York Region

YORK REGION INFLOW & INFILTRATION REDUCTION STRATEGY

ANNUAL REPORT

MARCH 31, 2017

Aurora · Town of East Gwillimbury · Georgina · King · Markham · Newmarket · Richmond Hill · Vaughan · Town of Whitchurch-Stouffville

The Region and the local municipalities are demonstrating leadership in inflow and infiltration reduction within the water and wastewater industry.

Inflow

Water from rainfall or snow melt that enters the sewage system through direct sources such as yard, roof and downspouts, cross connections with storm drains, foundation drains, and maintenance hole covers.

Infiltration

Groundwater that enters through holes and cracks in maintenance holes, laterals, and sewer pipes.

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1.0 Purpose and Need for the Annual Report

On March 31, 2010, the Ministry of the Environment and Climate Change (MOECC) approved the Southeast Collector Trunk Sewer Individual Environmental Assessment (SEC IEA) subject to 13 conditions (with 74 sub-conditions) including Condition 8 which refers to the Long-Term Water Conservation and Inflow and Infiltration Reduction Monitoring Strategy.

This report is the sixth annual report prepared to address Conditions 8.8 and 8.9 of the SEC IEA Minister's Conditions of Approvals. It details the 2016 progress on implementation of the 2011 Inflow and Infiltration Reduction Strategy (Strategy) and 2016 Strategy Update submitted to the Ministry on March 31, 2011 and March 31, 2016 in accordance with Conditions 8.1 and 8.10 of the SEC IEA, respectively.

Requirements under Conditions 8.8 and 8.9 are as follows:

- York Region to submit to the Regional Director an annual report detailing its progress on implementing the Strategy including inflow and infiltration reduction.
- Each annual report prepared shall include at a minimum:
  a) Results of water conservation and efficiency measures
  b) Results of flow monitoring and visual inspections to determine the sources and amount of inflow and infiltration into the Southeast Collector Trunk Sewer within the Regional Municipality of York
  c) Progress in the reduction of inflow and infiltration into the Southeast Collector Trunk Sewer
  d) Details of any remedial work to the sewage system undertaken and the results of the remediation
  e) Results achieved within the Regional Municipality of York with respect to inflow and infiltration reduction measures

Results on water conservation and efficiency measures are submitted in the Long-Term Water Conservation Strategy Annual Report dated March 31, 2017. Progress made towards the implementation of the inflow and infiltration reductions are compiled in this report and include Regional, local municipal and private initiatives detailing the 2016 progress in achieving the Strategy goals and results with respect to inflow and infiltration reduction measures within York Region.

The Region will continue the preparation and submission of the annual reports to the Ministry with support from the Steering Committee and local municipalities until such date as the Regional Director indicates that updates are no longer required.

A change in this year's annual report is the tracking and reporting on the combined target of 71 million litres per day (MLD) to be achieved by 2031; 40 MLD of rainfall derived inflow and infiltration (RDII) reduction and 31 MLD dry weather flow reduction (water conservation and base infiltration). As detailed in Appendix A, the 31 MLD dry weather flow goal has been achieved; going forward the Region will continue reporting on the 40 MLD rainfall derived inflow and infiltration to be achieved by 2031.

1.1 Comments and Feedback Received

On May 13, 2016, the Central Region Director of the MOECC provided comments on the Inflow and Infiltration (I/I) Reduction Strategy Update dated March 31, 2016 which included the annual update on 2015 progress. The 2016 Strategy Update documented the lessons learned from the implementation of the 2011 Strategy and the results of the best-in-class review, updating a suite of measures and programs.

Comments received expressed that York Region continues to show leadership in inflow and infiltration reduction and "should be commended for its work to date on the implementation of the Strategy". A confirmation letter of satisfaction in accordance with Condition 8.10 of the Minister's Notice of Approval for the SEC IEA was also received.

2.0 2016 Inflow and Infiltration Reduction

A summary of inflow and infiltration reductions achieved in 2016 is presented in Table 1. Further detail is provided in the following sections.

Table 1 - Inflow and Infiltration Reductions from 2016 Remediation Activities

Municipality	Reduction Achieved (MLD)	Description
Total of Area Municipalities	0.06	Infiltration source repair in the Town of Aurora
	0.01	Infiltration source repair in the Township of King
	0.02	Infiltration source repair in the Town of Newmarket
	0.12	Disconnection of 30 downspouts in the City of Markham as part of Phase 1 of City-wide Multi Phase Sanitary System Disconnection Program
	0.03	Installation of maintenance hole dishes and maintenance hole repairs in low-lying areas in the Town of Richmond Hill
Total of Private Initiatives	0.06	Disconnection of 12 downspouts, 2 sump pumps, 2 reverse sloped driveways, and 2 sanitary cleanouts in the Town of Richmond Hill
	0.02	Disconnection of 7 downspouts and 1 foundation drain in the Town of Newmarket
Total of York Region	1.59	Rehabilitation of 399 lateral stubs (mainline to property line) by various methods in 5 catchment areas (some of which had previous mainline rehabilitation performed) as part of the Region's Rehabilitation Pilot of Private Sanitary Sewer Laterals
	0.01	Repair of 3 infiltration gushers during an emergency repair of a sinkhole in York Central Collector
	0.08	Repair of 1 large infiltration gusher during a pilot rehabilitation project in the existing York Durham Sewage System (YDSS) on 16th Avenue utilizing a new rehabilitation technology
TOTAL	**1.99**	

3.0 2016 Progress in Inflow and Infiltration Reduction in the Southeast Collector Trunk Sewer

Since implementing York Region's 2011 Inflow and Infiltration Reduction Strategy, regular reporting of successes and challenges of the program has been necessary to build on lessons learned and to establish whether targets and goals have been met. The Strategy is meeting all interim goals and is on track toward reaching the overall reduction of 40 MLD by 2031 (Figure 1).

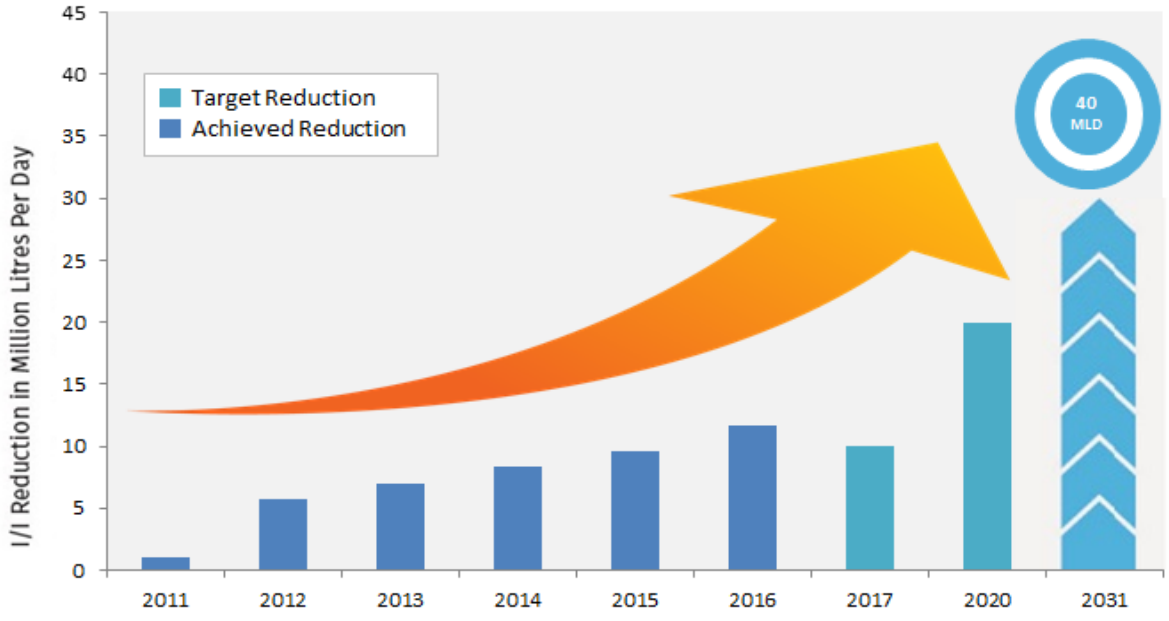


Figure 1 - Target and Achieved Inflow and Infiltration Reduction

To date, the Region and local municipalities reduced inflow and infiltration by 11.6 MLD in the York Durham Sewage System (YDSS), representing 29 per cent of the 2031 target reduction of

40 MLD. This achievement exceeds the interim target of 25 per cent as set in the Strategy for the end of 2017. Reduction targets as set in the 2016 Strategy Update are shown in Table 2 below.

Table 2 - Inflow and Infiltration Reduction Strategy Update Reduction Targets

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021- 2031
Reduction Targets											
Achieve Up to 25% of Target Reduction											
Achieve Up to 50% of Target Reduction											
Achieve 50-100% of Target Reduction											

The Region and the local municipalities achieved the goals and targets identified in the 2011 Strategy and 2016 Strategy Update. Through the efforts of the Region, local municipalities and private initiatives in 2016, a total inflow and infiltration reduction of 1.99 MLD has been achieved or 5 per cent of the overall 40 MLD target. Reductions achieved each year from 2011 to 2016 are provided in Table 3 below.

Table 3 - Yearly Inflow and Infiltration Reductions Achieved

Year	Inflow an Infiltration Reduction Achieved (MLD)	% Inflow and Infiltration Reduction Achieved
2011	1.01	2.5
2012	4.67	11.7
2013	1.34	3.4
2014	1.40	3.5
2015	1.18	2.9
2016	1.99	5.0
TOTAL	**11.6**	**29.0**

These reductions have been achieved through operation and maintenance programs, private initiatives and capital rehabilitation projects and were quantified through flow monitoring programs and investigative studies. The programs have been supplemented and developed further through the use of pilot projects and the implementation of new technologies and

guidelines for new construction. The Region in partnership with local municipalities and the Steering Committee supports and maintains these programs. Progress achieved to date in the eight program areas of the Strategy are summarized in Table 4.

Additionally, this year the Region is reporting on the success achieved towards reduction of the 31 MLD in dry weather flow (DWF) resulting from water conservation and base infiltration reduction since 2011 to achieve the combined goal of 71 MLD reduced by 2031.

Analysis of DWF showed that wastewater production unit rate decreased from 223 litres per capita per day (l/c/d) in 2011 to 190 l/c/d in 2015 (Figure 2) despite the increase in York Region's population, which is a reduction of 33 l/c/d or 45.6 MLD in DWF. This reduction exceeds the 31 MLD goal required in the 2011 to 2031 period by over 40 per cent.

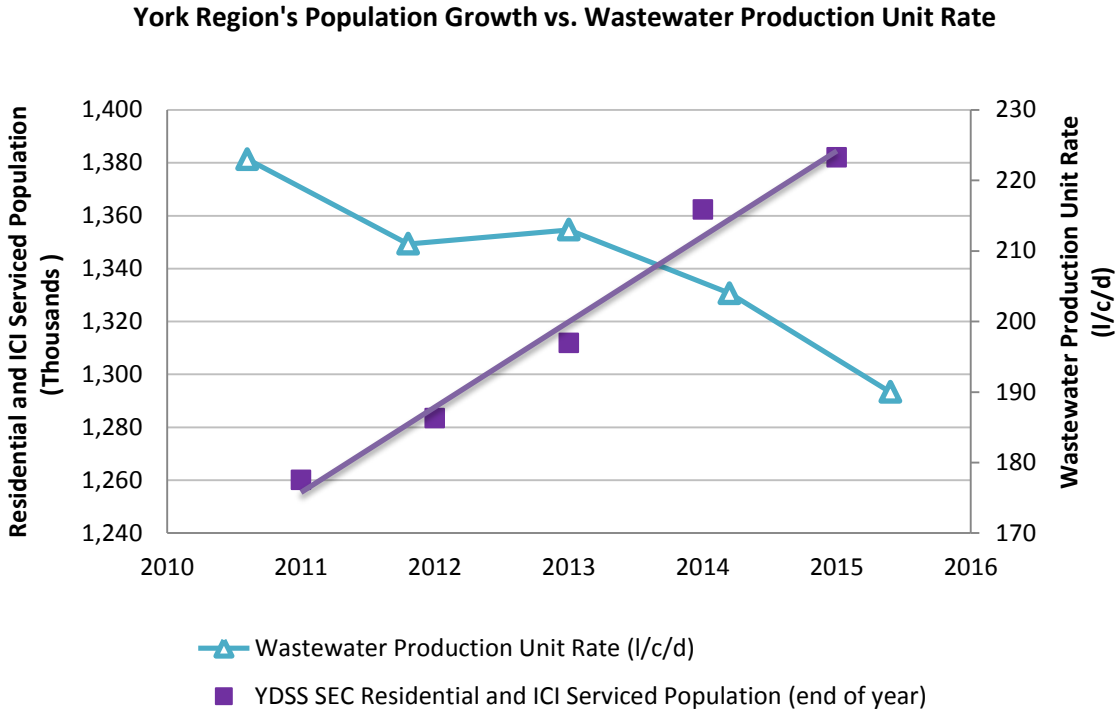


Figure 2 - York Region's Population Growth versus Wastewater Production Unit Rate

The DWF reduction by 2031 is expected to be even much higher as water conservation efforts increase and the use of water-efficient fixtures and appliances become the norm. A detailed methodology for the background calculations is provided in Appendix A.

Table 4 – Progress to Date in the 8 Key Program Areas

PROGRAM AREA 1 I/I REDUCTION PROGRAM GOALS AND TARGETS	PROGRAM AREA 2 MONITOR AND ANALYZE FLOWS	PROGRAM AREA 3 INVESTIGATE & REHABILITATE	PROGRAM AREA 4 DESIGN & COMMISSIONING
☑ Establish W&WW Steering Committee	☑ Establish I/I Audit & Flow Monitoring program	☑ Establish mini-basin flow monitoring and analysis	☑ Update design and construction standards
☑ Integrate I/I Reduction with the LTWC strategy	☑ Maintain Region permanent flow metering equipment and rain gauges	☑ Determine condition assessment requirements and SSES inspections	☑ Adopt Sanitary Sewer System Inspection, Testing and Acceptance Guideline by local municipalities
☑ Set target of 40 MLD I/I Reduction by 2031	☑ Develop detailed data QA/QC procedures	☑ Pilot lateral sewer inspection and rehabilitation s	☑ Collect post-construction flow monitoring data
☑ Refine audit basin locations and develop I/I audit and flow monitoring program	☑ Analyze data on an ongoing basis	☑ Conduct rehabilitation pilot projects	☑ Implement incentive programs
☑ hydraulic model development and calibration	☑ Establish thresholds to identify problem areas	☑ Develop standards for maintenance hole and sewer mainlines inspections	☐ Review and update design and construction standards on a continual basis
☑ Establish wastewater geodatabase	☑ Complete Phase 1 of Region SSES	☑ Develop Sanitary Sewer System Inspection Testing and Acceptance Guideline	☐ Building Permit inspections and conditions
☑ Align I/I Reduction Program with One Water approach	☑ Achieve I/I Reductions through pilot, local, and developer funded projects	☐ Create and maintain database of project costs and benefits	☐ Update of Sewer System Inspection, Testing and Acceptance Guideline
☑ Develop Report template for local municipalities	☑ Support ongoing I/I projects in new developments	☐ Deliver prioritized capital projects	
☑ Develop and adopt goals for 2011-2015 and 2016-2021	☑ Implement Servicing Incentive Program (SIP)	☑ Assess I/I Reductions achieved	
☐ Develop and adopt goals for 2021-2031	☑ Determine improvements to maintain and manage current data needs	☐ Maintain inspection standards and frequency	
☐ Integrate I/I Reduction and Water Conservation into design standards	☑ Integrate monitoring data into data management software	☐ Coordinate and harmonize inspection procedures	
☐ Refine measures for I/I Reductions	☑ Complete internal review of program delivery	☐ Develop private property survey and consent form	
☐ Review technology and tools annually	☑ Complete review of monitoring equipment required and locations	☐ Review standard testing procedures	
	☑ Complete mini-basin and micro-basin monitoring	☐ Establish private property programs with the locals and support of the W&WW Steering Committee	
	☑ Complete quarterly rainfall and flow data analysis		
	☑ Complete annual data analysis technical reports		
	☑ Complete monitoring and analysis of rehabilitation projects and new developments areas		
	☑ Partner in pilot projects		
	☑ Review subdivisions for post-construction flow monitoring		

PROGRAM AREA 5 FINANCIAL MANAGEMENT	PROGRAM AREA 6 COMMUNICATION, EDUCATION, & ADVOCACY	PROGRAM AREA 7 REPORT I/I REDUCTION	PROGRAM AREA 8 INNOVATION & ADAPTATION
☑ Establish Regional and local municipal cost-sharing reserve fund	☑ Establish interagency communication through W&WW Steering committee between the local municipalities and the Region	☑ Develop 2011 I/I Reduction Strategy in collaboration with local municipalities	☑ Participate in 2011 Climate Change Risk Assessment and Adaptation Strategy
☑ Fund I/I control activities including inspection, data collection, and analysis	☑ Present 2011 I/I Reduction strategy to local and Regional Councils for their endorsement	☑ Update I/I Reduction Strategy in 2016	☑ Refine flow monitoring standards
☑ Commit to a 20-year funding program	☑ Present 2016 I/I Reduction strategy Update to Regional Councils for their endorsement	☑ Report to local municipal and Regional councils	☑ Evaluated lessons learned from pilot projects
☑ Establish alternate funding programs through involvement of the development community	☑ Create and maintain a robust website with resources for the public	☑ Report to MOECC annually	☑ Pilot new technologies for public and private property rehabilitation programs
☑ Region and local municipalities manage their own I/I reduction expenditures	☑ Conduct public outreach in pilot study areas	☐ Complete future strategy updates	☐ Refine inspection standards
☑ Review roles and responsibilities	☑ Post annual report on website	☐ Continue Council reporting	☐ Consider climate change impacts
☐ Have Steering Committee assist with determining pilot projects	☑ Begin outreach to development and construction communities	☐ Complete future annual reports to MOECC	☐ Refine flow monitoring programs
☐ Investigate additional short- and long-term alternate funding options	☑ Report progress to the MOECC annually with performance measures		☐ Implement rehabilitation standards
☐ Update implementation plan and I/I reduction expenditures allocated for short and long term plans	☐ Create local municipality coordinator position that is jointly-funded by local municipalities and the Region		☐ Update municipal bylaws
	☐ Produce I/I information bulletins		☐ Continue with updating the best-in-class review
	☐ Update website content		☑ Incorporate new tools, technologies and data management systems
	☐ Create marketing materials for I/I reduction		☐ Consider ways of capturing decreases in energy consumption as a result of I/I reduction
	☐ Establish industry forums		
	☑ Present I/I Reduction Strategy and Program to MOECC		
	☐ Establish I/I reduction education and public outreach program		
	☐ Establish internal and inter-agency communications		
	☐ Establish industry and provincial advocacy protocol		

☑ Implemented and Ongoing
☐ Under Implementation

4.0 2016 Summary of York Region Program Activities and Accomplishments

Since implementing the Inflow and Infiltration Reduction Strategy, York Region and its nine local municipalities have developed program component mirrored after best in class applications of inflow and infiltration reduction around the globe.

