York Region

INFLOW & INFILTRATION REDUCTION STRATEGY

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

The Region and the local municipalities have an opportunity to demonstrate leadership in inflow and infiltration reduction within the water and wastewater industry.

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Glossary of Terms and Acronyms

BI	Base Infiltration
BILD	Building Industry and Land Development Association
CCTV	Closed Circuit Television
DWF	Dry Weather Flow
GIS	Geographical Information System
GTSWCA	Greater Toronto Sewer and Watermain Contractors Association
GWI	Groundwater Infiltration
I/I	Inflow and Infiltration
IDF	Intensity-Duration-Frequency Curves
IEA	Individual Environmental Assessment
MLD	Mega Litres Per Day
MOE	Ministry of the Environment of the Province of Ontario
MMSD	Metropolitan Milwaukee Sewerage District
OBC	Ontario Building Code
OCPA	Ontario Concrete Pipe Association
O&M	Operations and Maintenance
PACP	Pipeline Assessment Certification Program
PF	Peak Flow
QA/QC	Quality Assurance and Quality Control
RDII	Rainfall Derived Inflow and Infiltration
ROE	Right of Entry
SEC	Southeast Collector Trunk Sewer
SeCAC	Southeast Collector Advisory Committee
SPS	Sewage Pumping Station
SSES	Sanitary Sewer Evaluation Study
SSO	Sanitary Sewer Overflow
USEPA	United States Environmental Protection Agency
WPCP	Water Pollution Control Plant
WRc	Water Resources Council
WWF	Wet Weather Flow
YDSS	York-Durham Sewage System

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 manhole covers.

infiltration

groundwater that enters through holes and cracks in manholes, laterals, and sewer pipes

the problem

Excessive inflow and infiltration can result in sewer backups, system overflows, risks to health, damage to the environment, and increased costs.

20 years

The implementation will commence in April 2011 and is anticipated to continue as a sustained program over the next 20 years.

Executive Summary

Wastewater servicing is multi-jurisdictional based on a two-tier municipal governance structure. Sewage from most of the communities in the Region is collected through a combination of local municipal and Regional sewer systems.

Wastewater servicing is multi-jurisdictional based on a two-tier municipal governance structure. Sewage from most of the communities in the Region is collected through a combination of local municipal and Regional sewer systems. The Region is responsible for major pumping stations, trunk sewers, and treatment plants. The local municipalities provide direct collection and management of the local system infrastructure and wastewater flows into the Regional trunk system. In addition, private property owners are responsible for wastewater mains and service laterals within their property.

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, which involves the construction of a 15 km tunneled sanitary trunk sewer. This capital project is vital to service the approved growth within the Region. The approval was subject to a series of conditions.

The Regional Municipality of York is made up of a confederation of nine municipalities and provides services to over 1 million residents, 29,000 businesses and 495,000 employees. York Region has a two-tier government structure, with services provided by the Region and local area municipal governments which include Georgina, East Gwillimbury, Newmarket, Aurora, Whitchurch-Stouffville, Richmond Hill, Markham, King and Vaughan.

Condition 8 and specifically, subsection 8.2 states that the Region is required to develop an Inflow and Infiltration Reduction Strategy (the Strategy), which "shall include a program for the reduction of inflow and infiltration by the Regional Municipality of York to the Southeast Collector Trunk Sewer from its and its lower tier municipalities' sewage systems. This program shall include reduction priorities, targets, timelines, tactics and initiatives, and the associated costs to implement these."

This Strategy document has been developed by the Region and local municipalities in response to the Minister's conditions and describes the process that the Region intends to undertake to successfully meet those conditions. It should be noted that this Strategy identifies a regionwide mitigation and reduction program for inflow and infiltration. The Strategy recommends an inflow and infiltration program to specifically address the communities' tributary to the Southeast Collector Trunk Sewer as required by Condition 8.

The Strategy will build upon programs already underway. The Region and local municipalities each have existing programs in place, including, but not limited to, operations and maintenance programs, asset management programs, inspection and monitoring programs, and inflow and infiltration reduction. It is the purpose and intent of this Strategy to build upon these existing programs to meet or exceed the requirements and intent of the Minister's conditions.

Through the development and implementation of the Strategy, the Region and the local municipalities have an opportunity to demonstrate leadership in inflow and infiltration reduction within the water and wastewater industry. The Region and local municipalities' current commitment to inflow and infiltration reduction will serve to form the foundation upon which a world class program can be developed.

INFLOW & INFILTRATION REDUCTION STRATEGY

This Strategy document is divided into three sections:

Section 1: Background and Rationale

Inflow and infiltration are surface water and groundwater that enter the sewage collection system. Inflow is 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 manhole covers. Infiltration is groundwater that enters through holes and cracks in manholes, laterals, and sewer pipes.

Reducing inflow and infiltration has been an integral part of the Region's servicing considerations since the first water and wastewater master plan was developed in 1997. The York-Durham Sewage System (YDSS) Master Plan, as subsequently updated, specifically identified "water conservation/extraneous flow reduction" as a significant design consideration for all YDSS projects. In conjunction with alternatives considered during the Southeast Collector Trunk Sewer Individual Environmental Assessment (SEC IEA), inflow and infiltration reduction efforts were stepped up in 2007 with the Regional Council approving a commitment of $23 million in the 10-year capital plan to study and implement pilot remediation projects in both Regional and local municipal systems.

Peak inflow and infiltration usually occurs during long periods of precipitation, snow melt, or large storm events. These flows can result in sewer backups, system overflows, risks to health, damage to the environment, and increased costs.

Excessive inflow and infiltration consumes sewer capacity for existing residents and future growth. As sewage systems age, it is also more likely that inflow and infiltration will enter the collection system. Developing and implementing the Inflow and Infiltration Reduction Strategy will advance the Region's goal for reducing inflow and infiltration throughout the Region while ensuring that all of the Minister of the Environment's conditions of approval related to the reduction of inflow and infiltration for the SEC project are met.

This section depicts the purpose and goals of the Strategy as well as asset principals, and provides a brief description of the Regional and local municipal sewage systems, the major hydraulic components, and the impact that anticipated growth could have on these systems. Previous projects and existing inflow and infiltration control efforts t being conducted within the system are also discussed in detail.

Section 2: Strategy Development

To develop such a comprehensive Strategy to meet the Minister's conditions, the Region formed an Inflow and Infiltration Reduction Task Force (the Task Force) in April 2010. The Task Force established a Water & Wastewater Task Force Steering Committee (the Steering Committee) that is comprised of representatives from each of the nine local municipalities and the Region. The Steering Committee is responsible for reviewing inflow and infiltration issues and formulating an overall direction for developing the Strategy.

To support the Steering Committee, five working groups were established to address the following Strategy areas:

- Strategy and Development
- Funding
- Communication, Education and Advocacy
- Audit, Monitor, and Measure
- Standards, Implementation, and Continuous Improvement.

Through a series of bi-weekly and monthly meetings, each working group reviewed, developed, and strategized the key program initiatives, and they developed work plans to implement the Strategy. In addition, another committee has been formalized at the direction of the Minister's conditions, which is the Southeast Collector Advisory Committee (SeCAC). This committee includes members of the local community, Regional staff, and staff from external agencies. The committee is charged with providing input, comments, and suggestions on topics relating to the commissioning of the SEC and input and comments on the Strategy document.

To ensure that the components meet or exceed leading industry practice, the Region undertook an industry wide international Best-in-Class review. The key findings from this international review are also included within this Strategy document and a number of programs have been identified to align with best practices within this Strategy. A gap analysis between

international practices and the Region's programs was completed and the recommended Strategy was developed. It was found that the programs and activities included within this Strategy meet and often exceed international best practices. Section 2.5.2 in the Strategy includes a comparison table describing key activities of leading edge practices against the current and future inflow and infiltration reduction program in the Region.

The recommendations, work plans, and conclusions of the working groups were determined through a consensus based approach using input gathered through the Best-in-Class review, from the Steering Committee, and from working group members.

Finally, a peer review of the overall Strategy document was completed in December 2010 by several leading agencies, which included King County (Seattle, Washington), Milwaukee Metropolitan Sewerage District (Milwaukee, Wisconsin), Metropolitan Council (St. Paul, Minnesota), and Metro Vancouver (Vancouver, British Columbia). A PowerPoint presentation and electronic copies of the Strategy document were presented to the peer reviewers. Comments were compiled, validated by the Region, and where appropriate, incorporated in the finalization of this Strategy. In general, the feedback received about the Strategy from the peer review agencies was very positive and constructive. No significant gaps were identified, demonstrating that the Strategy was well received and thorough.

Section 3: 2031 Inflow and Infiltration Reduction Strategy

The Strategy is defined in a series of high level program areas, each of which will require that a number of specific program activities be accomplished. The program areas were selected based on their consistent representation in other best-in-class inflow and infiltration reduction programs.

This approach includes defining or addressing issues in each of the following program areas:

- Establish overall program goals and targets
- Monitor and analyze flows
- Investigate and mitigate
- New construction and capital projects
- Financial management
- Communication and education
- Report inflow and infiltration reduction
- Continuous improvement

Section 3 defines each of these program areas and provides descriptions of the specific program activities and deliverables that will be required within each program area. These deliverables are necessary to successfully reduce inflow and infiltration in the area tributary to the SEC and to meet the Minister's conditions.

Governance and Formation of Strategy Leadership

It will be necessary to define the leadership for implementing the Strategy. The Region intends that the Strategy will be championed and led jointly by the Task Force with overall leadership, direction and assistance provided by Regional staff. The Task Force, comprised of representatives from each of the nine local municipalities and the Region, was initially responsible for reviewing inflow and infiltration issues and formulating an overall direction for developing this Strategy. Local municipal members were responsible for reporting back to their respective organizations and councils.

As the Strategy is implemented over the next 20 years, the Task Force will continue to provide primary leadership. The Task Force will represent the interests of both the Region and each of the local municipalities, and will be responsible for reporting to the Minister as required to meet the conditions that have been set forth.

Program Area 1 – Establish Inflow and Infiltration Reduction Program Goals and Targets

The SEC IEA contained a detailed evaluation of the effectiveness of water conservation and inflow and infiltration reduction measures across several local municipalities. In general, a targeted 10% reduction of flows is thought to be achievable in the Region.

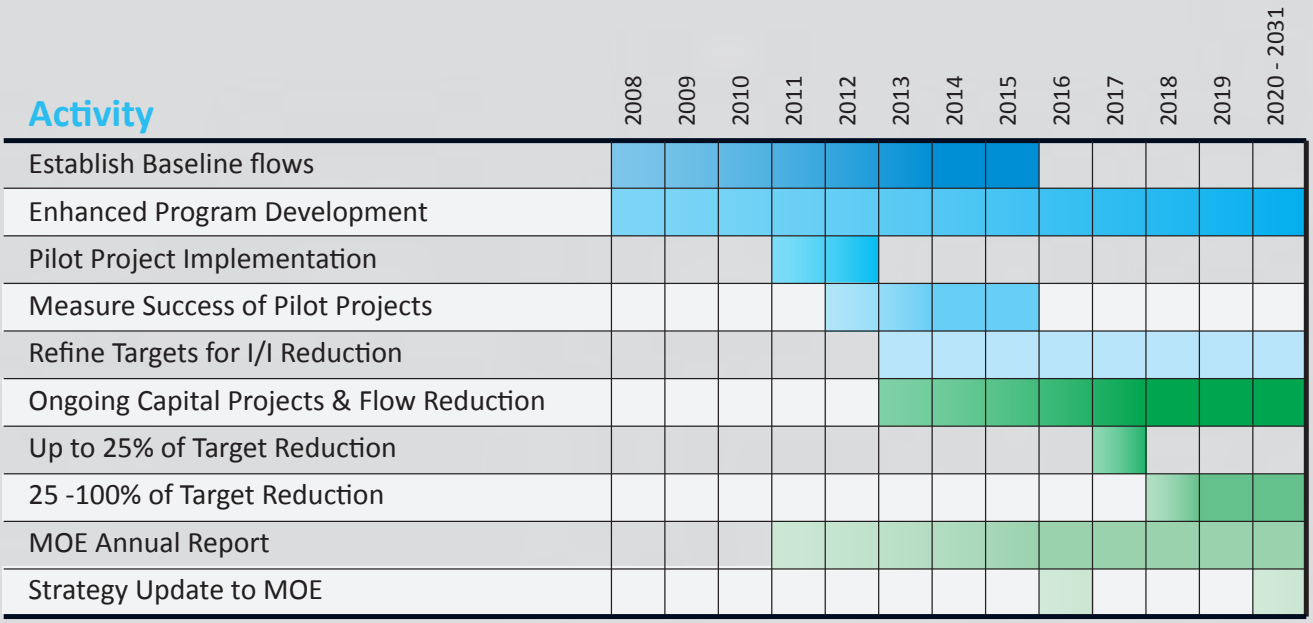
For the service area draining to the SEC, it was determined that the volumetric reduction target is 71 megalitres over a 24-hour period (MLD). Reduction of this volume will be accomplished through the combined efforts of the long-term water conservation strategy and this Strategy. Preliminary assessment has indicated that the long-term water conservation strategy would contribute 40% to 50% of the overall reduction required.

At the highest levels, the goals of the Region and the local municipalities include:

- Reduce inflow and infiltration rates over a 20-year period into the SEC and within the Region;
- Minimize total conveyance, treatment and disposal system costs; and
- Implement a long-term program that exceeds the conditions set forth by the Minister

Through the development of this Strategy, the Region and the local municipalities commit:

- To develop and maintain this Strategy including the programs, goals, and municipal and regulatory reporting requirements for a staged reduction of inflow and infiltration over the next 20 years;
- To recommend to future councils that they commit funds for inflow and infiltration reduction that is economically justified by the avoidance of future costs to treat and convey inflow and infiltration;
- To measure wastewater flows before and after carrying out construction/rehabilitation work on sewers and to document inflow and infiltration expenditures and flow reduction measures;
- To use the information gathered in future inflow and infiltration reduction processes; and
- To continue to work together in a collaborative manner over the life of the Strategy and to commit the appropriate staffing and financial resources toward the implementation of the Strategy.



The service area will be divided into a series of increasingly smaller, nested drainage basins to allow analysis, rehabilitation, and auditing within reasonably sized geographic areas.

Geographic Delineation of the YDSS

Existing inflow and infiltration volumes, targets, and successful reduction will be reported at the audit basin level.

Due to the complexity of the audit and measure process, the detailed procedures for the analysis and audit are included in Appendix A of this Strategy.

Program Area 2 – Monitor and Analyze Flows

Wet weather flows can be highly variable depending on seasonal groundwater table fluctuation, snow pack, and antecedent moisture condition. Continuous and permanent flow monitoring over a sufficient time period is necessary to reveal these variations in flow. The Region and the local municipalities will need to utilize a network of short duration and continuous flow monitors to measure and record the changes in inflow and infiltration rates over time and determine flow rates under a variety of seasonal conditions.

GEOGRAPHIC DELINEATION	NUMBER	AVG. LENGTH (KM)	DESCRIPTION
Service Area	1	2,751	Permanent monitoring of the entire area draining to the SEC.
Sewershed	5	540	Permanent monitoring of the YDSS by local municipalities.
Major Basin	53	51	Short duration monitoring of model calibration basins.
Audit Basin	160	17	Permanent monitoring of basins at the level where inflow and infiltration reduction is audited.
Mini Basin	450	7	Short duration monitoring of mini basins.
Catchment	2,900	1	Short duration monitoring of subcatchments

It is recognized that a variety of flow metering technologies will be required to meet the requirements of the Strategy beyond the equipment currently owned by the Region. The selection of flow monitoring equipment will be determined by matching the appropriate technology with local hydraulic conditions. The flow monitoring implementation will balance the cost/benefit of various technologies and will also consider site specific hydraulic conditions. The flow monitoring program requirements for all levels of flow monitoring will be developed early on in the Strategy and will include details such as flow meter type, meter accuracy, data quality and management procedures, financial costs, meter relocation planning, etc.

Flow monitoring will include:

- Permanent trunk / municipal monitoring
- Audit basin
- Mini basin
- Post construction
- New development areas
- Rainfall monitoring (including "virtual rain gauges")

Based on best practice experience and conclusions acquired from the Industry Best-in-Class Review, it is anticipated that ongoing flow monitoring activities will be required throughout the course of the Strategy.

During the Region and Local Municipal I/I Reduction Pilot Program in 2008-2010, the Region developed comprehensive inflow and infiltration analysis procedures. These will continue to be used in future years to implement the Strategy.

The major activities used in the analysis of inflow and infiltration related flows are generally:

- Rainfall analysis
- Dry weather flow analysis
- Wet weather flow analysis

Inflow and Infiltration Characterization and Prioritization

The Region has previously developed and will continue to use a colour coding system for plotting the inflow and infiltration responses for each rain event. Audit basins will be analyzed using the key factors identified in the following table. Based on the results of the thresholds, each basin will be categorized as a low (green), medium (yellow), or high priority (red).

KEY FACTORS FOR PRIORITIZATION	RANGES & COLOUR CODING
Instantaneous Peaking Factor	PF < 4 (low)
(Flow Peak/Flow Average)	4 < PF < 6 (medium)
	PF > 6 (high)
RDII per Pipe Area	RDII < 280 (low)
(Lpd/mm-km)	280 < RDII < 560 (medium)
	RDII > 560 (high)
% of Rain Entering System	Cv < 5% (low)
(%)	Cv > 5% (high)
York Region (Towns) Peak I/I Flow per hectare (Inflow + Infiltration)	Flow/ha < 0.25 (low)
(L/s/ha)	0.25 < Flow/ha < 0.35 (medium)
	Flow/ha > 0.35 (high)

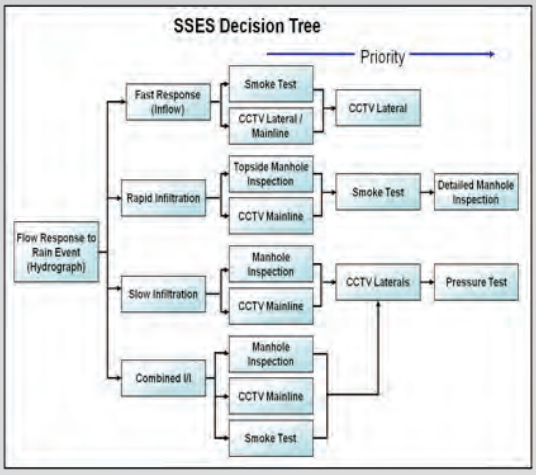
Program Area 3 – Investigate and Mitigate

The Strategy describes the processes that will be applied to investigate the severity, extent, and location of inflow and infiltration sources. The wastewater system that drains to the SEC has been delineated into a series of drainage basins. Additional flow monitoring will be conducted at the outlet of mini basins to identify specific locations or areas that display evidence of elevated inflow or infiltration flows.

Inspections

Specific basins will be identified where additional desktop, physical, and electronic inspections are required. In addition to specific inflow and infiltration related inspections, ongoing asset management related condition assessment programs will be completed. The inflow and infiltration related inspections will be conducted as a series of sanitary sewer evaluation studies (SSES) and/or as part of the condition assessment program.

A sample decision-making tree for inspection activities is shown on page 18.



The two major objectives of the field investigation activities and analysis are:

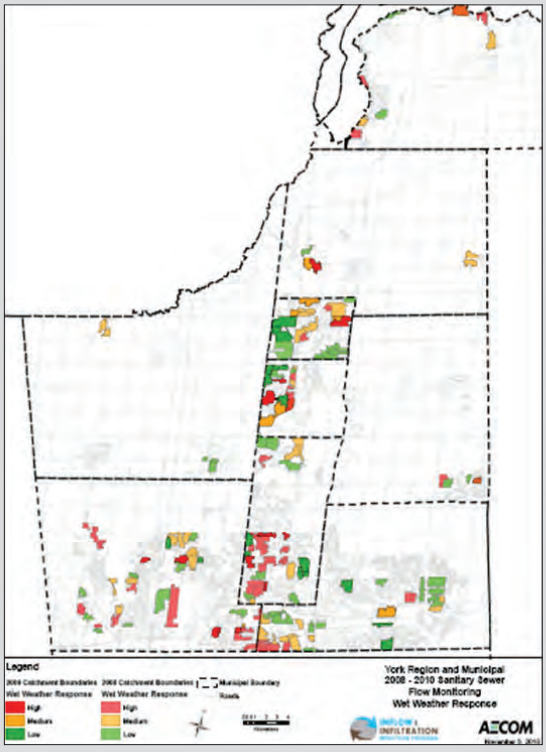
- Identifying specific inflow and infiltration sources and system structural and performance conditions; and
- Applying standardized defect distress coding and inspection practices to reflect the severity and extent of issues.

SSES investigation techniques will include:

- Desktop analysis and drive by inspections
- Smoke testing
- Closed circuit television mainline inspection
- Closed circuit television lateral inspections (in many cases of both private and public laterals)
- Manhole inspections
- Flood/dye testing
- Household drainage inspections

Mitigation through Project Delivery

Following the results of detailed flow analysis and structural and hydraulic assessments, cost effective solutions will be identified and specific rehabilitation techniques will be selected. Potential rehabilitation projects have been identified and prioritized based on several factors including: cost benefit, criticality, risk of failure, expected lifecycle and performance improvements, environmental impacts, social implications, plant performance, and operation and maintenance cost savings.



he project delivery and assessment phase of the Strategy will involve the design and construction of rehabilitation and replacement projects. Projects will be selected based on defined criteria and approved by the Steering Committee.

A risk framework and process has been implemented in the Region that includes an assessment of the risk associated with health and safety, financial impact, service level impact, socio-economic impact, liability, and regulatory compliance. The risk of failure is then reviewed against the probability of failure to determine an overall priority.

The initial phase of project delivery is already underway with the implementation of the initial nine pilot projects identified during the Region and Local Municipal Inflow and Infiltration Reduction Pilot Program - Phase 1. Construction of the initial public right-of-way pilot projects is anticipated to occur prior to 2013. Upon completion, post construction flow monitors will be installed to validate that inflow and infiltration reduction has been successfully achieved.

Future project prioritization activities include:

- Develop a project prioritization model (or optimized decision model) that will help ensure consistency in how inflow and infiltration reduction related projects are prioritized.
- Prioritize and provide funding for the 16 uncommitted Phase 1 Pilot Program Projects as described in Section 1 of the Strategy.

Determining Inflow and Infiltration Reduction Achieved

To determine reductions, the Strategy will use procedures similar to those used in the pilot projects for the Region and Local Municipal Inflow and Infiltration Pilot Program – Phase 1. After future projects are constructed, reduction will be measured and the structural condition of the rehabilitated sewer system will be evaluated to ensure that the predictions for flow reduction and the effectiveness of the selected solutions have been achieved.

A hydraulic model will be updated with revised hydrologic input parameters as system rehabilitation and repair work is completed, and post construction flow monitoring is conducted, and data are analyzed. The model will simulate inflow and infiltration entering the system. Upon recalibration, the hydraulic model will be used to characterize the newly repaired audit basin and simulate the 25-year design storm projections. Revised inflow and infiltration volumes and reduction targets will be input into an audit

process spreadsheet to reflect actual reductions and to quantify any remaining difference between actual and targeted inflow and infiltration reduction.

External Asset Management Condition Assessment Programs

To complement the Strategy, the Region and local municipalities are currently conducting ongoing condition assessment as part of their asset management programs, ongoing programs, procedures, and condition assessments as they relate to asset management or inflow and infiltration reduction should complement this Strategy. The Steering Committee or its designated working group has been collaborating to coordinate these municipal programs with the Strategy.

Inspection Standards

To support the efficient collection and use of inspection records, it is important that inspections are completed in a consistent manner (including the municipal right-of-way and private property) and that data are collected using standardized procedures and terminology. The Region has developed a series of technical specifications and standards for closed circuit television mainline/lateral inspections, manhole inspections, and smoke testing that will be collectively used by the Region and the local municipalities for future inspections.

A comprehensive "routine" inspection program, including the frequency and type of the inspection recommended, is being developed. The program is based on the age and criticality of the discrete components.

Design and Construction Standards

Efforts to prevent inflow and infiltration from occurring in new construction will be ongoing, even as the program addresses existing inflow and infiltration sources. Precluding the entry of potential future inflow and infiltration into the system from new construction is an important element of the Strategy. Key elements recognized for achieving a tighter sewer system include applying sound engineering design practices, developing specifications cognizant of inflow and infiltration, and enforcing the specifications through adequate construction inspection of both the public and private infrastructure at all phases of construction. A review and update of existing design standards has been recommended and is ongoing.

Program Area 4 – New Developments and Capital Projects

The objective of this section is to describe how construction standards for right-of-way and private infrastructure are being updated and utilized to ensure conformity to design intent.

New development commissioning practices have been developed and reviewed by the Region and local municipalities that consider:

- Visual inspection
- Leakage Tests (infiltration and exfiltration)
- Deflection testing
- Closed circuit television inspections
- Smoke tests
- Flow monitoring

Through the analysis of flows in new development areas, a review of the current allowance for inflow and infiltration will be completed.

In addition, future activities identified include:

- Finalizing development of design and rehabilitation standards.
- Compiling Regional and local municipal sewer use and discharge bylaws.
- Developing uniform sewer use bylaws to allow access and improvements on private property.
- Developing standard procedures for flow analysis and catchment prioritization.

Program Area 5 – Financial Management

The funding objective is to develop a sustainable source of revenue to support the long-term implementation of this Strategy that is equitable to the partners and community while addressing the inflow and infiltration reduction targets required by the Minister's conditions.

In the absence of a full program scope and based on Regional estimates, an initial target of $100 million over a 20-year period was used to assess the potential funding requirements. This equates to a future annual investment of $5 million per year across the Region.

The Strategy will be supported by a collaborative long-term funding model based on a cost shared approach between the two tiers of government.

The key funding principles are:

- A set rate will be collected at both the local and Regional level as identified through the needs of the Strategy and as agreed to by the local municipal partners.
- The amount collected at the local level will be used to address priorities identified both through the Strategy and as determined by each local municipality. The funding is to be used to meet the objectives of the Strategy in support of inflow and infiltration reduction. Any additional investments required to maintain local sanitary infrastructure will be on top of the amounts required by the Strategy.

- The amount collected at the Regional level will be used to address Regional inflow and infiltration priorities both at the Regional and local municipal level. Investments in the local systems will be made to accelerate resolution of Regional priorities through augmenting local funding sources.
- Regional funds intended for use in the local systems will be managed and allocated by a joint board made up of representatives from each local municipality and the Region. Funds will be granted based on the most effective application to achieve the desired inflow and infiltration improvements as quickly as possible.

The Strategy requires that each local municipality contributes and maintains a specific and sustainable funding allocation towards the Inflow and Infiltration Reduction Program. However, this funding shall be allocated to the local system from which it is collected for future allocation through reserves or other appropriate means.

The funding requirement does not preclude the local municipality from collecting additional revenue from the rates for other infrastructure and asset management needs of the local sewer system.

The net impact of the new Strategy could be an increase in local rates or a reallocation of existing local rates. This would be dependent on current and future needs as determined by each local municipality and provided that the local municipal system meets a Regional performance standard determined through the Strategy.

Funding is a regionwide controlled pool that is directed by the Task Force, and is allocated based on the priorities developed through the Strategy to achieve the greatest system benefits regionwide.

A preliminary list of program activities that will require funding includes:

- Flow monitoring
- Inspection programs
- Data analysis
- Development of common guidelines and standards
- Continuous improvement
- Communications programs
- Rehabilitation/replacement programs
- Pilot tests

To accomplish this, short-term (1 to 5 years), medium-term (5 to 10 years), and long-term (10 years and beyond) planning horizons have been developed to establish and sustain funding for the Strategy. Funding requirements will continue to be reviewed and updated as the Strategy is implemented.

Program Area 6 – Communication, Education and Advocacy

Communications, education, and advocacy have been identified as one component required to successfully achieve inflow and infiltration reduction in the Region. A coordinated team of Regional and local municipal staff will oversee the creation of clear and consistent messaging with a consistent brand identified for use both internally and externally with the various stakeholder groups. The communications and advocacy staff will work closely with other members of the program team to create a communications plan that will meet the needs of the evolving program.

Communications, education, and advocacy will play a strong support role in working with technical staff in delivering the key messages to the various stakeholders.

The key areas of focus will be:

- Internal communication for Steering Committee and staff;
- External communication for council, public, other agencies;
- Identification of whom needs to know what and when;
- Development of consistent and appropriate messaging (for council, staff, public, other agencies);
- Coordination with leadership and advocacy to identify stakeholders; and
- Development of a communication plan (timing, media, based on communication template, etc.)

The communications, education, and advocacy staff will liaise with regulatory compliance and policy staff to ensure that current and future works comply with all applicable regulations.

Program Area 7 – Report Inflow and Infiltration Reductions

The Region has developed this Strategy for long-term inflow and infiltration reduction. It is anticipated that the Strategy will evolve over time. As such, it will be a living document to be used by the Region and local municipalities to guide the management of the inflow and infiltration reduction programs.

Per the Minister's conditions (Condition 8.8), the Region is charged with submitting an annual report to the Ministry of the Environment and the SeCAC, detailing the progress on implementing the Strategy including inflow and infiltration reductions achieved. The first report is required to be provided one year following finalization of the Strategy and every 12 months thereafter.

The first annual report will be submitted to the Ministry of the Environment on March 31, 2012. This report will describe the status of each milestone activity and the progress towards the stated inflow and infiltration reduction target.

In compliance with and support of the annual and five-year update reporting requirements that the Region has with the Ministry of the Environment, each local municipality will be required to plan for and develop an annual Municipal Summary Progress Status as well as develop Achievement reports.

The local municipal reports will contain information describing the local municipality's inflow and infiltration reduction activities over the previous year and activities planned for the upcoming period:

- Sewer system mapping
- Update on the amount of infrastructure inspected for inflow and infiltration source detection purposes
- The extent of new sewer construction and sewer repair and replacement work
- A summary of the results of all flow monitoring work undertaken
- The location and frequency of all sanitary
- sewer overflows
- A summary of expenditures for sewer system evaluation, repair, and replacement activities
- Planned activities, milestones, and budget allocations for the upcoming period.

Program Area 8 – Continuous Improvement

Continuous improvement is an ongoing effort to improve the way services or programs are implemented. While this Strategy serves as a starting point and seeks to provide the technical requirements for implementing the various programs, a number of key areas and future initiatives will require development over the short and long terms.

The following areas have been identified as areas to focus on which may require enhancement as the Strategy is implemented:

- Review and refine data analysis and exchange procedures.
- Review and refine flow monitoring standards.
- Review and refine/implement rehabilitation standards.
- Develop/update sewer use bylaws and
- building codes.
- Review and refine inspection SSES.
- Review new technologies
- (inspection and rehabilitation).
- Review and refine design and construction standards and commissioning standards.
- Review and implement private property mitigation programs.
- Review and update overall Strategy document.

Private Property Inflow and Infiltration Reduction Programs

Private property mitigation is a key component of any best practice program. This Strategy makes specific recommendations about future programs required within the Region to mitigate extraneous wet weather flows from private property. These programs include the access and inspection of properties to confirm the locations of any direct stormwater connections and the structural condition assessment of private laterals through implementation of projects on private property.

Private property site inspection and mitigation projects could include:

- Enhanced standards for construction on private property
- Household drainage and inspection programs
- Authoritative power review such as consent to enter
- Downspout and foundation drain disconnection projects
- Lateral rehabilitation and replacement projects
- Outreach and communication programs
- Financial assistance programs.

Review and Update Overall Strategy

The Steering Committee led by, and in collaboration with, an assigned program manager employed by the Region, will assume joint responsibility to implement this Strategy. They will also be required to further define and implement the activities necessary to ensure that the Strategy is continually maintained, enhanced, and carried out properly and in a timely manner. This process will commence in 2011 and is anticipated to continue until the Strategy is finalized.

The Strategy will be updated when necessary as data are collected, new information is learned, and new technology becomes available. Review and update of the overall Strategy will require the continued commitment of Regional and local municipal resources over the life of the Strategy. Updates and revisions to this Strategy will be presented to the Ministry of the Environment in annual and five-year update reports.

Conclusion

The Region and local municipalities will take joint overall responsibility to implement the Inflow and Infiltration Reduction Strategy. Furthermore, they will be required to further define and implement the requisite activities necessary to ensure that the Strategy is continually maintained, enhanced, and implemented. The implementation process will commence in April 2011 and is anticipated to continue as a sustained program. The Strategy will be updated as required as data are collected, as new information is learned, and as new technology becomes available. Review and update of the overall Strategy will require the continued commitment of Regional and municipal resources over the life of the program.

Short Term Project Timeline (2011 – 2015)

	2011	2012
Goals & Objectives	• Develop the audit spreadsheet and establish preliminary baseline and predict I/I rates and potential reduction targets based on current GIS and monitoring data. • Begin development of the Regional all-pipes hydraulic model and establish data exchange protocols to ensure data is provided and integrated on a regular basis.	• Finalize and calibrate all pipes hydraulic model. • Refine the detailed Audit and Measure procedures using data from 2011 flow monitoring program, flow reduction achievements, and outputs from the calibrated all pipes model.
Monitor & Analyze Flows	• Develop flow and rainfall monitoring program and complete pre-design for 200 flow monitors at 160 audit basinsincluding defining budget, hardware, software and resource requirements , complete site assessments and develop installation schedule. • Commence flow monitor installation within 80 audit basins using existing flow monitoring inventory and start data site maintenance and data retrieval. • Complete the wet weather data analysis of 85 flow monitor sites (45 model calibration & 40 I/I) and 20 rain gauges for 2009-2010 sites and begin data recovery of 2010-2011 sites. • Review flow analysis software applications to ensure existing Regional software can replicate dry/wet weather analysis procedures developed in recent analysis efforts. • Contingent upon execution of agreement, validate flow monitoring and analysis findings of developer funded initiatives and any pre-post mitigation.	• Prepare tender and purchase additional flow monitors and continue with flow monitor installations and maintenance for monitors that were identified in the flow monitoring program (estimated cost $1.0M) and continue the installation and maintenance of 100 audit basin flow monitors. • Select locations, relocate and maintain short term flow monitors at the mini basins based on 2010 analysis of audit basins (estimated 30 flow monitors). • Complete short-term post construction flow monitoring and data analysis of the 9 pilot remediation projects and determine the actual flow reduction achieved by pre-2012 remediation projects. • Contingent upon execution of an agreement, validate flow monitoring and flow reduction analysis of developer funded initiatives
Investigate & Mitigate	• Develop SSES inspection program and develop budgetary costing for any priority areas from the 40, 2009-2010 flow monitoring locations. • Commence remediation at nine (9) priority catchment areas including 12 km mainline, 162 point and surface repairs, and rehabilitation of 444 manholes. • Establish remediation schedule for 2012-2015 resulting from completed investigation program. • Contingent upon execution of agreement, validate the investigations and work performed through development funding.	• Complete SSES investigations and assess inspection results to validate I/I sources within the priority mini basin sites (estimated budget $1.0M) • Prioritize & budget short term capital and maintenance programs for highest priority mini basins resulting from SSES analysis. • Establish procedures, policies and complete a private side full length lateral rehabilitation "pilot" project (estimated budget $500k). • Complete the remediation of nine (9) priority catchments and commence flow monitoring to determine success of flow mitigation.
Development & Capital Projects	• Compile and review existing municipal development /sub-division agreements to determine gaps and opportunities and develop consistent wording between agencies. • Review 2010 flow monitoring results of new development location and determine if changes are possible to the I/I allowance for new construction.	• Based on the flow analysis results from new development monitoring locations from 2011 monitoring, establish common wording for new sub-division agreements that could include additional testing and acceptance criteria.
Financial Management	• Establish short term funding model and identify possible revenue streams, secure endorsement by Regional and Municipal Councils. • Review financial requirements for 2011-2015 activities to allocate budget for short term activities, including a review of alternative funding sources(i.e. development funded remediation) and budget for the construction of additional remediation projects.	• Review and refine the short & long term funding requirements for Capital and Operating program costs based on works and costs/benefits completed to date. • Investigate private property subsidy and grant programs for lateral rehabilitation, downspout and foundation drain removal, review alternatives, establish funding impacts and potential funding sources.
Communication	• Create a template for municipal reporting and secure endorsement by respective Council's. • Develop short and long term communication materials including establishing an industry focus group that will meet twice annually to discuss changes in Regional guidelines and procedures. • Develop 2011 Council Report and work with municipalities to ensure key program messages are presented to Council.	• Update the public communication plan and develop new Region and municipal I/I reduction program websites to include promotional and outreach materials (i.e. describe grant programs, overall program status, basement flooding awareness etc.). • Industry focus group will meet annually to discuss guidelines and procedures.
Report I/I Reduction	•Receive and review Regional and municipal I/I reports and evaluate current conditions throughout the YDSS. •Receive and review reports describing I/I initiatives implemented within the Region and each municipality over 2010/2011. This report will be used to generate the 2012 MOE report.	• Develop and present the annual Council Report describing program status, financial impacts and progress to date based on information received from the municipalities. • York Program Manager to prepare and submit an annual report meeting the compliance requirements for the MOE describing I/I reduction achieved in previous year, re-confirm and/or update reduction goals and targets.
Continuous Improvement	• Finalize and validate rehabilitation standards and engage industry as required. • Finalize and implement the new Construction and Development Commissioning Standards and Guidelines. • Establish Private Property Working Group whose mandate will develop short/long term activities related to private property I/I flow mitigation. • Begin to develop consistent wording and clauses in local sewer use by-laws to include provisions such as right of entry for inspection to ensure access to the private wastewater system for the purpose of work or inspection.	• Review permanent flow monitoring procedures and analysis procedures and enhance flow monitoring programs including defining requirement for additional or enhanced flow monitors (i.e. different technologies) • Develop a Region wide climate change model to identify the impact of changing weather patterns on I/I, review impact climate change could have on I/I targets. • Review Regional and Municipal Design and Construction Standard and revise Criteria where required (i.e. recommend and implement new I/I design allowance based on 2011 analysis results). • Implement new sewer use by-laws as developed in 2011. • Review potential impacts and reporting requirements of Bill 72, Water Opportunities Act , once Regulations are developed by the Provincial Government.


