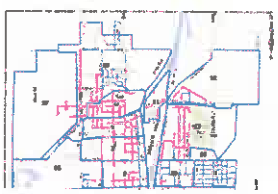
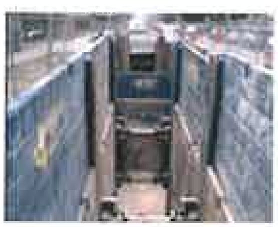
FINAL REPORT

The City of Port Colborne

Storm Sewer System
Infrastructure Needs Study





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January 2015

Executive Summary

1 INTRODUCTION

1.1 Background

The City of Port Colborne's Storm System collects runoff from approximately 1,530 ha of catchment area, with an urban area of approximately 2,380 ha and a population of approximately 19,300. The City's storm water collection system is a mix of urban and semi urban design comprised of approximately 96km of storm sewers plus a series of roadside ditches and swales. The City's drainage system has evolved and expanded from the earliest storm pipe installations dating back to 1929. Over the years, many roadside ditches were informally replaced with local storm pipes that were not necessarily deigned to any prevailing standard.

In some areas where basements were susceptible to high water tables and seepage, private sump pumps were installed and directed to the sanitary sewer system. To relieve the pressure on the sanitary collection system and the wastewater treatment plant, it is desirable to redirect these sump pump discharges to the storm water collection system, assuming adequate capacity exists.

The City's previous storm sewer master plan was completed in 1978. The City now requires an up to date assessment of storm sewer servicing needs, and a sustainable means of financing the needed capital investments and maintenance works.

1.2 Study Objectives

The objectives of this study are to:

- undertake a comprehensive analysis of the City's existing storm sewer network to identify existing and potential future deficiencies in the collection of storm water runoff,
- address applicable storm water discharge quality regulations including the Niagara Peninsula Conservation Authority, Ministry of the Environment, and the City of Port Colborne,
- define and prioritize maintenance works and capital upgrades that are required to service existing and future land use for the next 25 years, and
- develop a suitable financing strategy to support the recommended capital and maintenance program.

1.3 Study Area

The Study Area is defined as the Urban Area Boundary of the City of Port Colborne, as illustrated by Figure ES-1.

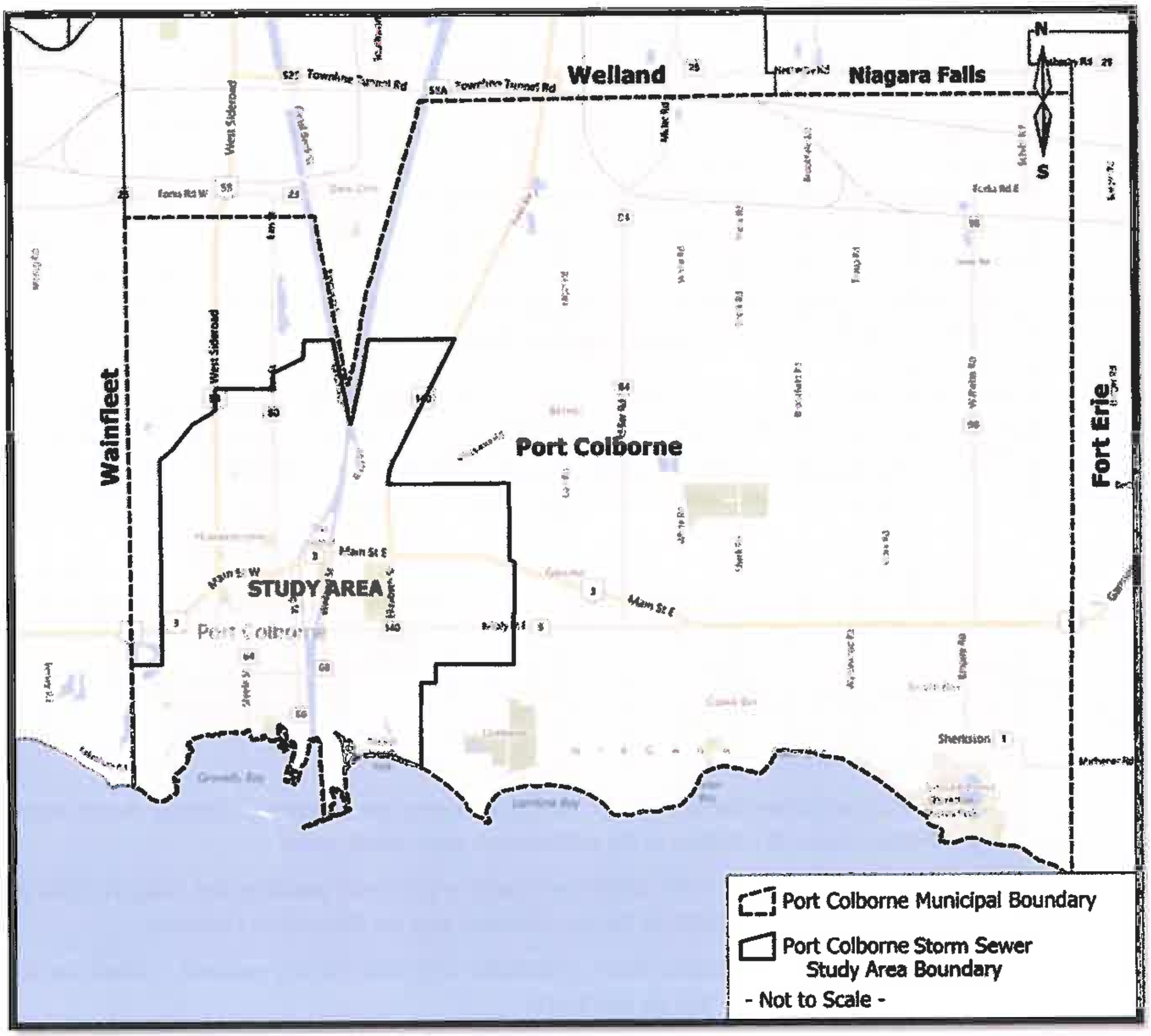

Figure ES-1
Storm Sewer Study Area Boundary

1.4 Municipal Class Environmental Assessment Process

This study was undertaken as a Master Plan in accordance with the Municipal Engineer's Association Municipal Class Environmental Assessment (EA) Guidelines. As a Master Plan project, this study is intended to satisfy Phases 1 and 2 of the Municipal Class EA planning process. Individual projects identified by the study may be subject to additional Municipal Class EA planning and approvals prior to implementation. Additional information regarding the Municipal Class EA process is included in Appendix A.

The Problem Statement for this study is as follows:

> *The City of Port Colborne requires a comprehensive assessment of its existing storm sewer infrastructure to identify and prioritize policies, upgrades and expansion that are required to achieve the City's level of service objectives for storm drainage over the next 25 years.*

2 EXISTING SYSTEM CHARACTERISTICS

2.1 Existing Storm Sewer Drainage Areas and Outlets

The existing storm sewer network is divided into 22 drainage areas, which are generally defined by the ground surface topography as illustrated by Figure ES-2. Review of the supplied background data and information collected during field surveys concluded that the existing storm sewers discharge through 32 outlets to the Welland Canal, Lake Erie, the Eagle Marsh Municipal Drain including some smaller outlets to rear yard ditches.

It is recommended that all outfalls that are directly affected by Lake Erie water levels be equipped with flap gates to provide flood protection. It is also recommended that all flap gates be regularly inspected and maintained to ensure closure during high lake and marsh levels.

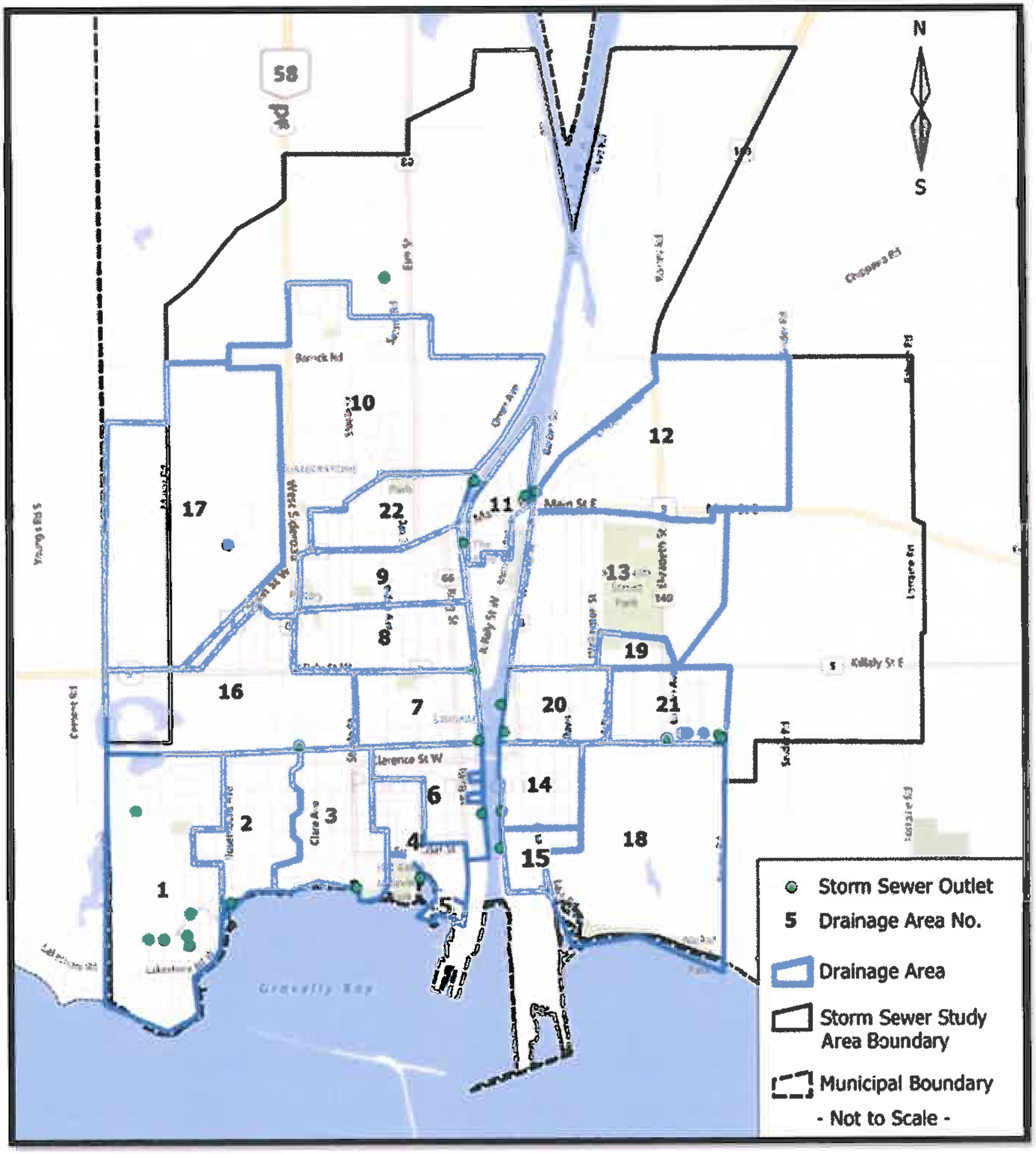

Figure ES-2
Storm Sewer Drainage Areas

2.2 Existing Storm Sewer Condition

As part of the City's Inflow and Infiltration (I&I) Reduction Program, AE conducted a detailed review of the storm sewers in the Nickel Area (Storm Drainage Areas 14 and 15), and a portion of the Omer Area (Storm Drainage Area 22). As part of the current study, AE also reviewed a number of storm sewer inspection reports for Storm Drainage Areas 2, 3 and 4.

In general, the sewers reviewed by AE were in poor condition, with several exhibiting significant defects and stages of collapse. Based on the available information, the sewers reviewed appear to be classified as "non-designed" or "semi-designed". Presumably, the more recently constructed "designed" sewers are in better condition than the sewers reviewed by AE, however this can only be verified by inspection.

It is recommended that the City initiate a regularly scheduled program of flushing and inspection to monitor the condition of its storm sewers, and identify repair/upgrade needs on a proactive, rather than reactive, basis. Such a program will require careful planning to ensure that the resulting reports accurately identify the exact location of the subject sewers, which will require improvement of the City's storm sewer GIS to create unique identifiers for each asset, particularly manholes.

2.3 Existing Level of Service

The level of service provided by the existing storm sewer network varies throughout the City based on factors such as the design and construction methodologies that have been employed over the duration of the network's development, and the age of the various portions of the network.

In order to characterize the existing level of service, AE conducted a cursory review of drainage issues recorded in the City's "Lotus Notes" customer service/work order database. Review of the issue descriptions indicated that, other than those related to debris and tall grass in ditches, many of the issues were related to surface ponding due to poor grading. Issues were found to be evenly distributed across the City, with no one area identified as particularly problematic.

3 HYDRAULIC MODEL DEVELOPMENT

A model of the City's existing storm sewer system was developed on behalf of Associated Engineering by GeoAdvice Engineering, using the InfoSWMM hydraulic modeling software application.

The model's network topology was built primarily using the City's existing storm sewer infrastructure GIS data sets. The supplied GIS data was used as much as possible; however a number of connectivity issues and data gaps remained. As well, a substantial amount of the storm water data was found to be missing either diameter or invert elevation data. In order to fill the data gaps, AE relied on field surveys, existing engineering drawings and interviews with City Staff. Remaining data gaps were filled by interpolating data from neighbouring pipes and from ground elevations.

The hydraulic model was calibrated using storm sewer flow and rainfall data collected between April 8, 2013 and June 17, 2013. Rainfall data collected at the Region of Niagara's Seaway wastewater treatment plant was provided by the Region of Niagara. Storm sewer flow data was collected at the Princess St. and Killaly St. storm sewer outlets.

4 HYDRAULIC MODELLING - EXISTING CONDITIONS

4.1 System Performance Criteria

The evaluation criteria used to assess the City of Port Colborne drainage system are summarized below.

Table ES-1
System Performance Criteria

Criteria For	Criteria
Upgrading existing pipes	
Deficient	if $d/D > 1.0$ and $q/Q > 1.0$ and surcharged > 15min
Not Deficient	if $d/D > 1.0$ and $q/Q > 1.0$ and surcharged < 15min
	if $d/D > 1.0$ and $q/Q < 1.0$
	if $d/D < 1.0$ and $q/Q < 1.0$
Replacing existing frontage tiles	All replaced with pipe(s) or ditch, scenario based
Upgrading existing channels & swales	Upgrade if HGL > GE
New pipe design	At peak flow rate $d/D =< 0.8$ and $q/Q < 1.0$
New channel design	At peak flow rate HGL < GE

Notes:
- Criteria is based on the 5-year return period Chicago design storm
- HGL: Hydraulic Grade Line
- GE: Ground Elevation
- d: depth of flow
- D: pipe diameter
- q: peak flow rate
- Q: full pipe capacity flow rate

4.2 Existing System Capacity – 2 Year Storm

Hydraulic model simulation of the 1:2 year storm was used to assess the existing system capacity under relatively frequent rainfall events. This simulation used existing land use conditions and assumed that private sump pumps were not contributing to the storm sewer network.

The results of this simulation indicate that approximately 11km of the City's existing storm sewers are considered deficient under the 1:2 year storm, and therefore do not meet the City's current 1:5 year design storm standard.

4.3 Existing System Capacity – 5 Year Storm with Sump Pump Discharges

Hydraulic model simulation of the 1:5 year storm was used to assess the existing system capacity relative to the City's design storm event, and to assess the impact of redirecting private sump pumps to the storm sewers in the Nickel and Omer Inflow and Infiltration Reduction Program study areas.

The results of this simulation indicate that:

- Approximately 16km of the City's existing storm sewers are considered deficient under the 1:5 year storm.
- With the exception of those in Drainage Area 1, the majority of the "designed" sewers meet the City's design standard. While the model does indicate that some of the "designed" sewers do not have adequate capacity, surface flooding is only predicted at four locations. Many of these hydraulic deficiencies may be due to the limited accuracy of assumed sewer inverts.
- The majority of "semi-designed" and "non-designed" sewers are deficient under both the 1:2 year and 1:5 year storm events, with surface flooding predicted at several locations. This is not surprising given that these sewers were not designed to current standards, and that many are the tiled system that resulted from infilling of ditches with little consistency in sewer sizes or grades.

5 PLANNING FOR GROWTH AND IMPROVEMENTS

Drivers for system improvements include:

- The need to address the structural condition of the existing storm sewers.
- The need to improve the level of service based on customer complaints.
- The need to provide additional capacity to accommodate potential development.
- The need to provide additional capacity to accommodate Community Improvement Plans, or to coordinate system improvements with implementation of CIP's.
- The need to address the recommendations of other City Initiatives such as the Inflow and Infiltration Reduction Program (primarily to accommodate sump pump disconnection).

Table ES-2, below, lists the drivers that were identified for each drainage area, based on the available background information. Note that the need to address the structural condition of the existing storm sewers likely applies to more areas than those listed below.

Table ES-2
Drivers for System Improvements

Area No./Outlet Name	Drivers for System Improvements
1 - Eagle Marsh Drain	• Development Capacity - Bayview Lane (0.7ha) Westwood Phase 2 (9.6ha), Westwood Park Secondary Plan (V8, 30.6ha)
2 - Rosemount Avenue	• Development Capacity - CMT Lots (1.2ha)
3 - Steele Street/Sugarloaf	• None identified
4 - Elm Street	• None identified
5 - Marina	• None identified
6 - Victoria Street/Downtown	• Downtown Central Business Area CIP
7 - Princess Street	• None identified
8 - Killaly Street West/Steele	• None identified
9 - Neff Street	• Olde Humberstone CIP
10 - Cedar Street *	• Development Capacity - V6* Residential Development (1.9ha), Rosedale (V2, 12.8ha), Meadow Heights (30.5ha) • Satisfy I&I reduction initiatives (Omer Area I&I Program).
11 – Island *	• Olde Humberstone Village* (3.1ha)
12 - Barber Drive *	• Development Capacity - Chippawa Estates (3.5ha), V5* Residential Development (0.9ha)
13 - Bell Street North * (Clarke)	• Development Capacity - V1 and V7* Residential Developments (3.1ha, 31.2ha) • Address resident complaints identified by City
14 - Nickel Street	• East Waterfront CIP • Satisfy I&I reduction initiatives (Nickel Area I&I Program). • Address condition of existing storm sewer identified by I&I program. • Separate "Municipal" runoff from "Vale" runoff tributary to Vale's private treatment facility.
15 - Rodney Street	• East Waterfront CIP • Satisfy I&I reduction initiatives (Nickel Area I&I Program). • Address condition of existing storm sewer identified by I&I program.

Area No./Outlet Name	Drivers for System Improvements
	• Separate "Municipal" runoff from "Vale" runoff tributary to Vale's private treatment facility.
16 - Quarry	• Development Capacity - Rosemount Estates (38.5ha)
17 - Eagle Marsh Ext.	• Development Capacity - Northland Estates (15.8ha), V3 and V4 Residential Developments (54.2ha, 7.8ha)
18 - Vale	• Coordinate with work in Areas 14 and 15 to separate "Municipal" and "Vale" runoff.
19 - Bell Street Northeast	• None Identified
20 - Bell Street East	• None Identified
21 - Bell Street West	• None Identified
22 - Omer Avenue	• Satisfy I&I reduction initiatives (Omer Area I&I Program). • Address condition of existing storm sewer identified by I&I program.

Potential future residential development areas are identified by the City are illustrated by Figure ES-3. No additional industrial, commercial, or institutional developments were identified.

It is assumed that all future developments will include provisions for the construction of storm sewers and storm water management facilities. Internal servicing costs associated with new developments will therefore be borne by the developers. It is also assumed that future storm water management facilities will meet objectives for storm water runoff quality and quantity, and will therefore mitigate impacts of post-development runoff. For some of the identified potential developments, marked * in the table above, extension or upgrades of existing storm sewers may be required in order to convey future development flows to existing outlets. In these cases, the required extension or upgrades may benefit existing users, and the costs may be shared by the developer and the City. In other cases, future developments will include provisions for new storm sewer outlets and will have no impact on the existing system.

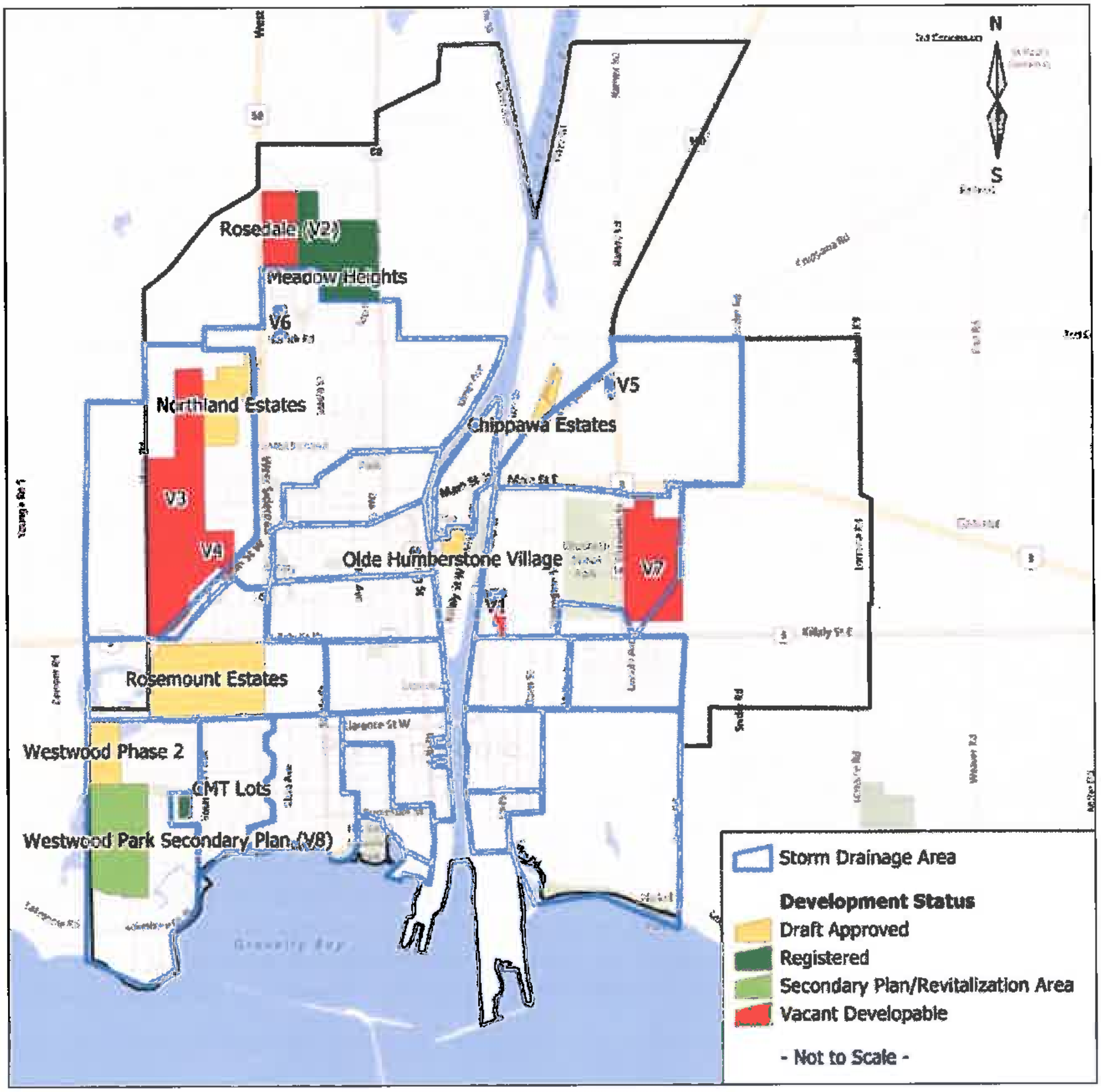

Figure ES-3
Future Residential Development Areas

6 CAPITAL PLAN

6.1 Proposed Improvements

The following system improvement categories are defined for the development of the Capital Plan:

- Upgrade Existing Sewer - Upsize existing "Designed" or "Semi-Designed" sewers to 5-year storm capacity
- Reconstruct Existing Sewer - Replace existing "Non-Designed" sewers with a conduit (ditch, single pipe, or dual pipe). Also includes "Semi-Designed" sewers in Areas 14 and 15. Cost estimate assumes single pipe.
- New Dedicated Sump Pump Drain - New storm sewers to accommodate sump pumps only in existing un-serviced areas
- Service New Developments – Construct new storm sewers required to service proposed developments

Table ES-3 summarizes the proposed improvements for each drainage area. Approximately 31km of pipe upgrades and reconstruction are recommended, in addition to the construction of approximately 4.7km of new infrastructure to service new development and accommodate sump pump disconnection in currently un-serviced areas. A complete listing of each conduit is provided in Appendix C, Table C-1 and forms the basis of the Capital Plan.

Figure ES-4 illustrates the recommended capital works by system improvement category, and indicates pipe diameters to accommodate the 5-year storm. The improvement categories and pipe diameters shown correspond to those listed in Appendix C, Table C-1.

Table ES-3
Proposed Improvement Summary (in 2014 $)

Drainage Area	Upgrade Ex. Sewer	Reconstruct Ex. Sewer	New Third Pipe	New Storm Service	Total	Estimated Cost
	------ Length of Upgrades (m) ------					
1	760	529			1,289	$1,941,560
2	970	2,157			3,127	$4,971,996
3		1,304	1,084		2,388	$3,653,896
4	329	720	308		1,357	$1,954,816
6	69	1,203	351		1,623	$2,400,308
7		1,867	75		1,942	$2,916,525
8	450	1,690			2,140	$3,153,645
9	793	2,707			3,500	$5,220,875
10	988	2,358	406	145	3,897	$5,424,044
11	421			495	916	$1,610,425
12	55	825		688	1,568	$2,262,235
13		2,545		628	3,173	$5,071,906
14-15		3,889			3,889	$6,380,462
17		778			778	$1,158,240
20	52	206	519		777	$988,041
21	45				45	$191,287
22		3,278			3,278	$4,837,708
Total	**4,932**	**26,056**	**2,743**	**1,956**	**35,687**	**$54,137,969**

A complete listing of all conduits, including length, required flow rate, and suggested pipe diameter is included in Appendix C. Details of the cost estimate are provided in Appendix D.

7 INFRASTRUCTURE RENEWAL AND SUSTAINABILITY

The infrastructure improvements recommended by this Master Plan represent a significant capital investment program for the City of Port Colborne. Potential revenue sources, user fees and rate structures to fund the recommended capital plan are examined and cash flow requirements are presented.

7.1 Development of Revenue Sources

Potential municipal revenue sources including property taxes, local improvement charges, development charges, and storm sewer user fees are compared against basic evaluation criteria in Table ES-4. Each revenue source has merits under particular conditions. The development of storm sewer user fees, which can be assessed based on various combinations of parcel area and parcel imperviousness, and various rate structures, is examined in detail.

Table ES-4
Comparison of Revenue Instruments

Criteria	Property Taxes	Local Improvement Charges	Development Charges	Storm Sewer User Fees
EQUITABLE – payments by customers are commensurate with the level of service required and the benefit received*	NO –based on assessed property value which has little bearing on the demand for service	Can be if costs are apportioned appropriately. Apportionment by frontage is not equitable.	NO – costs are apportioned by floor area of buildings which has little bearing on the demand for service	YES - if costs are apportioned based on contribution to runoff (some fee structures do not do this)
DEDICATED – collected revenues should be dedicated to storm water services	NO – revenues go to general fund (special area rates are dedicated)	YES – to specific growth related capital projects	YES – to specific growth related capital projects	YES – dedicated to storm water services
SUSTAINABLE – allows budgeting based on long term planning of funding requirements	NO – competing priorities can cause funding levels to vary	YES – funding for the covered project is guaranteed	YES – funding for the covered projects is guaranteed	YES – dedicated funding allows long term financial planning
AREA-WIDE – covers the total program area	YES – covers entire municipal area	NO – applies only to the local improvement area	NO – applies only to lands subject to new development or redevelopment	YES – covers entire storm water system service area
ALL COSTS – applies to all program costs	YES – revenues cover operating, maintenance and investments	NO – revenues cover only capital investments	NO – revenues cover only capital investments	YES – revenues cover operating, maintenance and investments
INCENTIVE –customers can save by reducing their demands for service**	NO – no credits for on-site storm water controls	NO – no credits for on-site storm water controls	NO – no credits for on-site storm water controls	YES – user fee program can include credits for on-site storm water controls
UNDERSTANDABLE – the customer charge is reasonably easy to understand	YES –in place long enough that most customers understand it now	YES – relatively simple charge levied on the tax bill	YES – Property owners not charged directly. Most developers understand the charge	NO – Many will likely be confused at first since storm water systems are probably poorly understood
IMPLEMENTATION – implementation costs should be relatively low	YES – already implemented	NO – case by case implementation with possibility of petitions to challenge projects	YES – already implemented	NO – new program costs incurred for design and public consultation and to establish customer data base, billing and collections system
ADMINISTRATION – administrative effort should be relatively low	YES – resources already committed	YES – once implemented, annual charges should be easy to levy	YES – resources already committed	NO – customer records require periodic updating, any credit program involves additional resources

* Requires that storm water service costs be allocated to customers in proportion to the contribution of their properties to storm water runoff.

** Requires that customers can reduce their service charge by controlling runoff from their property.

7.2 Financial Plan

The financial analysis indicates that the levelized annual cash requirement of the proposed capital improvements is estimated to be approximately $3.02 million at 2014 prices.

Three alternative approaches to recover the required costs are considered: two based on storm water user fees and one based on property tax. The user fee approaches include one based on total parcel size and one based on the size of the parcel's impervious area.

Table ES-5 summarizes the charge schedules to recover the required amount of $3.02 million per year.

Table ES-5
Sewer User Charges

Parcel Class	Sewer User Charge		Property tax (0.1701%**)
	By Parcel Area ($0.0268/m^2)	By Impervious Area ($1.0661/m^2)	
Not Coded	$76	$403	na
Commercial	$274	$1,275	$762
Industrial	$1,039	$1,838	$1,676
Multi-residential	$99	$1,134	$3,842
Public*	$0	$0	$0
Residential	$114	$218	$295
Farm/forest	$3,959	$995	$29
All	$346	$346	$346

* No cost recovery from public properties
**% of assessed parcel value

The following observations can be made based on the above:

- The different approaches to cost recovery allocate costs in markedly different ways but the average cost per parcel is the same across all three approaches as expected.
- The amount that individual property owners pay will differ from the amounts calculated since several parcels may be owned by single persons or companies.
- The parcel area storm water charge places a heavy burden on farm properties. This burden shifts to industrial, commercial and multi-residential properties with the two other charges.
- Charges for residential parcels vary least across the three charging approaches.
- The impervious area charge likely comes closest to a charge that allocates costs based on average parcel contributions of storm water runoff to flows in storm sewers.

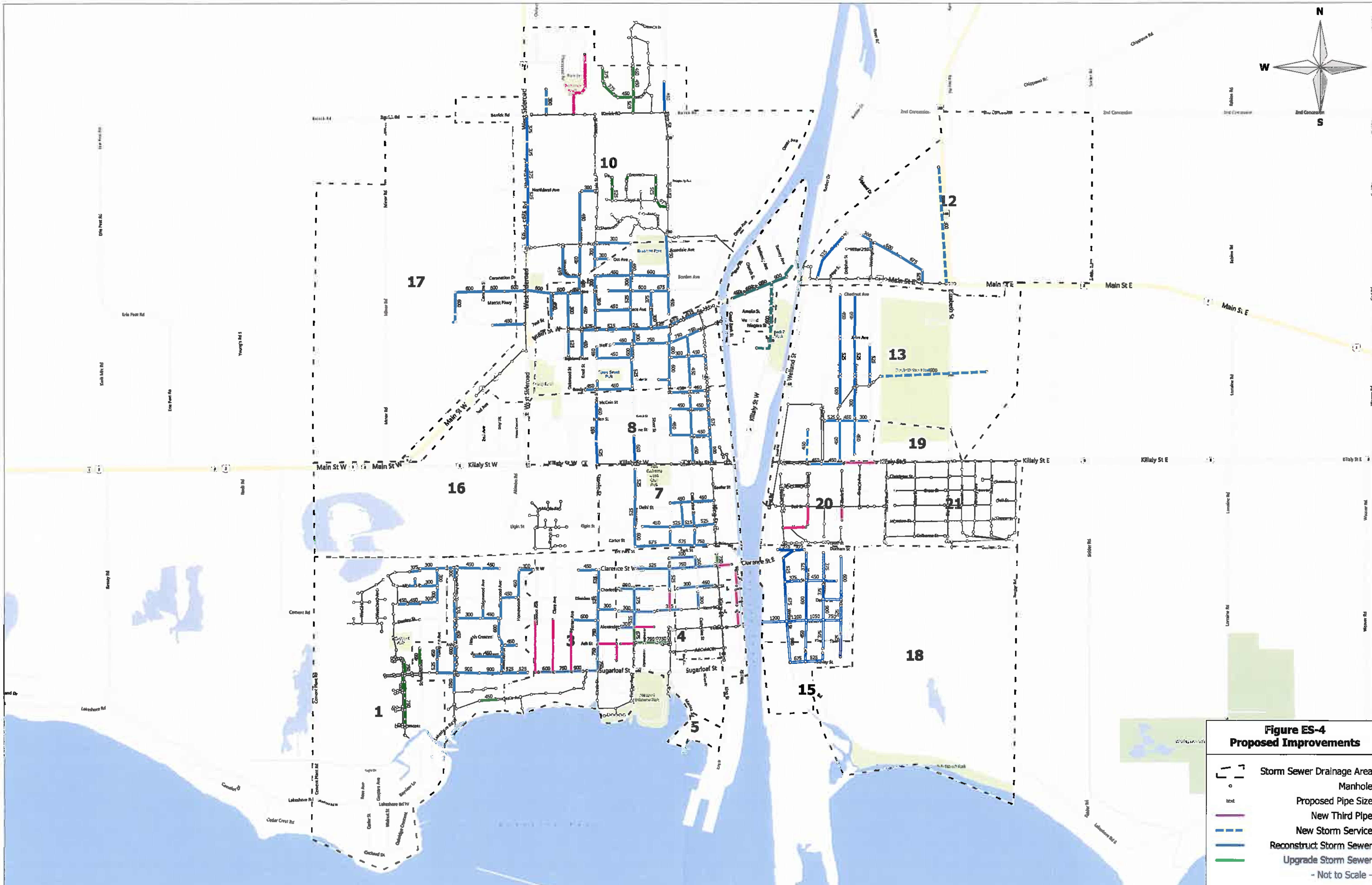

Figure ES-4
Proposed Improvements

8 IMPLEMENTATION OF PROPOSED IMPROVEMENTS

Implementation of the recommended improvements considers a variety of factors including condition, capacity, planned development and infill, I&I reduction, and complaints. However, improvements to the storm water system, particularly when flow is being added, should generally progress starting from the most downstream end. The recommended implementation strategy is as follows:

- Continue collection of storm sewer network data including pipe inverts, material, and diameters, manhole rim elevations, pipe connectivity, and records of houses with sump pumps. We note that the model results are only as good as the network data that was available through the various investigations completed as part of this study. We recommend an ongoing program to collect storm sewer network data so that a complete GIS database can be developed to the degree possible. The hydraulic models should be updated and re-run upon the collection of significant amounts of data.
- Inspect and maintain all outfalls and make sure flap gates are in good working order.
- Replace all failing pipes and expand inspection efforts with Closed Circuit Television (CCTV).
- Replace storm sewer pipes that are identified as being undersized for the 2-year storm without the addition of sump pump flows. Proceed from the most downstream location. Focus first on areas where infill development is anticipated.
- Upgrade storm sewer pipes to the specified level of service (5-year return period with sump pump flows added), proceeding from downstream to upstream. Focus first on areas where development is anticipated.
- Encourage re-direction of sump pumps from the sanitary to the storm system as the downstream storm sewer network is upgraded.
- Add new laterals to currently un-serviced areas as the downstream network is upgraded from the outfall to the point of interest. Connect sump pumps. If larger pipes are selected, add CB's and other drainage infrastructure.

With respect to implementation of a storm water user fee, it is recommended that the City undertake the following tasks.

- Establish and maintain a geo-referenced customer data set with data fields including property ID and ownership, customer classification, gross area, impervious area, status of credits, etc.
- Develop policies, procedures and resources for revising, validating and updating the database.
- Review system costs and determine full-costs of the storm water system including capital plans and asset management costs. Estimate any new costs associated with implementation of the new user fee including for billing software.
- Review cost reporting policies and procedures including the chart of accounts and revise as needed to facilitate future budgeting and rate setting exercises. Storm water costs should be segregated in accounting records.

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1 Introduction

1.1 BACKGROUND

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1.2 STUDY OBJECTIVES

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- address applicable storm water discharge quality regulations including the Niagara Peninsula Conservation Authority, Ministry of the Environment, and the City of Port Colborne,
- define and prioritize maintenance works and capital upgrades that are required to service existing and future land use for the next 25 years, and
- develop a suitable financing strategy to support the recommended capital and maintenance program.

1.3 PREVIOUS STUDIES

1.3.1 City of Port Colborne Storm Sewer Study, 1978

The 1978 City of Port Colborne Storm Sewer Study was the City's most recent storm drainage master plan. Objectives of the 1978 master plan were to provide the basis for storm sewer design for the next 20 years, and to develop a solution for existing flooding problems, particularly in the low lying downtown area. The master plan recommended the construction of storm sewers throughout the urban area to replace existing substandard sewers, and to extend urban service to existing un-serviced areas. The proposed system consisted of approximately 70km of new and existing storm sewers servicing 26 drainage areas. Preliminary sizing and construction cost estimates were included in the master plan.

Where many areas of the City were, and still are, serviced by ditches, frontage tiles, or storm sewers on both sides of the road, the 1978 master plan called for the construction of new single pipe storm sewers having adequate size, depth and grade to service both sides of the street.

The 1978 master plan proposed sewers designed to accommodate the 1:5 year storm where outlets were unaffected by lake levels. Where outlets were affected by lake levels, the 1978 master plan proposed sewers designed to accommodate the 1:2 year storm at a high lake level, and the 1:5 year storm at a moderate lake level.

Since 1978, the City has constructed portions of the recommended system. Based on review of the City's existing infrastructure, it appears that approximately 50km of the sewers recommended in 1978 have yet to be constructed.

1.3.2 Inflow and Infiltration Reduction Program

The City of Port Colborne initiated the Inflow and Infiltration (I&I) Reduction Program in 2008 with the objective of eliminating extraneous flow in its sanitary sewers in order to reduce sewage overflows to the environment, to reduce basement flooding, to reduce wastewater treatment costs, and to accommodate infill in existing serviced areas. All sources of I&I were targeted for remediation, whether on private property or within the municipal right-of-way. The I&I program was initially undertaken as a pilot study in the Marina sanitary pump station service area. The second and third phases of the I&I program focused on the Omer and Nickel sanitary pump station service areas respectively.

The I&I Program included the following components:

- Inspection of private properties to identify sources of extraneous flow such as sump pumps, foundation drains, and roof drains. In portions of the Marina and Omer Areas, this also included Closed Circuit Television (CCTV) inspection of private sanitary sewer laterals.
- CCTV inspection of municipal sanitary sewers to identify defects or other conditions that contribute extraneous flow.
- Flow monitoring to quantify observed extraneous flow.
- Development, and where possible execution, of a remediation strategy to reduce extraneous flow originating on private property and within the municipal right-of-way.

In conjunction with the Marina Pilot I&I Program, the City of Port Colborne enacted a new sewer use bylaw (Bylaw No. 5228/134/08) to provide an enforceable means of executing the I&I reduction program. The Bylaw includes the following provisions:

- Grants City Staff, or their agents, the authority to enter private property for the purposes of investigating I&I.
- Mandates the removal of any storm inflow sources, including direct connections of roof leaders and sump pumps, to the sanitary sewer system.
- Provides municipal funding to assist private property owners in completing retrofits required to comply with the Bylaw.

The Marina Area I&I program identified 16 private properties with sump pumps connected to the sanitary sewer system. Each of the 16 sump pumps were disconnected from the sanitary sewer system and redirected to nearby ditches and storm sewers.

The Omer and Nickel I&I programs identified approximately 160 private properties with sump pumps connected to the sanitary sewer system. The preferred remediation strategy is to disconnect the sump pumps from the sanitary sewer; however there are several major impediments to moving the disconnection program forward as follows:

- The study areas are built up neighbourhoods; few of the properties have adequate space, or grade to provide positive surface drainage, making it difficult to redirect foundation drains from the sanitary sewer to the surface without causing surface flooding on adjacent properties.
- Surface discharge of sump pumps without free and unfettered outlets will lead to surface ponding and ice accumulation on areas surrounding the properties in the winter months. This could negatively impact City Operations and cause liability concerns.
- The inventory and connectivity of the storm sewer system is not well understood.
- The adequacy from both hydraulic and serviceability perspectives of the local storm system and outlet to accept additional flow from foundation drains is currently unknown.

In general, the redirection of sump pump flows to the storm water collection system is a positive step in managing wastewater and storm water flows, but this separation of flows must be carefully managed to ensure that the storm sewer system has the available capacity to accommodate the additional flows without increasing the risk of surface flooding.

1.4 STUDY AREA

The Study Area for this Master Plan is the same as the Urban Area Boundary of the City of Port Colborne, as illustrated by Figure 1-1.

Associated Engineering (Ontario) Ltd. (AE) understands that, based on local topography, any storm water runoff generated outside of the existing service area will flow away from, and therefore have no impact on the existing service area.

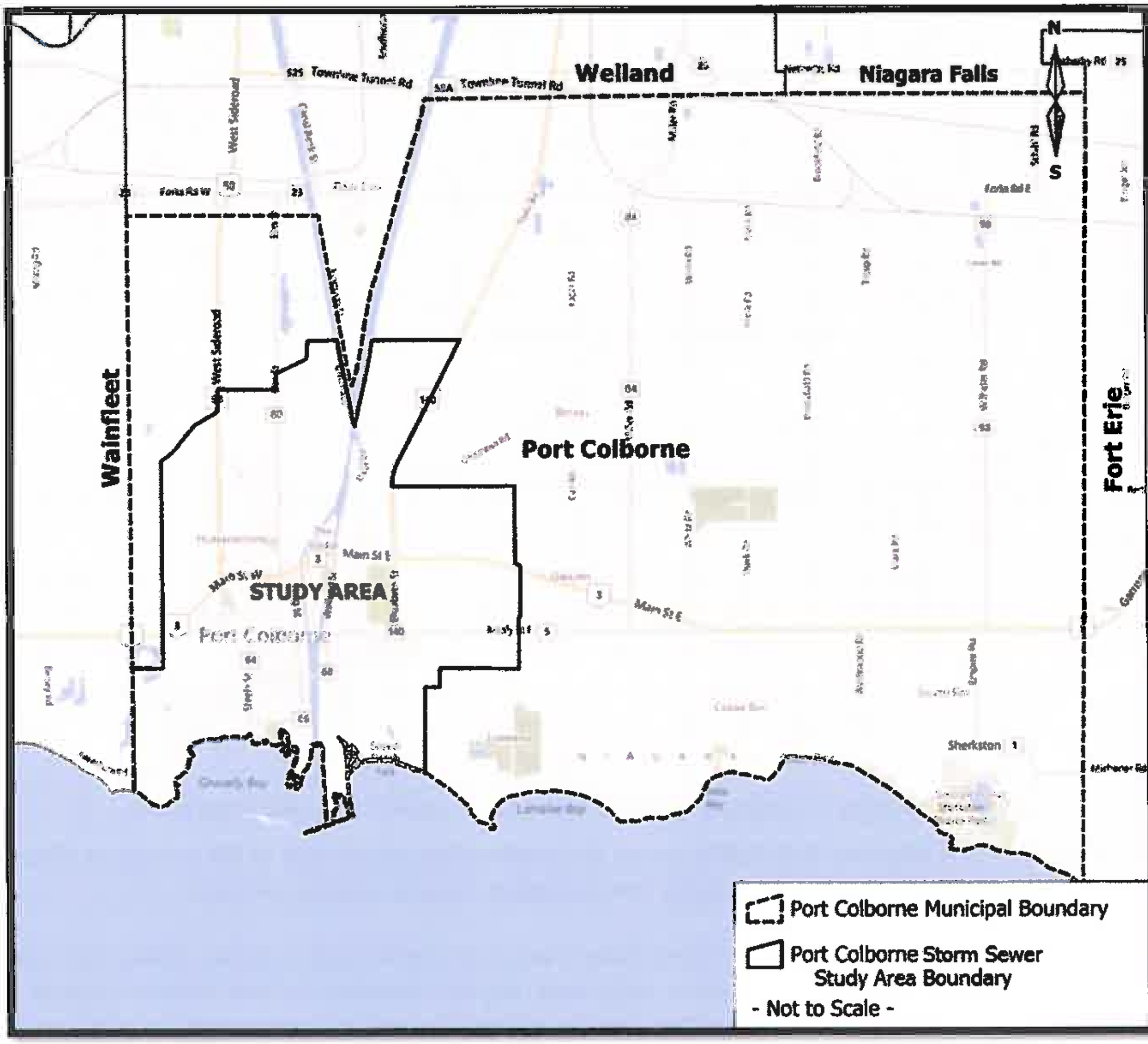


Figure 1-1
Study Area

1.5 MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT AND MASTER PLAN PROCESS

The Environmental Assessment Act (the Act) recognizes that certain municipal undertakings are similar in nature, occur frequently, are limited in scale, have a predictable range of environmental impacts and are responsive to mitigating measures. To ensure that a degree of standardization in the planning process for such projects is followed province wide, the Act permits the use of the "Municipal Class Environmental Assessment" procedure. Projects that do not display these characteristics may not be planned using the Class EA process; they must undergo an Individual Environmental Assessment.