Over the course of 2016, the Region spent close to $3.6 M as part of the I/I reduction program, on such activities as flow and rainfall monitoring, sanitary sewer evaluation surveys, and lateral repairs in local municipalities. The following provides a summary of the Regional, local municipal and private initiatives accomplished in 2016.

4.1 Analysis Tools and Procedures

The Region has undertaken both dry and wet weather analyses in 2016, with the latter completed for a range of rainfall events utilizing state-of-the-art analysis tools.

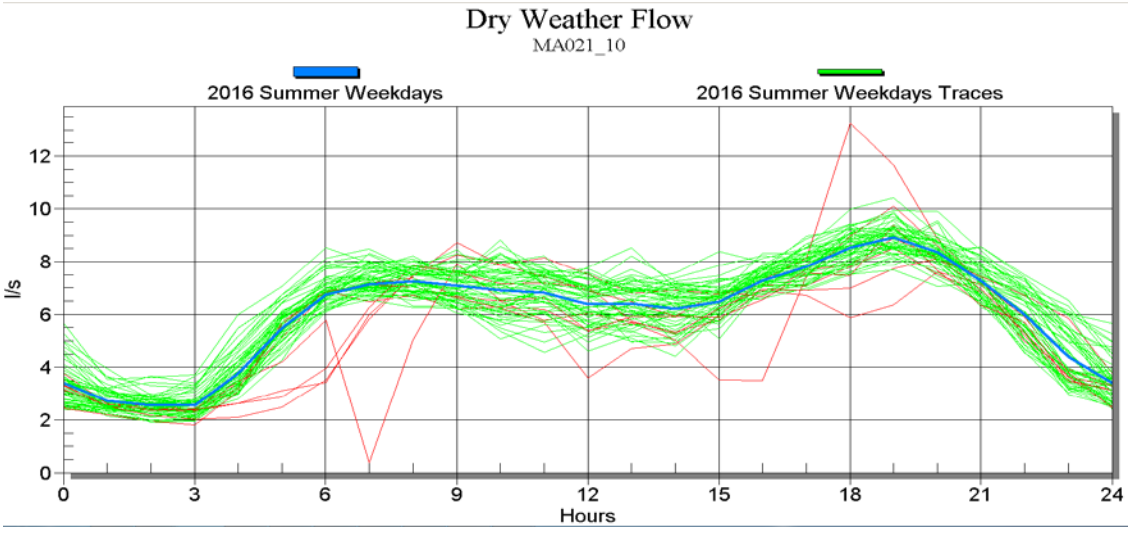


Figure 3 - Dry Day Pattern Correction

A number of key performance indicators (KPI's) and thresholds were reviewed in 2016 that incorporated both peak and volumetric response. Table 5 shows the various KPI's used to prioritize further Sanitary Sewer Evaluation Studies (SSES) and repair work, and the threshold levels for low, medium, and high risk.

Table 5 - Key Performance Indicators for Catchment Prioritization

Key Performance Indicators	Thresholds	
Hourly Averaged Peak Flow (Average of 12 peak 5min readings / Average Dry Weather Flow)	PF < 1 x Acceptable ***	Low
	1 < PF < 1.5 Acceptable	Medium
	PF > 1.5 x Acceptable	High
RDII per Pipe Length per mm of Rainfall L/m*mm (Total Litres in 72 hours of storm response, divided by length of pipe in meters and rainfall in millimeters)	L/m*mm < 3.42	Low
	3.42 < L/m*mm < 5.86	Medium
	L/m*mm > 5.86	High
RDII per Area per mm of Rainfall % Rain entering the system (Cv) Volume RDII in pipe for up to 72 hours following the start of the storm divided by total volume of rain that falls on the basin's total area.	Cv < 5%	Low
	5% < Cv < 7.5 %	Medium
	Cv > 7.5%	High
Peak RDII per Area L/s/ha	L/s/ha < 0.26	Low
	0.26 < L/s/ha < 0.58	Medium
	L/s/ha > 0.58	High
Peak RDII per Pipe Length L/s/km	L/s/km < 3	Low
	3 < L/s/km < 6	Medium
	L/s/km > 6	High

*** Acceptable is determined by the size of the average dry day flow from the St. Paul Minnesota table referenced in the Region's 2015 Best in Class Review.

Figure 3 and Figure 4 show the dry weather pattern and RDII analysis of a wet period during a storm event; both these figures are examples of the analysis output of the software tool Sliicer used to resolve wet and dry day patterns.

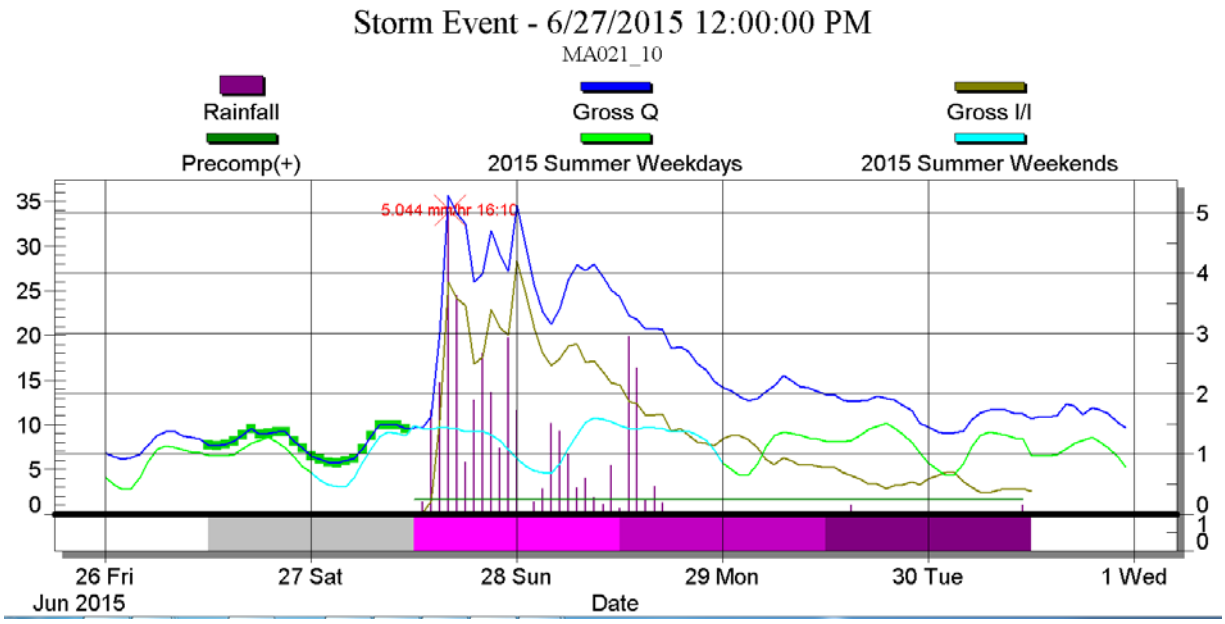


Figure 4 - Storm Viewer Window

All of the KPI figures are determined by regression analysis and all points are reviewed and outliers are investigated. Basins with an r^2 value less than 0.7 are studied more intensely before further SSES or repair activities are prescribed, because of the lower level of uncertainly in the prediction. The r^2 value for the prediction shown in Figure 5 below is 0.76, which is acceptable.

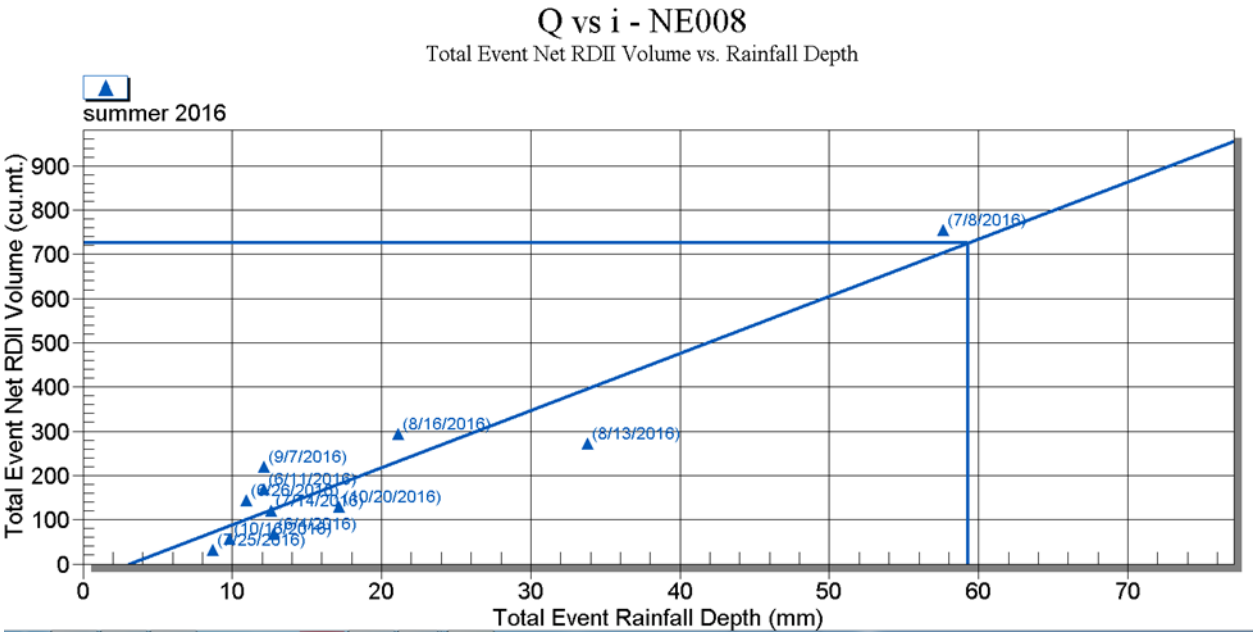


Figure 5 - RDII Volume Regression Prediction

4.2 Inflow and Infiltration Audit and Flow Monitoring Program – Long-Term Flow and Rainfall Monitoring

The Inflow and Infiltration Audit Program (or the Long-Term Flow and Rainfall Monitoring Program) continues to be a key component of the Inflow and Infiltration Reduction Strategy. In 2012, Regional Council approved funding and resources needed for initiating the program which included development, implementation, purchase of equipment and installation, data management, field operation, maintenance and data review for a total of four years. Subsequently, in late 2016 Council approved the continuation of the monitoring program including the installation, operation, and maintenance of the existing and future flow meters and rain gauges.

Maintaining the monitoring sites has been necessary to provide accurate data required by Regional staff to carry out inflow and infiltration related analysis and to quantify inflow and infiltration reductions as a result of completed remedial works.

The sanitary sewer flow and rainfall monitoring data collected through the monitoring program is constantly used to:

- **Reveal deficiencies** in local and regional sanitary sewer systems and identify high priority areas
- **Assess levels of inflow and infiltration** during and after a major rainfall event
- **Assess progress** towards meeting interim and ultimate inflow and infiltration reduction targets as mandated by the Ministry
- **Infra-stretch** - adjust capital projects timing based on reduced flow in the system realized through inflow and infiltration reductions, and advancing capacity to developers as per the inflow and infiltration reduction pilot project agreements

As shown in Table 6, the Region is currently collecting data from 251 long-term flow monitoring sites in 217 audit basins using 244 flow meters. This captures 86 per cent of the contributing areas and 91 percent of sanitary sewer pipes by length assigned to an audit basin. 18 new audit basins were identified following an audit basin delineation update completed in early 2016 and 10 new flow meters have been installed this year to capture the changes in the sanitary sewer system due to growth from new developments. Delineation of meter basins was also essential to establishing an accurate understanding of the flow meter tributary area, contributing pipe length and downstream-upstream meter relationships for analysis purposes.

A total of over 9,228 months of data from 250 long-term flow monitoring sites and 70 rain gauges have been collected as part of the current Long-Term Flow and Rainfall Monitoring project over the last three years.

Table 6 - Summary of Long-Term Flow Monitoring Sites Installed in Local Systems

Municipality	Audit Basins With Sites Installed	Sites Installed (meter basins)	Meters Installed	Meters Serving 2 Sites
Town of Aurora	16	17	17	0
Town of East Gwillimbury	3	5	5	0
Town of Georgina	10	15	14	0
Township of King	6	8	8	0
City of Markham	63	66	66	0
Town of Newmarket	16	18	17	1
Town of Richmond Hill	45	54	51	3
City of Vaughan	53	63	61	2
Town of Whitchurch-Stouffville	5	5	5	0
TOTAL	**217**	**251**	**244**	**6**

Closely monitoring all sewer catchments throughout the Region optimizes the operation and lifecycle of both existing and future wastewater infrastructure, better positioning the Region to maintain sustainable services over the long term. A final report was prepared summarizing the program's development and implementation (Figure 6).

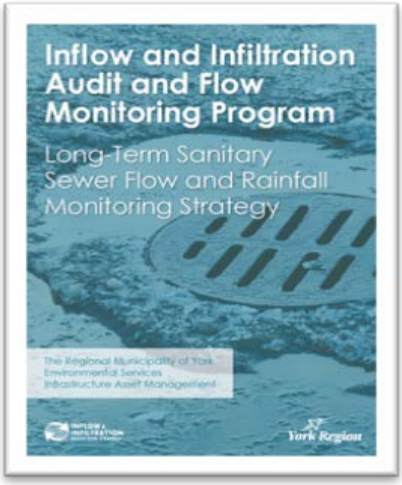


Figure 6 - Flow Monitoring Program Final Report

The main objectives of the Program remain to be:

- System-wide temporary and long-term flow monitoring and rainfall program within the nine local municipalities
- Enhanced means to identify and monitor areas with extraneous flows and evaluate the system's response to rainfall in order to further identify areas of potential high I/I that may require remediation
- Provide accurate flow and rainfall monitoring to validate the data and ensure accurate, high quality datasets required for analyzing and monitoring performance of audit basins
- Evaluate lifecycle components including operation, maintenance and monitoring of equipment, data management, asset management, replacement strategy and reporting

All flow meters are recording data in real-time in both the Regional and local municipal systems. Data is used by Regional and local staff and is available online through FlowWorks – a web-based "big data" management system. Over 92,000 records are transferred daily to the Region's Oracle data warehouse with over 2.8 million readings collected each month. Flow and

rainfall monitoring site assessments, installation, and maintenance reports are completed and updated for every site and over 2297 site visits were completed over the past 14 months to ensure good quality data.

As of November 30, 2016 the Region owns and operates 43 rain gauges (Table 7) and shares data from 27 rain gauges owned by stakeholders (Toronto Region Conservation Authority (TRCA), Lake Simcoe Region Conservation Authority (LSRCA), Town of Richmond Hill and City of Markham). Rain gauge field maintenance is performed on a biannual basis in the spring and fall, and within 48 business hours if any issue is suspected or noted via critical alarms.

Figures 7 and 8 present the current locations of long-term flow and rainfall monitoring locations.