2013
2014
2015
Goals & Objectives
• Continue to calibrate, maintain and re-assess the outputs from the Region's all pipe hydraulic model and use calibrated model to update audit spreadsheet and refine catchment targets.
• Continue to maintain, calibrate and re-assess the outputs from the Region's all pipe hydraulic model including flow and rainfall data gathered at 200 flow monitoring locations isolating the 160 audit basins.
• Assess program status to date, including the cumulative impact of remediation projects implemented, reconfirm I/I reduction goals targets and timelines for flow reduction based on previous 5 years and update overall Strategy document.
Monitor & Analyze Flows
• Complete the installation of the remaining 100 audit basin flow monitors and relocate up to 30 mini basin monitors to newly identified priority areas (estimated costs $1.5M).
• Analyze post construction flow monitoring data from 2011, 2012 remediation projects and determine flow reduction achieved, update audit spreadsheet to reflect.
• Ongoing maintenance and support of audit basin and mini basin flow monitors and data retrieval and analysis.
• Complete an initial mass-balance analysis to determine base infiltration rates using water consumption and flow monitoring results to validate base and wet weather I/I rates across the YDSS and Regional system.
• Complete the wet weather flow analysis of the 2012 audit basins (100 sites) and complete detailed wet weather analysis for up to 30 mini basin flow monitors.
• Ongoing maintenance and support of all 200 audit basin flow monitor, 30 mini basin flow monitors and 10 post construction flow monitors (estimated cost $2.0M annually).
• Analyze post construction data for previous years remediation project flow monitoring to determine flow reduction.
• Confirm possible relocations of mini basin flow monitoring locations to new priority audit basin's
• Complete the wet weather flow analysis of the 2013 audit basin (200 sites) and up to 30 mini basin flow monitor to determine new priority locations.
• Refine mass balance analysis based on data gathered across entire audit basin network and assess base infiltration rates within each audit basin.
• Ongoing maintenance and support of all 200 audit basin flow monitors, 30 mini basin flow monitors and approx. 10 post construction flow monitors (estimated cost $2.0M annually).
• Confirm possible relocations of mini basin flow monitoring locations to new priority audit basin's
• Complete the wet weather flow analysis of the 2014 audit basin (200 sites) and up to 30 mini basin flow monitor to determine new priority locations for 2016 mini basin Program.
• Update Strategy, goals, workplan and objectives as required to support the 5 year update of the Strategy.
Investigate & Mitigate
• Complete the analysis of 2012 SSES investigations and establish priority remediation projects, budgetary cost estimates and define the priority of remediation projects.
• Complete SSES investigations at approximately 20 mini basin sites as identified in previous years flow monitoring program and analysis (estimated budget $1.0M).
• Complete additional remediation projects based on previous years analysis and current year budget allocation.
• Complete the wet weather analysis and establish priority SSES inspection areas from previous years flow monitoring locations
• Complete SSES investigations of approximately 20 mini basin catchments as identified in previous year mini basin flow monitoring program (estimated budget $1.0M).
• Review project list and complete additional remediation projects based on previous years analysis and current year budget allocation.
• Complete the wet weather analysis and establish priority areas based on the previous years flow monitoring locations
• Complete SSES investigations of approximately 20 mini basin sites as identified in previous years mini basin flow monitoring program (estimated budget $1.0M).
• Complete additional remediation projects based on previous years analysis and current year budget allocation.
Development & Capital Project
• Review OBC related building practices for new construction and evaluate need for Ontario Building Code changes (i.e. improved materials, inspection, backwater valves).
• Continue to meet with contractor, developer community and suppliers/materials industry to discuss potential changes to building construction standards.
• Coordinate with development community and seek endorsement for the implementation of new OBC related procedures for new construction, including stakeholder meetings and communication materials.
• Review Subdivision Agreements, inspection procedures and revise Design, Construction and Commissioning Standards to reflect the initial years of the Strategy.
Financial Management
• If implemented, develop the financial procedures for releasing and auditing subsidy and grant programs.
• Review project expenditures and revenue stream for funding the program to date and refine short and long term funding requirements to reflect known costs/benefits and future funding requirements.
• Assess the I/I reserve against project and financial forecasts to confirm that sufficient short and long term funding is available.
• Review available subsidy and grant programs that are offered from other levels of government.
• Review and update all Financial Management activities to reflect the current state of the overall I/I Reduction program.
• Develop 10-year Operational and Capital budget.
Communication
• Develop enhanced I/I program web site and create communication materials geared towards residents that will include interactive mapping and web-tv segments describing program status, projects and priority areas.
• Review and implement social media campaigns (i.e. project status updates, Facebook, Twitter).
•Industry focus group will meet twice annually to discuss guidelines and procedures.
• Assess gaps in the communication program review of industry communication practices, refine communication program.
• Review feasibility of extending I/I into existing outreach programs (i.e. Children's Water Festival), develop required displays, activities and materials.
• Industry focus group will meet twice annually to discuss guidelines and procedures.
• Review the success and gaps and update all communication activities and update overall I/I Reduction program.
• Industry focus group will meet twice annually to discuss guidelines and procedures.
Report I/I Reduction
• Receive annual municipal reports that describe the I/I program status and the initiatives implemented within each municipality over previous calendar year, develop consolidated Regional report.
• Incorporate results from the post construction analysis of prior years remediation projects and update the audit and measures template with resulting flow reduction attainment.
• York Program Manager and Steering Committee to prepare and submit annual report to MOE.
• Receive annual municipal reports that describe the I/I program status and the initiatives implemented within each municipality over previous calendar year, develop consolidated Regional report.
• Incorporate the results from the post construction analysis of prior years remediation projects and update the audit and measures template with resulting flow reduction attainment.
• York Program Manager and Steering Committee to prepare and submit annual report to MOE.
• Receive municipal reports that describe the I/I program status and the initiatives implemented within each municipality over the previous year.
• Complete post construction analysis of previous years remediation projects and post construction flow analysis and update the audit template with resulting flow reduction.
• York Program Manager to prepare and submit annual report to MOE.
• Steering Committee to review and update the Regional I/I Strategy including review of programs, milestones, targets, resources etc. Strategy report to be updated and submitted to MOE per 5 year cycle.
Continuous Improvement
• Define and implement the required administrative structure, procedures and retain staffing resources to administer private property subsidy programs such as downspout disconnection.
•Update Regional and municipal Design Standards to reflect outputs of the 2012 climate change models (IDF peaking factors, sewage generation, I/I allowance)
•Continue to enhance the inspection procedures for new construction to reflect advancements in technologies.
• Review program staffing requirements to reflect works completed to date and short term timeframe, develop new job descriptions and retain staffing to support program.
• Integrate I/I program (asset management, finance, technology) with Bill 72, Water Opportunities Act Regulations.
• Review the implementation of mandatory or voluntary downspout disconnection programs including assessment of downspout locations, quantities, costs and expected benefits.
• Establish procedures for establishing costs and benefits for I/I reduction programs using flow reduction and costs spent to date, review effectiveness of remediation projects against costs incurred, extrapolate cost benefit across the Regional drainage area.
• Re-assess Strategy components against industry practices to determine new best practices and possible changes and opportunities to York's Strategy for inclusion in the 2015 MOE update.
• Repeat the industry best-in-class review to determine advancements in I/I removal /mitigation programs within the industry.
• Review success of the first 4 years of the I/I program and complete an update of the /I Strategy per the requirements of the MOE Conditions (update every 5 years).
• Review staffing and financial requirements to support revised Strategy, develop short/long term workplan.

1.0 Background and Rationale

This Strategy document has been developed by the Region and local municipalities in response to the Minister's Conditions and describes the process that the Region intends to undertake in order to successfully meet those conditions.

1.1 Strategy Purpose – Minister's Conditions and Background

The Regional Municipality of York (the Region) is proceeding with construction of the Southeast Collector Trunk Sewer (SEC). The SEC is a 15 km tunnelled sanitary trunk sewer that will start in the community of Box Grove in the Town of Markham and end around the intersection of Finch Avenue and Valley Farm Road in the City of Pickering. This capital project is vital to service provincially-approved growth to the year 2031. On March 31, 2010, the Minister of the Environment of Ontario (MOE) approved the Individual Environmental Assessment (IEA) for the project and added a number of stringent conditions of approval.

Section 8 of the Minister's conditions refers to a *Water Efficiency and Inflow and Infiltration Reduction Monitoring Strategy*. The conditions pertinent to this section and their requirements are as follows:

- **Condition 8.1** requires that a Water Conservation and Efficiency Strategy for water and wastewater flows into the SEC be prepared.
- **Condition 8.2** states specifically that the Region is required to develop an Inflow and Infiltration Reduction Strategy (the Strategy), which *"shall include a program for the reduction of inflow and infiltration by the Regional Municipality of York to the Southeast Collector (SEC) Trunk Sewer from its and its lower tier municipalities' sewage systems. This program shall include reduction priorities, targets, timelines, tactics and initiatives, and the associated costs to implement these."*
- **Condition 8.4** requires that the Region complete a review of best-in-class infiltration and inflow (I/I) reduction programs, initiatives, strategies, and tactics adopted by other jurisdictions.

The Region has ongoing programs in water conservation and I/I reduction that were relied upon as mitigation measures to support developing the new SEC. Reducing I/I has been an integral part of the Region's servicing considerations since the first water and wastewater master plan was developed in 1997 subsequent to the transfer of sewer systems to the Region by the Province of Ontario. The *York-Durham Sewage System (YDSS) Master Plan*, as subsequently updated, specifically identified water conservation

and extraneous flow reduction as a significant design consideration for all YDSS projects. In combination with alternatives considered during the SEC IEA, I/I reduction efforts across the Region were increased in 2007 with the Regional Council approving a commitment of $23 million in the 10-year capital plan to support ongoing efforts by both Regional and local municipal staff towards I/I reduction.

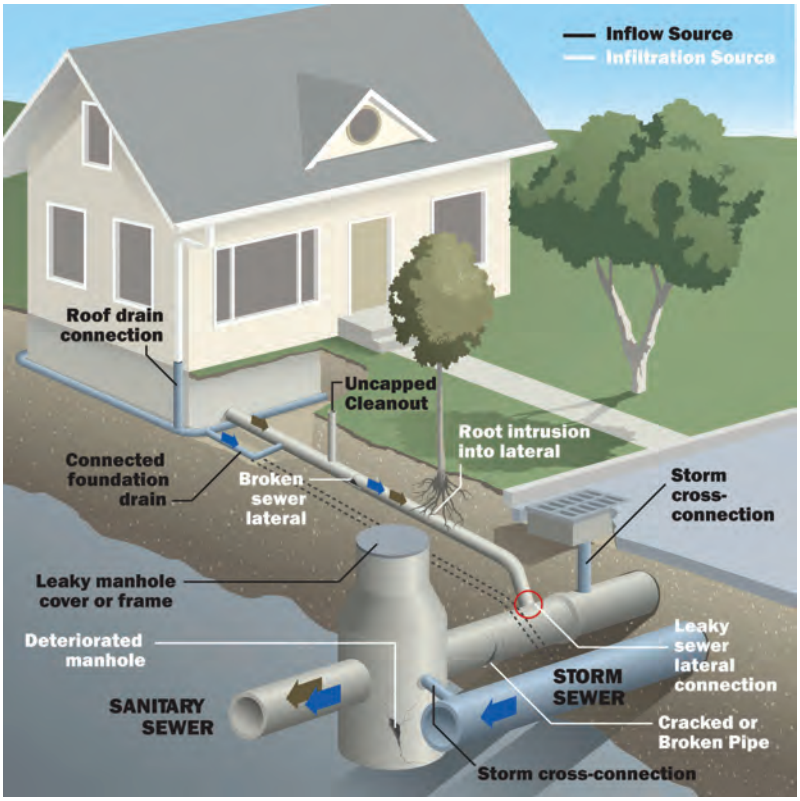
The Region and all of the local municipalities, including the City of Vaughan, the Towns of Aurora, East Gwillimbury, Georgina, Markham, Newmarket, Richmond Hill, Whitchurch-Stouffville, and the Township of King, are currently involved in the Region and Local Municipal Inflow and Infiltration Reduction Pilot Program - Phase 1. This ongoing initiative is the largest project of its kind in Canada and involves identifying best practices and cost-effective remediation projects to reduce I/I. Once completed, the detailed studies and analysis of the pilot program will provide a full suite of tested I/I reduction measures available to local municipalities and the Region to use in their ongoing asset management programs.

Although advances in water conservation, water use efficiency, and I/I reduction measures have been significant, as detailed in subsequent sections, a considerable amount of work is now required to meet the Minister's conditions. In summary, the approval of the SEC is subject to stringent conditions based upon the following overall directions:

1. A compliance monitoring and reporting program is to be established to document that the project will be undertaken and will continue to be operated in conformance with the commitments made by the Region in the SEC IEA.
2. The Region is required to establish a stakeholder advisory committee consisting of representatives from local and Regional municipalities, agencies, environmental groups, and residents within three months of approval of the SEC IEA to enable ongoing liaison between the community and the Region during the construction period. The Southeast Collector Advisory Committee (SeCAC) was formed in April 2010 to meet this requirement.
3. A review of Best-in-Class water conservation and efficiency measures and development of I/I reduction strategies are to be completed in conjunction with the Region and the local municipalities. It is to be independently peer reviewed, presented to the advisory committee, submitted to the MOE, implemented, monitored, and reported on annually to the MOE.
4. A performance management plan will be developed and submitted to the SeCAC and the MOE to document performance targets for improvements to water conservation, efficiency, and reductions in I/I.

The purpose of this Strategy is: (a) to provide an overview of current I/I issues in the Region and the local municipalities; and (b) to describe the targets, activities, timelines, and milestones of future objectives and programs being considered by the Region and the local municipalities for managing I/I. The Strategy ensures the utilization of a number of I/I programs and practices implemented by leading agencies around the world. The work processes of the Strategy follow a rigorous path and the research and development of the Strategy enabled important documentation to be captured and incorporated.

Future updates of this document will enable the Strategy to reflect the successes and progression of I/I reduction and any knowledge gained through implementation.



Source: Capital Regional District CRD, Victoria, B.C.

Figure 1: Sources of Inflow & Infiltration

1.2 Inflow and Infiltration – Background

As systems age, the infrastructure tends to deteriorate and in turn the likelihood that I/I will enter the sewer generally increases. To complicate matters, in some cases, past construction practices allowed household stormwater drainage systems to connect directly into the sanitary system. For example, some residential areas were constructed prior to formation of the Region in the early 1970s. At this time, households were allowed to connect rain water downspouts and foundation/footing drains directly into the sanitary sewer pipe network. Through numerous studies, it has been estimated that 50 to 70% of I/I is actually generated within private property.

Inflow and Infiltration can be described as follows:

Inflow: Inflow is water from rainfall, snowfall, or snow melt that enters the sewage system through direct sources such as yard, roof, and footing drains, from cross-connections with storm drains, downspouts, and through holes in manhole covers. Peak inflow usually occurs during heavy rainfall or snow melt events and can sometimes result in sewer backups or system overflows.

Infiltration: Infiltration is groundwater that enters sewer pipes, laterals, and manholes through holes, breaks, failed joints, connection failures, and other openings in the system. Infiltration quantities often exhibit seasonal variations in response to groundwater levels. Storm events or wet weather periods can trigger a rise in groundwater levels and increase infiltration flows. The highest infiltration flows are seen after large storm events or after long periods of precipitation or snow melt. Figure 1 depicts some of the potential sources.

1.3 Impacts of Inflow and Infiltration

Receiving environments can be adversely affected by sewer overflows, which can occur when I/I flow rates exceed the design allowances or the hydraulic capacity of the wastewater system. These extraneous flows could result in backups and overflows that could pose risks to public health, property, and the natural environment. If the volume of I/I entering the Region's sanitary system is reduced, the risk of overflows and the costs of conveying and treating the I/I flows can also be reduced. Reduction in peak flow rates or volumes will also free pipe capacity for future growth and may extend the design life of conveyance and treatment facilities. I/I reduction involves many different programs, tactics, and initiatives that work in combination to provide short-term and long-term benefits.

The Region's sewage system is responsible for providing adequate capacity to convey and treat all flows sent to the trunk system from the local municipalities.

The range of potential impacts from I/I includes:

Environmental Impacts:

- Sewage overflows, markedly at peak capacity, damage sensitive ecosystems and the natural environment.
- Any overflow affects groundwater, local ecosystems, and water quality in lakes, streams, and rivers.
- Clear water entering the system through infiltration could be a major factor contributing to lower groundwater levels and could affect local water resources.

Potential Health & Safety Risks:

- Sewage overflows, bypasses, and basement flooding present a public health risk.

Exceeding Sewer Capacity:

- Excessive I/I flows consume sewer capacity that could be required for existing residents and future approved growth. The extra flow can overload the sewage collection system pipes, causing back-ups or surcharging. Raw sewage can potentially overflow at locations, including basements before it reaches the treatment plant.

Financial Impacts:

- During wet weather events, the increased flows in the sanitary system raise the operational and capital costs at facilities and treatment plants as the additional flows must be conveyed and treated.
- Increased flows could also require new or accelerated capital works to expand pipes and facilities.
- Decontamination measures to treat sewer overflows and basement back-ups (i.e., compensation claims management procedures) can be extensive and costly.

In summary, reducing I/I flows provides a number of benefits including cost savings and improvements to the environment. These include reduced conveyance costs (pumping), reduced treatment costs, and hydraulic benefits (plants and pipes will be in service longer and cost less to maintain). Also, reducing sewer overflows and their associated health risks, property damage, and environmental effects provide both environmental and social benefits.

1.4 Relationship with Water Opportunities Act (Bill 72)

The Water Opportunities and Water Conservation Act was passed in the Ontario Legislature on November 23, 2010. The legislation was introduced in the spring of 2010 and received Royal Assent on November 29, 2010. At this time, the regulations which will provide detailed directives on implementing provisions of the Act are still pending.

The purposes of this Act, as detailed in Part I, are:

- To foster innovative water, wastewater and stormwater technologies, services and practices in the private and public sectors.
- To create opportunities for economic development and clean-technology jobs in Ontario.
- To conserve and sustain water resources for present and future generations.

Under the Act, the Region could be responsible to prepare, approve, and submit a municipal water sustainability plan to the MOE. It is anticipated that the regulations will require the plan to include the following with respect to the Region's water and wastewater services:

1. An asset management plan for the physical infrastructure.
2. A financial plan.
3. A water conservation plan.
4. An assessment of risks that may interfere with the future delivery of the municipal service, including the risks posed by climate change and a plan to deal with those risks.
5. Strategies for maintaining and improving the municipal service, including strategies to ensure that the municipal service can satisfy future demand.
6. Technologies, services, and practices that promote the efficient use of water and reduce negative impacts on Ontario's water resources.
7. Increased co-operation with other municipal service providers

As detailed in Part III of the Act, the Region could be required to prepare, approve, and submit municipal water sustainability plans to the MOE for municipal water services, municipal wastewater services, and municipal stormwater services. The MOE may establish performance indicators and targets for those services. The performance indicators and targets may vary for different municipal service providers and areas of the Province.

It is anticipated that the Act will require more detailed review of various aspects of the Region's water, wastewater, and storm systems. The Strategy developed by the Region has identified innovative procedures, technologies, and methodologies for managing I/I entering the Region and local municipal system. The Strategy also includes the financial resources and commitment to continue to address I/I into the future.

The implementation of and long-term commitment to this Strategy will help the Region and local municipalities meet many of the objectives and requirements stated above.

1.5 Demonstrating Municipal Leadership

Through the development and implementation of a Regionally adopted Strategy, the Region and the local municipalities have an opportunity to demonstrate leadership in I/I reduction within the entire water and wastewater industry. The current commitment by the Region and the local municipalities to I/I reduction serves to form the building blocks on which a leading edge I/I reduction program can be developed.

1.6 Asset Management Principals

Municipalities in Ontario will be required to establish sustainable asset management practices and report on the state of infrastructure where applicable as described above with the passing of Bill 72, *Water Opportunities and Water Conservation Act*, as described above.

The MOE, in a commitment to sustainable drinking water systems, enacted Ontario Regulation 453/07 under the *Safe Drinking Water Act, 2002*. This regulation prescribes the requirements for financial plans to be prepared as part of the Municipal Drinking Water License Program. In the supporting guidance document, *Financial Plans Guidance Document for Municipal Drinking-Water Systems and Municipal Wastewater Systems, 2007*, references indicate the potential for a financial plan to be submitted for wastewater and stormwater systems.

To comply with pending financial regulations and to provide long-term sustainable management of water and wastewater systems, municipalities will need to assess how costs are recovered to support ongoing programs and the delivery of wastewater services.

Successful asset management and I/I programs that accurately identify the locations of I/I distribution and severity depend upon choosing the correct strategies and techniques throughout the entire service life of the wastewater infrastructure. In September 2010, the Region released a *Sewer Management Framework for Regional Wastewater Assets*. The framework is intended to assist the Region with making decisions on managing performance throughout the various lifecycle stages of sewer and manhole infrastructure. The Region is aggressively moving towards the development and implementation of condition based predictive lifecycle management models for wastewater infrastructure. The performance management of gravity sewers and manholes is one vital component of I/I reduction and the overall sewer management framework.

When the framework is implemented in full, the Region's infrastructure management program will address the following infrastructure management components focusing on gravity sewers and manholes:

1. Performance management framework;
2. Baseline data requirements/data inventory;
3. Condition assessment framework;
4. Risk management framework;
5. Predictive lifecycle modeling; and
6. Optimized renewal decision-making.

A key component of the ongoing infrastructure management program will be the adoption of the Strategy.

1.7 Description of the Regional and Local Municipal Sewerage System Description

The Region is one of six Regional, "upper tier" governments in Ontario. The Region has nine local municipalities or "lower tier" municipalities: the City of Vaughan, the Towns of Aurora, East Gwillimbury, Georgina, Markham, Newmarket, Richmond Hill, Whitchurch-Stouffville, and the Township of King.

A map of the Region is shown in Figure 2.

Wastewater servicing is multi-jurisdictional based upon a two-tier municipal governance structure. Sewage from most communities in the Region is collected through a combination of local municipal and Regional trunk sewer systems. The collection system is extensive and varies in age, construction materials, complexity, capacity, and condition.

The responsibility for wastewater servicing in the Region is divided between the local municipalities, who are responsible for local wastewater collection and local pumping, and the Region, who is responsible for major pumping stations, trunk sewers that aggregate sewage from the local municipal sewers, and treatment facilities.

The Region's wastewater system is also divided into distinct service areas:

1. The YDSS, which serves the Region's larger urban communities;
2. The individual systems serving the smaller communities, located mainly in the northern and central parts of the Region;
3. Local municipal wastewater systems; and
4. Sewer infrastructure located on private property.

Figure 2: Map Illustrating York Region and the Location of Local Area Municipalities.

1.7.1 York-Durham Sewage System (YDSS)

The YDSS is a wastewater collection system that was constructed by the Province of Ontario in the late 1970s and early 1980s. The idea for the YDSS, a centralized sewage treatment system, dates back to 1965. At that time, the province decided no additional sewage treatment plants could be built on the Don River, Rouge River, and Duffin Creek due to concerns over their ability to assimilate additional volumes of treated effluent. In the southern half of the Region, wastewater is primarily treated in facilities discharging directly to Lake Ontario or its tributaries. Urban areas within the Region, including Aurora, King City, Markham, Newmarket, Richmond Hill, Stouffville, and Vaughan, are connected to the YDSS; and depending upon the location, the system is operated by either York Region or Durham Region. The YDSS consists of a series of gravity sewers, pumping stations, equalization tanks, and forcemains that collect and convey the bulk of wastewater to the Duffin Creek WPCP, which then treats and discharges clear effluent that meets stringent provincial requirements into Lake Ontario. The Duffin Creek WPCP has a current rated capacity of 630 mega litres per day (MLD).

A small fraction of the wastewater from the Region is directed to Peel Region for treatment at the G.E. Booth water pollution control facility in accordance with provincial requirements.

A number of smaller communities, located in the northern and central parts of the Region, are not connected to the YDSS, but are served by individual sewer systems. Wastewater systems servicing these communities include six existing wastewater treatment facilities located in the communities of Schomberg, Holland Landing, Keswick, Sutton, Mount Albert, and Kleinburg. In addition, construction of a new water pollution control plant and collection system for the community of Nobleton has commenced. The wastewater treatment facilities serving most of these communities are located either on or near Lake Simcoe or on a tributary of Lake Simcoe's. The wastewater treatment facility serving residents of Kleinburg and the new facility, serving residents of Nobleton are both located on the Humber River. The Humber River also has a limited assimilative capacity to accept additional wastewater discharges.

The local municipalities provide direct collection and management of the local system infrastructure and flows into the Regional trunk system. In addition, private property owners are responsible for wastewater mains and service laterals within their properties. During wet weather and snow melt events, the Region's facilities experience increased flows due to I/I, and this increased flow has a large impact on the capacity of sewer facilities and mains.

1.7.2 Overall Sewer System Profile

Within the Region, the total estimated combined length of wastewater mains (including public and private mains/laterals) is approximately 7,000 km.

The approximate lengths of the different sewer system mains are shown below and are illustrated in Figure 3:

- The Regional trunk system – 300 km in length
- Local municipal sewer system – 3,000 km in length
- Private infrastructure including laterals and private collection mains ~ 3,700 km in length
- 17 pumping stations
- Two equalization tanks
- Six wastewater treatment plants

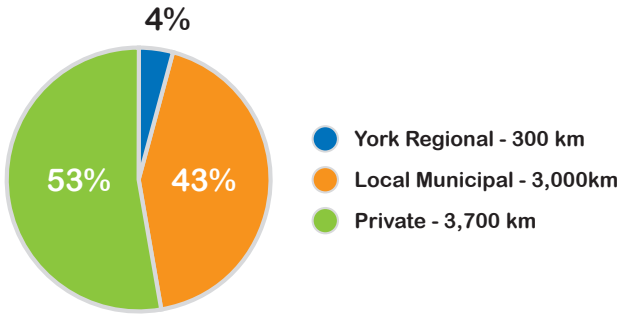


Figure 3: YDSS System Profile

1.8 Knowledge of the Physical System (Data Inventory)

Reliable decision-making requires current and accurate spatial, attribute, and performance data. The physical pipe system is currently inventoried by the Region and local municipalities through a variety of paper based and electronic data systems. The respective agencies are responsible for managing the data. The majority of local municipalities maintain a Geographic Information System (GIS) that contains the physical location and attribute data. Attribute data generally consist of information such as the pipe length, diameter, material, and often the installation date of the infrastructure. The Town of Georgina relies on CAD based mapping but has expressed interest in migrating to a GIS based system. Through previous projects, a consolidated base map was compiled bringing all municipal datasets together in one central database. Maintaining this consolidated base map will be critical and future analysis will require access to information from one central location (i.e., for all pipes hydraulic modeling, system design, etc.). Through this Strategy, new business processes will be implemented, allowing for a more seamless integration of the various datasets and ensuring that the consolidated base map and relevant attribute information are maintained.

Experience shows that many problems and inefficiencies exist in data access, exchange, and management. In the case of the wastewater network, the infrastructure and flow routes between the local municipal and Regional systems are integrated and the analysis of information, flows, capacities, etc. (i.e., hydraulic modeling) is dependent upon having a seamless and current database to work from regardless of the ownership of the asset. Going forward, how to support the integration and efficient sharing and exchange of geographic and attribute data between the local municipalities and the Region will be a major challenge.

To address this challenge, standardized methods to model, validate, and exchange wastewater data are being recommended. Standardizing the representation of the Region's wastewater collection system data would enable interoperability and exchange. A standard Regional wastewater data model would provide a schematic for representing and exchanging the wastewater infrastructure data including spatial and non-spatial objects, attributes, and interrelationships.

Similar to the geographic inventory, local municipalities are responsible for completing their respective condition assessment/inspection programs and maintaining their own condition assessment data. Condition and performance assessment data, such as the results of manhole inspections, closed circuit television of mainlines and laterals, and flow monitoring, exist for many of the systems. However, the information is captured in a variety of formats, including paper based records. In many cases, data are not directly linked to the geographic feature (infrastructure). For example, CCTV records are referenced according to a street name as opposed to the actual sewer or pipe that is positioned below the road.

A complete inventory compiling the condition assessments from each of the local municipalities has not been developed since historic projects have focused on specific priority areas.

Another key data gap is that private side stormwater connections such as weeping tiles and foundation drains are poorly documented. In the future, data collection programs, including household drainage inspections, will be utilized to quantify and locate these direct connections. As efforts to reduce I/I on private property are a key component across the system, this inventory of private system connections will be critical.

1.9 Knowledge of the System Hydraulics

Based on the physical characteristics of the wastewater system, the system attenuates flow as a result of its inherent storage capacity. This is mainly a result of the storage capacity of facilities, the physical diameter of the mains, and the physical length of the system. During rain events, flows can be rerouted through sewers and detained in equalization tanks. The storage capacity at the pumping station and the pumps operating capacity govern the wastewater flow rate immediately downstream of the pumping station regardless of the flow rate upstream of the station.

This attenuation and the pumping effects make it difficult to measure and report I/I flow rates (instantaneous flow rates) and reductions in the SEC or at Regional facilities, since the further downstream you are from the rain event, the more attenuation occurs. For instance, should reconstruction reduce I/I in the northern local municipalities, one would see very little reduction of instantaneous peaking factors or flow rates further down in the SEC.

Efforts are taken to prevent overflows from the Region's system, and equalization tanks located in the towns of Aurora and Newmarket help to store wet weather or excessive flows during peak flow periods. Overflows do occur periodically, typically during extreme weather events, but are not frequent occurrences. The Region has reported known overflows to the MOE and works toward the target of having no overflows in the system. The past history of overflows has been captured and priority areas have been identified for potential I/I reduction using these data. Table 1 below summarizes some known overflows in the Region's sanitary sewer system.

Table 1: Summary of Sanitary Sewer Overflows (SSO-York Region's Sanitary Sewer System)

DATE	OVERFLOW LOCATION
Aug. 19, 2005	Duffin Creek Water Pollution Control Plant (WPCP)
Dec. 23, 2007	Duffin Creek WPCP
Apr. 1, 2008	Duffin Creek WPCP and Newmarket Sewage Pumping Station (SPS)
Feb. 12, 2009	Newmarket and Aurora SPS

1.9.1 The Region's Operations and Emergency Procedures for Overflow

The Region has an *Operating and Emergency Procedures Manual* that staff uses as a communication protocol in the event of a spill/overflow occurring at a Regional facility. The Region's facility operators are trained to follow a standardized set of rules and regulations to deal with emergency spills and overflows. This can include immediate determination of the extent of the spill, notification of emergency contacts and higher level management as deemed necessary, containment, sampling procedures, and spill reporting. For example, the Certified Operator must contact the MOE Spills Action Centre immediately if the particular facility is not equipped with an internal overflow bypass system and the extent of spill is significant. The Region currently has a number of facilities equipped with safe bypasses into an internal overflow system to contain any spill or overflows. Internal overflows into these facilities do not need to be reported to parties outside of the Environmental Services Department, as there would be no spill to the environment.

The implementation of the Strategy will seek to mitigate the possible occurrences of any future overflow or spill as a result of I/I in any of the Region's facilities.

1.10 Design Standard of the new Southeast Collector Trunk Sewer (SEC)

Construction of the new SEC system will use a precast concrete segmental lining to construct the tunnel. The concrete will be "impermeable" with permeability less than 1×10-13 metres per second (m/s).

The segments will be fitted with ethylene propylene diene monomer gaskets, which will support outside pressures of more than 20 bar when the rings are erected properly. Once a ring is erected, the tunnel boring machine pushes against this ring, compressing the gaskets between the rings. Grout extruded from the trailing shield will fill the annulus space between the external surface of the segments and the excavated material. This prevents material/soil from loosening up and confines the rings uniformly, which ensures that the gaskets remain compressed. The grout also helps seal the joints.

The design plan of the SEC includes a monitoring program that will ensure that the system has zero or very little I/I. The SEC will be set and measured by a stringent water leakage detection survey during construction. This includes:

- Conducting a leak survey after the permanent tunnel and shaft linings are constructed. Classify categories of leaks based upon width, length, and the amount of infiltration through the structure.
- If water leakage after tunnel lining is completed exceeds an average of 15.0 litres per linear metre of tunnel per 24 hours measured over any 1,000 metre length of tunnel, or an average of 30.0 litres per linear metre of tunnel per 24 hours measured over any 10 metre length of tunnel, remedial measures shall be undertaken.
- If water leakage after permanent shaft construction is completed exceeds an average of 30.0 litres per vertical linear metre of shaft per 24 hours measured over any 10 metre vertical length of shaft, remedial measures shall be undertaken.
- Repair all visible leaks in structures, joints, shaft, and tunnel linings, regardless if the maximum infiltration criterion specified herein have not been exceeded.

1.11 System Growth

The existing SEC is a critical component of the YDSS that conveys wastewater flows from the York Region and Durham Region to the Duffin Creek Water Pollution Control Plant (WPCP) in the City of Pickering.

Expanding the YDSS is critical to ensure adequate wastewater treatment for current and future Region residents and businesses. The Region's residential population is currently estimated to be 1.04 million (June 2010) and it is forecasted to grow to more than 1.5 million by 2031.

In 1997, the Region completed the YDSS Master Plan study. This study was completed to identify and review current conditions and future alternatives necessary to meet population projections in the Region. Subsequently, the YDSS Master Plan was updated to reflect more current planning forecasts and to confirm the timing of the required infrastructure. Figure 4 illustrates the capital planning map of the YDSS and demonstrates the location of the SEC.

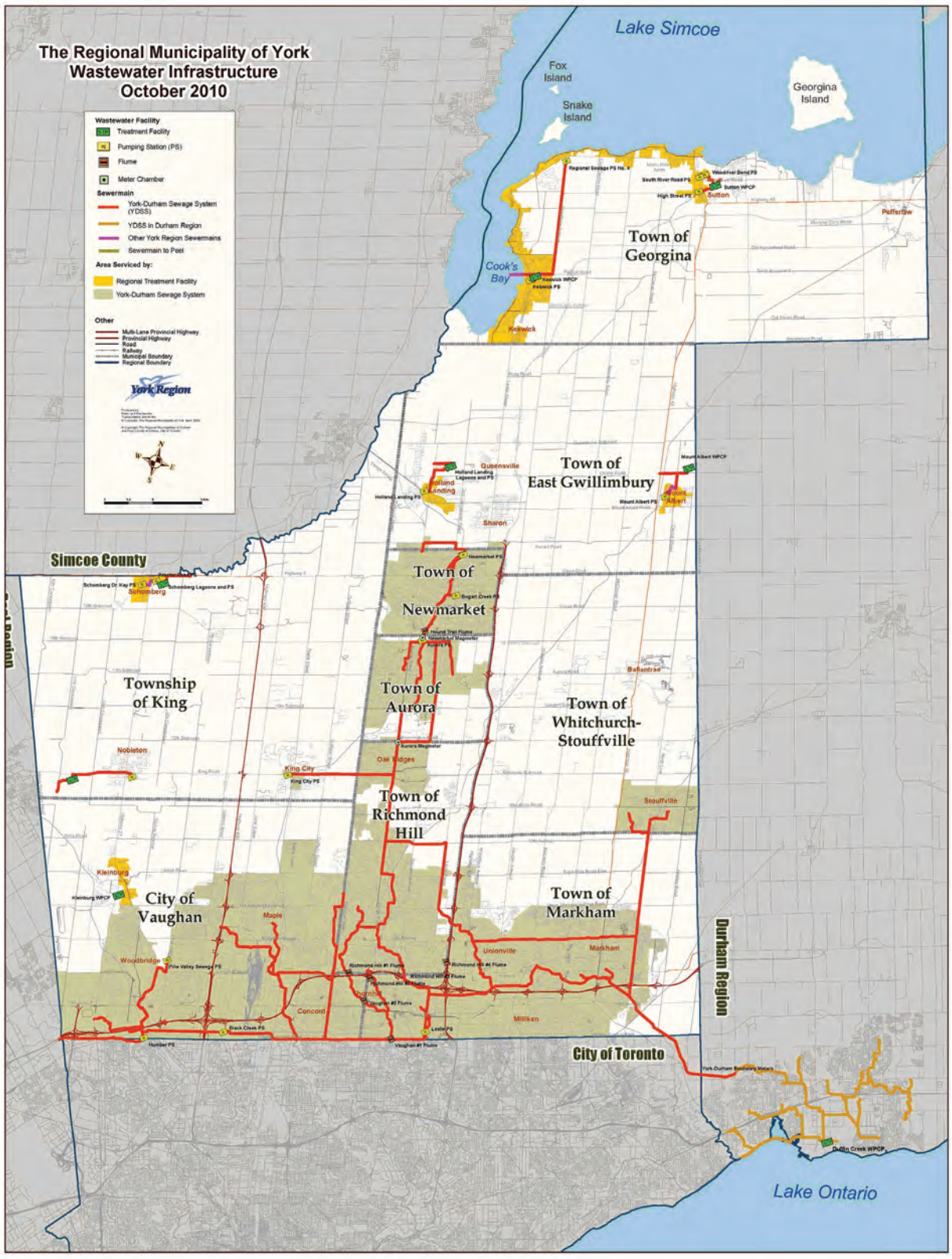


Figure 4: York-Durham Sewage System Map

1.12 Previous York Region I/I Reduction Pilot Program Efforts

Reducing I/I has been an integral part of the servicing considerations by the Region since the first Water and Wastewater Master Plan was developed in 1997. I/I reduction efforts were stepped up in 2007 with a Regional commitment of $23 million in the 10-year capital plan to study and implement pilot remediation projects in both Regional and local municipal systems.

A brief history of some of the additional I/I projects that have or will be completed within the Region is shown below.

- In 1997, the *Water and Wastewater Master Plan* recognized I/I as an issue in the Towns of Newmarket, Aurora, and Richmond Hill;
- Flow monitoring projects were initiated in 2000, with recommendations provided to the three local municipalities.
- In 2002, the *Water and Wastewater Master Plan* again recommended investigating sources of I/I in Newmarket, Aurora, and Richmond Hill;
- In 2005-2006, the Newmarket, Aurora, and Richmond Hill I/I project was completed;
- In April 2007, the Regional Council endorsed the creation of the Region and Local Municipal Inflow and Infiltration Reduction Program;
- September 2007, Phase I - the Region and Local Municipal I/I Reduction Program was initiated.
- July 2008, commissioning and inspection procedures were developed for new construction projects;
- August 2009, Phase II - the Region Flow Monitoring Program began;
- In 2009/2010, the Town of Aurora completed approximately $2.0M in mainline rehabilitation projects. An additional $1.0M is identified for rehabilitation projects in 2011;
- The Town of Markham is currently completing public and private side lateral rehabilitations within a pilot area of Thornhill.

