City of Guelph

Water and Wastewater Servicing Master Plan

Technical Memorandum 4: Capital Infrastructure Funding and Risk Analysis

June 2023

TECHNICAL MEMORANDUM

To:	**Colleen Gammie, P.Eng** **Infrastructure Planning Engineer**	Company:	**City of Guelph**
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Copy:		Date:	**June 5, 2023**
Subject:	**TM#4 Capital Infrastructure Funding & Risk Analysis**		

City of Guelph

Water and Wastewater Servicing Master Plan

TM#4 Capital Infrastructure Funding & Risk Analysis

C3 WATER INC.

STANTEC CONSULTING LTD.

June 5, 2023

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	March 10, 2023	First Draft	Michelle Scott, Marc Telmosse	Sam Ziemann, Dave Eadie Matt Phillips, Colleen Gammie, Emily Stahl
2	June 5, 2023	Final	Michelle Scott, Marc Telmosse	Sam Ziemann, Dave Eadie

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C3W and Stantec certify that the information contained in this report is accurate, complete and in accordance to the terms of our engagement. This assessment is based, in part, on information provided by others. Unless specifically noted, C3W and Stantec have assumed that this information is correct, and has relied on it in the development of conclusions.

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DATE: June 5, 2023

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1.0 INTRODUCTION

The Water and Wastewater Servicing Master Plan (WWSMP) has identified recommended infrastructure upgrades and associated studies. The City needs to develop a plan to implement these recommendations.

The purpose of this technical memo is to present an opinion of Capital Infrastructure Funding strategies to implement the recommendations of the WWSMP, as well as to explore various risk factors and potential risk mitigation activities.

An understanding of risk is a key component of project prioritization determination. The analysis provided herein examines the risks of implementation delays and how climate change may impact the effectiveness of the recommended upgrades. Additionally, a number of asset lifecycle extension activities are discussed for the purpose of informing the corporate asset management plan.

2.0 PROPOSED CAPITAL PLAN

The proposed Capital Plan provides a 25-year forecast of expected funding requirements to implement the capital works and associated studies recommended in the WWSMP. The forecast of funding requirements is provided to accommodate both growth and intensification. The following sections provide details of the funding methodology applied for the water and wastewater servicing requirements, as well as the prioritization and timing implications.

2.1 Funding Methodology

For each project recommended through the WWSMP, cost estimates were developed, and the proposed funding source was determined as either growth, non-growth or a split. The wastewater project funding sources were developed using a quantitative approach based on available pipe capacity described in Section 2.1.2 below. Due to the nature of water distribution systems, determining the available capacity of a watermain is not straightforward and therefore, the funding sources were determined using a qualitative methodology.

2.1.1 Water

The funding methodology employed for the water projects is a qualitative based approach that considered two main questions;

1. Is the project required under existing conditions?
2. Is the project required to facilitate growth?

Each project was reviewed with the City's hydraulic model to determine the answer to the above questions. If, under existing conditions, there was a water system deficiency and the project was required to remedy the concern, the allocation was considered Non-Growth. If the deficiency did not show up until growth was applied to the model, the project was considered a Growth related project.

Where there was an advantage to both the existing conditions and to facilitate growth, the allocation was split between Growth and Non-Growth.

If the project provided system redundancy and provided a benefit to both Growth and Non-Growth the allocation was also split.

2.1.2 Wastewater

The funding methodology employed for the wastewater projects is a quantitative approach based on the peak flow observed in each of the sewers identified in the wastewater project list, under existing conditions and ultimate growth conditions (2051+). The approach considers the differences between the existing and ultimate wastewater collection system configuration and generated flows to quantify the flows from existing and growth throughout. The approach is varied from that applied to the potable water distribution network assessment due to the difference in metrics and outputs provided by the models for both systems.

The allocation that can be attributed to existing development is the peak flow under existing conditions (Qmax-EX) divided by the Manning's full pipe capacity (Qman) expressed as a percent:

$$\text{Existing Allocation} = \text{Qmax-EX} / \text{Qman}$$

The allocation that can be attributed to growth (greenfield and infill) is the proportion of the additional future flow (Qmax-FUT) that is due to the growth alone. This is established by subtracting the flow attributed to existing development (Qmax-EX) from the buildout flow and expressing this as a proportion of the Manning's full pipe capacity (Qman):

$$\text{Growth Allocation} = (\text{Qmax-FUT} – \text{Qmax-EX}) / \text{Qman}$$

The residual capacity is the remaining capacity in the upgraded pipe. It is established by subtracting the future flow (Qmax-FUT) from the Manning's full pipe capacity (Qman), divided by the Manning's full pipe capacity (Qman). The residual capacity is of interest as it identifies capacity achieved from the recommended upgrade that has not been allocated to either existing or growth triggered flows. It is a proportion that could be allocated in the future to either existing servicing interests or allocated to new growth.

$$\text{Residual Capacity} = (\text{Qman} – \text{Qmax-FUT}) / \text{Qman}$$

The proportion of flow for each condition was then multiplied by the asset cost to calculate the total cost for each sewer segment that can be attributed to each condition. Then the total cost for each project was summarized for each, Existing, Growth and Residual Capacity. This resulted in a "weighted" cost allocation for each project by pipe segment.

2.2 Capital Projects Cost, EA Schedule, and Implementation Prioritization

Cost estimates and funding justification for each recommended water and wastewater infrastructure project are presented in Table 2-1 to Table 2-3 below. Short term projects have been listed in order of prioritization based on need and alignment with other projects.

Environmental Assessment (EA) project schedules and justification have also been provided. This WWSMP is being undertaken in accordance with Approach #1 of the Master Planning Process, as outlined in Appendix 4 of the Municipal Class Environmental Assessment (MCEA) document, using a broad level assessment. Detailed investigations at the project-specific level will be required in order to fulfil the MCEA documentation requirements for the specific Schedule B and C projects identified within this Master Plan. This Master Plan will become the basis for, and be used in support of, future investigations for the specific Schedule B and C projects identified within it. Schedule B projects would require the filing of the Project file for public review while Schedule C projects would have to fulfil Phases 3 and 4 prior to filing an Environmental Study Report (ESR) for public review. The schedules for future projects identified as part of this master plan were reviewed utilizing the 2023 MCEA amendments.

2.3 Cost Estimates for Other Programs and Studies

A number of studies are recommended under the planning horizon of this WWSMP including 5-year updates to the WWSMP itself. Additional water studies include the Integrated Water Management study, a conceptual design and Schedule C EA for the Arkell Alternative and Schedule B EA for the Zone 2 elevated tank (ET). Recommended wastewater studies include preliminary studies for system improvements in specific areas and annual flow monitoring and I/I studies. These are summarized in Table 2-4 below.

Additionally, a number of pilot programs from the Innovation Strategy were recommended. Further information on these programs can be found in the *Innovation Strategy TM*. Cost estimates have been developed for these programs and are summarized in Table 2-5 below.

Table 2-1 Water Capital Projects Summary- Facilities

Project Number	Timing	Triggers/Sequencing	Location	Summary of Upgrades	Purpose	Cost**	Land Costs***	Funding Type	% Growth Related	Funding Type Justification	EA Schedule	EA Schedule Justification
Facilities												
F-1	Short-Term	Ongoing	Woods WTP	Upgrades to pump station, dual discharge feedermains. Upgrades to office spaces.	Replace aging infrastructure and improve redundancy within facility.	N/A*		N/A*	N/A*	N/A*	N/A*	N/A*
F-2	Short-Term	Ongoing	Clythe WTP. PS and Reservoir	New WTP, Pump Station and 6.9 ML Reservoir	Bring Clythe Well online. Increase storage in Zone 2 and pump capacity on east side of Zone 2.	N/A*		N/A*	N/A*	N/A*	N/A*	N/A*
F-4	Short-Term	Prior to Clythe Upgrades (F-2)	Park Zone 2 PS	New PS at Park Wells Site	Supply to the east side of Zone 2	$2,600,000		Non-Growth	0%	Address existing Criticality of Clythe PS	Exempt	Increasing pumping station flexibility by adding or replacing equipment where new equipment is located within an existing building or structure;
F-3	Short-Term	In the Proposal Stage	Verney BPS	New BPS to replace existing Robertson	Increase pump capacity	$7,600,000		Growth/Non-Growth	50%	Increase Pump Supply to meet future growth and address deficiencies of existing station.	B	Already completed (GMBP, 2021)
F-5	Mid-Term	Clair Maltby ET	Clair BPS	Retrofit Existing PS	Replace existing pumps with suitable size once Clair Maltby ET is online.	$400,000		Growth	100%	Supply future Zone 3 growth	n/a	Retrofit within existing building. No capacity increase.
W-S-1	Mid-Term	Speedvale ET Lifecycle	North end of Zone 2.	6ML Elevated Tank	New ET to Improve Zone 2 floating storage. Increased volume and improved location.	$10,500,000	$125,000	Growth	100%	Improve Zone 2 Floating Storage to supply future growth	B	Establish new or expand/replace existing water storage facilities.
Arkell Alt 4B2	Short-Term	Existing Criticality	New Arkell PS, Reservoir and WM	New PS, Reservoir and Watermain	Transfer water from Arkell/Carter Wellfields supply redundancy/resiliency	$110,400,000	$550,000	Growth/Non-Growth	50%	Address existing criticality of Arkell Aqueduct. Improves supply to south end to meet growth.	C	Construct new water treatment plant.