Table 7 - Summary of Rain Gauges Installed Throughout the Region

Municipality	Total Number of Rain Gauges
York Region	43
TRCA	10
LSRCA	3
Town of Richmond Hill	2
City of Markham	12
TOTAL	**70**

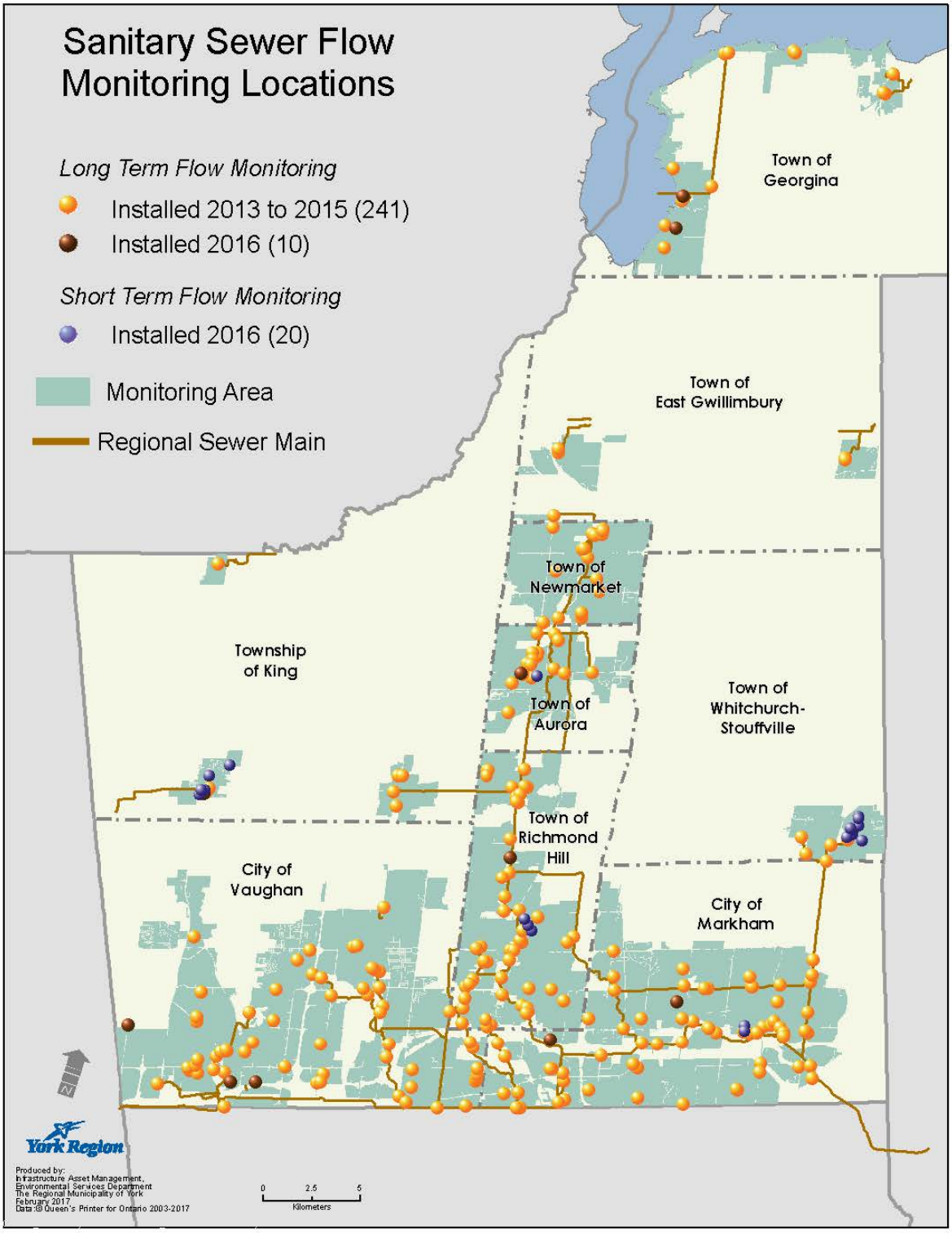


Figure 7 – Sanitary Sewer Flow Monitoring Locations

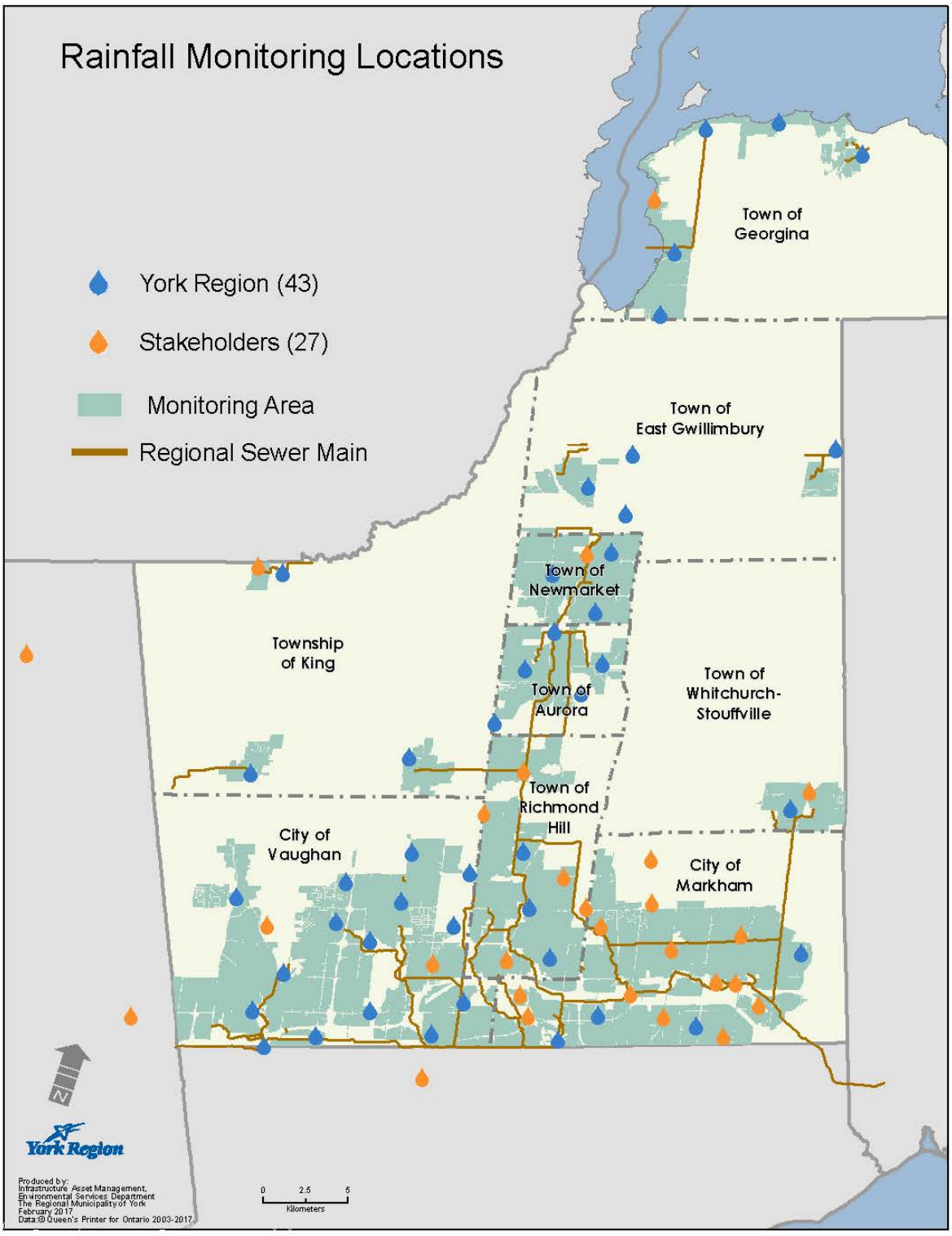


Figure 8 – Rainfall Monitoring Locations

4.3 Short-Term Mini-Basin Monitoring

One of the outcomes of the Inflow and Infiltration Audit and Flow Monitoring Program is the ongoing identification of audit basins where measured inflow and infiltration exceed certain performance thresholds (see Section 4.1). When these audit basins are identified, mini-basin monitoring followed by Sanitary Sewer Evaluation Surveys (SSES) or micro-monitoring are initiated.

Overall, 44 priority meter basins with potential I/I issues have been identified and subdivided into 3 to 5 mini-basins for additional flow monitoring. Figure 9 provides an example of an audit basin in the Town of Richmond Hill (RH056) that was broken down into 4 smaller mini-basins, which **average 3 km** in pipe length. In 2016, the top 4 meter basins in the Region exhibiting I/I issues were selected for mini-basin monitoring, and an additional 15 flow meters were installed to measure flows. Due to the low flows associated with mini-basin monitoring, the Region installed ADS Triton flow monitors, which have been proved to perform well in these conditions.

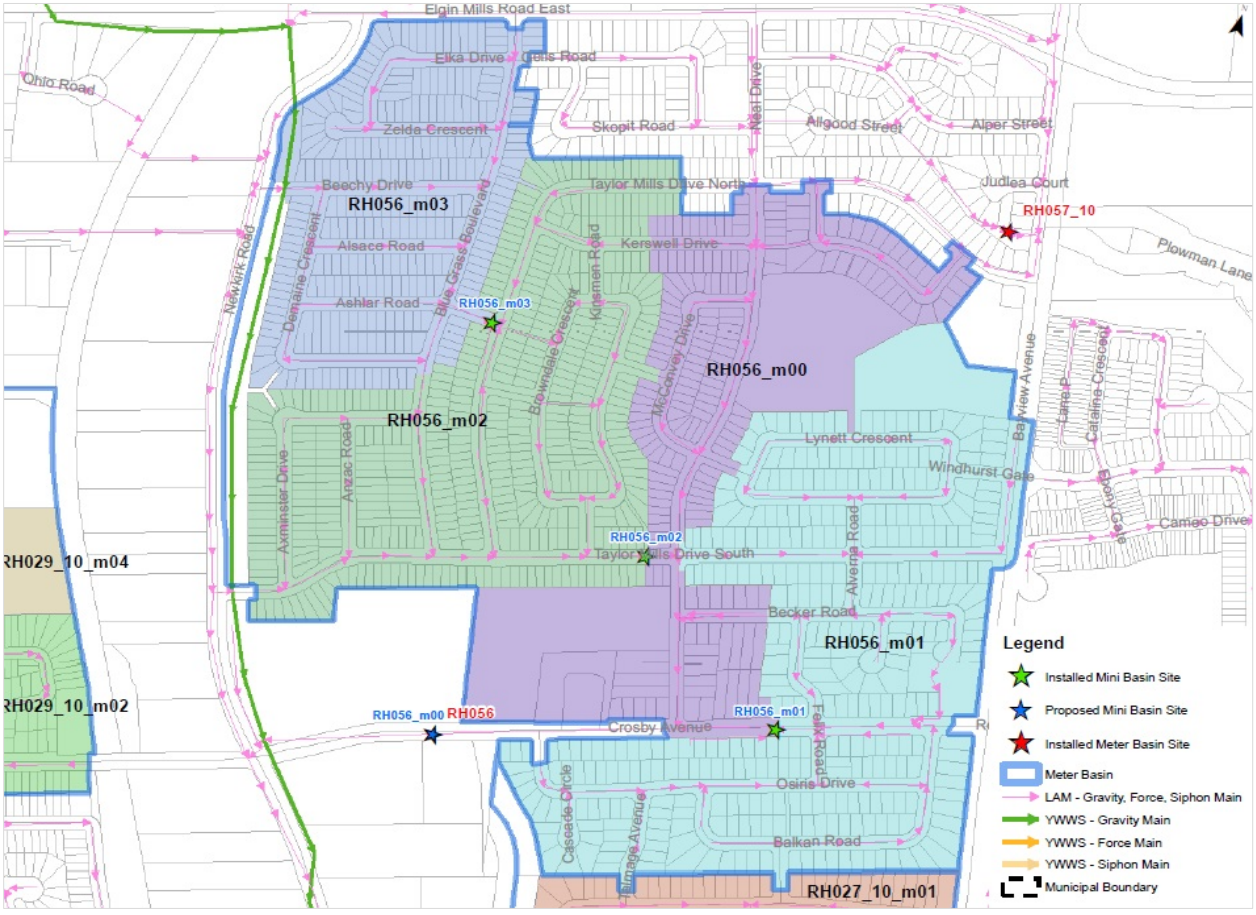


Figure 9 - Map Showing Mini-Basins Generated in RH056 Audit Basin in Richmond Hill

4.4 Short-Term Micro-Basin Monitoring

The Region embarked on a micro-monitoring pilot within the Town of Richmond Hill, where downward-looking ultrasonic sensors measure only the level of flow in a sanitary sewer. Data will be correlated with significant rainfall events to isolate areas that show a high peak response. High priority basins are currently being delineated into micro-basins for further review and to assess the viability of micro-monitoring in these areas. As shown in Figure 10, micro-basins are **less than 3 km** in pipe length and will allow for a more targeted study to identify inflow and infiltration sources.

Two micro-basin monitoring locations were installed in 2016 in the local system in the Town of Richmond Hill as pilot monitoring catchments averaging 10 hectares in area and 1.3 km in pipe length (Figure 10). Additional locations will be installed throughout the Region in 2017 depending on inflow and infiltration analysis results and criticality mapping.

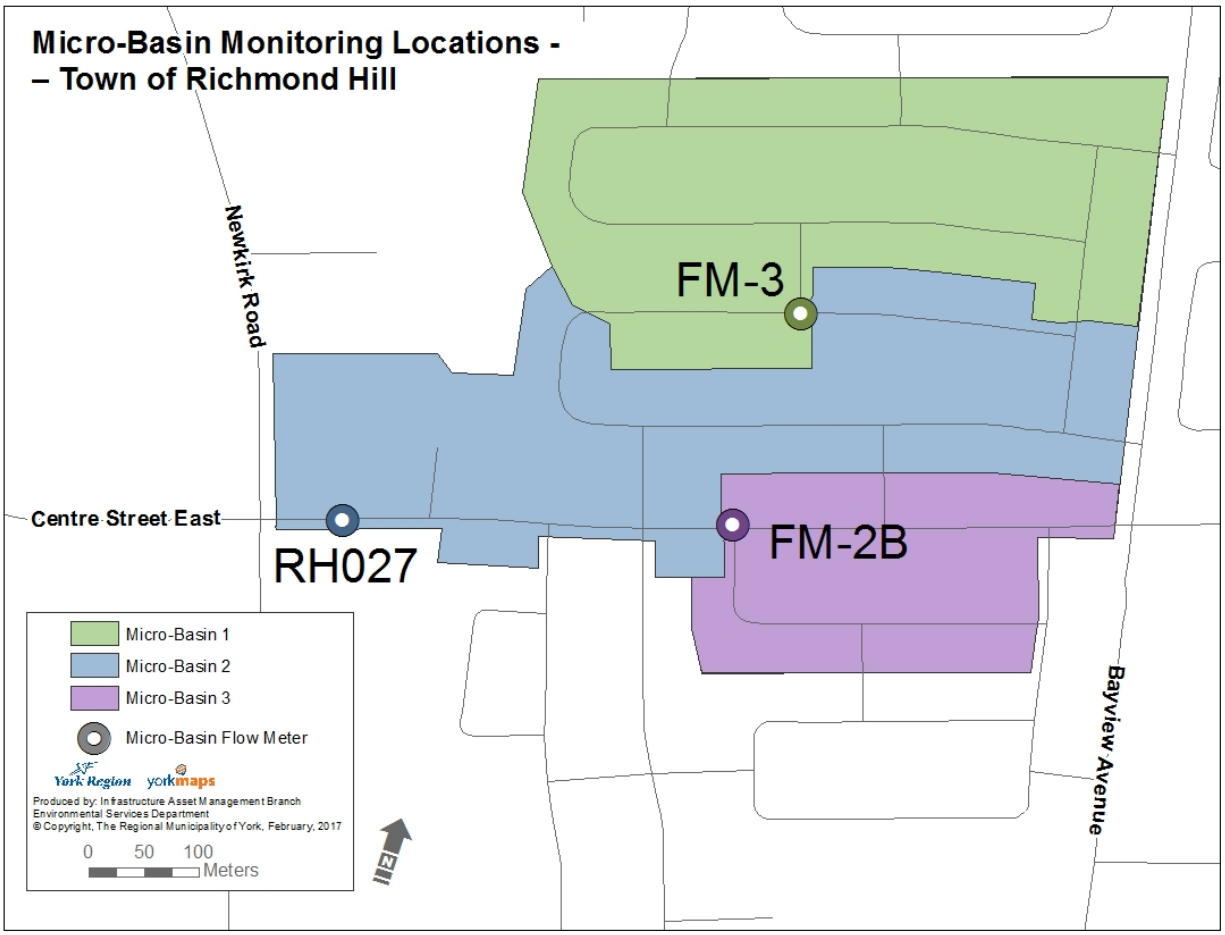


Figure 10 - Map Showing Micro-Basin Monitoring Locations in Richmond Hill

4.5 Sanitary Sewer Evaluation Surveys

Once mini-basins are identified as being sources of significant inflow and infiltration, SSES programs are developed and executed by York Region and coordinated with any SSES programs undertaken by the local municipalities.

The Region conducted SSES activities in 2016 in the City of Vaughan (Kleinburg), the Township of King (Nobleton), and the Town of Richmond Hill (Yonge Street and Highway 7 – Pomona) to identify sources of inflow and infiltration. These activities have included micro monitoring, smoke and dye inspection, household drainage surveys and closed-circuit television (CCTV) and groundwater investigations.

Smoke inspections in Kleinburg, Pomona and Nobleton identified a number of deficiencies to be prioritized for remediation and recommended further investigations, such as dye testing., These tests be performed to confirm the presence of potential direct connections that were suspected. In most cases, dye inspections can confirm direct connections to the sanitary sewer system where an earlier visual inspection or data review has identified a probability that there is a direct connection to the sanitary sewer. Table 8 summarizes the total inspections that were conducted in each study area.

Table 8 - Summary of Sanitary Sewer Evaluation Studies

Municipality	Location	Smoke Tests Performed (Total No.)	Length of Sewer Inspected (m)	Drainage Surveys Performed (Total No.)	Maintenance Holes Inspected (Total No.)
Township of King	Nobleton Village	39	5742	267	109
Town of Richmond Hill	Pomona Area	46	9763	721	0
City of Vaughan	Kleinburg Village	42	9385	469	0
TOTAL		**127**	**24890**	**1457**	**109**

In total, the Region tested nearly 25 km of local municipal sanitary sewer which revealed a total of 131 defects such as cross-connections, missing cleanout caps, and structural defects. In addition, maintenance hole inspections in the Village of Nobleton discovered 59 of them had active infiltration, with another 71 that had the potential for inflow during wet weather. The Region is working with local municipalities to address the defects as part of normal maintenance activities as well as through private programs with local developers. See Table 9

for a complete breakdown of the defects identified during SSES and Figure 11 and Figure 12 for smoking I/I sources.

