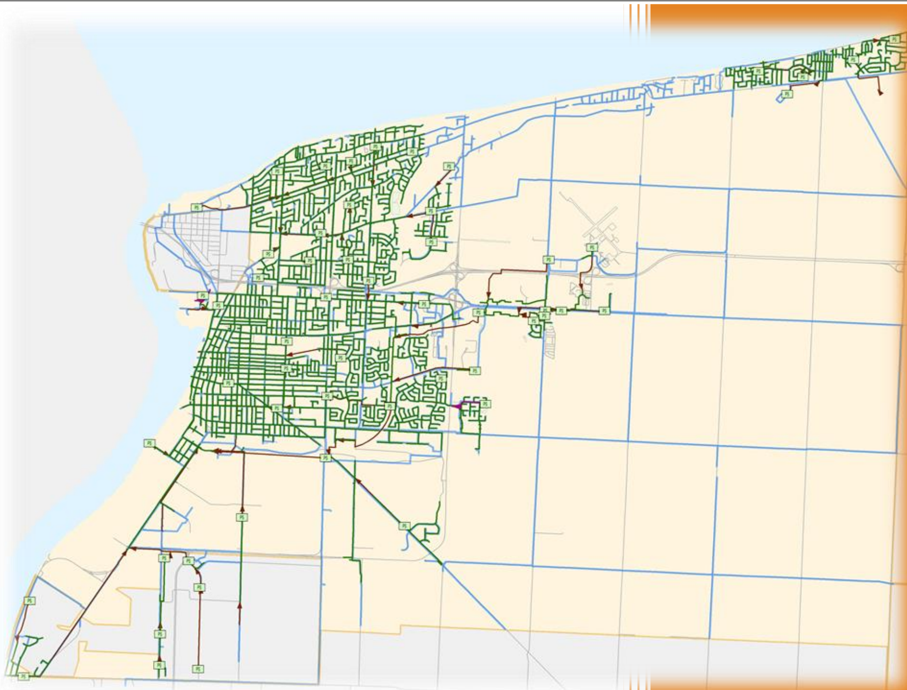
**THE CORPORATION
OF THE
CITY OF SARNIA**

Asset Management Plan



CORE INFRASTRUCTURE SERVICES

This plan was

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and

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Prepared by the

Engineering and Finance

Departments

The Corporation

of

The City of Sarnia

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1. Executive Summary

This 'Asset Management Plan' document has been developed for the core infrastructure assets of the City of Sarnia, which include water, wastewater, roads, and bridges. The plan is intended to provide a comprehensive reference for renewing, operating, maintaining, building, replacing, and disposing of the City's core infrastructure assets. The plan is based on the guidelines provided in the Province of Ontario Ministry of Infrastructure's Building Together Guide for Municipal Asset Management Plans.

The asset management planning process is driving a change in philosophy in regards to capital improvement projects: The old approach of "worst first" is being replaced with a more proactive approach focused on the rehabilitation within windows of opportunity and combined reconstruction projects.

This plan reflects on the current and desired condition of core infrastructure assets, levels of service, optimal asset management, and financial strategies, all based on the infrastructure information and data currently available for the City of Sarnia's core assets.

The City's data collection programs and data updating processes are ongoing, and as such, the plan will be updated over time as more data regarding condition, capacity, expansion, and risks become available through ongoing data collection, modelling, and master planning.

The replacement costs, current needs, and rehabilitation needs based on windows of opportunity for the core infrastructure assets of the City are summarized in Tables 1, 2, and 3, respectively, and illustrated in Figures 1 and 2. Table 4 identifies the top 6 priority projects for the City of Sarnia across all asset types.

Table 1 Total Replacement Cost of Core Infrastructure Assets

Asset Type	Total Length/Quantity	Replacement Cost
Roads	921 km *	$701,313,061
Watermains	502 km	$396,205,716
Sanitary Sewer	351 km	$317,215,187
Storm Sewer	321 km	$380,989,591
Forcemains	46 km	$39,592,639
Pump Stations	57	$52,663,000
Wastewater Treatment Facilities	3	$139,057,140
Bridges	31	$64,675,000
Shoreline Protection	11 km	$111,483,750
	Total	**$2,203,195,084**

*Denotes lane length

Figure 1 Percentage of Total Replacement Cost of the Core Infrastructure Assets

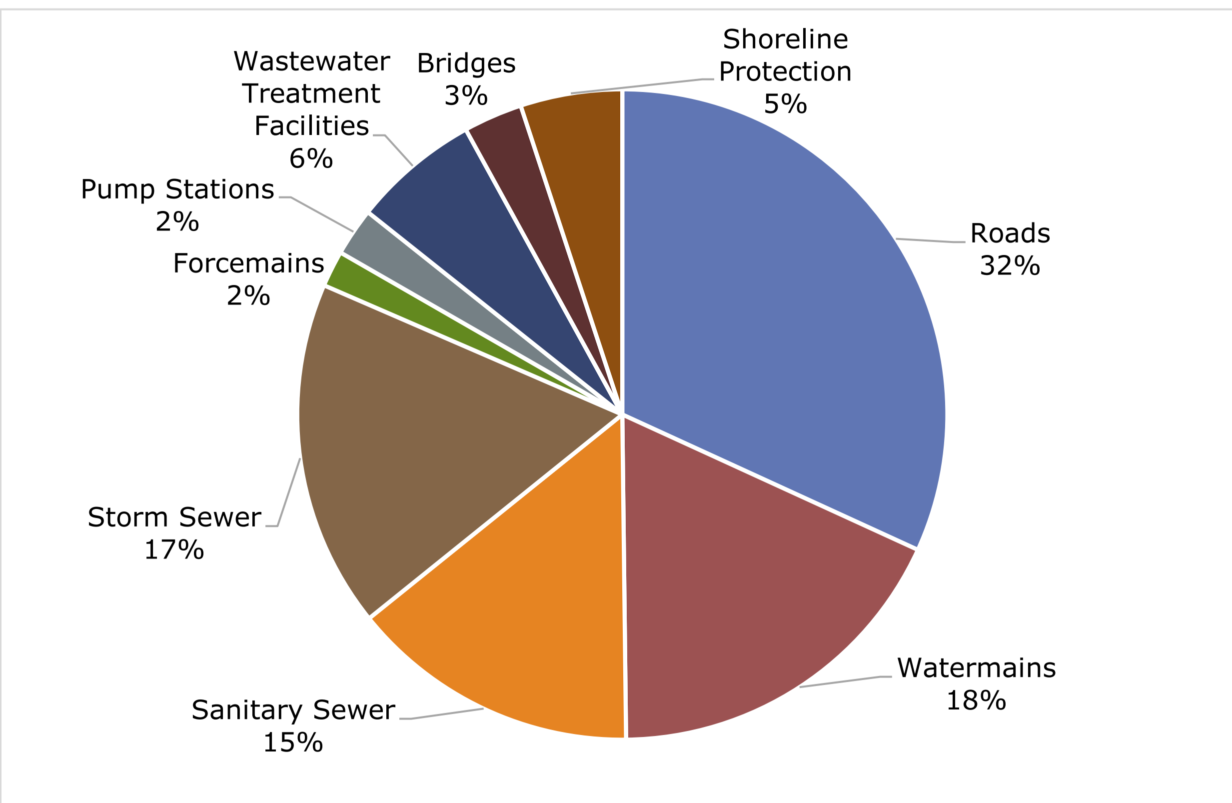


Table 2 Current Need of all Core Infrastructure Assets

Asset Type	% Of Total Asset Currently In Need	Estimated Current Need	Length Of Asset In Need
Roads	7%	$46,350,705	68 km*
Watermains	22%	$78,600,778	110 km
Sanitary Sewer	24%	$75,840,526	84 km
Storm Sewer	24%	$101,345,457	76 km
Forcemains	15%	$6,330,239	7 km
Pump Stations	0%	$25,453,249	-
Wastewater Treatment Facilities	0%	$8,300,000	-
Bridges	35%	$6,945,000	-
Shoreline Protection	15%	$17,118,150	3 km
	Total Current Need	**$366,284,104**	

*Denotes lane length

Figure 2 Percentage of Total Current Need of Core Infrastructure

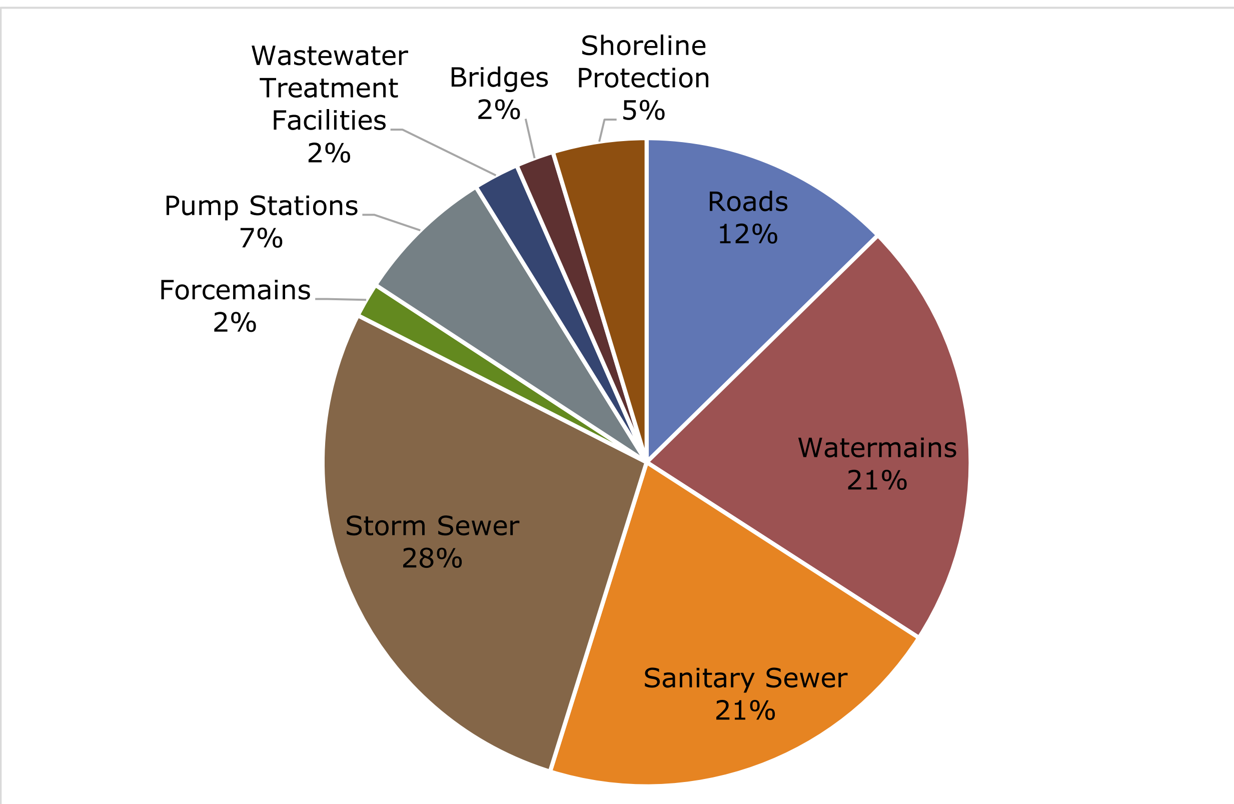


Table 3 Rehabilitation Need Based on Window of Opportunity

Asset Type	Length	% Rehabilitation Need	Estimated Cost
Roads	411 km	44.6%	$410,929
Water Distribution System	36.9 km	9.4%	$9,159,023
Sanitary & Combined Sewers	80.3 km	20.3%	$25,688,013
Storm Sewers	70.9 km	22.6 %	$45,372,702
		Total	**$80,630,667**

Table 4 Top Identified Priority Projects across Asset Type

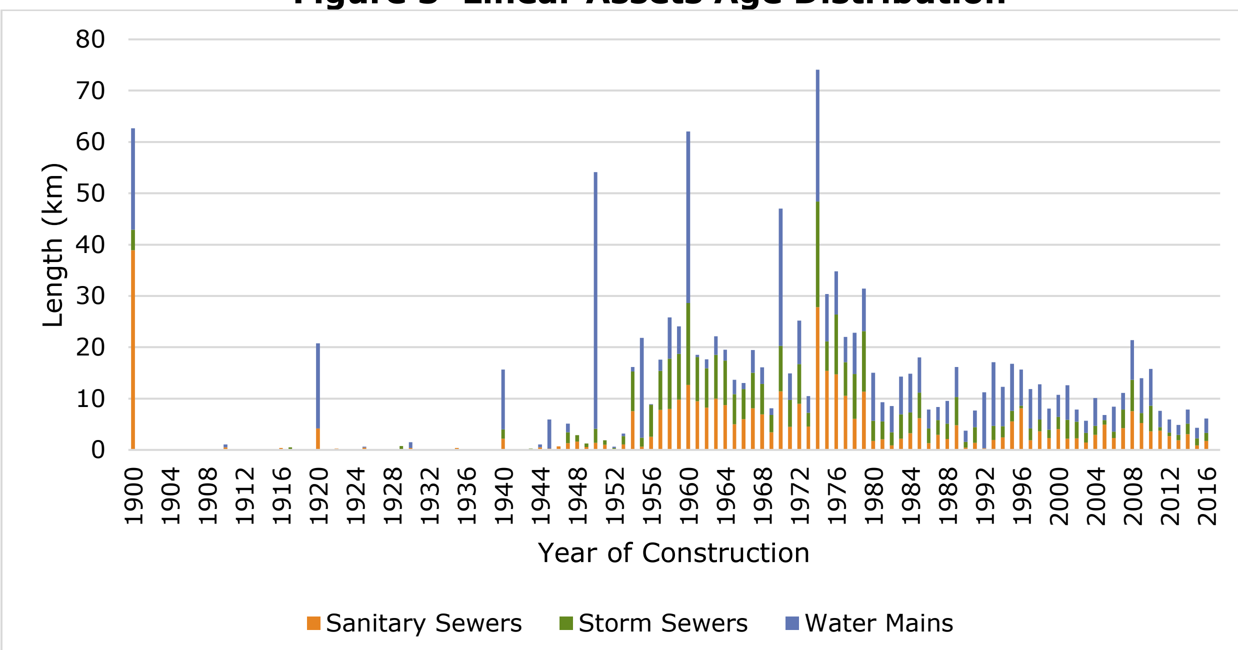
Rank	Project	Consequence Of Failure (0 to 10)	Potential Of Failure (0 to 10)	Overall Index (Consequence x Potential)	Comments	Estimated Cost
1	Water Only Project	6.66	9.21	61.34	Copland Road, Plank Road, Rosedale Avenue, Oldham Place, & Exmouth Street	$45,300,000
2	Road Only Project	6.23	8.98	55.95	Plank Road, Waterworks, Blackwell & Various Local	$12,725,000
3	Major Bridges & Culverts	8.02	6.12	49.08	Rehabilitation	$2,875,000
4	Sewer Rehabilitation Project - St. Clair Parkway & Various Locations	5.31	8.92	47.37	Rehabilitation/ Relining	$1,107,000
5	Road, Water, & Sewer Project/ Combined Sewer Project	4.91	8.40	41.24	Exmouth Street & Devine Street Areas	$34,450,000
6	Shoreline Protection	4.88	5.91	28.84	Erosion Control	$7,775,000

2. Introduction

2.1 The City and Infrastructure Assets

The City of Sarnia is located on the south shore of Lake Huron at the headwaters of the St. Clair River. The City's current population is approximately 72,000 people. Most of the City's infrastructures assets, which were installed and paid for during previous economic boom periods in the 1950s, 1960s, and 1970s, are now approaching the end of their design life. As a result, the City is faced with ever increasing infrastructure needs and limited financial resources. Figure 3 shows the age distribution of the City's linear infrastructure assets.

Figure 3 Linear Assets Age Distribution



In 2005, the City of Sarnia hired Dillon Consulting Limited to conduct an initial inventory assessment of the City's core linear infrastructure assets and to identify the associated capital needs: The City's core linear infrastructure assets include watermains, roads, sanitary sewers, storm sewers, and combined sewers. As a result of the study, the City of Sarnia has initiated a number of data collection programs, and has implemented a GIS system to catalogue and manage the City's infrastructure assets.

A complete road condition assessment was completed by the City through IMS Infrastructure Management Services in 2012. The City has also completed a master plan study, which includes system modelling for water distribution and sanitary sewer collection systems by Stantec Consulting Limited.

2.2 Core Infrastructure Services

Core municipal infrastructure services (referred to as core infrastructure assets in previous sections) as defined by the Province of Ontario include water, sewer, drainage, and road networks. As per the recommendations of the 'Building Together Guide for Municipal Asset Management Plans', maintaining roads, bridges, water, wastewater and social housing assets should be a top priority for municipalities.

The City of Sarnia is a lower-tier municipality within the County of Lambton. The City's social housing services are managed by the County of Lambton, and Water treatment and supply services are managed by the Lambton Area Water Supply System (LAWSS).

As a starting point, the following core infrastructure assets have been included in this asset management plan:

i. Water distribution system,
ii. Wastewater collection and wastewater treatment systems,
iii. Storm sewer system,
iv. Pumping stations and forcemains, and
v. Roads and bridges

2.3 Objectives of the Asset Management Plan

In September 2012, the City formed an asset management committee consisting of City staff representatives from the Engineering and Finance Departments, to put together this 'Asset Management Plan' (AMP) based on the 'Building Together Guide for Municipal Asset Management Plans'. The engineering and finance department heads chair the committee along with a number of sub-working groups from both departments.

The overall objectives of the AMP are as follows:

i. To provide a comprehensive reference for council, managers, and City staff for operating, maintaining, building, rehabilitating, replacing, and disposing of the City's assets;
ii. To quantify the current and desired system conditions, levels of service, and safety;
iii. To provide a basis for recommendations for optimal asset management and financial strategies;
iv. To identify strategic priorities in order to optimize decisions; and
v. To maximize benefits, manage risks, and provide satisfactory levels of service.

2.4 Guiding Principles

The guiding principles adopted in the development of this AMP are consistent with the goals set out in the City's 'Official Plan' and the City's 'Integrated Community Sustainability Plan'.

As per City's 'Draft Official Plan':

> "Infrastructure tends to be capital intensive and carries high fixed costs that do not go down with reductions in population density. The City's Official Plan promotes the optimal use and function of existing infrastructure in ways that reduce current costs and minimize future obligations, while still preserving opportunities for future development."

The Sarnia City Council adopted the 'Integrated Community Sustainability Plan' (ICSP), created by the City of Sarnia, in March 2013. This plan is aimed at helping the City build a socially, economically, culturally, and environmentally sustainable community.

As per the Sarnia ICSP:

> "The Sarnia Integrated Community Sustainability Plan is a reference and resource document that will be used by those planning and developing sustainable community projects to ensure that the targets, goals, and outcomes for a sustainable community can be achieved."

The guiding principles established for the AMP are summarized as follows:

i. Maintaining the integrity of the City's infrastructure and recognizing infrastructure life cycle costs;
ii. Mitigating combined sewer overflows and reducing basement flooding;
iii. Maintaining adequate fire flows and pressures in the City's water distribution system;
iv. Supplying safe drinking water and protecting the receiving water body quality;
v. Maintaining or exceeding the current service levels to residents and industry;
vi. Encouraging and implementing measures and activities that reduce resource consumption, waste, and pollution; and
vii. Ensuring that, when it is feasible, those who benefit from municipal infrastructure pay for the services they are provided.

2.5 GIS and Data Management

The City has an extensive inventory of core infrastructure asset attributes and conditions recorded in the Sarnia Geographic Information System (GIS). As part of the City's going data collection programs, the Sarnia GIS database is continuously being updated.

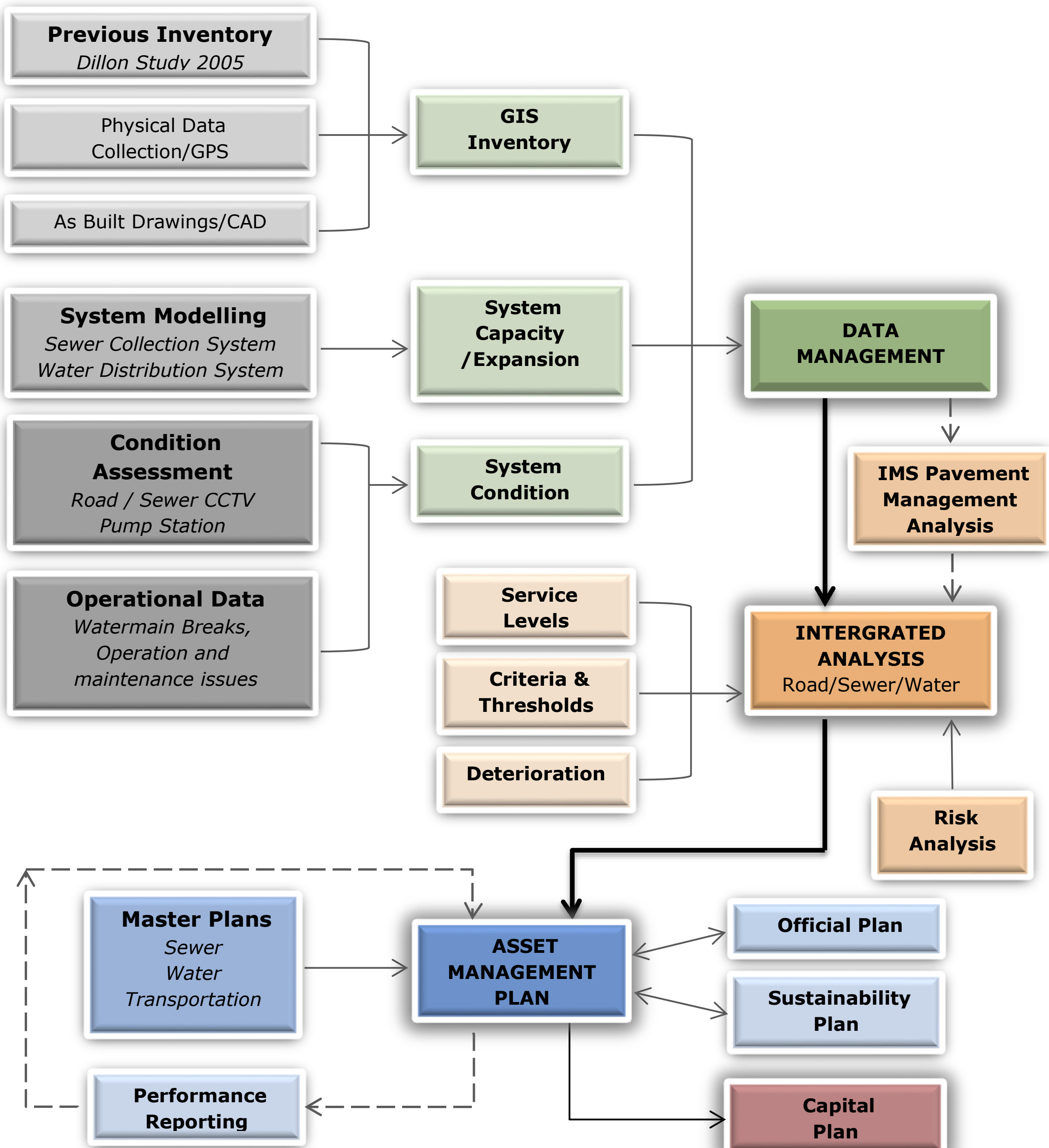
In July 2005, the City retained Dillon Consulting Limited to aid in the implementation of an asset management system (AMS). The AMS included the creation of a linear infrastructure asset inventory and the identification of their associated needs of capital needs. Due to budget limitations and data availability constraints, a sampling approach was adopted to carry out the AMS assessments.

The City's AMS progressed as follows:

i. Under the direction of the City, Dillion Consulting Limited completed an initial inventory assessment and identification of capital needs for linear infrastructure assets in 2005.
ii. The City acquired the Autodesk Map Guide "Mi-Town GIS Application" in 2006 and upgraded to the ESRI Enterprise Geo Cortex GIS system in 2010.
iii. The City initiated data collection programs, which included hydrant flushing, water valve turning, and sewer flushing programs in 2004.
iv. IMS Infrastructure Management Services completed a road condition assessment in 2012.
v. A sewer condition assessment is being completed in phases and is currently ongoing. The sewer condition assessment is a challenging task for the City as there is uncertainty as to the extent of sewer cleaning required.
vi. In 2012, Stantec Consulting Limited completed a sewer collection system model and a sewer master plan study for the City of Sarnia.
vii. In 2013, Stantec Consulting Limited also completed a water distribution system model and a water distribution system master plan for the City.
viii. R.V. Anderson Associates completed a pumping station condition assessment for the City in 2009.
ix. The City bridges are inspected every two years as per provincial regulation. The last inspection of City bridges was completed in August 2018.
x. The infrastructure asset data in the GIS System is being updated on a regular basis.

The majority of the information required for this AMP was obtained from a number of sources, which include as-built construction drawings, reports, GIS inventories, GIS maps, capacity assessments, condition assessments, infrastructure master plans, etc. All of this information was first integrated into the Sarnia GIS system, and then analysed and assessed using the Integrated Analysis Engine (IAE). Figure 4 serves to illustrate the City's asset management process.

Figure 4 The City of Sarnia Asset Management Process



2.6 General

The City's current capital project priorities are focused mainly on the following issues:

i. Combined sewer separation;
ii. Sewer and watermain breaks and outflows;
iii. Known system capacity and back-up issues;
iv. Operational and maintenance issues;
v. Flooding complaints; and
vi. Design and construction constraints

All of these issues are discussed in various capital project meetings and, based on these meetings and the findings of this AMP, capital projects are prioritized and planned accordingly.

An integrated spreadsheet program was developed by the AMP Committee to aid and facilitate the prioritization of capital projects. The program serves to analyse various factors across each of the linear infrastructure asset types and to generate priority lists of projects, replacement costs, and capital improvement plans based on the established service levels.

The City has been actively exploring opportunities to consolidate and share services with other municipalities in order to improve service levels and reduce user costs. Recently, the City of Sarnia has entered into two separate agreements with the Township of St. Clair to connect our water distribution systems at two different locations along the southern boundary of the City. These two connections will improve water pressures, redundancy, and water securities within the Sarnia water distribution system.

Since the sewer condition assessments are still in progress, for the purposes of this revision of the AMP, the condition assessments of the sewer system have been primarily based on the accepted age of the pipes and their material-based deterioration curves. Once the actual condition assessments of all infrastructure assets are complete, the plan will be updated to fully reflect actual conditions rather than those approximated by deterioration curves.

This AMP currently includes short term and long-term strategies for the rehabilitation, reconstruction, and construction of the City's roads, bridges, water network, and wastewater systems infrastructure. This plan is a living document and will be updated on a regular basis as more information becomes available.

3. State of Local infrastructure

3.1 Existing Infrastructure network

The City of Sarnia currently manages approximately 439 kilometers of roads, 336 kilometers of sanitary and combined sewers, 293 kilometers of storm sewers, 53 sanitary pump stations, 4 storm water pump stations, 53 kilometers of sanitary and storm forcemains, 496 kilometers of watermains, 2 wastewater treatment facilities, and 32 bridges and culverts.

Most of the City's linear infrastructure assets were built from the 1950s through to the 1980s. For some infrastructure assets, particularly those constructed between 1920 and 1950, no as-built drawings are available. In such cases, construction years for the affected assets were assumed based on material-based deterioration curves.

Figure 5 and Table 5 detail the age distribution of all the types of existing linear infrastructure assets within the City.

Figure 5 Age Distribution of Existing Networks

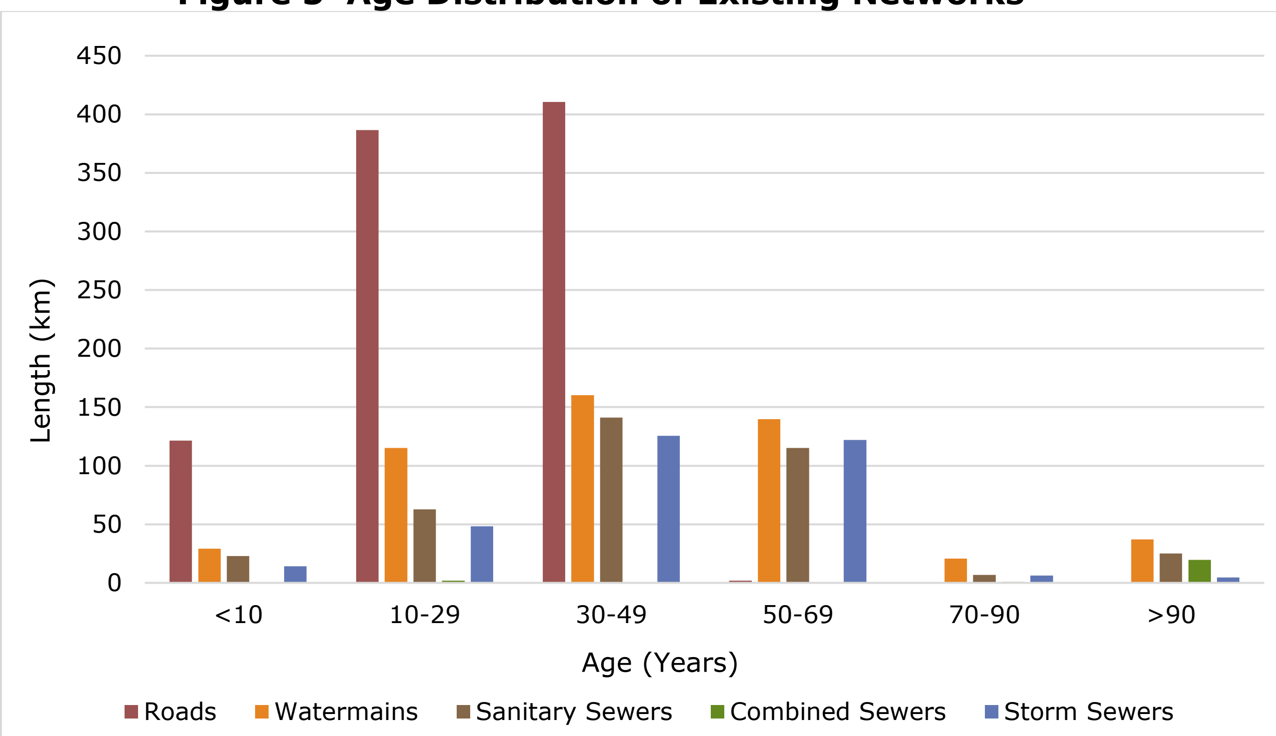


Table 5 Percent Age Distribution of Existing Networks (% of Total Number of Kilometres in Network)

Age (Years)	Roads	Watermains	Sanitary Sewers	Combined Sewers	Storm Sewers
<10	13%	6%	6%	0%	4%
10-29	42%	23%	17%	8%	15%
30-49	45%	32%	38%	1%	39%
50-69	0%	28%	31%	2%	38%
70-90	0%	4%	2%	3%	2%
>90	0%	7%	7%	86%	1%

3.1.1 Replacement Cost and Valuation

Tables 6 and 7 summarize the current replacement cost and the financial accounting valuation of the City's core infrastructure assets. The financial valuation is based on historical costs and depreciation assumptions. The replacement cost is based on current unit rates, and will be updated annually.

Table 6 Current Replacement Cost of Core Infrastructures

Asset Type	Total Length/Quantity	Replacement Cost
Roads	921 km*	$701,313,061
Watermains	502 km	$396,205,716
Sanitary Sewer	351 km	$317,215,187
Storm Sewer	321 km	$380,989,591
Forcemains	46 km	$39,592,639
Pump Stations	57	$52,663,000
Wastewater Treatment Facilities	3	$139,057,140
Bridges	31	$64,675,000
Shoreline	11 km	$111,483,750
	Total	**$2,203,195,084**

*Denotes lane length

Table 7 Financial Valuation of City's Core Infrastructures

Asset Type	Total Original Cost	Current Accumulated Amortization	Net Book Value
Roads	$308,771,534.80	$93,540,289.94	$215,231,244.86
Bridges & Culverts	$9,559,800.83	$4,129,951.02	$5,429,849.81
Urban Storm Water Collection	$79,449,543.91	$32,689,689.63	$46,759,854.28
Wastewater Collection	$56,621,631.94	$21,990,891.48	$34,630,740.46
Wastewater Treatment	$69,544,331.34	$29,786,864.85	$39,757,466.49
Water Distribution	$74,124,749.03	$29,584,073.39	$44,540,675.64
Totals	**$598,071,591.85**	**$211,721,760.31**	**$386,349,831.54**

3.2 Methodology

3.2.1 Data Collection and Data Management

The City recognizes that data collection and data management is one of the most critical aspects of the asset management planning process. The accuracy, reliability, and consistency of the data are all extremely important in developing a sound AMP.

Since the completion of the City's asset management system in 2005 by Dillon Consulting Limited, the City has initiated several data collection programs and is continually working to refine data flow protocols. The majority of the City's infrastructure data is stored and continuously updated in the Sarnia GIS database.

3.2.2 Network Segmentation

Network segmentation and the establishment of spatial relationships between infrastructure asset types is a critical step in the asset management process. In order to complete this step in the process, City staff assigned separate unique identifiers to each section of the linear infrastructure: Each block of the road was segmented from intersection to intersection and was assigned a unique identifier. The watermain network was segmented and assigned unique identifiers based on the location of main line valves, hydrant laterals, and connection tees. Similarly, the sewer network was segmented and assigned identifiers based on the location of manholes, main connections, and pipe size changes. Figure 6 and Table 8 illustrate this process for the three asset types discussed.

Figure 6 Sample Integrated Segment for Linear Assets

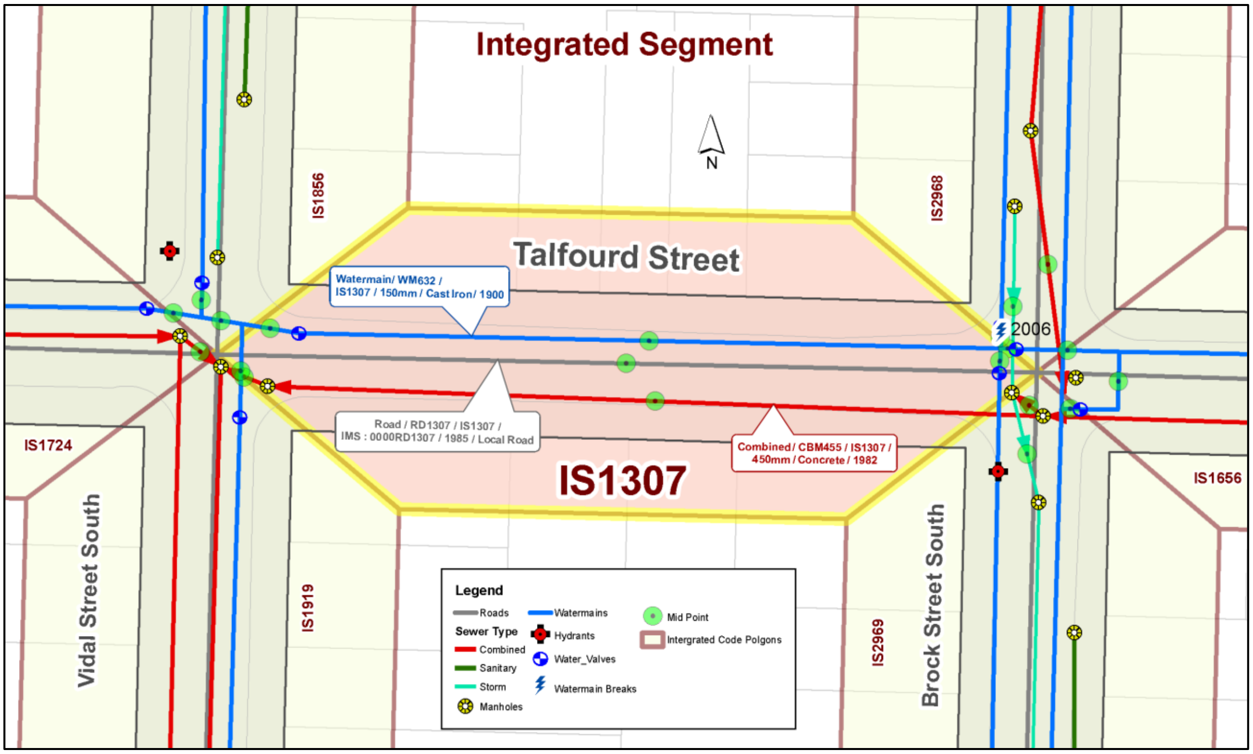


Table 8 Sample Data Attributed Linear Assets

Road		**Watermain**		**Sewer**	
Shape	Polyline	Shape	Polyline	Shape	Polyline
OBJECTID	1307	OBJECTID	632	OBJECTID	179
Asset_NO	1307	Type	Watermain	Type	Combined
RD_ASSETID	**RD1307**	Code	WM	Code	CBM
IntegrCode	**IS1307**	Asset_NO	632	Asset_NO	455
Block	200	Asset_ID	**WM632**	Asset_ID	**CBM455**
SubBlkArea	A	IntegrCode	**IS1307**	IntegrCode	**IS1307**
STREETNAME	Talfourd Street	Block	200	Block	200
FromStreet	Brock Street South	SubBlkArea	A	SubBlkArea	A
ToStreet	Vidal Street South	Street	Talfourd Street	Street	Talfourd Street
JURISDICTN	City of Sarnia	FromStreet	Brock Street South	FromStreet	Brock Street South
MUN_LEFT	Sarnia	ToStreet	Vidal Street South	ToStreet	Vidal Street South
MUN_RIGHT	Sarnia	Owner	Sarnia	Owner	Sarnia
LEFTFROM	168	Mun_Area	Urban	Mun_Area	Urban
LEFTTO	190	Material	Cast Iron	Sewer_Area	Devine Street
RIGHTFROM	167	Diam_m	150	Material	Asbestos Cement
RIGHTTO	189	DiammLabel	150mm	Diam_m	450
STREET_LBL	Talfourd St	Diam_Imper	6	DiammLabel	450mm
BASE_NAME	Talfourd	DiamImpLab	6"	Diam_Imper	18
STTYPE	Street	Depth	1.5	DiamImpLab	18"
SUFFIX_TYP	St	INST_YEAR	1900	UpStreamIn	179.71
SUB_AREA	Urban	Asset_Date	07/01/1900	DownStream	179.09
DIRECTION	BOTH	GENCOMMENT	Operation Staff / Age of bldgs	InstYear	1982
Class_Type	Local Road	Status		Asset_Date	07/01/1982
NBRLANES	2	Edit_Date	27/01/2012	GenComment	Material source= Assumed by Project Team.
SPEED_ZONE	50	Edit_By	RJ		Installation Year source= As-built drawings.
PAVEMTYEAR	1985	Edit_Notes			Condition Index source= Old CCTV inspection.
PAVSTATUS	Paved Surface	NoWMBreaks	0	Status	Last Inspected on 01/01/2000
LENGTH	114.269195	RD_AssetID	RD1307	CCTVStrucl	0.7
PAVEMENTWI	10.8	Shape_Length	97.795177	InspecLen	111.06
SURFACE	1234.107311			InspecDate	01/01/2000
GENCOMMENT	Width source= RIMS.			Edit_Date	19/06/2013
	Condition Index source=			Edit_By	RJ
	Based on Condition Index.			Edit_Notes	
UPDATED	07/05/2008			RD_AssetID	RD1307
UPDATEDBY	RJ			Shape_Length	108.174001

An integrated segment ID was created based on each unique road segment identifier. Using these ID numbers and GIS, a buffered polygon data layer was created from intersection to intersection throughout the entire City. Subsequently, each unique watermain, sanitary sewer, and storm sewer identifier was then spatially assigned to the ID associated with the polygon layer identifying its location within the City. This process allows different asset types within close proximity to each other to be compared and analysed simultaneously.

As a result of these data processes, information regarding any and all linear infrastructure assets within the City can be readily accessed using the Sarnia GIS system.

3.2.3 Condition Assessment and Analysis

IMS Infrastructure Management Services was hired by the City in 2012 to carry-out a detailed pavement condition assessment and road needs study of the entire road network in Sarnia. The IMS laser road surface tester was used for this assessment. All road data necessary for the assessment was provided to IMS from the City's GIS database. A pavement management system was used by the IMS to analyse the pavement data and provide information on the measured conditions, road classification, construction needs, and construction cost estimates. The system also identified critical deficiencies, and provided a list of all City roads classified by their priority rating with respect to their reconstruction and/or upgrade need.

Since the sewer condition assessments are currently still in progress, the sanitary sewers and storm sewers were evaluated using a combination of the actual field condition ratings and deterioration curves based on asset age and material when actual field conditions were unavailable. Once the condition assessments of all infrastructure assets are complete, the AMP will be updated to fully reflect all of the actual field condition ratings, rather than those approximated from material-based deterioration curves.

The City's water network was analysed based on recorded watermain break data, pipe age, pipe material, known operational and maintenance issues, and known capacity issues identified through the water distribution network model completed by Stantec Consulting Limited in 2013.

An integrated analysis engine (IAE) was developed using Microsoft Excel in order to carry-out an integrated analysis for all linear infrastructures.

