Pollution Prevention and Control Plan Update for the City of St. Catharines

FINAL SUMMARY REPORT

September 2024

Hatch Corporation
4342 Queen Street, 3rd Floor
Oakville, ON, L2E 7J7
T 905.486.0742

Table of Contents

Tables

Figures

Appendices

1. Introduction

1.1 Background

The original St. Catharines and Area Pollution Control Plan (PCP) was completed in 1990 (City of St. Catharines, 1990), and included a number of recommendations aimed at reducing combined sewer overflows (CSO), including the removal of extraneous flows from roof downspouts, and construction of several CSO storage facilities. The 1990 PCP was completed prior to the development and promulgation of Ontario Ministry of Environment (MOE) Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems (MOE, 1997). Note that the term MOE is used throughout this document and is intended to include the various related ministries (e.g. Ministry of the Environment and Energy, Ministry of the Environment and Climate Change, and Ministry of Environment, Conservation and Parks).

1.2 Previous PPCP

The most recent update of the PCP was completed in August 2008, incorporating both the Port Weller and Port Dalhousie sewersheds (CH2M Hill, 2008). The 2008 PCP provided a Master Plan including a strategy to address current sewer system constraints and issues related to CSOs and identify future system requirements in St. Catharines and Thorold to accommodate the future demands on the system, in accordance with the requirements of MOE Procedure F-5-5 and assessed the relative impact of CSO discharges to local receiving waters. We are aware that the City of Thorold has since completed their own PCP update, and the conclusions presented therein will not be covered by the current St. Catharines Pollution Prevention and Control Plan (PPCP) Update Study. The recommendations from the previous PPCP are discussed in further detail in Chapter 4 of this report.

1.3 Objectives of the Current Study

The current St Catharines PPCP Update Study provides an opportunity to summarize the recommendations implemented to date, quantify the impacts of growth and improvements to the sewer system since the 2008 PPCP, and revaluate CSO control alternatives in order to update the long-term strategy for the management of the City's CSO and wastewater collection system, which considers the interrelationship between environmental issues (CSOs), wastewater infrastructure, and basement and surface flooding.

1.4 Report Outline

Chapter 2 outlines the PPCP Update Study framework, including the Problem/Opportunity Statement, and an explanation of the Class Environmental Assessment and Master Planning processes employed to complete the project.

Chapter 3 provides a description of existing conditions within the Study Area, including the existing wastewater collection and treatment system and CSO system.

Chapter 4 provides a review of previous studies and reports related to wastewater servicing and CSO and basement flooding control in the City of St. Catharines, including the previous 2008 Pollution Control

Plan, with additional details provided in TM #1 (Review of Previous Studies) and TM #2 (Review of 2008 Pollution Control Plan), which are included in Appendix A and B.

Chapter 5 provides a discussion of existing PPCP Best Management Practices employed by the City, including a summary of relevant policies, existing CSO and basement flooding control programs, existing CSO and sewer system operations and maintenance activities, and existing CSO and sewer system performance.

Chapter 6 discusses the methodology and results of the updated Hydraulic Modelling Analysis, including the sewer modelling methodology, average annual CSO frequency and volume estimates for each of the City's existing CSO outfalls, and the results of the sewer system capacity analysis.

Chapter 7 provides a detailed review of available CSO control technologies and approaches, including source controls, sewer system controls, CSO treatment, floatables control, disinfections and odour control.

Chapter 8 provides a detailed review of available CSO and sewer system operations and maintenance options, including sewer system monitoring, CSO and sewer system inspection and maintenance, sewer system modelling and other general operations and maintenance activities.

Chapter 9 describes the process used to evaluate the available CSO and basement flooding control options, including an initial pre-screening and more detailed evaluation of the various options.

Chapter 10 describes the various components of the proposed PPCP Action Plan, including a number of City-wide CSO Control Programs/Projects aimed at improving the management and operations of the City's CSO and wastewater collection systems; as well as a number of Site-specific CSO Control Projects aimed at reducing the frequency/volume/duration/pollution from specific CSO regulators/outfalls; and

Chapter 11 provides a Summary of the PPCP Action Plan Recommendations presented above, including planning/budget level cost estimates, and suggested timing for implementation of the proposed CSO control programs and projects.

The report also includes a number of appendices, including the following:

Appendix A includes Tech Memo (TM) #1 (Existing Document Review and Summary), which comprises a detailed review of previous reports and studies, and background information and data, which was available to support the PPCP Update Study.

Appendix B includes TM #2 (Review of 2008 Pollution Control Plan), which comprises a comprehensive review and summary of the contents of the 2008 PCP report (in much more detail than the report's Executive Summary), the progress the City has made since then in implementing the recommendations of the 2008 PCP Update, and compares the City's current practices to the requirements of MOE Procedure F-5-5 and summarizes how well they conform.

Appendix C includes TM #3 (Rainfall/Flow Monitoring and O&M Program Review), which comprises a review and assessment of the City's existing Rainfall and Sewer Flow Monitoring and CSO and Sewer System Operations and Maintenance (O&M) Programs.

Appendix D includes TM #4 (Sewer Model Review and Assessment), which comprises review and assessment of the City's existing sewer hydraulic model and provision of a plan for managing the City's future sewer modeling activities.

Appendix E includes TM #5 (Gap Analysis), which comprises review and assessment of available background information, to identify if there are any information/data gaps that could impact the ability to complete the current PPCP Update.

Appendix F includes TM #6 (Updated Hydraulic Modelling Analysis), which documents how the sewer hydraulic models were developed, and applied to help with the preparation of the current PPCP Update Study, and presents the results of the model simulations.

Appendix G includes TM #7 (CSO Control Alternatives and Evaluation Methods), which includes a review of available CSO control approaches and technologies, and documents the method used to pre-screen and evaluate the most feasible options.

Appendix H includes TM #8 (PPCP Action Plan), which includes a review and evaluation of available CSO control approaches and technologies and presents a proposed PPCP Action Plan to manage the City’s future CSO control efforts and reduce CSOs and basement flooding.

Appendix I includes TM #9 (Climate Change Assessment), which comprises a review and assessment of climate change considerations related to the current PPCP Update Study.

2. Study Framework

The St. Catharines sewer system currently experiences combined sewer overflows (CSOs) and basement flooding at some locations during intense wet weather periods. The City completed a system wide Pollution Control Plan in 2008 to identify actions to help manage the sanitary and combined sewer system in order to reduce overflows and basement flooding. The City of St. Catharines has initiated a Class Environmental Assessment (Class EA) to update the plan to reflect the improvements already made and to identify and prioritize the remaining projects/programs required to further reduce CSOs, protect against basement flooding and reduce pollution to local recreational water bodies.

Public consultation is a key component of the Class EA study. The study will define the problem/opportunity, identify and evaluate alternative solutions, and determine a preferred solution in consultation with the City of St. Catharines, regulatory agencies, affected stakeholders and the general public.

2.1 Problem/Opportunity Statement

The first step was to develop a new Problem/Opportunity Statement for the PPCP Update Study, in conjunction withy the Project Steering Committee, which in full, reads as follows:

+ *The St. Catharines sewer system currently experiences combined sewer overflows and basement flooding at some locations during intense wet weather periods. The City completed a system wide Pollution Control Plan in 2008 to identify actions to help manage the sanitary and combined sewer system in order to reduce overflows and basement flooding. It is now time to update the plan to reflect the improvements already made and to identify and prioritize the remaining projects/programs required to further reduce combined sewer overflows, protect against basement flooding and reduce pollution to local recreational water bodies.*

2.2 Ontario's Environmental Assessment Act

Ontario's Environmental Assessment (EA) Act was passed in 1975 and was first applied to municipalities in 1981. The EA Act requires the study, documentation, and examination of the environmental effects that could result from projects or activities.

The objective of the EA Act is to consider the possible effects of these projects early in the planning process, when concerns may be most easily resolved, and to select a preferred alternative with the fewest identified impacts.

The EA Act defines "environment" very broadly as:

a) Air, land, or water
b) Plant and animal life, including humans
c) Social, economic, and cultural conditions that influence the life of humans or a community
d) Any building, structure, machine, or other device or thing made by humans
e) Any solid, liquid, gas, odour, heat, sound, vibration, or radiation resulting directly or indirectly from human activities

f) Any part or combination of the foregoing, and the interrelationships between any two or more of them, in or of Ontario

Two types of EA planning and approval processes are identified when applying the requirements of the EA Act to municipal projects:

1) Individual EAs (Part II of the EA Act): Projects for which Terms of Reference and an individual EA are carried out and submitted to the Minister of the Environment for review and approval.
2) Class EAs: Projects are approved subject to compliance with an approved Class EA process; provided that the appropriate Class EA approval process is followed, a proponent will comply with the requirements of the EA Act.

2.3 Class EA Process

The Municipal Class Environmental Assessment (Class EA) document prepared by the Municipal Engineer's Association in June 2000, as amended in 2024, is an approved Class EA process. There are five phases of assessment in the Class EA document. The five phases include:

+ Phase 1: Definition of the Problem
+ Phase 2: Identification and Assessment of Alternative Solutions and Selection of a Preferred Solution
+ Phase 3: Identification and Assessment of Alternative Sites/Design Concepts and Selection of a Preferred Site/Design
+ Phase 4: Preparation of an Environmental Study Report (ESR)
+ Phase 5: Implementation

The Class EA planning and design process is shown in Figure 2-1.

The Class EA document places projects into three possible schedules, depending on their characteristics (that is, Schedule A, B, or C projects). The schedule under which a project falls determines the planning and design phases that must be followed. Schedule A projects are minor operational and upgrade activities and may go ahead without further assessment once Phase 1 of the Class EA process is complete (that is, the problem is reviewed and a solution is confirmed). Schedule B projects must proceed through the first two phases of the process. Proponents must identify and assess alternative solutions to the problem, inventory impacts, and select a preferred solution. They must also contact relevant agencies and affected members of the public. Provided that no significant impacts are found and no requests are received to elevate the project to Schedule C or undertake the project as an Individual EA (Part II Order), the project may proceed to detailed design (Phase 5).

Schedule C projects require more detailed study, public consultation, and documentation, as they may have more significant impacts. Projects categorized as Schedule C must proceed through all five phases of assessment. An ESR must be completed and available for a 30-day public review period, prior to proceeding to implementation (Phase 5).

In the event that there are major issues that cannot be resolved upon completion of the final ESR, individuals may request the Minister of Environment to require the Regions to comply with Part II of the EA Act. Upon receiving a Part II Order request, the Minister reviews the request and study information and makes one of the following decisions: deny the request, refer the matter to mediation, or require completion of an Individual EA. Many factors are considered by the Minister in making decisions, including the adequacy of the planning process, the potential for significant adverse environmental effects after mitigation measures are considered, the participation of the requester in the planning process, and the nature of the request.

2.4 Master Planning Process

This project was completed in accordance with the requirements of a Master Plan as outlined in the Municipal Engineers Association Municipal Class EA process (MCEA) document (October 2000, as amended in 2007 and 2011), and will fulfil Phases 1 and 2 of the Class EA process, as they relate to the individual CSO control projects that may be recommended as part of the ultimately preferred solution(s) for CSO control in St. Catharines.

Master Plans are long range plans which examine the current and future requirements of a given infrastructure system using environmental assessment planning principles. Master Plans at a minimum must address Phases 1 and 2 of the Class EA process. Master plans develop a framework for planning a group of related projects required to accommodate demands on a system over a long period of time.

The Master Planning process allows a municipality to develop the need and justification for specific projects under a broad planning framework. A Master Plan should be reviewed every five years to determine the need for detailed review and updates. Specific projects identified in the Master Plan may require additional Class EA planning and approvals prior to their implementation.

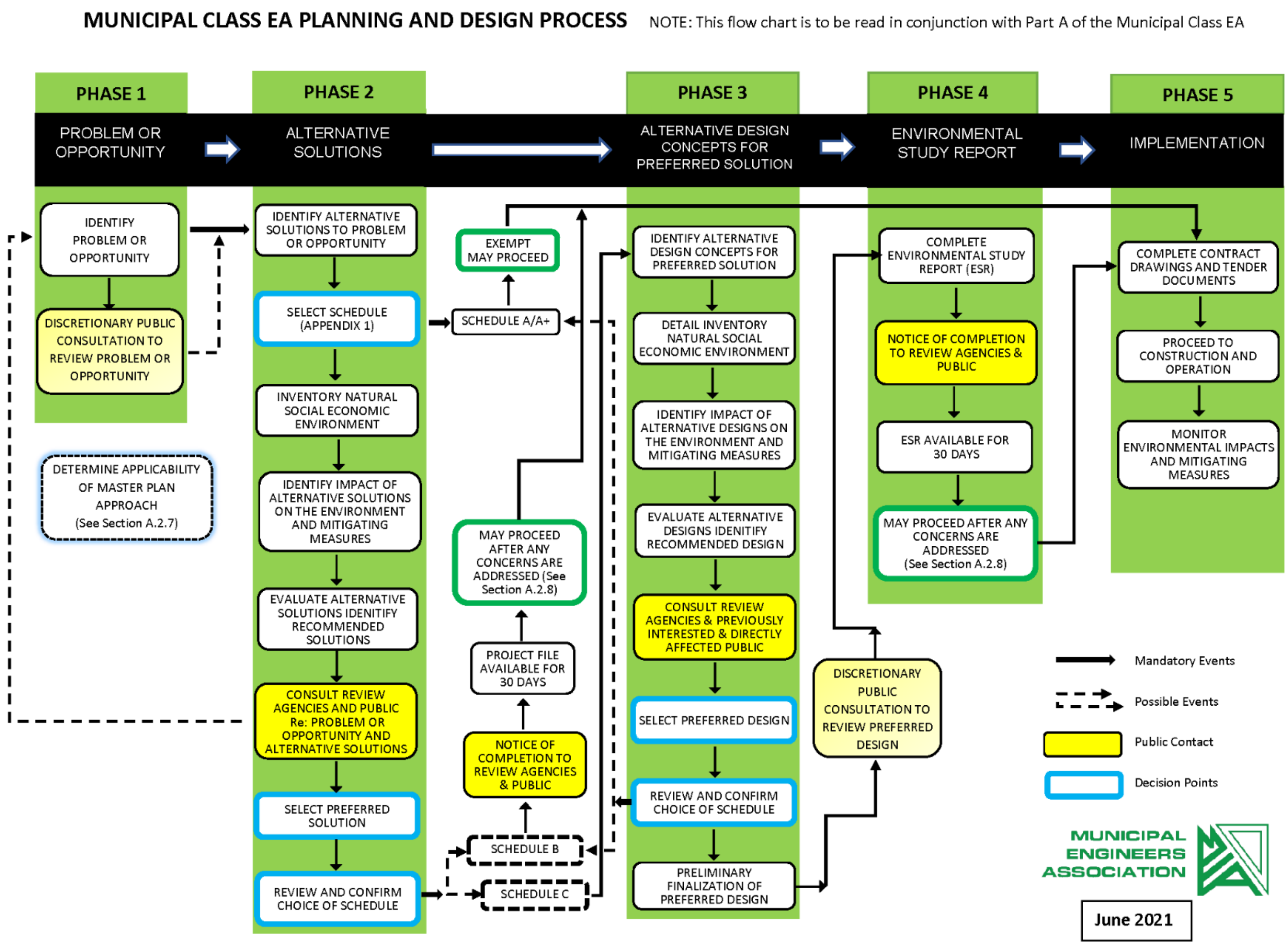


Figure 2-1: Municipal Class Environmental Planning and Design Process

3. Existing Conditions

3.1 Study Area Description

The City of St. Catharines is located in Southern Ontario, in the northeastern portion of the Niagara Peninsula. Figure 3-1 shows the study area for the PPCP Update Study, which includes the urban areas of the City of St. Catharines.

.

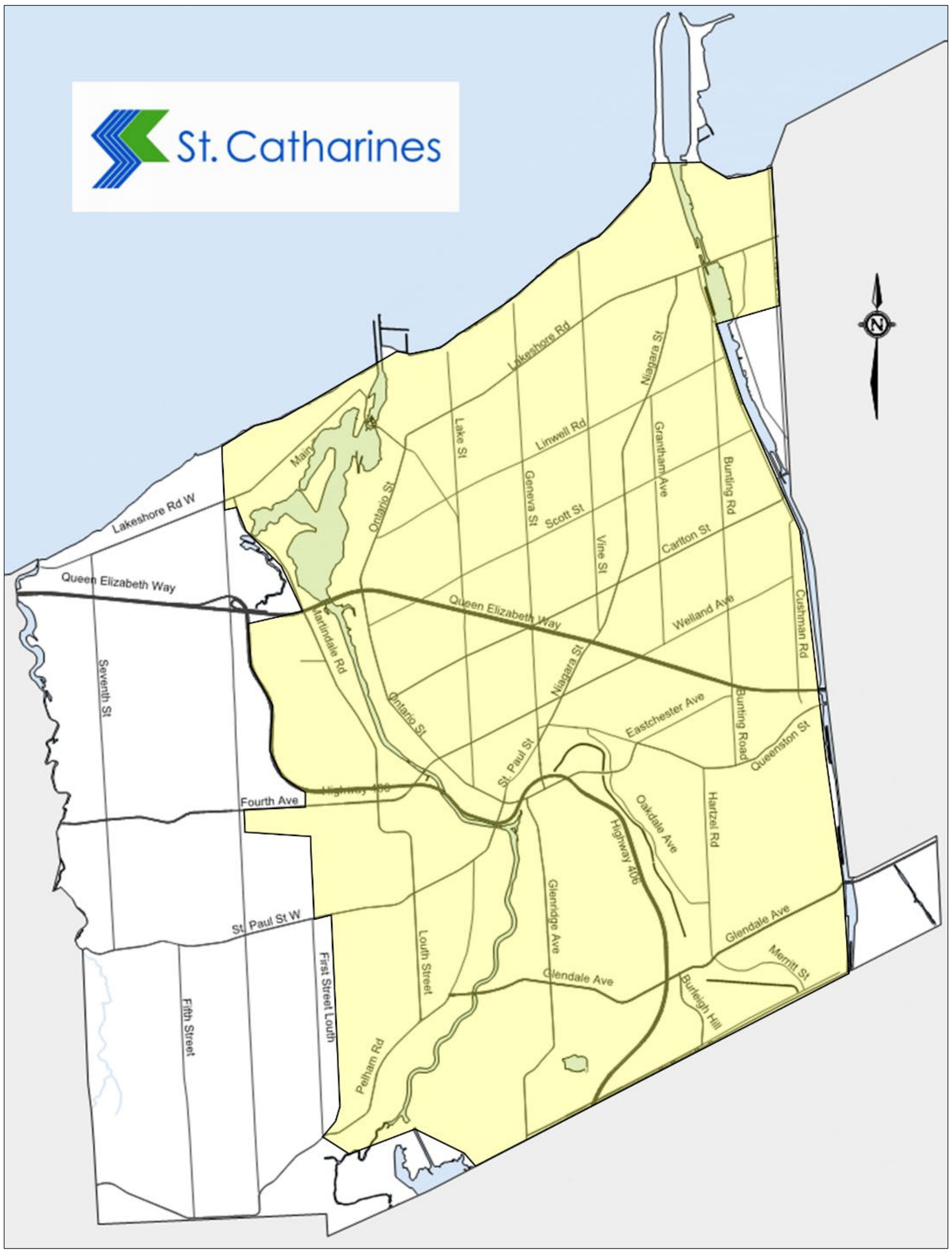


Figure 3-1: St. Catharines Pollution and Prevention Control Plan Study Area

The study area consists primarily of residential land uses, with some large industrial centres located near the edges of the urban area, and some smaller commercial and mixed-used areas scattered across the City.

Downtown St. Catharines has been designated as an Urban Growth Centre by the Growth Plan for the Greater Golden Horseshoe area, and as such, new development and redevelopment within the area must meet specified minimum population density targets.

3.2 Existing Wastewater Collection and Treatment System

Wastewater is collected and treated by two distinct systems, one serviced by the Port Dalhousie WWTP and the other service by the Port Weller WWTP. Each system includes networks of combined, partially separated, and completely separated sanitary and storm sewers. Figure 3-2 shows the components of a typical separated sanitary and storm sewer system, and a typical combined sewer system, where sanitary and storm flows are collected in a single sewer, and Figure 3-3 shows how a CSO system works.

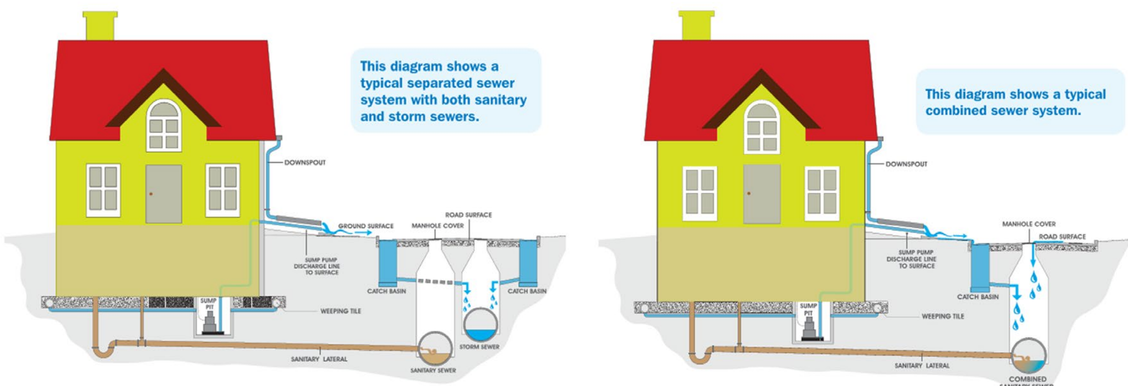


Figure 3-2: Typical Components of Separated and Combined Sewer Systems

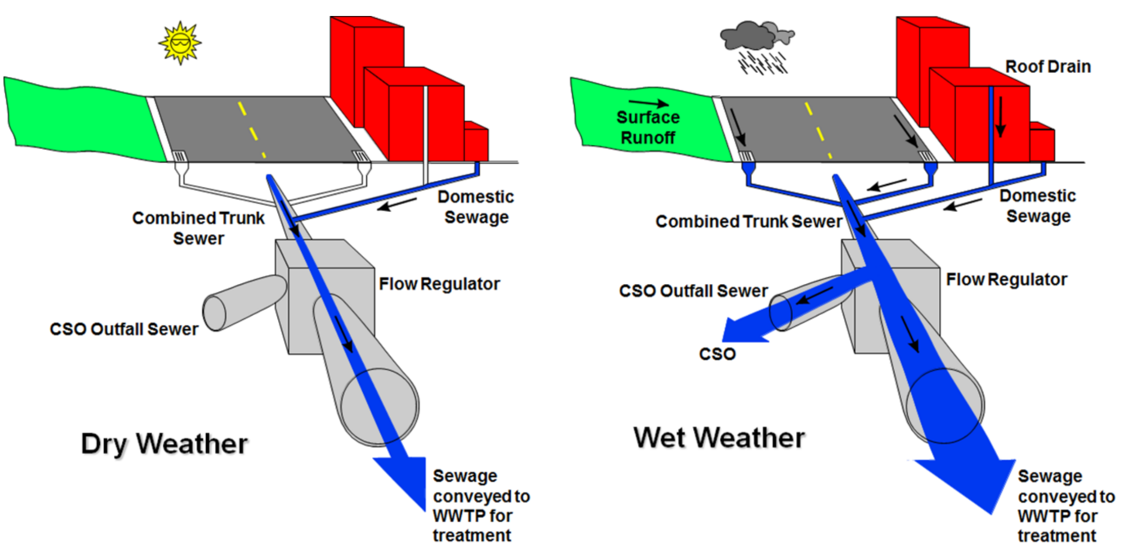


Figure 3-3: How a Combined Sewer System Works

Figure 3-5 shows the location and extent of the separated sanitary and storm, and combined sewer systems within the study area, and Figure 3-5 shows the locations of the City's CSO outfalls.

Figure 3-4: St. Catharines Wastewater Collection System

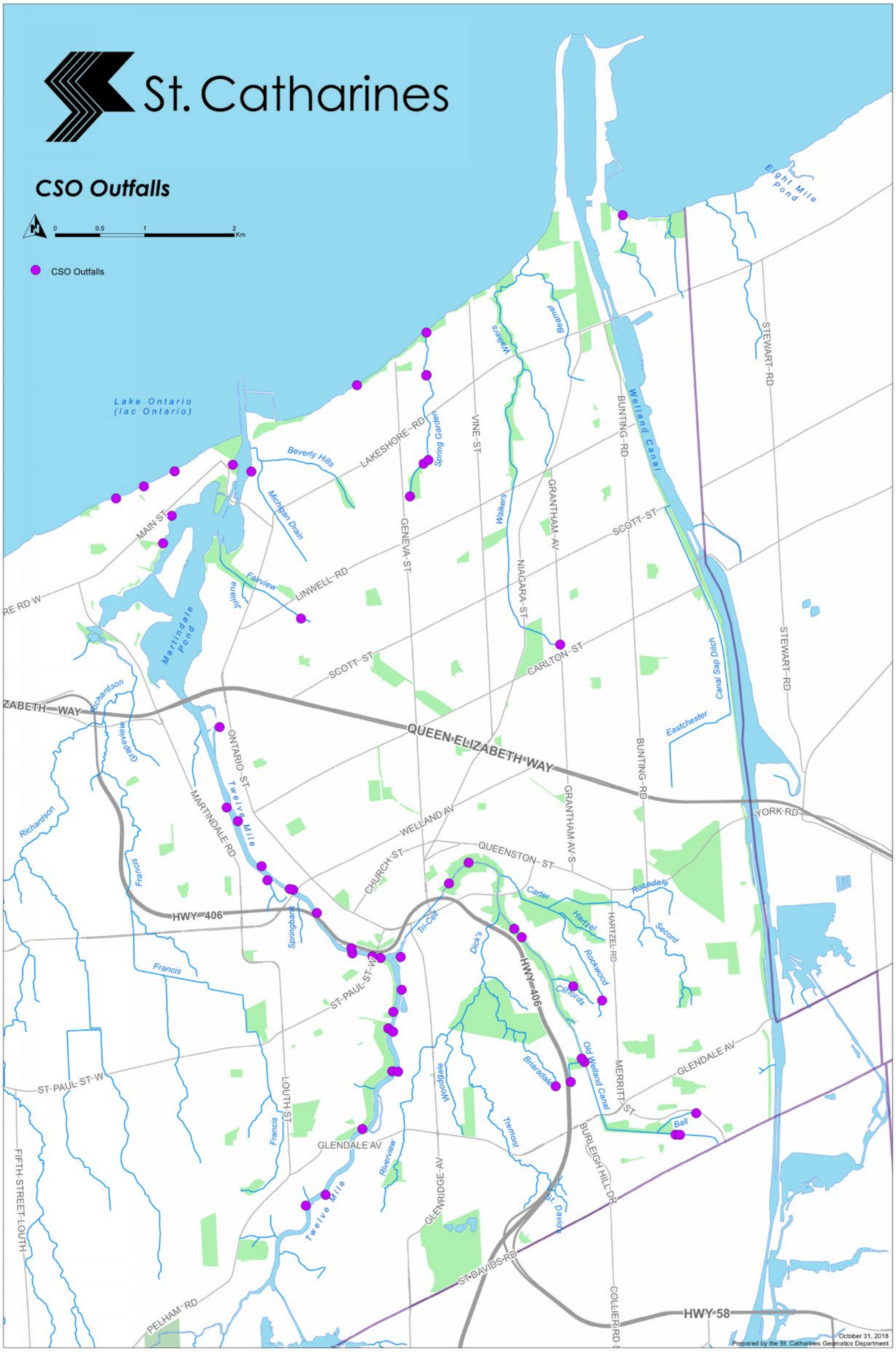


Figure 3-5: Combined Sewer Outfall Locations in the City of St. Catharines

CSO Regulators

The Port Dalhousie and Port Weller sewersheds include over a hundred CSO regulators, including a wide variety of types and designs (e.g. transverse and side weir overflows, half-pipe overflows, and orifice/orifice plate overflows). Some flow regulators are more complex than others, and some have difficult access issues, many requiring complicated confined space entry (CSE) procedures and equipment. In many cases, multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall, complicating CSO flow monitoring and O&M activities.

CSO Storage Facilities

The City operates nine wet weather storage facilities including seven (7) off-line and two (2) in-line facilities. Table 3-1 provides some information relating to the City's existing CSO storage facilities.

Table 3-1: Existing Wet Weather Storage Facilities

Facility Name	Location and Description	Storage Capacity	Year Commissioned	ECA[1] #
Corbett Avenue	Corbett Avenue Road Allowance - Inline Storage	450 m^3	1992	3-0723-92-006
Guy Road[2]	Guy Road Park, 61A Duncan Dr, - Storage Phase III Expansion	2,770 m^3	2007	1184-6VJJTS
Lakeside Park	Lakeside Park Parking Lot, 9 Main St. – Inline Storage	700 m^3	1994	3-1362-93-947
Walkers Creek	142A Parnell Rd. – Offline Storage	400 m^3	2003	3435-5R7HMM
Kernahan Park	381 Queenston St. – Offline Storage	600 m^3	2004	5413-64MPM4
Welland/Ontario	2 Welland Ave. – Offline Storage	7,000 m^3	2006	3815-6QWJ3H
Lockview	28A Rochelle Dr. – Offline Storage	2,800 m^3	2007	7706-78KRF5
Capner/Oakdale	166 Westchester Cres. – Offline Storage	1,000 m^3	2007	9285-76KLSE
Glengarry	Glengarry Park – 63 Glengarry - Offline Storage	3,300 m^3	2021	5366-B46Q5X

Notes:
1 ECA – Environmental Compliance Approval (formerly known as Certificates of Approval)
2 At the completion of Phase III expansion the total capacity at the Guy Road Site is approximately 2,770 m^3

Port Dalhousie WWTP

The Port Dalhousie WWTP receives sanitary and combined sewage from the western portion of the City of St. Catharines and the City of Thorold.

The Port Dalhousie WWTP is a conventional activated sludge treatment plant, incorporating screening, grit removal, primary clarification, aeration and secondary clarification. The plant is owned and operated by the Region, and is located north of Lakeshore Road and east of Lighthouse Road in Port Dalhousie, within the City of St. Catharines. The plant has a rated average day capacity of 61,370 m^3/day, and a peak primary (storm) treatment capacity of 122,740 m^3/day, and treated effluent is discharge into Port Dalhousie Harbour, at the mouth of Twelve Mile Creek. Flows exceeding the peak plant capacity are bypassed at a diversion chamber upstream of a Parshall flume where flows entering the treatment plant are measured. Bypassed flows are currently discharged, untreated, directly to Lake Ontario.

The facility's final effluent objectives are 15.0 mg/L for carbonaceous Biochemical Oxygen Demand ($cBOD_5$) and Total Suspended Solids (TSS), 0.5 mg/L for Total Phosphorus (TP), 200 organisms/100 ml for E. Coli, and 0.5 mg/L for Total Chlorine Residual.

Port Dalhousie SPS

Table 3-2 provides an overview of the fourteen (14) existing sewage pumping stations (SPS) serving the Port Dalhousie wastewater collection system and WWTP, including the location, number of pumps, ECA firm capacity, operational firm capacity, and total dynamic head for each SPS.

Table 3-2: Port Dalhousie Pumping Stations Overview

SPS Name	Location	No. of Pumps	ECA Firm Capacity (L/s)	Operational Firm Capacity (L/s)	Total Dynamic Head (m)
Lakeside	Lakeside Park, St. Catharines	3	150.0	95.0	Unknown
Cole Farm	26 Colton Ave, St. Catharines	3	111.0	111.0	18.2
Snug Harbour	Lakeport Rd, St. Catharines	2	3.3	3.3	Unknown
Lighthouse Road	Lot 20 Concession 1 Grantham, St. Catharines	2	28.1	28.0	12.2
October Village	October Dr, St. Catharines	2	9.4	9.0	10.0
St. Georges Point	St. George Subdv, St. Catharines	2	10.2	10.0	11.7
Wellandvale	81 Wellandvale Rd, St. Catharines	2	41.0	41.0	27.1
Argyle	Argyle Cr, St. Catharines	3	34.0	34.0	Unknown
Eastchester	2A Eastchester Av, St. Catharines	2	63.0	63.0	28.0
Renown	Renown Rd, St. Catharines	4	1,515.0	1,077.4	15.5
Glendale		2	7.6	7.6	Unknown
Riverview	Riverview Blvd, St. Catharines	2	9.5	8.0	12.5
Confederation Hts	Richmond St, St. Catharines	2	173.5	173.0	Unknown
Beaverdams	Beaverdams Rd, Thorold	2	14.0	10.7	20.1

Port Weller WWTP

The Port Weller WWTP services the eastern portion of St. Catharines, eastern portion of Thorold North, Thorold South, Glendale, and the Niagara District Airport.

The Port Weller WWTP is a conventional activated sludge treatment plant, incorporating screening, grit removal, alum and polymer addition, phosphorus removal and secondary clarification. The plant is owned and operated by the Region, and is located at 27 Lombardy Avenue in Port Weller, on the west side of the Welland Canal, within the City of St. Catharines.

The plant has a rated average day capacity of 56,200 m^3/day, a peak dry weather flow capacity of 120,400 m^3/day, and a peak wet weather flow capacity of 136,200 m^3/day. The existing WWTP includes a wet weather disinfection facility, which chlorinates (and dechlorinates) existing WWTP bypasses, but no other treatment is provided for the plant bypasses or upstream CSOs.

The facility's final effluent objectives are 15.0 mg/L for carbonaceous Biochemical Oxygen Demand ($cBOD_5$) and Total Suspended Solids (TSS), 1.0 mg/L for Total Phosphorus (TP), 200 organisms/100 ml for E. Coli, and 0.5 mg/L for Total Chlorine Residual.

Port Weller SPS

Table 3-3 provides an overview of the eight (8) existing sewage pumping stations (SPS) serving the Port Weller wastewater collection system and WWTP, including the location, number of pumps, ECA firm capacity, operational firm capacity, and total dynamic head for each SPS.

Table 3-3: Port Weller Pumping Stations Overview

SPS Name	Location	No. of Pumps	ECA Firm Capacity (L/s)	Operational Firm Capacity (L/s)	Total Dynamic Head (m)
Lombardy Ave	27 Lombardy Ave, St. Catharines	3	110.0	110.0	8.5
Haulage Rd	Haulage Rd, St. Catharines	2	37.9	44.1	Unknown
Spring Gardens	Spring Garden Blvd, St. Catharines	3	Unknown	273.0	Unknown
Airport Rd	Airport Rd, NOTL	2	12.5	10.0	21.0
Carlton St	94 ½ Carleton St, St. Catharines	2	150.0	150.0	19.1
Peel St	Allanburg Rd, Thorold	3	170.0	125.0	41.0
Black Horse	2525 Highway 58, Thorold	2	70.0	67.1	27.0
Centre St	2408 Centre St, Thorold	2	40.0	38.6	12.0

4. Previous Studies

The following significant reports and studies were reviewed, and a summary of each is provided below, including its relevance to, and intended use, in the PPCP Update Study:

- Pollution Control Plan for the Cities of St. Catharines and Thorold (CH2M Hill, 2008)
- 2016 Niagara Region Water and Wastewater Master Servicing Plan Update (GMBP, 2017).
- Northeast Area Wastewater Servicing Study (HMM/XCG, 2008)
- Port Weller WWTP HRT Facility Environmental Study Report (XCG/HMM, 2011)
- Port Weller WWTP HRT Preliminary Design Brief (HMM, 2012)
- Evaluation and Audit of Sanitary Combined Sewer Overflows (DFA, 2006)
- Niagara Region CSO Control Policy (Niagara Region, 2016)
- MOE Procedure F-5-5 (MOECC, 1997)
- Niagara Peninsula Source Protection Plan (NPCA, 2013)

The following older reports and studies were also reviewed, but were already summarized and considered as part of the 2008 PCP Update, so are not covered again here, but summaries can be found in Appendix E of the Final Report for the 2008 PCP (CH2M Hill, 2008).

- St. Catharines Area Pollution Control Plan (St. Catharines, 1990)
- Port Weller Sanitary Trunk Sewer Analysis (CH2M Hill, 1999)
- Port Dalhousie Trunk Sewer and CSO Study (CH2M Hill, 2006)
- Water and Wastewater Master Plan for the Region of Niagara (CH2M Hill/MacViro, 2003)
- Combined Sewer Separation Project Remedial Works Class EA (MacViro, 2004)
- City of St. Catharines CSO HRT Feasibility Study (Hydromantis/CH2M Hill, 2005)
- Twelve Mile Creek Watershed Plan (NPCA, 2006)

4.1.1 2008 St. Catharines Pollution Control Plan

The 2008 St. Catharines PCP update provided an update of the original 1990 PCP, which was required because many of the original recommendations for infrastructure renewal and CSO abatement in the 1990 PCP had already been implemented, and the remaining recommendations needed to be revisited to consider the current situation, to consider new approaches and/or technologies for CSO control, and also to consider the new regulatory environment created by the promulgation of MOE Procedure F-5-5 in 1997.

The project was carried out as a Master Plan following the requirements of the Ontario Environmental Assessment (EA) Act, following the Municipal Engineers Association (MEA) Municipal Class EA guidance document (MEA, 2000).

The 2008 PCP Update included:

+ An outline of the main objectives and framework for the study.
+ A description of existing conditions, including a detailed description/characterization of the City's wastewater collection and treatment systems, for both the Port Dalhousie and Port Weller sewersheds.
+ A summary of existing best management practices/programs employed by the City.
+ A description of the existing natural and social environments.
+ A review of previous technical reports and studies, and policies related to CSO control.
+ An assessment of the existing sewer systems, employing hydrologic/hydraulic modelling, in terms of hydraulic capacity and CSO volume and frequency for all existing CSO outfalls.
+ An assessment of future sewer system requirements, to accommodate future growth in the study area, to the year 2032.
+ An inventory of contaminant discharges from CSOs, including estimates of annual pollutant loadings from CSOs using available CSO water quality data and estimated CSO volumes generated by the sewer system models, and potential impacts on receiving streams.
+ Identification and assessment of a variety of different CSO control alternatives.
+ Identification and evaluation of site-specific infrastructure upgrades for each remaining CSO outfall, including weir/overflow adjustments, sewer separation, inline storage, off-line storage, pump capacity upgrades, and high rate treatment (HRT) and continuous deflective separation (CDS).
+ A final priority-based list of recommended CSO control projects for each CSO outfall to be addressed, including proposed implementation timelines and construction cost estimates.

The 2008 PCP update recommended a number of CSO control measures in different areas of the City, for implementation by the City, Region, and City/Region together (under the cost-sharing agreement between the two parties); and the City (and Region) have already implemented several of the recommended CSO control measures/projects. The critical locations identified for CSO abatement included the following recommended capital works, which were in addition to works which were already in various design and construction phases at the time the final report was being prepared:

1) *Carlton & Ontario CSO Outfall:* A 8,680 m^3 storage facility was recommended for this CSO outfall, at an estimated cost of $8,700,000. It was noted that the size of the storage tank could possibly be reduced if integration of upstream sewer separation and/or storage is found to be suitable during a more detailed site investigation and Class EA. It was also noted that the proximity of this outfall to the Thomas St outfall could make an integrated CSO abatement approach (for both locations) feasible.