Table 9 - Summary of Defects Identified During Sanitary Sewer Evaluation Studies

Municipality	Location	Missing Cap on Cleanout (Total No.)	Potential Cross-Connection (Total No.)	Smoking Foundation (Total (Total No.)	Smoking Maintenance Hole (Total No.)
Township of King	Nobleton Village	18	0	0	58
Town of Richmond Hill	Pomona Area	6	16	11	11
City of Vaughan	Kleinburg Village	1	4	0	6
TOTAL		**25**	**20**	**11**	**75**

Figure 11 - Smoking Maintenance Hole through Chimney and Frame in Vaughan

Figure 12 - Smoking Downspout and Open Sanitary Cleanout in Richmond Hill and Vaughan

4.6 Rehabilitation of Private Sanitary Sewer Laterals

In addition to focusing on identifying and reducing extraneous flows that originate from public infrastructure, the Region and its local municipal partners are initiating activities to tackle I/I from private sources. Per the Region's Industry Best- in- Class Review, it is estimated that more than 60 per cent of I/I originates from private property sources, which makes private-side rehabilitation necessary for successfully reducing I/I.

Potential sources of I/I from private property take the form of broken sewer laterals, or those that have root intrusions from overlying trees. In addition, uncapped sewer cleanouts as well as cross connections from roof or foundation drains allow clear water a direct path into the sanitary sewer system, as do connected downspouts and sump pumps.

As a continuation of Pilot I Rehabilitation project completed in 2012, the Region, in collaboration with the local municipalities have completed work in the private side of the majority of the catchments included as part of Pilot I. The project works for the Rehabilitation of Private Sanitary Sewer Laterals were located in catchments within five local municipalities – Aurora, East Gwillimbury, Georgina, Newmarket, and Vaughan – and focused on repairing or replacing damaged sanitary sewer laterals between the mainline and property line.

Figure 13 - Lateral Replacement in Aurora

Where possible, laterals were rehabilitated using full-length cured-in-place pipe (CIPP) or spot repairs. Laterals that were too damaged for rehabilitation were completely replaced or capped at the mainline sewer. Table 10 below summarizes the type and number of repairs completed and I/I reduction achieved in each of the catchments as a result of this pilot project and Figure 13 shows a lateral replacement in East Gwillimbury. Figure 14 compares a pipe before and after lateral lining.

Table 10 - Summary of Lateral Repair and I/I Reductions Achieved as part of the Region's Private Sanitary Sewer Lateral Rehabilitation Project

Municipality	Catchment	Total Number of Laterals Remediated	Remediation Type						
			Full Length Liner		Full Length Replacement		Spot Dig	Capped at Main	RDII Reduced[1]
			Count	Length (m)	Count	Length (m)	Count	Count	MLD
Aurora	AU01	92	51	453	28	176	17	3	0.56
East Gwillimbury	HL01	41	22	192	5	44	17	0	0.40
Georgina	KE04	32	10	96	0	0	24	0	0.18
Vaughan	KL02	87	85	942	1	4	1	0	Pending[2]
Newmarket	NE06	147	138	1,201	4	26	19	1	0.45
TOTAL		**399**	**306**	**2884**	**38**	**250**	**78**	**4**	**1.59**

[1]Reductions are based on 2014/2015 pre-monitoring data and 2016 post monitoring data. Post monitoring will continue in 2017 and reduction numbers may be revised.

[2]Post-monitoring data was insufficient to quantify reductions. Reduction numbers will be reported next year as more data becomes available.

Reductions in I/I were quantified through area-velocity flow meters that measured flows in the sanitary sewer before and after repairs. Pre- and post-remediation flow data was compared to calculate the I/I reductions achieved. Monitoring will continue for another year to ensure two years of post-rehabilitation monitoring data is captured.

Figure 14 - Lateral Lining Before and After Rehab Illustration

Using data from the Region's rain gauge network, rainfall derived inflow and infiltration (RDII) was calculated by taking storms over 12.5 mm in volume, and subtracting the typical diurnal pattern observed at the specific flow meter to give an estimate of the RDII entering the collection system. RDII volume response for each measured storm is plotted against the rainfall depth and a linear regression analysis is used to predict a volume response to the Chicago 25-year design storm for all the monitoring sites before and after rehabilitation (see figures in Appendix B). As-built of each of the completed rehabilitation works for each catchment are provided in Appendix C.

Figure 15 - CIPP liner prior to installation

4.7 York-Durham Sewage System Trunk Sewer Investigation and Rehabilitation

The Region has undertaken a Feasibility Study for the Rehabilitation of six sections of the York Durham Sewage System (YDSS): Aurora West Collector, the 404 Trunk Sewer, the Jane/Rutherford Trunk Sewer, the Maple Collector Relief Sewer, Maple Collector and the North Don collector in the Town of Aurora, City of Markham and City of Vaughan to identify the most suitable rehabilitation method for each section and its associated risks.

As part of the Region's on-going Infrastructure Improvement Program, the six trunk sewer locations have been identified as requiring priority rehabilitation. From detailed CCTV inspections, these sections were found to have a number of deficiencies including cracks, fractures, encrustations, as well as roots and debris. Four of the six sections investigated had active infiltration. The objectives of this capital project are to identify projects to restore sewer capacity, reduce inflow and infiltration and improve sewer integrity and soil stability in the sections in need of repair.

Repair has taken place in the Aurora West Collector where a number of active infiltration points were discovered during a routine CCTV inspection. A weir was installed and the sewer flow diverted in order to quantify the amount of infiltration entering the sanitary sewer, which was determined to be 0.001 MLD. To address the infiltration, a 900 mm diameter CIPP liner approximately 225 m in length was installed (Figure 15), and rehabilitation was performed on three maintenance holes. A map of the project area is provided in Appendix D.

Overall, 38 sources of infiltration, from drippers to gushers were identified in the 404 Trunk Sewer, the Jane/Rutherford Trunk Sewer, the Maple Collector Relief Sewer, Maple Collector and the North Don collector and further investigations and rehabilitation will take place in 2017 and 2018.

4.8 16th Avenue York Durham Sewage System Rehabilitation Pilot Project

Based on CCTV inspection data from the Region's asset management program, it was determined that three kilometres of the YDSS, along 16th Avenue in Markham, required rehabilitation. Specific sewer sections were recommended for rehabilitation to reduce infiltration and address issues with sewer structural integrity and soil stability surrounding the pipe. In addition, high water table conditions and high groundwater pressures are suspected to have contributed to the sewer's degradation.

Traditional rehabilitation methods, either by CIPP or sliplining, would typically be used in such a scenario, but each carried with them several drawbacks. As a result, the Region sought proposals for an alternative solution. The aim was to identify the best technical solution that was innovative and provided the greatest value, while minimizing disruption to residents, construction risks, and impact on the hydraulic capacity of the sewer.

An innovative method under consideration by the Region is to use GeoSpray®, a geopolymer mortar lining product that essentially constructs a new pipe within the existing sanitary sewer. This method has the benefits of being cost effective with a minimal construction footprint, and eliminates the need for expensive external flow bypass pumping. This method has been utilized for pipe rehabilitation throughout the United States since 2011, and the United States Environmental Protection Agency has successfully demonstrated its viability for use in large-diameter sewers.

Although this material has been used effectively for pipe rehabilitation, site-specific conditions that exist, particularly the high ground water pressure and active infiltration, add challenges to implementing this solution. As such, the Region has undertaken a pilot study to rehabilitate two sections of pipe, totaling 210 metres (Figure 16), to determine the performance and reliability of this method prior to completing detailed design for the entire three kilometres of sewer.

The two areas selected for the pilot have longitudinal cracks on their internal surface, and active, heavy infiltration (Figure 17), calculated to be 0.082 MLD via a tipping bucket test (see Table 11). This pilot enables evaluation of the method's performance, and provides valuable information on its durability and how effective it will be at reducing inflow and infiltration. If proven successful under the pilot study, the Region will proceed with the design of the YDSS 16th Avenue Rehabilitation Project recommending the use of a geopolymer mortar lining as the specified method (Figure 18) and reductions will be reported next year.

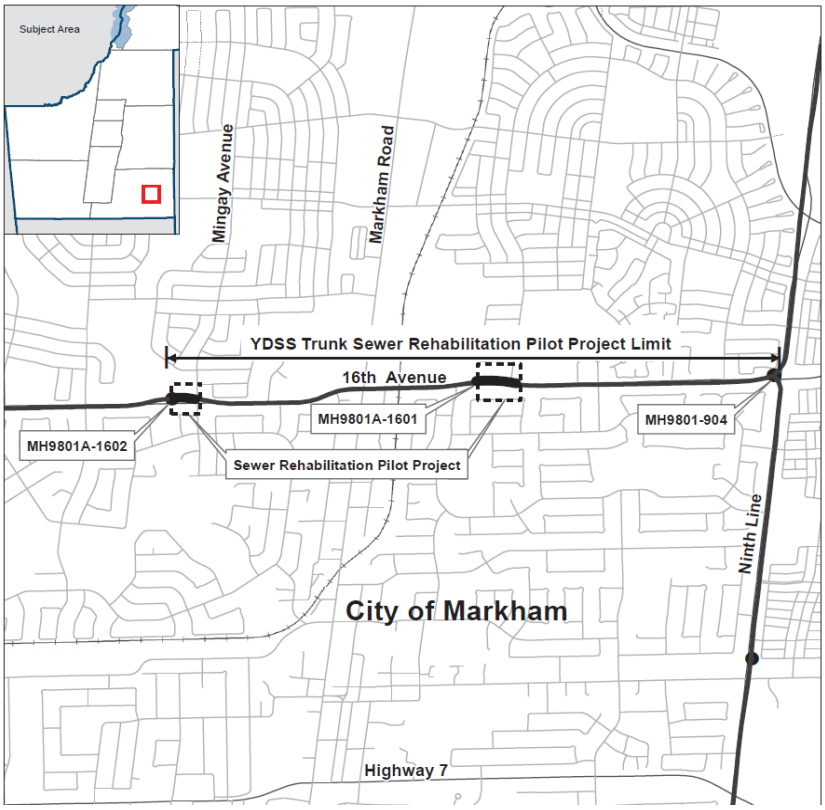


Figure 16 - Location of Sewer Rehabilitation Pilot Project in the YDSS Trunk Sewer on 16th Ave

Table 11 - Results of the 16th Avenue Bucket Test

Date	Start Time	End Time	Volume (L)	Flow Rate (L/s)	Flow Rate (MLD)
1/9/2017	0:09	0:28	18.9	1.00	0.086
1/9/2017	0:08	0:28	18.9	0.95	0.082
1/9/2017	0:08	0:29	18.9	0.90	0.078
AVERAGE				**0.95**	**0.082**

Figure 17 - 16th Avenue Trunk Sewer Gusher Prior to Rehabilitation

Figure 18 - 16th Avenue Trunk Sewer Gusher after Application of Geopolymer

4.9 York Central Collector Sewer – Pomona Mills Park Emergency Sewer Repair

Two infiltration gushers and a runner were repaired in the course of decommissioning a section of York Central Collector Sewer located at 200 John Street in Pomona Mills Park, City of Markham. In August 2015 Region staff were notified of a sinkhole located at the northeast corner of the Pomona Mills Tennis Club parking lot (Figure 19). The sinkhole was identified above an 825 mm diameter reinforced concrete pipe of the Region's Central Collector sewer system.

Figure 19 - Map Showing Pomona Mills Park Sinkhole location in York Central Collector

CCTV inspections of the sewer system were initiated, which identified the displacement of two maintenance holes and open pipe joints and emergency sewer repair was completed in the fall of 2016. The scope of work included installation of new sewer pipe and maintenance holes, decommissioning of the affected sewer infrastructure and ongoing operation of the sewage bypass system throughout construction activities.

While only 3 infiltration gushers/runners were observed in pre-remediation videos. If the line had been allowed to continue to sink, there could have been significant ground water infiltration quantification potential. Therefore the project circumvented potentially significant I/I that cannot be quantified. A reduction of 0.01 MLD is reported following the CCTV review and quantification of the infiltration runner.

4.10 Inflow and Infiltration in New Development

York Region and its local municipalities have initiated several programs to reduce inflow and infiltration in their sanitary sewer systems. In the past five years the Region and its local municipal partners have begun to report on I/I issues in new developments. Standard issues in new sanitary sewer systems on the public side include offset joints, poor connections at the maintenance holes, leaking maintenance holes and poor connections at the lateral to mainline. These issues are not always identified in post construction CCTV. As well it is common for builders to drain excavations through the newly constructed sanitary sewers, which can be a large source of inflow into the municipal system which should not be occurring.

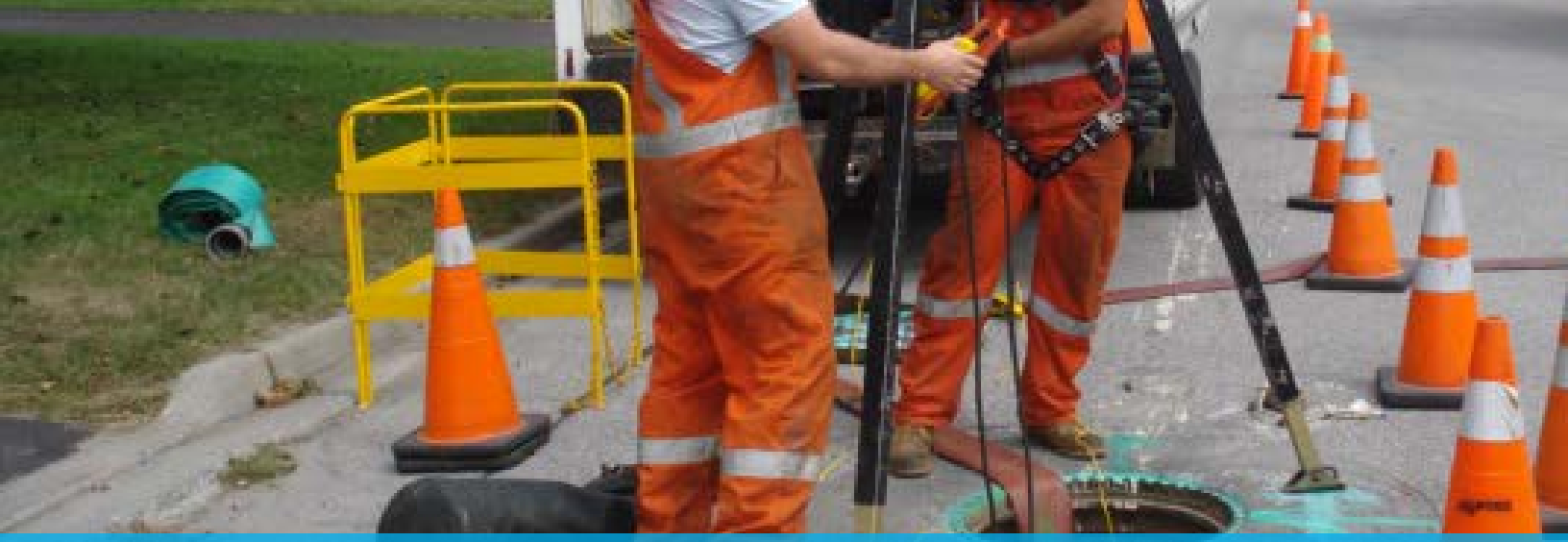
In 2016 the Region continued funding a project in partnership with Peel Region, the Institute for Catastrophic Loss Reduction (ICLR), and other municipalities to study I/I in new developments. As well, through the Servicing Incentive Program (SIP) developers in York Region are able to gain a 20 percent capacity credit to be used toward additional development if their developments meet certain water conservation and wastewater flow reduction targets. Flow monitors are set-up to verify that the wastewater flow and inflow and infiltration targets are being met as part of this incentive program.

As part of new development initiatives, the Region's I/I team is also working with a number of internal and external stakeholders to modernize the Region's Wastewater Design Guidelines, which were last updated in 2006. As part of the update, I/I allowances for sewer performance will be examined against other existing guidelines – such as the SIP Implementation Guideline and the Sanitary Sewer System Inspection, Testing and Acceptance Guideline – to determine appropriate values. As well, other design and construction requirements currently in use by the SIP and other municipalities are being examined for their potential to become Regional standards. As an example, in the future the Region may require the use of watertight covers when maintenance holes are located in low-lying areas with the potential for ponding to occur. Another example is the possibility of fully inspecting sewer laterals via CCTV, as opposed to purely visual inspections required by the Ontario Building Code (OBC), before occupancy, as many problems are observed at the lateral/mainline connection. Further to this, York Region will be collaborating with all nine local municipalities in 2017 to make recommendations for improving the design, construction, inspection, testing and acceptance of new sanitary sewer infrastructure in the public and private right-of-way following a literature review and on-site inspection survey that will address suspect problems contributing to inflow and infiltration at the construction stage.

On November 14, 2016, the Region held its first Inflow and Infiltration Reduction Design Standards working group meeting. The goal of the meeting was to bring together the Region and its local municipalities to discuss I/I in new developments and how to address it through

new design ideas, new inspection practices and new technologies. Representatives from the local municipalities were surveyed regarding their design and inspection practices, with the intent to utilize the feedback received to update the Region's existing Sanitary Sewer System Inspection Testing and Acceptance Guideline and the Region's Wastewater Design Guidelines.

Although the latest working group meeting covered a wide variety of topics, a number of issues were identified as having significant importance and will be addressed in 2017 and years to come. One such issue was the need to improve private side lateral construction and testing to prevent I/I. As well it was recognized that standardizing inspection procedures in general throughout the Region is critical. Consistency is required by inspectors and consultants, as is their approach to the type and timing of inspections.