This study was undertaken as a Master Plan in accordance with the Municipal Engineer's Association Municipal Class Environmental Assessment (EA) Guidelines. As a Master Plan project, this study is intended to satisfy Phases 1 and 2 of the Municipal Class EA planning process. Individual projects identified by the study may be subject to additional Municipal Class EA planning and approvals prior to implementation. Additional information regarding the Municipal Class EA process is included in Appendix A.

Phase 1 of the Municipal Class EA planning process begins with the clear definition of a problem or opportunity to be investigated. This study was initiated in response to municipal servicing needs identified by the City of Port Colborne. The Problem Statement for this study is as follows:

> *The City of Port Colborne requires a comprehensive assessment of its existing storm sewer infrastructure to identify and prioritize policies, upgrades and expansion that are required to achieve the City's level of service objectives for storm drainage over the next 25 years.*

Phase 2 of the Municipal Class EA planning process focuses on the development and evaluation of alternative solutions to the identified problem, giving due consideration to all facets of the environment. Phase 2 also requires consultation with the public and stakeholders to solicit input on the planning process. Details of the public and stakeholder consultation program are included in Appendix A.

2 Existing System Characteristics

2.1 EXISTING STORM SEWER SYSTEM

The GIS data supplied by the City indicates that the City's storm water drainage system consists of approximately:

- 2700 catch basins;
- 700 manholes;
- 96 km of storm sewers and catchbasin leads
- 1 storm water management pond;
- 22 drainage areas; and,
- 32 storm sewer outlets

2.2 EXISTING STORM SEWER DRAINAGE AREAS AND OUTLETS

The existing storm sewer network is divided into 22 drainage areas, which are generally defined by the ground surface topography as illustrated by Figure 2-1 and Table 2-1. Drainage area boundaries were supplied by the City and minor revisions were made by AE based on City Staff comments.

Review of the supplied background data and information collected during field surveys concluded that the existing storm sewers primarily discharge through 32 outlets to the Welland Canal, Lake Erie, the Eagle Marsh Municipal Drain including some smaller outlets to rear yard ditches.

The storm sewers in the core of the City drain to the Welland Canal. Areas along the lakeshore drain to Lake Erie. Runoff from the westernmost portion of the city drains to the Eagle Marsh Municipal drain, which ultimately flows to Lake Erie. A portion of the north-west area of the city drains through an extension of the Eagle Mash Drain, which flows through Wainfleet before it re-enters the city limits and discharges into Lake Erie.

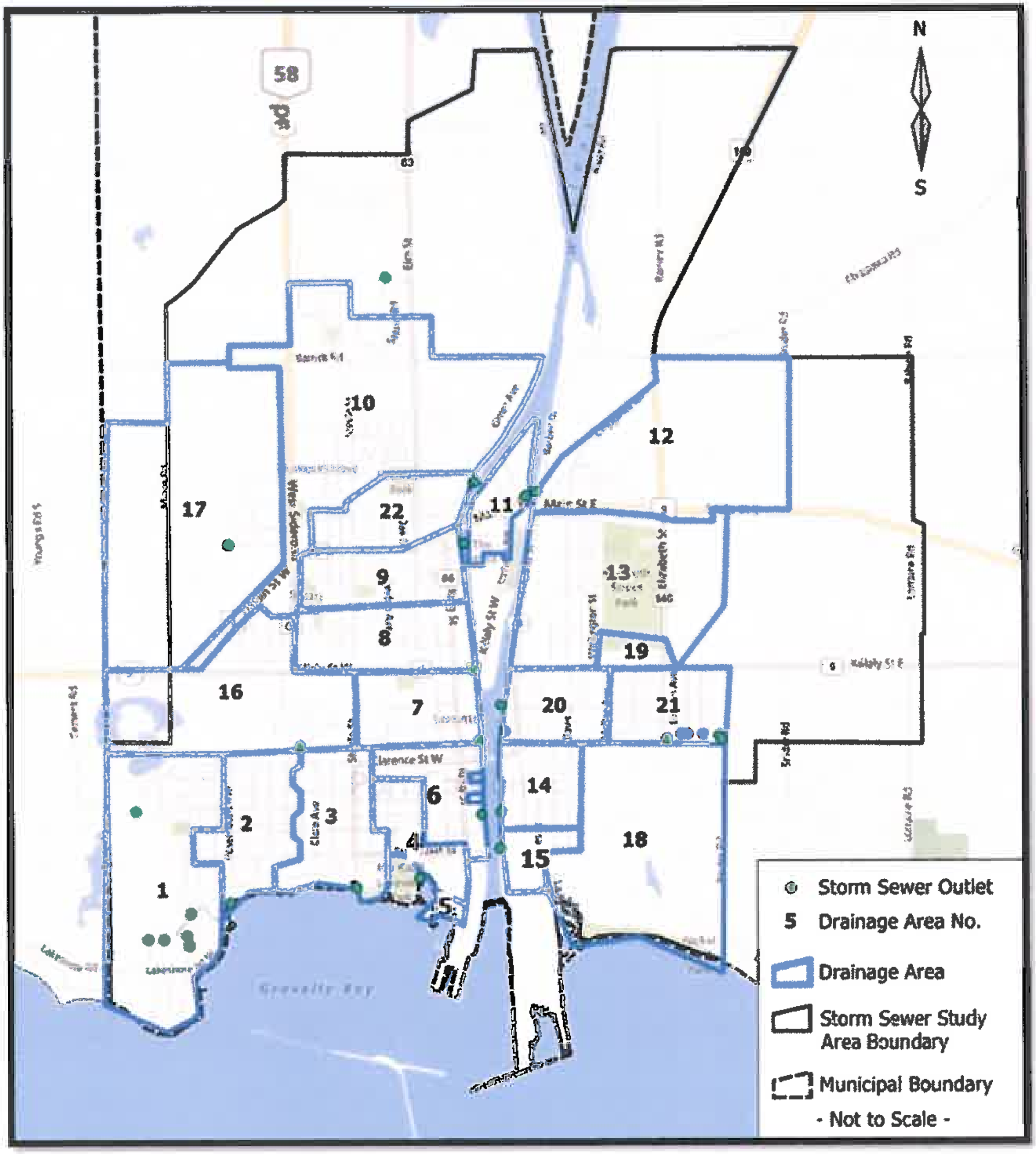


Figure 2-1
Storm Sewer Drainage Areas

Table 2-1
Storm Sewer Drainage Areas

Area No./Outlet Name	Receiving Waterbody	Area (ha)
1 - Eagle Marsh Drain	*Eagle Marsh Drain	126.8
2 - Rosemount Avenue	*Lake Erie	49.3
3 - Steele Street/Sugarloaf	*Lake Erie	53.9
4 - Elm Street	*Lake Erie	25.9
5 - Marina	Lake Erie	3.7
6 - Victoria Street/Downtown	*Welland Canal	35.6
7 - Princess Street	*Welland Canal	40.6
8 - Killaly Street West/Steele	*Welland Canal	51.8
9 - Neff Street	*Welland Canal	43.9
10 - Cedar Street	Welland Canal	199.2
11 - Island	Welland Canal	22.6
12 - Barber Drive	Welland Canal	136.1
13 - Bell Street - North	Welland Canal (Via Area 20)	122.3
14 - Nickel Street	*Welland Canal	30.6
15 - Rodney Street	*Welland Canal	15.1
16 - Quarry	Eagle Marsh Drain	108.6
17 - Eagle Marsh Ext.	Eagle Marsh Drain	198.4
18 - Vale	*Lake Erie	142.1
19 - Bell Street – Northeast	Welland Canal (Via Area 20)	10.5
20 - Bell Street – East	*Welland Canal	34.8
21 - Bell Street – West	Welland Canal (Via Area 20)	39.6
22 – Omer Ave	Welland Canal	40.4
Total		1531.8

*Drainage areas that are directly affected by changes in Lake Erie water levels.

Each of the City's storm drainage areas ultimately outlet to a water body. Outfalls to the Welland canal are difficult to inspect since they may be submerged during high water levels and/or they may be concealed by canal fenders and protective works. All outfalls that are directly affected by Lake Erie water levels should be equipped with flap gates to provide flood protection. All outfalls equipped with flap gates must be regularly inspected and maintained to ensure closure during high lake and marsh levels. The photo below shows that the flap gate located Rosemount Ave. (Outlet 21) would be unable to close if the lake level rises. Inspection and maintenance of outfalls should be a priority item.

Figure 2-2
Rosemount Ave. Storm Sewer Outlet

2.3 EXISTING STORM SEWERS

The City supplied storm sewer geometry included a data field with the header "DESIGN" and approximately 50% of the sewers were classified under that field as either "Design" or "Semi-Design". Approximately 50% of the sewers had no entry in the "DESIGN" field and are referred to henceforth as "Non-Designed" sewers. Figure 2-3 illustrates the locations of the sewers in the each of the design categories and is followed by a description of each category.

Review of the sewers in each of the design categories, summarized by Table 2-2, below, indicates that the classification is largely related to the age of the sewer, and the availability and detail of record drawings. The records supplied by the City indicate that portions of the storm sewer network were constructed as early as 1929.

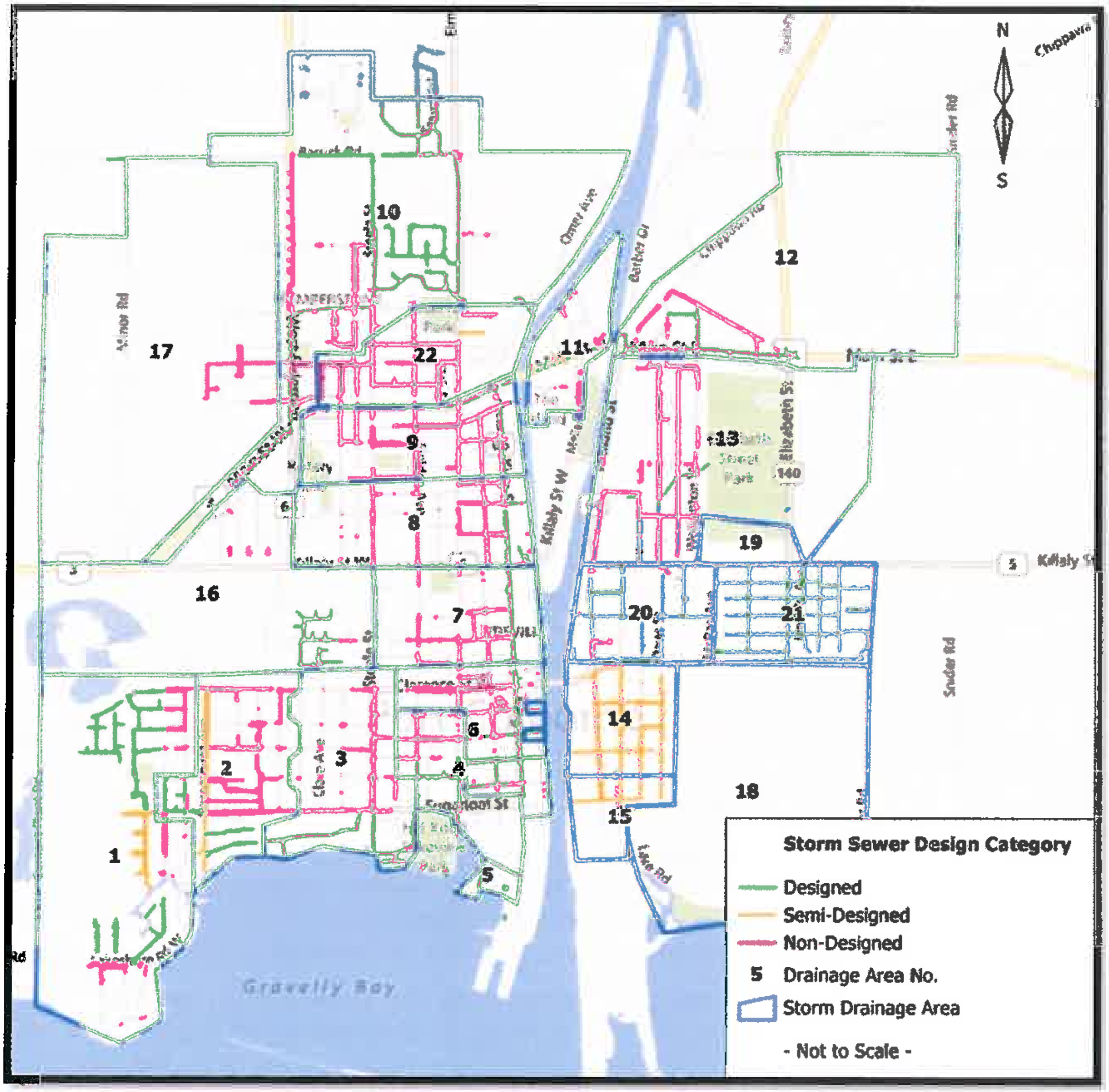


Figure 2-3
Storm Sewer "Design" Categories

Table 2-2
Storm Sewer Classification

Design Type	Number of Pipes	*Total Length (m)
Design	784	38,233
Semi-Design	250	8,739
Non-Design (null)	2,109	43,879
Total	3,143	90,851

*These figures exclude pipes recorded as CB leads.

- **"Design" Sewers**
  "Design" storm sewers were typically found to be those that were constructed relatively recently, documented in relatively complete construction contract drawing packages, and with construction dates, pipe material and diameter recorded in the GIS. These sewers represent approximately 40%, by length, of all storm sewers.

- **"Semi-Design" Sewers**
  "Semi-Design" storm sewers are generally older than the designed sewers. Based on GIS records, these sewers appear to have been designed to some standard, and constructed in phases since 1929 (servicing the Nickel area), 1955 (servicing the Rosemount Avenue trunk storm sewer), and 1968 (servicing the Lena Crescent/Olga Drive area). These sewers are typically located on both sides of the roads they service and are relatively shallow compared to the "Design" sewers. These sewers represent approximately 10%, by length of all storm sewers.

- **"Non-Designed" Sewers**
  Approximately 50%, by length, of the storm sewers (excluding CB leads) are not categorized in the GIS and are henceforth referred to as "Non-Design" sewers. Construction dates, pipe diameters and materials of these sewers are generally not documented in the GIS. The level of detail provided by existing engineering drawings varies, but in general, the drawings provide little detail.

  Drainage on many of the City's older residential streets was originally provided by roadside ditches. Over the years, the City allowed the placement of culverts and infilling of ditches, creating a tiled drainage network which makes up much of the non-designed system. The tiled system generally follows the surface topography and has been augmented over the years with catchbasins and manholes. Based on discussion with City Staff, and review of available information, the tiled system was not constructed to any consistent standard and a variety of pipe materials and diameters were installed. The pipe grades are often inconsistent from one end of any given street to the other, with possible crests and sags along a particular reach. City Staff often refer to these sewers as "frontage tile".

Not all of the non-designed pipes are necessarily frontage tiles however, and for many of these sewers the term "non-designed" is a misnomer. The information included in the City's existing storm sewer records simply does not indicate which sewers are frontage tiles.

Appendix B includes a summary of the City's Drainage Network along with a description of the existing performance and/or concerns within each drainage area.

2.4 EXISTING LEVEL OF SERVICE

The level of service provided by the existing storm sewer network varies throughout the City due to factors such as the various design and construction methodologies that have been employed over the duration of the network's development, and the age of the various portions of the network. The City currently designs all new storm sewers to accommodate the 1:5 year return frequency storm.

In order to characterize the existing level of service, AE conducted a cursory review of drainage issues recorded in the City's "Lotus Notes" customer service/work order database. City Staff extracted a total of 2,461 instances of the following search terms from the 1880 records in the database:

- Ditch - 512 instances found
- Drainage - 636 instances found
- Flooding - 250 instances found
- Storm Sewer - 441 instances found
- Water Ponding - 622 instances found

Figure 2-4 illustrates the locations of the reported drainage issues, based on the addresses recorded in the database. Given that some records contained multiple search terms, a total of 1,880 unique records were identified, 1,565 of which included adequate address information to be mapped on Figure 2-4. Entry dates of the records ranged from May 1997 to June 2013 (records were supplied in June 2013). Generally, the specific actions taken to resolve the issues were not well documented in the supplied dataset. Issues were found to be evenly distributed across the City, with no one area identified as particularly problematic.

Ditch Complaints

Many of the issues related to the search term "Ditch" were resident complaints of debris and tall grass in roadside ditches and related culverts. Other "Ditch"-related complaints included surface ponding due to poor grading, and culverts that either failed or were inadequate causing backups into ditches. Many descriptions included resident requests for the placement of stone to fill depressions in roadside shoulders.

Drainage

Many of the issues related to the search term "Drainage" were general complaints about drainage concerns that needed to be investigated. Many of the investigation requests were related to backyard drainage issues. Most issues were related to ditch and culvert deficiencies.

Flooding

Most of the reported issues related to the term "Flooding" were due to failed or blocked culverts. There were also complaints of plugged catchbasins and ditches, and claims of flooding caused by new development – either impacting an existing drain, or adding more runoff to private property. There were a few claims of basement flooding, attributed to inadequate surface drainage.

Storm Sewer

Complaints related to "Storm Sewer" varied quite a bit, including: failures of ground and/or pavement, attributed to a failing storm sewer; lack of storm sewer in flooded area; and storm sewer and storm lateral blockage due to debris (cleaning required), both in public and private areas;

Water Ponding

Most of the reports of "Water Ponding" were due to poor grading, usually due to recent construction that appears deficient, or granular shoulders/entrances/boulevards that have become deficient. There were also overlapping complaints with previous categories, indicating water ponding due to failure of an existing system (culvert, storm sewer, ditch).

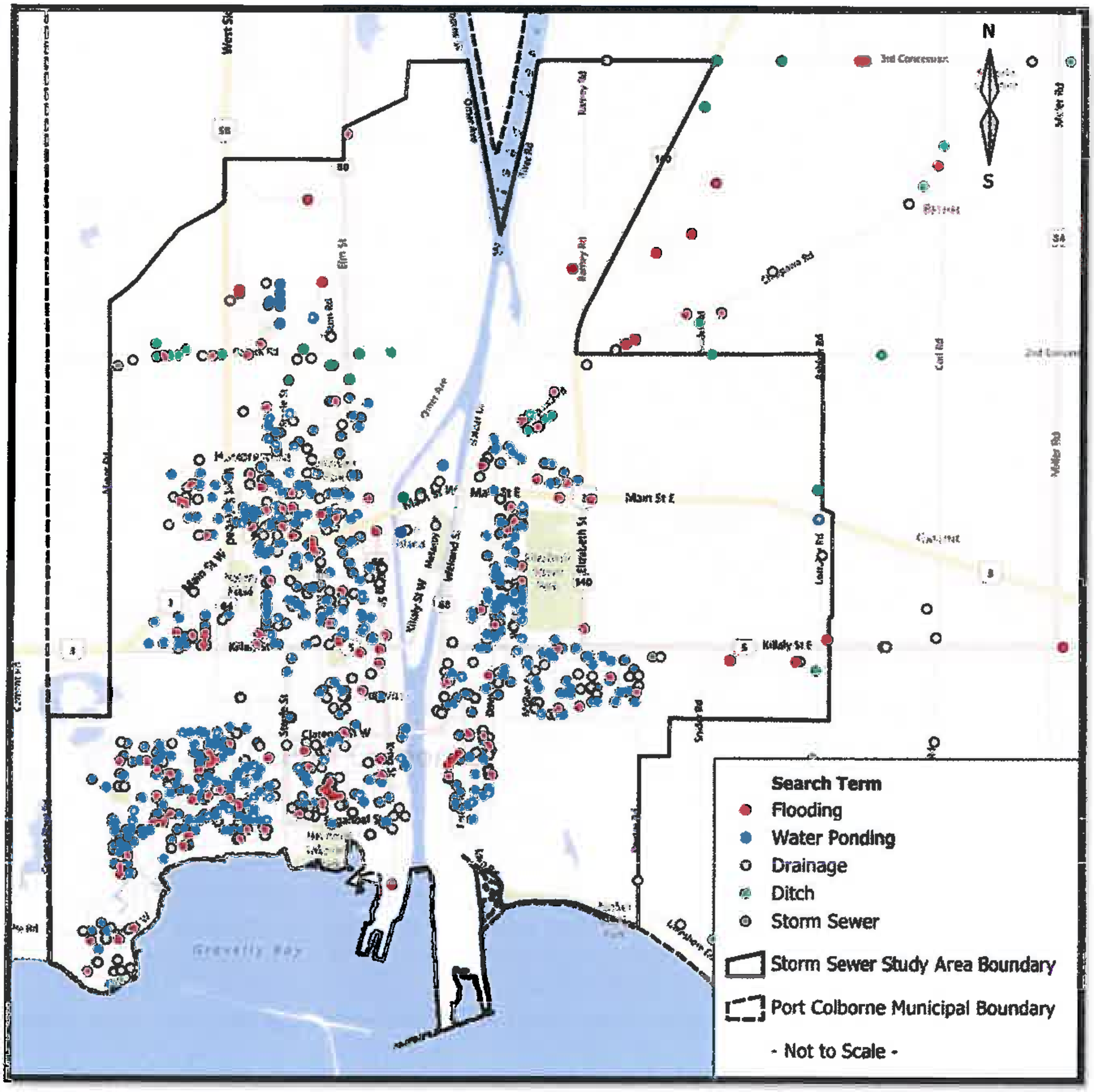


Figure 2-4
Existing Level of Service

2.5 EXISTING SYSTEM CONDITION

As part of the City's Inflow and Infiltration (I&I) Reduction Program, AE conducted a detailed review of the storm sewers in the Nickel Area (Storm Drainage Areas 14 and 15), and a portion of the Omer Area (Storm Drainage Area 22). All inspection records were linked to the City's storm sewer GIS.

AE's review of storm sewer inspection reports is summarized below. In general, the sewers reviewed by AE were in poor condition, with several exhibiting significant defects and early stages of collapse. Based on the available information, the sewers reviewed appear to be classified as "non-designed" or "semi-designed". Presumably, the more recently constructed "designed" sewers are in better condition than the sewers reviewed by AE, however this can only be verified by inspection.

- **Nickel Area Storm Sewers**

  The Nickel Area storm sewers are predominantly vitrified clay pipe, constructed as early as 1929 to service the residential neighbourhood adjacent to the former Inco (now Vale) refinery. The storm sewers are classified by the City as "semi-designed", which AE understands to mean that they were constructed as storm sewers, but were not necessarily designed to a particular standard. The storm sewers are relatively shallow, with approximately 1.0 m to 1.5 m cover. Most of the streets in the area have storm sewers on both sides of the road.

  In general, the Nickel Area storm sewers are in poor structural condition. Sewer inspection records indicate that several sections exhibit early signs of collapse. From discussion with City Staff, it is understood that changing moisture conditions in the surrounding peat soil has resulted in noticeable settlement in the Nickel Area; it is likely that this has contributed to loss of support, and settlement of the local storm sewers.

  The storm sewers are also in poor operational condition, largely a result of their poor structural condition. Significant effort was expended in 2012 to clean and inspect the Nickel Area Storm Sewers. Despite recent cleaning efforts, there are several pipes that still have heavy debris and/or blockages that will exacerbate future sediment build up, and impede the maintenance and performance of the system. Furthermore, partial collapse of sections of the storm sewer system, such as that shown below, will soon result in a sink hole and create a public safety hazard. The soil from around the pipe will also enter the storm drain further exacerbating flooding concerns, water quality issues and maintenance costs.

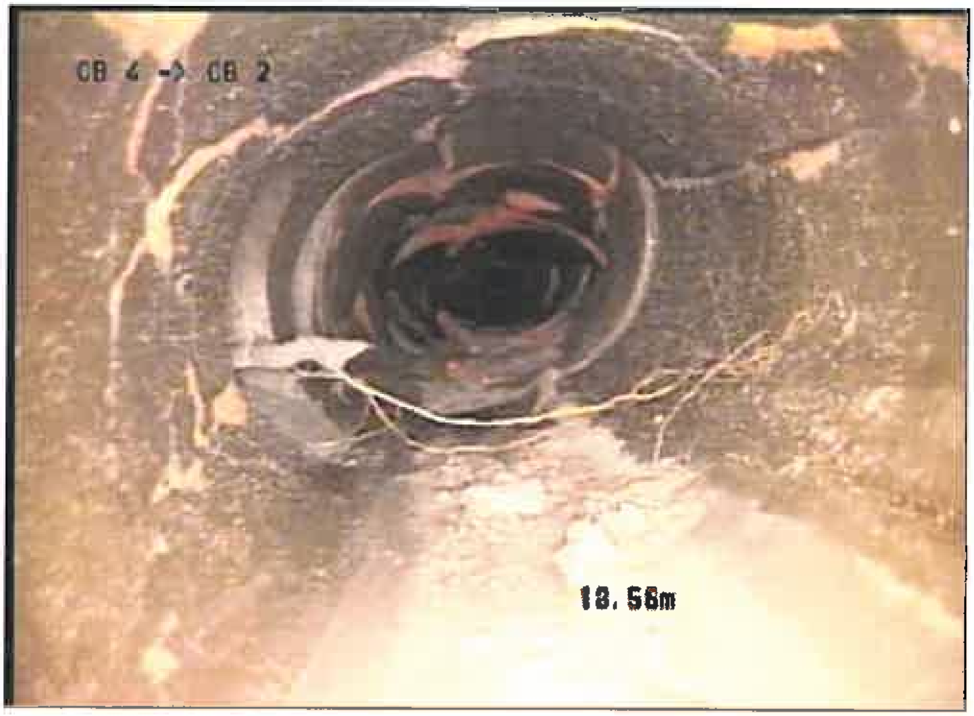


Figure 2-5
Partially Collapsed Storm Sewer, Welland Street

Figure 2-6 illustrates the classification, severity and distribution of observed defects in the Nickel Area Storm Sewers.

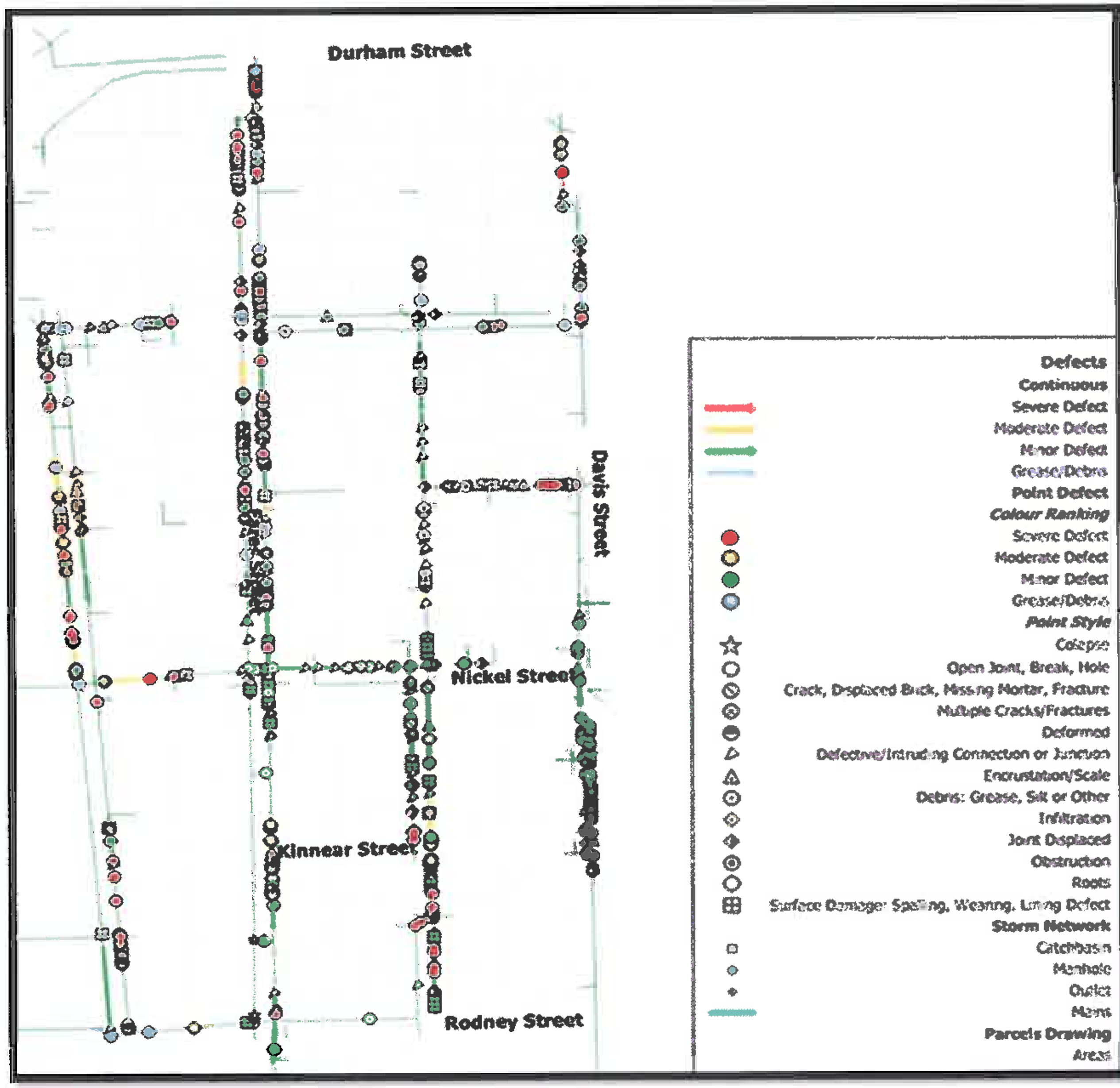


Figure 2-6
Nickel Area Storm Sewer Inspection Observations

- **Omer Area Storm Sewers**

  The storm sewers investigated in the Omer Area I&I Reduction Program were those in the City's Storm Drainage Area 22. The existing storm sewers are classified by the City as "Non-Designed" pipes, and are comprised of a tiled system that was created by the piecemeal infilling of roadside ditches.

  Field investigations that were undertaken to assess the condition of the existing storm sewers included topographic survey, visual inspection of manholes and catchbasins, and (CCTV) inspection. The results of these investigations indicate that the storm sewers are inconsistent in grade, diameter and material. Numerous localized low points were identified in the surveyed pipe inverts, likely due to the piecemeal construction of the tiled system.

  The inspected storm sewers are in poor condition with a heavy buildup of sediment being observed in most of the pipes. In fact, 66% of the sewers in the study scope could not have CCTV completed, due to: (1) Collapsed Pipe, (2) Debris in Pipe, or (3) Roots in Pipe. Many of the storm sewers exhibited various stages of collapse. Partial collapse of a storm sewer such as that shown below will soon result in a sink hole and create a public safety hazard. The soil from around the pipe will also enter the storm drain further exacerbating flooding concerns, water quality issues and maintenance costs.

Figure 2-7
Partially Collapsed Sewer on Omer Avenue

Figure 2-8 below illustrates the locations of the sewers that we attempted to inspect in the Omer Area. Since the majority of the sewer inspection attempts were abandoned in this area, a detailed analysis as presented by Figure 2-6 for the Nickel Area, could not completed.

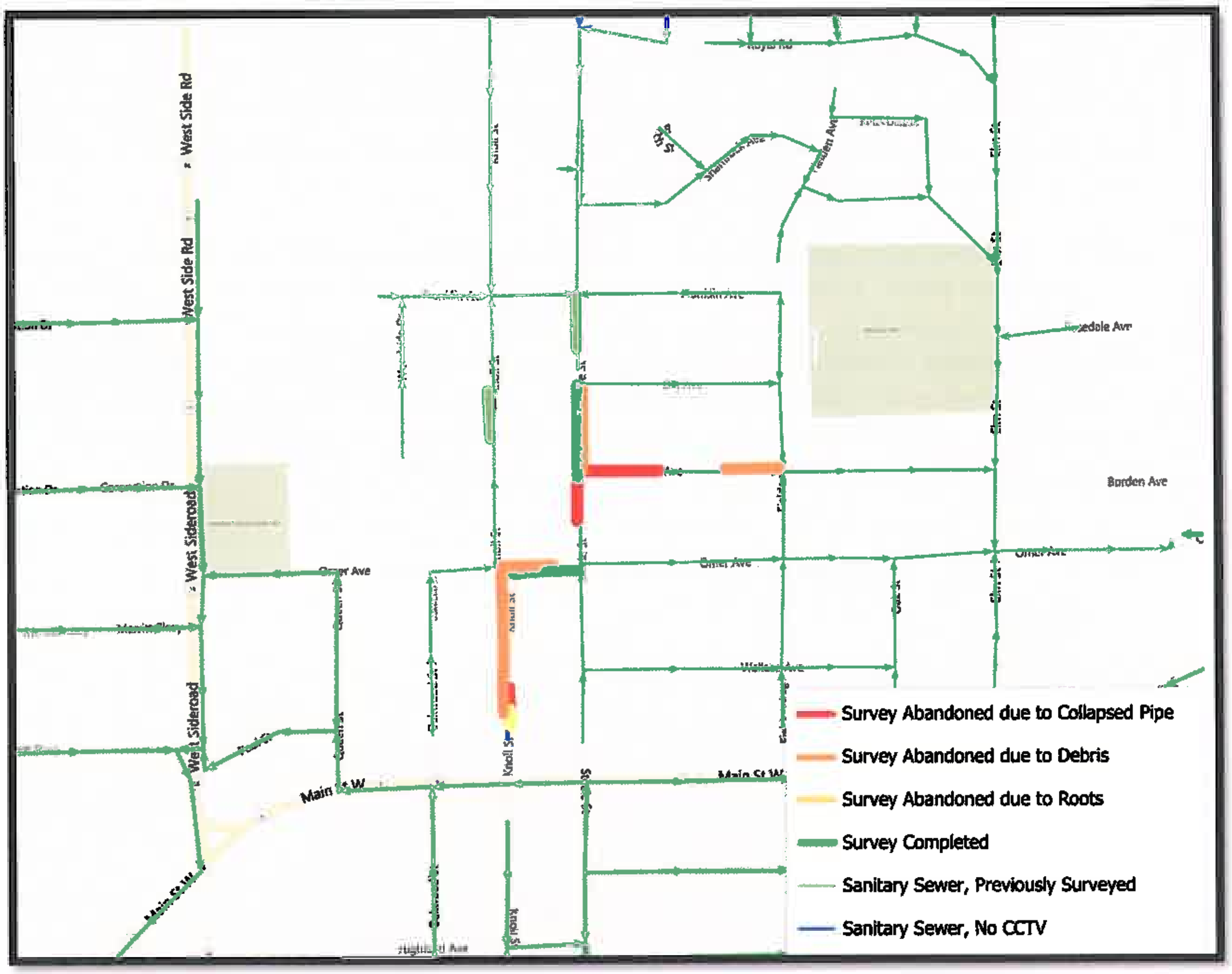


Figure 2-8
Omer Area Storm Sewer Inspection Progress

- **Other Sewer Inspection Reports**
  A selection of reports documenting various storm sewer inspections completed between September 2007 and November 2009 were supplied to AE for use in assessing the condition of the existing storm sewers. The lack of storm sewer asset identifiers (manhole ID's) and the reporting format employed for these inspections made it impossible to determine the exact location of the subject sewers.

  A cursory review of the printed reports and photographs revealed several sewers in poor condition on Charlotte St., Catherine St., Alma St., Clarence St., Berkley St., Ash St., Jefferson Ave. The subject sewers exhibit heavy sediment deposits, debris, roots, holes, cracks and early stages of collapse.

It is recommended that the City initiate a regularly scheduled program of flushing and inspection to monitor the condition of its storm sewers, to allow for the identification of repair/upgrade needs, on a proactive, rather than reactive, basis.

Such a program will require careful planning to ensure that the resulting reports accurately identify the exact location of the subject sewers. This will require improvement to the City's storm sewer GIS by creating unique identifiers for each asset, particularly manholes. However, given the current condition of the storm sewers, many sections will be difficult if not impossible to inspect, and a city-wide inspection program will be a time consuming and costly undertaking. By overlaying GIS data indicating the oldest storm sewer infrastructure, areas of known problems, and storm sewers that are significantly undersized, it may be possible to prioritize areas for inspection. This information could then be used to focus further investigative effort including existing storm sewer condition information, CCTV inspection records, construction and maintenance records, work orders and field inspections. Furthermore, this information can be used to assess the likelihood that the sewers will be passable by a CCTV camera.

3 Hydraulic Model Development

3.1 BACKGROUND DATA

A model of the City's existing storm sewer system was developed on behalf of Associated Engineering by GeoAdvice Engineering, using the InfoSWMM hydraulic modeling software application.

Prior to developing the model, the following information related to the storm water system was reviewed by GeoAdvice and AE:

- City of Port Colborne GIS drainage infrastructure database
- Topographic survey information
- Orthophoto imagery
- DEM contour information
- Site visit pictures
- Precipitation data
- Flow monitoring data
- Community improvement plans
- Previous reports

3.2 DRAINAGE NETWORK

The model's network topology was built primarily using the City's existing storm sewer infrastructure GIS, and supplemented with information from the sources listed above. In addition to defining the approximate location and length of each storm sewer, the GIS data included pipe attributes such as pipe diameter and material, year of construction, inverts and the serviced drainage area identifier.

Following the creation of the network model, a data gap and connectivity review was completed. To complete this task, an iterative approach was used where GeoAdvice worked cooperatively with AE to resolve data gap and connectivity issues. The supplied information was used as much as possible; however a number of connectivity issues and data gaps remained. As well, a substantial amount of the storm water data was found to be missing either diameter or invert elevation data.

To increase the accuracy of the model, AE completed field visits to aid in populating missing infrastructure data. Further, the results of an interview with City Staff were used to populate a number of data gaps. Data gaps that field survey or City Staff input could not resolve were augmented using data interpolation from neighbouring pipes and from ground surface elevations.

Table 3-1, below, summarizes the number of recorded pipe attributes for each design category.

Table 3-1
Storm Sewer Data Gap Analysis

Design Type	All Pipes	Install Year	Diameter	Material	US Invert	DS Invert	Drainage Area
Design	784	769	775	767	4	4	571
Semi-Design	250	248	232	223	0	0	228
Non-Design	2109	23	516	39	5	3	1,871
Total	3,143	1,040	1,523	1,029	9	7	2,670

The following key observations were made based on review of the supplied storm sewer geometry:

- The "AREA" column appeared to reference sanitary drainage areas, not storm drainage areas and was therefore not relied upon.
- Most semi-designed sewers (60% by length) were located in the Nickel Area (Storm Drainage Areas 14 and 15), and most had diameters recorded. However based on AE's field work in the Nickel Area many of the diameters were found to be incorrect. Pipe diameters and inverts recorded during AE's field work were applied to the Nickel Area.
- Many pipes were defined in a reverse flow direction, resulting in the supplied inverts being in question.
- Many pipe reaches had multiple sags and crests with unknown inverts. Upstream and downstream inverts were surveyed where possible with the remaining intermediate inverts being interpolated.
- As constructed inverts based on record drawings were used for designed pipes. Where no other information was available, inverts were estimated at 1.0 m below the Digital Elevation Model (DEM).

To effectively model the drainage system in the absence of complete network information, some network data including inverts, pipe diameters and conduit connectivity had to be assumed. Figure 3-1 graphically displays the sewer network locations of assumed inverts and diameters for the purpose of modeling. Figure 3-2 shows the sewer network locations of assumed altered connections used for modeling. Both of these figures have been placed at the end of the report, in large format.

3.3 SUBCATCHMENT GEOMETRY

Subcatchment geometry including area, slope, and width were delineated using the following data sets:

- Topographic data (DEM)
- Parcel boundaries
- Aerial photography
- Infrastructure information (storm services, catch basins, drainage ditches, etc.)

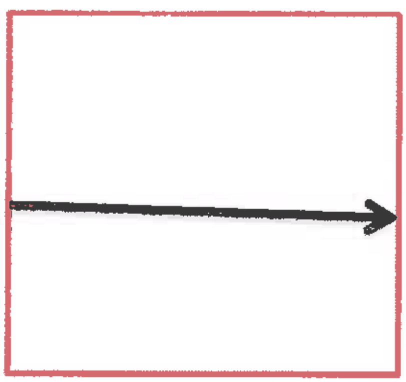
Subcatchment widths were estimated based on the catchment areas using the relationship below:

$$W = A / L \quad \text{and} \quad L = 1.75\sqrt{A}$$

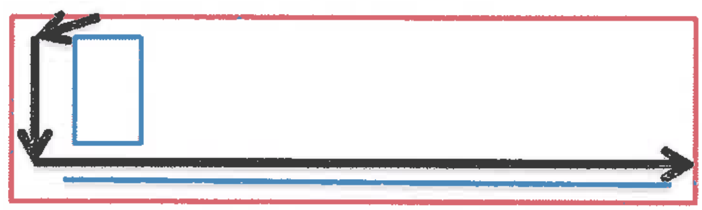
Where:

W = subcatchment width
L = subcatchment length
A = subcatchment area

The rational for this method is that both catchment shape and local flow barriers increase the overland flow length, as illustrated below:



$W = A / L$



$L = 1.75\sqrt{A}$

Subcatchment slopes were estimated using the local topography and the following equation:

$$Slope_{Catchment} = Slope_{Topography} / 1.5$$

All subcatchments in a given drainage area were assigned the same slope. Subcatchment slopes for each drainage area are listed in Table 3-2.

Table 3-2
Subcatchment Slopes

Drainage Area	Slope (%)	Drainage Area	Slope (%)
1	0.23	12	0.59
2	0.45	13	0.19
3	0.47	14	0.34
4	0.13	15	1.48
5	1.09	16	0.46
6	0.34	17	0.35
7	0.68	18	1.04
8	0.55	19	0.77
9	0.48	20	0.51
10	0.74	21	0.47
11	0.83	22	0.82

While developing the subcatchment geometry it was assumed that along the roadway there was either a roadside ditch/swale or curb acting as a localized drainage barrier. Appendix B provides details on the subcatchment geometry parameters.

3.4 IMPERVIOUS COVER

Aerial photographs (orthophotos) were used to estimate the existing impervious cover. Figure 3-3, below, illustrates how the aerial imagery was used to classify impervious cover. To account for older established residential areas, it was generally assumed that impervious roof areas are disconnected from sewers. Therefore, the total impervious area (TIA) was reduced by the removal of roof areas to estimate the effective impervious area (EIA). . Private driveways and sidewalks are accounted for by assuming a slightly wider impervious roadway.