**Costs not included for projects previously approved through WSMP.*
***Facility costs include 50% Contingency & 15% Engineering*
**** Included in total cost*

Table 2-2 Water Capital Projects Summary- Watermains

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost*	Funding Type	% Growth Related	Funding Type Justification	EA Sched.	EA Schedule Justification
Watermains												
W-8	Short-Term	Existing Criticality and Growth	Speedvale from Edinburgh to Manhattan	400	2150	Complete east/west Speedvale transmission main.	$3,400,000	Growth/Non-Growth	50%	Improve existing east-west limitations in Zone 2 and Zone 2 growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-24	Short-Term	W-8	Speedvale from Westmount to east of Woolwich	200	930	Improve watermain capacity near Robertson PS discharge	$800,000	Growth/Non-Growth	50%	Address existing capacity constraints and meet growth requirements.	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-19	Short-Term	W-8	Speedvale from East of Woolwich to Stevenson	200	1020	Improved transmission north end of Zone 1 and connectivity to Stevenson	$900,000	Growth/Non-Growth	50%	Address existing capacity constraints and meet growth requirements.	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-16	Short-Term	Existing Criticality/ Growth	Gordon from York to University	300	1110	Reduce criticality of University River Crossing.	$1,400,000	Growth/Non-Growth	50%	Address existing river crossing criticality. Improved capacity to supply growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-CI-1a	Short-Term	Existing Capacity Constraints	Small Diameter CI WMs throughout system	150	13600	Improve existing fire flow constraints	$10,400,000	Non-Growth	0%	Address existing WM capacity constraints	Exempt	Within existing road right-of-way. Presented at PIC2.
W-2	Short-Term	Growth	York from Brockville to Watson	600	2500	Improve connectivity to Clythe PS fill.	$6,700,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-26	Short-Term	W-2	York Road from Brockville to Clythe PS	300	450	Improve HL and FF	$500,000	Growth/Non-Growth	50%	Address existing capacity constraints and meet growth requirements.	Exempt	Within existing road right-of-way. Presented at PIC2.
W-11	Short-Term	Verney BPS (F-3)	Exhibition from Robertson/Verney PS to Speedvale	400	375	Improve watermain capacity at Verney PS discharge	$600,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-20	Short-Term	Existing Capacity Constraints	University/College from River Crossing to Edinburgh	200	1760	Improve Capacity and Looping in University Area	$1,500,000	Non-Growth	0%	Address existing capacity constraints in Old University Area	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-17	Short-Term	Existing Capacity Constraints	Dufferin from Mac to London	200	1300	Connectivity between London and Woolwich. Local FF improvements.	$1,100,000	Non-Growth	0%	Existing FF Improvement	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-18	Short-Term	Existing Capacity Constraints	Delhi from Eramosa to existing 250mm	250	690	Connectivity between W-1 on Eramosa and Verney Feedermain. Improve fire flow capacity to Hospital	$600,000	Non-Growth	0%	Existing FF Improvement	Exempt	Within existing road right-of-way. Presented at PIC2.

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost*	Funding Type	% Growth Related	Funding Type Justification	EA Sched.	EA Schedule Justification
Watermains												
W-M-23	Short-Term	Existing Capacity Constraints	Talbot/Forest Hill from Water to University	200	850	Improve Capacity and Looping in University Area	$700,000	Non-Growth	0%	Address existing capacity constraints in Old University Area	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-21	Short-Term	Existing Capacity Constraints	Water/Albert from River Crossing to Gordon	200	790	Improve Capacity and Looping in University Area	$700,000	Non-Growth	0%	Address existing capacity constraints in Old University Area	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-22	Short-Term	Existing Capacity Constraints	Dean from Edinburgh to Talbot	200	520	Improve Capacity and Looping in University Area	$400,000	Non-Growth	0%	Address existing capacity constraints in Old University Area	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-1	Short-Term	Existing Capacity/Growth	Woolwich from Norfolk to Macdonnell	300	930	Improve Downtown Looping	$1,000,000	Growth/Non-Growth	50%	Address existing FF and HL through DT core and improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-3	Short-Term	Existing Capacity/Growth	Wyndham from Woolwich to Carden	300	480	Local Downtown Improvements	$500,000	Growth/Non-Growth	50%	Address existing FF and HL through DT core and improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-12	Short-Term	Clythe PS (F-2) and Zone Boundary Change	Watson from Clythe PS to Grange	600	760	Improve watermain capacity at Clythe PS discharge	$2,000,000	Growth/Non-Growth	50%	Required for Zone boundary change to address existing high pressures. Required increased capacity for Clythe upgrades to meet growth in area.	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-6	Short-Term	Existing Capacity/Growth	Waterloo from Yorkshire to Essex	300	500	Improve Downtown Looping	$500,000	Growth/Non-Growth	50%	Address existing FF and HL through DT core and improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-13	Short-Term	Growth	Wellington from Gordon to Neeve	300	480	Improve Downtown Looping	$500,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-5a	Short-Term	Existing Criticality	Imperial/Elmira from Paisley PS to Willow	400	1970	Redundancy for Paisley PS discharge.	$3,100,000	Growth/Non-Growth	50%	Addresses existing criticality of Paisley PS discharge and Zone 2 growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-3	Short-Term	Growth	Paisley from Hanlon to Paisley PS	400	400	Improve Connectivity to Paisley PS fill.	$600,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-CI-1b	Short-Term	Existing Capacity Constraints	Small Diameter CI WMs throughout system	150	28000	Improve existing fire flow constraints	$21,500,000	Non-Growth	0%	Address existing WM capacity constraints	Exempt	Within existing road right-of-way. Presented at PIC2.