5.0 2016 Summary of Local Municipality Program Activities and Accomplishments

Over the course of 2016, the nine local municipalities continued with I/I investigation, operation and maintenance programs, and other I/I reduction initiatives started in 2015. Repairs are performed on priority assets deemed critical for rehabilitation and replacement.

5.1 Inflow and Infiltration Reduction Programs

The City of Vaughan formalized a city-wide Inflow and Infiltration Program in September of 2016. The program focuses on 5 main areas:

1. Flow Monitoring
2. Identification of I/I Sources
3. Data Management and GIS integration
4. Rehabilitation Programs
5. Communication and Outreach.

I/I Reduction Program development is also underway in the Town of Aurora following an update of their I/I Strategic Plan. While the Town of Newmarket does not have a formalized I/I reduction program, the Town is expanding its asset management services to include an I/I component.

City of Markham also has continuous efforts to reduce I/I from their local sanitary sewer system through various programs including high-standard routine operation and maintenance activities; flow and rainfall monitoring and analysis; and the Council approved City-Wide Sanitary System Downspout Disconnection Program.

Based on the sanitary sewer mainline and lateral inspection and flow monitoring results, City of Markham issues an annual sanitary sewer rehabilitation and upgrade program to repair the structural and I/I related sewer deficiencies including sewer mainline spot repairs, CIPP lining,

lateral repair/relining, maintenance hole repair and grouting. Similarly the Towns of Whithurch Stouffville and Aurora are developing capital sanitary sewer rehabilitation projects.

In addition to the City of Markham's regular CCTV inspection program of the entire system, the City has also a sanitary lateral inspection program that started in 2013. Currently, approximately 2,000 laterals are camera inspected per year. This inspection data is used to plan the Annual Sanitary Sewer System Rehabilitation and Upgrade Program.

5.2 Sanitary Sewer Flow Monitoring

To supplement data from the Region's Long-Term Monitoring Program, the Cities of Markham and Vaughan have installed 23 and 6 short-term flow monitors respectively in their sanitary sewers systems. Generally, the monitors are in place for approximately 12 months after which they are moved to other areas of interest.

The local monitoring programs focus on mini-basins and smaller catchment areas, within areas with significant I/I, to better identify I/I sources, to provide data to support the local municipal wastewater models and evaluate system capacity. City of Markham will also be using the monitoring data collected to continue evaluation of its downspout disconnection program (Section 5.6).

5.3 Investigation and Rehabilitation

The Cities of Markham and Vaughan and the Towns of Aurora, East Gwillimbury, Richmond Hill and Newmarket have annual CCTV inspection programs for sanitary sewer mains. The Town of Richmond Hill launched their CCTV program in regards to I/I issues in 2015 and will provide the results of rehabilitation in 2017.

Below is a summary of the investigation and rehabilitation activities completed by the local municipalities in 2016:

- Over 125.24 km of mainlines were inspected and more than 120 km were flushed
- 17 structural problems and three debris buildup locations were noticed in the Town of Aurora and will be remediated in the upcoming year.
- More than 1355 sanitary sewer laterals (to the property line) were inspected by CCTV. Nine of these laterals were repaired in the Town of Aurora due to identified deficiencies
- CCTV videos for potential I/I sources were provided to the Region for further investigation and quantification. The Towns of Aurora and Newmarket and the Township of King repaired major infiltration gushers at 8 Cedar Crescent (Basin AU007_20), Prospect Street and 6120 King Road property lateral (Basin KI004a_10) respectively. A total reduction of 0.09 MLD was quantified.

- CCTV inspections also identified four active infiltration runners and three active infiltration drippers in the Town of Aurora. Other problems identified include 28 deposit encrustations, seven cracks/ holes, three failure defects and one offset joint defect. These problems can lead to significant infiltration and will be remediated and reported in 2017
- 600 maintenance hole inspections were conducted in the City of Vaughan, of which more than a hundred were in response to recommendations made by the Region. Other municipal inspections led to the sealing of 70 maintenance holes to prevent water infiltration. The Town of Richmond Hill also added pick hole covers to maintenance holes in low lying areas identified through SSES activity
- Township of King coordinated future work plans to assess and address problems in Nobleton and King City. So far potential problems include a connected downspout and significant sanitary sewer deficiencies in Schomberg, all of which will be addressed in the upcoming year
- $2.4M were spent by local municipalities on I/I investigation and reduction activities as specified in Table 12 below.

Table 12 - 2016 Expenditures by Local Municipalities

Activity	Dollars Spent in 2016
Flow and Rainfall Monitoring	$217,316
Mainline Inspections, Maintenance and Repair	$1,951,897
Lateral Inspections and Repair	$136,984
Maintenance Hole Sealing	$22,750
Downspout Disconnections	$76,670
TOTAL	**$2.4M**

5.4 New Developments

The implementation of new development initiatives is to reduce the amount of I/I occurring in new infrastructure. Notably, the Town of East Gwillimbury has imposed stringent allowances as part of their subdivision agreement approval process through their Sustainable Development Incentive Program (SDIP) and the City Vaughan is enforcing a zero leakage policy in all newly constructed sanitary system including laterals (prior to assumption). The Township of King is

conducting similar work in Nobleton where previous I/I had been found. All inspections occur prior to assumption.

5.5 Design Standards

In parallel with the Region's work with changing the Sanitary Sewer System Inspection, Testing and Acceptance Guidelines, the Cities of Markham and Vaughan updated their engineering design criteria, aiming to create water-tight systems in 2016. Ideas include, but are not limited to, water-tight maintenance hole covers and frames in low-lying areas, as well as water-tight joints and gaskets.

5.6 City of Markham's Downspout Disconnection Program

The City of Markham's Downspout Disconnection Program started in 2013 and aims to locate and repair locations where downspouts are connected to the sanitary sewers. The program targets at risk areas and replaces the connections with splash pads that direct water away from property foundation walls.

Following initial flow monitoring, the City launched a wide spread communication and education program. Smoke tests were then used to identify the connected downspouts, and homeowners were notified of procedures and municipal aid that could be used to address the problem. If disconnection was not complete after 1 year, the City commenced with the By-Law enforcement process. Lastly, effectiveness of the program was captured through a follow up period of flow monitoring.

The City's Downspout Disconnection Program is composed of 4 phases (Figure 20). Phase 1, occurring between Yonge Street and Don Mills Road has been quantified. Over the course of Phase 1 which started in April 2014, 2256 properties were inspected - of which 21 were found to be connected to the sanitary system. All 21 disconnections occurred without the need for enforcement. In addition to the connected downspouts, the smoke testing identified 48 other I/I contributors and 65 lateral interactions. The remediation of these I/I sources has not been captured in the 2017 Annual Report and will be included in future reports.

The total benefit derived from the repair activities was estimated to be approximately 0.118 MLD for the disconnection of 30 downspouts as part of Phase I. The volume for each downspout was derived using a simple modified Rational Method where the volume of rain was multiplied by the rooftop area and a runoff coefficient. The rainfall is simply 62.7 mm derived from a 4-hour Chicago storm using Pearson International Airport (Intensity-Duration-Frequency) IDF values. The area is determined by roof shape and eavestrough slopes and field images are sketched out and transferred to GIS images to derive the total area. A 0.95 runoff coefficient for a roof in a 25-year storm is then applied to the area.

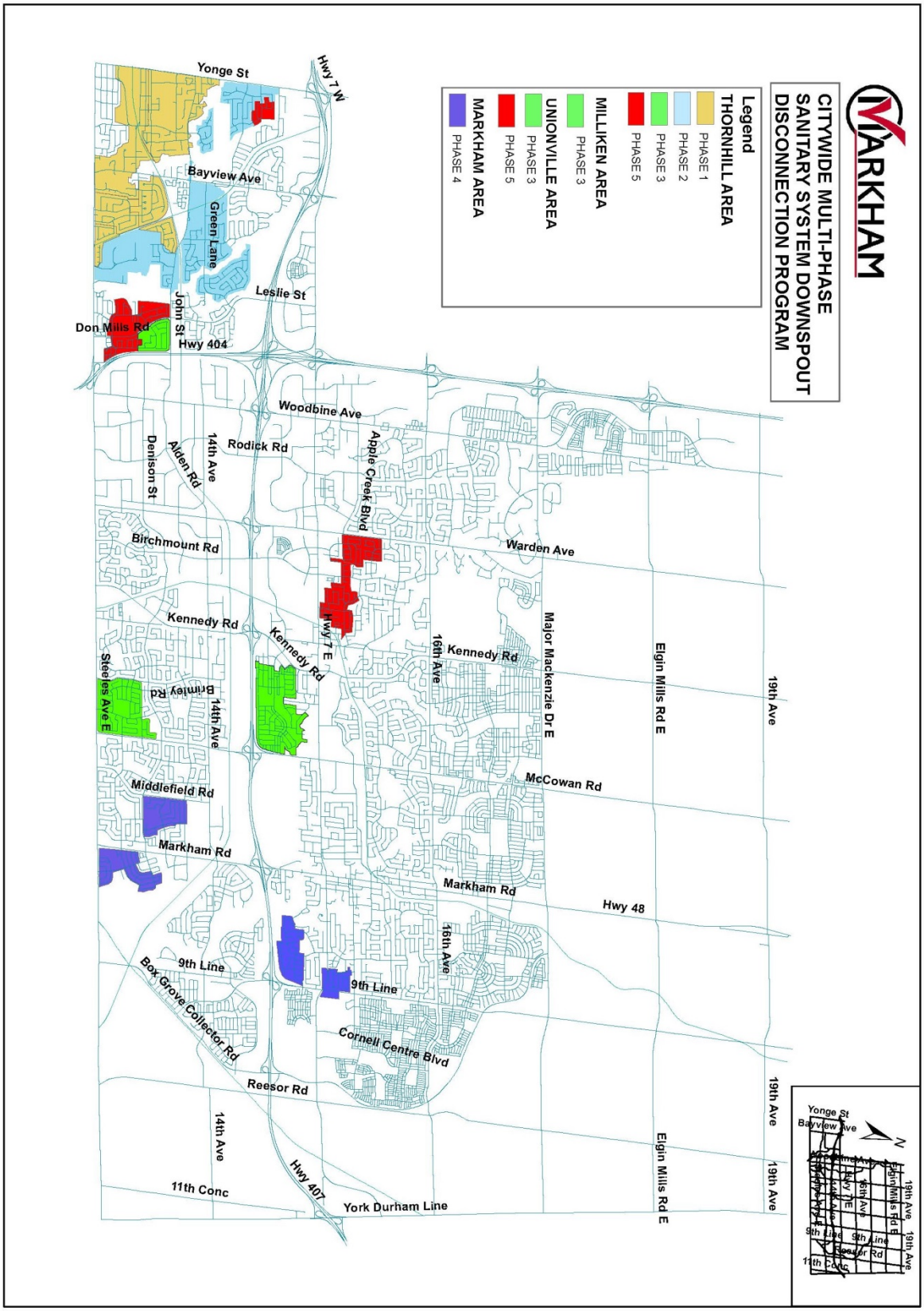


Figure 20 - City of Markham's Downspout Disconnection Program

6.0 2016 Summary of Program Activities and Accomplishments for Private Initiatives

The Region has entered into five tri-party inflow and infiltration reduction pilot agreements with local municipalities and developer groups since 2011. The following local municipalities have participated in the past 5 years:

- City of Markham
- Town of Aurora
- City of Vaughan
- Town of Richmond Hill
- Town of Newmarket

Subsequent sections will cover new and on-going work in 2016 through the agreements in the towns of Richmond Hill and Newmarket.

6.1 Inflow and Infiltration Reduction Pilot Agreement - Town of Richmond Hill

In 2016, the following inflow and infiltration sources were disconnected or repaired in Richmond Hill:

- 2 sanitary cleanout caps
- 2 reverse slope driveway drains
- 2 residential sump pumps
- 12 residential downspouts at eight properties

The total benefit derived from the repair activities was estimated to be approximately 0.06 MLD.

6.2 Inflow and Infiltration Reduction Pilot Agreement - Town of Newmarket

Developer funded activities completed in Newmarket in 2016 were mainly further investigation activities. Repair work started in 2016 included:

- 7 downspout disconnections at five residential properties (see areas in Figure 21 below).
- One foundation drain was disconnected that was potentially draining significant stormwater flows.

Areas 3, 10, 11, and 14 are mini-basins within Regional Audit basins monitored by the Region.

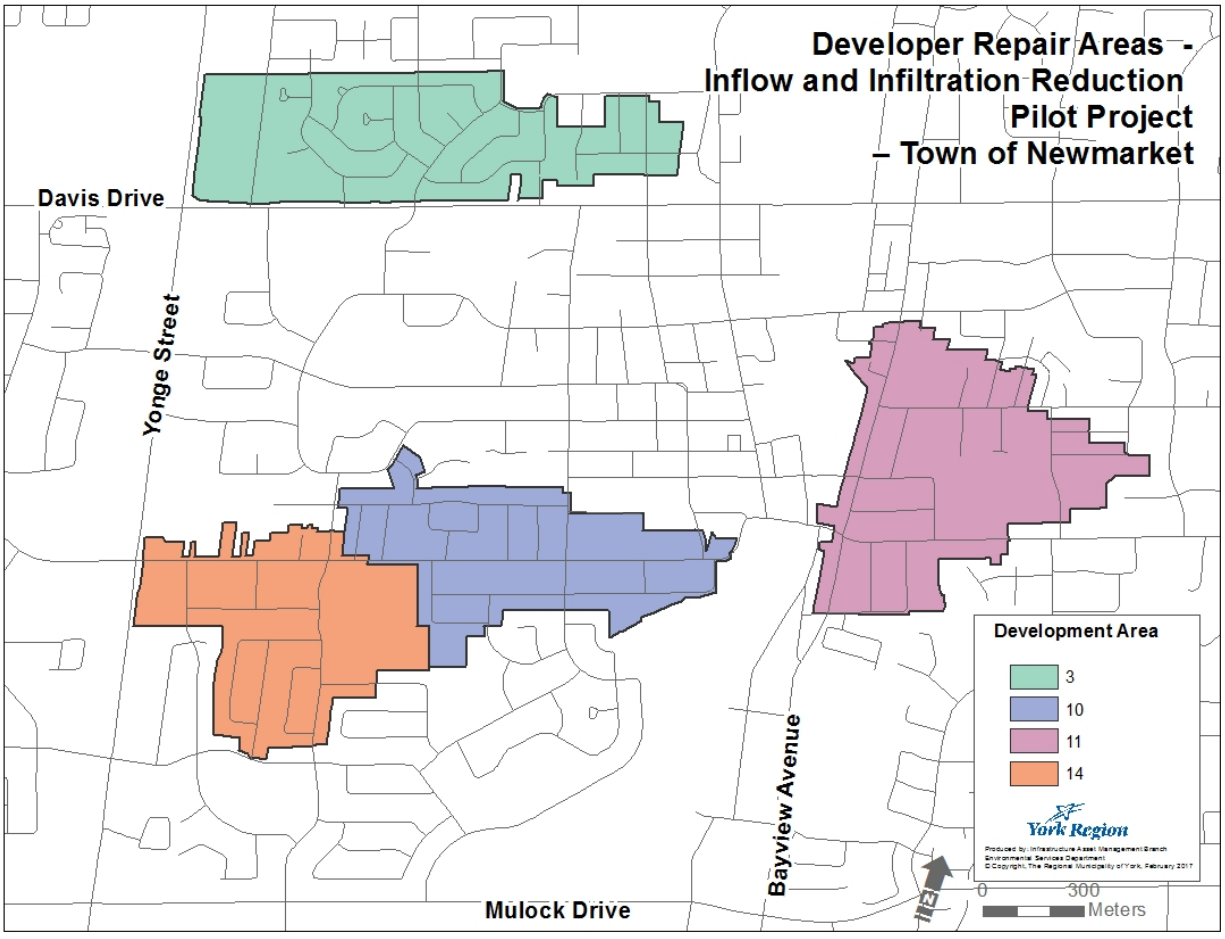


Figure 21 - Private Initiative Pilot Areas 3, 10, 11, and 14

The total benefit derived from the repair activities was estimated to be approximately 0.02 MLD. Additional repair work will be done in 2017 as a result of the investigation done in 2016. Figures 22 through 24 summarize the investigative work highlighting the areas where CCTV, smoke tests and dye tests were performed. The smoke test numbers refer to the number of times one to two sewer segments were blocked to test the properties along the line and a dye

test refers to an injection point on a property suspected of a positive connection. There were a total of 20,274 m of CCTV inspections (Figure 22), 612 smoke tests (Figure 23), 3,830 dye injections (Figure 24), and 463 maintenance hole inspections performed by the developer group over 2015 and 2016.