The integrated analysis provides City staff with the following results:

i. Current needs,
ii. Future needs,
iii. Budget scenarios, and
iv. Schematic mapping

In the IAE, a composite index method was used to determine the condition score of each asset: Each asset was assessed based on a condition score between 0 and 100, with a score of 100 representing a perfect condition. The scores were based on either actual condition data or the use of material-based deterioration curves, depending on the availability of actual field condition data. Rehabilitation scenarios based on available windows of opportunities were also explored in the IAE.

The main purpose of the IAE was to assess the condition of each linear infrastructure asset, estimate their replacement costs and lifespans, and carryout integrated analyses for the assets falling within the 15-year rehabilitation and reconstruction window of opportunity range.

The IAE processes data automatically and performs a network of calculations. The program was developed with a number of separate input files, analysis files, and output files linking to both the IAE and GIS.

The IAE input data files include internal GIS databases, road assessment data from IMS Infrastructure Management Services, maintenance records, previous assessment studies, and master plan recommendations. Separate analysis files were developed within the IAE to conduct sensitivity, financial, current need, and future need analyses. The IAE is setup to update automatically as the geodatabase in the GIS system is updated. Figure 6 summarizes the IAE system processes.

Figure 7 Integrated Analysis Process

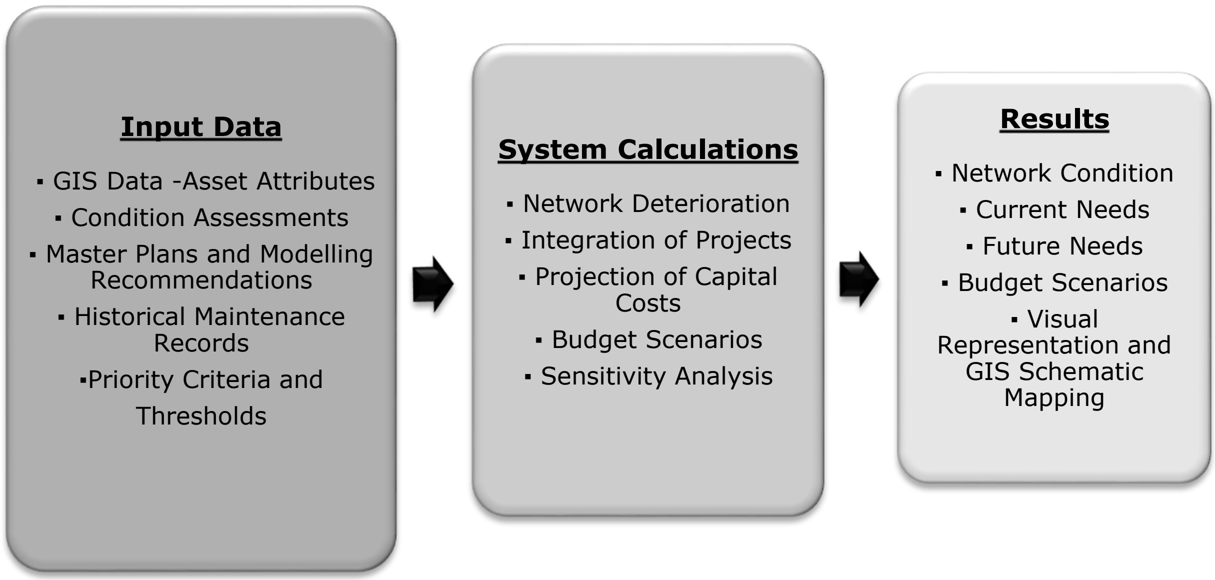


Figure 8 and Table 9 represent the general state of the City's linear infrastructure as calculated by the IAE.

Figure 8 State of Linear Infrastructure

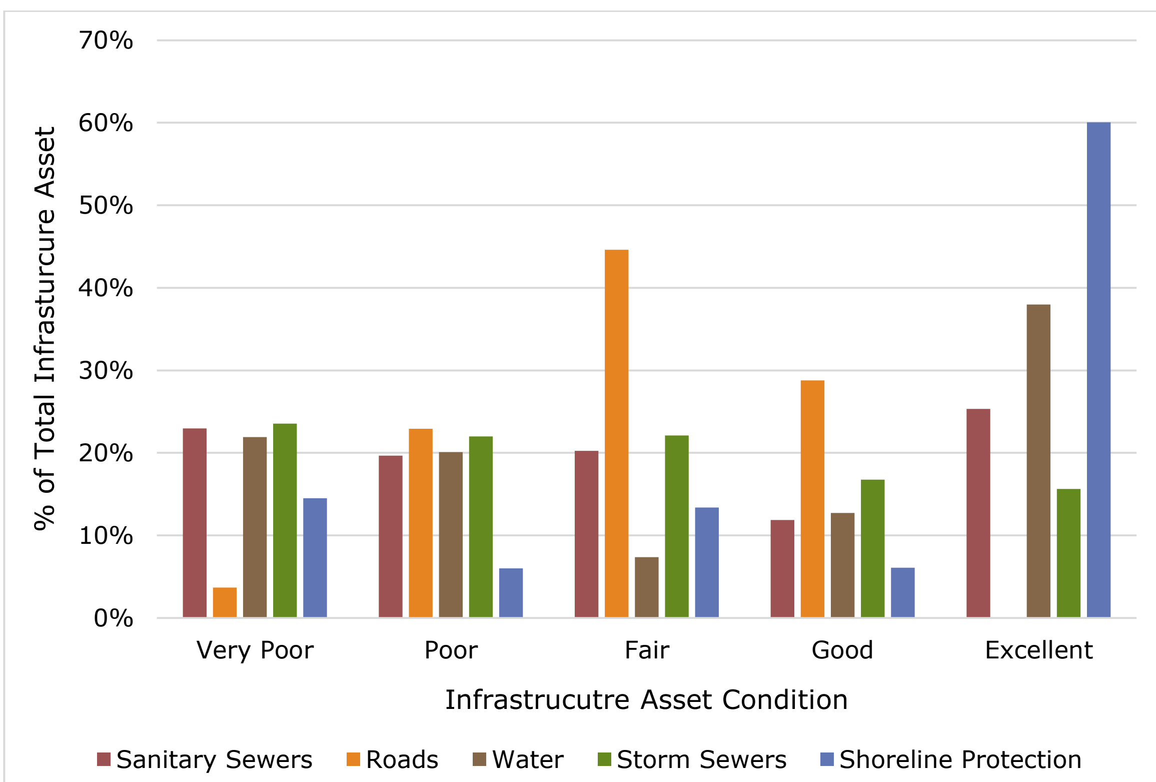


Table 9 Evaluation Criteria for the State of Linear Infrastructures

Evaluation	Road (Remaining Service Life)	Water/Sanitary/Storm (Remaining Service Life)
Excellent	30+ years	80+ years
Acceptable	30 to 25 years	80 to 45 years
Poor	25 to 10 years	45 to 30 years
Critical	10 to 0 years	30 to 0 years

The deterioration curves were developed for linear infrastructure materials based on the study completed by Dillon Consulting Limited in 2005. These deterioration curves were further modified as more information was collected based on the age and material of the linear assets within the city. These deterioration curves were used to estimate both the current condition ratings and the future condition projections of the linear infrastructure assets. These deterioration curves will be further revised and updated as more data is collected.

Various criteria were used to identify the replacement and reconstruction needs: Many of these criteria were adopted from the study completed by Dillon Consulting Limited in 2005 and were modified following discussions in various AMP Committee meetings to accommodate the specific needs of the individual assets. Figure 8 is an example of a material-based deterioration curve graph for various watermain pipe materials. While Figures 9 and 10 both illustrate the relationship between pipe conditions and the rehabilitation and replacement thresholds, Table 10 provides a summary of the length and number of the City's core infrastructure assets.

Figure 9 Watermain Pipe Deterioration Curves

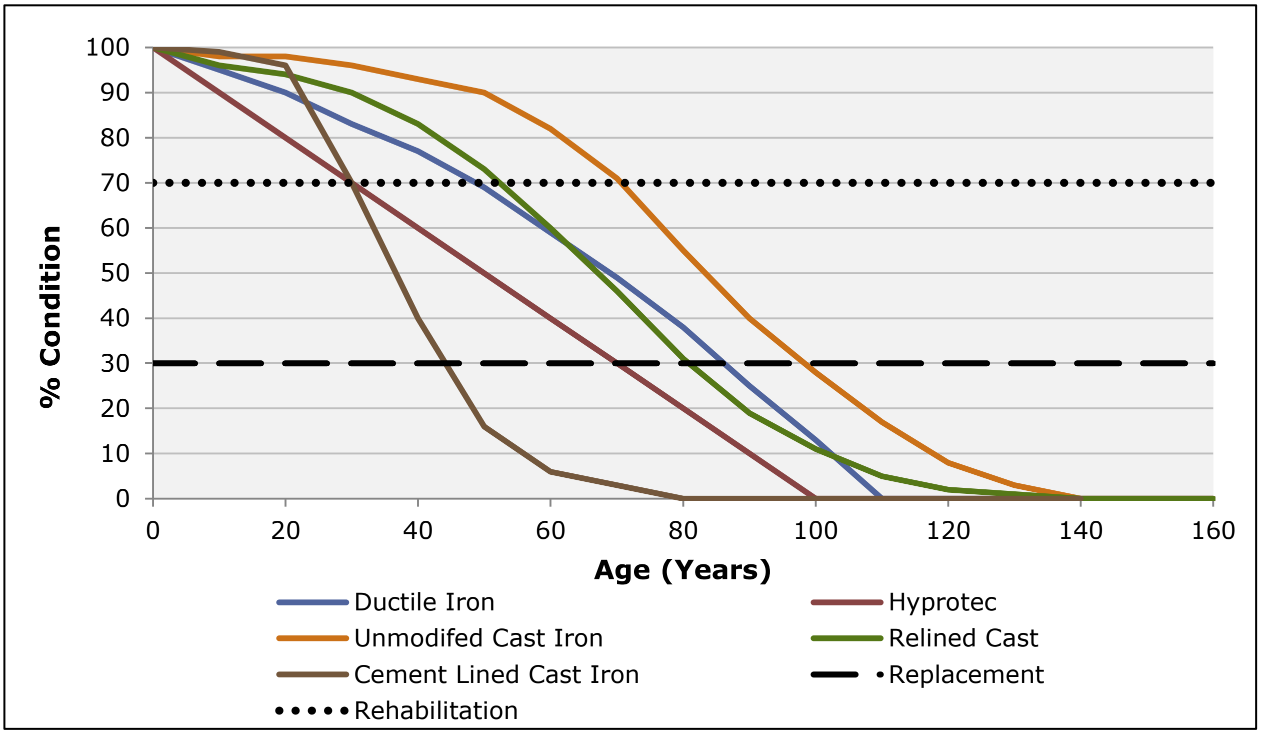


Figure 10 Rehabilitation and Replacement Thresholds for Sewer Pipe

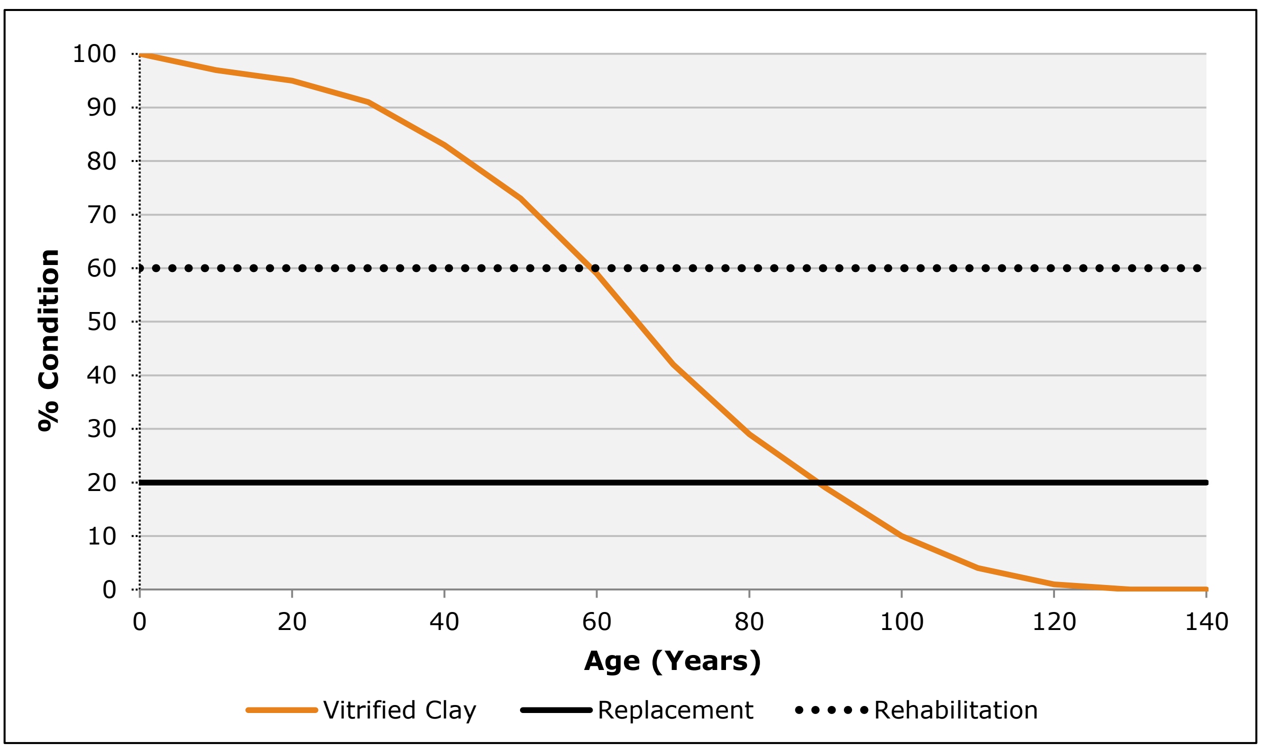


Table 10 Quick Facts about the City's Core Infrastructure Assets

No.	Description	Length/Number	Unit
1	**Water Distribution System**		
	Watermains	502	km
	Fire Hydrants	2881	number
	Valves	3671	number
2	**Road Network**		
	Road	921	km (lane-length)
	Sidewalk	328	km
3	**Stormwater & Wastewater Collection Systems**		
	Sanitary Sewer	328	km
	Combined Sewer	23	km
	Storm Sewer	319	km
	Sanitary & Combined Sewer Manholes	6630	number
	Storm Sewer Manholes	4142	number
	Catch Basins	9173	number
	CSO Tank	1	number
	Sanitary Forcemains	46	km
	Storm Forcemains	1	km
	Sanitary Pump Stations (In Service)	48	number
	Sanitary Pump Stations (Out Of Service)	4	number
	Storm Pump Station	4	number
4	**Wastewater Treatment Facilities**	3	number
5	**Stormwater Management Facilities**	8	number
6	**Bridges & Culverts**	31	number
7	**Shoreline Protection**	11	km

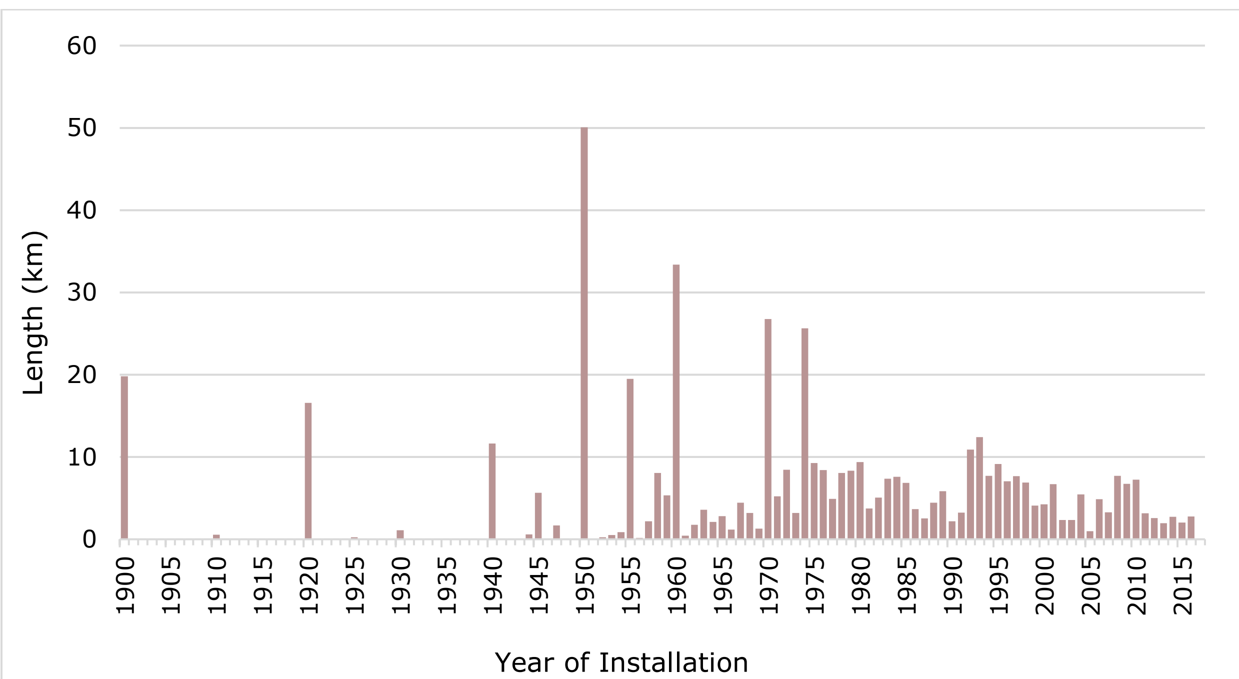
3.3 Water Distribution System

The City of Sarnia's water distribution system (WDS) is an integral part of Lambton Area Water Supply System (LAWSS). The water is supplied to the City's distribution system from the LAWSS Water Treatment Plant located within City of Sarnia's municipal boundary. Vertical turbine high lift pumps deliver the water from the treatment plant into four transmission mains that extend through the Village of Point Edward towards Sarnia. The Sarnia WDS is a large municipal water distribution system that serves approximately 25,000 customers (approximately 72,000 people).

3.3.1 Inventory

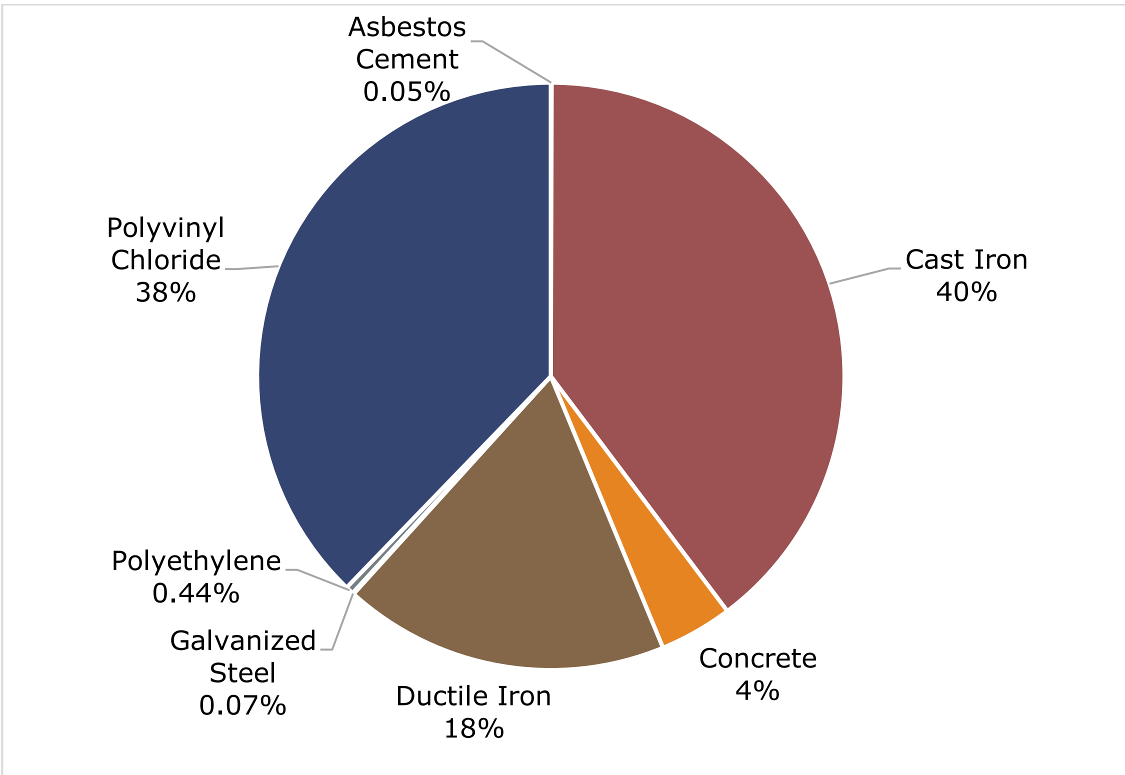
The Sarnia WDS consists of approximately 496 kilometres of watermains, 2639 hydrants, and 3492 main valves. There are 47 kilometres of LAWSS supply watermains located throughout the City that connect to the Sarnia WDS in 56 locations. The City's watermains range from 100mm (4") to 600mm (24") in diameter. Of the 2639 hydrants located within the City, 43 are privately owned and 36 are owned by LAWSS. Figure 11 shows the age distribution of the City's watermains.

Figure 11 Watermain Installation Years Distribution



The inventory and maping of the majority of the City's WDS, including location, size, length, type of watermain pipe, fire hydrants, valves, connections, watermain breaks etc., are available in our GIS System geodatabase. A chart illustrating the material distribution of the City's watermains can be found in Figure 12; this data was obtained from the Sarnia GIS database.

Figure 12 Watermain Material Distribution by Percentage



3.3.2 Condition

The City of Sarnia WDS experienced a total of 138 watermain breaks in 2011, which equates to nearly 28 breaks per 100 kilometres of watermain per year. In comparison to the provincial average, this number of watermain breaks per kilometre is very high. According to the data collected during the City's annual water loss audits, the number of watermain breaks has increased consistently over the past few years. This increase can be directly attributed to the significant reconstruction and rehabilitation needs of the WDS.

Figures 13 serves to compare the gross non-revenue water losses and the number of watermain breaks over an 8-year period, while Figure 14 shows the age and material distribution of the City's watermains. The gross water loss includes both accounted and unaccounted water losses within the WDS, while the net water loss includes only unaccountable water losses. Accountable water losses can be attributed to watermain breaks within the WDS, while unaccountable water loses can be attributed to meter inaccuracies, leakages, water theft, etc.

Figure 13 Annual Gross Non-Revenue Water

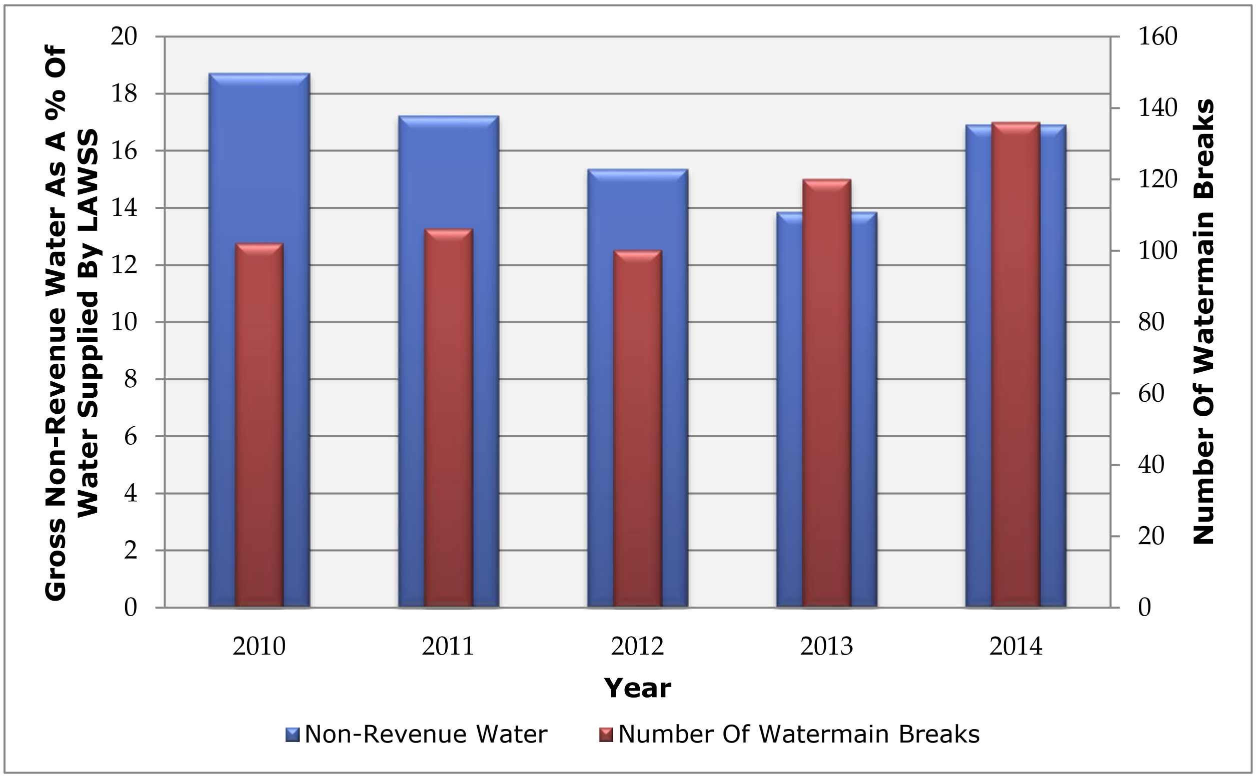
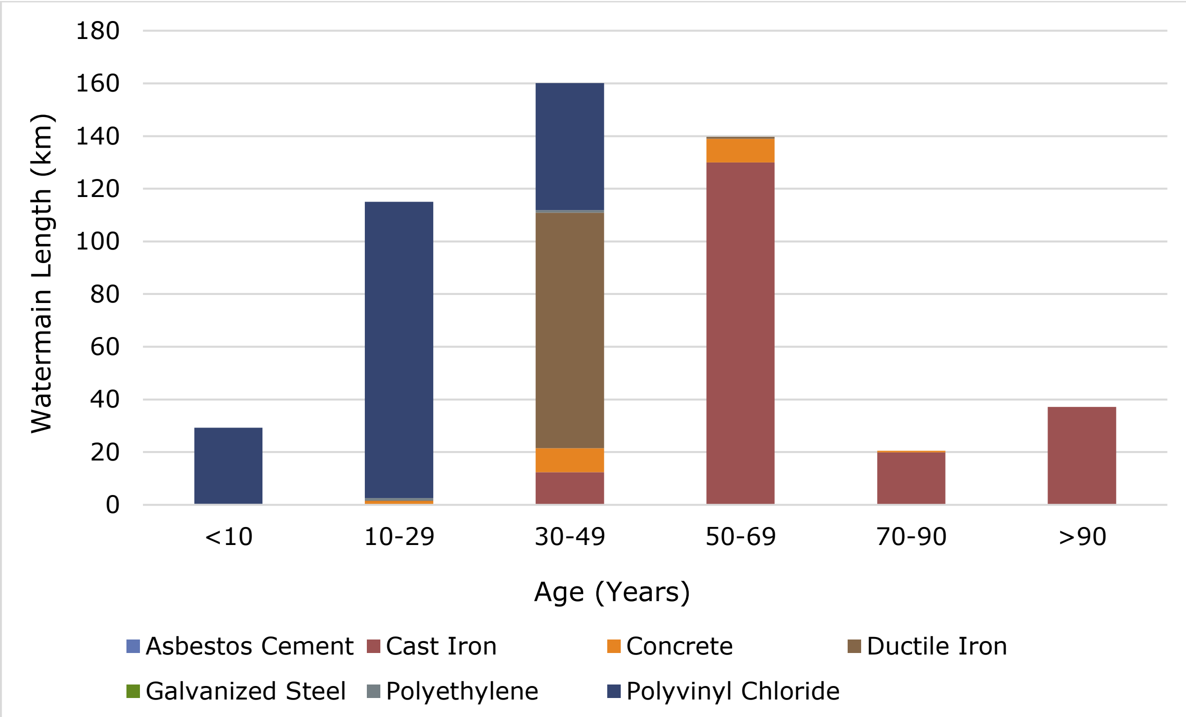


Figure 14 Watermain Age and Material



The WDS was assessed based on a variety of factors which include pipe age, pipe material, number of watermain breaks, water pressure, flow rate, etc.

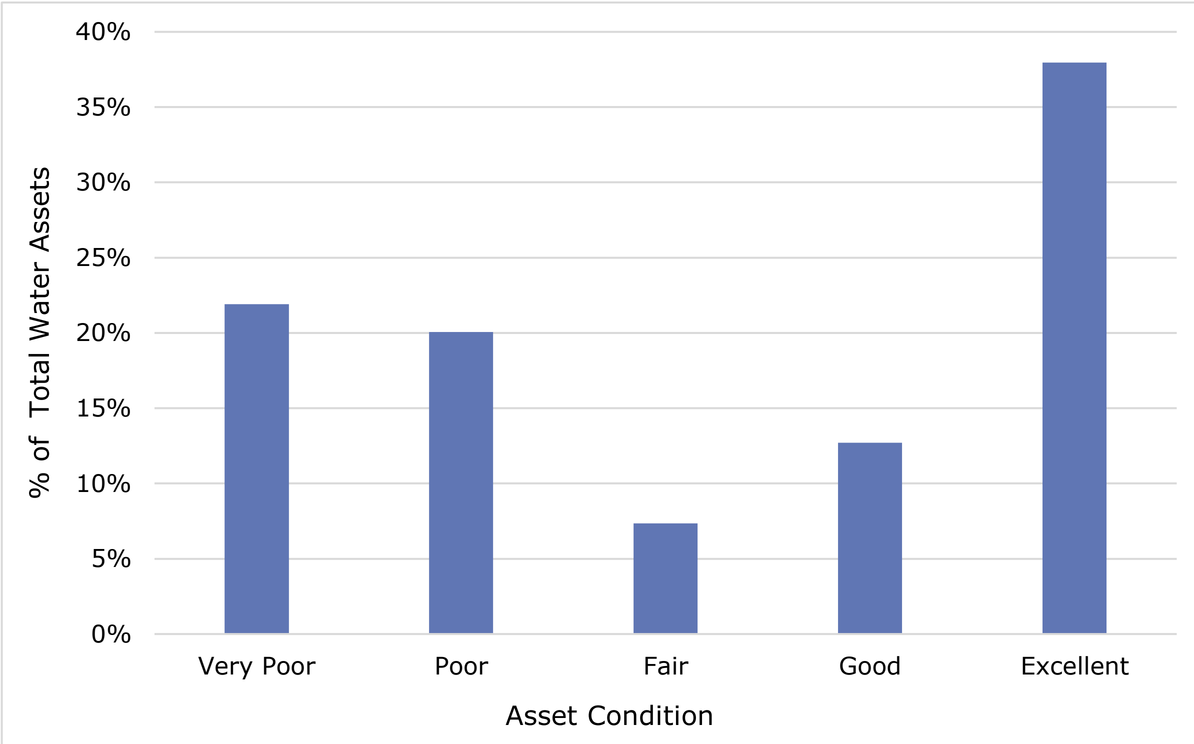
A few of such factors for determining watermain condition are discussed in Table 11 below.

Table 11 Factors for Determining Watermain Condition

Factor	Comments
Age and Material	"Age and Material" is the most significant assessment criterion: As a watermain ages its condition deteriorates by a combination of increased calcium deposits, low flows, low pressure, rusting, and breakage. The type of material significantly affects the rate at which deterioration occurs. Lead containing watermain materials can affect the quality of drinking water, and therefore are a significant factor in assigning watermain project priority.
Watermain Breaks per 100 metres	The number of watermain breaks provides an accurate measure of operational decline due to pipe deterioration. Watermains that have a history of breakage are a significant burden on the operational budget.
Fire Flow	Several areas within the City experience very low water flows. Such low flow areas are both an operational and safety concern. Low flows are also directly related to increased water ages within the affected pipes.
Pipe Diameter	Large diameter pipes are often transmission lines that supply significant quantities of water to large areas within the City: As such, problems with larger diameter pipes are considered to have high associated social and economic risks. Small diameter pipes, less than 150mm, are also a priority as they often have low pressures and/or lead services. Lead services need to be removed as they have significant detrimental effects on water quality.

Figure 15 below illustrates the state of the City's water infrastructure.

Figure 15 State of Water Infrastructure



3.3.3 System Capacity and Expansion

In 2013, Stantec Consulting Limited completed a hydraulic computer model of the City's WDS and a 'Water Distribution System Master Plan' (WDMP) for the City of Sarnia.

The objective of this study was to obtain a detailed hydraulic assessment of the City's WDS and to develop a hydraulic computer model that accurately portrays the pressure, flow, and age of the water being distributed throughout the City's water network.

Using the hydraulic model, City staff are able to identify deficiencies in the available fire flows and/or in pipe water ages for different flow conditions, and to model possible solutions quickly and accurately so that they may be implemented as quickly as possible.

The WDMP provides direction to the long-term management and operation of the City's water infrastructure. Specifically, its prioritised list of water projects and recommendations provides direct input for the City's long-term Capital Plan.

Any WDS capacity constraints identified through the hydraulic modelling process will be incorporated into the next update of this plan.

3.3.4 Data Flow Verification Policy

The City's Engineering Department and Public Works Division has annual valve-turning, hydrant flushing, and pipe inspection programs, which have been in place since 2010. City staff currently flush all 2639 City hydrants and turn an average of 300 watermain gate valves every year.

In addition to the above activities, City staff also record the field locations of all the hydrants and valves they service using hand-held global positioning system (GPS) devices. This collected information is uploaded into the Sarnia GIS system on a regular basis. Data integrity checks and flow protocols are currently being developed to ensure that all collected data is reliable and consistent.

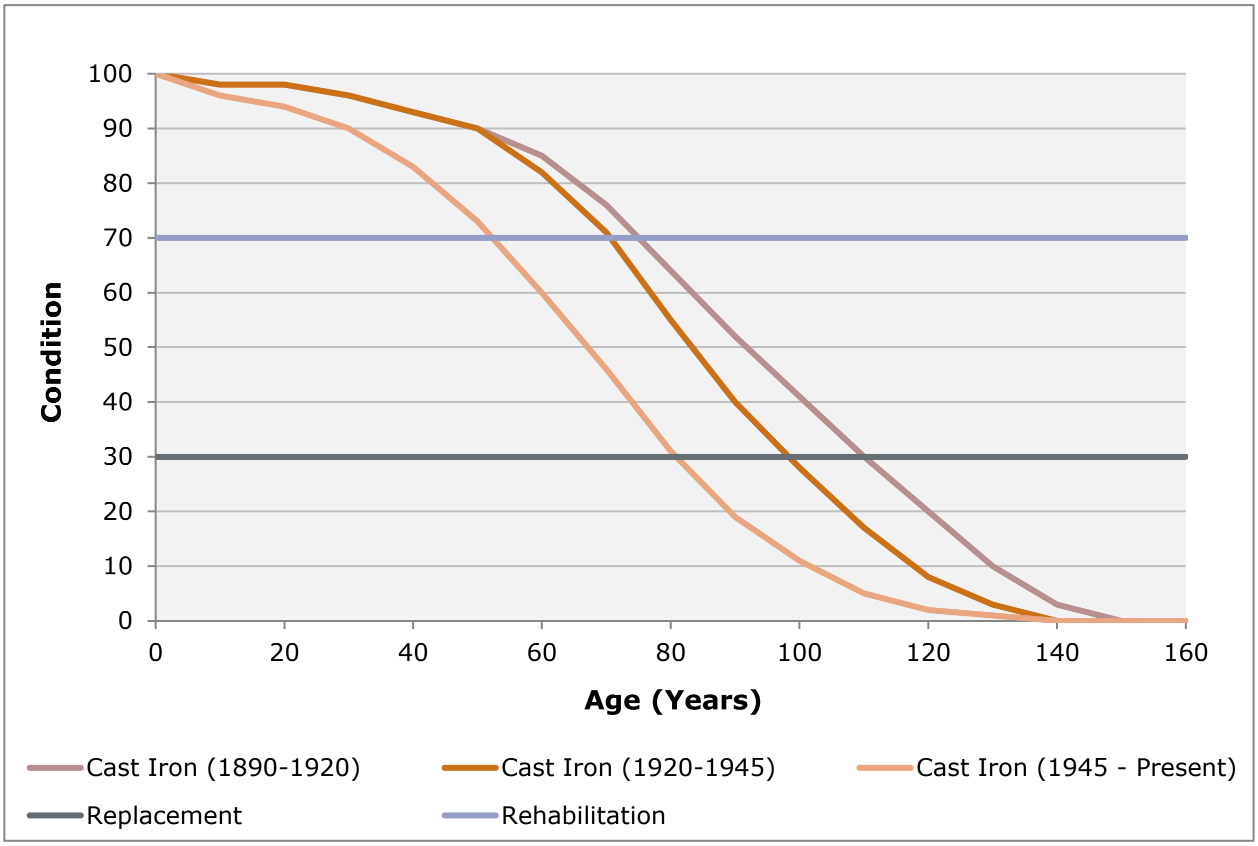
3.3.5 Analysis

The state of the City's WDS has been analysed based on watermain break data, pipe age, pipe material, pipe diameter, available pressure, and available fire flows. Risk analyses were carried-out based on the probability of failure and the consequence of the failure. More weight was assigned to higher diameter watermains as well as watermains with a higher number of breaks, as they tend to be of higher risk.

Capacity, fire flow, and water age issues in the distribution system were assessed separately and before being incorporated into the risk analyses. The above factors were further modified based on known system issues and other risks specific to certain sections of the WDS.

Figure 16 depicts the material-based deterioration curves for the Sarnia WDS, which were modified from the results obtained from the study conducted by Dillon Consulting Limited to reflect newly available data regarding pipe age and material. These deterioration curves were used for determining the current condition index and projecting future condition indices for the water network components.

Figure 16 Water Network Deterioration Curves for Modified Cast Iron



3.4 Wastewater Collection Systems

3.4.1 Inventory

The City of Sarnia owns and operates two wastewater treatment facilities: The St. Andrew's Street Sarnia Pollution Control Centre (SPCC) located in the south end of the City's urban area, and the Bright's Grove Sewage Lagoons (BGSL) located in the community of Bright's Grove. The SPCC services approximately 65,000 people, whereas the BGSL services only approximately 5,000 people. The wastewater collection system (WCS) servicing the SPCC treatment facility consists of approximately 286 kilometres of gravity sanitary sewer, 24 kilometres of combined sewers, 49 sanitary pumping stations, and approximately 49 kilometres of sanitary forcemains. The BGSL are serviced by approximately 26 kilometres of gravity sanitary sewers, 4 sanitary pumping stations, and 3.5 kilometres of sanitary forcemains.

The City's stormwater collection system consists of 293 kilometres of storm sewers, 4 storm pumping stations, and 7 stormwater management facilities.

The City's WCS maps and inventories are available in the Sarnia GIS geodatabase. Such inventories include pipe locations, pipe diameters or sizes, pipe lengths, type of pipe, pipe material, manhole locations, and service connection locations, etc. The WCS Geodatabase was created based on the inventories from the 2005 Dillon Consulting study as well as data collected through condition assessment programs conducted by the City.

Charts illustrating the material distribution of the City's sanitary pipes, combined sewer pipes, and storm sewer pipes can be found in Figures 17, 18, and 19, respectively.