Figure 3-3
Impervious Cover

3.5 PRECIPITATION

The design storms are based on a Chicago Storm shape using the Port Colborne IDF curve as presented below:

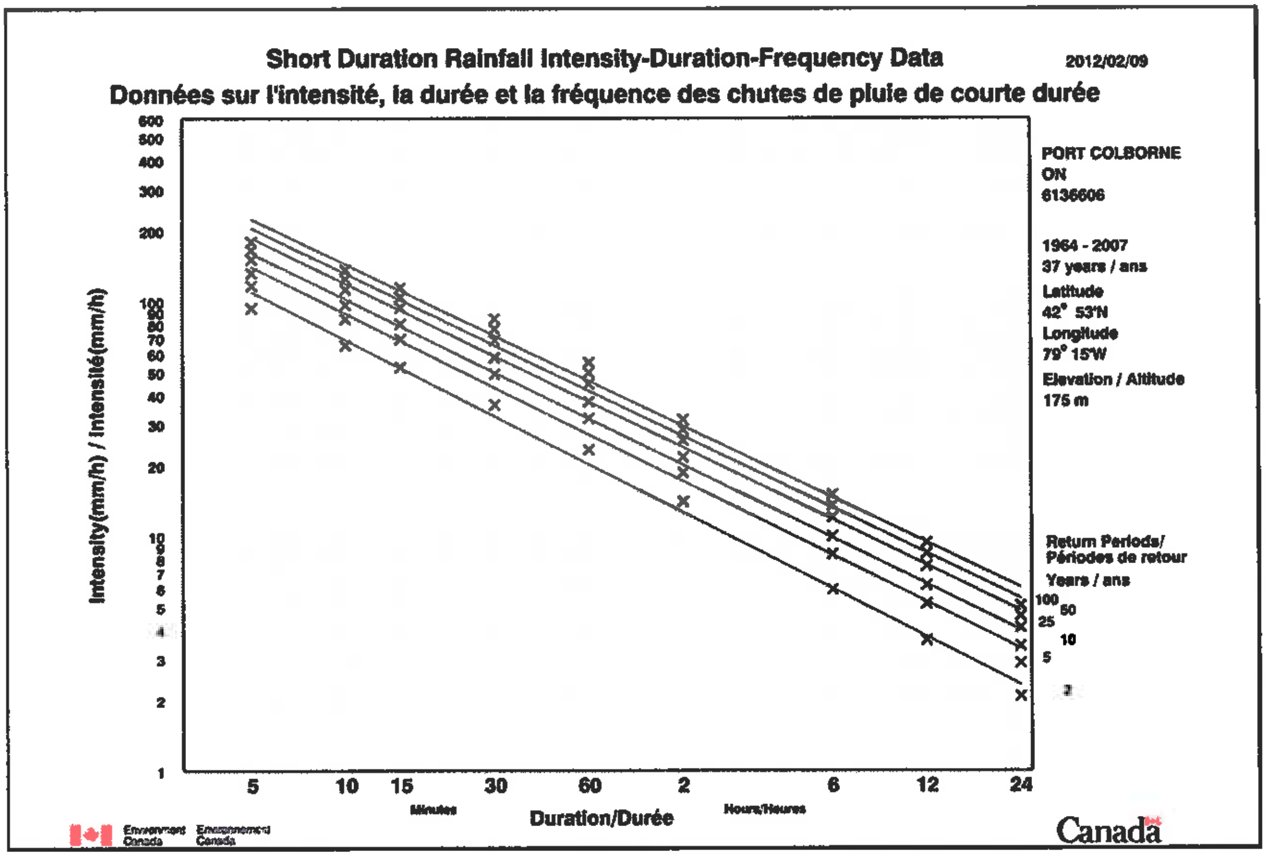


Figure 3-4
Short Duration Rainfall Intensity

Table 3-3 below presents the design events used to assess the drainage system.

Table 3-3
Design Storms

Storm Duration	1:2-year Total Depth (mm)	1:5-year Total Depth (mm)	1:10-year Total Depth (mm)	Design Storm Shape
24 Hour	49.8	68.9	81.5	Chicago All Duration

The City currently designs all new storm sewers to accommodate the 1:5 year return frequency storm. The hyetographs for the 2, 5 and 10 year return period events are shown below.

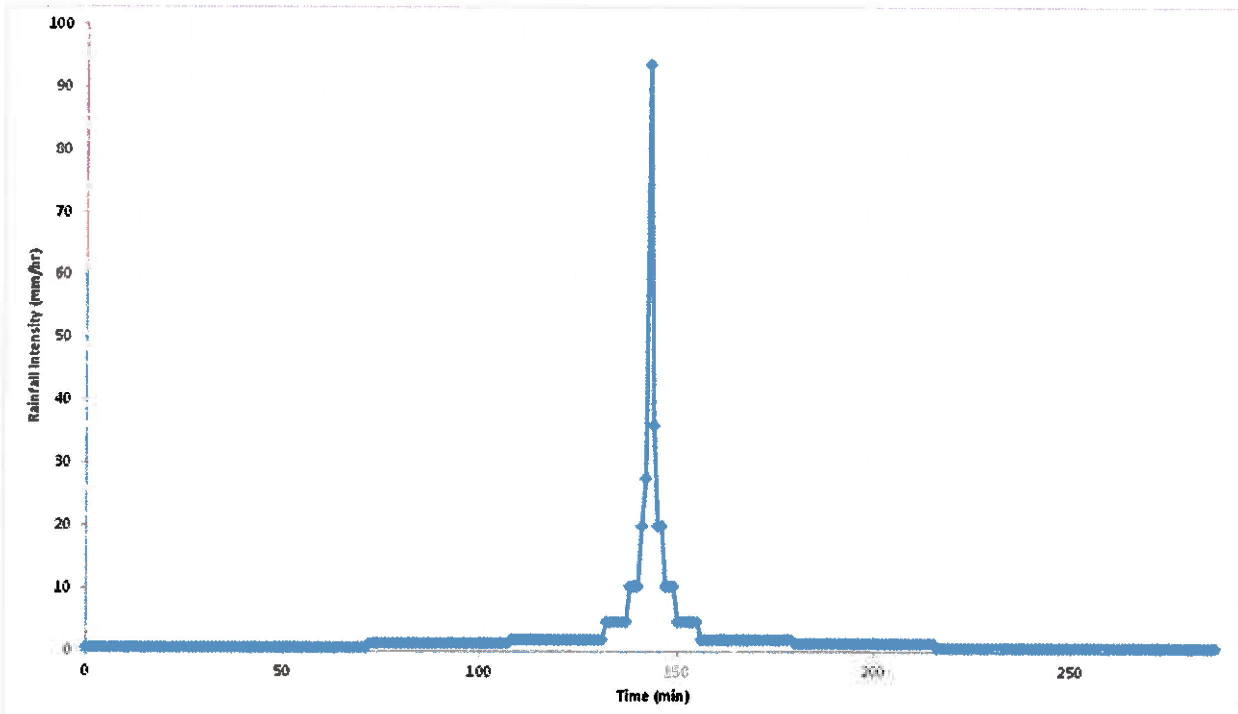


Figure 3-5
Port Colborne 2-Year Chicago Hyetograph

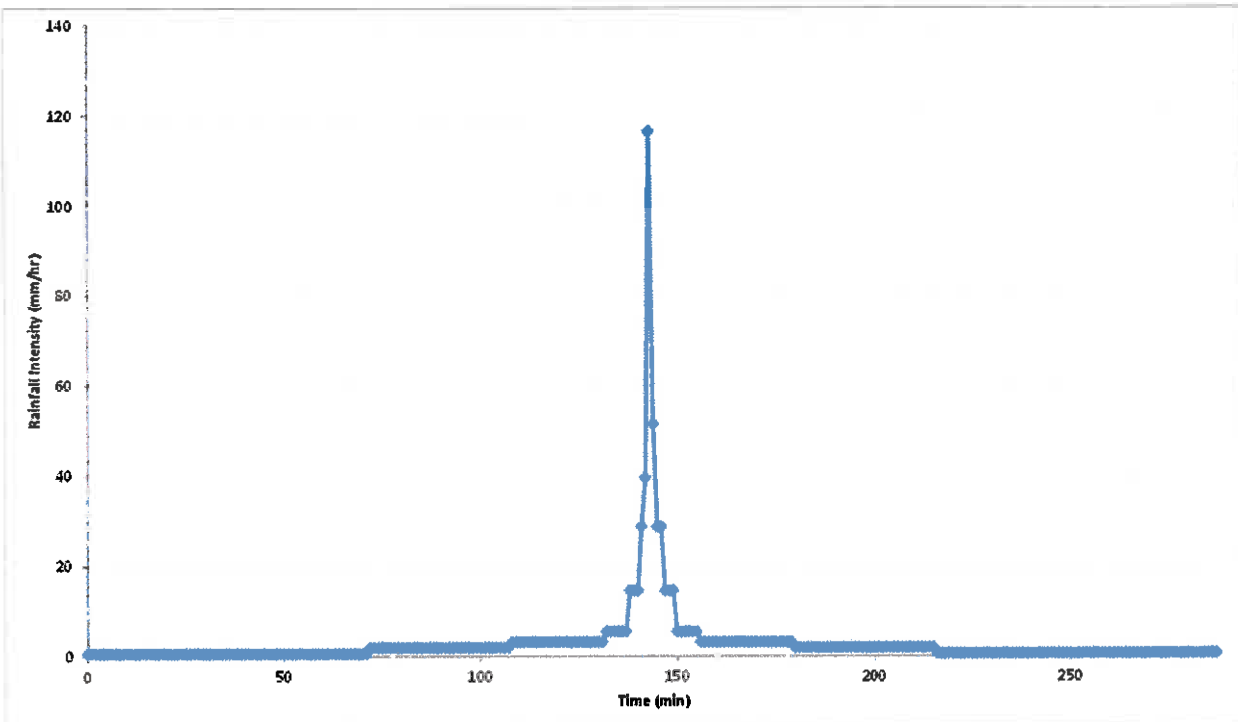


Figure 3-6
Port Colborne 5-Year Chicago Hyetograph

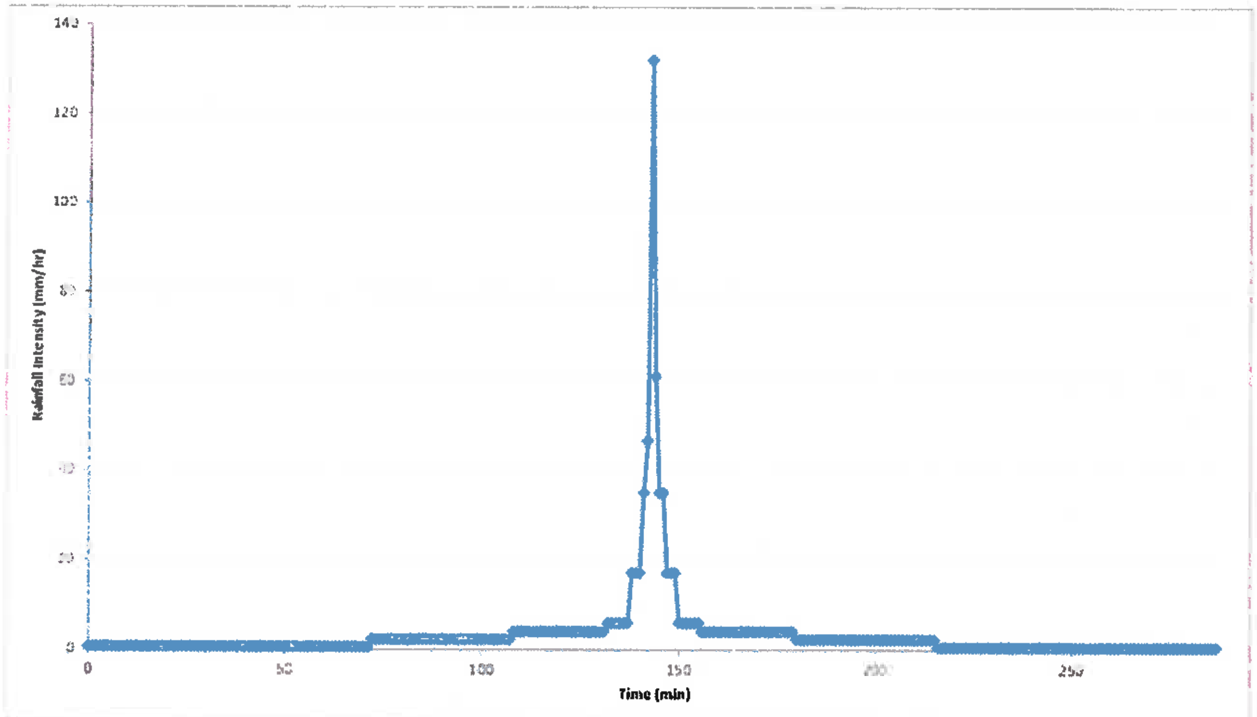


Figure 3-7
Port Colborne 10-Year Chicago Hyetograph

3.6 BOUNDARY CONDITIONS

The majority of the City's storm sewers drain either to the Welland Canal or Lake Erie, and are therefore influenced by fluctuations in the level of these major water bodies.

Over the period of record extending from 1918 to 2012, the maximum recorded monthly water level on Lake Erie was 175.04 m GSC recorded in June 1986. The minimum recorded monthly water level over the same period was 173.18 m GSC recorded in February 1935 and February 1936. The average recorded monthly water level over the period of record was 174.14 m GSC.

Precipitation events on the watershed and peak lake levels are generally independent events, although there is some seasonal dependence. Therefore, the design return period is approximately the product of the rainfall probability and the receiving water percentage exceedance.

The initial model setup and validation used surveyed water surface elevations. The following survey data was used to define the boundary conditions in the Welland Canal for the outfalls in the model:

- Water surface elevations north of Lock No. 8, near the Main St. Bridge was established at elevation 174.18 m.
- Water surface elevations south of Lock No. 8, near the Main St. Bridge was established at elevation 175.80 m.

Some of the City's outfalls are equipped with flap gates to prevent backwater effects caused by rising water surface levels. Where they are known to exist, flap gates were modeled in the pipe immediately upstream of the outfall. Table 3-4 summarizes the outfall boundary conditions.

Table 3-4
Outlet Boundary Conditions

AE Outlet ID	Storm Drainage Area	Fixed Outfall Stage	Flap Gate
OUT_100	N/A - Meadow Heights, North of Area 10		No
*OUT_23	1 - Eagle Marsh Drain		Yes
*OUT_24	1 - Eagle Marsh Drain		Yes
*OUT_25	1 - Eagle Marsh Drain		No
*OUT_26	1 - Eagle Marsh Drain		No
OUT_27	1 - Eagle Marsh Drain		No
OUT_103	1 - Eagle Marsh Drain		No
OUT_21	2 - Rosemount Avenue	175.8	Yes
OUT_22	3 - Steele Street/Sugarloaf	175.8	No
OUT_50	3 - Steele Street/Sugarloaf	175.8	Yes
OUT_34	4 - Elm Street	175.8	Yes
OUT_15	6 - Victoria Street/Downtown	175.8	Yes
OUT_11	7 - Princess Street	175.8	Yes
OUT_47	8 - Killaly Street West/Steele	175.8	No
OUT_56	9 - Neff Street	175.8	No
OUT_1	10 - Cedar Street	174.18	No
OUT_57	11 - Island	174.18	No
OUT_53	12 - Barber Drive	174.18	No
OUT_16	14 - Nickel Street	175.8	No
OUT_19	15 - Rodney Street	175.8	No
OUT_46	16 - Quarry		No
OUT_144	17 - Eagle Marsh Ext		No
OUT_12	20 - Bell Street - East	175.8	No
OUT_42	21 - Bell Street - West		No
OUT_43	21 - Bell Street - West		No
OUT_44	21 - Bell Street - West		No
OUT_45	21 - Bell Street - West		No
OUT_48	21 - Bell Street - West		No
OUT_49	21 - Bell Street - West		No
OUT_54	21 - Bell Street - West		No
OUT_110	21 - Bell Street - West		No
OUT_40	22 – Omer Ave	174.18	No

*Outlet is not included in the model.

3.7 SUMP PUMPS AND FOUNDATION DRAINS

Model validation and existing condition modelling recognizes that sump pump and foundation drain discharges do not currently contribute to the storm sewer system. However, sump pump disconnection programs have been recommended in the Omer Avenue and Nickel Street drainage areas that will redirect storm water discharge from sump pumps away from the sanitary sewers and into the storm water system. All modeled "future" scenarios and subsequent "improvement" scenarios in this report are based on the assumption that the existing sump pumps in these areas will be redirected to storm sewers. It is further assumed that all future construction will direct all precipitation runoff and foundation drains to the storm water system.

3.8 MODEL CALIBRATION AND VALIDATION

The hydraulic model was calibrated using storm sewer flow and rainfall data collected between April 8, 2013 and June 17, 2013. Rainfall data collected at the Region of Niagara's Seaway wastewater treatment plant was provided by the Region of Niagara. Storm sewer flow data was collected at the Princess St. and Killaly St. storm sewer outlets. Prior to installation of the flow monitors, AE conducted a field investigation of potential flow monitoring sites. The field investigation concluded that the Princess St. and Killaly St. sites were the only identified locations that were safely accessible, likely representative of flow conditions in other areas, and were anticipated to provide reliable flow data based on their configuration.

Two flow meters were installed upstream of outlets 11 and 47 at Princess and Killaly Streets, respectively. The available flow data was evaluated and used to verify the hydrologic assumptions that were made. Upon review of the data, the quality of the Princess St. meter was not sufficiently accurate for use in this project. However, the Killaly St. meter data was sufficiently accurate and was used to provide an independent data set against which model results were compared.

Flow inputs into the model were initially defined using industry accepted parameters. The initial model parameter settings were then adjusted in an iterative fashion as required to approximate flows recorded by the Killaly St. meter.

Storm water runoff parameter values that were developed for the calibration basin were then assigned to the remaining model subcatchments. These parameters, in combination with the impervious area definitions described previously, were used to simulate storm water runoff conveyed through the City's network of drainage pipes and ditches.

The following model parameters were adjusted to calibrate the simulated flow volume and flow rates:

- Percentage of runoff routed to pervious surfaces
- Depression depth/storage
- Manning's 'n' value for overland flow
- Soil infiltration parameters

Tables 3-5 and 3-6 summarize the hydrologic parameters used. The subcatchment infiltration parameters were uniformly assigned to all catchments in the model.

Table 3-5
Hydrologic Parameters

Parameter	Impervious	Pervious
Depression depth/storage (mm)	2.0	4.0
Manning's 'n' value	0.011	0.24

Table 3-6
Soil Infiltration Parameters (Curve Number)

Parameter	Value
Curve Number	75
Conductivity (mm/hr)	8
Drying Time (hr)	14

The existing condition scenario was simulated and the model's predicted flows were compared against the observed flows measured by the Killaly St. flow meter. Figure 3-8 presents a graphical comparison of the modeled results against the recorded flow data.

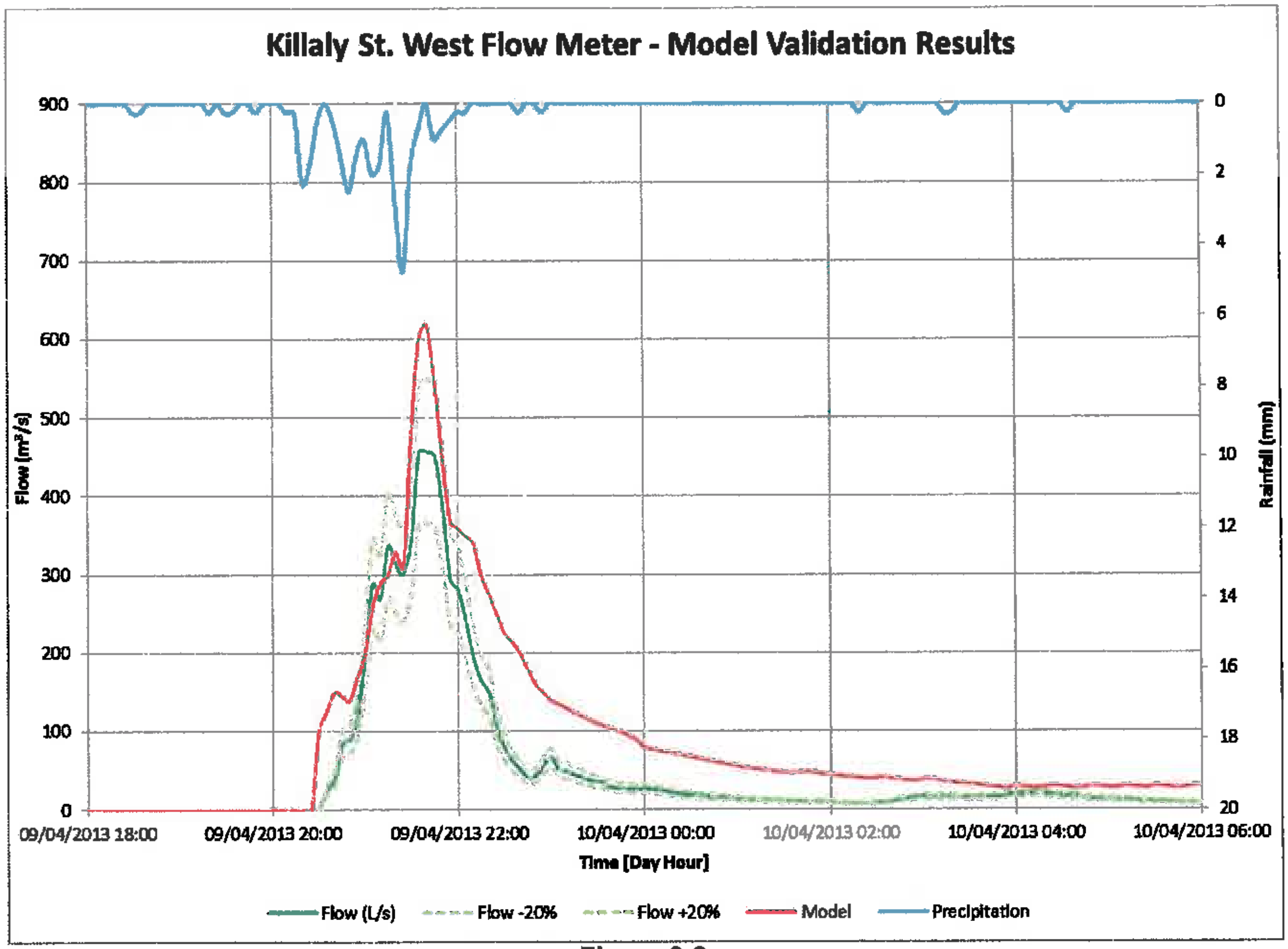


Figure 3-8
Model Validation - Killaly Street Outlet

As illustrated by the above figure, the model results slightly over-predict peak flows in the Killaly St. drainage area. However, the model is generally representative of peak flows for isolated events. Groundwater infiltration is also under-predicted for this isolated rain event. However, during extended periods of rain, and for rainfall events in close succession, the model provides a conservative representation of groundwater infiltrating into the existing system of storm water pipes.

4 Hydraulic Modelling - Existing Conditions

4.1 SYSTEM PERFORMANCE CRITERIA

The evaluation criteria used to assess the City of Port Colborne drainage system are summarized in Table 4-1 below.

Table 4-1
System Performance Criteria

Criteria For	Criteria
Upgrading existing pipes	
Deficient	if d/D > 1.0 and q/Q > 1.0 and surcharged > 15min
Not Deficient	if d/D > 1.0 and q/Q > 1.0 and surcharged < 15min
	if d/D > 1.0 and q/Q < 1.0
	if d/D < 1.0 and q/Q < 1.0
Replacing existing frontage tiles	All replaced with pipe(s) or ditch, scenario based
Upgrading existing channels & swales	Upgrade if HGL > GE
New pipe design	At peak flow rate d/D =< 0.8 and q/Q < 1.0
New channel design	At peak flow rate HGL < GE

Notes:
- Criteria is based on the 5-year return period Chicago design storm
- HGL: Hydraulic Grade Line
- GE: Ground Elevation
- d: depth of flow
- D: pipe diameter
- q: peak flow rate
- Q: full pipe capacity flow rate

The adequacy of the sewer network is represented as follows:

- Locations of surface flooding at manholes are indicated by coloured dots, with red dots representing surface flooding, yellow dots representing water levels that are 300mm or less below the surface, and black dots representing water levels that are more than 300mm below the surface.
- Flow conditions in each of the sewer segments are indicated by line colours, with red lines representing flow that exceeds the sewer capacity, orange lines representing sewers under backwater conditions (which is indicative of inadequate capacity), and blue lines representing sewers having adequate capacity.

- "Designed" sewers are represented by solid lines, while "semi-designed" and "non-designed" sewers are represented by dashed and dotted lines respectively.

4.2 EXISTING SYSTEM CAPACITY – 2-YEAR STORM

Simulation of the 1:2 year storm was used to assess the existing system capacity under relatively frequent rainfall events. This simulation used existing land use conditions and assumed that private sump pumps were not contributing to the storm sewer network.

The deficiencies identified during our analysis of the model are summarized in Table 4-2. This is also illustrated by Figure 4-1, located at the end of this report in large format.

Table 4-2
Existing 2-Year Deficiencies

Drainage Area	Conduit Count	Conduit Length (m)
1	10	507
2	29	1,219
3	5	203
6	13	544
7	11	377
8	11	360
9	56	1,841
10	7	238
11	1	94
12	5	173
13	36	1,973
14	13	1,852
20	1	19
21	1	33
22	46	1,594
Total	**245**	**11,025**

4.3 EXISTING SYSTEM CAPACITY - 5-YEAR STORM WITH SUMP PUMP DISCHARGES

Simulation of the 1:5 year storm was used to assess the existing system capacity relative to the City's design storm event, and to assess the impact of redirecting private sump pumps to the storm sewers in the Nickel and Omer I/I Reduction Program study areas. The deficiencies identified as a result of our analysis are summarized in Table 4-3 and illustrated in Figure 4-2, found at the end of this report, in large format.

Table 4-3
Existing 5-Year Deficiencies

Drainage Area	Conduit Count	Conduit Length (m)
1	21	952
2	35	1,870
3	14	610
4	6	169
6	13	544
7	17	705
8	18	647
9	72	2,400
10	15	674
11	2	171
12	10	347
13	37	1,998
14	18	2,523
15	5	389
20	1	19
21	1	33
22	54	1,920
Total	**339**	**15,970**

The results indicate that the majority of the "designed" sewers (Areas 20 and 21) meet the City's design standard. The results also indicate that the majority of "semi-designed" and "non-designed" sewers are deficient under both the 1:2 year and 1:5 year storm events, with surface flooding predicted at many locations. This is not surprising given that these sewers were not designed to current standards, and that many are the 'tiled system' that resulted from infilling of ditches with little consistency in sewer sizes or grades.

5 Planning for Growth and Improvements

5.1 DEVELOPMENT AREAS

Storm water flows for the future storm drainage system are based on projected future land use. Potential future residential development areas identified by the City are listed in Table 5-1 and illustrated by Figure 5-1. No additional industrial, commercial, or institutional developments were identified.

Table 5-1
Future Residential Areas

Development Name	Area (ha)
CMT Lots	1.2
Meadow Heights	30.5
*Olde Humberstone Village	3.1
Chippawa Estates	3.5
Northland Estates	15.8
Westwood Phase 2	9.6
V1	3.1
Rosedale (V2)	12.8
V3	54.2
V4	7.8
*V5	0.9
*V6	1.9
*V7	31.2
Westwood Park Secondary Plan (V8)	30.6

It is assumed that all future developments will include provisions for the construction of storm sewers and storm water management facilities. Internal servicing costs associated with new developments will therefore be borne by the developers. It is also assumed that future storm water management facilities will meet objectives for storm water runoff quality and quantity, and will therefore mitigate impacts of post-development runoff. For some of the identified potential developments, marked * in the table above, extension or upgrades of existing storm sewers may be required in order to convey future development flows to existing outlets. In these cases, the required extension or upgrades may benefit existing users, and the costs may be shared by the developer and the City. In other cases, future developments will include provisions for new storm sewer outlets and will have no impact on the existing system.

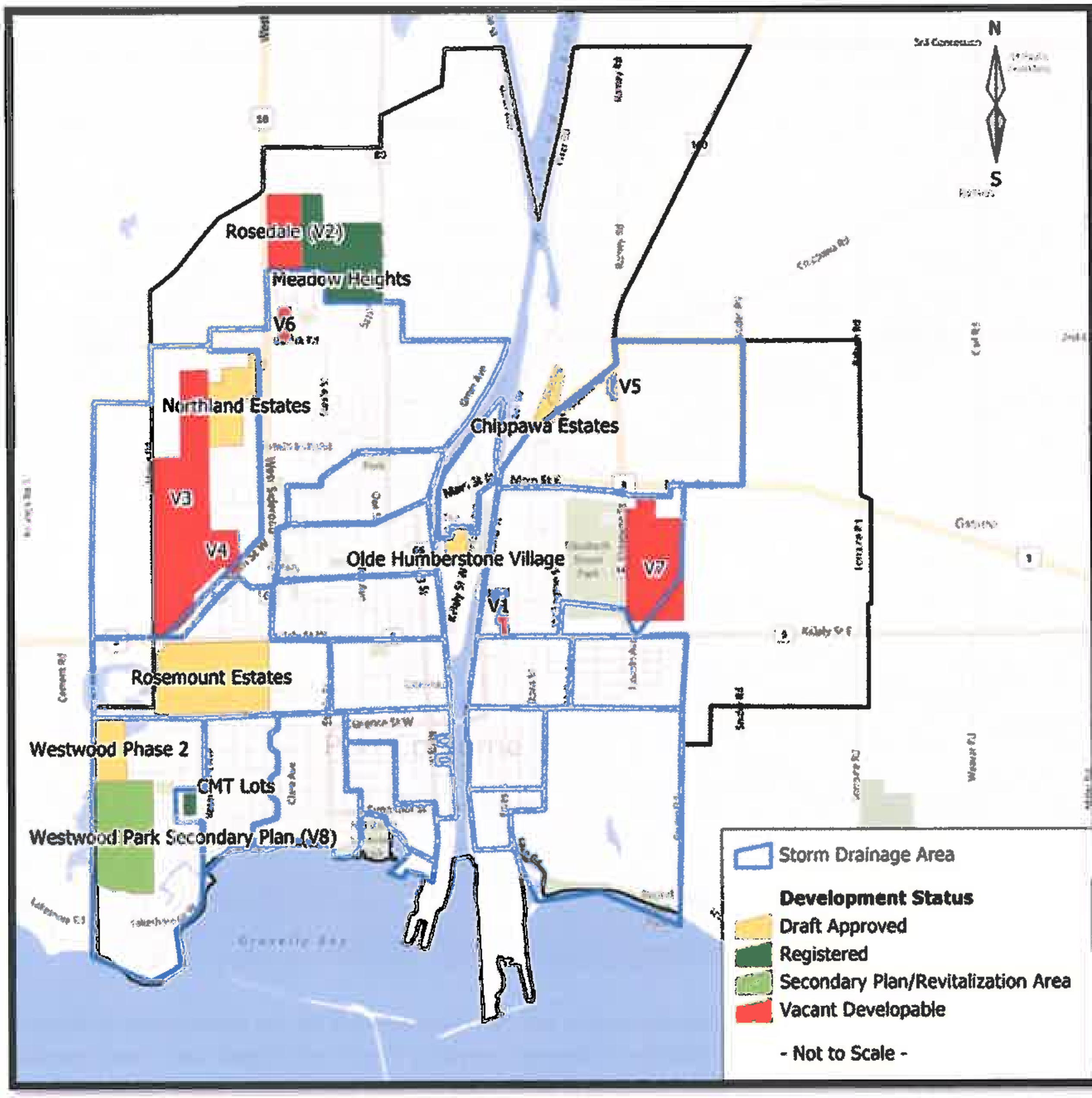


Figure 5-1
Future Residential Development Areas

The following provides a brief description of the future residential development areas, and the assumptions applied to each for the purposes of hydraulic modeling:

- **The CMT Lots** are sixteen residential lots created by the City of Port Colborne on the site of the former Caroline M. Thomson School. Storm sewers to service the development were constructed on Scholfield Ave., Sugarloaf St. and Hampton Ave., and discharge to the Rosemount Ave. trunk storm sewer in Drainage Area 2. This drainage network was included in the existing condition model. Only the land-use changes in the future condition model.
- **Meadow Heights** is a residential development that is currently under construction near the north limit of the Port Colborne urban area. Storm water runoff from Meadow Heights is not tributary to the existing storm sewer network and was therefore not modelled. Runoff from this area ultimately discharges to the Biedermain Drain.
- **Olde Humberstone Village** is a residential development proposed on the island, south of Main St. For the purposes of modeling, it was assumed that the development would discharge via a new sewer on Mellanby Ave. to the existing sewer on Main St.
- **Chippawa Estates** is a residential development proposed outside the existing storm sewer service area. Storm water runoff from Chippawa Estates is not tributary to the existing storm sewer network and was therefore not modelled.
- **Northland Estates** is a residential development proposed in the area tributary to the Eagle Marsh Drain Extension. Northland Estates is not tributary to the existing storm sewer network and was therefore not modelled.
- **Westwood Phase 2 and the Westwood Park Secondary Plan** area are residential developments proposed at the south- west limit of the City. Storm water management facilities will be incorporated in both developments and will ultimately discharge to the Eagle Marsh Drain. These developments will have no impact on other existing or future servicing and were therefore not included in the hydraulic model.
- **Rosedale (V2)** is a residential development proposed adjacent to Meadow Heights. Similar to Meadow Heights, the Rosedale development will incorporate storm water management facilities discharging to the Biedermain Drain and will have no impact on other existing or future servicing. The Rosedale subdivision was not included in the hydraulic model.

Areas V1, and V3 through V7 were identified by the City as vacant developable residential land.

- **Area V1** is assumed to discharge to the existing sewer on Killaly St.
- **Areas V3 and V4** are potential residential development areas tributary to the Eagle Marsh Drain Extension. Neither development is tributary to the existing storm network and were not modelled.
- **Area V5** was assumed to discharge via a new 600m long sewer on Highway 140 to the existing sewer on Main St.
- **Area V6** is assumed to discharge to the existing storm sewer on Barrick Road and ultimately to the North-End trunk sewer.

- **Area V7** is assumed to discharge to a future watercourse or sewer crossing the T.A. Lannan Sports Complex property, then to a future trunk sewer along Russell Ave. from Wellington St. to Janet St.

5.2 COMMUNITY IMPROVEMENT PLANS

Community Improvement Plans (CIP's) provide a framework for improvements to encourage development and growth in an urban area. CIP's provide a long term vision for the given study area, they identify required improvements, and they identify policies, guidelines and strategies for development.

Where the implementation of a CIP will result in development or a change in land use, surface runoff may increase, and trigger the need for additional storm drainage capacity. Implementation of CIP's that focus on specific areas will require specific infrastructure improvements. Implementation of more general CIP's that apply to the entire City, on the other hand, will require more general improvements, if any, such as new or improved policies regarding development standards.

The City of Port Colborne has prepared a number of CIP's, described below, that will have varying impacts on storm drainage.

5.2.1 Downtown Central Business Area Community Improvement Plan (September 2010)

Storm Drainage Area Affected: Area 6 – Victoria St. (Downtown)
Timeline for Implementation: Not Indicated

- Extension of "downtown" designation to areas of King St. south of Victoria St. and north of Elgin St.
- Majority of the Improvement Plan visions are aesthetic improvements to the downtown area, including signage, streetscapes, and the establishment of a Civic Square.
- Financial incentives given for the construction of new residential units (on excess commercial and vacant space).

Drainage Impact: Implementation of streetscaping may provide an opportunity for storm sewer upgrades, and surface runoff improvements.

5.2.2 East Waterfront Community Improvement Plan (March 2012)

Storm Drainage Areas Affected: Areas 14 and 15 – Nickel St. and Rodney St.
Timeline for Implementation: Not Indicated

The City's East Waterfront CIP calls for:

- A green edge – Streetscaping on Welland St. including Storm Sewer Upgrades (identified as 1st priority of 10), landscaped parkland on existing industrial land on the west side of Welland St. to provide a buffer between the canal and the Nickel Area.
- Neighbourhood Infill – infill of existing vacant properties.

- Neighbourhood Extension – Add townhouses and low-rise apartments on existing vacant land south of existing properties.
- Green Streets – modification of roadway widths and extensive tree planting, including Storm Sewer Upgrades (identified as step 3 of 10).
- Neighbourhood renovation including converting several vacant or underutilized plots to residential (townhouses, storefronts, houses, etc.).
- Neighbourhood extension south of Rodney St. between Welland St. and Mitchell St. (townhouses and low-rise apartment buildings).
- Conversion of heavy industrial area south of Lake Rd. to and Natural Heritage Park.

Drainage Impact: Implementation of storm drainage network extension, to accommodate neighbourhood extension, combined with streetscaping, may provide an opportunity for storm sewer replacement. The existing system cannot accommodate additional development. Green Streets can include Low Impact Development (LID) to manage runoff.

5.2.3 Olde Humberstone Community Improvement Plan (December 2008)

Storm Drainage Area Affected: Areas 9, 11 and 12 – Neff Street, Island and Barber Drive
Timeline for Implementation: CIP is a 25 year vision.

- Current storm water drainage system has minimal additional capacity available, and if additional impervious surfaces increase in a substantive manner, the City will require additional storm capacity.
- Extensive parking areas proposed north of Main St. may require new storm outlets into the Weir Canal.
- Proposed parking area east of the Weir Canal south of Main St. would either require a new outlet or could tie into the existing storm system.
- Water-side development including commercial uses and public open space.
- Additional commercial buildings to fill in gaps between existing buildings.
- Additional aesthetic improvement.

Drainage Impact: Implementation of streetscaping may provide an opportunity for storm sewer upgrades, and surface runoff improvements.

5.2.4 City of Port Colborne Industrial Community Improvement Plan

Storm Drainage Areas Affected: All
Timeline for Implementation: Not Indicated

- Includes all lands zoned as "Industrial" in the Official Plan.

- CIP aims to identify new and desirable sectors of the economy and attract new businesses into those sectors through grants and incentives.

Drainage Impact: Development of industrial properties may result in increased surface runoff.

5.2.5 Brownfield Strategy (October 2009)

Storm Drainage Areas Affected: All
Timeline for Implementation: Not Indicated

- 38 potential brownfield sites identified throughout the City, totaling 210 acres.
- Large concentration of these sites on the waterfront at the entrance to the Welland Canal, and on the Canal itself; others disbursed throughout the City, on both sides of the Canal.
- Redevelopment into residential and commercial uses.

Drainage Impact: None likely, given that these sites are already brownfields. Note that the location of the sites was not provided for assessment.

5.3 SUMMARY OF IDENTIFIED DRIVERS FOR SYSTEM IMPROVEMENTS

Drivers for system improvements include:

- The need to address the structural condition of the existing storm sewers.
- The need to improve the level of service based on customer complaints.
- The need to provide additional capacity to accommodate potential development.
- The need to provide additional capacity to accommodate Community Improvement Plans, or to coordinate system improvements with implementation of CIP's.
- The need to address the recommendations of other City Initiatives such as the Inflow and Infiltration Reduction Program (primarily to accommodate sump pump disconnection).

Table 5-2, below, lists the drivers that were identified for each drainage area, based on the available background information. Note that the need to address the structural condition of the existing storm sewers likely applies to more areas than those listed below.

Table 5-2
Drivers for System Improvements

Area No./Outlet Name	Drivers for System Improvements
1 - Eagle Marsh Drain	• Development Capacity - Bayview Lane (0.7ha) Westwood Phase 2 (9.6ha), Westwood Park Secondary Plan (V8, 30.6ha)
2 - Rosemount Avenue	• Development Capacity - CMT Lots (1.2ha)
3 - Steele Street/Sugarloaf	• None identified
4 - Elm Street	• None identified
5 - Marina	• None identified
6 - Victoria Street/Downtown	• Downtown Central Business Area CIP
7 - Princess Street	• None identified
8 - Killaly Street West/Steele	• None identified
9 - Neff Street	• Olde Humberstone CIP
10 - Cedar Street	• Development Capacity - V6 Residential Development (1.9ha), Rosedale (V2, 12.8ha), Meadow Heights (30.5ha) • Satisfy I&I reduction initiatives (Omer Area I&I Program).
11 - Island	• Olde Humberstone Village (3.1ha)
12 - Barber Drive	• Development Capacity - Chippawa Estates (3.5ha), V5 Residential Development (0.9ha)
13 - Bell Street North (Clarke)	• Development Capacity - V1 and V7 Residential Developments (3.1ha, 31.2ha) • Address resident complaints identified by City
14 - Nickel Street	• East Waterfront CIP • Satisfy I&I reduction initiatives (Nickel Area I&I Program). • Address condition of existing storm sewer identified by I&I program. • Separate "Municipal" runoff from "Vale" runoff tributary to Vale's private treatment facility.
15 - Rodney Street	• East Waterfront CIP • Satisfy I&I reduction initiatives (Nickel Area I&I Program). • Address condition of existing storm sewer identified by I&I program. • Separate "Municipal" runoff from "Vale" runoff tributary to Vale's private treatment facility.
16 - Quarry	• Development Capacity - Rosemount Estates (38.5ha)

Area No./Outlet Name	Drivers for System Improvements
17 - Eagle Marsh Ext.	• Development Capacity - Northland Estates (15.8ha), V3 and V4 Residential Developments (54.2ha, 7.8ha)
18 - Vale	• Coordinate with work in Areas 14 and 15 to separate "Municipal" and "Vale" runoff.
19 - Bell Street Northeast	• None Identified
20 - Bell Street East	• None Identified
21 - Bell Street West	• None Identified
22 - Omer Ave	• Satisfy I&I reduction initiatives (Omer Area I&I Program). • Address condition of existing storm sewer identified by I&I program.

6 Hydraulic Modelling - Future Conditions

6.1 APPROACH

The volume and rate of storm water to be conveyed by the City's drainage system is expected to increase in the future as a result of development, community improvement plans, and inflow and infiltration reduction programs.

Private property inspection information collected during the City's Inflow and Infiltration Programs, along with the potential growth and community improvement plan areas presented in the previous section was used to identify future land use changes that will likely impact the rate and volume of storm water runoff that must be conveyed by the drainage network.

Using the information listed above, future development areas were added to the model and the model's impervious areas were adjusted in affected subcatchments. Model simulations were run to characterize changes in runoff volume and rate expected to occur due the various changes in land use and sump pump configurations.

Some of the potential residential development areas (V5, V6, V7 and Olde Humberstone Village) are assumed to connect to the existing storm sewer network in the future. The assumed connection locations are described in Section 5. All other potential residential development areas are assumed to require new outfalls to the Biederman Drain (north of the existing service area), the Eagle Marsh Drain, the Welland Canal, or Lake Erie and will not impact the existing storm sewer system.

Runoff from the future development areas illustrated by Figure 5-1 was simulated to determine the required size and capacity of the connection piping and to assess impacts to the existing downstream system. Because the layout and configuration of future developments are not yet known, and because the costs of these improvements would presumably be borne by the developers, storm water piping internal to each development was not modeled.

For future developments that will be located within, or immediately adjacent to the existing system and where connection to it appears reasonable and feasible, the required connection piping was sized and a connection point to the existing system was selected. Thus, impacts to the existing downstream infrastructure requiring capacity improvements are included in the improvement plan. Outlet locations and connection piping for future developments which are not anticipated to connect to the existing system were not included.

6.2 FUTURE SYSTEM CAPACITY– 5-YEAR STORM

Simulation of the 1:5 year storm was used to assess the future system capacity relative to the system performance criteria, and to assess the impact of redirecting private sump pumps to the storm sewers in the Nickel and Omer I&I Program study areas.

Figure 6-1 illustrates proposed improvements to the existing drainage system. The improvements were sized to convey the 5-year storm flows under the future land use conditions as outlined earlier. The future system incorporates the following improvements:

- All "Non-Designed" sewers and the "Semi-Designed" sewers in Drainage Areas 14 and 15 were replaced with conduits of adequate capacity to convey the 5-year design storm flows. As illustrated by Figure 6-1, these conduits were assumed to take the form of ditches, culverts, or storm sewers.
- The required capacity of each conduit is provided in Appendix C, Table C-1, so that the conduit on a particular street can be selected as a single enclosed pipe, dual pipe, or ditch system depending on the physical constraints of that particular street, cost, and homeowner/community preference.
- The existing outlet for Drainage Area 22 is decommissioned, abandoning the culvert and ditch network branching from Borden Avenue and Elm Street. Flows are redirected north along Elm Street via a 750mm storm sewer main from Borden Avenue and connecting to the existing 2300mm North End trunk storm sewer.
- The existing Nickel Street and Rodney Street outlets for Drainage Areas 14 and 15 are decommissioned. A new outlet at the west end of Nickel Street is created to accommodate flows from Drainage Areas 14 and 15.