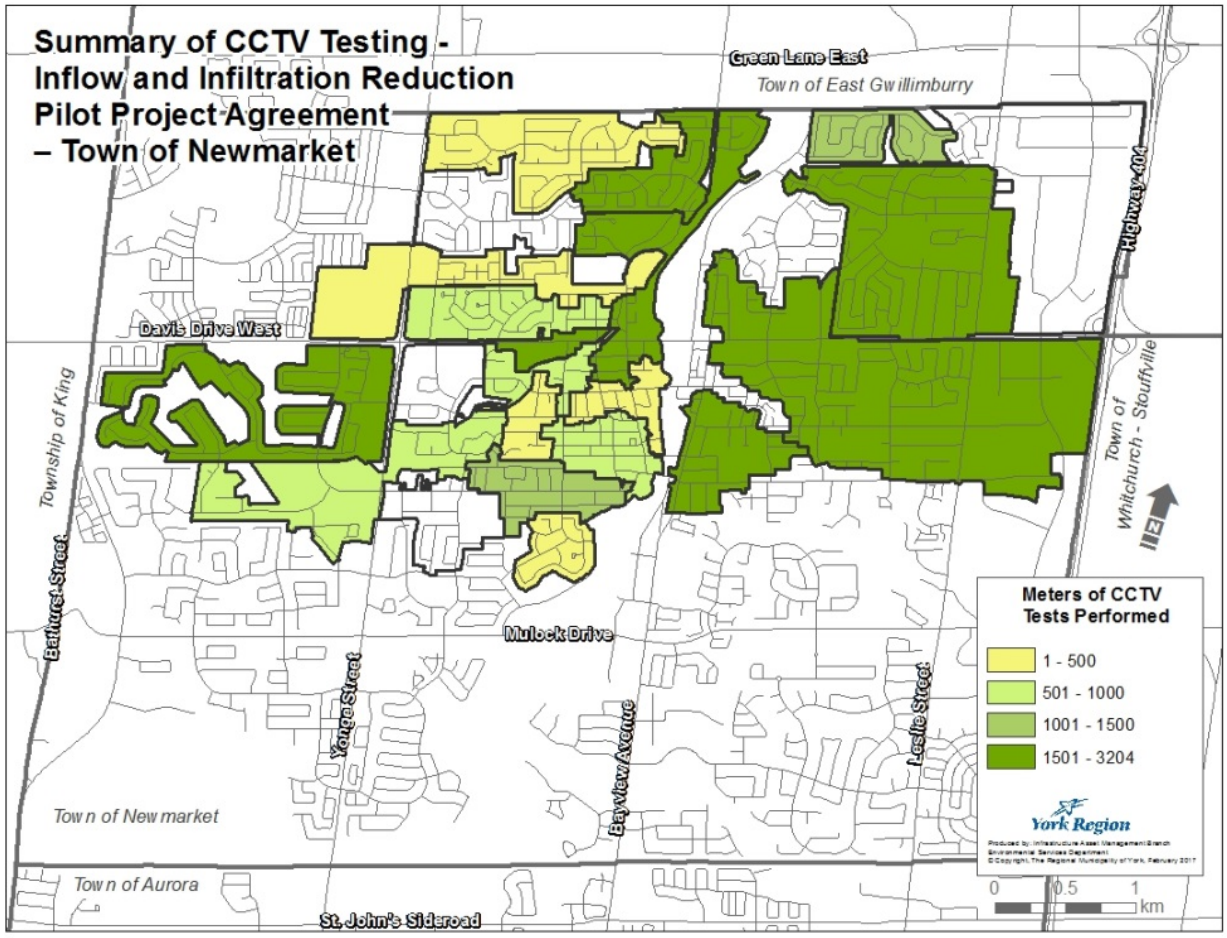


Figure 22 - Metres of CCTV Investigated in the Town of Newmarket in 2015 and 2016

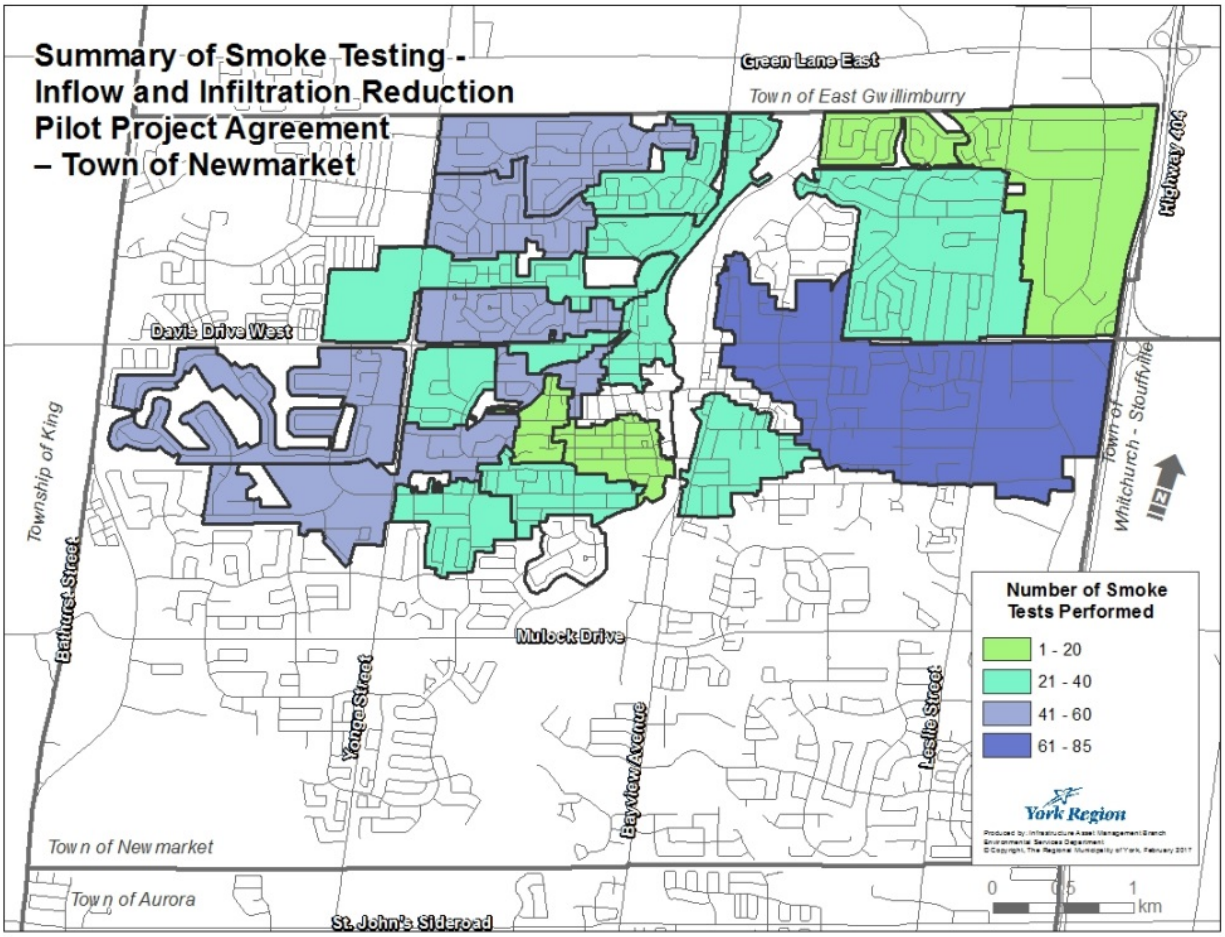


Figure 23 - Number of Smoke Tests Performed in the town of Newmarket in 2015 and 2016

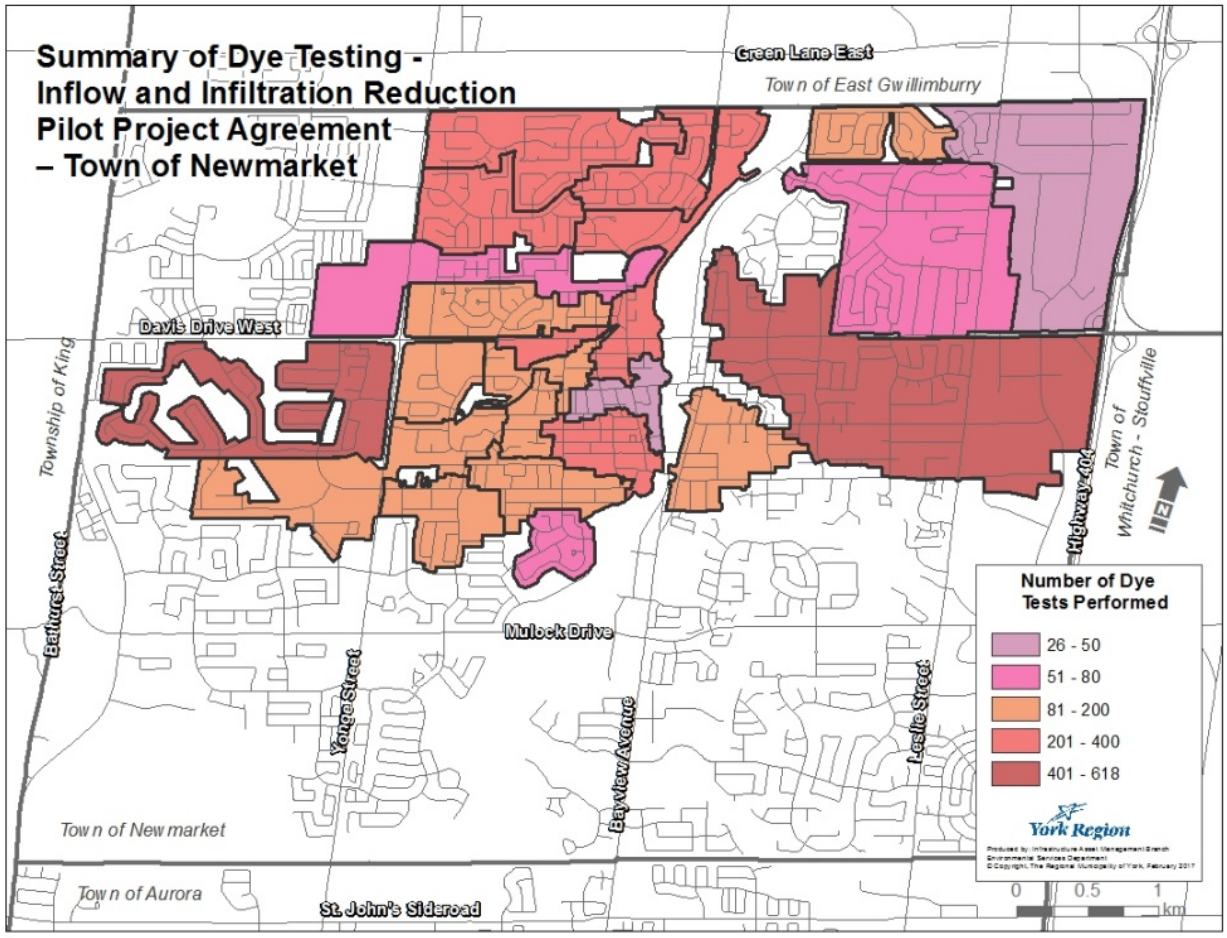


Figure 24 - Number of Dye Tests Performed in the Town of Newmarket in 2015 and 2016

7.0 Conclusion

The Region and its nine local municipalities will continue their partnership for reducing inflow and infiltration and build on the significant progress made since the program was implemented in 2011. In 2016, 1.99 MLD of I/I was reduced in the YDSS, bringing the overall total to 11.6 MLD. This represents 29 per cent of the 2031 target of 40 MLD which exceeds the 25 per cent reduction target set for 2017.

The Region continued to demonstrate leadership in I/I reduction in 2016 through a number of Region-led initiatives, and also through programs in partnership with the local municipalities and other Regional municipalities and institutions. In November, 2016 Council approved the extension of the Inflow and Infiltration Audit and Flow Monitoring Program, which is necessary to reveal deficiencies in existing infrastructure and quantify I/I reductions. Short-term flow monitoring in mini-basins continued in 2016, and a pilot began to monitor micro-basins. Additionally, a number of rehabilitation projects were completed in 2016; from private sewer laterals to large trunk sewer repairs, using both proven methods and utilizing new and innovative technologies.

Discussions over construction practices and the need for inspection update in the public and private right-of-ways were highlighted in 2016; recommendations for certain updates in those areas will be discussed in next year's annual report following literature review and on-site survey of the inspection procedures.

Overall the Region and local municipalities spent a combined total of $6 M on I/I-related activities, including flow and rainfall monitoring; inspection and repair of mainlines and laterals; sealing of maintenance holes; downspout disconnections; and SSES. Moving forward the Region will continue to leverage its knowledge and experience as it seeks to refine and expand its best-in-class I/I Reduction Strategy, and demonstrate world leadership in the field of I/I reduction.


York Region

Appendices A to D

Appendix A
Dry Weather Flow Reduction Analysis

This appendix describes techniques that the I/I Reduction Analytics team used to measures the success in dry weather flow (DWF) reduction in the YDSS against the combined 71 MLD goal set to be achieved by 2031.

Background

On March 31, 2010, the Minister of the Environment (the Minister) approved the Individual Environmental Assessment for the Region's Southeast Collector Trunk Sewer project (SEC), which involved the construction of a 15 km tunneled sanitary trunk sewer. The approval was subject to a series of conditions. The result of condition 8 is that a 71 MLD reduction in flow in the SEC over a 24 hour period during a theoretical 25-year storm event by 2031 is required. The success will be measured against the combined reduction of 71 MLD to be achieved by 2031; 40 MLD of rainfall derived inflow and infiltration (RDII) and 31 MLD dry weather flow reduction (primarily water conservation) to achieve the combined reduction goal of 71MLD.

Actions Taken

A reduction of 31 MLD in the DWF can be shown by using flow data from the YDSS York-Durham boundary flow meter and the contributing population. York Region's average daily flows (ADFs) at the York Durham boundary flow meter are shown below, along with population and unit rate calculations:

York Region's ADFs, Population and Unit Rates in the YDSS SEC

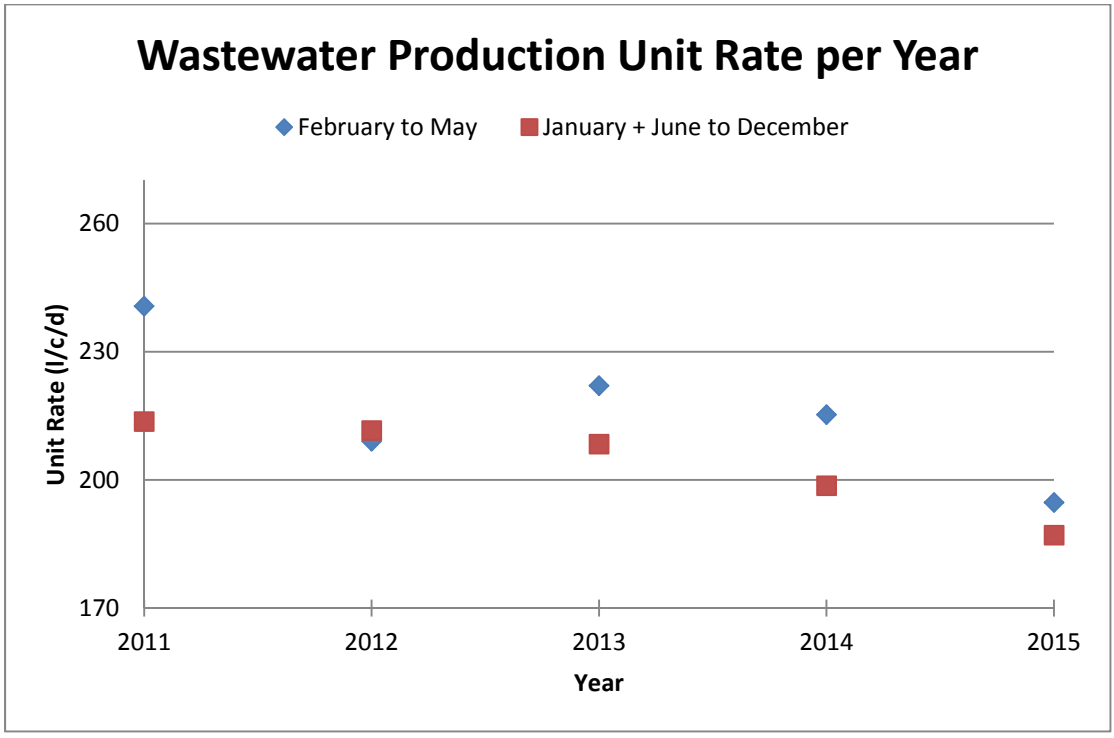
Year	2011	2012	2013	2014	2015
YDSS SEC ADF (MLD)	280.6	270.4	279.3	278.1	262
YDSS SEC Residential and ICI Serviced Population (end of year in 1000s)	1,260	1,283	1,312	1,362	1,382
Unit Rate (l/c/d)	223	211	213	204	190

The unit rate decreased from 223 l/c/d in 2011 to 190 l/c/d in 2015, which is a reduction of 33 l/c/d. Multiplying this 33 l/c/d by the 2015 population of 1,382,040 gives a total DWF reduction of 45.6 MLD, which is far in excess of the required 31 MLD goal. The actual DWF reduction by 2031 is expected to be even much larger as water conservation efforts increase.

The method is somewhat complicated by the fact that the DWF can vary from year to year due to ground water infiltration (GWI) changes. The long cyclic change in ground water levels due to seasonal rainfall patterns has the greatest influence on GWI. However, there does appear to be a clear downward trend in

the unit rate over the 2011 to 2015 period, so GWI should not be a significant concern in proving a 31 MLD reduction. As well, the expected reduction in DWF over the 2011 to 2031 period should be so far in excess of 31 MLD that GWI changes should not invalidate the results.

To confirm that GWI has an impact on the ADFs, the unit rates were calculated on a per month basis. One would expect that the ADFs would be higher during the February to May period every year, since this is the period of highest groundwater levels and highest GWI. Below is a graph showing the period of highest GWI (Feb-May) vs. the rest of the months.



As one would expect, the months of highest GWI (February to May) generally have a higher unit rate. However, even if the February to May months are removed from the data, the unit rates still show a large reduction. The unit rate decreases from 214 l/c/d in 2011 to 187 l/c/d in 2015, which is a reduction of 27 l/c/d and is very close to the 33 l/c/d reduction obtained when the February to May months were included.

One could look at the ADFs during the two months of the year that typically have the lowest amount of precipitation. In the table below the average ADFs for January and February are compared to the average ADFs for all the months.