2) *Thomas Street, Henry & Beech, George & Beech CSO Outfalls:* A 4,470 m^3 storage facility was recommended for Thomas Street. It was noted that the size of the storage tank could possibly be reduced if integration of upstream sewer separation and/or storage is found to be suitable during a more detailed site investigation and Class EA. As noted above, the proximity of this outfall to Carlton & Ontario outfall could make an integrated abatement approach (for both locations) feasible.

3) *Westchester & Old Welland Canal (OWC) CSO Outfall:* A 3,000 m^3 storage tank had been previously recommended and designed for this overflow location. The estimated cost for this project was $5,306,000 based on submitted construction tenders, and due to the high cost, it was recommended that this location be examined in further detail to determine if there were any upstream opportunities that would reduce the required size of the proposed facility.

4) *Parkway & OWC CSO Outfall:* A 1,890 m^3 storage facility would be required for the Parkway outfall location to capture the volume from a two-year storm event. The estimated cost for this facility would be $3,800,000, and it was recommended that a joint project be examined for the Westchester and Parkway outfall locations to develop a more efficient means of abating CSOs at the two locations.

5) *Hartzel & CNR Line CSO Outfall:* A 4,110 m^3 storage tank would be required for this overflow location, at an estimated cost of $4,100,000. A previous study found that locating land for a storage facility of this size in this location would be challenging, so it was recommended that the upstream area be examined in further detail to determine if there are opportunities for source control and/or sewer separation. It was also noted that the proximity of this outfall to the Wedsworth & Hastings outfall could make a joint CSO abatement approach (for both locations) feasible.

6) *Wedsworth & Hastings CSO Outfall:* A 1,790 m^3 storage facility was recommended for this location at an estimated cost of $3,600,000. As noted above, this overflow is located near the Hartzel & CNR Line overflow location, so it was also recommended that the feasibility of a joint abatement approach, as well as the opportunity for upstream source control, should be examined.

7) *Renown Road SPS Overflow:* A 4,300 m^3 storage facility was recommended for the Renown Road PS at an estimated cost of $4,300,000. It was noted that the size of this storage tank could be reduced if integration of upstream sewer separation and/or storage is found to be suitable during a more detailed site investigation and Class EA.

8) *Eastchester SPS Overflow:* It was recommended that the flows to the Eastchester SPS be monitored after the Capner & Oakdale CSO control works are completed to determine their effect, before considering any upgrades to the station.

9) *Michigan Avenue CSO Outfall:* Due to the proximity to the Port Dalhousie WWTP, it was recommended that no capital works be constructed at this outfall. The Michigan Avenue CSO overflows at a much higher rate than the treatment plant (26 versus 6 events during the typical year), therefore increasing the flow through capacity to the plant would allow more CSO to be treated during moderate events. Instead, it was recommended that the diameter of the pipe conveying flows to the WWTP be increased from 350 to 525 mm, at an estimated cost of $150,000.

10) *Forster & Linwell CSO Outfall:* It was recommended that the feasibility of conveying flows to the new Guy Road storage facility should be examined on a site-specific level due to the proximity of the Forster & Linwell outfall to the proposed storage tank.

11) *Oakdale & Marren CSO Outfall:* A 640 m^3 tank was recommended for this overflow location at an estimated cost of $1,300,000. It was noted that there is limited opportunity for upstream source control at this location, as it is this overflow is located on the Regional trunk sewer.

12) *Burleigh Hill & Glendale CSO Outfall:* A 380 m^3 storage facility was recommended for this overflow location at an estimated cost of $760,000. It was noted that the size of this storage tank

could possibly be reduced if integration of upstream sewer separation and/or storage is found to be feasible/suitable during a more detailed site investigation and Class EA.

The 2008 PCP Update also provided recommendations for additional sewer system upgrades to address basement flooding issues; updates to existing combined sewer and capital works mapping and database systems; consideration of integrated sewer flow monitoring programs between the Cities of St. Catharines and Thorold, and the Region; preparation of an annual report on CSO and sewer system management projects/programs undertaken and success thereof, including recommendations for future project/programs; and the completion regular PPCP updates, every five years.

A more detailed summary of the 2008 St. Catharines PCP Study can be found in TM #2 (Review of 2008 Pollution Control Plan), included in Appendix B.

4.1.2 2016 Niagara Region Water and Wastewater Master Plan Update

The Region of Niagara currently services the urban area of the municipalities of Grimsby, West Lincoln, Lincoln, St. Catharines, Thorold, Welland, Pelham, Port Colborne, Niagara-on-the-Lake, Niagara Falls, and Fort Erie. Water and wastewater servicing is operated under a two-tier system. Niagara Region is responsible for water treatment, transmission mains, storage facilities and major booster pumping stations; as well as wastewater treatment, trunk sewers and sewage pumping stations. The area municipalities are responsible for local water distribution networks and local sewer collection systems. In the case of the City of St. Catharines, this includes the operation and maintenance of the sanitary and combined sewer systems within the Port Dalhousie and Port Weller WWTP sewersheds, and some CSO outfalls discharging into local rivers and creeks, and directly into Lake Ontario.

Readily available and accessible public infrastructure is essential to the viability of existing and growing communities, and infrastructure planning, land use planning and infrastructure investment require close integration to ensure efficient, safe and economically achievable solutions to provide the required water and wastewater infrastructure. To balance the needs of growth with the protection and preservation of natural, environmental and heritage resources, the Region initiated an integrated process under the umbrella Niagara 2041 to complete a Municipal Comprehensive Review, a new Transportation Master Plan, and a Water and Wastewater Master Servicing Plan Update.

The 2016 Master Servicing Plan Update, completed by GM BluePlan in June 2017 provided a review, evaluation and development of water and wastewater servicing strategies for all servicing within the urban areas of the Region, including the CSO and wastewater collection systems within the Port Dalhousie and Port Weller WWTP sewersheds. The 2016 Master Servicing Plan Update builds on previous work undertaken as part of the 2011 Master Servicing Plan and previous long-term infrastructure planning studies, including the 2008 St. Catharines PPCP. The 2016 Master Servicing Plan Update is a critical component in the Region's planning for growth and provides a framework and vision for the water and wastewater servicing needs for the lake-based service areas of the Region to the year 2041 (GMBP, 2017).

The 2016 Master Servicing Plan Update provides recommendations for future water and wastewater servicing with the Region, broken down by WTP and WWTP service areas. With respect to the City of St. Catharines and Thorold wastewater collection systems, this includes the Port Dalhousie and Port Weller WWTP sewersheds, and specific findings and recommendations of the 2016 Master Servicing Plan Update with regards to these two areas included the following (GMBP, 2017):

For the Port Dalhousie WWTP Service Area

- The Port Dalhousie WWTP Wastewater System services the west portion of St. Catharines plus areas in Thorold North. There is a large amount of growth on this system to the year 2041 primarily attributed to intensification.
- The area includes significant combined sewer areas. These areas are designed and see significant wet weather peak flows. Management of combined service areas requires local system management as well as trunk system management.
- While infrastructure capacity upgrades were considered, the recommended solution for the Port Dalhousie WWTP wastewater system is to provide wet weather management across the system. This will require Regional solutions as well as local municipal solutions.
- An upgrade to the Beaverdams SPS is identified to support growth in the area.
- With implementation of the wet weather program, the Port Dalhousie WWTP will have sufficient capacity to meet growth to year 2041.

For the Port Weller WWTP Service Area

- The Port Weller WWTP Wastewater System services the east portion of St. Catharines plus areas in Thorold South. There is a large amount of growth on this system to the year 2041 attributed to intensification and greenfield growth in the south.
- The area includes significant combined sewer areas. These areas are designed and see significant wet weather peak flows. Management of combined service areas requires local system management as well as trunk system management.
- Similar to the Port Dalhousie WWTP wastewater system, while infrastructure capacity upgrades were considered, the recommended solution for the Port Weller WWTP wastewater system is to provide wet weather management across the system. This will require Regional solutions as well as local municipal solutions.
- In addition to the wet weather program, there is opportunity to re-direct the Thorold South wastewater flows to the new South Niagara Falls system. The preferred strategy includes upgrades to the Peel Street SPS and forcemain to pump south and upgrades to the Black Horse SPS and forcemain to pump to the new South Niagara Falls wastewater system. This strategy will remove flows from Thorold South on the Port Weller system alleviating some existing capacity impacts.
- With implementation of the wet weather program and redirecting the Thorold South flows, the Port Weller WWTP will have sufficient capacity to meet growth to year 2041.

Proposed Wet Weather Management Strategy

A significant element of the Niagara Region wastewater servicing strategy is the wet weather management program. The wastewater collection systems in Niagara Region are a mix of separated and combined sewer systems, no more so than within the City of St. Catharines. Each system is experiencing varying levels of impact during wet weather conditions. Climate change continues to create changing weather conditions and the wastewater systems are experiencing in most cases high peak flows under rainfall events. Providing infrastructure capacity for the peak flow events would require upgrades not only for local sewers, but also trunk sewers, pumping stations and ultimately the treatment plants. The infrastructure capacity approach can prove costly.

The wet weather management program in the Master Servicing Plan Update has been developed to identify targeted amounts of inflow and infiltration reduction intended to deal with existing capacity constraints as well as provide for growth related capacity without or minimizing expanding/upgrading existing trunk infrastructure.

The wet weather program in the Master Servicing Plan Update currently identifies overall preliminary priority, staging of location and target amount of inflow and infiltration reduction across all systems. This program provides for a proactive and targeted approach to addressing wet weather impacts (GMBP, 2017).

This proposed approach to wet weather management will be reviewed in further detail as part of the review of CSO control alternatives as part of the current PPCP Update, to confirm its feasibility and provide some additional details on how this objective might be achieved within the Port Dalhousie and Port Weller WWTP service areas.

4.1.3 Northeast Area Wastewater Servicing Study

This Master Plan Class EA study was initiated by the Region, and conducted by Hatch Mott MacDonald (HMM) and XCG Consultants (XCG), to evaluate and report upon wastewater servicing options for the Northeast Area of the Niagara Region, including the Town of Niagara-on-the-Lake (NOTL) and the Cities of Niagara Falls, St. Catharines and Thorold. The objective of the study was to evaluate existing infrastructure, and address existing and future requirements for both dry and wet weather flows, including CSOs at the Niagara Falls, Port Dalhousie and Port Weller WWTPs.

The project addressed servicing requirements up to the year 2026, including a review of population growth forecasts with Regional and local municipal planning departments. Significant growth areas were found to be in southwest NOTL (Glendale), east and north Thorold, south Niagara Falls/Chippawa, St. David's and NOTL/Virgil. St. Catharines was not identified as a significant growth area over this period.

A long list of 24 servicing concepts and sub-concepts was identified and evaluated, which was reduced to a short list of three alternatives for further evaluation, and ultimately one final preferred solution. The recommended major wastewater servicing elements included:

- New NOTL WWTP for 6,900 m^3/day rated capacity with nitrification
- Decommissioning of the existing NOTL lagoon system
- New CSO High Rate Treatment Facility at Port Weller WWTP with a capacity of 47,600 m^3/day
- New CSO High Rate Treatment Facility at Port Dalhousie WWTP with a capacity of 57,350 m^3/day
- New CSO High Rate Treatment Facility at Niagara Falls High Lift PS with a capacity of 17,450 m^3/day
- Upgrading Niagara Falls WWTP to 72,400 m^3/day rated capacity with nitrification
- New CSO High Rate Treatment Facility at Niagara Falls WWTP with a capacity of 69,750 m^3/day

HMM and XCG were subsequently retained by the Region in 2009 to complete Schedule 'C' Class EA studies for the proposed HRT facilities at the Niagara Falls and Port Weller WWTPs, and Dillon and

Hydromantis were retained to do the same for the Port Dalhousie WWTP HRT facility. The Port Weller and Port Dalhousie Class EA studies are discussed further below.

4.1.4 Port Weller WWTP HRT Facility ESR and Preliminary Design

The Port Weller Wastewater Treatment Plant (WWTP) is owned and operated by the Region and receives wastewater from the eastern portion of St. Catharines (Port Weller) and portions of Thorold and Niagara-on-the-Lake. The 56,200 m^3/day capacity plant experiences significant increases in flows during wet weather, and during larger events, excess flows from the WWTP and numerous CSOs within the contributing sewershed are diverted to local receiving waters without treatment.

The existing WWTP includes a wet weather disinfection facility, which chlorinates (and dechlorinates) existing WWTP bypasses, but no other treatment is provided for the plant bypasses or upstream CSOs. As noted above, the Northeast Area Wastewater Servicing Study identified High Rate Treatment (HRT) as the preferred solution for controlling the CSO from this sewershed, and recommended implementation of an HRT facility located at (or near) the WWTP, with a wet weather treatment capacity of approximately 47,600 m^3/d required to meet the CSO control targets of MOE Procedure F-5-5.

The Region retained HMM and XCG in 2009 to complete a Schedule ‘C’ Class EA study to identify the preferred HRT technology and facility location, followed by preliminary design of the preferred solution. Possible HRT solutions considered included chemically enhanced primary treatment (CEPT) provided within the plant’s existing primary clarifiers; ballasted flocculation; or a retention treatment basin (RTB). The recommended solution involves:

+ Providing CEPT within Cell 1 of the existing bypass chlorination tank, by adding polymer and alum to the inflows to increase settling
+ Providing chlorination of the CEPT treated flow in Cell 2, by adding sodium hypochlorite to the flow
+ Providing dichlorination, by adding sodium bisulphite at the point of exit of the treated bypass flow from Cell 2 of the existing tank

Preliminary design of the proposed HRT facility was completed in March 2013, but to date, the Region has not proceeded with the proposed upgrades. This is one project we intend to consider revisiting as part of the current PPCP Update Study, as it has the capacity to significantly reduce CSO pollutant loads coming from the Port Weller WWTP bypass.

4.1.5 Other Port Weller WWTP Upgrades

The Region has completed several other upgrades at the Port Weller WWTP since completion of the 2008 PCP, to improve the efficacy and reliability of the sewage treatment process, and help to reduce effluent pollutant loadings during both dry and wet weather, and improve local receiving water quality.

Some examples of completed and/or ongoing upgrade project at the Port Weller WWTP include:

+ Return activated sludge (RAS) pumping and alum addition systems upgrades, tendered in 2014
+ Replacement of existing mechanical bar screens with new units.
+ Replacement of existing grit removal system with two new vortex grit removal units, tendered in 2017

- Aeration system upgrades, in design phase, but apparently put on hold by Region
- Electrical and controls systems upgrades, in design phase, construction expected to begin in 2018

Port Weller WWTP upgrade projects that may impact or be impacted by the recommendations of the 2008 PCP Study (and/or 2016 Niagara Region Water and Wastewater Master Plan Update) are discussed in more detail in Tech Memo #2 - St. Catharines PCP Review and Summary.

4.1.6 Port Dalhousie WWTP HRT Facility ESR

The Port Dalhousie WWTP is a conventional activated sludge treatment plant, incorporating screening, grit removal, primary clarification, aeration and secondary clarification. The plant is owned and operated by the Region, and is located north of Lakeshore Road and east of Lighthouse Road in Port Dalhousie, within the City of St. Catharines. The plant has a rated average day capacity of 61,370 m^3/day, and a peak primary (storm) treatment capacity of 122,740 m^3/day, and treated effluent is discharge into Port Dalhousie Harbour, at the mouth of Twelve Mile Creek. Flows exceeding the peak plant capacity are bypassed at a diversion chamber upstream of a Parshall flume where flows entering the treatment plant are measured. Bypassed flows are currently discharged, untreated, directly to Lake Ontario.

As noted above in Section 2.3, the Region retained Dillon and Hydromantis in 2009 to complete a Schedule ‘C’ Class EA for the proposed CSO HRT facility at the Port Dalhousie WWTP in St. Catharines. The Class EA study was completed in 2011, and recommended installation of a new retention treatment basin (RTB) to treat the plant bypasses (CSOs), but to date, the proposed CSO HRT facility has not been constructed, and we are not aware of any plans by the Region to do so.

4.1.7 Other Port Dalhousie WWTP Upgrades

The Region has completed several other upgrades at the Port Dalhousie WWTP since completion of the 2008 PCP, to improve the efficacy and reliability of the sewage treatment process, and help to reduce effluent pollutant loadings during both dry and wet weather, and improve local receiving water quality.

The following plant-wide upgrades are at the 90% design stage, with construction expected to begin in 2019:

- New admin building
- New plant influent/bypass overflow channel
- New screening washer/compactor system
- New fine-bubble aeration system including new tanks, blowers and blower building
- New switchgear, transformer and generator dedicated to the aeration system
- Refurbishment of the existing ineffective biofilter system
- Replacement of existing RAS pumps
- Upgrade of Master Control Centre (MCC)
- Replacement of existing Remote Processing Units (RPUs)
- Other miscellaneous upgrades

4.1.8 Evaluation and Audit of Sanitary Combined Sewer Overflows

As part of the Niagara Water Quality Protection Strategy (NWQPS), the Region, in cooperation with the Area Municipalities (including the City of St. Catharines), the Niagara Peninsula Conservation Authority (NPCA), and the MOE, conducted a project to review the current status (in 2010) of CSOs within the watershed; prioritize current and proposed CSO control projects; provide a framework for a more unified and coordinated approach to CSO control across Niagara Region; and assist the Region and Area Municipalities to allocate funds to the most critical CSO control projects first, while at the same time addressing the issues of affordability and environmental protection.

The methodology used in the study was based on the need to prioritize projects in a manner that would support the funding of the most critical projects first. This would allow the Region and the Area Municipalities to achieve the "best bang for their buck" given the high cost of CSO control and difficulties in terms of affordability in some of the smaller communities. The methodology involved a two-step scoring process, first assessing the potential impacts of the CSOs, and secondly assessing the potential benefits and costs of the associated required CSO control projects, including the following key steps:

+ Identification of all known CSO locations and development of a GIS database and mapping of all CSO locations and projects.
+ Review and identification of planned CSO reduction projects and efforts in Niagara Region.
+ Review of programs undertaken by others to identify CSO control "best practices" for consideration in Niagara and supplement the current list of projects.
+ Development of criteria and a scoring system for assessing the potential impacts of the CSOs
+ Assessment of the potential impact of the CSOs based on the criteria and scoring system developed.
+ Linking of CSO control projects to the specific CSOs so that the potential of each project to reduce CSO could be assessed.
+ Prioritization of proposed CSO control projects based on their potential to reduce CSO occurrences, potential to reduce basement flooding, whether they are already in progress, and whether there is third party funding available for the projects.
+ Development of an overall CSO Strategy and Implementation Plan outlining the schedule and cost estimates for future CSO control programs and projects.

The main conclusions of the study were as follows:

+ Current CSO policies and programs were very fragmented across the Niagara Region (in 2010).
+ CSO works should be a high priority, with similar reduction efforts being conducted across the Region
+ The Region and the Area Municipalities all recognize the significance of the CSO problem, and as a result, had identified several projects and programs, some of which were already in progress or completed (in 2010). For the most part, these projects were already aimed at the most critical CSOs.

- There were approximately 283 CSO locations across Niagara Region (in 2010), and approximately 57% of these outfalls were in the Port Weller and Port Dalhousie wastewater collection systems.
- Approximately 96 CSO (ongoing and/or proposed) control projects were identified (in 2010), and approximately 30 of them were already in progress of being implemented.
- The cost of CSO management across Niagara Region (in 2010) was estimated to be $194,675,000 excluding third party funding of $33,061,658, leaving estimated net costs to the Region and the Area Municipalities of $161,613,342.
- In order to achieve the proposed 50/50 cost sharing of CSO projects between the Region and the Area Municipalities, the average annual contribution by the Region would need to be approximately $5,387,111 per year over the next 15 years (2011-2025).
- Not all municipalities have policies and by-law as specific to CSO control.
- The existing data on CSOs is limited in that the volume of CSO discharges during wet weather events are not normally measured, making it difficult to determine the true impact of a particular CSO location.

The City retained Hatch to investigate the proposed Westchester/Old Welland Canal CSO storage facility project, which included consideration of the adjacent Parkway/Old Welland Canal CSO outfall. The project included updating and recalibrating an existing XP-SWMM model of the sewer system, which was used to confirm the required volume of the tank. In the end, Hatch determined that a smaller tank would be required to capture the 5-year storm (to meet typical basement flooding protection levels); but the previously proposed tank would not be required at all for CSO control purposes (to meet the 90% WWF control requirements of MOE Procedure F-5-5). Since the study area had not experienced any basement flooding in the past, Hatch suggested the tank was not necessary.

4.1.9 Niagara Water Quality Protection Strategy

Niagara Region together with the Local Municipalities developed a Source Protection Plan to meet requirements under the Clean Water Act (NPCA, 2013). The Niagara Peninsula Source Protection Area (NPSPA) overlies the same jurisdiction as the Niagara Peninsula Conservation Authority (NPCA), covering an area of 2,430 km^2 with over 450,00 residents, including the Regional Municipality of Niagara (including the City of St. Catharines) and parts of the City of Hamilton and Haldimand County.

The Source Protection Plan policies address potential threats to Niagara's municipal drinking water sources through defined Intake Protection Zones (IPZ) that are near water treatment plant (WTP) intakes and are considered vital in the delivery of safe drinking water.

Potable water for the City of St. Catharines is provided by the DeCew Falls WTP, located at 2700 DeCew Road in St. Catharines. The facility is a conventional surface water treatment plant which incorporates Zebra mussel control, travelling screens, coagulation, flocculation, sedimentation, filtration and disinfection, in three separate treatment trains with a combined rated capacity of 227,300 m^3/d. Primary disinfection is achieved utilizing Sodium Hypochlorite and enhanced by Ultraviolet (UV) irradiation. The facility supplies drinking water to the City of St. Catharines, City of Thorold, Town of Niagara-on-the-Lake, and sections of the Town of Lincoln.

Of specific relevance to the CSO issue, the Source Protection Plan includes Policy DC-2, which mandates that no new combined sewers, wastewater treatment facilities, stormwater management facilities, or industrial effluent systems shall be permitted where they would be a significant threat within the DeCew Falls Main Intake Protection Zone One (IPZ-1).

4.1.10 Other Available Information and Data

In addition to the previous reports and studies reviewed above, the following available information/data has been catalogued and reviewed, and a summary of each is provided below, including the type, extent and location of the information/data, and its value to the PPCP Update Study:

CSO and Sewer System Program Updates

- Annual CSO Model Updates
- Downspout Disconnection Program
- Flood Alleviation Program (FLAP)
- Rain Barrel Program
- Annual Budgets
- Council Reports

CSO and Sewer System Operations and Maintenance Activities

- Level of Service Review
- Asset Management Plan
- Sewer Inspection
- Sewer Flushing
- Smoke Testing
- Sewer Sampling

CSO and Sewer System Information/Data

- CSO System Maps and Information Packages
- Environmental Compliance Approvals
- Recent Sewer Infrastructure Update Data
- Existing XPSWMM Sewer Model and Supporting Info
- Historical Rainfall Data
- Historical Sewer Flow Data
- Climate Change

CSO and Sewer System Performance

- Annual CofA Compliance Reports
- Water Quality Index (WQI) Reports
- Beach Water Quality Data
- Basement Flooding Reports/Locations

5. Existing PPCP Best Management Practices

5.1 Relevant Policies

5.1.1 Ontario MOE Procedure F-5-5

In February 1997, the MOE, released CSO Control Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems. The goals of this procedure are to eliminate the occurrence of dry weather overflows, minimize the potential for impacts on human health and aquatic life resulting from CSOs, and achieve as a minimum, compliance with body contact recreational water quality objectives at beaches impacted by CSOs. The procedure requires municipalities with CSS to develop Pollution Prevention and Control Plans (PPCPs) that outline the nature, cause and extent of pollution problems, examine CSO control alternatives and propose remedial measures, and recommend an implementation program including costs and schedules.

Procedure F-5-5 lists seven (7) minimum CSO controls, which must be provided by the municipality, including the following:

a) Eliminate CSOs during dry weather periods, except under emergency conditions
b) Establish and implement Pollution Prevention programs that focus on pollutant reduction activities at source
c) Establish and implement proper operation and regular inspection and maintenance programs for the CSS
d) Establish and implement a floatables control program to control coarse solids and floatable materials
e) Maximize the use of the collection system for the storage and subsequent conveyance of wet weather flows to the WWTP
f) Maximize the flow to the WWTP for the treatment of wet weather flows
g) Capture and treat for an average year, all of the dry weather flow, plus 90% of the wet weather flow entering the CSS

The 90% volumetric control criterion is applied to the flow collected by the CSS immediately above each overflow location, unless it can be shown through modelling and on-going monitoring, that the criterion is being achieved on a system-wide basis. No increases in CSO volumes above existing levels at each outfall will be allowed except where the increase is due to the elimination of upstream CSO outfalls. During the remainder of the year, at least the same storage and treatment capacity should be maintained for treating wet weather flow (WWF). The minimum level of treatment of the controlled CSO volume is primary treatment or equivalent (MOE, 1997).

CSO control measures that should be examined, include, but are not limited to the following:

+ Source controls
+ Inflow/infiltration reduction
+ Operation and maintenance improvements
+ Control structure improvements

- Collection system improvements
- Storage technologies
- Treatment technologies
- Sewer separation

Additional controls above the minimum CSO controls presented above are required for the protection of swimming and bathing beaches affected by CSOs. The procedure recognizes the site-specific nature and impacts of CSOs, and there is flexibility for selecting controls for local situations.

The procedure is also different from past approaches in that it makes it possible to view CSO control, not just in isolation, but also in conjunction with the wet weather operation of WWTPs. This permits municipalities to consider their collection and treatment systems as a single entity, and opens a number of other innovative approaches to operating these systems in the future. This is something we intend to look at more closely as part of the current PPCP Study Update.

The complete text of Procedure F-5-5 can be found on the MOE website at:

F-5-5 Determination of treatment requirements for municipal and private combined | ontario.ca

5.1.2 Federal Wastewater Systems Effluent Regulation

The Canadian Federal Wastewater Systems Effluent Regulations (WSER) require reporting of quantity and frequency of all CSO effluent discharges, dates effluent was deposited, and for each day the duration of deposit (actual or estimated), volume deposited (actual or estimated), monthly volume deposited (actual or estimated), and the number of days per month effluent was deposited. This includes uploading of this CSO system performance data to the Federal Effluent Regulatory Reporting Information System (ERRIS) by the middle of February, covering the period from January 1 to December 31, of the previous reporting year. The City's WSER retorting requirements are fulfilled by the Annual Compliance Report program discussed further below.

5.1.3 Niagara Region CSO Control Policy

The Region's CSO Control Policy (originally known as CSO-MAP) has been in place since 2007 and is intended to facilitate shared funding with the Area Municipalities (including the City of St. Catharines) to help mitigate the impacts of wet weather events on municipal sanitary systems and the environment. The Region benefits from this program by removing flow from the wastewater systems which takes up existing capacity, and the Area Municipalities benefit from the availability of funding to address their own CSO problems. The CSO Control Policy supports Regional Council's Strategic Priorities with a goal to increase capacity in the wastewater systems by reducing inflow and infiltration, which are also goals of the City of St. Catharines.

Representatives of the Region's CSO Control Work Group developed administrative procedures to support this Policy, and Guiding Principles to rank project submissions by the Area Municipalities, in accordance with the guiding principles.

The CSO Control Work Group developed a new funding options structure for the eligible CSO cost share projects in October 2014. The new funding structure favours projects of greater betterment for the collection system as a whole, and replaces the previous cost share structure of financing all projects on a

50/50 share basis regardless of their significance to the rest of the collection system. The new funding structure favors projects which identify reduction of extraneous flows at the source versus projects to manage and treat extra flows conveyed by the wastewater collection system. This approach supports a Region-wide One-Team connection with all relevant stakeholders regardless of Municipal or Regional authority boundaries.

One of the key objectives of the current PPCP Update will be to prioritize CSO control projects that are candidates for external funding, including but not limited to the Niagara Region CSO Control Policy; and this will be an integral part of the evaluation and prioritization of CSO control projects as part of the PPCP Update.

5.2 Existing CSO/Basement Flooding Control Programs

5.2.1 Annual CSO Model Updates

The City conducts periodic updates of its existing XPSWMM models of the Port Dalhousie and Port Weller WWTP sewersheds, to reflect any physical upgrades made to the existing sanitary/combined sewer system and/or recalibration/validation of any portions of the models to improve their accuracy.

This task has been completed annually by CH2M Hill since 2010, and typically each year they provide two Tech Memos to the City. The first Tech Memo, entitled *City of St. Catharines XPSWMM Model Update,* provides an analysis of annual rainfall data collected by the City's permanent rain gauge network, to confirm the reliability of the data and compare it to the typical year (1989); presents and discusses the results of the model simulations for the year, comparing them to that of the typical year, and computes the estimated WWF capture rates for the Port Dalhousie and Port Weller sewersheds in relation to the 90% WWF volume control target set by MOE Procedure F-5-5.

The second Tech Memo, entitled *City of St. Catharines Wastewater System Effluent Reporting (WSER),* describes the updates made to the XPSWMM models; discusses the limitations of the models (including the accuracy of the models and the rainfall and flow data used to calibrate them, when the models were last calibrated and validated, and identification of any significant differences observed between modelled and measured values); echoes the rainfall data analysis provided in the first Tech Memo; and presents the results of the current year model runs in terms of annual CSO deposit volume and annual number of CSO deposit days, as per the requirements of Environment Canada's WSER, for both the Port Dalhousie and Port Weller sewersheds.

5.2.2 Downspout Disconnection Program

In 1991, the City implemented a Downspout Disconnection Program and updated its Sewer Use By-Law (By-Law 91-364). The Sewer Use By-Law prohibits the direct connection and discharge of roof water into the municipal sanitary or combined sewer system in order to assist in alleviating sanitary sewer surcharging during large storm events.

St. Catharines proactivly enforced the Downspout Disconnection Program between 1992 and 2005. During that period staff inspected approximately 17,000 residential properties in areas of the City that were known to have combined sewer systems. Follow-up inspections documented that the vast majority of these properties remain compliant with the Sewer Use By-Law. Table 5-4 summarizes the number of properties inspected for compliance with the Sewer Use By-Law from 1992-2005.

Table 5-1: Number of properties inspected by Year from 1990-2005

Year	Number of Properties Inspected
1992	3,102
1993	2,499
1994	1,270
1995	2,014
1996	1,332
1997	2,900
1998	390
1999	1,732
2000	645
2001	512
2002	153
2003	436
2004	36
2005	55
Total	17,076

5.2.3 Flood Alleviation Program (FLAP)

In 1995, City Council approved the recommendation that a Flood Alleviation Program (FLAP) be prepared in response to the basement flooding problems experienced throughout the City from a major rainstorm in 1994. The original objective of the FLAP program was to provide immediate basement flooding protection for homeowners in the short-term, while long-term solutions were investigated and implemented as funds become available.

The FLAP program offers a grant to eligible homeowners to subsidize the cost of flood protection devices. Typically, this includes the installation of a mainline backwater valve on the properties sewer lateral. It also includes disconnecting any weeping tiles from the sanitary lateral and re-directing them to a sump pump where applicable. Disconnecting the weeping tiles provide a secondary benefit of removing flows from the sanitary sewer.

Currently it is the responsibility of the FLAP Coordinator to determine a homeowner's eligibility for the program based on a basement-flooding questionnaire and a preliminary assessment. To ensure the correct technical solution each property requires a site inspection by the FLAP Coordinator, a City Plumbing Inspector and includes a CCTV inspection of the residence's sewer lateral.

A report submitted to City Council in July 2014 recommended that the maximum grant under FLAP be increased to $3,500 for eligible works; and that for FLAP grant applications that exceed $3,500, the City will contribute 50% of the eligible FLAP costs in excess of $3,500, at the discretion of the Director of Transportation and Environmental Services/City Engineer; and that the FLAP application fee be waived until removed from the Rates and Fees bylaw for 2015.

5.2.4 Rain Barrel Program

The City has held a one-day rain barrel sale each spring since 2006 for residents of the City. Rain barrels are offered for sale at a subsidized price. Subsidized funding is provided by the City with additional funding from the Region for the first sale in 2006. Rain barrels provide multiple benefits in terms of WWF reduction and CSO control, as they not only assist with water conservation, but also capture a significant volume of rain water that would otherwise enter the sanitary/combined sewer system, and increase CSO volumes.

5.2.5 Annual Budgets

The City and Region both prepare (rate-based) Annual Capital Planning and Operating Budgets (and multi-year forecasts) for their water and wastewater conveyance and treatment systems, which include projects and programs related to CSO and basement flooding control, some of which are undertaken to implement recommendations coming from the 2008 St. Catharines PCP (CH2M, 2008), 2006 CSO Evaluation and Audit (DFA, 2006), and the Region's 2017 Wastewater Master Plan (GMBP, 2017); and also to continue to implement the O&M practices defined by the City's LOS documents.

5.3 CSO and Sewer System Operations & Maintenance Activities

The following CSO and Sewer System Operations and Maintenance information was collected and reviewed, and a summary of each item is provided below, including the type, extent and location of the information/data, and its value to the PPCP Update Study:

1) Level of Service Review
2) Asset Management Plan
3) Sewer Inspection
4) Sewer Flushing
5) Smoke Testing
6) Sewer Sampling

5.3.1 Level of Service Review

The City has developed a number of procedures that define the Level of Service (LOS) to be provided with regard to the operation and maintenance of its sanitary/combined/storm sewer systems, road drainage systems, and watercourses, including the following documents:

+ S-1 – Catch Basin Cleaning and Repairs
+ S-2 – Cleaning Blocked Private Drains
+ S-3 – Main Sewer Maintenance
+ S-4 – Storm Sewer Maintenance
+ S-5 – Manhole Placement
+ S-6 – Manhole Repairs
+ S-7 – New Services – Water and Sewer
+ S-8 – Repair Service Broken by Contractor
+ S-9 – Sewer Lateral Repair

- S-10 – Storm Flooding
- R-3 – Box Culverts
- R-10 – Road Culvert Maintenance
- R-14 – Roadside Ditch Maintenance
- R-19 – Culvert Grate Maintenance
- R-20 – Street Cleaning
- OS-1 – Off Street Patrol
- OS-4 – Watercourse Cleaning

S-3 - Main Sewer Maintenance

The main objectives of the City's Main Sewer Maintenance activities are:

- To keep sewers clean, free of debris and functioning properly.
- To prevent public health hazards and inconvenience through interruptions in the services for which the sewer systems are provided.
- To protect the public investment in the sewer systems by maintaining maximum capacities and by extending the useful life of the system.
- To prevent unnecessary damage to public and private property.
- To update and correct errors or omissions in current sewer systems records, maps and inventories.

The following specific LOS for the City's Main Sewer Maintenance activities include the following are:

1) Flushing will be done on an emergency basis to affected sewer sections whenever there are reports of blockages or suspected blockages.
2) Blockages from all sewers will be removed and a record of blockage locations will be maintained.
3) All sanitary sewers up to 500 mm in diameter shall be cleaned with the hydro-jet sewer flusher to remove silt and debris on a planned program at least once every five years, and records kept of all dates when cleaning was performed.
4) Sanitary sewers with diameters between 150 mm and 450 mm that are in root infested areas shall be cleaned with a bucket or rodding machine prior to any sewer flushing.
5) A list of sanitary sewer sections that require more attention due to heavy deposition, frequent blockage and poor slope will be maintained. Sanitary sewers on this list shall be flushed semi-annually.
6) An on-going program of CCTV inspection of sanitary sewers is done to define the status of the sewer system. Generally, all sewers are CCTV inspected on a 10-year frequency with specific areas sewer system of concern on a more frequent basis. CCTV inspection is also done prior to road reconstruction projects to determine if sewer work should be done at the same time.
7) General deterioration and cracking of pipe which could cause future service disruptions is noted during the sewer inspection and flushing program. Such deterioration is monitored in future inspections to determine when corrective action is required.

8) Connections protruding into the main sewer, which restrict the capacity of the pipe or block the passage of the bucket or rodding machine or inspections camera, shall be recorded and scheduled for corrective repair to form a smooth, uninterrupted surface within the main sewer pipe.
9) Sections of sewer pipe that are badly cracked, partially collapsed or fully collapsed shall be monitored and repaired at the first available opportunity.
10) Sections of sewer pipe that are found during the regular flushing program to be flooded or having heavy deposition, are to be recorded for consideration on the semi-annual flushing list.
11) Storm storage tank sewers are listed for annual inspection, pump down and assessment for need to be cleaned. Deposits of more than 6" will be scheduled for cleaning.
12) Sewers and storm storage tanks with overflow grates, weirs, bar screens, throttling valves and sluice gates are listed for annual inspection, cleaning and maintenance. Additional maintenance and cleaning is done in response to any reports of active overflows, diversions, or back-ups to ensure their continued proper operation.

Budgeted CSO and sewer system maintenance activities covered by LOS document S-3 include:

+ SR200OP – Supervision – Sewers
+ SR201OP – Emergency Cleaning - Main Sewers
+ SR206OP – Sewer Replacement
+ SR209OP – Sewer Flushing - City
+ SR210OP – Rodding and Bucket Cleaning
+ SR211OP – Storm Flooding
+ SR212OP – Locating Sewers
+ SR213OP – Other Sewer Activities
+ SR214OP – Sewer Flushing - Contractor
+ SR215OP – Overflow Inspection

5.3.2 Asset Management Plan

To meet the requirements of Ontario Regulation 588/17, Asset Management Planning for Municipal Infrastructure, municipalities were required to have asset management plans in place. Wastewater services are considered a 'core' asset class and were included in St. Catharines 2021 Asset Management Plan.

As in many other communities, aging infrastructure in St. Catharines places tremendous burden on municipal resources. While the City's infrastructure is currently in fair to good condition, current spending levels for bridges, roads, water distribution and sanitary sewers will not maintain acceptable levels of service on a long-term basis.

The City's Asset Management Plan identifies current funding shortfalls and proposes financing strategies to address these shortfalls, and contains the following information, as per guidelines issued by the Province of Ontario:

+ Goals of the municipal asset management planning process
+ State of local infrastructure

+ Desired levels of services
+ Plans to meet desired levels of service
+ Financing strategy

With respect to the City's Sanitary Sewer System, the findings of the Asset Management Plan can be summarized as follows:

+ In 2021, the City's wastewater system consisted of 563 km of sanitary mainline, 5.4 km of forcemains, 9 storage facilities, one pump station, and 7,878 manholes, with an estimated replacement value of $1.5 billion.
+ The majority of pipes (87.5 per cent) were rated in good to fair condition, with 11% in poor condition and 9% in very poor condition.
+ To address current deficiencies and avoid deficiencies in the future, the City has employed several financing strategies. In general, operating and maintenance needs are funded from water/wastewater rates and other user fees, and the City has also previously used federal gas tax funding as well as funding from Niagara Region to remediate CSOs.
+ An update of the City's PCP, including a comprehensive condition assessment of all sewer assets as well as a technical analysis of how the system functions in dry and wet weather conditions, is required before recommending any significant changes to funding strategies. One of the deliverables from the update to the PCP will be to identify the funding required to operate a sustainable sewer system.