Figure 6-2 shows that with the improvements implemented in the model there are no deficiencies under the 5-year design storm event.

Figures 6-1 and 6-2 can be found at the end of this report, in large format.

6.3 FUTURE SYSTEM CAPACITY - 10-YEAR STORM

Hydraulic model simulation of the 1:10 year storm was used to assess the capacity of the system improvements under a less frequent, but more demanding storm event. This analysis was undertaken as a sensitivity analysis. Table 6-1 below, summarizes system deficiencies in the recommended system under the 10-year storm event. The deficiencies are illustrated by Figure 6-3, which can be found at the end of this report, in large format.

Table 6-1
Future 10-Year Storm Deficiencies

Drainage Area	Conduit Count	Conduit Length (m)
1	6	325
2	5	287
3	2	109
6	1	14
8	2	25
9	1	4
12	1	17
13	1	21
14	6	477
20	2	22
21	1	13
Total	**28**	**1,313**

7 Capital Plan

7.1 EXISTING UN-SERVICED AREA IMPROVEMENTS

The City of Port Colborne initiated the Inflow and Infiltration Reduction Program in 2008 with the intention of reducing the negative impacts of I&I on its sanitary sewer network. Phases 2 and 3 of the I&I Program were focused on the sanitary sewers that generally correspond to Storm Drainage Areas 10 and 22 (the Omer sanitary pump station service area) and Storm Drainage Areas 14 and 15 (the Nickel sanitary pump station service area). Both programs concluded that the City's objectives for I&I reduction would require significant improvements to the local storm sewer systems.

The Nickel Area I&I Program was initiated with the intention of re-directing sump pump discharges to the existing local storm sewers. In order to proceed with the intended sump pump disconnection/re-direction program, the capacity and condition of the storm sewers needed to be addressed. This assessment is inherent to the work completed above.

The Omer Area I&I Program was initiated with the intention of reducing I&I at the source, and particularly by re-directing sump pump discharges to grade or to the local storm sewer system. Field investigations conducted as part of this study concluded that local surface grading is usually unsuitable, and that the current condition of the existing storm sewers is inadequate to support a sump pump re-direction program.

Upgrades to the existing drainage system were previously discussed. This section discusses expansion of the drainage system to historical development areas that are currently un-serviced.
Servicing these areas could take several forms including constructing traditional storm sewers based on collecting road runoff and runoff from private properties. However, we believe a more prudent and cost-effective approach is to restrict inflows to these new sewers from sump pumps only, and leave road drainage to be collected by the ditches. This "made in Port Colborne" solution would be cost effective and capitalize on the existing surface drainage system that has evolved over time.

AE compiled the results of the City of Port Colborne's 1992 House to House Drainage Survey and the results of the private property inspection conducted under the Inflow and Infiltration Program between 2008 and 2012. Based on the records of the previous surveys/inspections, Figure 7-1 illustrates the locations of sump pumps connected to the sanitary sewer.

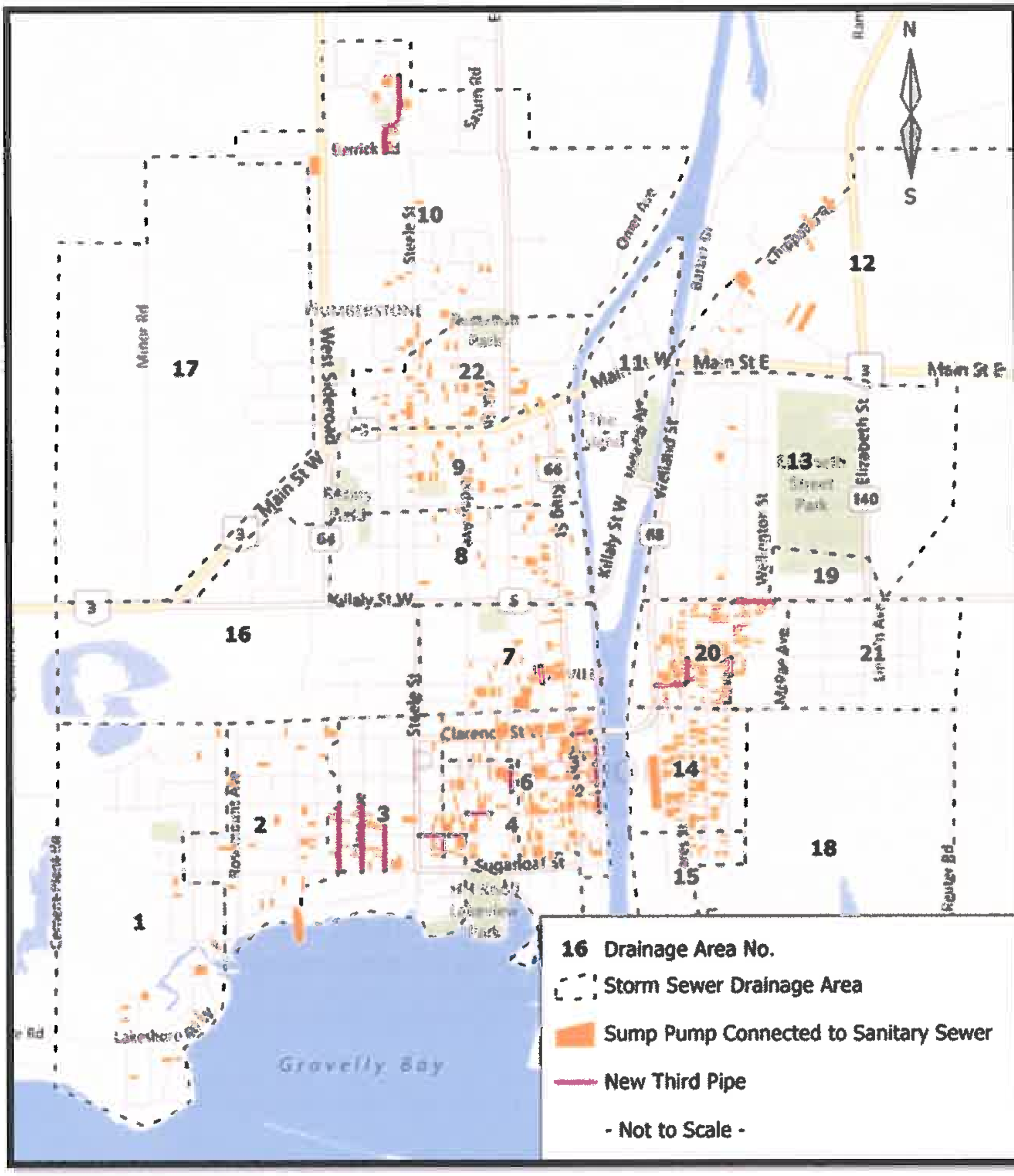


Figure 7-1
Sump Pumps Connected to Sanitary Sewer

By redirecting the sump pumps flows to a "dedicated sump pump drain", a pipe would be required on currently un-serviced streets to accept only the redirected sump pump flows. These small diameter storm sewers would connect to the upgraded storm drains located downstream. This solution would retain existing ditches and swales and would rely on existing grading patterns. It would not require installation of CB's or any additional road improvements. Sump pumps from private properties could be connected to the small diameter pipe once downstream improvements are confirmed. Typically, a sump pump delivers 4L/s of flow. The proposed dedicated sump pump drains would be sized to accommodate approximately 4L/s from each property by re-directing the drain pipes that are currently connected to the sanitary sewer. Dedicated sump pump drain pipes servicing less than three properties have not been included in the analysis.

Figure 7-1 illustrates the proposed "dedicated sump pump drain" pipe locations that would be required using this approach.

7.2 PROPOSED IMPROVEMENTS

The following system improvement categories are defined for the development of the Capital Plan:

- **Upgrade Existing Sewer** - Upsize existing "Designed" or "Semi-Designed" sewers to 5-year storm capacity.
- **Reconstruct Existing Sewer** - Replace existing "Non-Designed" sewers with a conduit (ditch, single pipe, or dual pipe). Also includes "Semi-Designed" sewers in Areas 14 and 15. Cost estimate assumes single pipe.
- **New Dedicated Sump Pump Drain** - New storm sewers to accommodate sump pumps only in existing un-serviced areas.
- **Service New Developments** – Construct new storm sewers required to service proposed developments.

Table 7-1 summarizes the proposed improvements for each drainage area. Approximately 31km of pipe upgrades and reconstruction are recommended, in addition to the construction of approximately 4.7km of new infrastructure to service new development and accommodate sump pump disconnection in currently un-serviced areas. A complete listing of each conduit is provided in Appendix C, Table C-1 and forms the basis of the Capital Plan.

Figure 7-2 illustrates the recommended capital works by system improvement category, and indicates pipe diameters to accommodate the 5-year storm. The improvement categories and pipe diameters shown correspond to those listed in Appendix C, Table C-1.

Table 7-1
Recommended Improvement Summary

Drainage Area	Upgrade Ex. Sewer	Reconstruct Ex. Sewer	New Third Pipe	New Storm Service	Total	Estimated Cost
			Length of Upgrade (m)			
1	760	529			1,289	$1,941,560
2	970	2,157			3,127	$4,971,996
3		1,304	1,084		2,388	$3,653,896
4	329	720	308		1,357	$1,954,816
6	69	1,203	351		1,623	$2,400,308
7		1,867	75		1,942	$2,916,525
8	450	1,690			2,140	$3,153,645
9	793	2,707			3,500	$5,220,875
10	988	2,358	406	145	3,897	$5,424,044
11	421			495	916	$1,610,425
12	55	825		688	1,568	$2,262,235
13		2,545		628	3,173	$5,071,906
14-15		3,598			3,598	$6,380,462
17		778			778	$1,158,240
20	52	206	519		777	$988,041
21	45				45	$191,287
22		3,278			3,278	$4,837,708
Total	**4,932**	**25,765**	**2,743**	**1,956**	**35,396**	**$54,137,969**

A complete listing of all conduits, including length, required flow rate, and suggested pipe diameter is included in Appendix C. Details of the cost estimate are provided in Appendix D.

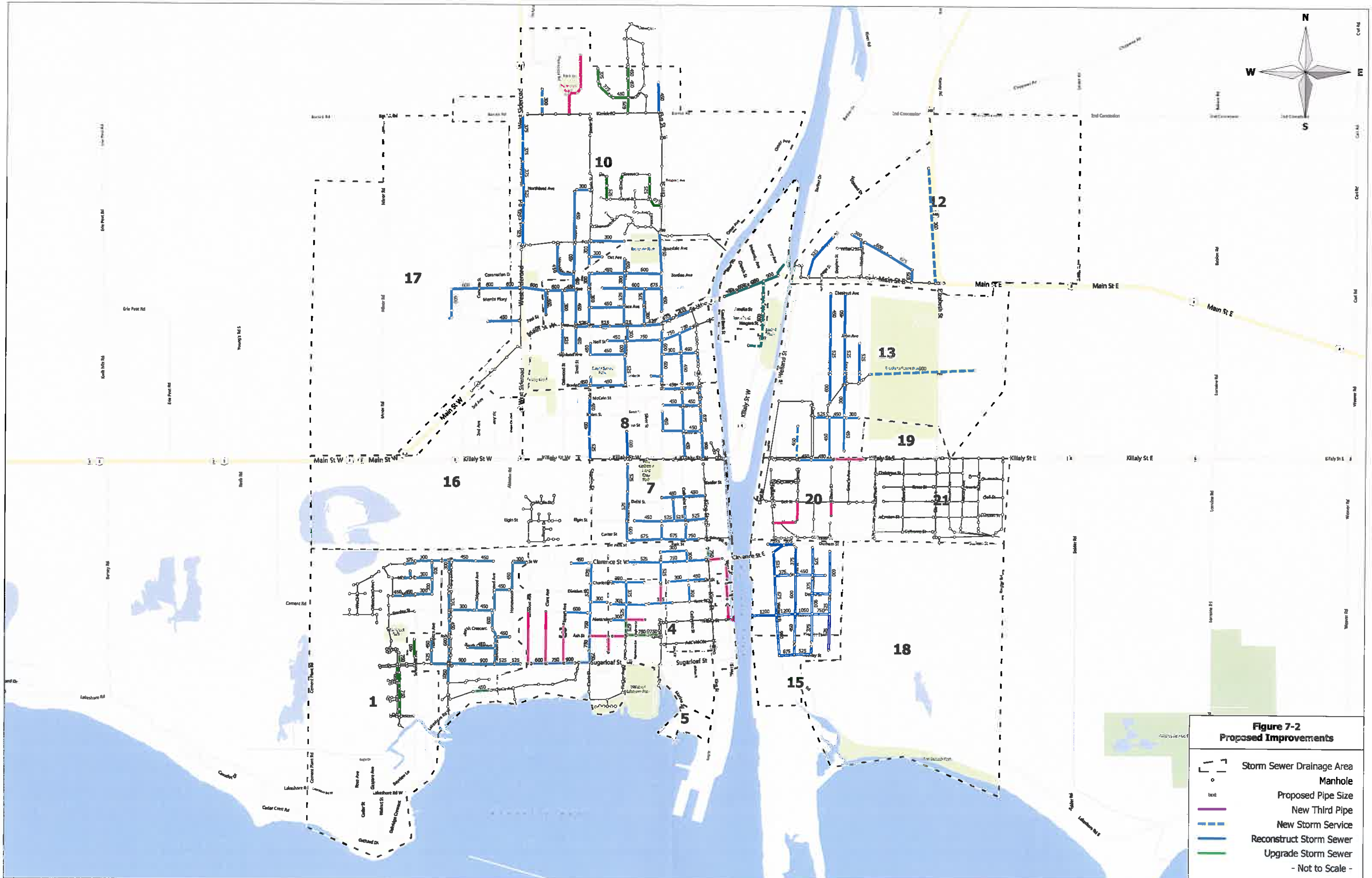

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Figure 7-2
Proposed Improvements
Storm Sewer Drainage Area
Manhole
Proposed Pipe Size
New Third Pipe
New Storm Service
Reconstruct Storm Sewer
Upgrade Storm Sewer
- Not to Scale -

The improvements shown above include all identified upgrades to the existing system for future development. Each of the improvements listed under "Reconstruct Ex. Sewer" in Table 7-1 above could be interchanged with a single pipe or dual pipe solution. The selected solution should be determined by physical site constraints, cost and homeowner/community preference.

It is clear that significant portions of the existing storm water collection system require upgrading. These needs exist for a variety of reasons including capacity and condition. Adding flows prior to completing a systematic upgrade to the existing system is not recommended. However, significant development areas can proceed on the basis that they manage post development flowrates to predevelopment levels. In this manner, undersized pipes located downstream will not be adversely affected.

The redirection of sump pumps to the storm sewer system should be encouraged. However, this should take place in a downstream to upstream direction, concurrent with recommended storm sewer upgrades. In other words, the sewer upgrade and separation program should start near each outfall and work its way upstream as the pipe network capacity downstream is confirmed to meet an acceptable level of service. The addition of new storm drains on currently un-serviced streets should not proceed until the upgrades and separation program has propagated upstream to that location.

7.3 IMPLEMENTATION OF SYSTEM UPGRADES

Implementation of the recommended improvements considers a variety of factors including condition, capacity, planned development and infill, I&I reduction, and complaints. However, improvements to the storm water system, particularly when flow is being added, should generally progress starting from the most downstream end. The recommended implementation strategy is as follows:

- Continue collection of storm sewer network data including pipe inverts, material, and diameters, manhole rim elevations, pipe connectivity, and records of houses with sump pumps. We note that the model results are only as good as the network data that was available through the various investigations completed as part of this study. We recommend an ongoing program to collect storm sewer network data so that a complete GIS database can be developed to the degree possible. The hydraulic models should be updated and re-run upon the collection of significant amounts of data.
- Inspect and maintain all outfalls and make sure flap gates are in good working order.
- Replace all failing pipes and expand inspection efforts with CCTV.
- Replace storm sewer pipes that are identified as being undersized for the 2-year storm without the addition of sump pump flows. Proceed from the most downstream location. Focus first on areas where infill development is anticipated.
- Upgrade storm sewer pipes to the specified level of service (5-year return period with sump pump flows added), proceeding from downstream to upstream. Focus first on areas where development is anticipated.

- Encourage re-direction of sump pumps from the sanitary to the storm system as the downstream storm sewer network is upgraded.
- Add new laterals to currently un-serviced areas as the downstream network is upgraded from the outfall to the point of interest. Connect sump pumps. If larger pipes are selected, add CB's and other drainage infrastructure.

7.4 ENVIRONMENTAL CONSTRAINTS

Port Colborne's existing drainage system does not include pro-active water quality controls. Furthermore, many homes have sump pumps that are currently directed to the sanitary sewer system, thereby negatively affecting the sanitary sewer capacity and generating high flows at the wastewater treatment plant.

Current practices in storm water management encourage storage and infiltration practices. Open ditches and swales provide these benefits as well as reducing capital and maintenance costs. However, it is recognized that homeowners often prefer an enclosed drainage system complete with curb and gutter roadways.

This project has the ability to improve water quality controls by using the following means:

- Redirection of sump pump flows from the sanitary to the storm sewer alleviates pressure on the sanitary sewer system and provides a source of "filtered" storm water to the storm drainage system.
- Replacement of aging sewers will protect against pipe collapse and the subsequent migration of eroded soils.
- In addition to the enclosed storm drain pipe, existing ditches and swales can be retained on currently un-serviced streets thereby providing passive storm water treatment. In some cases these ditches could be converted to bio-swales providing improved aesthetic and storm water quality.
- New development areas should include Low Impact Development (LID's) and Best Management Practices (BMP's) for storm water management. Storm water management faculties should control the rate, volume and quality of storm water runoff.

Converting un-serviced areas to traditional curb and gutter roadways with an enclosed storm sewer, catch basins and service connections will add significant capital costs to the City. The benefits of retaining open ditches should not be overlooked. In addition to providing passive water quality benefits, open ditches and swales provide a storage and conveyance function that relieves pressure on the downstream system. In many areas the ditches have been landscaped to provide an aesthetic solution. As a longer term goal, some existing ditches, and or drainage tile areas could be converted to bio-swales. This solution requires consideration of the parallel pipe sizing and connections between the bio-swale and storm sewer.

8 Policy and Standards Development

The City of Port Colborne enacted a sewer use bylaw (Bylaw No. 5228/134/08) to provide an enforceable means of executing the I&I reduction program. The Bylaw includes the following provisions:

- Grants City Staff, or their agents, the authority to enter private property for the purposes of investigating I&I.
- Mandates the removal of any storm inflow sources, including direct connections of roof leaders and sump pumps, to the sanitary sewer system.
- Provides municipal funding to assist private property owners in completing retrofits required to comply with the Bylaw.

The following suggested policies are general in nature, but will provide a framework from which to develop specific policies throughout the City.

Roof Leaders and Foundation Drains

Roof drains should discharge on grade at least 1.5m away from the building foundation using drainage extensions with the ground sloped away from the building. Roof drains should not be permitted to connect directly to foundation drains or the municipal drainage system. Foundation drains should be routed to flow to the storm sewer system.

Lot Grading

All future and redevelopment lots should be graded to ensure surface drainage flows away from the house and is effectively conveyed overland towards the street. This reduces inflows to the perimeter drains and reduces seepage volumes to the sump pumps. As well, the necessary rise in the height of land away from the street ultimately creates an effective major overland flow path within the municipal right-of-way.

Existing Drainage System

The existing drainage system should be upgraded to accommodate the 1:5 year storm. Major overland flow paths, for the 100-year event, will need to be developed over time with improved lot grading. Existing ditch and swale infilling on residential streets should not be permitted. New storm drains on currently un-serviced streets will be provided to collect flows originating from sump pumps only. The minimum pipe size will be 300 mm diameter. Minimum culvert size will be 450 mm diameter.

Frontage tiles are of unknown condition and effectiveness and cannot reliably accept new sump pump flows. Frontage tiles should be replaced with a single pipe, dual pipes, or open ditches depending on physical site constraints, cost and homeowner/community preference. Bio-swales should be encouraged in conjunction with pipe upgrades.

Sump Pumps

Where the entire downstream storm water system, from the new connection point to the outfall is upgraded to the required level of service, sump pumps should be re-directed from the sanitary sewer system to the storm sewer system. In newer development areas, where lot grading provides effective overland drainage and the existence of effective major overland flow paths are confirmed, runoff from sump pumps should be directed across pervious ground surfaces prior to entering the storm sewer system.

9 Infrastructure Renewal and Sustainability

The infrastructure improvements recommended by this Master Plan represent a significant capital investment program for the City of Port Colborne. The following section examines potential revenue sources, user fees and cash flow requirements to fund the recommended capital plan.

9.1 MUNICIPAL REVENUE SOURCES FOR STORM WATER

9.1.1 Property Taxes

Property taxes are the main funding source for municipalities in Ontario. The cost of storm water service is recovered through the mill rate applied to the market value of properties. The main advantage of tax based funding is that it is an existing and accepted approach with a well established billing system. However, tax based funding is not a dedicated source and is subject to competition for limited funds. It is not therefore considered sustainable in terms of routinely covering the full costs of the service.

Tax levies are not expected to correlate closely with storm water from a property. A charge based on property taxes is therefore not equitable since it does not reflect the benefit received by the property owner from storm water management services. Moreover the tax system does not give property owners an incentive to manage storm water on-site.

Exemptions from property tax under subsection 3(1) of the Assessment Act, 1990 for non-profit organizations, religious organizations and charities among others mean that these properties contribute to runoff but do not help fund storm water programs unless they make payments in lieu of taxes.

Section 326 of the Municipal Act, 2001 allows municipalities to impose special area rates. These rates apply to properties within a designated area which receive benefit from a "special service" that is not provided or provided to the same level elsewhere in the municipality. Special area rates are commonly applied to waste management, fire, sewer and water[1]. They cannot be used to fund a municipal-wide storm water management program.

9.1.2 Local Improvement Charge

Ontario Regulations 586/06 and 322/12 under the Municipal Act, 2001 empower municipalities to use local improvement charges to recover the costs of capital improvements on public or private land from property owners benefiting from the improvement. The municipality and property owners must enter into an agreement regarding imposition of the charge and property owners can petition to either initiate or block a local improvement. Costs can be apportioned to property owners "on any basis that the municipality considers appropriate"; presumably including apportionment according to each property's contribution to

[1] Ministry of Municipal Affairs and Housing. The Municipal Councillor's Guide 2010 (http://www.mah.gov.on.ca/Page8393.aspx)

storm water runoff[2]. Local improvement charges do not cover maintenance work and cannot be applied to municipal-wide projects.

9.1.3 Development Charges and Related Mechanisms

Municipalities are authorized to recover the costs of certain infrastructure investments that service new growth and redevelopment by the Development Charges Act, 1997. Development charges can only be used to fund eligible project costs and associated revenues are earmarked for funding of those projects.

Like development charges, subdivision agreements are used to fund the local infrastructure associated with new subdivisions. Under these agreements, developers provide infrastructure such as storm sewers and the municipality assumes ownership and responsibility for these once construction is complete.

These instruments are limited in application to storm water infrastructure on newly developed land within the municipality and are therefore dependent on growth. They do not help with maintenance or replacement of existing infrastructure.

9.1.4 Storm Sewer User Fees

Municipalities are authorized to impose fees and charges for storm water services under sections 9, 10, 11 and 391 of the Municipal Act, 2001. Storm water user fees recover the cost of storm water management from property owners who benefit from that management. The benefit experienced by property owners is the safe removal of runoff from their property and its conveyance to a suitable downstream outlet without jeopardizing downstream properties.

A variety of approaches are used in the design of storm water user fees. There are examples of charges based on metrics such as metered water use or assessed property value, but these earlier designs are not best practice and are not considered in this report. More recent implementations of storm water user fees tend to base charges on surrogate measures of a property's contribution to storm water runoff such as the property size or the surface area that is impervious to rainfall infiltration. Revenues from storm water user fees are normally dedicated to funding of storm water services. They can be used to recover both capital and operating costs and, depending on the structure of the charge, can do so in an equitable manner. They can also be structured to give property owners an incentive to implement on-site controls of storm water runoff such as detention ponds. The storm water user fee allows the municipality to recover storm water management costs from properties that are exempt from property taxes.

Like water and wastewater charges, storm water user fees are set annually by Council. The charges are often levied on the water and wastewater bill but some municipalities recover them on the tax bill.

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[2] Local Improvement Charges Regulation Amendments Under the Municipal Act and the City of Toronto Act (http://www.ontariocanada.com/registry/view.do?postingId=6982). Provisions in these regulations resemble those for funding of drainage works in rural areas under the Drainage Act, 1990. The Drainage Act however stipulates the approach to cost apportionment, requires the involvement of a drainage engineer, and provides for construction and maintenance. Property owners can petition for work under the Drainage Act, and decisions can be appealed to the Drainage Tribunal. Environmental Impact and Cost Benefit studies can be required under the Drainage Act.

Unlike other revenue instruments described above, storm water charges are not common in Canada and may not have broad public acceptance. Their implementation therefore requires a concerted public information and consultation campaign. Implementation costs are incurred to establish and maintain customer records and a billing and collections system.

9.1.5 Comparing Revenue Instruments

Comparisons of Revenue Instruments as shown in Table 9-1 below are based on the specified criteria. An overall ranking of revenue sources cannot be made until local priorities and circumstances in Port Colborne are better understood.

Table 9-1
Comparison of Revenue Instruments

Criteria	Property Taxes	Local Improvement Charges	Development Charges	Storm Sewer User Fees
EQUITABLE – payments by customers are commensurate with the level of service required and the benefit received*	NO –based on assessed property value which has little bearing on the demand for service	Can be if costs are apportioned appropriately. Apportionment by frontage is not equitable	NO – costs are apportioned by floor area of buildings which has little bearing on the demand for service	YES - if costs are apportioned based on contribution to runoff (some fee structures do not do this)
DEDICATED – collected revenues should be dedicated to storm water services	NO – revenues go to general fund (special area rates are dedicated)	YES – to specific growth related capital projects	YES – to specific growth related capital projects	YES – dedicated to storm water services
SUSTAINABLE – allows budgeting based on long term planning of funding requirements	NO – competing priorities can cause funding levels to vary	YES – funding for the covered project is guaranteed	YES – funding for the covered projects is guaranteed	YES – dedicated funding allows long term financial planning
AREA-WIDE – covers the total program area	YES – covers entire municipal area	NO – applies only to the local improvement area	NO – applies only to lands subject to new development or redevelopment	YES – covers entire storm water system service area
ALL COSTS – applies to all program costs	YES – revenues cover operating, maintenance and investments	NO – revenues cover only capital investments	NO – revenues cover only capital investments	YES – revenues cover operating, maintenance and investments
INCENTIVE –customers can save by reducing their demands for service**	NO – no credits for on-site storm water controls	NO – no credits for on-site storm water controls	NO – no credits for on-site storm water controls	YES – user fee program can include credits for on-site storm water controls
UNDERSTANDABLE – the customer charge is reasonably easy to understand	YES –in place long enough that most customers understand it now	YES – relatively simple charge levied on the tax bill	YES – Property owners not charged directly. Most developers understand the charge.	NO – Many will likely be confused at first since storm water systems are probably poorly understood.
IMPLEMENTATION – implementation costs should be relatively low	YES – already implemented	NO – case by case implementation with possibility of petitions to challenge projects	YES – already implemented	NO – new program costs incurred for design and public consultation and to establish customer data base, billing and collections system

Criteria	Property Taxes	Local Improvement Charges	Development Charges	Storm Sewer User Fees
ADMINISTRATION – administrative effort should be relatively low	YES – resources already committed	YES – once implemented, annual charges should be easy to levy	YES – resources already committed	NO – customer records require periodic updating, any credit program involves additional resources

* Requires that storm water service costs be allocated to customers in proportion to the contribution of their properties to storm water runoff.

** Requires that customers can reduce their service charge by controlling runoff from their property.

9.2 STORM WATER USER FEES

This section examines storm water user fees in greater detail. The material is intended to provide a general overview that will inform the reader of options and issues relating to the adoption of a storm water user fee; no recommendations are made at this time. Additional information on storm water user fees can be found in Appendix E.

9.2.1 Design and Structure of Storm Water User Fees

Several recently completed storm water user fee feasibility studies were reviewed in preparation for this work.[3] Although these reports cover essentially the same topics, they do not apply a consistent terminology in describing storm water user fees. To avoid confusion we adopt the terminology used in the manual, "User-Fee Funded Storm water Programs", recently published by the Water Environment Federation[4]. In addition to the above mentioned reports, the discussion below benefited from material in the following publications:

- National Association of Flood and Storm water Management Agencies, 2006. Guidance for Municipal Storm water Funding (http://www.nafsma.org/Guidance%20Manual%20Version%202X.pdf)
- United States Environmental Protection Agency New England, 2009. "Funding Storm water Programs". EPA 901-F-09-004 April 2009 (http://www.epa.gov/region1/npdes/storm water/assets/pdfs/FundingStorm water.pdf)
- Inter Local Storm water Working Group, May 2005. Storm water Utility Fees, Considerations & Options. New England Environmental Finance Center. (http://efc.muskie.usm.maine.edu/docs/Storm waterUtilityFeeReport.pdf)

Like any utility user fee, the basic calculation of any storm water fee involves dividing required revenue by the number of service units.

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[3] TSH et. al., October 2008. Kitchener-Waterloo Storm water Management Program and Funding Review: Storm water Funding Analysis, Draft Final Report. AECOM, January 2010. City of Hamilton Storm water Rate Feasibility Study, Project Number: 60119509. Watson & Associates, JANUARY 7, 2013. Town of Richmond Hill Storm water Management Financing Feasibility Study

[4] Water Environment Federation, 2013. User-Fee Funded Storm water Programs, Alexandria VA (ISBN 978-1-57278-277-8) (the first edition of this publication was released in 1994)

9.2.1.1 System Costs

Required revenue in a year will be the sum total of system costs less non-rate revenues from sources such as the general tax fund, developer contributions and the proceeds of new debt. Currently, storm sewer costs in Port Colborne are provided under a single functional account code, 510. This reflects the departmental structure used to deliver storm sewer services for which accounts for various overhead activities relating to several services are reported at a departmental level. Ideally storm water system user fees should recover all costs related to service delivery including allocated overhead costs; asset maintenance, repair and replacement costs; the costs of capital finance; and operating costs associated with monitoring, customer billing and collections, customer records, public education and relations, and so on. This approach is common for municipal water supply services which are 'ring fenced' for purposes of financial reporting and have accounts that are segregated from other municipal operations. A similar segregation of storm water system costs would facilitate the implementation of a storm water user fee and help guarantee full cost recovery using the fee.

It has been a common practice among municipalities to calculate user fees annually based on next year's budget. More and more municipalities are however adopting a longer financial planning horizon, looking ahead several years when setting next year's rates. Some municipalities even set user fees for more than one year at a time. The multi-year horizon identifies cash needs that can vary widely in response to the capital program and it allows a more careful management of cash flow using revenues, reserves and debt. This in turn allows rate setting that anticipates future funding needs and that avoids large annual adjustments and rate shock. A multi-year financial planning framework is also essential for implementation of an asset management program.

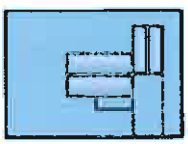
9.2.1.2 Service Units and Unit Costs

The definition of service units for storm water services parallels that for water supply and wastewater services. When user fees were first introduced for those services, flat rate billing was the norm and the service unit was essentially the customer. Over time the concept of the service unit was refined so that costs could be allocated to customers in proportion to their demands for service and the costs they caused for service delivery. This entailed identifying cost drivers that could be measured for purposes of billing.

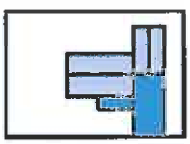
Differentiating customers by class is a basic step towards refinement of service units and is useful for purposes of cost allocation when levels of service vary by customer class. The differentiation reflects the fact that different classes of customer have, on average, different levels of demand. The simplest differentiation for storm water is between residential and non-residential customers. Residential customers can be further divided into single family and multi-residential, customers in each class being described in terms of the number of dwelling units in a building. A common classification of non-residential customers in storm water and other utility services is commercial, industrial and institutional.

Customer classification allows flat rate user fees to be differentiated by class, but customer classification fails to adequately capture the main cost drivers in storm water management systems. These drivers include peak runoff of extreme or 'design' storms, the average annual volume of runoff, and sediment and pollutant loads carried in surface runoff. These drivers are, in turn, determined by property characteristics such as size, soil type, vegetative cover, topography, presence of hard or impervious surfaces and existence of storm water control measures such as rain gardens or detention ponds. These characteristics govern whether and how fast rainwater leaves a property to enter the storm water management system.

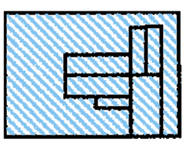
Equitable cost allocation across customers requires that the measure of service units provides a reasonably accurate proxy description of a property's contribution to storm water runoff. In water supply and wastewater services, the measure of service units is the metered volume of water used by a customer. Unfortunately, measuring storm water runoff volumes is not feasible. Instead proxy measures based on property characteristics are used to define service units. Several alternative measures are used:



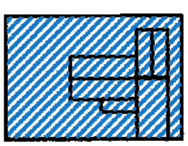
Gross area – The total area of a property. Directly related to the total incident rainfall onto a property but not necessarily to the amount of runoff due to the influence of factors identified above. If soils are saturated or rainfall is extreme gross area will correlate with runoff.



Impervious area – The area of hardened surface on a property (roof tops, pavement, sidewalks) that prevents infiltration and causes rainfall to runoff as soon as it falls. Impervious area "exerts the greatest influence on the peak rate, volume and quality of runoff."[5]



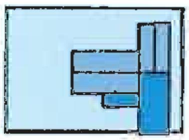
Gross Area Factored by a Runoff Coefficient – The gross area of a property multiplied by an assumed average runoff coefficient for that type or class of property. The runoff coefficient for a surface is a value representing the percentage of rainfall that is turned into storm water runoff and it captures the combined effect of various characteristics of the surface and the rainfall. The runoff coefficient for an impervious area is close to 1.0 while it might be near zero for a highly permeable area.



Gross Area Classified by Intensity of Development – Properties are classified by the intensity of development. The percentage of impervious area is assumed to fall within a range of values for each intensity-of-development category, for example:
- Vacant/Undeveloped - 0% to 3% impervious
- Light development - 3% to 20% impervious
- Moderate development - 21% to 40% impervious
- Heavy development - 41% to 70% impervious
- Very heavy development - 71% to 100% impervious

The property's gross area plus a rating factor for its intensity of development category provides the basis for calculating the customer's charge.

[5] Water Environment Federation, 2013. User Fee Funded Storm water Programs (pg 46).



Equivalent Hydraulic Area – Impervious and pervious areas are multiplied by hydrologic response factors to estimate the overall relative impact of a property on storm water runoff. This is a data intensive approach that captures the impact on runoff of undeveloped properties that have no impervious areas.

The following figure summarizes advantages and disadvantages of these alternative approaches:

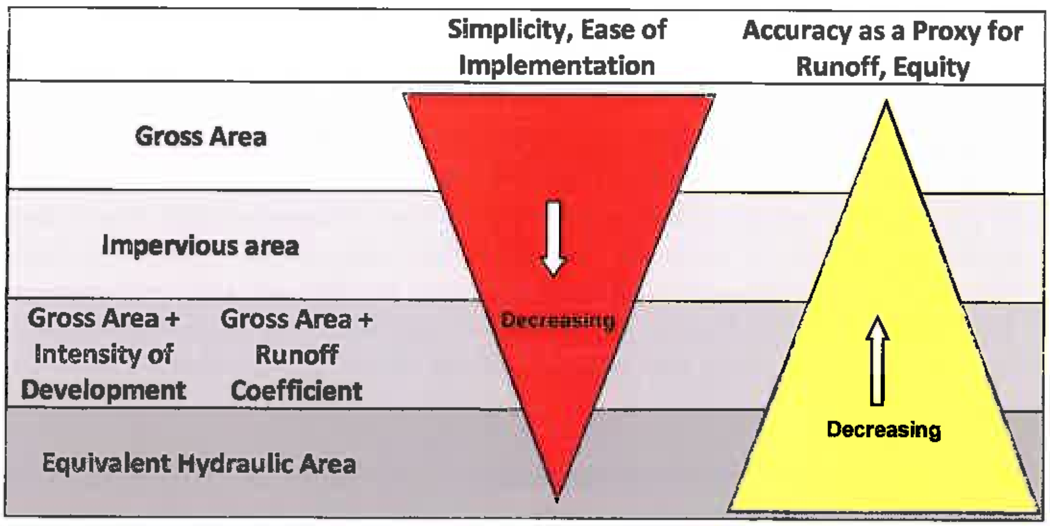


Figure 9-1
Comparison of Storm Water Service Units

The storm water service unit is a conversion of the area measure into an 'Equivalent Runoff Unit' (ERU). Typically one ERU is based on the average or median area of a residential property or detached single-family residential property. For example. if the standard is the median detached single-family residential property with an impervious area of 1500 square feet, then the ERU measure for an industrial property having 23,000 square feet of impervious area is estimated as:

23,000 sq.ft. / 1500 sq.ft = 15.33

The user fee is estimated as the total annual cost of service to be recovered from user fees divided by the total number of ERUs, for example:

Annual cost of service / total ERUs = $4,500,000 / 38,500 ERUs
= $116.88 / ERU / year

The customer's charge is estimated as the cost per service unit multiplied by the customer's number of service units, in the above example of an industrial property:

$116.88 X 15.33 ERUs = $1,791.77 / year

Using an 'intensity-of-development' approach, the rating factor for intensity of development is added to this calculation.

Note that 'Equivalent residential unit' and 'equivalent single detached unit' are alternative terms used for "equivalent runoff unit'.

Grouping of Customers – All of the customers within a customer class may be assigned a single value for ERU. This is commonly done for single-family residential customers who are all assumed to have an ERU of 1.0 despite the size of individual properties or their impervious areas. Where statistical analysis reveals significant variation in residential properties, the class can be 'tiered' into large, medium and small categories with normal properties falling within say the 10th and 90th percentiles of properties ranked by size. It is less common to group non-residential customers in this manner since gross and impervious areas can vary so widely within this category. Rather, ERUs are calculated directly for each non-residential property.

Multi-residential buildings can be treated in the same manner as non-residential properties or they can be classified with residential properties. As residential properties they can be assigned 1.0 ERU for each dwelling unit but a smaller value to reflect smaller areas contributing to runoff, say 0.7 ERUs per townhouse dwelling unit and 0.5 ERUs per dwelling unit in an apartment building. Specific values should be based on an analysis of areas for a sample of multi-residential buildings.

Geographic areas – It is also possible to split the storm water service area into separate service areas with distinct levels of service or attributes that cause costs of service to vary systematically, for example, topography or reliance on open ditches in a more rural setting versus storm sewers in an urban setting. The unit cost used in estimating customer bills is estimated separately for each service area. This approach is not common, but may be applicable in Port Colborne given the varying levels of service, i.e. ditches vs. sewers.

9.2.1.3 Rate Structures

Rate design elements described in the previous section include the basis for estimating service units, the calculation of unit costs, customer classification, rate tiers, grouping of customers and the delineation of distinct geographic areas for purposes of charging. These elements are combined to define the specific storm water rate structure that is used in a municipality. There are many ways to structure storm water rates. These increase in complexity as the measure of ERUs shifts from gross area to measures of impervious and pervious areas. To reduce complexity, customers are often classified into residential and non-residential classes; residential customers are grouped into flat rate tiers and the more refined measures of ERU are applied only to non-residential customers.

The following table describes some rate structure options listed in order of increasing complexity:

Table 9-2
Sample Rate Structures

Customer Class	Single detached	Multi-residential	Non-residential
Simple Flat Rate	Al customers grouped into a single class. Uniform flat rate paid by all customers		
Tiered Rate, ERU based on gross area	Storm water charge based on the unit cost per ERU times 0.8, 1.0 and 1.3 ERUs for small, median and large customers respectively.	Charge calculated as the unit cost per ERU times 0.8 ERUs per dwelling unit.	5 to 10 tiers with rates for each tier based on the average property ERU within each tier.
Tiered Rate, ERU based on impervious area	Similar to 'Tiered Flat Rate, gross area' except rate calculations are based on impervious area.		
Non-residential unit rate, ERU based on impervious area	Storm water charge based on the unit cost per ERU times 0.8, 1.0 and 1.3 ERUs for small, median and large customers respectively.	Duplexes, triplexes, townhouses charged the unit cost per ERU times 0.8 ERUs per dwelling unit. Apartment buildings charges as non-residential.	Charge calculated as unit cost per ERU times total ERUs. Total ERUs based on actual impervious area compared to the average area of a medium single detached property.
Unit rate, ERU based on impervious area	Charge calculated as unit cost per ERU times total ERUs. Total ERUs based on actual impervious area compared to the average area of the median single detached residential property.		
Unit rate, equivalent hydraulic area	Similar to 'Unit rate, ERU based on impervious area' except rate calculations are based on equivalent hydraulic area.		

9.2.1.4 Credits

Under the rate structures described above the only way a customer could reduce their storm water charge would be to reduce the area of impervious pavement and that works only if they are charged based on actual impervious area rather than a generic estimate such as is used for the tiered rate structures. The customer has no financial incentive to implement any of the many storm water management measures that can be used in situ such as rain gardens, retention ponds and pervious pavement.

A credit policy can be used to create a storm water management incentive. This allows customers to reduce their charge by a prescribed amount if they implement mitigation measures on their property to control runoff. Credit policies should stipulate:

- The type of credit (e.g. percentage reduction, absolute amount)
- Eligible measures and the level of credits for each
- The period of time the credit is in place

- Technical and administrative criteria and procedures to apply for the credit (e.g. need for an engineer's report, application forms, monitoring and inspection requirements)

Rate setting exercises should account for revenue losses from the issue of credits and those losses will hopefully be balanced with long run cost savings to storm water operations.

9.2.1.5 Exemptions

Exemptions are provided from property tax obligations for non-profit organizations, religious organizations and charities. These exemptions are inequitable in the context of storm water service provision. One benefit of a storm water user fee is the end of these exemptions but some municipalities may choose as a matter of local policy to continue the exemptions.

A stronger case for exemptions can be made in the case of undeveloped properties that contribute negligible amounts of runoff to storm sewers and for properties that drain into natural water courses that have no hydrological connection to storm water management systems.

9.2.2 Implementation

It is recommended that the City undertake the following tasks as part of a storm water user fee implementation process:

- Establish and maintain a geo-referenced customer data with data fields including property ID and ownership, customer classification, gross area, impervious area, status of credits, etc.
- Develop policies, procedures and resources for revising, validating and updating the data base.
- Review system costs and determine full-costs of the storm water system including capital plans and asset management costs. Estimate any new costs associated with implementation of the new user fee including for billing software.
- Review cost reporting policies and procedures including the chart of accounts and revise as needed to facilitate future budgeting and rate setting exercises. Storm water costs should be segregated in accounting records.

9.3 FINANCIAL PLAN DEVELOPMENT

9.3.1 Approach

This section documents an analysis of mechanisms to recover the cost of a capital plan to upgrade and restore the urban storm water drainage system of the City of Port Colborne.

A simple approach based on a sinking fund analysis[6] of cash flow requirements is used in order to develop preliminary estimates of the cost burden that must be incurred by property owners to finance renewal of the storm water drainage system. The focus of the analysis is the investment required to implement the storm water system capital plan summarized in Tables 7-1 and 9-2. Operating and maintenance costs are not addressed.