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost*	Funding Type	% Growth Related	Funding Type Justification	EA Sched.	EA Schedule Justification
Watermains												
W-1a	Short-Term	Growth	Yorkshire from Wellington to London and Exhibition	600	1850	Improves downtown looping and connectivity to Verney ET.	$4,900,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-1b	Short-Term	Growth	Exhibition from London to Verney	600	940	Improves downtown looping and connectivity to Verney ET.	$2,500,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-15	Short-Term	Growth	Woolwich from London to Norwich	300	210	Improve Downtown Looping. Connection to W-1	$200,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-2	Short-Term	Existing Capacity/Growth	Cardigan from Norwich to Woolwich	200	260	Local Downtown Improvements	$200,000	Growth/Non-Growth	50%	Address existing FF and HL through DT core and improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-4	Short-Term	Existing Capacity/Growth	Macdonell from Norfolk to Carden	200	440	Local Downtown Improvements	$400,000	Growth/Non-Growth	50%	Address existing FF and HL through DT core and improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-5	Short-Term	Existing Capacity/Growth	Dublin from Waterloo to Wellington	200	400	Local Downtown Improvements	$300,000	Growth/Non-Growth	50%	Address existing FF and HL through DT core and improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-7	Short-Term	Growth	Yarmouth from Woolwich to Quebec	200	320	Local Downtown Improvements	$300,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-9	Short-Term	Growth	Essex from Dublin to Waterloo	200	170	Local Downtown Improvements	$100,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-10	Short-Term	Growth	Nottingham from Dublin to Gordon	200	180	Local Downtown Improvements	$200,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-11	Short-Term	Growth	Fountain from Dublin to Neeve	200	550	Local Downtown Improvements	$500,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-12	Short-Term	Growth	Surrey from Dublin to Neeve	200	610	Local Downtown Improvements	$500,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-14	Short-Term	Growth	Duke from Alice to existing PVC	200	220	Local Downtown Improvements	$200,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost*	Funding Type	% Growth Related	Funding Type Justification	EA Sched.	EA Schedule Justification
Watermains												
												way. Presented at PIC2.
W-M-8	Short-Term	Growth	Baker from Woolwich to Quebec	300	300	Local Downtown Improvements	$300,000	Growth	100%	Improve capacity for future growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-1c	Mid-Term	Growth	London/Eramosa from Exhibition to Stevenson	400	2140	Improves downtown looping and connectivity to Verney ET. Reduces high headloss associated with future growth.	$3,600,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-4a	Mid-Term	Arkell PS and Growth	Arkell from Gordon to Victoria	600	1600	Improve connectivity between future Arkell PS and Clair ET.	$4,300,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 3	Exempt	Within existing road right-of-way. Presented at PIC2.
W-5b	Mid-Term	Zone 2 ET	Elmira from Speedvale to Willow	400	800	Redundancy for Paisley PS discharge.	$1,300,000	Growth/Non-Growth	50%	Addresses existing criticality of Paisley PS discharge and Zone 2 growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-6a	Mid-Term	Zone 2 ET	Woodlawn from Elmira to Silvercreek	400	2030	Improve East/West transmission. Reduce criticality of Paisley and Clythe PSs. Redundancy for Speed River Crossing.	$3,200,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-13	Mid-Term	Zone 2 ET	Silvercreek from Woodlawn to Proposed Zone 2 ET	400	900	Connection to proposed Zone 2 ET	$1,600,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-4b	Long Term	Growth	Gordon from Arkell to Clair	600	1760	Improve connectivity between future Arkell PS and Clair ET.	$4,700,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 3	Exempt	Within existing road right-of-way. Presented at PIC2.
W-4c	Long Term	Growth	Clair from Gordon to ET	600	1200	Improve connectivity between future Arkell PS and Clair ET.	$3,200,000	Growth	100%	Improve Zone 1 feedermain capacity to service growth in Zones 1 and 3	Exempt	Within existing road right-of-way. Presented at PIC2.
W-6b	Long Term	Growth	Woodlawn from Silvercreek to Woolwich	400	2160	Improve East/West transmission. Reduce criticality of Paisley and Clythe PSs. Redundancy for Speed River Crossing.	$3,400,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost*	Funding Type	% Growth Related	Funding Type Justification	EA Sched.	EA Schedule Justification
Watermains												
W-6c	Long Term	Growth	Woodlawn from Woolwich to Victoria	400	2022	Improve East/West transmission. Reduce criticality of Paisley and Clythe PSs. Redundancy for Speed River Crossing.	$3,400,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-7	Long Term	Growth	Elmira from Speedvale to Woodlawn	400	1070	Improve system looping.	$1,700,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-9	Long Term	Growth	Victoria from Speedvale to Woodlawn	400	1010	Improve system looping.	$1,600,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-10	Long Term	Guelph Lake WTP	Victoria from Woodlawn to Goldenview Drive	400	1000	Connectivity to Guelph Lake supply.	$1,600,000	Growth	100%	Improve Zone 2 feedermain capacity to service growth in Zone 2	Exempt	Within existing road right-of-way. Presented at PIC2.
W-M-25	Mid-Term	Clair Maltby ET	Crawley to Maltby	300	2130	Improve West Zone 3 Looping	$2,200,000	Growth	100%	Servicing Zone 3 Growth	Exempt	Within existing road right-of-way. Presented at PIC2.
W-CI-2	Mid-Term	Existing Capacity Constraints	Small Diameter CI WMs throughout system	150	41600	Improve existing fire flow constraints	$32,000,000	Non-Growth	0%	Address existing WM capacity constraints	Exempt	Within existing road right-of-way. Presented at PIC2.
W-CI-3	Long Term	Existing Capacity Constraints	Small Diameter CI WMs throughout system	150	41600	Improve existing fire flow constraints	$32,000,000	Non-Growth	0%	Address existing WM capacity constraints	Exempt	Within existing road right-of-way. Presented at PIC2.
Water Infrastructure Total (Facilities and Watermains)							**$301,300,000**					

** Watermain unit costs include 20% Contingency and 15% Engineering*

Table 2-3 Wastewater Capital Projects Summary

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost	Funding Type	% Existing Needs	% Growth Related	% Residual Capacity	Funding Type Justification	EA Schedule	EA Schedule Justification
Sewers														
WW5-1	Short-Term	Existing Capacity Constraints	York Rd and Wellington St	1200 / 1350	3284	Capacity	$27,820,000	Non-Growth	85%	17%	6%	Address Existing Capacity Constraint	Exempt or B	Possible work outside of existing right-of-way
WW4-4	Short-Term	Existing Capacity Constraints	Victoria Rd	375	777	Capacity	$4,350,000	Non-Growth	57%	1%	43%	Address Existing Capacity Constraint / Meet Design guidelines	Exempt	Within existing right-of-way
WW2-3	Short-Term	Existing Capacity Constraints	Wilton Rd, Inverness Dr and Speedvale Ave	150 / 300 / 375	1128	Capacity	$3,640,000	Growth / Non-Growth	59%	1%	41%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW5-4	Short-Term	Existing Capacity Constraints	Quebec St and Wyndham St	375 - 600	1066	Capacity	$5,450,000	Non-Growth	68%	10%	23%	Address Existing Capacity Constraint / Meet Design guidelines	Exempt	Within existing right-of-way
WW4-1	Short-Term	Existing Capacity Constraints	Audin Rd and Victoria Rd	300 / 375	186	Capacity	$680,000	Growth / Non-Growth	45%	1%	54%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW2-2	Short-Term	Existing Capacity Constraints	Inverness Dr, Balmoral Dr, Windsor St, Waverley Dr & Stevenson St	375 / 450	1593	Capacity	$5,260,000	Non-Growth	84%	0%	18%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW5-6	Short-Term	Existing Capacity Constraints	Waterloo Ave	300	166	Capacity	$510,000	Non-Growth	71%	6%	24%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW5-5	Short-Term	Existing Capacity Constraints	Woolwhich St	300	167	Capacity	$510,000	Non-Growth	52%	9%	40%	Address Existing Capacity Constraint / Meet Design guidelines	Exempt	Within existing right-of-way
WW4-5	Short-Term	Existing Capacity Constraints	Summit Ridge Dr	300	173	Capacity	$530,000	Non-Growth	44%	0%	56%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost	Funding Type	% Existing Needs	% Growth Related	% Residual Capacity	Funding Type Justification	EA Schedule	EA Schedule Justification
WW1-1	Short-Term	Existing Capacity Constraints	Silvercreek Parkway	375	472	Capacity	$3,340,000	Growth / Non-Growth	68%	5%	26%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW6-1	Short-Term	Existing Capacity Constraints	College Ave	300 / 375	281	Capacity	$850,000	Non-Growth	64%	9%	27%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW3-1	Short-Term	Existing Capacity Constraints	Exhibition Park / Kathleen St	450	926	Capacity	$3,110,000	Growth / Non-Growth	76%	3%	20%	Address Existing Capacity Constraint / Meet Design guidelines	Exempt	Within existing right-of-way
WW2-1	Short-Term	Existing Capacity Constraints	Victoria Rd and Waverley Dr	300 / 375	1032	Capacity	$3,240,000	Non-Growth	67%	0%	33%	Address Existing Capacity Constraint	Exempt	Within existing right-of-way
WW1-2	Short-Term	Existing Capacity Constraints	Westwood Rd	300	82	Capacity	$2,710,000	Growth	0%	100%	0%	Improve capacity for future growth	Exempt	Within existing right-of-way
WW2-4	Mid-Term	Growth	Speedvale Ave	375	237	Capacity	$930,000	Growth	0%	100%	0%	Improve capacity for future growth	Exempt	Within existing right-of-way
WW4-2	Mid-Term	Growth	York Rd and Beaumont Cres.	675 / 900	1364	Capacity / Operational	$8,460,000	Non-Growth	0%	100%	0%	Improve capacity for future growth / operational improvements	Exempt	Within existing right-of-way
WW5-2	Mid-Term	Growth	Waterloo Ave	825	528	Capacity	$2,660,000	Growth / Non-Growth	0%	100%	0%	Improve capacity for future growth / operational improvements	Exempt	Within existing right-of-way
WW7-1	Mid-Term	Growth	Clair Rd	250 / 300	834	Capacity	$2,370,000	Growth	0%	100%	0%	Improve capacity for future growth	Exempt	Within existing right-of-way
WW5-3	Long-Term	Growth	Bristol St	600	1014	Capacity	$3,680,000	Growth / Non-Growth	0%	100%	0%	Improve capacity for future growth / operational improvements	Exempt	Within existing right-of-way
Siphons														
S1 - Manor Park Siphon	Long-Term	Operations	Manor Park Crescent / Speed River	-	-	Operational / Redundancy	$1,500,000	Non-Growth	100%	0%	-	Previous Assessment	Exempt	Within existing utility corridor