The latter requirement will be addressed by the current PPCP Update Study, as part of the evaluation of alternatives for controlling the City's remaining CSOs, and generally improving the operation and maintenance of its CSO and wastewater collection system.

5.3.3 Sewer Inspection

CCTV Inspection

As per LOS # S-3 discussed above, the City conducts an on-going program of closed circuit television (CCTV) inspection of sanitary sewers to define the status of portions the sewer system. The desired level of service is for all sewers to be CCTV inspected on a 10-year frequency with specific areas of concern investigated on a more frequent basis. CCTV inspection is also completed prior to road reconstruction projects to determine if sewer work should be done at the same time. The actual frequency of CCTV inspections, based on the available budget, is closer to a 1 in 17-year frequency.

The approved funding for CCTV inspections is included in the annual wastewater budgets. When the inspections identify minor repairs to the sanitary sewer system they are funded out of a sewer spot repair account in the City's wastewater budget. There is no corresponding budget for CCTV inspections of storm sewers. In fact the City does not budget for annual maintenance or minor repairs to the storm sewer system. Emergency repairs, when required, are funded from various sources including the annual operating budget, capital budget and/or water/wastewater budget.

5.3.4 City-Wide Zoom Camera Inspection

The City has completed a condition assessment project of its wastewater and stormwater systems using zoom camera inspection technology to get a snap-shot of both systems. The objective of this project was to complete a detailed inspection of sewer manholes and a rapid assessment of sewer mains, as observed from the manholes, to confirm system location and geometry, and provide a high-level condition assessment of the City's wastewater and storm sewer networks. The data from this project helps inform program forecasts for incorporation in the City's future capital and operating budgets.

The project followed OPSS 409 and CSA Plus 4012 and included both structural and operational grading of the sewers, in accordance with NASSCO PACP and MACP standards. The data collected and generated by the sewer condition assessment has been integrated and included into the City's existing GIS system.

The results of the investigations will be used to inform sewer pipe and maintenance hole (MH) rehabilitation projects, which will facilitate sewer system O&M, and help to reduce I/I (which should help reduce CSO volumes and pollutant loads).

It may also be possible to use other observations coming from the zoom camera inspection (e.g. general condition of the sewers, and location/depth of silt/debris deposits in the pipes) to develop more cost-effective future CCTV inspection and sewer flushing programs to prioritize the sewers that really require these activities. Sewers that exhibit good structural and O&M conditions don't need to be inspected in more detail by CCTV (at least not any time soon), and sewers that do not exhibit silt/debris deposits do not need to be cleaned as frequently as ones that do.

Work on the City-wide zoom camera inspection program was completed in 2020 and assessed both the structural and operation condition of the system. The study assessed most of the sewer assets within the road allowance, but not the off-street infrastructure. The final report by GM BluePlan (2021) found from a structural perspective; the wastewater system is overall in good condition, including the following additional observations for the portion of the system it assessed:

- Approximately 64% of the system exhibited no structural defects.
- Approximately 28% exhibited structural defects of Grades 1, 2, or 3, which included cracks, less severe fractures and surface damage.
- Less than 10% of the wastewater mains exhibited structural defects of Grades 4 or 5, which primarily included fractures, breaks, holes and two collapsed sections.

The project also found from an operational perspective, the system is overall in good condition, including the following additional observations for the portion of the system it assessed:

- Approximately 16% of the system exhibited no operational defects.
- Approximately 60% exhibited defects of Grades 1, 2 and 3
- Approximately 16% of the system which exhibited operational defects of Grades 4 or 5. The most prevalent and severe operational defects were encrustations (which is evidence of infiltration) followed by active infiltration, and deposits (not including grease).

5.3.5 Sewer Flushing

As per LOS # S-3 discussed above, the City conducts an ongoing program of sewer flushing to remove silt and debris from its sanitary/combined sewers, with the objective of cleaning all sewers up to 500 mm in diameter with a hydro-jet sewer flusher at least once every 5-years. In addition, flushing is done on an emergency basis to clean affected sewer sections whenever there are reports of blockages or suspected blockages. According to the LOS, sewers with diameters between 150-450 mm, located in areas subject to root intrusion are to be cleaned with a bucket or rodding machine prior to any sewer flushing.

Sewer flushing activities are to be documented, including maintaining a list of all sewer sections flushed; and a priority list of sewer sections that require more attention due to heavy deposition, frequent blockage and/or flooding, and poor slope (with these sewers to be flushed semi-annually). Maps are also kept showing the priority areas to be flushed, and have been provided for the years 2013-2015.

Our experience is that most sewers will be relatively clean (free of significant silt and debris), especially in combined sewer systems where incoming stormwater runoff will flush the sewers during each rainfall event (or in sanitary sewers prone to some additional I/I), and the number of sewers that need to be flushed every 5-years will comprise a relatively small portion of the overall sewer system; and as discussed above, the results of the City's ongoing zoom camera inspection project will provided useful information that can be used to develop a more cost-effective, priority-based sewer flushing program for the future.

5.3.6 Smoke Testing

From time to time, the City conducts smoke testing of portions of the sanitary/combined sewer system to identify potential sources of I/I into the system, including connected roof downspouts (most of these have already been removed by the City), improperly disconnected roof downspouts, cross-connected storm sewers and/or catchbasins, leaky manhole covers and/or frames, sump pumps, foundation drains, weeping tiles, uncapped cleanouts, and broken sewer laterals.

Each year from 2014 to 2017, the City retained Thomson Flow Investigations Inc to conduct smoke testing studies, including the Westland/Welstead sewershed in 2014, and City Work Sector 36 in 2015.

The Westland/Welstead sewershed (City Work Sector 46) is located in the southwest corner of the City, bounded by Rykert St, First St Louth, 12 Mile Creek, and Louth St, and includes approximately 19 km of sewer lines. The smoke testing study of this area documented 57 problematic findings, including connected sump pumps, weeping tile/window well drains, and improperly capped former downspout connection pipes, and some still connected roof downspouts (TQI, 2014). Remedial works were recommended to resolve the identified problems to remove I/I from the sewer system.

Work Sector 36 is located in the west end of the City, bounded by First St Louth, Rykert St, 12 Mile Creek, and the CNR line, and includes approximately 23 km of sewer lines and 286 sanitary/combined maintenance holes. The smoke testing study of this area documented 128 problematic findings, including large holes discovered in the sanitary sewer lines flowing down the ravine towards 12 Mile Creek from the end of Hamilton St, with the remainder of the problems including predominantly weeping tile/window well drains, and improperly capped former downspout connection pipes (TQI, 2015). Remedial works were recommended to resolve the identified problems to remove I/I from the sewer system.

The City also conducted smoke testing within Work Sectors 43 and 50 in 2016. Both areas are located in the south end of the City; Sector 43 bounded by Glenridge Ave, Glendale Ave, Brookdale Ave, and the CNR line; and Sector 50 bounded by Glendale Ave, Warkdale Dr and Barbican Tr, St. Davids Rd, and Bradley St. The smoke testing study of this area documented 90 problematic findings, including predominantly weeping tile connections, improperly capped former downspout connection pipes, and some still connected roof downspouts.

5.3.7 Other Sewer Inspection Activities

According to the City's level of service, sewers and CSO/storm storage tanks with overflow grates, weirs, bar screens, throttling valves and sluice gates are scheduled for annual inspection, cleaning and maintenance, and additional maintenance and cleaning is done in response to any reports of active overflows, diversions, or back-ups to ensure their continued proper operation.

The City also conducts annual inspections of the sewers connected to its CSO/storm storage tanks, including pumping down the facilities and determining whether the sewers need to be cleaned (with sewers with deposits deeper than 6" (150 mm) scheduled for cleaning.

5.3.8 Sewer Sampling

In 2014, St. Catharines provided in-kind contributions to a McMaster University research project. The project, entitled Water Pathogen Sampling and Analysis Program, was funded through the Natural Sciences and Engineering Research Council of Canada (NSERC).

For this project City staff collected samples from various locations to monitor and quantify receiving water impacts from stormwater and combined sewer overflows. This included installing automatic samplers in storm sewers and combined sewers and collecting samples after rainfall events. The automatic samplers were connected to flow monitors which activated during rainfall events. This equipment allowed the collection of stormwater and wastewater samples during storms (up to 24 hours in duration). The sampling equipment was relocated to a number of different sites over the duration of the project. In addition to the above a parallel water course sampling program monitoring several urban and rural creeks in St. Catharines.

The City's staff collected samples from fifteen CSO and storm sewer outfall locations in 2014, and conducted bacteria and pathogen testing of the samples, including DC, DNA and Polymerase Chain Reaction (PCR) tests, the latter including differentiation of PCR between human, animal (cow) and bird sources.

The City also installed auto-samplers to collect samples at seven locations in 2015 and six locations in 2016, for a wide range of parameters, including a variety organics, inorganics, bacteria, and metals.

The results of the pollutant sampling will be used later in the project, in conjunction with CSO volume estimates (from continuous modelling) and/or measurements (where available) to generate estimates of annual CSO pollutant loads discharged to local receiving waters, and also as input to consideration of CSO treatment options as part of the PPCP Update Study.

5.4 CSO and Sewer System Information/Data

The following CSO and Sewer System information and data was collected and reviewed, and a summary of each item is provided below, including the type, extent and location of the information/data, and its value to the PPCP Update Study:

1) CSO System Maps and Information Packages
2) Environmental Compliance Approvals
3) Recent Sewer Infrastructure Update Data
4) Existing XPSWMM Sewer Model and Supporting Info
5) Historical Rainfall Data
6) Historical Sewer Flow Data
7) Climate Change

5.4.1 CSO System Maps and Information Packages

Some additional detailed information provided by the City with respect to the design and operations of its sanitary/combined sewer systems includes the following:

+ Overall system maps of the Port Dalhousie and Port Weller sewersheds, showing the location of each individual CSO outfall.
+ More detailed operation maps of the CSO outfalls and sewer systems within the City's Work Sectors.
+ Detailed information packages for each of the City's CSO outfalls/regulators, including exact coordinates, as-built drawings, colour photographs, and engineering design calculations.

5.4.2 Existing Environmental Compliance Approvals

The St. Catharines Wastewater Collection System, which is operated under a Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA), ECA Number: 023-W601, issued by the Ministry of Environment, Conservation, and Parks (MECP). CLI-ECA's replace the numerous pipe-by-pipe Environmental Compliance Approvals (ECAs) that were previously issued for components of the municipal sewage collection system. The streamlined CLI-ECA outlines pre-authorized conditions for changes to the sewage works system and ensures standardized operating and reporting conditions to safeguard accountability and oversight, with enhanced requirements for monitoring and system operation.

5.5 CSO and Sewer System Performance

5.5.1 Annual Compliance Reporting

In February 2006, the City of St. Catharines was granted a Municipal and Private Sewage Works Environmental Compliance Approval (ECA), formerly a Certificate of Approval (CofA), Number 2668-6L4TK, for new sanitary sewer service connections to a combined sewer. Previously, a separate ECA was required for each new connection to a combined sewer (new development and in-fills). Under the ECA, all sanitary service connections involving a combined sewer fall under a single ECA. A condition of this ECA is providing the MOE with an annual performance report outlining works relating to combined sewers in the City.

In addition, the City of St. Catharines has constructed a number of capacity improvements in its wastewater collection system to address wet weather-related issues. Since 2006, the City has constructed combined sewage storage facilities each under a separate ECA issued by the MOE. Five of these ECAs also have various annual reporting requirements the City must fulfill.

Accordingly, the City prepares an annual report on the performance of its wastewater collection system, for submission each Spring to the MOE. The purpose of these reports is to fulfill the above reporting requirements, and has a secondary purpose to summarize the City's efforts to conform with MOE Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems.

Each annual report typically provides the following information:

+ A brief description about the St. Catharines wastewater collection system
+ A summary of activities undertaken to achieve ECA and MOE Procedure F-5-5 requirements
+ An evaluation of the wastewater collection system performance for the past year
+ A summary of activities that are planned for the next year
+ A summary of the cumulative impact of collection system actions taken since 2006
+ Final conclusions and summary

5.5.2 Water Quality Index (WQI) Reports

The Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) is based on a formula developed by the British Columbia Ministry of the Environment, Lands and Parks and modified by Alberta Environment. The WQI measures water quality by incorporating three elements, including: 1) Scope - the number of variables not meeting water quality objectives; 2) Frequency - the number of times these objectives are not met; and 3) Amplitude - the amount by which the objectives are not met. The Index produces a number between 0 (worst water quality) and 100 (best water quality). These numbers are divided into 5 descriptive categories to simplify presentation. In this way, the Index can be used to assess water quality relative to its desirable state (as defined by water quality objectives) and to provide insight into the degree to which water quality is affected by human activity.

Table 5-10 defines the different WQI categories and scores, ranging from Excellent (95-100) to Good (80-94) to Fair (65-79) to Marginal (45-64) to Poor (0-44).

Table 5-2: CCME Water Quality Index Categories (CCME, 2001)

Category	Water Quality Index	Description
Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Fair	65-79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

The WQI provides a mathematical framework for assessing ambient water quality conditions relative to water quality objectives (for parameters including un-ionized Ammonia, Nitrate, Chloride, Total Phosphorus, Chromium, Nickel and Zinc), which can be used to standardize calculations nationally and eliminate pollutant parameters which may be influenced by regional differences in environmental factors that may impact sampling results and hinder regional comparisons in water quality. The WQI is used extensively by water management agencies, Conservation Authorities, municipalities, consultants and environmental non-governmental organizations to calculate, compare and report surface water quality monitoring results. As such, the City of St. Catharines has adopted the WQI process, as a recognized, standard methodology for analyzing and reporting surface water quality monitoring results, and prepares a report each year, which summarizes the monitoring program completed, the results of the monitoring program in terms of the exact WQI value and WQI ranking, and recommendations for the next year's monitoring program. Table 5-11 presents the results of the City's 2015 WQI evaluation, and Figure 5-2 shows the WQI results and trends for the years 2008-2015.

In general, the WQI rankings for watercourses are poor (with a couple exceptions). This is true both for creeks which are impacted by CSO discharges as well as creeks that do not have CSO discharges.

Table 5-3: WQI Rankings

Sampling Location	Water Quality Index	WQI Ranking
Beverly Hills Creek	32.2	Poor
Carter Creek	32.0	Poor
Dick's Creek	30.9	Poor
Fairview Creek	30.4	Poor
Fifteen Mile Creek	37.4	Poor
Gregroy Creek	29.9	Poor
Happy Rolph's	32.1	Poor
Julianna Creek	30.2	Poor
Old Welland Canal	36.2	Poor
Port Weller Creek	31.8	Poor
Richardson's Creek	31.9	Poor
SAP Ditch	30.2	Poor
Springbank Creek	29.4	Poor
Spring Garden Creek	31.9	Poor
Walkers Creek	31.7	Poor

5.5.3 Beach Water Quality

There are three beaches in St. Catharines, including Sunset Beach (formerly Municipal Beach), Jones Beach, and Lakeside Beach. The beaches and associated lands are maintained by the City, and the Niagara Region Public Health Department is responsible for water sampling and determining if the beaches are considered safe for swimming. The Ontario Ministry of Health and Long-Term Care, and Ministry of Environment and Climate Change have established guidelines with respect to bacteria counts for recreational waters; and to avoid the risk of health problems, these agencies have restricted swimming to those beaches with *E. coli* levels of less than 100 *E. coli* per 100 ml. The Health Department collects bacterial samples at the three beaches, during the summer months, monitors the results to determine whether the beaches need to be closed to protect the public, and updates beach conditions on its website. During the period from 2011-2017, Sunset and Lakeside Beaches were closed approximately 35% of the time, and Jones Beach was closed over 70% of the time. Past research has shown that the water quality at Lakeside and Sunset Beaches is heavily affected by the amount of rainfall. It should also be noted that Lakeside Beach was not safe form swimming for the first half of the summer in 2017, due to the historically high Lake Ontario water level.

CSO and stormwater outfalls are not the only source of bacteria at the beaches. The City also distributes a fact sheets about how ‘Waterfowl are Fouling our Beaches’, asking the public to respect the beach posting signs, not to feed the geese/gulls/ducks near watercourses or at the beach, not to leave garbage and left-over food behind when they visit the beach, and to educate others about the impact of waterfowl on the City’s beaches.

5.5.4 Basement Flooding Reports/Locations

Neighbourhoods in southwest St. Catharines experienced significant basement flooding during a significant storm event occurring on July 27 and 28, 2014. Figure 5-3 shows the locations where basement flooding was reported (in red), with the majority of problems occurring within areas along both sides of the CNR line running across the centre of the City; and the south-west corner of the City, bounded roughly by Rykert St, First Street Louth, and 12 Mile Creek (St. Catharines Work Sector #46), as well as several properties in rural west St. Catharines.

The basement flooding was the subject of two staff reports to Council, one for each of flooded areas described above. The report for the south-west area of the City described the events of July 27/28, including the magnitude of the storm event (with up to 70 mm of rainfall recorded in these areas over a period of about 16 hours); summarized the City’s investigation (including sewer flushing, CCTV and zoom camera inspections, smoke testing, and sewer flow monitoring), public communication (including information flyers, website info, and door-to-door surveys), and mitigation efforts (including installation of manhole inserts to reduce inflow, and installation of sewage backflow preventers and disconnection of sump pumps under FLAP); and recommended an Action Plan including:

1) Enhanced sewer maintenance, including re-flushing of sewers where debris was encountered previously.
2) Capital Works at Valley Road, to address the I/I sources identified through smoke testing, including re-lining the sanitary sewer and laterals, and drainage improvements to the stormwater system.

3) Capital works at the Pelham Road / Louth Street / Mac Turnbull Drive intersection, including reconfiguration of the sanitary sewers to increase the hydraulic capacity of the sewers.
4) Additional smoke testing of sanitary sewers to identify I/I sources in other parts of the City, especially the downstream sewers to the north, and identify measures to reduce I/I, improve system performance and reduce the risk of future surcharging.
5) Investigation of how I/I impacts sewer performance on a City-wide basis, including an evaluation of the required level of service for sewer maintenance, assessment of the potential risk and impact of climate change on the operation of the City's sanitary/combined/storm sewer systems, and development of a municipal flood response protocol, all as part of the next PCP Update.
6) Enhanced communications with residents, including providing information and technical advice for residents to protect their homes from flooding. A basement flooding protection guide for residents is being developed by Staff. In addition, specific information will be prepared about the maintenance requirements for sump pumps and backwater valves.
7) Continuation of the FLAP Program, including offering the program to residents in this area, even if they may not have been impacted by recent flooding events, in order to provide residents with greater individual protection while also reducing the amount of groundwater flowing into the sanitary sewer system.

As part of the follow up investigations, City staff identified an existing partially collapsed 450mm diameter PVC sanitary sewer located within an easement between Rykert Street and Strada Boulevard. A tender was prepared specifying the use of a trenchless technology due to the narrow easement and the nearby residential houses. The work was completed in the spring of 2017 and as a result the drainage area has had its sewer capacity re-established.

5.5.5 Operation and Maintenance of CSO Tanks

The City operates and maintains nine wet weather storage facilities. A workshop was held with City staff to learn more about the City's current CSO Tank Operation and Maintenance Program activities. Some key information and issues raised during the workshop included the following:

+ The City's CSO tank maintenance program includes annual inspections of each of the existing facilities, including follow up to address any problems that may be identified. The sewage pumps are pulled and inspected, and if necessary, only very occasionally, they are sent out for service. All pumps have been inspected in the last two years, allowing the City to build an accurate inventory and condition of all pumps, and which ones will next need service. Other issues are infrequent, but when noticed, they typically include problems with CSO tank level sensors. Ladders and safety railings and gratings inside the tank are inspected for evidence of corrosion, but no issues have been noted. As noted above, in general, sewer corrosion (by H2S) does not seem to be a significant issue in the City's CSO/sewer system.
+ There is no set O&M schedule for the individual facilities (other than the annual inspections). Each facility has an O&M manual, which is typically the O&M manual provided by the Consultant and/or Contractor that designed and constructed each facility. These are typically just a collection of specification sheets/brochures for the various mechanical/electrical/I&C components of the facility (e.g. pumps, sediment flushing systems, level sensors, flow meters, etc), which lacks practical instruction on general and preventative maintenance, and is not a true O&M manual providing information on how to operate and maintain the CSO tanks on a daily basis.
+ The CSO tanks are drained based solely on the capacity available in the immediate downstream sewer system (based on a water level measurement taken in the pipe that receives the pumped flows drained from the tank). There may be instances where the drained flows can be safely accommodated in the immediate downstream sewer system, but these additional flows may exceed the available treatment capacity at the downstream Port Dalhousie or Port Weller WWTP and be bypassed at the head of the plant, without receiving any treatment. Additional coordination with the Region, adding real-time information on available WWTP capacity to the decision process for draining the CSO tanks, would improve the overall operation and performance of the facilities, especially in situations involving two storms following closely together. There may also be a potential to time the drainage of the CSO tanks to optimize/minimize hydro costs, i.e. there may be instances where the drainage period can be moved forward or backward in time to take advantage of lower hydro rates during different times of day.
+ There may also be an opportunity to make better use of the storage available in some of the existing CSO tanks. For example, the Lockview CSO Tank has rarely if ever filled to its maximum storage capacity, and there may be similar situations at some of the other CSO tanks.

In some cases, it may be possible, elevations permitting, to divert additional adjacent drainage sub-areas towards the selected CSO tanks, making better use of its available storage capacity, and at the same time providing relief of any conveyance capacity, CSO and/or basement flooding issues in the sewer system the selected sub-area currently drains to.

+ The Walkers Creek, Kernahan Park, Welland/Ontario and Capner/Oakdale CSO tanks are cleaned by sediment flushing tanks (SFTs) and the Lockview and Guy Road facilities are cleaned by sediment flushing gates (SFGs). The cleaning systems are activated automatically by the CSO tank monitoring and control software (see more below), soon after the tanks have been drained. Ideally, staff would like to have more control over the cleaning of the CSO tanks, remotely from their office.
+ The CSO tanks generally include one (1) level sensor in the drainage pump well and one (1) level sensor in each storage cell, with the tanks typically having 1-3 storage cells. Some level sensors need to be replaced and are in installed in awkward spots.
+ The most challenging facility from an O&M standpoint is the Guy Road CSO Tank. There have been problems with the sewage pump(s). A Flygt pump that sometimes clogged was replaced with a chopper pump, but even this pump still sometimes seizes due to excessive debris/rags/etc. When the pump fails, the facility has to cleaned out by vacuum truck, and this has led to odour complaints from local residents. There are also other CSOs in the adjacent area, which could ideally be diverted to the Guy Road CSO Tank, if these issues could be resolved.
+ None of the existing CSO tanks include odour control systems, although one of them includes a spot to add a charcoal filter system should this ever be required. With the exception of the Guy Road CSO Tank (discussed above), the remaining facilities are all well sealed to prevent the escape of odours and have not any odour complaints from residents.
+ With respect to floatables control, most of the CSO tanks do not include an actual overflow to the environment, and floatables are simply vacuumed out from time to time, after the tanks have been drained. No additional floatable control measures (e.g. underflow baffles or screens) are provided at the remaining facilities with overflows.
+ The biggest issue with the O&M of the CSO tanks is the existing monitoring and control systems. The existing systems were provided by the manufacturer of the submersible pumps provided to drain the tanks (i.e. Flygt), but these older systems are no longer supported by Flygt, and replacement parts are becoming harder to acquire. There are only two people in North America that still understand and can provide service for these systems, and response time is an issue. Also, the existing alarm system consists of messages being sent to a printer in the City's office (Monday to Friday), which need to be read by staff, who then create a work order to address the noted alarm issue. A more robust, reliable, modern alarm system is required.

5.5.6 CSO Tank Standard Operating Procedures (SOPs)

New Standard Operation Procedures (SOPs) should be developed for all of the City's existing CSO storage tanks, to provide clear and consistent guidance to City staff on how best to operate and maintain the facilities. Additional information is provided in TM #3 (Rainfall/Flow Monitoring and O&M Program Review), included in Appendix C.

5.5.7 Conformance with MOE Procedure F-5-5

In February 1997, the MOE, released CSO Control Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems. The goals of this procedure are to eliminate the occurrence of dry weather overflows, minimize the potential for impacts on human health and aquatic life resulting from CSOs, and achieve as a minimum, compliance with body contact recreational water quality objectives at beaches impacted by CSOs. The procedure requires municipalities with CSS to develop Pollution Prevention and Control Plans (PPCPs) that outline the nature, cause and extent of pollution problems, examine CSO control alternatives and propose remedial measures, and recommend an implementation program including costs and schedules.

MOE Procedure F-5-5 lists seven (7) minimum CSO controls, which must be provided by the municipality, including the following:

a) Eliminate CSOs during dry weather periods, except under emergency conditions
b) Establish and implement Pollution Prevention programs that focus on pollutant reduction activities at source
c) Establish and implement proper operation and regular inspection and maintenance programs for the CSS
d) Establish and implement a floatables control program to control coarse solids and floatable materials
e) Maximize the use of the collection system for the storage and subsequent conveyance of wet weather flows to the WWTP
f) Maximize the flow to the WWTP for the treatment of wet weather flows
g) Capture and treat for an average year, all of the dry weather flow, plus 90% of the wet weather flow entering the CSS

The 90% volumetric control criterion is applied to the flow collected by the CSS immediately above each overflow location, unless it can be shown through modelling and on-going monitoring, that the criterion is being achieved on a system-wide basis. No increases in CSO volumes above existing levels at each outfall will be allowed except where the increase is due to the elimination of upstream CSO outfalls. During the remainder of the year, at least the same storage and treatment capacity should be maintained for treating wet weather flow (WWF). The minimum level of treatment of the controlled CSO volume is primary treatment or equivalent (MOE, 1997).

Additional controls above the minimum CSO controls presented above are required for the protection of swimming and bathing beaches affected by CSOs. The procedure recognizes the site-specific nature and impacts of CSOs, and there is flexibility for selecting controls for local situations.

The complete text of MOE Procedure F-5-5 can be found on the MOE website at:

https://www.ontario.ca/page/f-5-5-determination-treatment-requirements-municipal-and-private-combined

Table 5-14 provides a detailed assessment of the City's current programs and practices as they pertain to each of the seven minimum CSO controls; and Table 5-15 provides a high-level assessment of how well they are meeting these requirements.

Table 5-4: Detailed Assessment of Policies/Programs/Practices Compared to Procedure F-5-5

MOE Procedure F-5-5 Minimum CSO Requirement	Previous and Ongoing CSO Policies/Programs/Projects
Eliminate CSOs during dry weather periods, except under emergency conditions	From time to time, the City conducts smoke testing of portions of the sanitary/combined sewer system to identify possible sources of I/I into the sewer system and/or cross connections between the sanitary/combined and storm sewer systems. The City's monitors storm sewer outfalls for flow during dry weather periods. Based on the results of bacterial testing, homes are investigated for potential cross connections and improperly functioning septic tanks. Remedial measures are recommended and implemented as required. Additional details on some of these programs can be found in Tech Memo #1.
Establish and implement Pollution Prevention Programs that focus on pollutant reduction activities at source	The City employs several policies/programs aimed at preventing or reducing pollution at source, including: catch basin cleaning; street sweeping; pet litter control; household hazardous waste collection; and pesticide management; and conducts an ongoing environmental education and public outreach program with a focus on water conservation and water pollution. It also employs several policies/programs to reduce the volume of storm water entering the sanitary and combined sewer system at source, including: downspout disconnection program and by-law enforcement; subsidized rain barrel sales; and water conservation programs. Additional details on some of these policies/programs can be found in Tech Memo #1.
Establish and implement proper operation and regular inspection and maintenance programs for the CSS	The City has developed several procedures that define the level of service (LOS) to be provided with respect to the O&M of its sanitary/combined/storm sewer systems, road drainage systems, and watercourses. Regular sewer system inspection and maintenance activities covered by these documents include: catch basin cleaning and repairs; cleaning blocked private drains; main sewer maintenance; storm sewer maintenance; manhole repairs; and sewer lateral repairs. Regular main sanitary/combined sewer maintenance activities include: cleaning and flushing, blockage removal, reaming and rodding, CCTV inspection, and annual inspection of sewers and CSO regulators and storage tanks. The City has conducted a zoom camera inspection if its sanitary/combined sewer system, as part of a city-wide investigation of extraneous I/I into the system. The objectives of the project are to: identify the connectivity, material size, debris build-ups, I/I and general structural condition of the sewer system; identify any emergency repairs that should be completed immediately; and provide maintenance and capital budget forecasts for incorporation in future capital and operating budgets. These maintenance programs are also supported by ongoing rainfall and sewer flow monitoring programs, which help to understand the current performance of the system and investigate O&M issues/problems including CSOs, basement flooding and I/I. Additional details on some of these O&M, inspection and monitoring programs can be found in Tech Memo #1. The results of all these efforts are used to identify and prioritize remedial works (including CSO, basement flooding and I/I control, and general sewer system rehabilitation projects/programs) for incorporation in the City's annual capital and operating budgets.
Establish and implement a floatables control program to control coarse solids and floatable materials	The City has an anti-litter by-law that helps to decrease the amount of debris that enters the sewer system, and floatable controls have been installed at some CSO outfalls, but a more comprehensive CSO floatables control program needs to be established and implemented to control coarse solids and floatable materials throughout the sewer system. This is one of the key objectives of the ongoing PPCP update and additional details are in Tech Memo #7. Some possible floatables control options to consider include: underflow baffles; trash racks or bar screens; in-line or end-of-pipe netting systems; and containment booms.
Maximize use of collection system for storage and subsequent conveyance of wet weather flows to the WWTP	The City has constructed several underground CSO storage tanks to reduce CSO frequency and volume to local receiving waters. These facilities capture and temporarily store CSOs during wet weather and return the stored flows to the combined sewer system during dry weather for conveyance and treatment at the Port Dalhousie or Port Weller WWTP. CSO storage tanks have already been constructed at Guy Road Park, Walkers Creek, Queenston Street, Welland/Ontario, Page Street, Capner/Oakdale, Glengarry Park and Lockview Park in St. Catharines.
Maximize flow to the WWTP for the treatment of wet weather flows	In general, the operation of the Port Dalhousie and Port Weller sewer systems aims to maximize the flow conveyed to their respective WWTP for treatment, and several SPS capacity upgrade and CSO storage tank projects have been implemented to increase the volume of sewage conveyed to the WWTPs after WWF events. Recent projects completed by the Region include upgrades at the Renown and Eastchester SPS.
Capture and treat for an average year, all dry weather flow, plus 90% of the wet weather flow entering the CSS	The City has provided annual reports on the performance of the Port Dalhousie and Port Weller CSO systems since 2008, including estimates of annual WWF volume control levels from sewer system modeling. Annual WWF control levels are impacted by several different factors, most significantly rainfall coverage, volume, intensity, duration and timing, but can also be exacerbated by extenuating circumstances such as sewer surcharging and basement flooding that may be caused by infrequent sewer system operation and maintenance issues. In general, the system-wide WWF control level for the typical year is just above the 90% target in the typical year.

Table 5-5: High-Level Assessment of Policies/Programs/Practices Compared to Procedure F-5-5

MOE Procedure F-5-5 Minimum CSO Requirement	Component Policy/Program	Preliminary Assessment	Comments
Eliminate CSOs during dry weather periods, except under emergency conditions	From time to time, the City conducts smoke testing of portions of the system to identify possible sources of I/I and/or sanitary cross connections	Meets or Exceeds Requirement	No known dry weather CSOs
	City's Dry Weather Seepage Abatement program surveys storm sewer outfalls for evidence of flow during dry weather periods	Meets or Exceeds Requirement	No known dry weather CSOs
Establish and implement Pollution Prevention Programs that focus on pollutant reduction activities at source	Water conservation to reduce dry weather sanitary flow and hence CSOs	Meets or Exceeds Requirement	City has long standing water conservation programs
	Reduce use of potential pollutants like fertilizer and pesticides in parks	Meets or Exceeds Requirement	City does not use pesticides in parks except for health and safety reasons (e.g. spraying for poison ivy)
	Public education programs on e.g. anti-littering and illegal dumping of used motor oil and other materials into catchbasins	Meets or Exceeds Requirement	City has long standing environmental education programs
Establish and implement proper operation and regular inspection and maintenance programs for the CSS	City has suite of procedures that define the level of service (LOS) to be provided with respect to O&M of sanitary/combined/storm sewer systems, road drainage systems, and water courses	Opportunity for Improvement	LOS for sewer system O&M, for activities such as sewer inspection, and sewer cleaning and flushing could be made more site specific, with frequencies based on actual need, not on system-wide frequency targets
	City has conducted a zoom camera inspection of its entire sanitary/combined sewer system, as part of a city-wide investigation of extraneous I/I into the system.	Meets or Exceeds Requirement	Will help plan and budget for future sewer maintenance, repair and replacement activities
	These maintenance programs are also supported by ongoing rainfall and sewer flow monitoring programs	Meets or Exceeds Requirement	This helps to understand the current performance of the system and investigate O&M issues/problems including CSOs, basement flooding and I/I
Establish and implement a floatables control program to control coarse solids and floatable materials	City has an anti-litter bylaw	Meets or Exceeds Requirement	Helps reduce amount of debris entering the CSS
	City has installed floatable controls at some CSO outfalls	Opportunity for Improvement	A more comprehensive floatables control program needs to be considered as part of the PPCP Update
Maximize use of collection system for storage and subsequent conveyance of wet weather flows to the WWTP	City has constructed several underground combined sewage storage facilities to reduce CSO frequency and volume to local receiving waters, at locations noted elsewhere in this Tech Memo.	Meets or Exceeds Requirement	Meets or exceeds 90% control level at these outfalls, but still room for improvement at some remaining uncontrolled CSO outfalls
Maximize flow to the WWTP for the treatment of wet weather flows	In general, the operation of the sewer system does aim to maximize flow conveyed to the Port Dalhousie and Port Weller WWTPs, and the Region has conducted or continues to conduct upgrades at these facilities and at contributing sewage pump stations to increase the volume of sewage conveyed to and treated at the two WWTPs	Opportunity for Improvement	Overflows do still occur from time to time, so there is still room for improvement
Capture and treat for an average year, all dry weather flow, plus 90% of the wet weather flow entering the CSS	As noted above, the City has implemented several combined sewage storage facilities to capture and temporarily store CSO, for subsequent conveyance and treatment at the two WWTPs	Meets or Exceeds Requirement	In general, the system-wide WWF control level for the typical year is just above the 90% target.

6. Hydraulic Modelling Analysis

6.1 Historical Rainfall Data

The City has operated a network of rain gauges since 1988; the Region of Niagara also operates gauges at its facilities; and Environment Canada operates several nearby gauges. Table 6-1 lists the locations and period of record of all the rainfall monitoring stations located in and around St. Catharines (for all stations operating between 2008-2018).

Table 6-1: Permanent Rain Gauge Stations in the City of St. Catharines

Station Name	Location[1]	Period of Record[2]	Interval[3]
Rain Gauges operated by the City of St. Catharines			
City Hall	50 Church St.	9/17/88 to 12/31/16	5-minute
Firehall #2	192 Linwell Rd.	9/17/88 to 12/31/16	5-minute
Fire Hall #4 Merritton Fire Station[5]	405 Merritt St.	9/17/88 to 08/26/15	5-minute
St. Catharines Museum[5]	1932 Welland Canals Parkway	10/24/15 to date	5-minute
Malcomson Park Greenhouse	325 Lakeshore Rd.	12/2/92 to 12/31/16	5-minute
Fire Hall #3	285 Pelham Rd.	3/18/94 to 12/31/16	5-minute
Rain Gauges operated by the Region of Niagara			
Port Dalhousie WWTP	40 Lighthouse Road, St. Catharines	1/1/16 to 5/31/17	5-minute
Environmental Centre	3501 Schmon Parkway, Thorold	1/1/16 to 5/31/17	5-minute
Rain Gauges operated by Environment Canada (EC)[4]			
St. Catharines Airport	Niagara District Airport, Niagara-on-the-Lake	5-7-12 to date	hourly
Port Weller Coast Guard Station	North end of Port Weller Pier, St. Catharines	9-30-93 to date	hourly
Royal Canadian Henley	North End of Henley Island, St. Catharines	9-19-14 to 11-17-15	hourly
Vineland Station RCS	Vineland Station, south of QEW, Lincoln	2-15-02 to date	hourly
Brock University	Brock University, St. Catharines	Apr-67 to Apr-17	daily

Notes:
1 Exact locations of some rain gauges still to be filled in.
2 Indicates period of record for data already obtained. More recent data should also be available.
3 Data from Regional rain gauges prior to 2016 should also be available.
4 Hourly/daily data from EC likely not useful for sewer model calibration, but may be for climate change analysis.
5 Former Fire Hall #4 (Merritton) was sold in 2015 and rain gauge was relocated to St. Catharines Museum site.

The suitability of the available rainfall data for updating the PPCP (e.g. number of monitoring sites and quality of data) was reviewed and discussed in more detail in TM #3 (Sewer Flow Monitoring, Rainfall Monitoring and O&M Program Review) and TM #5 (Gap Analysis), included in Appendix C and E, which confirm that the historical rainfall data described above should be sufficient for the PPCP Update.

6.2 Historical Sewer Flow Data

In St. Catharines, sewer flow monitors have been installed for many years. Currently both the City and Region operate a network of area-velocity meters that can be used to characterize the flows in the wastewater system. Table 6-2 lists the locations and period of record of the current permanent sewer flow monitoring stations located within St. Catharines, and Figures 6-1 and 6-2 show the locations of the meters operated by the City and Region respectively. Staff submitted a report to Council in July 2015 (approved in August 2015), which recommended the purchase of 13 Hach FL900 Series Flow Loggers, to replace the City's existing outdated/unsupported data loggers, with costs to be shared with the Region, under the Region's CSO Control Policy. The Hach Flo Dar sensors were not replaced at that time.