Most recently, the Region and Local Municipal Inflow and Infiltration Reduction Pilot Program - Phase 1 was implemented to help assess the impacts of I/I. The Pilot Program was founded on a collaborative working partnership between the Region and the local municipalities. This project provides a critical starting point for this Strategy. As such, the Pilot Project is described in detail in Section 1.13.

The Pilot Program developed overall program goals. These goals were established to ensure that the program direction and outcomes met the needs and priorities of the respective system owners.

The initial stated goals for the Pilot Program included:

- Make I/I reduction a priority across the Region;
- Protect the environment by reducing I/I;
- Demonstrate stewardship of infrastructure;
- Develop funding models and mechanisms;
- Demonstrate the effectiveness of I/I reduction;
- Develop education and outreach programs;
- Develop a long-term regionwide strategy for I/I reduction;
- Implement new guidelines for constructing or reconstructing infrastructure.

The major short-term milestones for both the Region and local municipal I/I Reduction Program and the pilot remediation projects are shown in Figure 5.

Figure 6 depicts the timeline that was created by the Region and local municipalities to support the long-term goal for I/I flow reduction.

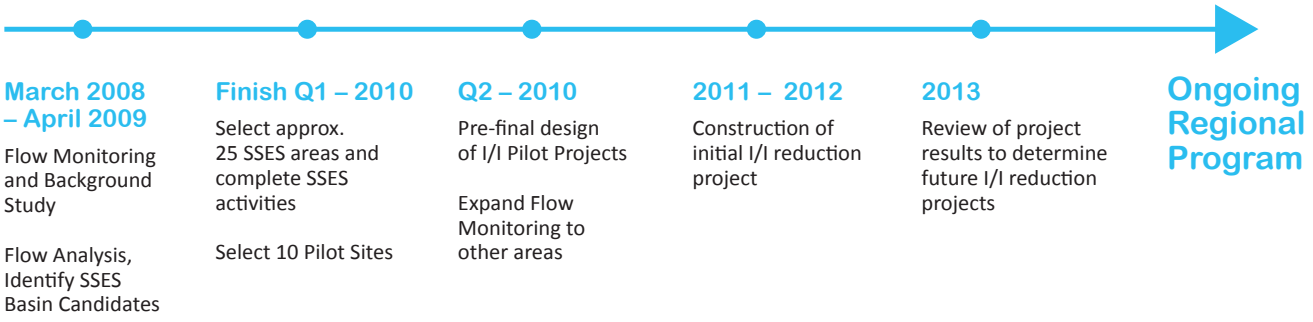


Figure 5: Short Term Program Timeline

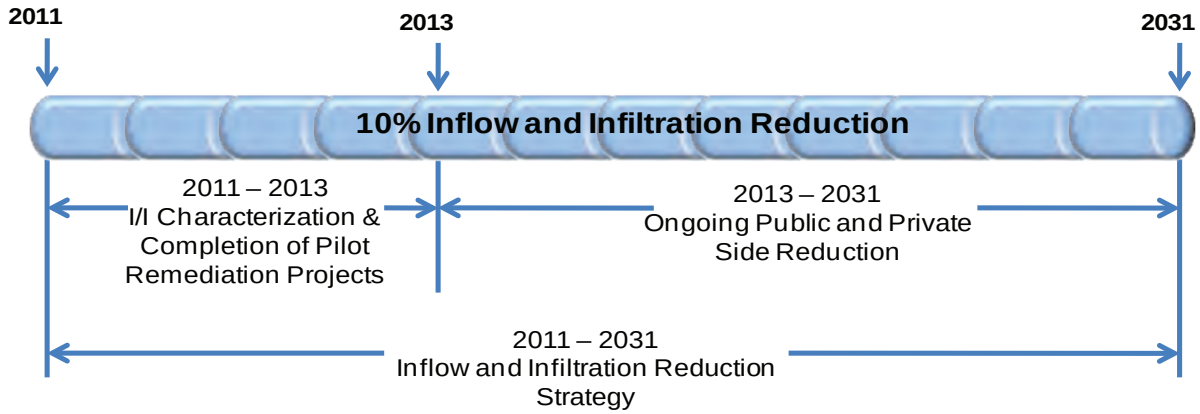


Figure 6: Long Term Timeline

1.13 The Regional and Local Municipal Inflow and Infiltration Reduction Program - Phase 1

Since the start of the I/I reduction initiatives, the workflow shown in Figure 7 was used to guide the various processes and sequence of activities. This workflow is aligned with a number of best practice programs, including the national guide to sustainable infrastructure's best practice guidelines, entitled *Infiltration/Inflow Control/Reduction for Wastewater Collection Systems*[1].

The following sections describe each stage of the Program. Many of the procedures and resulting analysis developed or resulting from the Program were used to develop this Strategy and they will be used as the baseline for future activities.

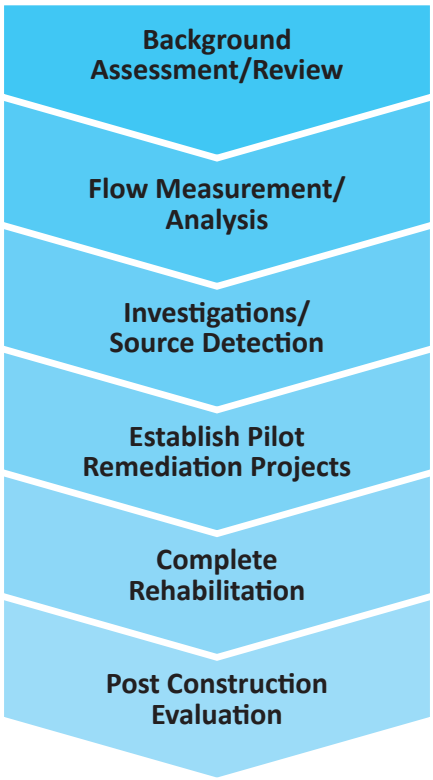


Figure 7: I/I Reduction Program Framework

[1]Infiltration/Inflow Control/Reduction for Wastewater Collection Systems, Issue No. 1.0, Publication Date: March 2003.

1.13.1 Background Assessment and Review (2007-2010)

The purpose of the background assessment was to gain a better understanding of the flow and hydraulic characteristics and conditions of the Regional wastewater systems. The background information was used to develop a flow monitoring and analysis program that was based on areas of the system that were known or thought to be of concern with regard to wet weather flows. Before starting the flow monitoring program, the available historical background for the sewer system relating to operational conditions and other basic data needs was gathered. This information included items such as the spatial and attribute GIS data inventories, paper maps, historic reports, and other details of the sewer system (pipe layout, attributes, etc.) as well as operational data (overflows, basement flooding, etc.).

The actual sources of information from the local municipalities and the Region included:

- Past I/I or related engineering studies,
- Maps and GIS databases of the wastewater system,
- Maps or observations of areas with known direct connections,
- Interviews with staff familiar with the system at the Regional and municipal level,
- Historical observations on high flow and overflow areas or known locations of basement flooding, and
- Planned capital works.

This background information highlighted specific areas of the wastewater system where more detailed analyses were conducted.

A critical aspect of the background assessment was to determine priority areas for the entire Regional system and not just the mains feeding into the SEC. The selection of priority areas (or areas where I/I potential could also exist) included the assessment of the following supporting information.

- Operational staff input
- Observed overflows and any known system bypasses
- Basement flooding
- Surcharging records
- Customer complaints
- Maintenance records
- System age/materials
- Groundwater and areas susceptible to flooding/snow melt
- Existing flow monitoring data for basins requiring inspections
- Past construction practices (roof leaders, deficiencies)
- Condition assessment reports where available (i.e., closed circuit television, manholes, visual inspections).

In the absence of any operating records or historic flow monitoring data, asset information such as age and material was used to highlight areas that were likely to be of concern.

1.13.2 Flow and Rainfall Measurement and Analysis

The purpose of the sewer flow monitoring program was to collect accurate level, velocity, and flow data to determine wet weather performance in many of the priority areas identified. The information collected during the flow monitoring activities assisted in locating areas that exhibited excessive I/I and helped in identifying any areas that warranted further investigation. In total, 122 flow monitoring locations were selected for one year of flow monitoring. This encompassed approximately 25-30% of the entire wastewater service area, including local municipal wastewater mains.

Flow monitoring activities included:

- Distributing flow monitors in a manner that provided equal representation across the system and created representative flow monitoring areas (catchments).
- Ensuring equipment was properly maintained in the field and regular data quality checks were completed.
- Completing manual field verifications of levels and velocities on a regular basis (each time the site was visited).
- Quantifying flow trends and I/I levels within each catchment for a multitude of wet weather events.
- Relocating monitors for sites that did not exhibit significant wet weather responses.

To assist with the comparative analysis of catchment I/I rates and based on industry practices, it was decided that catchment tributary length (the area of mains upstream of the monitor) and land area should be fairly uniform. Catchment lengths ranged from four to seven kilometres; in some cases, larger catchment lengths were required due to the configuration of the network and the feasibility of establishing a suitable monitoring location. Using the municipal GIS and land-base/parcel data provided, the physical geographic service area of each monitoring location was delineated (drawn) in GIS.

Similar to flow monitors, a rain gauge network was also established. The goal of establishing the rain gauge coverage was to ensure that the gauges were distributed spatially throughout the final flow monitoring network. In addition to 10 permanent Regional locations, the Region used an additional 12 heated rain gauges spread throughout the Region.

In 2009, the initial 122 flow monitoring sites were removed and 40 new flow monitoring sites were selected. These locations were selected based on the original prioritization process or were located in areas adjacent to the 2008 sites that exhibited high I/I flows.

In addition to the 2009 I/I locations, 45 flow monitors were then installed in the trunk and subtrunk system to establish flows at the trunk level and to develop and

calibrate the Region's trunk hydraulic model. These calibration sites will operate until June 2011.

Following a full year of flow monitoring, the 2009 I/I flow monitoring sites were moved to new locations, including 10 sites in recently assumed development areas. Flow monitoring will have been conducted in approximately 40% of the Region between 2008 and 2011.

1.13.3 Flow and Monitoring Data Analysis

Flow and rainfall data for the original 122 monitoring sites were analyzed to determine the location, quantity, and speed/response of I/I entering the wastewater system. This analysis provided information regarding how severe I/I was and the reaction time and magnitude of the wet weather responses provided some insight into the sources of I/I. A key component of the analysis was the information obtained about the system response time and volume (i.e., how quick the flows increased and fell in a particular catchment during and after wet weather events and how long the system took to return to normal dry weather flow patterns). Through the analysis of this information, the Region was able to identify whether sources of extraneous flows were likely inflow or infiltration, or a combination of the two.

Flow Monitoring Objective

The objective of the initial flow monitoring activities and the analysis of the data captured was to identify basins and smaller catchments with the most significant I/I rates. These data were also used to highlight where further detailed investigations were to be carried out. To achieve this objective, the Region and the local municipalities formulated a standardized approach for analyzing flow monitoring and rainfall data. This standardized approach will be used in future I/I analysis projects.

The major flow and rainfall analysis activities were:

- Rainfall analysis
- Dry weather flow analysis
- Wet weather flow analysis
- I/I characterization and prioritization.

Threshold Limits

Commonly used thresholds were then used during the analysis process since they provide a baseline for comparing results obtained from the wet weather and dry weather analyses.

The recommended allowance values for I/I in sanitary systems from many sources were reviewed. These included guidelines such as municipal and Regional design standards, Regional standards, the MOE, and international sources such as the United States Environmental Protection Agency (USEPA).

The specific criteria for rating catchments used for this project are shown in Table 2.

Table 2: Threshold Limits for I/I Analysis

		LOW	MEDIUM	HIGH
Criteria 1	Instantaneous peaking factor	PF < 4	4 < PF < 6	PF > 6
Criteria 2	Rainfall derived inflow and infiltration (RDII) per pipe area (Lpd/mm-km)	RDII < 280	280 < RDII < 560	RDII > 560
Criteria 3	Allowance for I/I - Peak I/I flow per area (L/s/Ha)	Peak II Flow/ ha < 0.25	0.25 < Peak II Flow/ha < 0.35	Peak II Flow/ ha > 0.35
Criteria 4	Percentage of rain entering system (Cv, Volumetric Coefficient)	Cv < 5%	-	Cv > 5%

1.13.4 I/I Detection (Sanitary Sewer Evaluation Studies (SSES) Inspection Activities)

A total of 26 catchments were identified as high priority following the comprehensive condition assessment and standardized grading and threshold limits application mentioned above. Various SSES inspection activities were applied to the catchments, including smoke testing, closed-circuit television (CCTV) mainline and lateral (both private and public laterals) inspection, and manhole inspections. A remediation project sheet was developed for each of the 26 SSES catchments. These projects were then discussed in a workshop with the Region and municipalities where it was decided to limit the number to the highest ten priority catchments; nine of which were categorized for rehabilitation in phase 1 in addition to one that was regarded as part of the Inflow and Infiltration Reduction Development Funded Program.

The three major objectives for the inspection programs were to:

- Identify specific I/I sources and the structural and performance conditions within each high priority catchment through the application of a variety of inspection techniques.
- Apply a variety of inspection techniques in different locations to understand the effectiveness of each technique for identifying I/I sources on a regionwide basis.
- Apply standardized defect distress coding and inspection practices to reflect the severity and extent of issues.

The inspection and investigation techniques employed within each catchment were tailored specifically to each area based on the type of response (I/I).

1.13.5 Establish Rehabilitation Projects

The different techniques used as part of the SSES inspection activities proved to be efficient in identifying actual and potential sources of I/I. Remediation projects were subsequently proposed for the nine projects categorized as the highest priority catchments. The proposed rehabilitation work, expected to commence in summer of 2011, includes remediation of approximately 12 km of mainline, 162 point and surface repairs, and 444 manholes in seven local municipalities (see Table 3). Each rehabilitation project will target achieving the greatest reduction of I/I within the selected priority catchments in the most cost effective and efficient manner possible. However, based on the input received during the peer review process, a primary goal is to assess the Region's ability to identify sources of I/I and employ a broad range of technologies to determine their effectiveness in reducing wet weather flows. Future projects will also include works on private property.

From the $23 million I/I Reduction Program budget approved by the Regional Council in 2007 as part of the 10-year capital plan, $10 million have been allocated to be spent in 2011 through 2012 on the nine local municipal high priority pilot projects for I/I rehabilitation. The goal of the final selection process was to target the highest priority areas, yet still maintain a geographic distribution of projects across the Region.

The main goals are:

1. Reduction or removal of I/I generated in local municipal sewers;
2. Demonstrate the effectiveness of various I/I reduction technologies in local municipal sewers;
3. To focus on areas that are tributaries to the Regional conveyance and treatment systems;
4. To generate data regarding the unit costs for various reduction technologies;
5. To learn more about the effectiveness (both in terms of cost and I/I reduction) of working on publicly and privately owned portions of the collection system; and
6. To learn more about the issues and opportunities of working on private property.

The nine rehabilitation projects shown in Table 3 will be implemented during the 2011/2012 construction season.

Table 3: 2011/2012 Pilot Projects

CATCHMENT ID	MUNICIPALITY	DESCRIPTION OF ACTIVITIES
AU01	Aurora	0.35 km of mainline rehabilitation, 12 point repairs & 70 manhole rehabilitations
HL01	East Gwillimbury	0.55 km of mainline rehabilitation, 23 point repairs & 51 manhole rehabilitations
KE04	Georgina	0.35 km of mainline rehabilitation, 5 point repairs & 53 manhole rehabilitations
MA08	Markham	2.19 km of mainline rehabilitation, 38 point repairs & 54 manhole rehabilitations
NE06	Newmarket	2.12 km of mainline rehabilitation, 9 point repairs & 9 manhole rehabilitations
NE13	Newmarket	2.48 km of mainline rehabilitation, 31 point repairs & 84 manhole rehabilitations
RH10	Richmond Hill	1.05 km of mainline rehabilitation, 1 point repair
ST02	Whitchurch-Stouffville	1.74 km of mainline rehabilitation, 3 point repairs & 32 manhole rehabilitations
SU02	Georgina	1.39 km of mainline rehabilitation, 40 point repairs & 91 manhole rehabilitations

Inflow and Infiltration Reduction Development Funded Program

In September 2010, Regional Council approved the proposal of an innovative project funded by a developer to reduce inflow and infiltration in the local system in lieu of obtaining capacity allocation for a new development with the net flow result being an overall peak reduction. This approach has been proposed instead of the conventional method of flow attenuation and as an alternative source of funding. The Region will determine eligible allocation capacity based on proven I/I reduction through remedial work performed by the developer and reviewed by the Region or its agent. A tri-party agreement between the developer, the Region, and the local municipality will be issued on the basis of sound principles to guide the work and provide verifiable benefits to the Region to justify granting wastewater allocation.

Opportunities include:

- Developer funding of the project at no cost to the Region or the local municipality.
- Quick commencement of work with readily available resources from the developer.
- Acquiring project experience that can be used for other I/I reduction projects in the Region.
- A reduction in inflow and infiltration and peak sewer flows.

It was recommended that similar allocation-seeking proposals be considered in each of nine local municipalities (1 per) and project, will be deemed complete if enough inflow and infiltration savings are identified to support the total capacity assignment requested by the developer.

1.13.6 Post Construction Flow Monitoring

After completing phase 1 projects, the Region will conduct follow-up flow monitoring to determine the effectiveness and permanence of the project on reducing extraneous flows. A cost benefit analysis will be conducted to determine the most cost effective and successful rehabilitation and replacement techniques to reduce I/I. Cost effectiveness may be assessed, among other things, by taking the cost to the Region for removing the flows and dividing it by the flow reduction achieved. Results from the rehabilitation projects, in conjunction with a thorough understanding of other deficient areas, will continue to form the basis for an economic analysis to determine the potential costs and benefits of expanding the pilot projects to full scale rehabilitation projects.

The remaining 16 high priority catchments, in addition to the 10 initial rehabilitation projects, will also be rehabilitated upon completion of follow-up analysis on the initial projects. The Region and the municipalities will continue to evaluate the success of rehabilitation projects and will develop capital plans and timelines for additional work not included in the Phase 1 Program.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2.0 2011 – 2031 Strategy Development

The following sections describe the process that the Region and the local municipalities used to develop the 2011–2031 Strategy.

2.1 Formation of Water and Wastewater Task Force Steering Committee & Working Groups

To successfully develop such a comprehensive Strategy to meet the Minister's conditions, the Region formed an I/I Steering Committee in April 2010. The Steering Committee was later renamed to the Water and Wastewater Task Force Steering Committee (the Steering Committee) and is comprised of representatives from each of the nine local municipalities and the Region. The Steering Committee is responsible for reviewing inflow/infiltration (I/I) issues and formulating an overall direction for development of the Strategy.

The Steering Committee is also responsible for reporting back to their respective organizations and councils.

To support the Steering Committee, five working groups (Figure 8 – Water and Wastewater Task Force Steering Committee and Working Group Organization Chart) have been established to address the following Strategy areas:

1. Strategy and Development
2. Funding
3. Communication, Education, and Advocacy
4. Audit, Monitor, and Measure
5. Standards, Implementation, and Continuous Improvement.

The membership of the working groups consists of personnel from the Region and the nine local municipalities. The chair of each working group is responsible for reporting back to the Steering Committee.

Figure 8: Water and Wastewater Task Force Steering Committee and Working Group Organization Chart

Each working group meets several times a month to review, develop, and strategize on the key program initiatives. The groups also develop work plans for implementing the Strategy to reduce I/I. The working groups use a consensus based approach to arrive at recommendations, work plans, and conclusions.

The **Strategy and Development Working Group** is charged with developing the framework and table of contents for the various other working groups. This table of contents is based on the Region's and local municipalities' existing knowledge and uses the Industry Practices Scan as additional guiding principles.

The **Funding Working Group** compiles and summarizes information relating to projected costs and existing funding levels to address and mitigate I/I. The working group also determines potential funding gaps and identifies potential funding sources and commitments.

The **Communication, Education, and Advocacy Working Group** develops and selects a preferred strategy for communication and advocacy based in part on the results of the Industry Practices Scan. This includes, but is not limited to, developing communication protocols, including process and data sharing for internal and external groups; setting processes for follow up on intermunicipal action items; and creating presentation templates and content material for council and stakeholders.

The **Standards, Implementation, & Continuous Improvement Working Group** tasks include a number of components:

- Develop rehabilitation standards.
- Compile Regional and municipal sewer use and discharge bylaws.
- Review and recommend inspection procedures to ensure that they include inspection frequency, and alternative inspection techniques.
- Develop standard procedures for flow analysis and catchment prioritization.
- Review opportunities to develop regionwide maintenance standard practices.
- Develop procedures for post-construction monitoring activities to determine success of flow reductions; and
- Develop a long-term water conservation program.

Finally, the **Audit, Monitor, and Measure Working Group** focuses on establishing the appropriate I/I reduction targets and determining the most practical way to measure and report on the progress towards these targets. It also identifies and develops lists and maps of potential or known high priority areas.

The Region and local municipalities agreed that this collaboration would be a key factor in the progress and endorsement of the Strategy document. Going forward, the Steering Committee and working groups will continue to meet and address opportunities on a regular basis. The Steering Committee and working groups are committed to working together collaboratively over the coming years to ensure the Strategy is implemented, maintained, and enhanced over time.

2.2 Southeast Collector Advisory Committee (SeCAC) Review

In response to the Minister's conditions, the Southeast Collector Advisory Committee (SeCAC) was formalized in April 2010. The role of SeCAC is to provide meaningful input, comments, and suggestions on scoped topics established by the Minister's conditions related to the construction, commissioning, and operation of the Southeast Collector Trunk Sewer (SEC). On October 14, 2010, a presentation was made to SeCAC describing the Industry Practices Scan results and how these would be used in the Strategy. A subsequent meeting was held on December 9, 2010, at which the first draft of this Strategy was presented with a follow-up meeting on January 13, 2011. The comments from the SeCAC Committee were considered and where appropriate were included in the Strategy.

Table 4 depicts when the SeCAC was engaged in developing the Strategy document.

Table 4: SeCAC Schedule of Events

PROGRAM AREA	ACTIVITY
Presentations	October 14, 2010 & December 9, 2010
First Draft Strategy document	Review of First Draft Strategy document, December 9, 2010
Comments on First Draft of Strategy Document	January 13, 2011
Final Strategy Document	Discussion about Final Document March 24, 2011

2.3 Peer Review of Strategy

A draft of the Strategy document was circulated to several agencies (King County, Washington; Milwaukee Metropolitan Sewerage District, Wisconsin; Metropolitan Council, St. Paul, Minnesota; and Metro Vancouver, British Columbia) for their review and comment. This peer review ensured that industry experts had a chance to review and comment on the appropriateness of the activities within the Strategy based on their previous experience. Comments and suggestions from peer reviewers for the document, irrespective of their current practices, were received on December 20, 2010. Comments were reviewed and considered in preparation of the final Strategy document. In general, leading practitioners endorsed the Strategy document and confirmed that the document was well presented, was comprehensive, and met and often exceeded industry practices.

2.4 Industry Engagement

In developing this Strategy, the Region has and will continue to engage relevant stakeholders and industry organizations such as materials suppliers, contractors, development consultants, and the Building Industry and the Land Development Association (BILD). BILD was formed through the merger of the Greater Toronto Home Builders' Association and the Urban Development Institute/Ontario and represents the interests of residential land development, home building, and professional renovation industries in the Greater Toronto Area. Other stakeholder groups contacted for this Strategy document included the Ontario Concrete Pipe Association (OCPA) and the Greater Toronto Sewer and Watermain Contractors Association (GTSWCA). The Region's Strategy will include various task forces, communication programs, and key contact points with the building industry to solicit input and gain feedback on the Strategy document. Further information on the outreach component and industry engagement can be found in the Communications and Education section of this Strategy.

2.5 Industry Best-in-Class Review

To assist in developing this Strategy and to ensure that the components meet or exceed leading industry practice, the Region undertook a comprehensive industry-wide international Best-in-Class Review. This review included developing a Strategy framework of the components and programs to be investigated.

Once a conceptual framework for the Strategy had been developed, detailed questions were created. The initial research stages were completed through an internet and document scan. With the knowledge gained during this web scan, a more comprehensive and focused review of sixteen international and North American agencies regarding specific I/I strategies, programs and tactics, and other potential focus areas for the Strategy framework was undertaken. The final list of agencies selected for review in detail was refined to ensure that the agencies met the following characteristics:

1. Had well documented and current strategies (or components of strategies).
2. Operated in a similar governance structure to the Region.
3. Were considered progressive based on industry knowledge and reputation.
4. Had goals and targets for I/I reduction similar to the Region.

To augment information, follow-up telephone interviews and web scans were completed as necessary. After the final assembly of the response data, an Industry Practice Review Technical Memorandum was developed and presented to the Region. The final summary report can be found at: http://www.york.ca/Departments/Transportation+and+Works/Water+and+Wastewater/IIRP+Main.htm.

In general, the following main Strategy components were reviewed as part of the practice scan:

- **Governance** – Described how the wastewater system is operated, including general ownership and responsibilities.
- **Goals & Objectives** – Described the drivers, goals, and objectives for the agencies I/I reduction strategies.
- **Statutory Regulations** – Described the regulatory framework under which the agencies operate.
- **Sewage System Knowledge** – Described how agencies gained an understanding of their system, including flow monitoring, condition assessment, flow data analysis, lifecycle analysis, and prioritization programs.
- **Data & Information Management** – Described how information was managed and shared internally and between organizations.
- **Program Tracking & Reporting** – Described the processes used to measure and report on successes and the progress towards stated goals and targets.
- **Private-Side Management** – Described the policies, programs, and procedures for reducing extraneous flows from private property.
- **New Infrastructure** – Described the procedures for ensuring that new infrastructure is constructed in an optimal manner.
- **Program Funding** – Described how agencies fund I/I mitigation programs, including intermunicipal funding scenarios.
- **Program Management** – Described project teams, organizational structure, personnel, and resources.
- **Bylaws & Agreements** – Described the authoritative mechanisms and policies required to mitigate I/I flows.
- **Public Education & Outreach** – Described the practices related to educating customers and rate payers about the benefits of I/I reduction or programs/projects required for reducing extraneous flows.

The following table (Table 5 – International Best-in-Class Scan Survey Matrix) outlines the agency programs that were reviewed at various levels ranging from a scan of available information via the internet to formal questions and personal contact.

The practice scan confirmed that the Region's initial Pilot Programs have a number of consistent practices. Also, a number of consistent processes and procedures are being utilized by most agencies, as described further below.

Table 5: International Best-in-Class Scan Survey Matrix

	AGENCY	WEB SCAN	DOCUMENT REVIEW	SURVEY/ INTERVIEW RECOMMENDED	SURVEY/ INTERVIEW COMPLETED
American	Metropolitan Council, St. Paul, Minnesota	✓	✓	✓	✓
	Western Lake Superior Sanitary District (WLSSD)	✓			
	Renewable Water Resources, South Carolina	✓			
	Milwaukee Metropolitan Sewerage District, Wisconsin	✓	✓	✓	✓
	King County, Washington	✓	✓	✓	✓
	Metropolitan Sewer District of Greater Cincinnati	✓	✓		
	Massachusetts Water Resources Authority (MWRA)	✓	✓		
Canadian	Metro Vancouver, British Columbia	✓	✓	✓	✓
	Capital Regional District, British Columbia	✓	✓	✓	✓
	Halifax Regional Municipality, Nova Scotia	✓	✓	✓	✓
	Region of Waterloo, Ontario	✓	✓		
	Region of Niagara, Ontario	✓	✓		
International	Greater Dublin, Ireland	✓	✓		
	Mullumbimby, Australia	✓	✓		
	Auckland - New Zealand (WaterCare)	✓		✓	✓
	North Shore City, New Zealand			✓	✓

2.5.1 Observations and Conclusions from the Best-in-Class Review

The agencies investigated were at various stages in implementing their respective I/I reduction strategies. It was found that each agency's progress and successes were a direct result of the original goals, objectives, or mandates established by/for them. For example, North Shore N.Z. had developed their program to address overflow issues and peak flow reduction. However, each agency reviewed had adopted innovative and successful components that allowed them to address their own unique I/I issues and goals. Thus, the observations described below should be understood in the context that not all agencies were at the same stage of development in their respective I/I programs, but each agency was considered to be progressive within the industry.

- Sophisticated agencies tended to have clear reduction targets that were well-defined and understood by all stakeholders.
- Most I/I reduction programs focused on reducing recurring events of overflows or basement flooding incidents. Where program objectives were tied to flow rates, the programs were typically based on reducing instantaneous peak flows but not on reducing volumetric flow.
- All progressive agencies researched engaged their satellite agencies through formal and ongoing working groups or task forces. However, no single or "one-size fits all" organizational model was found for I/I programs. In some cases, agencies had identified an I/I team or working group; while in other cases, I/I is not shown on an organization chart. Perhaps the most important organizational characteristic found in the agencies was the use of a team approach in defining and implementing their I/I strategy.
- The majority of multi-tiered agencies monitor and measure in-coming wastewater flows from their local satellite agencies.
- No single model for I/I strategy presentations or strategy document templates was noted. Many of the programs had processes and components that were consistent between them, but no discernable template or guidance document was found for preparing a strategy.
- Through discussions with the agencies it was apparent that each one recognized that strategies were working guidance documents that evolve over time. As such, strategies need to be reviewed regularly. As an interesting fact, several agencies were on their 2nd and 3rd strategy iteration.
- All agencies had either future plans or are currently conducting work on private property.
- The majority of programs were adopted to address system deficiencies. Many were just starting to review new development, design, and construction issues. It was noted that infrastructure and development standards and policies must be reviewed and/or developed to ensure that new sewer systems are designed and built using materials and techniques that protect against future I/I problems. During the construction of new infrastructure, consistent inspection and verification practices must also be instituted and proper operational procedures should be followed after commissioning.
- The Metropolitan Milwaukee Sewerage District (MMSD) is considered to be the closest comparable agency to the Region as far as having a stated volumetric goal reduction. A review of MMSD's program confirmed that the Region's proposed approach is valid.
- For agencies that have completed post construction cost-benefit analyzes, a clear relationship between the dollars spent on rehabilitation activities and treatment/storage cost savings resulting from the works was not found.
- All agencies agreed that public education programs must be maintained or introduced to inform the population on how to separate properly sources of water discharged into sewers and the consequences of diverting excess water to a sanitary sewer system.

2.5.2 Best-in-Class Adopted Practices

One of the key findings in both the Peer Review and Best-in-Class reviews was a common message around co-ordinating activities between agencies through stakeholder groups and task forces. The growing pains associated with the implementing a comprehensive I/I strategy almost always fostered enhanced communication among many different organizational units or satellite agencies. Many of the agencies agreed that cross organizational coordination has led to more effective planning and decision-making in general. One of the other key findings was that the approach to assess and report I/I reduction using a volumetric approach, while unique to a few organizations, is yet valid.

Many findings and observations from the Best-in-Class review were incorporated within the Strategy, including the approach to analyzing flows and the need for systemwide flow monitoring, the standardization of analysis procedures, the requirements for policies to allow inspections and activities that will help to reduce flows from private property, and the communication requirements to ensure the programs are understood by all stakeholders.

Table 6 depicts the general findings of the Best-in-Class review from a program perspective. The table highlights where the Region's current and planned programs are in relation to the practices considered to be leading edge.

Table 6: Best-in-Class Review Applied to the Region

INDUSTRY PRACTICES SCAN (IPS) ACTIVITY	COMPARATIVE AGENCY	YORK REGION TODAY	FUTURE STRATEGY
Formation of Steering Committee to guide program implementation	King County Washington, MMSD, Metro Council	Established partnership with municipalities over past 10 years, ongoing commitment through the Steering Committee.	Strategy includes ongoing activities to ensure communication and leadership occurs between agencies.
Flow monitoring across entire system	All agencies identified flow monitoring as a key component. Robust programs identified in King County, Metro Vancouver, and MMSD	The Region has isolated flow monitoring systems at pumping stations in key locations and has embraced the use of short duration monitoring.	The Region is working to develop a permanent flow monitoring network and audit process, including provision for systemwide flow monitoring.
I/I inspection programs	All agencies indicated common and standardized inspection activities are key to finding sources of I/I after flow monitoring.	The Region and the local municipalities have developed and implemented consistent inspection activities; industry peer review has identified the Region's program as leading edge.	Continue to refine inspection activities based on flow monitoring analysis and changes in technologies.
Construction & remediation programs and standards to ensure new infrastructure is constructed effectively	King County has developed comprehensive standards for public and private infrastructure.	In 2008, the Region developed a comprehensive inspection and commissioning guideline that has been endorsed by local municipalities. New standards for construction to be developed as part of the Strategy implementation.	Strategy activities include a review of design and construction standards for new and existing works (public and private infrastructure).
Private side I/I reduction, bylaws, inspection, and flow reduction activities.	Most agencies have identified that private property flow reduction is a key to meeting I/I reduction targets.	Work on private property is not currently completed in the Region.	Strategy has identified various activities including changes to bylaws and inspection activities and requirements for private property remediation projects.

INDUSTRY PRACTICES SCAN (IPS) ACTIVITY	COMPARATIVE AGENCY	YORK REGION TODAY	FUTURE STRATEGY
Funding	Financial commitments between organizations and dedicated funding towards I/I reduction (Metro Council, King County, MMSD)	Funding is currently managed by each satellite agency.	Strategy has identified current and future activities including the development and implementation of a regionwide funding model.
Communication and outreach materials	King County and Metro Council currently utilize comprehensive outreach materials including web based and paper based materials.	The Region and the local municipalities currently have limited communication programs for I/I. However, the Water for Tomorrow Model is identified as a leading practice that can be used as a template for I/I.	Many activities are recommended in the short-term and long-term to address various stakeholder needs for information.
Peer Review	No other agencies had their Strategy peer reviewed in such a formal manner.	Peer review and Best-in-Class review process is considered very progressive.	The Region's process is considered leading edge.
Audit and measures processes	Volumetric measure and analysis was identified as credible approach although peak flow reduction (i.e., elimination of overflows) is the primary driver for most other programs. (MMSD)	The Region's current analysis and approach was identified as leading edge and progressive by both Industry Scan and Peer Review processes.	Significant activities for audit and measure of flow reduction have been identified in the Strategy.
Annual MOE and interagency reporting	Metro Vancouver and U.S. agencies have strict reporting requirements (especially those under consent decree)	The Region and agencies do not currently report I/I reduction or targets.	Strategy includes a number of activities related to reporting of program status (interagency and to MOE)
Continuous improvement	Not mentioned in many strategies. Peer reviewers indicated that there is a need to ensure the Strategy evolves over time.	The Region currently has no formal process in place, although the Region has developed a comprehensive sewer management framework.	Strategy includes a section on continuous improvement activities that are recommended to ensure Strategy continues to be current and reflective of changes to technologies, etc.

3.0 2011-2031 I/I Reduction Strategy

The Strategy is a document formulated to describe the recommended processes and the implementation sequence of programs for the Region and the local municipalities to reduce wet weather flows from entering the separated sewer systems within the Region.

3.1 Strategy Introduction

This Strategy outlines the efforts that the Region and the local municipalities feel are important for reducing wet weather flows and meeting the requirements of the Minister's conditions and commitments contained in the Southeast Collector Trunk Sewer (SEC) Individual Environmental Assessment (IEA) described earlier. The Strategy has been developed by highlighting the key processes to reduce inflow/infiltration (I/I) through an intense study of current programs undertaken by leading industry practitioners. The resulting action plan described within this Strategy document is based upon the Region's previous project experience, input by the various working groups, and findings from the Industry Practices Scan.

The Strategy is comprised of eight key program areas and program activities:

1. Overall program goals and I/I targets
2. Monitor and analyze flows
3. Investigate and mitigate
4. New construction and capital projects
5. Financial management
6. Communication, education, and advocacy
7. Report I/I reduction
8. Continuous improvement

This Strategy speaks to each program area and describes the required activities and the short-term and long-term goals and deliverables for each program area.

3.2 Governance Structure

The Region is not unique in the governance structure as a two-tier wastewater service provider. Across North America, many multi-tier wastewater service providers have experience in developing and implementing I/I programs. These agencies often have rigorous reporting requirements to environmental agencies such as the USEPA. As described in Section 1, the Region is responsible for the supply and storage of all municipal water through pumping stations, storage tanks, wells and reservoirs, and water distribution systems within the Region. The Region sells water in bulk to the nine local municipalities, which in turn distribute and sell it to end users. Sewage from most of the communities in the Region is collected through a combination of local municipal and Regional sewer systems. The Region is responsible for major pumping stations, trunk sewers, and treatment facilities and their critical components.

Similar to the Region, many agencies and municipalities across North America are working to implement practices and develop short-term and long-term plans to respond to I/I in a more proactive manner. A component of the industry practices scan involved researching agencies that have similar wastewater governance or reporting structures.

The focus of the review was to identify potential guidelines, criteria, and agreements/annual reports that define or support the attainment of I/I reduction goals. The results were used to establish which governance system model may work best within the current operating environment.