Figure 17 Sanitary Pipe Material Distribution

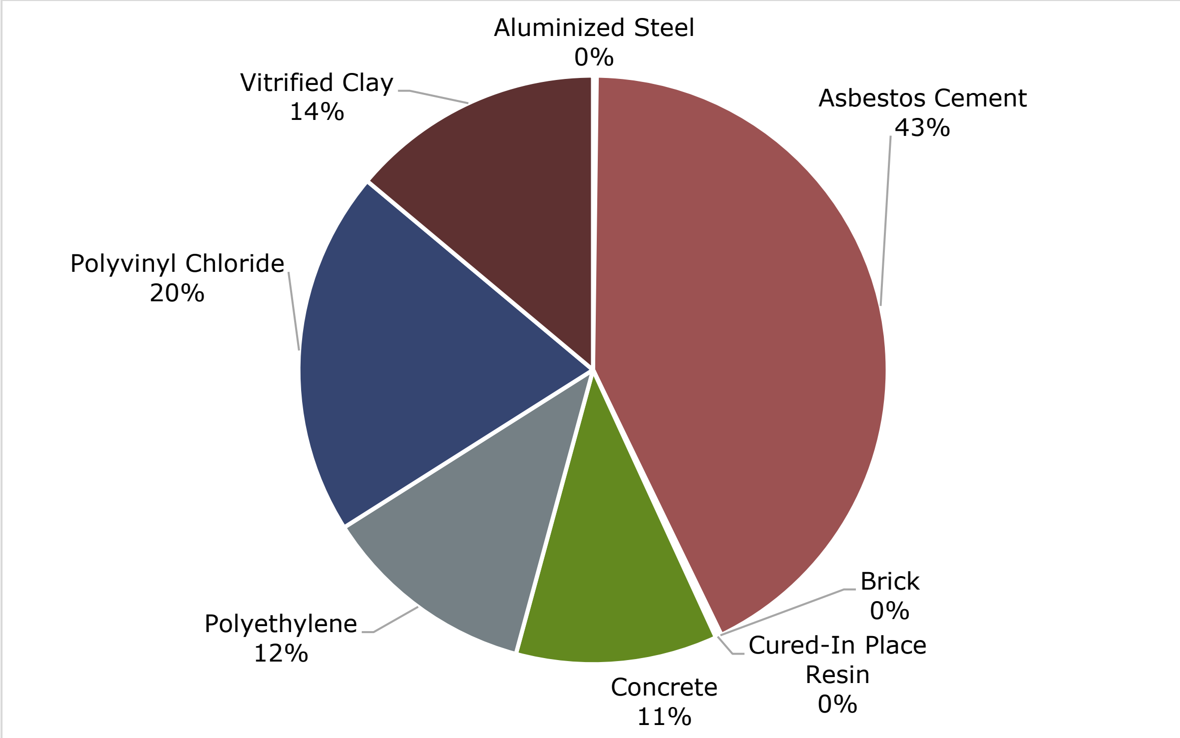


Figure 18 Combined Sewer Pipe Material Distribution

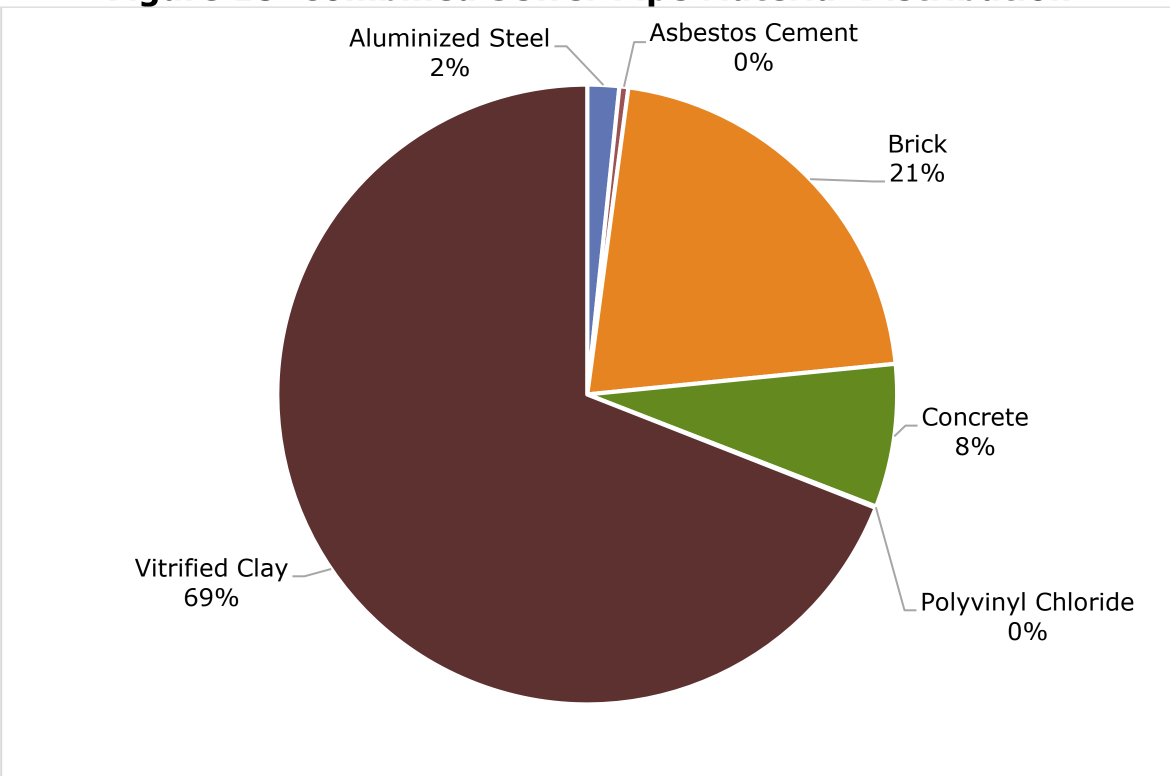
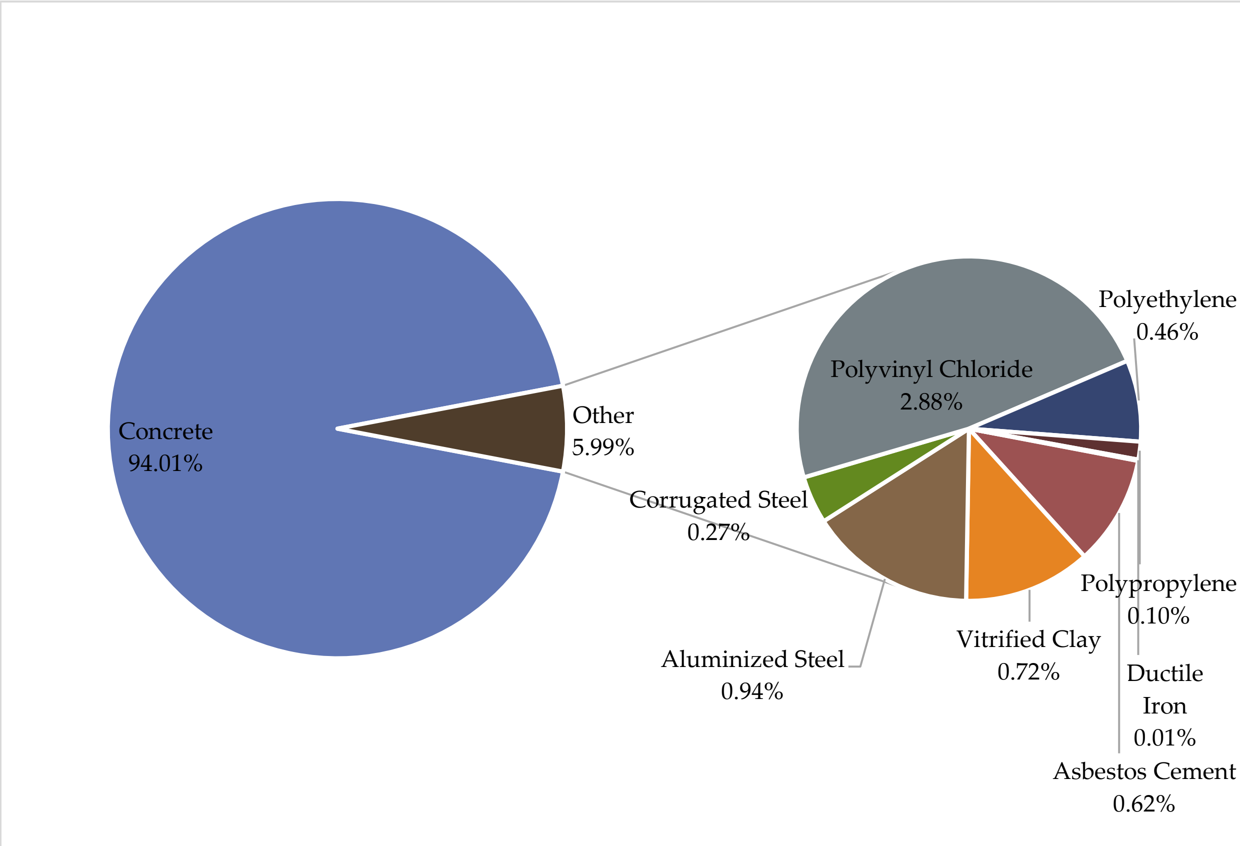


Figure 19 Storm Sewer Pipe Material Distribution



3.4.2 Condition

3.4.2.1 Sewers

Most of the City's separated sewer systems were built in the 1950s, 1960s, and 1970s. However, a significant portion of the core area of the City is still being serviced by combined sewer systems that were, for the most part, installed prior to the 1900s. The age distribution of the City's sewer linear infrastructure can be seen in Figure 20. Figure 21 illustrates the condition of the wastewater infrastructure within the City.

Figure 20 Sanitary and Combined Sewers Installation Age Distribution

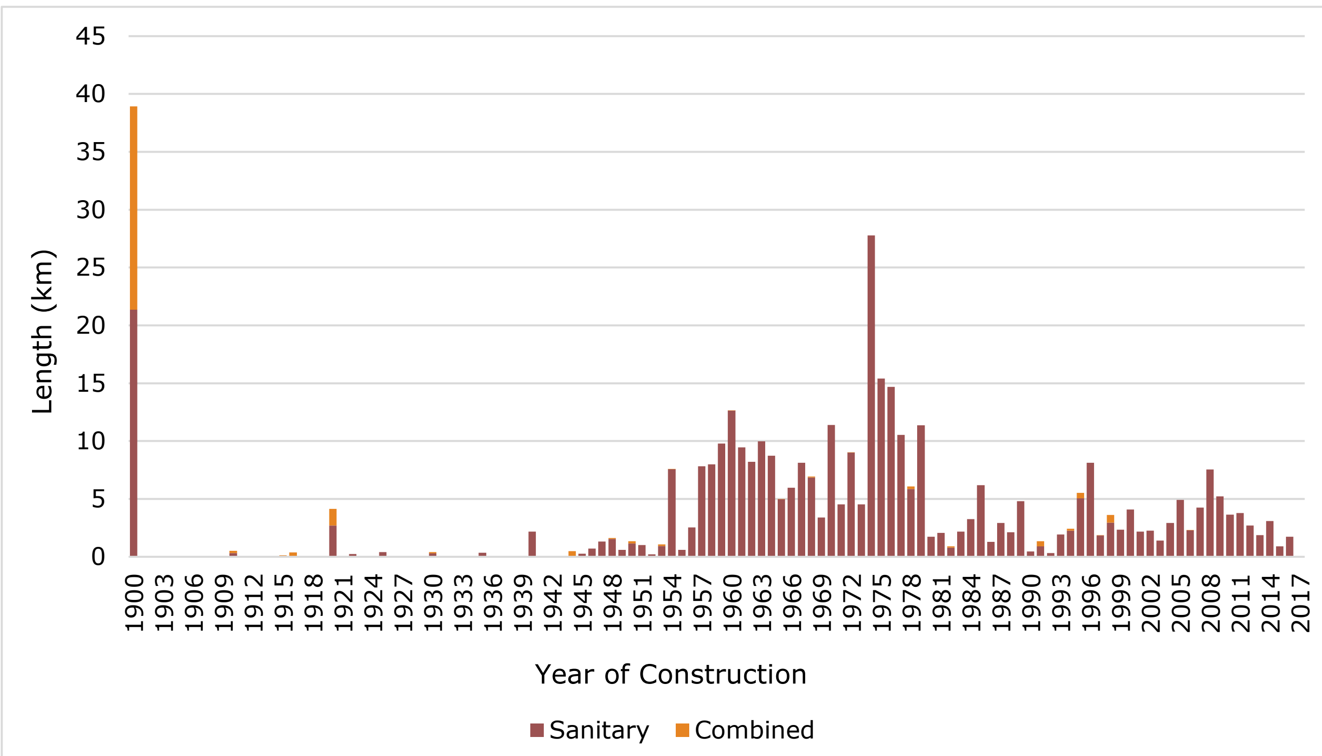
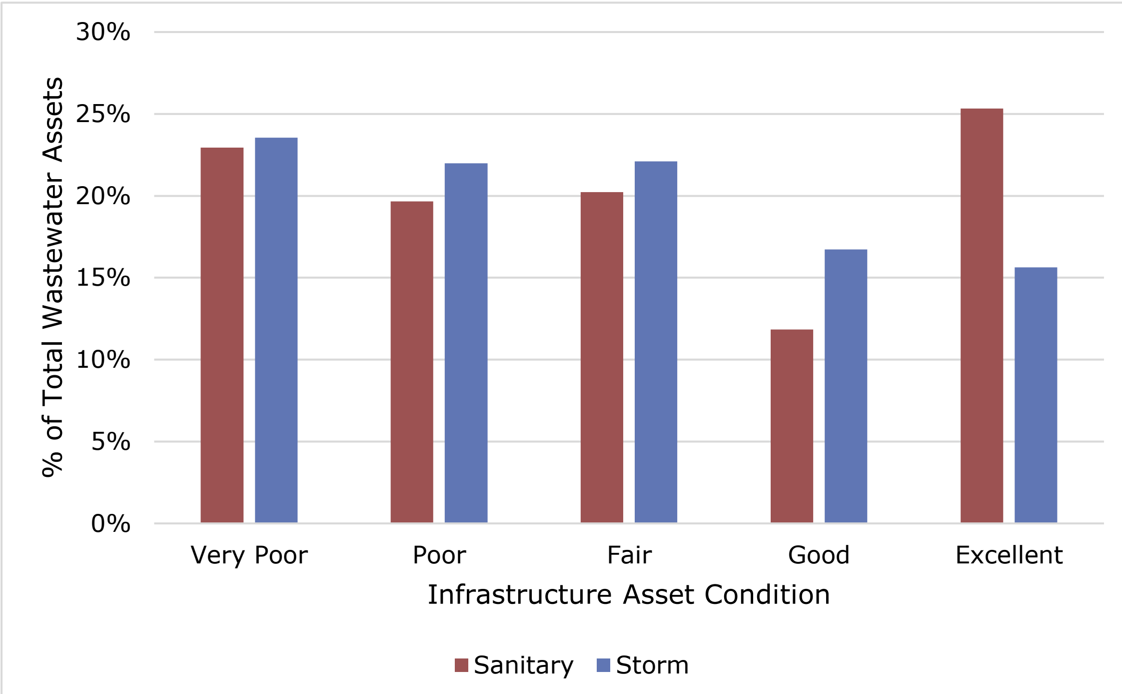


Figure 21 State of Linear Wastewater Infrastructure



Basement flooding and combined sewer overflows discharged into the St. Clair River have been the long-standing, major areas of concern for the City of Sarnia. In order to improve in these areas of concern, the City has undertaken a number of major sewer separation projects over past five years with the help of funding from senior levels of government. These projects have greatly reduced the amount of combined sewer overflows discharged into the St. Clair River, thereby improving the river water quality. The projects have also served mitigate basement flooding issues, particularly in the core area of the City.

Sewer condition assessments have proved to be a major challenge for the City due to the high costs associated with the uncertainty and extent of sewer cleaning required. As a result, sewer condition assessments are ongoing and are expected to be completed in phases over the next two years.

For the purposes of this AMP, the condition of the existing sewer network has been based largely on the age and material of the sewer pipes, and in part on the sample condition assessments done previously by Dillon Consulting Limited. This AMP will be updated as more sewer condition assessment data becomes available.

3.4.2.2 Pumping Stations

R. V. Anderson Associates completed pumping station assessments for the City of Sarnia in 2009.

Table 12 shows the weighted average service life of the different components of a pump station as reported in the R.V. Anderson Associates report. The condition analyses of all the pump stations have been calculated using a declining straight-line method based on their weighted average service life and completed upgrades, if applicable.

Table 12 Wastewater Pump Station Component Service Life

Component	% Of Total Facility Cost	Expected Service Life Of Wastewater Pumping Station
Architectural	10	30 years
Electrical	15	25 years
Life Safety	5	50 years
Mechanical	10	30 years
Process	25	40 years
Site Elements	5	50 years
Structural	30	100 years

In determining the overall score for each pumping station within the City, a condition score, a capacity score, a compound score, and a risk score were all determined and incorporated. Firstly, the capacity score was calculated based for each pumping station based on a combination of the actual design capacity of the station and the calculated flow received by the pump station obtained from the City sewer model prepared by Stantec Consulting Limited. Next, the compound score was calculated 80% based on condition and 20% based on capacity. A risk score was then assigned to each station based on the difference between its design capacity and its actual capacity. Additional risk was assigned to pump stations with known operational and developmental issues.

The priority list of pump stations based on their capacity, condition, and risk scores is provided in Table 13. As shown in the table below, the City's three pump stations with known operational issues are of greatest priority.

Table 13 Wastewater Pump Station Capacity and Condition Assessment

Pump Station	Condition Score	Capacity Score	Compound Score	Normalized Risk Score	Overall Score	Known Operational & Developmental Issues	Overall Score After Issue Override
CNR Tracks at Bedford	34	29	33	75	25	Yes	0
Green Street	67	0	54	81.5	44	Yes	0
Murphy Road at 402	34	66	41	75	30	Yes	0
Giffel Road	11	-	11	100	11	-	11
East Street at Maple	12	-	12	100	12	-	12
Holland Street	11	35	15	90.4	14	-	14
Briarfield	14	-	14	100	14	-	14
McCaw	18	25	19	86.6	17	-	17
Rosedale	14	69	25	82.9	21	-	21
Errol Road	23	-	23	100	23	-	23
Exmouth West of Indian	32	21	30	84.2	25	-	25
Mayfair	29	46	32	80.8	26	-	26
Talfourd Street	34	48	37	75	28	-	28
East Street at Huey's	29	-	29	100	29	-	29
Forsyth	32	48	36	95.2	34	-	34
Scott Road	25	81	36	95.7	35	-	36
Exmouth Street at Lambton Mall	34	82	44	81.6	36	-	36
Lecaron	53	23	47	77.4	36	-	36
Clifford	27	94	40	93	37	-	37
1801 London at Blackwell	34	77	43	91.7	39	-	39
Chippewa Park	40	-	40	100	40	-	40
London Line at Briarwood	34	89	45	88	40	-	40
Cathcart at Rutherglen	42	-	42	100	42	-	42
Elrick at Vye	53	43	51	82.4	42	-	42
Blackwell at Sim's	34	72	42	100	42	-	42
River Road	45	-	45	100	45	-	45
Tashmoo Avenue North	49	-	49	100	49	-	49
Sandy Lane	49	-	49	100	49	-	49
Airport Road North of 402	43	92	53	96.9	51	-	51
1642 Murphy Road	67	82	70	75	53	-	53
Penhuron Lane/Hamilton	67	12	56	96.4	54	-	54
161 Nelson Street	54	-	54	100	54	-	54
Plank Road at Indian Road	71	98	76	75	57	-	57
Rapids Parkway	69	78	71	81.5	58	-	58
Plain Lane	58	-	58	100	58	-	58
Bershire Road	58	-	58	100	58	-	58
1350 Plank	67	51	64	94.3	60	-	60

Table 13 Continued

Pump Station	Condition Score	Capacity Score	Compound Score	Normalized Risk Score	Overall Score	Known Operational & Developmental Issues	Overall Score After Issue Override
1569 London Line at Lou's	85	66	81	76.6	62	-	62
LaSallle	67	62	66	98.9	65	-	65
Kaymar	67	-	67	100	67	-	67
Huronview/Lakeshore	67	-	67	100	67	-	67
Devine Street	96	-	96	75	72	-	72
ARI	73	-	73	100	73	-	73
1264 Tashmoo South	73	-	73	700	73	-	73
Michigan Avenue	80	80	80	92.7	74	-	74
Heritage Park	80	89	80	95.2	76	-	76
Augusta Drive	76	-	76	100	76	-	76
5960 Blackwell Side Road	76	-	76	100	76	-	76
London Road Industrial Park	85	96	88	88.3	77	-	77
Stone Hedge Park	84	-	84	100	84	-	84

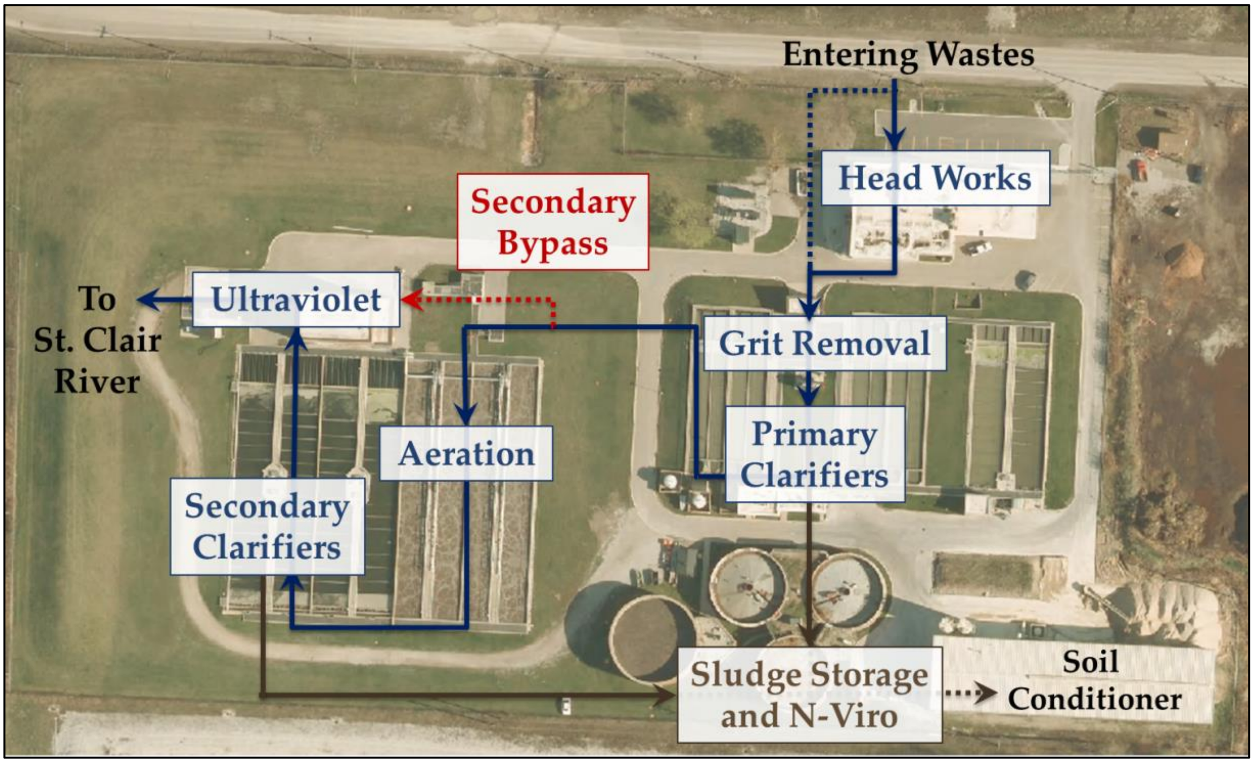
3.4.2.3 Wastewater Treatment Facilities

The City of Sarnia owns and operates two wastewater treatment facilities: The St. Andrew's Street Sarnia Pollution Control Centre (SPCC) located in the south end of the City's urban area, and the Bright's Grove Sewage Lagoons (BGSL) located in the community of Bright's Grove.

The BGSL facility is a system of waste lagoons. This facility has been identified as one of the City's top needs based of its capacity constraints and legislative requirements. Further details regarding the facility's capacity can be found in Section 3.4.3 of this AMP.

The condition scores for various components of the SPCC have been calculated based on the average age of the components identified in Figure 22 below.

Figure 22 Water Pollution Control Centre



All of the components of the SPCC were divided into 3 major categories: process, structural, and equipment. A service life of 25 years was assumed for components in the process and equipment categories, whereas a service life of 100 years was assumed for components in the structural category. The condition score for all components will be updated once an actual condition assessment of the plant is carried-out in the near future.

The original SPCC plant, built in 1959, used an anaerobic waste treatment process with only primary treatment capabilities. In 2000, the plant was upgraded to include an aerobic primary treatment process and additional secondary treatment processes. Figure 23, Figure 24, and Table 14 detail the treatment processes used at the SPCC prior to and after the facility upgrades.

Figure 23 Water Pollution Control Centre Upgrades

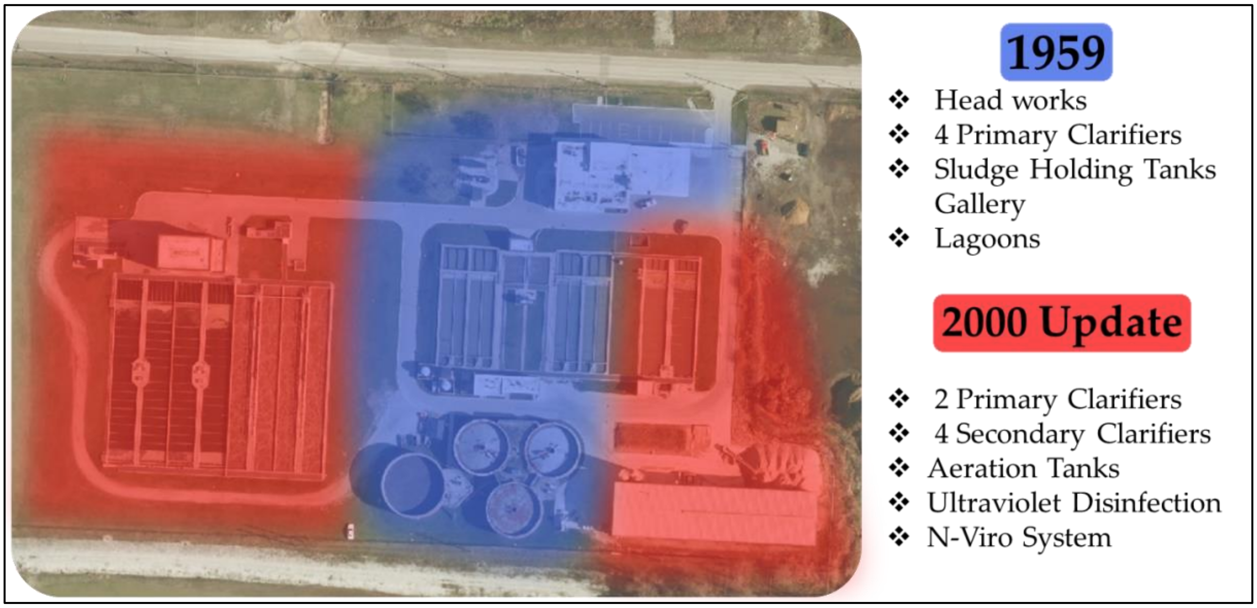


Figure 24 Average Condition Score of the SPCC

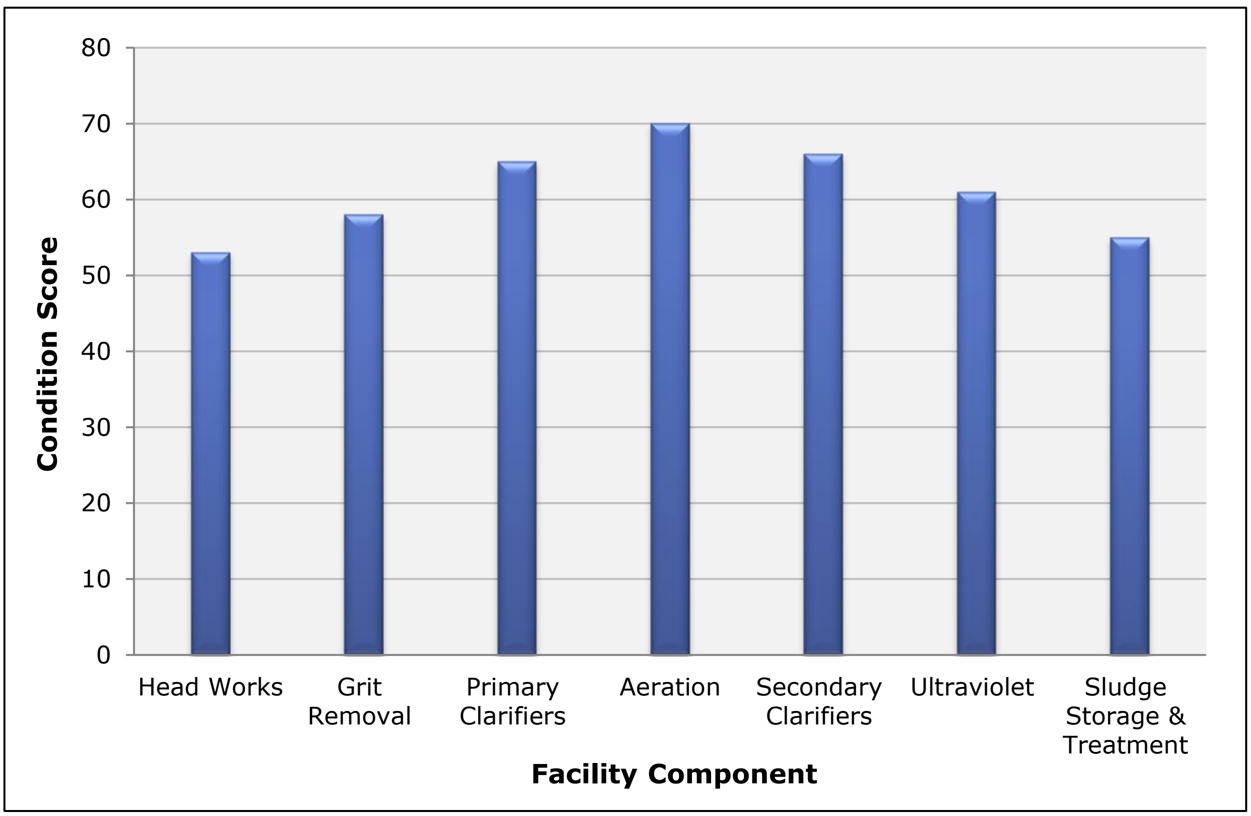


Table 14 Water Pollution Control Centre Condition Assessment

No.	Section/Category	Year Built	Age	Condition Score
1	**Head Works**			
	Process	2004	11	64
	Structural	1959	56	46
	Equipment	2000	15	48
	Average	-	-	*53*
2	**Grit Removal**			
	Process	2008	7	80
	Structural	1959	56	46
	Equipment	2000	15	48
	Average	-	-	58
3	**Primary Clarifiers**			
	Process	2005	10	68
	Structural	1973	42	60
	Equipment	2005	10	68
	Average	-	-	*65*
4	**Aeration**			
	Process	2005	10	68
	Structural	2000	15	87
	Equipment	2002	13	56
	Average	-	-	*70*
5	**Secondary Clarifiers**			
	Process	2004	11	64
	Structural	2000	15	87
	Equipment	2000	15	48
	Average	-	-	*66*
6	**Ultraviolet**			
	Process	2000	15	48
	Structural	2000	15	87
	Equipment	2000	15	48
	Average	-	-	*61*
7	**Sludge Storage & Treatment**			
	Process	2002	13	56
	Structural	1973	42	60
	Equipment	2000	15	48
	Average	-	-	*55*

3.4.3 System Capacity and Expansion

In 2009, the City undertook an assessment of the reserve capacity of each wastewater treatment facility. The resulting report, 'The City of Sarnia Wastewater Treatment Systems Reserve Capacity Calculations 2009', concluded that both the SPCC and BGSL facilities had limited uncommitted reserve capacities. The report also recommended that the City undertake a detailed hydraulic assessment of the City's entire wastewater collection system.

In 2012, Stantec Consulting Limited completed a hydraulic model of the City's wastewater collection system. The objectives of this hydraulic model were as follows:

i. To provide a detailed hydraulic assessment of the City's wastewater collection system, including pumping stations and forcemains,
ii. To develop a hydraulic computer model of the collection system to enable the review of the wastewater collection system and to identify trunk sewer service areas,
iii. To initiate a sanitary flow monitoring program in order to more accurately determine the actual flows in the trunk sewer systems under low and peak flow events,
iv. To identify hydraulically deficient trunk sewers,
v. To assess the impacts of further development on the hydraulic capacity of the existing sewer infrastructure,
vi. To identify areas of high infiltration/inflow (I/I), and,
vii. To provide the City with recommendations for system improvements.

The Wastewater Collection System Master Plan (WCS Master Plan) was developed by Stantec Consulting Limited following the hydraulic assessment in order to provide input and direction to the long term management and operation of wastewater infrastructure.

In 2010, a Ministry of Environment (MOE) report indicated that the capacities of the Bright's Grove sewage lagoons were approaching 85% of their designed capacity. Additionally, the facility has also been experiencing operational issues, as the current treatment system does not allow for the discharge of flows during the winter period. The MOE has required the City to develop a plan to expand the current 2,045m^3/day. As recommended by the WCS Master Plan and the MOE, further environmental studies were undertaken by Stantec Consulting Limited at the Bright's Grove sewage treatment facility to assess what expansion options are available and will meet future sewer demands.

The top two expansion projects identified in the study are the Bright's Grove sewage treatment facility expansion and the Bedford pumping station expansion.

The system capacity constraints identified in the WCS Master Plan have been incorporated into this AMP.

3.4.4 Data flow verification policy

The City's Engineering Department and the Public Works Division have scheduled a regular sewer inspection and flushing program. As a part of this program, sewer network data is being collected on a regular basis by operations staff using hand held GPS devices and the database is being constantly updated in the City's GIS database using established protocols.

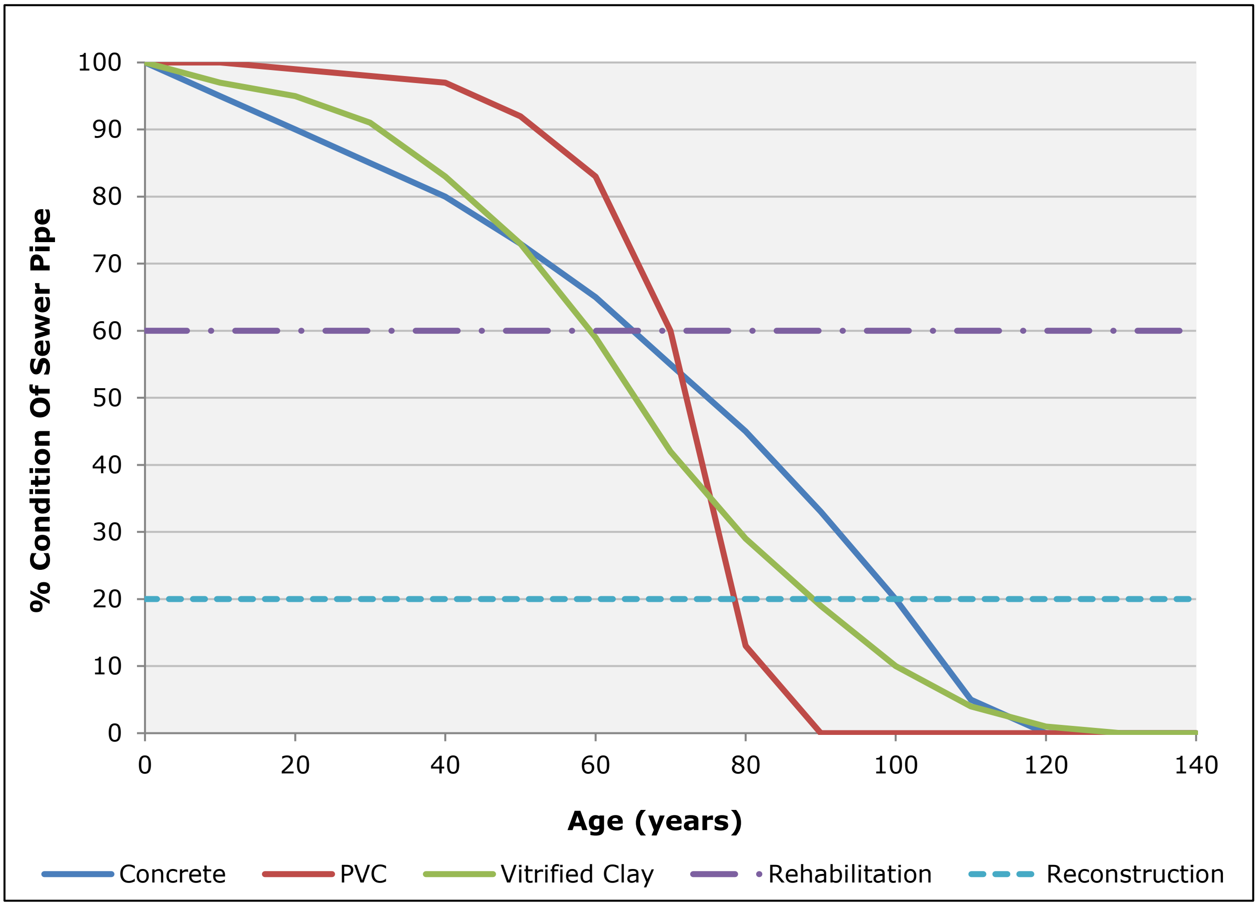
Consultants hired by the City of Sarnia are completing sewer network flushing, closed circuit television recording (CCTV), and condition assessments of the City's sewer systems. From the CCTV recordings, the consultants will assign to each sewer pipe an overall condition rating based on the Pipeline Assessment Certification Program (PACP) coding system. The sewer condition data is being collected in phases over the next 2 years.

3.4.5 Analysis

The state of the City's wastewater collection system has been analysed based on age, material, size, receiving water quality, association with basement flooding events, available CCTV ratings, and known operational and/or capacity issues.

Material-based pipe deterioration curves for the wastewater collection system, modified from the Dillon Consulting Limited study, were used for determining the current condition, rehabilitation window of opportunity, and future condition projections when actual field data was not available. The sewer network deterioration curve used for the purposes of this AMP can be found in Figure 25.

Figure 25 Sewer Network Deterioration Curves



3.5 Road network

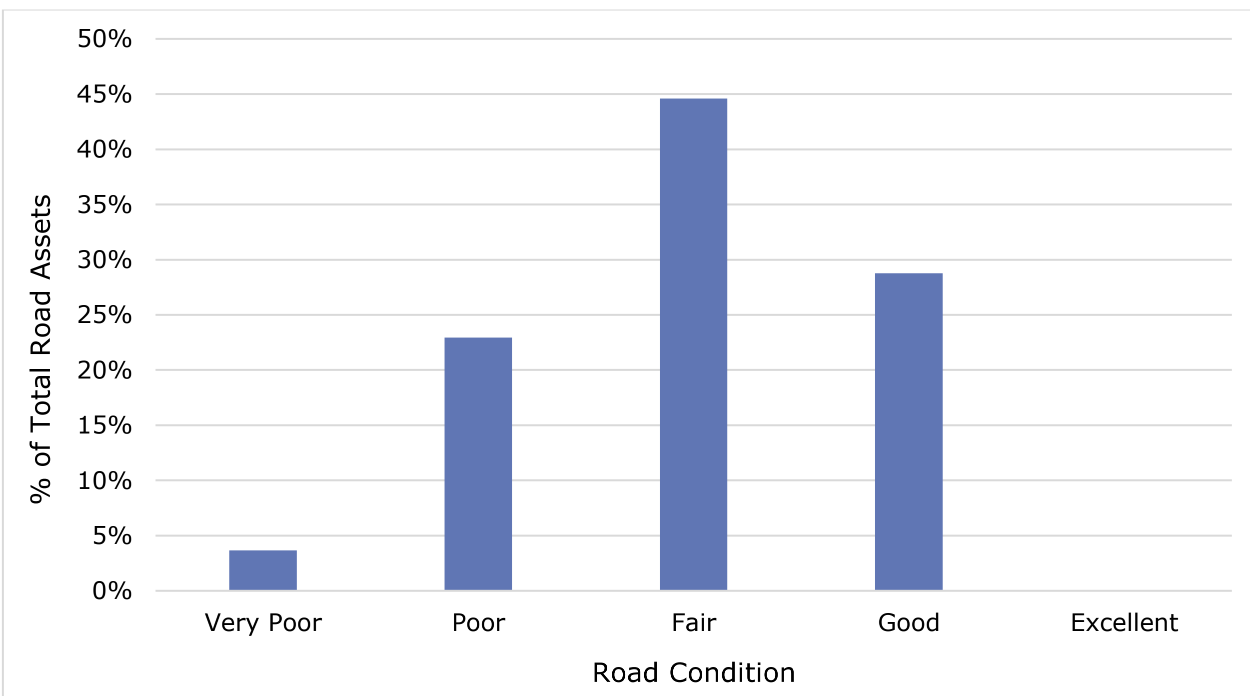
3.5.1 Inventory, Condition and Analysis

IMS Infrastructure Management Services (IMS) carried-out a detailed pavement condition assessment and road need analysis using their IMS pavement management program. The analysis provided information regarding measured road conditions, road classifications, construction cost estimates, construction needs, and critical road deficiencies. IMS compiled a list of the City roads in order of their priority rating with respect to reconstruction and/or rehabilitation.

In the past, City road need assessments were done visually in a very generalized and subjective manner, which yielded varying results. The approach used by IMS was fully automated and consistent as the detailed distress and roughness survey used was consistent with the Ministry of Transportation and Ontario Good Road Association's methodologies.

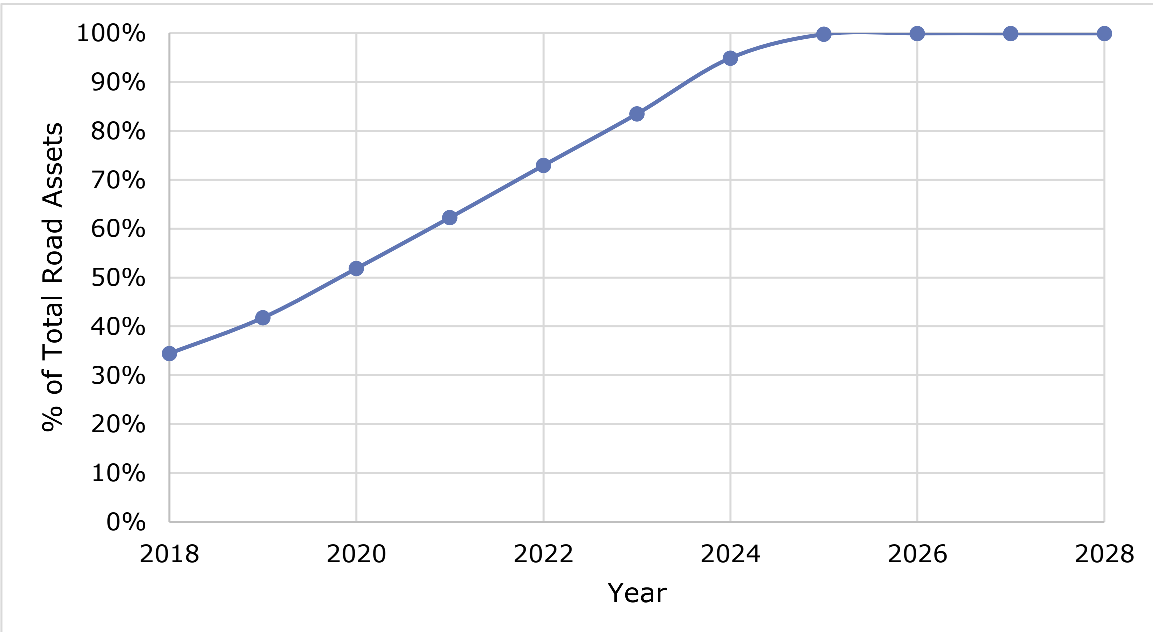
The state of the City's road infrastructure is shown in Figure 26 below.