Table 9-3
Summary of Improvement Costs

Drainage Area	Upgrade Ex. Sewer	Reconstruct Ex. Sewer	New Dedicated Sump Pump Drain	New Storm Service	Total
1	$1,274,346	$667,214			$1,941,560
2	$1,634,680	$3,337,316			$4,971,996
3		$2,295,788	$1,358,108		$3,653,896
4	$642,721	$925,744	$386,350		$1,954,816
6	$146,225	$1,803,247	$450,836		$2,400,308
7		$2,820,318	$96,206		$2,916,525
8	$877,802	$2,275,842			$3,153,645
9	$1,228,185	$3,992,690			$5,220,875
10	$1,448,669	$3,285,647	$509,753	$179,975	$5,424,044
11	$851,882			$758,544	$1,610,425
12	$87,555	$1,304,486		$870,194	$2,262,235
13*		$3,514,830		$1,557,076	$5,071,906
14-15*		$6,380,462			$6,380,462
17		$1,158,240			$1,158,240
20	$62,649	$276,245	$649,148		$988,041
21	$191,287				$191,287
22*		$4,837,708			$4,837,708
Total	$8,446,002	$38,875,778	$3,450,401	$3,365,789	$54,137,969

* High priority investment; these are prioritised in this analysis.

[6] A sinking fund analysis converts a varying profile of future costs, such as is expected in a capital plan, into an equivalent profile of uniform cash flow requirements. The present value of the levelized cash flow profile equals the present value of the original varying cost profile. From a financial perspective the two cash flow profiles are equivalent provided that periods of deficit can be financed out of reserves and debt.

Key assumptions of the analysis are as follows:

- Inflation is not considered; the analysis is based on constant 2014 price levels.
- Engineering costs comprise 10% of total costs and are incurred in the year prior to construction.
- High priority investments are implemented first. Other investments are arbitrarily ordered based on their drainage area number (this assumption can be refined at a later date).
- The opportunity cost of capital for the municipality is assumed to be 3.6%, approximately the rate for 20 year debt[7]. This represents a nominal rate in a financial market where inflation prevails. Assuming a 2% annual rate of inflation, the opportunity cost of capital in real terms is 1.57%.
- Parcels classified as 'Public' do not contribute to cost recovery.
- New storm service investments are financed using development charge funds.
- Two alternative approaches to cost recovery are considered: a storm water user fee and the property tax. Two forms of the storm water user fee are evaluated, one based on total parcel size and one based on the size of the parcel's impervious area. Base data used for calculation of storm water system charges are listed in Table 9-3.

Table 9-4
Parcel Data

Parcel Class	Number of Parcels	Parcel Area (m2)		Impervious Area (m^2)		Property Tax Assessment**		
		Avg	TOTAL	Avg	TOTAL	Number of Parcels	Average	Total (million)
Not Coded	81	2,821	228,530	378	30,615	na***	na	na
Commercial	379	10,240	3,880,982	1,196	453,239	379	$254,774	$96.6
Industrial	188	38,774	7,289,579	1,724	324,034	188	$374,521	$70.4
Multi-residential	38	3,683	139,955	1,064	40,420	38	$1,104,851	$42.0
Public	99	55,264	5,471,172	1,946	192,656	99	na	na
Residential	7,574	4,239	32,108,134	204	1,547,175	7,655***	$173,167	$1,325.6
Farm/forest	467	147,775	69,010,929	933	435,694	467	$67,389	$31.5
All	8,826	13,384	118,129,280	343	3,023,833	8,826	$179,445	$1,566.0

** Province of Ontario, Financial Information Returns, 2012 (http://csconramp.mah.gov.on.ca/fir/Welcome.htm)
*** Residential parcel count under tax assessment is assumed to include drainage parcels that are not coded

[7] Infrastructure Ontario, May 26, 2014, http://www.infrastructureontario.ca/Templates/RateForm.aspx?ekfrm=2147483942&sector=mun

9.3.2 Results and Discussion

The analysis of funding requirements is summarized in the following table:

Table 9-5
Analysis of Funding Requirements

Year	Drainage Area	Total	DC Funding	Net Funding Requirement	Annual Cash Requirement	Levelized Cash Flow
2015	13	$5,071,906	$1,557,076	$3,514,830	$351,483	$3,018,389
2016	22	$4,837,708	$0	$4,837,708	$3,647,118	$3,018,389
2017	14-15	$6,380,462	$0	$6,380,462	$4,991,984	$3,018,389
2018	1	$1,941,560	$0	$1,941,560	$5,936,572	$3,018,389
2019	2	$4,971,996	$0	$4,971,996	$2,244,604	$3,018,389
2020	3	$3,653,896	$0	$3,653,896	$4,840,186	$3,018,389
2021	4	$1,954,816	$0	$1,954,816	$3,483,988	$3,018,389
2022	6	$2,400,308	$0	$2,400,308	$1,999,365	$3,018,389
2023	7	$2,916,525	$0	$2,916,525	$2,451,929	$3,018,389
2024	8	$3,153,645	$0	$3,153,645	$2,940,237	$3,018,389
2025	9	$5,220,875	$0	$5,220,875	$3,360,368	$3,018,389
2026	10	$5,424,044	$179,974.69	$5,244,069	$5,223,195	$3,018,389
2027	11	$1,610,425	$758,543.71	$851,882	$4,804,850	$3,018,389
2028	12	$2,262,235	$870,194.01	$1,392,041	$905,898	$3,018,389
2029	17	$1,158,240	$0	$1,158,240	$1,368,661	$3,018,389
2030	20	$988,041	$0	$988,041	$1,141,220	$3,018,389
2031	21	$191,287	$0	$191,287	$908,366	$3,018,389
TOTAL			**$3,365,789**	**$50,772,180**	**$50,600,022**	**$51,312,607**
NET PRESENT VALUE					**$44,735,223**	**$44,735,223**

Only engineering design costs are incurred in the first year and construction commences in the second year. Works in each drainage area are assumed to be completed in one construction season. The levelized annual cash requirement is estimated to be $3.02 million at 2014 prices.

The annual cash requirements and levelized cash flow are compared in the following figure.

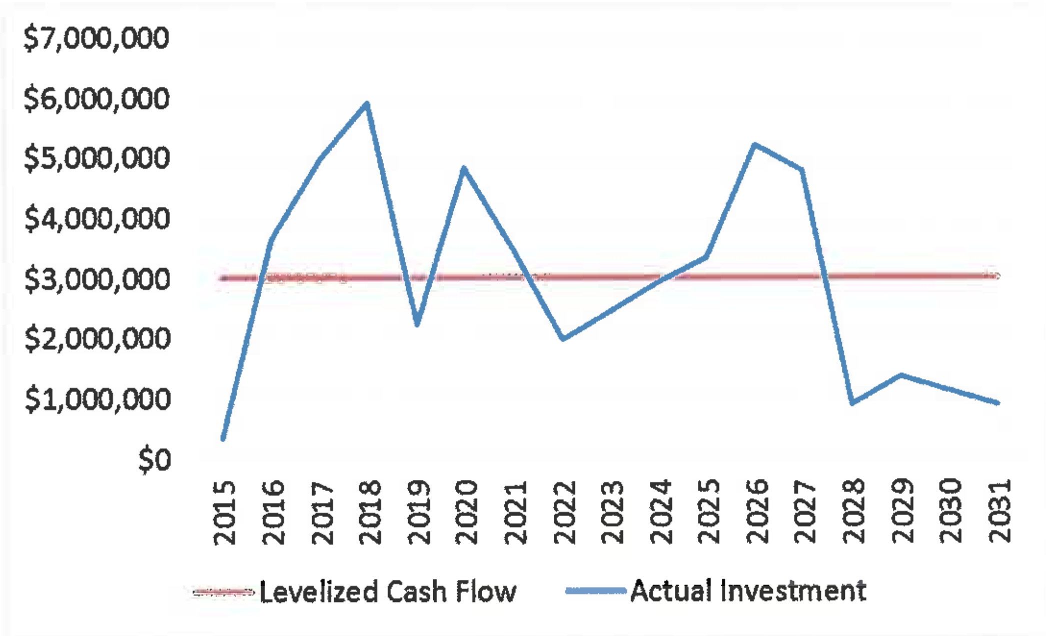


Figure 9-2
Cash Flow Requirements

The following charge rates were calculated:

- Parcel area storm water charge ($/m^2) = $0.0268
- Impervious area storm water charge ($/m^2) = $1.0661
- Property tax rate (% of assessed parcel value) = 0.1701%

The average annual charge levied against each parcel class to recover the levelized annual cash requirement to finance the storm water capital plan is reported in Table 9-5.

Table 9-6
Sewer Use Charges

Parcel Class	Sewer User Charge		Property tax
	By Parcel Area	By Impervious Area	
Not Coded	$76	$403	na
Commercial	$274	$1,275	$762
Industrial	$1,039	$1,838	$1,676
Multi-residential	$99	$1,134	$3,842
Public*	$0	$0	$0
Residential	$114	$218	$295
Farm/forest	$3,959	$995	$29
All	$346	$346	$346

* No cost recovery from public properties

Each of these charge schedules recovers the required amount ($3.018 million) using a different base for charging. The following observations can be made:

- The different approaches to cost recovery allocate costs in markedly different ways but the average cost per parcel is the same across all three approaches as expected.
- The amount that individual property owners pay will differ from the amounts calculated since several parcels may be owned by single persons or companies.
- The parcel area storm water charge places a heavy burden on farm properties. This burden shifts to industrial, commercial and multi-residential properties with the two other charges.
- Charges for residential parcels vary least across the three charging approaches.
- The impervious area charge likely comes closest to a charge that allocates costs based on average parcel contributions of storm water runoff to flows in storm sewers.

9.4 FOLLOW UP

The analysis documented in this section is a preliminary assessment of alternative approaches to the recovery of costs that will be incurred to finance the storm water capital plan. A simple sinking fund analysis is used to estimate charge rates under three alternative charges and average annual charges for 7 classes of parcel are determined.

A number of refinements can be made to this analysis once more complete information is obtained on storm sewer system costs including operating and maintenance costs. These refinements can consider phase in of charges, spreading capital costs over a longer time period, exempting certain classes of parcel from the charges and charge schedules that vary across classes of parcels.

10 Conclusions and Recommendations

10.1 SUMP PUMP FLOWS

10.1.1 Conclusions

The Omer and Nickel I&I programs identified approximately 160 private properties with sump pumps connected to the sanitary sewer system. The preferred remediation strategy is to disconnect the sump pumps from the sanitary sewer; however, there are several major impediments to moving the disconnection program forward as follows:

- The study areas are built up neighbourhoods; few of the properties have adequate space, or grade to provide positive surface drainage, making it difficult to redirect foundation drains from the sanitary sewer to the surface without causing surface flooding on adjacent properties.
- Surface discharge of sump pumps without free and unfettered outlets will lead to surface ponding and ice accumulation on areas surrounding the properties in the winter months. This could negatively impact City Operations and cause liability concerns.
- The inventory and connectivity of the storm sewer system is not well understood.
- The adequacy from both hydraulic and serviceability perspectives of the local storm system and outlet to accept additional flow from foundation drains is currently unknown.

The redirection of sump pump flows to the storm water collection system is a positive step in managing wastewater and storm water flows.

10.1.2 Recommendations

This separation of flows <u>must be carefully managed</u> to ensure that the storm sewer system has the available capacity to accommodate the additional flows without increasing the risk of surface flooding.

It is recommended that the City initiate a regularly scheduled program of flushing and inspection to monitor the condition of its storm sewers, to allow for the identification of repair/upgrade needs, on a proactive, rather than reactive, basis.

10.2 STORM SYSTEM OUTFALLS

10.2.1 Conclusions

The review of the supplied background data and information collected during field surveys concluded that the existing storm sewers discharge through 32 outlets to the Welland Canal, Lake Erie, the Eagle Marsh Municipal Drain, and some smaller outlets that provide localized drainage, primarily to rear-yard ditches.

Each of the City's storm drainage areas ultimately outlet to a water body. Outfalls to the Welland canal are difficult to inspect since they may be submerged during high water levels and/or they may be concealed by canal fenders and protective works.

10.2.2 Recommendation

All outfalls that are directly affected by Lake Erie and Welland Canal water levels should be equipped with flap gates to provide flood protection. All outfalls equipped with flap gates should be regularly inspected and maintained to ensure closure during high lake and marsh levels.

10.3 PLANNING FOR GROWTH AND IMPROVEMENTS

The City of Port Colborne has prepared a number of Community Improvement Plans, described below, that will have varying impacts on storm drainage.

Downtown Central Business Area Community Improvement Plan (September 2010)

Drainage Impact: Implementation of streetscaping may provide an opportunity for storm sewer upgrades, and surface runoff improvements.

East Waterfront Community Improvement Plan (March 2012)

Drainage Impact: Implementation of storm drainage network extension, to accommodate neighbourhood extension, combined with streetscaping, may provide an opportunity for storm sewer replacement. The existing system cannot accommodate additional development.

Olde Humberstone Community Improvement Plan (December 2008)

Drainage Impact: Implementation of streetscaping may provide an opportunity for storm sewer upgrades, and surface runoff improvements.

City of Port Colborne Industrial Community Improvement Plan

Drainage Impact: Development of industrial properties may result in increased surface runoff.

Brownfield Strategy (October 2009)

Drainage Impact: None likely, given that these sites are already brownfields. Note that the location of the sites was not provided for assessment.

Summary of Identified Drivers for System Improvements

Table 10-1, reproduced below from Section 5, lists the drivers that were identified for each drainage area, based on the available background information. Note that the need to address the structural condition of the existing storm sewers likely applies to more areas than those listed.

Table 10-1
Drivers for System Improvements

Area No./Outlet Name	Drivers for System Improvements
1 - Eagle Marsh Drain	• Development Capacity - Bayview Lane (0.7ha) Westwood Phase 2 (9.6ha), Westwood Park Secondary Plan (V8, 30.6ha)
2 - Rosemount Avenue	• Development Capacity - CMT Lots (1.2ha)
3 - Steele Street/Sugarloaf	• None identified
4 - Elm Street	• None identified
5 - Marina	• None identified
6 - Victoria Street/Downtown	• Downtown Central Business Area CIP
7 - Princess Street	• None identified
8 - Killaly Street West/Steele	• None identified
9 - Neff Street	• Olde Humberstone CIP
10 - Cedar Street	• Development Capacity - V6 Residential Development (1.9ha), Rosedale (V2, 12.8ha), Meadow Heights (30.5ha) • Satisfy I&I reduction initiatives (Omer Area I&I Program).
11 - Island	• Olde Humberstone Village (3.1ha)
12 - Barber Drive	• Development Capacity - Chippawa Estates (3.5ha), V5 Residential Development (0.9ha)
13 - Bell Street North (Clarke)	• Development Capacity - V1 and V7 Residential Developments (3.1ha, 31.2ha) • Address resident complaints identified by City
14 - Nickel Street	• East Waterfront CIP • Satisfy I&I reduction initiatives (Nickel Area I&I Program). • Address condition of existing storm sewer identified by I&I program. • Separate "Municipal" runoff from "Vale" runoff tributary to Vale's private

Area No./Outlet Name	Drivers for System Improvements
	treatment facility
15 - Rodney Street	• East Waterfront CIP • Satisfy I&I reduction initiatives (Nickel Area I&I Program). • Address condition of existing storm sewer identified by I&I program. • Separate "Municipal" runoff from "Vale" runoff tributary to Vale's private treatment facility.
16 - Quarry	• Development Capacity - Rosemount Estates (38.5ha)
17 - Eagle Marsh Ext.	• Development Capacity - Northland Estates (15.8ha), V3 and V4 Residential Developments (54.2ha, 7.8ha)
18 - Vale	• Coordinate with work in Areas 14 and 15 to separate "Municipal" and "Vale" runoff.
19 - Bell Street Northeast	• None Identified
20 - Bell Street East	• None Identified
21 - Bell Street West	• None Identified
22 - Omer Ave	• Satisfy I&I reduction initiatives (Omer Area I&I Program). • Address condition of existing storm sewer identified by I&I program.

10.4 HYDRAULIC MODEL ANALYSIS

10.4.1 Conclusions

During calibration of the model, we found that the model is generally representative of peak flows for isolated events. Groundwater infiltration is also under-predicted for this isolated rain event. During extended periods of rain, and for rainfall events in close succession, the model provides a conservative representation of groundwater infiltrating into the existing system of storm water pipes.

The hydraulic grade line in the upgraded system will continue to be affected by the water levels in the Eagle Marsh Drain, Welland Canal and Lake Erie. The lower reaches of the drainage network will become surcharged at locations where the water level at outfalls is close to or above the drainage system obvert elevations.

The modeling results indicate that, with the exception of those in Drainage Area 1, the majority of the "designed" sewers meet the City's design standard. The results also indicate that the majority of "semi-designed" and "non-designed" sewers are deficient under both the 1:2 year and 1:5 year storm events, with surface flooding predicted at many locations.

10.4.2 Recommended Improvements

Figure 6-1 illustrates proposed improvements to the existing drainage system. The improvements were sized to convey the 5-year storm flows under the future land use conditions as outlined earlier. The future system incorporates the following improvements:

- All "Non-Designed" sewers and the "Semi-Designed" sewers in Drainage Areas 14 and 15 were replaced with conduits of adequate capacity to convey the 5-year design storm flows. As illustrated by Figure 6-1, these conduits were assumed to take the form of ditches, culverts, or storm sewers.
- The required capacity of each conduit is provided in Appendix C, Table C-1, so that the conduit on a particular street can be selected as a single enclosed pipe, dual pipe, or ditch system depending on the physical constraints of that particular street, cost, and homeowner/community preference.
- The existing outlet for Drainage Area 22 is decommissioned, abandoning the culvert and ditch network branching from Borden Avenue and Elm Street. Flows are redirected north along Elm Street via a 750mm storm sewer main from Borden Avenue and connecting to the existing 2300mm North End trunk storm sewer.
- The existing Nickel Street and Rodney Street outlets for Drainage Areas 14 and 15 are decommissioned. A new outlet at the west end of Nickel Street is created to accommodate flows from Drainage Areas 14 and 15.

10.5 CAPITAL PLAN

10.5.1 Conclusions

The City of Port Colborne initiated the Inflow and Infiltration Reduction Program in 2008 with the intention of reducing the negative impacts of I&I on its sanitary sewer network. Phases 2 and 3 of the I&I Program were focused on the sanitary sewers that generally correspond to Storm Drainage Areas 10 and 22 (the Omer sanitary pump station service area) and Storm Drainage Areas 14 and 15 (the Nickel sanitary pump station service area). Both programs concluded that the City's objectives for I&I reduction would require significant improvements to the local storm sewer systems.

The Nickel Area I&I Program was initiated with the intention of re-directing sump pump discharges to the existing local storm sewers. In order to proceed with the intended sump pump disconnection/re-direction program, the capacity and condition of the storm sewers needed to be addressed. This assessment is inherent to the work completed above.

The Omer Area I&I Program was initiated with the intention of reducing I&I at the source, and particularly by re-directing sump pump discharges to grade or to the local storm sewer system. Field investigations conducted as part of this study concluded that local surface grading is usually unsuitable, and that the current condition of the existing storm sewers is inadequate to support a sump pump re-direction program.

By redirecting the storm sewer flows to a "sump pump only" small diameter storm drain, or "dedicated sump pump drain" pipe would be required on currently un-serviced streets to accept only the redirected sump pump flows. These small diameter storm sewers would connect to the upgraded storm drains located downstream. This solution would retain existing ditches and swales and would rely on existing grading patterns. It would not require installation of CB's or any additional road improvements. Sump pumps from private properties could be connected to the small diameter pipe once downstream improvements are confirmed.

It is clear that significant portions of the existing storm water collection system require upgrading. These needs exist for a variety of reasons including capacity and condition. Adding flows prior to completing a systematic upgrade to the existing system is not recommended. However, significant development areas can proceed on the basis that they manage post development flow rates to predevelopment levels. In this manner, undersized pipes located downstream will not be adversely affected.

10.5.2 Recommendations

Sump pump flows should be redirected to new storm sewers that will receive flow from sump pumps only, and leave road drainage to be collected by the ditches. This "made in Port Colborne" solution would be cost effective and capitalize on the existing surface drainage system that has evolved over time.

Table 7-1 summarizes the proposed improvements for each drainage area. Approximately 31km of pipe upgrades and reconstruction are recommended, in addition to the construction of approximately 4.7km of new infrastructure to service new development and accommodate sump pump disconnection in currently un-serviced areas. A complete listing of each conduit is provided in Appendix C, Table C-1 and forms the basis of the Capital Plan.

Figure 7-2 illustrates the recommended capital works by system improvement category, and indicates pipe diameters to accommodate the 5-year storm. The improvement categories and pipe diameters shown correspond to those listed in Appendix C, Table C-1.

Table 10-2
Recommended Improvement Summary

Drainage Area	Upgrade Ex. Sewer	Reconstruct Ex. Sewer	New Third Pipe	New Storm Service	Total	Estimated Cost
			Length of Upgrade (m)			
1	760	529			1,289	$1,941,560
2	970	2,157			3,127	$4,971,996
3		1,304	1,084		2,388	$3,653,896
4	329	720	308		1,357	$1,954,816
6	69	1,203	351		1,623	$2,400,308

Drainage Area	Upgrade Ex. Sewer	Reconstruct Ex. Sewer	New Third Pipe	New Storm Service	Total	Estimated Cost
7		1,867	75		1,942	$2,916,525
8	450	1,690			2,140	$3,153,645
9	793	2,707			3,500	$5,220,875
10	988	2,358	406	145	3,897	$5,424,044
11	421			495	916	$1,610,425
12	55	825		688	1,568	$2,262,235
13		2,545		628	3,173	$5,071,906
14-15		3,889			3,889	$6,380,462
17		778			778	$1,158,240
20	52	206	519		777	$988,041
21	45				45	$191,287
22		3,278			3,278	$4,837,708
Total	**4,932**	**26,056**	**2,743**	**1,956**	**35,687**	**$54,137,969**

A complete listing of all conduits, including length, required flow rate, and suggested pipe diameter is included in Appendix C. Details of the cost estimate are provided in Appendix D.

The redirection of sump pumps to the storm sewer system should be encouraged. However, this should take place in a downstream to upstream direction, concurrent with recommended storm sewer upgrades.

Recommendations for Implementation of System Upgrades

Implementation of the recommended improvements considers a variety of factors including condition, capacity, planned development and infill, I&I reduction, and complaints. However, improvements to the storm water system, particularly when flow is being added, should generally progress starting from the most downstream end.

The recommended implementation strategy is as follows:

- Continue collection of storm sewer network data including pipe inverts, material, and diameters, manhole rim elevations, pipe connectivity, and records of houses with sump pumps. We note that the model results are only as good as the network data that was available through the various investigations completed as part of this study. We recommend an ongoing program to collect storm sewer network data so that a complete GIS database can be developed to the degree possible.

The hydraulic models should be updated and re-run upon the collection of significant amounts of data.

- Inspect and maintain all outfalls and make sure flap gates are in good working order.
- Replace all failing pipes and expand inspection efforts with CCTV.
- Replace storm sewer pipes that are identified as being undersized for the 2-year storm without the addition of sump pump flows. Proceed from the most downstream location. Focus first on areas where infill development is anticipated.
- Upgrade storm sewer pipes to the specified level of service (5-year return period with sump pump flows added), proceeding from downstream to upstream. Focus first on areas where development is anticipated.
- Encourage re-direction of sump pumps from the sanitary to the storm system as the downstream storm sewer network is upgraded.
- Add new laterals to currently un-serviced areas as the downstream network is upgraded from the outfall to the point of interest. Connect sump pumps. If larger pipes are selected, add CB's and other drainage infrastructure.

10.6 FINANCIAL PLAN DEVELOPMENT

Assumptions

Key assumptions of the analysis are as follows:

- Inflation is not considered; the analysis is based on constant 2014 price levels.
- Engineering costs comprise 10% of total costs and are incurred in the year prior to construction.
- High priority investments are implemented first. Other investments are arbitrarily ordered based on their drainage area number (this assumption can be refined at a later date).
- The opportunity cost of capital for the municipality is assumed to be 3.6%, approximately the rate for 20 year debt[8]. This represents a nominal rate in a financial market where inflation prevails. Assuming a 2% annual rate of inflation, the opportunity cost of capital in real terms is 1.57%.
- Parcels classified as 'Public' do not contribute to cost recovery.
- New storm service investments are financed using development charge funds.
- Two alternative approaches to cost recovery are considered: a storm water user fee and the property tax. Two forms of the storm water user fee are evaluated, one based on total parcel size and one based on the size of the parcel's impervious area. Base data used for calculation of storm water system charges are listed in Table 9-3.

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[8] Infrastructure Ontario, May 26, 2014, http://www.infrastructureontario.ca/Templates/RateForm.aspx?ekfrm=2147483942&sector=mun

- Establish and maintain a geo-referenced customer data with data fields including property ID and ownership, customer classification, gross area, impervious area, status of credits, etc.
- Develop policies, procedures and resources for revising, validating and updating the data base.
- Review system costs and determine full-costs of the storm water system including capital plans and asset management costs. Estimate any new costs associated with implementation of the new user fee including for billing software.
- Review cost reporting policies and procedures including the chart of accounts and revise as needed to facilitate future budgeting and rate setting exercises. Storm water costs should be segregated in accounting records.

Recommended Financial Plan

The analysis of funding requirements is summarized in the following Table (10-3):

Table 10-3
Analysis of Funding Requirements

Year	Drainage Area	Total	DC Funding	Net Funding Requirement	Annual Cash Requirement	Levelized Cash Flow
2015	13	$5,071,906	$1,557,076	$3,514,830	$351,483	$3,018,389
2016	22	$4,837,708	$0	$4,837,708	$3,647,118	$3,018,389
2017	14-15	$6,380,462	$0	$6,380,462	$4,991,984	$3,018,389
2018	1	$1,941,560	$0	$1,941,560	$5,936,572	$3,018,389
2019	2	$4,971,996	$0	$4,971,996	$2,244,604	$3,018,389
2020	3	$3,653,896	$0	$3,653,896	$4,840,186	$3,018,389
2021	4	$1,954,816	$0	$1,954,816	$3,483,988	$3,018,389
2022	6	$2,400,308	$0	$2,400,308	$1,999,365	$3,018,389
2023	7	$2,916,525	$0	$2,916,525	$2,451,929	$3,018,389
2024	8	$3,153,645	$0	$3,153,645	$2,940,237	$3,018,389
2025	9	$5,220,875	$0	$5,220,875	$3,360,368	$3,018,389
2026	10	$5,424,044	$179,974.69	$5,244,069	$5,223,195	$3,018,389
2027	11	$1,610,425	$758,543.71	$851,882	$4,804,850	$3,018,389
2028	12	$2,262,235	$870,194.01	$1,392,041	$905,898	$3,018,389
2029	17	$1,158,240	$0	$1,158,240	$1,368,661	$3,018,389
2030	20	$988,041	$0	$988,041	$1,141,220	$3,018,389
2031	21	$191,287	$0	$191,287	$908,366	$3,018,389
TOTAL			$3,365,789	$50,772,180	$50,600,022	$51,312,607
NET PRESENT VALUE					$44,735,223	$44,735,223

Only engineering design costs are incurred in the first year and construction commences in the second year. Works in each drainage area are assumed to be completed in one construction season. The levelized annual cash requirement is estimated to be $3.02 million at 2014 prices.

The following charge rates were calculated:

- Parcel area storm water charge ($\$/m^2$) = $0.0268
- Impervious area storm water charge ($\$/m^2$) = $1.0661
- Property tax rate (% of assessed parcel value) = 0.1701%

The average annual charge levied against each parcel class to recover the levelized annual cash requirement to finance the storm water capital plan is reported in Table 10-4.

Table 10-4
Sewer Use Charges

Parcel Class	Sewer User Charge		Property tax
	By Parcel Area	By Impervious Area	
Not Coded	$76	$403	na
Commercial	$274	$1,275	$762
Industrial	$1,039	$1,838	$1,676
Multi-residential	$99	$1,134	$3,842
Public*	$0	$0	$0
Residential	$114	$218	$295
Farm/forest	$3,959	$995	$29
All	$346	$346	$346

* No cost recovery from public properties

This analysis is a preliminary assessment of alternative approaches to the recovery of costs that will be incurred to finance the storm water capital plan. A simple sinking fund analysis is used to estimate charge rates under three alternative charges and average annual charges for 7 classes of parcel are determined.

A number of refinements can be made to the analysis once more complete information is obtained on storm sewer system costs including operating and maintenance costs. These refinements should consider phase-in of charges, spreading capital costs over a longer time period, exempting certain classes of parcel from the charges and charge schedules that vary across classes of parcels.

10.6.1 Sewer Use Charges

Each of these charge schedules recovers the required amount ($3.018 million) using a different base for charging. The following observations can be made:

- The different approaches to cost recovery allocate costs in markedly different ways but the average cost per parcel is the same across all three approaches as expected.
- The amount that individual property owners pay will differ from the amounts calculated since several parcels may be owned by single persons or companies.
- The parcel area storm water charge places a heavy burden on farm properties. This burden shifts to industrial, commercial and multi-residential properties with the two other charges.
- Charges for residential parcels vary least across the three charging approaches.
- The impervious area charge likely comes closest to a charge that allocates costs based on average parcel contributions of storm water runoff to flows in storm sewers.

10.7 POLICY DEVELOPMENT

Roof Leaders and Foundation Drains

Roof drains should discharge on grade at least 1.5m away from the building foundation using drainage extensions with the ground sloped away from the building. Roof drains should not be permitted to connect directly to foundation drains or the municipal drainage system. Foundation drains should be routed to flow to the storm sewer system.

Lot Grading

All future and redevelopment lots should be graded to ensure surface drainage flows away from the house and is effectively conveyed overland towards the street. This reduces inflows to the perimeter drains and reduces seepage volumes to the sump pumps. As well, the necessary rise in the height of land away from the street ultimately creates an effective major overland flow path within the municipal right-of-way.

Existing Drainage System

The existing drainage system should be upgraded to accommodate the 1:5 year storm. Major overland flow paths, for the 100-year event, will need to be developed over time with improved lot grading. Existing ditch and swale infilling on residential streets should not be permitted. New storm drains on currently un-serviced streets will be provided to collect flows originating from sump pumps only. The minimum pipe size will be 300 mm diameter. Minimum culvert size will be 450 mm diameter.

Frontage tiles are of unknown condition and effectiveness and cannot reliably accept new sump pump flows. Frontage tiles should be replaced with a single pipe, dual pipes, or open ditches depending on physical site constraints, cost and homeowner/community preference. Bio-swales should be encouraged in conjunction with pipe upgrades.

Sump Pumps

Where the entire downstream storm water system, from the new connection point to the outfall is upgraded to the required level of service, sump pumps should be re-directed from the sanitary sewer system to the storm sewer system. In newer development areas, where lot grading provides effective overland drainage and the existence of effective major overland flow paths are confirmed, runoff from sump pumps should be directed across pervious ground surfaces prior to entering the storm sewer system.

10.8 ENVIRONMENTAL CONSTRAINTS

It is recognized that homeowners often prefer an enclosed drainage system complete with curb and gutter roadways.

This project has the ability to improve water quality controls by using the following means:

- Redirection of sump pump flows from the sanitary to the storm sewer alleviates pressure on the sanitary sewer system and provides a source of "filtered" storm water to the storm drainage system.
- Replacement of aging sewers will protect against pipe collapse and the subsequent migration of eroded soils.
- In addition to the enclosed storm drain pipe, existing ditches and swales can be retained on currently un-serviced streets thereby providing passive storm water treatment. In some cases these ditches could be converted to bio-swales providing improved aesthetic and storm water quality.
- New development areas should include Low Impact Development (LID's) and Best Management Practices (BMP's) for storm water management. Storm water management faculties should control the rate, volume and quality of storm water runoff.

The benefits of retaining open ditches should not be overlooked. In addition to providing passive water quality benefits, open ditches and swales provide a storage and conveyance function that relieves pressure on the downstream system. In many areas the ditches have been landscaped to provide an aesthetic solution. As a longer term goal, some existing ditches, and or drainage tile areas could be converted to bio-swales.

Appendix A – Municipal Class EA Process

A.1 MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT PROCESS

The Environmental Assessment Act (the Act) recognizes that certain municipal undertakings are similar in nature, occur frequently, are limited in scale, have a predictable range of environmental impacts and are responsive to mitigating measures. To ensure that a degree of standardization in the planning process for such projects is followed province wide, the Act permits the use of the "Municipal Class Environmental Assessment" procedure. Projects that do not display these characteristics may not be planned using the Class EA process; they must undergo an Individual Environmental Assessment.

The need to involve the public and interested agencies directly in the decision making process for capital works projects has been recognized by the Act since 1975. The Act requires that opportunities be provided for the public and interested agencies to provide input on projects to ensure the elimination or mitigation of adverse impacts on the environment.

Provided the Class EA planning process is followed, a proponent does not have to apply for additional approvals under the Act. The Class EA process ensures that an adequate environmental planning process is followed and places emphasis on project assessment and stakeholder involvement rather than on review and approvals.

The Class EA process reflects the following five key principles of successful planning under the EAA:

- **Consultation** with affected parties early on, and at key decision points, to ensure that the planning process is a co-operative venture.
- Consideration of a reasonable range of **alternatives** to accomplish the solution.
- Identification and consideration of the **effects** of each alternative on all aspects of the environment including natural, social, cultural, technical and economic environments.
- Systematic **evaluation** of alternatives in terms of their advantages and disadvantages to determine their net environmental effects.
- Provision of clear and complete **documentation** of the planning process followed, to allow traceability of decision making with respect to the project.

The Class EA process involves the following 5 phases:

- **Phase 1** – Establishment of a problem or opportunity
- **Phase 2** – Identification and assessment of alternative solutions to the problem or opportunity, and selection of a preferred solution.
- **Phase 3** – Identification and assessment of alternative design concepts for the preferred solution
- **Phase 4** – Preparation of an Environmental Study Report
- **Phase 5** – Implementation

Under the Municipal Class EA process, proposed projects are categorized under various "Schedules" as follows:

- **Schedule 'A'**
  Projects categorized as Schedule 'A' undertakings are limited in scale and are anticipated to have a negligible environmental effect. These projects include the majority of municipal maintenance and operational activities, such as repairing water main breaks, cleaning sanitary sewers, or adding traffic control signals to an intersection. Schedule 'A' projects are pre-approved, and may proceed to implementation without following the full Municipal Class EA process.
- **Schedule 'A+'**
  Schedule 'A+' projects are also limited in scale, but they have a somewhat broader scale than Schedule 'A' projects. Schedule 'A+' projects are anticipated to have a minimal environmental impact; therefore, they are also pre-approved and may proceed to implementation without following the full Municipal Class EA process. Some examples of Schedule 'A+' projects are refurbishing a water supply plant, installing a sewer within an existing road allowance, and adding turning lanes to an intersection.
- **Schedule 'B'**
  Projects categorized as Schedule 'B' undertakings have the potential for some adverse environmental impacts, therefore, the proponent is required to proceed through a screening process. This includes consultation with all parties that may potentially be affected by the project to ensure that they are aware of the project and that any concerns are suitably addressed. If there are no outstanding concerns, then the project may proceed to implementation. Schedule 'B' projects generally involve minor modifications to existing facilities, such as increasing the depth of a municipal well, retiring a water pollution control plant, or constructing a minor expansion to a road.
- **Schedule 'C'**
  Projects categorized as Schedule 'C' undertakings have the potential for significant environmental effects, and are required to follow the full planning and design process specified under the Municipal Class EA. Schedule 'C' projects require the compilation of all relevant information into a clear and easily understood report called an "Environmental Study Report" (ESR), which must be made available for review by the public and regulatory review agencies. Schedule 'C' projects generally involve the construction of new facilities or major modifications to existing facilities, such as constructing a new water treatment plant, expanding an existing water pollution control plant beyond its rated capacity, or significantly widening an existing road.

Figure A-1 outlines the Municipal Class EA process.

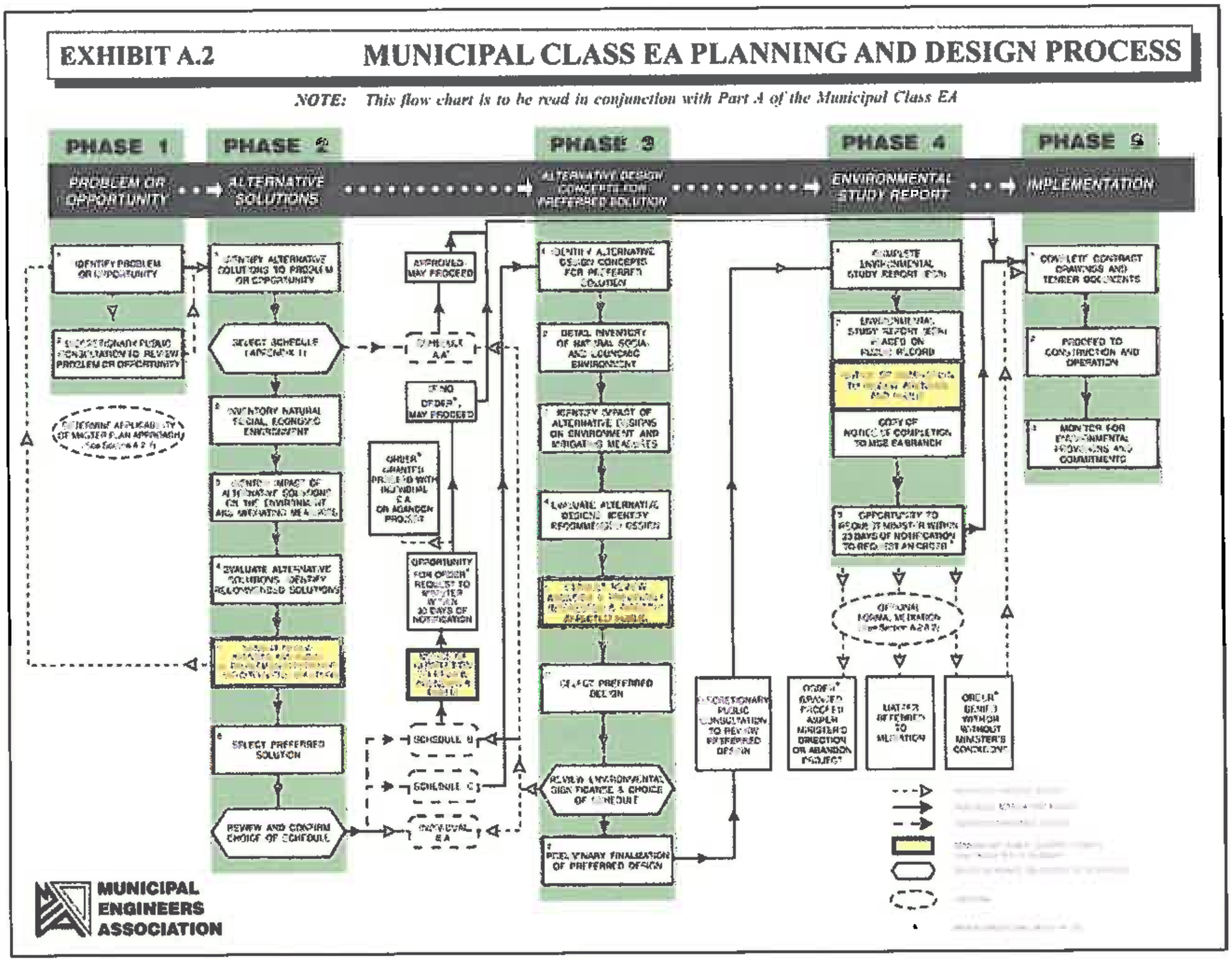

Figure A-1
Municipal Class EA Planning Process

A.2 MASTER PLANNING

This study was undertaken as a Master Plan in accordance with the Municipal Engineer's Association Municipal Class Environmental Assessment (EA) Guidelines. As a Master Plan project, this study is intended to satisfy Phases 1 and 2 of the Municipal Class EA planning process. Individual projects identified by the study may be subject to additional Municipal Class EA planning and approvals prior to implementation.

The individual projects recommended under this Master Plan may be categorized as Schedule 'A', Schedule 'B' or Schedule 'C' under the Municipal Class EA process. At the time that the individual projects included in the Master Plan are to be implemented, they are subject to the requirements of the Municipal Class EA process. For Schedule 'B' and Schedule 'C' projects identified within a Master Plan, the work undertaken during the development of the Master Plan can be used in support of the requirements of Phases 1 and 2 of the Municipal Class EA.

For example, if an individual project is to be implemented and it is a Schedule 'C' project under the Municipal Class EA process, the work undertaken during the development of the Master Plan can be used in support of the requirements of Phases 1 and 2 of the Municipal Class EA. It would be necessary to fulfil the additional requirements of Phases 3 and 4 in order to consider the project specific issues that were beyond the scope of the Master Planning process. Similarly, for Schedule 'B' projects it would be necessary to fulfil the consultation and documentation requirements.

A.3 STAKEHOLDER CONSULTATION

The Notice of Commencement was mailed to various agencies and stakeholders on April 12, 2013 and was published in the Welland Tribune on April 18, 2013. A copy of the Notice, the cover letter to stakeholders, and the stakeholder contact list are included in this Appendix.

A Public Information Centre will be held in the near future to present the recommendations of the Master Plan and solicit feedback from stakeholders.

Appendix B - Existing System Characteristics

Storm Drainage Area 1 - Eagle Marsh Drain (EMD)

- This area does not have a history of flooding issues.
- Piped outlets to the EMD are located at the south end of Olga Dr., the north end of Rose Ave., the north end of Gaspare Ave., and two located north and west of Bayview Ln.
- The outlets range in size from 300mm to 825mm and were constructed between 1993 and 2002.
- Westwood Estates (Phase 1), including West Wood Dr., Wood Ln., and a portion of Clarence St. and Stanley St. drain to an open channel running parallel to Cement Plant Rd., ultimately to the EMD.
- The EMD also receives surface drainage from areas west of the municipal boundary, including Wainfleet. Storm Drainage Areas 16 and 17 eventually drain to the EMD.
- The water level in the EMD is controlled at the south end to protect against fluctuations in Lake Erie water levels. Information on the control structure including pump setpoints, curves, capacity, control structure operation manual were not provided and were not included in the hydraulic analysis.
- May receive overflow from Area 2 when lake levels are high, the configuration and location of the overflow were not included in the supplied GIS information, and the overflow manhole was not accessible for inspection by AE's field staff. The configuration of this overflow was not included in the hydraulic analysis.
- A dewatering station is located at the south end of Scholfield Ave; the City has a permit to take water. This station was not included in the hydraulic analysis.
- The proposed development of Westwood Estates Phase 2 will include an oversized storm sewer for flow control. Proposed storm drainage plans for Westwood Estates Phase 2 were not available for review.

Storm Drainage Area 2 - Rosemount

- This area does not have any "designed" storm sewers.
- The 1200mm outlet to Lake Erie is located at the south end of Rosemount Ave. and is equipped with a flap gate located in the upstream manhole.
- The outlet was constructed in approximately 1955.
- This area has not had any recent flooding issues. The area was subject to flooding prior to installation of the flap gate on the outlet.
- Drainage from this area can overflow to Area 1 if the Lake Erie water level rises high enough to force the flap gate shut and prevent drainage. The configuration of this overflow was not included in the supplied GIS, nor was it accessible for inspection by field staff. The configuration of this overflow has not been included in the hydraulic analysis.

Storm Drainage Area 3 - Steele St.

- This area does not have any "designed" storm sewers.
- The 1050mm outlet to Lake Erie is located at the south end of Steele St., was constructed in the 1920's and is equipped with a flap gate in the first manhole upstream of the outlet.
- City Staff indicated that the area around the manhole floods when the flap is closed, however this has not happened since December 2, 1985; such an even would result in 6" of flooding in the nearby seniors residence. A similar event happened in the 1970's.
- A secondary outlet located at the south end of Steel St., captures runoff from a portion of the hospital property, and the parking area to the south. The secondary outlet is equipped with a Stormceptor oil/grit separator, which is maintained on a regular basis.

Storm Drainage Area 4 - Elm St.

- The outlet to Lake Erie is located at the south end of Elm St., east of H.H. Knoll Park. There is a flap gate in the first manhole upstream of the outlet. The 1050mm outlet was constructed in approximately 1929.

Storm Drainage Area 5 – Marina

- This area consists of the Marina parking lot. Drainage of this area is primarily achieved by overland flow and was not included in the hydraulic analysis.

Storm Drainage Area 6 - Victoria St.