York Region's ADFs and Population in the YDSS SEC					
Year	2011	2012	2013	2014	2015
YDSS SEC ADF (Average of all months) (MLD)	280.6	270.4	279.3	278.1	262.0
YDSS SEC ADF (January and February Average) (MLD)	264.9	275.9	275.0	265.2	252.0
Percentage Difference in ADFs	5.9%	2.0%	1.6%	4.9%	4.0%
YDSS SEC Residential and ICI Serviced Population (end of year)	1,260,072	1,283,381	1,311,825	1,362,308	1,382,040

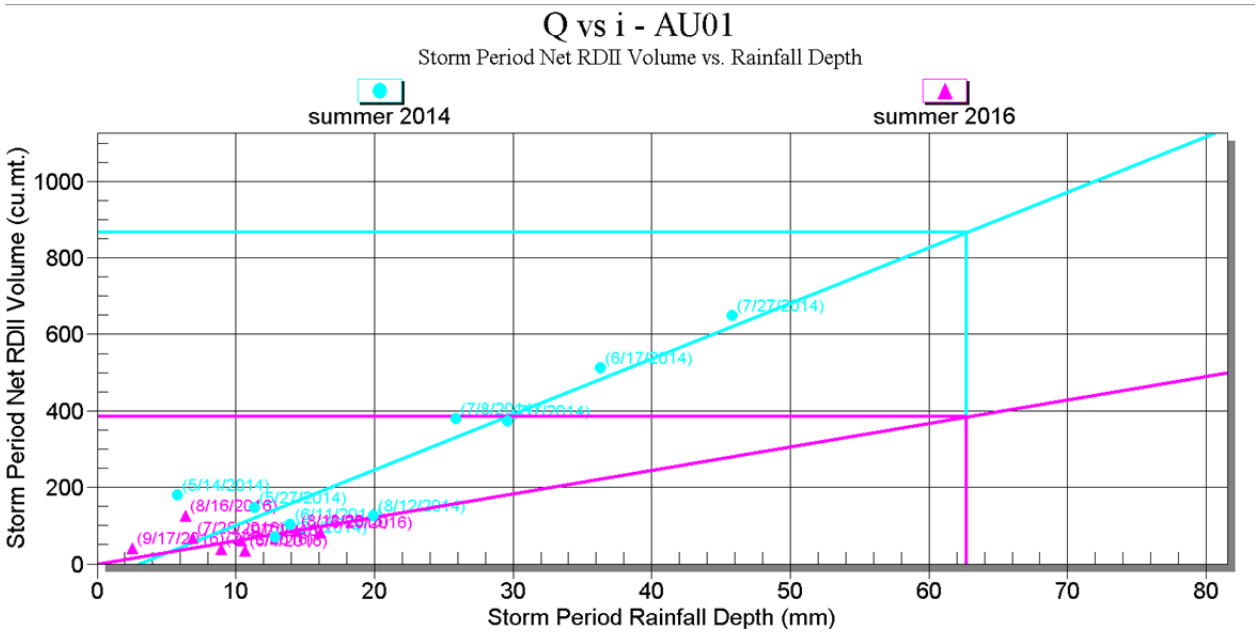
Using January and February data only, there is a reduction in ADF of 12.9 MLD in the 2011 to 2015 period, compared to a reduction in ADF of 18.6 MLD using data from all the months. It is clear that the ADFs over the 2011 to 2015 period are decreasing even when contributing population is increasing.

Conclusions

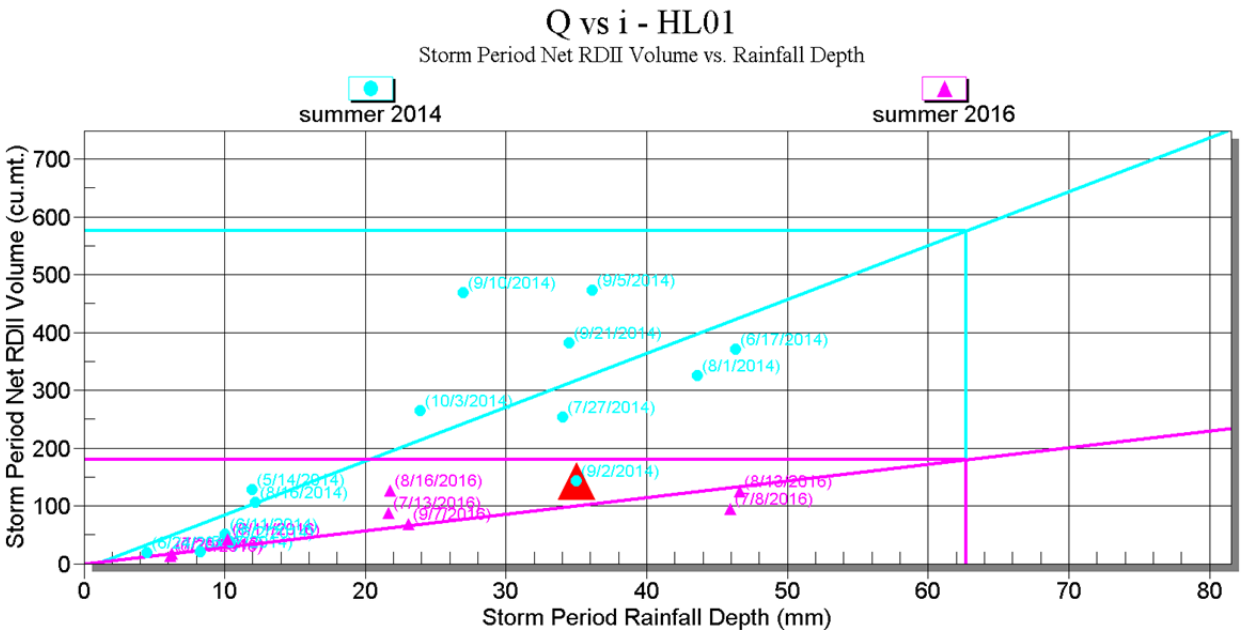
Using flow data from the YDSS York-Durham boundary flow meter we have shown a 45.6 MLD reduction in DWF in the York Region SEC portion of the YDSS between 2011 and 2015. This is around 40% more than the required 31 MLD reduction required in the 2011 to 2031 period. The DWF reduction by 2031 is expected to be even much larger as water conservation efforts increase. York Region will continue to monitor the dry weather flow and include the findings in future annual reports.

Appendix B
Private Sanitary Sewer Laterals Rehabilitation – I/I Reduction & Quantification

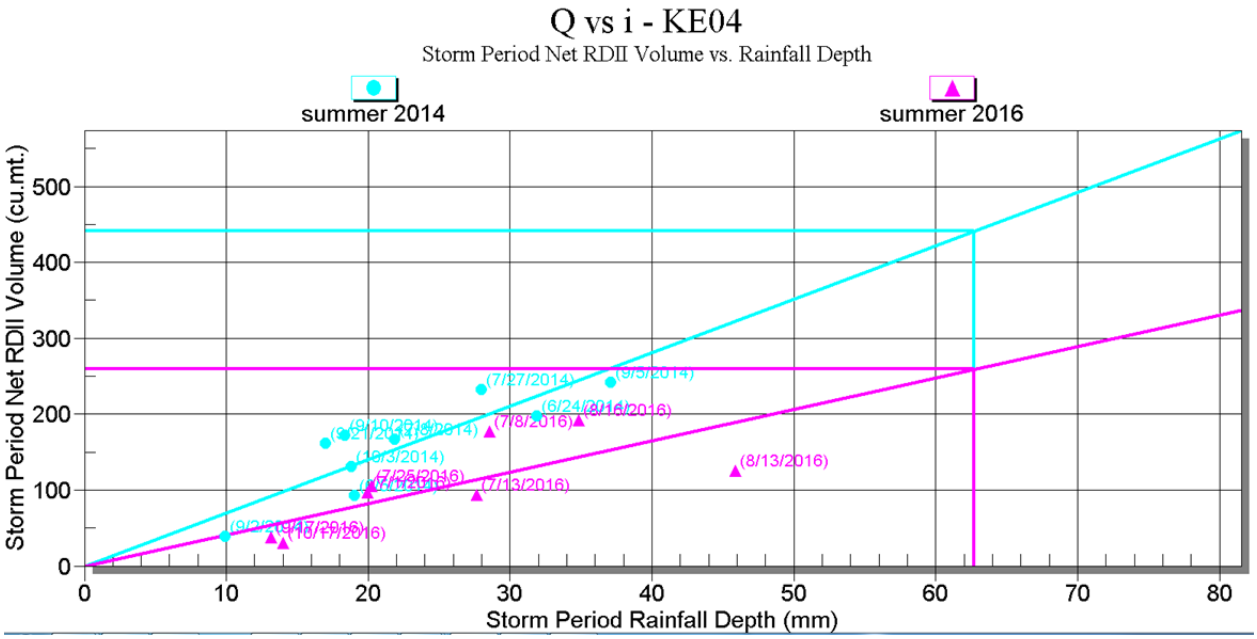
Town of Aurora - Catchment AU01: RDII Volume versus Rainfall Depth



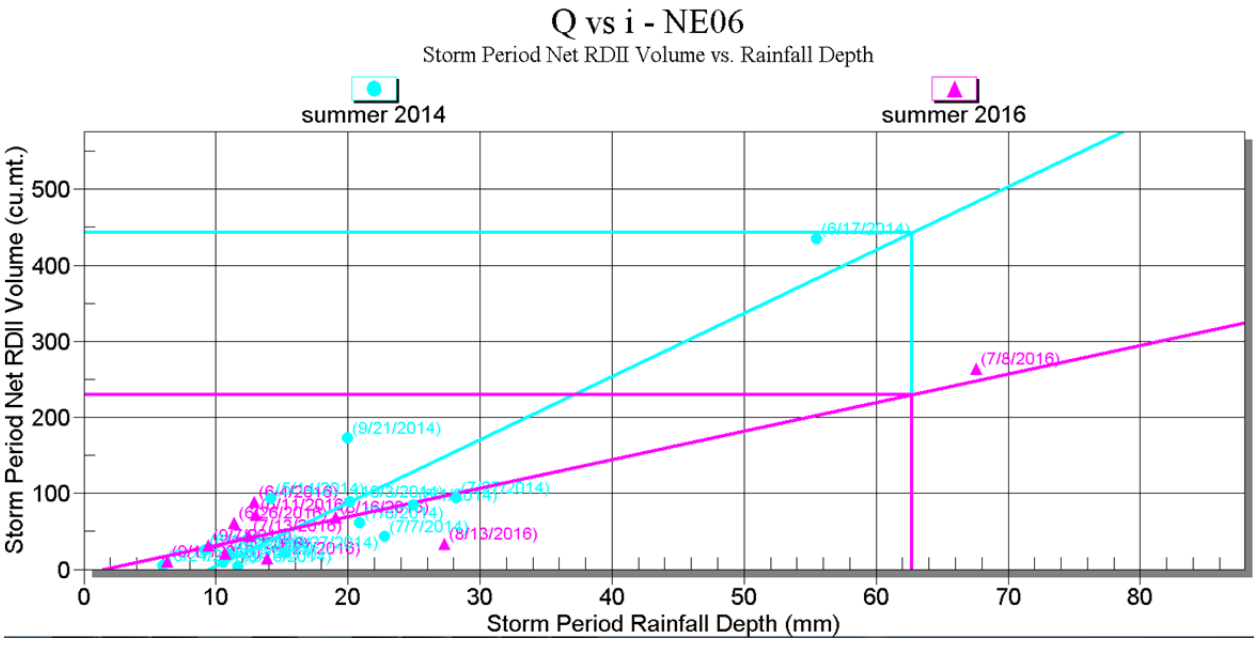
Town of East Gwillimbury - Catchment HL01: RDII Volume versus Rainfall Depth



Town of Georgina - Catchment KE04: RDII Volume versus Rainfall Depth



Town of Newmarket - Catchment NE06: RDII Volume versus Rainfall Depth



Appendix C
Rehabilitation of Private Sanitary Sewer Laterals – Catchment Maps

Additional Lining after Full Dig

Key Map

AU01

AU10

Legend

- Sanitary Manhole
- Sanitary Sewer
- Investigation Area

As-Built Remediation Completed

- Spot Dig
- Lined
- Lateral Replacement (Full Dig)
- Capped at Main

Scale:

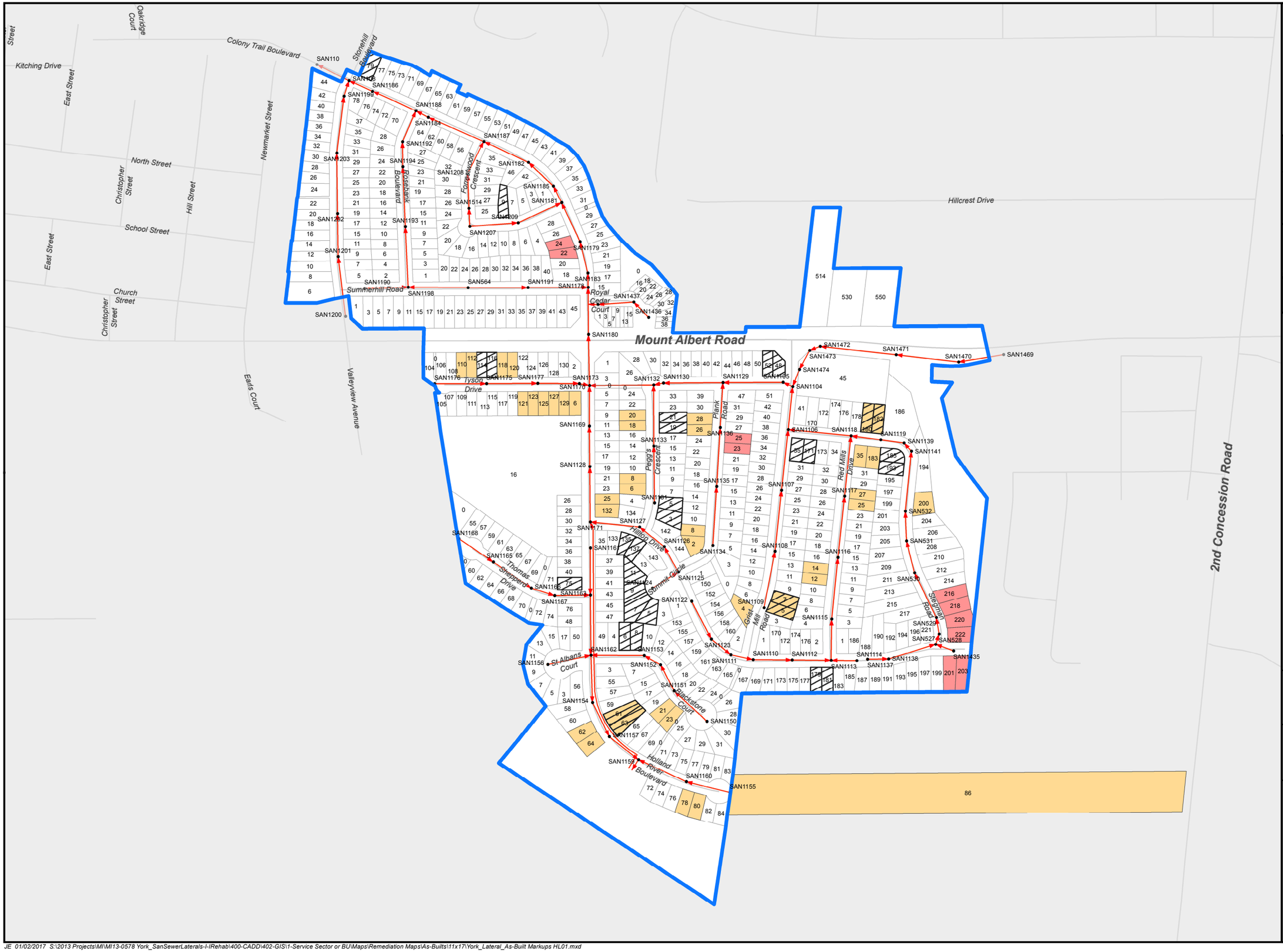
0 30 60 120 180 Meters

Aurora - AU01 / AU10 As-Built Lateral Rehabilitation

Rehabilitation of Private Property Sanitary Sewer Laterals
The Regional Municipality of York

York Region

S:\2013 Projects\MI\MI13-0578 York_SanSewerLaterals-I-IRehab\400-CADD\402-GIS\1-Service Sector or BU\Maps\Remediation Maps\As-Builts\11x17\York_Lateral_As-Built Markups AU01.mxd