Figure 26 State of Road Network



From the surface distress and roughness data collected by IMS a distress manifestation index (DMI) and riding comfort index (RCI) were determined. These indices were then combined into an overall pavement condition index (PCI), which provides an overall condition rating for each section of road. Based on the PCI rating of each road, a priority list of road reconstruction and/or rehabilitation needs was compiled.

Figure 27 Percentage of Road Network below Minimum PCI



3.5.2 System Expansion

The City is currently in the process of carrying-out its transportation master plan study. In this study, the future road expansion needs will be assessed based on the future growth opportunities and population projections. The outputs and recommendations from this plan will be incorporated into future iterations of this AMP.

3.5.3 Data flow verification policy

The City plans to carry out the road assessment and needs study for its entire road network in phases over a 5-year interval. This AMP will be updated to reflect the actual conditions and needs of the road network as data becomes available.

Some of the results of the pavement assessment are included in this plan as annexures.

3.6 Bridges and Culverts

The City hired Engineered Management Systems Incorporated (EMS) in 2014 to carry out inspections and assessments of all its bridges and culverts in accordance with the Ontario Structure Inspection Manual. The bridge and culvert assessments conducted by the City every two years as mandated by the Public Transportation and Highway Improvement Act. In their reports, EMS also prepared a 20 year capital improvement plan for all the City's bridges and culverts using the Bridge Management System program.

The study reports contain a summary of findings, recommendations, and prioritization of rehabilitative maintenance for each bridge and culvert structure in the City of Sarnia. A summary of the bridge and culvert report findings are attached to this plan as annexures.

Tables 15 and 16 summarize the key aspects of the City of Sarnia's bridge and culvert inventory.

Table 15 Summary of Bridge Inspections

Bridge ID Number	Bridge Name	Condition Index	Last Inspection Date
10	Old Lakeshore Road Over Cow Creek Bridge	98.7	August 2018
20	Telfer Sideroad Over Perch Creek Bridge	91	August 2018
30	Michigan Avenue Over Cow Creek Bridge	92	August 2018
40	Michigan Avenue Over Cow Creek Bridge	78.6	August 2018
50	Michigan Line Over Drainage Canal Bridge	90.4	August 2018
60	Blackwell Sideroad Over Perch Creek Bridge	50.3	August 2018
70	Jackson Road Over Drainage Canal Bridge	81.1	August 2018
90	Telfer Sideroad Over Perch Creek Bridge	0	August 2018
100	Scott Road Over Talfourd Creek Bridge	87.4	August 2018
110	Scott Road Over Cut-Off Drain Culvert	96.5	August 2018
150	Kenny Street Bridge	42.7	August 2018
160	Donohue Bridge	56.8	August 2018
180	River Road Over CSX & Local Road Bridge	95	August 2018
190	Michigan Road Over Broughton Drain Culvert	100	August 2018
210	Finch Drive Culvert	100	August 2018
220	Wellington Street Culvert	0	August 2018
230	Confederation Line Over Portor Creek Bridge	96.7	August 2018
240	Confederation Line Over Perch Creek Bridge	0	August 2018
250	Confederation Line Over Waddel Creek Bridge	0	August 2018
260	Telfer Road Over Waddel Creek Culvert	0	August 2018
270	Waterworks Road Over Waddel Creek Bridge	0	August 2018
280	Brigden Road Over Perch Creek Culvert	100	August 2018
290	Marshall Line Over Perch Creek Culvert	0	August 2018
300	McGregor Sideroad Over Cole Drain Culvert	0	August 2018
320	Vidal Street Walkway Bridge	3.1	August 2018
NC_01	Howard Watson Nature Trail Over Drain Culvert	100	August 2018
NC_02	Road To Lambton College Over Johnson Drain Culvert	100	August 2018
NC_03	Road To Lambton College Over Johnson Drain Culvert	34.1	August 2018
NP_01	Trail Over Perch Creek Bridge	0	August 2018
NP_02	Howard Watson Nature Trail Over Cow Creek Bridge	0	August 2018
NP_03	Howard Watson Nature Trail Over Perch Creek Bridge	98.7	August 2018

Table 16 Bridge and Culvert Capital Needs

Bridge ID Number	Bridge Name	Replacement Cost	Estimated Rehabilitation Cost
10	Old Lakeshore Road Over Cow Creek Bridge	$1,456,000.00	$19,000.00
20	Telfer Sideroad Over Perch Creek Bridge	$1,636,000	$147,000
30	Michigan Avenue Over Cow Creek Bridge	$1,283,000	$102,000
40	Michigan Avenue Over Cow Creek Bridge	$1,713,000	$378,000
50	Michigan Line Over Drainage Canal Bridge	$1,535,000	$148,000
60	Blackwell Sideroad Over Perch Creek Bridge	$2,213,000	$1,100,000
70	Jackson Road Over Drainage Canal Bridge	$1,742,000	$329,000
90	Telfer Sideroad Over Perch Creek Bridge	$1,133,000	$1,296,000
100	Scott Road Over Talfourd Creek Bridge	$451,000	$57,000
110	Scott Road Over Cut-Off Drain Culvert	$572,000	$20,000.00
150	Kenny Street Bridge	$1,996,000	$1,143,000
160	Donohue Bridge	$30,078,000	$12,995,000.00
180	River Road Over CSX & Local Road Bridge	$8,097,000	$402,000
190	Michigan Road Over Broughton Drain Culvert	$139,000	$0.00
210	Finch Drive Culvert	$530,000	$0.00
220	Wellington Street Culvert	$1,137,000	$0.00
230	Confederation Line Over Portor Creek Bridge	$357,000	$422,000
240	Confederation Line Over Perch Creek Bridge	$1,443,000	$47,000.00
250	Confederation Line Over Waddel Creek Bridge	$638,000	$678,000
260	Telfer Road Over Waddel Creek Culvert	$415,000	$453,000
270	Waterworks Road Over Waddel Creek Bridge	$309,000	$340,000
280	Brigden Road Over Perch Creek Culvert	$178,000	$414,000
290	Marshall Line Over Perch Creek Culvert	$439,000	$0.00
300	McGregor Sideroad Over Cole Drain Culvert	$248,000	$82,000
320	Vidal Street Walkway Bridge	$1,090,000	$1,526,800
NC_01	Howard Watson Nature Trail Over Drain Culvert	$193,000	$187,000
NC_02	Road To Lambton College Over Johnson Drain Culvert	$254,000	$0.00
NC_03	Road To Lambton College Over Johnson Drain Culvert	$849,000	$0.00
NP_01	Trail Over Perch Creek Bridge	$167,000	$110,000
NP_02	Howard Watson Nature Trail Over Cow Creek Bridge	$1,379,000	$1,512,000
NP_03	Howard Watson Nature Trail Over Perch Creek Bridge	$1,005,000	$1,083,000
Total Costs		**$64,675,000.00**	**$24,990,800.00**

4. Desired Levels of Service

The expected levels of service for linear infrastructure assets were determined based on the 'Initial Inventory Assessment and Identification of Capital Needs for Linear Assets Report' completed by Dillon Consulting Limited in 2006 and discussions that took place in asset management committee meetings. For the purposes of this AMP, the following desired service level criteria for replacement and rehabilitation of various linear infrastructure assets were adopted.

Service levels continue to be a part of asset management committee meeting discussions. Future iterations of this AMP will be updated to reflect any changes.

Table 17 Linear Infrastructure Service Level Thresholds

Improvement	Road (Arterial)	Road (Collector)	Road (Local)	Water	Sanitary	Storm
Rehabilitation	≤55	≤50	≤45	≤70	≤60	≤60
Replacement	≤45	≤35	≤30	≤30	≤20	≤20

The City aims to achieve major reductions in the number of combined sewer overflows and basement flooding events. The City also aims to provide adequate fire flows and pressures throughout the entire water distribution system.

In recent years, the City has made significant progress in mitigating the combined sewer overflows and the basement flooding by carrying out its sewer separation programs. The City is pleased to report that these sewer separation programs have resulted in improved quality in the St. Clair River.

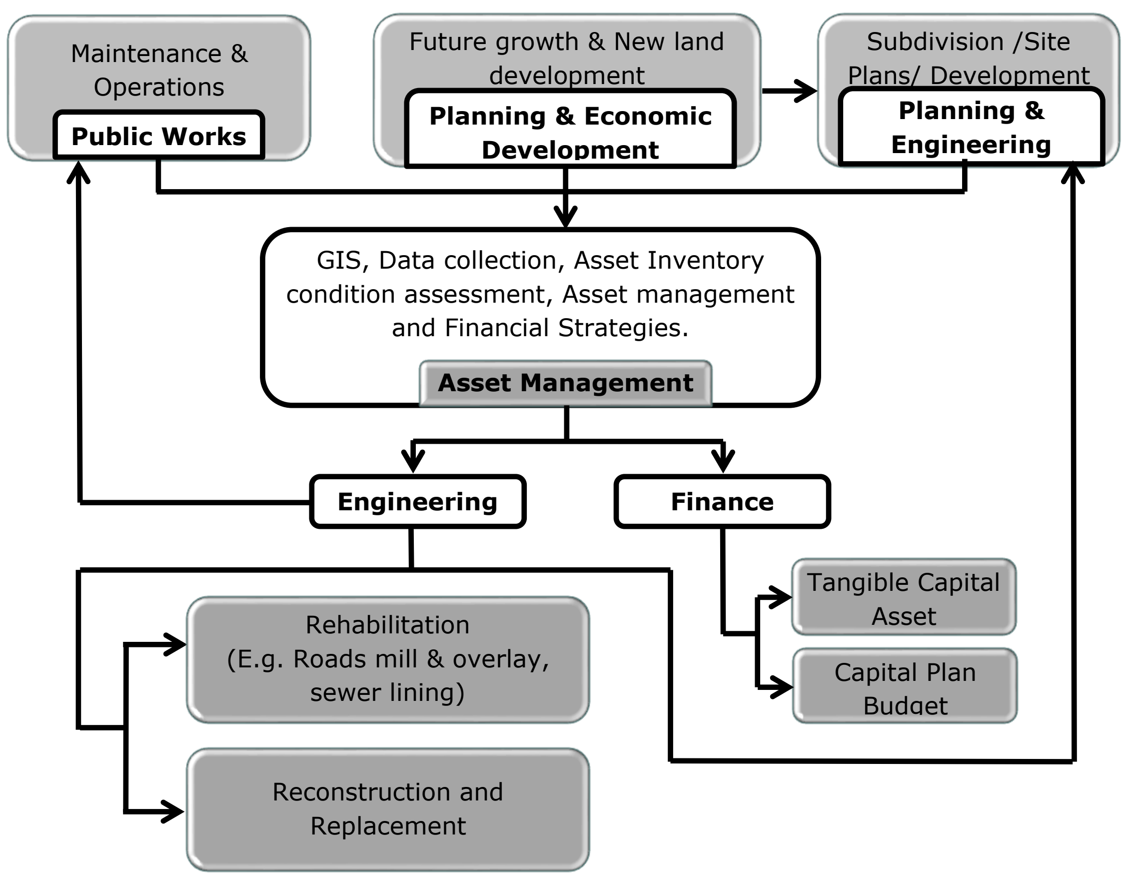
Over the next 10 years, the City plans to significantly reduce the number of watermain breaks from the current level of over 28 breaks per 100 kilometres per year.

5. Asset Management Strategy

5.1 Organization Overview of Asset Management Strategy

At an organization level, the City of Sarnia's asset management process for the core infrastructure services involves interactions among various departments within the Corporation. The interactions and decision-making processes are shown in the flow chart below. Information relating to maintenance, operation, and repair activities (completed through maintenance management system), and condition assessment data, future growth, and subdivision and site plan development (completed through modelling and the master planning process) all flow into the asset management system. The output from the asset management plan will serve as a framework for the City's capital project planning, capital project financial planning, reconstruction and rehabilitation strategies, and maintenance, operation, and repair activities.

Figure 28 City of Sarnia Asset Management Strategy Flowchart



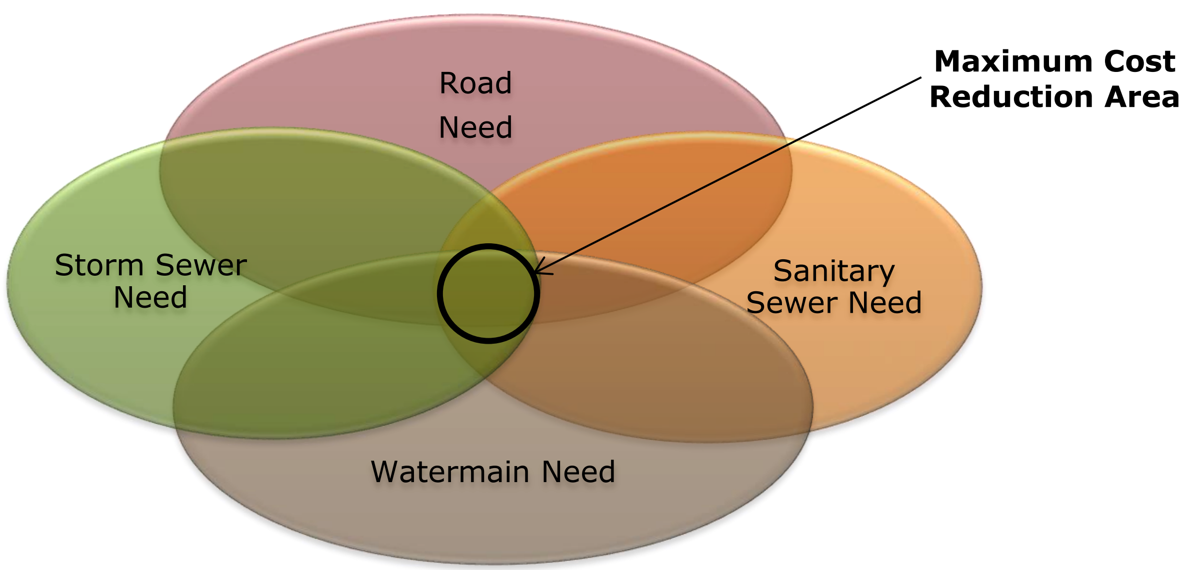
The City's maintenance management system is currently in the process of being implemented. Once the system is implemented, it will be fully integrated with the asset management process. The City is also in the process of carrying out water distribution system and transportation system master planning studies.

5.2 Integrated Approach for Linear Infrastructures

The City of Sarnia owns, operates, and maintains all of the major core infrastructures within the right of way. In order to make the most cost-effective decisions for the reconstruction and rehabilitation of infrastructure assets, it is extremely beneficial to use an integrated approach.

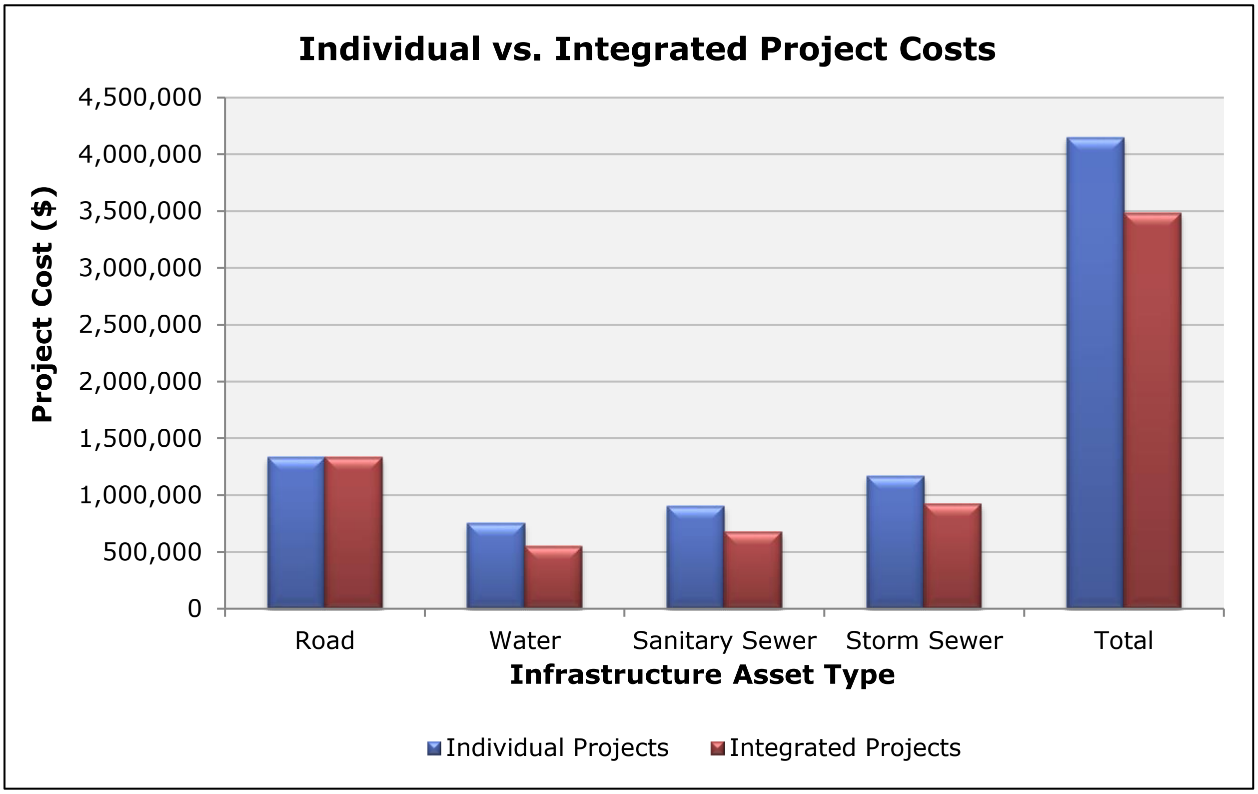
An integrated approach involves simultaneously analyzing assets that are located in a close proximity to each other, such as a road and the buried infrastructure beneath it (i.e. watermains, sanitary sewers, and storm sewers).

Figure 29 Integrated Approach for Linear Infrastructures



Based on this integrated approach, the reconstruction of infrastructure assets requiring attention can be either postponed or accelerated in order to coordinate the timing with other improvement projects nearby. The integration of road and buried infrastructure projects provides significant reductions in overall capital projects costs when compared to replacement projects involving only one asset type. Figure 30 provides an illustration of the costs saving afforded by the integration of different types of infrastructure projects.

Figure 30 Sample Project Replacement Cost



5.3 Planned Actions

5.3.1 Non-infrastructure Solutions

The wastewater collection system analysis recently completed by Stantec Consulting Limited has revealed that the City's wastewater system has major storm runoff inflow and infiltration (I/I) issues. During a rainfall event the flow within the wastewater collection system is much higher than expected, even in separated sewer areas. Higher than expected flows during rain events puts unanticipated strain on the downstream infrastructure, including pumping stations and wastewater treatment facilities. Staff members in the Engineering Department are currently establishing a plan for the reduction of inflow and infiltration issues.

Some of the measures recommended for reduction of I/I are as follows:

i. Roof leader disconnection programs,
ii. Green programs for reducing storm water runoff,
iii. Sump pump disconnection from sanitary to storm sewers, and,
iv. Flow monitoring programs to isolate and identify the areas contributing runoff inflows into the system.

The City has revised its stormwater management standards to include the potential impacts of climate change, as well as to incorporate low impact stormwater management practices for new developments.

5.3.2 Maintenance, Renewal, and Rehabilitation

5.3.2.1 Road Network

Currently, the City carries out regular maintenance activities on its road network based on minimum maintenance standards and customer complaints. This AMP recommends carrying out preventive maintenance activities based on windows of opportunity.

Currently, the City carries out road rehabilitation and/or resurfacing when the road surface conditions fall below minimum acceptable levels. Due to funding limitations, no road reconstruction projects have traditionally been done without being integrated with the replacement of other infrastructure assets beneath and/or in close proximity to the road in need.

In Table 18, specific road maintenance, rehabilitation, and reconstruction options have recommended based on the remaining service life of the road section and/or the window of opportunity provided by other infrastructure assets in close proximity.

Table 18 Road Treatment Options/Alternatives

	Activities	Trigger In Years			Average Unit Price/Meter
		Arterial	Collector	Local	
Maintenance	1st Rout & Seal	10	12	14	-
	2nd Rout & Seal	16	17	18	-
Rehabilitation & Reconstruction Options	Resurfacing (Top Layer)	20	21	22	$225.81
	Complete Asphalt Replacement (Top & Bottom Layers)	22	23	24	$369.20
	Minor Rehabilitation (Top and Bottom Layers) with spot curb and gutter repairs	24	25	26	$401.20
	Major Rehabilitation (Top and Bottom Layers) with full curb and gutter repairs	26	27	28	$601.20
	Major Reconstruction	28	31	34	$1,320.24

As a part of this AMP, the maintenance options recommended in Table 18 are to be carried out on a regular basis rather than on the traditional as-needed basis.

Both the rehabilitation and reconstruction options have the effect of extending the service life of the particular section of road by varying degrees. Therefore, rehabilitation options will be implemented for individual sections of road within the window of opportunity according to the current road conditions and the desired service life extension.

Figures 31 to 35 illustrate the extension of road service life and estimated cost per running meter for local roads corresponding to each of the rehabilitation and reconstruction options recommended in Table 18.

Figure 31 Deterioration Curve Road Rehabilitation Option 1

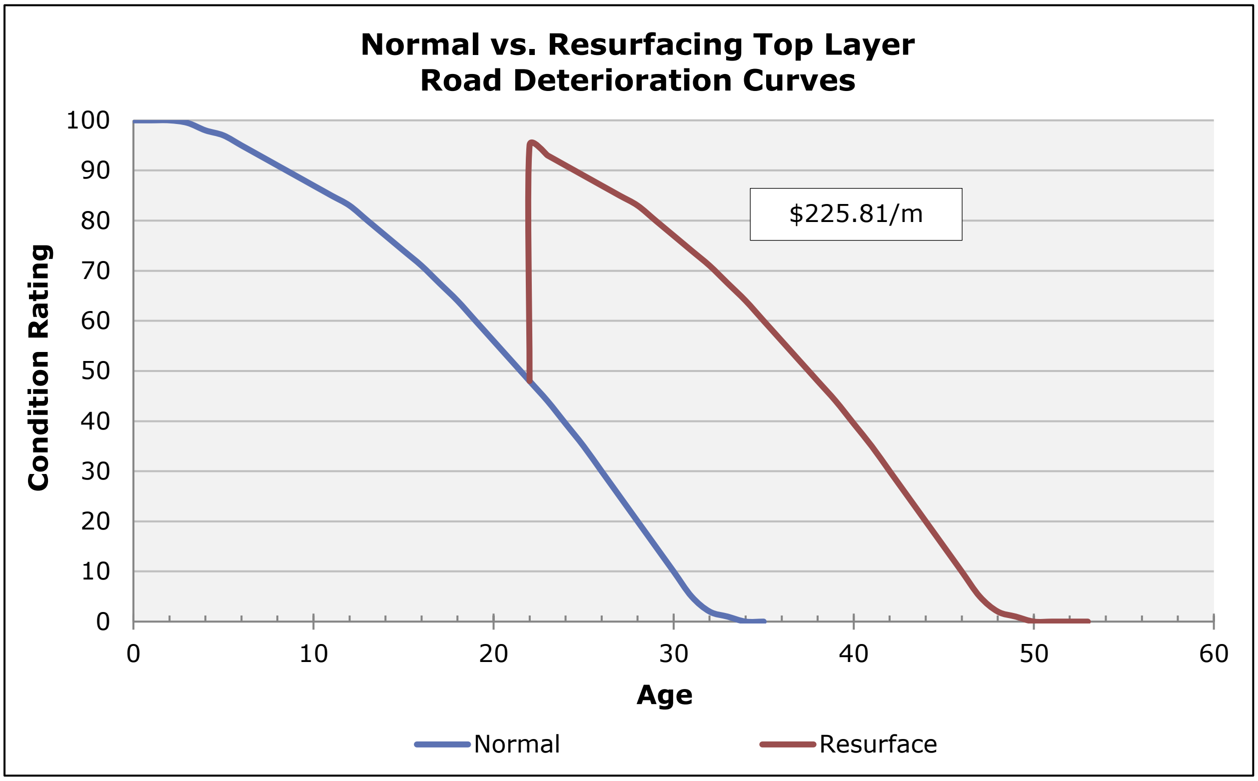


Figure 32 Deterioration Curve for Road Rehabilitation Option 2

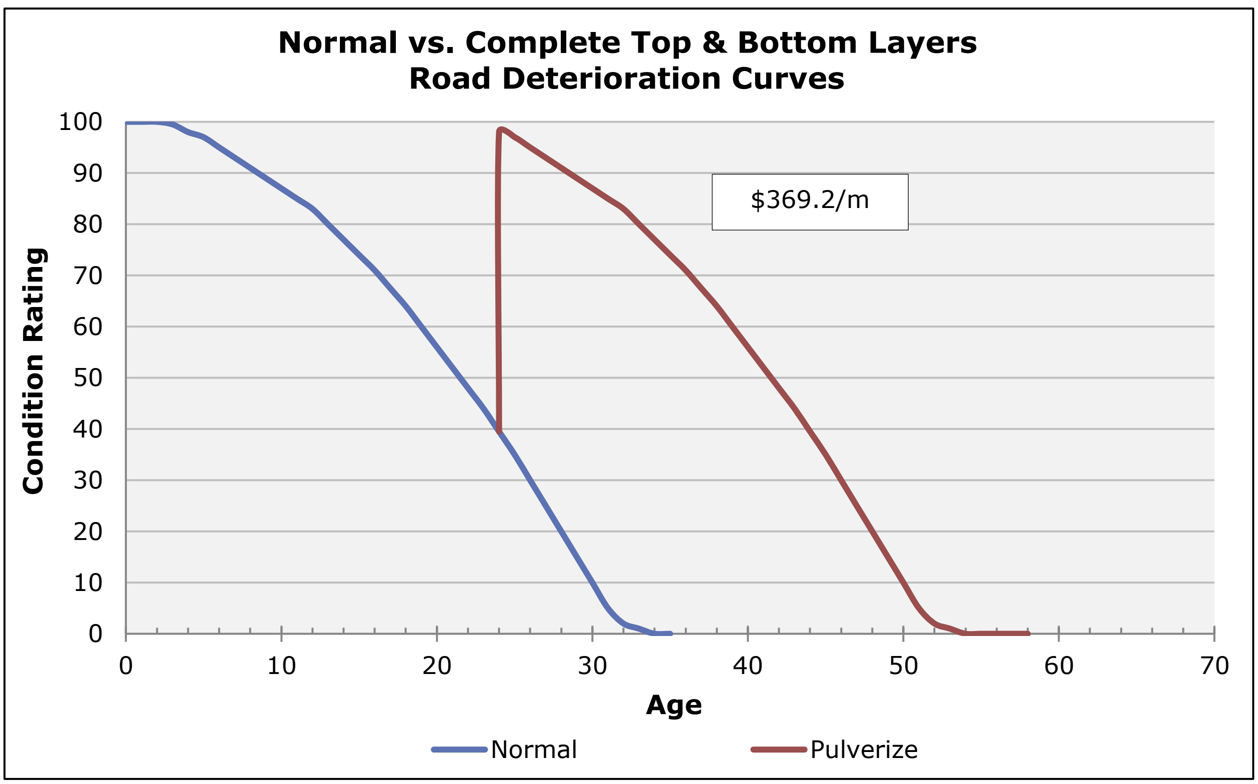


Figure 33 Deterioration Curve for Road Rehabilitation Option 3

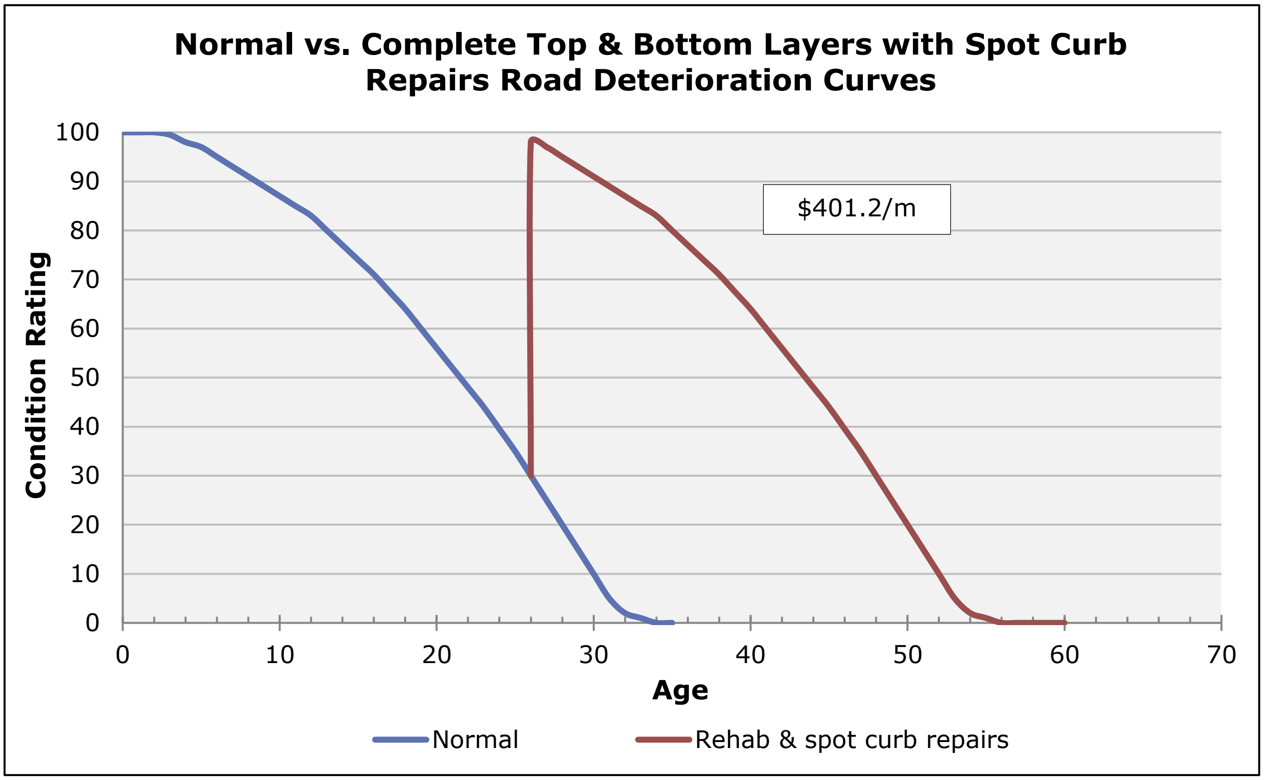


Figure 34 Deterioration Curve for Road Rehabilitation Option 4

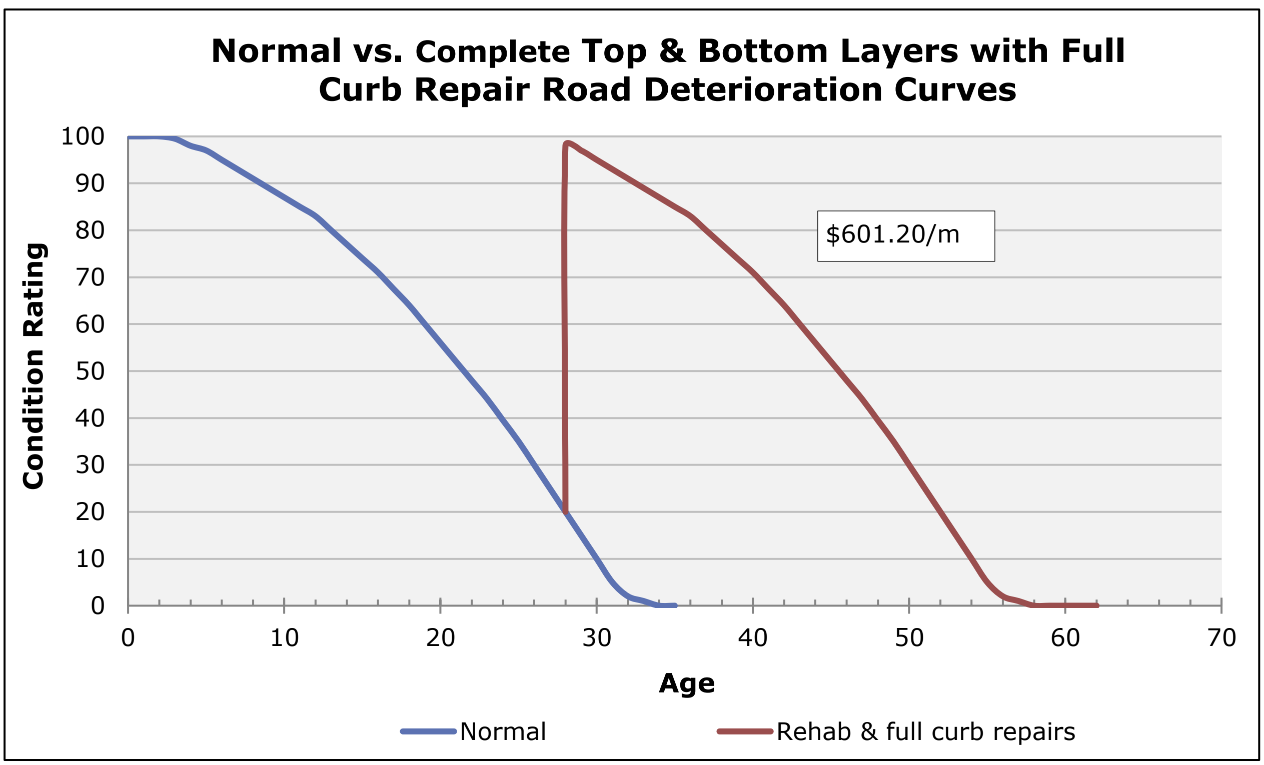
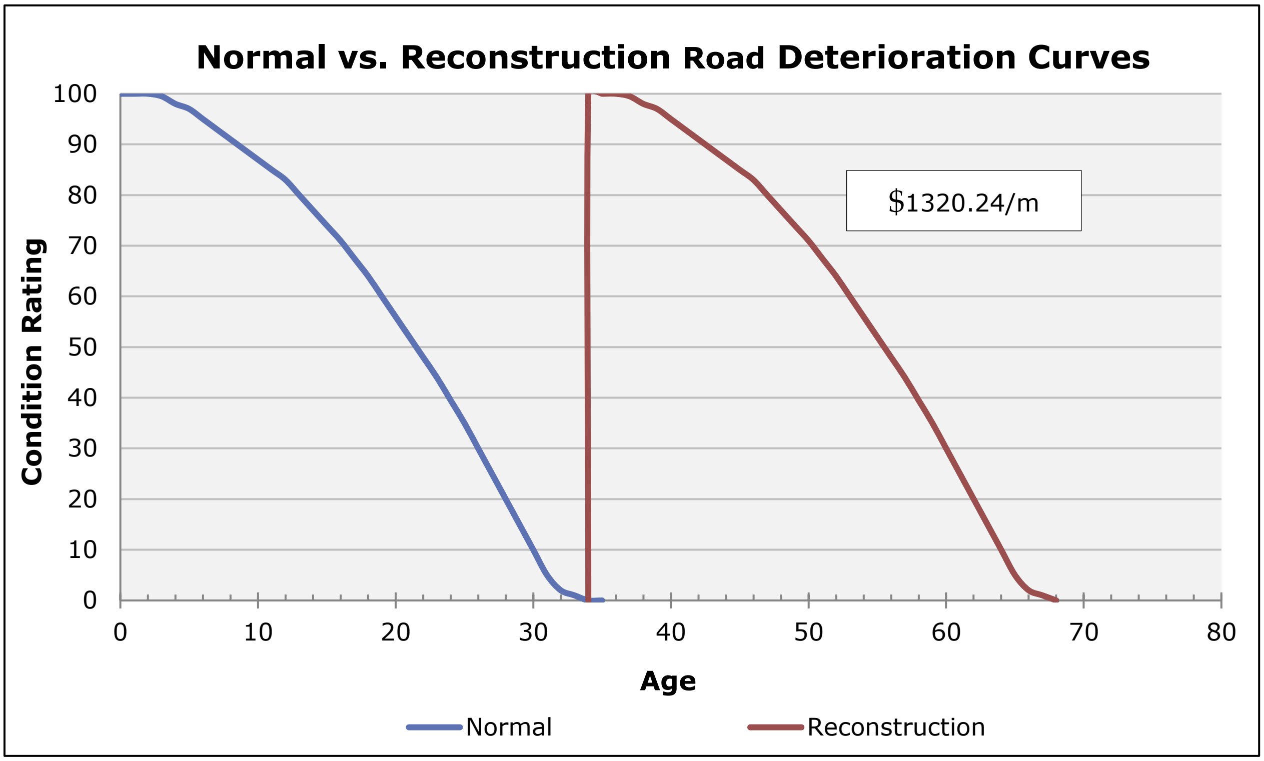


Figure 35 Deterioration Curve for Road Reconstruction



The following strategies have been proposed for future road rehabilitation and replacement projects based on the overall condition of the road:

I. Resurface the top asphalt layer once, and then carry out one complete asphalt surface replacement (both the top and bottom layers) until other assets in close proximity are due for reconstruction.

II. Resurface the top asphalt layer once, and then carry out one complete asphalt surface replacement (top and bottom layer) with spot curb repairs until other assets in close proximity are due for reconstruction.

III. Resurface the top asphalt layer once, and then carry out two complete asphalt surface replacements (top and bottom layer) until other assets in close proximity are due for reconstruction.

IV. Resurface the top asphalt layer three times until other assets in close proximity are due for reconstruction.

V. Resurface the top asphalt layer twice, and then carry out one complete asphalt replacement (top and bottom layer) until other assets in close proximity are due for reconstruction.

Figures 36 to 40 illustrate the extension of road service life and estimated cost per running meter for each strategy previously described. A strategy cost analysis can be found in Table 19.