Project Number	Timing	Triggers	Location	Size (mm)	Length (m)	Purpose	Cost	Funding Type	% Existing Needs	% Growth Related	% Residual Capacity	Funding Type Justification	EA Schedule	EA Schedule Justification
S2 - Municipal Street Siphon	Long-Term	Operations	Municipal Street / Speed River	-	-	Operational / Redundancy	$4,000,000	Non-Growth	99%	1%	-	Previous Assessment	Exempt	Gravity improvements within existing right-of-way
S3 - Alma Mercer	Long-Term	Operations	Alma Street North / Mercer Street	600	80	Operational / Redundancy	$270,000	Non-Growth	91%	9%	-	To be monitored and assessed if/as needed	Exempt	Within existing right-of-way
S4 - Elizabeth-Beaumont	Long-Term	Operations	Elizabeth Street North / Beaumont Crescent	450	22	Operational / Redundancy	$210,000	Non-Growth	90%	10%	-	To be monitored and assessed if/as needed	Exempt	Within existing utility corridor
S5 - Eramosa River	Long-Term	Operations	Eramosa River / Cutten Fields Golf Course	500	150	Operational / Redundancy	$1,460,000	Non-Growth	99%	1%	-	To be monitored and assessed if/as needed	Exempt	Within existing utility corridor
S6 - Hanlon-Massey-Campbell	Long-Term	Operations	Hanlon Parkway - Massey Road / Campbell Road	200 / 450	44	Operational / Redundancy	$400,000	Non-Growth	95%	5%	-	To be monitored and assessed if/as needed	Exempt	Within existing utility corridor
S7 - Ptarmigan	Long-Term	Operations	Ptarmigan Drive	150 / 200	324	Operational / Redundancy	$2,620,000	Non-Growth	92%	8%	-	To be monitored and assessed if/as needed	Exempt	Within existing utility corridor
S8 - Speed River Crane Park	Long-Term	Operations	Speed River - Crane Park	750 / 600 / 300	921	Operational / Redundancy	$9,090,000	Non-Growth	64%	36%	-	To be monitored and assessed if/as needed	Exempt	Within existing utility corridor
S9 - Stevenson-Eramosa	Long-Term	Operations	Stevenson Street North / Eramosa Road	200	23	Operational / Redundancy	$40,000	Non-Growth	95%	5%	-	To be monitored and assessed if/as needed	Exempt	Within existing right-of-way
S10 - Willow-Guelph	Long-Term	Operations	Willow Road / Guelph Street	750	19	Operational / Redundancy	$80,000	Non-Growth	92%	8%	-	To be monitored and assessed if/as needed	Exempt	Within existing right-of-way
Wastewater Infrastructure Total							**$99,770,000**							

**A is Exempt under 2023 MEA Amendment*

Table 2-4 Studies Summary

Project Number	Timing	Triggers/Sequencing	Description	Cost	Funding Type	% Growth Related	Justification	EA Sched.	EA Schedule Justification
MP-1	Short-Term	5 yr update	Water and Wastewater Servicing Master Plan: 5yr Update	$700,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	B	
MP-2	Mid-Term	5 yr update	Water and Wastewater Servicing Master Plan: 10yr Update	$800,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	B	
MP-3	Mid-Term	5 yr update	Water and Wastewater Servicing Master Plan: 15yr Update	$900,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	B	
MP-4	Mid-Term	5 yr update	Water and Wastewater Servicing Master Plan: 20yr Update	$1,000,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	B	
MP-5	Long-Term	5 yr update	Water and Wastewater Servicing Master Plan: 25yr Update	$1,100,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	B	
MP-6	Long-Term	5 yr update	Water and Wastewater Servicing Master Plan: 30yr Update	$1,200,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	B	
WS-1	Short-Term		Integrated Water Management	$300,000	Growth/Non-Growth	50%*	Study existing constraints and plan for growth	N/A	
WS-2	Short-Term	Short-term for existing criticality	Arkell Conceptual Design and Schedule C EA	$600,000	Growth/Non-Growth	50%	Address existing criticality of Arkell Aqueduct. Improves supply to south end to meet growth.	C	Construct new water treatment plant.
WS-3	Short-Term	Short-term to secure land	Zone 2 ET Schedule B EA	$200,000	Non-Growth	100%	Improve Zone 2 Floating Storage to supply future growth	B	Establish new or expand/replace existing water storage facilities
WWS-1	Short-Term	Required to further scope upgrades	Preliminary Study - Area 5	$100,000	Growth / Non-Growth	50%*	Preliminary studies for system improvements	B	
WWS-2	Short-Term	Required to further scope upgrades	Preliminary Studies (6 areas)	$300,000	Growth / Non-Growth	50%*	Preliminary studies for system improvements	B	
WWS-2	Short-Term	Required to further scope upgrades	Environmental Approvals and Mitigation	$1,050,000	Growth / Non-Growth	50%*	Preliminary studies for system improvements	B	
WWFM1	Short-Term	Annual Data Collection	Annual Flow Monitoring / I/I Studies (10 Years)	$500,000	Growth / Non-Growth	50%*	Data Collection for MP Updates	N/A	
WWFM2	Mid-Term	Annual Data Collection	Annual Flow Monitoring / I/I Studies (10 Years)	$500,000	Growth / Non-Growth	50%*	Data Collection for MP Updates	N/A	
WWFM3	Long-Term	Annual Data Collection	Annual Flow Monitoring / I/I Studies (10 Years)	$500,000	Growth / Non-Growth	50%*	Data Collection for MP Updates	N/A	
Studies Total				**$9,750,000**					

*Needed for growth but may not be included under Bill-23.

Table 2-5 Pilot Projects

Project Number	Timing	Triggers/Sequencing	Description	Cost	Funding Type	% Growth Related	Justification	EA Sched.
Pilot-1	Short-Term	n/a	Advanced Metering Infrastructure Business Case	$100,000	Growth	100%	Provide accurate real-time data for customer and municipal decision making and more equitable cost sharing	N/A
Pilot-2	Short-Term	n/a	Integrated Water Management and Analytics Platform Plan Development	$50,000	Growth	100%	Tool to help make better decisions by leveraging the data currently being gathered and stored in databases.	N/A
Pilot-3	Short-Term	n/a	Demand Prediction Tool Development	$50,000	Growth	100%	Development of a tool to help predict future water demand utilizing existing data streams.	N/A
Pilot-4	Short-Term	n/a	Water Availability Supply Capacity Model Development	$50,000	Growth	100%	Build on Water Services existing tool with an automated system reporting on the available capacity now and in the future.	N/A
Pilot-5	Short-Term	n/a	Leak Detection Pilot	$250,000	Growth	100%	Further the existing program through the testing of technology to identify and locate leaks.	N/A
Pilot-6	Short-Term	n/a	Development of a Digital Twin	$75,000	Growth	100%	Help to optimize operations and better prepare for emergency events	N/A
Pilot Programs Total				**$575,000**				

3.0 CITY STAFFING REQUIREMENTS FOR IMPLEMENTATION OF CAPITAL PLAN

To aid in the delivery of the capital projects recommended within each planning horizon, an estimate of required City staffing resources has been provided.

3.1 Project Managers

The City manages the delivery of capital projects with City Project Managers based in Design and Construction and Water Services. Typically, watermain projects are managed by the Design and Construction project managers while vertical asset projects are managed by Water Services project managers. Representatives from both groups are involved in all capital delivery projects. The City utilizes internal resources to manage and design smaller watermain projects. Current staffing includes;

- An Infrastructure Planning Engineer,
- 8 Project Engineers/Project Managers (Design and Construction and Water Services),
- 2 Designers.

Based on the project delivery history at the City, a required staffing estimate was completed utilizing project-years in the proposed capital plan. The analysis indicated that one additional project management staff is needed in the short term as there are significant projects upcoming in the next 8 years. Over the duration of the capital plan, the project management staffing should be reviewed.

3.2 Operational Staff

As the City grows and the water and wastewater systems expand, more infrastructure will need to be maintained. For each watermain added, additional valves and hydrants are implemented. Similarly, for additional sanitary sewers and siphons. Each asset requires maintenance including such activities as:

- Valve turning program,
- Watermain break repair,
- Hydrant maintenance,
- Watermain and collection system flushing.
- Siphon inspection and flushing
- Collection system and maintenance hole inspections

As the number of assets grows, operations support staff should be scaled accordingly.

A significant capital project has been recommended at the Arkell Water Supply System. This includes a new reservoir, a new water treatment plant including UV and chlorination, and two (2) new pumping stations, as well as approximately 3 km of watermain. The facility will be approximately equal to FM Woods in production capacity, providing full redundancy should Woods or its aqueduct fail. In practice, flows are expected to be split between the new facility and Woods the majority of the time. Although this new facility will be automated, operation and maintenance of this facility will be required, including daily physical checks. Items such as chemicals and replacement parts (e.g., UV lamps) will need to be delivered, and general maintenance of mechanical equipment required on at least an annual basis.

3.3 Innovation Projects

A number of innovation pilot projects have been identified in the capital plan. These projects are typically smaller studies investigating and piloting new technologies. Staffing requirements will include a Project Manager. Results of the adoption of new technology could result in the addition of new roles at the City with a specific set of skills to support the technology.