Legend

- Sanitary Manhole
- Sanitary Sewer
- Investigation Area

As-Built Remediation Completed

- Spot Dig
- Lined
- Lateral Replacement (Full Dig)
- Capped at Main

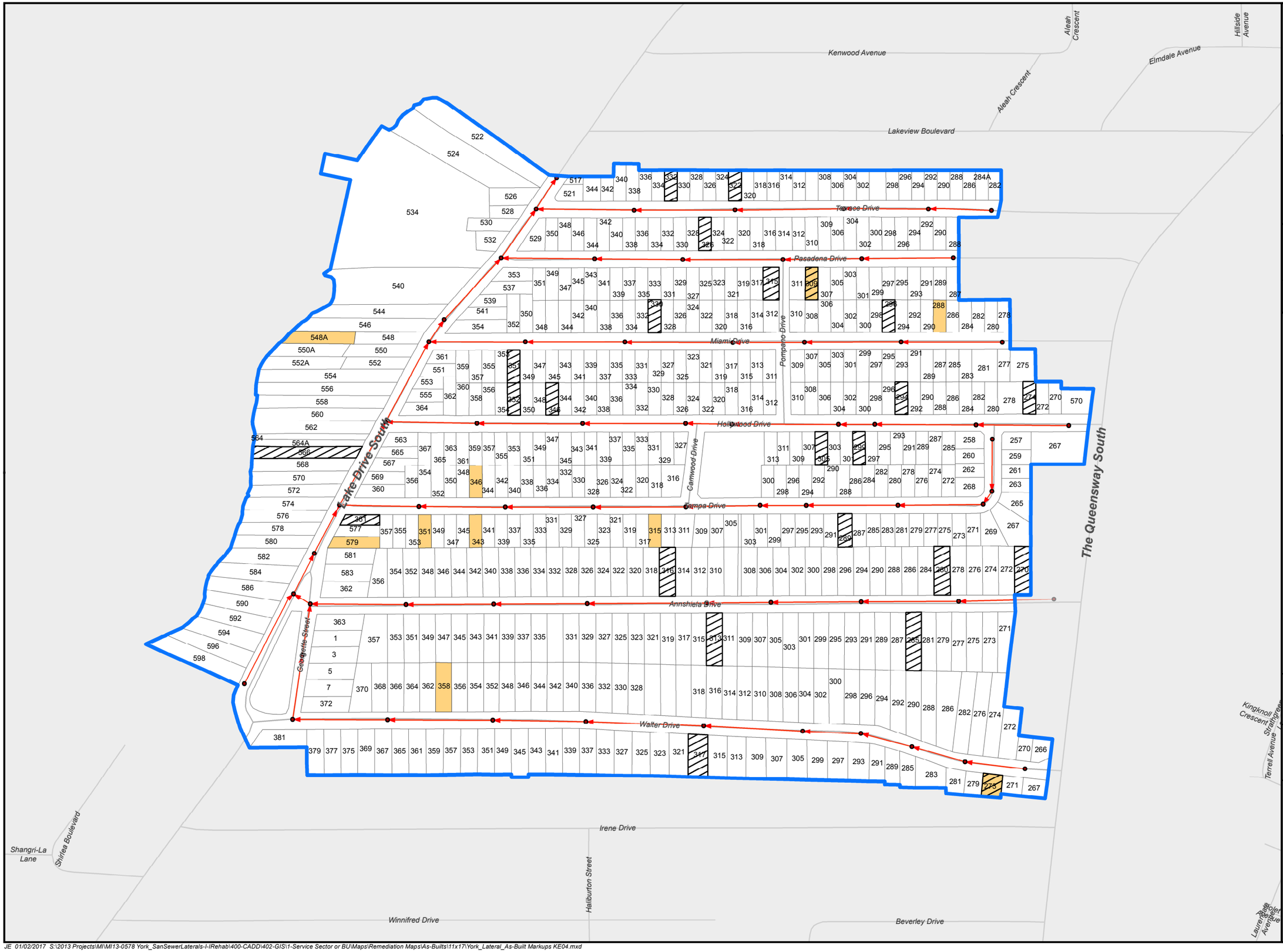
Scale: 0 30 60 120 180 Meters

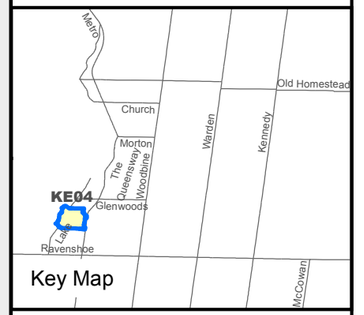
East Gwillimbury - HL01 As-Built Lateral Rehabilitation

Rehabilitation of Private Property
Sanitary Sewer Laterals
The Regional Municipality of York

York Region

JE 01/02/2017 S:\2013 Projects\MI\MI13-0578 York_SanSewerLaterals-I-IRehab\400-CADD\402-GIS\1-Service Sector or BU\Maps\Remediation Maps\As-Builts\11x17\York_Lateral_As-Built Markups HL01.mxd





Legend

- Sanitary Manhole
- Sanitary Sewer
- Investigation Area

As-Built Remediation Completed

- Spot Dig
- Lined
- Lateral Replacement (Full Dig)
- Capped at Main

Scale:

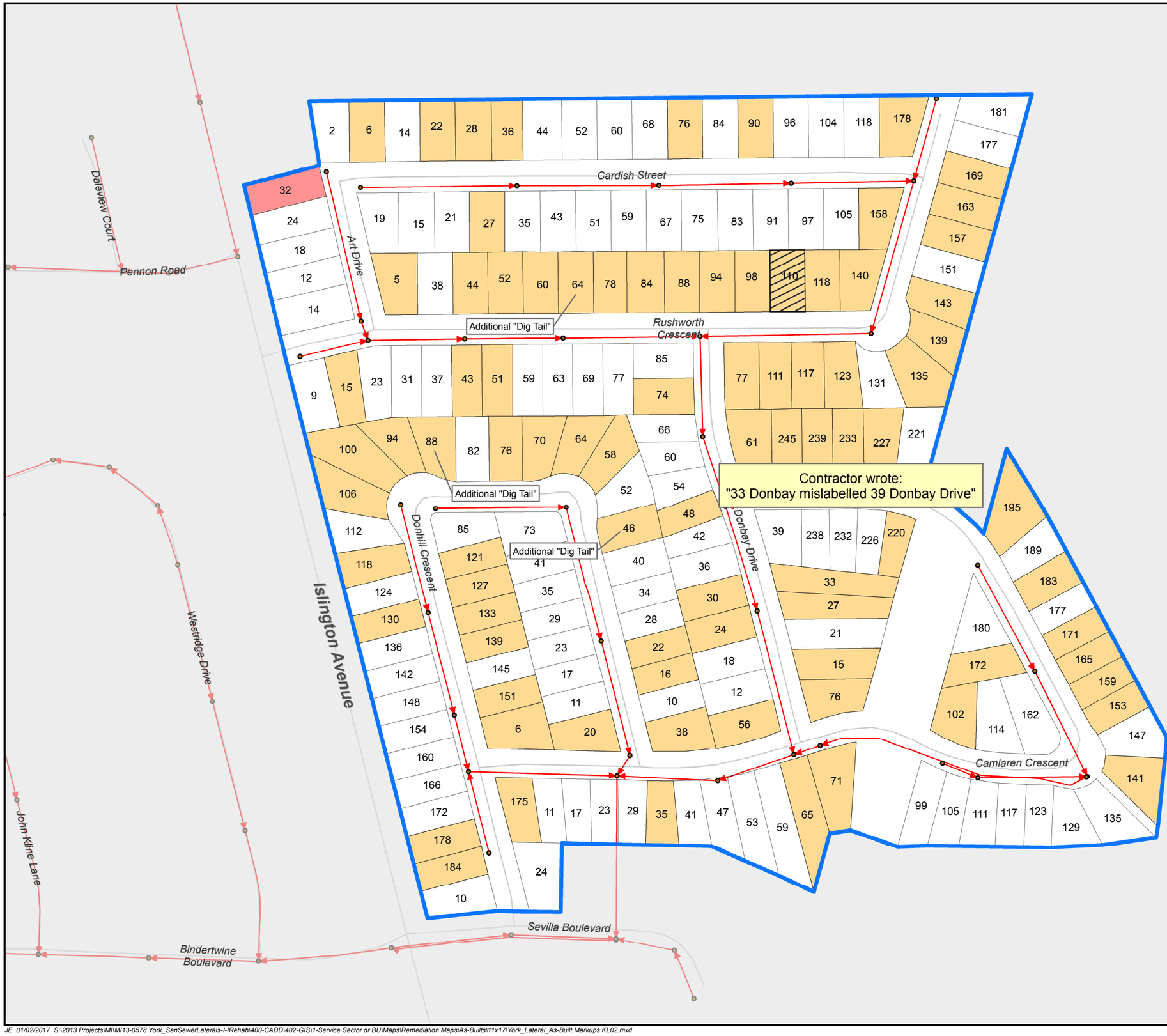
0 25 50 100 150 Meters

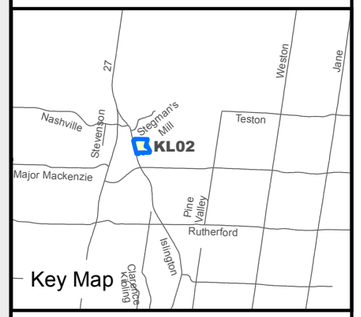
Township of Georgina - KE04 As-Built Lateral Rehabilitation

Rehabilitation of Private Property
Sanitary Sewer Laterals
The Regional Municipality of York

York Region

JE 01/02/2017 S:\2013 Projects\MI\MI13-0578 York_SanSewerLaterals-I-IRehab\400-CADD\402-GIS\1-Service Sector or BU\Maps\Remediation Maps\As-Builts\11x17\York_Lateral_As-Built Markups KE04.mxd





Legend

- Sanitary Manhole
- Sanitary Sewer
- Investigation Area

As-Built Remediation Completed

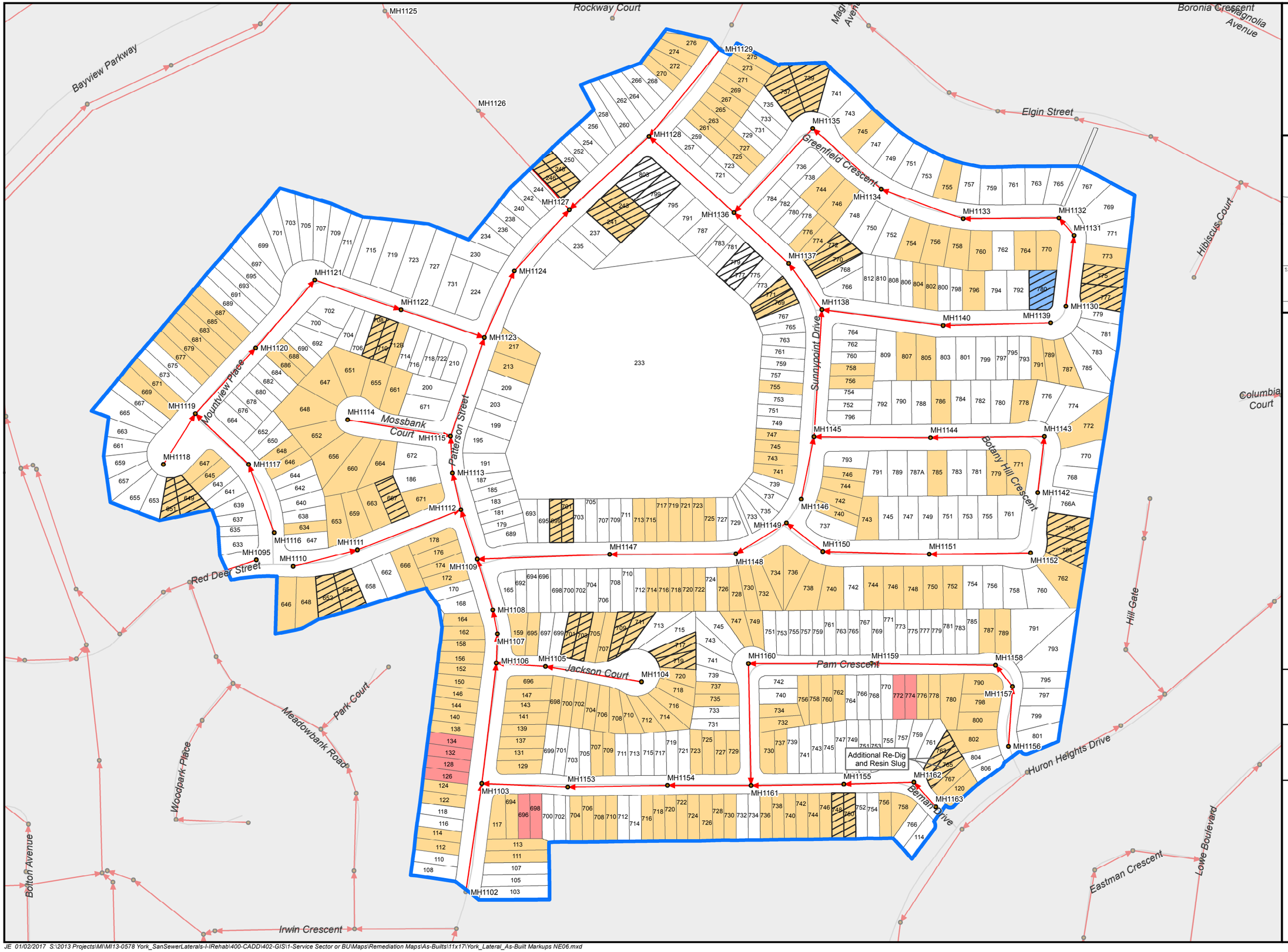
- Spot Dig
- Lined
- Lateral Replacement (Full Dig)
- Capped at Main

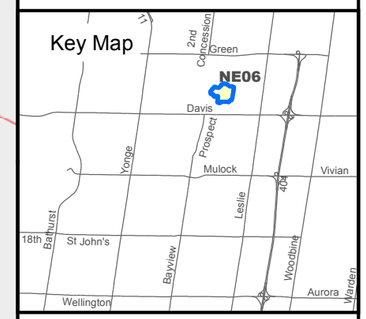
Scale: 0 15 30 60 90 Meters

Vaughan - KL02
As-Built Lateral Rehabilitation

Rehabilitation of Private Property
Sanitary Sewer Laterals
The Regional Municipality of York

York Region





Legend

- Sanitary Manhole
- Sanitary Sewer
- Investigation Area

As-Built Remediation Completed

- Spot Dig
- Lined
- Lateral Replacement (Full Dig)
- Capped at Main

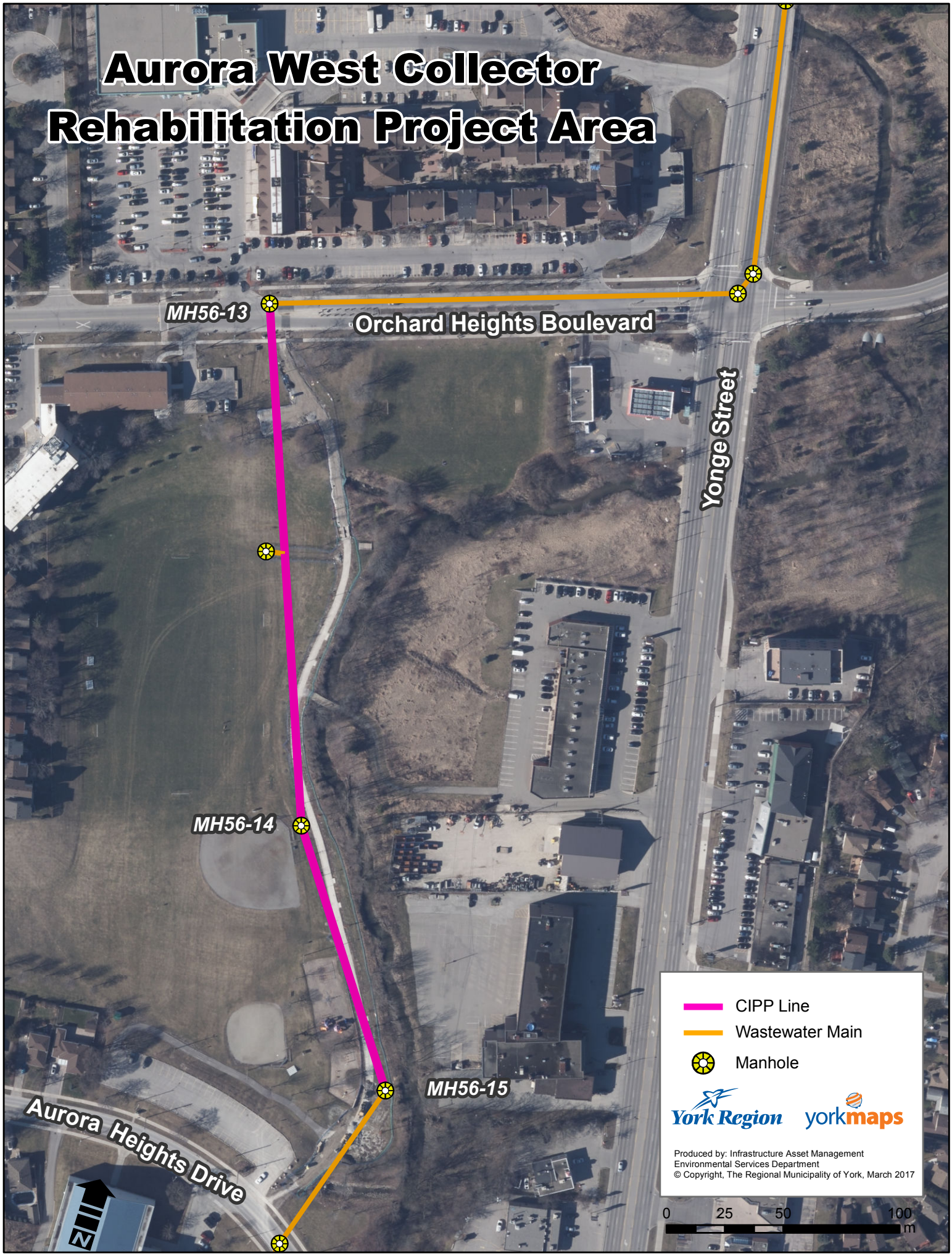
Scale: 0 25 50 100 Meters

Newmarket - NE06
As-Built Lateral Rehabilitation

Rehabilitation of Private Property
Sanitary Sewer Laterals
The Regional Municipality of York

York Region

Appendix D
York-Durham Sewage System Trunk Sewer Rehabilitation


Aurora West Collector
Rehabilitation Project Area
MH56-13
Orchard Heights Boulevard
Yonge Street
MH56-14
MH56-15
Aurora Heights Drive
N
CIPP Line
Wastewater Main
Manhole
York Region
yorkmaps
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Environmental Services Department
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