Figure 36 Proposed Strategy I for Road Rehabilitation

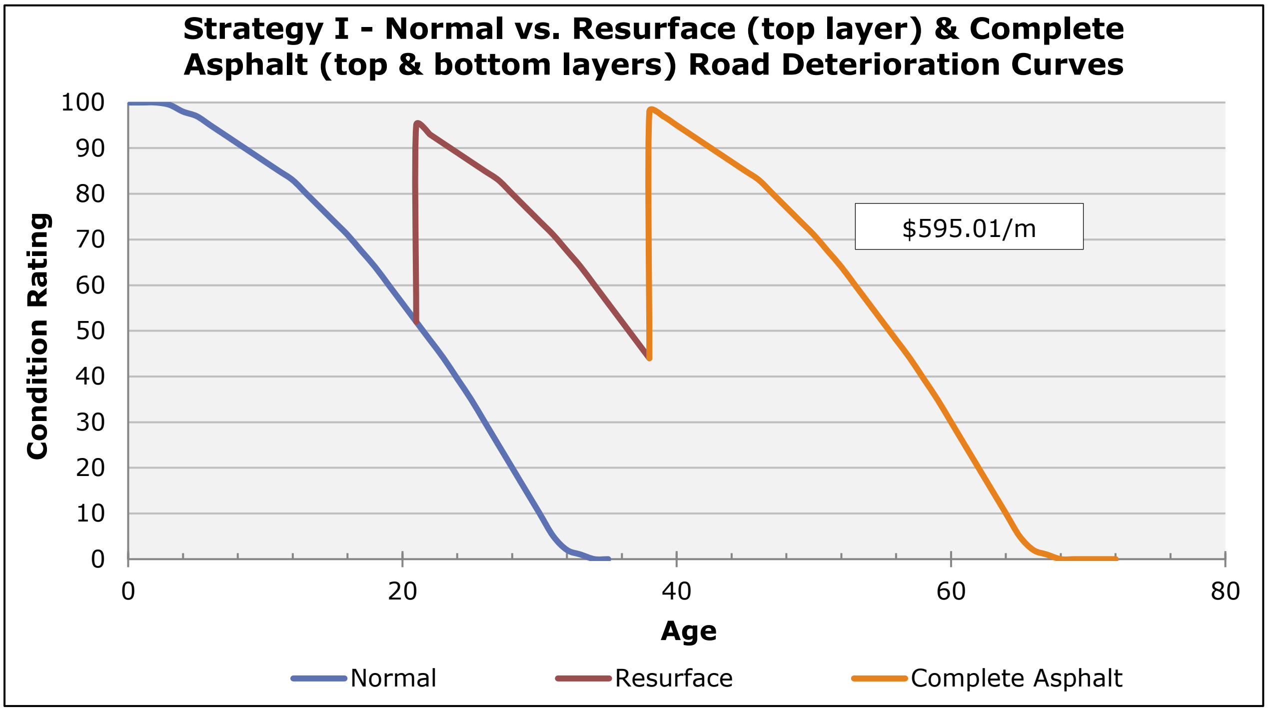


Figure 37 Proposed Strategy II for Road Rehabilitation

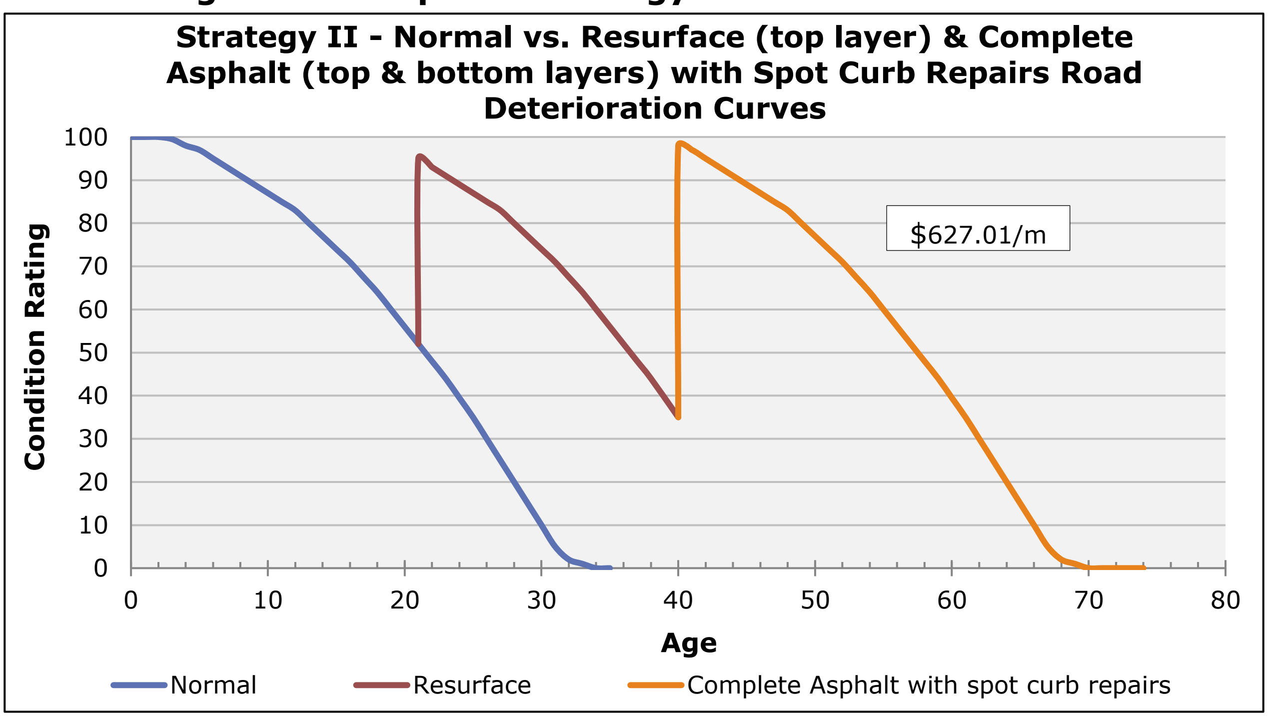


Figure 38 Proposed Strategy III for Road Rehabilitation

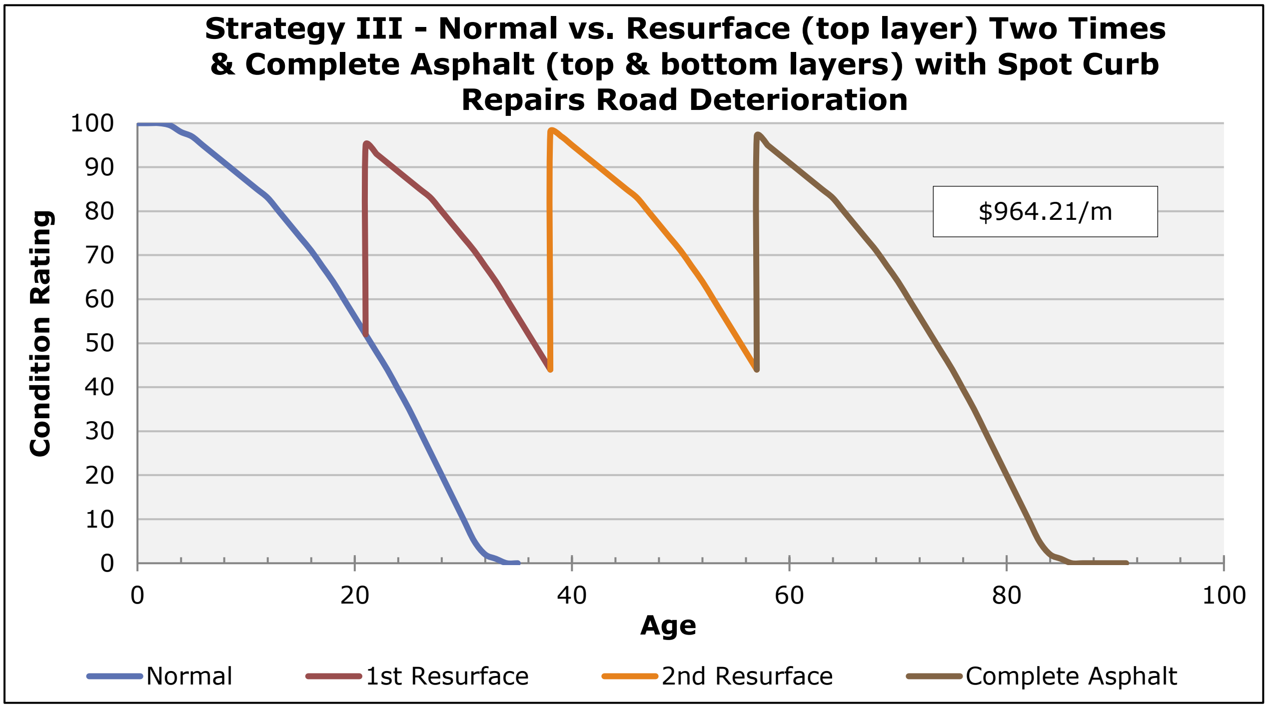


Figure 39 Proposed Strategy IV for Road Rehabilitation

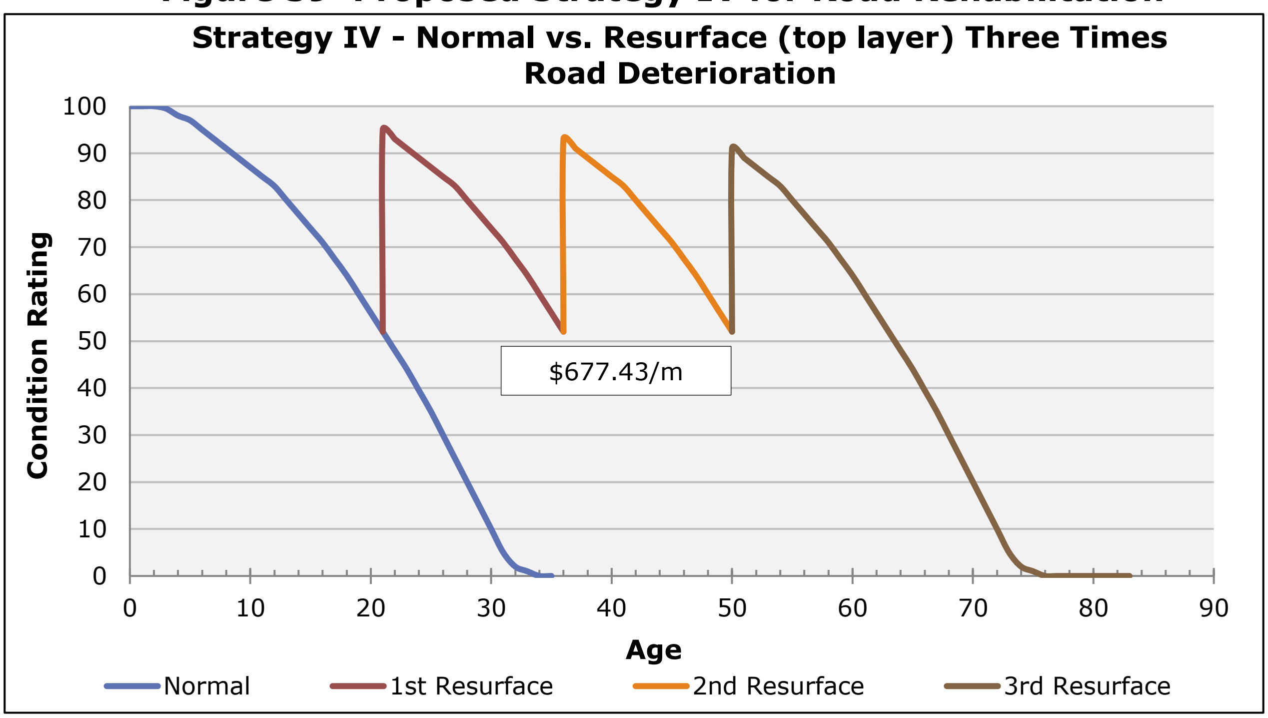


Figure 40 Proposed Strategy V for Road Rehabilitation

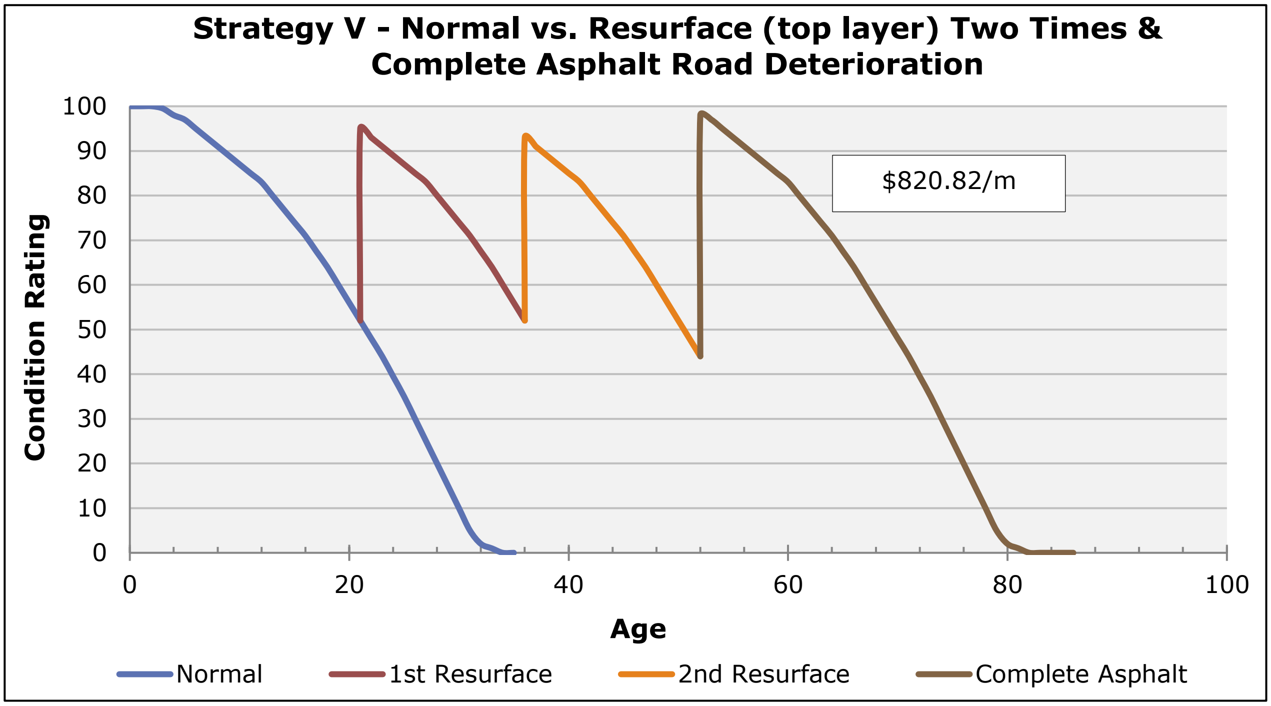


Table 19 Rehabilitation Strategies for Roads

No.	Description Of Strategy	Unit Cost Per Meter	Extended Road Service Life	Unit Cost/ Service Life
I	Resurfacing (top layer) at 21 years + Complete asphalt (top & bottom layers) at year 38	$595.01	34 years	$17.50/year
II	Resurfacing (top layer) at 21 years + Complete asphalt (top & bottom layers) with spot curb repairs at year 40	$627.01	36 years	$17.42/year
III	Resurfacing (top layer) at 21 years + Complete asphalt (top & bottom layers) at year 38 and year 57, respectively	$964.21	52 years	$18.54/year
IV	Resurfacing (top layer) at year 21, year 36, and year 50, respectively	$677.43	42 years	$16.13/year
V	Resurfacing (top layer) at year 21 and year 36, respectively + Complete asphalt at year 52	$820.82	48 years	$17.10/year

Based on the road deterioration curves and the strategy cost table provided above, Strategy IV appears to be the most economical for road only projects. Additional strategies for integrated infrastructure asset projects will need to be explored in subsequent revisions of this AMP, as the City prefers to replace multiple types of infrastructure assets that are in close proximity to one another simultaneously.

5.3.2.2 Sewer Network

Separating the existing combined sewers has been one of the City's major focuses since 2004, as poor water quality in the St. Clair River and basement flooding are known to result from combined sewer overflows.

Environment Canada currently lists the St. Clair River in Sarnia as an area of concern for receiving water quality, and as such reducing polluting outflows from combined sewers is of high priority. The 'St. Clair River Remedial Action Plan' recommends that sewer separation work be undertaken by the City of Sarnia as soon as possible.

The objectives of the sewer separation projects undertaken by the City are to improve the water quality in the St. Clair River and to mitigate basement flooding by reducing combined sewer overflows.

Given that majority of the combined sewers are located in the core area of the City, sewer separation projects will markedly reduce the number of basement flooding events in this area. In order to achieve the City's objective of complete sewer separation, all of the existing combined sewers will be replaced with a new storm sewer line and a new sanitary sewer line that are completely independent of one another.

Given its proximity to all other linear infrastructure assets, a combined sewer project will generally include the complete reconstruction of all infrastructures within the right of way: Complete reconstruction would include the installation of a new storm sewer, a new sanitary sewer, new watermains, new roads, new curbs and gutters, new sidewalks, etc.

In addition to the sewer separation programs, the City of Sarnia has also initiated concrete sewer relining programs for sewers with 500mm diameters or greater. Concrete sewer relining is a cost effective way of extending the service life of concrete sewers.

The City is currently exploring two different concrete sewer relining strategies, non-structural and structural relining. Figures 41 to 43 serve to compare the extended service lives yielded by non-structural and structural relining technologies.

Figure 41 Sewer Non-Structural Relining Deterioration Curve

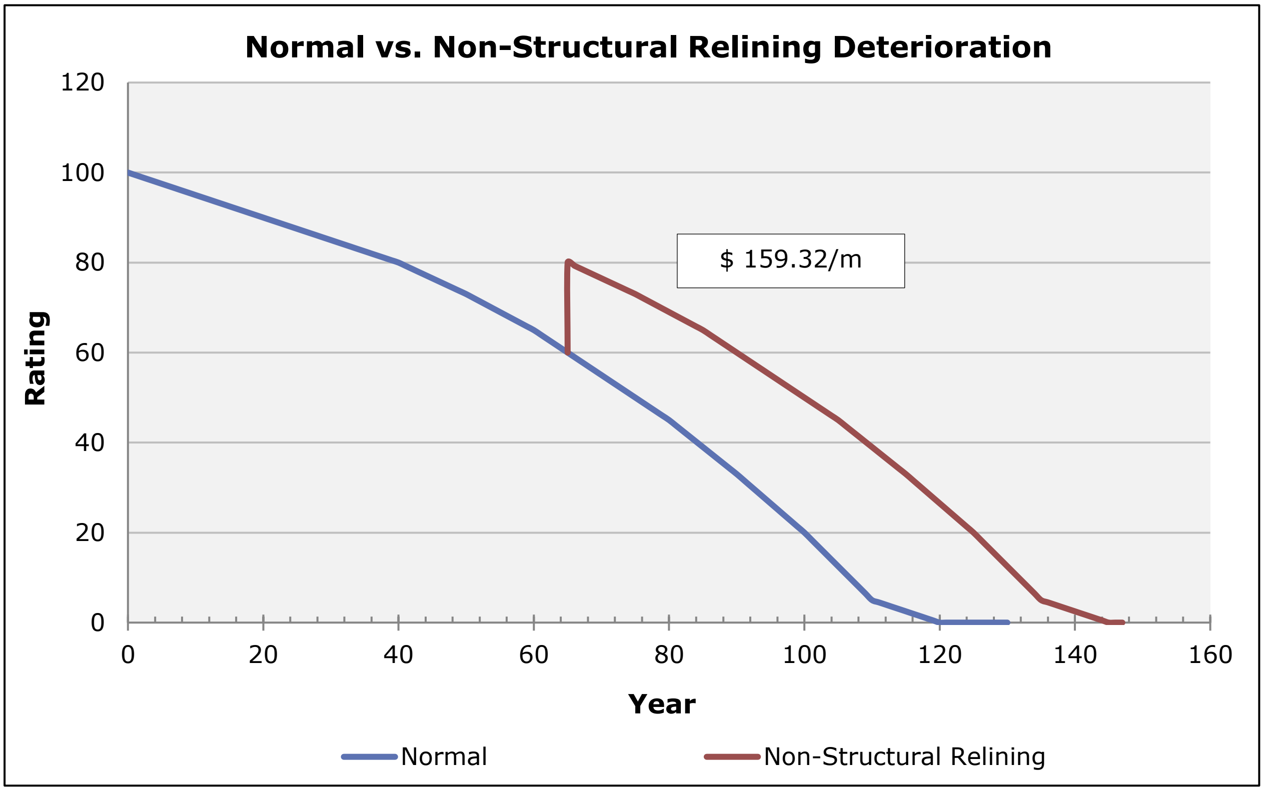


Figure 42 Sewer Structural Relining Deterioration Curve

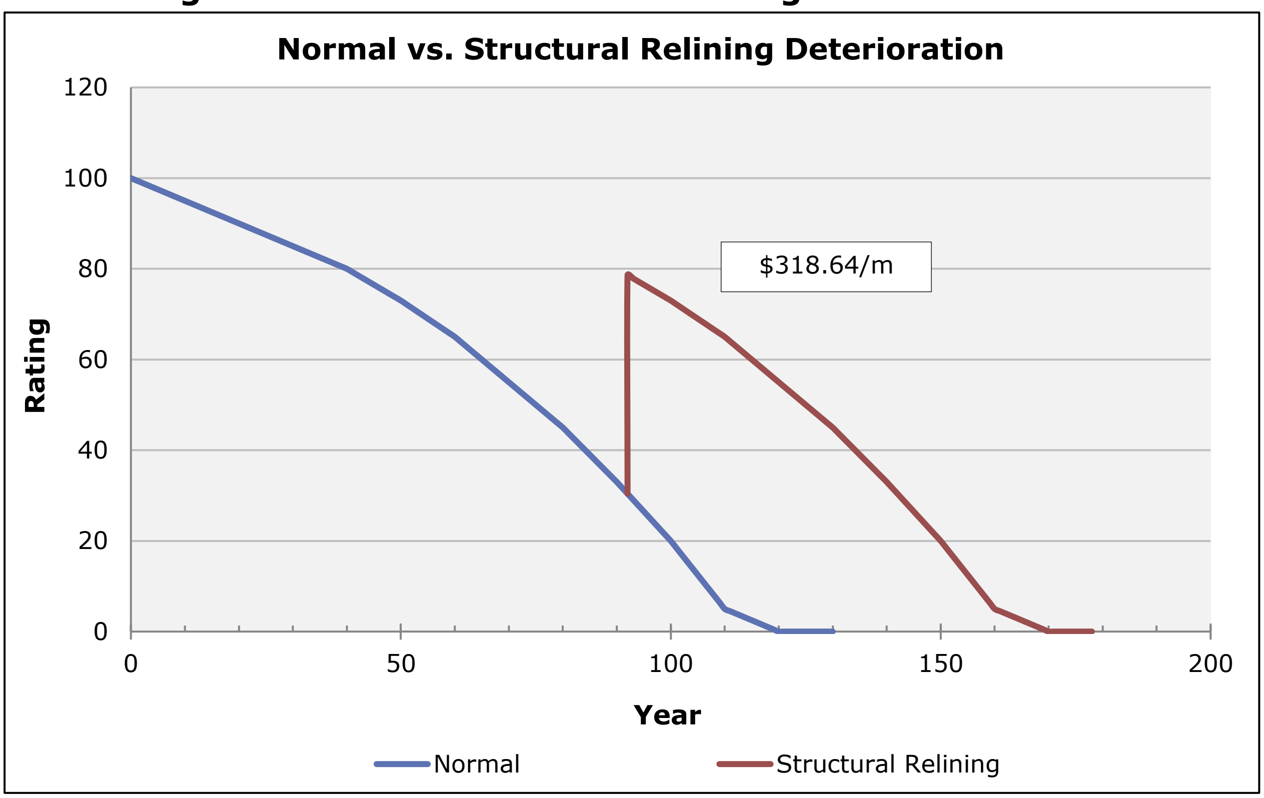


Figure 43 Sewer Reconstruction Deterioration Curve

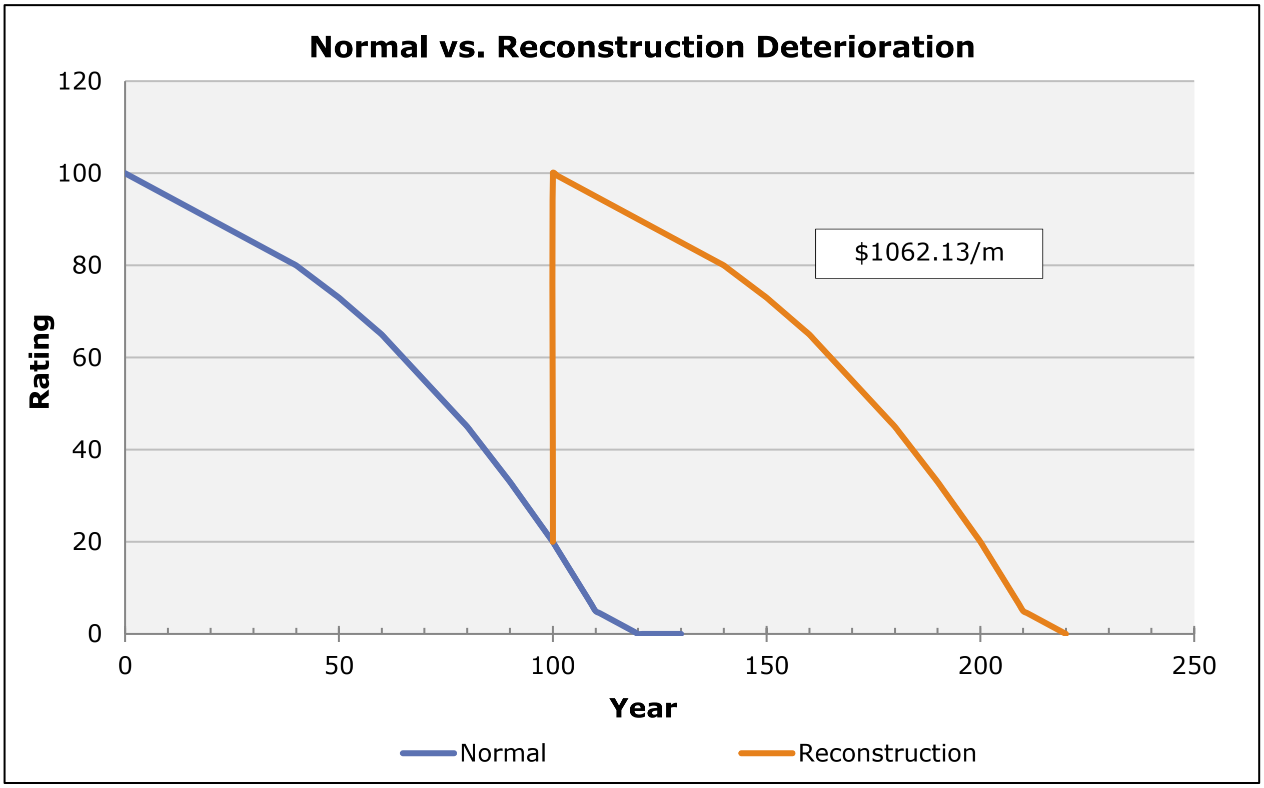


Table 20 provides an sample cost comparison between sewer relining and reconstruction. Based on the results shown in Table 20, it is recommended that the relining of concrete sewers continue based on windows of opportunity, as reconstruction is much more costly. Since sewer network condition assessments are currently ongoing, a revision of the sewer reconstruction and rehabilitation strategies will be required in the future, once the actual sewer conditions are known.

Table 20 Typical Cost of Sewer Rehabilitation Strategies

Option	Cost Per Meter For 500mm Concrete Sewer	Service Life Extension
Reconstruction	$1,062.13/m	100 years
Non-Structural Relining	$159.32/m	25 years
Structural Relining	$318.64/m	50 years

5.3.2.3 Water Network

The City has been exploring alternative technologies for the rehabilitation of watermains. Some of the technologies being considered include pipe-bursting, spray on coatings, and internal relining. Nevertheless, watermain rehabilitation is not common practice in the City of Sarnia for the following reasons:

1. The City of Sarnia is a relatively open area where trench excavations are easy to conduct without disturbing the surrounding environment and/or residences.
2. The City maintains the water distribution system and not the water supply system, therefore watermain sizes are typically not big enough for the application of rehabilitation activities.
3. The City staff have determined that replacing a watermain is actually a more economical and prudent option than the application of the rehabilitation techniques researched by the City thus far.

The City will continue to explore new watermain rehabilitation technologies in the future in order to ensure that only the most viable and economical options are pursued.

The City currently carries out regular watermain maintenance activities in order to ensure proper flow, pressure, age, and quality, as well as to help to extend the network service life. Table 21 lists the watermain maintenance activities conducted by the City in the past.

Table 21 Past Maintenance Activities for Watermains

Maintenance Activity	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Water Main Break Repair	171	113	85	113	150	88	98	104	105	98
Water Main Valve Replacement or Repair	23	27	17	21	22	15	30	43	31	20
Water Main BV Replacement or Repair	1	0	0	0	0	1	2	0	1	0
Valve Chambers Service	-	-	-	-	-	-	-	10	2	10
Service Repair (Excavation)			93	93	122	138	133	108	73	128
Lead Services Replacement	-	-	1	2	2	12	9	5	3	17
Hydrant Repair (Excavation)	7	10	14	13	13	11	13	20	9	8
Hydrant Repair (Internal)	-	-	177		103	121	91		42	20
Hydrant Repair (External)		0							24	14
Hydrant Internal Anode Repair		-							3	4
Hydrant Flushing	0	13	2560	2560	2560	2560	2560	2560	2599	2600
Excavation Exploration	-	-	-	-	3	0	2	0	6	1
Hydrant Back Flow Installation	4	-	24	26	35	38	32	40	37	51
Hydrant Checking After Fire Use	-	-								29
Valve Operation (Program & Repair)	-	-	-	-	-	-	-		420	641
Water Quality Inquiries	-	-	-	-	-	-	-	38	42	58
Water Pressure Inquiries	-	-	-	-	-	-	-	12	28	34
Monitor Re-Occurrence	-	-	-	-	-	-	-	7	9	5
Anodes Instalation	0	0	0	0	0	0	0	3	33	12
Accountable Water Loss	-				8.29 %	7.33 %	8.25 %	9.13 %	4.86 %	
Auto Flusher Instalation	0	0	0	0	0	1	2	0	1	1
Water Adverse Reports			1	0	0	1	0	0	2	
QA Water Testing (bacT)										7
Locates							-	-	-	3905

5.4 Risks Associated with the Strategies

The City recognizes that the accuracy of data is extremely crucial to the reliability of an asset management plan. In order to ensure that the data contained in the City of Sarnia's AMP is accurate and up to date, the City plans to continue the ongoing data collection programs, and to constantly update and refine the Sarnia infrastructure database as more data becomes available.

In the coming years, the City plans to collect up to date road maintenance data through the implementation of a works management system (WMS). The data collected through the WMS will aid in the creation of accurate road deterioration curves for various road classes within the City. In addition to this, a detailed road inspection survey of the City's road will be carried out every five years.

The City plans to implement flow-monitoring programs to further calibrate the water and sewer computer models further, and to measure the performance of combined sewer elimination programs and other sewer works projects. The City will continue closed circuit television (CCTV) inspections on the sewers to further update the sewer condition data and deterioration curves. This AMP will be updated to include actual deterioration curve data, and strategies will be revised accordingly as more data is collected and accuracy is improved. A contingency plan will be developed to address any risk associated with the employed strategies.

The bridge inspections will be carried-out every two years as per the provincial requirements.

5.5 Risk Analysis

Risk analyses are conducted for infrastructure asset types based on the consequence of failure and the potential of failure. Potential of failure is analysed by consulting companies during the condition assessment of assets, while consequence of failure is assessed based on the impact that failure would have on the six following factors:

1. Human health and safety,
2. The environment,
3. Finances,
4. Economic development,
5. Legislative requirements, and,
6. Performance

An analytical hierarchy process (AHP) was used to determine the consequence of failure index for each asset type. The weightages of each of the six factors were analyzed based on a pair-wise comparison method, and then each asset type was assigned a certain score from 0 to 10, where 10 represents the highest risk under each factor.

The top five priority projects across the asset types identified based on risk analyses are identified in Section 7 Recommendations.

6. Financing Strategy

6.1 Introduction

The financial strategy has been broken into two sections: One section for linear infrastructure assets and another for non-linear infrastructure assets.

By separating the linear infrastructure assets from those that are non-linear, this report can better illustrate how all the linear infrastructure components can be integrated within the right of way as recommended in the section of this report detailing the integrated approach to linear infrastructure management.

The current needs identified in the executive summary for linear and non-linear infrastructure are summarized in Tables 22 and 23 below.

Table 22 Current Need of all Linear Core Infrastructure Assets

Asset Type	% of Asset in Need	Estimated Cost	Length in Need (km)
Roads	7%	$46,350,705	68
Water Distribution Systems	22%	$78,600,778	110
Sanitary & Combined Sewers	24%	$75,840,526	84
Storm Sewers	24%	$101,345,457	76
Shoreline Protection	15%	$17,118,150	2
Total Needs		**$319,255,616**	

Table 23 Current Need of all Non Linear Core Infrastructure Assets

Asset Type	% if Asset in Need	Estimated Cost	Length in Need (km)
Forcemains	15%	$6,330,239	7
Pump Stations	0%	$25,453,249	-
Wastewater Treatment Facilities	0%	$8,300,000	-
Bridges	35%	$6,945,000	-
Total Needs		**$47,028,488**	

6.2 Funding Sources

The city utilizes the following funding sources for capital projects:

1. Federal gas tax,
2. Tax levy/operating,
3. Retired debt, and,
4. User fees (water and sewer fees)

Federal gas tax funding has been a stable source of funding for a variety of projects including complete road, water, sanitary sewer, and storm sewer reconstruction, pump station upgrades, and wastewater treatment facility upgrades. It is assumed that federal gas tax will continue to be a steady funding contributor for the duration of this financial plan.

Regular contributions have been transferred from the operating budget to reserves for capital spending. In 2009, the contribution transferred was $800,000, and in the 2013, the contribution was increased to $2,030,000. Growth of $100,000 per annum has been assumed in the financial plan so that by the end of the 20-year plan the estimated contribution will be $3,830,000.

Retired debt is another key component in the funding strategy. In prior decades, the majority of capital work was financed by debt. In the mid-2000s, a pay-as-you-go strategy was adopted. Now most projects are funded from city reserves and grants from the federal and provincial governments. As the debt is paid off, the City is re-directing debt payments to reserves. The re-directed debt payments in 2011 were $702,538. By 2020, the anticipated re-directed debt payments will be $3,520,373. By the end of the plan, re-directed payments are projected to be $4,818,673.

User fees consist of water and sewer charges, which are utilized for capital projects. A growth of 2% per year has been assumed for the purposes of this plan.

Projected linear asset funding sources are illustrated in Figures 44 to 47.

Figure 44 Linear Asset Funding Sources Breakdown 2014

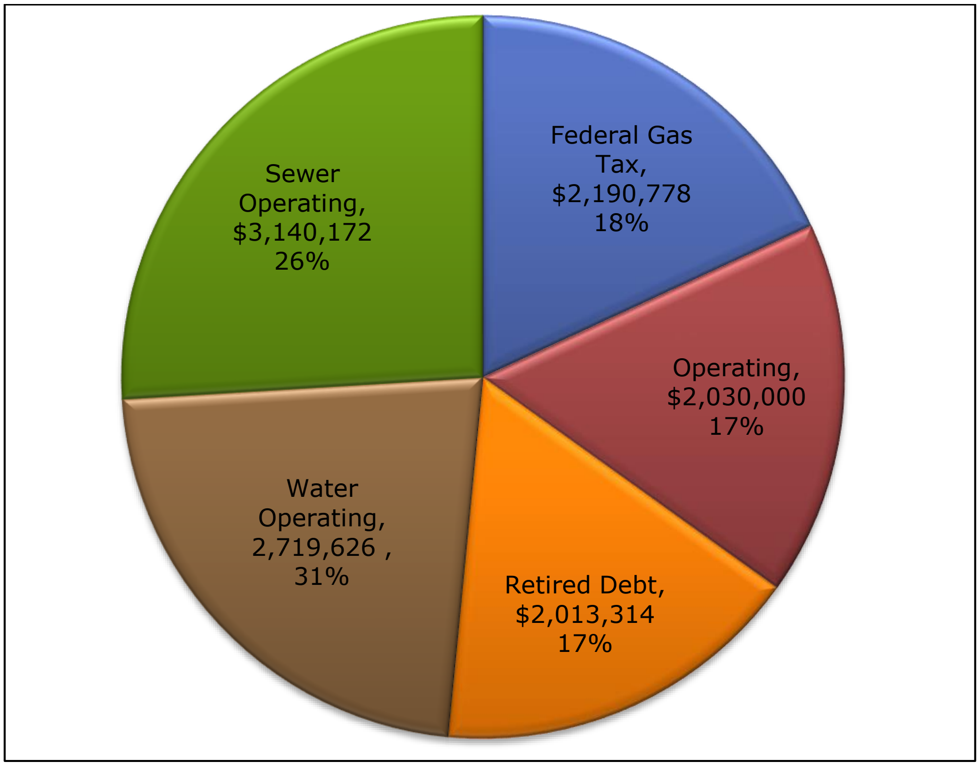


Figure 45 Linear Asset Funding Sources Breakdown 2019

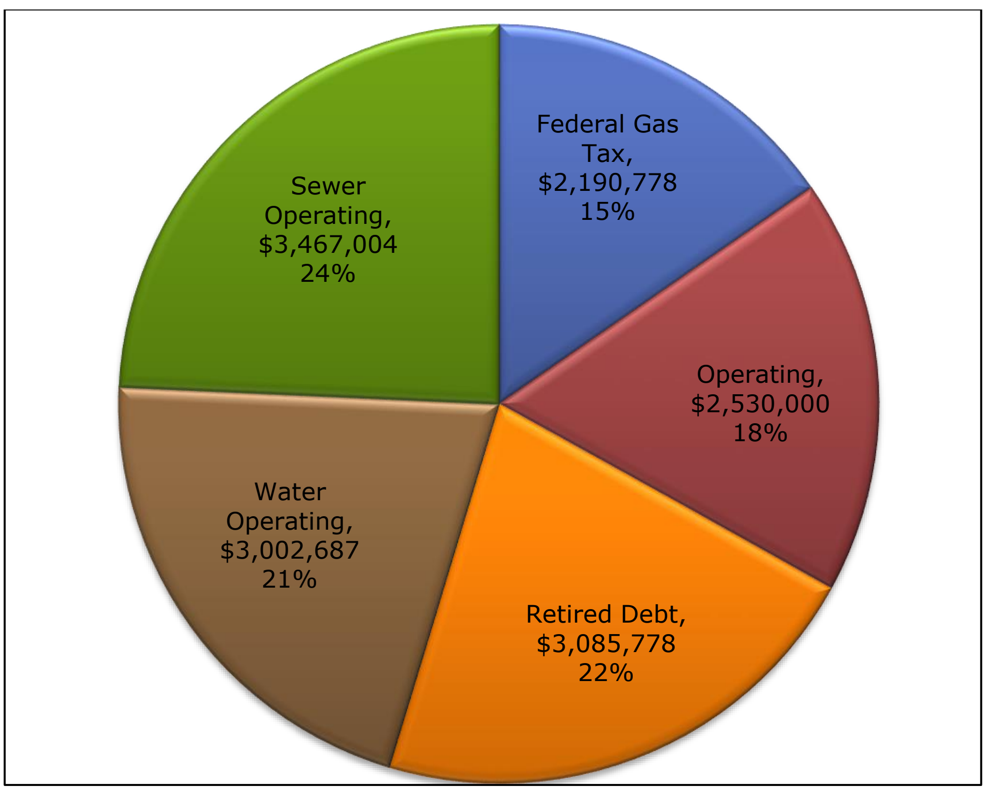


Figure 46 Linear Asset Funding Sources Breakdown 2024

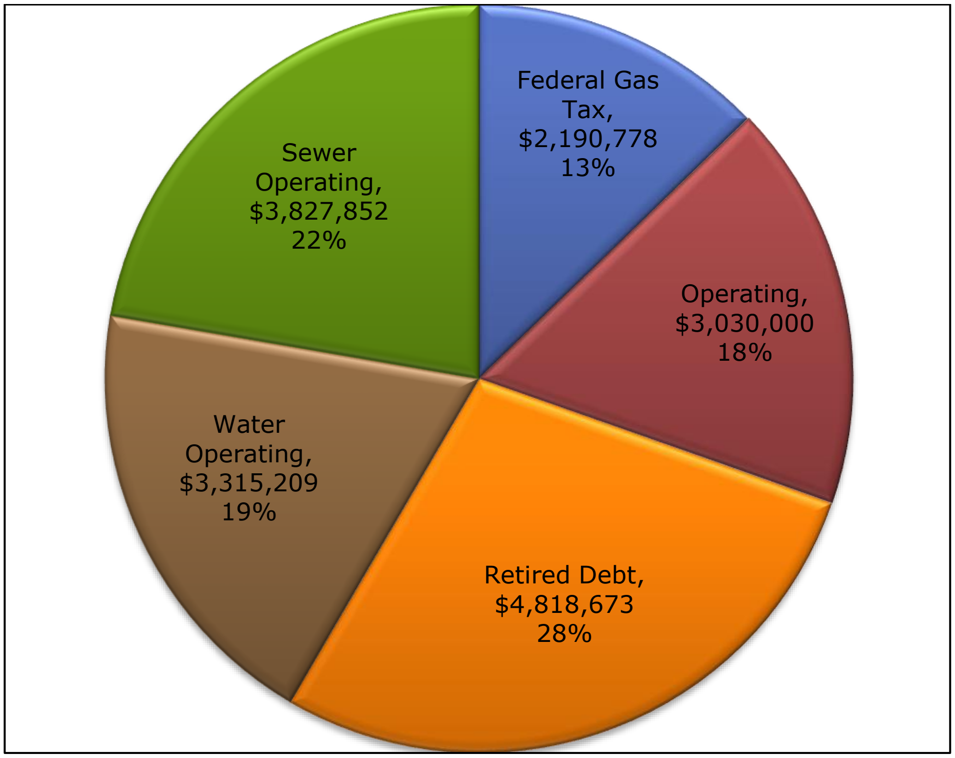
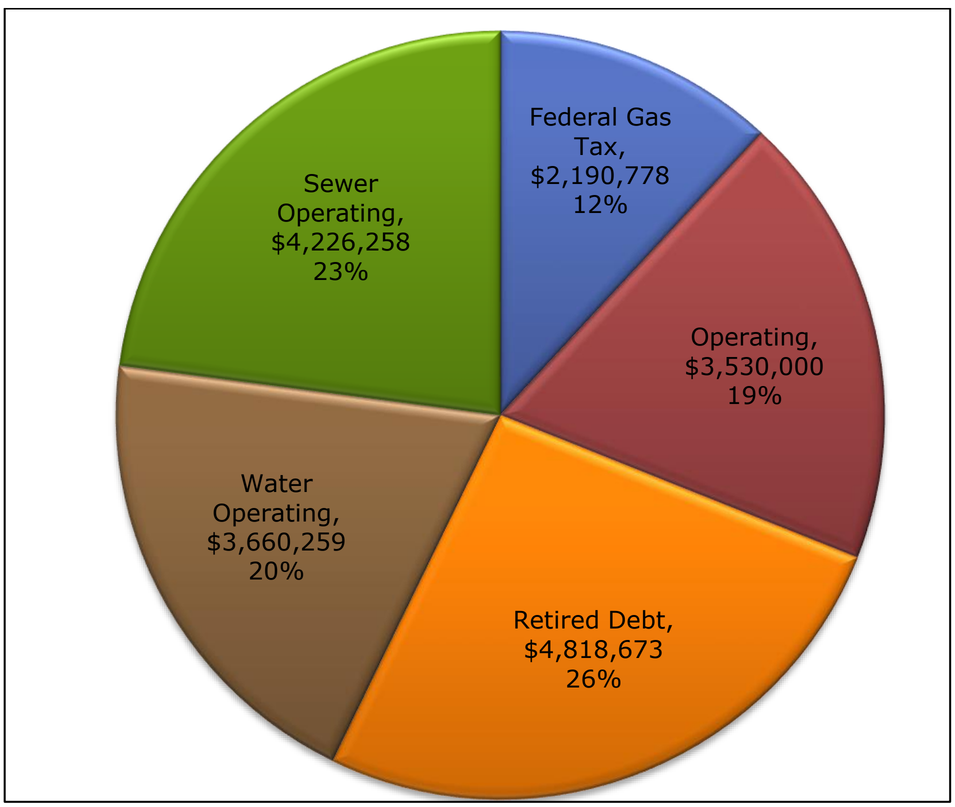


Figure 47 Linear Asset Funding Sources Breakdown 2029



6.3 Linear Assets

The asset management system developed by the City of Sarnia has calculated both current and future infrastructure needs for linear infrastructure. For the financial plan, three scenarios for a twenty-year period forecast were created to illustrate how the City can best manage its assets. Each scenario shifts priorities and funding among asset types to show the effects on the current and future deficit, as well as the replacement cycle of each asset. In each scenario, assumptions have been made to arrive at the figures in the tables and projections.