Table 6-2: Permanent Sewer Flow Meters in the City of St. Catharines

#	Station Name	Location	Install Date[1]	Data Provided[2]
Flow Meters operated by the City of St. Catharines				
PW07	Sunnylea / former CNR Line	14 Apollo Ct.	Nov. 2003	12/8/10 - 6/30/17
PW12	Forster St	3a Forster St.	Sept. 2000	12/9/10 - 6/30/17
PW04	Hartzel Rd	149 Hartzel Rd.	May 2004	12/8/10 - 6/30/17
PD02	Kent St	60 Kent St.	Feb. 2000	12/1/10 - 6/30/17
PD10	Lakeport Rd	14a Lakeport Rd.	Oct. 2003	12/8/10 - 6/30/17
PD02	Moffatt St	65a Moffatt St.	Nov. 1998	12/8/10 - 6/30/17
PW10	Niagara St	716 Niagara St.	Nov. 2003	12/9/10 - 6/30/17
PD06	Ontario Carlton-City	296 Ontario St.	Nov. 1998	12/15/10 - 6/19/17
	Ontario Carlton Region	296 Ontario St.	Nov. 1998	
PD05	Page St	74 Page St.	Nov. 2003	12/9/10 - 6/30/17
PW03	Park Ave	2 Park Ave.	Feb. 2008	12/8/10 - 6/30/17
PW05	Ravine Rd	43a Ravine Rd.	Nov. 1998	12/8/10 - 6/30/17
	Welland/Ontario	169 Ontario St.	May 2000	
	Walkers Creek	145 Parnell Rd.	Sept. 2000	
	Thomas St.	82a Thomas St.	Feb. 2000	
Flow Meters operated by the Region of Niagara				
PD04	Brewery	Brewery St, south of Yates St		1/1/13 - 4/30/17
PW15	Cumberland	Cumberland St, near Beachaven Dr	10/22/04	1/1/13 - 5/9/17
PD08	Gladman	Gladman Ave, south of Henley Dr	4/16/04	1/1/13 - 5/7/17
PD01	Glenridge	Glenridge Plaza		1/1/13 - 4/30/17
PW01	John	John St, north of McNamara St	10/22/04	1/1/13 - 4/30/17
PD09	Lighthouse	Lighthouse Rd, north of Lakeshore Rd	Prior to 1/1/04	1/1/13 - 5/8/17
PW09	Lockview	Goldsmith Ave, west of Bunting Rd	6/30/04	1/1/13 - 5/8/17
PD07	Meadowvale	Meadowvale Dr, south of Dorothy St	Prior to 1/1/04	1/1/14 - 5/7/17
PD11	Michigan	Michigan Ave & John St		1/1/13 - 4/30/17
PW11	Niagara	Niagara St, south of Lakeshore Rd		1/1/13 - 5/8/17
PW14	O'Mara	O'Mara Dr, south of Lakeshore Rd	Prior to 1/1/04	1/1/13 - 4/30/17

PW06	Petrie	Petrie St, north of Eastchester Ave	6/24/04	1/1/13 - 4/30/17
PD03	Renown	East end of Renown Rd		1/1/13 - 4/30/17
PW08	Tamarack	Tamarack Ave, east of Grantham Ave	Prior to 1/1/04	1/1/13 - 5/8/17
Notes: [1] Original installation date for some flow meters still to be confirmed. [2] This is period of record for data already provided. Additional prior and more recent data should also be available.				

The suitability of the available flow data for updating the PPCP (e.g. number of monitoring sites and quality of data) was reviewed and discussed in more detail in TM #3(Sewer Flow Monitoring, Rainfall Monitoring and O&M Program Review) and TM #5 (Gap Analysis), included in Appendix C and E, which confirm that the historical rainfall data described above should be sufficient for the PPCP Update.

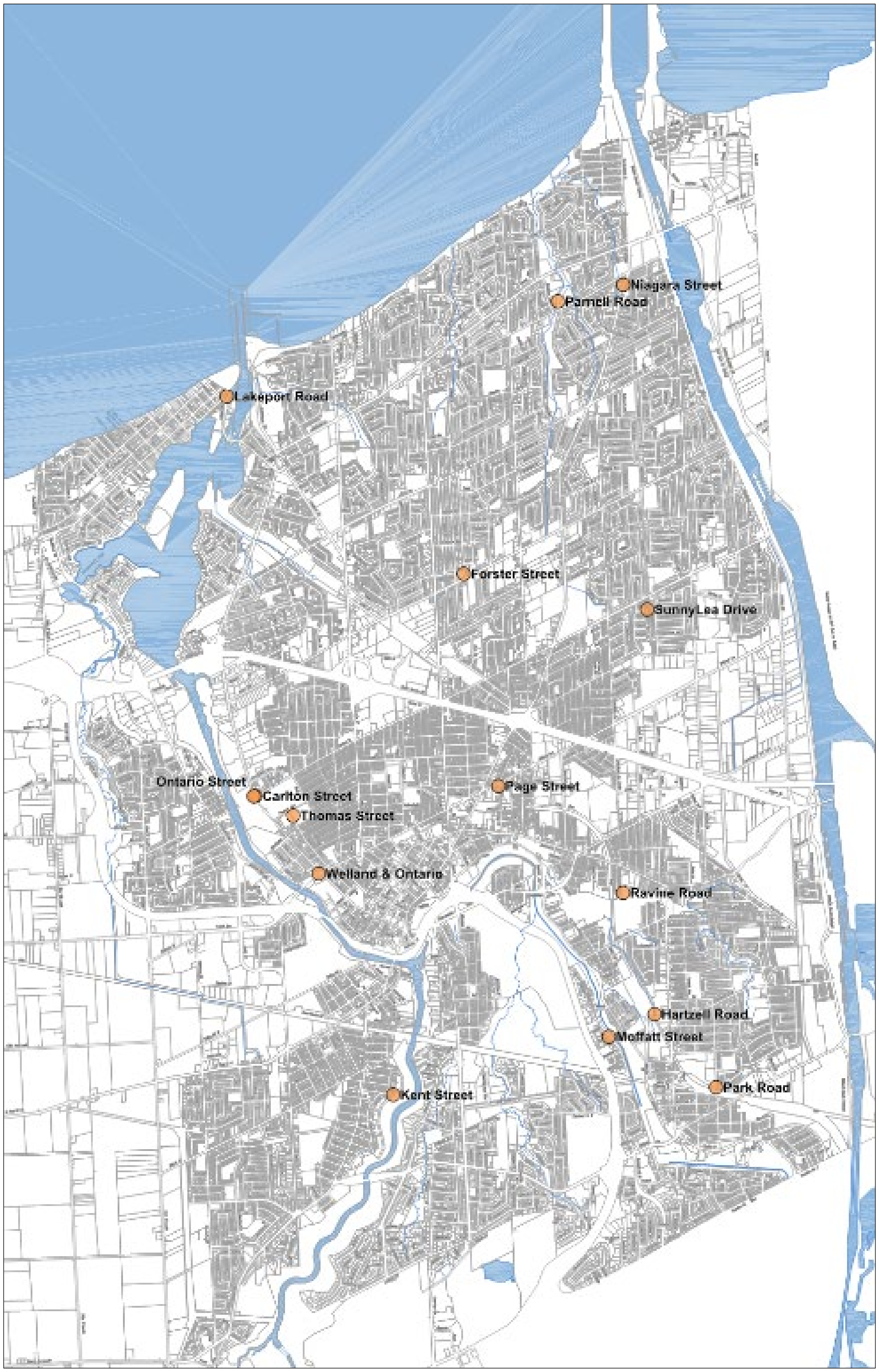


Figure 6-1: Permanent Sewer Flow Meters Operated by the City of St. Catharines

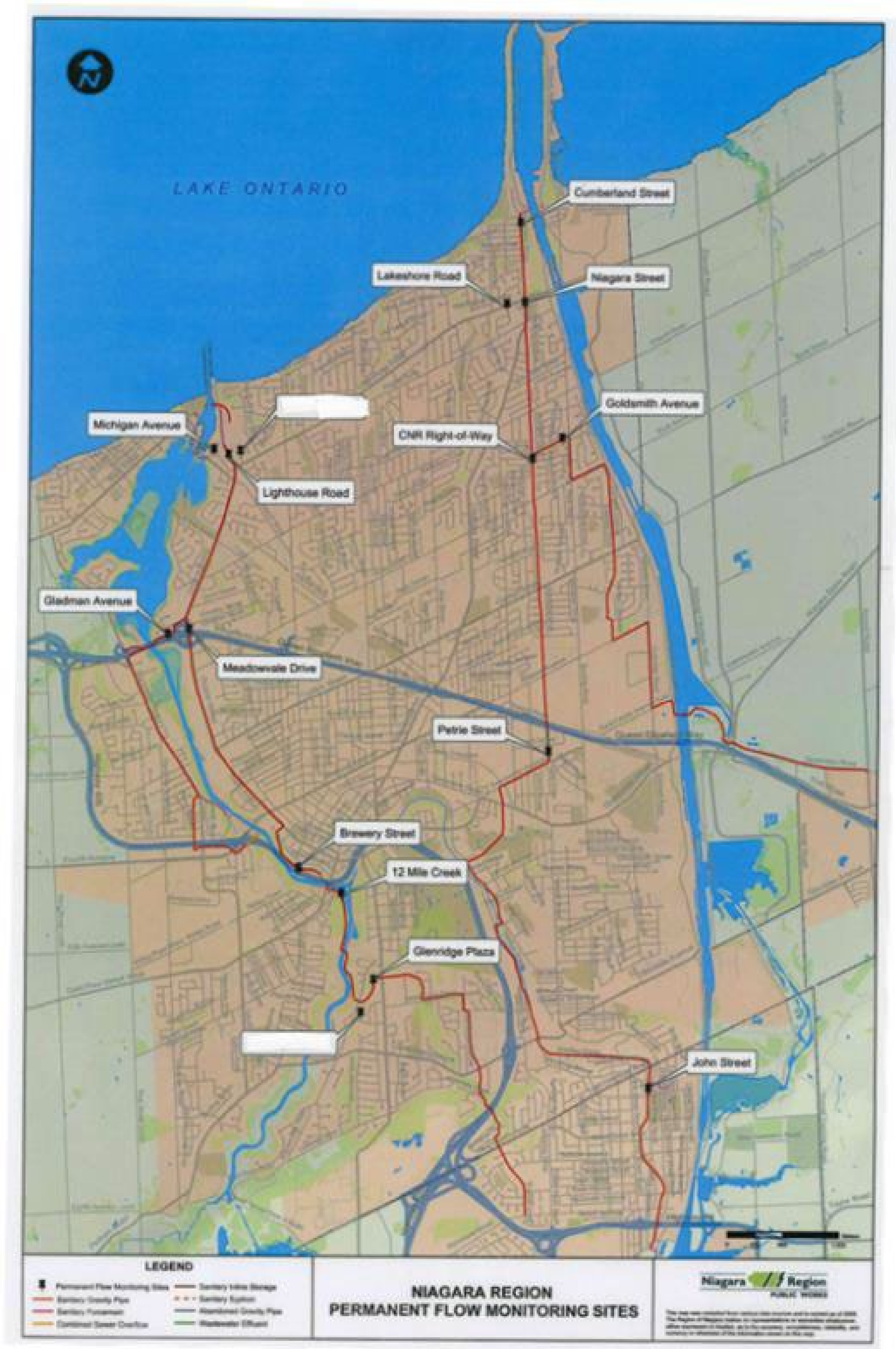


Figure 6-2: Permanent Sewer Flow Meters Operated by the Region of Niagara

6.3 Sewer Modelling Methodology

The City employs computer modeling to simulate the hydrology and hydraulics of its wastewater collection system and CSOs. The City's sewer model was originally developed as part of the development of its original PCP in 1989 and primarily represented the trunk sanitary and combined sewer system. Subsequent studies have expanded the models to include additional, more detailed areas of the sanitary and combined sewer system, but still not down to the level of an all pipes model. The City actually maintains two separate models, one for the Port Dalhousie WWTP sewershed, and one for the Port Weller WWTP sewershed. The models of the two systems can be separated because they have no interconnecting sewers, and do not impact each other's performance.

The models simulate dry and wet weather flows (DWF and WWF) generated within the City's sanitary and combined sewer system, and can be used to assess the performance of the sewer system, including sanitary capacity analyses; estimation of annual CSO frequencies, volume and durations at the City CSO outfalls; and to a more limited extent, analysis of basement flooding issues. The models can be used to simulate sewer system performance for selected historical rainfall storm events; for longer term historical rainfall records (annual or several years); and/or selected synthetic design storm events; for existing and/or future conditions.

The existing models are based on XPSWMM, a proprietary software package, supported by Innovyze (formerly XP-Software), which is based on the United States Environmental Protection Agency (USEPA) Stormwater Management Model (SWMM) hydrologic and hydraulic computation.

The hydrologic module defines the drainage area characteristics and generates the inflow hydrographs for input to the hydraulic routing module, and the hydraulic module defines the sewer system network (manholes, pipes, CSO diversion structures, outfalls, etc.) and simulates how the sanitary and combined sewer system responds to given flow conditions. Model outputs include sewer flows and elevations (hydraulic grade lines), and CSO frequencies, volumes and durations covering the selected simulation time frame.

The XPSWMM hydrologic module is based on the SWMM RUNOFF computation engine, which simulates the filling of surface storage, infiltration of rainfall into the soil, and routes the remaining surface runoff (when infiltration rates are exceeded) to inlets into the sewer system using the kinematic wave computation option. The overall drainage basin comprises multiple subcatchments, each with a drainage outlet connected to a specific sewer inlet in the hydraulic model to allow the surface runoff to enter the sewer system.

The XPSWMM hydraulic module is based on the SWMM Extended Transport (EXTRAN) hydraulic computation engine, which employs the full (Saint Venant) dynamic equations of flow continuity and momentum, allowing the model to accurately simulate backwater effects, surcharging, and gravity and pressure flow modeling in branched, dendritic and looped pipe networks; features often found in combined sewer systems.

6.4 Sewer Model Input Data

Key hydrologic module inputs include:

- rainfall/runoff generation methodology (employing the SWMM kinematic wave model option);
- subcatchment characteristics including area, slope, flow length/width, % imperviousness; and
- rainfall infiltration methodology (e.g. Horton/Green-Ampt) and max/min/decay rates.

Some additional, less significant/impactful hydrologic model input parameters include surface roughness, depression storage, etc. These are usually based on default parameters provided by the model, since they have much less impact on the model results, as confirmed by previous sensitivity analyses.

Key hydraulic model parameters include:

- manhole and pipe connectivity;
- manhole invert and rim/ground elevations;
- upstream and downstream pipe invert elevations (pipe slope);
- manning's pipe roughness;
- CSO diversion structure dimensions and elevations (including overflow weirs/orifices/gates); and
- parameters describing the operation of any sewage pumping stations situated within the sewer system (including number/size of pumps and operating mode/levels).

With just a couple of exceptions, these parameters generally have little impact on predicted CSO volumes, which are affected much more by the rate and volume of rainfall-related surface runoff that enters the combined sewer system, than changes in pipe roughness.

This being said, it is of course important that the physical data describing the sewer systems is accurate, including correct pipe shapes, dimensions, invert elevations and slopes; manhole rim elevations; and CSO regulator type and dimensions, in order to most accurately estimate CSO volume and frequency.

The main exceptions are manhole and pipe connectivity, and the CSO regulator data, which can impact the proportion of flow sent to the WWTP or CSO outfalls. If orifice openings are too small or weir crest elevations are set too low, modeled CSO frequencies and volumes will be underestimated; and conversely if orifice openings are too large or weir crest elevation are set too high, computed CSO frequencies and volumes will be overestimated.

The piping layout of the current XPSWMM models was reviewed by comparison with available sewer maps and CSO regulator sketches and drawings, confirming the correctness of the manhole and pipe connectivity in both models. Similarly, detailed model input data for the CSO regulators was checked against the dimensions and elevations contained in the CSO regulator information packages provided by the City, particularly the sizes of flow control orifices and length/height/elevation of overflow weirs, again confirming the correctness of these input parameters.

6.5 Updated Sewer Hydraulic Models

The City provided a copy of the existing XPSWMM models of the Port Dalhousie and Port Weller sanitary/combined sewer systems, along with additional supporting information, including sewer maps and sewershed boundaries, catchment shapefiles, background imagery, and CSO regulator and sewer data sheets.

Other useful information provided by the City included the following:

+ Overall system maps of the Port Dalhousie and Port Weller sewersheds, showing the location of each individual CSO outfall.
+ More detailed operation maps of the CSO outfalls and sewer systems within the City's Work Sectors.
+ Detailed information packages for each of the City's CSO outfalls/regulators, including exact coordinates, as-built drawings, colour photographs, and engineering design calculations.
+ A list of CSO outfall inspections conducted by City staff from 2014-2016.

CSO/sewer system modelling typically employs the rainfall data collected by the City's own rain gauges, and the data from the Region of Niagara and Environment Canada gauges (primarily the Niagara Airport and Port Weller Coast Guard Station) has generally only been used for comparison purposes with the City's own gauges. Model calibration activities also make use of the sewer flow data collected by the City's permanent sewer flow monitoring network, occasionally supplemented by data from the Region's flow monitoring network. Tech Memo #3 (Rainfall/Sewer Flow Monitoring and O&M Program Review) included a more detailed review and assessment of these monitoring programs, and the suitability of the data for CSO/sewer modeling and completion of the current PPCP Update Study.

As part of the 2008 PCP Update (CH2M Hill, 2008), the XPSWMM model version was updated to version 10.5 for both the Port Dalhousie and Port Weller WWTP sewershed models, and a number of recent capital works projects were incorporated in the models, including the Bunting Road sewer upgrade, and Kernahan Park and Walker's Creek CSO storage facilities.

The City also conducts periodic updates of its existing XPSWMM models of the Port Dalhousie and Port Weller WWTP sewersheds, to reflect any physical upgrades made to the existing sanitary/combined sewer system and/or recalibration/validation of any portions of the models to improve their accuracy. This task has been completed annually by CH2M Hill since 2010, and typically each year they provide two Tech Memos to the City:

The first Tech Memo, entitled *City of St. Catharines XPSWMM Model Update,* provides an analysis of annual rainfall data collected by the City's permanent rain gauge network, to confirm the reliability of the data and compare it to the typical year (1989); presents and discusses the results of the model simulations for the year, comparing them to that of the typical year, and computes the estimated Wet Weather Flows (WWF) capture rates for the Port Dalhousie and Port Weller WWTP sewersheds in relation to the 90% WWF volume control target set by MOE Procedure F-5-5.

The second Tech Memo, entitled *City of St. Catharines Wastewater System Effluent Reporting (WSER),* describes the updates made to the XPSWMM models; discusses the limitations of the models (including the accuracy of the models and the rainfall and flow data used to calibrate them, when the models were last calibrated and validated, and identification of any significant differences observed between modelled and measured values); echoes the rainfall data analysis provided in the first Tech Memo; and presents the results of the current year model runs in terms of annual CSO deposit volume and annual number of CSO deposit days, as per the requirements of Environment Canada's WSER, for both the Port Dalhousie and Port Weller sewersheds.

The following major model updates/additions were made in 2010:

+ Capner/Oakdale CSO Storage Tank (1,030 m^3), brought on-line in September 2008
+ Guy Road Phase 3 In-line CSO Storage (1,400 m^3), brought on-line in October 2008
+ Lockview CSO Storage Tank (2,500 m^3), brought on-line in May 2009
+ Welland/Ontario CSO Storage Tank (7,080 m^3), brought on-line in July 2009
+ Updates to existing storage facilities to modelling of tank drainage during long-term simulations

The following major model updates/additions were made in 2011:

+ Port Dalhousie and Port Weller Trunk Sewers updated based on Niagara Region GIS data, to include all known manholes and sewer segments
+ Port Weller Trunk Sewer cross-section shape updated to reflect existing arch shaped sewer

The City also provided additional information related to more recent CSO and sewer system infrastructure improvement projects completed since the previous PCP update in 2006. This information was used to update the existing XPSWMM model of the City's CSO/sewer system (including all the previous updates above), so it more accurately reflects the current state and performance of the system.

Figure 6-3 shows the extent of the modelled CSO/sewer systems, with the Port Dalhousie sewershed highlighted in green, and the Port Weller sewershed highlighted in orange.

In general, as noted in the 2016 tech memos, the level of accuracy of the modelled CSO volumes can be influenced by many factors, such as physical changes in the collection system not being captured in the models (e.g. sewer separation, new developments, etc.); the proximity of the CSO outfall relative to the available flow monitoring data; flow measurement accuracy; and modelling assumptions. The Port Dalhousie and Port Weller WWTP sewershed models were last calibrated using 2010 flow monitoring data collected along the trunk sanitary trunk sewers, but a more recent model validation was completed in 2016 using 2015 rainfall and flow data, and it was determined that the models were as accurate as can be expected, and further model calibration was not necessary.

A similar exercise was conducted by Hatch using more recent sewer flow data collected in 2016/17, to determine if further model calibrated is warranted to successfully complete the current PPCP update. Based on our analysis, we confirm that the existing models are as accurate as can be expected, and further model calibration is not necessary to complete the PPCP, also realizing that in any case, the City intends to soon move their sewer modeling platform from XPSWMM to InfoSWMM and adopt the same model as Niagara Region.

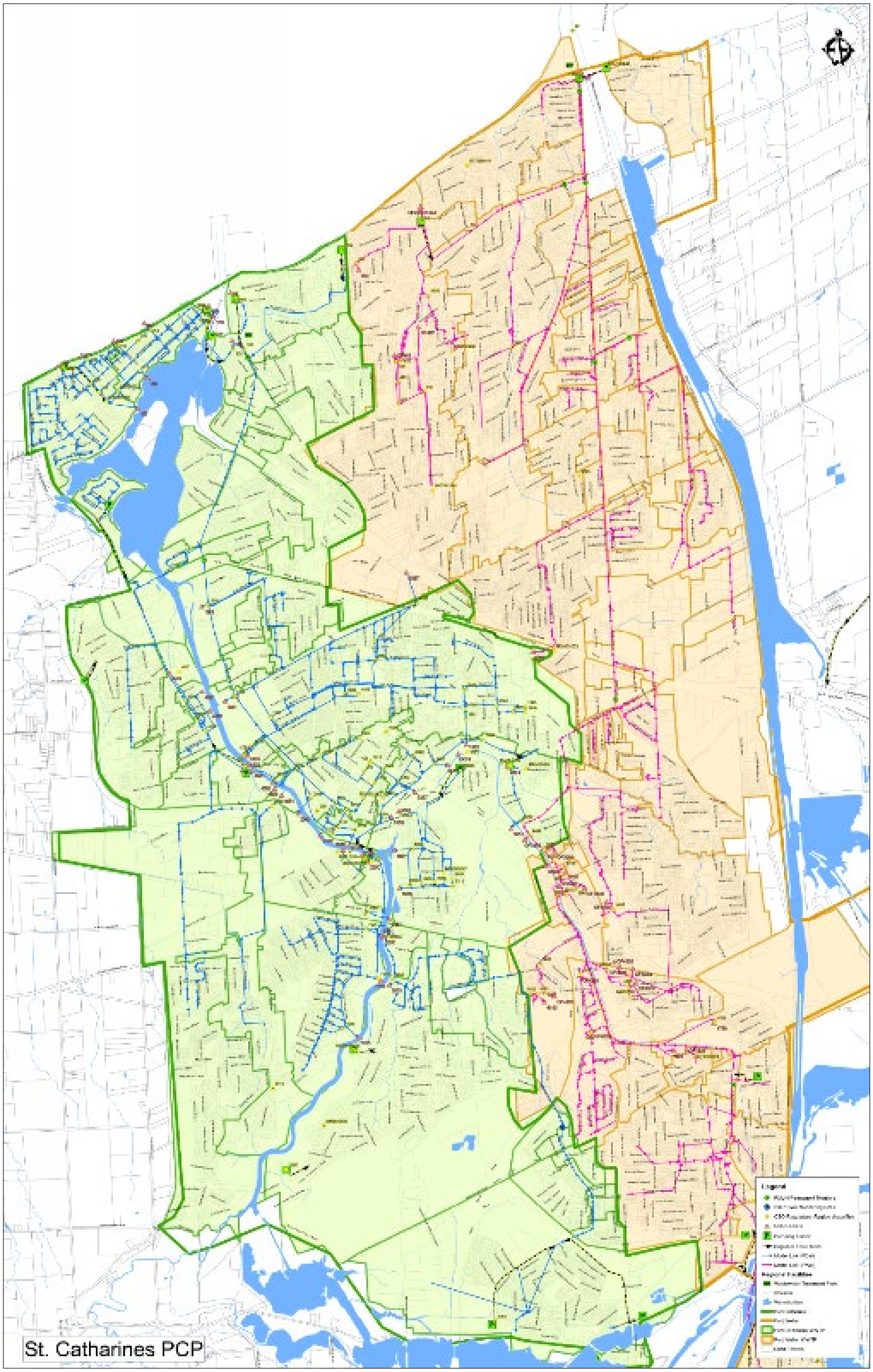


Figure 6-3: XPSWMM Model of St. Catharines Sanitary/Combined Sewer System

In general, our sewer model review and assessment confirms the extent and level of discretization of the existing XPSWMM model is adequate to support CSO and sewer system modeling, including a reasonably accurate simulation of CSO flow rates, event volumes and durations at each CSO regulator/outfall site (within the limits of the model calibration at each site); which can in turn be used to estimate the overall performance of the CSO system (e.g. annual WWF control levels versus MOE Procedure F-5-5 requirements), determine the conveyance capacity and/or storage volume of required CSO control measures (and related life-cycle cost estimates), and in general support the objectives of the current PPCP Update Study.

This being said, there are some known discrepancies between the modelled and measured bypass volumes at both the Port Dalhousie and Port Weller WWTPs. This is because the models do not limit the capacity of the mainline trunk sewers at the WWTPs, in part because it is not feasible to model the complex hydraulics of a secondary treatment plant within the system-wide XPSWMM sewer system dynamic models. It is suggested that where actual CSO volume measurements are available (e.g. at the Region's sewage pumping stations and WWTPs), they should be used in place of the model results for official reporting purposes.

The model may also be used to support other sewer system analyses such as basement flooding and infiltration and inflow (I/I) studies, but the ability to do so depends on the specific location, extent and objectives of the studies. The existing CSO/sewer system model is calibrated on a more lumped basis using the historical rainfall and sewer flow data from the existing rain gauges and flow meters described above (and other monitoring sites operated in the past, but have since been removed in favour of the current sites). In most cases, the existing model will not have been calibrated in the immediate vicinity of the specific basement flooding or I/I problem/area to be investigated, especially if the study area is much smaller than the drainage catchment area of the nearest flow meter used for the model calibration. More accurate analysis of these more specific sewer problems/areas would require further model update and calibration/validation efforts, including the development of all-pipes models of the subject sewer systems and collection of at least a few months of site-specific sewer flow data for model calibration/validation at the selected site. The possible creation of such a future model is discussed in further detail in TM #4 (Sewer Model Review and Recommendations), included in Appendix D.

6.6 Estimated CSO Frequency and Volume

The updated XPSWMM models of the Port Dalhousie and Port Weller collection systems were run for the Typical Year (for April 15 to November 14, representing the seven-month CSO reporting period prescribed by MOE Procedure F-5-5) to estimate typical annual CSO frequencies and volumes for all the City's CSO outfalls.

<u>*Port Dalhousie System*</u>

Tables 6-3 to 6-5 present the results of the typical year models runs for the Port Dalhousie system, for the prescribed seven-month CSO reporting period noted above. Table 6-3 presents the results for all CSO outfalls, active or not during the typical year, and Tables 6-4 and 6-5 show the results for the active CSOs only, ranked from largest to smallest, by annual CSO volume and frequency respectively.

The estimated total typical year CSO volume generated by the Port Dalhousie system is approximately 164,610 m^3, with 20 of its 46 CSO outfalls expected to generate at least one CSO event during the prescribed seven-month CSO reporting period. The overall typical year WWF Volume Capture Rate for the Port Dalhousie system is 89.0% including the Port Dalhousie WWTP Bypass (just shy of the 90% requirement from MOE Procedure F-5-5), and 91.7% excluding the plant bypass (already exceeding this same requirement).

Estimated annual CSO volumes generated by the 20 active outfalls range from 30 to 43,550 m^3, and estimated annual CSO frequencies range from one 1 to 41 per year.

The highest volume CSO sites, in order of significance, are:

1) Port Dalhousie WWTP Bypass (43,550 m^3)
2) Carlton & Ontario CSO Outfall (37,300 m^3)
3) Page south of Welland, Ida Street, Berryman & Richmond CSO Outfall (32,820 m^3)
4) Thomas Street, Henry & Beech, George & Beech CSO Outfall (17,000 m^3)

These four outfalls account for nearly 80% of the estimated typical year CSO volume for the entire Port Dalhousie System, and represent the greatest opportunities for further CSO volume reduction, should the City (and Region, in the case of the WWTP Bypass) wish to provide in excess of the overall system 90% WWF capture rate prescribed by MOE Procedure F-5-5.

The remaining outfalls all have estimated annual CSO volumes < 10,000 m^3, accounting for just over 20% of the estimated typical year CSO volume for the Port Dalhousie System, and represent a lower priority for action, at least from a CSO volume and WWF volume capture rate standpoint.

The highest frequency CSO sites, in order of significance, are:

1) Eastchester Sewage PS (41 times/yr)
2) Page south of Welland, Ida Street, Berryman & Richmond CSO Outfall (24 times/yr)
3) Michigan Ave CSO Outfall (10 times/yr)

Additional controls should be considered at the first two sites to reduce the frequency (and volume) of overflows, since the frequency of CSOs is so high compared to the rest of the outfalls. The remaining outfalls are typically active < 10 times/yr, and most of them no more than 4 times/yr, which incidentally meets the US EPA CSO frequency target level of 4/yr, if following their Presumptive CSO Control approach (USEPA, 1994).

Port Weller System

Tables 6-6 to 6-8 present the results of the typical year models runs for the Port Weller system, for the prescribed seven-month CSO reporting period. Table 6-6 presents the results for all CSO outfalls, active or not during the typical year, and Tables 6-7 and 6-8 show the results for the active CSOs only, ranked from largest to smallest, by annual CSO volume and frequency respectively.

The estimated total typical year CSO volume generated by the Port Weller system is approximately 55,310 m^3, with 16 of its 39 CSO outfalls expected to generate at least one CSO event during the prescribed seven-month CSO reporting period. The overall typical year WWF Volume Capture Rate for the Port Weller system is 92.1% including the Port Weller WWTP Bypass, and 93.5% excluding the plant bypass (both exceeding the 90% requirement from MOE Procedure F-5-5).

Estimated annual CSO volumes generated by the 16 active outfalls range from 10 to 14,430 m^3, and estimated annual CSO frequencies range from one 1 to 27 per year.

The highest volume CSO sites, in order of significance, are:

1) Hartzel & CNR Line CSO Outfall (14,430 m^3)
2) Port Weller WWTP Bypass (11,460 m^3)
3) Wedsworth & Hastings CSO Outfall (7,640 m^3)

These three outfalls account for over 60% of the estimated typical year CSO volume for the entire Port Weller System, and represent the greatest opportunities for further CSO volume reduction, should the City (and Region, in the case of the WWTP Bypass) wish to provide in excess of the overall system 90% WWF capture rate prescribed by MOE Procedure F-5-5.

The remaining outfalls all have estimated annual CSO volumes < 4,000 m^3, accounting for under 40% of the estimated typical year CSO volume for the Port Dalhousie System, and represent a lower priority for action, at least from a CSO volume and WWF volume capture rate standpoint.

The highest frequency CSO sites, in order of significance, are:

1) Wedsworth & Hastings CSO Outfall (27 times/yr)
2) Elmwood & QEW CSO Outfall (15 times/yr)
3) Hartzel & CNR Line CSO Outfall (6 times/yr)

Additional controls should be considered at the first two sites to reduce the frequency (and volume) of overflows, since the frequency of CSOs is so high compared to the rest of the outfalls, and the third site is also the highest CSO volume outfall, so additional controls should be considered here in any case. The remaining outfalls are typically active no more than 4 times/yr, which incidentally meets the US EPA CSO frequency target level of 4/yr, if following their Presumptive CSO Control approach (USEPA, 1994).

Table 6-3: Typical Year CSO Volumes and Frequencies for Port Dalhousie System

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Volume[2] (m^3)	Frequency[2] (#)
Michigan Avenue	102	150	1,520	10
Lakeside PS	135	153	0	0
Main & Christie	113	155	0	0
Bayview & Ann	115	157	0	0
Christie Street	117	158	0	0
Colton & Shelley	128	161	0	0
Corbett & Bayview	130, 131, 132, 133	167	2,730	4
Lock Street	107	168	0	0
Cole Farm PS	125	169	470	4
Scott & Ontario	1301	1351	3,560	4
Carlton & Ontario	1601	1651	37,300	6
Page south of Welland, Ida, Berryman & Richmond	1614, 1615, 1633	1662	32,820	24
Grote & Carlton	1606, 1622, 1624	1667	1,690	4
Thomas Street, Henry & Beech, George & Beech	1607, 1620, 1621	1670	14,630	4
Kensington & Wooodruff	1702	1751	490	4
Welland & Ontario, Welland & Montebello, Welland & Wellington, Welland & Lake, Welland & Clark	1803, 1805, 1806, 1807, 1808	1888	320	1
Adam Street	2001	2051	0	0
Lake & Ontario, Salina & Ontario, Yates & Salina, Norris & Yates	1812, 1813, 2101, 2103	2152	0	0
Yates & Trafalgar	2102	2156	0	0
Henrietta Street	2203	2250	0	0
Renown Road PS	2200	2253	3,500	4
St. Paul Crescent	2301	3350	0	0
End of Monck Street	2401	2451	0	0
Rivercrest	2501a	2551	150	2
Rivercrest Drive	2596	2553	0	0
Thorold (southeast of Niagara Region)	3251	3253	0	0
Violet Street	4301	4351	3,010	7
Bridge & Martindale, Barton Street	4302	4451	0	0
Grapeview & Martindale	4401	4455	0	0
Wellandvale PS	4502	4551	0	0
Wellandvale Road	4504	4552	0	0
Martindale Road	4503	4553	0	0
Crestcomb & Springbank	4600	1651	0	0
Dittrick Street	5008	5037	0	0

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Volume[2] (m^3)	Frequency[2] (#)
Hilcrest & Rockcliffe, Glenridge & Rockcliffe, South & Rockcliffe, Highland & Rockcliffe, Glenwood & Ridgewood	5009, 5010, 5012, 5015, 5016	5050	0	0
Westchester and Old Welland Canal (OWC)	5001	5057	0	0
Argyle PS	5006a	5061	300	4
Parkway & Old Welland Canal (OWC)	5100	5150	0	0
Carlisle & Church, James & King, King Street, Carlisle & St. Paul, James & St. Paul, Court & St. Paul	1810, 1815, 1816, 5202, 5204, 5402	5257	60	2
Riordon & Gale	5500	5551	0	0
Eastchester PS	5800a	5851	9.690	41
Capner & Oakdale	6000	6051	0	0
Hamilton Street	7001	7051	3,890	4
Kent Street	7100	7152	4,370	6
Kinsey Street	7105	7153	30	2
Port Dalhousie WWTP Bypass	100	10000332	43,550	6
Total CSO Volume (including WWTP Bypass)			**164,110**	
WWF Volume Capture (including WWTP Bypass)			**89.1%**	
Total CSO Volume (excluding WWTP Bypass)			**120,560**	
WWF Volume Capture (excluding WWTP Bypass)			**91.8%**	

Notes:
1 Model Node / Outfall Node ID
2 For April 15 to November 14, from XPSWMM Model Typical Year Simulation, volumes rounded to nearest 10 m^3.

Table 6-4: Ranked Typical Year CSO Volumes for Port Dalhousie System

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Volume[2] (m^3)
Port Dalhousie WWTP Bypass	100	10000332	43,550
Carlton & Ontario	1601	1651	37,300
Page south of Welland, Ida Street, Berryman & Richmond	1614, 1615, 1633	1662	32,820
Thomas Street, Henry & Beech, George & Beech	1607, 1620, 1621	1670	14,630
Eastchester PS	5800a	5851	9,690
Kent Street	7100	7152	4,370
Hamilton Street	7001	7051	3,890
Scott & Ontario	1301	1351	3,560
Renown Road PS	2200	2253	3,500
Violet Street	4301	4351	3,040
Corbett & Bayview	130, 131, 132, 133	167	2,730
Grote & Carlton	1606, 1622, 1624	1667	1,690
Michigan Avenue	102	150	1,520
Kensington & Wooodruff	1702	1751	490
Cole Farm PS	125	169	470
Welland & Ontario, Welland & Montebello, Welland & Wellington, Welland & Lake, Welland & Clark	1803, 1805, 1806, 1807, 1808	1858	320
Argyle PS	5006a	5061	300
Rivercrest	2501a	2551	150
Carlisle & Church, James & King, King Street, Carlisle & St. Paul, James & St. Paul, Court & St. Paul	1810, 1815, 1816, 5202, 5204, 5402	5257	60
Kinsey Street	7105	7153	30
Total CSO Volume (including WWTP Bypass)			**164,110**
Total CSO Volume (excluding WWTP Bypass)			**120,560**

Notes:
1 Model Node / Outfall Node ID
2 For April 15 to November 14, from XPSWMM Model Typical Year Simulation, volumes rounded to nearest 10 m^3.

Table 6-5: Ranked Typical Year CSO Frequencies for Port Dalhousie System

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Frequency[2] (#)
Eastchester PS	5800a	5851	41
Page south of Welland, Ida Street, Berryman & Richmond	1614, 1615, 1633	1662	24
Michigan Avenue	102	150	10
Violet Street	4301	4351	7
Port Dalhousie WWTP Bypass	100	10000332	6
Carlton & Ontario	1601	1651	6
Kent Street	7100	7152	6
Thomas Street, Henry & Beech, George & Beech	1607, 1620, 1621	1670	4
Hamilton Street	7001	7051	4
Scott & Ontario	1301	1351	4
Renown Road PS	2200	2253	4
Corbett & Bayview	130, 131, 132, 133	167	4
Grote & Carlton	1606, 1622, 1624	1667	4
Kensington & Wooodruff	1702	1751	4
Cole Farm PS	125	169	4
Argyle PS	5006a	5061	4
Rivercrest	2501a	2551	2
Carlisle & Church, James & King, King Street, Carlisle & St. Paul, James & St. Paul, Court & St. Paul	1810, 1815, 1816, 5202, 5204, 5402	5257	2
Kinsey Street	7105	7153	2
Welland & Ontario, Welland & Montebello, Welland & Wellington, Welland & Lake, Welland & Clark	1803, 1805, 1806, 1807, 1808	1858	1
Notes: 1 Model Node / Outfall Node ID 2 For April 15 to November 14, from XPSWMM Model Typical Year Simulation.			