4.0 RISK ANALYSIS

The Capital Infrastructure Funding plan provides a vision of how the recommended projects will be supported as the City grows. The intent is to maintain or improve the existing and/or future level of service to the residents and businesses that reside within the City. Notwithstanding this plan, it is a worthwhile and prudent exercise to explore the risks associated with deviations to the implementation plan. The following sections present topics aligned to risk associated with the implementation plan with regards to:

- Prioritization plan for the identified infrastructure recommendations
- Potential impacts of climate change on the effectiveness of the recommendations

4.1 Risk Analysis and Priority Projects

It is appreciated that funding availability and capital investment priorities can change. The risk analysis and priority projects have been identified to further establish an understanding of the triggers and requirements that best serve the City's needs and enhance the level of service provided. This plan should be updated as components of the City's Official Plan progress, and at minimum after each capital project is further assessed and confirmed, and then implemented.

4.1.1 Water

The City's water system is a well-designed robust system able to handle many types of planned maintenance activities and emergencies. Interconnectivity between pressure zones, large redundant watermains and significant storage are just some examples of how the system has been planned with redundancy and safety of supply and distribution in mind. Several key projects of the City's capital plan have been highlighted below.

The criticality analysis identified the **Arkell Aqueduct** as a key component currently lacking redundancy. The Aqueduct is a single supply line between the Arkell Water Supply System and the FM Woods Water Treatment Plant that provides between 60-80% of the City's water. Portions of the aqueduct are in need of rehabilitation. The aqueduct is also located in difficult to access locations and repairs would be difficult should a break occur. A project has been identified that will provide a secondary supply line from the Arkell Water Supply System to the City. Failure to provide a redundant system will put the City at risk of losing water supply within 24 hours should the existing aqueduct fail.

The existing water system is quite reliant on pumped storage through reservoirs, with approximately 80% of the storage located at ground level. It is important that the proposed **elevated tanks for Zone 2 and Zone 3** are completed to maintain a portion of water storage in the air. As the system and demands grow, additional stress is placed on the water system and the time to react is reduced during emergencies. Elevated tanks provide system redundancy during power failures and other emergencies. They also provide a release to system pressures when pumps are stopped and started or other changes in the water system occur, protecting the assets and reducing leakage and ultimately watermain breaks. If these projects are not completed as anticipated, the water system will be stressed further by growth and operations will be challenged in responding very quickly to emergency situations.

There are a significant number of old, small diameter cast iron watermains, some as small as 100 mm. A **Cast Iron Watermain Replacement Program** has been recommended as part of the capital plan. Generally, areas with small cast iron watermains have limited capacity due to tuberculation of the inner pipe-walls. Over the years, fire flow requirements have changed and the minimum watermain diameter has been increased to 150mm. The combination of reduced capacity due to tuberculation and additional fire flow requirements have left several areas within the City with reduced fire flows. As the watermains continue to age there will be further reduction in capacity and a risk of reduced fire flows. The replacement of these smaller cast iron watermains should remain a priority.

4.1.2 Wastewater

There are a total of 19 wastewater projects identified (excluding siphons upgrades), and of those, 14 are required under existing conditions (short term), 4 are required in the Mid-Term (2041 – 2051), and 1 is required in the Long-Term (2051+).

The risks associated with not constructing the recommended projects following the identified timelines are similar for each of the projects but vary in magnitude. The projects recommended in this study are needed to prevent surcharge in the associated project areas and maintain the City's targeted level of service. The impact of surcharge will vary depending on the severity of surcharge, as well as the depth of the connected sewers and sewer services upstream.

A qualitative prioritization rating has been assigned to each wastewater project in Table 4-1 below. This rating considers the recommended timing of the project (needed under existing conditions, triggered by growth, or identified as an operational improvement), severity of the surcharge identified, and presence of freeboard. In general, the following rating logic is applied:

- **Priority rating = High:** Project or recommendation is identified as needed immediately (i.e., short-term) to provide the City's target level of service to existing properties. Generally, have higher surcharge depths, reduced available freeboard. Expected impact of not implementing the recommendation is an expected increase in basement and/or surface flooding risk.
- **Priority rating = Moderate:** Project or recommendation is needed immediately (i.e., short-term) to provide the City's target level of service to existing properties. The expected impact of not implementing the recommendation is limited, however. The impacts of not implementing the project may be reduced in comparison to the high priority projects due to expected lower surcharge states, and/or the presence of freeboard that may provide additional protection to existing properties. These projects may be triggered by operational interests as well. Note that all siphon upgrades have been provided a rating of Moderate-Low as these are all triggered by redundancy and guideline compliance interests. The City is recommended to prioritize inspection and maintenance of these locations to maintain an understanding of their performance so that their criticality and priority ratings can be adjusted if needed.
- **Priority rating = Low:** Project or recommendation is dependent on growth occurring (i.e., mid-term or long-term).

Table 4-1 Wastewater Infrastructure Projects Risk Prioritization

Priority Rating	Project Number	Timing	Triggers	Location	Surcharge (approx.)	Freeboard (approx.)	Additional Comment
Moderate	WW1-1	Short-Term	Existing Capacity Constraints	Silvercreek Parkway	250mm	2.0m	
Low	WW1-2	Short-Term	Existing Capacity Constraints	Westwood Rd			Minor surcharge at 1 MH
Moderate-Low	WW2-1	Short-Term	Existing Capacity Constraints	Victoria Rd & Waverley Dr	250mm	1.8m	
Moderate	WW2-2	Short-Term	Existing Capacity Constraints	Inverness Dr, Balmoral Dr, Windsor St, Waverley Dr & Stevenson St	650mm	1.3m	
High	WW2-3	Short-Term	Existing Capacity Constraints	Wilton Rd, Inverness Dr & Speedvale Ave			Shallow sewer – Adjacent to Speed River
Low	WW2-4	Mid-Term	Growth	Speedvale Ave			Minor surcharge at 1 MH
Moderate	WW3-1	Short-Term	Existing Capacity Constraints	Exhibition Park / Kathleen St	225mm	1.5m	
Moderate	WW4-1	Short-Term	Existing Capacity Constraints	Audin Rd & Victoria Rd	800mm	2.0m	
Low	WW4-2	Mid-Term	Growth	York Rd & Beaumont Cres.			Minor surcharge at 1 MH
High	WW4-4	Short-Term	Existing Capacity Constraints	Victoria Rd	500mm	<1.8m	Shallow sewer – limited freeboard
Moderate	WW4-5	Short-Term	Existing Capacity Constraints	Summit Ridge Dr	500mm	3.0m	
High	WW5-1	Short-Term	Existing Capacity Constraints	York Rd & Wellington St	900mm	1.3m	Shallow sewer – Adjacent to Speed River
Low	WW5-2	Mid-Term	Growth	Waterloo Ave			Minor surcharge at 1 MH
Low	WW5-3	Long-Term	Growth	Bristol St			Operational triggered and Long-term
Moderate	WW5-4	Short-Term	Existing Capacity Constraints	Quebec St & Wyndham St	1900mm	0.9m	
Moderate	WW5-5	Short-Term	Existing Capacity Constraints	Woolwhich St	500mm	2.4m	
Moderate	WW5-6	Short-Term	Existing Capacity Constraints	Waterloo Ave	600mm	2.2m	
Moderate	WW6-1	Short-Term	Existing Capacity Constraints	College Ave	250mm	2.7m	
Low	WW7-1	Mid-Term	Growth	Clair Rd	70mm	3.4m	
Moderate	S1 - Manor Park Siphon	Long-Term	Operations	Manor Park Crescent / Speed River			Previous Assessment
Moderate	S2 - Municipal Street Siphon	Long-Term	Operations	Municipal Street / Speed River			Previous Assessment
Moderate-Low	S3 - Alma Mercer	Long-Term	Operations	Alma Street North / Mercer Street			Operational/Redundancy

Priority Rating	Project Number	Timing	Triggers	Location	Surcharge (approx.)	Freeboard (approx.)	Additional Comment
Moderate-Low	S4 - Elizabeth-Beaumont	Long-Term	Operations	Elizabeth Street North / Beaumont Crescent			Operational/Redundancy
Moderate-Low	S5 - Eramosa River	Long-Term	Operations	Eramosa River / Cutten Fields Golf Course			Operational/Redundancy
Moderate-Low	S6 - Hanlon-Massey-Campbell	Long-Term	Operations	Hanlon Parkway - Massey Road / Campbell Road			Operational/Redundancy
Moderate-Low	S7 - Ptarmigan	Long-Term	Operations	Ptarmigan Drive			Operational/Redundancy
Moderate-Low	S8 - Speed River Crane Park	Long-Term	Operations	Speed River - Crane Park			Operational/Redundancy
Moderate-Low	S9 - Stevenson-Eramosa	Long-Term	Operations	Stevenson Street North / Eramosa Road			Operational/Redundancy
Moderate-Low	S10 - Willow-Guelph	Long-Term	Operations	Willow Road / Guelph Street			Operational/Redundancy

4.2 Climate Change Risks

The impacts of climate change should be considered as it relates to the effectiveness of the recommendations provided. Many climate models exist and there is no way to project what the climate will be in the future from a municipal, provincial, or national perspective with certainty. The climate models consider the effectiveness of encouraged and legislated societal behavioral change, and the results of these are yet to be realized. Nonetheless, assessment of the recommended project effectiveness when considered with projected climatologically impacted variables remains warranted.