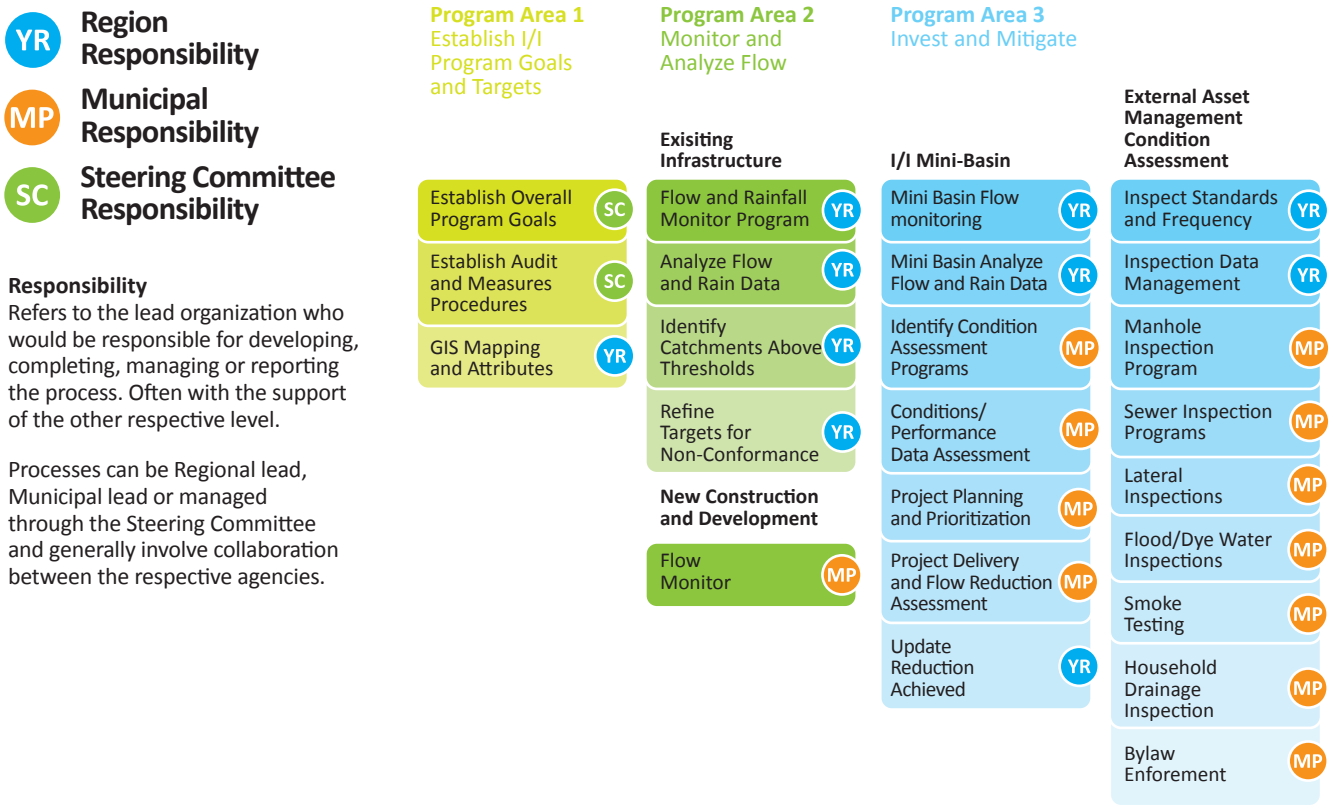


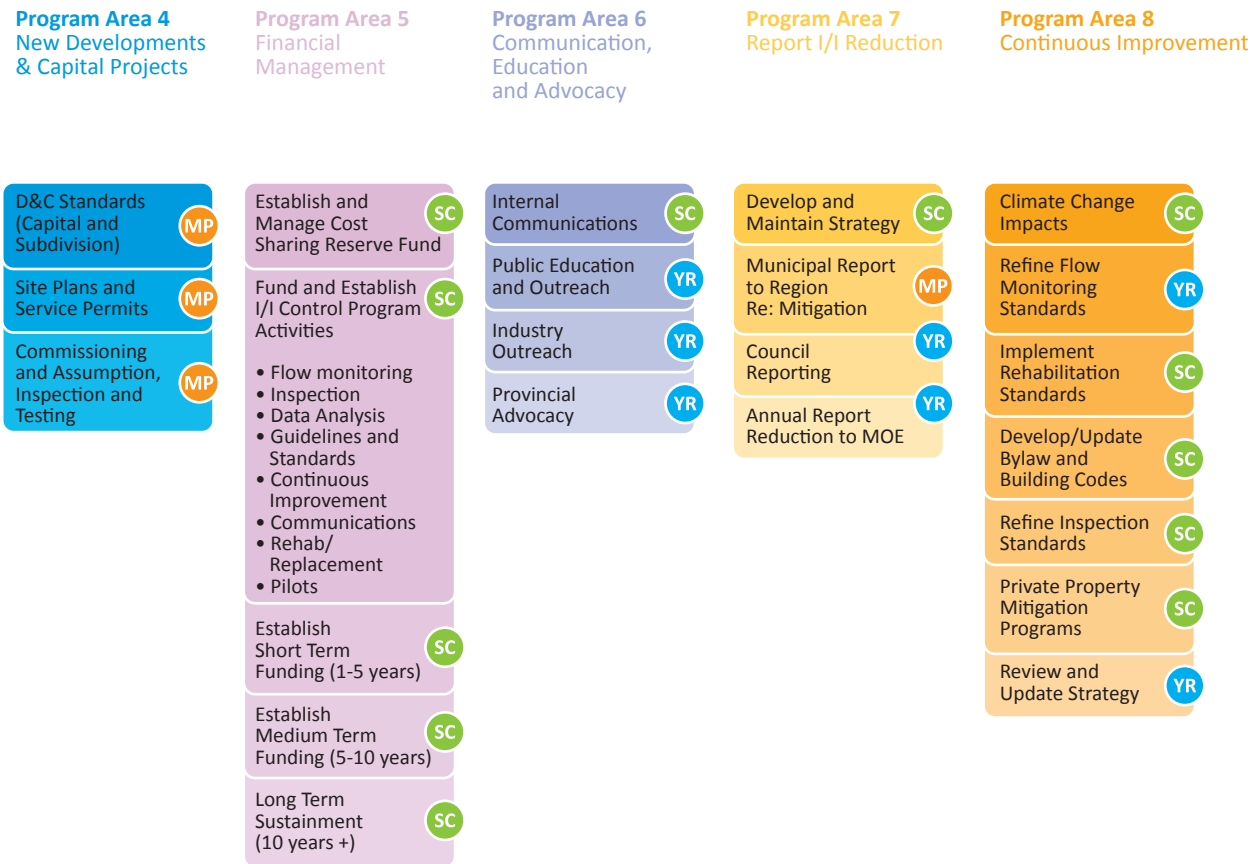
Figure 9: Program Areas and Activities Matrix

The multi-tier collaborative approach to I/I reduction is one in which the senior level (in this case the Region) may or may not set actual reduction goals or targets but the senior level works in a very collaborative manner with the lower tier agencies. In some instances, simple high level goals could be established between agencies such as "reduce extraneous flows coming into the sewerage system". Regardless of the program goals, the upper tier municipality acts more as an active partner in the program. They provide collaborative support to communities in areas such as public education, engineering, technical support, flow monitoring, and in some instances funding or some form of cost sharing mechanism. The senior level agency often works with the local communities to develop and guide the preparation and implementation of area wide I/I strategies.

In the development of this Strategy, the Region and the local municipalities have worked in collaboration to identify the various activities and the respective roles of their organizations.

Figure 9 provides an overview of the various program areas and program activities that are included within the Strategy.

Specific activities have been identified as led either by the Region or a local municipality, or in many cases, a Water and the Steering Committee comprised of representatives from both levels. In many cases, regular communications and ongoing commitment to the various working groups is required to ensure that the program progresses in a uniform manner.



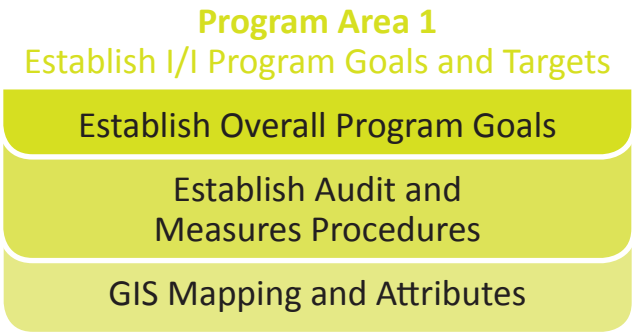
3.3 Program Area 1 - Establish I/I Program Goals and Targets

The reduction of I/I flows is a long-term program and commitment, one that the Region and its member municipalities are committed to addressing over the next 20 years.

3.3.1 Establish Overall Program Goals

The 2011 – 2015 goals of the Region and the local municipalities are:

- Work collaboratively with the municipalities and gain acceptance and endorsement of this Strategy including the goals, targets and tactics to be used.
- Define a preliminary target for I/I reduction that will be used as the starting point and refined over time.
- Implement pilot projects in catchment basins building on the Phase 1 rehabilitation projects including work on private property.
- Increase the amount of flow monitoring in audit basins to support an audit and measurement process.
- Continue to analyze flow data and establish priority basins for future I/I remediation projects.
- Adopt an audit and measure process that can be used to track the success of I/I reduction over time.
- Continue to refine new construction and commissioning standards ensuring that new infrastructure produces very little or almost no I/I.
- Establish and implement financial models and possible revenue streams, and to secure endorsement of the funding model by Regional and local councils.
- Complete the development and implementation of a regionwide wastewater hydraulic model.
- Ensure, as part of continuous improvement, the coordination with rainwater/stormwater and low impact development planning to preserve water resources.



At the highest levels, the long-term goals of the Region and the local municipalities are:

- Reduce I/I over a 20-year period into the SEC.
- Support continuous improvement activities required to enhance the Strategy over time.
- Minimize total conveyance, treatment, and disposal system costs.
- Implement a long-term program based on the programs described in this Strategy that meets the conditions set forth by the MOE for the SEC IEA.

Through the development of this Strategy, the Region and local municipalities commit to:

- Develop, endorse, and refine this Strategy including the programs, goals, and intermunicipal and regulatory reporting requirements for a staged reduction of I/I over the next 20 years.
- Recommend to future councils that they commit funds for I/I reduction that are economically justified by the avoidance of future costs to treat and convey I/I.
- Measure wastewater flows before and after carrying out construction/rehabilitation work on sewers and to document I/I expenditures and flow reduction measures.
- Use the information for future I/I reduction processes.
- Coordinate the efforts of I/I reduction with water efficiency and conservation initiatives.
- Continue to work together collaboratively over the life of the Strategy and to commit the appropriate staffing and financial resources towards implementing the Strategy.

An instantaneous peak flow reduction of 10% within the SEC under a 25-year storm event was the target outlined in the SEC IEA. This amount of instantaneous peak reduction corresponds to a volumetric reduction of approximately 71 mega litres (ML) over a 24-hour period under a 25-year storm event. Reducing this volume will be accomplished through the combined efforts of the long-term water conservation strategy and I/I reduction through better construction and commissioning standards and system rehabilitation as part of the Strategy.

Recent preliminary assessment has indicated that long-term water conservation strategy would contribute 40% to 50% of the overall reduction required; leaving approximately 40 MLD targeted for I/I reduction.

3.3.2 Long-Term Water Conservation Strategy

In addition to this Strategy, the Minister's conditions required the Region to develop a long-term water conservation strategy similar to the process and guidelines of this Strategy. These two Strategies will be critical in the overall flow reduction strategy of the SEC project and IEA Conditions. The Region and municipalities will work in a collaborative nature and towards a common goal and target for both water efficiency and I/I reduction. The programs and activities identified within the respective strategies will form the basis of long-term asset management and will assist in meeting long-term sustainability goals and targets.

3.3.3 Establish Audit and Measures Procedures

The Minister's conditions require the Region to embark upon water conservation and I/I reductions to reduce flows into the SEC. Under the SEC IEA, the Region established a 10% instantaneous peak reduction in the SEC as an initial preliminary target. This Strategy includes a description of the activities required to support the audit and measures procedures, detailed steps of the processes can be found in Appendix A. Two major issues are associated with measuring and quantifying the success of I/I reduction against these criteria:

1. **Audit basin size:** Quantifying I/I reduction requires comparing wastewater flows prior to and after remediation is complete. The SEC service area has a total area of 34,295 hectares. With a basin this size, actual storm events are not distributed uniformly across such a large area and rainfall intensity can vary significantly across the service area. Therefore, the service area was divided into smaller geographic areas called audit basins to provide a better pre and post-rehabilitation comparison of flows. See Table 7 for Geographic Delineation of the York-Durham Sewage System (YDSS) and the characteristics of the various basins.

2. **Instantaneous peak versus volumetric approach:** Approximately 7,000 km of private and public sewers, 17 pumping stations, and 2 equalization tanks are components of the YDSS. Attenuation in such a large linear amount of sewer means that a substantial volume of unused sewer capacity exists during periods of dry weather flow. Flow is attenuated as sewage is routed through sewers and detained in the available volume of sewer pipe, at pump stations, and in equalization tanks. In addition, flow rates immediately downstream of pumping stations are governed by pump operating capacity regardless of the flow rate entering the stations. This natural flow attenuation and pump control makes it difficult to meaningfully audit I/I reduction activities that take place in the upper reaches of the YDSS service area when instantaneous flow is measured in the SEC. For example, I/I reduction upstream of the Leslie Street pumping station would have much less impact in reducing instantaneous flow rates in the SEC than I/I reduction efforts located closer to the SEC.

A more suitable methodology for the Region is to measure volumetric flow reduction. Volumetric reduction is not skewed by flow attenuation and

pumping. For mass balance, one unit of volume reduction upstream will generate one unit of volume reduction downstream.

It is the intent of the Region to promote I/I reduction for all nine local municipalities and to achieve a tighter sewer system across the entire region. A volumetric approach over the entire network will not favour carrying out I/I remediation work in one location over another due to attenuation or the effects of pumping.

In view of the above, the Region's preferred approach is to subdivide the SEC basin into smaller and more auditable basins (herein called audit basins), each with its own volumetric reduction target. The sum of volumetric reductions in all audit basins will equal the overall volumetric reduction in the service area tributary to the SEC.

The following discussion presents the methodology used to determine appropriate:

- Volumetric reduction target(s)
- Number and location of audit basins

Volumetric Reduction Target for SEC Service Area

In establishing a volumetric reduction target, it is recognized that the I/I reduction target will meet certain criteria. Specifically, I/I reduction targets will:

- Align with the 10% reduction in instantaneous peak flow reduction target identified in the SEC IEA.
- Use a target year that has some certainty in population projection.
- Be compatible with the approach used for setting water conservation targets.

To this end, it is proposed that the year 2031 be used as the target year as opposed to 2036 used in the SEC IEA. Year 2031 corresponds with the planning horizon adopted in the Places to Grow Act and is consistent with established population targets approved under the Regional Official Plan.

For flow volume measurement, a 24-hour duration is proposed. This aligns with the methods used to measure water consumption, as any period less than one day is skewed by diurnal variation.

To align with the 10% flow reduction target contemplated in the SEC IEA, the volumetric target is based on estimating the corresponding volumetric reduction of a hypothetical storm event that would produce a peak flow 10% less than the peak generated by the 25-year Chicago design storm in 2031. To this end, hydraulic modeling was used to generate two hydrographs (at the SEC) under:

1. a 25-year storm event in the year 2031
2. a hypothetical event that produces an instantaneous peak 10% less than the above.

Figure 10 below presents a graphic view of the two hydrographs.

The top curve represents the expected flow at the SEC (near Boxgrove) under a 25-year storm event in 2031. Simulation results predict the peak flow to be 13.3 cubic metres per second (m3/s). The lower curve represents a hypothetical event that generates a peak flow of 12.0 m3/s (10% less than 13.3 m3/s). As the analyses reveal, the difference in volumes is approximately 71 ML over a 24-hour period.

It is expected that water conservation will contribute 40% to 50% of the total required reduction of 71 MLD. With this, an overall I/I reduction target of 40 MLD was established for 2031 for I/I related initiatives.

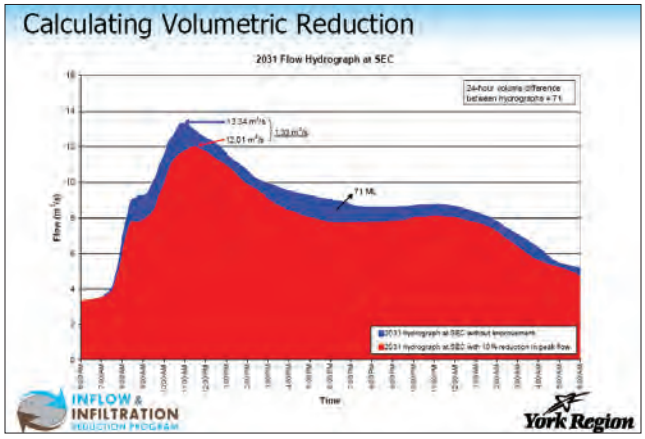


Figure 10: Calculating Volumetric Reduction

Volumetric Reduction Target for Audit Basins

Because of the attenuation issues and complexity of the Region's system as previously described, the entire service area tributary to the SEC was deemed too large to permit proper auditing at a system wide level. To address this issue, the service area will be divided into a series of increasingly smaller, nested drainage basins that would allow analysis, rehabilitation, and auditing to occur in reasonably sized geographic areas. This delineation is shown in Table 7.

Existing I/I volume, reduction targets and audit results will be modelled at the catchment level, analyzed at the mini basin level and reported at the audit basin level. Existing I/I volumes, I/I reduction targets, and successful I/I reduction will be reported at the audit basin level. Currently, the SEC service area is comprised of 160 audit basins. The number of audit basins will likely increase as the wastewater service area expands with development.

An example of how basins were delineated is shown in the Figure 11. The Newmarket Sewershed and its audit basin and mini basin configurations are displayed, where each unique colour represents wa different audit basin.

Table 7: Geographic Delineation of the York-Durham Sewage System

GEOGRAPHIC DELINEATION	NUMBER	AVG. AREA (HA)	AVG. LENGTH (KM)	DESCRIPTION
Service Area	1	33,374	2,751	Entire area draining to SEC
Sewer Shed	5	6,675	540	Municipality
Major Basin	53	630	51	Model calibration basins
Audit Basin	160	207	17	Level at which I/I reduction is audited
Mini Basin	450	100	7	SSES basins
Catchment	2,900	15	1	Model sub catchments

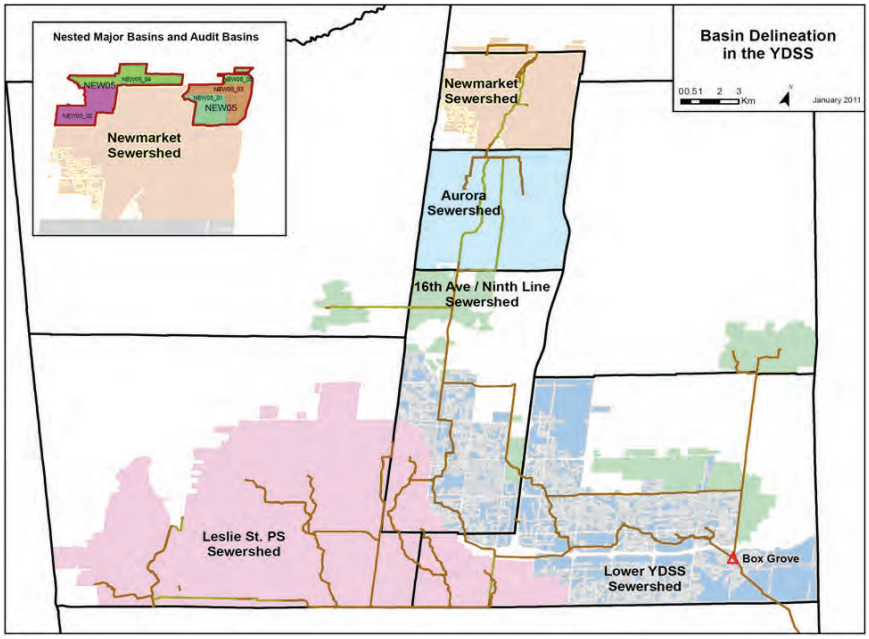


Figure 11: Sewershed Delineation

The reduction schedule (Figure 12 - Timeline to Achieve Goals) and timeline for achieving the wastewater reduction goals is preliminary and will be updated over time as progress is made through implementing the Strategy. The timing of activities is contingent upon successfully implementing the preceding activities.

In many cases, the activities form a critical path and are dependent upon one another to begin. For example, eliminating flows from private property through a downspout disconnection program may require policies and bylaws be changed and funding may need to be put in place to accommodate the work.

As information is gathered through the implementation of the various programs, the reduction schedule will be updated to reflect baseline flows and removal targets. A series of near term and ongoing activities will be required to permit adequate planning activities to be conducted and that resources are available to implement the Strategy. The following table indicates some of these anticipated activities.

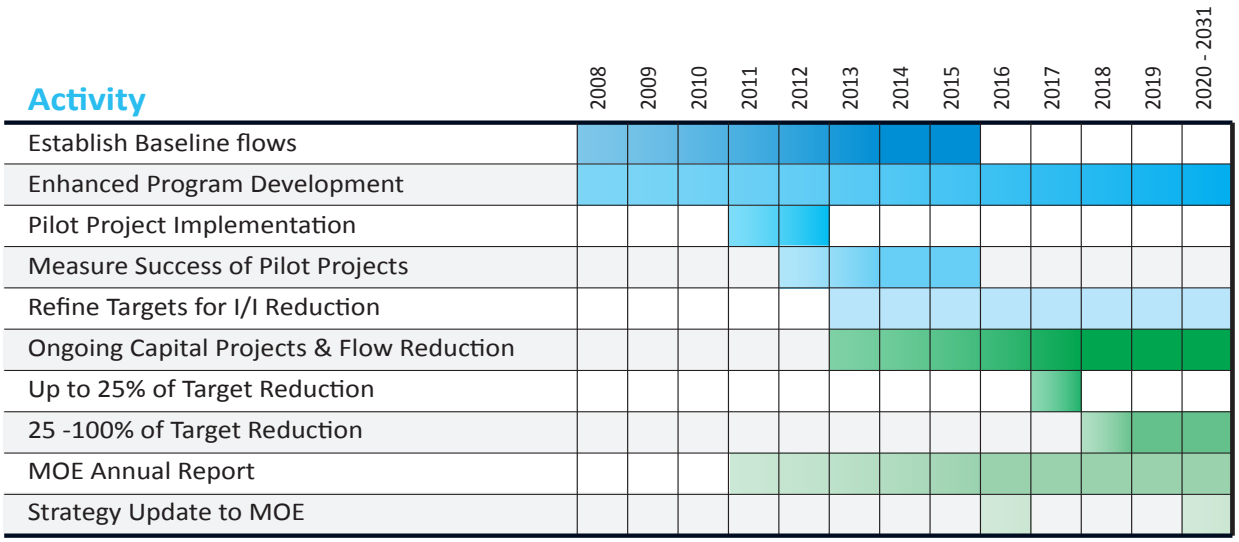


Figure 12: Timeline for Achieving Goals

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Management Plan	Annual performance management plan will be developed and submitted to the MOE	Region	March 31, 2011	Staffing required to manage overall performance
Strategy Update	The Region and local municipalities to update Strategy every 5 years as mandated in MOE conditions	Region	March 31, 2016	
Schedule Management	Update and maintain schedule based on actual progress and measured flow reduction versus targets	Region	Ongoing	
Resource Planning	Assess financial and staff resource levels on regular basis to support sustainability of program	The Steering Committee	Ongoing	

Establish Audit and Measures Procedures

Because I/I enters the YDSS through many processes, successful I/I reduction will be achieved by utilizing a broad range of techniques and methodologies. The Region plans to utilize the following process to accomplish this:

1. Install flow meters at strategic locations, which will identify geographic and hydraulically connected areas where extraneous flow enters the system.
2. Sanitary System Evaluation Studies (SSES) will be conducted, which include physical and electronic inspection of the system. The SSES will identify locations of specific defects and locations where groundwater, surface water, and other extraneous water enter the system.
3. An audit process spreadsheet will be used to tabulate remediation projects as they are undertaken, and actual I/I reduction is accomplished.
4. Graphical methods will be applied to estimate of projected rainfall derived inflow and infiltration of a synthetic 25-year design storm.
5. Hydraulic computer models will be used to estimate future wastewater flows and to test potential reduction strategies.
6. Decisions based on cost analysis, site conditions, effectiveness will be made to define the type of rehabilitation, repair, or operational enhancements that should be implemented.

The process for recording existing and future wastewater volumes (including I/I), for identifying reduction targets, and for tracking actual I/I reduction in the YDSS is referred in this document as the Audit, Measure, and Monitoring Process. This process is presented below.

Wastewater Flow Components

To determine I/I removal targets, it will be necessary to record or calculate the following elements of the flow regime in each audit basin:

- Dry weather flow (DWF) without rainfall derived inflow and infiltration (RDII) from recorded data;
- Peak wet weather flows from recorded data; and
- Predicted I/I volume during synthetic 25-year storm events (initially from graphical analysis, later from calibrated hydraulic models).

The DWF will be affected by population growth and sewage generated within each audit basin.

Flow Monitoring Program

A flow monitoring strategy will be defined in the early stages of the strategy implementation to support the audit process. This Strategy will include the use of recently recorded flow data in the Region and local municipalities to assist in establishing preliminary baseline flows. The Region and most of the local municipalities have data that can be used for this purpose.

It is anticipated that ongoing flow monitoring activities will be required throughout the course of implementing the Strategy. Flow data will be required at the mini basin level to determine where SSES activities will be conducted and to measure wastewater flows before and after rehabilitation activities. These data will also be used to assist in model calibration. As discussed previously, post construction flow data are required to determine the effectiveness of specific I/I reduction measures and to calculate whether reduction targets are being met.

Flow data will be required at the audit basin level to determine the I/I volumes that are available for removal and for audit and reporting purposes. It is anticipated that a combination of permanent and short duration flow monitoring sites will be established.

The Flow Monitoring Program requirements will include details such as flow meter type, meter accuracy, data review and management, meter relocation planning, etc. Example elements of the flow monitoring strategy could include the following processes:

- Install flow meters at the outlet of each audit basin.
- Install flow meters at the outlets of the mini basins.
- Use data to calculate I/I rates.
- Use data to construct flow vs. rain intensity graphs to project future I/I.
- Use data for model calibration.
- Conduct post construction flow monitoring.

Flow data obtained in the last 12 months, along with data from future flow monitoring activities within the audit basins, will used to establish preliminary baseline I/I rates for the 160 audit basins. The Region is currently monitoring wastewater flow and analyzing data at 45 locations, which measure flow at the major basin level. More information on the Regional Flow Monitoring Program can be found in Section 3.4 Monitor and Analyze Flows.

Sanitary Sewer Evaluation Studies (SSES)

Flow data will be used to quantify I/I rates, assign I/I volumes to specific mini basins and to provide information on where to focus increased physical and electronic inspections. SSES will be conducted in mini basins, which display excessive I/I.

The Region and several of the municipalities currently have SSES programs in place, and all have historical data of some kind that describes structural or operational problems that have occurred within their systems. These historical data will be evaluated along with new SSES data gathered during field investigations such as manhole inspections, smoke testing, sanitary sewer mainline closed circuit television (CCTV) inspections, and public/private lateral CCTV inspection to identify specific I/I sources. Data gathered during these activities will be used to identify specific locations and sources of extraneous flow and to identify specific I/I reduction projects.

Hydraulic Modeling

Numerical modeling will be a key technical component of the Strategy. The Region's current hydraulic model has been used to support various uses including master planning, establish initial design parameters for the SEC, and evaluate the impact of I/I reduction measures on the SEC. This work provides a good basis upon which to build and provide a consistent approach with previous activities. Hydraulic modeling will therefore form an integral part of the audit, measure, and monitoring process.

To assess the impact of I/I reduction programs in the local municipal collection systems, an all-pipe hydraulic computer model will be developed. The all-pipe model will include all pipes within the local collection systems, all subtrunks and trunk sewers comprising the YDSS and all pumping stations. The model will be capable of simulating hydraulic and hydrologic conditions in the YDSS. Existing and future wastewater flows across the system will be simulated and the impact of extraneous flow reduction measures on the system will be evaluated.

Since proposed reduction targets are based on a synthetic 25-year storm event, and measured flow data are for real storms that have different rainfall volume and intensities, development of a methodology to normalize measured flow rate to a 25-year theoretical flow rate is required. Numerical modelling will be a key component of the Region's I/I control strategy. The model will be calibrated using recorded storm events. The model will be used to predict wastewater flows (including I/I) during the synthetic 25-year storm event.

Audit Spreadsheet

A comprehensive audit spreadsheet will be developed to assist in tracking I/I reduction targets and achieved reductions.

During the early phase of Strategy implementation the spreadsheet will be used to track remediation projects and their corresponding I/I reductions. *I/I reduction volume will be estimated using the techniques described in Appendix A, Section D.5.

Figure 13 below presents a sample section from the audit spreadsheet. Additional parameters will be added to the audit spreadsheet, including existing flows and I/I reduction targets, as additional flow data are collected, existing I/I rates defined, and predictive tools are developed to accurately predict future I/I flows.

The spreadsheet will be updated on an annual basis or more frequently as new flow data are analyzed. Updates on the audit process will be provided with the annual report submitted to the MOE.

Figure 13: Excerpt from the Audit Process Spreadsheet

PROJECT ID	YEAR CONSTRUCTED	AUDIT BASIN	DESCRIPTION OF SYSTEM REHABILITATED	ESTIMATED I/I REDUCTION (MLD)*
M-10-1	2010	LES02_01	45 Downspout disconnections in Thornhill, Markham	0.8 MLD
A-10-01	2009 2010	AU01/AU05	8 linear kilometres on sewer rehabilitation (full length lining) in Aurora	Pending analysis of pre and post flow data
A-11-01	2011	AU01/AU03	Rehabilitation of 25 high priority manholes	Pending analysis of pre and post flow data

*I/I reduction volume will be estimated using the techniques described in Appendix A, Section D.5

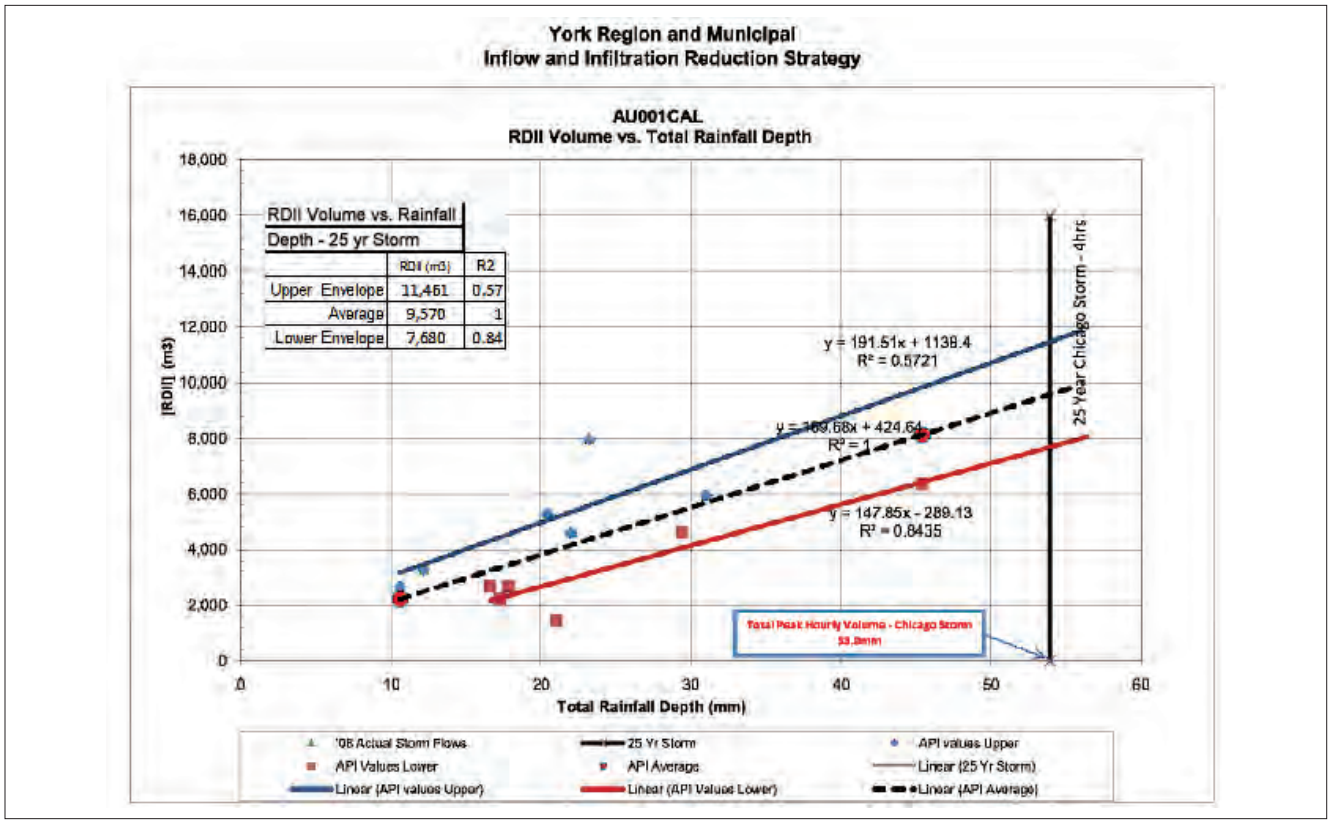
Normalizing Monitored Data to 25-year Synthetic Design Storm Projection

The overall reduction target is based on a 25-year design storm event. The likelihood of recording an actual storm event large enough to match the volume of the 25-year synthetic design storm is statistically remote. As a result, a method to normalize measured flows to establish a baseline flow for each audit basin under a 25-year design storm needs to be developed. This will be accomplished using a two-step approach:

1. Measured I/I flows will be evaluated graphically by preparing Q vs. I (RDII volume vs. rainfall depth) scatter graphs as shown on Figure 14. Preliminary 25-year RDII characteristics will be defined at each flow meter by fitting a best fit curve through the RDII values recorded for all storm events. Baseline flow will be determined through extrapolation of these points. Preliminary baseline rates will be defined and revised annually or as warranted as additional flow data become available.
2. Once sufficient flow data have been collected to support the development of a calibrated hydraulic model, hydraulic modelling will be used to establish final 25-year baseline flows for each audit basin.

A more detailed description of the audit and measure process is located in Appendix A.

Figure 14: I/I Volume vs. Rainfall Depth



3.3.4 GIS Mapping and Attributes

Sustainable management of the Region's wastewater depends to a large extent on the ability to efficiently share, exchange, and manage physical and location information of buried wastewater assets throughout their life cycle. Although many of the municipalities within the Region use tools to support almost every asset management process, data exchange is mainly done using neutral file formats based on municipal specific data models or an ad-hoc structure for one time hydraulic modeling projects.

This results in an inability to concisely transfer wastewater asset information that has created inefficiencies and impedes sustainability. Wastewater data interoperability is crucial to support better management of infrastructure data, to improve information flow, and to streamline I/I workflow processes.

Experience obtained by the Region through previous projects indicates that many problems and inefficiencies in data access, exchange, and management exist. In the case of the wastewater network, the infrastructure and flow routes between the local municipal and Regional systems are integrated and the analysis of information, flows, capacities, etc. (i.e., hydraulic modeling) is dependent upon having a seamless and current base to work from regardless of the ownership of the asset. Going forward, a major challenge is how to support the integration and efficient sharing and exchange of geographic and attribute data among the local municipalities and the Region.

To address this challenge, standardized methods to model, validate, and exchange wastewater data will need to be adopted using mechanisms such as the existing YorkInfo Partnership. Standardizing the representation of the Region's wastewater collection system data would enable interoperability and exchange. A standard Regional wastewater data model would provide a schematic for representing and exchanging the wastewater infrastructure data including spatial and non-spatial objects, attributes, and interrelationships. The Region's wastewater geodatabase data model will be "ready to use" and would require customizing and configuring for the local municipalities who may not have the resources or technical capacity to build and maintain such a model.

A Regional standardized approach to wastewater information management will increase accuracy, decrease costs, and enhance the exchange of information between the Region and the local municipalities. This data management framework will also enhance the conversion of data between GIS and CAD environments. The results of which:

- Can be used across the Region and local municipalities.
- Meet the primary needs of all YorkInfo partners and disciplines.
- Facilitate the exchange and sharing of information and data.
- Eliminate disparate standards currently in place.
- Help to ensure the usability and quality of Regional spatial wastewater data.
- Will be a common geo-referencing platform for sharing data.
- Can benefit both upper and lower tier municipalities.

It has also been recognised that the complete network includes private side laterals. At the moment, neither the Regional nor local municipal GIS systems capture private side laterals.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Lateral Mapping	Develop mapping requirements for laying out and identifying sewer connection laterals.	YorkInfo Partners The Region	2011-2012	GIS/Database Management technical staffing
Household Drainage Data Collection	Complete review and compile plumbing cards and as-built records to determine historic plumbing connections of storm to sanitary system (downspouts, foundation drains)	Region/ Municipal Team	2012-2013	
Data Exchange Protocols	Develop data exchange processes and procedures for pushing and pulling sewer related information into one central repository and providing to local municipalities via mechanisms such as ESRI Web Mapping Services.	YorkInfo Partners The Region	2011	
Common Regional Asset Identification System	Develop asset identification system that can be adopted by the local municipalities who do not have a wastewater GIS in place.	YorkInfo Partners The Region	2011	
Lower Tier Wastewater GIS Mapping and Attribution	Aid smaller local municipalities through the YorkInfo Partnership who may not have the technical resources to map and attribute wastewater assets. Focus on minimum attribution including: diameter, material, depth, installation year, upstream manhole, downstream manhole.	YorkInfo Partners	2012	
Metadata Standards	Develop tools for local municipalities to search and retrieve relevant spatial sewer information.	YorkInfo Partners	2012	
Wastewater Geodatabase modification	Modify geodatabase model to include sewer collection attributes in addition to the conveyance asset.	YorkInfo Partners The Region	2013	

3.4 Program Area 2 - Monitor and Analyze Flows

Flow monitoring and data analysis during dry and wet weather conditions help to identify areas that are subject to excessive I/I. Flow monitoring is important in assessing the I/I portion of the total wastewater volume collected within the sewer system.

I/I flows can be highly variable depending on factors such as seasonal groundwater table fluctuation, snow pack, and antecedent moisture condition. Continuous flow monitoring over a sufficient time period is necessary to reveal these variations in flow. In addition, the overflows and emergency pumping from the system will also be monitored as a part of the program.

The Region and the local municipalities will utilize a network of short duration and continuous flow monitors to track the changes to I/I rates over time and determine flow rates under a variety of seasonal conditions.

3.4.1 Flow & Rainfall Monitoring Program

A flow monitoring strategy will be defined in the early stages of the implementation of the Strategy. It is anticipated that ongoing flow monitoring activities will be required throughout the Strategy implementation.

Where possible, recently recorded flow data will be used to establish baseline flows. The majority of the 122 flow meters acquired by the Region in 2008 have been in constant use at various locations around the region, monitoring a variety of drainage basins ranging from small mini basins to entire sewersheds. Additional flow metering technology has been utilized to monitor major trunks including a single meter that can measure the entire YDSS service area. The technology used to date has proven to be accurate and reliable and will form part of the overall flow monitoring strategy.