To get a more precise funding forecast for linear infrastructure assets only, the projected budget for pump stations, water pollution control centres (WPCC), city road resurfacing, rural road resurfacing, water meters, storm water management ponds, shoreline protection, and bridges are subtracted from the original twenty-year forecasted funding. Funding then is distributed among the reconstruction of roads, watermains, sanitary sewers, and storm sewers. Table 24 and 25 illustrate the prior year's actual expenditures for linear assets and the projected funding for the 20-year plan, respectively.

Table 24 Prior Years Actual Linear Expenditures

Asset Type	Description	2009	2010	2011	2012
	Total Length of System (KM)	439	439	439	439
Road Reconstruction	Cost	$5,650,617.09	$2,902,506.40	$953,487.79	$3,688,010.54
	Kilometers of System Replaced	5.33	2.48	1.09	2.72
Resurfacing	Cost	$2,604,068.87	$611,689.35	$838,954.31	$929,284.86
	Kilometers of System Replaced	12.72	4.32	4.04	4.41
	Percentage of System Replaced	4.11%	1.55%	1.17%	1.62%
	Replacement Cycle	24.33	64.60	85.62	61.57
	Total Length of System (KM)	496	496	496	496
Watermains	Cost	$2,673,027.26	$2,916,245.72	$2,040,207.84	$2,254,596.01
	Kilometers of System Replaced	7.77	6.29	3.71	4.42
	Percentage of System Replaced	1.57%	1.27%	0.75%	0.89%
	Replacement Cycle	63.82	78.83	133.84	112.20
	Total Length of System (KM)	388	388	388	388
Sewer - Sanitary	Cost	$3,258,232.21	$2,237,506.07	$3,896,307.53	$2,107,963.23
	Kilometers of System Replaced	5.46	4.60	3.87	3.40
	Percentage of System Replaced	1.41%	1.18%	1.00%	0.88%
	Replacement Cycle	71.12	84.40	100.19	114.05
	Total Length of System (KM)	293	293	293	293
Sewer - Storm	Cost	$2,046,197.50	$3,773,699.76	$2,049,786.91	$1,687,162.64
	Kilometers of System Replaced	2.88	5.01	2.18	2.35
	Percentage of System Replaced	0.98%	1.71%	0.74%	0.80%
	Replacement Cycle	101.86	58.53	134.26	124.79

Table 25 Projected Funding Sources for 20 Years

Year	Federal Gas Tax	Operating	Retired Debt	Water Operating	Sewer Operating	Total
2013	$ 2,190,778.00	$ 2,330,000.00	$ 1,141,716.91	$ 2,516,300.00	$ 1,278,600.00	$ 9,457,394.91
2014	$ 2,190,778.00	$ 1,830,000.00	$ 1,813,314.31	$ 2,569,626.00	$ 1,340,172.00	$ 9,743,890.31
2015	$ 2,190,778.00	$ 1,780,000.00	$ 2,240,706.97	$ 2,624,018.52	$ 1,402,975.44	$ 10,238,478.93
2016	$ 2,190,778.00	$ 1,780,000.00	$ 2,695,510.79	$ 2,679,498.89	$ 1,467,034.95	$ 10,812,822.63
2017	$ 2,190,778.00	$ 1,880,000.00	$ 2,705,847.75	$ 2,736,088.87	$ 1,532,375.65	$ 11,045,090.27
2018	$ 2,190,778.00	$ 1,980,000.00	$ 2,750,415.27	$ 2,793,810.65	$ 1,599,023.16	$ 11,314,027.08
2019	$ 2,190,778.00	$ 2,080,000.00	$ 2,885,778.41	$ 2,852,686.86	$ 1,667,003.62	$ 11,676,246.89
2020	$ 2,190,778.00	$ 2,180,000.00	$ 3,320,373.25	$ 2,912,740.60	$ 1,736,343.70	$ 12,340,235.54
2021	$ 2,190,778.00	$ 2,280,000.00	$ 3,801,692.43	$ 2,973,995.41	$ 1,807,070.57	$ 13,053,536.41
2022	$ 2,190,778.00	$ 2,380,000.00	$ 4,618,672.80	$ 3,036,475.32	$ 1,879,211.98	$ 14,105,138.10
2023	$ 2,190,778.00	$ 2,480,000.00	$ 4,618,672.80	$ 3,100,204.82	$ 1,952,796.22	$ 14,342,451.84
2024	$ 2,190,778.00	$ 2,580,000.00	$ 4,618,672.80	$ 3,165,208.92	$ 2,027,852.15	$ 14,582,511.86
2025	$ 2,190,778.00	$ 2,680,000.00	$ 4,618,672.80	$ 3,231,513.10	$ 2,104,409.19	$ 14,825,373.09
2026	$ 2,190,778.00	$ 2,780,000.00	$ 4,618,672.80	$ 3,299,143.36	$ 2,182,497.37	$ 15,071,091.53
2027	$ 2,190,778.00	$ 2,880,000.00	$ 4,618,672.80	$ 3,368,126.23	$ 2,262,147.32	$ 15,319,724.35
2028	$ 2,190,778.00	$ 2,980,000.00	$ 4,618,672.80	$ 3,438,488.75	$ 2,343,390.27	$ 15,571,329.82
2029	$ 2,190,778.00	$ 3,080,000.00	$ 4,618,672.80	$ 3,510,258.53	$ 2,426,258.07	$ 15,825,967.40
2030	$ 2,190,778.00	$ 3,180,000.00	$ 4,618,672.80	$ 3,583,463.70	$ 2,510,783.23	$ 16,083,697.73
2031	$ 2,190,778.00	$ 3,280,000.00	$ 4,618,672.80	$ 3,658,132.97	$ 2,596,998.90	$ 16,344,582.67
2032	$ 2,190,778.00	$ 3,380,000.00	$ 4,618,672.80	$ 3,734,295.63	$ 2,684,938.88	$ 16,608,685.31

6.3.1 Linear Asset Scenario 1

Table 26 Projected Project Completion For Scenario 1

Year	Description	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Total Length of System (KM)	439	439	439	439	439	439	439	439	439	439
Road Reconstruction	Budget	$2,853,380.25	$2,949,470.81	$3,081,815.83	$3,190,600.71	$3,234,963.28	$3,291,624.68	$3,379,573.21	$3,568,735.00	$3,774,436.11	$4,093,603.32
	Kilometers of System Replaced	2.16	2.19	2.24	2.28	2.26	2.26	2.27	2.35	2.44	2.59
Road Resurfacing	Budget	$950,000.00	$950,000.00	$1,050,000.00	$1,300,000.00	$1,400,000.00	$1,500,000.00	$1,600,000.00	$1,700,000.00	$1,800,000.00	$1,900,000.00
	Kilometers of System Replaced	4.21	4.12	4.47	5.43	5.73	6.02	6.29	6.55	6.80	7.04
	Percentage of System Replaced	1.45%	1.44%	1.53%	1.75%	1.82%	1.88%	1.95%	2.03%	2.11%	2.19%
	Replacement Cycle	68.93	69.52	65.39	57.00	54.93	53.05	51.26	49.29	47.49	45.56
	Total Length of System (KM)	496	496	496	496	496	496	496	496	496	496
Water mains	Budget	$1,947,342.69	$2,012,921.49	$2,103,242.83	$2,177,485.10	$2,207,761.16	$2,246,430.80	$2,306,452.91	$2,435,549.92	$2,575,934.48	$2,793,756.11
	Kilometers of System Replaced	3.16	3.20	3.28	3.33	3.31	3.30	3.32	3.44	3.57	3.79
	Percentage of System Replaced	0.64%	0.65%	0.66%	0.67%	0.67%	0.67%	0.67%	0.69%	0.72%	0.77%
	Replacement Cycle	156.91	154.83	151.15	148.91	149.81	150.17	149.19	144.11	138.98	130.71
	Total Length of System (KM)	388	388	388	388	388	388	388	388	388	388
Sewer - Sanitary	Budget	$1,863,119.49	$1,925,861.98	$2,012,276.89	$2,083,308.16	$2,112,274.77	$2,149,271.93	$2,206,698.07	$2,330,211.58	$2,464,524.47	$2,672,925.24
	Kilometers of System Replaced	2.16	2.19	2.24	2.28	2.26	2.26	2.27	2.35	2.44	2.59
	Percentage of System Replaced	0.56%	0.56%	0.58%	0.59%	0.58%	0.58%	0.59%	0.61%	0.63%	0.67%
	Replacement Cycle	179.54	177.16	172.95	170.39	171.42	171.83	170.71	164.89	159.03	149.56
	Total Length of System (KM)	293	293	293	293	293	293	293	293	293	293
Sewer - Storm	Budget	$1,843,552.48	$1,905,636.03	$1,991,143.38	$2,061,428.66	$2,090,091.06	$2,126,699.67	$2,183,522.70	$2,305,739.04	$2,438,641.34	$2,644,853.43
	Kilometers of System Replaced	2.16	2.19	2.24	2.28	2.26	2.26	2.27	2.35	2.44	2.59
	Percentage of System Replaced	0.74%	0.75%	0.77%	0.78%	0.77%	0.77%	0.78%	0.80%	0.83%	0.89%
	Replacement Cycle	135.56	133.77	130.59	128.66	129.43	129.75	128.90	124.51	120.07	112.93

Year	Description	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Total Length of System (KM)	439	439	439	439	439	439	439	439	439	439
Road Reconstruction	Budget	$4,139,658.35	$4,186,634.48	$4,234,550.13	$4,283,424.10	$4,333,275.55	$4,384,124.02	$4,435,989.47	$4,488,892.22	$4,542,853.03	$4,597,893.05
	Kilometers of System Replaced	2.57	2.55	2.53	2.51	2.49	2.47	2.45	2.43	2.41	2.39
Road Resurfacing	Budget	$2,000,000.00	$2,100,000.00	$2,200,000.00	$2,300,000.00	$2,400,000.00	$2,500,000.00	$2,600,000.00	$2,700,000.00	$2,800,000.00	$2,900,000.00
	Kilometers of System Replaced	7.27	7.48	7.68	7.87	8.06	8.23	8.39	8.54	8.68	8.82
	Percentage of System Replaced	2.24%	2.28%	2.33%	2.36%	2.40%	2.44%	2.47%	2.50%	2.53%	2.55%
	Replacement Cycle	44.62	43.77	42.99	42.29	41.64	41.05	40.52	40.03	39.58	39.17
	Total Length of System (KM)	496	496	496	496	496	496	496	496	496	496
Water mains	Budget	$2,825,187.23	$2,857,246.97	$2,889,947.90	$2,923,302.85	$2,957,324.90	$2,992,027.40	$3,027,423.94	$3,063,528.41	$3,100,354.97	$3,137,918.07
	Kilometers of System Replaced	3.76	3.73	3.70	3.67	3.64	3.61	3.58	3.55	3.52	3.50
	Percentage of System Replaced	0.76%	0.75%	0.75%	0.74%	0.73%	0.73%	0.72%	0.72%	0.71%	0.70%
	Replacement Cycle	131.84	132.97	134.09	135.21	136.33	137.44	138.55	139.66	140.76	141.86
	Total Length of System (KM)	388	388	388	388	388	388	388	388	388	388
Sewer - Sanitary	Budget	$2,702,996.95	$2,733,670.10	$2,764,956.71	$2,796,869.05	$2,829,419.63	$2,862,621.23	$2,896,486.86	$2,931,029.80	$2,966,263.60	$3,002,202.08
	Kilometers of System Replaced	2.57	2.55	2.53	2.51	2.49	2.47	2.45	2.43	2.41	2.39
	Percentage of System Replaced	0.66%	0.66%	0.65%	0.65%	0.64%	0.64%	0.63%	0.63%	0.62%	0.62%
	Replacement Cycle	150.85	152.14	153.43	154.71	155.99	157.27	158.54	159.80	161.06	162.32
	Total Length of System (KM)	293	293	293	293	293	293	293	293	293	293
Sewer - Storm	Budget	$2,674,609.31	$2,704,960.32	$2,735,918.35	$2,767,495.53	$2,799,704.27	$2,832,557.17	$2,866,067.13	$2,900,247.30	$2,935,111.06	$2,970,672.11
	Kilometers of System Replaced	2.57	2.55	2.53	2.51	2.49	2.47	2.45	2.43	2.41	2.39
	Percentage of System Replaced	0.88%	0.87%	0.86%	0.86%	0.85%	0.84%	0.84%	0.83%	0.82%	0.82%
	Replacement Cycle	113.90	114.88	115.85	116.82	117.78	118.75	119.71	120.66	121.61	122.56

6.3.1.1 Scenario 1 Background

Table 26 shows a summary of the Scenario 1 details. The focus of Scenario 1 is road rehabilitation and full reconstruction of all other assets. With the projected available funding, the City of Sarnia can achieve the following quantity of reconstruction and rehabilitation work.

Table 27 Summary of Project Completion For Scenario 1

Asset Type	Length of Work (km)	Cost of Work ($)	% Funding	Total % System Replaced	Average Replacement Cycle
Road Reconstruction	47.84	$77,045,497.59	33.54%	42.26%	48.90
Watermain Reconstruction	69.98	$52,581,140.12	22.89%	14.11%	142.17
Sanitary Sewer Reconstruction	47.84	$50,306,988.59	21.90%	12.33%	162.68
Storm Sewer Reconstruction	47.85	$49,778,650.35	21.67%	16.33%	122.83
Road Rehabilitation	137.67	$38,650,000.00			
Total	351.18	$268,362,276.65	Average Replacement Cycle		119.15

The City has focused the majority of its recent capital spending on combined sewer separation. This continues to be a very important task for the City, as it is anticipated that a large portion of the needs addressed in the twenty-year forecast will consist of combined sewer separation projects.

Watermain replacement also continues to be one of the major focuses of the City's capital spending. Not only do watermains make up the largest portion of City's assets at 496km, but they are also the largest asset currently in need at 70km.

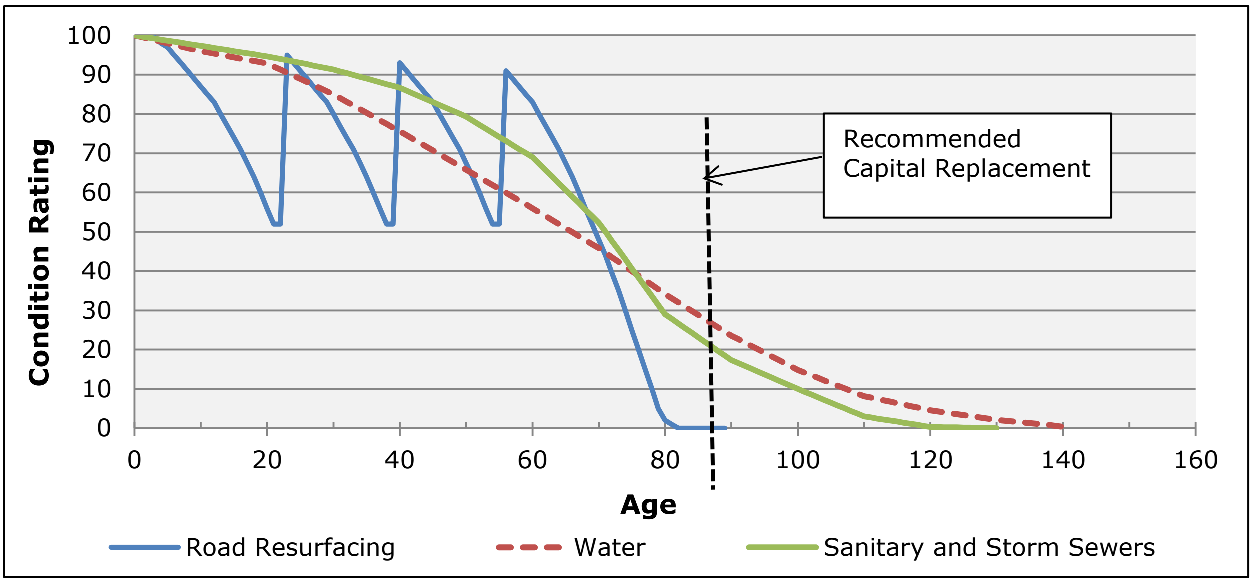
In Scenario 1, approximately 1 km of watermain is to be completed per year in addition to the standard watermain reconstruction projects. Another core element of this scenario is the aggressive increase in road rehabilitation funding. Road rehabilitation strategy IV proved to be the most efficient method of upgrading our road infrastructure, and therefore it is the recommended approach. Figure 48 shows the lifecycles of integrated assets in which the life of the road is lengthened to match that of the underground infrastructure. This integrated approach allows all infrastructure assets in close proximity of one another to be reconstructed at the same time, therefore providing maximum benefit with the least cost as illustrated in Table 28.

Table 28 Comparative Replacement Cost of Individual vs. Integrated

Project Type	Road	Water	Sanitary Sewer	Storm Sewer	Total
Individual Projects	$1,363,550	$722,870	$904,200	$1,179,770	$4,170,390
Integrated Projects	$1,363,550	$552,870	$656,200	$931,770	$3,504,390
Savings on Integrated Projects	-	**$170,000**	**$248,000**	**$248,000**	**$666,000**

Road, sanitary sewer, and storm sewer reconstruction are all shown as combined reconstruction projects. It is projected that the 20-year need for such combined projects is approximately 48km.

Figure 48 Integrated Asset Life Cycles



6.3.1.2 Current Linear Asset Deficit for Scenario 1

The current linear asset deficit for this scenario consists of the costs shown in Table 29.

Table 29 Scenario 1 Current Linear Asset Deficit

Asset Type	Cost
Road Reconstrution	$46,103,406.34
Road Rehabilitation	$5,186,162.00
Watermain	$43,340,309.10
Sanitary Sewer	$32,919,227.27
Storm Sewer	$21,489,004.10
Total	**$149,038,108.81**

Two road costs have been considered in this scenario. If the road and underground infrastructure for that segment need replacement, the full road reconstruction cost of $1,320.24 per meter was used. If the road segment needs replacement but the underground infrastructure does not then the road resurfacing cost of $225.81 per meter was used. Given funding restrictions, resurfacing the stand-alone road network included in the current need is not a cost effective practice; therefore it is avoided whenever possible. At the end of the projection, the current linear asset deficit is expected to decrease to $342,908, as shown in Table 30.

Table 30 Current Linear Asset Deficit Addressed in Scenario 1

Year	Linear Asset Opening Deficit	Inflation	Funding	Linear Asset Closing Deficit
2013	$149,038,108.81	$2,791,614.28	$9,457,394.91	$142,372,328.18
2014	$142,372,328.18	$2,652,568.76	$9,743,890.31	$135,281,006.63
2015	$135,281,006.63	$2,500,850.55	$10,238,478.93	$127,543,378.25
2016	$127,543,378.25	$2,334,611.11	$10,812,822.63	$119,065,166.74
2017	$119,065,166.74	$2,165,225.72	$10,803,880.65	$110,426,511.81
2018	$110,426,511.81	$2,012,249.69	$9,814,027.08	$102,624,734.43
2019	$102,624,734.43	$1,850,969.75	$10,076,246.89	$94,399,457.29
2020	$94,399,457.29	$1,675,184.43	$10,640,235.54	$85,434,406.18
2021	$85,434,406.18	$1,483,617.40	$11,253,536.41	$75,664,487.17
2022	$75,664,487.17	$1,269,186.98	$12,205,138.10	$64,728,536.05
2023	$64,728,536.05	$1,056,768.23	$11,890,124.45	$53,895,179.83
2024	$53,895,179.83	$882,352.57	$9,777,551.54	$44,999,980.85
2025	$44,999,980.85	$702,210.52	$9,889,454.74	$35,812,736.63
2026	$35,812,736.63	$516,182.81	$10,003,596.00	$26,325,323.45
2027	$26,325,323.45	$351,344.16	$8,758,115.28	$17,918,552.33
2028	$17,918,552.33	$241,278.07	$5,854,648.62	$12,305,181.78
2029	$12,305,181.78	$185,142.95	$3,048,034.31	$9,442,290.42
2030	$9,442,290.42	$127,575.24	$3,063,528.41	$6,506,337.25
2031	$6,506,337.25	$68,119.65	$3,100,354.97	$3,474,101.92
2032	$3,474,101.92	$6,723.68	$3,137,918.07	$342,907.53

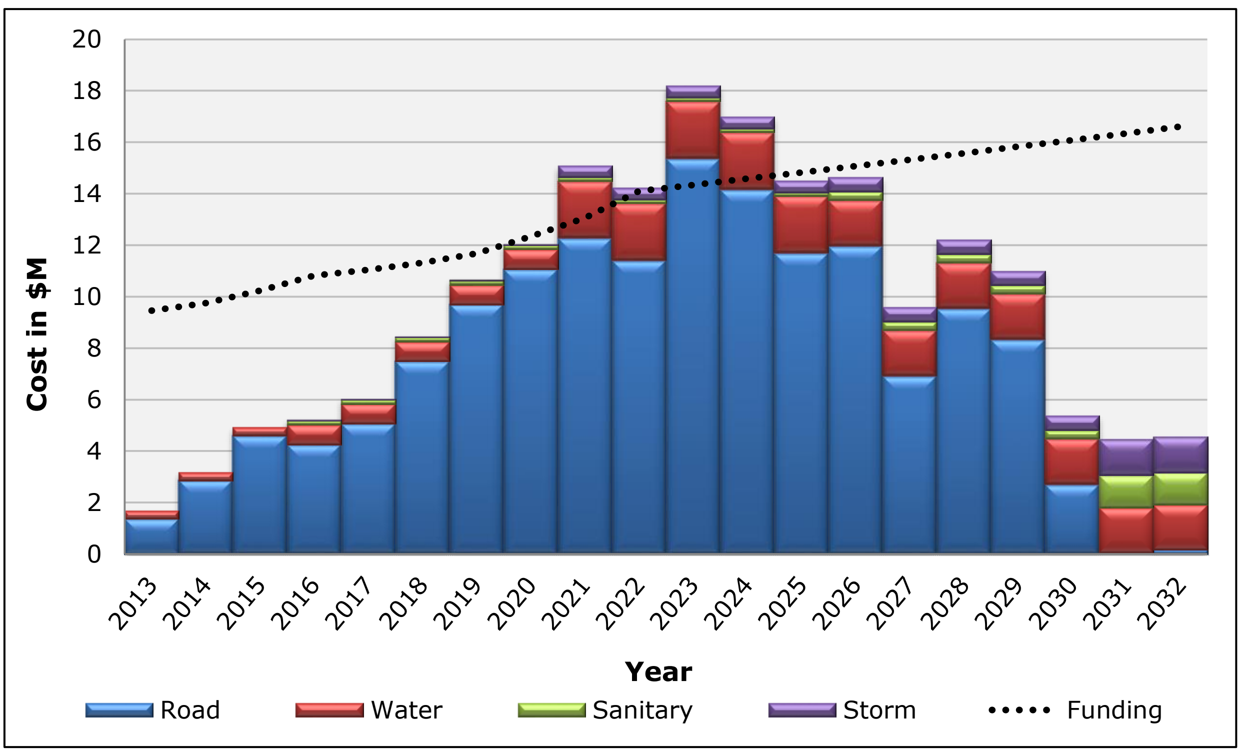
6.3.1.3 Overall Linear Asset Deficit for Scenario 1

By the end of the projection, it is estimated that the overall linear asset deficit will be $126,129,725, as shown in Table 31. This is a decrease of $22,908,384 over the 20-year term. Since the life cycle of the road network is considerably shorter than that of the underground infrastructure, it is anticipated that an increasing proportion of the total future needs are going to be road needs. Figure 49 shows the increased proportion of road needs over time.

Table 31 Overall Linear Asset Deficit Addressed in Scenario 1

Year	Linear Asset Opening Deficit	Inflation	Future Need	Funded	Linear Asset Closing Deficit
2013	$149,038,108.81	$2,791,614.28	$1,699,240.51	$9,457,394.91	$144,071,568.69
2014	$144,071,568.69	$2,686,553.57	$3,177,298.74	$9,743,890.31	$140,191,530.68
2015	$140,191,530.68	$2,599,061.04	$4,925,691.21	$10,238,478.93	$137,477,803.99
2016	$137,477,803.99	$2,533,299.63	$5,241,811.88	$10,812,822.63	$134,440,092.87
2017	$134,440,092.87	$2,467,900.05	$6,049,770.24	$11,045,090.27	$131,912,672.90
2018	$131,912,672.90	$2,411,972.92	$8,471,763.73	$11,314,027.08	$131,482,382.48
2019	$131,482,382.48	$2,396,122.71	$10,681,863.23	$11,676,246.89	$132,884,121.52
2020	$132,884,121.52	$2,410,877.72	$12,054,936.97	$12,340,235.54	$135,009,700.67
2021	$135,009,700.67	$2,439,123.29	$15,100,473.12	$13,053,536.41	$139,495,760.67
2022	$139,495,760.67	$2,507,812.45	$14,234,469.14	$14,105,138.10	$142,132,904.16
2023	$142,132,904.16	$2,555,809.05	$18,204,222.64	$14,342,451.84	$148,550,484.00
2024	$148,550,484.00	$2,679,359.44	$16,994,322.71	$14,582,511.86	$153,641,654.28
2025	$153,641,654.28	$2,776,325.62	$14,521,821.89	$14,825,373.09	$156,114,428.71
2026	$156,114,428.71	$2,820,866.74	$14,645,153.51	$15,071,091.53	$158,509,357.43
2027	$158,509,357.43	$2,863,792.66	$9,590,760.19	$15,319,724.35	$155,644,185.94
2028	$155,644,185.94	$2,801,457.12	$12,216,162.05	$15,571,329.82	$155,090,475.29
2029	$155,090,475.29	$2,785,290.16	$11,003,852.07	$15,825,967.40	$153,053,650.12
2030	$153,053,650.12	$2,739,399.05	$5,377,642.83	$16,083,697.73	$145,086,994.26
2031	$145,086,994.26	$2,574,848.23	$4,462,042.82	$16,344,582.67	$135,779,302.64
2032	$135,779,302.64	$2,383,412.35	$4,575,695.46	$16,608,685.31	$126,129,725.15

Figure 49 Yearly Linear Asset Need Forecast



6.3.1.4 Scenario 1 Replacement Life Cycle

The desired replacement life cycle for road and underground infrastructures (watermains, sanitary sewers, and storm sewers) are 35 years and 100 years respectively. In this projection, significant progress is made in lowering the actual replacement life cycle of all asset types to levels at or below the desired/expected life cycles mentioned above. However, as shown in Table 32, the replacement cycles of all four types of assets are well above the desired replacement cycle.

Table 32 Scenario 1 Average Replacement Life Cycles

	Average Replacement Cycle	Expected Life Cycle
Road	48.90	35.00
Watermains	142.17	100.00
Sanitary Sewer	162.68	100.00
Storm Sewer	122.83	100.00
Average	119.15	83.75

6.3.2 Linear Asset Scenario 2

Table 33 Projected Project Completion For Scenario 2

Year	Description	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Total Length of System (KM)	439	439	439	439	439	439	439	439	439	439
Road Reconstruction	Budget	$2,722,366.37	$2,814,044.90	$2,940,313.26	$3,044,103.24	$3,086,428.89	$3,140,488.66	$3,320,399.01	$3,532,875.37	$3,761,131.65	$4,097,644.19
	Kilometers of System Replaced	2.06	2.09	2.14	2.17	2.16	2.15	2.23	2.33	2.43	2.60
Road Resurfacing	Budget	$950,000.00	$950,000.00	$1,050,000.00	$1,300,000.00	$1,400,000.00	$1,500,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00
	Kilometers of System Replaced	1.63	1.70	1.73	2.84	3.15	3.43	2.53	2.43	2.33	2.24
	Percentage of System Replaced	0.84%	0.86%	0.88%	1.14%	1.21%	1.27%	1.09%	1.08%	1.08%	1.10%
	Replacement Cycle	119.06	115.72	113.53	87.52	82.74	78.55	92.16	92.24	92.17	90.85
	Total Length of System (KM)	496	496	496	496	496	496	496	496	496	496
Water mains	Budget	$2,552,218.47	$2,638,167.09	$2,756,543.68	$2,853,846.79	$2,893,527.08	$2,944,208.12	$3,112,874.07	$3,312,070.66	$3,526,060.92	$3,841,541.43
	Kilometers of System Replaced	4.14	4.20	4.30	4.37	4.34	4.33	4.49	4.68	4.89	5.22
	Percentage of System Replaced	0.84%	0.85%	0.87%	0.88%	0.87%	0.87%	0.90%	0.94%	0.98%	1.05%
	Replacement Cycle	119.72	118.14	115.33	113.62	114.30	114.58	110.54	105.97	101.53	95.06
	Total Length of System (KM)	388	388	388	388	388	388	388	388	388	388
Sewer - Sanitary	Budget	$1,956,700.83	$2,022,594.77	$2,113,350.15	$2,187,949.20	$2,218,370.76	$2,257,226.23	$2,386,536.79	$2,539,254.17	$2,703,313.37	$2,945,181.76
	Kilometers of System Replaced	2.27	2.30	2.36	2.39	2.38	2.37	2.46	2.56	2.68	2.86
	Percentage of System Replaced	0.58%	0.59%	0.61%	0.62%	0.61%	0.61%	0.63%	0.66%	0.69%	0.74%
	Replacement Cycle	170.95	168.69	164.68	162.24	163.22	163.62	157.85	151.32	144.98	135.73
	Total Length of System (KM)	293	293	293	293	293	293	293	293	293	293
Sewer - Storm	Budget	$1,276,109.24	$1,319,083.55	$1,378,271.84	$1,426,923.39	$1,446,763.54	$1,472,104.06	$1,556,437.03	$1,656,035.33	$1,763,030.46	$1,920,770.71
	Kilometers of System Replaced	1.50	1.52	1.55	1.58	1.57	1.56	1.62	1.69	1.76	1.88
	Percentage of System Replaced	0.51%	0.52%	0.53%	0.54%	0.53%	0.53%	0.55%	0.58%	0.60%	0.64%
	Replacement Cycle	195.84	193.25	188.65	185.87	186.98	187.44	180.83	173.35	166.09	155.50

Year	Description	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Total Length of System (KM)	439	439	439	439	439	439	439	439	439	439
Road Reconstruction	Budget	$4,173,584.59	$4,250,403.80	$4,328,119.39	$4,406,749.29	$4,486,311.79	$4,566,825.54	$4,648,309.57	$4,730,783.27	$4,814,266.45	$4,898,779.30
	Kilometers of System Replaced	2.59	2.59	2.58	2.58	2.58	2.57	2.56	2.56	2.55	2.55
Road Resurfacing	Budget	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00	$1,300,000.00
	Kilometers of System Replaced	2.14	2.05	1.96	1.87	1.78	1.70	4.19	4.11	4.03	3.95
	Percentage of System Replaced	1.08%	1.06%	1.03%	1.01%	0.99%	0.97%	1.54%	1.52%	1.50%	1.48%
	Replacement Cycle	92.73	94.66	96.64	98.68	100.77	102.91	64.96	65.81	66.68	67.55
	Total Length of System (KM)	496	496	496	496	496	496	496	496	496	496
Water mains	Budget	$3,912,735.55	$3,984,753.56	$4,057,611.93	$4,131,327.46	$4,205,917.30	$4,281,398.95	$4,357,790.22	$4,435,109.32	$4,513,374.80	$4,592,605.59
	Kilometers of System Replaced	5.21	5.20	5.19	5.18	5.17	5.16	5.15	5.14	5.13	5.12
	Percentage of System Replaced	1.05%	1.05%	1.05%	1.05%	1.04%	1.04%	1.04%	1.04%	1.03%	1.03%
	Replacement Cycle	95.19	95.34	95.50	95.68	95.86	96.05	96.26	96.47	96.69	96.92
	Total Length of System (KM)	388	388	388	388	388	388	388	388	388	388
Sewer - Sanitary	Budget	$2,999,763.92	$3,054,977.73	$3,110,835.81	$3,167,351.05	$3,224,536.60	$3,282,405.86	$3,340,972.50	$3,400,250.48	$3,460,254.01	$3,520,997.62
	Kilometers of System Replaced	2.85	2.85	2.85	2.84	2.83	2.83	2.82	2.82	2.81	2.80
	Percentage of System Replaced	0.74%	0.73%	0.73%	0.73%	0.73%	0.73%	0.73%	0.73%	0.72%	0.72%
	Replacement Cycle	135.93	136.14	136.37	136.62	136.88	137.15	137.45	137.75	138.07	138.40
	Total Length of System (KM)	293	293	293	293	293	293	293	293	293	293
Sewer - Storm	Budget	$1,956,367.78	$1,992,376.78	$2,028,805.96	$2,065,663.73	$2,102,958.65	$2,140,699.47	$2,178,895.11	$2,217,554.66	$2,256,687.40	$2,296,302.80
	Kilometers of System Replaced	1.88	1.88	1.88	1.87	1.87	1.86	1.86	1.86	1.85	1.85
	Percentage of System Replaced	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	0.64%	0.63%	0.63%	0.63%
	Replacement Cycle	155.72	155.97	156.23	156.51	156.81	157.13	157.46	157.81	158.17	158.55

6.3.2.1 Scenario 2 Background

Table 33 shows a summary of the Scenario 2 details. Scenario 2 illustrates how the City of Sarnia can eliminate the current backlog of infrastructure projects in 15 years' time with the same funding as Scenario 1. In this scenario, roads have been accounted for differently than in Scenario 1. Scenario 1 considers stand-alone road projects at a resurfacing cost of $225.81 per metre. In Scenario 2, the road cost for stand-alone projects has been calculated using a cost of $590.20 per meter, which includes major road rehabilitation as well as full curb and gutter repair. Much of the road network in the current need is beyond the point where resurfacing/minor rehabilitation is feasible. Thus, in order to properly rehabilitate the road network in need, major rehabilitation or full reconstruction should be done to achieve the desired service level. As a result, this scenario includes less funding for minor rehabilitation and more funding for road reconstruction.

Table 34 Summary of Project Completion For Scenario 2

Asset Type	Length of Work (km)	Cost of Work ($)	% Funding	Total % System Replaced	Average Replacement Cycle
Road Reconstruction	48.09	$77,763,928.53	32.00%	23.34%	88.86
Watermain Reconstruction	96.62	$72,903,682.99	30.00%	19.48%	103.44
Sanitary Sewer Reconstruction	52.93	$55,892,823.63	23.00%	13.64%	147.70
Storm Sewer Reconstruction	34.89	$36,451,841.50	15.00%	11.91%	169.21
Road Rehabilitation	54.37	$25,350,000.00			
Total	286.89	$268,362,276.65	Average Replacement Cycle		127.30

In order to realize the goal of eliminating the current linear asset deficit in 15 years, a reallocation of funding was necessary. The watermain network has largest quantity of network in current need and therefore requires the greatest reallocation of funding. To accommodate the watermain needs, funding was transferred from road rehabilitation and storm sewers.

Unlike in Scenario 1, road, sanitary sewers, and storm sewer reconstruction are not shown as combined reconstruction projects in Scenario 2. In this scenario an estimated 35km of network would consist of combined reconstruction projects, while 92km would consist of more costly individual network projects. Although Scenario 2 focuses on improving the watermain network, which is currently in great need, over time such a scenario would significantly deteriorate the road network.

6.3.2.2 Current Linear Asset Deficit for Scenario 2

The current linear asset deficit in Scenario 2 is made up of the costs shown in Table 35.

Table 35 Scenario 2 Current Linear Asset Deficit

Asset Type	Cost
Road Reconstrution	$46,103,406.34
Road Rehabilitation	$13,807,986.18
Watermain	$43,340,309.10
Sanitary Sewer	$32,919,227.27
Storm Sewer	$21,489,004.10
Total	**$157,659,932.99**

In Scenario 2, the current linear asset deficit is completely addressed by 2027, as shown in Table 36.

Table 36 Current Linear Asset Deficit Addressed in Scenario 2

Year	Linear Asset Opening Deficit	Inflation	Funding	Linear Asset Closing Deficit
2013	$157,659,932.99	$2,964,050.76	$9,457,394.91	$151,166,588.84
2014	$151,166,588.84	$2,828,453.97	$9,743,890.31	$144,251,152.50
2015	$144,251,152.50	$2,680,253.47	$10,238,478.93	$136,692,927.05
2016	$136,692,927.05	$2,517,602.09	$10,812,822.63	$128,397,706.50
2017	$128,397,706.50	$2,347,052.32	$11,045,090.27	$119,699,668.56
2018	$119,699,668.56	$2,167,712.83	$11,314,027.08	$110,553,354.32
2019	$110,553,354.32	$1,977,542.15	$11,676,246.89	$100,854,649.57
2020	$100,854,649.57	$1,770,288.28	$12,340,235.54	$90,284,702.31
2021	$90,284,702.31	$1,544,623.32	$13,053,536.41	$78,775,789.22
2022	$78,775,789.22	$1,293,413.02	$14,105,138.10	$65,964,064.15
2023	$65,964,064.15	$1,032,432.25	$14,342,451.84	$52,654,044.55
2024	$52,654,044.55	$761,430.65	$14,582,511.86	$38,832,963.34
2025	$38,832,963.34	$494,864.90	$14,089,718.44	$25,238,109.79
2026	$25,238,109.79	$229,340.37	$13,771,091.53	$11,696,358.63
2027	$11,696,358.63	$0.00	$11,696,358.63	$0.00
2028	$0.00	$0.00	$0.00	$0.00
2029	$0.00	$0.00	$0.00	$0.00
2030	$0.00	$0.00	$0.00	$0.00
2031	$0.00	$0.00	$0.00	$0.00
2032	$0.00	$0.00	$0.00	$0.00

6.3.2.3 Overall Linear Asset Deficit for Scenario 2

The overall linear asset deficit is reduced to $138,941,302 by the end of the projection as shown in Table 37. This reduces the deficit by $18,718,630. The majority of the remaining overall deficit is due to the road network needs.

Table 37 Overall Linear Asset Deficit Addressed in Scenario 2

Year	Linear Asset Opening Deficit	Inflation	Future Needs	Funded	Linear Asset Closing Deficit
2013	$157,659,932.99	$2,964,050.76	$1,699,240.51	$9,457,394.91	$152,865,829.35
2014	$152,865,829.35	$2,862,438.78	$3,177,298.74	$9,743,890.31	$149,161,676.56
2015	$149,161,676.56	$2,778,463.95	$4,925,691.21	$10,238,478.93	$146,627,352.79
2016	$146,627,352.79	$2,716,290.60	$5,241,811.88	$10,812,822.63	$143,772,632.64
2017	$143,772,632.64	$2,654,550.85	$6,049,770.24	$11,045,090.27	$141,431,863.46
2018	$141,431,863.46	$2,602,356.73	$8,471,763.73	$11,314,027.08	$141,191,956.85
2019	$141,191,956.85	$2,590,314.20	$10,681,863.23	$11,676,246.89	$142,787,887.38
2020	$142,787,887.38	$2,608,953.04	$12,054,936.97	$12,340,235.54	$145,111,541.85
2021	$145,111,541.85	$2,641,160.11	$15,100,473.12	$13,053,536.41	$149,799,638.67
2022	$149,799,638.67	$2,713,890.01	$14,234,469.14	$14,105,138.10	$152,642,859.72
2023	$152,642,859.72	$2,766,008.16	$18,204,222.64	$14,342,451.84	$159,270,638.67
2024	$159,270,638.67	$2,893,762.54	$16,994,322.71	$14,582,511.86	$164,576,212.05
2025	$164,576,212.05	$2,995,016.78	$14,521,821.89	$14,825,373.09	$167,267,677.64
2026	$167,267,677.64	$3,043,931.72	$14,645,153.51	$15,071,091.53	$169,885,671.34
2027	$169,885,671.34	$3,091,318.94	$9,590,760.19	$15,319,724.35	$167,248,026.12
2028	$167,248,026.12	$3,033,533.93	$12,216,162.05	$15,571,329.82	$166,926,392.27
2029	$166,926,392.27	$3,022,008.50	$11,003,852.07	$15,825,967.40	$165,126,285.44
2030	$165,126,285.44	$2,980,851.75	$5,377,642.83	$16,083,697.73	$157,401,082.29
2031	$157,401,082.29	$2,821,129.99	$4,462,042.82	$16,344,582.67	$148,339,672.43
2032	$148,339,672.43	$2,634,619.74	$4,575,695.46	$16,608,685.31	$138,941,302.33

6.3.2.4 Scenario 2 Replacement Life Cycle

The replacement cycle for watermains is drastically reduced due to the reallocation of funding from road rehabilitation and storm sewers. However, as shown in Table 38, the replacement cycles for the other asset types are above the desired replacement cycle. The road network is critically underfunded in this scenario causing its replacement cycle to be twice its suggested length.