4.2.1 Water

The impact of climate change on the water distribution system relates mainly to how the weather may impact water consumption habits. The biggest concern would be water supply and the potential for wells to reduce in capacity based on a reduction in precipitation and recharge if weather patterns become hotter and drier. This WWSMP focuses on the distribution system while the Water Supply Master Plan (WSMP) was focused on the sources.

Many models are predicting the weather to become more extreme for both heat and precipitation. If the weather becomes hotter with less precipitation, water consumption will increase and put a strain on the water distribution system. The City has an Outside Water Use Program and bylaw which can be used to limit outside water use should the City be concerned that water demands are nearing the City's supply capacity. The City has used this bylaw frequently in the past based on precipitation rates and have seen significant drops in water consumption when enacted. It is an effective tool that should be continued to be relied upon to reduce the risk of demand exceeding system capacity during hot and dry seasons.

If more precipitation falls within a given year, historical data shows us that water consumption decreases. The concern of reduced water consumption is age of water in the system and potential water quality concerns. This concern is considered minimal based on the level of growth anticipated by the City. The reduction in consumption will be countered by the increased number of customers in the system.

4.2.2 Wastewater

In addition to the risk analysis presented above as it relates to upgrade timing, an additional model scenario was conducted to assess the potential impact to the collection system as it relates to climate change. The City has recently completed the Stormwater Management Master Plan: Rainfall and IDF Curve Analysis (Aquafor Beach, 2021). This document provided analysis of historical rainfall trends and projected impacts of climate change on IDF curves. The memo provided recommended IDF parameters for a "Worst Case Scenario" and a "Mid-Range Scenario". The Mid-Range scenario was used to test the collection system and determine what impact the adjusted IDF parameters would have on the rainfall distribution and how that would impact the results observed in the model.

The Aquafor Beach memo provided revised IDF parameters that can be used to derive a rainfall hyetograph to use in the model. Table 4-2 below is an excerpt from the Aquafor Beach memo and lists the IDF parameters.

Table 4-2 Mid-Range Climate Adjusted IDF Data

Return-Period	A	B	R^2
2-year	75.61	-0.738	0.9883
5-year	632.75	-0.741	0.9794
10-year	721.92	-0.736	0.9706
25-year	***822.74***	***-0.725***	***0.9513***
50-year	893.8	-0.719	0.9365
100-year	953.29	-0.711	0.9199

The A and B parameters for the 25-year were used to derive a new rainfall hyetograph for use in the model. Figure 4-1 and Figure 4-2 below show the hyetographs and total rainfall accumulation for the rainfall design storm used in the analysis to date and the climate change adjusted rainfall.