It is recognized that a variety of flow metering technologies will be required to meet the needs of the

Program Area 2
Monitor and Analyze Flows

AUDIT BASIN LEVEL

- Flow and Rainfall Monitor Program
- Analyze Flow and Rain Data
- Identity Catchments above Thresholds
- Refine Targets for Non-Conformance

NEW CONSTRUCTION AND DEVELOPMENTS

- Flow and Rainfall Monitor Program

Strategy. The flow monitoring strategy must balance the cost / benefit of various technologies and also consider site specific and hydraulic conditions. Based upon industry experience, matching the flow monitoring technology with local site and hydraulic conditions will yield the most favourable results. For instance, due to depth and debris issues, shallow and fast flows may not be accurately measured using the Region's existing ISCO flow monitoring devices that use sensors installed in the pipe. The selection of the appropriate flow monitoring technology is dependent on the need for accuracy, pipe diameters, flow rates, accessibility, costs, and a number of other factors. The flow monitoring program will include details such as flow meter type, meter accuracy, data quality and management procedures, meter relocation planning, etc.

Regardless of the program established, quality data are the building blocks of future analyses. Meter uptime and data quality are critical. The flow monitoring program must define how the Region or its contractors will verify meter accuracy, including the frequency of verification and acceptable margins of error. Today, since most Regional devices are not connected to remote databases, flow monitoring quality assurance is completed through site visits and manual verification of depth and velocity. A detailed criteria for quality control and accepting data needs to be established.

Permanent Trunk / Municipal Monitoring

It is anticipated that a combination of permanent and short duration flow monitoring sites will be required to effectively monitor and report at the trunk and local municipal level. Permanent metering sites will be connected to SCADA and provide overall flows for a sewershed or flows crossing municipal borders. These are important for operational purposes, creating an overall service area mass balance, and providing QA/QC check points for the monitoring taking place upstream at the major basin and audit basin levels. Currently, the Region has numerous permanent meter installations and has actively managed these sites over the years through various operational and maintenance programs to assess their condition, the quality of the data, and to provide upgrades and enhancements as required. The ongoing permanent metering activities will be coordinated with this Strategy to ensure common permanent flow monitoring objectives are achieved. It is anticipated that 9 to 15 permanent meter locations connected to SCADA will be required for this purpose.

The Region has recently embarked on a program to complete a condition assessment for six flumes in the YDSS. Currently, these flow monitoring flumes are used to measure flows and maintain flow records electronically and temporarily. It is imperative that these structures are operating effectively and efficiently to provide the necessary flow monitoring data required in the I/I flow reduction program. Completion of the condition assessment will provide recommendations for improvements/replacements of the flumes if necessary.

Audit Basin

Flow data are required at the audit basin level on a permanent basis to determine the I/I volumes that are available for removal and for audit and reporting purposes. A complete flow monitoring strategy will be developed to include continuous flow monitoring in each of the 160 audit basins. It is anticipated that development of the full monitoring network will be completed within 2 years with the installation of 100 monitoring locations per year. The existing inventory of flow meters can be utilized initially to increase the number of audit basins being monitored as new equipment is acquired. It is anticipated that the number of flow monitors introduced early in the program to establish baseline flows will increase. Appropriate technology for each audit basin will be considered, which optimizes the long-term monitoring requirements against the annual operation and maintenance costs. Where appropriate, links to SCADA and / or telemetry will be considered at the audit basin level. It should be noted that the flow monitoring plan will need to determine the appropriate hardware selection based on the hydraulic conditions of the site. While the Region's existing meters used to date (ISCO 2150s) can be utilized in many locations, this inventory will need to be enhanced with different technologies.

An implementation schedule will be developed based on financial resources and staff availability. Locations will be prioritized based on analysis of the 2008 – 2010 flow monitoring data.

Mini Basin

Flow monitoring at the mini basin level is required to determine where SSES activities will be conducted and to measure wastewater flows before and after rehabilitation activities. These data will also be used to assist in model calibration and further characterize the audit basin. It is anticipated that 50–100 mini basins will be monitored on a rotating annual basis. The existing inventory of flow meters will be utilized for this purpose.

Post Construction

Post construction flow data are required to determine the effectiveness of specific I/I reduction measures and to calculate whether reduction targets are being met. Post construction flow monitoring will occur immediately following the completion of remediation projects to verify the flow reduction achieved. The existing inventory of flow meters will be utilized for this purpose at an estimated 10 sites per year. The duration of post construction flow monitoring will be dictated primarily by the weather that occurs after construction because it is important to capture normal and above normal precipitation levels to confirm the success in flow reduction.

New Development Areas

The I/I reduction targets of 40 MLD is achieved through better construction standards and system rehabilitation. It is important to monitor the flow in newly commissioned subdivisions to provide the necessary data to quantify the I/I reductions, as well as to assess I/I rates under current construction/ inspection procedures and to align with development of commissioning standards Future evaluations of the current commissioning procedures will establish flow monitoring requirements for new developments prior to the assumption period. The Region's existing inventory of flow meters will be utilized for this purpose at an estimated five sites per year until such a time as the commissioning process is enhanced. A program activity has been recommended that would review the requirements and develop new business processes for completing flow monitoring activities within new developments (refer to section 3.10.5, Refine Inspection Standards). A detailed report, entitled Sanitary Sewer Commissioning Guidelines, describes the processes and procedures for inspection infrastructure prior to assumption by the municipalities.

Rainfall Monitoring

The Region also maintains a network of 22 tipping bucket rain gauges distributed across the region to measure rain events. The majority of rain gauges are heated, which minimizes lost data due to freezing weather and the heat converts snowfall to an equivalent rainfall depth. The current rain gauge site locations will be reviewed to ensure sufficient spatial distribution to support the flow monitoring strategy. Rain data are currently collected at 5-minute intervals.

In addition to using conventional rain gauges at fixed locations, radar-calibrated rainfall data systems are becoming popular due to advantages that they offer over conventional rainfall monitoring networks. Fixed location rain gauges, distributed widely across the service area, do not represent where the rain actually falls across the service area because they are merely point samples. With rainfall events becoming more localized, the use of radar to determine how rain fell between monitoring points will be a useful tool in flow monitoring analysis. The Region will continue to use existing rainfall monitoring methods but will assess the use of virtual radar based rainfall data in the future.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Trunk / Municipal System	Establish flow monitoring program for permanent continuous monitoring of the municipal trunk system (approx 9 to 15 locations)	The Region	2011-2016	Capital cost to acquire and install permanent meters over a 3-year to 5-year period
Flow Monitoring	Establish flow monitoring data quality assurance procedures	The Region	2011	Standards committee to develop documented procedures for data quality assurance.
Rainfall Monitoring	The Region to review coverage of rain gauges and assess usefulness of virtual rain gauge network to support ongoing data analysis.	The Region	2011-2012	Standards and Audit working groups to work together to determine technical requirements.
Audit Basins	Develop implementation strategy to install permanent flow monitors at 160 audit basins over a 2-year period. Strategy to include resource requirements, technical standards, flow monitor selection, and funding provisions.	The Region	2011-2016	Annual capital cost over 2 years to acquire (where required) and install 160 new meters. Estimated installation of 80 monitors per year, utilizing the Region's current meter inventory where feasible. Ongoing annual cost to maintain meters and analyze data.
Mini Basins	Continue flow monitoring at approximately 20-30 mini basins, based on audit basin analysis or ongoing condition assessment results. Results from flow monitoring at mini basins will characterize and be rolled up and reported at the audit basin level.	Local Municipalities	ongoing	Use the Region's current flow meter inventory. Capital cost to replace Region's current inventory of flow meters (required 2016 to 2018). Ongoing annual cost to maintain meters and analyze data.
Post Construction	Monitor pilot rehabilitation program sites or other municipal rehabilitation sites as they are completed.	Local Municipalities	ongoing	Use the Region's current flow meter inventory at an estimated 10 sites per year.
New Development	Establish flow monitoring in a subset of newly commissioned subdivisions to assess I/I rates under current construction & inspection procedures, align with development commissioning standards.	Local Municipalities	ongoing	Use the Region's current flow meter inventory at an estimated 5 sites per year. Ongoing annual cost to maintain meters and analyze data.

3.4.2 Analyze Flow and Rain Data

During the Region and Local Municipal Inflow and Infiltration Reduction Pilot Program - Phase 1 project in 2008-2010, the Region developed comprehensive I/I analysis procedures. These will continue to be used in future years of the Strategy. A summary of the analysis procedures is described further below. The details of the analysis approach can be found within the Region and Municipal Inflow and Infiltration Reduction Program - Phase 1 project report from 2010 (AECOM Canada Ltd).

The major activities used in the analysis of I/I related flows are generally:

- Rainfall analysis
- Dry weather flow analysis, including base flow and base infiltration rates
- Wet weather flow analysis
- I/I characterization and prioritization.

Rainfall Analysis

By analyzing each rain event (a rain event consists of 10 mm of rainfall within a 24-hour period), a return period (the likelihood or probability that an event with a specified intensity and duration will occur, is called the return period or frequency). Estimates can be developed for the peak, 24-hour, 48-hour and successively larger continuous peak durations of rainfall. By using return period as a measure of the rainfall depth/intensity for each peak event, the Region can correlate the "return frequency" of the rainfall occurrence to the flow rate in the wastewater system triggered by rainfall against current intensity, frequency and duration (IDF) curves. For I/I studies, I/I estimates can be developed by using the IDF relationship and then extrapolating flow estimates.

Dry Weather Analysis

At its simplest, the calculation of I/I is the subtraction of 'normal' dry weather flow from wet weather flow. To isolate these two conditions, dry weather flow must be determined. Periods of dry weather sanitary flow at each flow metering site are identified and documented, allowing baseline flows to be established for each catchment for dry weather conditions. This information is used to determine I/I volumes and to analyze the effects that antecedent moisture conditions (a hydrologic term that describes the relative wetness or dryness of the soil condition) within the catchment have on sewage flows.

A dry weather period is defined to be 5 dry days within an 8-day period (or more) without rain. Precipitation events totalling 5 mm of rainfall or less are deemed insignificant and were considered as a dry weather day. During the analysis of dry weather periods in the audit basins and the corresponding flow data, the base infiltration rates across each basin will be calculated.

Wet Weather Analysis

Many factors need to be considered in determining and quantifying I/I because no single factor in isolation can tell the complete story. The analysis of wet weather events is started by identifying the largest instantaneous peak flow rate recorded by the flow monitor during a rain event. From that point, a number of other components such as flow and volumetric peaking factors as well as total volumes of clear water entering the sanitary system are calculated. This rainfall derived I/I (RDII) volume was applied to both the overland area and the physical volume of sanitary sewers in a catchment to normalize calculated results over a range of different sized catchments and communities for comparative analysis. In addition, recorded peak flows and their storm intensities will be graphed to predict system behaviours over a range of storm events, which may not have been experienced during the current monitoring period.

The following criteria will be reviewed during analysis of dry weather and wet weather conditions:

- Criteria 1. Instantaneous Peaking Factor (average daily dry weather flow to instantaneous wet weather response)
- Criteria 2. Rainfall Derived Inflow and Infiltration (RDII) per Pipe Area (lpd/mm-km)
- Criteria 3. RDII (m3)
- Criteria 4. Peak I/I Flow per Area (l/s/Ha)
- Criteria 5. Percentage of Rain Entering System (Volumetric Coefficient)
- Criteria 6. Base Infiltration (BI) (l/s)
- Criteria 7. Peak to Average Daily/Hourly Flow Rates.

A useful tool for predicting a sanitary system's reaction to different frequency wet weather events is a peak flow versus intensity graph as shown on Figure 15. Using the peak 30-minute intensity/1-hour duration and plotting it against the peak instantaneous flows observed at the corresponding flow monitor during the event, a straight line correlation can be made between both sets of values as a mean together with a maximum and minimum line. This relationship can be used to estimate peak flows (maximum, average, and minimum) during rain events that may not have been observed during the project monitoring period. However, care should be taken if this approach is used to extrapolate beyond the limits of collected project data, as the catchment may behave differently for larger (or smaller) events, and the amount of flow under larger events will tend to hit a maximum range due to upstream attenuation, hydraulics, restrictions, overflows, etc

As a general rule, a minimum of 10 data points should be used for these projections. Although no control over the rainfall events during the gauging period is possible, these projections tend to deliver representative results when a wide range of values is present for both rainfall totals and peak intensities. These projections can also be compared to the theoretical capacity of the sanitary sewer at the monitoring location to determine if sewer backups are likely or if the system has other deficiencies.

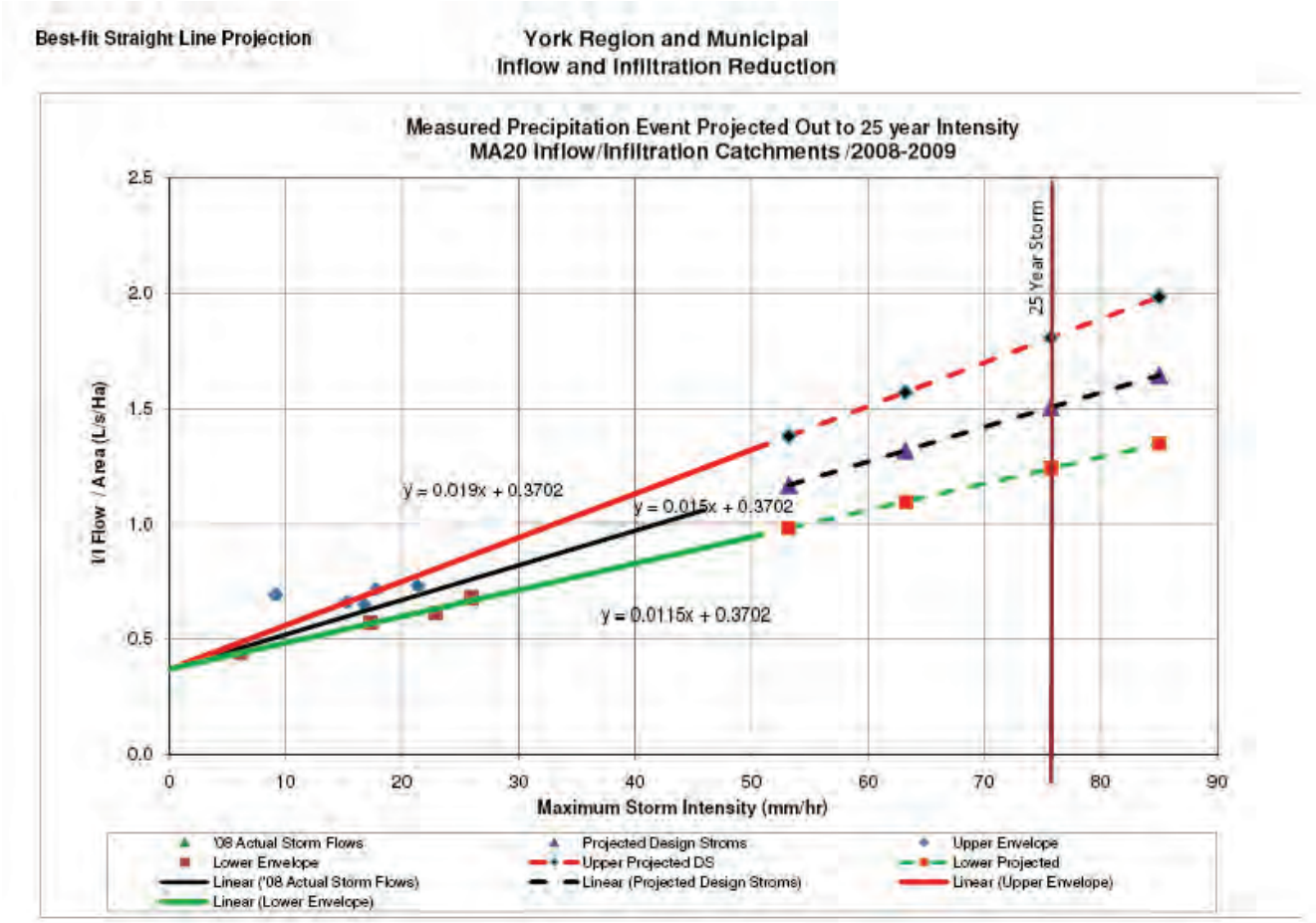


Figure 15: Peak Flow Intensity Graph

Individual Catchment Analysis

During this stage, a number of components such as flow and volumetric peaking factors as well as total volumes of clear water entering the sanitary system will be calculated. RDII volume will be compared to both the catchment area and the physical amount of sanitary sewers in a catchment to normalize calculated results.

The following components will be evaluated during this analysis (Figure 16):

- The type of response in each catchment to be determined; that is, low, medium, or high infiltration with low, medium, or high inflow.
- I/I volumes (RDII) of the maximum recorded response during a given rain event to be quantified to determine how reactive each catchment is to the event.
- The groundwater infiltration (GWI) for each catchment will be identified, seasonal patterns analyzed, and variation throughout the year determined.
- The minimum night time level and flow will be identified to isolate potential maintenance and operation requirements/debris issues.
- Wastewater generation per catchment will be established.
- Volumetric peaking factor is calculated as this provides a more representative measure of the overall RDII than using flow rates alone.
- Calculation of RDII volume for wet weather events will be completed.

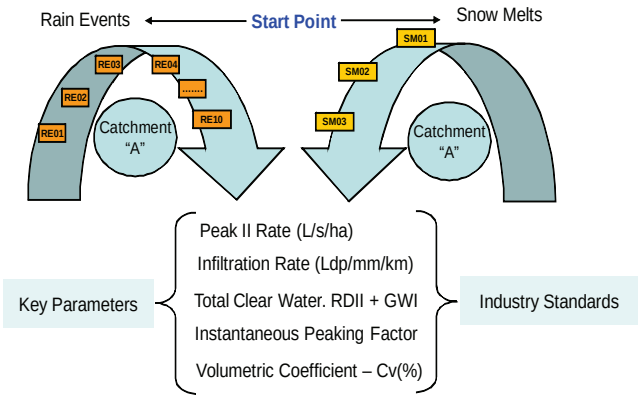


Figure 16: Catchment Analysis

A complete description of the wet weather components and calculated values is summarized in tabular format as shown in Figure 17 below.

Prioritization	Site ID	Storm / Snowmelt	Instantaneous Peaking Factor	RDII per Pipe Area (Lpd/mm-km)	% of Rain Entering System	York Region (Towns) Peak I/I Flow per hectare (Inflow+Infiltration)	MOE Ontario Design Guidelines (Infiltration_Total Clear water)
	Site ID	[ID]	H/D	R*1000/T	R/Y		

Prioritization	Site ID	Max. Snow Melt / Max. Rain	Min, / Max.	Summary of MAXIMUM RESPONSES all events			
				L/s/ha < 0.25 (Low) 0.28 <L/s/ha< 0.35 (Medium) L/s/ha> 0.35 (High)	RDII per Pipe Area (Lpd/mm-km)	Average Instantaneous Peaking Factor (4-6X medium, >6 high)	Average CV (> 5% high)

Figure 17: Description of Wet Weather Components and Values

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Rainfall Analysis	Review current rainfall analysis tools, data management processes, and assess effectiveness.	Region	2011	Provide technical staff and analytical tools to perform data analysis procedures.
Flow Analysis	Complete assessment of EI technologies software versus previous methodologies used in pilot project.	Region		
Analyse Thresholds	Review individual rain event thresholds on regular basis to ensure they adequately reflect the severity and extent of flows in the Region's system.	Region	2011 and beyond	
Flow Analysis (Mini Basins)	Complete the detailed flow analysis of 2009 and beyond mini basins to determine extent of I/I. Update list of priority sites based on findings.	Region		
Flow Analysis (Audit Basins)	Complete analysis on a regular basis of the 2011 and beyond audit basins (30-160 locations) and determine I/I rates within these areas. Use information to establish priorities for flow monitoring and follow-up activities in mini basins.	Region		

3.4.3 Identify Catchments above Thresholds

The Region has developed and will continue to utilize a colour coding system for plotting the I/I responses for each event. Table 8 below summarizes the colour coding for factors and thresholds. Audit basins will be analyzed using the key factors identified in the following table. Based on the results of the analysis, the audit basin will be categorized as a low priority (green), medium priority (yellow), or high priority (red). After priorities are set, rehabilitation or repair work will be undertaken and I/I levels will be measured. If levels are not acceptable, additional work will be undertaken and I/I levels will be measured until they meet acceptable levels.

Table 9 demonstrates a typical site and the application of the colour coding system.

Table 8: Factors and Thresholds

KEY FACTORS FOR PRIORITIZATION	RANGES & COLOUR CODING
Instantaneous Peaking Factor (Flow Peak/Flow Average)	PF < 4 (low)
	4 < PF < 6 (medium)
	PF > 6 (high)
RDII per Pipe Area (Lpd/mm-km)	RDII < 280 (low)
	280 < RDII < 560 (medium)
	RDII > 560 (high)
% of Rain Entering System (%)	Cv < 5% (low)
	Cv > 5% (high)
York Region (Towns) Peak I/I Flow per hectare (Inflow + Infiltration) (L/s/ha)	Flow/ha < 0.25 (low)
	0.25 < Flow/ha < 0.35 (medium)
	Flow/ha > 0.35 (high)

Table 9: Individual Event Analysis

PRIORITIZATION	SITE ID	STORM/ SNOWMELT	INSTANTANEOUS PEAKING FACTOR	RDII PER PIPE AREA (LPD/ MM-KM)	% OF RAIN ENTERING SYSTEM	YORK REGION (TOWNS) PEAK I/I FLOW PER HECTARE (INFLOW + INFILTRATION)
High	AU01	storm1	4.1	20.2	0.2%	0.326
	AU01	storm2	5.1	54.6	0.7%	0.415
	AU01	storm3	6.7	361.7	1.6%	0.567
	AU01	storm4	3.2	138.6	1.6%	0.240
	AU01	storm5	3.2	255.9	3.2%	0.246
	AU01	storm6	4.2	237.9	2.8%	0.336
	AU01	storm7	2.5	174.9	3.2%	0.181
	AU01	storm8	3.9	435.2	5.3%	0.310
	AU01	storm9	2.9	201.5	7.7%	0.220
	AU01	storm10 - SM	6.0	1,330.0	20.3%	0.505
	AU01	storm11 - SM	6.7	1,491.0	9.8%	0.665

Upon assessment of all rain events, a catchment prioritization is to be completed and a rating of low, medium, or high priority will be applied to the entire catchment. The colour coding of events and catchments allows for a quick visual geographic depiction of the system responses and priorities.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Catchment Analysis	Analyze flow data and determine I/I peaking factors, volumes to prioritize individual catchments.	Region	2011 and beyond	Provide technical staff and analytical tools to perform data analysis.
Analyze & update thresholds where appropriate	The Region and local municipalities review and refine the use of the stated thresholds as more information is gathered through Strategy implementation.	Audit & Measures Working Group	2011 and beyond	Provide technical staff to participate in the process.
Prioritize & Selection of Audit Basins	Select and prioritize individual audit basins for further investigation at the mini basin level.	Region	2011 and beyond	Provide technical staff and analytical tools to perform data analysis.

3.4.4 Refine Targets for Non-Conformance

Upon completion of the required investigation (SSES) activities, the potential flow reduction volume in each priority mini basin will be estimated. This stage will involve the review of the flow monitoring analysis results against the audit process and other historical data to estimate the potential flow reduction that can be achieved.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Analyze & update target reduction estimates	The Region to review the consolidated mini basin analysis results against the audit process and other historical data to estimate the potential flow reduction that can be achieved	Audit & Measures Working Group	2011 and beyond	Provide technical staff to participate in the process.

3.4.5 Flow Monitor New Developments

In the future, flow monitoring in new developments will be conducted upon assumption and/or during actual construction activities so that flow monitoring data will provide a baseline of current I/I leakage rates. Prior to monitoring new developments during the acceptance process, it will also be valuable to assess the flow rates experienced in other new areas (recently assumed). This information will provide insight into potential construction quality.

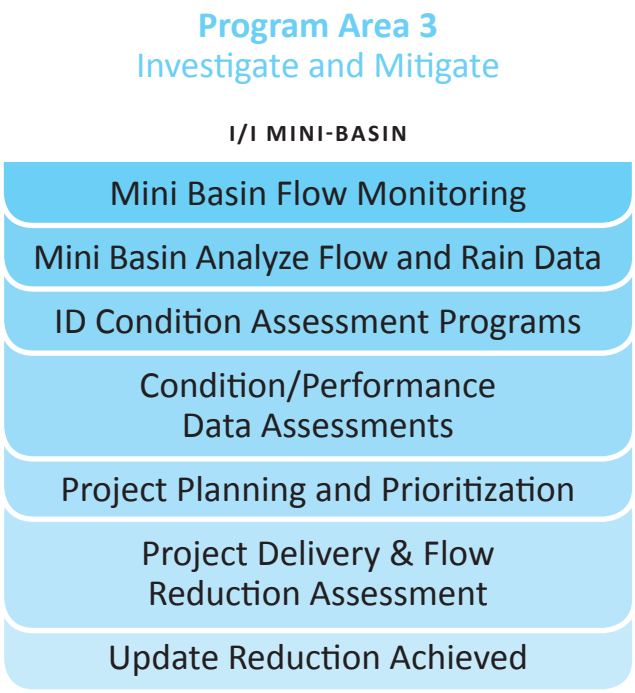
In 2011, 10 pilot metering sites were identified in recently assumed subdivisions to confirm the current I/I rates in new construction. Based on the results of this analysis, a review of current design guidelines could be required.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Flow Monitoring	Selection of 5-10 sites that have been recently assumed to determine existing I/I rates in relation to design allowance.	Region	2011	Short-term activity using contracted resources
Flow Monitoring	Review existing policies and standards to determine where it would be appropriate to include flow monitoring in the assumption/inspection stage.	Standards Working Group	2012	Region and local municipalities to ensure representation in working group activities.
Sub-Division Agreements	Pending the results of analysis, confirm flow monitoring will be included in future subdivision agreements at various points in the maintenance/warranty/ assumption period.	Standards Working Group	2012-2013	Region and local municipalities to ensure representation in working group activities.

3.5 Program Area 3 - Investigate and Mitigate

This section of the Strategy describes the processes utilized to investigate the severity, extent and location of sources of I/I within the mini basins that are resulting from the audit basin analysis.



3.5.1 Mini Basin Flow Monitoring

Upon completion of the audit basin analysis and prioritization activities, the audit basin will be subdivided into mini basins. After which, short duration "pre-construction" flow monitors will capture flow rates in smaller areas, mini basins. For this purpose, it is assumed that the Region will obtain a sufficient inventory of flow meters that could include the existing ISCO 2150 Region owned devices. The duration of mini basin monitoring will be dependent upon the size and frequency of rain events. Regional staff will determine on an individual mini basin level when the appropriate number of events have been recorded. However, in general, the duration of pre and post construction flow monitoring periods are anticipated to last approximately one year.

Mini basins can also be established for the purpose of comparative analysis. In this way, basins that received rehabilitation can be compared against similar basins where no rehabilitation had occurred. A control basin will be established based on the similarity it has to the mini basin in question. The criteria used to select control basins includes similar area, pipe materials, age, response to rain events, land use, geographic proximity, and construction technique.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Flow Monitoring	Establish preliminary flow monitoring program and define resource requirements for flow monitoring program based on the findings of the audit basin flow monitoring program.	Region	2011-2013	Region to establish flow monitoring technical lead/coordinator and data analysis team (2 FTE) + field crew to manage flow monitoring network. Alternative data analysis by external resources (est. $100k annual for mini basin and $300k for audit basin level).
Flow Monitoring	Install, maintain, and complete data QA/QC for approximately 20 mini basin short duration flow monitors.	Region	2011 – 2031	Two flow monitoring crews that would also be responsible for audit monitoring plus in-house data analysts. Alternative option would be to use an external flow service provider (estimated $1.0 - $1.5M annual, not including hardware acquisition/rental).

3.5.2 Mini Basin Analyze Flow and Rain Data

This stage includes the detailed analysis procedures as described above. However, an additional step is utilized in which specific I/I responses are compared against allowable thresholds. This will allow the Region to determine the potential severity and extent of I/I flows and compare mini basins against one another.

An "XY" severity matrix as shown in Figure 18 has been developed, where each mini basin is represented by a combination of two industry standard values, "X" being the peaking factor (PF) value and "Y" being the ratio of RDII peak flow to mm-km diameter pipe.

Each of the axes for the severity matrix have a low, medium, and high range assigned, meaning each plotted point will fall in a unique zone representing the severity of each catchment. Threshold values are assigned to each zone representing the severity of inflow and I/I volume based on the combinations described below:

Inflow Component Thresholds -
Instantaneous Peaking Factor (PF):

- 0<PF<4, Low
- 4<PF<6, Medium
- PF>6, High

I/I Component Thresholds:

- 0< Lpd/mm-km <280, Low
- 280< Lpd/mm-km <560, Medium
- Lpd/mm-km >560, High

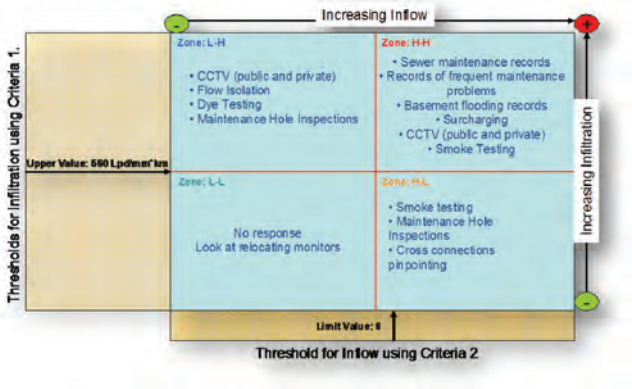


Figure 18: SSES Inspection Thresholds

The system response is then used to determine any potential data requirements to pinpoint the sources of flows. By slightly modifying the matrix shown in Figure 18, it can be used as a guideline for selecting the appropriate inspection activities and the specific data requirements (see Figure 19 below).

Based on the severity matrix in Figure 19, a total of five zones can be read. These zones provide a complete overview of the diverse type of I/I responses based on the selected rain event.

The lower left side of the matrix corresponds to the Zone L-L (highlighted in green), which represents catchments that have low values of I/I, indicative of tight catchments. The middle Zone M-M (highlighted in yellow) represents those catchments that showed medium response for both I/I. A high reactive zone (highlighted in red) was further divided as Zone L-H. Zone H-L and Zone H-H represent, respectively, those catchments that had a low PF value but a high value of infiltration, catchments that had high PF values but low infiltration, and those catchments that were highly reactive during wet weather flow with high PF and high infiltration.

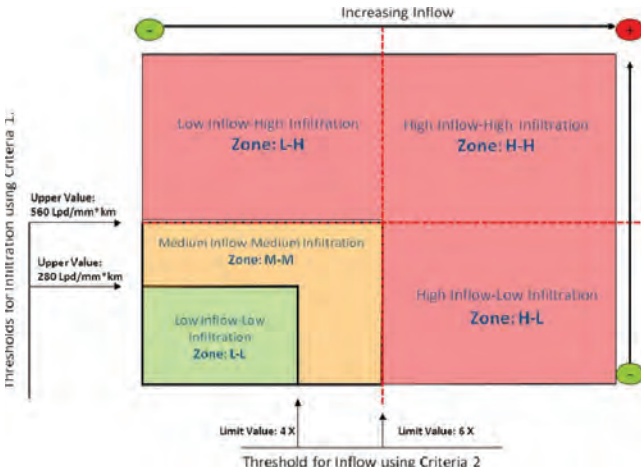


Figure 19: XY Severity Matrix

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Implement Process	Implement above noted process on all future mini basin monitoring sites and re-assess process as program is implemented.	Region	Ongoing	Based on estimated 20 sites per year, would require a minimum of 1 full time staff person (for analysis of wet weather including audit basin analysis)

Each rain event is plotted in the matrix regardless of the intensity, duration, or frequency. If catchments are continuously identified as having a low rate of I/I (or are in the bottom left quadrant, L-L), no significant I/I issues are identified and therefore no additional inspection data would be required. If catchments had high inflow and minimal infiltration (the bottom right quadrant, H-L), the efforts focused on finding sources of direct inflow such as downspout connections.

3.5.3 Identify Condition Assessment Programs

Once the severity and extent of I/I has been quantified and assigned to specific mini basins and an area is determined to have high I/I rates, a physical inspection program is generally performed. Inspection activities include investigations on both the public and private infrastructure. The resulting data from each inspection is critical in pinpointing the specific locations and sources of extraneous flow. Inspection activities will generally include field investigations such as manhole inspections, smoke testing, sanitary sewer mainline CCTV inspections, and public/private lateral CCTV inspections. Prior to employing these more expensive methods of inspection, simple less expensive techniques will be utilized. These include drive-by surveys (preferably during wet weather events), top side manhole inspections, and other visual inspections.

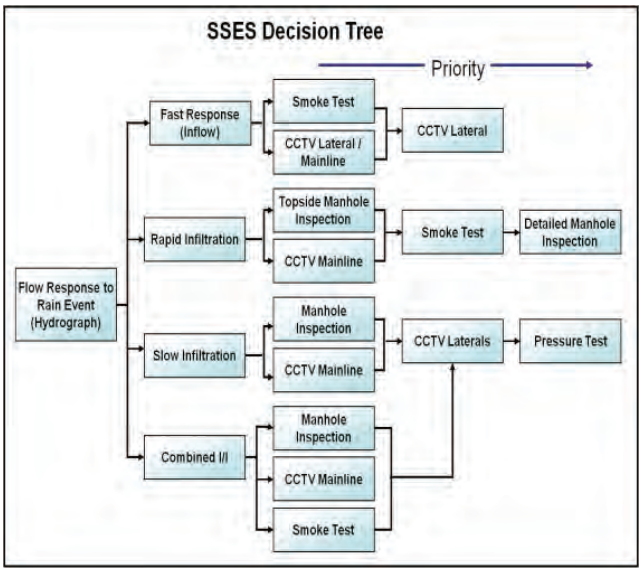


Figure 20: SSES Decision Tree

The type, priority and estimated costs for SSES activities will be defined as a function of the flow monitoring analysis and availability of current inspection/condition related data. Figure 20 depicts a sample decision-making process for selecting the appropriate investigation activities based on flow monitoring data analysis.

Condition assessment techniques for I/I flow reduction are a component of the Region's and each municipality's ongoing condition assessment/asset management programs. As such, the details and procedures for these programs can be found in Section 3.5.8, External Asset Management Condition Assessment.

3.5.4 Condition/Performance Data Assessments

To more closely pinpoint the sources of the extraneous flows and in turn use the information in developing the preferred remediation strategies, additional analyses are required.

The two major objectives of the SSES analyses are:
1. Identifying specific I/I sources and system conditions.
2. Applying standardized defect distress coding and inspection practices to reflect the severity and extent of issues.

The various SSES investigation techniques include:
- Smoke testing
- CCTV mainline inspection
- CCTV lateral inspections (in many cases both private and public laterals)
- Manhole inspections
- Flood/dye testing
- Household drainage inspections.

By utilizing standard data analysis procedures, the Region can ensure that information is reviewed and reported in a consistent manner. The inspection and analysis procedures are described in more detail later in this document.

3.5.5 Project Planning and Prioritization

The objective of the planning and prioritization process is to establish priorities for rehabilitation, repair, or replacement projects. The identification and type of rehabilitation selected requires assessing the structural and hydraulic performance of the system.

Following the results of the detailed flow analysis and the structural and hydraulic assessments, cost-effective solutions can be identified. These will be prioritized based on criticality, risk of failure, costs and expected benefits, expected lifecycle and performance improvements, environmental impacts, social implications, plant performance, and operation and maintenance (O&M) cost savings. To determine appropriate condition assessment, O&M, and capital replacement/rehabilitation priorities and to competitively weigh these priorities, it is important to understand the criticality of the assets and the potential impact (risk) associated in the event of failure or deprival of the asset.

A risk framework and process has been implemented in the Region that includes an assessment of the risks associated with health and safety, financial impact, service level impact, socio-economic impact, liability, and regulatory compliance. The risk of failure is then reviewed against the probability of failure to determine an overall priority.

The Region has also developed a sewer management framework that provides information on the various risk factors and failure modes of gravity sewers and manholes. The framework will be reviewed by the local municipalities and if appropriate will be adopted. A standardised project prioritization model (or Optimized Decision Model) will be developed that will help to ensure consistency in the way that I/I related projects are prioritized across organizations.

In addition to selecting projects based on mitigating risk, the cost effectiveness of the projects needs to be established. While a definition for cost effectiveness has yet to be established in the Region, an example of cost-effective projects used in other jurisdictions includes "*projects for which the capital savings that result from the I/I reduction exceeds the costs of constructing the I/I project*". The Region, in conjunction with local municipalities, will utilize the results of pilot projects and develop a definition of cost effectiveness.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Project Prioritization	Develop a model for prioritizing projects to reflect I/I as an input/ risk, using existing processes as the baseline.	The Steering Committee	2011-2012	Region and local municipalities to ensure representation in working group activities.
Project Prioritization	Prioritize and provide funding for, the 16 un-committed Phase 1 pilot program projects against other Regional/municipal priorities (i.e., risk, criticality, impact of failure, competing road projects, political drivers).	The Steering Committee	2011 and beyond	
Costs/Benefits	Develop a definition and an approach for determining costs versus benefits of I/I reduction projects.	The Steering Committee	2012	
Project Forecast	Develop and implement processes to validate and prioritize new mini basin projects as they are identified.	Local Municipality	2012-2015	Local municipality to ensure that future capital planning processes are reflective of the I/I prioritization model.
Project Cost Estimates	Develop procedures for refining project cost estimates based on the implementation of previous projects.	Local Municipality	2012-2015	

3.5.6 Project Delivery & Flow Reduction Assessments

The project delivery and assessment phase involves the design and construction of rehabilitation and replacement projects that have been evaluated on a cost/benefit and other risk based processes.

Once the required works are completed, I/I reduction and the structural condition of the sewer system must be monitored to ensure that the predictions for flow reduction and the effectiveness of the selected solutions were achieved.