Table 6-6: Typical Year CSO Volumes and Frequencies for Port Weller System

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Volume[2] (m^3)	CSO Frequency[2] (#)
Elmwood & QEW	2303	2351	3,100	15
Beachview & Lake Ontario	428	252	160	3
Hartzel & CNR Line	3405	OF3405	14,430	6
Oakdale & Marren	3498	OF3498	2,240	4
Lincoln & Oakdale at corner	3501	OF3501	10	1
Turner & Oakdale	3601	3650	0	0
Phelps & Old Welland Canal (OWC)	3701	3750	0	0
Haight & Disher	3803	OF3803	0	0
131 Moffat	3997	OF3997	0	0
Spring Garden PS Old Coach Road	413	OF413	0	0
Chestnut & Briarsdale	4102, 4103	4150	0	0
Aerial Sewer Briarsdale	4153	OF4153	10	2
Brookdale & Glengarry	4201	OF4201	1,530	4
Burleigh Hill & Glendale[3]	4202	OF4202	3,350	4
Old Coach Road & Spring Garden Creek	424	OF424	0	0
Wedsworth & Hastings	4302	OF4302	7,640	27
Chestnut & Merritt	4304	OF4304	0	0
Almond & Merritt	4306	OF4306	0	0
Walnut & Merritt	4309	OF4309	0	0
Forster & Linwell	422, 423	OF457	20	1
Guy Road	421, 462, 420, 419	OF461	330	1
Bradley & Dundas	4650	4650	0	0
Ball & Merritt	4702	4750	60	2
Ursula & Roundtree	M75155004	OF4801	190	4
Port Weller WWTP Bypass	100	151	11,460	4
Total CSO Volume (including WWTP Bypass)			**55,310**	
WWF Volume Capture (including WWTP Bypass)			**92.1%**	
Total CSO Volume (excluding WWTP Bypass)			**43,850**	
WWF Volume Capture (excluding WWTP Bypass)			**93.5%**	

Notes:
1 Model Node / Outfall Node ID
2 For April 15 to November 14, from XPSWMM Model Typical Year Simulation, volumes rounded to nearest 10 m^3.
3 Prior to the Glengarry Park CSO Tank in operation.

Table 6-7: Ranked Typical Year CSO Volumes for Port Weller System

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Volume[2] (m^3)
Hartzel & CNR Line	3405	OF3405	14,430
Port Weller WWTP Bypass	100	151	11,460
Wedsworth & Hastings	4302	OF4302	7,640
Burleigh Hill & Glendale[3]	4202	OF4202	3,350
Elmwood & QEW	2303	2351	3,100
Oakdale & Marren	3498	OF3498	2,240
Brookdale & Glengarry	4201	OF4201	1,530
Guy Road	421, 462, 420, 419	OF461	330
Ursula & Roundtree	M75155004	OF4801	190
Beachview & Lake Ontario	428	252	160
Ball & Merritt	4702	4750	60
Forster & Linwell	422, 423	OF457	20
Aerial Sewer Briarsdale	4153	OF4153	10
Lincoln & Oakdale at corner	3501	OF3501	10
Total CSO Volume (including WWTP Bypass)			**55,310**
Total CSO Volume (excluding WWTP Bypass)			**43,850**

Notes:
1 Model Node / Outfall Node ID
2 For April 15 to November 14, from XPSWMM Model Typical Year Simulation, volumes rounded to nearest 10 m^3.
3 Prior to the Glengarry Park CSO Tank in operation.

Table 6-8: Ranked Typical Year CSO Frequencies for Port Weller System

CSO Location	Overflow ID[1]	Outfall ID[1]	CSO Frequency[2] (#)
Wedsworth & Hastings	4302	OF4302	27
Elmwood & QEW	2303	2351	15
Hartzel & CNR Line	3405	OF3405	6
Oakdale & Marren	3498	OF3498	4
Brookdale & Glengarry	4201	OF4201	4
Burleigh Hill & Glendale[3]	4202	OF4202	4
Ursula & Roundtree	M75155004	OF4801	4
Port Weller WWTP Bypass	100	151	4
Beachview & Lake Ontario	428	252	3
Aerial Sewer Briarsdale	4153	OF4153	2
Ball & Merritt	4702	4750	2
Lincoln & Oakdale at corner	3501	OF3501	1
Forster & Linwell	422, 423	OF457	1
Guy Road	421, 462, 420, 419	OF461	1

Notes:
1 Model Node / Outfall Node ID
2 For April 15 to November 14, from XPSWMM Model Typical Year Simulation.
3 Prior to the Glengarry Park CSO Tank in operation.

Possible CSO control measures include underground off-line storage tanks; in-line (under roadway) storage pipes with end-of-pipe orifice controls at the downstream end; CSO regulator adjustments; strategic sewer separation (e.g. with nearby receiving water discharge points); and/or Green Infrastructure (GI) and Low Impact Development (LID) measures, best implemented along with other future planned road, sewer and watermain works.

CSO outfalls with larger annual CSO volumes are possible candidates for CSO storage facilities, including off-line underground storage tanks for the largest CSO volumes (> 10,000 m^3/yr); and/or in-line (under roadway) storage pipes for the next largest annual CSO volumes (between 5,000-10,000 m^3/yr).

Possible candidates for the former include the following sites:

1) Port Dalhousie WWTP Bypass (43,550 m^3/yr, 6 times/yr)
2) Carlton & Ontario CSO Outfall (37,300 m^3/yr, 6 times/yr)
3) Page south of Welland, Ida Street, Berryman & Richmond CSO Outfall (32,820 m^3/yr, 24 times/yr)
4) Thomas Street, Henry & Beech, George & Beech CSO Outfall (14,630 m^3/yr, 4 times/yr)
5) Hartzel & CNR Line CSO Outfall (14,430 m^3/yr, 6 times/yr)
6) Port Weller WWTP Bypass (11,460 m^3/yr, 4 times/yr)

Another option for the two WWTP bypasses is on-site CSO treatment.

Possible candidates for the latter include the following sites:

1) Eastchester Sewage PS Overflow (9,690 m^3/yr, 41 times/yr)
2) Wedsworth & Hastings CSO Outfall (7,640 m^3/yr, 27 times/yr)
3) Regent & Front CSO Outfall (located in Thorold) (5,540 m^3/yr, 4 times/yr)
4) Upstream of Parshall Flume CSO Outfall (located in Thorold) (5,240 m^3/yr, 4 times/yr)

CSO outfalls with higher CSO frequencies (> 10 times/yr) but smaller annual CSO volumes (< 10,000 m^3), i.e. with a larger number of smaller volume CSO events; are possible candidates for smaller in-line storage facilities, enlarged pipes with end-of-pipe orifice controls to slowly drain the stored CSO volumes back into the downstream CSS; and/or CSO regulator adjustments; to send more flow to the downstream WWTP during WWF events.

Possible candidates include the following sites:

1) Eastchester Sewage PS Overflow (9,690 m^3/yr, 41 times/yr)
2) Wedsworth & Hastings CSO Outfall (7,640 m^3/yr, 27 times/yr)
3) Elmwood & QEW CSO Outfall (3,100 m^3/yr, 15 times/yr)
4) Michigan Avenue CSO Outfall (1,520 m^3/yr, 10 times/yr)

CSO outfalls with smaller annual CSO volumes (< 5,000-10,000 m^3) but still relatively high CSO frequencies (between 5-10 times/yr), i.e. with a still relatively high number of smaller volume CSO events; are possible candidates for smaller in-line storage facilities; CSO regulator adjustments; and/or GI/LID measures to reduce the amount of stormwater entering the CSS (done in conjunction with other future planned road, sewer and watermain improvement projects).

Possible candidates include the following sites:

1) Violet Street CSO Outfall (3,040 m^3/yr, 7 times/yr)
2) Kent Street CSO Outfall (4,370 m^3/yr, 6 times/yr)

Reducing the typical annual CSO volumes at the above priority sites by even 80% would increase the typical annual WWF volume capture rate for the two sewer systems by the following amounts, far exceeding the 90% requirement from MOE Procedure F-5-5:

+ From 89.1% to 96.7% for the Port Dalhousie System (including the Port Dalhousie WWTP Bypass), and from 91.8% to 97.2% (excluding the WWTP Bypass).
+ From 92.1% to 97.5% for the Port Weller System (including the Port Weller WWTP Bypass), and from 93.5% to 97.8% (excluding the WWTP Bypass).

The remaining CSO outfalls with smaller annual CSO volumes (<5,000 m^3) and relatively low CSO frequencies (< 5 times/yr) are also possible candidates for CSO regulator adjustments and/or GI/LID measures done in conjunction with other future planned road, sewer and watermain works; but we would recommend these locations represent a lower priority for action, since the potential CSO control measures for the sites discussed above, added to the CSO control measures already implemented by the City over the past couple of decades, will already exceed the required overall CSO system control targets (e.g. 90% WWF volume control as per MOE Procedure F-5-5) during the typical year.

The potential impacts of the proposed CSO control measures on the downstream sewer systems can be summarized as follows:

1) Flows captured by the off-line storage tanks and in-line storage pipes will be held during wet weather and only released back into the downstream sewer system when the latter has the spare capacity available to fully accommodate the released flows and convey them to the downstream WWTP for full secondary treatment. The operation of such facilities would include real time flow/level monitoring within the downstream CSS (or incoming flows at the downstream WWTP) to determine when it is safe to release the stored flows back into the downstream CSS.
2) CSO regulator adjustments implemented to reduce CSO volume and/or frequency at the subject regulator will marginally increase flows in the downstream CSS, and the impacts of doing so will need to be looked at further by modelling to confirm they are not negatively impacting the CSO volume and/or frequency at other downstream CSO outfalls. On the positive side, from a capacity standpoint, increasing the capacity of the CSO regulator will provide an additional buffer to handle the peak DWF arriving at the structure, to ensure it is not active during dry weather.
3) Strategic combined sewer separation projects, implemented on their own or in conjunction with other planned road, sewer and watermain works, will remove stormwater from the CSS, reducing wet weather flows in the downstream CSS, actually freeing up conveyance capacity within the

downstream CSS, and possibly reducing the CSO volume and/or frequency at other downstream CSO outfalls, especially at the downstream WWTP.

4) GI/LID measures, implemented in conjunction with other planned road, sewer and watermain works, will also remove stormwater from the downstream CSS and provide similar benefits as combined sewer separation.

6.7 Sewer System Capacity Analysis

Sewer modelling was completed using the updated XPSWMM Model to assess the performance of the Port Dalhousie and Port Weller WWTP sewer systems, under existing conditions. The hydraulic performance of the system was modelled under three different flow scenarios, including normal DWF conditions, and WWF conditions including the 2-year and 5-year design storms, to identify any sewer capacity issues under each flow scenario. The model results were analyzed to identify any pipes where simulated flows exceed their theoretic hydraulic capacity, as well as any pipes/manholes with simulated Hydraulic Grade Line elevations within 1.8 m of the ground surface (the assumed typical depth of basements). The findings of the simulations are discussed briefly below:

Normal DWF

The model simulation results for this scenario indicate there are no capacity constraints within the system during normal DWF conditions. There are no pipes with DWF > 100% of capacity, and no simulated dry weather overflows from the CSS.

The model simulation results do show a few isolated locations where the HGL freeboard is < 1.8m, but as noted above, the results also show that none of these sewer segments are surcharged, so the lower freeboard is actually due to the shallow depth of these existing sewers, and not due to any surcharge or basement flooding predicted during normal DWF conditions.

2-year Design Storm

The model simulation results for this scenario predict surcharging within a number of sewer segments for the 2-year design storm. The impacted sewers are mainly larger trunk and sub-trunk sewers, including but not limited to, the following locations:

+ Most segments along Lakeport Rd & Lake St, from Welland Ave to Port Dalhousie WWTP
+ Most segments along Neilson Av & Cumberland Rd, from Queenston St to Port Weller WWTP
+ Most segments along Forster St, Linwell Rd, Geneva St & Lakeshore Rd, from Scott St to Niagara St
+ All segments along Walker's Creek between Linwell Rd & Costen Blvd
+ Most segments along Oakdale Av, Westchester Cr & Eastchester Av, from Glendale Ave to Petrie St
+ Most segments along First St Louth & Erion Rd, from Grapeview Dr to Martindale Rd
+ All segments along Longfellow Av, Haig St & Scott St West, from Carlton St to Ontario St
+ Most segments along Village Rd & Glen Morris Drive, from Glendale Av to Glenridge Rd
+ Several other short segments connecting to the Lakeport/Lake & Neilson/Cumberland trunk sewers

+ Several short segments in the downtown core

The model results also indicate several locations where the HGL freeboard is < 1.8m, but far less than the number of surcharged sewer segments indicated above, confirming that many of the segments noted above are only barely surcharged and not expected to raise the HGL to levels that will cause basement flooding during the 2-year design storm. In general, although there are still some isolated upstream locations with a predicted HGL freeboard < 1.8m, the predicted HGL in the larger trunk sewers along Lakeport Rd and Lake St (into the Port Dalhousie WWTP) and along Neilson Ave and Cumberland Rd (into the Port Weller WWTP) is generally well in excess of 1.8m, due to their greater depth, and these larger trunk sewers are not a cause of basement flooding for the 2-year design storm.

Some other areas (in smaller upstream sewers) where the model predicts a more concentrated number of HGL freeboards < 1.8m for the 2-year storm include the following locations:

+ Along Arthur St, Cumberland St, Beachaven Dr & Lombardy Av, north of Wildwood Rd
+ Along Walker's Creek between Gordon Pl & Parnell Rd
+ Along Manor Rd between Grammar Av & Glen Park Rd
+ Along Shoreline Dr between Grenada Dr & Geneva St
+ Along Russell Ave between Catharine St & Geneva St
+ Along Vine St & Manning St between Welland Av & Niagara St
+ Along Barbican Gate & east end of Barbican Trail, on north side of St. David's Rd

<u>*5-year Design Storm*</u>

The model simulation results for this scenario predict surcharging within a number of sewer segments for the 5-year design storm. Again, the impacted sewers are mainly larger trunk and sub-trunk sewers, including but not limited to, the following locations:

+ Most segments along Lakeport Rd & Lake St, from Welland Av to Port Dalhousie WWTP
+ Most segments along Neilson Av & Cumberland Rd, from Eastchester Av to Port Weller WWTP
+ All segments along Arthur St, Beachaven Dr & Lombardy Ave, north of Wildwood Rd
+ Most segments along Forster St, Linwell Rd, Geneva St & Lakeshore Rd, from Scott St to Bunting Rd
+ Most segments along Vine St, Linwell Rd & Walker's Creek, from Scott St to Parnell Rd
+ Most segments along Shoreline Dr, Geneva St & Spring Garden Blvd, from Granada Dr to Lakeshore Rd
+ Most segments along Oakdale Av, Westchester Cr & Eastchester Av, from Glendale Av to Petrie St
+ Most segments along Bayview Dr & Dalhousie Av, from west end of Bayview Dr to Lock St
+ All segments along First St Louth & Erion Rd, from Grapeview Dr to Martindale Rd
+ All segments along Longfellow Av, Haig St & Scott St West, from Carlton St to Ontario St
+ All segments along Yale St, Vine St & Manning St, from Berryman Av to Fitzgerald St
+ All segments along Village Rd & Glen Morris Dr, from Glendale Av to Glenridge Rd
+ Several other short segments connecting to Lakeport/Lake & Neilson/Cumberland trunk sewers

- Several short segments in the downtown core

Again, the model results also indicate several locations where the HGL freeboard is < 1.8m, but again still far less than the number of surcharged sewer segments indicated above, confirming that many of the segments noted above are only barely surcharged and not expected to raise the HGL to levels that will cause basement flooding during the 5-year design storm. Again, in general, although there are still some isolated upstream locations with a predicted HGL freeboard < 1.8m, the predicted HGL in the larger trunk sewers along Lakeport Rd and Lake St (into the Port Dalhousie WWTP) and along Cumberland Rd (into the Port Weller WWTP) is still generally well in excess of 1.8m, due to their greater depth, and these larger trunk sewers are not a cause of basement flooding for the 5-year design storm.

One notable exception is the very downstream portion of the Cumberland Rd trunk sewer just before it enters the Port Weller WWTP, with a predicted HGL freeboard < 1.8m from Wildwood Rd to Lombardy Av. This issue needs to be looked at in more detail, and if the capacity of this section of sewer needs to be increased, an upgrade will be proposed as part of the final PPCP Action Plan.

Some other areas (in smaller upstream sewers) where the model predicts a more concentrated number of HGL freeboards < 1.8m for the 5-year storm include the following locations:

- Along Bayview Dr from west end to Elgin St
- Along Arthur St, Beachaven Dr & Lombardy Av, north of Wildwood Rd
- Along Lakeshore Rd between Vine St & Eastfield Ct
- Along Walker's Creek sewer between Linwell Rd & Parnell Rd
- Along Shoreline Dr between Grenada Dr & Geneva St
- Along Nickerson Av, Grammar Rd & Governor Simcoe Dr
- Along Manor Rd between Grammar Ave & Glen Park Rd
- Along Glen Park Rd between Rodger St & Manor Rd
- Along Brucedale Av between Hanson Dr & Rochelle Dr
- Along Grosvenor St, Appleby Dr, Regina Av & Roxanne Dr
- Along Rainbow Dr between Tavistock Rd & Rochelle Dr
- Along Carlton St between Stoyanoff Dr & Patricia Dr
- Along Dunraven Av, Hawthorne Av & Sunnylea Dr
- Along Ancaster Blvd, Meredith Dr & Dorchester Blvd
- Along Russell Ave between George St & Geneva St
- Along Manning St & Vine St between Erie St & Niagara St
- Along Eastchester Av between Marmora St & Bunting Rd
- Along Franklin Blvd, Barnes Rd & McPhail Cr
- Along Hartzel Rd between Lonsdale Av & QEW
- Along Oakdale Av between Disher St & Lincoln Av
- Along Barbican Gate & east end of Barbican Trail, on north side of St. David's Rd

7. Review of CSO Control Technologies and Approaches

Potential CSO control alternatives can generally be grouped into three main categories:

Source Controls

Source Controls are measures implemented upstream of the CSS, which help decrease CSO volume and/or pollution by reducing the amount (or rate) of runoff and/or pollutants entering the CSS. Reducing inflows into the CSS can also helps to reduce basement flooding. Some examples of commonly employed source controls are listed in Table 7-1. Although these measures typically cannot provide the reductions required to meet desired CSO reduction targets on their own, combinations of source controls can yield noticeable CSO reductions and can reduce the overall costs of CSO control when considered as part of an overall implementation program. Source controls to manage wet weather flow through infiltration, evapotranspiration, and rainwater harvesting are increasingly being referred to as 'Green Infrastructure'. Green Infrastructure approaches currently in use include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. Green infrastructure can be used almost anywhere where soil and vegetation can be worked into the urban or suburban landscape. Green Infrastructure is most effective when supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets.

Sewer System Controls

Sewer System Controls are measures implemented within the CSS, which help decrease CSO volume and basement flooding by increasing the hydraulic capacity of the sanitary/storm/combined sewer systems to handle storm inflows. Improved CSS maintenance, regulator adjustments, sewer separation, storage and real-time control can all be highly effective in reducing CSO volumes and reducing basement flooding. Some common sewer system control options are listed in Table 7-1.

CSO Treatment

CSOs can also be treated, either at a central WWTP or by satellite treatment facilities located at the upstream CSO outfalls. The treatment processes of the WWTPs should first be optimized to minimize the pollutant loadings under wet weather conditions. This may lead to wet weather-specific operating conditions that may produce lower overall pollutant loadings. Options to be considered for WWTPs include expansion and/or upgrade of existing treatment processes, installation of new treatment technologies, and innovative approaches to the operation of existing or new treatment processes.

Satellite treatment facilities may be cost-effective where there are space limitations or limited capacity in the collection system to convey excess flows to the WWTP. Some of these technologies are only effective at removing certain types of pollutants (e.g. disinfection, screening and floatables control), and technologies may need to be combined to ensure that specified CSO treatment requirements are met. Close attention needs to be paid to the effluent treatment requirement for satellite treatment facilities. For example, MOE Procedure F-5-5 requires a minimum level of primary treatment, and the discharge from these facilities must achieve an effluent concentration for Total Suspended Solids of not more than 90 mg/l, for at least 50 % of the period from April 1 to October 31 (MOE, 1997).

Table 7-1: Potential CSO Control Alternatives

SOURCE CONTROLS	Bioretention Areas Catch Basin Cleaning Green Roofs Infiltration and Inflow Control Low Impact Development Permeable Pavement Pesticide Reduction Public Education Rainwater Harvesting/ Water Conservation Roof / Downspout Disconnection Sewer Use By-laws Street Sweeping
SEWER SYSTEM CONTROLS	Backflow Preventers Catch Basin Inlet Control Deep Tunnel Storage Drainage Area Diversion Dynamic Regulators Flow Balance Method Off-line Storage Real Time Control Regulator Adjustments Sewer Separation Tide and Flap Gates
CSO TREATMENT	Continuous Deflective Separation Coarse and Fine Screens Dissolved Air Floatation High Rate Filtration High Rate Physical Chemical Treatment Treatment Shafts Vortex Separators
FLOATABLES CONTROL	Catch Basin Modifications Containment Booms Floating Debris Traps Netting Systems Screens and Trash Racks Underflow Baffles
DISINFECTION	Chlorine Chlorine Dioxide Electron Beam Irradiation Ozone Peracetic Acid UV Irradiation

Additional information is contained in Appendix G TM #7, CSO Control Alternatives and Evaluation Methods, which includes a review of available CSO control approaches and technologies, and documents the method used to pre-screen and evaluate the most feasible options.

8. Review of Operations and Maintenance Options

In addition to the more physical control measures discussed in Chapter 7, there are also a number of sewer system operation and maintenance activities that can help to improve the everyday operation of the wastewater collection system and reduce CSOs and basement flooding, which are also a key focus of MOE Procedure F-5-5.

Table 8-1: Potential CSO/Sewer System O&M Activities

SEWER SYSTEM MONITORING	Rainfall Monitoring Sewer Flow Monitoring CSO Regulator/Outfall Monitoring CSO Regulator/Outfall Modifications CSO Regulator/Outfall Consolidation Contracted Services Improved Data Management Coordination with Niagara Region
SEWER INSPECTION & MAINTENANCE	Zoom Camera Inspection CCTV Camera Inspection Sewer Flushing Smoke Testing
CSO INSPECTION & MAINTENANCE	CSO Regulator/Outfall Inspection CSO Storage Tanks O&M
SEWER SYSTEM MODELLING	Sewer Model Platform Sewer Model Maintenance/Updates Development of All-Pipes Sewer Model Coordination with Niagara Region
OTHER GENERAL O&M ACTIVITIES	Level of Service Reviews Sewer System Asset Management Plan

The following sections provide a brief discussion of each of the O&M activities and approaches presented above. The discussions below are grouped into the same categories presented above: Sewer System Monitoring, Sewer System Inspection & Maintenance, CSO Inspection & Maintenance, Sewer System Modelling, and Other O&M Activities.

8.1 Sewer System Monitoring

Rainfall Monitoring:

Rainfall monitoring is a useful tool to support the modeling and analysis of CSO and basement flooding issues, and help develop effective CSO and basement flooding control measures. TM #3 (Rainfall/Flow Monitoring and O&M Program Review), included in Appendix C, provided a detailed review of the City's existing Rainfall and Sewer Flow Monitoring and CSO and Sewer System Operations and

Maintenance (O&M) Programs, which proposed the following possible upgrades and investigations related to the City's rainfall monitoring program:

+ The current TBRGs are aging and beyond their expected service life. A plan/project should be developed to upgrade the City's existing rainfall monitoring network, including new tipping bucket rain gauges (TBRGs), new electronic dataloggers with improved real-time communications capabilities, and better data processing software
+ One new rain gauge station should be added to cover the central-eastern part of the City, possibly located at 360 Niagara Street (City owned office building) or at the Scott Street Fire Station, to fill in a slight gap in coverage in this area.
+ The City's one existing full weather station (including temperature and wind direction and speed monitoring) should be decommissioned as the additional weather data is not required or used by the City.
+ Rainfall radar data can be a useful adjunct to the ground-level rain gauge network, providing confirmation of the accuracy of the latter after rainfall events; and real time rainfall radar data can even provide advance warning of expected rainfall intensity and coverage, which could be used to help optimize the operation of the City's existing CSO tanks. If such an approach is feasible, beneficial and cost- effective, a plan/project could be included in the PPCP Action Plan; including estimated life-cycle costs (including any license fees and/or service costs), and timelines for implementation.

Rainfall Data Management:

A Data Sharing Agreement should be developed with the Region to allow seamless interchanging of rainfall (and sewer flow) monitoring data, using standardized equipment and communications protocols.

Sewer Flow Monitoring:

Sewer flow monitoring is a useful tool to support the modeling and analysis of CSO and basement flooding issues, measure the performance of the combined sewer system and identify problem spots, and help develop effective CSO and basement flooding control measures. Tech Memo #3 (Hatch, 2020a) provided a detailed review of the City's existing sewer flow monitoring program, which proposed the following possible investigations and upgrades:

+ The current temporary sewer flow meters are aging and beyond their expected service life. A plan/project should be developed to upgrade the City's existing sewer flow meters, including new sewer flow meters with improved real-time communications capabilities, and better data processing software.
+ This being said, the specific number, location, and type of equipment will depend on a number of factors, most notably the new MOE requirements for CSO regulator/outfall monitoring, which are discussed further below.

CSO Regulator/Outfall Monitoring:

The MOE intends to require much more extensive monitoring of CSO outfalls in the future, and this will have significant implications on the City's CSO outfall monitoring program. Tech Memo #3 discussed some of the related impacts, and proposed some possible approaches for providing improved CSO outfall monitoring, including the following:

Discussions should be initiated with the local MOE office to discuss their plans regarding future CSO monitoring/reporting requirements, including some of the questions posed in TM #3, included in Appendix C. Will they require real time measurement and reporting of CSO frequency/volume/duration at all existing CSO outfalls? Or will some type of hybrid CSO monitoring/reporting approach be permitted? Will they provide a reasonable timeframe to comply with the new requirements, and will they provide funding to help municipalities do so?

Based on these discussions, a phased implementation plan/project or projects should be developed to meet the expected future CSO monitoring/reporting requirements, to be incorporated in the PPCP Action Plan; including recommendations for new flow monitoring equipment (e.g. CSO detection sensors, level sensors and/or velocity-area flow meters) locations, estimated life-cycle costs (including purchase, installation and ongoing O&M costs), and timelines for implementation of the program.

Some possible options/projects to consider as part of the PPCP Update Study Report include the following:

+ Upgrade and relocate the existing velocity-area flow meters, including options for different flow meter manufacturers, models, number, locations of meters, and associated life-cycle costs.
+ Conversely, consideration should be given to whether the network of permanent sites is still required or if other options would be preferable. Given the capital cost of replacing these sites, the limited use of this data and the lack of flexibility in the future, there may be other options for obtaining the required data. If some or all of the sites are no longer required, there would be a decommissioning cost.
+ Conduct a pilot study of level-only flow measurement devices (including I-Tracker, SmartCover, and/or other similar equipment), to determine if they can provide a feasible, acceptable and cost-effective alternative to velocity-area meters, at least at some sites. If the pilot study is successful, purchase and install units at selected CSO outfall sites or other locations within the sewer system.

CSO Regulator/Outfall Modifications:

In some cases, it may be possible to make physical modifications to the existing CSO regulator and/or outfall structures to make them more suitable for accurate flow measurement. A project should be included as part of the PPCP Update Study, to investigate and identify sites where this may be a viable and cost-effective option to installing new flow meters at multiple sites.

CSO Regulator/Outfall Consolidation:

In many cases within the City's CSS, multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall. At first glance, it would make sense to simply monitor the downstream CSO outfall, but in many cases these outfalls also receive flow from separate stormwater outfalls, which should not be measured and reported as CSOs, so it is not that simple.

Options for consolidating CSO regulator monitoring sites should be investigated further as part of the PPCP Action Plan including development of a phased implementation plan for a project/program to implement the recommended works, including estimated costs and timing.

Contracted Services:

Other options should be considered for acquiring sewer flow data, such as renting equipment or contracting out services instead of capital purchases. These options could potentially provide more flexibility to address future regulatory changes and technological improvements.

Improved Data Management:

The various types of flow monitors (Hatch Flo-Dar, I-Tracker, SmartCover) typically come with their own software for data communication/download and data processing. Each package is different, and the data formats are not well integrated with the others, making it difficult and time consuming to merge and process data from various flow monitors into a single integrated report (e.g. for CSO/sewer model calibration or CSO reporting). The same can be said for the software used for the rain gauges. Possible options to provide better, more seamless integration of the data from the different flow monitors, as well integration of rainfall and flow data (so they can be graphed together to properly analyze the impact of rainfall on the CSO/sewer system) should be investigated further as part of the PPCP Action Plan); including recommendations for purchasing or developing a new software package that better suits the City's needs.

Coordination with Region:

A Data Sharing Agreement should also be developed with the Region to allow seamless interchanging of rainfall and CSO/sewer flow monitoring data, using standardized equipment and communications protocols.

8.2 Sewer Inspection and Maintenance

The City's current Sewer Inspection Program includes two key components: an annual closed-circuit television (CCTV) inspection program to collect detailed sewer condition data, including a detailed assessment and rating of the structural and O&M condition of each pipe segment surveyed; and an ongoing City-wide zoom camera inspection program to collect higher level information on the entire CSO and sanitary system, which will ultimately be used to develop more priority-based annual sewer inspection and flushing programs. Both programs are completed in in accordance with (NASSCO) Pipeline Assessment Certification Program (PACP) and Manhole Assessment Certification Program (MACP) standards. Each component is discussed further below.

Zoom Camera Inspection:

The City has completed a condition assessment project of its wastewater and stormwater systems using zoom camera inspection technology to get a snap-shot of both systems. The objective of this project was to complete a detailed inspection of sewer manholes and a rapid assessment of sewer mains, as observed from the manholes, to confirm system location and geometry, and provide a high-level condition assessment of the City's wastewater and storm sewer networks. The data from this project helps inform program forecasts for incorporation in the City's future capital and operating budgets.

The project followed OPSS 409 and CSA Plus 4012 and included both structural and operational grading of the sewers, in accordance with NASSCO PACP and MACP standards. The data collected and generated by the sewer condition assessment has been integrated and included into the City's existing GIS system.

The results of the investigations will be used to inform sewer pipe and maintenance hole (MH) rehabilitation projects, which will facilitate sewer system O&M, and help to reduce I/I (which should help reduce CSO volumes and pollutant loads).

It may also be possible to use other observations coming from the zoom camera inspection (e.g. general condition of the sewers, and location/depth of silt/debris deposits in the pipes) to develop more cost-effective future CCTV inspection and sewer flushing programs to prioritize the sewers that really require these activities. Sewers that exhibit good structural and O&M conditions don't need to be inspected in more detail by CCTV (at least not any time soon), and sewers that do not exhibit silt/debris deposits do not need to be cleaned as frequently as ones that do.

Work on the City-wide zoom camera inspection program was completed in 2020 and assessed both the structural and operation condition of the system. The study assessed most of the sewer assets within the road allowance, but not the off-street infrastructure. The final report by GM BluePlan (2021) found from a structural perspective; the wastewater system is overall in good condition, including the following additional observations for the portion of the system it assessed:

+ Approximately 64% of the system exhibited no structural defects.
+ Approximately 28% exhibited structural defects of Grades 1, 2, or 3, which included cracks, less severe fractures and surface damage.
+ Less than 10% of the wastewater mains exhibited structural defects of Grades 4 or 5, which primarily included fractures, breaks, holes and two collapsed sections.

The project also found from an operational perspective, the system is overall in good condition, including the following additional observations for the portion of the system it assessed:

+ Approximately 16% of the system exhibited no operational defects.
+ Approximately 60% exhibited defects of Grades 1, 2 and 3
+ Approximately 16% of the system which exhibited operational defects of Grades 4 or 5. The most prevalent and severe operational defects were encrustations (which is evidence of infiltration) followed by active infiltration, and deposits (not including grease).

CCTV Camera Inspection:

The City conducts an on-going program of CCTV inspection of sanitary sewers to define the status of portions the sewer system. The desired level of service is for all sewers to be CCTV inspected on a 10-year frequency with specific areas of concern investigated on a more frequent basis. CCTV inspection is also completed prior to road reconstruction projects to determine if sewer work should be done at the same time. The actual frequency of CCTV inspections, based on the available budget, is closer to a 1 in 17-year frequency.

When the inspections identify minor repairs to the sanitary sewer system they are funded out of a sewer spot repair account in the City's wastewater budget. There is no corresponding budget for CCTV inspections of storm sewers. In fact, the City does not budget for annual maintenance or minor repairs to the storm sewer system. Emergency repairs, when required, are funded from various sources including the annual operating budget, capital budget and/or water/wastewater budget.

Some possible changes/improvements to City's Sewer Inspection Programs include the following:

+ The City's future CCTV sewer inspection program should be aimed at the sanitary/combined sewers that really require more detailed inspections.
+ For areas with elevated I/I, consider undertaking studies and remedial actions to reduce the sources of I/I. This could include performing camera inspections (e.g. zoom camera and/or CCTV), smoke testing, dye testing and/or flow monitoring.
+ Develop a new storm sewer investigation and inspection program, including zoom camera and/or CCTV inspection.

Sewer Flushing:

The City conducts an ongoing program of sewer flushing to remove silt and debris from its sanitary/combined sewers, with the objective of cleaning all sewers up to 500 mm in diameter with a hydro-jet sewer flusher at least once every 5-years. In practice, the City generally meets this objective. The sanitary sewer system is divided into a number of different O&M sectors, and the sewers in each sector get flushed every five-years. The existing sector boundaries do not necessarily match the sewage system drainage boundaries, so sometimes not all the sewers in a given drainage area get flushed at the same time.

Flushing is also done on an emergency basis to clean affected sewer sections whenever there are reports of blockages or suspected blockages, under a separate budget item from the regular sewer flushing program.

Our experience is that most sewers will be relatively clean (free of significant silt and debris), especially in combined sewer systems where incoming stormwater runoff will flush the sewers during each rainfall event (or in sanitary sewers prone to some additional I/I), and the number of sewers that need to be flushed every 5-years will comprise a relatively small portion of the overall sewer system; and as discussed above, the results of the City's ongoing zoom camera inspection project will provided useful information that can be used to develop a more cost-effective, priority-based sewer flushing program for the future.

As discussed above, the findings of the completed zoom camera inspection program will be used to identify sewers with excessive sediment buildup, reviewed in conjunction with existing sewer flow data, and used to identify areas of the sanitary/combined sewer system that are prone to excessive I/I.

Some possible changes/improvements to the City's Sewer Flushing Program include the following:

- The City's sewer flushing, and reaming programs should be aimed at the sewers that really require these cleaning activities.
- The current LOS for sewer flushing has not been updated in some time. Some possible new activities/metrics to consider as part of the City's sewer flushing LOS include the following:
  a) Possible maintenance for sewers with a diameter greater than 50 mm;
  b) Performing maintenance on a catchment basis instead of a work sector basis;
  c) Including a maintenance schedule for storm sewer assets.

Smoke Testing:

From time to time, the City conducts smoke testing of portions of the sanitary/combined sewer system to identify potential sources of I/I into the system, including connected roof downspouts (most of these have already been removed by the City), improperly disconnected roof downspouts, cross-connected storm sewers and/or catch basins, leaky manhole covers and/or frames, sump pumps, foundation drains, weeping tiles, uncapped cleanouts, and broken sewer laterals.

Some possible changes/improvements to the City's Smoke Testing activities include the following:

- The City should continue with smoke testing activities in selected areas to locate extraneous sources of I/I, including improperly disconnected downspouts, downspouts still connected to sanitary sewers, weeping tiles/window wells connected to sanitary sewers, broken/uncapped sanitary sewer laterals, storm catch basins connected to sanitary sewers, and manhole lids with multiple perforations.
- Smoke testing investigations should be coordinated with other related sewer inspection activities, including the results of zoom camera, CCTV and flow monitoring programs to develop a more comprehensive approach to I/I reduction.
- The City should consider offering a weeping tile disconnection program to help homeowners partially pay for the removal of weeping tiles still connected to the combined sewer system.

Other Sewer Inspection Activities

According to the City's LOS documents, sewers and CSO/storm storage tanks with overflow grates, weirs, bar screens, throttling valves and sluice gates are scheduled for annual inspection, cleaning and maintenance, and additional maintenance and cleaning is done in response to any reports of active overflows, diversions, or back-ups to ensure their continued proper operation.

The City also conducts annual inspections of the sewers connected to its CSO/storm storage tanks, including pumping down the facilities and determining whether the sewers need to be cleaned (sewers with deposits deeper than 6" (150 mm) scheduled for cleaning.

8.3 CSO Inspection & Maintenance

CSO Regulator/Outfall Inspection:

The Port Dalhousie and Port Weller sewersheds include over a hundred CSO outfalls, some including multiple CSO regulators, and including a wide variety of types and designs (e.g. transverse and side weir overflows, half-pipe overflows, and orifice/orifice plate overflows). Some are more complex than others, and some have difficult access issues, many requiring complicated confined space entry (CSE) procedures and equipment. In many cases, multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall, complicating CSO flow monitoring and O&M activities.

Some possible improvements to the City's CSO Regulator Inspection and Maintenance Program activities include the following:

+ In some cases, due to the design and/or complexity of the regulators, it is often difficult for O&M staff to discern between normal flows and possible dry weather overflows. It is also difficult to know which CSO regulators are most critical and require the most attention in terms of inspection and maintenance. To address these issues, we would recommend additional training and education be provided to O&M staff on what each structure looks like, what the overflow looks like, how to identify potential issues that require notification to their supervisors, and which regulators require the most attention. A good starting point for this are the CSO Regulator Information Packages the City has already prepared, which include detailed notes, sketches and drawings of the structures, as well as photos of the chamber taken from various angles. It would also be advantageous to expand upon the information collected during CSO regulator inspections, including documenting visual observations/evidence of current or previous chamber surcharging and overflows, compared with actual sewage level and/or flow rate measurements.
+ In some cases, it may be possible to make physical changes to the existing CSO regulator and/or outfall structures to reduce their complexity, improve understanding of how they work, and generally and simplify access and O&M. Changes could also be made to make the structures more suitable for accurate flow measurement (as already discussed above), including the possibility of removing and/or consolidating adjacent regulators to reduce future monitoring/inspection/maintenance efforts.

CSO Storage Tanks O&M:

The City operates and maintains seven (7) off-line and two (2) in-line CSO storage facilities. Some possible improvements to the City's CSO Tank O&M activities include the following:

+ New Standard Operating Procedures (SOPs) should be developed for all of the City's CSO storage tanks to provide better documentation and guidance on the O&M of the CSO tanks for City staff, and also to facilitate succession planning for when current O&M staff retire or otherwise leave the City.
+ There may be the potential to provide additional coordination with the Region, adding real-time information on available WWTP capacity to optimize the decision process for draining the CSO tanks. Alternatively, there may be an option for Niagara Regional staff at the WWTP to empty the tanks remotely when sufficient capacity exists at the plant and trunk sewers.