Table 38 Scenario 2 Average Replacement Life Cycles

	Average Replacement Cycle	Expected Life Cycle
Road	88.86	35.00
Watermains	103.44	100.00
Sanitary Sewer	147.70	100.00
Storm Sewer	169.21	100.00
Average	127.30	83.75

6.3.3 Linear Asset Scenario 3

Table 39 Projected Project Completion For Scenario 3

Year	Description	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Total Length of System (KM)	439	439	439	439	439	439	439	439	439	439
Road Reconstruct	Budget	$4,642,366.37	$4,734,044.90	$4,860,313.26	$4,964,103.24	$5,006,428.89	$5,060,488.66	$5,144,399.01	$5,324,875.37	$5,521,131.65	$5,825,644.19
	Kilometers of System Replaced	3.52	3.52	3.54	3.54	3.50	3.47	3.46	3.51	3.57	3.69
Road Resurfacing	Budget	$1,442,887.46	$1,471,745.21	$1,501,180.12	$1,531,203.72	$1,561,827.79	$1,593,064.35	$1,600,000.00	$1,700,000.00	$1,800,000.00	$1,900,000.00
	Kilometers of System Replaced	2.40	2.40	2.40	2.40	2.40	2.40	2.30	2.56	2.81	3.05
	Percentage of System Replaced	1.35%	1.35%	1.35%	1.35%	1.34%	1.34%	1.31%	1.38%	1.45%	1.54%
	Replacement Cycle	74.20	74.21	73.93	73.87	74.37	74.77	76.19	72.26	68.78	65.10
	Total Length of System (KM)	496	496	496	496	496	496	496	496	496	496
Watermains	Budget	$4,352,218.47	$4,438,167.09	$4,556,543.68	$4,653,846.79	$4,693,527.08	$4,744,208.12	$4,822,874.07	$4,992,070.66	$5,176,060.92	$5,461,541.43
	Kilometers of System Replaced	7.06	7.06	7.11	7.12	7.04	6.98	6.95	7.05	7.17	7.42
	Percentage of System Replaced	1.42%	1.42%	1.43%	1.44%	1.42%	1.41%	1.40%	1.42%	1.45%	1.50%
	Replacement Cycle	70.21	70.22	69.77	69.68	70.47	71.11	71.35	70.31	69.17	66.86
	Total Length of System (KM)	388	388	388	388	388	388	388	388	388	388
Sewer - Sanitary	Budget	$3,336,700.83	$3,402,594.77	$3,493,350.15	$3,567,949.20	$3,598,370.76	$3,637,226.23	$3,697,536.79	$3,827,254.17	$3,968,313.37	$4,187,181.76
	Kilometers of System Replaced	3.87	3.87	3.89	3.90	3.86	3.82	3.81	3.86	3.93	4.06
	Percentage of System Replaced	1.00%	1.00%	1.00%	1.01%	0.99%	0.98%	0.98%	1.00%	1.01%	1.05%
	Replacement Cycle	100.25	100.27	99.62	99.49	100.62	101.54	101.88	100.40	98.76	95.47
	Total Length of System (KM)	293	293	293	293	293	293	293	293	293	293
Sewer - Storm	Budget	$2,176,109.24	$2,219,083.55	$2,278,271.84	$2,326,923.39	$2,346,763.54	$2,372,104.06	$2,411,437.03	$2,496,035.33	$2,588,030.46	$2,730,770.71
	Kilometers of System Replaced	2.55	2.55	2.57	2.57	2.54	2.52	2.51	2.55	2.59	2.68
	Percentage of System Replaced	0.87%	0.87%	0.88%	0.88%	0.87%	0.86%	0.86%	0.87%	0.88%	0.91%
	Replacement Cycle	114.85	114.87	114.13	113.98	115.27	116.32	116.71	115.01	113.14	109.37

Year	Description	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Total Length of System (KM)	439	439	439	439	439	439	439	439	439	439
Road Reconstruct	Budget	$3,949,584.59	$3,994,403.80	$4,040,119.39	$4,086,749.29	$4,134,311.79	$4,182,825.54	$4,232,309.57	$4,282,783.27	$4,334,266.45	$4,386,779.30
	Kilometers of System Replaced	2.45	2.43	2.41	2.39	2.37	2.35	2.34	2.32	2.30	2.28
Road Resurfacing	Budget	$2,000,000.00	$2,100,000.00	$2,200,000.00	$2,300,000.00	$2,400,000.00	$2,500,000.00	$2,600,000.00	$2,700,000.00	$2,800,000.00	$2,900,000.00
	Kilometers of System Replaced	8.87	9.08	9.28	9.47	9.66	8.23	8.39	8.54	8.68	8.82
	Percentage of System Replaced	2.58%	2.62%	2.66%	2.70%	2.74%	2.41%	2.44%	2.47%	2.50%	2.53%
	Replacement Cycle	38.78	38.13	37.54	36.99	36.50	41.49	40.94	40.44	39.98	39.56
	Total Length of System (KM)	496	496	496	496	496	496	496	496	496	496
Watermains	Budget	$3,702,735.55	$3,744,753.56	$3,787,611.93	$3,831,327.46	$3,875,917.30	$3,921,398.95	$3,967,790.22	$4,015,109.32	$4,063,374.80	$4,112,605.59
	Kilometers of System Replaced	4.93	4.89	4.85	4.81	4.77	4.73	4.69	4.65	4.62	4.58
	Percentage of System Replaced	0.99%	0.99%	0.98%	0.97%	0.96%	0.95%	0.95%	0.94%	0.93%	0.92%
	Replacement Cycle	100.59	101.45	102.31	103.17	104.02	104.87	105.72	106.56	107.40	108.24
	Total Length of System (KM)	388	388	388	388	388	388	388	388	388	388
Sewer - Sanitary	Budget	$2,838,763.92	$2,870,977.73	$2,903,835.81	$2,937,351.05	$2,971,536.60	$3,006,405.86	$3,041,972.50	$3,078,250.48	$3,115,254.01	$3,152,997.62
	Kilometers of System Replaced	2.70	2.68	2.66	2.63	2.61	2.59	2.57	2.55	2.53	2.51
	Percentage of System Replaced	0.70%	0.69%	0.68%	0.68%	0.67%	0.67%	0.66%	0.66%	0.65%	0.65%
	Replacement Cycle	143.64	144.87	146.09	147.32	148.53	149.75	150.96	152.16	153.36	154.55
	Total Length of System (KM)	293	293	293	293	293	293	293	293	293	293
Sewer - Storm	Budget	$1,851,367.78	$1,872,376.78	$1,893,805.96	$1,915,663.73	$1,937,958.65	$1,960,699.47	$1,983,895.11	$2,007,554.66	$2,031,687.40	$2,056,302.80
	Kilometers of System Replaced	1.78	1.77	1.75	1.74	1.72	1.71	1.69	1.68	1.67	1.65
	Percentage of System Replaced	0.61%	0.60%	0.60%	0.59%	0.59%	0.58%	0.58%	0.57%	0.57%	0.56%
	Replacement Cycle	164.55	165.96	167.37	168.76	170.16	171.55	172.93	174.31	175.69	177.06

6.3.3.1 Scenario 3 Background

Table 39 shows a summary of the Scenario 3 details. Scenario 3 is an extension of Scenario 2: The only difference between the two scenarios is that in Scenario 3 the current deficit expected to be fully addressed in 10 years rather than 15 years. This is achieved by assuming that the City will receive additional outside funding of approximately $62 million. Similar to Scenario 2, Scenario 3 adopts major road rehabilitation work that includes full curb and gutter repairs at a cost of $590.20 per meter to treat stand-alone road projects.

Table 40 Summary of Project Completion For Scenario 3

Asset Type	Length of Work (km)	Cost of Work ($)	% Funding	Total % System Replaced	Average Replacement Cycle
Road Reconstruction	58.97	$92,707,928.53	32.00%	39.43%	55.90
Watermain Reconstruction	118.49	$86,913,682.99	30.00%	23.89%	87.17
Sanitary Sewer Reconstruction	64.91	$66,633,823.63	23.00%	16.73%	124.48
Storm Sewer Reconstruction	42.79	$43,456,841.50	15.00%	14.60%	142.60
Road Rehabilitation	114.14	$40,601,908.66			
Total	399.29	$330,314,185.30	Average Replacement Cycle		102.54

In order to achieve the goal of eliminating the current deficit in 10 years, more funding needs to be allocated to the road and watermain network since their current need is significantly higher than that of the sanitary and storm sewer networks.

6.3.3.2 Current Linear Asset Deficit for Scenario 3

The current linear asset deficit in this scenario is made up of the cost shown in Figure 41.

Table 41 Scenario 3 Current Linear Asset Deficit

Asset Type	Cost
Road Reconstruction	$46,103,406.34
Road Resurfacing	$13,807,986.18
Watermains	$43,340,309.10
Sanitary Sewer	$32,919,227.27
Storm Sewer	$21,489,004.10
Total	**$157,659,932.99**

The current linear asset deficit is completly addressed by the end of year 2022 in this scenario, as shown in Table 42.

Table 42 Current Linear Asset Deficit Addressed in Scenario 3

Year	Linear Asset Opening Deficit	Inflation	Funding	Linear Asset Closing Deficit
2013	$157,659,932.99	$2,834,193.01	$15,950,282.37	$144,543,843.63
2014	$144,543,843.63	$2,565,564.16	$16,265,635.52	$130,843,772.27
2015	$130,843,772.27	$2,283,082.26	$16,689,659.05	$116,437,195.49
2016	$116,437,195.49	$1,987,863.38	$17,044,026.35	$101,381,032.52
2017	$101,381,032.52	$1,683,482.29	$17,206,918.06	$85,857,596.75
2018	$85,857,596.75	$1,369,010.11	$17,407,091.43	$69,819,515.43
2019	$69,819,515.43	$1,042,865.37	$17,676,246.89	$53,186,133.91
2020	$53,186,133.91	$696,917.97	$18,340,235.54	$35,542,816.34
2021	$35,542,816.34	$329,785.60	$19,053,536.41	$16,819,065.53
2022	$16,819,065.53	$0.00	$16,819,065.53	$0.00
2023	$0.00	$0.00	$0.00	$0.00
2024	$0.00	$0.00	$0.00	$0.00
2025	$0.00	$0.00	$0.00	$0.00
2026	$0.00	$0.00	$0.00	$0.00
2027	$0.00	$0.00	$0.00	$0.00
2028	$0.00	$0.00	$0.00	$0.00
2029	$0.00	$0.00	$0.00	$0.00
2030	$0.00	$0.00	$0.00	$0.00
2031	$0.00	$0.00	$0.00	$0.00
2032	$0.00	$0.00	$0.00	$0.00

6.3.3.3 Overall Linear Asset Deficit for Scenario 3

The overall linear asset deficit is reduced to $56,102,435 by the end of the projection as shown in Table 43. This reduces the deficit by $101,557,498. The majority of the remaining overall deficit is due to the road network needs.

Table 43 Overall Linear Asset Deficit Addressed in Scenario 3

Year	Linear Asset Opening Deficit	Inflation	Future Needs	Funded	Funding Deficit	Assumed Funding Total	Linear Asset Closing Deficit
2013	$157,659,932.99	$2,964,050.76	$1,699,240.51	$9,457,394.91	$6,492,887.46	$15,950,282.37	$146,372,941.89
2014	$146,372,941.89	$2,732,581.03	$3,177,298.74	$9,743,890.31	$6,521,745.21	$16,265,635.52	$136,017,186.13
2015	$136,017,186.13	$2,515,574.14	$4,925,691.21	$10,238,478.93	$6,451,180.12	$16,689,659.05	$126,768,792.43
2016	$126,768,792.43	$2,319,119.40	$5,241,811.88	$10,812,822.63	$6,231,203.72	$17,044,026.35	$117,285,697.36
2017	$117,285,697.36	$2,124,812.14	$6,049,770.24	$11,045,090.27	$6,161,827.79	$17,206,918.06	$108,253,361.69
2018	$108,253,361.69	$1,938,786.69	$8,471,763.73	$11,314,027.08	$6,093,064.35	$17,407,091.43	$101,256,820.69
2019	$101,256,820.69	$1,791,611.48	$10,681,863.23	$11,676,246.89	$6,000,000.00	$17,676,246.89	$96,054,048.50
2020	$96,054,048.50	$1,674,276.26	$12,054,936.97	$12,340,235.54	$6,000,000.00	$18,340,235.54	$91,443,026.19
2021	$91,443,026.19	$1,567,789.80	$15,100,473.12	$13,053,536.41	$6,000,000.00	$19,053,536.41	$89,057,752.69
2022	$89,057,752.69	$1,499,052.29	$14,234,469.14	$14,105,138.10	$6,000,000.00	$20,105,138.10	$84,686,136.02
2023	$84,686,136.02	$1,406,873.68	$18,204,222.64	$14,342,451.84	$0.00	$14,342,451.84	$89,954,780.50
2024	$89,954,780.50	$1,507,445.37	$16,994,322.71	$14,582,511.86	$0.00	$14,582,511.86	$93,874,036.72
2025	$93,874,036.72	$1,580,973.27	$14,521,821.89	$14,825,373.09	$0.00	$14,825,373.09	$95,151,458.80
2026	$95,151,458.80	$1,601,607.35	$14,645,153.51	$15,071,091.53	$0.00	$15,071,091.53	$96,327,128.12
2027	$96,327,128.12	$1,620,148.08	$9,590,760.19	$15,319,724.35	$0.00	$15,319,724.35	$92,218,312.04
2028	$92,218,312.04	$1,532,939.64	$12,216,162.05	$15,571,329.82	$0.00	$15,571,329.82	$90,396,083.91
2029	$90,396,083.91	$1,491,402.33	$11,003,852.07	$15,825,967.40	$0.00	$15,825,967.40	$87,065,370.91
2030	$87,065,370.91	$1,419,633.46	$5,377,642.83	$16,083,697.73	$0.00	$16,083,697.73	$77,778,949.47
2031	$77,778,949.47	$1,228,687.34	$4,462,042.82	$16,344,582.67	$0.00	$16,344,582.67	$67,125,096.96
2032	$67,125,096.96	$1,010,328.23	$4,575,695.46	$16,608,685.31	$0.00	$16,608,685.31	$56,102,435.34

6.3.3.4 Scenario 3 Replacement Life Cycle

Due to the external funding provided in this scenario, the replacement life cycles for all the assets are drastically reduced in the projection. Although the desired replacement cycle is achieved for the watermain network in this scenario, the replacement cycle for the road, sanitary sewer, and storm sewer networks are still above their desired replacement cycles. Table 44 below summarizes the life cycle results.

Table 44 Scenario 3 Asset Average Replacement Life Cycles

	Average Replacement Cycle	Expected Life Cycle
Road	55.90	35.00
Watermains	87.17	100.00
Sanitary Sewer	124.48	100.00
Storm Sewer	142.60	100.00
Average	102.54	83.75

6.3.4 Linear Asset Scenario Conclusion

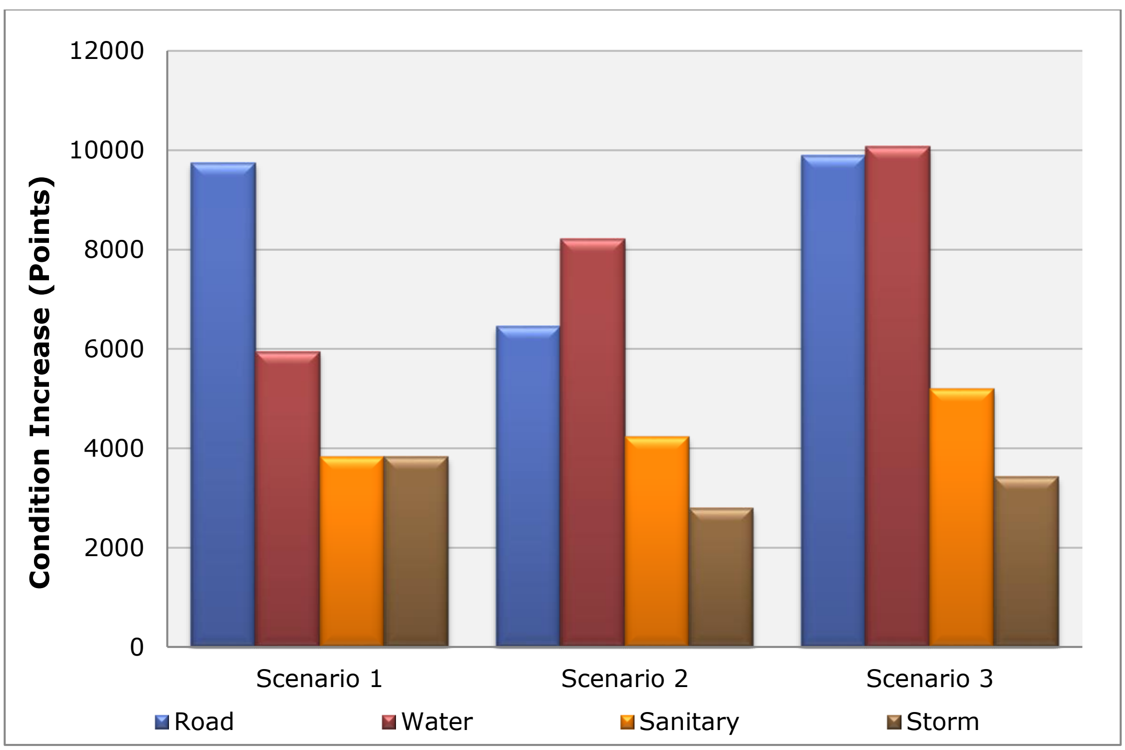
When comparing the scenarios it is critical to understand what impact each scenario has on the entire infrastructure network as well as each individual asset network. Each asset network is a vital component to the City's overall infrastructure network. Over the past few years, the City's major focuses have been on the replacement of watermains and the elimination of combined sewers. However, the financial analyses contained in this section of this AMP have revealed that attention should be paid to the road network as reconstruction works will demand an increasingly large portion of funding.

Although Scenario 3 would be preferred, it cannot be implemented without first securing additional external funding. Consequently, the focus of subsequent sections of this financial plan will be on Scenarios 1 and 2.

Based on the City's infrastructure priorities, it is recommended that Scenario 1 be implemented. Scenario 1 focuses more on road network rehabilitation and integrated projects, and as such, it allows more of the road network to be upgraded at a lower overall cost.

As shown in Figure 50, in Scenario 1 the road network is improved by 9,747 points, whereas is it only improved by 6,453 points in Scenario 2.

Figure 50 Condition Increase Across Asset Type



The length of road network upgraded in Scenario 1 is 186 km, versus 102 km in Scenario 2. In Scenario 1, approximately 48km of combined projects are completed compared to approximately 35km in Scenario 2. Being that integrated projects are more cost effective than individual network projects, Scenario 1 provides the greatest cost savings benefit in this regard. For Scenario 1, the overall length of network upgraded is 351km compared to 287km for Scenario 2; that is, Scenario 1 allows 64km more of the road network to be upgraded than Scenario 2. Table 45 provides a summary of the quantity of work completed in each scenario.

Table 45 Quantitiy of Work Breakdown in 3 Financial Scenarios

	Scenario 1		**Scenario 2**		**Scenario 3**	
	Reconstruction (km)	Rehabilitation (km)	Reconstruction (km)	Rehabilitation (km)	Reconstruction (km)	Rehabilitation (km)
Road	47.84	137.67	48.09	54.37	58.97	114.14
Watermains	69.98		96.62		118.49	
Sanitary Sewer	47.84		52.93		64.91	
Storm Sewer	47.85		34.89		42.79	

The asset management planning process is driving a change in philosophy regarding capital improvement. The old philosophy of "worst first" is being replaced with a more proactive approach focused on rehabilitation based on the windows of opportunity and integrated projects.

Based on this new philosophy, it is believed that the recommended financial scenario presented in this plan firmly sets the City of Sarnia on a proactive and fiscally responsible path.

6.3.5 Optional Scenario

This scenario is an alternate approach to Scenario 1 that uses the same current road need, but instead of considering future road need cost as rehabilitation cost, the full reconstruction cost has been considered. As shown in Table 46 below, the total overall linear closing deficit went up to $535,641,663.19 from the original deficit of $126,129,725.15 seen in Scenario 1.

Despite the fact that it is the City of Sarnia standard practice to resurface/rehabilitate roads and not reconstruct them until the buried infrastructure needs to be replaced, this optional scenario was included in order to provide an additional basis for the comparison of other scenarios.

Table 46 Overall Linear Asset Deficit Addressed in Optional Scenario

Year	Linear Asset Opening Deficit	Inflation	Future Need	Funded	Linear Asset Closing Deficit
2013	$149,038,108.81	$2,791,614.28	$3,604,276.61	$9,457,394.91	$145,976,604.79
2014	$145,976,604.79	$2,724,654.29	$9,906,001.09	$9,743,890.31	$148,863,369.86
2015	$148,863,369.86	$2,772,497.82	$15,552,389.74	$10,238,478.93	$156,949,778.49
2016	$156,949,778.49	$2,922,739.12	$15,229,247.61	$10,812,822.63	$164,288,942.58
2017	$164,288,942.58	$3,064,877.05	$17,516,859.31	$11,045,090.27	$173,825,588.67
2018	$173,825,588.67	$3,250,231.23	$20,839,632.29	$11,314,027.08	$186,601,425.11
2019	$186,601,425.11	$3,498,503.56	$30,048,325.31	$11,676,246.89	$208,472,007.10
2020	$208,472,007.10	$3,922,635.43	$36,811,586.08	$12,340,235.54	$236,865,993.06
2021	$236,865,993.06	$4,476,249.13	$43,082,302.62	$13,053,536.41	$271,371,008.40
2022	$271,371,008.40	$5,145,317.41	$41,907,620.51	$14,105,138.10	$304,318,808.22
2023	$304,318,808.22	$5,799,527.13	$57,670,930.15	$14,342,451.84	$353,446,813.66
2024	$353,446,813.66	$6,777,286.04	$54,595,022.24	$14,582,511.86	$400,236,610.06
2025	$400,236,610.06	$7,708,224.74	$41,281,298.53	$14,825,373.09	$434,400,760.25
2026	$434,400,760.25	$8,386,593.37	$38,279,524.12	$15,071,091.53	$465,995,786.21
2027	$465,995,786.21	$9,013,521.24	$21,086,367.61	$15,319,724.35	$480,775,950.72
2028	$480,775,950.72	$9,304,092.42	$35,479,764.09	$15,571,329.82	$509,988,477.40
2029	$509,988,477.40	$9,883,250.20	$29,560,157.74	$15,825,967.40	$533,605,917.95
2030	$533,605,917.95	$10,350,444.40	$5,424,821.86	$16,083,697.73	$533,297,486.49
2031	$533,297,486.49	$10,339,058.08	$7,248,871.10	$16,344,582.67	$534,540,832.99
2032	$534,540,832.99	$10,358,642.95	$7,350,872.56	$16,608,685.31	$535,641,663.19

6.4 Non-Linear Assets

Stantec Consulting Limited identified the current needs of the pump stations and wastewater treatment facilities as part of the Wastewater Master Plan (WMP) study. The top projects identified in this study were the replacement of both the Bedford Pump Station and the Bright's Grove Sewage Lagoons.

Most of the future needs of the City's pump stations were identified in the pump station assessment carried out by R. V. Anderson in 2009.

Since upgrading the pump and electrical components of pump stations has historically been the rehabilitation approach adopted by the City, only these components have been included in this plan.

The future need for the Water Pollution Control Centre was based on the City's 10-year capital plan compiled by City staff.

The bridge condition, urgent needs, and future needs are all determined and detailed in the bridge inspection reports provided by Engineered Management Systems Incorporated in 2014, in accordance with the 'Ontario Structure Inspection Manual'. Table 47 illustrates the previous years' actual expenditures for non-linear assets.

Table 47 Prior Years' Actual Non-Linear Expenditures

Asset Type	Description	2009	2010	2011	2012
Bridges					
	Donohue Bridge North Bound Lanes		$3,601,581		
Pump Stations					
	Devine Street Pumping Station			$8,988,928	
	Business Park PS			$645,800	
Water Pollution Control Centre					
	New Raw Sewage Pumps	$242,112			
	Clarifier Rehabilitation		$288,565		$181,239
	New VFD's for Blowers			$230,973	
	New Controls for Scada System			$154,602	

Tables 48, 49, and 50 detail projected project completion dates for pump stations, wastewater treatment plants, and bridges, respectively.

Table 48 Projected Project Completion Pump Stations

Station ID	Pump Station	Condition	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
33	CNR Tracks at Bedford	0																				
41	Green Street	0																				
35	Murphy Road at 402	0																				
18	Giffel Road	11	10,000																			
6	East St at Maple	12																				
1	Holland Street	14	20,000																20,000			
2	Briarfield	14	10,000																20,000			
13	McCaw	17	20,000																			
14	Rosedale	21	10,000																20,000			
8	Errol Road	23						15,000														
9	Exmouth West of Indian	25			75,000																	
17	Mayfair	26													20,000							
16	Talfourd Street	28																				
5	East St at Huey's	29																				
10	Forsyth	34	10,000																			10,000
15	Scott Road	35	20,000	15,000																		
32	Exmouth St. (Lambton Mall)	36	20,000																			
12	Lecaron	36																				
3	Clifford	37					10,000	20,000														
28	1801 London @ Blackwell	39	20,000				15,000															
44	Chippewa Park	40	20,000		10,000																	
29	London Line at Briarwood	40	10,000				15,000															
37	Cathcart at Rutherglen	42	20,000			5,000																
7	Elrick at Vye	42						20,000														
30	Blackwell @ Sim's	42	10,000				15,000															
24	River Road	45	10,000					10,000														
20	Tashmoo Ave (North)	49	10,000												10,000							
23	Sandy Lane	49	20,000												25,000							
31	Airport Road North of 402	51	20,000				10,000															
36	1642 Murphy Road	53								20,000												20,000
38	Penhuron Lane (Hamilton)	54	20,000		10,000																	
25	161 Nelson Street	54																				
34	Plank Road at Indian Road	57																				
46	Rapids Parkway	58									15,000											
21	Plain Lane	58	10,000												10,000							
22	Berkshire Road	58																				
26	1350 Plank	60								20,000												15,000
27	1569 London Line(Lou's)	62																		20,000		
11	Lasalle	65																				
39	Kaymar	67	15,000		5,000																	
40	Huronview (Lakeshore)	67	15,000		10,000																	
47	Devine Street	72																				
4	ARI	73											10,000									15,000
43	1264 Tashmoo (South)	73											10,000									10,000
50	Michigan Avenue	74										15,000										
51	Heritage Park	76										15,000										
45	Augusta Drive	76													10,000							
49	5960 Blackwell Side Road	76								15,000												
53	London Rd Industrial Park	77													20,000							
52	Stone Hedge Park	84												15,000								
	Total Future Need		**320,000**	**15,000**	**110,000**	**5,000**	**65,000**	**65,000**	**-**	**55,000**	**15,000**	**30,000**	**20,000**	**15,000**	**95,000**	**-**	**-**	**-**	**60,000**	**20,000**	**-**	**70,000**

Legend	
Improvement	
Pumps	
Electrical	
Generator	
Stations	
To be Rebuilt	
To be Decomissioned	

Table 49 Projected Project Completion Wastewater Treatment Plant

Components of WPCC	Category	Condition Score	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Head Works	Process	64		170,000	240,000		90,000							170,000	240,000		90,000					
	Structural	46		40,000	100,000	100,000				100,000				40,000								
	Equipment	48		120,000	200,000				200,000	90,000				120,000					200,000			
Grit Removal	Process	80			50,000	90,000	40,000								50,000	90,000	40,000					
	Structural	46					80,000										80,000					
	Equipment	48							40,000	40,000	40,000								40,000	40,000	40,000	
Primary Clarifiers	Process	68	110,000	40,000		100,000	100,000		60,000	60,000			110,000	40,000		100,000	100,000		60,000	60,000		
	Structural	60		257,000	257,000		35,000	35,000	35,000	35,000		150,000		257,000	257,000		35,000	35,000	35,000	35,000		150,000
	Equipment	68	15,000									100,000	15,000									100,000
Aeration	Process	68				78,000	78,000	88,000	88,000							78,000	78,000	88,000	88,000			
	Structural	87																				
	Equipment	56				8,000	100,000	500,000								8,000	100,000	500,000				
Secondary Clarifiers	Process	64		52,000	52,000	52,000	112,000	150,000	160,000	160,000	100,000			52,000	52,000	52,000	112,000	150,000	160,000	160,000	100,000	
	Structural	87	600,000				35,000	35,000	35,000								35,000	35,000	35,000			
	Equipment	48				70,000										70,000						
Ultraviolet	Process	48	12,000	12,000		46,000	30,000	16,000		18,000			12,000	12,000		46,000	30,000	16,000		18,000		
	Structural	87										800,000										
	Equipment	48																				
Sludge Storage and Treatment	Process	56		30,000	30,000	60,000	60,000	90,000						30,000	30,000	60,000	60,000	90,000				
	Structural	60				150,000		150,000	150,000	180,000												
	Equipment	48	120,000	120,000									120,000	120,000								
Total Future Need			**857,000**	**841,000**	**929,000**	**754,000**	**760,000**	**1,064,000**	**768,000**	**683,000**	**140,000**	**1,050,000**	**257,000**	**841,000**	**629,000**	**504,000**	**760,000**	**914,000**	**618,000**	**313,000**	**140,000**	**250,000**

Table 50 Projected Project Completion Bridges

Structure ID	Bridge Name	Condition Index (BCI)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
000260	Telfer Road	0																				
000270	Waterworks Road	0																				
000280	Brigden Road	0																				
000310	Old Lakeshore Road Over Cull Drain	0					600,000															
000200	Blackwell Sideroad	27																				
000320	Vidal Street Walkway	39.6																				
000160-3-3	Donohue Bridge (North Structure)	43.3						6,000,000														
000230	Confederation Line	47.6																				
000160-1-3	Donohue Bridge (South Structure)	59.3																				
000090	Perch Creek Bridge	60.9															723,000					
000160-2-3	Donohue Bridge (Centre Structure)	72.5																				
000060	Perch Creek Bridge	76.7																			3,420,000	
000070	Jackson Road Bridge	79.3																	1,665,000			
000150	Kenny Bridge	79.6													1,130,000							
000040	Michigan Avenue Bridge	79.8																1,530,000				
000300	McGregor Sideroad Over Cole Drain	82.9																				
000250	Confederation Line over Waddel Creek	85.1																				
000050	Perch Creek Bridge	90.8																			448,000	
000180	CSX Overpass	91.5													2,400,000							
000030	Cow Creek Bridge	92.1													354,000							
000020	Perch Creek Bridge	92.4															363,000					
000100	Scott Road Bridge	96.3																				
000010	Cow Creek Bridge	97.5													135,000							
000240	Confederation Line over Perch Creek	98.7																				
000110	Scott Road Culvert	100																				
000190	Michigan Road	100																				
000210	Finch Drive	100																				
000220	Wellington Street	100																				
000290	Marshall Line	100																				
	Total Future Need		**-**	**-**	**-**	**-**	**600,000**	**6,000,000**	**-**	**-**	**-**	**-**	**-**	**-**	**4,019,000**	**-**	**1,086,000**	**1,530,000**	**1,665,000**	**-**	**3,868,000**	**-**

Tables 51 to 53 detail the funding available, the opening deficit, and the closing deficit for each non-linear asset. The opening deficit for pump stations and wastewater treatment facilities consist of the top two priority projects identified in this AMP; the Bright's Grove Waste Water Treatment Facility project and Bedford and Murphy Road Pump Stations project. The City is considering several alternate funding approaches to address these needs, as the funding resources for these projects are currently not available.

Table 51 Current Pump Station Deficit

Year	Opening Pump Station Deficit	Future Need	Funding	Closing Pump Station Deficit
2013	37,000,000	320,000	800,000	36,520,000
2014	36,520,000	15,000	800,000	35,735,000
2015	35,735,000	110,000	800,000	35,045,000
2016	35,045,000	5,000	800,000	34,250,000
2017	34,250,000	65,000	800,000	33,515,000
2018	33,515,000	65,000	800,000	32,780,000
2019	32,780,000	-	800,000	31,980,000
2020	31,980,000	55,000	800,000	31,235,000
2021	31,235,000	15,000	800,000	30,450,000
2022	30,450,000	30,000	800,000	29,680,000
2023	29,680,000	20,000	800,000	28,900,000
2024	28,900,000	15,000	800,000	28,115,000
2025	28,115,000	95,000	800,000	27,410,000
2026	27,410,000	-	800,000	26,610,000
2027	26,610,000	-	800,000	25,810,000
2028	25,810,000	-	800,000	25,010,000
2029	25,010,000	60,000	800,000	24,270,000
2030	24,270,000	20,000	800,000	23,490,000
2031	23,490,000	-	800,000	22,690,000
2032	22,690,000	70,000	800,000	21,960,000

Table 52 Current Wastewater Treatment Facilities Deficit

Year	Opening WPCC Deficit	Future Need	Funding	Closing WPCC Deficit
2013	8,300,000	857,000	1,000,000	8,157,000
2014	8,157,000	841,000	1,000,000	7,998,000
2015	7,998,000	929,000	1,000,000	7,927,000
2016	7,927,000	754,000	1,000,000	7,681,000
2017	7,681,000	760,000	1,000,000	7,441,000
2018	7,441,000	1,064,000	1,000,000	7,505,000
2019	7,505,000	768,000	1,000,000	7,273,000
2020	7,273,000	683,000	1,000,000	6,956,000
2021	6,956,000	140,000	1,000,000	6,096,000
2022	6,096,000	1,050,000	1,000,000	6,146,000
2023	6,146,000	257,000	1,000,000	5,403,000
2024	5,403,000	841,000	1,000,000	5,244,000
2025	5,244,000	629,000	1,000,000	4,873,000
2026	4,873,000	504,000	1,000,000	4,377,000
2027	4,377,000	760,000	1,000,000	4,137,000
2028	4,137,000	914,000	1,000,000	4,051,000
2029	4,051,000	618,000	1,000,000	3,669,000
2030	3,669,000	313,000	1,000,000	2,982,000
2031	2,982,000	140,000	1,000,000	2,122,000
2032	2,122,000	250,000	1,000,000	1,372,000

Table 53 Current Bridge Deficit

Year	Opening Bridge Deficit	Future Need	Funding	Closing Bridge Deficit
2013	2,469,785	-	200,000	2,269,785
2014	2,269,785	-	200,000	2,069,785
2015	2,069,785	-	200,000	1,869,785
2016	1,869,785	-	200,000	1,669,785
2017	1,669,785	600,000	200,000	2,069,785
2018	2,069,785	6,000,000	200,000	7,869,785
2019	7,869,785	-	200,000	7,669,785
2020	7,669,785	-	200,000	7,469,785
2021	7,469,785	-	200,000	7,269,785
2022	7,269,785	-	200,000	7,069,785
2023	7,069,785	-	200,000	6,869,785
2024	6,869,785	-	200,000	6,669,785
2025	6,669,785	4,019,000	200,000	10,488,785
2026	10,488,785	-	200,000	10,288,785
2027	10,288,785	1,086,000	200,000	11,174,785
2028	11,174,785	1,530,000	200,000	12,504,785
2029	12,504,785	1,665,000	200,000	13,969,785
2030	13,969,785	-	200,000	13,769,785
2031	13,769,785	3,868,000	200,000	17,437,785
2032	17,437,785	-	200,000	17,237,785

Note: The substructure work for Donohue Bridge has since been completed; therefore, the above table will be updated during the next revision phase of this document.

7. Recommendations

The following table represents the top five priority projects across all of the asset types identified based on risk analyses.

Table 54 Top Identified Priority Projects across Asset Type

Rank	Project	Consequence Of Failure (0 to 10)	Potential Of Failure (0 to 10)	Overall Index (Consequence x Potential)	Comments	Estimated Cost
1	Water Only Project	6.66	9.21	61.34	Copland Road, Plank Road, Rosedale Avenue, Oldham Place, & Exmouth Street	$45,300,000
2	Road Only Project	6.23	8.98	55.95	Plank Road, Waterworks, Blackwell & Various Local	$12,725,000
3	Major Bridges & Culverts	8.02	6.12	49.08	Rehabilitation	$2,875,000
4	Sewer Rehabilitation Project - St. Clair Parkway & Various Locations	5.31	8.92	47.37	Rehabilitation/ Relining	$1,107,000
5	Road, Water, & Sewer Project/ Combined Sewer Project	4.91	8.40	41.24	Exmouth Street & Devine Street Areas	$34,450,000
6	Shoreline Protection	4.88	5.91	28.84	Erosion Control	$7,775,000

The upgrade of the Bright's Grove Wastewater Treatment Facility and the existing Green Street Pump Station were identified to be the top priority project due to their urgent capacity constraints. The existing sewage lagoons are currently operating at close to full capacity and they are not able to discharge during the winter months. These capacity and discharge constraint are limiting new development and are cause for environmental concern.

The Bedford pump station was also identified through computer modelling as one of the top priority projects. The Bedford pumping station is one of the largest pumping stations in the City of Sarnia. It receives the flow from 23 of the 50 other pumping stations within the City. There are multiple issues with the Bedford pumping station, which include capacity constraints, operational problems, economic development issues, and future growth concerns.

A number of the City's bridges are included in second listed priority project category. The priority rehabilitation needs of the City's bridges are detailed in the 2014 bridge inspection reports provided by Engineering Management Systems Incorporated.

The top identified road only project is Waterworks Road between Michigan Line and Lakeshore Road. The priority index of this arterial section of road is based on condition, maintenance records, and risk assessment.

The top identified road, watermain, and sewer projects are in the Exmouth and Devine drainage areas. Both of these areas are located in older sections of the city that contain combined sewers and aged linear infrastructure that is due for replacement.

The top identified watermain only project is in the Copland Road, Rosedale Avenue, Oldham Place, and Exmouth Street area. These watermains have been identified as having low pressure, fire flow issues, and a high number of watermain breaks.