The initial phase of project delivery is the implementation of the initial 10 pilot projects as identified in the Region and Local Municipal I/I Pilot Program – Phase 1. Construction is anticipated to occur prior to 2013. Upon completion of the projects, post construction flow monitoring will be conducted to validate the reduction savings achieved. This information will be used to update the audit and measures process and spreadsheet model.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Construction of Current Pilot Remediation Projects	Complete detailed design and construction of identified pilot projects	Region/Local Municipality	2011-2012	Region has approved $10M in funding
Construction of Future Remediation Projects	Complete detailed design and construction of identified pilot projects	Local Municipality	2012 and beyond	Region has currently forecast $100M in funding.
Post Construction Flow Analysis	Complete flow monitoring at all remediation project locations to determine the success and flow reduction and update the audit and measure process.	Region	2011 and beyond	Region to provide technical staff to complete flow analysis and maintain the audit process.

3.5.7 Update I/I Reduction Achieved

During the first year, the planned I/I reduction volumes for each audit basin will be calculated and entered into an audit spreadsheet as described in Section 3.3.2.8, Audit Spreadsheet. During subsequent years, newly recorded flow data and updated population data will continue to be analyzed. Using this data, sewage generation rates, I/I volumes, and projected I/I reduction factors will be recalculated manually or predicted using the hydraulic model, and then updated in the audit spreadsheet. As more and more data becomes available over each successive year, the accuracy of I/I flow projections for the 25-year design storm will increase. This, in turn, will increase the accuracy of the planned I/I reduction targets.

The hydraulic model will be updated with revised hydrologic input parameters, which simulate I/I entering the system, as system rehabilitation and repair work is completed and post construction flow monitoring is conducted and the data are analyzed. After recalibration, the hydraulic model will be used to characterize the newly repaired audit basin and 25-year design storm I/I projections can be simulated. Revised I/I volumes and reduction targets will be input into the audit spreadsheet.

As system remediation is completed and the I/I volume is reduced in each audit basin, the difference between the peak flow reduction target established for the basin and the actual I/I rates observed after construction will provide an indication of how successful the process has been in removing flows. The difference between what would have been observed if the catchment had not had remediation and what was actually observed will be the resulting reported flow reduction volume.

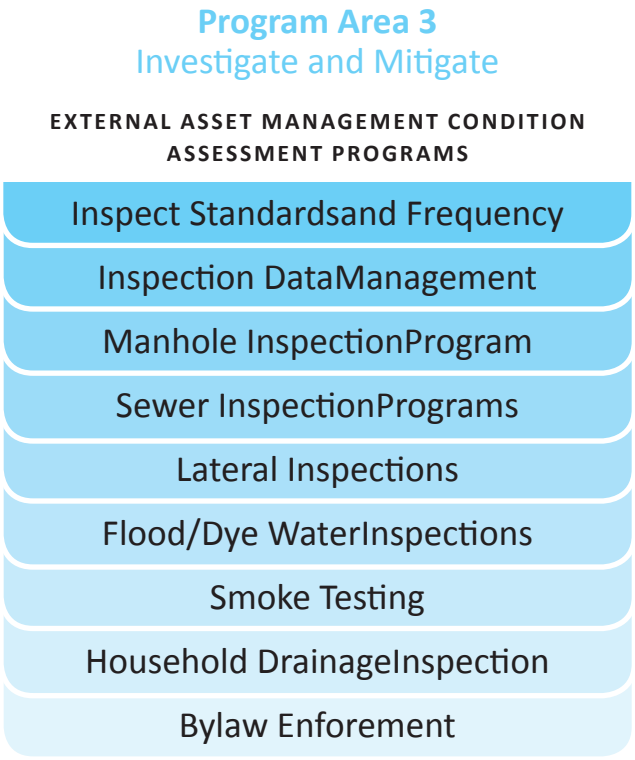
Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Hydraulic Model	Update the hydraulic model to reflect new I/I rates under the 25-year design storm.	Region	2011 and beyond	Technical staff to complete ongoing analysis and modeling activities.
Audit Spreadsheet	Update the audit process spreadsheet to reflect actual I/I reduction and quantify gap between actual and targeted reduction.			

3.5.8 External Asset Management Condition Assessment Programs

Recognizing that the Region and local municipalities each conduct ongoing condition assessments as part of their asset management programs, any procedures will recognize I/I as a system deficiency. Ongoing condition assessment and any future inspections specific to I/I reduction will complement this Strategy.

While the Region and municipalities currently complete a number of condition assessment programs as part of their ongoing condition assessment programs, selecting the most suitable methods specific to finding the sources of I/I is critical. Standardized inspection procedures, focused on I/I sources, will be prepared that will lead to development of a rehabilitation plan to solve hydraulic or I/I related problems.



Inspection Standards and Frequency

To support the efficient collection and use of inspection records, it is essential that inspection data are collected using standardized procedures and terminology. The Region has developed a series of technical specifications and standards for CCTV mainline/lateral inspections, manhole inspections, and smoke testing that will be used for future inspections.

The following procedures have been established:

- **Data Defect and Coding Standards:** Where applicable, the technical specifications use industry accepted standards such as the Water Research Centre (WRc) Manual of Sewer Condition Classification (3rd Edition).
- **Data Collection Methodologies:** Each inspection activity has specific data collection methodologies and procedures identified. In general each inspection specification details the requirements for equipment, inspection procedures, defect coding, naming conventions, and data delivery formats.
- **Training/Certification:** The training and certification requirements for contractor staff involved in the inspection activities have been identified. This includes all Health and Safety and Confined Space entry requirements.
- **Data QA/QC:** To verify the completeness and accuracy of the inspections, the defect coding must go through a structured Quality Assurance, Quality Control (QA/QC) process by the contractor and the Region or municipality. The technical specifications outline the required data QA/QC process, acceptable error tolerances, and subsequent follow-up inspection requirements.

All sanitary sewage systems must be inspected regularly to ensure that they are in sound structural condition and that they can deliver the required levels of service and hydraulic capacities as originally designed. Sound infrastructure management processes will include recurring inspection programs as part of regular system maintenance and inspection programs.

The frequency of the inspections will depend on factors such as the criticality, age, depth, or risk of failure. Critical wastewater components such as mains with known structural or hydraulic deficiencies, or those nearing the end of their theoretical service life, will be inspected more frequently. For example, topside visual inspections of manholes might be adequate for those in the initial stages of their service life or with a "good" condition and service grade. However, more rigorous and detailed inspections (such as man entry or destructive testing) might be appropriate as the manhole ages, or if the structure is a critical component of the system. A comprehensive "routine" inspection program including the frequency and type of the inspection recommended will be developed based on the age and criticality of the discrete components.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Inspection Schedule	The Standards Working Group will develop a short-term and long-term work plan to guide activities, including timelines, milestones, and resource requirements for inspection activities.	Standards Working Group	2011	Adequate representation from the Region and local municipalities.
Annual Work Plan	Standards Working Group to develop annual work plan.	Standards Working Group	2011 to 2031	
Inspection Protocols	Standards Working Group to develop inspection protocols, including the extent and frequency of inspections. The working group will consider the use of the Region's sewer management framework as starting point.	Standards Working Group	2011 to 2031	

Inspection Data Management

All inspection data will be stored in centralized relational databases for access by the required stakeholders. To graphically map the information, the various inspections will include linkages to pipe or manhole reference identification numbers. This allows the database to be linked to the corresponding record in GIS, allowing the results to be viewed graphically. Within the databases, the identification numbers also allow the linkage to other database tables containing additional information, such as the defect observations, WRc defect scoring or condition code, or linking a lateral connection to the corresponding detail on the mainline record.

Structural and performance related condition assessment information, such as manhole inspections, CCTV of mainlines and laterals, and flow monitoring results exist for many parts of the local municipal and Regional systems.

Similar to the physical pipe system, inspection data are currently managed by both the Region and local municipalities for their respective systems using a variety of paper based and electronic data systems. During the Region and Local Municipal Inflow and Infiltration Reduction Pilot Program - Phase 1, a small consolidated dataset was compiled for approximately 10% of the overall systems that included condition assessment data for manholes, mainlines, and lateral inspections. For the implementation of this Strategy, new streamlined business processes will be required that will allow for a more seamless integration and sharing of the various datasets between the Region and local municipalities. It will be necessary to establish a Technical Advisory Committee to review the data management systems in use within the Region and recommend a long-term data and application sharing tool such as MWH Soft Inc's InfoNet software.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Work Plan	Develop a long-term work plan to guide activities including the timelines, milestones and group resource requirements.	Technical Advisory Committee	2011	Staff from various municipalities to form a Technical Advisory Committee required to meet on a regular basis.
Database and Analysis Tools	Compile an inventory of existing data management systems or analysis tools that are used within each organization. Recommend long-term data management tool.	Technical Advisory Committee	2011-2012	
Baseline Data	Compile an inventory and complete a data gap analysis.	Technical Advisory Committee	2011-2012	
Data Collection Processes	Develop new data collection processes to support the management, analysis, and reporting of asset condition data.	Technical Advisory Committee	2013	

Manhole Inspections

Manhole inspections are conducted by trained maintenance personnel who can visually inspect and assess the condition of the manhole from a surface and structural perspective to determine any defects or conditions that may be sources of I/I. Visual inspections can be performed on the sewer system manhole at a higher frequency than internal inspections because of the relative ease of inspection. This type of inspection can give a good indication as to the condition and proper functioning of the manhole. Inspections during rain events are recommended because this allows the inspector to quantify non-structural defects such as ponding on the surface that otherwise might not be visible.

Today, the various municipalities use numerous manhole inspection databases. Some of these are very sophisticated (such as the inspection program developed for the Region and Municipal Inflow and Infiltration Reduction Pilot Program - Phase 1 that has been designed in MS-Access™). The purpose of the database is to (1) manage the information compiled from the field inspections, including structural properties, the severity and extent of signs of degradation, evidence of infiltration, and any photos taken during the inspection; and (2) develop an overall structural condition and service condition grade. The database assigns ratings and defect scores to the components of the manholes and the scoring is based loosely on the principals of the WRc 3rd Edition. The data are then linked to GIS, allowing for a graphical display of condition scores.

Manhole inspections will be completed at two levels or "orders". The first order inspection is at a much higher level and this is generally accomplished through a drive by inspection survey and top side inspection. The purpose of this level of inspection is to review and identify significant structural degradation and review health and safety issues. The frequency of these inspections will be annual or more frequent.

The second level "order" of inspection requires a more rigorous inspection including entry or visual assessment by CCTV camera. This more detailed assessment could also include the sampling or destructive testing of manhole components to confirm structural integrity and determine possible failure modes. The frequency of second order inspections will depend on a number of factors including the assets condition and criticality.

The inspection frequency for manholes is recommended to be as follows:

- Annual drive by/top side inspections of all manholes.
- Ten-year "entry" re-inspection for manholes in sound structural condition.
- Five-year "entry" re-inspection for highly critical manholes or manholes exhibiting signs of deterioration.
- More frequent "entry" inspection as condition/risk of failure warrants.
- As required to support I/I mini basin or flow analyses.

The Standards Working Group will continue to review new and evolving inspection procedures, and where possible, establish regionwide standards for inspection and data management. This Working Group will also investigate and select an appropriate inspection frequency based on the asset management approach.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Condition Assessment/ Inspection Procedures	Compile local municipal and Regional inspection procedures and tools (e.g., applications and data inventory) and refine inspection procedures to include the frequency and extent of inspections. The goal is to standardize the inspection processes to help ensure that the investigations progress from routine to more rigorous as infrastructure ages, condition is degrading, or if elevated I/I is experienced. Source detection activities will be more integrated into overall maintenance, inspection and asset management procedures.	Standards Working Group	2011	Monthly meetings by working group or more frequent as specific activities require.
Inspection Schedule	Develop short-and long-term inspection schedule for local municipal and Regional assets based on the inspection frequency and extent developed by working group.	Local Municipality	Initial plan to be developed in 2011	Monthly meetings by working group or more frequent as specific activities require.
Complete Inspections	Complete scheduled inspections and analyze results. Include the results in future inspection schedule forecasts.	Local Municipality	Ongoing	Resource requirements will vary for each municipality depending on asset base and I/I investigation requirements.
New Technologies & Standards	Continue to review and investigate emerging technologies and refine standards to reflect changes in the industry.	Standards Working Group	Ongoing	Monthly meetings by working group or more frequent as specific activities require.

Sewer Inspections

The CCTV inspections of the mainline and laterals provide a recorded video account of the condition of a sewer, identifying defects such as cracks and cross connections, which are sources of I/I. A number of industry standard defect coding and rating systems attempt to ensure consistency in CCTV inspection results, including rating systems developed by the WRc and the National Association of Pipeline Inspectors Pipeline Assessment Certification Program (PACP). Both rating systems have separate codes that depict the severity of I/I observed during inspections. Additional benefits of CCTV inspections include a visual image of what is occurring in the system at the time of the inspections and the ability to see changes to conditions from one survey to another or over multiple inspections. For the purposes of I/I investigations, CCTV inspection during or immediately following rain events can be beneficial in recording the location's extraneous flows.

Similar to manhole inspections, the Region and local municipalities use numerous CCTV applications and databases. Some of these are very sophisticated (such as the CCTV data management system used by the Town of Markham), others are prepackaged programs such as Examiner, and some still use paper based reports.

The purpose of the databases is to (1) manage the information compiled from the field inspections, including physical pipe inventory data, structural and service properties, the severity and extent of signs of degradation, evidence of infiltration; and (2) develop an overall structural condition and service condition grade. Most local municipalities are capturing data using WRc 3rd Edition. The data are then linked to GIS, allowing for a graphical display of condition scores.

CCTV inspections can also be completed at two levels or "orders". The first order inspection is at a much higher level, this is generally accomplished through the use of techniques such as Zoom Camera inspection. The purpose of this level of inspection is to review any significant structural degradation at a screening level. The second level "order" of inspection requires a more rigorous inspection including detailed CCTV camera or a more detailed technique such as acoustic or sonar/laser profiling. This more detailed assessment could also include the sampling or destructive testing of pipe wall components to confirm structural integrity and determine possible failure modes. The frequency of second order inspections will depend on a number of factors including the condition and criticality.

The inspection frequency for sewers is recommended to be as follows:

- High level zoom pan and tilt camera as required to capture baseline condition of the system;
- Ten-year inspection for mains with sound structural condition;
- Five-year re-inspection for highly critical mains or mains exhibiting signs of deterioration;
- More frequent detailed inspection as condition/ risk of failure warrant; and
- As required to support I/I mini basin or flow analyses.

The Standards Working Group will continue to review new and evolving inspection procedures, and where possible, establish regionwide standards for inspection and data management. This working group will also investigate and select an appropriate inspection frequency based on an asset management/ lifecycle management approach.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Condition Assessment/ Inspection Procedures	Compile local municipal and Regional inspection procedures and tools for mainline CCTV inspections (e.g., applications and data inventory) and refine inspection procedures to include the frequency and extent of inspections. The goal is to standardize the inspection processes to help ensure that the investigations progress from routine to more rigorous as infrastructure ages, condition is degrading or if elevated I/I is experienced. Improve integration of source detection activities into overall maintenance, inspection, and asset management procedures.	Standards Working Group	2011	Monthly meetings by working group or more frequent as specific activities require.
Inspection Schedule	Develop short-and long-term mainline CCTV inspection schedule for local municipal and Regional assets based on the inspection frequency and extent developed by working group.	Local Municipality	Initial plan to be developed in 2011	Monthly meetings by working group or more frequent as specific activities require.
Complete Inspections	Complete scheduled mainline CCTV inspections and analyze results. Include the results in future inspection schedule forecasts.	Local Municipality	Ongoing	Resource requirements will vary for each municipality depending on asset base and I/I investigation requirements.
New Technologies & Standards	Continue to review and investigate emerging mainline investigation technologies and refine standards to reflect changes in the industry.	Standards Working Group	Ongoing	Monthly meetings by working group or more frequent as specific activities require.

Lateral Inspections

CCTV inspections of mainline and sewer laterals provide a recorded video account of a sewer's condition, identifying defects such as cracks and cross connections, which are sources of I/I. A number of industry standard defect coding and rating systems attempt to ensure consistency in CCTV inspection results including rating systems developed by the WRc and PACP. Both rating systems have separate codes that depict the severity of I/I observed during inspections. Additional benefits of CCTV inspections include a visual image of what is occurring in the system at the time of the inspections and the ability to see changes in conditions from one survey to another or over multiple inspections. For the purposes of I/I investigations, CCTV inspection during or immediately following rain events can be beneficial in recording the location of extraneous flows.

The Standards Working Group will continue to review new and evolving inspection techniques and tools, and where possible establish regionwide standards for ongoing inspections and data management. This Working Group will also investigate and select an appropriate inspection frequency based on an asset management/lifecycle management approach.

Unlike mainline and manhole inspections, lateral inspection techniques are limited due to the diameter and length of the laterals, limitations in equipment, and limited access points. Inspections involve using lateral launch cameras (these can be directed from the mainline sewer or from within the property being inspected). Alternatively, inspections can be completed using a rod/push camera from within the property, in the event that inspection bylaws allow access to private residences. This would require that the homeowner be home at the time of inspection. It is also important that when the inspection of a lateral occurs that the entire lateral is inspected, including the private portion.

Due to the current cost and complexity of inspecting a lateral, the inspection frequency would be considerably less than for mainline sewers. The frequency of inspection would be as follows:

- 20-year inspection for laterals with sound structural condition.
- 10-year inspection for highly critical laterals exhibiting signs of deterioration.
- More frequent detailed inspection as condition/risk of failure warrants.
- As required to support I/I mini basin or flow analyses.

The Standards Working Group will continue to review new and evolving inspection techniques and tools to determine cost effective lateral inspection techniques, and where possible, establish new regionwide standards for ongoing inspections and data management. This working group will also investigate and select an appropriate inspection frequency based on an asset management/lifecycle management approach.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Condition Assessment/ Inspection Procedures	Compile local municipal and Regional inspection procedures and tools for lateral CCTV inspections (e.g., applications and data inventory) and refine inspection procedures to include the frequency and extent of inspections. The goal is to standardize inspection processes to help ensure that the investigations progress from routine to more rigorous as infrastructure ages, condition degrades, or if elevated I/I is observed. Improve integration of source detection activities into overall maintenance, inspection, and asset management procedures.	Standards Working Group	2011	Monthly meetings by working group or more frequent as specific activities require.
CCTV Lateral Technologies & Standards	Assess the available and appropriate lateral inspection technologies, including launch of CCTV camera from the mainline or within property, and continue to review emerging lateral inspection technologies. Refine standards to reflect changes in the industry and develop procedures for completing inspections from private property.	Standards Working Group	2012 - Ongoing	Monthly meetings by working group or more frequent as specific activities require.
Inspection Schedule	Develop short-and long-term lateral inspection schedule for local municipal and Regional assets based on the inspection frequency and extent developed by working group.	Local Municipality	Initial plan to be developed in 2011	Monthly meetings by working group or more frequent as specific activities require.
Complete Inspections	Complete scheduled lateral inspections and analyze results. Include the results in future inspection schedule forecasts.	Local Municipality	Ongoing	Resource requirements will vary for each municipality depending on asset base and I/I investigation requirements.

Flood/Dye Water Inspections

Flood/dye testing is a method used to locate rain or groundwater entry points into the sanitary sewer system. During this process, non-toxic dyed water is introduced into roof drain leaders, driveway drains, or area drains. In some instances, dyed water is injected into the ground around foundations to check for the presence of a connection to foundation drains. After introducing the dyed water, the downstream sanitary sewer manhole is checked or individual lateral connections could be monitored by CCTV equipment.

A standard procedure for flood/dye testing does not currently exist. However, some local municipalities have completed testing in specific "problem" areas. Due to the costs and complexity of flood/dye water inspections, these would primarily be conducted to support I/I programs.

Flood/dye testing will be completed in areas where direct storm connections are thought to exist and where identified through I/I data analysis procedures to confirm the presence of direct connections. Completing these inspections generally requires access to private property and homeowner consent will be required. Information gathered through the inspections will be compiled in a centralized database for future use. Return inspections are generally not required as the intent is to determine the presence and location of direct connections.

The Standards Working Group will work in cooperation to develop a standard for flood/dye testing and will continue to review new and evolving inspection techniques. This standard will also require new municipal standards for data capture and data management.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Inspection Standard	Develop standard flood and dye water testing procedures.	Special Standards Working Group and Task Force	2011	Monthly meetings by working group or more frequent as specific activities require.
Condition Assessment/ Inspection Procedures	Compile local municipal and Regional inspection procedures and tools (e.g., applications and data inventory) procedures.	Standards Working Group	2011	Monthly meetings by working group or more frequent as specific activities require.
Inspection Schedule	Develop short-and long-term flood and dye water inspection schedule.	Local Municipality	Initial plan to be developed in 2011	Monthly meetings by working group or more frequent as specific activities require.
Complete Inspections	Complete scheduled flood and dye water inspections and analyze results.	Local Municipality	Ongoing	Resource requirements will vary for each municipality depending on asset base and I/I investigation requirements.
Property Owner Consent	Develop homeowner consent/ authorization procedures as work requires access to private property.	Working Group and Special Task Force	2011	Legal counsel and working group members or could be led by one municipality or the Region on behalf of working group.

Smoke Testing

Smoke testing is one of the most efficient and cost-effective methods for locating sources of I/I problems with sewers. The introduction of non-toxic "smoke" helps to locate where storm and other surface waters enter the sanitary sewers. It is conducted by placing a blower over a centrally located manhole and forcing non-toxic smoke through a sewer line. The smoke under pressure will fill the main line plus any connections, then follow the path of any leaks to the ground's surface, quickly revealing the source of I/I. A standard procedure for Smoke Testing currently exists and some municipalities within the Region have completed testing in specific "problem" areas.

Smoke testing will be completed in areas where direct storm connections are thought to exist and where identified through I/I data analysis procedures to confirm the presence of direct connections.

Completing smoke inspections could require access to private property and homeowner notification will be required. Information gathered through the inspections will be compiled in a centralized database for future use. Return inspections are generally not required because the intent of the inspection is to determine the presence and location of direct connections.

Smoke testing would be conducted primarily to support I/I programs because gathering an inventory of direct connections would indicate areas of potential high flows. This information would be used to guide future I/I program activities.

The Standards Working Group will work to develop a standard for smoke testing and continue to review new and evolving inspection techniques. This standard will also require new regionwide standards for data capture and data management.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Permission to Inspect/Bylaws	Develop homeowner consent/ authorization procedures as smoke testing work requires access to private property.	Standards Working Group	2011	Legal counsel and working group members or could be led by the Region or municipality on behalf of working group.
Inspection Standard	Review smoke testing standard procedures.	Standards Working Group	2011	Monthly meetings by working group or more frequent as specific activities require
Inspection Schedule	Assess areas where smoke testing is recommended and develop schedule and budget estimate to complete inspections.	Local Municipality	2011-2015	Monthly meetings by working group or more frequent as specific activities require.
New Technologies & Standards	Continue to investigate new/ emerging smoke technologies and refine standards to reflect changes in the industry.	Standards Working Group	Ongoing	Monthly meetings by working group or more frequent as specific activities require.

Household Drainage Inspections and Inventory

Visual inspections of private side infrastructure on properties will be conducted in areas where flows from private property are experienced, and this will be a critical component and activity within the Strategy. The purpose of household inspections is to identify potential sources of stormwater entering the sanitary sewer and collect data regarding the home including a flood history and other internal plumbing characteristics such as plumbing configurations, cross connections, illegal connections, and basement drain elevations. These inspections can also serve to locate any illegal sewer connections such as sump pits with direct connections to sanitary laterals/floor drains.

Household drainage inspections will include a review of the building site and exterior perimeter of the house in addition to an internal plumbing review. These elements are important in the event that the inspection program is associated with weeping tile or roof leader disconnection projects.

To inspect private property infrastructure, a local municipality must ensure that bylaws are in place to allow access to property. These bylaws are described further in later sections of the Strategy. Also, procedures relating to the inspection of private property will include a provision for notification procedures, materials, and timelines along with supporting waivers and/or authorizations and homeowner consent documentation.

Initially, household drainage inspections will be conducted to support the I/I program. Additionally, the Region and local municipalities will also review historic plumbing/building department records to determine the age of house and area of the municipalities that have permitted historic stormwater connections to determine if there are documented records of foundation drain or downspout connections to the sanitary system. An inventory of these locations should be established and compiled within the Region's GIS dataset.

In the future, a more structured inspection program will be developed that would serve to build an inventory of properties and a baseline of potential high flow areas. The Region and local municipalities will work together to develop consistent inspection procedures and bylaws in the early stages of this Strategy.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Permission to Inspect/Bylaws	Develop homeowner consent/ authorization procedures as work requires access to private property.	Standards Working Group	2011	Legal counsel and working group members or could be led by one municipality or the Region on behalf of working group.
Inspection Procedures and data collection of private side information	Consolidate existing procedures and assess effectiveness, develop regionwide standardized procedures including notification materials and consent/waivers.	Standards Working Group or smaller Task Force	2012 - 2015	Requires that bylaws have been reviewed and if they allow access to private property.
Inspection Procedures and data collection of private side information	Develop inspection forms, templates, and centralized data management environment to store inspection results.	Standards Working Group	2012-2015	Monthly or more frequent meetings as specific activities require.
Data Collection and Plumbing Record Review	Review historic plumbing records to determine where historic direct connections (downspout and foundation drains) were permitted, compile information into GIS database.	Region's geomatics staff and research technicians	2012-2013	GIS research staff or students with access to municipal plumbing records.

3.5.9 Bylaw Enforcement

To ensure that access to the private portion of the sewer network is possible for all future I/I related projects, including any pilot remediation projects, the local municipalities and the Region will ensure that their sewer use bylaws include the necessary provisions such as right-of-entry (ROE) or inspection that will allow for access by the municipality or their contractors.

An example of such a provision can be found within the Town of Markham's Sewer Bylaw 436-86[2]. This bylaw states: "*Employees of the Town shall be permitted to enter upon private property for the purpose of inspection, observation, measurement, sampling and testing in accordance with the provisions of the bylaw.*"

As part of the process to gain access to private property, a signed ROE agreement will be entered into with property owners. ROE agreements can be used to grant local municipalities, the Region, and their contractor's access to the property for any purpose including routine inspection and rehabilitation such as the installation of cleanouts, CCTV inspections on the lateral, household drainage inspections, and installation of liners or new pipe.

In the case of ROE agreements for specific projects, allowances will be made in the ROE agreement for full excavation and replacement of the private lateral, if conditions do not allow trenchless technology to be applied. The ROE agreement will not indicate a promise to do the work. The ROE agreement will state that the Region or local municipality will be responsible to take reasonable efforts to restore the property as close to its preconstruction condition as reasonably possible.

On completion of any work, the property owners will be fully responsible for maintaining the landscaping and laterals after restoration is complete and for future maintenance, cleaning, or repair.

The Region will consider that obtaining ROE agreements from all or most of the property owners in the pilot project catchments will be a very labour-intensive activity and allowances will be made for continued communication and follow-up to obtain all required authorizations.

Education and information programs are a very effective way to gain public support for I/I reduction programs. Public meetings will be arranged to educate property owners about the project benefits and impacts, educational flyers will be sent to property owners and informative website(s) will be made available to the public.

Personal visits to the site and households will be expected. Based on AECOM experience with similar private side initiatives, approximately five percent of the property owners in each pilot catchment can be expected not to sign an ROE agreement.

It will be important for local municipalities to be actively involved during all phases of the pilot projects. Property owners directly affected by the projects are customers of the local municipalities. Local municipal expertise and knowledge are an additional resource to both the Region and the public.

[2]Town of Markham, Sewer Bylaw 436-86.

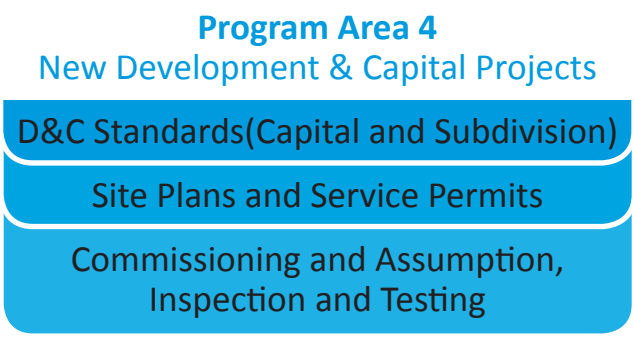
Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Permission to Inspect/Bylaws	Develop homeowner consent/ authorization procedures as work requires access to private property.	Standards Working Group	2011	Legal councel and working group members or could be led by one municipality on behalf of working group.
Resource/Staffing Review	Standards Working Group to develop plan for resourcing and enforcing bylaw related issues including the possible use of bylaw enforcement officers (could also be used for water efficiency related offences).	Task Force	2012-2015	Could involve a requirement for dedicated inspection staff with bylaw enforcement status.

3.6 Program Area 4 - New Developments & Capital Projects

Mainline sewers or trunk sewers are the major conveyance element of the sanitary sewer system before discharging to a treatment facility or connecting into another sewer. In new developments, the mainline sewer is the first segment of the sanitary sewer collection system. This segment is constructed before the system is connected to an existing main or to a manhole that permits lateral service connections to residential, commercial, industrial, or institutional developments.

Under present planning and approval protocols, new developments (site plan approvals) are granted on the basis that the design is completed using proper engineering principles and designs standards. In the case of monitoring construction of sewer works in new developments, it would be necessary to set up appropriate construction guidelines that allow for certification and approval of manholes, lateral connections, and mainline sewer construction.



New subdivision procedures must be reviewed legally and implemented consistently. These will provide for a provision that indemnifies and protects the Region and local municipalities against defective work for at least three to five years after the defect liability period is completed. This would likely require that developers/contractors extend their current warranty period for a longer time.

3.6.1 Design and Construction Standards (Capital & Subdivision)

Efforts to prevent I/I from occurring in new construction will be ongoing as the I/I reduction program addresses existing I/I sources. Future infrastructure will not be overlooked.

Key elements for achieving a tighter sewer system are using sound engineering specifications in design and enforcing the specifications during construction through inspections. Enhanced plumbing and building inspections can also help prevent I/I from private property sources.

Further, a review of existing design standards is recommended. To mitigate future I/I, some key elements that could be included in new subdivision agreements and design standards are:

- Ensuring that the infrastructure is constructed in accordance with design specifications and standards (type and class of material).
- Ensuring minimum depth of cover is in accordance with the MOE's guidelines and that this is maintained at all times and not compromised by incidental obstruction or causes. This can reduce the possibility of sewer upheaval that cause breaks in pipes and disconnection during freezing and thawing periods.
- Ensuring proper bedding and that bedding material is well compacted and tested in accordance with the appropriate guidelines to eliminate possibility for pipe deflection and further collapse.
- Ensuring that all joints are properly sealed and cured in accordance to manufacturer's specifications prior to backfilling and pressure testing.
- Ensuring that adequate support is given to keep joints and connections from dislodging or breaking off where wye connections are made off mainline sewers.
- Checking to ensure pipe slope meets the specifications contained in the design drawings.

- Inspecting construction of the manhole to ensure that proper parging is done on the inner and outer walls to allow for a water tight structure.
- Connecting mainline sewers into manholes will ensure that they are properly sealed inside and outside around the pipe.
- Checking that all lateral connections follow similar construction and inspection procedures as a mainline sewer.
- Installing flow monitoring devices at strategic locations of the sewer system to monitor the system for possible failures.
- Committing to follow the Region's previously developed Inspection and Commissioning Guidelines across all local municipalities.

Ensuring all or most of these construction procedures are adhered to in new developments is the first step to reducing I/I into the sanitary sewer system. As a result, lower I/I rates than the currently accepted industry rates can be achieved.

The current Regional infiltration allowance for I/I is 0.286 l/s/ha. By combining a more rigorous inspection program with more I/I focused design standards, lower allowances could be implemented and enforced (for example, many municipalities across Canada currently have an allowable I/I rate for new construction that is close to 0.1 l/s/ha).

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Development Agreements	Compile municipal development standards and subdivision agreements, site plan approvals and permits to determine how agencies are currently administering new construction.	Standards Working Group	2011-2012	Working Group and local municipal, engineering and development staff.
Design Standard	Develop a new design standard that describes materials and design considerations to reflect I/I reduction and mitigation.	Standards Working Group	2012-2015	
I/I Allowance for New Construction	Validate current I/I rates to determine if a reduction to the "allowable" infiltration rates is warranted. Refine the infiltration allowance over time as new processes are implemented.	Audit Working Group/ Standards Working Group	Flow monitoring to start in 2011, analysis and new allowance if required in 2012, 2013	

3.6.2 Site Plans and Service Permits

Similar to the anticipated improvements to I/I rates through more rigorous inspection of new infrastructure on the public rights-of-way, opportunities exist for reducing I/I flows from private property. A great deal of infrastructure is constructed by private contractors within private property. This presents an opportunity to engage the building and sewer contractors and local building departments in an effort to reduce I/I potential in newly constructed sewer infrastructure through improved inspection and approval processes.

Future I/I could be reduced through a review of the current requirements for compliance and enhancements of existing subdivision/site plan design standards. This review will include service permits and the site plan approval processes, inspection procedures and testing, acceptance, and adherence the Ontario Building Code (OBC). This review could also lead to recommended revisions to the OBC for reducing future I/I.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Building inspection process	Review of the current processes involved in the design, constructing and approvals of sewer infrastructure on private property.	Local Municipalities	2013-2015	Local municipal resources including approvals and inspection staffing.
Building inspection process	If appropriate, develop a regionwide standard for the above noted activities.			

3.6.3 Commissioning & Assumption, Inspection and Testing Procedures

Construction standards are used to ensure conformity to the design intent. This conformity is accomplished through comprehensive inspection and testing procedures at various stages of construction. These construction standards and objectives for sewer lines cannot be met and verified without adequate inspection.

The I/I program will also consider implementing inspection procedures and protocols to ensure that I/I is not an issue after a new sewer is commissioned. New development commissioning practices have been created that consider a combination of the following inspection and commissioning tests:

- Visual Inspection – Visual Inspections identify defects or improper installation that cause leakage or are more likely to in the future.
- Leakage Tests (infiltration, exfiltration with water, exfiltration with low pressure air) – Leakage tests using air or water can be completed on sewer lines, laterals, and manholes to ensure that the total leakage is within allowable limits. Additionally, new systems can be "blocked" for certain periods prior to services coming on line to calculate the rate/volume of infiltration that could be occurring;
- Deflection Testing – Deflection testing demonstrates that the pipe deflection does not exceed the allowable deflected sewer diameter through either visual CCTV observations and/or by pulling a mandrel through the sewer.
- CCTV Inspections - CCTV inspections provide a recorded video account of the condition of a sewer, identifying defects such as cracks and cross connections, which are sources of I/I.
- Smoke Tests - Smoke testing uses a non-toxic smoke injected into a sanitary sewer to indicate the location of broken sewers, manholes, catch basins, or where roof or foundation drains may inadvertently be connected to the sewer system.
- Flow Monitoring - Flow monitoring during dry and wet weather conditions help identify areas that are subject to excessive I/I. Flow monitoring in new developments as they are constructed or assumed provides a baseline for flows, construction quality, and the identification of potential issues. The Region and municipalities will develop procedures and protocols for flow monitoring as part of the commissioning process. These procedures will include the thresholds for flow monitoring such as establishing the minimum criteria for the infrastructure length of main being constructed or minimum number of properties within the subdivision that would be flow monitored.

The Region has developed Sanitary Sewer Commissioning Guidelines for use by local municipalities and consultants constructing new infrastructure. The guideline summarizes the recommended requirements for commissioning and testing new sanitary sewer infrastructure (i.e. gravity sanitary sewers, forcemains, and manholes).

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Inspection and Commissioning Guidelines	Implement current Regional commissioning guidelines and update these guidelines in the future as required.	Standards Working Group	2011 and beyond	Development and engineering/ inspection staff
Flow monitoring of new subdivisions	Establish procedures for flow monitoring including minimum development size and length of mains, responsibilities (developer and municipal leads), financial procedures, and minimum duration of monitoring.	Standards Working Group	2011 and beyond	Development and engineering/ inspection staff

3.7 Program Area 5 - Financial Management

The objective of the funding component is to develop a sustainable source of funding to support the long-term implementation of this Strategy. The funding arrangement is intended to be equitable to the partners and community while addressing the long-term water efficiency strategy and I/I reduction targets required through the Minister's conditions.

In the absence of a full program scope and based on Regional estimates, an initial funding target of $100M over a 20-year period was used to assess the potential funding requirements. This equates to a future annual investment of $5M per year across the Region.

Being a two-tier system, the local municipalities currently have responsibility for ensuring that the local sanitary collection system is maintained and operating effectively. Programs are funded at the local municipal level with each municipality determining annual capital requirements based on asset condition. Funding sources for these programs are derived primarily from the user rates calculated based on water consumption flows for each system user. Alternate funding has also been made available from time to time from various provincial and federal programs.

The Region is responsible for transmission of sewage from the local systems to final treatment facilities and final treatment. Funding for the Regional system is provided through wholesale user rates incorporated into the local water/sewer billing. The Region applies this funding primarily to the Regional infrastructure with some contribution towards infrastructure studies that benefit the local municipalities. The studies typically recommend improvements, which are then implemented by the local municipalities. Until recently, capital investment from the Region has been limited for improving the local systems because these systems are not controlled by or under the jurisdiction of the Region. With the Region's recent 2008 program for flow monitoring and associated pilot projects, a significant investment has been approved for application to the local municipal systems regionwide.

Program Area 5
Financial Management

- Establish and Manage Cost Sharing Reserve Fund
- Fund and Establish I/I Control Program Activities
  - Flow monitoring
  - Inspection
  - Data Analysis
  - Guidelines and Standards
  - Continuous Improvement
  - Communications
  - Rehab/ Replacement
  - Pilots
- Establish Short Term Funding (1-5 years)
- Establish Medium Term Funding (5-10 years)
- Long Term Sustainment (10 years +)

Currently, a considerable amount of investment is occurring at the local municipal level for I/I management as each municipality implements their own I/I reduction programs. The current level of funding for all nine local municipalities is estimated to be approximately $6M for 2010. The programs and activities associated within this Strategy are intended to supplement the existing asset management and I/I reduction efforts already in place regionwide.