- The Victoria St. outlet services downtown Port Colborne. The 1500mm diameter outlet is located at the east end of Victoria St. and discharges to the Welland Canal. The outlet is equipped with a flap gate on the canal wall.
- The trunk storm sewer on King St. extends from Victoria St. north to Park St. and south to Sugarloaf St. The Victoria St. section of the trunk sewer, between King St. and West. St. is a siphon.
- The outlet and trunk sewer were constructed in approximately 1993.
- This drainage area is subject to some rear yard flooding issues due to low lake levels inducing settling of peat soil.

Storm Drainage Area 7 - Princess St.

- The 1500mm diameter outlet is located at the east end of Princess St. and discharges to the Welland Canal. The outlet is equipped with a flap gate on the canal wall.
- The trunk storm sewer on King St. extends north from Princess St. to south of Killaly St.
- The outlet and trunk sewer were constructed in approximately 1993.

Storm Drainage Area 8 - Killaly St. West

- The drainage area boundary was modified based on markups by City Staff.
- The outlet to the Welland Canal is located on the south side of Killaly St. at the canal wall. The outlet was reconstructed in approximately 2002 and consists of two 900mm pipes.
- The trunk storm sewer on King St. was constructed in approximately 1990 and extends north from Killaly St. to Charles Dr.
- The trunk storm sewer on Killaly St. was constructed in approximately 1980 and extends west from the outlet to Steele St.

Storm Drainage Area 9 - Neff St.

- The outlet to the Welland Canal is located at the east end of Neff St. City staff indicated that the outlet is 675mm, not 1040mm as indicated on the record drawings.
- The trunk storm sewer on King St. was constructed in approximately 1989 and extends north to Main St. and south to Charles Dr.
- The trunk storm sewer on Main St. was constructed in approximately 1963 and extends west from King St. to Oakwood St.
- City Staff indicated that the only incident of flooding occurred on King St. at Neff St. as a result of the outlet collapsing.
- A secondary outlet, located ? of George St., drains rear yard swales.

Storm Drainage Area 10 – Cedar St.

- Most of the storm sewers in this drainage area are relatively new and were designed to service residential developments constructed generally as follows:
- Elmvale Subdivision circa 1970,
- Shamrock Park Subdivision circa 1990,
- Meadow Heights Subdivision circa 1988 to present.
- The drainage area is serviced by the North End trunk storm sewer, which was constructed in approximately 1974.
- The 2400mm trunk storm sewer discharges to an open channel parallel to, and north of Rosedale Ave., then through a 2400mm diameter outlet to the Welland Canal.

Storm Drainage Area 11 – Island

- The trunk sewer on Main St. between Canal Bank St. and Ramey Ave. follows the path of the former O-T Minor drain.
- Drainage is predominantly achieved through roadside ditches and culverts.

- A deep channel with several small outlets to the Welland Canal runs along the north-west side of the island.
- There is a 300mm diameter outlet at Amelia St.

Storm Drainage Area 12 – Barber Drive

- The trunk sewer on Main St. between Elizabeth St. and the Welland Canal follows the path of the former O-T Minor drain.
- The nearby quarry has the ability to drain to this outlet, but does not always do so.

Storm Drainage Area 13 – Bell St.

- This area is also referred to as the Clark Area and the Central Park Area.
- City Staff indicate that they have received several complaints regarding surface flooding in this area.
- This area has few designed storm sewers.
- Trunk drainage to the Bell St. outlet is provided by a concrete channel that runs parallel to the Welland Canal from north of Russell Ave. to Bell St.

Storm Drainage Areas 14 and 15 – Nickel St. and Rodney St.

- No flooding issues in this area have been identified by City Staff.
- Storm sewers in this area were constructed in approximately 1929.
- The area north of Kinnear St. drains to the Welland Canal via the 750mm outlet located west of the west end of Nickel St.
- The area south of Kinnear St. drains to the Welland Canal via the 450mm outlet located west of the west end of Rodney St.
- Based on investigations completed under the Nickel Area Inflow and Infiltration Program, the storm sewers in this area are in poor condition. Attempts to locate and inspect the condition of the outlet sewers to the Welland Canal were unsuccessful.

Storm Drainage Area 16 – Quarry

- Designed sewers in Portal Village (Maple St., Elgin St, Portal Dr.) discharge via a 1050mm diameter outlet to open channel and ultimately to quarry. First Ave., Second Ave., Third Ave., and Sheba Cres. have ditches that drain to the quarry via an open channel south and west of Third Ave./Killaly St. intersection.

Storm Drainage Area 17 – Eagle Marsh Extension

- There are no storm sewers in this area.

- Roadside ditches drain to the west to the Eagle Mash Extension, which drains to the west, through Wainfleet, and eventually back into Drainage Area 1.

Storm Drainage Area 18 – Vale

- The original trunk storm sewer servicing the Vale, Nickel and Rodney drainage areas, ran from north to south on Davis St., then on to the Vale property. This trunk sewer remains in operation, capturing surface runoff from the Davis St. right of way, and possibly from foundation drains of private properties on Davis St.
- The Davis St. trunk sewer discharges to Vale's private on-site treatment facility, and ultimately to Lake Erie via Vale's private outlet.
- The Davis St. trunk sewer, and runoff from the Vale property, were not included in the hydraulic analysis.

Storm Drainage Area 19 – Bell St.

- There are no storm sewers in this area.
- Surface runoff from this area follows the local topography to Drainage Area 13, and ultimately flows to the Bell St. outlet.

Storm Drainage Area 20 – Bell St.

- The 2250mm Bell St. outlet to the Welland Canal is located at the west end of Bell St. The outlet is equipped with a flap gate.
- Drainage areas 13, 19 and 21 all discharge through the Bell St. outlet.
- The area is serviced by storm sewers that were constructed in the 1990's.

Storm Drainage Area 21 – Bell St.

- The storm sewers in this area were constructed in the 1990's.
- The storm sewers discharge via five outlets to a storm water detention pond. Storm water in the detention pond is discharged via the Johnson Street Pumping Station through a forcemain to the Bell Street outlet to the Welland Canal.
- The detention pond is equipped with an emergency overflow to the Vale property that will only activate if the storm pumping station is not operating.

Storm Drainage Area 22 – Omer Ave.

- There are no designed storm sewers in this area.
- The existing piped sewers are a tiled system, referred to as frontage tiles, that were constructed by the infilling of ditches.

- This area was the Focus Area of a drainage investigation conducted in conjunction with the Omer Area Inflow and Infiltration reduction program. The drainage investigation concluded that the existing sewers in the Omer Ave. drainage area are in poor condition.
- The drainage outlet that serves this area is a combination of culverts and open ditches crossing Elm Street at Borden Avenue, following Borden Avenue and Omer Avenue, and discharging to the Welland Canal adjacent to the North End Trunk Storm Sewer outlet. A portion of the outlet is located within an easement.

Appendix C - Proposed Improvements

Table C-1
Recommended Improvements

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
1	Clarence Street	CDT12945	61	300	375	90	Upgrade
1	Clarence Street	FCDT2062	54	-	300	21	Replace Conduit
1	Clarence Street	FCDT2063	97	-	300	66	Replace Conduit
1	Clarence Street	FCDT2064	3	-	300	65	Replace Conduit
1	Hampton Avenue	FCDT2065	87	-	300	28	Replace Conduit
1	Hampton Avenue	FCDT2068	84	-	300	35	Replace Conduit
1	Lena Crescent	CDT12806	8	600	750	767	Upgrade
1	Michael Drive North	CDT13657	42	200	300	21	Upgrade
1	Michael Drive North	CDT12275	45	300	375	92	Upgrade
1	Michael Drive North	CDT13665	24	450	525	171	Upgrade
1	Michael Drive North	FCDT2066	99	-	300	48	Replace Conduit
1	Michael Drive North	FCDT2067	3	-	300	55	Replace Conduit
1	Michael Drive South	CDT13667	58	300	450	117	Upgrade
1	Michael Drive South	CDT13835	75	300	450	117	Upgrade
1	Michael Drive South	CDT13836	8	300	450	67	Upgrade
1	Michael Drive South	FCDT2069	98	-	300	70	Replace Conduit
1	Michael Drive South	FCDT2070	4	-	300	67	Replace Conduit
1	Olga Drive	CDT11462	12	300	750	578	Upgrade
1	Olga Drive	CDT11471	22	300	750	578	Upgrade
1	Olga Drive	CDT11472	68	300	750	578	Upgrade
1	Olga Drive	CDT11438	48	380	600	107	Upgrade
1	Olga Drive	CDT11439	38	380	600	106	Upgrade
1	Olga Drive	CDT11449	33	450	750	702	Upgrade
1	Olga Drive	CDT11450	62	450	750	614	Upgrade
1	Olga Drive	CDT11446	33	600	750	766	Upgrade
1	Olga Drive	CDT11447	55	600	750	766	Upgrade
1	Olga Drive	CDT11448	68	600	750	702	Upgrade
2	Ash Street	FCDT2043	67	-	450	100	Replace Conduit
2	Clarence Street	FCDT2048	106	-	450	85	Replace Conduit
2	Clarence Street	FCDT2049	140	-	450	135	Replace Conduit
2	Clarence Street	FCDT2050	6	-	450	133	Replace Conduit
2	Clarence Street	FCDT2051	85	-	300	54	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
2	Clarence Street	FCDT2060	34	-	300	15	Replace Conduit
2	Clarence Street	FCDT2061	7	-	300	15	Replace Conduit
2	Division Street	FCDT2053	88	-	450	125	Replace Conduit
2	Division Street	FCDT2156	17	-	450	310	Replace Conduit
2	Glenwood Avenue	FCDT2054	105	-	600	295	Replace Conduit
2	Glenwood Avenue	FCDT2157	17	-	525	289	Replace Conduit
2	Hampton Avenue	CDT10362	66	300	450	145	Upgrade
2	Hampton Avenue	CDT10361	80	450	525	176	Upgrade
2	Homewood Avenue	FCDT2052	161	-	450	147	Replace Conduit
2	Homewood Avenue	FCDT2155	16	-	450	126	Replace Conduit
2	Jefferson Avenue	FCDT2044	37	-	675	483	Replace Conduit
2	Jefferson Avenue	FCDT2058	45	-	750	539	Replace Conduit
2	Jefferson Avenue	FCDT2059	43	-	750	539	Replace Conduit
2	Jefferson Avenue	FCDT2160	19	-	450	93	Replace Conduit
2	Jefferson Avenue	FCDT2161	29	-	750	461	Replace Conduit
2	Lakeside Place West	CDT13894	17	300	450	84	Upgrade
2	North Crescent	FCDT2042	43	-	675	441	Replace Conduit
2	North Crescent	FCDT2159	18	-	600	475	Replace Conduit
2	Ridgewood Avenue	FCDT2057	59	-	450	107	Replace Conduit
2	Ridgewood Avenue	FCDT2158	17	-	450	37	Replace Conduit
2	Rosemount Avenue	CDT10680	70	200	300	45	Upgrade
2	Rosemount Avenue	CDT10647	58	300	600	185	Upgrade
2	Rosemount Avenue	CDT10654	39	300	600	174	Upgrade
2	Rosemount Avenue	CDT10672	38	300	450	124	Upgrade
2	Rosemount Avenue	CDT10678	102	300	375	101	Upgrade
2	Rosemount Avenue	CDT10653	54	530	600	167	Upgrade
2	Rosemount Avenue	CDT10660	102	812	1050	1397	Upgrade
2	Rosemount Avenue	FCDT4124	85	-	450	124	Replace Conduit
2	Schofield Avenue	CDT11572	98	375	450	118	Upgrade
2	South Crescent	FCDT2045	188	-	450	158	Replace Conduit
2	Stanley Street	CDT10670	13	300	375	124	Upgrade
2	Stanley Street	FCDT2055	89	-	450	104	Replace Conduit
2	Stanley Street	FCDT2056	129	-	300	0	Replace Conduit
2	Stanley Street	FCDT2188	18	-	600	382	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
2	Sugarloaf Street	CDT10657	6	250	450	2	Upgrade
2	Sugarloaf Street	CDT10659	13	685	1050	1328	Upgrade
2	Sugarloaf Street	CDT11574	103	750	900	415	Upgrade
2	Sugarloaf Street	FCDT2190	9	-	900	544	Replace Conduit
2	Sugarloaf Street	FCDT4054	57	-	525	99	Replace Conduit
2	Sugarloaf Street	FCDT4056	97	-	525	122	Replace Conduit
2	Sugarloaf Street	FCDT4058	128	-	900	648	Replace Conduit
2	Sugarloaf Street	FCDT4060	133	-	900	686	Replace Conduit
2	Tennesee Avenue	CDT13699	111	300	450	94	Upgrade
2	Tophat Lane	FCDT2041	65	-	600	414	Replace Conduit
3	Ash Street	FCDT10014	113	-	300	24	Sump Pump Drain
3	Clare Avenue	FCDT10001	310	-	300	24	Sump Pump Drain
3	Clarence Street	FCDT2038	104	-	450	69	Replace Conduit
3	Forest Avenue	FCDT10002	232	-	300	16	Sump Pump Drain
3	Harbour Laneway	FCDT4078	111	-	525	305	Replace Conduit
3	Isabel Street	FCDT10013	98	-	300	12	Sump Pump Drain
3	Kent Street	FCDT2039	93	-	300	46	Replace Conduit
3	Kent Street	FCDT2192	7	-	300	55	Replace Conduit
3	Linwood Avenue	FCDT10003	311	-	300	16	Sump Pump Drain
3	Lockmaster Laneway	FCDT4080	125	-	525	240	Replace Conduit
3	Stanley Street	FCDT2040	146	-	600	272	Replace Conduit
3	Steele Street	FCDT2144	15	-	450	65	Replace Conduit
3	Steele Street	FCDT2145	16	-	600	241	Replace Conduit
3	Steele Street	FCDT4070	70	-	750	834	Replace Conduit
3	Steele Street	FCDT4072	82	-	750	784	Replace Conduit
3	Steele Street	FCDT4074	144	-	750	651	Replace Conduit
3	Steele Street	FCDT4076	65	-	600	376	Replace Conduit
3	Sugarloaf Street	FCDT4062	91	-	600	227	Replace Conduit
3	Sugarloaf Street	FCDT4064	105	-	750	475	Replace Conduit
3	Sugarloaf Street	FCDT4066	65	-	900	729	Replace Conduit
3	Sugarloaf Street	FCDT4068	65	-	1050	909	Replace Conduit
3	Sugarloaf Street	FCDT10004	20	-	300	16	Sump Pump Drain
4	Alexander Street	FCDT10005	117	-	300	16	Sump Pump Drain
4	Alexandra Street	FCDT4002	87	-	300	34	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
4	Ash Street	CDT11880	25	300	375	71	Upgrade
4	Ash Street	CDT11886	12	300	375	50	Upgrade
4	Ash Street	CDT10474	72	600	750	414	Upgrade
4	Ash Street	CDT11903	51	600	750	415	Upgrade
4	Ash Street	CDT12283	68	600	750	473	Upgrade
4	Ash Street	FCDT10015	80	-	300	12	Sump Pump Drain
4	Charlotte Street	FCDT4012	89	-	300	31	Replace Conduit
4	Charlotte Street	FCDT4014	108	-	300	37	Replace Conduit
4	Elm Street	CDT10346	11	600	750	520	Upgrade
4	Elm Street	FCDT10016	111	-	300	16	Sump Pump Drain
4	Fielden Avenue	CDT11864	90	600	675	301	Upgrade
4	Fielden Avenue	FCDT4004	93	-	525	228	Replace Conduit
4	Harbour Laneway	FCDT4006	134	-	375	90	Replace Conduit
4	Kent Street	FCDT4008	92	-	300	52	Replace Conduit
4	Kent Street	FCDT4010	117	-	300	56	Replace Conduit
6	Catharine Street	FCDT3010	60	-	300	56	Replace Conduit
6	Catharine Street	FCDT3018	96	-	300	28	Replace Conduit
6	Charlotte Street	FCDT3014	107	-	450	161	Replace Conduit
6	Charlotte Street	FCDT3016	115	-	300	74	Replace Conduit
6	Clarence Street	FCDT3002	115	-	750	606	Replace Conduit
6	Clarence Street	FCDT3004	158	-	750	460	Replace Conduit
6	Clarence Street	FCDT3006	200	-	525	240	Replace Conduit
6	Clarence Street	FCDT10017	83	-	300	16	Sump Pump Drain
6	Elm Street	FCDT3008	119	-	525	139	Replace Conduit
6	Elm Street	FCDT3020	78	-	375	161	Replace Conduit
6	King Street	CDT11409	69	450	750	207	Upgrade
6	Park Street	FCDT3012	155	-	300	63	Replace Conduit
6	West Street	FCDT10006	89	-	300	12	Sump Pump Drain
6	West Street	FCDT10007	90	-	300	16	Sump Pump Drain
6	West Street	FCDT10008	89	-	300	12	Sump Pump Drain
7	Catharine Street	FCDT4050	89	-	375	162	Replace Conduit
7	Catharine Street	FCDT10018	75	-	300	12	Sump Pump Drain
7	Chandler Laneway	FCDT4018	131	-	450	169	Replace Conduit
7	Chandler Laneway	FCDT4032	126	-	300	37	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
7	Delhi Street	FCDT4016	128	-	450	252	Replace Conduit
7	Elgin Street	FCDT4024	125	-	525	282	Replace Conduit
7	Elgin Street	FCDT4026	67	-	525	290	Replace Conduit
7	Elgin Street	FCDT4028	163	-	450	152	Replace Conduit
7	Elgin Street	FCDT4030	76	-	525	258	Replace Conduit
7	Elm Street	FCDT4048	77	-	300	25	Replace Conduit
7	Fielden Avenue	FCDT4040	115	-	600	461	Replace Conduit
7	Fielden Avenue	FCDT4042	177	-	525	298	Replace Conduit
7	Fielden Avenue	FCDT4044	163	-	525	315	Replace Conduit
7	Park Street	FCDT4036	144	-	675	543	Replace Conduit
7	Princess Street	FCDT4034	80	-	750	669	Replace Conduit
7	Princess Street	FCDT4038	206	-	675	532	Replace Conduit
8	Charles Street	FCDT2001	105	-	450	86	Replace Conduit
8	Charles Street	FCDT2002	78	-	450	169	Replace Conduit
8	Charles Street	FCDT2142	9	-	450	169	Replace Conduit
8	Elm Street	FCDT2006	120	-	450	79	Replace Conduit
8	Erie Street	FCDT2010	138	-	450	100	Replace Conduit
8	Erie Street	FCDT2011	84	-	450	67	Replace Conduit
8	Erie Street	FCDT2012	143	-	450	73	Replace Conduit
8	Erie Street	FCDT2013	6	-	450	72	Replace Conduit
8	Erie Street	FCDT2163	12	-	450	79	Replace Conduit
8	Erie Street	FCDT2164	11	-	450	133	Replace Conduit
8	Erie Street	FCDT2165	17	-	450	145	Replace Conduit
8	Fielden Avenue	FCDT2014	149	-	600	280	Replace Conduit
8	Fielden Avenue	FCDT2141	9	-	300	280	Replace Conduit
8	King Street	CDT11259	9	300	450	168	Upgrade
8	King Street	CDT11250	61	450	675	284	Upgrade
8	King Street	CDT11260	3	450	525	3	Upgrade
8	King Street	CDT11283	57	450	675	283	Upgrade
8	King Street	CDT11286	21	450	525	162	Upgrade
8	King Street	CDT11293	20	450	525	166	Upgrade
8	King Street	CDT12489	8	450	525	7	Upgrade
8	King Street	CDT12493	31	450	525	160	Upgrade
8	King Street	CDT12517	28	450	525	165	Upgrade

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
8	King Street	CDT12519	5	450	525	163	Upgrade
8	King Street	CDT12693	40	450	675	286	Upgrade
8	King Street	CDT12697	13	450	525	159	Upgrade
8	King Street	CDT11151	154	685	900	518	Upgrade
8	Minto Street	FCDT2007	131	-	450	70	Replace Conduit
8	Minto Street	FCDT2008	79	-	450	145	Replace Conduit
8	Minto Street	FCDT2009	9	-	450	145	Replace Conduit
8	Steele Street	FCDT4084	100	-	450	105	Replace Conduit
8	Steele Street	FCDT4086	129	-	450	99	Replace Conduit
8	Steele Street	FCDT4088	135	-	525	236	Replace Conduit
8	Union Street	FCDT2003	133	-	450	98	Replace Conduit
8	Union Street	FCDT2004	84	-	450	132	Replace Conduit
8	Union Street	FCDT2005	9	-	450	132	Replace Conduit
9	Brady Street	FCDT2015	57	-	450	71	Replace Conduit
9	Brady Street	FCDT2016	219	-	450	112	Replace Conduit
9	Brady Street	FCDT2167	12	-	450	31	Replace Conduit
9	Brady Street	FCDT2169	16	-	600	157	Replace Conduit
9	Elm Street	FCDT2175	10	-	450	99	Replace Conduit
9	Elm Street	FCDT4116	57	-	300	14	Replace Conduit
9	Elm Street	FCDT4118	42	-	450	91	Replace Conduit
9	Elm Street	FCDT4120	129	-	600	182	Replace Conduit
9	Elm Street	FCDT4122	86	-	600	249	Replace Conduit
9	Erie Street	FCDT2033	107	-	300	46	Replace Conduit
9	Erie Street	FCDT2034	182	-	450	125	Replace Conduit
9	Erie Street	FCDT2168	13	-	375	13	Replace Conduit
9	Fielden Avenue	FCDT2018	151	-	525	175	Replace Conduit
9	Fielden Avenue	FCDT2024	76	-	300	27	Replace Conduit
9	Fielden Avenue	FCDT2026	66	-	600	311	Replace Conduit
9	Fielden Avenue	FCDT2174	15	-	600	372	Replace Conduit
9	George Street	FCDT2032	90	-	300	0	Replace Conduit
9	George Street	FCDT2035	94	-	450	103	Replace Conduit
9	George Street	FCDT2036	7	-	300	103	Replace Conduit
9	Highland Avenue	FCDT2017	209	-	450	76	Replace Conduit
9	Highland Avenue	FCDT2170	15	-	600	193	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
9	King Street	CDT11299	20	450	600	77	Upgrade
9	King Street	CDT12521	39	450	600	81	Upgrade
9	King Street	CDT12523	21	450	600	86	Upgrade
9	King Street	CDT12695	15	450	600	40	Upgrade
9	Knoll Street	FCDT2021	157	-	450	78	Replace Conduit
9	Knoll Street	FCDT2022	5	-	300	77	Replace Conduit
9	Main Street West	CDT10033	81	450	525	209	Upgrade
9	Main Street West	CDT10150	101	450	525	260	Upgrade
9	Main Street West	CDT11733	54	450	525	263	Upgrade
9	Main Street West	CDT11739	208	450	525	262	Upgrade
9	Main Street West	CDT11740	58	450	525	262	Upgrade
9	Main Street West	CDT11741	9	450	525	209	Upgrade
9	Main Street West	CDT10074	8	600	675	530	Upgrade
9	Main Street West	CDT10090	87	600	675	529	Upgrade
9	Main Street West	CDT10091	25	600	675	530	Upgrade
9	Main Street West	CDT10093	67	600	675	530	Upgrade
9	Neff Street	FCDT2025	104	-	450	104	Replace Conduit
9	Neff Street	FCDT2027	191	-	750	530	Replace Conduit
9	Neff Street	FCDT2028	99	-	750	761	Replace Conduit
9	Neff Street	FCDT2029	81	-	750	814	Replace Conduit
9	Neff Street	FCDT2030	6	-	600	814	Replace Conduit
9	Neff Street	FCDT2171	15	-	600	335	Replace Conduit
9	Neff Street	FCDT2172	13	-	750	529	Replace Conduit
9	Neff Street	FCDT2173	16	-	750	704	Replace Conduit
9	Oakwood Street	FCDT2019	166	-	525	190	Replace Conduit
9	Oakwood Street	FCDT2020	5	-	300	138	Replace Conduit
9	Snider Street	FCDT2031	52	-	450	101	Replace Conduit
9	Steele Street	FCDT2023	94	-	450	97	Replace Conduit
9	Steele Street	FCDT2037	37	-	300	40	Replace Conduit
9	Steele Street	FCDT2166	13	-	450	57	Replace Conduit
10	Apollo Drive	CDT12611	46	300	450	123	Upgrade
10	Apollo Drive	CDT12922	67	300	450	130	Upgrade
10	Apollo Drive	CDT12925	70	300	450	125	Upgrade
10	Apollo Drive	CDT11638	94	450	675	272	Upgrade

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
10	Barrick Road	FCDT2140	6	-	450	124	Replace Conduit
10	Barrick Road	FCDT4126	145	-	300	119	New Service
10	Bartok Avenue	CDT10142	84	540	675	497	Upgrade
10	Donlea Drive	CDT13656	55	300	525	54	Upgrade
10	Donlea Drive	CDT11071	82	380	525	89	Upgrade
10	Elm Street	FCDT2139	176	-	450	130	Replace Conduit
10	Elmvale Crescent	CDT13637	37	300	375	78	Upgrade
10	Elmvale Crescent	CDT13636	75	400	525	265	Upgrade
10	Elmvale Crescent	CDT13645	55	400	525	221	Upgrade
10	Franklin Avenue	FCDT2128	8	-	300	6	Replace Conduit
10	Franklin Avenue	FCDT2130	202	-	300	11	Replace Conduit
10	Highway 58	FCDT4102	149	-	375	114	Replace Conduit
10	Highway 58	FCDT4104	124	-	375	109	Replace Conduit
10	Highway 58	FCDT4106	140	-	375	153	Replace Conduit
10	Highway 58	FCDT4108	107	-	525	252	Replace Conduit
10	Highway 58	FCDT4110	119	-	675	358	Replace Conduit
10	Highway 58	FCDT4112	128	-	675	508	Replace Conduit
10	Highway 58	FCDT4114	15	-	675	508	Replace Conduit
10	Hillcrest Drive	CDT12927	90	300	450	234	Upgrade
10	Hillcrest Drive	CDT13614	75	300	375	135	Upgrade
10	Hillcrest Drive	CDT13617	28	300	375	134	Upgrade
10	Hillcrest Drive	CDT13620	82	300	375	237	Upgrade
10	Hillcrest Drive	CDT13621	28	300	375	237	Upgrade
10	Knoll Street	FCDT2124	162	-	450	96	Replace Conduit
10	Knoll Street	FCDT2125	4	-	450	96	Replace Conduit
10	Knoll Street	FCDT2136	290	-	450	146	Replace Conduit
10	Knoll Street	FCDT2137	6	-	450	146	Replace Conduit
10	Merritt Parkway South	FCDT2098	6	-	450	52	Replace Conduit
10	Northland Avenue	FCDT2134	81	-	300	44	Replace Conduit
10	Omer Avenue	FCDT2096	151	-	600	188	Replace Conduit
10	Ost Avenue	FCDT2129	63	-	300	2	Replace Conduit
10	Royal Road	CDT12317	20	540	600	262	Upgrade
10	Runnymeade Road	FCDT10019	406	-	300	20	Sump Pump Drain

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
10	Steele Street	FCDT2126	52	-	300	2	Replace Conduit
10	Steele Street	FCDT2127	80	-	300	6	Replace Conduit
10	Steele Street	FCDT2131	4	-	300	9	Replace Conduit
10	Steele Street	FCDT2135	8	-	300	45	Replace Conduit
10	Steele Street	FCDT2162	15	-	300	4	Replace Conduit
10	Woodside Drive	FCDT2122	257	-	450	106	Replace Conduit
10	Woodside Drive	FCDT2123	5	-	300	103	Replace Conduit
11	Main Street West	CDT10069	77	300	600	375	Upgrade
11	Main Street West	CDT10103	79	300	450	192	Upgrade
11	Main Street West	CDT10068	94	380	900	1059	Upgrade
11	Mellanby Avenue	FCDT4134	495	-	600	163	New Service
11	Ramp	CDT13933	94	300	750	668	Upgrade
11	Welland Canal Service Road	CDT13934	77	300	900	1154	Upgrade
12	Berkley Avenue	FCDT2071	175	-	600	135	Replace Conduit
12	Berkley Avenue	FCDT2072	58	-	300	32	Replace Conduit
12	Berkley Avenue	FCDT2146	6	-	300	32	Replace Conduit
12	Berkley Avenue	FCDT2191	150	-	675	169	Replace Conduit
12	Chippawa Road	FCDT2074	359	-	525	275	Replace Conduit
12	Chippawa Road	FCDT2143	4	-	525	264	Replace Conduit
12	Highway 140	FCDT4128	688	-	300	52	New Service
12	Highway 3 Access	CDT11146	2	300	675	160	Upgrade
12	Highway 3 Access	FCDT2073	73	-	675	159	Replace Conduit
12	Wellington Street	CDT10167	53	300	600	148	Upgrade
13	Clarke Street	FCDT2082	255	-	450	155	Replace Conduit
13	Clarke Street	FCDT2083	204	-	525	205	Replace Conduit
13	Clarke Street	FCDT2084	162	-	600	287	Replace Conduit
13	Clarke Street	FCDT2085	8	-	600	285	Replace Conduit
13	Clarke Street	FCDT2087	88	-	450	108	Replace Conduit
13	Clarke Street	FCDT2092	233	-	450	98	Replace Conduit
13	Clarke Street	FCDT2147	19	-	450	131	Replace Conduit
13	Clarke Street	FCDT2154	14	-	525	180	Replace Conduit
13	Crescent Avenue	FCDT2149	19	-	525	201	Replace Conduit
13	Crescent Avenue	FCDT2150	20	-	525	197	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
13	Crescent Avenue	FCDT2151	18	-	525	158	Replace Conduit
13	Humboldt Parkway	FCDT2078	252	-	450	142	Replace Conduit
13	Humboldt Parkway	FCDT2079	202	-	525	203	Replace Conduit
13	Humboldt Parkway	FCDT2080	55	-	600	284	Replace Conduit
13	Humboldt Parkway	FCDT2081	12	-	600	283	Replace Conduit
13	Humboldt Parkway	FCDT2086	72	-	300	42	Replace Conduit
13	Humboldt Parkway	FCDT2090	180	-	300	0	Replace Conduit
13	Humboldt Parkway	FCDT2091	197	-	450	83	Replace Conduit
13	Humboldt Parkway	FCDT2152	16	-	300	12	Replace Conduit
13	Humboldt Parkway	FCDT2153	14	-	300	40	Replace Conduit
13	John Avenue	FCDT2148	18	-	450	126	Replace Conduit
13	Killaly Street East	FCDT4130	187	-	450	135	Replace Conduit
13	Russell Avenue	FCDT2088	74	-	525	180	Replace Conduit
13	Russell Avenue	FCDT2089	4	-	450	180	Replace Conduit
13	Wellington Street	FCDT2075	170	-	525	174	Replace Conduit
13	Wellington Street	FCDT2076	45	-	525	186	Replace Conduit
13	Wellington Street	FCDT2077	7	-	525	184	Replace Conduit
13	Wellington Street	FCDT4132	628	-	900	801	New Service
14	Davis Street	FCDT1026	253	-	600	266	Replace Conduit
14	Davis Street	FCDT1050	215	-	525	177	Replace Conduit
14	Davis Street	FCDT1054	84	-	525	154	Replace Conduit
14	Decew Street	FCDT1024	106	-	750	309	Replace Conduit
14	Durham Street	FCDT1000	96	-	375	64	Replace Conduit
14	Durham Street	FCDT1002	60	-	375	94	Replace Conduit
14	Durham Street	FCDT1004	77	-	450	154	Replace Conduit
14	Fares Street	FCDT1008	160	-	375	99	Replace Conduit
14	Fares Street	FCDT1016	233	-	600	237	Replace Conduit
14	Fares Street	FCDT1046	168	-	450	64	Replace Conduit
14	Louis Street	FCDT1018	94	-	375	58	Replace Conduit
14	Louis Street	FCDT1030	76	-	300	23	Replace Conduit
14	Louis Street	FCDT1032	101	-	450	134	Replace Conduit
14	Mitchell Street	FCDT1020	53	-	375	190	Replace Conduit
14	Mitchell Street	FCDT1022	123	-	900	474	Replace Conduit
14	Mitchell Street	FCDT1034	164	-	375	116	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
14	Mitchell Street	FCDT1048	169	-	375	50	Replace Conduit
14	Nickel Street	FCDT1012	101	-	1050	1041	Replace Conduit
14	Nickel Street	FCDT1014	113	-	1200	1359	Replace Conduit
14	Nickel Street	FCDT1052	103	-	750	556	Replace Conduit
14	Welland Street	FCDT1006	141	-	525	229	Replace Conduit
14	Welland Street	FCDT1010	233	-	675	408	Replace Conduit
14	Welland Street	FCDT1036	242	-	900	518	Replace Conduit
14	Welland Street	FCDT1055	142	-	1200	2215	Replace Conduit
15	Fares Street	FCDT1042	56	-	450	83	Replace Conduit
15	Mitchell Street	FCDT1044	45	-	375	64	Replace Conduit
15	Rodney Street	FCDT1038	101	-	525	117	Replace Conduit
15	Rodney Street	FCDT1040	89	-	675	278	Replace Conduit
17	Corvette Street	FCDT4092	122	-	600	280	Replace Conduit
17	Merritt Parkway North	FCDT4090	118	-	600	288	Replace Conduit
17	Merritt Parkway North	FCDT4094	166	-	600	268	Replace Conduit
17	Merritt Parkway North	FCDT4096	128	-	600	394	Replace Conduit
17	Merritt Parkway South	FCDT2097	188	-	450	61	Replace Conduit
17	Merritt Parkway South	FCDT4098	43	-	600	393	Replace Conduit
17	Merritt Parkway South	FCDT4100	13	-	600	393	Replace Conduit
20	Alma Street	FCDT10010	135	-	300	28	Sump Pump Drain
20	Davis Street	FCDT10011	81	-	300	12	Sump Pump Drain
20	Fares Street	CDT10486	9	450	600	93	Upgrade
20	Fares Street	FCDT2095	7	-	450	94	Replace Conduit
20	Fares Street	FCDT10009	106	-	300	32	Sump Pump Drain
20	Killaly Street East	FCDT2093	130	-	450	114	Replace Conduit
20	Killaly Street East	FCDT2094	69	-	450	94	Replace Conduit
20	Killaly Street East	FCDT10012	197	-	300	16	Sump Pump Drain
20	Saint Arnaud Street	CDT12301	13	300	450	81	Upgrade
20	Saint Arnaud Street	CDT12299	12	375	450	81	Upgrade
20	Welland Street	CDT12296	8	300	450	129	Upgrade
20	Welland Street	CDT12300	10	375	450	129	Upgrade
21	Colborne Street	CDT10311	33	300	1500	1299	Upgrade

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
21	Durham Street	CDT13465	12	600	1500	1296	Upgrade
22	Borden Avenue	FCDT2108	192	-	450	88	Replace Conduit
22	Borden Avenue	FCDT2110	203	-	600	330	Replace Conduit
22	Borden Avenue	FCDT2178	14	-	600	76	Replace Conduit
22	Borden Avenue	FCDT2179	17	-	600	306	Replace Conduit
22	Borden Avenue	FCDT2180	17	-	375	41	Replace Conduit
22	Borden Avenue	FCDT2189	83	-	900	823	Replace Conduit
22	Elm Street	FCDT2117	83	-	750	540	Replace Conduit
22	Elm Street	FCDT2120	138	-	450	137	Replace Conduit
22	Elm Street	FCDT4136	234	-	750	979	Replace Conduit
22	Fielden Avenue	FCDT2109	71	-	450	95	Replace Conduit
22	Fielden Avenue	FCDT2111	81	-	300	3	Replace Conduit
22	Fielden Avenue	FCDT2112	99	-	450	71	Replace Conduit
22	Fielden Avenue	FCDT2114	97	-	525	209	Replace Conduit
22	Knoll Street	FCDT2104	202	-	450	89	Replace Conduit
22	Knoll Street	FCDT2121	82	-	450	72	Replace Conduit
22	Oak Street	FCDT2118	100	-	300	0	Replace Conduit
22	Oak Street	FCDT2119	95	-	375	24	Replace Conduit
22	Oak Street	FCDT2183	14	-	600	493	Replace Conduit
22	Oakwood Street	FCDT2103	201	-	300	8	Replace Conduit
22	Oakwood Street	FCDT2177	15	-	600	77	Replace Conduit
22	Omer Avenue	FCDT2099	82	-	600	77	Replace Conduit
22	Omer Avenue	FCDT2100	65	-	450	83	Replace Conduit
22	Omer Avenue	FCDT2115	105	-	600	419	Replace Conduit
22	Omer Avenue	FCDT2116	90	-	675	422	Replace Conduit
22	Omer Avenue	FCDT2185	14	-	600	696	Replace Conduit
22	Omer Avenue	FCDT2187	15	-	600	412	Replace Conduit
22	Omer Avenue	FCDT4082	132	-	450	221	Replace Conduit
22	Queen Street	FCDT2102	198	-	450	74	Replace Conduit
22	Queen Street	FCDT2176	16	-	600	135	Replace Conduit
22	Steele Street	FCDT2105	97	-	450	93	Replace Conduit
22	Steele Street	FCDT2106	106	-	300	11	Replace Conduit
22	Steele Street	FCDT2107	83	-	300	46	Replace Conduit
22	Steele Street	FCDT2181	15	-	450	85	Replace Conduit

Drainage Area	Location	Conduit ID	Length (m)	Ex. Dia. (mm)	Prop. Dia. (mm)	Peak Flow (L/s)	Upgrade Category
22	Wallace Avenue	FCDT2113	194	-	450	162	Replace Conduit
22	Wallace Avenue	FCDT2182	15	-	450	208	Replace Conduit
22	Wallace Avenue	FCDT2184	13	-	375	7	Replace Conduit

Appendix D - Cost Estimates

The City of Port Colborne
Storm Sewer System Infrastructure Needs Study

Capital Plan Cost Estimate

Estimate Constants

Trench Width	Pipe Diameter + 600mm, note minimum width.
Minimum Trench Width (m)	1
Average Trench Depth (m)	3.5
Average Rock Depth (m)	1.2
CB Lead Length (m)	7.5
Granular Weight (t/m^3)	2.45
Granular Buffer	1.1
HL8 Thickness (mm)	50
HL3 Thickness (mm)	40
Asphalt Weight (t/m^3)	2.54
Asphalt Buffer	1.1

Removals

Rock from Trench	Trench L x W x Rock Depth
Rock from MH's and CB's	Trench x 15%
Asphalt from Trench	Trench L x W
Asphalt from MH's and CB's	Trench x 15%
Ex. MH's and CB's	Equal to quantity installed
Ex. Sewers	Equal to quantity installed

Installation

Manhole Quantities	1 MH every 100m
Manhole Sizes	based on pipe diameter
Catchbasin Quantities	2 CB's every 50m
Granular for Trench	Trench L x W x D
Granular for Mh's and CB's	Trench x 15%

Reinstatements

Milling	Area of trench + 0.5m on either side
HL8 Asphalt	Area of milling x 50mm thick
HL3 Asphalt	Area of milling x 30mm thick
MH's and CB's	Add 15% to Milling, HL8 and HL3

Not Included

Concrete Road Deck Removal or Replacement
Concrete Curb Removal or Replacement

The City of Port Colborne
Storm Sewer System Infrastructure Needs Study

Capital Plan Cost Estimate

Unit Prices

Item	Unit	List Price	Unit Price
Removals			
Asphalt Removal	m^2		$5.00
Removal of Existing Sewers	m		$10.00
Removal of Existing MH's and CB's	each		$600.00
Rock Excavation	m^3		$100.00
Installation		List Price	
Granular 'A'	t		$14.00
Catchbasin Leads (200mm)	m		$150.00
300mm Diameter Storm Sewer	m	$74.70	$200.00
375mm Diameter Storm Sewer	m	$92.20	$220.00
450mm Diameter Storm Sewer	m	$95.00	$240.00
525mm Diameter Storm Sewer	m	$103.60	$260.00
600mm Diameter Storm Sewer	m	$139.50	$300.00
675mm Diameter Storm Sewer	m	$213.80	$500.00
* 750mm Diameter Storm Sewer	m	$281.90	$563.80
* 825mm Diameter Storm Sewer	m	$327.00	$654.00
* 900mm Diameter Storm Sewer	m	$392.30	$784.60
* 975mm Diameter Storm Sewer	m	$453.10	$906.20
* 1050mm Diameter Storm Sewer	m	$517.60	$1,035.20
* 1200mm Diameter Storm Sewer	m	$649.00	$1,298.00
* 1350mm Diameter Storm Sewer	m	$794.40	$1,588.80
* 1500mm Diameter Storm Sewer	m	$971.40	$1,942.80
* 1200mm Diameter Manhole	each	$2,608.00	$5,216.00
* 1500mm Diameter Manhole	each	$4,650.00	$9,300.00
* 1800mm Diameter Manhole	each	$5,952.00	$11,904.00
* 2400mm Diameter Manhole	each	$11,320.00	$22,640.00
Catchbasins	each	$525.00	$1,500.00
Reinstatements			
Asphalt Milling	m^2		$5.00
HL8	t		$120.00
HL3	t		$120.00

* Based on Hanson Pipe 2014 Ontario Pipe List
http://www.hansonpipeandprecast.com/tech_specs/CAN4/2014Ontario_PriceList.pdf
Reinforced Circular Concrete Pipe - 65-D
Manholes +/- 3.5m deep
Unit Price = 2 x List Price

All other prices based on recent construction administration projects

The City of Port Colborne
Storm Sewer System Infrastructure Needs Study

Capital Plan Cost Estimate

Item	Unit	Unit Price	Estimate of Quantities by Drainage Area																		Total
			1	2	3	4	6	7	8	9	10	11	12	13	14	15	17	20	21	22	
Removals																					
Asphalt Removal	m^2	$5	1,659	4,167	3,108	1,684	2,056	2,514	2,753	4,538	4,781	1,326	1,979	4,248	4,676	381	1,041	910	109	4,188	46,116
Removal of Existing Sewers	m	$10	1,289	3,127	2,388	1,357	1,623	1,942	2,140	3,500	3,897	916	1,568	3,173	3,307	291	778	777	45	3,278	35,396
Removal of Existing MH's and CB's	each	$600	58	152	114	64	80	95	95	170	190	44	77	153	157	14	40	36	1	162	1,702
Rock Excavation	m^3	$100	3,816	9,585	7,148	3,873	4,729	5,782	6,331	10,437	10,997	3,049	4,552	9,770	10,754	875	2,395	2,093	250	9,631	106,067
Installation																					
Granular 'A'	t	$14	15,648	39,307	29,316	15,885	19,396	23,712	25,964	42,801	45,099	12,504	18,667	40,067	44,104	3,589	9,821	8,584	1,025	39,499	434,989
Catchbasin Leads	m	$150	368	953	728	405	495	593	608	1,050	1,155	278	465	953	998	90	248	218	8	1,013	10,620
300mm Diameter Storm Sewer	m	$200	571	325	1,184	801	777	278	9	384	1,069	0	752	282	76	0	0	519	0	571	7,598
375mm Diameter Storm Sewer	m	$220	106	115	0	171	78	89	0	13	663	0	0	0	796	45	0	0	0	125	2,201
450mm Diameter Storm Sewer	m	$240	141	1,394	119	0	107	422	1,406	1,245	1,180	79	0	1,253	346	56	188	249	0	1,500	9,685
525mm Diameter Storm Sewer	m	$260	24	251	236	93	319	608	264	828	374	0	363	773	440	101	0	0	0	97	4,771
600mm Diameter Storm Sewer	m	$300	86	357	318	0	0	115	149	443	171	572	228	237	486	0	590	9	0	495	4,256
675mm Diameter Storm Sewer	m	$500	0	80	0	90	0	350	158	187	440	0	225	0	233	89	0	0	0	90	1,942
750mm Diameter Storm Sewer	m	$564	361	117	401	202	342	80	0	400	0	94	0	0	209	0	0	0	0	317	2,523
825mm Diameter Storm Sewer	m	$654	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
900mm Diameter Storm Sewer	m	$785	0	373	65	0	0	0	154	0	0	171	0	628	365	0	0	0	0	83	1,839
975mm Diameter Storm Sewer	m	$906	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1050mm Diameter Storm Sewer	m	$1,035	0	115	65	0	0	0	0	0	0	0	0	0	101	0	0	0	0	0	281
1200mm Diameter Storm Sewer	m	$1,298	0	0	0	0	0	0	0	0	0	0	0	0	255	0	0	0	0	0	255
1350mm Diameter Storm Sewer	m	$1,589	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1500mm Diameter Storm Sewer	m	$1,943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0	45
1200mm Diameter Manhole	each	$5,216	9	25	17	10	14	16	14	30	36	7	15	26	24	2	7	7	0	27	286
1500mm Diameter Manhole	each	$9,300	4	0	4	4	4	4	2	6	4	1	3	0	4	1	0	0	0	4	45
1800mm Diameter Manhole	each	$11,904	0	4	2	0	0	0	2	0	0	2	0	6	4	0	0	0	0	1	21
2400mm Diameter Manhole	each	$22,640	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
Catchbasins	each	$1,500	49	127	97	54	66	79	81	140	154	37	62	127	133	12	33	29	1	135	1,416
Reinstatements																					
Asphalt Milling	m^2	$5	3,141	7,763	5,855	3,245	3,923	4,747	5,214	8,563	9,262	2,379	3,782	7,897	8,479	715	1,936	1,804	160	7,957	86,822
HL8	t	$120	439	1,085	818	453	548	663	728	1,196	1,294	332	528	1,103	1,184	100	270	252	22	1,112	12,129
HL3	t	$120	351	868	654	363	438	531	583	957	1,035	266	423	883	948	80	216	202	18	889	9,703
Total Pipe Length (m)			1,289	3,127	2,388	1,357	1,623	1,942	2,140	3,500	3,897	916	1,568	3,173	3,307	291	778	777	45	3,278	35,396

Appendix E - Background Information on Stormwater Fees

Report

The City of Port Colborne
Storm Sewer System
Infrastructure Needs Study

Background Information on Stormwater User Fees

Prepared by:
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October 2013

Table of Contents

1 Introduction

The ongoing Storm Sewer System Infrastructure Needs Study undertaken by Associated Engineering for the City of Port Colborne must address the following tasks identified in the terms of reference:[1]

1. Prepare a detailed breakdown of the projected rate required for full cost recovery and ultimately the replacement cost of the infrastructure at the end of its lifecycle;
2. Determine optimum supporting revenue source (i.e. tax based vs. user fees);
3. Investigate the feasibility of integrating a "fee for service" based charge in existing policy and systems;

This report presents information and analysis relating to the second and third tasks.