Appendix: A

Priority Listings of Linear Infrastructures

Combined Complete Reconstruction Priority Listing Top 50 Sections

Priority Listing	Integr Code	Road	To	From	Project Type				Drainage Area	Combined cost (2012 Dollar Value)
1	IS2018	Capel Street	Nelson Street	Admiral Avenue	Road	Water	Sanitary	Storm	Exmouth Street	$528,760.81
2	IS1118	Capel Street	Maxwell Street	Nelson Street	Road	Water	Sanitary	Storm	Exmouth Street	$406,629.38
3	IS1386	East Street N.	Lincoln Park Avenue	Maxwell Street	Road	Water	Sanitary	Storm	Exmouth Street	$596,539.75
4	IS2286	Lydia Street	Nelson Street	Felix Street	Road	Water	Sanitary	Storm	Exmouth Street	$207,117.78
5	IS1258	Nelson Street	Felix Street	Lydia Street	Road	Water	Sanitary	Storm	Exmouth Street	$257,442.71
6	IS1809	Lydia Street	Maxwell Street	Nelson Street	Road	Water	Sanitary	Storm	Exmouth Street	$660,799.87
7	IS2300	Maxwell Street	Capel Street	Lydia Street	Road	Water	Sanitary	Storm	Exmouth Street	$284,779.77
8	IS1724	Talfourd Street	Vidal Street S.	Queen Street	Road	Water	Sanitary	Storm	Devine Street	$308,924.00
9	IS2565	Talfourd Street	Stuart Street	Emma Street	Road	Water	Sanitary	Storm	Devine Street	$370,809.11
10	IS1707	Talfourd Street	Queen Street	Christina Street S.	Road	Water	Sanitary	Storm	Devine Street	$408,176.19
11	IS1270	Talfourd Street	Crawford Street	Margaret Street	Road	Water	Sanitary	Storm	Devine Street	$227,697.43
12	IS1277	Talfourd Street	Emma Street	Crawford Street	Road	Water	Sanitary	Storm	Devine Street	$399,627.14
13	IS1656	Talfourd Street	Margaret Street	Brock Street S.	Road	Water	Sanitary	Storm	Devine Street	$434,775.57
14	IS1280	Talfourd Street	Mitton Street S.	Stuart Street	Road	Water	Sanitary	Storm	Devine Street	$520,447.18
15	IS1818	Talfourd Street	Proctor Street	Mitton Street S.	Road	Water	Sanitary	Storm	Devine Street	$321,342.41
16	IS1307	Talfourd Street	Brock Street S.	Vidal Street S.	Road	Water	Sanitary	Storm	Devine Street	$344,419.16
17	IS1920	Queen Street	Devine Street	Talfourd Street	Road	Water	Sanitary	Storm	Devine Street	$394,323.04
18	IS1115	Margaret Street	Richard Street	Talfourd Street	Road	Water	Sanitary	Storm	Devine Street	$350,093.49
19	IS1119	Margaret Street	Devine Street	Richard Street	Road	Water	Sanitary	Storm	Devine Street	$459,223.82
20	IS1298	Johnston Street	Queen Street	Christina Street S.	Road	Water	Sanitary	Storm	Devine Street	$194,680.66
21	IS2217	Queen Street	Talfourd Street	Johnston Street	Road	Water	Sanitary	Storm	Devine Street	$347,173.95
22	IS1284	Queen Street	Confederation Street	Devine Street	Road	Water	Sanitary	Storm	Devine Street	$568,586.56
23	IS1919	Vidal Street S.	Devine Street	Talfourd Street	Road	Water	Sanitary	Storm	Devine Street	$1,292,917.19
24	IS0841	Emma Street	Richard Street	Talfourd Street	Road	Water	Sanitary	Storm	Devine Street	$308,714.46
25	IS1242	Emma Street	Devine Street	Richard Street	Road	Water	Sanitary	Storm	Devine Street	$458,315.54
26	IS2911	John Street	Mary Street	Devine Street	Road	Water	Sanitary	Storm	Devine Street	$554,296.07
27	IS1655	Mary Street	John Street	Brock Street S.	Road	Water	Sanitary	Storm	Devine Street	$454,088.73
28	IS1290	Stuart Street	Talfourd Street	Wellington Street	Road	Water	Sanitary	Storm	Devine Street	$1,364,287.42
29	IS2912	John Street	Confederation Street	Mary Street	Road	Water	Sanitary	Storm	Devine Street	$308,311.05
30	IS2483	Emma Street	Confederation Street	Devine Street	Road	Water	Sanitary	Storm	Devine Street	$986,326.06
31	IS1238	Richard Street	Emma Street	Margaret Street	Road	Water	Sanitary	Storm	Devine Street	$562,218.52
32	IS1354	Richard Street	Stuart Street	Emma Street	Road	Water	Sanitary	Storm	Devine Street	$384,112.00
33	IS1708	Stuart Street	Richard Street	Talfourd Street	Road	Water	Sanitary	Storm	Devine Street	$511,677.15
34	IS3007	East Street S.	Confederation Street	Ontario Street	Road	Water	Sanitary	Storm	Devine Street	$291,226.53
35	IS1872	Stuart Street	Devine Street	Richard Street	Road	Water	Sanitary	Storm	Devine Street	$483,574.93
36	IS2137	Richard Street	Mitton Street S.	Stuart Street	Road	Water	Sanitary	Storm	Devine Street	$370,191.36
37	IS3209	Ontario Street	Devine Street	Gibson Street	Road	Water	Sanitary	Storm	Devine Street	$181,987.43
38	IS2349	Ontario Street	East Street South	Mack Avenue	Road	Water	Sanitary	Storm	Devine Street	$242,409.22
39	IS2220	Ontario Street	Palmerston Street S.	Devine Street	Road	Water	Sanitary	Storm	Devine Street	$402,054.44
40	IS1802	Ontario Street	Mack Avenue	Palmerston Street S.	Road	Water	Sanitary	Storm	Devine Street	$315,438.78
41	IS1917	Wellington Street	Russell Street S.	Mackenzie Street S.	Road	Water	Sanitary	Storm	East Street	$1,004,766.73
42	IS1117	Wellington Street	East Street S.	Russell Street S.	Road	Water	Sanitary	Storm	East Street	$854,281.08
43	IS1450	Cromwell Street	Palmerston Street N.	Russell Street N.	Road	Water	Sanitary	Storm	East Street	$457,499.80
44	IS1281	Cromwell Street	East Street N.	Palmerston Street N.	Road	Water	Sanitary	Storm	East Street	$521,429.95
45	IS1851	Cameron Street	Palmerston Street N.	Russell Street N.	Road	Water	Sanitary	Storm	East Street	$598,818.97
46	IS1295	Cameron Street	East Street N.	Palmerston Street N.	Road	Water	Sanitary	Storm	East Street	$711,727.80
47	IS0690	Cobden Street	Palmerston Street N.	Russell Street N.	Road	Water	Sanitary	Storm	East Street	$567,991.02
48	IS1289	Cobden Street	East Street N.	Palmerston Street N.	Road	Water	Sanitary	Storm	East Street	$556,094.28
49	IS1772	Bright Street	East Street N.	Palmerston Street N.	Road	Water	Sanitary	Storm	East Street	$523,074.09
50	IS1086	Bright Street	Palmerston Street N.	Russell Street N.	Road	Water	Sanitary	Storm	East Street	$821,405.66

Note: Combined complete reconstruction priority list will be updated based on future updated data

Watermain Only Reconstruction Priority Listing Top 50 Sections

Priority Listing	Integr Code	Road	From	To	Water Cost
1	IS1812	Copland Road	Claxton Avenue	Alexander Street	$76,552
2	IS1176	Copland Road	Alexander Street	Maxwell Street	$123,929
3	IS2859	Copland Road	Maxwell Street	London Road	$195,147
4	IS1820	Copland Road	Exmouth Street	Claxton Avenue	$81,301
5	IS1236	Coronation Lane	Modeland Road	Crestwood Place	$98,457
6	IS1714	Coronation Lane	Crestwood Place	west end	$425,275
7	IS0463	Bruce Street	Hansard Lane	Mulberry Street	$173,829
8	IS0712	Oldham Place	north end	Clarence Street	$48,724
9	IS2821	Charlesworth Drive	Colborne Road	Baxter Avenue	$177,318
10	IS2820	Charlesworth Drive	Baxter Avenue	Amesbury Court	$177,318
11	IS0672	Charlesworth Drive	Amesbury Court	McKay Avenue	$258,877
12	IS0217	Donalda Street	Lakeshore Road	Clarence Street	$162,301
13	IS2214	Rosedale Avenue	Colborne Road	Pineview Avenue	$161,152
14	IS0353	Hickory Avenue	Aberdeen Avenue	Montcalm Avenue	$73,417
15	IS0352	Aberdeen Avenue	Hickory Avenue	Hemlock Avenue	$47,269
16	IS0728	Aberdeen Avenue	Hemlock Avenue	Oak Avenue	$64,529
17	IS1600	Aberdeen Avenue	Oak Avenue	Sycamore Drive	$49,324
18	IS2126	Aberdeen Avenue	Sycamore Drive	Lorne Crescent	$62,292
19	IS1205	Exmouth Street	Venetian Boulevard	Harbour Road	$98,883
20	IS2368	Exmouth Street	Exmouth Street fork	Harbour Road	$353,760
21	IS2178	Haight Lane	Murphy Road	Lake Huron Parkway	$255,631
22	IS1925	Cotterbury Street	Exmouth Street	Eddy Drive	$338,633
23	IS1557	Lakeshore Road	Blackwell Sideroad	Modeland Road	$1,260,620
24	IS3227	Vidal Street South	LaSalle Line	Beaver Circle	$248,684
25	IS2197	College Avenue North	George Street	Essex Street	$81,389
26	IS1716	Rutherglen Drive	Chudleigh Road	Hillcrest Nisbet Drive	$64,483
27	IS1968	Stuart Street	Confederation Street	Devine Street	$241,529
28	IS0393	Chippewa Street	Shamrock Street	Rose Street	$66,867
29	IS1720	Murphy Road	Haight Lane	north end (Lake Huron)	$19,983
30	IS1315	McLaren Avenue	Russell Street South	Conrad Street	$184,054
31	IS1197	Braemar Lane	Murphy Road	Wilgrun Drive	$60,168
32	IS1446	Siddall Street	Wellington Street	Ross Avenue	$117,590
33	IS1149	Siddall Street	Ross Avenue	Talfourd Street	$117,590
34	IS1417	Kathleen Avenue	Walnut Avenue South	west end	$280,570
35	IS1983	Kathleen Avenue	East Street South	east end	$280,570
36	IS2083	Walnut Avenue North	Oak Avenue	Walnut Avenue South	$22,910
37	IS0357	Ann Street	Stuart Street	Samuel Street	$286,307
38	IS0345	Ontario Street	Agnes Street	Campbell Street	$306,757
39	IS0770	Egmond Drive	Charlesworth Drive	Valleyfield Drive	$136,337
40	IS1648	Egmond Drive	Valleyfield Drive	Devonshire Road	$136,337
41	IS3102	Egmond Drive	Roosevelt Drive	Cathcart Boulevard	$136,337
42	IS2824	Kemsley Drive	Indian Road North	Spartan Avenue	$137,018
43	IS1027	Kemsley Drive	Spartan Avenue	Athena Avenue	$137,018
44	IS1593	Kemsley Drive	Athena Avenue	Kim Street	$137,018
45	IS2108	Kemsley Drive	Kim Street	Coral Way	$137,018
46	IS0790	Charlesworth Drive	Evan Street	McKay Avenue	$306,757
47	IS2714	LaSalle Line	Virgil Avenue	Wahboose Circle	$234,095
48	IS2712	LaSalle Line	Virgil Avenue	Fairview Boulevard	$68,175
49	IS1479	LaSalle Line	Vidal Street South	Wahboose Circle	$80,163
50	IS2087	LaSalle Line	Wayne Avenue	St. Clair Parkway	$73,804

Road Only Priority Listing Based on Condition and Risk Analysis

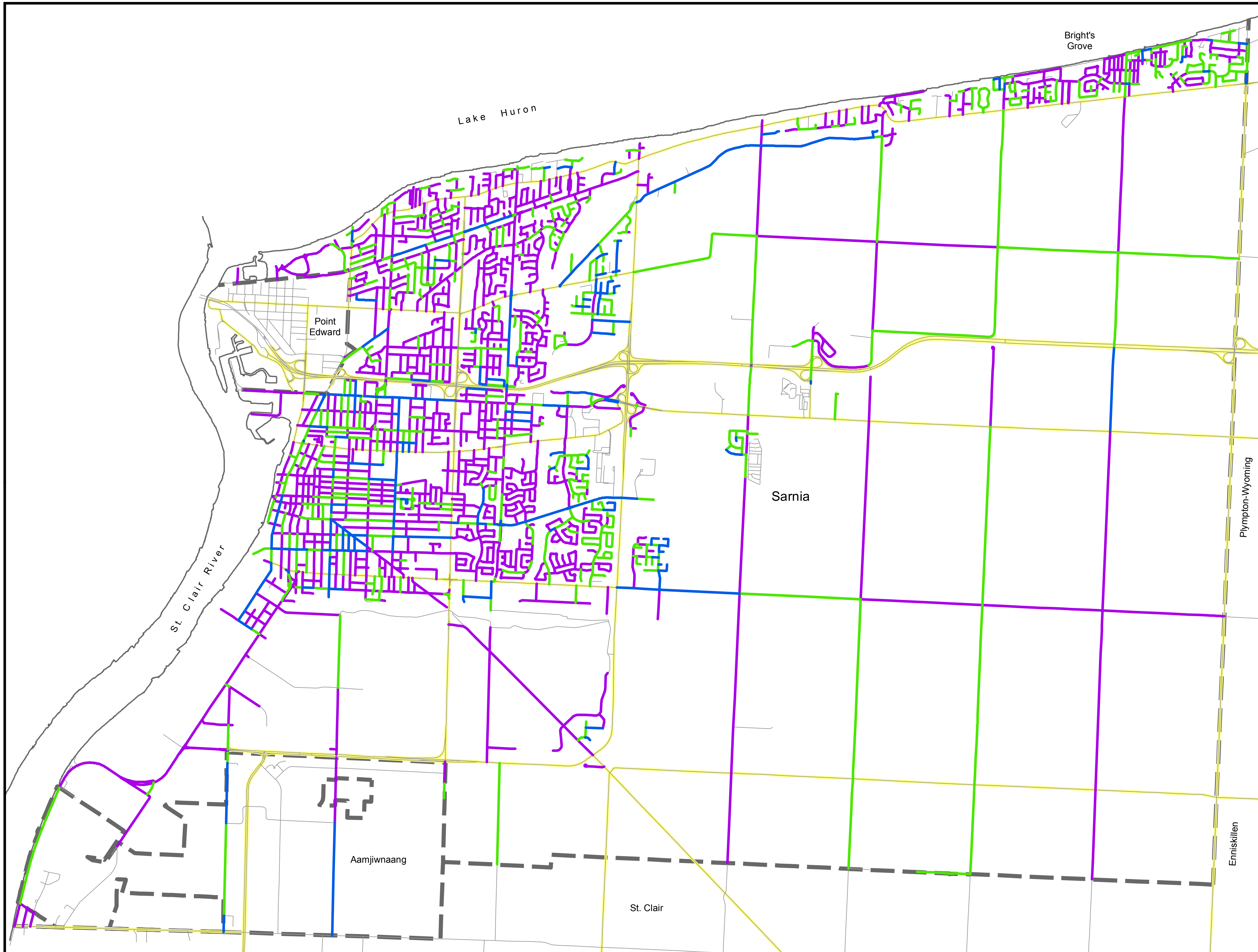
Priority Listing	Section ID	Street	From	To	Cost ($)
1	0000RD1765	Waterworks Road	Michigan Line	Lakeshore Road	$4,500,000
2	0000RD2700	Blackwell Sideroad	Brookview Court	Augusta Boulevard	$28,116
3	0000RD2699	Blackwell Sideroad	north service entrance	Brookview Court	$140,296
4	0000RD2811	Blackwell Sideroad	Glen Abbey Drive	north service entrance	$24,620
5	0000RD2313	Confederation Line	Mandaumin Road	Waterworks Road	$2,877,062
6	0000RD0578	Confederation Line	Waterworks Road	Brigden Road	$2,840,568
7	0000RD3210	Plank Road	McGregor Sideroad	69m W of Indian Road / ramps	$732,010
8	0000RD1598	Plank Road	Duff Drive	Highway 40	$330,718
9	0000RD3348	Plank Road	Gladwish Drive	Duff Drive	$320,494
10	0000RD0480	Plank Road	Indian Road South	Indian Road South	$71,852
11	0000RD0317	Plank Road	Gladwish Drive	McGregor Sideroad	$1,639,816
12	0000RD0978	Blackwell Sideroad	Lakeshore Road	Lake Huron Shore	$15,004
13	0000RD1603	Waterworks Road	Churchill Line	1353m S Churchill Line (CL)	$178,662
14	0000RD2356	Blackwell Sideroad	Michigan Line	Blackwell Road	$221,933
15	0000RD0016	Blackwell Sideroad	Confederation Line	south service entrance	$257,502

Other Assets Priority Listing Based on Risk Analysis

Priority Listing	Asset Type	Cost ($)
1	Bright's Grove Wastewater Treatment Facility	$11,000,000
2	Bedford and Murphy Road Pump Stations	$34,300,000
3	Donohue Bridge	$2,469,785

Appendix: B

Linear Infrastructure Needs Maps



Appendix: B

Map 1

City of Sarnia

Asset Management Plan

Legend

Roads

Remaining Service Life

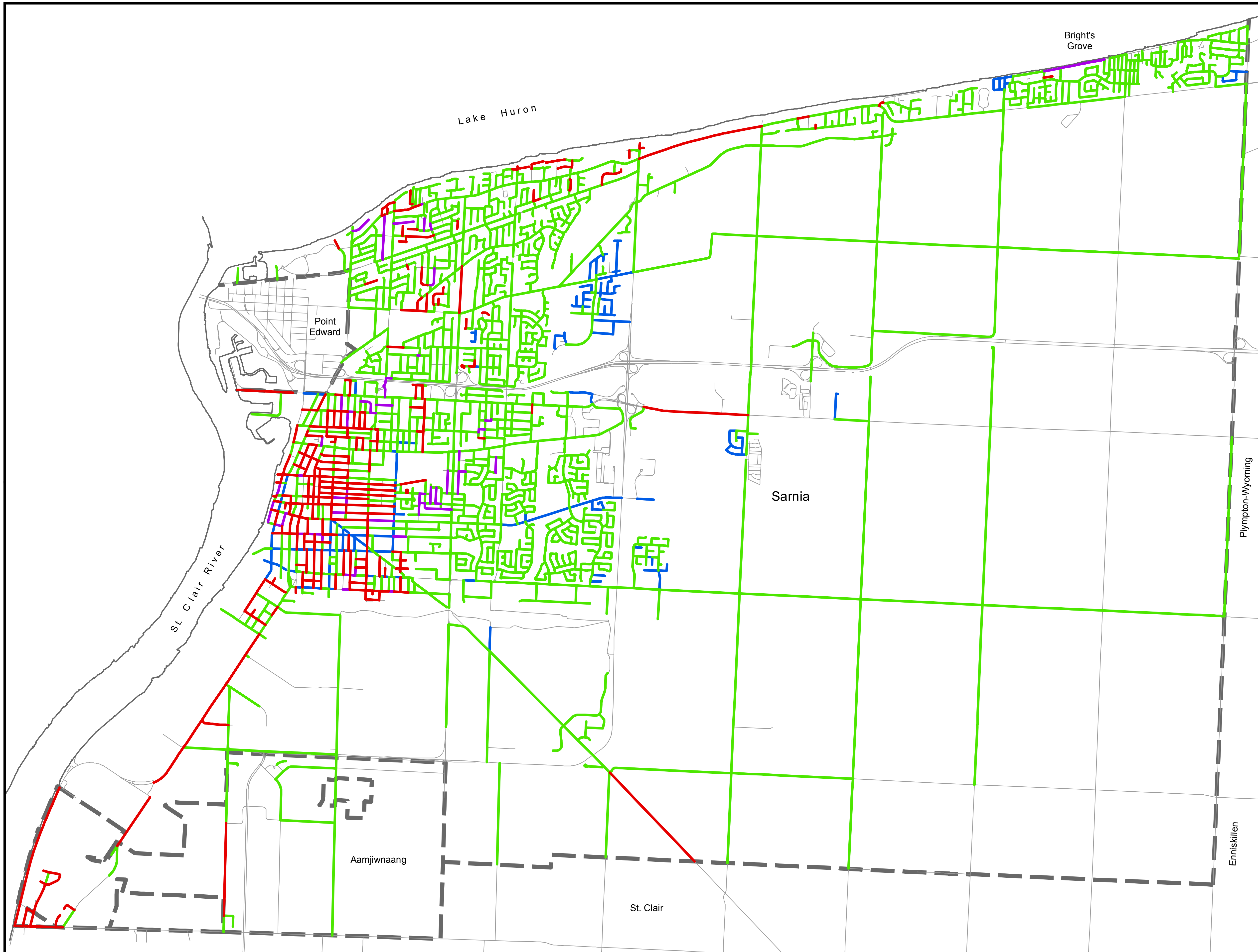
- >= 30 years
- 30 - 25 years
- 25 - 10 years
- 10 - 0 years

County / MTO Roads

N

0 500 1,000 2,000 Meters

Prepared by:
Engineering Department,
City of Sarnia,
Dated December 2, 2014.



Appendix: B

Map 2

City of Sarnia

Asset Management Plan

Legend

Water

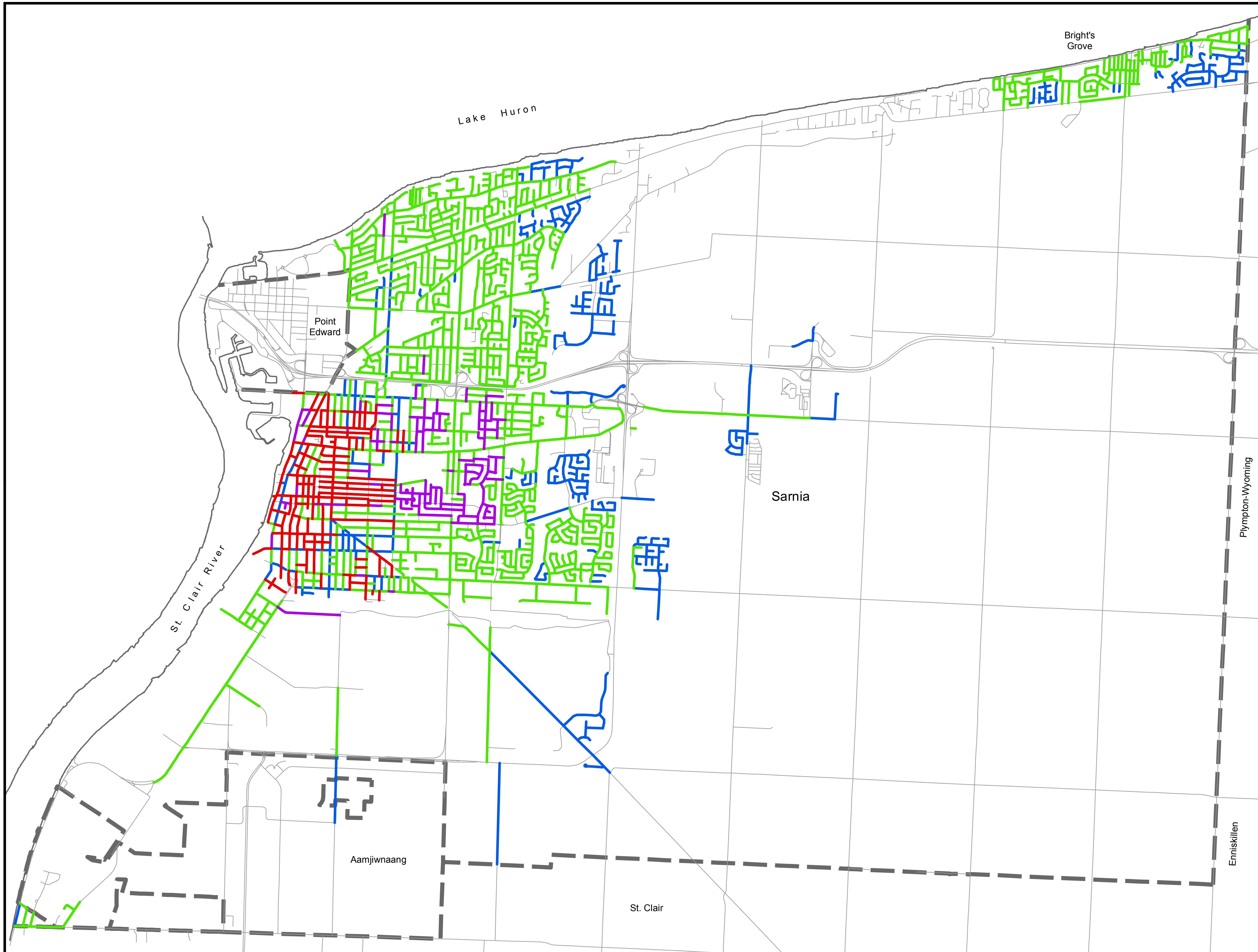
Remaining Service Life

- >= 80 years
- 80 - 45 years
- 45 - 30 years
- 30 - 0 years

N

0 500 1,000 2,000 Meters

Prepared by:
Engineering Department,
City of Sarnia,
Dated December 2, 2014.



Appendix: B

Map 3

City of Sarnia

Asset Management Plan

Legend

Sanitary

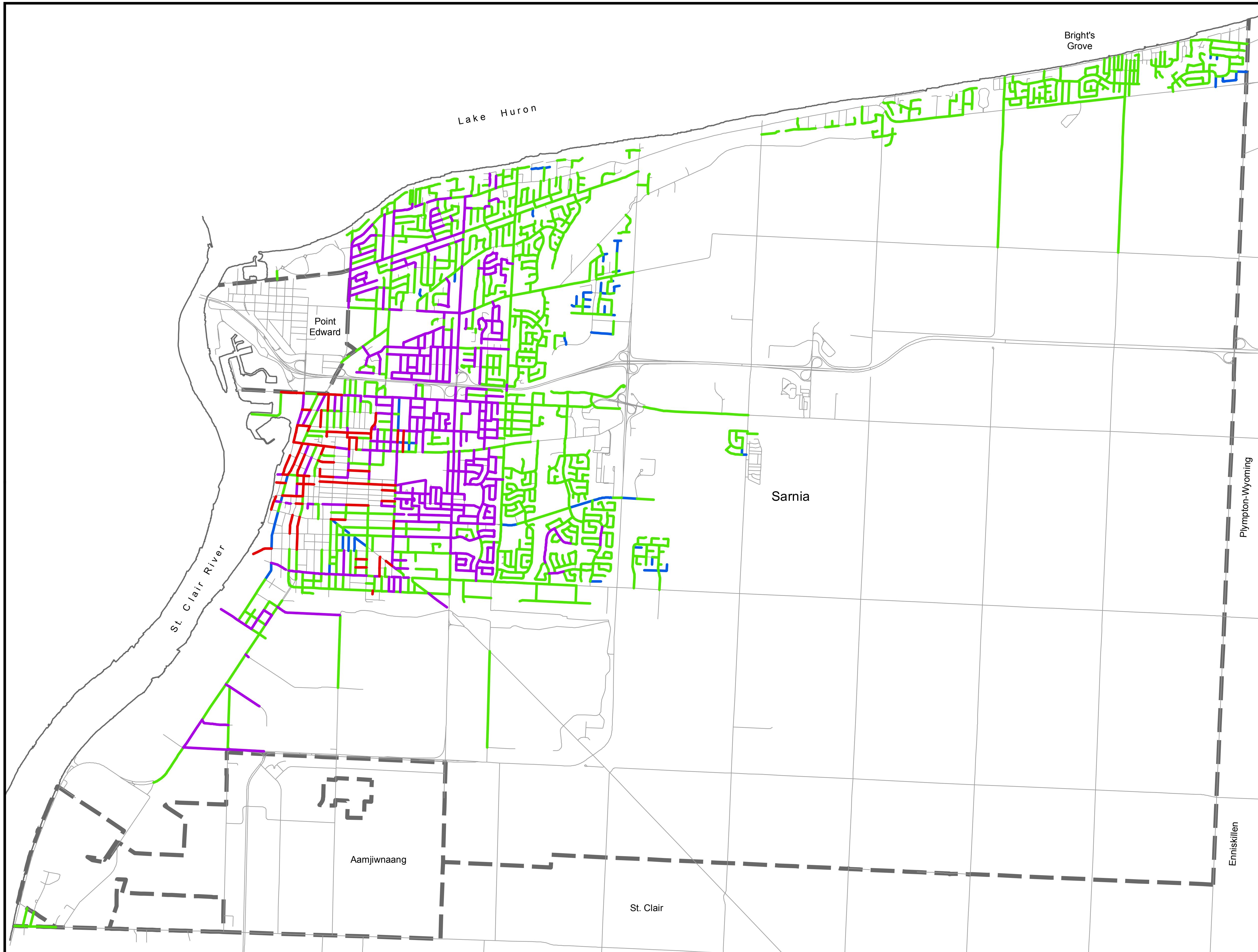
Remaining Service Life

- >= 80 years
- 80 - 45 years
- 45 - 30 years
- 30 - 0 years

N

0 500 1,000 2,000 Meters

Prepared by:
Engineering Department,
City of Sarnia,
Dated December 2, 2014.



Appendix: B

Map 4

City of Sarnia

Asset Management Plan

Legend

Storm

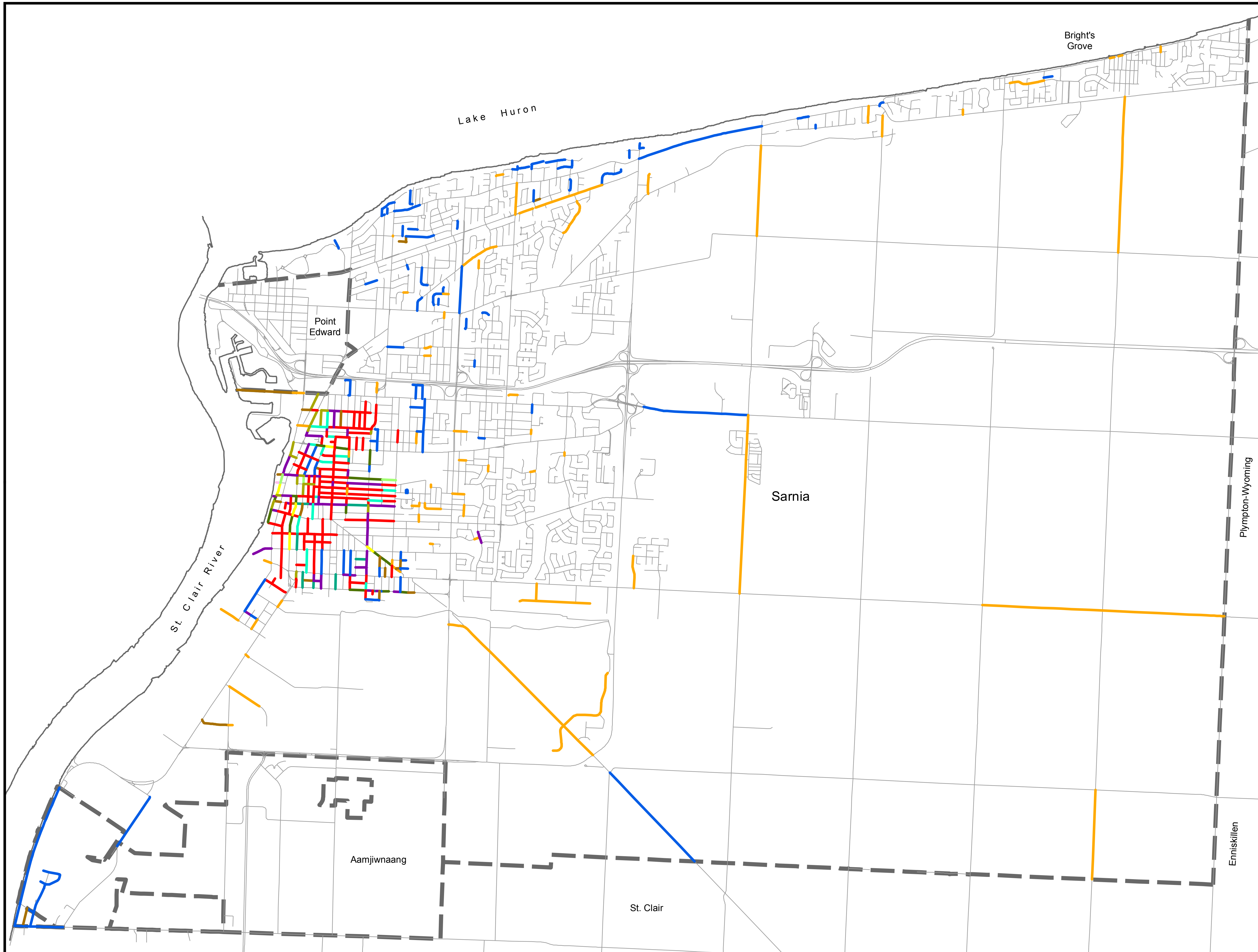
Remaining Service Life

- >= 80 years
- 80 - 45 years
- 45 - 30 years
- 30 - 0 years

N

0 500 1,000 2,000 Meters

Prepared by:
Engineering Department,
City of Sarnia,
Dated December 2, 2014.



Appendix: B

Map 5

City of Sarnia

Asset Management Plan

Legend

Current Need Project

Areas by Type

- Road
- Sanitary
- Water
- Road/Water
- Road/Sanitary
- Road/Sanitary/Storm
- Road/Water/Sanitary
- Road/Water/Storm
- Sanitary/Storm
- Water/Sanitary
- Water/Sanitary/Storm
- Road/Water/Sanitary/Storm

N

0 500 1,000 2,000 Meters

Prepared by:
Engineering Department,
City of Sarnia,
Dated December 2, 2014.

Appendix: C

Unit Prices of Linear Assets

Weighted Average Unit Price Used in Financing Strategies

Road Weigthed Average Unit Cost per Running Metre

Road Class	Length (km)	% Net Work	Reconstruction cost/m	Resurface cost/m	Major Rehabilitation with full curb repairs cost/m
Local	253	57.63%	$1,292.20	$200.20	$559.00
Collector	61	13.78%	$1,391.60	$215.60	$584.00
Arterial	64	14.62%	$1,917.00	$297.00	$719.00
Rural	61	13.96%	$1,050.80	$162.80	
Total	**439**	**100%**			
Average Cost			**$1,363.55**	**$211.25**	**$590.20**
Unit Price Used in Financial Plan = Current Need/Length = $46,103,406.34/34920.36m =			**$1,320.24**	**$225.81**	**$601.20**

Watermian Weighted Average Unit Cost per Running Metre

Water Diameter (mm)	Length (km)	% Net Work	Reconstruction Cost/m	Reconstruction Cost include Trench Repair/m
25	0.09	0.02%	$461.82	$631.82
38	0.04	0.01%	$461.82	$631.82
50	0.36	0.07%	$461.82	$631.82
75	0.07	0.01%	$461.82	$631.82
100	30.27	6.10%	$461.82	$631.82
150	220.07	44.37%	$461.82	$631.82
200	79.70	16.07%	$525.03	$695.03
250	14.25	2.87%	$595.98	$765.98
300	108.14	21.80%	$666.93	$836.93
350	1.68	0.34%	$711.89	$881.89
400	14.06	2.83%	$715.95	$885.95
450	16.21	3.27%	$795.93	$965.93
500	2.77	0.56%	$907.24	$1,077.24
600	7.77	1.57%	$1,091.34	$1,261.34
750	0.00	0.00%	$1,232.82	$1,402.82
900	0.51	0.10%	$1,428.18	$1,598.18
1050	0.00	0.00%	$1,623.53	$1,793.53
Total	**496**	**100%**		
Average Cost			**$552.87**	**$722.87**
Unit Price Used in Financial Plan = Current Need/Length = $43,340,309.10/70353.39m =				**$616.04**

Weighted Average Unit Price Used in Financing Strategies

Sanitary Sewers Weighted Average Unit Cost per Running Metre

Sanitary Diameter (mm)	Length (km)	% Net Work	Reconstruction Cost/m	Reconstruction Cost include Trench Repair/m	Cost split based on current need %
12	0.003	0.00%	$0.00	$0.00	$0.00
50	0.03	0.01%	$530.19	$778.19	$584.06
100	0.11	0.03%	$530.19	$778.19	$584.06
120	0.00	0.00%	$530.19	$778.19	$584.06
150	0.56	0.17%	$530.19	$778.19	$584.06
200	174.58	51.92%	$530.19	$778.19	$584.06
250	50.78	15.10%	$581.79	$829.79	$635.66
300	41.60	12.37%	$684.99	$932.99	$738.86
350	3.71	1.10%	$690.50	$938.50	$744.37
375	14.74	4.38%	$710.79	$958.79	$764.66
400	4.14	1.23%	$732.29	$980.29	$786.16
450	12.12	3.60%	$775.29	$1,023.29	$829.16
480	0	0.00%	$782.74	$1,030.74	$836.60
500	1.43	0.43%	$814.13	$1,062.13	$868.00
525	2.28	0.68%	$749.49	$997.49	$803.36
600	6.46	1.92%	$781.74	$1,029.74	$835.61
675	4.20	1.25%	$1,003.62	$1,251.62	$1,057.49
750	2.00	0.59%	$1,061.67	$1,309.67	$1,115.54
800	0.43	0.13%	$1,061.67	$1,309.67	$1,115.54
825	0.58	0.17%	$1,093.92	$1,341.92	$1,147.79
900	6.60	1.96%	$1,126.17	$1,374.17	$1,180.04
975	0.67	0.20%	$1,380.30	$1,628.30	$1,434.17
1050	2.26	0.67%	$1,638.30	$1,886.30	$1,692.17
1145	0.02	0.00%	$1,638.30	$1,886.30	$1,692.17
1200	1.45	0.43%	$2,141.40	$2,389.40	$2,195.27
1350	1.97	0.59%	$2,334.90	$2,582.90	$2,388.77
1400	0	0.00%	$2,429.33	$2,677.33	$2,483.19
1450	0	0.00%	$2,543.76	$2,791.76	$2,597.63
1500	2.11	0.63%	$2,592.90	$2,840.90	$2,646.77
1525	0.01	0.00%	$2,592.90	$2,840.90	$2,646.77
1575	0.27	0.08%	$2,592.90	$2,840.90	$2,646.77
1650	0.20	0.06%	$2,592.90	$2,840.90	$2,646.77
1800	0.89	0.26%	$2,592.90	$2,840.90	$2,646.77
Total	**336.22**	**100.00%**			
Average Cost			**$656.20**	**$904.20**	**$710.06**
Unit Price Used in Financial Plan = Current Need/Length = $32,919,227.27/38183.91m =				**$862.12**	

Weighted Average Unit Price Used in Financing Strategies

Storm Sewers Weighted Average Unit Cost per Running Metre

Storm Diameter (mm)	Length (km)	% Net Work	Reconstruction Cost/m	Reconstruction Cost include Trench Repair/m
50	0.00	0.00%	$657.90	$905.90
100	0.00	0.00%	$657.90	$905.90
150	0.05	0.02%	$657.90	$905.90
200	1.63	0.56%	$657.90	$905.90
250	28.59	9.76%	$657.90	$905.90
300	41.35	14.12%	$657.90	$905.90
350	0.37	0.13%	$679.40	$927.40
375	44.37	15.15%	$690.15	$938.15
400	1.21	0.41%	$700.90	$948.90
450	39.76	13.57%	$722.40	$970.40
500	0.11	0.04%	$739.60	$987.60
525	23.25	7.94%	$754.65	$1,002.65
600	23.88	8.15%	$761.10	$1,009.10
675	10.85	3.70%	$886.23	$1,134.23
750	14.28	4.87%	$976.53	$1,224.53
825	7.35	2.51%	$1,041.03	$1,289.03
900	13.20	4.51%	$1,105.53	$1,353.53
975	0.90	0.31%	$1,237.11	$1,485.11
1000	0.10	0.04%	$1,260.33	$1,508.33
1050	8.41	2.87%	$1,327.41	$1,575.41
1200	7.40	2.53%	$1,456.41	$1,704.41
1350	4.44	1.51%	$1,649.91	$1,897.91
1450	0.29	0.10%	$1,768.16	$2,016.16
1500	9.05	3.09%	$1,875.66	$2,123.66
1575	0.36	0.12%	$1,913.29	$2,161.29
1650	2.47	0.84%	$1,972.41	$2,220.41
1800	1.95	0.66%	$2,359.41	$2,607.41
1900	0.03	0.01%	$2,746.41	$2,994.41
1950	2.59	0.88%	$3,004.41	$3,252.41
2025	0.23	0.08%	$3,176.41	$3,424.41
2100	2.33	0.80%	$3,391.41	$3,639.41
2250	0.91	0.31%	$3,999.55	$4,247.55
2400	1.20	0.41%	$4,552.41	$4,800.41
Total	**292.89**	**100.00%**		
Average Cost			**$931.77**	**$1,179.77**
Unit Price Used in Financial Plan = Current Need/Length = $21,489,004.10/25,193.33m =				**$852.96**

Appendix: D

Assumptions

Assumptions

Current Needs Projected by System

- ***General***
  - Cost is based on individual asset length and unit prices derived from tender sheets
  - Unit prices are based on road class, watermains and sewer pipe diameters

- ***Combined Projects***
  - All the buried infrastructure projects due within 15-year window are combined.
  - Combined Projects cost include water installation, sewer installations and complete road reconstruction. The road reconstruction includes curb, gutter, sidewalk, boulevard, driveway repairs and etc.
  - Combined sewer separation projects are same as Combined projects (a combined sewer is replaced by a sanitary and a storm sewer; water and road will also be reconstructed at the same physical location)

- ***Road/Water/Sanitary/Storm Integrated costs***
  - Cost of either Road, Water, Sanitary or Storm includes their respective individual costs as well as the components from the combined project costs

- ***Road***
  - If only road is in need then road minor rehabilitation (top layer resurfacing and spot curb and gutter repairs) will be done
  - If one buried asset and the road are in need, then road minor rehabilitation (top layer resurfacing and spot curb and gutter repairs) will be done

  - In addition to road if two or more of buried assets or a combined sewer underneath are in need, complete road reconstruction will be done
  - If only one buried asset (and no road) is in need then only minor rehabilitation (top layer resurfacing of road) is counted
  - If two or more buried assets (and no road) underneath are in need then complete road reconstruction will be done and road reconstruction cost will be distributed among the buried assets
  - If a rural road is in need a complete reconstruction will be done
  - The road future needs have been considered as 29% (weighted average of rehabilitation cost/weighted average of reconstruction cost) of the road reconstruction cost.

Financial Strategy

- ***General***
  - Needs for the financial strategy includes current needs of linear infrastructures as of end of year 2012 and forecasted future needs in each year for up to 20 years
  - Current needs costs used are from system projected output
  - Future needs costs are based on the system projected output
  - In the combined projects where the road is not in need and is to be constructed, the road costs in such cases are not included in the financial plan.
- ***Unit Price***
  - **Road**
    - The unit costs for the specific treatment options are based on system projected needs divide by length in need
    - For road needs in combined complete reconstruction projects, the unit price are calculated using system projected needs divide by length in need

Appendix: E

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