3.7.1 Establish and Manage Cost Sharing Reserve Fund

The Strategy will be supported by a collaborative long-term funding model based on a cost shared approach between the two tiers of government. The key funding principles are:

- A set rate will be collected at both the local municipal and Regional level as identified through the needs of the Strategy and as agreed to by the Region and local municipalities.
- The amount collected by the local municipality level will be used to address priorities identified both through the Strategy and as determined by each local municipality. The funding is to be used to meet the objectives of the Strategy in support of I/I reduction. Any additional investment required to maintain local sanitary infrastructure will be on top of the amounts required by the Strategy.
- The amount collected at the Regional level will be used to address Regional I/I priorities both at the Regional and local municipal level. Investments in the local systems will be made to accelerate resolution of Regional priorities through augmenting local funding sources.
- The allocation of Regional funds intended for use with local municipal systems will be managed and allocated by a joint board made up of representatives from each local municipality and the Region, and will be granted based on the most effective application to achieve the desired I/I improvements as quickly as possible.

3.7.2 Establish and Maintain I/I and Water Conservation Programs

The Strategy will require that each local municipality contributes and maintains a specific and sustainable funding allocation towards the I/I reduction and long-term water conservation strategies. However, this funding will be allocated to the local municipal system that it was collected from for future allocation through reserves or other appropriate means. The funding requirement does not preclude the local municipality from collecting additional funding for other infrastructure and asset management needs of the local municipal sewer system.

The net impact of the Strategy could be an increase in local user rates or a reallocation of existing local rates. This would be dependent on current and future needs as determined by each local municipality and provided that the local municipal system meets a Regional performance standard determined through the Strategy.

Funding for the Strategy is a regionwide controlled pool that is directed by the Steering Committee, and is allocated based on the priorities developed through the Strategy to achieve the greatest system benefits regionwide. Regional funding will be allocated based on greatest I/I benefit to the communal local municipal/Regional system.

Potential program activities that will require funding include:

- Water conservation programs
- Flow monitoring
- Sanitary sewer overflow (SSO) and bypass monitoring and reporting
- Inspection programs
- Data analysis
- Development of common guidelines and standards
- Continuous improvement
- Communications programs
- Rehabilitation/replacement programs
- Pilot tests.

To accomplish this, a series of planning horizons have been developed for establishing and sustaining funding. The following sections describe the anticipated short-term to long-term program activities required to establish the funding to implement the Strategy.

3.7.3 Strategic Action Plan

Establish Short-Term Funding (1-5 Years)

- Develop preliminary cash flow plan to establish interim funding requirements.
- Establish reserves where necessary to maintain funds.
- Investigate other funding strategies used in governments with successful I/I and water conservation programs.
- Review funding and financing options to address private side I/I reduction.
- Establish process to identify and apply for alternative external funding sources.
- Investigate development charge collection for an equitable proportion of funding.
- Establish an appropriate governance and coordination model to manage overall funding and promote effective prioritization of projects.
- Initiate governance meetings.
- Implement early phases of capital projects to achieve long-term objectives.

Establish Medium-Term Funding (5-10 years)

- Update the cash flow plan and funding requirements to verify adequate funds are being collected.
- Monitor funding program success and adjust as required based on flow monitoring results.
- Verify equity of investment distribution across local municipalities and adjust as necessary.
- Review linkages of Regional plan to local municipal capital asset plans to ensure coordination and effective investment.

Long-Term Sustainability (10 years and beyond)

- Establish cyclic funding needs assessment to verify adequacy of reserves.
- Establish cyclic flow monitoring review to verify success and future priorities.
- Continue to identify and update, at a minimum, a 10-year cash flow and capital plan for the purposes of rate verification, project implementation, and effectiveness of the program.

3.8 Program Area 6 – Communication, Education and Advocacy

Communications, education, and advocacy have been identified as key components required to achieve I/I reduction in the Region. A coordinated team of Regional and local municipal staff will oversee the creation of clear and consistent messaging with a consistent brand identity for use, both internally and externally, with the various stakeholder groups. The communication, education, and advocacy staff will work closely with other members of the program team to create a communications plan that will meet the needs of the evolving program.

Communication, education, and advocacy will play a strong support role in working with technical staff in delivering the key messages to the various stakeholders. The key areas of focus are:

- Maintain internal communication between Steering Committee and staff
- Maintain external communication for council, public, other agencies
- Identify who needs to know what and when
- Develop consistent and appropriate messaging (for councils, staff, public, other agencies)
- Coordinate with leadership and advocacy to identify stakeholders.
- Develop communication plan (timing, media, based on communication template, etc.)

Figure 21 provides an overview of the various stakeholders to be engaged in I/I Communication initiatives.

The strategy for communications, education, and advocacy has been broken down into four main areas:

- Regional and local municipal internal communications,
- Public education and outreach,
- Industry communications, and
- Provincial advocacy.

Figure 21: Communication, Education, and Advocacy Stakeholders

3.8.1 Region and Local Municipal Internal Communications

The Region and local municipal staff will work in collaboration to develop materials, workshops, and tools required to assist staff to meet the goals and objectives of the I/I reduction program. A toolbox of program related information will be created for use by managers, local officials, and other decision makers. The toolbox will contain a variety of fact sheets, case studies, and other information that highlights the key components of the I/I reduction program.

The communication, education, and advocacy staff will liaise with regulatory compliance and policy staff to ensure that current and future works comply with all applicable regulations.

Other opportunities for continued communication and knowledge sharing between the Region and the local municipalities include:

- Workshops with technical committees/ working groups
- Coordination of capital planning
- Provide support to technical groups
- Develop communication protocol.

Proposed Ongoing Activities

PROGRAM ACTIVITY	RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Create municipal reporting template	Communications working group with task force	2011	Existing Region and local municipal staff
Create fact sheets and case studies	Communications working group with technical groups	2011	Existing Region staff
Create presentation templates	Communications working group	2011	Existing Region staff
Establish technical committees and workshop requirements	Communications working group to identify the need for and then pass onto technical committee	2011	Existing Region and local municipal staff
Interactive mapping tools	Task Force	2013	Existing Region and local municipal staff
Task Force meetings	Task Force	On going	Existing Region and local municipal staff

3.8.2 Public Education and Outreach

The public education and outreach components of the I/I reduction program will provide balanced, informative, and objective information on the planned and ongoing program components.

The overarching goals of I/I reduction education and outreach are to:

- Increase overall awareness of the program including opportunities and issues.
- Work with stakeholders to ensure that issues are understood and all options are considered.
- Investigate partnership opportunities in communities to facilitate remediation projects on public and private property.
- Create strong messaging and communication tools in form of newsletters, flyers or booklets that may be distributed door to door to homeowners regarding the inflow and infiltration coming from private side. Putting emphasis on homes that may have been connected legally 50 years ago but according to today's standards are negatively impacting the sewer systems. This includes weeper connections to downspout, risk of causing basement flooding, increased treatment costs, and increased risk to the environment from spills.

Information about the I/I reduction program will be shared with the public and other stakeholders, including agencies, through:

- Website content describing program components, key messaging regarding need for I/I reduction, maps showing works in progress, and plans for future work, etc. (e.g., york.ca with links to local municipal public works pages);
- Public notices and newsletters describing monitoring and evaluation activities in local neighbourhoods;
- Fact sheets and information packages related to specific program components;
- News releases describing upcoming works;
- Public meetings and information centres held prior to local construction; and
- Creation of a Citizen Advisory Committee, Task Force, or community panel especially in areas of work focusing on private property issues.

It has been revealed through numerous studies and past projects that I/I from private property could account for over 60% of the overall I/I. Communications to the homeowners regarding the sources and impacts of I/I coming from private side through faulty or non-conforming connections, and how their homes may be

Proposed Ongoing Activities

PROGRAM ACTIVITY	RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Update website	Communications and Advocacy Working Group	On going	Existing Region staff
Create fact sheets and case studies, door hangers, brochures, and information packages for private properties	Communications and Advocacy Working Group with technical groups	2011	Existing Region staff
Develop public communication plan (through brochures, newsletters, charettes, door to door campaign etc focused effort will be needed in areas where the private side system is contributing heavily to I/I)	Communications and Advocacy Working Group	On going	Existing Region and local municipal staff
Annual report card (public document based on MOE annual report)	Communications and Advocacy Working Group	2012 and beyond	Existing Region and local municipal staff
Develop standard communication plan for construction projects	Communications and Advocacy Working Group with technical groups and project management staff	2011	Existing Region and local municipal staff

impacting I/I rates and increasing the risk of basement flooding will be completed.

To address I/I reduction on private property, property owners will need to be engaged, either individually or as a community group, to facilitate the need for modifications to private property and to enforce any future bylaws that require:

- Downspout disconnections
- Lateral repairs
- Sump pump disconnections
- Other related matters.

Property owners must be educated and be a part of the decision-making process to ensure that a solution is identified that best suits the needs of the local municipality and the property owner. At this time, public meetings, workshops, and information centres would be used to design a private property program that is responsive to the needs of the community. Further, specific information packages for residents will be prepared in the early stages of the communication program.

The Region and the local municipalities will assess individual projects and work to determine the appropriate level of communication required for the various stakeholders. Similar to communications plans for other construction projects, a standardized plan will be written that will aid in getting the right information communicated to the project stakeholders at the appropriate time.

3.8.3 Industry Communication and Outreach

The I/I reduction program will consult with industry stakeholders on a regular basis to ensure that developing policies and standards meet the needs of I/I reduction and the building/construction industry. Ongoing communication through an industry advisory committee could effectively engage the various stakeholders.

Stakeholders that will be included in this type of consultation include:

- Building inspection officials
- Product & equipment manufacturers
- Engineering and design consultants
- Sewer and water contractors
- Developers and local homebuilders associations
- Environmental regulators
- Conservation authorities
- Trade groups.

The communications group will identify opportunities to promote the ongoing I/I reduction work to the water and wastewater industry through conferences, workshops, webinars, trade magazines, and seminars. Through continuous improvement efforts, partnerships for research, innovation, and demonstration projects will be explored.

The communications group will identify and support these initiatives with the I/I technical groups to communicate program components to the various stakeholder groups.

Proposed Ongoing Activities

PROGRAM ACTIVITY	RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Create fact sheets and case studies	Communications Working Group with technical groups	2011	Existing York Region staff
Establish industry advisory committee requirements	Communications Working Group with technical groups	as required based on technical need	Existing York Region and local municipal staff
Promotion opportunities to water and wastewater industry	Communications Working Group with technical groups	On going	Existing York Region and municipal staff

3.8.4 Provincial Advocacy

The Region and local municipalities will continue to work with the Province to ensure the successful reduction of I/I in the Region. Continued communication the MOE could be accomplished through the creation of a core team of technical experts from both levels of government.

A partnership approach with the Region staff and MOE staff can be developed to demonstrate leadership and efficient public governance throughout the Province. This approach can enable successful I/I in other communities, as well as provide a unified perspective for tax payers and stakeholders throughout the Province.

As the program evolves, it will become apparent where provincial support and input will be required to directly support the efforts of I/I. At this time, it is expected that the following topics could be areas for future discussion and advocacy:

- Building codes and building standards
- Measurement and quantification of I/I reduction.

3.8.5 Sustainable Neighbourhood Retrofit Action Plan (SNAP)

SNAP is an action plan developed by the Toronto and Region Conservation Authority and its municipal partners to engage a diverse range of stakeholders in improving environmental sustainability in established neighbourhoods. It will identify priority action plans on private and public property to address environmental objectives and will include I/I reduction. The SNAP initiative will place emphasis on finding creative, integrated solutions that achieve multiple benefits such as permeable pavements, low impact development and sustainable retrofits programs among other things. The Region's I/I reduction program will review the potential to support the mandate of this initiative.

Proposed Ongoing Activities

PROGRAM ACTIVITY	RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Identify technical leads from MOE, the Region and local municipalities.	MOE and Task Force	2011 and beyond	Existing Region and local municipal staff

3.9 Program Area 7 - Report I/I Reduction

The Region and local municipalities have developed this Strategy for long-term I/I reduction. It is anticipated that the Strategy will evolve over time. As a result, it is considered to be a living document that the Region and local municipalities will use to guide and manage I/I reduction programs.

The following sections describe the various reporting requirements as defined in the Minister's conditions. In addition, the processes described below will provide guidance on the intergovernmental reporting procedures.

3.9.1 Develop and Maintain Strategy

It is anticipated that the Steering Committee will continue to provide direction to Region staff to update and maintain this Strategy. Through the Steering Committee, protocols will be developed for ongoing communication and collaboration with local municipal staff.

The Region and local municipalities will each provide adequate staff resources and the Region will assign a primary staff person who will be responsible for championing the Strategy. Leading programs within the industry such as King County, Halton Region, Peel Region, and others identified in the Industry Practices Scan have assigned dedicated key personnel to I/I reduction reporting.

On May 12, 2010 Regional Council approved three (3) full time staff to support the development and implementation of the Inflow and Infiltration Reduction Strategy and Program. A Program Coordinator and Infrastructure Engineer have been hired to date and further staff are being retained in 2011 including a Program Manager. As the Program is refined and further processes and practices are established to meet system performance commitments, resource requirements will be reviewed on an annual basis and communicated to the respective Regional and Local Municipal Councils.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Strategy Communications	Provide staff resources and assign a primary staff person that will be responsible for championing the Strategy	Region and local municipalities	2011 and beyond	The Region and local municipalities to assign key staff contacts.

3.9.2 Municipal Report to Region

To meet the annual reporting requirements that the Region has with the MOE, local municipalities will need to plan for and develop a summary progress status and achievement report. This report, a sample is shown in Figure 22 (see additional example in Appendix B – Municipal I/I Annual Report), will be refined in the early stages of the Strategy, but could contain the following information:

- Electronic sewer system mapping that shows the overall extent of the sanitary sewer system evaluation program and the condition of infrastructure;
- Update on the amount of infrastructure inspected for I/I source detection purposes over the previous year;
- The extent of new sewer construction and sewer repair and replacement work over previous year;
- A summary of the results of all flow monitoring work undertaken by the municipality for any purpose;
- The location and frequency of SSO and bypasses occurring from the municipal collection system;
- A summary of expenditures for sewer system evaluation and repair and replacement activities;
- Planned activities, milestones, and budget allocations for the upcoming period;
- Planned program activities for the next year and supporting budgetary information.; and
- Staffing needs and current/forecasted resources.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Municipal Report	Develop framework, template, and timeline for a report describing municipal progress in I/I inspection and removal efforts.	Standards Working Group	2011	Existing Steering Committee/Working Group resources.
Municipal Report	Local municipal commitment to develop reports and present to Region as required.	Local Municipality	2011-2021	Local municipal resource required to manage program and consolidation of information.

1. Table 1 Example Sanitary Sewer System Infrastructure Management Report for Inter-Agency Reporting

AGENCY NAME				
Date:				
Reporting Period:	From:		To:	
Description	**Unit**	**Existing** (prior to this reporting period)	**New** (during this reporting period)	**Total**
SEWER INVENTORY				
Sanitary gravity Sewers	m			
Sanitary force mains	m			
Sanitary service laterals	ea.			
Combined sewers	m			
Combined service laterals	ea.			
No. of Manholes/cleanouts	ea.			
SEWER SYSTEM EVALUATION PROGRAM				
Smoke Testing				
Sanitary sewers smoke tested	m			
% of entire agency sewers smoke tested	%			
No. of sewer deficiencies detected	ea.			
Sanitary service laterals smoke tested	ea.			
% of entire agency laterals smoke tested	%			
No. of laterals deficiencies detected by smoke test	ea.			
Dye Testing				
Sanitary sewers dye tested	m			

Figure 22: Sample Annual Municipal Report

3.9.3 Council Reporting

To meet the annual reporting requirements the Region has with the MOE and given the investment that each government will be making over the next 20 years towards reducing I/I flows, it will be critical to keep the respective councils informed about the status of I/I reduction programs. The Region and local municipal staff are committed to preparing information reports on a regular basis or at key milestone activities. These reports will describe:

- Current and future funding and resource requirements;
- Budgetary commitments & forecasts;
- Schedule forecasts;
- Follow-up activities as prescribed by the Ministry of the Environment;
- Activities completed and planned, and the progress in achieving the reduction targets;
- Status of any local municipal council resolutions that might be required to achieve flow reduction targets; and
- Public concerns, outreach or engagement activities.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Council Report Template	Develop Template for Staff Reports to ensure consistency in reporting	The Steering Committee	2011	Existing York Region and Municipal Staff
Report Schedule	Determine the frequency of reports to Councils and get commitment of The Steering Committee for ongoing reports			

3.9.4 Annual Report of Reduction to MOE

Per the Minister's conditions (Condition 8.8), the Region is charged with submitting, to the Regional Director (MOE) and the SeCAC, an annual report detailing its progress on implementing the Strategy, including I/I reduction achieved. The first report shall be provided one year following finalization of the Strategy and every twelve months thereafter until such a date as the Regional Director determines the reports are no longer required.

The first annual report will be submitted to the Director on March 31, 2012. This report will describe the status of each of the milestone activities and the progress towards the stated I/I reduction target.

A template for this report will be developed by the Region during 2011. During the report template development process, the Region will work with the local municipalities and the MOE to ensure that the annual report addresses MOE requirements.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Research Report Template	Complete review of other interagency or upper/lower tier reports (i.e., USEPA Mandatory Reports) to determine if framework can be applied to the Region's program.	Standards Working Group	2011	Standards Working Group
Finalize Report Template	Develop the annual report template and work in collaboration with the MOE to ensure template adequately addresses applicable requirements.	The Steering Committee	2011	
Submit Annual Report	Prepare annual report and submit to MOE per the Minister's conditions.	the Region	2012 and beyond	Existing Region staff.

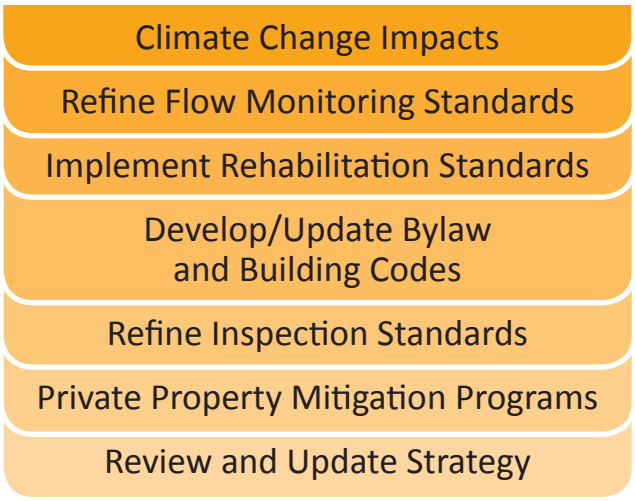
3.10 Program Area 8 - Continuous Improvement

Continuous improvement is an ongoing effort to improve the way services or programs are implemented. While the Region and the local municipalities have made great progress to date, this is the first iteration of a holistic strategy document and the continued review and implementation of more efficient programs will be required. In this regard, the development of the Strategy is the first step in the continuous improvement process. Other steps will be to:

- Plan: Identify an opportunity and plan for change;
- Do: Implement the change;
- Check: Use data to analyze the results of implementing the Strategy and determine whether it made a difference; and
- Act/Improve: If the change was successful, continue to assess the results. If the change did not work, begin the cycle again.

While this Strategy serves as a starting point and often provides the technical requirements for implementing the various programs, a number of key areas and future initiatives are required over the short and long terms. These areas have been identified as areas to focus on and enhance over the short-term and long-term:

- Review and refine data analysis and exchange procedures
- Review and refine flow monitoring standards including monitoring of overflows and system bypasses



- Review and refine/implement rehabilitation standards
- Develop/update sewer use bylaws and building codes
- Review and refine inspection standards (SSES)
- Review new technologies (Inspection and rehabilitation)
- Review and refine design and construction standards
- Review the integration of the I/I reduction strategy with the Water Efficiency and Source Water Protection Program, including coordination with rainwater/stormwater management to incorporate water re-use
- Review and implement private property mitigation programs
- Review and update overall Strategy document.

3.10.1 Climate Change Impacts

Recent provincial and municipal strategies and Toronto and Region Conservation Authority watershed plans call for greater attention to sustainable community design and the role of individual homeowners and businesses in helping to address climate change and other environmental issues. This approach is becoming well reflected in the design of newly developed infrastructure, but the greater challenge of transforming existing infrastructure still needs to be examined.

Climate change is a long-term shift in average weather conditions over time, including temperature, precipitation, winds, and other indicators. The impacts of climate change are far-reaching, affecting our infrastructure, weather patterns, wildlife, and landscapes.

Average temperatures in the Northern Hemisphere over the past half century are the highest they have been in over a thousand years. Canada's climate has warmed on average by 1.3 degrees Celsius since 1948 with the western part of the country and the Arctic experiencing the greatest change. Most of Canada has also become wetter during the same period, as average precipitation has increased from about 5% to 35% across the Country.

A warming climate in Canada will affect water quantity and quality across the Country. For example, climate models for the Great Lakes basin predict decreases in annual stream flow and lake levels. More frequent, heavy downpours may cause localized flooding and overwhelm current sewage treatment facilities with increased volumes of stormwater and sewage flows.

The Region must consider two fundamental factors when planning to address the implications of climate change:

- Risk Mitigation: Mitigation of the impacts of climate change on infrastructure.
- Adaptation: Updating infrastructure planning, design, and asset management procedures to respond to the changes.

The risks associated with not adapting to changes affecting the infrastructure systems include increased vulnerability to physical pipe and system failures, accelerated deterioration of the physical condition, and the inability to handle increased pipe flows and instantaneous flow peaks. Current planning criteria and design standards are typically based on the climate patterns of the past. Return frequency of rain events is based upon local RDII curves, many of which are becoming dated. If not addressed, the Region's planning criteria and design standards may be inadequate to handle the predicated changes.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Climate Change Model - Background	The Region to develop Regional climate change models. The model would be used to highlight climatic trends and future potential impacts of climate change.	Region	2012	Region and Municipalities to establish Climate Change Technical Committee to review impacts of climate change on Regional and municipal assets.
Develop Region Methodology and Model	Utilize a standard methodology (such as the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol) to undertake a pre-screening assessment of the potential climate change impacts to identify the vulnerability of the various sanitary sewer systems.	Region	2012	
Policy/Standards Update	Address the need for policies, procedures and design guideline changes to address adaptation to climate change.	Region	2013	

3.10.2 Refine Flow Monitoring Standards

As new flow monitoring locations are commissioned using a variety of flow metering equipment, the Region will refine the standards and procedures in use to reflect changes in technologies and enhancements to analytical procedures. Based on the flow monitoring programs used historically, an ongoing review of flow monitoring procedures (e.g., the appropriate duration of monitoring periods, type of equipment, calibration, and validation requirements) will need to continue. In addition, as the system expands into previously undeveloped areas, new flow monitoring locations will be required to capture flows from these new areas.

The Region will continue to review the latest permanent and short duration flow monitoring technologies as new technologies are released to the marketplace. The selection of metering equipment and sites will be based on the premise that flow monitoring data have many other purposes such as hydraulic model calibration, master plan, SSO monitoring, and real time control. These will also be investigated and implemented where appropriate.

One opportunity is to review subdivision agreements and design processes and require the developers to install new permanent metering locations at the time of construction.

3.10.3 Implement Rehabilitation Standards

The selection and success of rehabilitation methods depends on an understanding of the specific problems to be corrected in addition to applying the appropriate rehabilitation method for the conditions. Since many rehabilitation methods are available on the market, the choice of methods depends on criteria such as pipe size, materials, location, dimensional changes, sewer flow, and other physical factors. The Region has recently developed and is in the process of adopting rehabilitation standards. The endorsement of these standards by local municipalities is a short-term milestone.

In addition, the Region's experience with sewer pipeline rehabilitation has generally been limited to the past 10 years. As new technologies are developed and implemented and as post construction follow-up activities are conducted to determine the success in reducing I/I flows, the Region will continue to evaluate new techniques and approaches.

The introduction of new technologies for rehabilitation has many factors. As such, new specifications and standards must be created; while at the same time, existing standards will be reviewed and modified based on actual field experience.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Flow Monitoring Standards	Assess new technologies, hardware and software tools to determine if suitable in the Region's systems.	Region	Ongoing	Technical Working Group or I/I lead to manage.
Permanent Flow Monitoring	Review subdivision agreements and design standards to determine if flow monitoring structures can be constructed in the development process	Local Municipalities	2012-2013	Technical Working Group or I/I lead to manage
Monitoring of overflows and bypass structures	Review flow monitoring requirements at SSO and other bypass locations and develop short/long-term monitoring programs.	Region	2012-2013	Technical Working Group or I/I lead to manage

3.10.4 Develop/Update Bylaws and Building Codes

The various sewer use bylaws across the region provide the legal authority that underpins all aspects of how municipalities manage their wastewater systems. Sewer use bylaws give municipalities the authority to prohibit private sources of inflow such as sump pumps and roof downspouts. The sewer use bylaws also establish the requirements for new sewer connections and extensions and thereby direct that new sewers are built properly and tested appropriately to minimize future infiltration. Sewer use bylaws are important for implementing I/I reduction programs, particularly in investigating I/I from private property such as household drainage inspections, lateral inspections, downspout/foundation drain removal, lateral certification programs, or time-of-sale remediation requirements.

Based upon the Industry Best in Class Review, local municipal and Regional bylaws should have provisions for:

- Prohibiting the discharge of rain water of other inflow into the sewer system (e.g., No direct storm connections to sanitary sewers);
- Standards for a maximum acceptable level of infiltration for existing private sewer laterals; AND
- A ROE to inspect for compliance with sewer use bylaw requirements on private property and the authority to order (or initiate) repairs if needed.

The sewer use bylaws and processes within each local municipality have been compiled to determine if they could support future I/I reduction programs. A formal legal review will need to be conducted by the Region and local municipal legal counsel to review and update existing bylaws as necessary to incorporate provisions such as:

- No person shall connect to a wastewater system without consent of local municipal authorities.
- Allow local municipal staff and contractors to access private properties for the purposes of testing, inspecting, installing, removing, and repairing the wastewater service connection.
- Allowing enforcement and the imposition of appropriate penalties for bylaw violations (e.g., potential consequences for not allowing access, discharge of forbidden or over limit items, etc.).
- Program incentives for users to fix wastewater connection problems.

The Region and the local municipalities will work collaboratively to develop the specific wording for inclusion within their respective sewer use bylaws.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Bylaw review	Complete research on Canadian municipalities and gather bylaws where work on private property is being completed.	Standards Working Group	2011	Existing working group members
Bylaw review	Review language of existing bylaws; complete legal review and highlight gaps in existing processes; and develop new terminology and clauses as required.	The Steering Committee	2012	Legal counsel or contracted services

3.10.5 Refine Inspection Standards

The Region currently has inspection standards for conventional mainline/lateral CCTV, manhole inspections, and smoke testing. As new technology is developed, these standards will need to be enhanced and updated. Some of this technology may include using more sophisticated tools and equipment for carrying out inspection procedures, which will in turn require additional funding, training, and knowledge. The use of advanced inspection techniques will be able to provide an increased level and quality of information on new construction or rehabilitation works. As a result, inspection standards will need to evolve as new technologies are developed and implemented in the marketplace. For example, other inspection techniques, such as sonar/infrared/laser technology for inspection of existing or newly constructed buildings, can be seen as a tool to augment the CCTV mainline and lateral inspections. In addition, as data management procedures change, the manner in which information is delivered, uploaded, and analyzed will also change.

Inspection standards will be treated as living documents. This will require keeping inspection standards up to date and reflective of new technologies. The Region will also need to develop new inspection standards for other techniques, such as household flood/dye testing and household drainage inspections, to complement the existing inspection program standards.

The Region's Standards Committee will continue to meet and review standards on a regular basis to ensure enhancements/modifications are implemented as required.

3.10.6 Private Property Mitigation Programs

Private property infrastructure generally refers to sewer service laterals, which connect building plumbing to the local municipality's sanitary sewer systems, downspout connections, or foundation drains. In some cases the private property infrastructure might also include collection pipes, pump stations, and/or treatment plants.

Potential sources of I/I from private property (Figure 23) include broken sewer laterals, root intrusions into laterals, uncapped sewer cleanouts, and cross connections from roof drains and/or foundation drains. Sump pumps, downspouts, and other cross connections are also sources of I/I.

To date, Regional and local municipal I/I pilot programs have focused on identifying and reducing flows that originate from public infrastructure within the right-of-way. However, I/I flows from private sources are fairly common throughout, most if not all, the municipalities within the Region. Based on similar systems across North America and the findings of the Industry Best-In-Class review, it is estimated that more than 60% of all I/I comes from private property sources. All agencies contacted during the development of this Strategy revealed that reducing flows from private property is necessary for successful I/I reduction. Reducing flows from private property through projects will be reviewed in the early stages of this Strategy in conjunction with establishing the various funding mechanisms to help support the reduction projects.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Maintain Standards	Continuously review existing standards for applicability to current practices.	Standards Working Group	2011 and beyond	Commitment of Existing Standards Working Group
Develop Standards	Develop new standards as required.	Standards Working Group	2011	

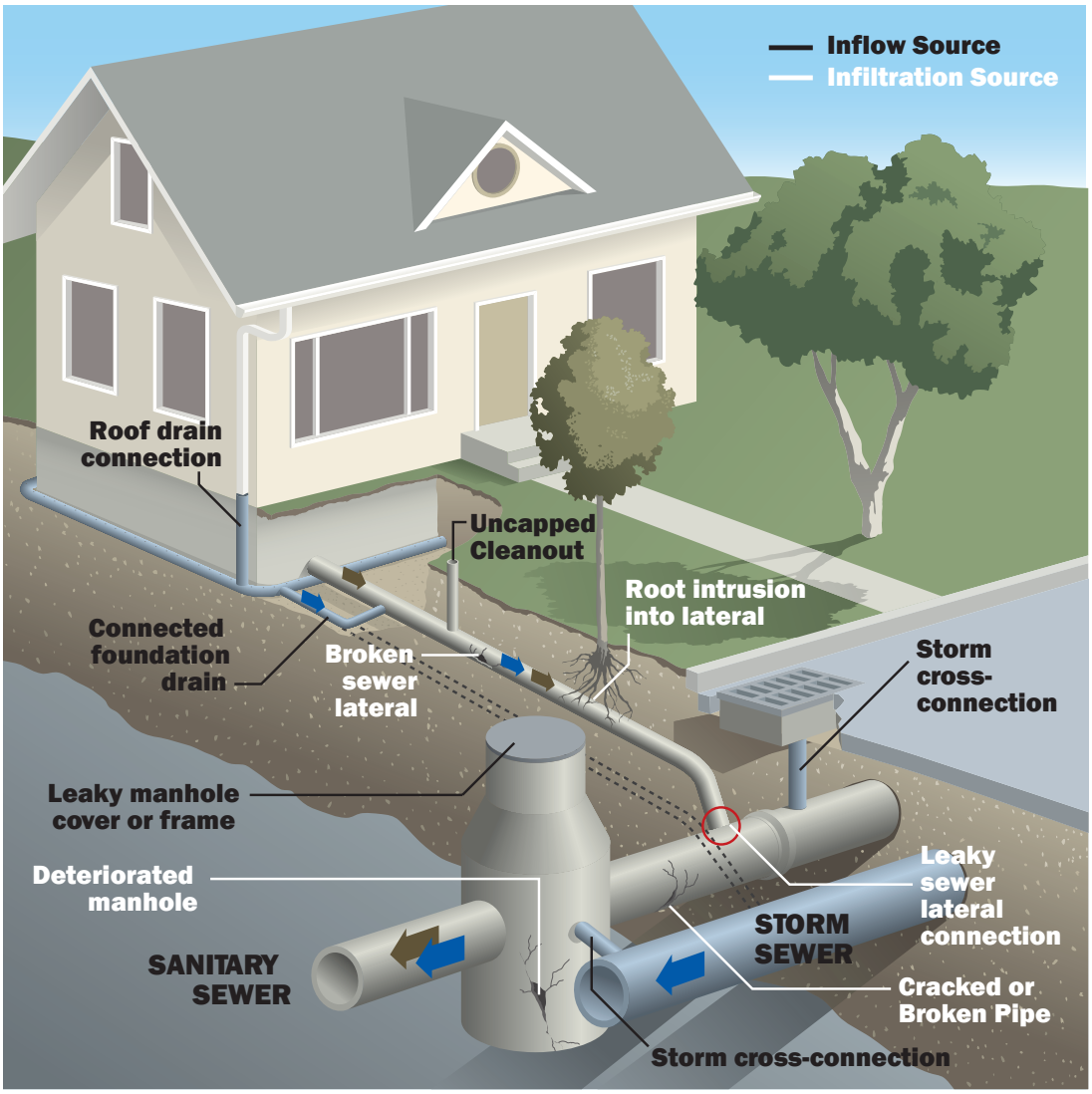


Figure 23: Sources of Infiltration/Inflow from Private and Public Property

It is important to address infiltration from private infrastructure into the Regional and local municipal sewer network to reduce I/I into the SEC and assist with achieving the goals established by this Strategy. A broad range of available options have been identified to address extraneous flows from private property. The Region and the local municipalities either have considered or will consider these options further within the coming years, including:

- Household/commercial plumbing/drainage inspections
- Downspout disconnection by Region, local municipality, or property owners
- Foundation drain disconnection programs by Region, local municipality, or property owners
- Lateral rehabilitation programs by Region, local municipality, or property owners
- Time of resale inspections and/or lateral inspection or certification programs
- Subsidy and grant programs to provide financial relief and incentives to homeowners.

As revealed in the Industry Best-In-Class review, one of the first steps in addressing private infiltration is to ensure that the local municipality's sewer use bylaws and specifications establish both "acceptable" levels of infiltration and the authority of the municipality to inspect private plumbing for infiltration and order repairs and maintenance. A more thorough effort to reduce private infiltration will require direct internal inspection of private lines.

To successfully address I/I from private property, the short-term goals of the Strategy will include:

- Establish a Regional and local municipal working group and task force to develop procedures, policies, and programs for working on private property (i.e., lateral inspections, household drainage inspections, etc.).
- Establish the legal authority to enter private property under municipal bylaws or other binding agreements.
- Create a strong program of communication and technical assistance to help property owners understand I/I and the impacts, possible solutions for homeowner involvement, and design an alternative discharge method for rainwater.
- Develop an inventory and review historic plumbing records and complete household drainage inspections to gain more understanding about where possible foundation drain or downspout connections exist.
- Establish a clear policy regarding responsibility for the cost of repairs, including a review of subsidy or grant programs to offer financial assistance to homeowners.
- Establish the local municipality's authority to order the remediation of a problem by the property owner, even in situations where the municipality may plan to fund the cost of disconnecting the flows itself.
- Include a program of follow-up inspections after any repairs are made and periodically inspect repairs/disconnections afterwards.
- Establish a strong public outreach and education component so that the public is aware of the problem and the benefits of inflow reduction, this will require constant interaction with the Communications and Advocacy Working Group.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Private Property Working Group	Region and local municipalities to establish a working group to start development of a private property mitigation program.	The Steering Committee	2011	New working group to be established
Private Property Drainage/ Plumbing Programs	Develop a procedure for inspection of private property plumbing systems for non-conformance and establish penalties as appropriate.	Standards Working Group	2011	Existing working group members
Assistance/ Subsidy Programs	Working group to review possible funding and assistance programs/models and develop protocols for who is responsible for paying for various activities.	Funding Working Group	2011 and beyond	
Legal/Non-Conforming Connections	Establish procedure and protocols for dealing with pre-1970 direct connections that were permissible at the time of construction.	Standards Working Group & Legal Counsel	2013	
Lateral Inspection Programs	Develop a procedure for inspecting private laterals including defining penalties for non-conformance; this could include lateral certification or point of sale programs.	Standards Working Group	2015	

3.10.7 Review and Update Strategy

The Steering Committee in collaboration with an assigned I/I Reduction Program Manager will jointly take overall responsibility to implement this Strategy. A specific responsibility will be to further define and implement the requisite activities necessary to ensure that this Strategy is continually maintained, enhanced, updated, and implemented. This process will commence in 2011 and is anticipated to continue as the Strategy continues to evolve. The Strategy will be updated as required as data are collected, as new information is learned, and as new technology becomes available. Review and update of the overall communication plan for private, public and agencies will also be part of the update work.

The review and updating of the overall Strategy will require the continual commitment of Regional and local municipal resources over the life of the Strategy. Updates and revisions to this Strategy will be presented to the MOE annually and in 5-year update reports. The Region will submit an annual report to the Regional Director and the SeCAC that details the implementation progress, including I/I reduction. In addition to the first report that will be delivered on March 31, 2011, the Region is required to update the Strategy, to the satisfaction of the Regional Director, at a minimum of once every five years until otherwise directed by the MOE.

Proposed Ongoing Activities

PROGRAM ACTIVITY		RESPONSIBILITY	PROPOSED TIMING	RESOURCE REQUIREMENTS
Assign Program Manager	Assign staff member with the primary responsibility for implementing the Strategy. Duties to include: overall program leadership; ongoing coordination with the Steering Committee and senior management, working groups, municipalities, committees and working groups, public outreach; and validation that reporting requirements are met and completed as required.	the Region	2011	Dedicated Program Manager
Water Opportunities Act (Bill 72)	Investigate reporting requirements and integration points of I/I Strategy with Act once regulations are developed.	the Region	2011-2012	Dedicated Program Manager
Strategy documentation, maintenance and updates	Define report format and prepare annual and five-year update reports. Incorporate local municipal report information where appropriate.	the Region	2011 and beyond	Region commits primary resource/ contact with responsibilities for maintaining the Strategy.

4.0 Conclusions

This Inflow and Infiltration reduction Strategy identifies a regionwide mitigation and reduction program covering the entire wastewater service area.

This Strategy document has been developed by the Region and local municipalities in a collaborative manner in response to the Minister's conditions for approval of the Southeast Collector Trunk Sewer Individual Environmental Assessment. The various sections of the Strategy describe the processes that will be implemented in the short and long terms.

The Strategy builds upon the success of programs already underway as the Region and local municipalities each have existing programs in place. It is the purpose and intent of this Strategy to build upon these existing programs and meet or exceed the requirements and intent of the Minister's conditions.

The Strategy is defined in a series of high level program areas, each of which has a number of specific program activities and the timeline for each activity has been identified. The program areas and activities were selected based on their consistent representation in the best-in-class inflow and infiltration reduction programs. The Region prepared a review of best-in-class inflow and infiltration reduction programs, initiatives, strategies, and tactics as adopted by other jurisdictions. The results of this review were posted on the Region's web site for stakeholders' review.