- There may also be an opportunity to make better use of the storage available in some of the existing CSO tanks. In some cases, it may be possible, elevations permitting, to divert additional adjacent drainage sub-areas towards the selected CSO tanks, making better use of its available storage capacity, and at the same time providing relief of any conveyance capacity, CSO and/or basement flooding issues in the sewer system the selected sub-area currently drains to.
- Some CSO tank levels sensors need to be replaced and are installed in awkward spots.
- The most challenging facility from an O&M standpoint is the Guy Road CSO Tank.
- The biggest issue with the O&M of the CSO tanks is the age/state of the existing CSO tank monitoring and control systems. The existing Flygt systems are now old and are no longer supported by Flygt, and replacement parts are becoming harder to acquire. A possible option proposed in Tech Memo #3 was to replace the existing systems with newer systems also provided by Xylem/Flygt. Specifically, it was recommended that the existing systems at each existing tank be replaced with the new Xylem Multismart CSO Station Controller and Micrologix 1400 Programmable Logic Controller (PLC), the same unit that was specified for the new Glengarry Park CSO Tank, which is currently under construction. It since became apparent that the new Xylem/Flygt control system is also no longer supported by the supplier, so the City has decided to employ a different system, based on the Region's SCADA standards, which specify the use of Allen Bradley Compact Logix PLC controllers and Ifix software. The main advantages of this option are compatibility with the Region's SCADA system, which will facilitate sharing of CSO tank operations data (including sewage level in tanks, sewage levels/flows in the downstream sewer system, which could even be used to optimize the operation (drainage) of the facilities to ensure that released flows are not bypassed at the downstream WWTP.
- Similar upgrades will need to be done at the City's other existing CSO storage facilities, and a program for this should be developed and included in the PPCP Update, including estimated costs and timing.
- Consider options to better coordinate O&M of CSO facilities with the Niagara Region.

8.4 Sewer System Modelling

TM #3 (Rainfall/Flow Monitoring and O&M Program Review), included in Appendix C, provides a detailed review of the City's existing sewer hydraulic model and proposed a plan for managing the City's future sewer modelling activities, including the following possible upgrades and activities:

The City employs computer modeling to simulate the hydrology and hydraulics of its wastewater collection system. The City's sewer model was originally developed as part of the development of its original Pollution Control Plan in 1989 and primarily represented the trunk sanitary and combined sewer system. Subsequent studies have expanded the models to include additional, more detailed areas of the sanitary and combined sewer system, but not down to the level of an all-pipes model. The City actually maintains two separate models, one for the Port Dalhousie WWTP sewershed and one for the Port Weller WWTP sewershed. The two models can be separated because they have no interconnecting sewers, and do not impact each other's performance.

The models simulate dry and wet weather flows generated within the City's sanitary and combined sewer system and can be used to assess the performance of the sewer system, including sanitary capacity analyses; estimation of annual CSO frequencies, volume and durations at the City CSO outfalls; and to a more limited extent, analysis of basement flooding issues. The models can be used to simulate sewer system performance for selected historical rainfall storm events; for longer term historical rainfall records (annual or several years); and/or selected synthetic design storm events; for existing and/or future conditions.

Sewer Model Maintenance/Updates:

The City conducts periodic updates of its existing XPSWMM models of the Port Dalhousie and Port Weller WWTP sewersheds, to reflect any physical upgrades made to the existing sanitary/combined sewer system and/or recalibration/validation of any portions of the models to improve their accuracy. This task has been completed annually by various consultants since 2010.

This City should continue with this model maintenance/update process.

Coordination with Niagara Region:

The City and Region should continue to work together to ensure to close coordination and integration of future sewer model management and modelling activities. A Working Group meeting on a regular basis is a good way to do this.

8.5 Other General O&M Activities

Some other relevant sewer system O&M activities and programs already employed by the City include the Level of Service Reviews and Sewer System Asset Management Plan. These are discussed briefly below, and in more detail in TM #3, included in Appendix C.

Level of Service Reviews:

The City has developed a number of procedures that define the Level of Service (LOS) to be provided with regard to the operation and maintenance of its sanitary/combined/storm sewer systems, road drainage systems, and watercourses, including the following documents:

- S-1 – Catch Basin Cleaning and Repairs
- S-2 – Cleaning Blocked Private Drains
- S-3 – Main Sewer Maintenance
- S-4 – Storm Sewer Maintenance
- S-5 – Manhole Placement
- S-6 – Manhole Repairs
- S-7 – New Services – Water and Sewer
- S-8 – Repair Service Broken by Contractor
- S-9 – Sewer Lateral Repair
- S-10 – Storm Flooding
- R-3 – Box Culverts
- R-10 – Road Culvert Maintenance
- R-14 – Roadside Ditch Maintenance

+ R-19 – Culvert Grate Maintenance
+ R-20 – Street Cleaning
+ OS-1 – Off Street Patrol
+ OS-4 – Watercourse Cleaning

TM # 3 proposed the following changes/improvements with regard to the City's LOS documents:

+ The LOS documents were last updated more than 16 years ago, and some of the requirements and metrics may no longer be appropriate for the City's current situation. Some of the existing metrics are too global (e.g. prescribed annual system-wide sewer inspection and flushing frequencies and lengths), and consideration should be given to developing more priority-based metrics, based on the actual condition and needs of the sewer system, especially for activities such as sewer flushing and reaming, and CCTV inspection. A new project/project program should be included in the City's future Operation or Capital Budget to update the existing LOS documents. This could either be done in-house and/or with the assistance of an outside consultant.
+ As per the requirements of LOS # OS-1 (Off-Street Patrol), the City should prepare a known list/database of the most critical and troublesome storm drainage locations, and the recorded information should include the extent of the problems observed (e.g., length of road/sewer flooded).
+ As per the mapping requirements of LOS # S-10 (Storm Flooding), the City may want to consider migrating or mirroring the location information in the off-street map book/atlas to a single map, possibly even an interactive map on a tablet or laptop computer that can be taken into the field by staff.

Sewer System Asset Management Plan:

The City has researched and is currently in the process of purchasing a new Asset Management software package, which will provide more powerful tools for documenting and tracking the condition of its CSO and sewer system assets; identifying, planning, budgeting and facilitating required O&M activities (including automatic work order generation) and infrastructure asset upgrade projects and programs; and generally improving the City's ability to manage and maintaining its wastewater collection system assets.

In general, there is also a need for more seamless integration between all of the City's software systems, including its new Asset Management System software; existing Geographic Information System (GIS) software; existing Computer Aided Design (CAD) software, existing/future Sewer System Hydraulic Model software; and possibly even its existing/future Rainfall and Sewer Flow Monitoring System software, to improve the day-to-day management of its CSO and sewer systems. Some of these issues were discussed further in TM #3 (Rainfall/Flow Monitoring and O&M Program Review) and TM #5 (Gap Analysis), included in Appendix C and E.

Some possible improvements with regard to the City's Asset Management Program include the following:

+ The City should continue to implement the new Asset Management System software package, including classroom and hands-on training sessions for relevant City staff, including Management, Engineering and O&M staff, focused on managing and maintaining its wastewater collection system assets, and incorporate the training in the City's Annual Operating Budget.

- Options to improve the integration of the City's various software systems (as described above) should be investigated further in conjunction with City Management, Engineering and O&M staff, focusing on managing and maintaining its wastewater collection system assets.

9. CSO Control Alternatives Evaluation

As discussed above, the PPCP Action Plan include recommendations grouped into two main categories, including:

1) City-wide policies and programs, aimed at improving the general performance of the City's CSO and wastewater collection system infrastructure, which will also provide benefits for CSO and basement flooding control.
2) Specific CSO control projects aimed at reducing existing CSO frequency, volume, duration, pollutant loadings discharged from; and improving the WWF control level provided at; at specific priority CSO regulator and outfall locations.

An effective approach for the Final PPCP Update may be to give initial priority to the CSO and wastewater collection system O&M programs and activities in the first couple of years of implementation (and City budgets); followed by specific projects for the design and construction of any more significant capital upgrades to control any remaining large volume CSO outfalls.

9.1 Pre-screening of CSO Control Alternatives

Chapter 7 and Tech Memo #7 discussed a number of available CSO control approaches and technologies, including a variety of different Source Control, Sewer System Control, CSO Treatment, Floatables Control, Effluent Disinfection, and Odour Control options; provided a brief description of each option, presented their key advantages and disadvantages; and commented on their suitability for further evaluation and potential inclusion in the Final PPCP Update.

Chapter 8 discussed a variety of existing City-wide CSO and Sewer System O&M policies and programs, including Sewer System Monitoring, Sewer Inspection and Maintenance, CSO Inspection and Maintenance, Sewer System Modelling, and Other General O&M Activities/Programs; provided a brief description of each policy/program/activity; and proposed some possible areas for improvements/additions for inclusion in the Final PPCP Update.

Tables 9-1 and 9-2 carry the above discussions a step further, pre-screening the considered CSO technology and O&M options, to create a short list of the best and most feasible CSO control alternatives for further detailed evaluation and possible inclusion in the current PPCP Update. Some key criteria considered as part of the pre-screening exercise included expected Environmental Benefits (CSO volume and/or pollution reduction); Feasibility and Ease of Implementation (specifically for City CSOs); Complexity of O&M (specifically for City staff); Life-cycle Costs (reasonable or cost prohibitive); and Potential Construction Impacts (disruption, noise, dust, etc).

Table 9-1: Short List of Potential CSO Control Alternatives

SOURCE CONTROLS	Bioretention Areas	
	Catch Basin Cleaning	YES, to all
	Green Roofs	
	Infiltration and Inflow Control	All programs and activities
	Low Impact Development	to be evaluated further
	Permeable Pavement	for possible inclusion in
	Pesticide Reduction	Final PPCP Update.
	Public Education	
	Rainwater Harvesting	Many of these practices are
	Roof Downspout Disconnection	already employed by the City,
	Sewer Use By-laws	and should be continued
	Street Sweeping	and/or improved upon.
	Water Conservation	
SEWER SYSTEM CONTROLS	Sewage Backflow Preventers	YES, as part of FLAP program
	Catch Basin Inlet Control	YES
	Deep Tunnel Storage	NO
	Drainage Area Diversion	YES
	Dynamic Regulators	NO
	Flow Balance Method	NO
	Off-line Storage	YES
	Real Time Control	NO
	Regulator Adjustments	YES
	Sewer Separation	YES, applied strategically
	Tide and Flap Gates	YES, at some outfalls
CSO TREATMENT	Continuous Deflective Separation	MAYBE, at some outfalls
	Coarse and Fine Screens	NO
	Dissolved Air Floatation	NO
	High-Rate Filtration	NO
	High-Rate Treatment	MAYBE, at WWTPs
	Treatment Shafts	NO
	Vortex Separators	NO
FLOATABLES CONTROL	Catch Basin Modifications	MAYBE
	Containments Booms	NO
	Floating Debris Traps	MAYBE, at some outfalls
	Netting Systems	NO
	Screens and Trash Racks	NO
	Underflow Baffles	YES, at some regulators
DISINFECTION	Chlorine or Chlorine Dioxide	NO to all
	Electron Beam Irradiation	
	Ozone	Due to H&S concerns
	Peracetic Acid	and complexity of O&M
	UV Irradiation	

Table 9-2: Short List of Potential CSO/Sewer System O&M Activities

SEWER SYSTEM MONITORING	Rainfall Monitoring Sewer Flow Monitoring CSO Regulator/Outfall Monitoring CSO Regulator/Outfall Modifications CSO Regulator/Outfall Consolidation
SEWER INSPECTION & MAINTENANCE	Zoom Camera Inspection CCTV Camera Inspection Sewer Flushing Smoke Testing
CSO INSPECTION & MAINTENANCE	CSO Regulator/Outfall Inspection CSO Storage Tanks O&M
SEWER SYSTEM MODELLING	Sewer Model Platform Sewer Model Maintenance/Updates Development of All-Pipes Sewer Model Coordination with Niagara Region
OTHER GENERAL O&M ACTIVITIES	Level of Service Reviews Sewer System Asset Management Plan
YES, to all	All of these programs/activities are already employed by the City, and should be Continued and/or improved upon.

Briefly, in no particular order, some key short-listed CSO control alternatives to carry forward for detailed analysis and evaluation include the following:

- Source Control/LID/Green Infrastructure projects, where practical and cost effective
- I/I Reduction projects, where practical and cost effective
- Selected Sewer Separation projects, where practical and cost effective
- Selected CSO Sub-catchment Diversions (to capture more flow in existing CSO tanks)
- Selected CSO Outfall Consolidation, where practical and cost effective
- Consider simplifying/improving O&M of Guy Road CSO Tank
- New CSO Storage Tanks may still be required at larger volume sites
- Possible CSO High-Rate Treatment at WWTP, but not practical at individual outfalls
- Possible Floatables Control projects at selected CSO outfalls
- Other possible treatment options include Constructed Wetlands

9.2 Detailed Evaluation Method

A two-stage evaluation process was applied to evaluate potential specific CSO (and basement flooding) control measures/projects at specific CSO regulator/outfall locations. The evaluation process is similar to the one used for the 2008 PCP Update (CH2M Hill, 2008), with some minor modifications.

9.2.1 Stage 1 Evaluation

The first stage of the process involves creating a priority ranking the CSO regulators/outfalls based their impact to local receiving stream environments, including consideration of the sensitivity of the receiver; the estimated annual volume, frequency and pollutant loadings associated with each CSO location.

The idea is to identify the CSO locations with the highest priority for action by the City, to achieve the greatest overall benefit to the environment, within a reasonable time frame and sustainable annual CSO control budget for the foreseeable future.

The next step involved ranking the various receiving stream environments (including Lake Ontario, Martindale Pond, Twelve Mile Creek, Old Welland Canal, Spring Garden Creek, Dicks Creek, and Welland Canal) according to their environmental sensitivity.

Receiving stream impacts considered as part of this ranking include: 1) drinking water impacts; 2) recreational impacts; 3) existing water quality; and 4) relative water quality.

Each impact was rated from 1-5, with a score of 1 representing the lowest potential for impact, and a score of 5 representing the highest potential for impact. The four above impacts will be weighted equally; an average overall priority ranking score of 1-5 will be assigned to each CSO location; and the locations will be ranked from highest to lowest based on their overall impact potential.

Based on the previous ranking done as part of the 2008 PCP Update (CH2M Hill, 2008), the two most sensitive receivers were Spring Garden Creek (3.5), Dicks Creek (3.0) and Old Welland Canal (3.0), largely due to their poorer existing and relative water quality). We have reviewed the previous water quality sensitivity ranking and see no reason to change it, since there have been no noticeable changes in the discharges going into, or the relative water quality within, these three receiving waters.

The total environmental impact scores for each for each CSO location are determined by summing their overflow volume score and receiving stream impact scores (i.e., providing equal weighting to each component).

The overflow volume score comes from the results of the updated CSO system modelling, which was presented in Chapter 6. CSO locations that do not overflow during the typical year analysis (based on the typical year modelling) are not included in the ranking.

9.2.2 Stage 2 Evaluation

The second stage of the evaluation of potential CSO control options included a more detailed technical evaluation of the different approaches and technologies that can be applied to reduce CSO volume/duration/frequency and pollutant loads at the most critical CSO locations identified by the environmental impact analysis. As noted above, a pre-screening of available options, including a variety of different Source Control, Sewer System Control, CSO Treatment, Floatables Control, Effluent Disinfection, and Odour Control options was conducted, arriving at the short list presented in Table 9-2.

This includes an examination of the benefits and impacts of each different approach/technology to determine their applicability to each critical CSO location.

It is worth noting that MOE Procedure F-5-5 permits the 90% WWF volume capture requirement to be met on a system-wide basis, so opportunities to consolidate existing overflows and/or provide higher control at some than others, will be also investigated.

The considered technical evaluation criteria included the following metrics:

+ Natural Environment: including surface water, ground water, and air (odour).
+ Social Environment: including nuisance, property, aesthetics, recreation, community health, sustainability, and public education.
+ Cultural Environment: including architectural, historical, and cultural heritage.
+ Technical Environment: including integration and flexibility, operation and maintenance, constructability, and land requirements.
+ Economic and Financial Environment: including capital and operating costs (life cycle costs) and associated peripheral costs.

10. PPCP Action Plan

10.1 PPCP Action Plan Components

The proposed PPCP Action Plan comprises two main components/phases, including:

1) City-wide CSO Control Programs/Projects aimed at improving the management, and operations and maintenance (O&M) of the City's CSO and wastewater collection systems, including Sewer System Monitoring, Sewer System Inspection & Maintenance, CSO Inspection & Maintenance, Sewer System Modelling, and Other General O&M Activities.
2) Site-specific CSO Control Projects aimed at reducing the frequency/volume/duration/pollution from specific CSO regulators/outfalls within the City's CSO system, including Source Controls, Sewer System Controls, CSO Treatment, Floatables Control and Disinfection.

Chapters 10.2 and 10.3 describe the recommended projects/programs under each of the above components, and Chapter 10.4 includes a proposed plan for implementing the proposed PPCP Action Plan, including a suggested implementation timetable and estimated costs for the various recommended CSO control projects/programs.

Chapter 7 included a review of available CSO control approaches and technologies, including a number of sewer system operation and maintenance activities that can help to improve the everyday operation of the City's wastewater collection system and reduce CSOs and basement flooding, and recommended a number of activities to be incorporated in the PPCP Action Plan Update.

Table 10-1 presents a short list of the best and most feasible CSO control alternatives for further detailed evaluation and possible inclusion in the current PPCP Update. Some key criteria considered as part of the pre-screening exercise included expected Environmental Benefits (CSO volume and/or pollution reduction); Feasibility and Ease of Implementation (specifically for City CSOs); Complexity of O&M (specifically for City staff); Life-cycle Costs (reasonable or cost prohibitive); and Potential Construction Impacts (disruption, noise, dust, etc.).

Table 10-1: Short List of Potential CSO/Sewer System O&M Activities

SEWER SYSTEM MONITORING	Rainfall Monitoring Sewer Flow Monitoring CSO Regulator/Outfall Monitoring CSO Regulator/Outfall Modifications CSO Regulator/Outfall Consolidation Sewer Flow Monitoring - Contracted Services Improved Data Management Coordination with Niagara Region
SEWER INSPECTION & MAINTENANCE	Zoom Camera Inspection CCTV Camera Inspection Sewer Flushing Smoke Testing
CSO INSPECTION & MAINTENANCE	CSO Regulator/Outfall Inspection CSO Storage Tanks O&M
SEWER SYSTEM MODELLING	Sewer Model Platform Sewer Model Maintenance/Updates Development of All-Pipes Sewer Model Coordination with Niagara Region
OTHER GENERAL O&M ACTIVITIES	Level of Service Reviews Sewer System Asset Management Plan
YES, to all	All of these programs/activities are already employed by the City, and should be Continued and/or improved upon.

10.2 Sewer System Monitoring

10.2.1 Rainfall Monitoring

+ The current Tipping Bucket Rain Gauges (TBRGs) are aging and beyond their expected service life. A plan/project should be developed to upgrade the City’s existing rainfall monitoring network, including new tipping bucket rain gauges, new electronic dataloggers with improved real-time communications capabilities, and better data processing software
+ One new rain gauge station should be added to cover the central-eastern part of the City, possibly located at 360 Niagara Street (City owned office building) or at the Scott Street Fire Station, to fill in a slight gap in coverage in this area.
+ The City’s one existing full weather station (including temperature and wind direction and speed monitoring) should be decommissioned as the additional weather data is not required or used by the City.

+ Rainfall radar data can be a useful adjunct to the ground-level rain gauge network, providing confirmation of the accuracy of the latter after rainfall events; and real time rainfall radar data can even provide advance warning of expected rainfall intensity and coverage, which could be used to help optimize the operation of the City's existing CSO tanks.

10.2.2 Sewer Flow Monitoring

Sewer flow monitoring is a useful tool to support the modeling and analysis of CSOs, basement flooding issues, measure the performance of the combined sewer system, identify potential problem spots, and help develop effective CSO and basement flooding control measures. TM#3 (Hatch, 2020a) provided a detailed review of the City's existing sewer flow monitoring program, which proposed the following possible investigations and upgrades:

+ The current temporary sewer flow meters are aging and beyond their expected service life. A plan/project should be developed to upgrade the City's existing sewer flow meters, including new sewer flow meters with improved real-time communications capabilities, and better data processing software.
+ This being said, the specific number, location, and type of equipment will depend on a number of factors, most notably the new MOE requirements for CSO regulator/outfall monitoring, which are discussed further below.

10.2.3 CSO Regulator/Outfall Monitoring

The MOE intends to require much more extensive monitoring of CSO outfalls in the future, and this will have significant implications on the City's CSO outfall monitoring program. The Ministry has issued St. Catharines Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA) #023-W601. The CLI-ECA contains requirements for monitoring and reporting CSO events. The specific details of these requirements are still pending and will be included in guidance documents that are under development by the Ministry. This guidance in expected to be finalized and released in late 2024 or early 2025.

TM#3 (Hatch, 2020a) discussed some of the related impacts, and proposed some possible approaches for providing improved CSO outfall monitoring, including the following:

+ Based on the Ministry's expectations, a phased implementation plan/project or projects should be developed to meet the expected future CSO monitoring/reporting requirements, to be included in the PPCP Action Plan; including recommendations for new flow monitoring equipment (e.g. CSO detection sensors, level sensors and/or velocity-area flow meters) locations, estimated life-cycle costs (including purchase, installation and ongoing O&M costs), and timelines for implementation of the program.

Some possible options/projects for incorporation in the PPCP Action Plan include the following:

+ Upgrade and relocate the existing velocity-area flow meters, including options for different flow meter manufacturers, models, number, locations of meters, and associated life-cycle costs.
+ Conversely, consideration should be given to whether the network of permanent sites is still required or if other options would be preferable. Given the capital cost of replacing these sites,

the limited use of this data and the lack of flexibility in the future, there may be other options for obtaining the required data. If some or all of the sites are no longer required, there would be a decommissioning cost.

+ Conduct a pilot study of level-only flow measurement devices (including I-Tracker, SmartCover, and/or other similar equipment), to determine if they can provide a feasible, acceptable, and cost-effective alternative to velocity-area meters, at least at some sites. If the pilot study is successful, purchase and install units at selected CSO outfall sites or other locations within the sewer system.

10.2.4 CSO Regulator/Outfall Modifications

In some cases, it may be possible to make physical modifications to the existing CSO regulator and/or outfall structures to make them more suitable for accurate flow measurement. A project should be included as part of the PPCP Action Plan, to investigate and identify sites where this may be a viable and cost-effective option to installing new flow meters at multiple sites.

10.2.5 CSO Regulator/Outfall Consolidation

In many cases within the City's Combined Sewer System (CSS), multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall. At first glance, it would make sense to simply monitor the downstream CSO outfall, but in many cases these outfalls also receive flow from separate stormwater outfalls, which should not be measured and reported as CSOs, so it is not that straight forward. A study should be undertaken as part of the PPCP Action Plan to investigate options for consolidating CSO regulator monitoring sites, to simplify O&M of these CSO structures and reduce future CSO monitoring costs.

10.2.6 Contracted Services

Other options should be considered for acquiring sewer flow data, such as renting equipment or contracting out services instead of capital purchases. These options could potentially provide more flexibility to address future regulatory changes and technological improvements.

10.2.7 Improved Data Management

The various types of flow monitors (Hatch Flo-Dar, I-Tracker, SmartCover) typically come with their own software for data communication/download and data processing. Each package is different, and the data formats are not well integrated with the others, making it difficult and time consuming to merge and process data from various flow monitors into a single integrated report (e.g. for CSO/sewer model calibration or CSO reporting). The same can be said for the software used for the rain gauges. A study should be undertaken as part of the PPCP Action Plan to investigate possible options to provide better, more seamless integration of the data from the different flow monitors, as well as the integration of rainfall and flow data, so they can be graphed together to properly analyze the impact of rainfall on the CSO/sewer system.

10.2.8 Coordination with Region

A Data Sharing Agreement should also be developed with the Region to allow seamless interchanging of rainfall and CSO/sewer flow monitoring data, using standardized equipment and communications protocols.

10.3 Sewer Inspection and Maintenance

The City's current Sewer Inspection Program includes two key components: an annual closed-circuit television (CCTV) inspection program to collect detailed sewer condition data, including a detailed assessment and rating of the structural and O&M condition of each pipe segment surveyed; and a City-wide zoom camera inspection program to collect higher level information on the entire CSO and sanitary system, which will ultimately be used to develop more priority-based annual sewer inspection and flushing programs. Both programs are completed in in accordance with (NASSCO) Pipeline Assessment Certification Program (PACP) and Manhole Assessment Certification Program (MACP) standards. Each component is discussed further below.

10.3.1 Zoom Camera Inspection

The City has completed a condition assessment project of its wastewater and stormwater systems using zoom camera inspection technology to get a snap-shot of both systems. The objective of this project was to complete a detailed inspection of sewer manholes and a rapid assessment of sewer mains, as observed from the manholes, to confirm system location and geometry, and provide a high-level condition assessment of the City's wastewater and storm sewer networks. The data from this project helps inform program forecasts for incorporation in the City's future capital and operating budgets.

The project followed OPSS 409 and CSA Plus 4012 and included both structural and operational grading of the sewers, in accordance with NASSCO PACP and MACP standards. The data collected and generated by the sewer condition assessment has been integrated and included into the City's existing GIS system.

The results of the investigations will be used to inform sewer pipe and maintenance hole (MH) rehabilitation projects, which will facilitate sewer system O&M, and help to reduce I/I (which should help reduce CSO volumes and pollutant loads).

10.3.2 CCTV Camera Inspection

The City conducts an on-going program of CCTV inspection of sanitary sewers to define the status of portions the sewer system. The desired level of service is for all sewers to be CCTV inspected on a 10-year frequency with specific areas of concern investigated on a more frequent basis. CCTV inspection is also completed prior to road reconstruction projects to determine if sewer work should be done at the same time. The actual frequency of CCTV inspections, based on the available budget, is closer to a 1 in 17-year frequency.

When the inspections identify minor repairs to the sanitary sewer system, they are funded out of a sewer spot repair account in the City's wastewater budget. Since 2020, a corresponding budget for CCTV inspections of storm sewers is in place. Historically the City did not budget for annual maintenance or minor repairs to the storm sewer system. Emergency repairs, when required, are funded from various sources including the annual operating budget, capital budget and/or water/wastewater budget.

Some possible changes/improvements to City's Sewer Inspection Programs include the following:

- The City's future CCTV sewer inspection and maintenance program should be aimed at the sanitary/combined sewers that really require more detailed inspection and maintenance, using the information from the zoom camera inspections program, and other factors such as age and material of pipe.
- For areas with elevated I/I, the City should continue to undertake studies and remedial actions to reduce the sources of I/I. This could include performing camera inspections (e.g., zoom camera and/or CCTV), smoke testing, dye testing and/or flow monitoring.
- Continue and enhance the storm sewer investigation and inspection program, including a prioritized plan for undertaking future zoom camera and/or CCTV inspections.
- Develop a lateral condition assessment program in order to address I&I entering the CSS from laterals. Possibly based on the NASSCO Lateral Assessment Certification Program (LACP).

10.3.3 Sewer Flushing

The City conducts an ongoing program of sewer flushing to remove silt and debris from its sanitary/combined sewers, with the objective of cleaning all sewers up to and including 525 mm in diameter with a hydro-jet sewer flusher at least once every 5-years. In practice, the City generally meets this objective. The sanitary sewer system is divided into a number of different O&M sectors, and the sewers in each sector get flushed every five-years. The existing sector boundaries do not necessarily match the sewage system drainage boundaries, so sometimes not all the sewers in a given drainage area get flushed at the same time. Sewers that require more work or have repetitively have maintenance issues are flushed on a higher frequency such as annual or semi-annual.

Flushing is also done on an emergency basis to clean affected sewer sections whenever there are reports of blockages or suspected blockages, under a separate budget item from the regular sewer flushing program.

Our experience is that most sewers will be relatively clean (free of significant silt and debris), especially in combined sewer systems where incoming stormwater runoff will flush the sewers during each rainfall event (or in sanitary sewers prone to some additional I/I), and the number of sewers that need to be flushed every 5-years will comprise a relatively small portion of the overall sewer system; and as discussed above, the results of the City's zoom camera inspection project will provide useful information that can be used to develop a more cost-effective, priority-based sewer flushing program for the future.

As discussed above, the findings of the CCTV and zoom camera inspections can be used to identify sewers with excessive sediment buildup, reviewed in conjunction with existing sewer flow data, and used to identify areas of the sanitary/combined sewer system that are prone to excessive I/I.

Some possible changes/improvements to the City's Sewer Flushing Program include the following:

- The City's sewer flushing, and reaming programs should be aimed at the sewers that really require these cleaning activities, using the information from the sewer inspection and condition assessments.

- The current LOS for sewer flushing has not been updated in some time. Some possible new activities/metrics to consider as part of the City's sewer flushing LOS include the following:
    - d) Possible maintenance for sewers with a diameter greater than 525 mm;
    - e) Performing maintenance on a catchment basis instead of a work sector basis;
    - f) Including a maintenance schedule for storm sewer assets.

10.3.4 Smoke Testing

From time to time, the City conducts smoke testing of portions of the sanitary/combined sewer system to identify potential sources of I/I into the system, including connected downspouts , improperly disconnected roof downspouts, cross-connected storm sewers and/or catch basins, leaky manhole covers and/or frames, sump pumps, foundation drains, weeping tiles, uncapped cleanouts, and broken sewer laterals.

Some possible changes/improvements to the City's Smoke Testing activities include the following:

- The City should continue with smoke testing activities in selected areas to locate extraneous sources of I/I, including improperly disconnected downspouts, downspouts still connected to sanitary sewers, weeping tiles/window wells connected to sanitary sewers, broken/uncapped sanitary sewer laterals, storm catch basins connected to sanitary sewers, and manhole lids with multiple perforations.
- Smoke testing investigations should be coordinated with other related sewer inspection activities, including the results of zoom camera, CCTV, and flow monitoring programs to develop a more comprehensive approach to I/I reduction.
- The City should consider offering a weeping tile disconnection program to help homeowners partially pay for the removal of weeping tiles still connected to the combined sewer system.
- Creating a GIS layer where the contractor can report information and where remedial actions can be documented.
- Use smoke testing to identify legacy connections that were not removed in the past.

10.3.5 Other Sewer Inspection Activities

According to the City's LOS documents (City of St. Catharines, 2002), sewers and CSO/storm storage tanks with overflow grates, weirs, bar screens, throttling valves and sluice gates are scheduled for annual inspection, cleaning and maintenance, and additional maintenance and cleaning is done in response to any reports of active overflows, diversions, or back-ups to ensure their continued proper operation.

The City also conducts annual inspections of the sewers connected to its CSO/storm storage tanks, including pumping down the facilities, and determining whether the sewers need to be cleaned (sewers with deposits deeper than 6" (150 mm) scheduled for cleaning.

Additional details on the City's CSO-related O&M activities are provided below in Chapters 5 and 8.

10.4 CSO Inspection & Maintenance

10.4.1 CSO Regulator/Outfall Inspection

The St. Catharines wastewater collection system includes over 50 CSO outfalls, some including multiple CSO regulators, and including a wide variety of types and designs (e.g., transverse and side weir overflows, half-pipe overflows, and orifice/orifice plate overflows). Some are more complex than others, and some have difficult access issues, many requiring complicated confined space entry (CSE) procedures and equipment. In many cases, multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall, complicating CSO flow monitoring and O&M activities.

Some possible improvements to the City's CSO Regulator Inspection and Maintenance Program activities include the following:

+ In some cases, due to the design and/or complexity of the regulators, it is often difficult for O&M staff to discern between normal flows and possible dry weather overflows. It is also difficult to know which CSO regulators are most critical and require the most attention in terms of inspection and maintenance. To address these issues, we would recommend additional training and education be provided to O&M staff on what each structure looks like, what the overflow looks like, how to identify potential issues that require notification to their supervisors, and which regulators require the most attention. A good starting point for this is the CSO Regulator Information Packages the City has already prepared, which include detailed notes, sketches, and drawings of the structures, as well as photos of the chamber taken from various angles. It would also be advantageous to expand upon the information collected during CSO regulator inspections, including documenting visual observations/evidence of current or previous chamber surcharging and overflows, compared with actual sewage level and/or flow rate measurements.
+ In some cases, it may be possible to make physical changes to the existing CSO regulator and/or outfall structures to reduce their complexity, improve understanding of how they work, and generally and simplify access and O&M. Changes could also be made to make the structures more suitable for accurate flow measurement (as already discussed above), including the possibility of removing and/or consolidating adjacent regulators to reduce future monitoring/inspection/maintenance efforts.

10.4.2 CSO Storage Tanks O&M

The City operates and maintains seven (7) off-line and two (2) in-line wet weather sewage storage facilities. Some possible improvements to the O&M activities include the following:

+ New Standard Operating Procedures (SOPs) should be developed for all of the storage facilities to provide better documentation and guidance on the O&M of the CSO tanks for City staff, and also to facilitate succession planning for when current O&M staff retire or otherwise leave the City.
+ There may be the potential to provide additional coordination with the Region, adding real-time information on available WWTP capacity to optimize the decision process for draining the flows

back into the system. Alternatively, there may be an option for Niagara Regional staff at the WWTP to empty the tanks remotely when sufficient capacity exists at the plant and trunk sewers.

+ There may also be an opportunity to make better use of the storage available in some of the existing CSO tanks. In some cases, it may be possible, elevations permitting, to divert additional adjacent drainage sub-areas towards the selected CSO tanks, making better use of its available storage capacity, and at the same time providing relief of any conveyance capacity, CSO and/or basement flooding issues in the sewer system the selected sub-area currently drains to.
+ Some CSO tank levels sensors need to be replaced and are installed in awkward spots.
+ The most challenging facility from an O&M standpoint is the Guy Road CSO Tank, where there have been problems with the operation of the sewage pumps, which often requires cleaning of the facility by vacuum truck, and this has led to odour complaints.
+ Options to provide improved floatables control at the CSO tanks that include infrequent overflows to the environment should further be investigated and incorporated in the PPCP Action Plan.
+ The biggest issue with the O&M of the CSO tanks is the age/state of the existing CSO tank monitoring and control systems. Six of the sites use Flygt monitoring systems. The existing Flygt systems are now old and are no longer supported by Flygt, and replacement parts are becoming harder to acquire. A possible option is to employ a different system, based on the Region's SCADA standards, which specify the use of Allen Bradley Compact Logix PLC controllers and Ifix software. The main advantages of this option are compatibility with the Region's SCADA system, which will facilitate sharing of CSO tank operations data (including sewage level in tanks, sewage levels/flows in the downstream sewer system, which could even be used to optimize the operation (drainage) of the facilities to ensure that released flows are not bypassed at the downstream WWTP. The Glengarry Park CSO Tank currently uses the Region's SCADA standards.
+ Similar upgrades will need to be done at the City's other six CSO storage facilities that still use the Flygt monitoring systems, and a program for this should be included in the PPCP Action Plan, including estimated costs and timing.
+ The City should consider options to better coordinate O&M of CSO facilities with Niagara Region.

10.5 Sewer System Modelling

TM #3 (Sewer Model Review and Assessment), included in Appendix D, provides a detailed review of the City's existing sewer hydraulic model and proposed a plan for managing the City's future sewer modelling activities, including the following possible upgrades and activities.

The City employs computer modeling to simulate the hydrology and hydraulics of its wastewater collection system. The City's sewer model was originally developed as part of the development of its original Pollution Control Plan in 1989 and primarily represented the trunk sanitary and parts of the combined sewer system. Subsequent studies have expanded the models to include additional, more detailed areas of the sanitary and combined sewer system, but not down to the level of an all-pipes model.

Historically, the City actually maintained two separate existing InfoSWMM trunk wastewater system models, one for the Port Dalhousie WWTP sewershed and one for the Port Weller WWTP sewershed. The two models can be separated because they have no interconnecting sewers, and do not impact each other's performance.

The models simulate dry and wet weather flows generated within the City's sanitary and combined sewer system and can be used to assess the performance of the sewer system, including sanitary capacity analyses; estimation of annual CSO frequencies, volume, and durations at the City CSO outfalls; and to a more limited extent, analysis of basement flooding issues. The models can be used to simulate sewer system performance for selected historical rainfall storm events; for longer term historical rainfall records (annual or several years); and/or selected synthetic design storm events; for existing and/or future conditions.

10.5.1 Sewer Model Platform

At the start of this study, the City's sewer models were based on XPSWMM, a proprietary software package, supported by Innovyze (formerly XP-Software), which is based on the United States Environmental Protection Agency (USEPA) Stormwater Management Model (SWMM) hydrologic and hydraulic computation.

The Region's CSO/sewer system model is based on the InfoSWMM sewer model platform, which is supported by Innovyze. Innovyze incidentally also support the XPSWMM, InfoWorks ICM, and InfoSewer sewer model platforms.

TM #4 compared the key features of Innovyze's various sewer model platforms, including XPSWMM, InfoSWMM, InfoWorks ICM, and InfoSewer; and Appendix A included vendor brochures outlining the features of XPSWMM and InfoSWMM.

Considering the features of all these programs and the needs of the City, maybe the most important feature of all, is the ability to provide better sewer model coordination with Niagara Region, by moving to InfoSWMM. TM #4 therefore proposed the following changes/improvements with regard to the City's Sewer Model Software Platform:

- Complete the PPCP Update using the existing XPSWMM models.
- Migrate to a 2,000 or 5,000 link license of InfoSWMM and adopt the Region's recently updated InfoSWMM model as a starting point for the City's new InfoSWMM model (whichever size model is required to run the Region's model, or at least the City's portion of it). Some verification still needs to be done on the exact extent of the City's CSO/sewer system within the Region's model, including the exact number of manholes/pipes and CSO diversion structures included in the model, and the basis and accuracy of the connected subcatchment data.

10.5.2 Sewer Model Update

Subsequent to TM #4 being finalized, in 2021, Niagara Region began an update to it's Water and Wastewater Master Servicing Plan (MSP) to identify water and wastewater infrastructure needs to the year 2051, while maintaining levels of service. The MSP incorporated recent knowledge and current priorities to ensure expected growth can be accommodated, as per the amended Growth Plan for the Greater Golden Horseshoe.

Part of this project included hydraulic modeling of the wastewater system. As wastewater falls within the jurisdiction of both the City and the Region, an opportunity arose to have the initial phase of an all-pipes model completed by the Region as part of its MSP Project.

10.5.3 Development of All-Pipes Model

The model was developed using InfoSWMM and Innovyze modelling software which predominantly utilizes the US EPA Stormwater Management Model (EPA-SWMM) model structure and computation engine. The rationale for selecting InfoSWMM was based on maintaining interoperability with the Region which historically used InfoSWMM for their wastewater system modelling.

The City's sanitary GIS data, which includes sanitary pipes, sanitary manholes and sanitary laterals, was used as the basis of the network development and will be the primary sources of sewer geometry including diameters and inverts.

In some cases the City's existing wastewater asset data still has substantial data gaps in the network's manhole and sewer inverts. In some instances manhole depths information was supplemented from the St. Catharines Zoom Camera Investigation project.

The InfoSWMM wastewater model consists of:

+ All City and Regional facilities (pumps) and downstream sewer network (including all City and Regional owned sewer mains) up to the wastewater treatment plant headworks.
+ All City and/or Regional owned sewer mains (including gravity and forcemains).
+ All City and/or Regional overflows in the collection system.
+ External connections and contributions from the City of Thorold and the Town of Niagara-On-The-Lake.

The model development focused on the following key areas:

+ Wastewater network development and geometry validation.
+ Facilities development including geometry, pump curves; controls; and system flow allocation and calibration.
+ Development of wet weather flow scenarios.