Alternative revenue sources are first described and evaluated. Following this alternative formats for storm sewer user fees are described and evaluated. The discussion of user fees provides an overview of options and reviews Canadian and US experience with storm water user fees. Results of a scan of Canadian municipalities using Storm water user fees are provided in the appendix. The report is only meant to provide information and does not make recommendations.

In this report, full cost is understood to include all administrative, operating and maintenance costs plus the capital expenditures required for asset repairs, replacements, refurbishments and upgrades that will assure ongoing provision of service at targeted standards to storm sewer service customers.

2 Municipal Revenue Sources for Storm Water

2.1 Property taxes

Property taxes are the main funding source for municipalities in Ontario. The cost of storm water service is recovered through the mill rate applied to the market value of properties. The main advantage of tax based funding is that it is an existing and accepted approach with a well established billing system. However tax based funding is not a dedicated source and is subject to competition for limited funds. It is not therefore considered sustainable in terms of routinely covering the full costs of the service.

Tax levies are not expected to correlate closely with storm water from a property. A charge based on property taxes is not therefore equitable since it does not reflect the benefit received by the property owner from storm water management services. Moreover the tax system does not give property owners an incentive to manage storm water on-site.

Exemptions from property tax under subsection 3(1) of the Assessment Act, 1990 for non-profit organizations, religious organizations and charities among others mean that these properties

[1] City of Port Colborne, 2012. Project No. 2012-09 Request for Proposal, Qualification of Consulting Services for the Development of a Storm Sewer System Infrastructure Needs Study, pg 7.

contribute to runoff but do not help fund storm water programs unless they make payments in lieu of taxes.

Section 326 of the Municipal Act, 2001 allows municipalities to impose special area rates. These rates apply to properties within a designated area which receive benefit from a "special service" that is not provided or provided to the same level elsewhere in the municipality. Special area rates are commonly applied to waste management, fire, sewer and water.[2] They cannot be used to fund a municipal-wide storm water management program.

2.2 Local Improvement Charge

Ontario Regulations 586/06 and 322/12 under the Municipal Act, 2001 empower municipalities to use local improvement charges to recover the costs of capital improvements on public or private land from property owners benefiting from the improvement. The municipality and property owners must enter into an agreement regarding imposition of the charge and property owners can petition to either initiate or block a local improvement. Costs can be apportioned to property owners "on any basis that the municipality considers appropriate"; presumably including apportionment according to each property's contribution to storm water runoff.[3] Local improvement charges do not cover maintenance work and cannot be applied to municipal-wide projects.

2.3 Development Charges and Related Mechanisms

Municipalities are authorized to recover the costs of certain infrastructure investments that service new growth and redevelopment by the Development Charges Act, 1997. Development charges can only be used to fund eligible project costs and associated revenues are earmarked for funding of those projects.

Like development charges, subdivision agreements are used to fund the local infrastructure associated with new subdivisions. Under these agreements, developers provide infrastructure such as storm sewers and the municipality assumes ownership and responsibility for these once construction is complete.

These instruments are limited in application to storm water infrastructure on newly developed land within the municipality and are therefore dependent on growth. They do not help with maintenance or replacement of existing infrastructure.

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[2] Ministry of Municipal Affairs and Housing. The Municipal Councillor's Guide 2010 (http://www.mah.gov.on.ca/Page8393.aspx)

[3] Local Improvement Charges Regulation Amendments Under the Municipal Act and the City of Toronto Act (http://www.ontariocanada.com/registry/view.do?postingId=6982). Provisions in these regulations resemble those for funding of drainage works in rural areas under the Drainage Act, 1990. The Drainage Act however stipulates the approach to cost apportionment, requires the involvement of a drainage engineer, and provides for construction and maintenance. Property owners can petition for work under the Drainage Act, and decisions can be appealed to the Drainage Tribunal. Environmental Impact and Cost Benefit studies can be required under the Drainage Act.

2.4 Storm Water User Fee

Municipalities are authorized to impose fees and charges for stormwater services under sections 9, 10, 11 and 391 of the Municipal Act, 2001. Storm water user fees recover the cost of storm water management from property owners who benefit from that management. The benefit experienced by property owners is the safe removal of runoff from their property and its conveyance to a suitable downstream outlet without jeopardizing downstream properties.

A variety of approaches are used in the design of stormwater user fees. There are examples of charges based on metrics such as metered water use or assessed property value, but these earlier designs are not best practice and are not considered in this report. More recent implementations of stormwater user fees tend to base charges on surrogate measures of a property's contribution to stormwater runoff such as the property size or the surface area that is impervious to rainfall infiltration (discussed at greater length in the next chapter). Revenues from stormwater user fees are normally dedicated to funding of stormwater services. They can be used to recover both capital and operating costs and, depending on the structure of the charge, can do so in an equitable manner. They can also be structured to give property owners an incentive to implement on-site controls of stormwater runoff such as detention ponds. The stormwater user fee allows the municipality to recover stormwater management costs from properties that are exempt from property taxes.

Like water and wastewater charges, stormwater user fees are set annually by Council. The charges are often levied on the water and wastewater bill but some municipalities recover them on the tax bill.

Unlike other revenue instruments described above, stormwater charges are not common in Canada and may not have broad public acceptance. Their implementation therefore requires a concerted public information and consultation campaign. Implementation costs are incurred to establish and maintain customer records and a billing and collections system.

2.5 Comparing Revenue Instruments

Comparisons below are based on the specified criteria. An overall ranking of revenue sources cannot be made until local priorities and circumstances in Port Colborne are better understood:

	PROPERTY TAX	LOCAL IMPROVEMENT CHARGE	DEVELOPMENT CHARGE	STORMWATER USER FEE
EQUITABLE – payments by customers are commensurate with the level of service required and the benefit received*	NO –based on assessed property value which has little bearing on the demand for service	Can be if costs are apportioned appropriately. Apportionment by frontage is not equitable.	NO – costs are apportioned by floor area of buildings which has little bearing on the demand for service	YES - if costs are apportioned based on contribution to runoff (some fee structures do not do this)
DEDICATED – collected revenues should be dedicated to storm water services	NO – revenues go to general fund (special area rates are dedicated)	YES – to specific growth related capital projects	YES – to specific growth related capital projects	YES – dedicated to stormwater services
SUSTAINABLE – allows budgeting based on long term planning of funding requirements	NO – competing priorities can cause funding levels to vary	YES – funding for the covered project is guaranteed	YES – funding for the covered projects is guaranteed	YES – dedicated funding allows long term financial planning
AREA-WIDE – covers the total program area	YES – covers entire municipal area	NO – applies only to the local improvement area	NO – applies only to lands subject to new development or redevelopment	YES – covers entire storm water system service area
ALL COSTS – applies to all program costs	YES – revenues cover operating, maintenance and investments	NO – revenues cover only capital investments	NO – revenues cover only capital investments	YES – revenues cover operating, maintenance and investments
INCENTIVE – customers can save by reducing their demands for service**	NO – no credits for on-site storm water controls	NO – no credits for on-site storm water controls	NO – no credits for on-site storm water controls	YES – user fee program can include credits for on-site storm water controls
UNDERSTANDABLE – the customer charge is reasonably easy to understand	YES –in place long enough that most customers understand it now	YES – relatively simple charge levied on the tax bill	YES – Property owners not charged directly. Most developers understand the charge.	NO – Many will likely be confused at first since storm water systems are probably poorly understood.
IMPLEMENTATION –implementation costs should be relatively low	YES – already implemented	NO – case by case implementation with possibility of petitions to challenge projects	YES – already implemented	NO – new program costs incurred for design and public consultation and to establish customer data base, billing and collections system

	PROPERTY TAX	LOCAL IMPROVEMENT CHARGE	DEVELOPMENT CHARGE	STORMWATER USER FEE
ADMINISTRATION – administrative effort should be relatively low	YES – resources already committed	YES – once implemented, annual charges should be easy to levy	YES – resources already committed	NO – customer records require periodic updating, any credit program involves additional resources

* Requires that storm water service costs be allocated to customers in proportion to the contribution of their properties to storm water runoff.

** Requires that customers can reduce their service charge by controlling runoff from their property.

3 Storm Water User Fees

This section of the report examines stormwater user fees in greater detail. The first part of the chapter discusses how fees are designed and structured and briefly discusses implementation issues. A final section reviews experience with these user fees in the US and Canada. The material is intended to provide a general overview that will inform the reader of options and issues relating to the adoption of a storm water user fee; no recommendations are made at this time.

3.1 Design and Structure of Storm Water User Fees

Several recently completed storm water user fee feasibility studies were reviewed in preparation for this work.[4] Although these reports cover essentially the same topics, they do not apply a consistent terminology in describing storm water user fees. To avoid confusion we adopt the terminology used in the manual, "User-Fee Funded Stormwater Programs", recently published by the Water Environment Federation.[5] In addition to the above mentioned reports, the discussion below benefited from material in the following publications:

- National Association of Flood and Stormwater Management Agencies, 2006. Guidance for Municipal Stormwater Funding (http://www.nafsma.org/Guidance%20Manual%20Version%202X.pdf)
- United States Environmental Protection Agency New England, 2009. "Funding Stormwater Programs". EPA 901-F-09-004 April 2009 (http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/FundingStormwater.pdf)
- Inter Local Stormwater Working Group, May 2005. Stormwater Utility Fees, Considerations & Options. New England Environmental Finance Center. (http://efc.muskie.usm.maine.edu/docs/StormwaterUtilityFeeReport.pdf)

[4] TSH et. al., October 2008. Kitchener-Waterloo Stormwater Management Program and Funding Review: Stormwater Funding Analysis, Draft Final Report. AECOM, January 2010. City of Hamilton Stormwater Rate Feasibility Study, Project Number: 60119509. Watson & Associates, JANUARY 7, 2013. Town of Richmond Hill Stormwater Management Financing Feasibility Study

[5] Water Environment Federation, 2013. User-Fee Funded Stormwater Programs, Alexandria VA (ISBN 978-1-57278-277-8) (the first edition of this publication was released in 1994)

Like any utility user fee, the basic calculation of any stormwater fee involves dividing required revenue by the number of service units.

3.1.1 System Costs

Required revenue in a year will be the sum total of system costs less non-rate revenues from sources such as the general tax fund, developer contributions and the proceeds of new debt. Currently, storm sewer costs in Port Colborne are provided under a single functional account code, 510. This reflects the departmental structure used to deliver storm sewer services for which accounts for various overhead activities relating to several services are reported at a departmental level. Ideally storm water system user fees should recover all costs related to service delivery including allocated overhead costs; asset maintenance, repair and replacement costs; the costs of capital finance; and operating costs associated with monitoring, customer billing and collections, customer records, public education and relations, and so on. This approach is common for municipal water supply services which are 'ring fenced' for purposes of financial reporting and have accounts that are segregated from other municipal operations. A similar segregation of storm water system costs would facilitate the implementation of a storm water user fee and help guarantee full cost recovery using the fee.

It has been a common practice among municipalities to calculate user fees annually based on next year's budget. More and more municipalities are however adopting a longer financial planning horizon, looking ahead several years when setting next year's rates. Some municipalities even set user fees for more than one year at a time. The multi-year horizon identifies cash needs that can vary widely in response to the capital program and it allows a more careful management of cash flow using revenues, reserves and debt. This in turn allows rate setting that anticipates future funding needs and that avoids large annual adjustments and rate shock. A multi-year financial planning framework is also essential for implementation of an asset management program.

3.1.2 Service Units and Unit Costs

The definition of service units for storm water services parallels that for water supply and wastewater services. When user fees were first introduced for those services, flat rate billing was the norm and the service unit was essentially the customer. Over time the concept of the service unit was refined so that costs could be allocated to customers in proportion to their demands for service and the costs they caused for service delivery. This entailed identifying cost drivers that could be measured for purposes of billing.

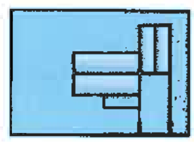
Differentiating customers by class is a basic step towards refinement of service units and is useful for purposes of cost allocation when levels of service vary by customer class. The differentiation reflects the fact that different classes of customer have, on average, different levels of demand. The simplest differentiation for storm water is between residential and non-residential customers. Residential customers can be further divided into single family and multi-residential, customers in each class being described in terms of the number of dwelling units in a building. A common classification of non-residential customers in stormwater and other utility services is commercial, industrial and institutional.

> ***Pervious Area*** *- Low hydrologic response due to a high rate of rainwater retention or infiltration. Results in slow runoff during most storms, although runoff can be fast when rain falls on soils that are saturated or during extreme storm events. Lawns, fields and gardens are pervious.*
>
> ***Impervious Area*** *- High hydrologic response due to the negligible rate of infiltration. Runoff is very fast during storms. Roof surfaces and pavement are impervious.*

Customer classification allows flat rate user fees to be differentiated by class, but customer classification fails to adequately capture the main cost drivers in stormwater management systems. These drivers include peak runoff of extreme or 'design' storms, the average annual volume of runoff, and sediment and pollutant loads carried in surface runoff. These drivers are, in turn, determined by property characteristics such as size, soil type, vegetative cover, topography, presence of hard or impervious surfaces and existence of stormwater control measures such as rain gardens or detention ponds. These characteristics govern whether and how fast rainwater leaves a property to enter the storm water management system.

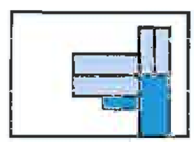
Equitable cost allocation across customers requires that the measure of service units provides a reasonably accurate proxy description of a property's contribution to stormwater runoff. In water supply and wastewater services, the measure of service units is the metered volume of water used by a customer. Unfortunately, measuring stormwater runoff volumes is not feasible. Instead proxy measures based on property characteristics are used to define service units. Several alternative measures are used:

Gross area – The total area of a property. Directly related to the total incident rainfall onto a property but not necessarily to the amount of runoff due to the influence of factors identified above. If soils are saturated or rainfall is extreme gross area will correlate with runoff.



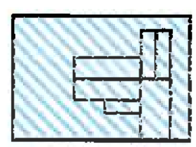
Gross area, no special consideration for impervious areas

Impervious area – The area of hardened surface on a property (roof tops, pavement, sidewalks) that prevents infiltration and causes rainfall to runoff as soon as it falls. Impervious area "exerts the greatest influence on the peak rate, volume and quality of runoff."[6]



Only impervious areas considered

Gross Area Factored by a Runoff Coefficient – The gross area of a property multiplied by an assumed average runoff coefficient for that type or class of property. The runoff coefficient for a surface is a value representing the percentage of rainfall that is turned into stormwater runoff and it captures the combined effect of various characteristics of the surface and the rainfall. The runoff coefficient for an impervious area is close to 1.0 while it might be near zero for a highly permeable area.



Gross area, plus a generic factor by property category to account for impervious areas

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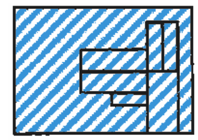
[6] Water Environment Federation, 2013. User Fee Funded Stormwater Programs (pg 46).

Gross Area Classified by Intensity of Development – Properties are classified by the intensity of development. The percentage of impervious area is assumed to fall within a range of values for each intensity-of-development category, for example:

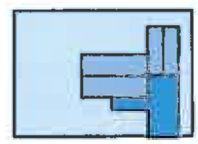
- Vacant/Undeveloped - 0% to 3% impervious
- Light development - 3% to 20% impervious
- Moderate development - 21% to 40% impervious
- Heavy development - 41% to 70% impervious
- Very heavy development - 71% to 100% impervious

The property's gross area plus a rating factor for its intensity of development category provides the basis for calculating the customer's charge.



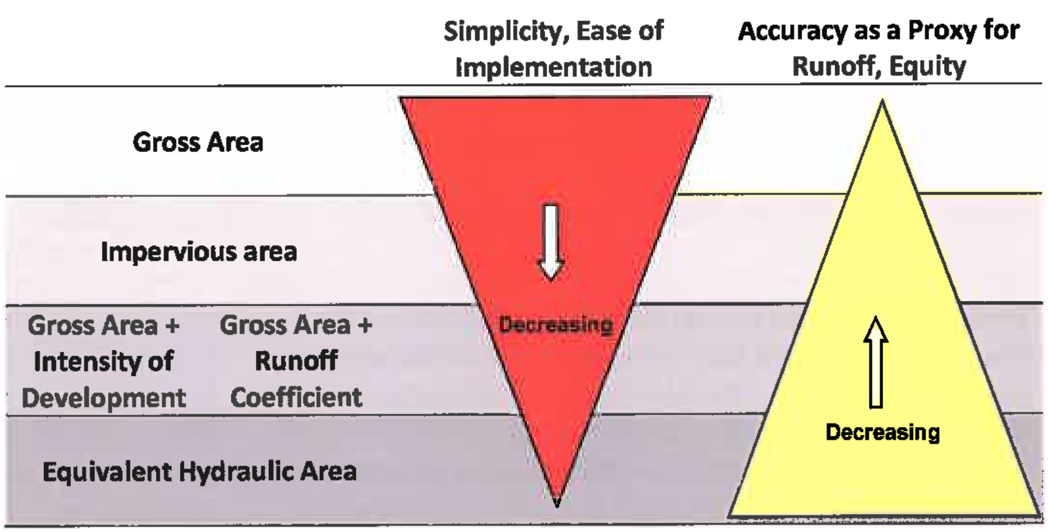
Gross area, plus a generic factor by property category to account for impervious areas.

Equivalent Hydraulic Area – Impervious and pervious areas are multiplied by hydrologic response factors to estimate the overall relative impact of a property on stormwater runoff. This is a data intensive approach that captures the impact on runoff of undeveloped properties that have no impervious areas.



Accounts separately for Pervious and impervious areas based on hydrologic response.

The following figure summarizes advantages and disadvantages of these alternative approaches:



Surface area—whether measured in hectares, square meters or some other unit—is the unit of measure for all of the above proxies for potential stormwater runoff. The stormwater service unit is a conversion of the area measure into an '**Equivalent Runoff Unit**' (ERU).[7] Typically one ERU is based on the average or median area of a residential property or detached single-family residential property. For example. if the standard is the median detached single-family residential property with an impervious area of 1500 square feet, then the ERU measure for an industrial property having 23,000 square feet of impervious area is estimated as:

23,000 sq.ft. / 1500 sq.ft = 15.33

The user fee is estimated as the total annual cost of service to be recovered from user fees divided by the total number of ERUs, for example:

Annual cost of service / total ERUs = $4,500,000 / 38,500 ERUs

= $116.88 / ERU / year

The customer's charge is estimated as the cost per service unit multiplied by the customer's number of service units, in the above example of an industrial property:

$116.88 X 15.33 ERUs = $1,791.77 / year

Using an 'intensity-of-development' approach, the rating factor for intensity of development is added to this calculation.

Grouping of Customers – All of the customers within a customer class may be assigned a single value for ERU. This is commonly done for single-family residential customers who are all assumed to have an ERU of 1.0 despite the size of individual properties or their impervious areas. Where statistical analysis reveals significant variation in residential properties, the class can be 'tiered' into large, medium and small categories with normal properties falling within say the 10^{th} and 90^{th} percentiles of properties ranked by size. It is less common to group non-residential customers in this manner since gross and impervious areas can vary so widely within this category. Rather, ERUs are calculated directly for each non-residential property.

Multi-residential buildings can be treated in the same manner as non-residential properties or they can be classified with residential properties. As residential properties they can be assigned 1.0 ERU for each dwelling unit but a smaller value to reflect smaller areas contributing to runoff, say 0.7 ERUs per townhouse dwelling unit and 0.5 ERUs per dwelling unit in an apartment building. Specific values should be based on an analysis of areas for a sample of multi-residential buildings.

Geographic areas – It is also possible to split the stormwater service area into separate service areas with distinct levels of service or attributes that cause costs of service to vary systematically, for example, topography or reliance on open ditches in a more rural setting versus storm sewers in an urban setting. The unit cost used in estimating customer bills is estimated separately for each service area. This approach is not common.

[7] 'Equivalent residential unit' and 'equivalent single detached unit' are alternative terms used for "equivalent runoff unit'.

3.1.3 Rate Structures

Rate design elements described in the previous section include the basis for estimating service units, the calculation of unit costs, customer classification, rate tiers, grouping of customers and the delineation of distinct geographic areas for purposes of charging. These elements are combined to define the specific stormwater rate structure that is used in a municipality. There are many ways to structure stormwater rates. These increase in complexity as the measure of ERUs shifts from gross area to measures of impervious and pervious areas. To reduce complexity, customers are often classified into residential and non-residential classes; residential customers are grouped into flat rate tiers and the more refined measures of ERU are applied only to non-residential customers.

The following table describes some rate structure options listed in order of increasing complexity:

	CUSTOMER CLASS		
	Single detached	**Multi-residential**	**Non-residential**
Simple Flat Rate	Al customers grouped into a single class. Uniform flat rate paid by all customers		
Tiered Rate, ERU based on gross area	Stormwater charge based on the unit cost per ERU times 0.8, 1.0 and 1.3 ERUs for small, median and large customers respectively.	Charge calculated as the unit cost per ERU times 0.8 ERUs per dwelling unit.	5 to 10 tiers with rates for each tier based on the average property ERU within each tier.
Tiered Rate, ERU based on impervious area	Similar to '**Tiered Flat Rate, gross area**' except rate calculations are based on impervious area.		
Non-residential unit rate, ERU based on impervious area	Stormwater charge based on the unit cost per ERU times 0.8, 1.0 and 1.3 ERUs for small, median and large customers respectively.	Duplexes, triplexes, townhouses charged the unit cost per ERU times 0.8 ERUs per dwelling unit. Apartment buildings charges as non-residential.	Charge calculated as unit cost per ERU times total ERUs. Total ERUs based on actual impervious area compared to the average area of a medium single detached property.
Unit rate, ERU based on impervious area	Charge calculated as unit cost per ERU times total ERUs. Total ERUs based on actual impervious area compared to the average area of the **median** single detached residential property.		
Unit rate, equivalent hydraulic area	Similar to '**Unit rate, ERU based on impervious area**' except rate calculations are based on equivalent hydraulic area.		

3.1.4 Credits

Under the rate structures described above the only way a customer could reduce their stormwater charge would be to reduce the area of impervious pavement and that works only if they are charged based on actual impervious area rather than a generic estimate such as is used for the tiered rate structures. The customer has no financial incentive to implement any of the many stormwater management measures that can be used in situ such as rain gardens, retention ponds and pervious pavement.

A credit policy can be used to create a stormwater management incentive. This allows customers to reduce their charge by a prescribed amount if they implement mitigation measures on their property to control runoff. Credit policies should stipulate:

- The type of credit (e.g. percentage reduction, absolute amount)
- Eligible measures and the level of credits for each
- The period of time the credit is in place
- Technical and administrative criteria and procedures to apply for the credit (e.g. need for an engineer's report, application forms, monitoring and inspection requirements)

Rate setting exercises should account for revenue losses from the issue of credits and those losses will hopefully be balanced with long run cost savings to stormwater operations.

3.1.5 Exemptions

Exemptions are provided from property tax obligations for non-profit organizations, religious organizations and charities. These exemptions are inequitable in the context of stormwater service provision. One benefit of a stormwater user fee is the end of these exemptions but some municipalities may choose as a matter of local policy to continue the exemptions.

A stronger case for exemptions can be made in the case of undeveloped properties that contribute negligible amounts of runoff to storm sewers and for properties that drain into natural water courses that have no hydrological connection to stormwater management systems.

3.2 Implementation

A detailed review of implementation issues is beyond the scope of this study. It is still important to be aware of the tasks involved in the implementation of a stormwater user fee. These are identified below:

- Establish and maintain a geo-referenced customer data base:
    - Customer data fields - property ID and ownership, customer classification, gross area, impervious area, status of credits ...
    - Policies, procedures and resources for revising, validating and updating the data base
- Review system costs and determine full-costs of the stormwater system including capital plans and asset management costs. Estimate any new costs associated with implementation of the new user fee including for billing software.
- Review cost reporting policies and procedures including the chart of accounts and revise as needed to facilitate future budgeting and rate setting exercises. Stormwater costs should be segregated in accounting records.

- Select a rate setting approach and rate structure. Set the initial rates and determine associated savings in the tax rate when these costs are removed from the tax bill (this information will be useful when the new charge is promoted).
- Identify a preferred approach for billing and collections (e.g. on the water bill, on the tax bill, separate bill) and develop related policies.
- Plan and implement a public information and consultation process.
- Train staff to respond effectively to customer queries and complaints related to the new fee.
- Develop user fee credit and exemption policies.
- Draft new or adapt existing stormwater bylaw.

3.3 Experience with Stormwater User Fees

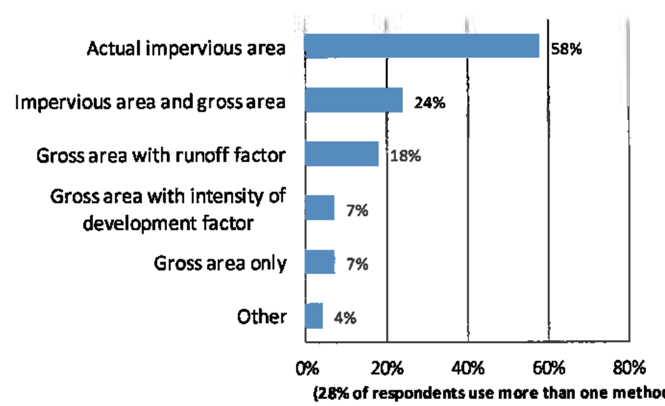
3.3.1 US Experience

The oldest stormwater utility in America was established in Bellevue, Washington in 1974. Since then many municipalities have opted for a user fee funding to manage stormwater systems. The findings of two recent surveys of existing stormwater utilities are summarized below:

3.3.1.1 Black & Veatch 2012 Stormwater Utility Survey

The Black and Veatch survey was a questionnaire based survey covering 67 utilities in 19 states (http://bv.com/docs/management-consulting-brochures/2012-stormwater-utility-survey). Key findings are as follows:

- Various organizational structures are used for stormwater:
  - stand alone storm water utility – 46%,
  - combined with water supply / wastewater utility – 21%,
  - combined with public works department – 28%,
  - other – 5%
- 91% of respondents get 75% or more of their program revenues from user fees.
- Area measurement used for calculation of user fee charges

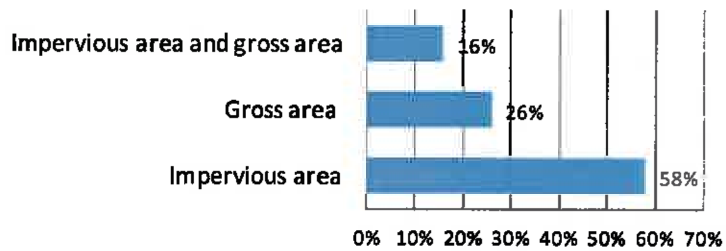


- Size of ERUs:

	For charges based on gross property area	For charges based on impervious area
Median size	12,020 sq.ft. (1117 m^2)	1,785 sq.ft. (166 m^2)
Range	500 sq.ft. (46 m^2) to 20,000 sq.ft. (1858 m2)	100 sq.ft. (9.3 m^2) to 7,500 sq.ft. (697 m^2)

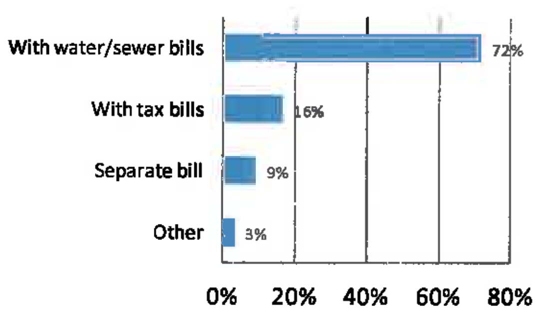
- Single family rate structures:

- Basis of tiered residential rates:

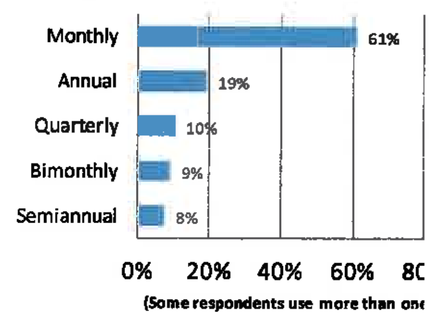


- The average single family residential charge was $6.08 / month
- Only 6% of respondents used rates that differed by service area or zone.

- Billing method:



Billing frequency:

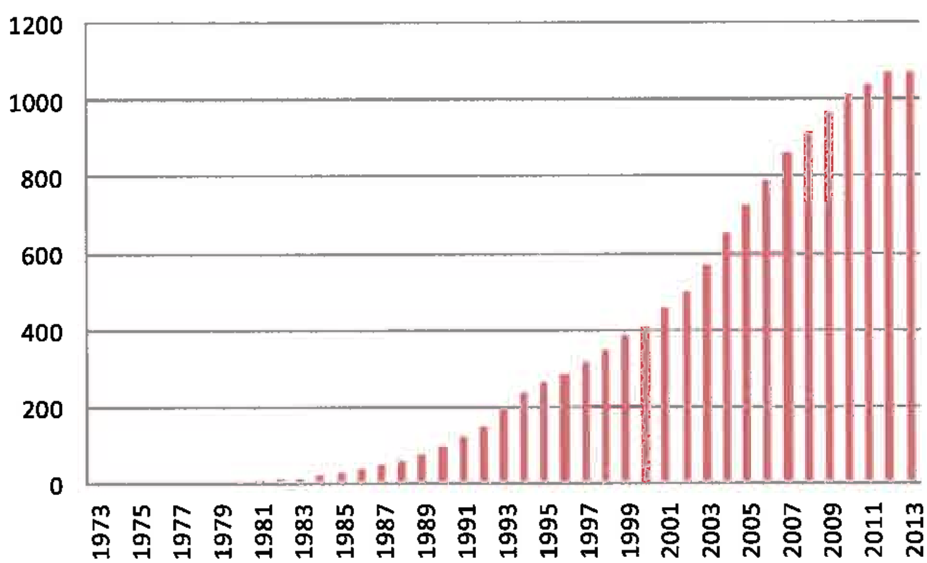


- Property exemptions were offered by 80.6% of respondents. The most common exemption was for undeveloped land (47.8%). Only 3% of respondents exempt religious organizations.
- 43% of respondents update property information annually or more frequently.
- 37% of respondents offer credits for implementation of storm water management practices. Most credit programs are only for non-residential customers and 73% of the credit programs are capped at a maximum amount. 32% of respondents offer incentive programs other than credits (e.g. design assistance, grants).

3.3.1.2 Western Kentucky University Stormwater Utility Survey 2013

This survey involved a web based search for information on municipal stormwater utilities. Data were obtained for 1417 stormwater utilities in 39 states and the District of Columbia (see http://www.wku.edu/engineering/documents/swusurveys/swusurvey-2012.pdf). Results of the survey are summarized below:

- Based on survey findings, the authors estimate that there are between 1800 and 2000 stormwater utilities in the U.S.
- 61.8% of posted user fees are based on impervious area and 11.7% on gross area of the property.
- Only 2.4% of utilities use a uniform flat fee for all customers and another 2.9% use a flat fee that differentiates customers by class.
- 19.6% of rate structures could not be classified in the survey. A small number (0.7%) used rates based on alternative metrics such as water meter size, water usage or number of parking spaces.
- The average monthly single family residential charge was $4.57.
- The average ERU for rate structures based on impervious area was 3050 square feet ($283m^2$).
- Based on reported dates when utilities were established, growth in stormwater utility programs was rapid in the 1990s (see figure).



US Storm Water Utilities by Date of Establishment

3.3.2 Canadian Experience

There are no comprehensive published surveys of Canadian stormwater utilities. Starting with published lists in various reports, the consultant located 16 municipalities across the country using stormwater user fees and another three with user fee proposals in place. Information was compiled for these municipalities using a web based search. Results are provided in the Appendix and are summarized below:

- The earliest program commenced in Calgary in 1994.
- The population of surveyed municipalities ranged from 17,000 to 1.2 million
- The predominant organizational structure in eastern Canada is the municipal department. Utility structures are more common west of Ontario.

- Annual stormwater operating budgets varied from $0.5 million to $40 million and capital budgets ranged from $0.5 million to $66 million. The average annual budgets on a per capita basis were estimated to be $24 and $37 for operation and capital respectively.
- A tiered rate structure based on the type and size of property was the most common structure (10 municipalities). A two or three tier classification based on a residential / non-residential classification was most common (6 municipalities), but more complex rate structures used up to 17 categories.
- Three rate structures were based on gross area. Saskatoon uses a charge based on impervious area that is capped at 100 ERUs (residential charges based on 1.0 ERU). Kitchener has a tiered rate structure with ICI charges based on impervious area. Edmonton has the most complex rate structure, based on gross area and a runoff coefficient.
- Other rate structures: simple flat rate (1), markup on the water bill (1), assessed property value (2).
- Two municipalities used more than one charging method in their rate structure.
- Exemptions from the charge are offered by 3 municipalities. Credits for implementation of runoff controls are offered by 3 municipalities and grants by 2.

4 Next Steps

The introduction states that this report is provided for information only. It will help inform the reader about stormwater user fees and other cost recovery options that are available to the City for its stormwater operations.

No evaluation of options is provided in this report. This will come once more detailed evaluations of user fee options are completed. The steps to follow include:

- Revise this report once feedback is provided,
- Develop a 10 year financial model of stormwater operations using new information on asset management costs being prepared for this study,
- Apply the model to evaluate user fee options and review findings with City staff,
- Final reporting.

Appendix – Canadian Case Studies

Name of municipality: AURORA, ON	**Population:** 53,200 (2011)
Information Sources: www.town.aurora.on.ca	
Storm water management organisation: department	
Budget for storm water management: $1.3 million in 2013	
Structure of the storm water charge: flat rate: Residential - $4.36/month; ICI - $61.53/month	
Exemptions: properties exempted through legislation	
Credits: no	
Date of implementation: 1998	
Purpose for implementation: full cost recovery	

Name of municipality: CALGARY, AB	**Population:** 1,120,225 (2012)
Information Sources: www.calgary.ca, Bylaw Number 14M2012	
Storm water management organisation: water services business unit within the Utilities & Environmental Protection department	
Budget for storm water management: The original storm water charge was designed to generate about $3 million annually. No information on current charge revenues, however the system no longer relies on property tax funding.	
Structure of the storm water charge: A flat rate called the Drainage Service Charge. Monthly charge of $8.77 levied on the customer's water bill. The charge is the same for all customers.	
Exemptions: no	
Credits: no	
Date of implementation: Originally introduced in 1994 as the Storm Drainage Upgrade Change to finance storm drainage improvement projects. Ten years later this was replaced by the Storm Sewer Service Charge and the Storm Sewer Operations Charge which together fully funded the storm water system. In 2006, these two charges were combined into the current Drainage Charge.	
Purpose for implementation: Secure funding	

Name of municipality: EDMONTON, AB	**Population:** 1,230,100 (2012, metropolitan area)
Information Sources: www.edmonton.ca	
Storm water management organisation: utility	
Budget for storm water management: Budgeted revenue from the Stormwater Utility Charge was $40.5 million. Annual capital costs for the period 2012 – 2021 average $65.8 million per year of which 75% is for system renewal and rehabilitation.	
Structure of the storm water charge: The charge is based on lot area and permeability as described in Edmonton's Drainage Rates Brochure (http://www.edmonton.ca/for_residents/DrainageRatesBrochure.pdf): "Charges are based on property size (A), development intensity (I), and a runoff coefficient (R) based on land zoning and a city-wide monthly rate. The charges are calculated as follows: "A x I x R x Rate = Stormwater Utility Charge "A= the area of the property in square metres (m2), and the proportion of the building lot area attributable to each unit for multiple units sharing a single building of property. "I= the development intensity factor of 1.0, except for properties where owners demonstrate under section 35.1 (2) and 35.1 (3) that they contribute significantly less stormwater runoff per property area to the City's land drainage system during rainfalls than other similarly zoned properties. "R= the runoff coefficient which is based on land zoning. "Rate= the monthly charge of $0.028307 per square metre (m2)." The Land Drainage Utility Charge is collected on the water bill. The cost for an average residential homeowner is about $6 per month. The average monthly charge across all customers is $8.38.	
Exemptions: no information	
Credits: "The Utility Credit Program is open to any customer wishing to apply, however, it is aimed at customers who can demonstrate they contribute significantly less storm water discharge rates for their land zoning class, including: • Larger non-residential properties that are largely undeveloped, • Commercial and industrial properties with on-lot storm water management (e.g. parking lot storage), and • Properties draining directly into the North Saskatchewan River without utilizing Edmonton's land drainage systems" (http://www.edmonton.ca/for_residents/LDUPolicy.pdf)	
Date of implementation: storm water utility established in 2003.	
Purpose for implementation: "The switch to a utility enables the City to reverse a growing $83 million infrastructure gap and to meet future construction, maintenance and environmental demands." (City of Edmonton News release "New Land Drainage Utility Effective January 1", Dec. 20, 2002)	

Name of municipality: **HAMILTON, ON**	**Population:** **519,900** (2012)
Information Sources: http://www.hamilton.ca/; http://www.horizonutilities.com/	
Organisation: department	
Budget for storm water management: 2013 operating budget of $6.2 million, capital $14.8 million	
Structure of the storm water charge: Storm water costs are recovered through the water and wastewater rates and property taxes (for costs related to catch basins/culverts/outfalls/storm ponds). The wastewater rate is a markup on the water rate. A recent review recommended funding through a separate wastewater rate charged on the volume of water used rather than a markup.	
Exemptions: no	
Credits: no	
Date of implementation: 2004 (flat fee originally used)	
Purpose for implementation: Secure funding	

Name of municipality: KITCHENER, ON | **Population:** 232,200 (2011)

Information Sources: http://www.kitchener.ca

Storm water management organisation: utility

Budget for storm water management: Ten year average budget of $13.0 million (2011 to 2020). The capital cost component of this budget is $8.8 million.

Structure of the storm water charge:

Type Code	Description	Basis for Charge	Number of Dwelling Units	Monthly Charge per Property
1	Residential Single Detached Small	Detached homes with building footprint size of 105 m^2 or less	1	$5.67
2	Residential Single Detached Medium	Detached homes with building footprint size between 106-236 m2	1	$9.45
3	Residential Single Detached Large	Detached homes with building footprint size of 237 m^2 or more	1	$12.42
4	Residential Townhouse / Semi- Detached	Per dwelling unit	1	$6.75
5	Residential Condominium	Per dwelling unit	1	$3.78
6	Multi-Residential (2-5 Units)	Per building	Duplex	$7.56
			Triplex	$11.34
			Four-plex	$15.12
			Five-plex	$18.90
7	Multi-Residential (>5 Units)	Per property (according to number of dwelling units)	varies	Charge = (# units) × ($1.89/month
8	Non-Residential Smallest	26 - 1,051 m^2 of impervious area	n/a	$18.09
9	Non-Residential Small	1,052 - 1,640 m^2 of impervious area	n/a	$48.33
10	Non-Residential Medium-Low	1,641 - 7,676 m2 of impervious area	n/a	$126.63
11	Non-Residential Medium-High	7,677 - 16,324 m^2 of impervious area	n/a	$369.63
12	Non-Residential Large	16,325 - 39,034 m^2 of impervious area	n/a	$895.86
13	Non-Residential Largest	39,035 m^2 or greater of impervious area	n/a	$1,923.21

Exemptions: places of worship, charitable organisations, properties exempted through legislation

Credits: All property owners are now able to apply for stormwater credits of up to 45% of the stormwater portion of their utility bill. Residential properties are credited for the volume of stromwater captured on-site while ICI properties are credited for stormwater quantity and quality controls and for educational activities. (see stormwater credit policy at http://www.kitchener.ca/en/livinginkitchener/resources/SWCPFINALMemo6.pdf)

Date of implementation: 2011

Purpose for implementation: dedicated sustainable funding; fair and equitable charges

Name of municipality: LANGLEY TWP, BC	**Population**: 104,200 (2011)
Information Sources: www.township.langley.bc.ca	
Storm water management organisation: utility	
Budget for storm water management: Operating budget for 2012 of $6.6 million (includes $1.4 million contribution to capital). Total capital budget for 2012 was $9.7 million of which $3.7 million was financed using development charges.	
Structure of the storm water charge: Based on property assessment and billed with the property tax bill. Water and sewer are billed In a similar manner. The stormwater tax rate per $1000 of assessed property value is 0.1930 and the average annual charge for a single family home is estimated to be $31.	
Exemptions: Property Tax Exemption is available to registered not-for-profit organizations and organizations using property for municipal, recreational, religious, cultural, or charitable purposes.	
Credits: no	
Date of implementation: 2003	
Purpose for implementation: Dedicated funding	

Name of municipality: LONDON, ON	**Population**: 366,200 (2011)
Information Sources: www.city.london.on.ca	
Storm water management organisation: department	
Budget for storm water management: Total 2013 operating budget for storm sewers and wastewater collection and treatment is $43.1 (includes capital finance costs). The stormwater component of this was estimated to be $13 million. The combined capital budget was $54.4 million.	
Structure of the storm water charge: Residential, commercial and institutional customers pay a flat rate. Industrial customers pay a charge based on their land area. The charge is levied with the water bill. Monthly charge rates for 2013 are as follows:	

Customer Class	Fixed charge	Charge per hectare
Residential below 0.4 ha	$13.11	
Institutional below 0.4 ha	$12.87	
Commercial below 0.4 ha	$14.96	
Industrial above 0.4 ha		$105.31
Residential, Institutional, Commercial above 0.4 ha		$35.1

Exemptions: Only if exempted through legislation.	
Credits: ICI lands are eligible for a Reduction of up to 50% of the charge subject to filing of a storm drainage report. Residential properties less than 0.4 ha in size are charged a reduced rate if no storm sewer is found within 90 m of the property.	
Date of implementation: 1996	
Purpose for implementation: Tax-based funding prior to 1996 was not adequate to finance wastewater and storm water services. With implementation of the wastewater and storm water surcharges on the water bill, these services were 100% funded by these user charges.	

