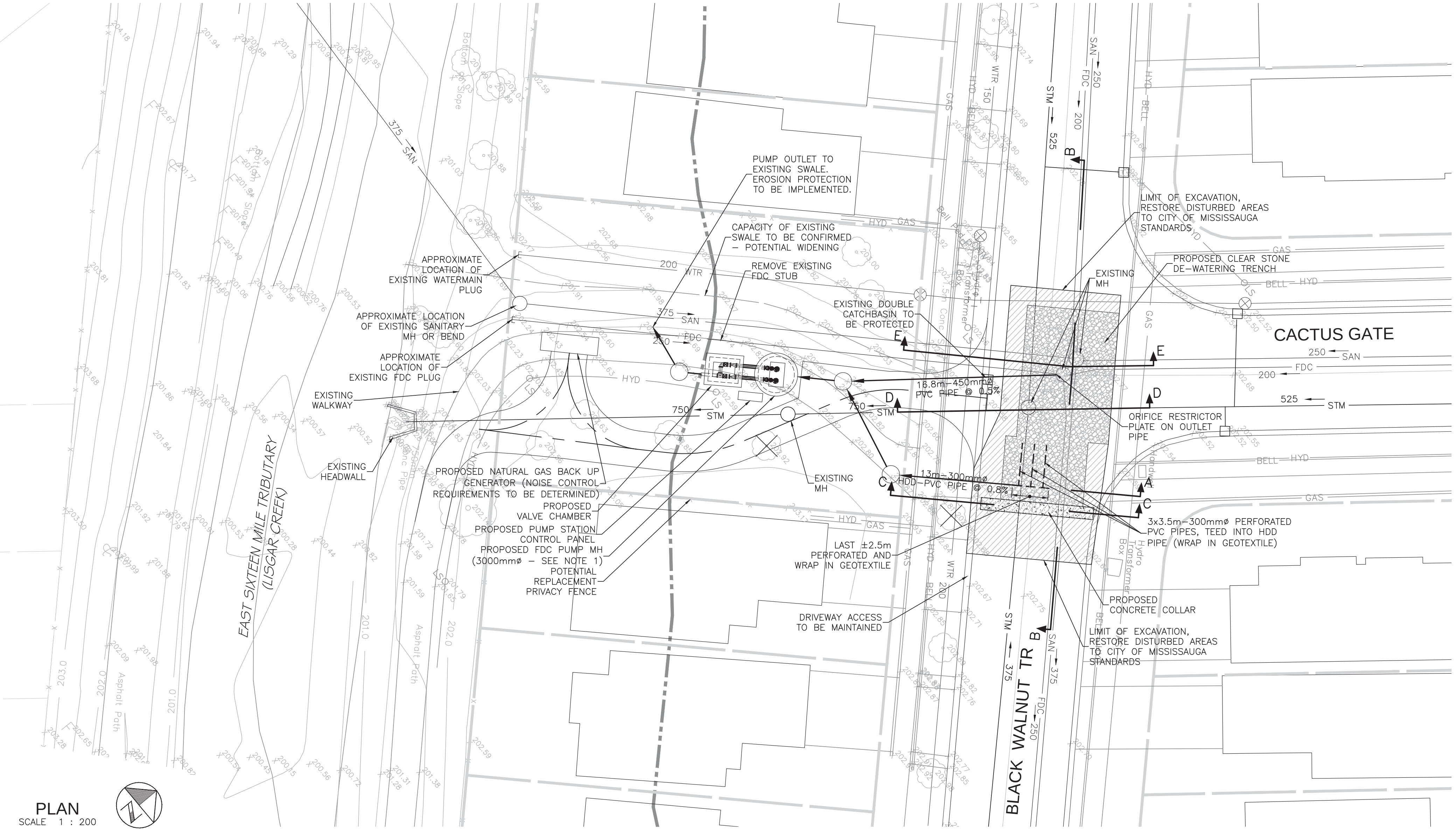
Preliminary Pumping Station (Low Flow) Plan and Details

SCALE AS NOTED	AREA	PROJECT No. TP115060
C.A.D.D. BY R.M.B.	CHECKED BY M.S.	PLAN No. Figure TD1
DATE JAN. 2017	SHEET 1 OF 3	

Appendix F

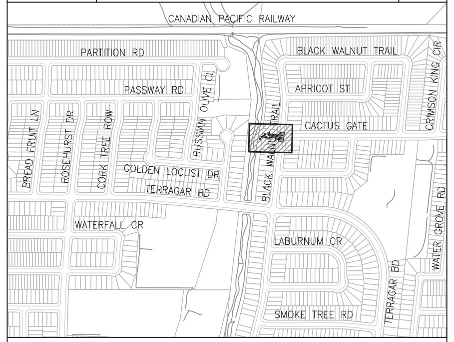
Preliminary FDC Pumping Station (Low and High Flow) Plan and Details

Path: V:\2018\Projects\TPB188016 – Design & Contract Admin. – Lisgar\06_DES-ENG\01_CAD\02_DWGS\05_WR\FigTD1-3 Cactus Gate Option 2.dwg
Plotted By: daniel.chan
Plotted: 2018-09-06
Last Saved By: daniel.chan
Last Saved: 2018-09-06



REVISIONS

DATE	DETAILS	INIT.
JAN. 2017	INITIAL CITY REVIEW	M.S.
JUN. 2018	ADD FDC PUMP STATION	M.S.



KEY PLAN

NOTE:
1. SIZE OF MH IS PROVIDED BASED ON AN ALLOWED 15 START/STOP PER HOUR BY PROPOSED PUMP MFG.

LEGEND

～	WATERCOURSE
～	CONTOUR (0.5m)
×200.44	EXISTING SURVEYED ELEVATION CITY OF MISSISSAUGA (DEC 2011)
— —	PROPERTY LINE
— · · —	CONSERVATION HALTON APPROXIMATE REGULATION LIMIT
—HYD—	HYDRO
—BELL—	BELL
—GAS—	GAS
—WTR—	WATERMAIN SYSTEM
—STM—	STORM SEWER SYSTEM
—FDC—	FDC SYSTEM
—SAN—	SANITARY SEWER SYSTEM
⊗	EXISTING TREE TO BE REMOVED
▨	COMPACTED NATIVE SILTY CLAY BACKFILL
▒	50mmø CLEAR STONE

LISGAR DISTRICT
UTILITY TRENCH DE-WATERING
AND FDC PUMPING SYSTEM

wood.

MISSISSAUGA

PRODUCED FOR – T&W, ENGINEERING AND WORKS

Preliminary FDC Pumping Station (Low and High Flow) Plan and Details

SCALE AS NOTED	AREA	PROJECT No. TPB188016
C.A.D.D. BY R.M.B.	CHECKED BY M.S.	PLAN No.
DATE JUN. 2018	SHEET 1 OF 3	Figure TD1