10.5.4 Coordination with Niagara Region

The City and Region should continue to work together to ensure to close coordination and integration of future sewer model management and modelling activities. A Working Group meeting on a regular basis is a good way to do this.

10.6 Other General O&M Activities

Some other relevant sewer system O&M activities and programs already employed by the City include the Level of Service Reviews and Sewer System Asset Management Plan. These are discussed briefly below, and in more detail in TM #3, included in Appendix C.

Level of Service Reviews:

The City has developed a number of procedures with a defined Level of Service (LOS) with regard to operation and maintenance of its sanitary/combined/storm sewer systems, road drainage systems, and watercourses.

TM#3 proposed the following changes/improvements with regard to the City's LOS documents:

+ Many of the LOS documents were last updated more than 16 years ago, and some of the requirements and metrics may no longer be appropriate for the City's current situation. Some of the existing metrics are too global (e.g., prescribed annual system-wide sewer inspection and flushing frequencies and lengths), and consideration should be given to developing more priority-based metrics, based on the actual condition and needs of the sewer system, especially for activities such as sewer flushing and reaming, and CCTV inspection. A new project/project program should be included in the City's future Operation or Capital Budget to update the existing LOS documents. This could either be done in-house and/or with the assistance of an outside consultant.
+ As per the requirements of LOS # OS-1 (Off-Street Patrol), the City should prepare a known list/database of the most critical and troublesome storm drainage locations, and the recorded information should include the extent of the problems observed (e.g., length of road/sewer flooded).
+ As per the mapping requirements of LOS # S-10 (Storm Flooding), the City may want to consider migrating or mirroring the location information in the off-street map book to a single map, possibly even an interactive map on a tablet or laptop computer that can be taken into the field by staff.

10.6.1 Sewer System Asset Management Plan

The City has researched and is currently in the process of purchasing a new Asset Management software package, which will provide more powerful tools for documenting and tracking the condition of its CSO and sewer system assets; identifying, planning, budgeting and facilitating required O&M activities (including automatic work order generation) and infrastructure asset upgrade projects and programs; and generally improving the City's ability to manage and maintaining its wastewater collection system assets. The existing Asset Management Plan focused on pipe condition, with the enhancement to the sewer model there is an opportunity to also include capacity, especially areas with potential capacity restrictions.

In general, there is also a need for more seamless integration between all of the City's software systems, including its new Asset Management System software; existing Geographic Information System (GIS) software; existing Computer Aided Design (CAD) software, existing/future Sewer System Hydraulic Model software; and possibly even its existing/future Rainfall and Sewer Flow Monitoring System software, to improve the day-to-day management of its CSO and sewer systems. Some of these issues were also discussed further in TM#3 - Rainfall/Flow Monitoring and O&M Program Review (Hatch, 2020a), and TM#5 - Gap Analysis (Hatch, 2020c).

Some possible improvements with regard to the City's Asset Management Program include the following:

+ The City should continue to implement the new Asset Management System software package, including classroom and hands-on training sessions for relevant City staff, including

Management, Engineering and O&M staff, focused on managing and maintaining its wastewater collection system assets, and incorporate the training in the City's Annual Operating Budget.

+ Options to improve the integration of the City's various software systems (as described above) should be investigated further in conjunction with City Management, Engineering and O&M staff, focusing on managing and maintaining its wastewater collection system assets.
+ Integration across platforms can be complicated and will require updated procedures to ensure data is managed and handled appropriately and information is available to staff when they require it.

10.7 Site-Specific CSO Control Projects

Potential CSO control alternatives can generally be grouped into three main categories of source control, sewer system controls and CSO treatment. Additional details on individual alternatives can be found in Chapter 7.

Source Controls

Source Controls are measures implemented upstream of the CSS, which help decrease CSO volume and/or pollution by reducing the amount (or rate) of runoff and/or pollutants entering the CSS. Reducing inflows into the CSS can also have additional benefits including reduced basement flooding risk, increased sewer capacity and reduced flows to the treatment plants. Some examples of commonly employed source controls are listed in Table 10-2. Although these measures typically cannot provide the reductions required to meet desired CSO reduction targets on their own, combinations of source controls can yield noticeable CSO reductions and can reduce the overall costs of CSO control when considered as part of an overall implementation program. Source controls to manage wet weather flow through infiltration, evapotranspiration, and rainwater harvesting are increasingly being referred to as 'Green Infrastructure'. Green Infrastructure approaches currently in use include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. Green infrastructure can be used almost anywhere where soil and vegetation can be worked into the urban or suburban landscape. Green Infrastructure is most effective when supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets.

Sewer System Controls

Sewer System Controls are measures implemented within the CSS, which help decrease CSO volume and basement flooding by increasing the hydraulic capacity of the sanitary/storm/combined sewer systems to handle storm inflows. Improved CSS maintenance, regulator adjustments, sewer separation, storage and real-time control can all be highly effective in reducing CSO volumes and reducing basement flooding. Some common sewer system control options are listed in Table 10-2.

CSO Treatment

CSOs can also be treated, either at a central WWTP or by satellite treatment facilities located at the upstream CSO outfalls. The treatment processes of the WWTPs should first be optimized to minimize the pollutant loadings under wet weather conditions. This may lead to wet weather-specific operating conditions that may produce lower overall pollutant loadings. Options to be considered for WWTPs include expansion and/or upgrade of existing treatment processes, installation of new treatment technologies, and innovative approaches to the operation of existing or new treatment processes.

Satellite treatment facilities may be cost-effective where there are space limitations or limited capacity in the collection system to convey excess flows to the WWTP. Some of these technologies are only effective at removing certain types of pollutants (e.g., disinfection, screening and floatables control), and technologies may need to be combined to ensure that specified CSO treatment requirements are met. Close attention needs to be paid to the effluent treatment requirement for satellite treatment facilities. For example, MOE Procedure F-5-5 requires a minimum level of primary treatment, and the discharge from these facilities must achieve an effluent concentration for Total Suspended Solids of not more than 90 mg/l, for at least 50 % of the period from April 1 to October 31 (MOE, 1997).

Table 10-2 – Potential CSO Control Alternatives

SOURCE CONTROLS	Bioretention Areas Catch Basin Cleaning Green Roofs Infiltration and Inflow Control Low Impact Development Permeable Pavement Pesticide Reduction	Public Education Rainwater Harvesting Roof Downspout Disconnection Sewer Use By-laws Street Sweeping Water Conservation
SEWER SYSTEM	Backflow Preventers Catch Basin Inlet Control Deep Tunnel Storage Drainage Area Diversion Dynamic Regulators Flow Balance Method	In-line and off-line Storage Real Time Control Regulator Adjustments Sewer Separation Tide and Flap Gates
CSO TREATMENT	Continuous Deflective Separation Coarse and Fine Screens Dissolved Air Floatation High-Rate Filtration	High-Rate Physical Chemical Treatment Shafts Vortex Separators
FLOATABLES	Catch Basin Modifications Containments Booms Floating Debris Traps	Netting Systems Screens and Trash Racks Underflow Baffles
DISINFECTION	Chlorine Chlorine Dioxide Electron Beam Irradiation	Ozone Peracetic Acid UV Irradiation

11. PPCP Action Plan Recommendations

Per discussions with the City and as previously outlined in this TM, Hatch recommends a two-fold approach for the PPCP Action Plan:

1) Development and implementation city-wide programs and projects, aimed at improving the general performance of the City's CSO and wastewater collection system infrastructure, which will also provide benefits for CSO and basement flooding control.
2) Development and implementation of specific CSO control projects aimed at reducing existing CSO frequency, volume, duration, pollutant loadings discharged, and improving the WWF control level provided at specific priority CSO regulator and outfall locations.

11.1 City-Wide CSO Programs/Projects

As part of the development and implementation of City-wide programs and projects related to CSO/Sewer System O&M, the following sections provide recommendations for the categories listed below:

1) Rainfall & Sewer System Monitoring
2) CSO Regulator/Outfall Monitoring
3) CSO Regulator/Outfall Modification & Consolidation
4) Sewer System Inspection and O&M
5) CSO Regulator/Outfall Inspection
6) CSO Storage Tank O&M
7) Sewer System Modelling
8) Other General O&M Activities

11.1.1 Rainfall & Sewer System Monitoring

Rainfall and sewer flow monitoring are useful tools for managing wastewater collection and CSO systems, providing valuable information on the performance of these systems during different types and sizes of storm events, and also about the longer-term performance of the system. The data can be used directly to help better understand and resolve issues and/or problems within the sewer system (e.g. areas with excessive I/I, locations with significant CSO and/or basement flooding), and also used indirectly to recalibrate/validate computer models used to predict the performance of the sewer systems, in the short or longer term.

Rainfall Monitoring

The current TBRGs are aging and beyond their expected service life and need to be decommissioned. A study should be conducted to review options for upgrading the City's Rain Gauge Network, including new TBRGs, new electronic dataloggers with improved real-time communications capabilities, and better data processing software.

Another option would be to rely on data from the Region's or Environment Canada's existing rain gauge stations. This might be an attractive option if additional stations were deployed in St. Catharines.

Rainfall radar data can be a useful adjunct to the ground-level rain gauge network, providing confirmation of the accuracy of the latter after rainfall events; and real time rainfall radar data can even provide advance warning of expected rainfall intensity and coverage, which could be used to help optimize the operation of the City's existing CSO tanks.

Sewer System Monitoring

The current temporary sewer flow meters are aging and beyond their expected service life and need to be decommissioned. A study should be conducted to review the City's Sewer Flow Monitoring Program, to consider options for upgrading the City's existing sewer flow meters, including new sewer flow meters with improved real-time communications capabilities, and better data processing software.

The specific number, location, and type of equipment will depend on a number of factors, most notably the new MECP requirements for CSO regulator/ outfall monitoring.

11.1.2 CSO Regulator/Outfall Flow Monitoring

There are several CSO flow monitoring options/projects to consider. Upgrading and relocating the existing velocity-area flow meters, including options for different flow meter manufacturers, models, number, locations of meters, and associated life-cycle costs. In addition, the City should consider installing temporary/permanent monitors at key system CSOs. These monitors would primarily serve to validate the City's existing model and estimated CSO volumes and discharge frequency. It is also recommended that only a subset of CSO locations be monitored, annually, with the primary objective to enhance model calibration, due to the nature of CSO locations being subject to intermittent flows it maybe very difficult to calibrate these monitors and/or ensure accuracy of the results.

Conversely, consideration should be given to whether the network of permanent sites is still required or if other options would be preferable. Given the capital cost of replacing these sites, the limited use of this data and the lack of flexibility in the future, there may be other options for obtaining the required data. If some or all of the sites are no longer required, there would be a decommissioning cost. Additionally, a pilot study of level-only flow measurement devices (including I-Tracker, SmartCover, and/or other similar equipment) can be conducted to determine if they can provide a feasible, acceptable, and cost-effective alternative to velocity-area meters, at least at some sites. If the pilot study is successful, purchase and install units at selected CSO outfall sites or other locations within the sewer system.

A study should be conducted to review the City's CSO Monitoring Program, to review the options discussed above, for upgrading and/or expanding the existing CSO monitoring program and equipment, considering the MECP's new CSO monitoring requirements.

11.1.3 CSO Regulator/Outfall Modifications & Consolidation

CSO Regulator/Outfall Modifications

In some cases, it may be possible to make physical modifications to the existing CSO regulator and/or outfall structures to make them more suitable for accurate flow measurement. A CSO Regulator Modifications Study should be conducted to investigate and identify existing CSO sites where this may be a viable and cost-effective option.

CSO Regulator/Outfall Consolidation

In many cases within the City's CSS, multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall. Typically, it would make sense to simply monitor the downstream CSO outfall, however, in many cases these outfalls also receive flow from separate stormwater outfalls, which should not be measured and reported as CSOs. A CSO Regulator Consolidation Study should be conducted, following identification of the preferred CSO Monitoring Program and CSO Regulator Modifications from the studies recommended above, to investigate and identify existing CSO sites, in close proximity, that could be most easily consolidated to facilitate real-time monitoring of CSO events, and be a viable, cost-effective option to installing new flow meters at multiple sites.

11.1.4 Sewer System Inspection and O&M

Contracted Flow Monitoring Services

Other options should be considered for acquiring sewer flow data, such as renting equipment or contracting out services instead of capital purchases.

These options could potentially provide more flexibility to address future regulatory changes and technological improvements.

Improved Data Management

The various types of flow monitors (Hatch Flo-Dar, I-Tracker, SmartCover) typically come with their own software for data communication/download/processing.

Each package is different, and the data formats are not well integrated with the others, making it difficult and time consuming to merge and process data from various flow monitors into a single integrated report.

Possible options to provide better, more seamless integration of the data from the different flow monitors, as well integration of rainfall and flow data (so they can be graphed together to properly analyze the impact of rainfall on the CSO/sewer system) should be investigated.

A Data Sharing Agreement should be developed with the Region to allow seamless interchanging of rainfall and sewer flow data, using standardized equipment and communications protocols.

Sewer Inspection and Maintenance

Recently the City's current Sewer Inspection Program includes two key components:

1) A one-time, city-wide, zoom camera inspection program to collect higher level information on the entire CSO and sanitary system, which will ultimately be used to develop more priority-based annual sewer inspection and flushing programs.
2) An annual closed-circuit television (CCTV) inspection program to collect detailed sewer condition data, including a detailed assessment and rating of the structural and O&M condition of each pipe segment surveyed.

Both programs are completed in accordance with (NASSCO) Pipeline Assessment Certification Program (PACP) and Manhole Assessment Certification Program (MACP) standards.

Zoom Camera Inspection

The City conducted a zoom camera inspection of its sanitary/ combined sewer system, as part of a city-wide investigation of extraneous I/I. The study was completed by GM BluePlan (2021), based on the field work conducted by Aqua Data Inc.

The objectives of the project were to identify the connectivity, material, size, debris build ups, I/I, and general structural condition of the sewer system; any emergency repairs that should be completed immediately; and provide 5 and 10-year maintenance and capital program forecasts for incorporation in future budgets.

The results of the investigations can be used to develop priority lists of required sewer pipe and MH rehabilitation projects, which will facilitate sewer system O&M, and help to reduce I/I (which should help reduce CSO volumes and pollutant loads).

It should also be possible to use other observations from the project (e.g., general condition of the sewers, and location/depth of silt/debris deposits in the pipes) to develop more cost-effective future CCTV inspection and sewer flushing programs that are aimed at the sewers that really require these activities.

Zoom camera inspection is most useful as a rapid method and therefore is recommended to be utilized as a tool to undertake a high-level system wide condition assessment to identify priority areas for further investigation, to verify system improvements, and to assist with O&M issues. This method alone does not provide sufficiently detailed information for the development of a system rehabilitation program.

The City-wide zoom camera project was a one-time project to obtain a snap-shot of the structural and operational condition of the City's sanitary, combined and storm sewer systems. It is not likely to be re-done any time soon, and certainly not during the period that this PPCP Action Plan addresses.

Having said this, there may be an opportunity to use more limited, site-specific, zoom camera inspections to support other sewer system work, including verifying sewer system improvements, supporting I/I studies, and assisting with resolving identified sewer system O&M issues, and future site-specific zoom camera inspections should be included in the O&M components of the PPCP Action Plan.

CCTV Camera Inspection

The City conducts an on-going program of CCTV inspection of sanitary sewers to define the status of portions the sewer system. The desired level of service is for all sewers to be CCTV inspected on a 10-year frequency with specific areas of concern investigated on a more frequent basis. It is recommended that the frequency of CCTV inspection be reviewed and increased dependent on circumstance where sewers identified as being in poor condition will be inspected more frequently and be assigned to Low (10 year), Medium (5 year) or High (2 year) inspection frequencies within inspection zones. CCTV inspection is also often completed prior to road reconstruction projects to determine if sewer work should be done at the same time.

It is critical that the system condition assessment undertaken reflects the most reliable and accurate pipe condition information in order the ensure the effective management of sewer networks. Thus, the CCTV inspection is the preferred method to identify and classify observations as either structural and/or operational defects and determine associated sewer condition ratings. The resources provided for comprehensive CCTV inspections must be sufficient to address requirements and effectively manage the sewer system to ensure it continues to operate without any significant problems. The City should review its previous CCTV efforts, and increase the annual frequency of CCTV inspection.

Furthermore, the City's future CCTV sewer inspection program should be aimed at the sanitary/combined sewers that really require more detailed inspections, using the findings of the recent zoom camera inspection, as well as new information obtained from normal/regular sewer inspection activities and/or new operational issues that may arise from time to time.

The zoom camera report (GM BluePlan, 2021) recommended the City development and implement a regular CCTV Sewer Inspection Program, and proposed two options, which can be summarized as follows:

1) A 5-year Quantity Based Program, where the City's sanitary/combined sewer system is divided into five (5) relatively equal areas based on the total length of sewers in each area. Each year, the program would focus on one inspection area, resulting in inspection of the entire wastewater collection system every five years. In addition, sewers identified as having ongoing operational issues (such as chronic grease deposits) would be inspected every year, or even more frequently, regardless of their location.
2) A 10-year Condition Based Program, which still ensures periodic inspection of the entire sanitary/combined sewer system, but makes better use of resources based on the condition rating of individual sewers. Sewers identified as being in poor condition would be inspected more frequently, while sewers in good condition would be inspected less frequently. The City's sanitary/combined sewer system is divided into ten (10) relatively equal inspection zones, again based on the total length of sewers in each area. Within each inspection zone, each sewer was assigned to Low, Medium or High inspection frequencies based on their observed condition from the zoom camera inspection report, with Low Priority Sewers inspected every 10 years, Medium Priority Sewers inspected every 5 years, and High Priority Sewers inspected every 2 years. Based on the analyses completed to date, 78% of the existing sewer system has been identified as Low Priority, 15% as Medium Priority, and 7% as High Priority for CCTV inspection.

The estimated cost of both of the above program options ranges between approximately $500-600k per year, and comprising between 110-115 km of CCTV sewer inspection length per year.

Ideally, the City should implement the 10-year Condition Based CCTV Sewer Inspection Program for the wastewater collection system.

The zoom camera report also recommends that the City update its existing CCTV inspection contract specifications, possibly with the assistance of a qualified consultant/contractor, to identify improved inspection practices and generate improved CCTV inspection deliverables (GM BluePlan, 2021).

Finally, the report recommends that the City develop and implement a permanent program to address structural defects found by zoom camera and CCTV sewer inspections, such as conveyance restrictions and active infiltration into the sanitary/combined sewer system, in conjunction with planned capital and maintenance upgrades, using the results of CCTV sewer inspections to validate the zoom camera data to ensure a well informed and robust approach to sewer system management (GM BluePlan, 2021).

Other Sewer Inspection Activities

According to the City's LOS documents, sewers and CSO/storm storage tanks with overflow grates, weirs, bar screens, throttling valves and sluice gates are scheduled for annual inspection, cleaning, and maintenance.

And additional maintenance and cleaning is done in response to any reports of active overflows, diversions, or back-ups to ensure their continued proper operation.

The City also conducts annual inspections of the sewers connected to its CSO/storm storage tanks, including pumping down the facilities, and determining whether the sewers need to be cleaned.

Sewers with deposits deeper than 150 mm are scheduled for cleaning.

Sewer Flushing

The City conducts an ongoing program of sewer flushing to remove silt and debris from its sanitary/combined sewers, with the objective of cleaning all sewers up to 500 mm in diameter with a hydro-jet sewer flusher at least once every 5-years. In practice, the City generally meets this objective, but the existing sector boundaries do not necessarily match the sewage system drainage boundaries, so sometimes not all the sewers in a given drainage area get flushed at the same time.

Flushing is also done on an emergency basis to clean affected sewer sections whenever there are reports of blockages or suspected blockages, under a separate budget item from the regular sewer flushing program.

The City's sewer flushing and reaming programs should be aimed at the sewers that really require these cleaning activities, and the findings of the recent zoom camera inspection program should be used to develop a new priority-based sewer flushing/cleaning program that addresses problem areas more regularly, as also recommended by the zoom camera program report (GM BluePlan, 2021).

The current LOS for sewer flushing has not been updated in some time. Some possible new activities/metrics to consider as part of this LOS include:

+ Possible maintenance for sewers with a diameter greater than 500 mm
+ Performing maintenance on a catchment basis instead of a work sector basis
+ Including a maintenance schedule for storm sewer assets

Inflow & Infiltration Reduction

From time to time, the City conducts smoke testing of portions of the sanitary/combined sewer system to identify potential sources of I/I into the system.

Some possible changes/improvements to these activities include:

+ A robust I/I program should include flow monitoring to determine problem areas, desktop work to understand neighbourhood characteristics (e.g. age of subdivisions, infrastructure type, age, condition etc.), field investigations (e.g. smoke & dye testing, inspections - visual, zoom camera, CCTV etc.), determine and classify the sources of I/I, remedial actions to address, tracking progress and verification to measure effectiveness.

- The City should continue with smoke testing activities in selected areas to locate extraneous sources of I/I, including improperly disconnected downspouts, downspouts still connected to sanitary sewers, weeping tiles/window wells connected to sanitary sewers, broken/uncapped sanitary sewer laterals, storm catch basins connected to sanitary sewers, and manhole lids with multiple perforations.
- The City should consider developing and offering a weeping tile disconnection program to help homeowners partially pay for the removal of weeping tiles still connected to the combined sewer system.
- The City should consider adopting development standards intended to reduce the risk of I/I when new sanitary sewers are built on the private side.
- The City should consider adopting watertight design standards for sewer rehabilitation and or replacement projects.

11.1.5 CSO Regulator/Outfall Inspection

The City's CSS include over fifty CSO outfalls, some including multiple CSO regulators, and including a wide variety of types and designs (e.g., transverse and side weir overflows, half-pipe overflows, and orifice/orifice plate overflows).

Some are more complex than others, and some have difficult access issues, many requiring complicated confined space entry (CSE) procedures and equipment. In many cases, multiple adjacent CSO regulators combine and discharge to the environment through a single downstream CSO outfall, complicating CSO flow monitoring and O&M activities. In some cases, due to the design and/or complexity of the regulators, it is often difficult for O&M staff to discern between normal flows and possible DWF overflows. It is also difficult to know which CSO regulators are most critical and require the most attention in terms of inspection and maintenance.

To address these issues, we would recommend additional training and education be provided to O&M staff on what each structure looks like, what the overflow looks like, how to identify potential issues that require notification to their supervisors, and which regulators require the most attention.

A good starting point for this is the CSO Regulator Information Packages the City has already prepared, which include detailed notes, sketches, and drawings of the structures, as well as photos of the chamber taken from various angles. It would also be advantageous to expand upon the information collected during CSO regulator inspections, including documenting visual observations/evidence of current or previous chamber surcharging and overflows, compared with actual sewage level and/or flow rate measurements. In general, existing CSO documentation should be improved to facilitate O&M of the existing CSO control structures and facilities.

In some cases, it may be possible to make physical changes to the existing CSO regulator and/or outfall structures to reduce their complexity, improve understanding of how they work, and generally and simplify access and O&M.

Changes could also be made to make the structures more suitable for accurate flow measurement, including the possibility of removing and/or consolidating adjacent regulators to reduce future monitoring/inspection/maintenance efforts. Recommendations for CSO Regulator Modification and Consolidation Studies, to review possible options for such improvements, were already provided above.

11.1.6 CSO Storage Tank O&M

New Standard Operating Procedures (SOPs) should be developed for all of the City's CSO storage tanks to provide better documentation and guidance on the O&M of the CSO tanks for City staff, and also to facilitate succession planning for when current O&M staff retire or otherwise leave the City.

There may be the potential to provide additional coordination with the Region, adding real-time information on available WWTP capacity to optimize the decision process for draining the CSO tanks.

Alternatively, there may be an option for Niagara Regional staff at the WWTP to empty the tanks remotely when sufficient capacity exists at the plant and trunk sewers.

There may also be an opportunity to make better use of the storage available in some of the existing CSO tanks. In some cases, it may be possible, elevations permitting, to divert additional adjacent drainage sub-areas towards the selected CSO tanks, making better use of its available storage capacity, and at the same time providing relief of any conveyance capacity, CSO and/or basement flooding issues in the sewer system the selected sub-area currently drains to.

Some CSO tank levels sensors need to be replaced and are installed in awkward spots. Options to address specific issues should be investigated further, as part of an overall CSO Tank Condition Assessment Program, after the new CSO storage tank SOPs have been developed.

The most challenging facility from an O&M standpoint is the Guy Road CSO Tank. This is discussed further below, along with recommendation for a study to investigate and review options for improving the O&M of this facility.

Options to provide improved floatables control at the CSO tanks that include infrequent overflows to the environment should be further investigated.

The biggest issue with the O&M of the CSO tanks is the age/state of the existing CSO tank monitoring and control systems. The existing Flygt systems are now old and are no longer supported, and they need to be replaced with something else. At the Glengarry Park CSO facility, the City has decided to employ a system, based on the Region's SCADA standards, which specify the use of Allen Bradley Compact Logix PLC controllers and Ifix software.

The main advantage of this option is compatibility with the Region's SCADA system, which will facilitate sharing of CSO tank operations data (including sewage level in tanks, sewage levels/flows in the downstream sewer system, which could even be used to optimize the operation (drainage) of the facilities to ensure that released flows are not bypassed at the downstream WWTP.

Similar upgrades will need to be done at the City's other existing CSO storage facilities with Flygt systems, and a program to standardize the SCADA-related equipment, and operation and control of all the existing CSO storage facilities should be developed and implemented over the next few years.

The O&M activities for the CSO control facilities should be coordinated with Niagara Region.

11.1.7 Sewer System Modelling

Part of this assignment was to review the City's existing sewer system models and potential for improvement. The previously completed TM#4 (Sewer Model Review and Assessment) provided a detailed review of the City's existing sewer hydraulic model and proposed a plan for managing the City's future sewer modelling activities.

In 2021, Niagara Region began an update to its Water and Wastewater Master Servicing Plan (MSP) to identify water and wastewater infrastructure needs to the year 2051. Part of this project included hydraulic modeling of the wastewater system. As wastewater falls within the jurisdiction of both the City and the Region, an opportunity arose to have the initial phase of an all-pipes model completed by the Region as part of its MSP Project. The all-pipes model was completed in April, 2023, including:

+ All City and Regional Facilities (pumps) and downstream sewer network (including all City and Regional owned sewer mains) up to the WWTP headworks
+ All City and/or Regional owned sewer mains (including gravity and forcemains)
+ All City and/or Regional overflows in the collection system
+ External connections and contributions from the City of Thorold and the Town of Niagara-On-The-Lake

The final report (GM Blue Plan, 2023) includes additional details on the development and calibration of the new InfoSWMM all-pipes model of the St. Catharines wastewater collection system, and includes some additional recommendations for future sewer modelling efforts, including the following items:

+ Maintain a consistent dataset of sewer network inverts and rim elevations
+ Improved flow monitoring, given size of system, recommend 20-40 catchments
+ Include a process when assets are "found" for getting put into the GIS system

It is important that efforts are made to keep the models up to date as the system changes and new data becomes available. A formalized process should be developed for model updates and implemented to ensure future sewer system updates are accurately reflected in the model. When known data gaps exist, efforts should be made to address them.

11.1.8 Other General O&M Activities

The MECP issued Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA) Number 023-W601 for the City of St. Catharines Wastewater Collection System in January 2023 (MECP, 2023).

Schedule A of the ECA provides general information about the Authorized System covered by the ECA, including previous ECAs and other supporting documents including the City's Sewer Design Criteria, 2021 Asset Management Plan, previous Pollution Control Plan (CH2M Hill, 2008), and formal name of the Operating Authority.

Schedule B provides additional details about the Authorized System, including a general overview of the City's wastewater collection system, a map of the system, and specific details about the key components of the system including the Sewage Pumping Stations, Combined Sewage Structures (CSO regulators), Combined Sewage Storage Tanks, Collection System Overflow Points (CSO and WWTP outfalls), including component ID #s, coordinate locations, and capacities (where applicable).

Schedule C provides a list of any and all notices of amendment to this Approval, of which, there are currently none.

Schedule D defines the key terms used in the ECA, lays out the General Conditions of the ECA, and covers more specific requirements related to: presents covers requirements relating to provides General information pertaining to the following items ECA, including instructions related to: Alterations to the Municipal Sewage Collection System; Authorizations of Future Alterations for Separate Sewers, Nominally Separate Sewers and Forcemains - Additions, Modifications, Replacements and Extensions; Authorizations of Future Alterations for Combined Sewers, Partially Separated Sewers and Combined Sewage Storage Tanks and Storage Structures; Authorizations of Future Alterations to Components of the Municipal Sewage Collection System; Authorizations of Future Alterations to Equipment with Emissions to the Air; Previously Approved Sewage Works; and Transition.

Schedule E of the new ECA provides guidelines and recommendations regarding the proper operation and maintenance of related equipment, appurtenances and effective performance for sewage works, as well as the preparation and implementation of inspections, manuals, and reporting procedures. Schedule E covers requirements related to: General Operations; Duties of Owners and Operating Authorities; Operations and Maintenance (including Inspection, O&M Manual, Collection System Overflows, and Monitoring); Reporting; Record Keeping; Review of this Approval; Source Water Protection; and Additional Studies (including an Assessment of Wet Weather Flows Compared to Dry Weather Flows and Assessment of Conformance to Procedure F-5-1 and F-5-5).

The following General Operations conditions from the ECA are of particular note:

1.1 The Owner shall ensure that, at all times, the Sewage Works comprising the Authorized System and the related Equipment and Appurtenances used to achieve compliance with this Approval are properly operated and maintained.

1.2 Prescribed Persons and Operating Authorities shall ensure that, at all times, the Sewage Works under their care and control and the related Equipment and Appurtenances used to achieve compliance with this Approval are properly operated and maintained.

1.3 In conditions 1.1 and 1.2 “properly operated and maintained” includes effective performance, adequate funding, adequate operator staffing and training, including training in applicable procedures and other requirements of this Approval and the EPA, OWRA, CWA, and regulations, adequate laboratory services, process controls and alarms and the use of process chemicals and other substances used in the Authorized System.

Some other relevant sewer system O&M activities and programs already employed by the City include the Level of Service (LOS) Reviews and Sewer System Asset Management Plan. Recommendations regarding changes/improvements to the LOS and Sewer System Asset Management Plan are presented below.

Level of Service (LOS) Review

The city has developed a number of procedures with defined LOS with regard to the O&M of its sewer and road drainage systems, and watercourses. These include procedures related to installation, maintenance, and repairs of catch basins, maintenance access points (i.e. manholes), sewers, and laterals. There are also related activities such as blocked drains, storm flooding and watercourses maintenance.

A new project/project program should be included in the City's future Operation or Capital Budget to update the existing LOS documents and ensure they meet the requirements of the CLI-ECA. This could either be done in-house and/or with the assistance of an outside consultant.

Sewer System Asset Management Plan

The City has researched and is currently in the process of purchasing a new Asset Management Software package, which will provide more powerful tools for documenting and tracking the condition of its CSO and sewer system assets; identifying, planning, budgeting and facilitating required O&M activities (including automatic work order generation) and infrastructure asset upgrade projects and programs; and generally improving the City's ability to manage and maintaining its wastewater collection system assets. The new Asset Management Software should incorporate all sewer system assets, including the sanitary, combined and separate storm systems.

11.2 Site-Specific CSO Control Projects

With regards to the development and implementation of site-specific CSO control projects, Hatch suggests that the completion of some additional studies/investigations of specific areas of the CSS are needed to better understand the issues at hand and develop the best possible solutions for each of these areas.

Chapter 7 included a detailed review of possible approaches to CSO control, identified a short list of preferred CSO control options for the City of St. Catharines, and identified the existing CSO locations with the highest priority for additional CSO controls.

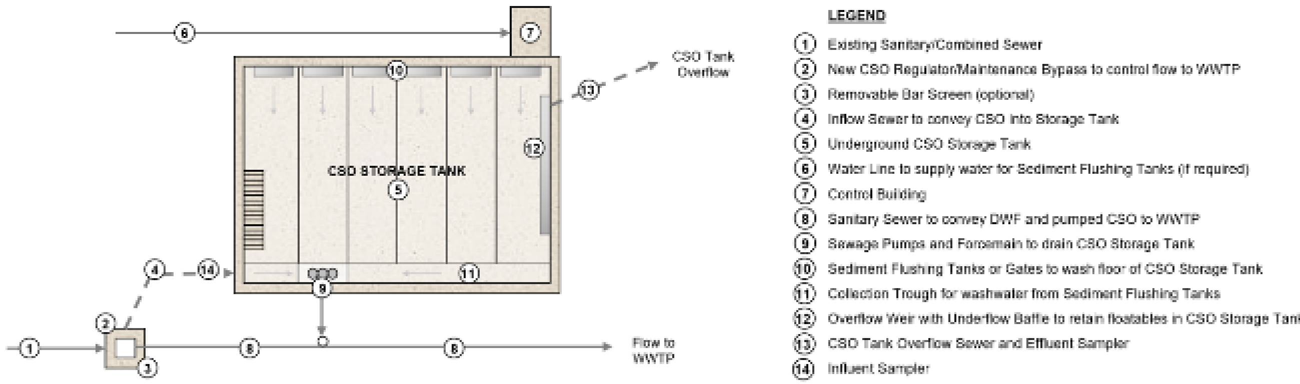
11.2.1 Possible CSO Control Measures

Possible CSO control options include: Off-line Storage; In-line Storage; Regulator Adjustments; Regulator Consolidation; Drainage Area Diversion; Increased WWF Conveyance; and/or Sewer Separation; each of which is summarized below:

Off-line Storage

Off-line detention storage is a popular and effective means of reducing CSOs. The city is already familiar with the technology, with seven existing off-line tanks (including the new facility in Glengarry Park).

This is a possible option for the higher volume CSO sites in St. Catharines, in locations where sufficient space is available. O&M requirements need to be considered, including cleaning and instrumentation and control.

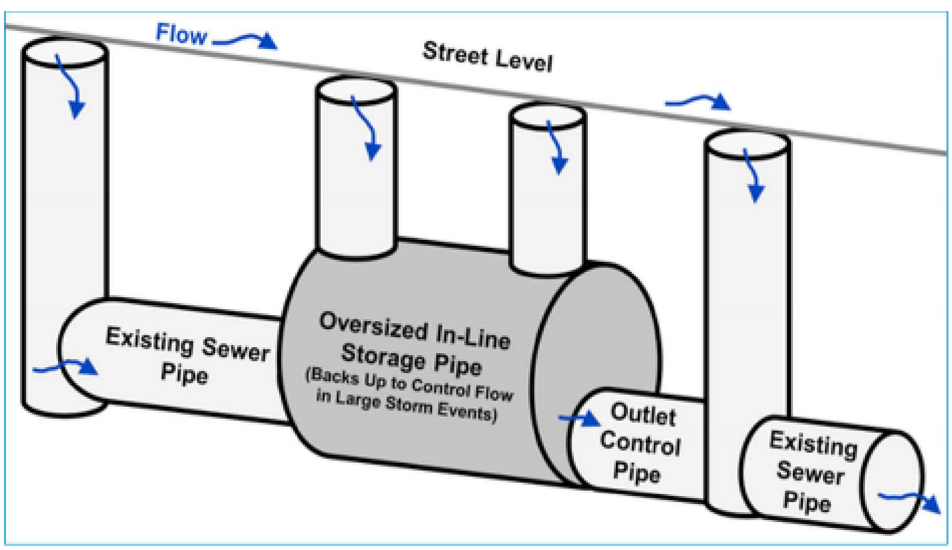


Off-line Storage

In-line Storage

In-line storage involves providing oversized (under roadway) storage pipes with end-of-pipe orifice controls to slowly drain the stored CSO volumes back into the downstream CSS. Control can be passive or dynamic, with passive control preferred due to simplicity of operation and maintenance.

In-line storage may be a cost-effective alternative to off-line storage, where the required storage volume is lower, under approximately 1,000 m^3. In-Line storage is a good option for low-medium volume / medium-high frequency CSO sites. O&M requirements will need to be considered, including possible sediment buildup.

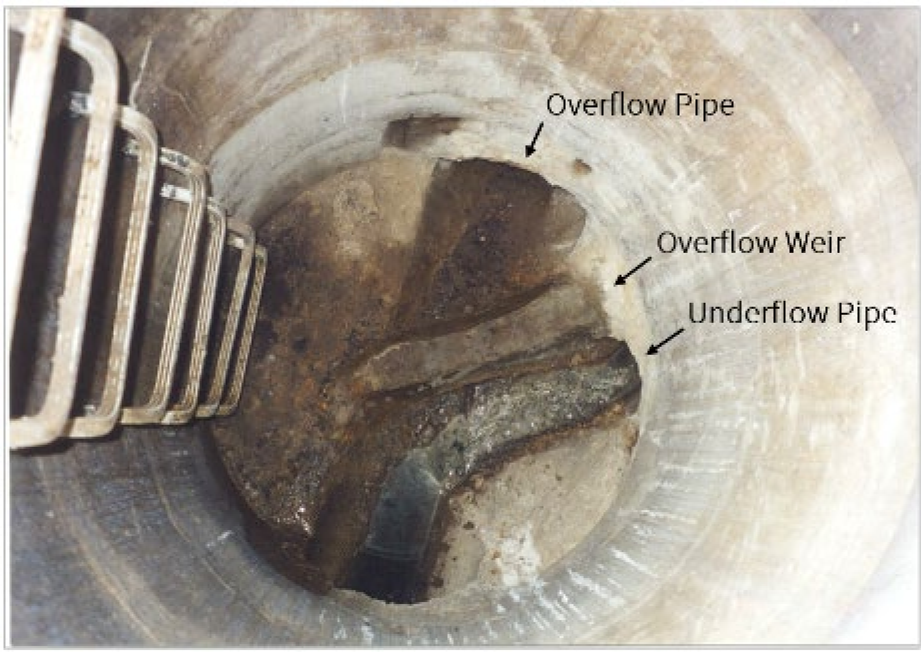


In-line Storage

Regulator Adjustment

Small adjustments can be made to CSO regulators, including orifices, transverse and side overflow weirs, and half-pipe overflow weirs, to convey more flow to the WWTP.

Where adjustments are practical, they must be carefully investigated to ensure the increased flows sent to the WWTP do not cause downstream flooding or are not simply diverted without treatment at some downstream location. These investigations require detailed knowledge of the system and how it operates, especially in respect to extreme weather events. Such adjustments are typically relatively less expensive to implement than additional storage facilities or introducing new dynamic CSO regulators, but require detailed knowledge of the system. Regulator Adjustment is a possible option for low volume / medium-high frequency CSO sites in St. Catharines.



Regulator Adjustment

Regulator Consolidation

Several of the higher priority CSO sites include multiple nearby regulators. As discussed above in Sections 6.1.3 and 6.1.5, it may be possible to consolidate and/or eliminate some of the smaller regulators to facilitate and improve cost-effect of CSO control and monitoring measures. This could involve providing relatively short interceptor sewers to collect and convey flows from multiple regulators to a single site for CSO control and monitoring. Regulator Consolidation is a possible option for CSO sites with multiple nearby CSO regulators, including: Old Port Dalhousie; the Guy Road area CSOs; and the Berryman Area CSOs.