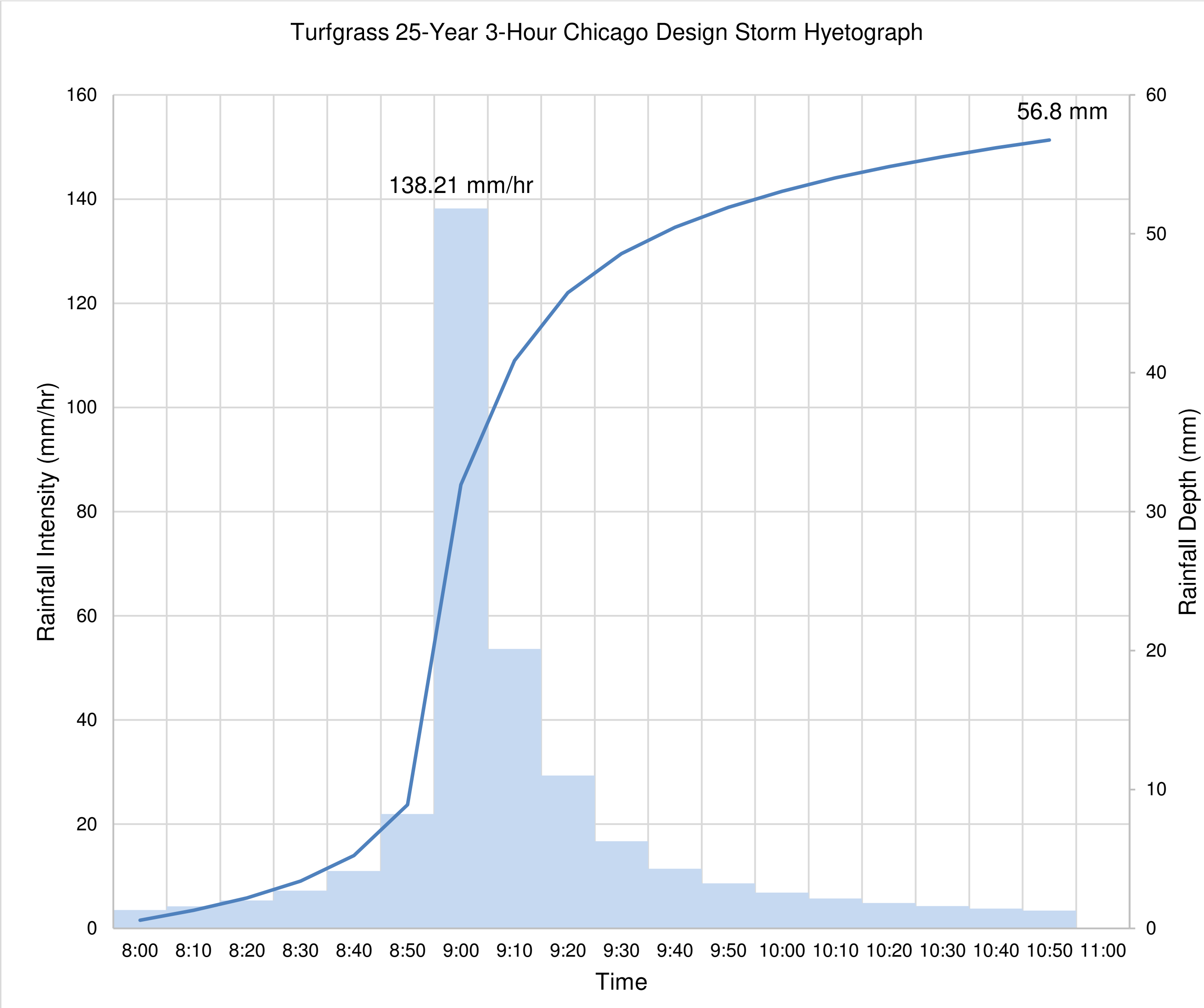

Figure 4-1 Turfgrass 25-Year 3-Hour Chiago Design Storm

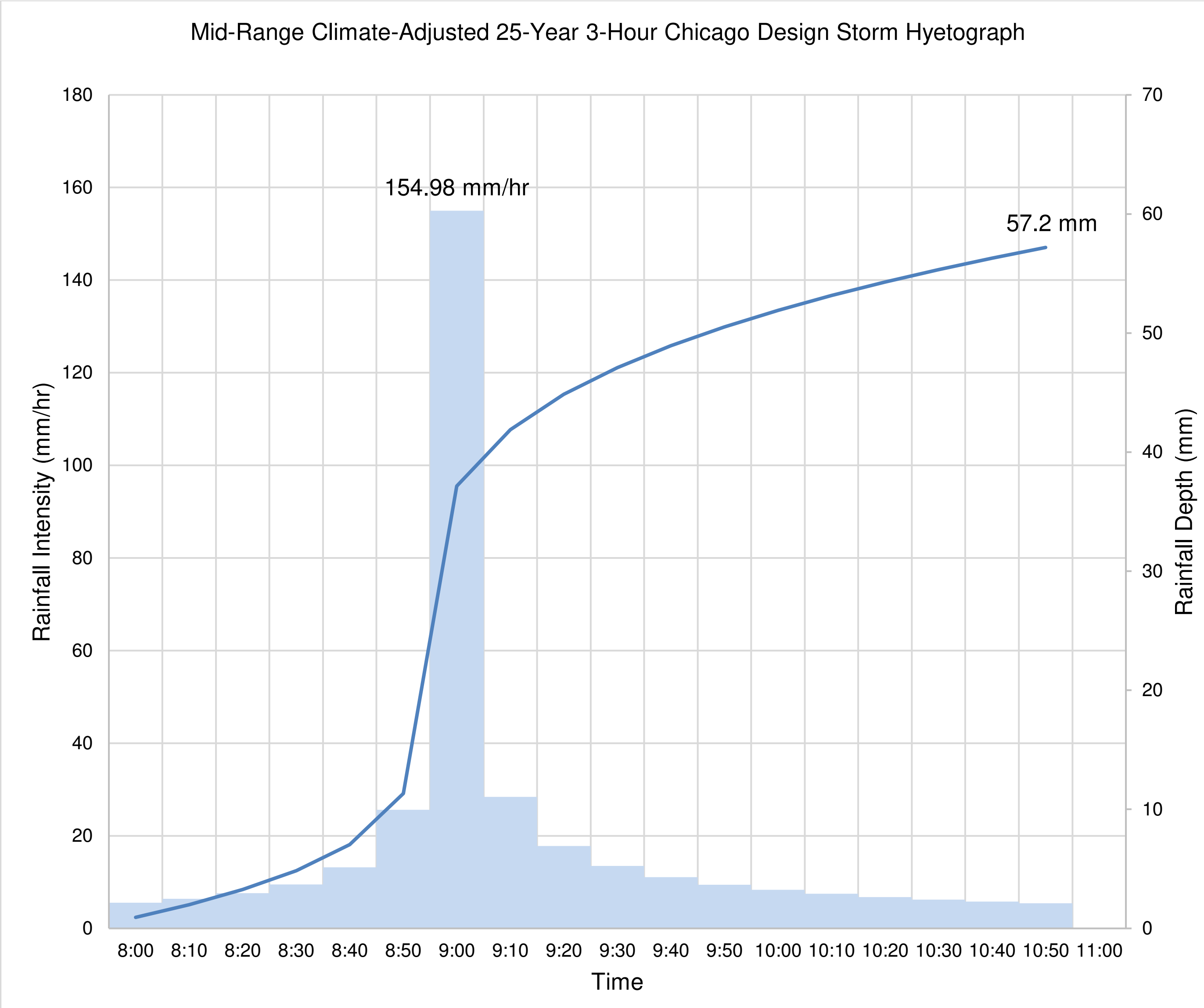

Figure 4-2 Mid-Range Climate Adjusted 25-Year 3-Hour Chicago Design Storm

As shown, the climate change adjusted rainfall is similar to the existing design storm data. The climate change design storm does see a higher peak intensity for the 25-year 3-hour Chicago design storm with 154.98 mm/hr, as compared to the existing 25-year 3-hour Chicago design storm peak intensity of 138.21 mm. The total rainfall accumulation for the two hyetographs are 57.2 mm vs 56.8 mm, an increase of only 0.4 mm.

The growth model (2051+) with upgrades was used, with the new rainfall hyetograph to assess the impact. The results of the new model scenario using the climate change adjusted rainfall are very similar to those presented in the results of *TM3*. The change is so small in fact that there is no observable difference in the HGL profiles and therefore no change to the improvements that were recommended. It is worth noting that this assessment looked at a single return period design storm under a single climate change scenario, and as such reflects the potential impact for these conditions only. The results cannot be used to infer potential impact using any other climate change conditions.

5.0 LIFECYCLE EXTENSION ACTIVITIES

There are a number of preventative measures and maintenance activities that can be used to prolong the life of a water or wastewater system asset. The following sections describe asset management activities that can extend the lifecycle of the City's infrastructure. This discussion is intended to inform the corporate asset management plan.

5.1 Water

There are many factors that contribute to the longevity of a water distribution system. Factors such as watermain material, operating pressure, age, and maintenance can influence the useful life of distribution assets. There are several watermain maintenance and small-scale upgrades that can benefit the overall lifespan of existing watermains through mitigation of risk factors. The proactive solutions are case specific and should be evaluated on a case-by-case basis to determine if one or more solutions would benefit the segment of distribution system in question. Through the implementation of applicable proactive solutions, the incidences of watermain failures and the requirement for costly and invasive watermain replacements and/or emergency repairs can be minimized.

Lifecycle extension activities can be separated into preventative maintenance and minor upgrades. Both categories of activities have unique benefits and drawbacks that should be considered when developing a distribution system lifecycle extension program.

5.1.1 Water Distribution Preventative Maintenance Based Lifecycle Extension Activities

Preventative maintenance activities represent the most cost-effective and easiest to implement lifecycle extension activities for water distribution system. Activities in this category include:

- Establishment of a regular watermain flushing/swabbing program,
- Adoption of a regular valve exercising program.

The goal of preventative maintenance activities is to help prolong asset life through the removal of accumulated films, corrosion, and scale buildup from within the distribution system. Valve operability is verified, and issues can be documented for tracking, prioritization, and correction. A flushing and valve exercising program can help to detect larger issues for correction prior to them becoming critical failures.

The cost of a preventative maintenance program is limited to the labour and mechanical equipment costs. Typically, existing swab points and hydrants are used and intrusive excavation is avoided. This may limit the range and areas that can be included in the maintenance program due to system layout constraints.

Depending on system configuration, a swabbing/exercising program may impact end users through temporary loss or reduction in pressure and/or water discolouration. A robust public communication plan should be included as part of the maintenance program.

5.1.2 Water Distribution Upgrades for Lifecycle Extension

There are minor upgrades to the distribution system that may help mitigate or eliminate damaging stresses within the distribution system. These upgrades include:

- Installation/replacement of sacrificial anodes on metallic mains/fittings,
- Installation of combination air release/vacuum breaking valves at critical system high points,
- Installation of transient protection devices (surge tanks, surge anticipator/relief valves, etc.),
- Re-lining existing watermains with cementitious grout or a cured-in-place liner system (CIPP).

Each of these options are case specific and should be evaluated for applicability on a case-by-case basis. The pertinence of each option will be based on system configuration, accessibility, construction impacts, and overall cost. Each of the options are described below and estimated lifecycle extension and costs are provided in Table 5-1 below.

Installation/Replacement of Sacrificial Anodes:

A cathodic protection program involving installing anodes on existing metallic mains and fittings is typically implemented in two methods, hotspot and full retrofit. For a hotspot program, anodes are installed in an opportunistic manner whenever a local repair or upgrade is completed. This method offers some local cathodic protection benefits but typically does not extend to the entire system due to anode size and electrical continuity breaks. Hotspot installations can be targeted at known older metallic mains/fittings to help prolong their lifespan. A full retrofit program involves the strategic design and implementation of cathodic protection by systematically installing anodes throughout the system. While a full retrofit program provides a higher degree of cathodic protection, it is more costly and intrusive when compared to a hotspot program.

Installation of Combination Air Release/Vacuum Breaking Valves:

Entrapped air and uncontrolled vacuums within a distribution system can result in dangerous pressure spikes and reduced capacity that can cause premature failure of pipelines and fittings. Through strategic design and implementation of combination valves targeted at areas where air entrainment or vacuums may occur within the system, the potential damaging effects of trapped air or vacuum events can be mitigated. Combination valves could potentially be added to existing valve chambers or within facilities if sufficient space exists. Otherwise, they would require the installation of a new chamber. It should be noted that combination valves require regular maintenance and can potentially be a source for contamination to enter the system should they fail. It is important that the valve be housed within a clean and dry environment to minimize the risk of back contamination through the valve. Dedicated chambers should be designed to include flood protection.

Installation of Transient Protection Devices:

Uncontrolled transient pressures within a system can result in premature failure of distribution piping and fittings. Transient protective devices such as surge tanks and anticipator valves (pressure and/or surge) can help to mitigate the effects of uncontrolled transient pressures. Due to size and cost restraints, surge tanks and anticipator valves would typically be added to the outlet existing facilities. System modelling should be conducted to evaluate the benefit of implementing transient protection devices at existing facilities.

Re-lining existing watermains:

Re-lining of watermains provides a restorative option that does not require the full excavation of the watermain. Access pits are placed at strategic intervals and the main is lined either using a sprayed in cementitious mortar or a cured-in-place pipe (CIPP). For both options, the main is cleaned internally of debris by high pressure water flushing or robotic scraping before the liner is installed. While cement mortar lining is still used in select instances, CIPP lining has become the more popular option in industry due to the ease of installation and the resulting longevity of the finished product.