The Strategy is comprised of eight key program areas and program activities:

1. Overall program goals and I/I targets
2. Monitor and analyze flows
3. Investigate and mitigate
4. New construction and capital projects
5. Financial management
6. Communication, education, and advocacy
7. Report I/I reduction
8. Continuous improvement

This Strategy speaks to each program area and describes the required activities, the short-term and long-term goals, and the deliverables for each one. A series of near term and ongoing activities will be required to permit adequate planning activities to be conducted and to ensure resources are available to implement the Strategy.

A reduction schedule and the timeline for achieving the wastewater reduction goals was developed and presented within the Strategy. In many cases, the

activities within the Strategy form a critical path and are dependent upon one another to commence. As information is gathered and programs are implemented, the reduction schedule will be updated.

This Strategy has also been peer reviewed by leading industry practitioners, including a comparative analysis of the proposed Strategy relative to best-in-class tactics/strategies used by jurisdictions throughout the world. The Strategy has also been presented to the SeCAC Advisory Committee for comment.

Going forward, the Steering Committee, led by, and in collaboration with an assigned Regional Program Manager will assume joint responsibility to implement this Strategy. They will define and implement the requisite activities to ensure that the Strategy is continually maintained, enhanced, and carried out in a timely manner per the requirements of the Minister's conditions.

The implementation will commence in April 2011 and is anticipated to continue as a sustained program over the next 20 years. The Strategy will be updated as data are collected, as new information is learned, and as new technology becomes available.

An annual report will be prepared and submitted to the MOE that describes the status of the programs including:

- Results of water conservation and efficiency measures.
- 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 Region.
- Progress in the reduction of inflow and infiltration into the Southeast Collector Trunk Sewer.
- Details of any remedial work to the sewage system undertaken and the results of the remediation.
- Results achieved within the Region with respect to inflow and infiltration reduction measures.

The review and update of the overall Strategy will require the continual commitment of Regional and local municipal resources over the life of the Strategy. Updates and revisions to this Strategy will be presented to the MOE in annual and 5-year update reports.

Through the development and implementation of the Strategy, the Region and the local municipalities have demonstrated leadership in inflow and infiltration reduction within the water and wastewater industry. The Region and local municipalities' current commitment to inflow and infiltration reduction will serve to form the foundation of a world class program.

Appendix A – Audit and Measures Procedures Document

Mandate of the Audit, Monitor and Measure Group

To meet the SEC IEA Conditions of Approval stipulated by the Minister of Environment, a long-term commitment to I/I reduction is required of the Region and the local municipalities. To coordinate the effort, a Steering Committee was established in May 2010 to oversee the overall I/I reduction program, which is expected to be implemented over the next 20 years and beyond.

Following the establishment of the Steering Committee, the Audit, Monitor and Measure Group (Audit Group) comprised of staff from the Region, local municipalities and consultants was formed and mandated to establish I/I reduction targets and determine a practical methodology to measure, monitor and report on the Region's progress toward achieving those targets.

With this mandate, the Audit Group identified a number of key objectives to be implemented:

1. **Establish Overall I/I Reduction Targets**
2. **Audit Basin and Catchment Delineation**
3. **Develop Audit Tools including:**
    - Flow monitoring programs will be developed to strategically monitor flows in the system. Data from flow monitors will help to identify areas with high I/I and provide input to hydraulic modelling for quantifying I/I reduction;
    - Precipitation Monitoring will be conducted and the data used to identify the meteorological conditions which promote I/I;
    - Temperature Monitoring will be conducted to assist in evaluating soil moisture conditions and the data used in the predictive computer and graphic analysis models and;
    - Hydraulic computer models: an all-pipe model will be used and updated continuously to reflect new flow, precipitation and temperature data. The model will be used to quantify projected extraneous flows and assess the impacts of I/I reduction measures on the system.
4. **Develop Audit Procedures**
   Audit Procedures will be developed which will include identification of areas of high I/I, where subsequent Sanitary System Evaluation Studies (SSES) to locate sources of I/I and the identification and implementation of rehabilitation projects will occur. The audit process will involve analyzing pre- and post construction flow monitoring data and carrying out modeling to quantify and document I/I reduction.
5. **Establish Need for Continuous Improvement**
   Continuous Improvement is required on all aspects of the audit process including reviewing the I/I reduction target(s), and updating the Audit tools, methodology and procedures to ensure that experience gained through the process is used effectively toward achieving the ultimate goal in reducing, tracking and quantifying I/I reduction.

Section A. Establishing Overall I/I Reduction Targets

The SEC Trunk Sewer IEA contemplated a 10% reduction of peak instantaneous flow in the SEC through:

- I/I reduction of existing development
- I/I reduction of new development (reduction from current design allowance of 0.29 L/s/ha to 0.26 L/s/ha or below)
- Water conservation measures

The 10% reduction target forms the initial goal upon which the Audit Group used to establish the overall reduction program.

Given that the goal is to achieve a numerical reduction target, quantifying I/I reduction becomes a requirement in the audit process. It is recognized that given an area as large as the SEC service area, it is rare for similar rainfall events to occur that would provide flow data sufficient to carry out proper comparison of pre- and post rehabilitation conditions. Many rainfall events have high rainfall intensity in one part of the Region while producing low to no rainfall elsewhere. As discussed later in Section B, it is proposed to divide the SEC basin into smaller and more manageable catchments for auditing purposes. Given the attenuation effect auditing smaller basins poses a challenging problem. If instantaneous peak flow is adopted as the measuring criteria one unit reduction of instantaneous peak flow rate in an audit basin upstream of the SEC does not necessarily generate one unit reduction of peak rate at the SEC, where the overall reduction target is based. Several potential methods in which the Region could practicably quantify and audit I/I reduction were closely studied by the Audit Group. It was determined that a 24-hour flow volumetric reduction is the preferred measuring criterion, as described in detail below.

A.1 Evaluating Instantaneous Peak Reductions versus Volumetric Reductions

Measuring Criteria Using Instantaneous Peak Flow Rates

As wastewater is routed through the sewer system peak flow rate is attenuated as sewage flow is slowed down and/or temporarily detained in the available volume of the sewer pipe, pump station wet wells and equalization tanks. There are approximately 7,000 km of private and public sewers, 17 pumping stations and 2 equalization tanks in the YDSS system, representing a substantial volume of attenuation capacity. In addition, flow rates immediately downstream of pumping stations are governed by pump operating capacity regardless of the flow rate entering the stations.

Measuring Criteria using Volumetric Reduction

A more practical methodology will be to divide the SEC basin into smaller catchments and audit I/I reduction based on volumetric flow reduction. Volumetric reduction is not skewed by the time of conveyance, flow attenuation and pumping. For mass balance, one unit of volume reduction upstream will generate one unit of volume reduction downstream. Volumetric reductions in all audit basins can handily be summed up and applied to the overall reduction in the SEC basin.

It is recommended that the Measuring Criteria for determining the success of the I/I Reduction Program be based on volumes and be audited in smaller catchments referred as audit basins and described in detail in Section B.

A.2 Determining Overall I/I Reduction Volume

In developing a volumetric reduction target, certain criteria were established by the Audit Group. Specifically, I/I reduction targets should: 1) use a target year that has some certainty in population projection; 2) be compatible with the approach used for setting water conservation targets; and 3) align with the 10% reduction in instantaneous reduction target previously proposed in the SEC IEA.

A.2.1 Establishing Target and Baseline Years

The SEC IEA contemplated a targeted reduction of 10% of total flow in SEC in the year 2036 under a 25-year using a design criteria of a 25-year storm event. The Audit Group recommended that the target year be revised to 2031, as the year 2031 corresponds to the Places to Grow Act, 2005 and the projected population in 2031 has more certainty given its planning status. The Audit Group also recommended that the baseline year be set at 2008, corresponding to the year that the IEA document was prepared and submitted for approval

A.2.2 Establishing Duration for Volumetric Measurement

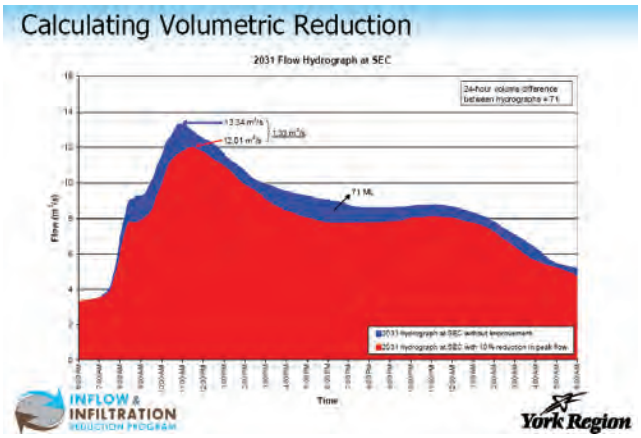
The overall reduction target comprised of both water conservation and I/I reduction. Water consumption varies throughout the day and is normally measured on a daily volume basis. To be compatible with the water conservation targets, it is recommended that a 24-hour duration be used for measuring the peak flow volumes

A.2.3 Establishing Numerical Target for Volumetric Reduction

To align with the 10% instantaneous peak flow reduction target contemplated in the SEC IEA, the volumetric target is based on estimating the corresponding volumetric reduction of a hypothetical storm event that has an instantaneous peak 10% less than the peak generated by the 25-year Chicago design storm in 2031. To this end, the existing hydraulic model was used to generate two hydrographs (at the SEC) under:

1. a 25-year storm event in the year 2031
2. a hypothetical event that produces an instantaneous peak 10% less than the above

The adjacent Figure presents a graphic view of the two hydrographs.



The top curve represents the expected flow at the SEC (near the community of Boxgrove in the Town of Markham) under a 25-year storm event in 2031. Simulation results predict the peak flow to be 13.3 m3/s. The lower curve represents a hypothetical event that generates a peak flow of 12.0 m3/s (10% less than 13.3 m3/s). As the analyzes reveals, the difference in volumes is approximately 71 ML over a 24-hour period.

It is expected that water conservation will contribute 40% to 50% of the total required reduction of 71 MLD. With this, a target reduction of 40 ML over a 24-hour period during a theoretical 25-year storm event in 2031 is proposed.

Section B. Delineation of Basin

B.1 Basin Delineation

As discussed above, because of the attenuation issues and complexity of the YDSS, the entire service area tributary to the SEC was deemed too large to permit proper auditing. To address this issue, the service area was divided into a series of increasingly smaller, nested drainage basins that would allow analysis, rehabilitation and auditing to occur in reasonably sized geographic areas.

In the first delineated level, the entire YDSS service area was divided into sanitary sewersheds, each of which have a single outlet and represent, at a Regional level, gravity versus pumped flows. Five (5) sewersheds were defined as follows:

- **Newmarket:** Wastewater flow that is pumped from Newmarket and East Gwillimbury to the Aurora sewershed
- **Aurora:** The combined pumped flow from Aurora and the Newmarket sewershed to the 16th Ave / Ninth Line sewershed
- **16th Ave/Ninth Line:** The gravity flow of 16th Ave/Ninth Line sewershed to the Southeast Collector (SEC) at Box Grove
- **Leslie St Pumping Station (PS):** The pumped flow from Leslie St PS sewershed to the Lower YDSS sewershed
- **Lower YDSS:** The gravity flow of the Lower YDSS sewershed to the SEC at Boxgrove

A map showing the existing wastewater service area within the YDSS is shown in **Figure 1 Existing Sewersheds within the YDSS Service Area**.

The delineation organizes the YDSS into increasingly smaller catchment areas. With few exceptions, each catchment area is wholly contained within a single parent catchment. For example, the Service Area is comprised of 5 Sewersheds. Each Sewershed contains an average of 10 Major Basins, while each Major Basin contains an average of three audit basins. There is an average of three mini basins in each audit basin, and so on. The delineation breakdown is presented below in Table 1.

An example of how basins were delineated is shown in the Table 1. The Newmarket Sewershed and its audit basin and mini basin configurations are displayed, where each unique colour represents a different audit basin.

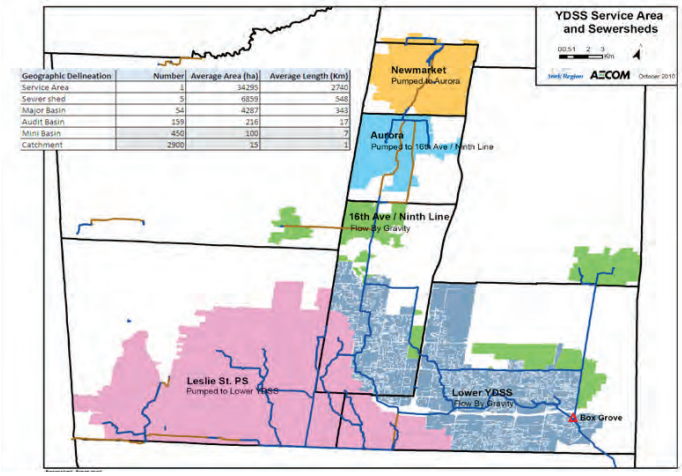


Figure 1: YDSS Service Area and Sewersheds

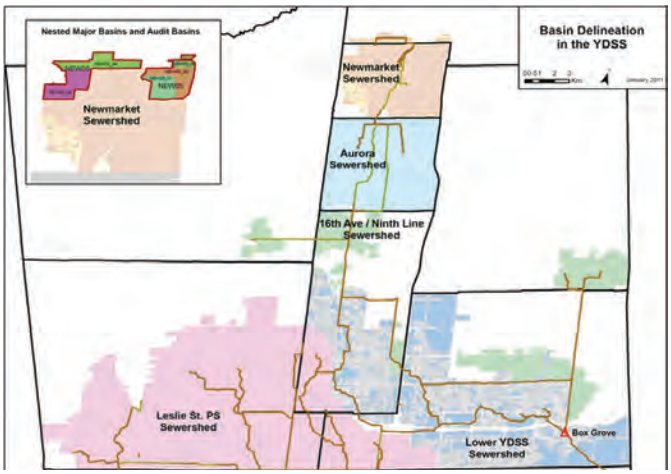


Figure 2: Sewershed Delineation

Table 1: Geographic Delineation of the York-Durham Sewage System

GEOGRAPHIC DELINEATION	NUMBER	AVG. AREA (HA)	AVG. LENGTH (KM)	DESCRIPTION
Service Area	1	33,374	2,751	Entire area draining to SEC
Sewershed	5	6,675	540	Major pumping and/or sewersheds
Major Basin	53	630	51	Model calibration basins
Audit Basin	160	207	17	Level at which I/I reduction is audited
Mini Basin	450	100	7	SSES basins
Catchment	2,900	15	1	Model subcatchments

Section C. Auditing Tools

C.1 Hydraulic Computer Model

Numerical modeling will be a key technical activity of the auditing process particularly in quantifying the success of I/I reduction. Since proposed reduction targets are based on a projected 25-year storm event, and measured flow data represents actual observed data of different rainfall volume and intensities, the model will be a key tool to normalize measured flow rate to a 25-year theoretical flow rate. The model will be calibrated to recorded storm events and used to predict wastewater flows (including I/I) for the projected 25-year design storm event.

Before and after rehabilitation activities, flow data at the Mini Basin levels will be collected to support model recalibration. Pre-construction and post construction 25-year storm volumes will be generated by modeling and the results will be entered into an audit spreadsheet (see Figure 4) to track remediation projects and document the reduction in I/I volume.

Model Development

Numerical models are mathematical models that use a numerical time-stepping procedure to obtain the behaviour of a particular system. Hydraulic modeling capabilities in the Region have evolved over the years from simple spreadsheet tools to the sophisticated hydraulic modeling software in use today. In 2004 a fully dynamic hydraulic computer model employing the full set of St. Venant equations was developed.

The model includes the major trunk and sub trunk sewers in the YDSS owned by the Region, plus some of the larger pipe lines and connecting sewers within the local collection systems. While the model was originally used software developed by the Danish Hydraulic Institute, the Region's current model currently being used by the Region has been converted to InfoWorks CS (Collection Systems) software from MWHSoft.

To help assess the impact of I/I reduction remediation projects, an all-pipe hydraulic computer model is currently under development. The all-pipe model will include all pipes, pumping stations, equalization tanks and flow control gates within both the local and Regional systems. The model will be capable of simulating hydraulic and hydrologic conditions in the YDSS. Existing and future wastewater flows across the system will be simulated and the success of I/I flow reduction projects will be evaluated.

Model Calibration

To provide reliable results, the hydraulic model must be representative of the actual system and must be calibrated. The Region currently maintains a network of flow and rainfall monitoring gauges and has carried out extensive monitoring activities between 2008 and 2011 to provide data for model calibration. The hydraulic model will be calibrated based on the above-mentioned flow monitoring data and later recalibrated at regular intervals as new flow and rainfall data becomes available through flow monitoring undertaken in selected Audit and mini basins.

Model Updates
The hydraulic model will be updated as the sewer network in the YDSS evolves and as I/I reduction measures are implemented. Protocols will need to be developed for these updates. Processes for information sharing and exchange with local municipalities will also be defined as part of the all-pipe model development program.

C.2 Flow Meters

C.2.1 A sound Flow Monitoring Program is necessary to provide essential data for identifying and quantifying I/I. It is anticipated that different flow meter types will be required to handle the varying flow conditions existed throughout the service area.

Identification of wet weather flows will be accomplished by measuring wastewater flows at key locations within the Regional and municipal sewer conveyance facilities and evaluating the change in system flows in response to precipitation events. Wastewater flow will initially be measured and recorded with flow meters from relatively large areas of the system (audit basin level). These data will be used to help prioritize which areas of the YDSS will receive increased scrutiny for I/I reduction. Design and initial implementation of the audit basin flow monitoring programs is anticipated to occur during the first three of the Strategy implementation period.

Once the preliminary assessment phase has been completed, sufficient information will be available to prioritize the audit basins which will require additional study or investigation. Additional flow meters will be installed (at the mini basin level) in those audit basins which show a measurable response to precipitation events. In this manner, specific neighbourhoods where I/I is being generated can be targeted and specific sources of I/I identified.

The Flow Monitoring Program will, in general, include installing a network of flow meters within the YDSS system. Flow data will be used to:

- Develop flow characteristics for dry weather flow
- Develop flow characteristics for wet weather flow
- Measure existing infiltration volumes
- Measure existing inflow volumes
- Derive preliminary design storm flows
- Derive preliminary I/I reduction targets
- Define basin prioritization
- Calibrate hydraulic models
- Measure post remediation flow
- Quantify I/I reduction

A flow monitoring strategy will be defined in the early stages of the Flow Monitoring Program. Program requirements will be defined in detail at that time, but will include the identification of specific locations where flow meters are to be installed and will address topics such as permanent flow monitors vs. rotating flow meters, relocation planning, flow meter types and styles to be used, meter accuracy, data review and management, QA/QC, etc.

It is anticipated that some locations will be selected as permanent flow monitoring sites. Other locations will be targeted for inclusion in a rotating flow monitoring program. The rotating flow meters are intended to be mobile and capable of being moved from site to site for different durations as needed to meet the needs of the program.

Based on input from the International Best-in-Class Review completed prior to developing this Strategy, the Region plans to measure wastewater flow in numerous locations across the YDSS service area. It is anticipated that flow meters will be installed at the outlet of each audit basin. The data recorded from these meters will be used to perform the Preliminary I/I Assessment described above in Section D-1.

Someof the 160 audit basins are known to have more than one connection to the Regional trunk system and there are 160 audit basins. With the assumption that on average, approximately 30% of the audit basins have more than one outlet and will require two or more flow meters to record flow from the entire basin, it is anticipated that approximately 200 flow meters will be required to simultaneously measure wastewater flow in all audit basins.

Currently the Region is conducting flow monitoring at approximately 45 locations to provide data for model calibration, referred hereinafter as "model calibration basins." An additional 40 locations within the local municipal systems, similar in nature to proposed mini basins, are currently being monitored as well. Preliminary analysis has been conducted on this data and some areas of high I/I potential have been identified. It is anticipated that additional mini basins will be targeted for monitoring in support of future SSES work to quickly identify rehabilitation projects in the early years of Strategy implementation. A rough estimate was made that additional 40-100 flow meters may be required for mini basin monitoring.

Table 2: Estimated Number of Flow Meters Required

GEOGRAPHIC DELINEATION	FLOW METERS REQUIRED
Audit Basin	200
Mini Basin	50-100
Total	250-300

It is anticipated that this large number of flow meters will be comprised from a combination of meters that are currently owned by the Region plus newly purchased meters. An evaluation of the preferred manufacturer(s), style and type of flow meter, for both permanent and temporary applications will need to be conducted.

C.3 Rainfall Monitoring

The goal for establishing the rain gauge coverage will be to ensure that there is sufficient spatial distribution of gauges to support the Flow Monitoring Program. Heated rain gauges will be utilized to minimize lost data due to freezing weather and in order to convert snowfall to an equivalent rainfall depth.

Precipitation data will be recorded in five-minute intervals. This will allow staff to calculate rainfall event duration and intensity and will be used to calibrate the hydraulic models. Rain gauge sites will be selected using criteria such as access to the gauge for field crews, equipment security, and clear horizon (typically within a 30º cone above the gauge is desired). The Region also maintains a network of 22 tipping bucket rain gauges distributed across the region. Proposed rain gauge site locations will be reviewed with Regional and local municipal staff prior to installation. It is anticipated that a combination of existing sites and new rain gauging sites will be required.

In addition to tipping bucket rainfall monitoring devises, use of virtual radar based rainfall data will be considered. Radar based rainfall data are useful in identifying rainfall intensities that occur between rain gauges and could be a useful tool in future flow monitoring analysis and for model calibration.

C.4 Temperature Monitoring

Where required, temperature data will be collected and used with precipitation data to correlate rainfall and snow depth information and to calculate evapouration rates. Soil moisture conditions will be derived for use in the predictive computer and graphical models.

Section D. Audit Procedures

D.1 Identification of Areas with High Extraneous I/I Flows using Mini Basin Flow Monitoring

To reduce I/I from the system it will first be necessary to identify specific locations where extraneous flows enter the system. This will be accomplished by first measuring wastewater flows exiting each audit basin and observing the change in flow rates and volume when precipitation events occur. Once a sufficient number of precipitation events have been recorded the audit basins will be ranked relative to one another in terms of peaking factors (the ratio of peak flow rate during a storm to average daily flow) and by RDII volume (total storm event volume minus average dry weather flow volume).

The flow data in high ranking basins will be evaluated to identify whether prevailing extraneous flows are inflow or infiltration based. Base flows and infiltration volumes will be derived and applied in the hydraulic model. Communication with municipal staff will be conducted to gain insight on possible I/I sources, and finally, each basin's potential for I/I reduction will be evaluated. This evaluation will provide the basis for prioritizing which audit basins will be targeted for further study.

D.2 Investigation (Sanitary Sewer Evaluation Studies)

As described earlier, each Audit basin is comprised of an average of three mini basins. In high priority audit basins, a flow monitor will be installed at the outlet of each mini basin. A Sanitary Sewer Evaluation Study (SSES) will be performed in mini basins that show high RDII. SSES activities include review of plumbing records and field investigations such as manhole inspections, smoke testing, sanitary sewer mainline closed circuit television (CCTV) inspections, and public/private lateral CCTV inspection.

Data gathered during inspection activities is critical in pinpointing specific locations and sources of extraneous flow. It is through activities conducted in the SSES program that specific defects will be identified and targeted for remediation activities. This investigation will also allow the estimation of the split between Inflow and Infiltration.

Assessment and Planning of Appropriate Rehabilitation/ Renewal or Replacement Strategies

As specific defects concerns are identified in the SSES, project plans will be developed and evaluated on their cost effectiveness. Similar to prioritizing audit basins in terms of potential I/I reduction, concerns will also be prioritized, this time not only in terms of I/I reduction, but also in terms of risk, cost and benefits.

D.3 Post Construction Monitoring

It will be necessary to record additional flow data after rehabilitation work is completed to assess whether RDII volume has been successfully removed from the system and to determine the effectiveness of specific I/I reduction measures. Flow meters will be installed in the same location that they were installed prior to remediation activities (the pre-construction flow meters). The duration of post construction flow monitoring will be dictated primarily by the number and magnitude of storm events that are recorded after construction is completed. One to three years of post construction monitoring is anticipated in each mini basin to collect the necessary flow data and associated rainfall data to adequately measure the I/I reduction volume.

D.4 Normalizing Flow Data to a 25-year Design Storm

Flow data collected before and after remediation are for real events with different intensities, durations and coverage areas. To permit equal comparison between pre-construction and post construction flow rates, normalizing measured flows to a common storm event is required. The 25-year Chicago theoretical storm has been used by the Region to prepare its 2009 Water and Wastewater Master Plan and the SEC IEA submission, and for consistency is chosen as the basis of comparison.

The likelihood of measuring and recording an actual storm that even approaches the volume of the 25-year design storm is statistically remote. As a result, methods to project flows under a 25-year storm event have to be used. Two key methods are proposed:

Method 1:
Hydraulic Model Simulations:
When sufficient flow and rainfall data are available, the Region's all-pipe hydraulic model can be calibrated and used to predict flows for a 25-year storm event. The hydraulic model will be used as the primary tool to predict future flows.

Method 2:
Rainfall/Flow Regression: Graphical Analysis of Precipitation Depth vs. RDII Volume
In the absence of a well calibrated model, this method provides a reasonable estimate of projected RDII of a 25-year design storm. This method, which is sometimes referred to as the Q vs. I or Rainfall/Flow Regression method, is presented in the United States Environmental Protection Agency document titled Review of Sewer Design Criteria and RDII Prediction Methods, (EPA/600/R-08/010), January 2008.

This method calculates RDII volume from rainfall data through a relationship between rainfall depth and RDII flows. Antecedent soil moisture conditions can be applied to the analysis by calculating an Antecedent Precipitation Index (API), which is a measure of antecedent rainfall. This method has been widely applied and is proven to be a successful predictor of RDII flow rates and volumes for other agencies. The method generally requires at least 2 years of rainfall and flow data to develop equations that adequately reflect seasonal variations in soil moisture and the response to rainfall under a wide range of antecedent conditions.

Using gathered data, recorded storm events will be evaluated utilizing scatter graphs, which portray measured RDII volume vs. simultaneously recorded rainfall depth. Scatter graphs will be prepared and used to project RDII volume during the 25-year design storm. Over time, as more and presumably larger storms are recorded, the accuracy of flow projection will increase.

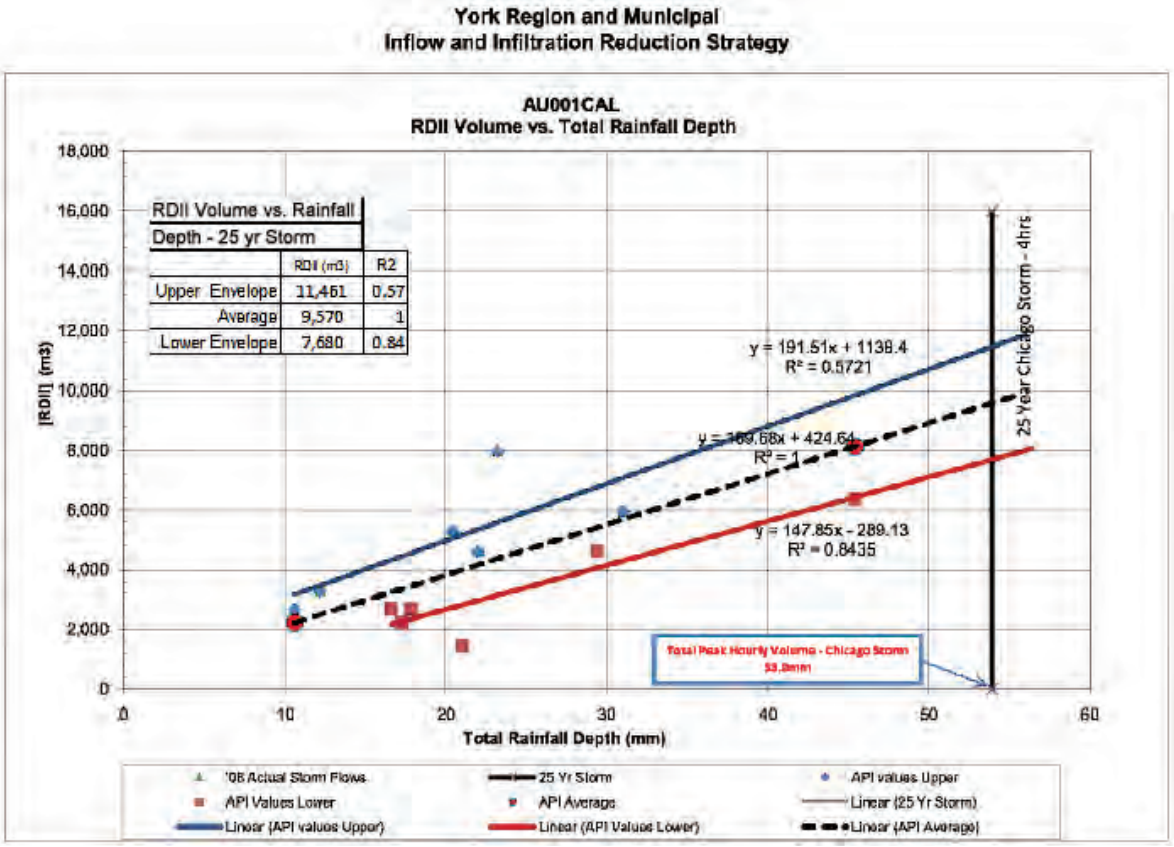


Figure 3: RDII Volume vs. Rainfall Depth

A typical graph plotting RDII volume (in m3) against total rainfall depth (in mm) of this type is presented in **Figure 3 RDII Volume vs. Rainfall Depth**.

In creating scatter plots, upper, lower and median predictive plots are made which represent the range of RDII volume that can be anticipated during the 25-yr Chicago design storm.

Upper and lower best-fit lines (shown as blue and red lines) are then plotted through the two datasets and extrapolated out until they cross the 25-yr. design storm depth. Design storm RDII volume for the catchment is calculated using either the median value of the upper and lower best-fit lines (as shown in Figure 3), or the average of all storms, depending on the closeness of fit, or R2 value of the points.

Other methods have also been explored including:

Constant Unit Rate Method

Experience gained from flow analyzes conducted during the Region and Local Municipal I/I Reduction Program – Phase 1 project and subsequent system wide monitoring for model calibration showed that I/I rates vary dramatically from area to area within the basins that were studied. As a result, it was determined that the constant unit rate method, which calculates RDII as a fixed constant (i.e., liters/second/hectare) and is applied over the entire catchment area, does not provide sufficient accuracy to be used as the primary method. However, this method may be used in the early stages of the program to calculate preliminary, placeholder RDII values for those areas where no flow data are available.

D.5 Quantification of I/I Reduction

Data from the pre-construction flow monitoring will be used to recalibrate and develop the pre-construction hydraulic model. Similarly, post construction flow data will be used to develop the post construction model. The two hydraulic models will be processed to determine the difference in 24-hour flow volumes during a 25-year storm event under pre- and post construction conditions. The calculated I/I reduction amount for each audit basin will be entered into an audit tracking spreadsheet in which the sum of reductions of all audit basins will be calculated to track the program progress in achieving its overall I/I reduction goal.

D.6 Deriving Inflow and Infiltration Volumes

Flow monitoring results will be used to determine inflow rates and infiltration volumes that currently enter the system. It will be necessary to differentiate inflow from infiltration to make important decisions in regard to identifying priorities for future enhanced flow monitoring, for SSES inspection activities, potential remediation works and for model calibration.

D.7 Auditing I/I for New Development

The Region traditionally used 0.29 L/s/ha as the maximum I/I allowance and the SEC IEA targeted a reduction to 0.26 L/s/ha for new construction. It is the Region's plan to implement new commissioning standards for sanitary sewer construction throughout the region. Flow monitoring of new subdivisions will be carried out to determine reduced flow rates in new construction.

D.8 Audit Tracking Spreadsheet

An Audit Tracking spreadsheet will be used to assist in tracking targeted and accomplished I/I reductions.

Planned Reduction vs. Achieved Reduction
During Year 1 of Strategy implementation, preliminary I/I reduction targets for each audit basin will be established and tracked. An audit spreadsheet will be prepared and updated on a regular basis as rehabilitation works are constructed. As post construction flow data are recorded and analyzed, flow reductions in each audit basin will be estimated for design storm conditions using the techniques described in Section D.5. I/I reduction volumes will be reported and totaled in the audit spreadsheet to determine the overall reduction.

Over time, as the Strategy is implemented, the audit spreadsheet may be expanded to include additional audit information such as individual audit basin reduction targets, baseline inflow and infiltration volumes and baseline RDII, etc. An example of the initial audit spreadsheet is shown in Table 3.

Table 3: Excerpt from the Audit Process Spreadsheet

PROJECT ID	YEAR CONSTRUCTED	AUDIT BASIN	DESCRIPTION OF SYSTEM REHABILITATED	ESTIMATED I/I REDUCTION (MLD)*
M-10-1	2010	LES02_01	45 Downspout disconnections in Thornhill, Markham	0.8 MLD
A-10-01	2009 2010	AU01/AU05	8 linear kilometres on sewer rehabilitation (full length lining) in Aurora	Pending analysis of pre and post flow data
A-11-01	2011	AU01/AU03	Rehabilitation of 25 high priority manholes	Pending analysis of pre and post flow data

*I/I reduction volume will be estimated using the techniques described in Appendix A, Section D.5

Section E. Adapting to Climate Change

The impact of climate change on the Region cannot be ignored in regard to the Strategy. A warmer climate will likely have impacts on the volume, duration and intensity of storm events. Larger storms and more frequent flooding are predicted as a result of climate change. The Region and local municipalities must find ways to mitigate risks associated with the impact of climate change on wastewater facilities. Planning, design and asset management procedures will need to be implemented that will allow flexibility and appropriate responses to conditions as they change.

In the future, infrastructure on both the public side and on the private side will need to be constructed in a manner that minimizes entry of excessive amounts of inflow and infiltration into the sanitary sewer system. Future planning, design and construction criteria may need to be revised to provide conveyance of larger storm volumes. Rehabilitation of leaking public and private infrastructure will be required to minimize flows. These issues will require close cooperation between the municipalities, their customers and the Region.

Section F. Establish Need for Continuous Improvement

This audit process will be reviewed and updated on a regular basis. The Region also anticipates that best practices in regard to I/I removal processes will be developed and improved over the life of the Strategy. It is likely that new technologies and analysis techniques will be developed that will enhance the Region's ability to remove I/I.

Appendix B – Municipal I/I Annual Report

Municipal I/I Annual Report - Sample				
Date:				
Reporting Period:	From:		To:	
DESCRIPTION	**UNIT**	**EXISTING** (prior to this reporting period)	**NEW** (during this reporting period)	**TOTAL**
SEWER INVENTORY				
Sanitary gravity sewers	m			
Sanitary force mains	m			
Sanitary service laterals	ea.			
Combined sewers	m			
Combined service laterals	ea.			
No. of Manholes/cleanouts	ea.			
SEWER SYSTEM EVALUATION PROGRAM				
Smoke Testing				
Sanitary sewers smoke tested	m			
% of entire local municipal laterals smoke tested	%			
No. of sewer deficiencies detected	ea.			
Sanitary service laterals smoke tested	ea.			
% of entire municipality's laterals smoke tested	%			
No. of laterals deficiencies detected by smoke test	ea.			
Dye Testing				
Sanitary sewers dye tested	m			
% of entire municipality's sewers dye tested	%			
No. of sewer deficiencies detected	ea.			
Sanitary service laterals dye tested	ea.			
% of entire municipality's laterals dye tested	%			
No. of lateral deficiencies detected by dye test	ea.			
CCTV Inspection of Sewers				
Sanitary sewers CCTV inspected	m			
% of entire municipality's sewers CCTV inspected	%			

Date:				
Reporting Period:	From:		To:	
DESCRIPTION	**UNIT**	**EXISTING** (prior to this reporting period)	**NEW** (during this reporting period)	**TOTAL**
STRUCTURAL CONDITION				
Sewers with a WRc structural rating of 1	m			
Sewers with a WRc structural rating of 2	m			
Sewers with a WRc structural rating of 3	m			
Sewers with a WRc structural rating of 4	m			
Sewers with a WRc structural rating of 5	m			
CCTV Inspection of Service Laterals				
No. of service laterals CCTV inspected	Ea			
% of entire municipality's laterals CCTV inspected	%			
Service laterals with a WRc structural rating of 1	ea			
Service laterals with a WRc structural rating of 2	ea			
Service laterals with a WRc structural rating of 3	ea			
Service laterals with a WRc structural rating of 4	ea			
Service laterals with a WRc structural rating of 5	ea			
Visual Inspection of Manholes / Cleanouts				
No. of Manholes/ cleanouts inspected	ea			
% of entire municipality's Manholes/cleanouts inspected	%			
No. of structurally defective Manholes/cleanouts	ea			
No. of leaky Manholes/cleanouts	ea			

CAPITAL IMPROVEMENT WORKS				
SEWER SYSTEM REHABILITATION				
Sewers				
Length of sewers needing rehabilitation	m			
Length of sewers re-lined	m			
Length of sewers point repairs	m			
Length of sewers replaced	m			
Total length of sewers rehabilitated	m			
Service Laterals				
No. of service laterals needing rehabilitation	ea			
No. of service laterals point repaired	ea			
No. of service laterals replaced	ea			
Total no. of services rehabilitated	ea			
Manholes/Cleanouts				
No. of Manholes / cleanouts repaired	ea			

Date:				
Reporting Period:	From:		To:	
DESCRIPTION	**UNIT**	**EXISTING** (prior to this reporting period)	**NEW** (during this reporting period)	**TOTAL**
CROSS CONNECTION / SMOKE TEST DETECTED DEFICIENCIES CORRECTION				
No. of cross connections detected	ea			
No. of cross connections corrected	ea			
COMBINED SEWER SEPARATION				
Length of combined sewers separated	m			
No. of coming services separated	ea			
SUMMARY OF COSTS				
Sewer System Evaluation				
Smoke Testing	$			
Dye Testing	$			
CCTV Inspection (of sewers)	$			
CCTV Inspection (of laterals)	$			
Visual Inspection of Manholes/Cleanouts	$			
Sewer Flow Monitoring	$			
Municipal Staff Costs	$			
Capital Improvement Works				
Sewer Rehabilitation	$			
Service Lateral Rehabilitation	$			
Manholes/Cleanouts Repair	$			
Cross-connection Rectification	$			
Combined Sewer Separation	$			
Engineering Fees	$			
Other Work (E.g. Pumping station upgrades)	$			

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