Drainage Area Diversion

There are several locations where it may be possible to divert additional adjacent drainage sub-areas towards existing CSO tanks. This would make better use of available storage capacity, simultaneously providing relief of any existing conveyance capacity, CSO and/or basement flooding issues within the sewer system the selected sub-area currently drains to. Drainage Area Diversion is a possible option for CSO sites with an existing nearby CSO storage tank, such as the Wedsworth & Hastings CSO, along the future Chestnut Street extension, conveying excess WWF to new Glengarry Park CSO Tank. Studies of existing CSO storage facilities, including their historical performance over a period of at least ten years, would be required, to analyze their historical performance (comparing volumes of CSO captured versus available storage volume) and determine the practicality and costs of diverting flows from adjacent drainage catchments.

Increased WWF Conveyance

This option involves increasing the WWF conveyance capacity of the immediate downstream sewer system, including sanitary/combined sewers and/or SPS. Downstream conveyance capacity must be carefully investigated to ensure the increased flows do not cause downstream flooding or are not simply diverted without treatment at some downstream location, or by-passed at a WWTP. This is a viable option where spare capacity exists in downstream sewer systems to accommodate additional WWF and/or SPS downstream capacity can be increased. This alternative will be more economical where capacity bottlenecks are localized and sewers to be upgraded are relatively short.

Sewer Separation

This alternative involves the separation of existing combined sewers into separate sanitary and storm sewers and eliminating all connections (or overflows) between the two systems. Complete separation of the CSS also involves the separation of combined sewer laterals on private property and/or disconnection of all stormwater inputs, including roof downspouts, foundation drains and sump pumps. If executed properly, the sewer separation will ultimately eliminate CSOs and help to reduce basement flooding. However, sewer separation can greatly increase the volume of stormwater discharged to receiving waters, which if not also treated, can significantly offset the pollutant loading reductions provided by separating the CSS. Complete system wide sewer separation would be extremely costly and disruptive, and would take decades to complete, but selective sewer separation is a viable option for CSO sites with nearby storm outlets or receiving waters. Partial sewer separation, where foundation drains are not separated can also reduce inflows to the sewer system.

Partial separation of the CSS involves the separation of catch basins within the roadway and re-directing these flows to a storm sewer; while not modifying the existing connections on private property (e.g. foundation drains, private catch basins etc.). This option can significantly reduce peak flows to the CSS, with the corresponding benefits. However, the flows from the private properties are not abated until such time when additional actions occur such as weeping tile disconnection, property redevelopment (e.g. demolition of existing buildings), etc. To be cost effective, partial separation has been utilized in the past in conjunction with other infrastructure such as water replacement and / or road reconstruction.

Floatables Control

Most existing CSO control policies/guidelines (e.g. MOE Procedure F-5-5 and the USEPA CSO Control Policy) require the development and implementation of a program to control the discharge of coarse solids and floatable materials from the CSS. This may include measures to reduce or eliminate the entry of these materials into the CSS, to remove them from the CSS before discharge, or to remove them from the receiving water after discharge.

A study should be conducted to investigate options to provide improved floatables control at specific CSO outfalls, particularly those discharging to local receiving that are regularly used by the public. Some commonly employed methods of CSO floatables control were discussed in TM #7, including: catch basin modifications, containment booms, floating debris traps (or trash skimmers), netting systems, screens and trash racks (typically employed on WWTP bypasses) and underflow baffles.

Some recommendations for Site-Specific CSO control projects at individual CSO locations are provided below.

11.2.2 Guy Road CSO

There are some existing issues with the O&M of the Guy Road CSO storage facility, and possibly some opportunities to consolidate nearby CSO outfalls to simplify O&M and reduce CSO volumes and frequencies (PCP #80/81/83/84/85/86). A study should be conducted to assess the existing facility and investigate potential upgrades including modifications to the existing in-line storage facility, regulator consolidation (to send additional flows to modified/improved storage facility), or potentially a new off-line storage tank/pipe.

Geneva/Guy Road

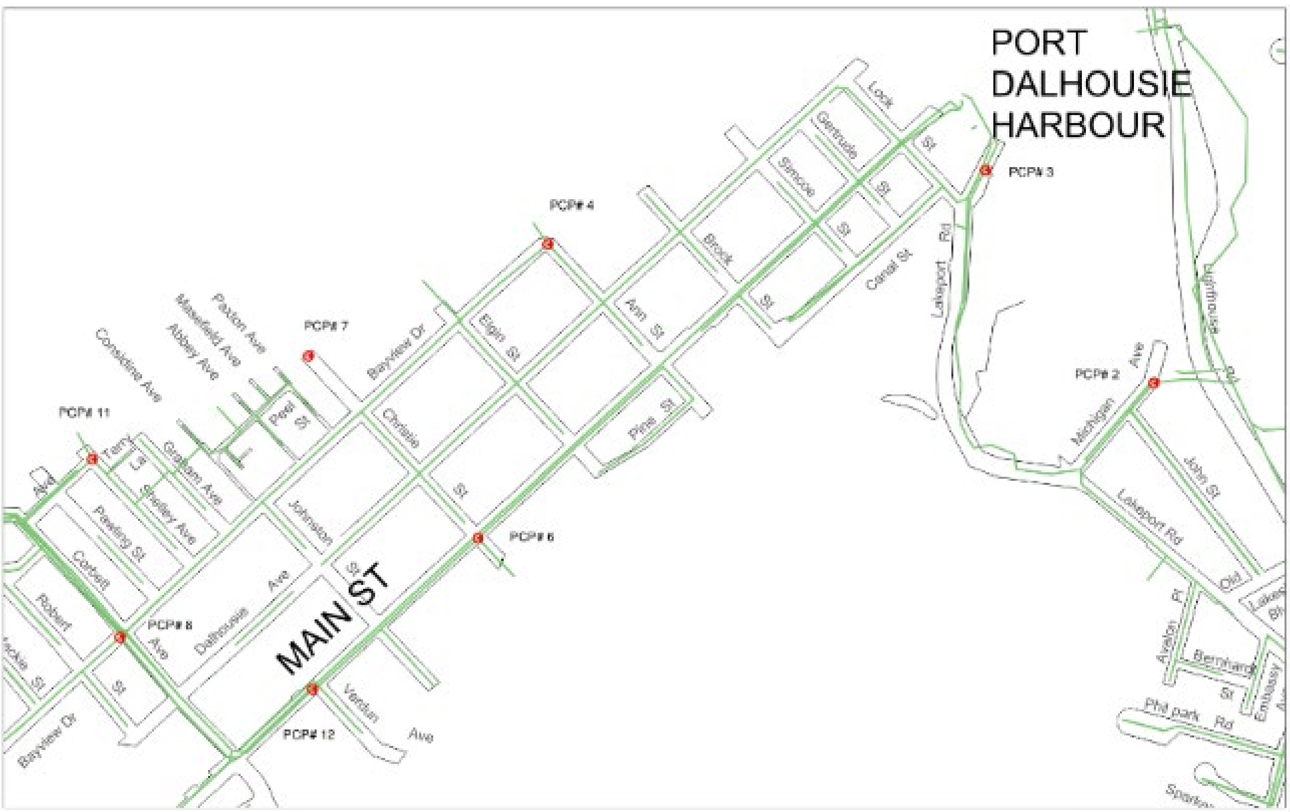
11.2.3 Old Port Dalhousie CSOs

There are a number of small CSOs in the Old Port Dalhousie area (just to the west of the WWTP), which discharge directly to Lake Ontario, including PCP #s 3/4/6/7/8/11/12, shown on the map below.

These comprise a variety of different types of overflow structures, including side/end overflow weirs and half-pipe overflows, a couple of which are shown below, including PCP #3 at the north end of Lakeport Road and PCP #6 at the intersection of Main and Christie Streets. The former includes a 0.36 m high x 2.13 m long overflow weir, overflowing to a 600 mm diameter outfall pipe; and the latter includes a 375 mm diameter half-pipe overflow, discharging to a 600 mm diameter outfall pipe.

Soils are an issue in the area, with silt/sand above but impermeable clay below, and newer homes have deeper basements where the clay layer may be increasing the potential for basement flooding.

A study should be conducted to investigate possible options for controlling the Old Port Dalhousie CSOs, including sewer separation, regulator adjustments, outfall consolidation and/or small in-line storage facilities.



Old Port Dalhousie CSOs

11.2.4 Berryman Area CSOs

There are several CSOs in the Berryman Avenue Area, which are in close proximity to each other, including PCP #s 25, 26, 115 and 116, as shown on the map below (at Ida Street, Richmond Avenue, Yale Crescent and Vine Street South respectively).

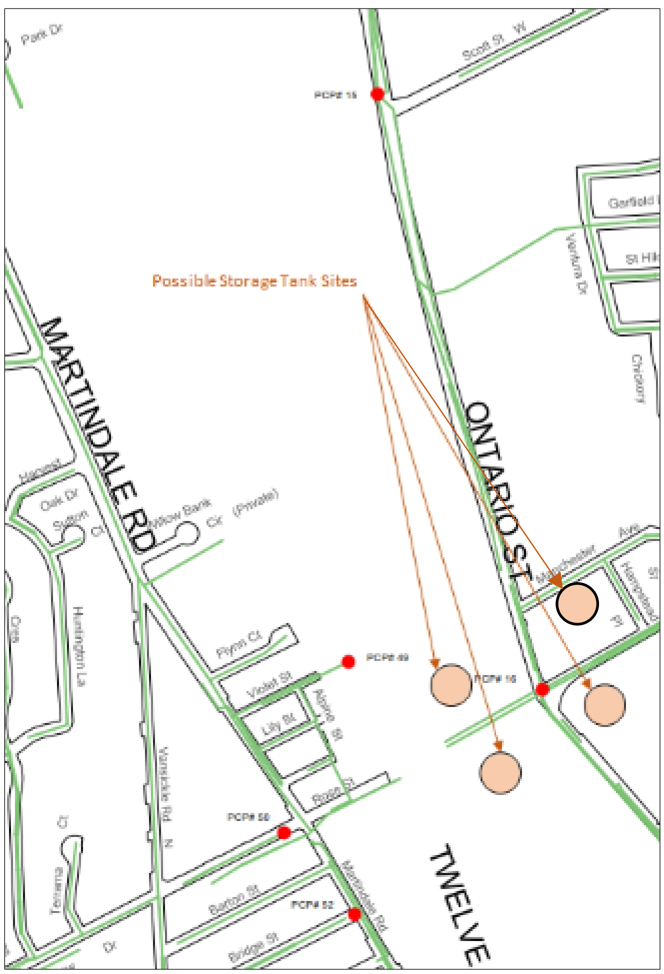
A study should be conducted to investigate possible options for controlling the Berryman Area CSOs, including the possible consolidation of these regulators to reduce CSOs, and also to facilitate future O&M activities including regulator/sewer inspection and CSO flow monitoring.   Other options for consideration include sewer separation and CSO regulator adjustments.

11.2.5 Ontario/Carlton CSO

In a typical year the CSO volumes and frequency at PCP #16, located at the intersection of Ontario/Carlton Streets, is estimated to be 37,300 m^3/yr and 6 times/yr respectively. A number of recently installed storm sewers in the Ontario/Carlton CSO service area (e.g. Lake Street, Russell Avenue) provide existing benefits in terms of reducing basement flooding, however, the flows continue to enter the downstream CSS. A study is already planned to determine how to provide an outlet for previously separated storm sewers in this area, and a further study should be conducted to investigate possible options and identify the preferred solution(s) for reducing CSO frequency, volume and duration at the Ottawa/Carlton CSO, including off-line storage, increased conveyance capacity, and sewer separation.

Future redevelopment of the nearby former General Motors site is also planned, which makes the option of a new CSO storage tank more attractive, and the study should include a detailed investigation of the practicality of this option, including confirmation of the volume of storage required to achieve the City's CSO control and basement flooding reduction targets, and estimated costs for implementation.

The map below shows the location of this CSO (and three nearby CSOs), and some possible locations for a new Ontario/Carlton CSO storage tank.



Ontario/Carlton CSO Possible Storage Tank Sites

11.3 Recommended PPCP Action Plan

Table 11-1 provides a Summary of the PPCP Action Plan Recommendations presented above, including planning/budget level cost estimates, and suggested implementation timing for implementation of the proposed CSO control programs and projects. The cost estimates and suggested implementation timing should be considered preliminary, to be refined and finalized in the Final PPCP Update Report, based on the results of further detailed discussions with the City.

Table 11-1: PPCP Action Plan Recommendations Summary

PPCP Action Plan Component	Project/Program Description	Cost Estimate	Proposed Timeline
City-Wide CSO Programs/Projects			
Rainfall & Sewer System Monitoring	Review options for modernizing the City's Rain Gauge Network, including new equipment, with improved real-time communications capabilities. Properly decommission obsolete stations. *See Chapter 11.1.1 for additional details.*	$25k	2024
	Review options for modernizing the City's Sewer Flow Monitoring Program, including real-time access to data. Properly decommission obsolete stations. *See Chapter 11.1.1 for additional details.*	$50k	2024
	Based on the preferred option (above), procure, and install rainfall monitoring and sewer flow monitoring equipment and/or services. *See Chapter 11.1.1 for additional details.*	$100k / year	2024-26
CSO Regulator /Outfall Flow Monitoring (CLI-ECA Requirement)	Assess options for a comprehensive CSO Monitoring Program, to comply with the MECP's new CSO monitoring requirements. *See Chapter 11.1.2 for additional details.*	$100k	2024/25
	Based on the preferred option (above), procure, and install CSO monitoring equipment and/or services.	$120k/yr	2024-26
CSO Regulator Modification/Consolidation	CSO Regulator Modifications Study to investigate and identify existing CSO regulators where physical modifications of the regulators may be a viable and cost-effective option to reducing CSO impacts, as well as site where modifications are required in order to install new flow meters to comply with the MECP's new CSO monitoring requirements. *See Chapter 11.1.3 for additional details.*	$150k	2025/26
	CSO Consolidation Study, following completion of the preferred CSO Monitoring Program and CSO Regulator Modification studies presented above, to investigate and identify existing CSO sites that could be most easily consolidated to facilitate real-time monitoring of CSO events, durations and/or discharge volumes. *See Chapter 11.1.3 for additional details.*	$150k	2025/26
	Capital Program to undertake the recommendations from the CSO Regulator Modifications Study and CSO Consolidation Study to modify and consolidate CSO's.	$150k/yr	2026>

Data Sharing Agreement	Agreement with Niagara Region to share collected rainfall and sanitary/combined sewer flow data.	N/C	2025/26
Sewer System Inspection and O&M	Pipeline Assessment Program - Sanitary System: Future CCTV Inspection Program - Increase frequency of CCTV inspection across the entire sanitary/combined sewer system, while also targeting the sewers that require more detailed inspections. Ideally, the City should implement the 10-year Condition Based CCTV Sewer Inspection Program proposed by the zoom camera inspection report. The report also recommended the City update its existing CCTV inspection contract specifications. *See Chapter 11.1.4 for additional details.*	$400k/yr	2024 >
	Sewer Flushing Program - The City's sewer flushing and reaming programs should be reviewed so it is aimed at the sewers that really require these cleaning activities, and the findings of the recent zoom camera inspection program should be used to develop a new priority based sewer flushing/cleaning program that addresses problem areas more regularly. *See Chapter 11.1.4 for additional details.*	$200k/yr	2024 >
	Develop and implement a formalized I/I Reduction Program including sewer flow monitoring to determine problem areas, desktop work to understand specific neighbourhood characteristics, field investigations (e.g. smoke & dye testing, inspections - visual, zoom camera, CCTV etc.) to determine and classify the sources and locations of I/I, remedial actions to address identified I/I issues, I/I reduction progress tracking and verification to measure effectiveness. Smoke testing investigations should be coordinated with other related sewer inspection activities, including the results of zoom camera, CCTV and flow monitoring programs to develop a more comprehensive and formalized approach to I/I reduction. *See Chapter 11.1.4 for additional details.*	$150/yr + repair funds budgeted elsewhere	2024 >
	The City should consider developing a Weeping Tile Disconnection Program to help homeowners partially pay for the removal of weeping tiles still connected to the CSS.	150k/yr	2024 >
CSO Regulator/Outfall Inspection (CLI-ECA Requirements)	Improved CSO O&M Staff Training - including additional training/education on layout, function and operation of each CSO structure, how to identify potential issues, and which regulators require the most attention. *See Chapter 11.1.5 for additional details.*	$20k/yr	2024 >

	In general, CSO Inspection Documentation should be improved to facilitate O&M of the existing CSO control structures, and tracking of actions taken to resolve issues. *See Chapter 11.1.5 for additional details.*	Internal Staff costs	2024 >
CSO Storage Tank O&M	CSO Tank SOPs - New Standard Operating Procedures (SOPs) should be developed for all of the City's CSO storage facilities, to provide better documentation and guidance on the O&M of the CSO tanks for City staff, and also to facilitate succession planning for when current O&M staff retire or otherwise leave the City. *See Chapter 11.1.6 for additional details.*	$50k	2024
	CSO Tank Performance Assessment - An assessment of the past performance of the City's existing CSO storage facilities should be conducted, including a review of historical CSO tank level and/or pumping data to quantify the past performance of each of the facilities in terms of CSO events prevented and/or CSO volume captured/prevented. *See Chapter 11.1.6 for additional details.*	$100k/yr	2026-28
	CSO Tank Condition Assessment - An assessment of the structural and operational condition of the City's existing CSO storage facilities should be conducted to address specific issues at each of the facilities, after the new CSO tank SOPS have been developed. *See Chapter 11.1.6 for additional details.*	$100k	2025
	SCADA Standards - Equipment and protocols related to the operation and control of the City's CSO control facilities should be standardized with Niagara Region's Supervisory Control and Data Acquisition (SCADA) system equipment and protocols. This has already been done at the new Glengarry Park CSO Tank. *See Chapter 11.1.6 for additional details.*	$1 Million	2024/25
	Coordination with Niagara Region - O&M activities for the City's CSO facilities should be closely coordinated with Niagara Region. One opportunity for additional coordination includes adding real-time information on available WWTP capacity to optimize the decision process for draining the CSO tanks. The option may also exist for Niagara Region staff at the WWTP to empty the tanks remotely when sufficient capacity exists at the plant and in the upstream trunk sewers. *See Chapter 11.1.6 for additional details.*	TBD	2024 >
Sewer System Modelling	TM #4 recommended migrating the existing XPSWMM sewer model platform to InfoSWMM, and also proposed the idea of creating a new all-pipes model of the City's wastewater collection system, and the City already retained a consultant to address both recommendations, resulting in the delivery of a new all-pipes model	$50k/yr	2024 >

	of the City's wastewater collection system, based on and expanding upon the Region's existing InfoSWMM trunk wastewater collection system model. Identify and address know gaps in the model and asset information, develop a formal process for future/ongoing model updates, and reporting. *See Chapter 11.1.7 for additional details.*		
Sewer Separation	Retrofitting or replacement of combined sewers with partially combined and new storm sewers. Typically, these are done opportunistically in conjunction with road reconstruction projects.	As per Capital Budget Forecast	2024>
Other General O&M Activities (CLI-ECA Requirements)	Level of Service (LOS) Review – A new project/program should be included in the City's future Operations or Capital Budget to update the existing LOS documents. *See Chapter 11.1.8 and TM #3 for additional details.*	$25k	2024
	Asset Management System – The City's new Asset Management Software/Database should incorporate all sewer system assets, including the sanitary, combined and separate storm sewer systems. *See Chapter 11.1.8 for additional details.*	Previously Budgeted	2024 >
	Embracing technology – utilize technology including field laptops, digital forms, electronic logbooks and mapping. Develop processes and training to facilitate this.	Budgeted elsewhere	2024>
	Pollution Prevention – Continue pollution prevention programs, including those aimed to meet F-5-5 minimum controls such as reducing fertilizer & pesticide use, street sweeping, anti-littering / anti-dumping, water conservation, rain barrels and environmental education programs.	Previously Budgeted	On-going
Site Specific CSO Control Projects			
Guy Road CSO	Guy Road CSO Tank Assessment and Investigation - Study to assess the existing facility and investigate potential upgrades including modifications to the existing in-line storage facility, regulator consolidation (to send additional flows to modified/improved storage facility), or potentially a new off-line storage tank/pipe. *See Chapter 11.2.2 for additional details.*	$100k	2027/28
Old Port Dalhousie CSOs	Old Port Dalhousie CSO Study - Study to investigate possible options for controlling the Old Port Dalhousie CSOs, including sewer separation, regulator adjustments, outfall consolidation and/or small in-line storage facilities. *See Chapter 11.2.3 for additional details.*	$100k	TBD

Berryman Area CSOs	Berryman Area CSO Consolidation Study - Study to investigate possible options for controlling the Berryman Area CSOs, including the possible consolidation of these regulators to reduce CSOs, and also to facilitate future O&M activities including regulator/sewer inspection and CSO flow monitoring. Other options for consideration include sewer separation and CSO regulator adjustments. *See Chapter 11.2.4 for additional details.*	$150k	Maybe 2027?
Ontario/Carlton CSO	Carlton Street Sewer Separation Study - Complete already planned to determine how to provide an outlet for previously separated storm sewers in this area. *See Chapter 11.2.5 for additional details.*	$75k	2027/28
	Ontario/Carlton CSO Study - Additional study to investigate possible options and identify the preferred solution(s) for reducing CSO frequency, volume and duration at the Ottawa/Carlton CSO, including off-line storage, increased conveyance capacity, and sewer separation. *See Chapter 11.2.5 for additional details.*	$250k	TBD

13. Public Consultation

Public and review agency consultation is a key element of the Class EA process for the PPCP Update Study and input was sought from various parties throughout the study.

13.1 Notice of Study Commencement

A formal Notice of Study Commencement was put on the City's website and placed in the St. Catharines Standard on October 24 and November 1, 2018. A copy of the notice is included in Figure 14-1.

13.2 Steering Committee

A Project Steering Committee was formed to oversee and direct the project, comprising City staff, and representatives from the Region of Niagara and Ontario Ministry of Environment, Conservation and Parks (MECP). The Committee met nine (9) times, including participation from the following individuals:

- Mark Green – City of St. Catharines
- Anthony Martuccio – City of St. Catharines
- Christine Adams – City of St. Catharines
- Fayaz Khan – City of St. Catharines
- Tim Marotta – City of St. Catharines
- Diane Allan Zwart – City of St. Catharines
- Nancy Brzozowski – City of St. Catharines
- Rocco Ditto – City of St. Catharines
- Dirk Hughes – City of St. Catharines
- David Stringer – City of St. Catharines
- MacKenzie Kretz – City of St. Catharines
- Mark Peat – City of St. Catharines
- Richard Daniel – City of St. Catharines
- Nick Colangelo – City of St. Catharines
- Samantha Downing – City of St. Catharines
- Olivia Groff – City of St. Catharines
- Mark Jemison – City of St. Catharines
- John Kukalis – City of St. Catharines
- Ilija Stetic – Region of Niagara
- Sean Roelofsen – MECP
- Sylvain Campbell – MECP
- Elizabeth Chee Sing – MECP

13.3 Public Information Centres

Two Public Information Centres (PICs) were held, which provided an opportunity for members of the public to learn more about the study, review the alternative solutions, and provide comments to the Project Team.

First PIC

The first PIC was held in person, on November 8, 2018, at the Kiwanis Aquatic Centre in St. Catharines. A copy of the Public Notice for the PIC was put on the City's website prior to the event and placed in the St. Catharines Standard on November 1, 2018. A copy of the notice is included in Appendix L (Public Consultation).

The objective of PIC #1 was to discuss the current situation and possible solutions and obtain the public's feedback on related issues and priorities, including CSOs and basement flooding. A number of display boards were prepared to provide information to attendees on the project, including:

+ Screen Shot from City's Project Website
+ Statement of Objective of the Project
+ Problem and Opportunity Statement
+ Flow Chart showing Municipal Class EA Process
+ Project History, Summary and Objectives
+ Common sources of Infiltration and Inflow into Sewer Systems
+ How Combined Sewers Work
+ Provincial CSO Control Requirements (Minimum CSO Controls from MECP Procedure F-5-5)
+ Possible Solutions, including pollution prevention, source controls and green infrastructure, sewer system controls, CSO storage facilities, CSO treatment, floatables control, enhanced operation and maintenance programs, and enhanced sewer system monitoring/control/reporting
+ Next Steps, including future opportunities for public consultation and feedback

Copies of the Display Boards presented at PIC #1 are included in Appendix L, along with a brief report summarizing the PIC.

Second PIC

The second PIC was held virtually, by Zoom Meeting, on November 30, 2023.

A copy of the Public Notice for the PIC was put on the City's website and placed in the St. Catharines Standard prior to the event. A copy of the notice is included in Appendix L (Public Consultation).

The objective of PIC #2 was to present the proposed PPCP Action Plan, and obtain the public's feedback on the recommended CSO and basement flooding control measures. A number of slides were presented during the virtual PIC to provide information to attendees on the project, including:

+ Summary of Meeting Agenda
+ Explanation of Combined Sewer Systems and Required Controls
+ PPCP Update Problem/Opportunity Statement
+ Explanation of Municipal Class EA Process
+ Overview/Summary of Proposed PPCP Action Plan, including:
+ City-wide CSO Programs/Projects
+ Site-specific Project/Studies
+ Next Steps, required to Complete the PPCP Update Study

Copies of the Presentation Slides from PIC #2 are included in Appendix L, along with a brief report summarizing the PIC.

13.4 Environmental Stewardship Advisory Committee

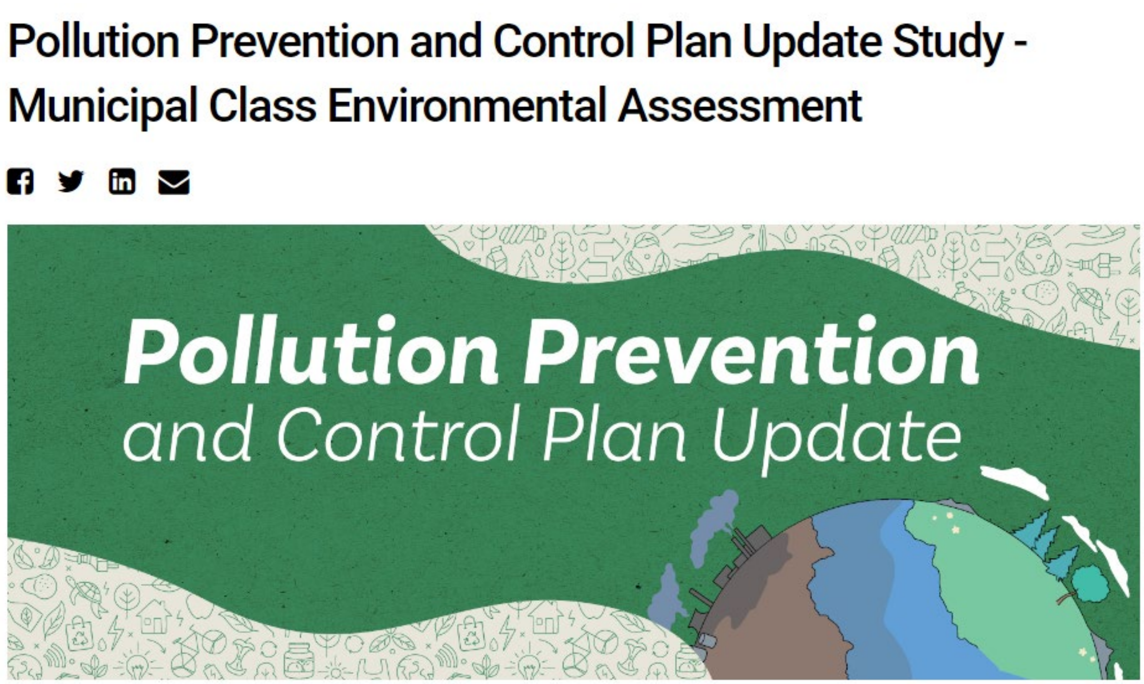
A presentation on the PPCP Update Study was also given to the City's Environmental Stewardship Advisory Committee (ESAC) at their meeting of November 7, 2023. ESAC is a volunteer committee established to provide input to City Council and staff on matters relating to the natural environment and infrastructure, which meets six times per year.

The presentation, held virtually, via Zoom Meeting, provided a progress update on the PPCP Update Study and obtain feedback from the Committee. The presentation content was similar to PIC #2, including:

+ Explanation of Combined Sewer Systems and Required Controls
+ PPCP Update Problem/Opportunity Statement
+ Overview/Summary of Proposed PPCP Action Plan, including:
+ City-wide CSO Programs/Projects
+ Site-specific Project/Studies
+ Next Steps and Timing
+ Questions and Comments

13.5 PPCP Update Study Project Website

The City maintained a PPCP Update Study Project Website for the duration of the project, which can be found on the City's Engage STC website, at engagestc.ca/PPCP



14. Glossary

ADF	Average Daily Flow
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CAD	Canadian Dollars
CAD	Computer Aided Design
CCDS	Canadian Climate Data and Scenarios
CCME	Canadian Council of Ministers of the Environment
CCTV	Closed-Circuit Television
CDS	Continuous Deflective Separation
CEPT	Chemically Enhanced Primary Treatment
CofA	Certificate of Approval
CSA	Canadian Standards Association
CSE	Confined Space Entry
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
DAF	Dissolved Air Flotation
DB	Database
DWF	Dry Weather Flow
EA	Environmental Assessment
ECA	Environmental Compliance Approval
ESR	Environmental Study Report
ESRI	Environmental Research Systems Institute
EXTRAN	Extended Transport Model of SWMM
FBM	Flow Balance Method
FLAP	Flood Alleviation Program
GI	Green Infrastructure
GIS	Geographic Information System
GWI	Groundwater Infiltration
H2S	Hydrogen Sulphide

HGL	Hydraulic Grade Line
HRPCT	High Rate Physical-Chemical Treatment
HRT	High Rate Treatment
I&C	Instrumentation and Control
ICLEI	International Council for Local Environmental Issues
IPCC	Intergovernmental Panel on Climate Change
IPZ	Intake Protection Zone
I/I	Infiltration and Inflow
LAM	Local Area Municipality
LOS	Level of Service
LID	Low Impact Development
MACP	Manhole Assessment Certification Program
MCEA	Municipal Engineers Association Class Environmental Assessment
MEA	Municipal Engineers Association
MH	Maintenance Hole
MOE	(Ontario) Ministry of Environment
MOECC	(Ontario) Ministry of Environment and Climate Change
MECP	(Ontario) Ministry of Environment, Conservation and Parks
MWWE	Municipal Waste Water Effluents
NASSCO	National Association of Sewer Service Companies
NOTL	Town of Niagara-on-the-Lake
NPCA	Niagara Peninsula Conservation Authority
NPSPA	Niagara Peninsula Source Protection Area
NWQPS	Niagara Water Quality Protection Strategy
O&G	Oil and Grease
OPSS	Ontario Provincial Standard Specification
PACP	Pipeline Assessment Certification Program
PWQO	(Ontario) Provincial Water Quality Objectives
O&M	Operation and Maintenance
PAA	Peracetic Acid
PCN	Process Control Narrative

PCP	Pollution Control Plan
PLC	Programmable Logic Controller
PPCP	Pollution Prevention and Control Plan
RDII	Rainfall Derived Inflow and Infiltration
RTB	Retention Treatment Basin
RTC	Real Time Control
SCADA	Supervisory Control and Data Acquisition
SCAPCP	St. Catharines and Area Pollution Control Plan
SEST	Sewage Equalization Storage Tank
SFG	Sediment Flushing Gate
SFT	Sediment Flushing Tank
SMP	Stormwater Master Plan
SOP	Standard Operating Procedure
SSO	Sanitary Sewer Overflow
SUDS	Sustainable Urban Drainage Systems
SWMM	Stormwater Management Model
TBRG	Tipping Bucket Rain Gauge
THM	Trihalomethane
TP	Total Phosphorus
TSS	Total Suspended Solids
USD	US Dollars
USEPA	United States Environmental Protection Agency
UV	Ultra-Violet
VSS	Vortex Solids Separator
WQI	Water Quality Index
WSER	(Canadian Federal) Wastewater Systems Effluent Regulation
WSUD	Water Sensitive Urban Design
WTP	Water Treatment Plant
WWF	Wet Weather Flow
WWMSP	Water and Wastewater Master Servicing Plan
WWTP	Wastewater Treatment Plant

15. References

Amos Environment + Planning and AWS Engineers & Planners (2003). Hamilton Ward One CSO Control Master Plan, Class EA Study. Final Report prepared for the City of Hamilton. December 2003.

CCME (2001). CCME Water Quality Index 1.0. Technical Report and Users Manual prepared by the Canadian Council of Ministers of the Environment (CCME).

CH2M Hill (2008). Port Weller Trunk Sanitary Sewer Analysis – Phase 2. Final Report prepared for the City of St. Catharines and the Regional Municipality of Niagara. August 1999.

CH2M Hill (2008). Port Dalhousie Trunk Sewer and CSO Study. Final Report prepared for the City of St. Catharines. March 2006.

CH2M Hill (2008). Pollution Control Plan for the Cities of St. Catharines and Thorold – Port Dalhousie and Port Weller Sewersheds. Final Report prepared for the City of St. Catharines, City of Thorold, and the Regional Municipality of Niagara. August 2008.

CH2M Hill (2010-16). City of St. Catharines – 2010-16 XPSWMM Model Updates. Tech Memos prepared for the City of St. Catharines. Prepared annually from 2011-2017.

CH2M Hill (2017). City of St. Catharines – Wastewater System Effluent Reporting – 2010-16. Tech Memos prepared for the City of St. Catharines. Prepared annually from 2011-17.

CH2M Hill and MacViro (2003). Water and Wastewater Master Service Plan. Final Report prepared for the Regional Municipality of Niagara.

CH2M Hill, MacViro and Philips (2003). Niagara Water Quality Protection Strategy. Series of different reports prepared for the City of St. Catharines. March 2006.

City of St. Catharines (1990). St. Catharines Area Pollution Control Plan. Final Report prepared for the Ontario Ministry of Environment (MOE).

City of St. Catharines (2002). Operations Levels of Service Documents, Prepared by the Transportation and Environmental Services Department, City of St. Catharines. July 2001.

City of St. Catharines (2013). Asset Management Plan. Recommendation Report FMS-TES-388-2013 prepared for City Council. November 2013.

City of St. Catharines (2014). Flood Alleviation Program Grant Limits. Recommendation Report TES-224-2014 prepared for City Council. July 2014.

City of St. Catharines (2015). Investigation into Flooding in South-West St. Catharines. Information Report TES-020-2015 prepared for City Council. January 2015.

City of St. Catharines (2015). Sewer Flow Monitoring Equipment Purchase. Recommendation Report TES-227-2015 prepared for City Council. July 2015.

City of St. Catharines (2015). Water Quality Index Evaluation for St. Catharines, 2014. Report prepared by City of St. Catharines Environmental Services Division. Prepared annually.

City of St. Catharines (2016). Certificate of Approval Municipal and Private Sewage Works 2015 Performance Report. Report prepared by City of St. Catharines Environmental Services Division for the Ontario Ministry of Environment and Climate Change (MOECC). March 2016. Prepared annually.

DFA Infrastructure International (2006). Evaluation and Audit of Sanitary Combined Sewer Overflows. Draft Final Report prepared for the Regional Municipality of Niagara. August 2006.

GM BluePlan (2017). 2016 Water and Wastewater Master Servicing Plan Update. Final Report prepared for the Regional Municipality of Niagara. June 2017.

Hatch Mott MacDonald and XCG (2008). Northeast Area Wastewater Servicing Study. Final Report prepared for the Regional Municipality of Niagara. July 2008.

Hatch Mott MacDonald (2012). Port Weller WWTP High Rate Treatment Preliminary Design Brief. Draft Report prepared for the Regional Municipality of Niagara. September 2012.

Hydromantis and CH2M Hill (2005). City of St. Catharines CSO HRT Feasibility Study. Final Report prepared for the City of St. Catharines.

ICLEI Canada (2016). Climate Change in Niagara Region. Report prepared for the City of St. Catharines in September 2016.

MacViro (2004). Combined Sewer Separation Project Remedial Works Class EA Report. Final Report prepared for the City of Thorold. March 2004.

Marbek Resource Consultants Ltd. (2009). Model Sewer Use Bylaw Guidance Document. Report prepared for the Canadian Council of Ministers of the Environment. February 2009.

Municipal Engineers Association (2000). Municipal Class Environmental Assessment (MCEA) Manual. October 2000, as amended in 2007, 2001 and 2015.

Niagara Peninsula Conservation Authority (2006). Twelve Mile Creek Watershed Plan. April 2006.

Niagara Peninsula Conservation Authority (2013). Source Protection Plan for the Niagara Peninsula Source Protections Area. Report prepared under the Clean Water Act, 2006 (Ontario Regulation 287/07). December 2013.

Ontario Ministry of the Environment (1997). Procedure F-5-5 for the Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems. February 1997.

Regional Municipality of Niagara (2016). Combined Sewer Overflow Control Policy 2016 Funding Recommendations. Report PW 19-2016 to Niagara Region Public Works Committee. May 2016.

Sustainable Technologies Evaluation Program - STEP (2011). Low Impact Development Stormwater Management Planning and Design Guide. Report prepared in cooperation with the Grand River Conservation Authority and Toronto and Region Conservation Authority. 2011.

Thompson Flow Investigations Inc. (2014). Smoke Testing of the Westland/Welstead Sewershed in the City of St. Catharines. Report prepared for the City of St. Catharines. September 2014.

Thompson Flow Investigations Inc. (2015). Smoke Testing of Sanitary Sewers in Work Sector 36 in the City of St. Catharines. Report prepared for the City of St. Catharines. November 2015.

United States Environmental Protection Agency (1997)\. Combined Sewer Overflow (CSO) Control Policy. National Pollutant Discharge Elimination System (NPDES) CSO Control Policy. April 1994.

XCG (2004). Combined Sewer Overflow Treatment Technologies Design Manual. Prepared in cooperation with the National Water Resources Institute (NWRI), Great Lakes Sustainability Fund, City of Welland and Niagara Region. 2004.

XCG and Hatch Mott MacDonald (2011). Port Weller WWTP High Rate Treatment Facility Environmental Study Report. Final Report prepared for the Regional Municipality of Niagara. December 2011.

Appendix A

Tech Memo #1
Review of Previous Reports

Appendix B

Tech Memo #2

Review of 2008 Pollution Control Plan

Appendix C

Tech Memo #3

Rainfall/Flow Monitoring and O&M Program Review

Appendix D

Tech Memo #4

Sewer Model Review and Assessment

Appendix E

Tech Memo #5

Gap Analysis

Appendix F

Tech Memo #6

Updated Hydraulic Modelling Analysis

Appendix G

Tech Memo #7

CSO Control Alternatives and Evaluation Methods

Appendix H

Tech Memo #8

PPCP Action Plan

Appendix I

Tech Memo #9

Climate Change Assessment