The level of effort required to complete CIPP lining is substantial. The subject section of watermain must be fully isolated, often requiring the establishment of a temporary watermain to service affected properties. The liner cannot be installed through valves and other watermain appurtenances. Valves and appurtenances have to individually excavated and reconfigured to the new liner. Services and branch connections must also be individually reconnected to the new liner pipe. This can be done by robotic cutter from within the main in certain circumstances but often it requires excavation at each service and branch connection. The benefit of lining an existing watermain, rather than replacing the watermain, is that the level of excavation and restoration is minimized to the access and connection points. Mains that are within sensitive areas or under recently restored roadways can be rehabilitated without requiring full excavation. The final product is a stable and strong piping system with a projected lifespan of 75+ years.

5.2 Wastewater

Several lifecycle extension activities exist to prolong the life of sanitary sewer. These differ in complexity and cost, but all aim to avoid open-cut methods. The primary lifecycle extension activity considered for this Master Plan and the City's wastewater collection system is CIPP lining. CIPP is a trenchless method of sewer rehabilitation that minimizes the excavation requirements and is much faster to implement than other traditional sewer repair (or replacement) methods. CIPP involves the introduction of an uncured tube of resin into an existing pipe to reinforce it.

When comparing CIPP lining to traditional open-cut replacement, key deciding factors whether to use CIPP lining or open-cut replacement for a specific sewer may include:

- Diameter and depth
- Location and accessibility
- Ground conditions and depth of water table
- The condition of the sewer
- Configuration of the sewer (e.g., are significant bends present)
- Configuration of the maintenance holes to facilitate CIPP lining (e.g., do they need to be partially replaced or fully replaced)
- Capacity requirements (e.g., does the system require a significant increase in capacity)
- Impact to existing utilities
- Critical Crossings where trenchless methods may be preferred (e.g., critical gas main, CN Rail, utility conflicts etc.)
- Soil conditions (e.g., CIPP may help mitigate contaminated and/or excess soils which may be problematic for open-cut replacement).
- Impact to stakeholders or property owners
- Overhead hydro
- Availability of staging area
- Traffic control requirements
- Asset management considerations and Risk to the Owner (e.g., capacity to rehabilitate infrastructure within a larger area over a faster timeframe)

When comparing CIPP lining to open-cut replacement, there can be various advantages or disadvantages that are applicable on a project-by-project basis. Several factors should be considered as noted above, such as cost, depth, accessibility, crossings, environmental impacts, and requirements, permitting, stakeholder impacts, etc. A major advantage of CIPP lining for a municipality is the ability to rehabilitate a significant amount of infrastructure in a shorter period and typically at relatively lower cost than would be possible with open-cut replacement.

The life cycle expectancy of a new sanitary sewer is generally accepted as approximately 100 years and is thus the baseline that the lifecycle extension activities are compared to. Certain lifecycle extension activities are considered as essentially establishing a new pipe, namely CIPP and slip lining. The other lifecycle extensions activities are challenging to assign estimates to. In all instances, there are several factors that influence the lifespan, such as: the corrosive nature of the flow, the amount of infiltration in the sewer, and the type and magnitude of the issue (if repairing a crack or break, etc.) being mitigated.

Other rehabilitation methods as alternatives to CIPP lining are available and include:

Robotic Packers / Grouters

Robotic joint packers are often used for entry-less rehabilitation of smaller diameter sewers. A wheeled or pull-through robot moves along the sewer and inflates its ends at each defect or joint to form a seal. The space between the seals and the pipe wall is pressurized with air to test the joint for leakage. Failed joints are then pumped full of grout. The robot moves on when the grout is set. The centre of the machine is usually hollow to allow dry weather flow to travel through.

Cementitious or Chemical Grout:

A cement-based or chemical (polyurethane) grout can be injected to fill potential voids in the soil behind the crack and to patch the crack from the inside wall. Since this method requires access from inside the sewer, worker safety is a concern. If necessary, divers with full air supply could be retained to complete the work, although this would incur additional costs. Flow bypass is typically not required as the grout can be set/cured in wet conditions (particularly the polyurethane-based grout). Any encrustation / calcite deposits must be grinded and cleaned prior to grouting. Access is provided through maintenance holes, so no excavation is required, and cost is relatively low compared to other options, even if using divers, and is dependent on the amount of grout used.

Epoxy Adhesive Injection:

Epoxy adhesive can also be used to fill minor cracks; however, it does not fill potential voids in the soil behind cracks. Like grouting, this method requires access from inside the sewer, so worker safety is a concern and flow bypass may be required. Furthermore, it requires the repair surface is clean and dry. Access is provided through maintenance holes, so no excavation is required, and cost is relatively low compared to other options and particularly based on the volume of epoxy used.

Internal Joint Seals:

Internal joint seals could be used to repair circumferential cracks and fractures or separated joints. This method requires direct access and presents the same worker safety and flow bypass concerns as grouting and epoxy injection. There are several different types and manufacturers of seals including LINK-PIPE, which involves installing a short pre-folded PVC sleeve at a joint or defect, and HYDRATITE, which consists of an EPDM rubber gasket and metal band. Both systems are hydraulically expanded into place. The metal bands and PVC sleeve hinges may introduce potential ragging points, although joint seals are generally low profile. Installation costs are like grouting as direct man access is required. The seals present an additional cost, however, provide a longer lasting solution than grouting.

Slip lining

Slip lining is another common rehabilitation method which involves inserting a new rigid liner (typically PVC, HDPE or polypropylene) of smaller diameter than the host pipe, while the annular space is grouted to prevent leakage and provide structural integrity. This method often requires insertion pits to be excavated, which can incur significant costs and disruptions at surface, and may not be feasible along a straight section of sewer. Although slip lining can often be completed in wet conditions, flow management is required to construct and prepare the insertion pit. Like CIPP, the reduction in hydraulic capacity is mitigated by the lower friction of the liner.

Table 5-1 Lifecycle Extension Activities (Potable Water & Wastewater)

Issue	Type	Treatment	Extension of Service Life	Anticipated Cost
Seized Valves	Water	Valve Exercising	10-12 years	$1,950,000 (assumes ~1500 valves exercised per year, or 6 per working day, $7500 per day cost for exercise truck and crew)
Reduced watermain capacity and water quality	Water	Flushing	10-12 years	$190,000 (assumes 75-100km of main flushing per year)
Reduced pipe capacity, leakage and structural integrity	Water/Wastewater	Cured-in-place liner (CIPP)	75-100 years	Water: $1,200-$4,000 per m Wastewater: $600 - $1,700 per m
Watermain integrity, leakage and breaks due to transient pressures	Water	Transient Protection devices Surge tank	10-15 years	$10,000 + (varies on size and installation location)
		Transient Protection devices Pressure relief valve/surge anticipating valve	10-15 years	$2500+ (varies on size and installation location)
Reduced capacity and watermain breaks due to trapped air	Water	Air Valves	10-15 years	$28,000-$35,000 per chamber
Corrosion of metallic pipes	Water/ Wastewater (forcemains only)	Hotspot Sacrificial Anode	10-15 years	$500-800 per anode (installed as part of other work)
		Full retrofit	10-15 years	$1500-$2,200 per anode, $30,000-$44,000 per km of watermain @ 50m spacing

5.2.1 CIPP Opinion of Probable Costs – Replacement versus Rehabilitation

As discussed above, CIPP is considered to essentially extend the service life of a pipe to the same extent as a pipe replacement. Table 5-2 provides cost ranges for CIPP lining compared to watermain and sewer replacement. Costs provided are for pipes located on-road, and with diameters ranging from 100 mm to greater than 750 mm. The costs are highly subjective to site conditions and restoration requirements. While CIPP may not necessarily be more cost effective than watermain replacement in all cases, it can reduce the excavation requirements or be used in instances where watermain accessibility makes excavation arduous.

Cost premiums for sewer or maintenance hole depths greater than 4 m is also provided, with a percentage of increased price per each additional meter depth. Larger sewers 600 mm to 700 mm in diameter and sewers greater than or equal to 750 mm in diameter can have a larger range in price due to potential project specific complexities.

Table 5-2 CIPP Lining Opinion of Probable Costs.

Infrastructure	Replacement $/m	Rehabilitation $/m CIPP Lining	Cost Premium per metre depth (4m – 8m)	Cost Premium per metre depth (≥ 8m)
Watermain (150mm-350mm)	$770 - $1,500	$1200-$2500	N/A	N/A
Watermain (400mm – 900mm)	$1,500 - $3,300	$1500-$4000	N/A	N/A
Sanitary Sewer (100mm – 525mm)	$1,000-$1,650	$600-$800	15-20%	25%
Sanitary Sewer (600mm - 675mm)	$1,700-$1,950	$900-$1,000	NA	NA
Sanitary Sewer (≧750mm)	$2,000-$3,550	$1,300-$1,700	NA	NA

6.0 CONCLUSIONS

Capital projects have been recommended and cost estimates have been summarized in this TM for the purpose of feeding into the City's capital budget. This TM has provided a summary of asset management activities including cost estimates and estimated extensions to service life to inform the corporate asset management plan.