Name of municipality: MISSISSAUGA, ON	**Population:** 713,400 (2011)
Information Sources: http://www.mississauga.ca/portal/home; Stormwater Financing Study Public Information Meeting No. 2 displays, Tuesday November 20, 2012	
Storm water management organisation: department	
Budget for storm water management: Operating budget for 2012 of $6.6 million. Total capital budget for 2012 was $8.0 million. The total budget of $14.6 million reflects current practice. The budget for a sustainable operation is estimated to be $39.5 million and for an interim budget $26.6 million.	
Structure of the storm water charge: A Tiered Single Family Unit rate has been recommended with 3 size classes for SFU accounts, a unit charge per dwelling unit for multi-residential accounts and an impervious area based charge for ICI accounts. The indicative SFU rate to finance the interim budget is $93.60/year.	
Exemptions: Only if exempted through legislation.	
Credits: Stormwater rate credits for non-residential accounts, financial incentives for residential accounts.	
Date of implementation: a feasibility study was completed and approval given to proceed with phase 2 analysis	
Purpose for implementation: dedicated, reliable and equitable funding with opportunity to create incentives for improved stormwater management	

Name of municipality: PRINCE GEORGE, BC	**Population:** 76,000
Information Sources: http://princegeorge.ca/cityhall/Pages/default.aspx	
Storm water management organisation: utility (proposed)	
Budget for storm water management: $961,300 (2012 budget), average capital spending 2005-2011 was $490,800 compared to required investment of $1,590,000.	
Structure of the storm water charge: two options under consideration: Tiered flat rate, user rate (based on property runoff potential)	
Exemptions: Places of public worship, non-profit organizations and publicly owned property are currently exempt from property taxes. Exemption Policy for a storm water utility is not set.	
Credits: policy not yet decided	
Date of implementation: not yet implemented as of Oct 2013, public consultation is underway	
Purpose for implementation: equitable charge, dedicated and secure funding	

Name of municipality: PITT MEADOWS, AB	**Population:** 17,700
Information Sources: http://www.pittmeadows.bc.ca/EN/main/28.html	
Storm water management organisation: department	
Budget for storm water management: $1.5 million (2013 budget), Capital budget for 2013 is $5.9 million and the average for 2013-17 is $2.0 million.	
Structure of the storm water charge: Charges include a mill rate based on assessed property value; and a levy which is flat rate for residential properties and a charge per area for rural and commercial properties. The levy accounted for 57% of revenues in 2012 and the mill rate, 36%. The mill rate varies by class of property. The annual mill rate cost for a residential property in 2012 was $46. Levies for 2013 are as follows: Urban Residential – single housing $33.75/unit Urban Residential – multiple housing $14.47/unit Urban Non-residential $994.00/hectare Rural Areas: $99.42/hectare	
Exemptions: Property tax exemptions granted on a case by case basis depending on contribution to community life. Exemptions in place for places of worship and publicly owned facilities.	
Credits: none	
Date of implementation: no information	
Purpose for implementation: no information	

Name of municipality: REGINA, SK

Population: Service population of 200,000; storm sewerage for 63,000 properties

Information Sources: www.cityregina.com

Storm water management organisation: Combined water, wastewater and drainage utility

Budget for storm water management:
Capital for drainage works (2012) - $6.1 million
Operating & maintenance (all 3 utilities) $60.6 million

Structure of the storm water charge: The charge is based on property size. Rates billed every 2 months are as follows:

Daily Base Fee by property size	2011 ($)	2012 ($)	2013 ($)
0 to 1,000 sq.m.	10.65	11.56	12.47
1,001 to 3,000 sq.m.	21.29	23.12	24.94
3,001 to 5,000 sq.m.	42.58	46.23	49.88
5,001 to 7,000 sq.m.	63.88	69.35	74.83
7,001 to 9,000 sq.m.	85.17	92.47	99.77
9,001 to 11,000 sq.m.	106.46	115.58	124.71
11,001 to 13,000 sq.m.	127.75	138.70	149.65
13,001 to 15,000 sq.m.	149.04	161.82	174.59
15,001 to 17,000 sq.m.	170.33	184.93	199.53
17,001 to 19,000 sq.m.	191.63	208.05	224.48
19,001 to 21,000 sq.m.	212.92	231.17	249.42
21,001 to 23,000 sq.m.	234.21	254.28	274.36
23,001 to 25,000 sq.m.	255.50	277.40	299.30
25,001 to 27,000 sq.m.	276.79	300.52	324.24
27,001 to 29,000 sq.m.	298.08	323.63	349.18
29,001 to 31,000 m	319.38	346.75	374.13
Over 31,000 sq.m.	340.67	369.87	399.07

Exemptions: none

Credits: none

Date of implementation: The charge based on property size was introduced in 1992. A flat rate was used prior to this.

Purpose for implementation: full cost recovery

Name of municipality: RICHMOND HILL, ON	**Population:** 185,500 (2011), 57,300 properties
Information Sources: www.town.richmond-hill.on.ca	
Storm water management organisation: department	
Budget for storm water management: operating costs - $2.9 million, estimated lifecycle asset replacement cost - $12.5 million/year	
Structure of the storm water charge: Flat rate: residential and farm - $11.86 per quarter; multi-residential, condominium complex, non-residential - $23.12 bimonthly Rates based on operating costs only in 2013 and a phase in of lifecycle capital costs beginning in 2014. Charged on the water bill.	
Exemptions: none	
Credits: none	
Date of implementation: 2013	
Purpose for implementation: dedicated funding, equitable charge, cost recovery	

Name of municipality: RICHMOND, BC	**Population:** 62,000 (2012)
Information Sources: http://www.richmond.ca/	
Storm water management organisation: utility (water, wastewater, stormwater, solid waste)	
Budget for storm water management: 2013 operating budget of $4.2 million including $3.0 million in transfers for capital	
Structure of the storm water charge: charge based on property type:	

Residential – single, duplex	$14.56 per month
Residential – stacked, condo	$10.06 per month
Non-residential	$39.66 per month

Exemptions: none	
Credits: none but a grant program is available for various environmental initiatives including projects for "land, air and/or water quality preservation and/or enhancement" (http://www.stalbert.ca/uploads/files/our_government/city_council/City%20Council%20Policies/Environmental_Utility_Services/C-EUS-02_EnvironmentalInitiativesGrant.pdf)	
Date of implementation: 2003	
Purpose for implementation: no information available	

Name of municipality: SASKATOON, AB	**Population:** 246,300 (2013)
Information Sources: www.saskatoon.ca	
Storm water management organisation: utility	
Budget for storm water management: total annual budget of $3.42 million including $1.5 million for capital.	
Structure of the storm water charge: Charges based on the number of equivalent runoff units reflecting the area of impervious surface on a property. One ERU represents 265.3 m^2 and is charged at $4.40/month or $52.80/year. Single detached residential properties are charged at one ERU. Charges for other properties are based on actual impermeable surface areas. The charge is capped at 100 ERUs. It will be phased in over 6 years. Charged on the water bill.	
Exemptions: none	
Credits: "Property owners could reduce their storm water utility rate by making improvements to their properties such as private storage ponds, storage tanks, green roofs, permeable paving, rain gardens or other "soft" landscaping. Owners are 'credited' for the equivalent amount of runoff that would be diverted during a storm event, due to the improvement. In addition to decreasing the amount of storm water that collects on properties, many of these improvements also provide environmental benefits as well. "Property owners may request a recalculation of the estimated amount of impervious area they generate by completing an ERU evaluation form. An investigation is then conducted by an engineering technician to ensure the estimated amount is accurate. Credit will be given for improvements the property owner makes to decrease the hard surface area." (www.saskatoon.ca/DEPARTMENTS/Infrastructure%20Services/StrategicServices/StormWaterUtility/Pages/ReduceYourStormUtilityRate.aspx)	
Date of implementation: Flat fee introduced in 2002. Current rate structure adopted in 2012.	
Purpose for implementation: equity, cost recovery	

Name of municipality: ST ALBERT, AB	**Population:** 62,000 (2012)

Information Sources: http://www.stalbert.ca/

Storm water management organisation: utility (water, wastewater, stormwater, solid waste)

Budget for storm water management: 2013 operating budget of $4.2 million including $3.0 million in transfers for capital

Structure of the storm water charge: charge based on property type:

Residential – single, duplex	$14.56 per month
Residential – stacked, condo	$10.06 per month
Non-residential	$39.66 per month

Exemptions: none

Credits: none but a grant program is available for various environmental initiatives including projects for "land, air and/or water quality preservation and/or enhancement" (http://www.stalbert.ca/uploads/files/our_government/city_council/City%20Council%20Policies/Environmental_Utility_Services/C-EUS-02_EnvironmentalInitiativesGrant.pdf)

Date of implementation: 2003

Purpose for implementation: no information available

Name of municipality: ST THOMAS, ON	**Population:** 37,900 (2011)

Information Sources: http://st-thomas.org/utilities/, www.city.st-thomas.on.ca

Storm water management organisation: department

Budget for storm water management: 2013 budget of $1.0 million for sanitary and storm sewers

Structure of the storm water charge: charge based on property size:

Residential	$7.39 per month
Non-residential (property < 1800 sq.m.)	$7.39 per month
Non-residential (property > 1800 sq.m.)	$102.06/ha/month

Exemptions: none

Credits: none

Date of implementation: no information available

Purpose for implementation: no information available

Name of municipality: SURREY, BC	**Size**: 502,000 (2013)
Information Sources: www.city.surrey.bc.ca	
Storm water management organisation: utility	
Budget for storm water management: 2013 budget of $22.6 million with $10.5 million of this for capital.	
Structure of the storm water charge: Residential sewer and drainage service customers are charged on a flat rate basis. The charge is also a drainage parcel charge on the property tax bill. The annual charges are as follows: - Residential $188. - Non-residential $198 - Farm $123	
Exemptions: churches, hospitals, schools, certain parks, recreation and athletic facilities	
Credits: none	
Date of implementation: utility billing system introduced in 2002	
Purpose for implementation: not known	

Name of municipality: VICTORIA, BC	**Size**: 344,600 (2011)
Information Sources: http://www.victoria.ca/EN/main/city-hall.html	
Storm water management organisation: utility	
Budget for storm water management: Capital budget 2013 to 2017 of $22.0 million ($4.4 million/year).	
Structure of the storm water charge: Utility charge to be based on impervious surface.	
Exemptions: none proposed	
Credits: under consideration	
Date of implementation: 2014	
Purpose for implementation: dedicated and equitable funding	

Name of municipality: WATERLOO, ON | **Population:** 98,800 (2011)

Information Sources: http://www.waterloo.ca/

Storm water management organisation: department

Budget for storm water management: 2013 budget of $2.8 million with $1.1 million of this for capital.

Structure of the storm water charge:

Tiered rate structure based on property size with 2013 monthly rates as follows:

Rate Tier	Property Size Range	Rate
Residential Large	Total property area greater than 1012 m^2 (0.25 acres)	$8.91
Multi-Residential Small	Total property area less than or equal to 1012 m^2 (0.25 acres)	$7.72
Multi-Residential Medium	Total property area greater than 1012 m^2 (0.25 acres) and less than or equal to 8094 m^2 (1 acre)	$32.67
Multi-Residential Large	Total property area greater than 8094 m^2 (1 acre)	$174.13
Institutional Small	Total property area less than or equal to 8094 m^2 (2 acres)	$12.52
Institutional Medium	Total property area greater than 8094 m^2 (2 acres) and less than or equal to 40469 m^2 (10 acres)	$33.83
Institutional Large	Total property area greater than 40469 m^2 (10 acres)	$69.27
Commercial/Industrial Small	Total property area less than or equal to 2023 m^2 (0.5 acres)	$10.36
Commercial/Industrial Medium	Total property area greater than 2023 m^2 (0.5 acres) and less than or equal to 10117 m^2 (2.5 acres)	$48.38
Commercial/Industrial Large	Total property area greater than 10117 m^2 (2.5 acres) and less than or equal to 40469 m^2 (10 acres)	$155.89
Commercial/Industrial Largest	Total property area greater than 40469 m^2 (10 acres)	$394.86

These rates represent 75% of storm water costs. Phase-in of the rate to 100% of costs will be completed in 2014.

Exemptions: none

Credits: "Non-residential and multi-residential Customers may qualify for stormwater rate credits when the Customer can demonstrate to the City's satisfaction that the property of interest contains impervious surfaces that are directed to an approved, or in accordance with, MOE accepted stormwater quantity and/or quality BMP's." (By Law No. 2012-125, By-Law To Impose a Stormwater Charge and Implement a Stormwater Credit Program)

Date of implementation: 2011

Purpose for implementation: dedicated sustainable funding; fair and equitable charges

ON-LINE RESOURCES

An Internet Guide to Stormwater Financing, Center for Urban Policy and the Environment at Indiana University-Purdue University Indianapolis. http://stormwaterfinance.urbancenter.iupui.edu/

Stormwater Magazine http://www.stormh2o.com/SW/articles.aspx?search=executesearch

Busco, Dan and Linsey, Greg. "Designing Stormwater User Fees: Issues and Options,"

Keller, Brant. "The Critical Elements to Success of Stormwater Utilities,"

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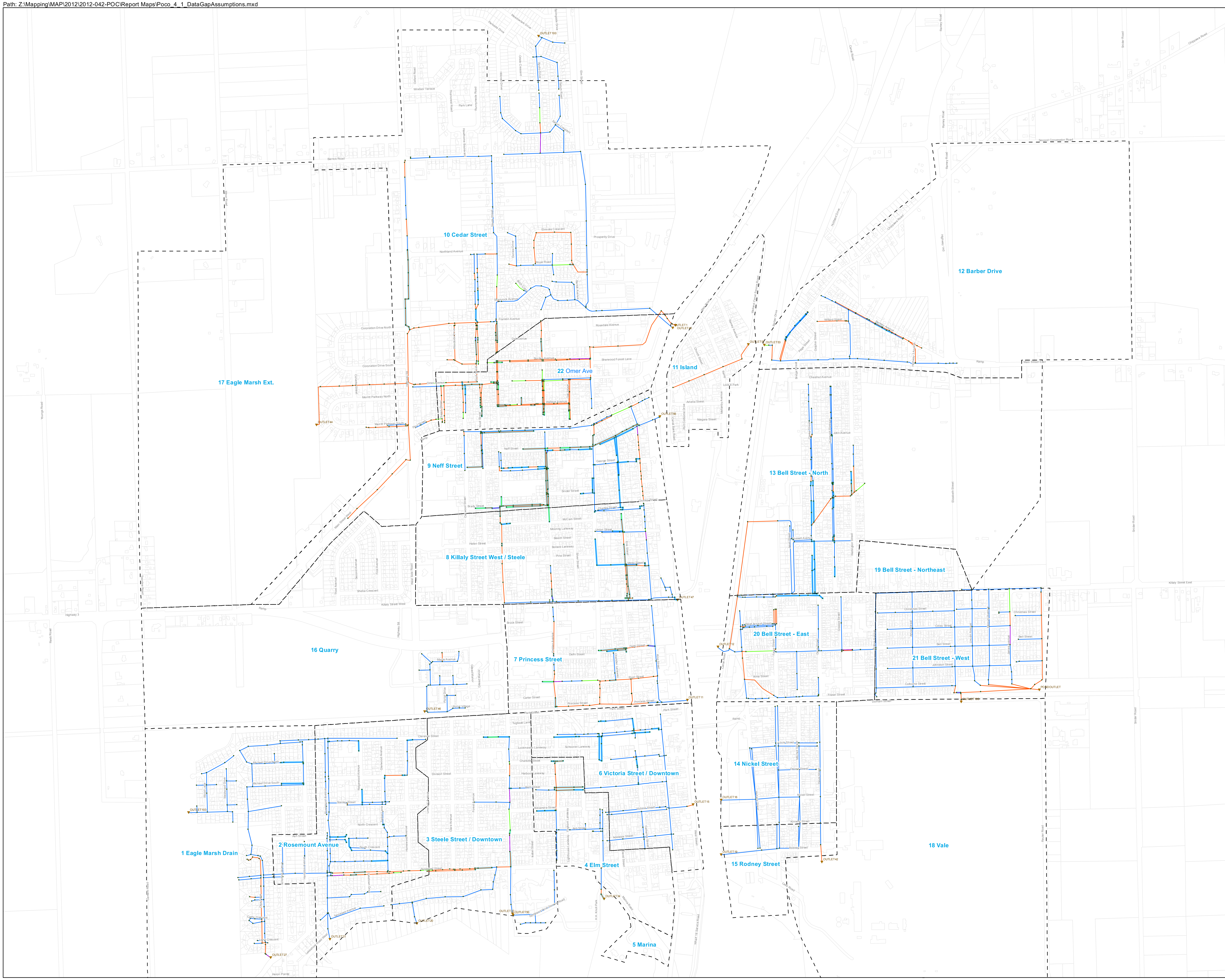

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Legend

- Storm Drainage Area
- Parcel
- Outfall
- Junction
- Original Conduit Invert
- Both Inverts Assumed
- Downstream Invert Assumed
- Upstream Invert Assumed
- Assumed Diameter

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

Project ID: **2012-042-POC**

Date: **April 2014**

Figure 3-1
(GeoAdvice Figure 4.1)
Data Gap Assumptions

Port Colborne

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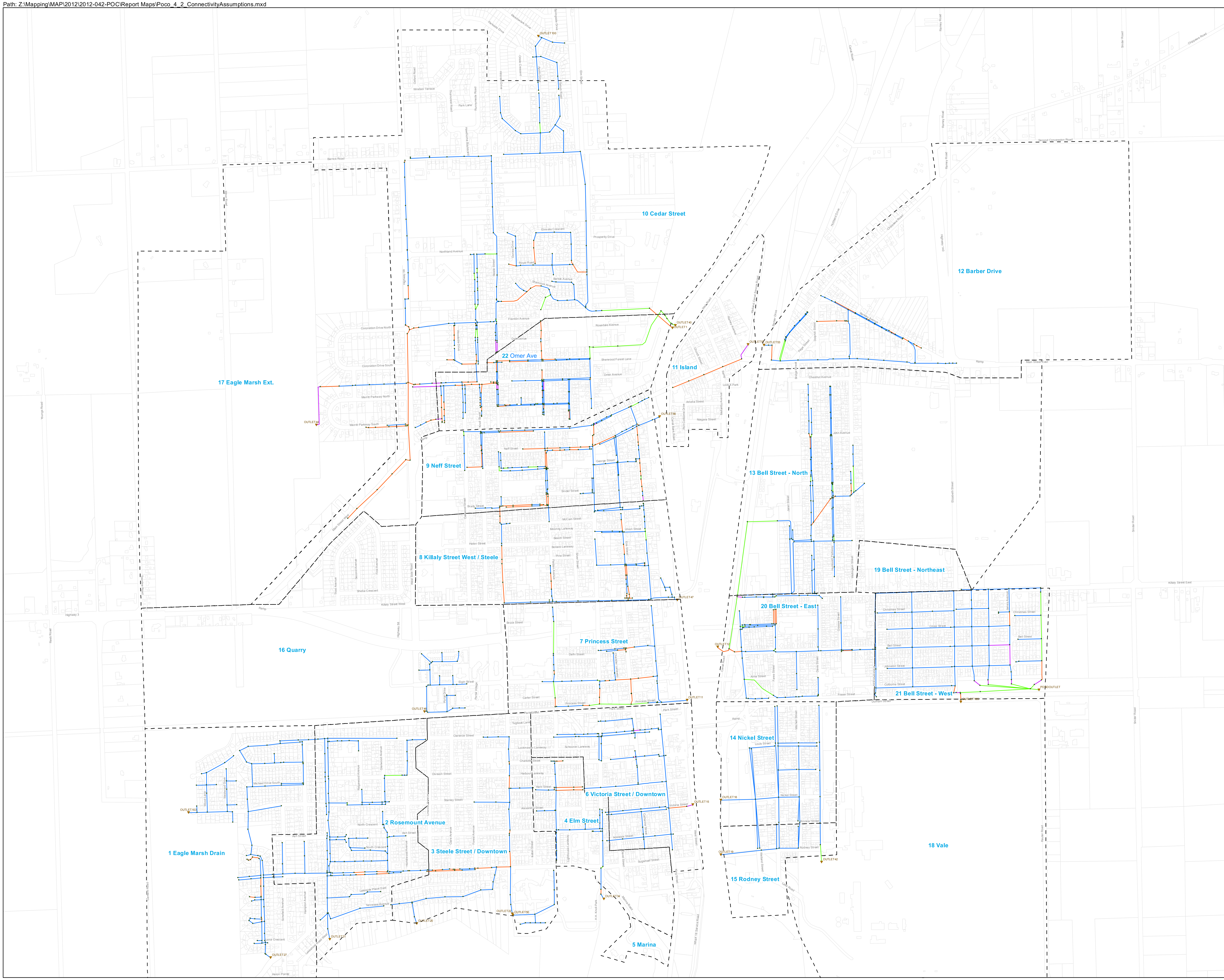

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Legend

- Storm Drainage Area
- Parcel
- Outfall
- Junction
- Original Conduit Connection
- Existing Conduit, New Connection
- Existing Conduit, Reversed Direction
- New Conduit

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

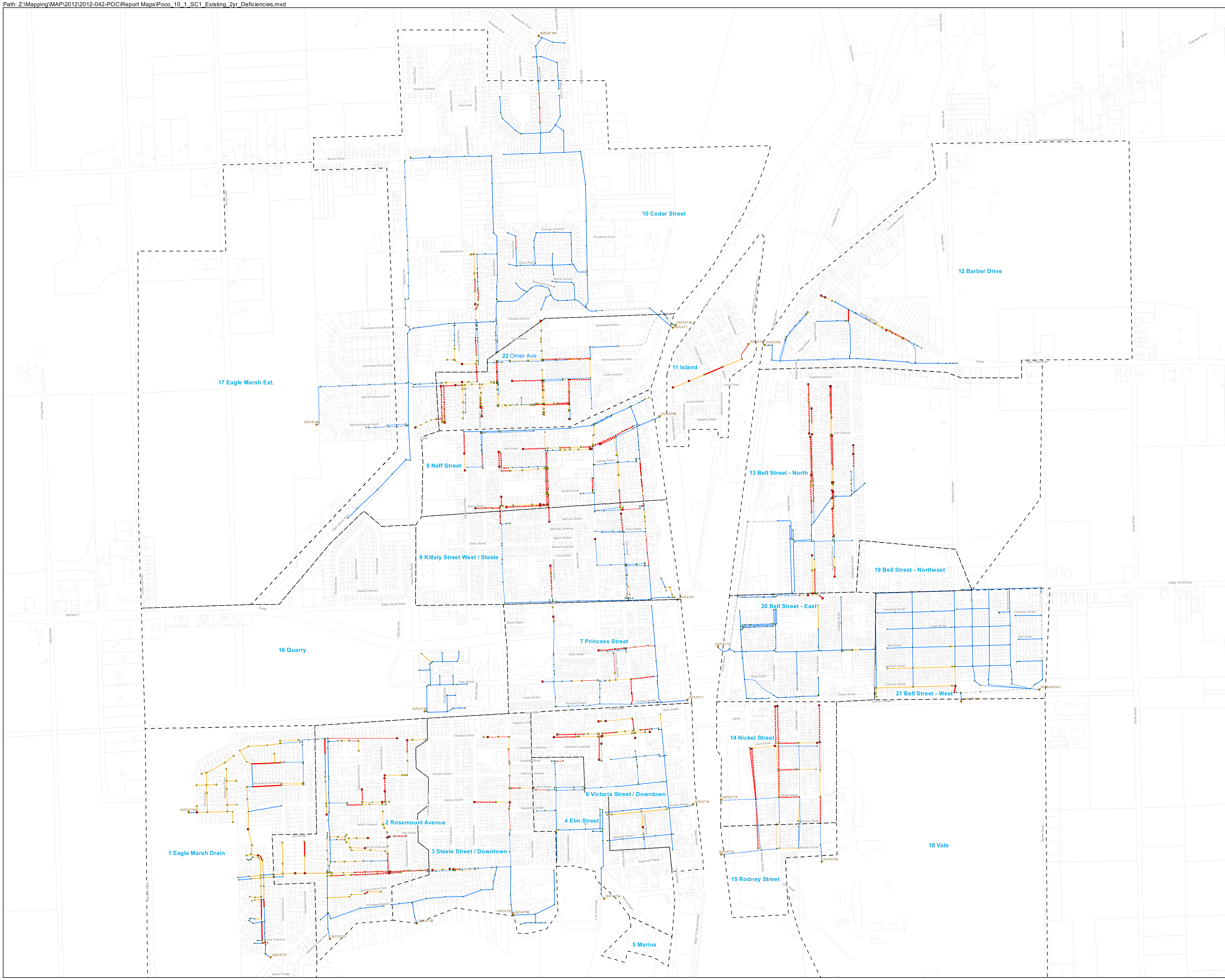
Project ID: **2012-042-POC**

Date: **April 2014**

Figure 3-2
(GeoAdvice Figure 4.2)
Connectivity Assumptions

Port Colborne

Path: Z:\Mapping\MAP\2012\2012-042-POC\Report Maps\Poco_10_1_SC1_Existing_2yr_Deficiencies.mxd



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Legend

- Storm Drainage Area
- Parcel
- Outfall

Junction HGL

- HGL > GE-300mm
- HGL > GE
- HGL < GE-300mm
- Ditch

Pipe Capacity

- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- d/D > 1 and q/Q > 1 (<15min surch.)
- d/D > 1 and q/Q > 1 (>15min surch.)

Frontage Tile (undesign) Capacity

- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- d/D > 1 and q/Q > 1 (<15min surch.)
- d/D > 1 and q/Q > 1 (>15min surch.)

N W E S

0 120 240 480 m

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

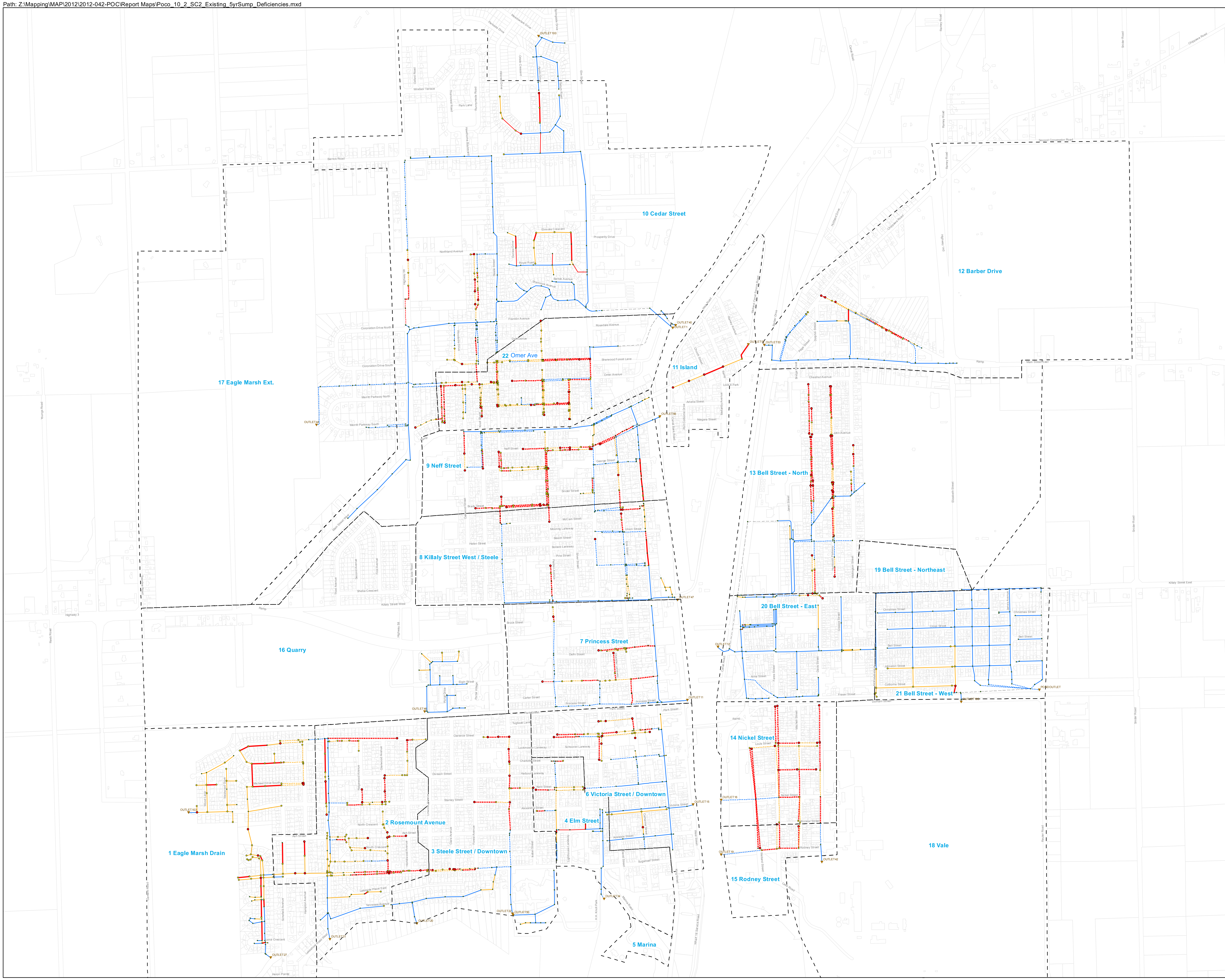
Project ID: **2012-042-POC**

Date: **April 2014**

Figure 4-1
(GeoAdvice Figure 10.1)
Scenario 1 Existing 2YR Deficiencies

Port Colborne

Path: Z:\Mapping\MAP\2012\2012-042-POC\Report Maps\Poco_10_2_SC2_Existing_5yrSump_Deficiencies.mxd



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Legend

- Storm Drainage Area
- Parcel
- Outfall

Junction HGL

- HGL > GE-300mm
- HGL > GE
- HGL < GE-300mm
- Ditch

Pipe Capacity

- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- d/D > 1 and q/Q > 1 (<15min surch.)
- d/D > 1 and q/Q > 1 (>15min surch.)

Frontage Tile (undesign) Capacity

- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- d/D > 1 and q/Q > 1 (<15min surch.)
- d/D > 1 and q/Q > 1 (>15min surch.)

N W E S

0 120 240 480 m

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

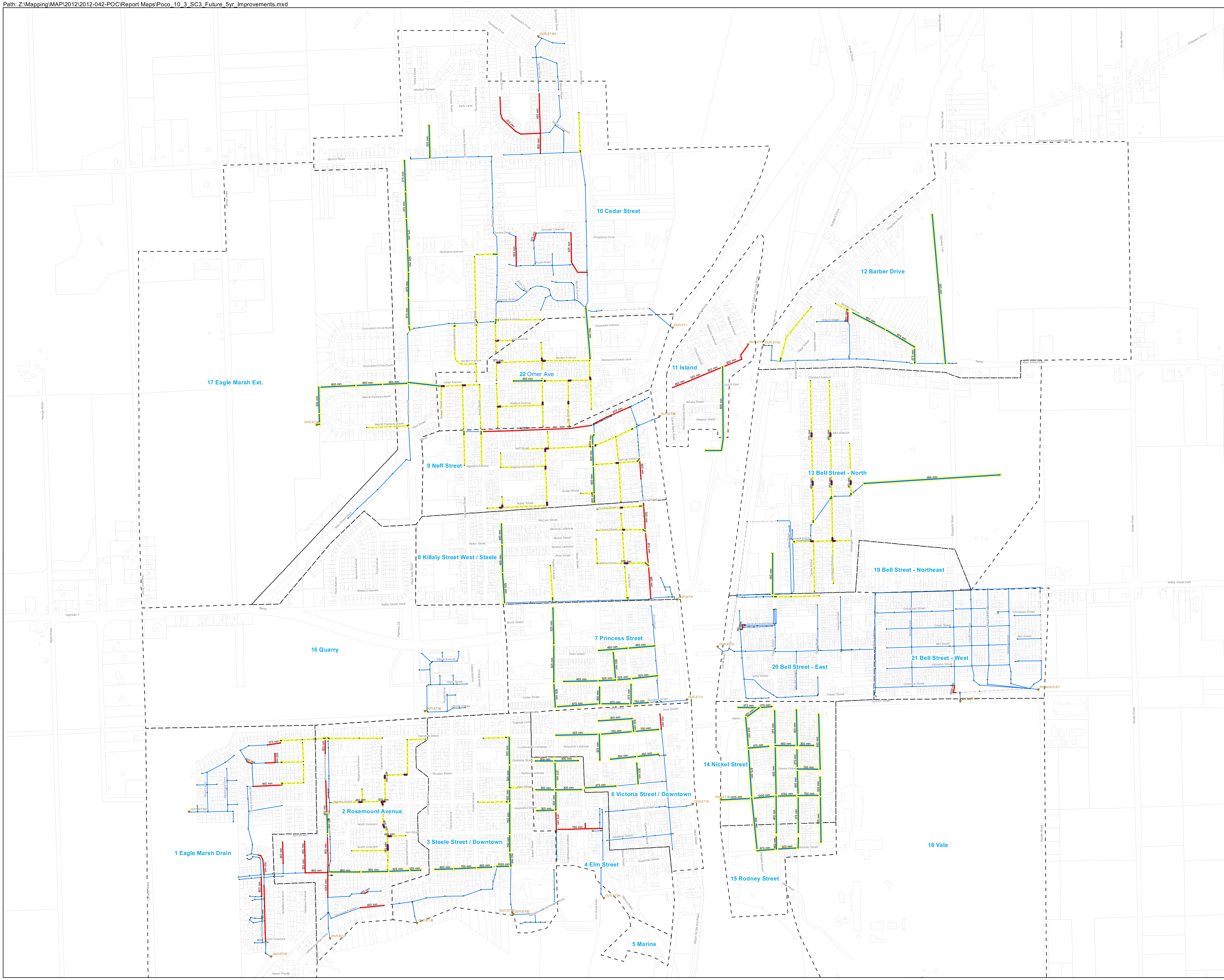
Project ID: **2012-042-POC**

Date: **April 2014**

Figure 4-2
(GeoAdvice Figure 10.2)
Scenario 2 Existing 5YR Deficiencies

Port Colborne

Path: Z:\Mapping\MAP\2012\2012-042-POC\Report Maps\Poco_10_3_SC3_Future_5yr_Improvements.mxd



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Legend

- Outfall
- Junction
- New Culvert
- New Pipe
- New Ditch
- Upgrade Pipe
- Existing Culvert
- Existing Pipe
- Existing Ditch
- Storm Drainage Area
- Parcel

N W E S

0 120 240 480 m

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

Project ID: **2012-042-POC**

Date: **April 2014**

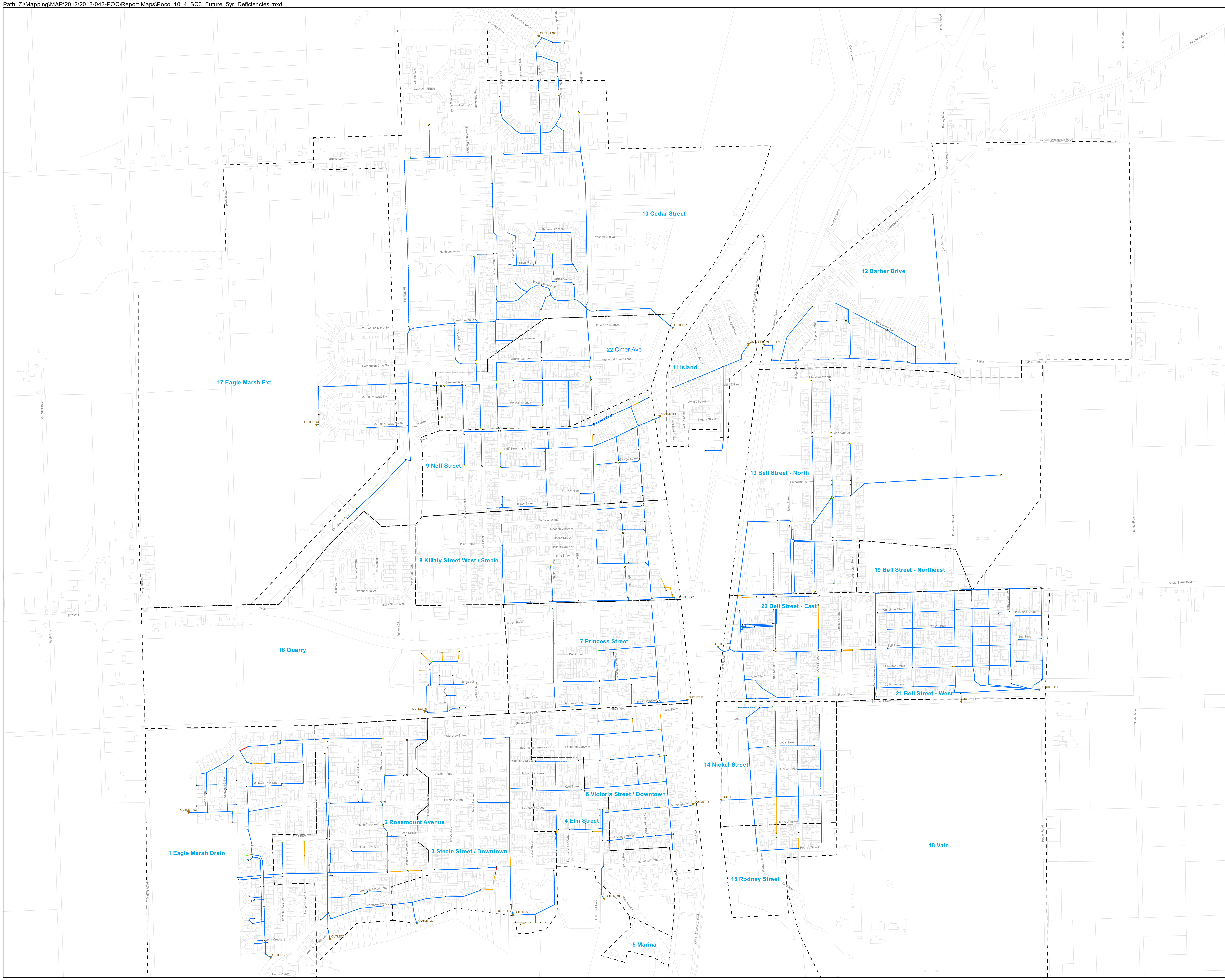
Figure 6-1

(GeoAdvice Figure 10.3)

Scenario 3 Future 5YR Proposed Improvements

Port Colborne

Path: Z:\Mapping\MAP\2012\2012-042-POC\Report Maps\Poco_10_4_SC3_Future_5yr_Deficiencies.mxd



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Legend

conduit - DESIGN and SEMI

Existing Pipe Capacity
- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- Storm Drainage Area
- Parcel
- Outfall
- Ditch

Junction HGL
- HGL > GE-300mm
- HGL > GE
- HGL < GE-300mm

Existing Pipe Capacity
- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- d/D > 1 and q/Q > 1 (<15min surch.)
- d/D > 1 and q/Q > 1 (>15min surch.)

Future Conduit Capacity
- d/D < 1 and q/Q < 1
- d/D > 1 and q/Q < 1
- d/D > 1 and q/Q > 1 (<15min surch.)
- d/D > 1 and q/Q > 1 (>15min surch.)

N E S W

0 120 240 480 m

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

Project ID: **2012-042-POC**

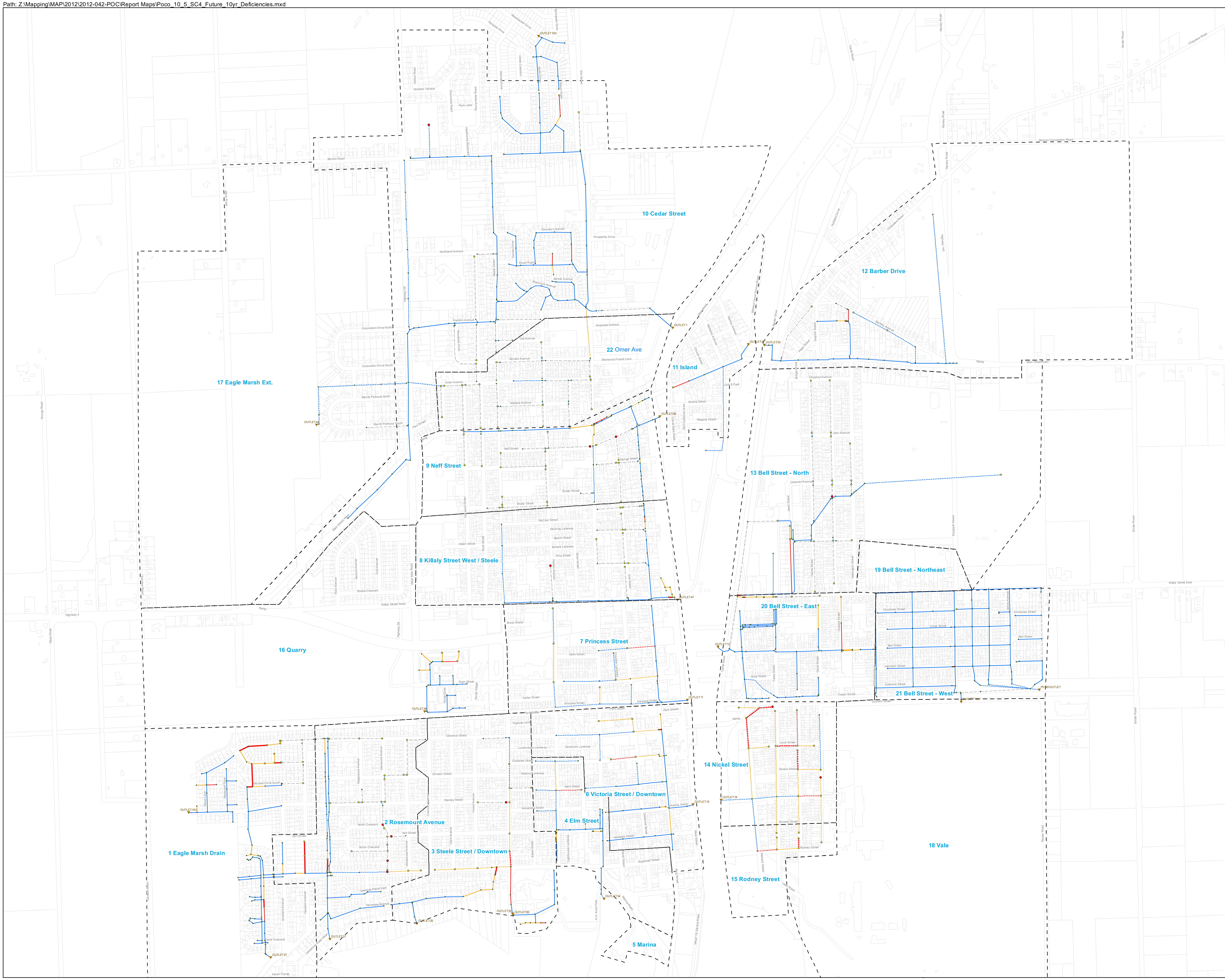
Date: **April 2014**

Figure 6-2
(GeoAdvice Figure 10.4)

Scenario 3 Future 5YR Deficiencies (With Improvements)

Port Colborne

Path: Z:\Mapping\MAP\2012\2012-042-POC\Report Maps\Poco_10_5_SC4_Future_10yr_Deficiencies.mxd



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Legend

Storm Drainage Area
Parcel
Outfall
Ditch

Junction HGL

HGL > GE-300mm
HGL > GE
HGL < GE-300mm

Existing Pipe Capacity

d/D < 1 and q/Q < 1
d/D > 1 and q/Q < 1
d/D > 1 and q/Q > 1 (<15min surch.)
d/D > 1 and q/Q > 1 (>15min surch.)

Future Conduit Capacity

d/D < 1 and q/Q < 1
d/D > 1 and q/Q < 1
d/D > 1 and q/Q > 1 (<15min surch.)
d/D > 1 and q/Q > 1 (>15min surch.)

N
W E
S

0 120 240 480
m

Project:

Storm Sewer System Infrastructure Needs Study

Client:

City of Port Colborne, ON

Project ID: **2012-042-POC**

Date: **April 2014**

Figure 6-3
(GeoAdvice Figure 10.5)
Scenario 4 Future 10YR Deficiencies (With Improvements)
Port Colborne